## AATSR Level 2 Detailed Processing Model & Parameter Data List

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Oxfordshire OX11 0QX

<table>
<thead>
<tr>
<th>Prepared by:</th>
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<th>Approved by:</th>
<th>Caroline Cox, RAL</th>
<th>Date:</th>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Caroline Cox</td>
<td></td>
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Commercial In Confidence  
AATSR Product Algorithm Detailed Documentation  
# Amendment Record

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<td>Revised to incorporate changes to the across-track banding scheme for SST derivation; to the infra-red brightness temperature precision in the ABT product, and to the definition of the Meteo product.</td>
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(to update these data, click on the field, hold down right mouse button and use Update Field)

Status(Draft / Controlled): Controlled
TABLE OF CONTENTS

1. PURPOSE OF DOCUMENT ......................................................................................... 8
2. INTRODUCTION ........................................................................................................ 8
  2.1 Acronyms ............................................................................................................. 8
3. REFERENCE DOCUMENTS ......................................................................................... 9
4. DETAILED PROCESSING MODEL ........................................................................... 10
  4.1 Overview of Processing Structure ....................................................................... 12
    4.1.1 General .......................................................................................................... 12
    4.1.2 Input Annotation Data Sets (Module 1) .......................................................... 12
    4.1.3 Assemble Regridded Brightness Temperature Arrays (Module 2) ............... 13
    4.1.4 Interpolate Solar Angles (Module 3) ............................................................. 13
    4.1.5 Interpolate Image Pixel position (Module 4) .................................................. 14
    4.1.6 Grided SST/Vegetation Retrieval (Module 5) ............................................... 14
    4.1.7 Output GSST Records (Module 6) ................................................................. 14
    4.1.8 Spatial Averaging (Half-Degree Cell) (Module 7) ........................................... 14
    4.1.9 Averaged SST Retrieval (Half-Degree Cell) (Module 8) ............................. 14
    4.1.10 Averaged NDVI Retrieval (Half-Degree Cell) (Module 9) ....................... 14
    4.1.11 Spatially Averaged Cloud parameters (Half-Degree Cell) (Module 10) ..... 14
    4.1.12 Spatial Averaging (50 km cell) (Module 11) .............................................. 15
    4.1.13 Averaged SST Retrieval (50 km cell) (Module 12) .................................. 15
    4.1.14 Averaged NDVI Retrieval (50 km cell) (Module 13) ................................. 15
    4.1.15 Spatially Averaged Cloud parameters (50 km cell) (Module 14) ............. 15
    4.1.16 Output AST Records (Module 15) ............................................................... 15
    4.1.17 Output ECMWF Product (Module 16) ....................................................... 15
    4.1.18 Breakpoints ................................................................................................. 15
  4.2 Module Definition: Input Annotation Data Sets .................................................. 21
    4.2.1 Functional Description .................................................................................. 21
    4.2.2 Interface Definition ....................................................................................... 21
4.2.3 Detailed Structure ................................................................. 23

4.3 Module Definition: Assemble Regridded Brightness Temperature Arrays .......... 24
4.3.1 Functional Description ......................................................... 24
4.3.2 Interface Definition .............................................................. 24
4.3.3 Detailed Structure ............................................................... 27
4.3.3.1 Initialise Arrays .............................................................. 27
4.3.3.2 Input MDS records ......................................................... 27

4.4 Module Definition: Interpolate Solar Angles ..................................... 29
4.4.1 Functional Description .......................................................... 29
4.4.2 Interface Definition .............................................................. 29
4.4.3 Detailed Structure ............................................................... 30

4.5 Module Definition: Interpolate Image Pixel Position ............................. 31
4.5.1 Functional Description .......................................................... 32
4.5.2 Interface Definition .............................................................. 32
4.5.3 Detailed Structure ............................................................... 33

4.6 Module Definition: Gridded SST / Vegetation Retrieval .......................... 34
4.6.1 Functional Description .......................................................... 34
4.6.2 Interface Definition .............................................................. 35
4.6.3 Detailed Structure ............................................................... 37

4.7 Module Definition: Output GSST Records ....................................... 47
4.7.1 Functional Description .......................................................... 51
4.7.2 Interface Definition .............................................................. 51
4.7.3 Detailed Structure ............................................................... 53

4.8 Module Definition: Spatial Averaging (Half Degree Cell) ....................... 56
4.8.1 Functional Description .......................................................... 56
4.8.2 Interface Definition .............................................................. 56
4.8.3 Detailed Structure ............................................................... 58

4.9 Module Definition: Averaged SST Retrieval (Half Degree Cell) ............... 66
4.9.1 Functional Description .......................................................... 66
4.9.2 Interface Definition .............................................................. 66
4.9.3 Detailed Structure ............................................................... 68

4.10 Module Definition: Averaged NDVI Retrieval (Half Degree Cell) ............ 74
4.10.1 Functional Description .................................................................................. 74
4.10.2 Interface Definition ....................................................................................... 75
4.10.3 Detailed Structure .......................................................................................... 76

4.11 Module Definition: Spatially Averaged Cloud Parameters (Half Degree Cell) .......... 77
  4.11.1 Functional Description .................................................................................... 82
  4.11.2 Interface Definition ....................................................................................... 83
  4.11.3 Detailed Structure ........................................................................................ 85

4.12 Module Definition: Spatial Averaging (50 km Cell) ........................................... 86
  4.12.1 Functional Description .................................................................................... 86
  4.12.2 Interface Definition ....................................................................................... 87
  4.12.3 Detailed Structure ........................................................................................ 89

4.13 Module Definition: Averaged SST Retrieval (50 km Cell) ................................. 97
  4.13.1 Functional Description .................................................................................... 97
  4.13.2 Interface Definition ....................................................................................... 97
  4.13.3 Detailed Structure ........................................................................................ 98

4.14 Module Definition: Averaged NDVI Retrieval (50 km Cell) ......................... 105
  4.14.1 Functional Description .................................................................................... 105
  4.14.2 Interface Definition ....................................................................................... 105
  4.14.3 Detailed Structure ........................................................................................ 107

4.15 Module Definition: Spatially Averaged Cloud Parameters (50 km Cell) ........... 107
  4.15.1 Functional Description .................................................................................... 112
  4.15.2 Interface Definition ....................................................................................... 113
  4.15.3 Detailed Structure ........................................................................................ 115

4.16 Module Definition: Output AST Product .......................................................... 116
  4.16.1 Functional Description .................................................................................... 116
  4.16.2 Interface Definition ....................................................................................... 116
  4.16.3 Detailed Structure ........................................................................................ 117

4.17 Module Definition: Output ECMWF Product .................................................. 132
  4.17.1 Functional Description .................................................................................... 132
  4.17.2 Interface Definition ....................................................................................... 132
  4.17.3 Detailed Structure ........................................................................................ 132

5. INTERNAL PARAMETER LIST ............................................................................. 134
1 PURPOSE OF DOCUMENT

This document defines the Data Processing Model and the Parameter Data List for ENVISAT AATSR Level 2 processing.

2 INTRODUCTION

AATSR Level 2 processing encompasses the derivation of the GSST and ASST products from GBTR products output at Level 1B (ref. [1]). This document describes the step by step procedures which should be implemented within the ENVISAT Ground Segment processing to produce near real-time (NRT) and offline products.

2.1 Acronyms

<table>
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<tr>
<th>Acronym</th>
<th>Definition</th>
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<tr>
<td>AATSR</td>
<td>Advanced Along-Track Scanning Radiometer</td>
</tr>
<tr>
<td>ADS</td>
<td>Annotation Data Set; a data set within an ENVISAT product containing annotation data.</td>
</tr>
<tr>
<td>AST</td>
<td>Averaged Surface Temperature.</td>
</tr>
<tr>
<td>BB</td>
<td>Black Body</td>
</tr>
<tr>
<td>CAEID</td>
<td>Critical Algorithm Elements Identification Document</td>
</tr>
<tr>
<td>CAPA</td>
<td>Critical Analysis of Processing Algorithms Document</td>
</tr>
<tr>
<td>CFI</td>
<td>Customer Furnished Item</td>
</tr>
<tr>
<td>CGU</td>
<td>Clock Generation Unit</td>
</tr>
<tr>
<td>CRC</td>
<td>Cyclical Redundancy Check</td>
</tr>
<tr>
<td>CRRD</td>
<td>Computer Resource Requirements Document</td>
</tr>
<tr>
<td>DPM</td>
<td>Detailed Processing Model</td>
</tr>
<tr>
<td>DS</td>
<td>Data Set</td>
</tr>
<tr>
<td>DSD</td>
<td>Data Set Descriptor</td>
</tr>
<tr>
<td>DSR</td>
<td>Data Set Record</td>
</tr>
<tr>
<td>FODP</td>
<td>Flight Operation and Data Plan</td>
</tr>
<tr>
<td>FPA</td>
<td>Focal Plane Assembly</td>
</tr>
<tr>
<td>GBTR</td>
<td>Gridded Brightness Temperature/Reflectance</td>
</tr>
<tr>
<td>GOME</td>
<td>Global Ozone Monitoring Experiment</td>
</tr>
<tr>
<td>GSST</td>
<td>Gridded Sea Surface Temperature</td>
</tr>
<tr>
<td>I/O DD</td>
<td>Input/Output Data Definition Document</td>
</tr>
<tr>
<td>LST</td>
<td>Land Surface Temperature</td>
</tr>
<tr>
<td>LUT</td>
<td>Look Up Table</td>
</tr>
<tr>
<td>MDS</td>
<td>Measurement Data Set; a data set within an ENVISAT product containing instrument data</td>
</tr>
<tr>
<td>MPH</td>
<td>Main Product Header</td>
</tr>
<tr>
<td>MX BB</td>
<td>Minus X black body</td>
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3 Reference Documents

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<td>RD-3</td>
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4 Detailed Processing Model

This section describes the level 2 processing. It includes a module by module breakdown of the processing structure. First a general overview of the processing structure can be found (see also Figure 4-1-1). This is followed by a more detailed description of each of the component modules; each module having:

- A functional description
- An interface definition
- An algorithm definition or detailed structure description
- A description of test procedures.

The interface definition consists of two tables, an Input table and an Internal table. The first deals principally with the interface to the IODD and to external files defined within the ENVISAT processing environment. The second defines parameters which are “internal to the processor”, that is to say parameters which are defined within a particular module, used by one or more modules. The Input table can contain parameters defined either in the IODD, or another external file - it represents the interface with the “outside world". The Internal table contains newly defined parameters or parameters defined in a previously declared Internal table, which the module under discussion needs to access. Internal parameters can be local (to the module), or global. Global parameters are available to other modules, including the product output module. All global internal parameters are summarized in Table 5-1: Internal Parameter summary list.

Parameter names are defined using the following conventions:

IODD parameters: format: <ProductCode>-<Data set>-<ID number> (e.g. L0-MDS1-1)

Internal parameters format (global variables): <DPM>-INT-<SEQ> (e.g. L1B-INT-1), where SEQ is a unique number for any given DPM level.

The data tables have the following columns:

<table>
<thead>
<tr>
<th>Parameter ID:</th>
<th>refers to the ID in the IODD (for external parameters) or the internal data ID for internally generated parameters. These are also used within pseudo code and text descriptions to refer to the parameters. In the case of internal parameters, if this field is blank, or contains “local”, the variable is taken to be local to the module. For example, loop counters would generally be defined as local variables. If an Internal ID is defined, the variable is assumed to be global.</th>
</tr>
</thead>
</table>
Variable: This is an optional entry, allowing a parameter to also be referred to within the text through a variable name, for ease of use, or to follow convention. If the column is blank, the parameter will always be referred to by its ID;

Name: A “long name” format, providing the means for a short description. This can be used for reference in text descriptions, but generally is not used within pseudo code for reasons of clarity.

Type: The parameter type, using standard ENVISAT PDS conventions;

Units: The parameter SI unit (where appropriate), and if necessary scaling factor;

Size: The space required by the parameter in bytes;

Fields: The number of fields for cases where the ID refers to an array of parameters;

Other conventions in use in this document are as follows:

Underscore is regarded as an alphabetic character in variable names.

Type font and style are of no significance; for example, the same variable is meant whether the name appears in italic or roman type, or in a different font.

Type of brackets is of no significance; either parentheses or square brackets may be used equivalently. Parameter IDs are designed to enable cross-referencing between this document and the I/O DD, and between modules within this document, and they may be used as variable names to reduce ambiguity. Parameter IDs used in equations are generally enclosed in square brackets, to enable them to be subscripted. Thus if a parameter ID refers to an indexed or subscripted variable, the following notation may be used to associate the subscript ‘i’ with the ID: \([L2\text{-INT\text{-nn}}](i)\).

For example

\([L2\text{-INT\text{-101}}](i, j)\) is equivalent to \(I(ir12, n; i, j)\)

\([L2\text{-INT\text{-110}}](i, j)\) is equivalent to \(frwrd\_fill\_state(i, j)\)

and so on.

Pointed brackets <> are (except for a few points in the Level 2 processing where they are used to denote averaged quantities: this should be clear from the context) metasyntactical; they enclose strings that are to be substituted by one of a set of optional strings to give the true variable name. For example, the construction \(<\text{view}\>_\_fill\_state(i, j)\) is to represent one of the two quantities \(nadir\_fill\_state(i, j)\) or \(frwrd\_fill\_state(i, j)\), according as whether the nadir or forward view data is being processed.

Indices in equations may appear indifferently as subscripts or enclosed in brackets. Sometimes the convention of separating parenthesised indices with semicolons is used: e.g. \(I(ch, v; i, j)\). The significance of this is that the indices preceding the square brackets are regarded as subscripts that may be thought of as part of the variable name (and therefore need
not correspond to variables in an implementation) while those following the semicolon are array indices.

Indexing

The following indexing conventions are adopted generally:

- \( i \) along track (image scan) index
- \( j \) across track (image pixel) index (\( j = 0, 511 \))

Unless otherwise stated, indices start at zero.

For the purpose of indexing and identifying the AATSR channels, the following conventional numbering scheme will be adopted.

<table>
<thead>
<tr>
<th>AATSR Channel</th>
<th>Symbol</th>
<th>Index (ch)</th>
</tr>
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<tbody>
<tr>
<td>12 micron</td>
<td>( \text{ir12} )</td>
<td>1</td>
</tr>
<tr>
<td>11 micron</td>
<td>( \text{ir11} )</td>
<td>2</td>
</tr>
<tr>
<td>3.7 micron</td>
<td>( \text{ir37} )</td>
<td>3</td>
</tr>
<tr>
<td>1.6 micron</td>
<td>( \text{v16} )</td>
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<td>0.870 micron</td>
<td>( \text{v870} )</td>
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<td>0.670 micron</td>
<td>( \text{v670} )</td>
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<tr>
<td>0.55 micron</td>
<td>( \text{v555} )</td>
<td>7</td>
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</tbody>
</table>

Requirements are identified by numbers of the form (Req. \(<\text{id}>-<\text{sequence}>\)) where \(<\text{id}>\) is an identifier that is unique to the module or chapter, and \(<\text{sequence}>\) is the sequence number within the series identified by \(<\text{id}>\).

4.1 Overview of Processing Structure

4.1.1 General

Figure 4-1-1 shows an overview of the Level 2 processing.

The main steps in the production of the Level 2 products are as follows:

- Derivation of Sea Surface Temperature (SST) and other parameters from the GBTR regridded brightness temperatures.
- Generation of averaged brightness temperatures and reflectances from the GBTR regridded brightness temperatures and visible channel reflectances.
- Derivation of averaged SST from the averaged brightness temperatures, and of NDVI from the averaged reflectances.

The processing makes use of some but not all of the supporting data from the GBTR ADS.

4.1.2 Input Annotation Data Sets (Module 1)

This module inputs those Annotation Data Sets of the GBTR product that are required for Level 2 Processing, and converts into appropriate units where necessary. It is described in Section 4.2.
4.1.3 Assemble Regridded Brightness Temperature Arrays (Module 2)

This module reads in grid co-ordinates and channel brightness temperatures / reflectances for forward and nadir views from the appropriate MDS of the GBTR product and arranges them in the required memory configuration. It is described in Section 4.3.

4.1.4 Interpolate Solar Angles (Module 3)

The solar azimuth and elevation and satellite azimuth and elevation, all measured at the pixel, are available for a series of uniformly spaced tie point pixels in ADS #5 for the nadir view and in ADS #6 for the forward view images. The present module derives those angles that are required for level 2 processing at every scan, and at the mid-points of the bands, by linear interpolation, between these tie points. Only the solar elevation is required for Level 2 processing as presently defined. It is described is Section 4.4.
4.1.5 Interpolate Image Pixel position (Module 4)

The (geodetic) latitudes and longitudes of a series of uniformly spaced tie point pixels are available in ADS #3. This module derives the latitude and longitude of each of image pixel by linear interpolation, in two dimensions, between these tie points. The module is described in Section 4.5.

4.1.6 Gridded SST/Vegetation Retrieval (Module 5)

This module derives the contents of the GSST product at 1 km resolution from the infra-red brightness temperatures. It derives the sea surface temperature (SST) or, over land, the vegetation index (NDVI), at 1 Km resolution, using cloud free data. It is described in Section 4.6.

4.1.7 Output GSST Records (Module 6)

All data required for the GSST product is now available, and is formatted into the products described in the IODD. The module is described in Section 4.16.

4.1.8 Spatial Averaging (Half-Degree Cell) (Module 7)

For the averaged products in half-degree cells, the globe is imagined as divided into cells 0.5° in latitude by 0.5° in longitude, and these cells are further subdivided into 9 sub-cells extending 10 arcmin in latitude by 10 arcmin in longitude. For each channel, the average brightness temperature (for the infra-red channels) or reflectance (for the visible channels) is averaged over all pixels of each type that fall within each sub-cell, to give distributions of a brightness temperature and radiance at 10 arc minute resolution. Averages are performed for the forward and nadir views separately, and a separate average is performed for each surface type (land and sea) and cloud state (clear or cloudy). There are thus 4 averages per channel per view. The mean across-track band number in each cell is also derived, for use by the averaged SST algorithm. The module is described in Section 4.8.

4.1.9 Averaged SST Retrieval (Half-Degree Cell) (Module 8)

This module derives the averaged SST for the cells and sub-cells from the averaged brightness temperatures determined above, for cells containing sea. It is described in Section 4.9.

4.1.10 Averaged NDVI Retrieval (Half-Degree Cell) (Module 9)

The NDVI is calculated for each sub-cell for which average reflectances over land have been calculated. The averaged NDVI over all the sub-cells, and its standard deviation, are also computed. The module is described in Section 4.10.

4.1.11 Spatially Averaged Cloud parameters (Half-Degree Cell) (Module 10)

This module provides physical information on the cloud state additional to the results of the cloud flagging provided in the Level 1b product. The product is based on the same half-degree cells defined above. In particular it derives an estimate of the cloud-top temperature. The latter is interpreted as the mean brightness temperature of the coldest 25% of the cloudy pixels in the cell. The module is described in Section 4.11.
4.1.12 Spatial Averaging (50 km cell) (Module 11)

This module derives spatially averaged brightness temperatures and reflectances as in Module 7, but averaged over cells and subcells of nominal dimensions 50 km x 50 km, and 17 x 17 km, respectively. It is described in Section 4.12

4.1.13 Averaged SST Retrieval (50 km cell) (Module 12)

This module derives spatially averaged brightness temperatures and reflectances as in Module 8, but averaged over cells and subcells of nominal dimensions 50 km x 50 km, and 17 x 17 km, respectively. It is described in Section 4.13

4.1.14 Averaged NDVI Retrieval (50 km cell) (Module 13)

This module derives spatially averaged NDVI as in Module 9, but averaged over cells and subcells of nominal dimensions 50 km x 50 km, and 17 x 17 km, respectively. It is described in Section 4.14.

4.1.15 Spatially Averaged Cloud parameters (50 km cell) (Module 14)

This module derives cloud parameters as in Module 9, but based on a cell of nominal dimensions 50 km x 50 km. It is described in Section 4.15.

4.1.16 Output AST Records (Module 15)

All data required for the AST product is now available, and is formatted into the products described in the IODD. The module is described in Section 4.16.

4.1.17 Output ECMWF Product (Module 16)

The ECMWF Averaged SST Product consists of an additional extraction of the AST product Measurement Data Set MDS #3. The product is generated in this module, which is described in Section 4.17.

4.1.18 Breakpoints

The following data shall be used as breakpoints in the testing of the Level 2 process. 
Interpolated Solar Angles at the output of Module 3.
Interpolated pixel co-ordinates at the output of Module 4.
GSST Product Outputs from module 5.
AST product outputs from modules 7 - 15.

The table below indicates the accuracy with which the data should be verified against the output of the reference processor.

<table>
<thead>
<tr>
<th>Parameter ID</th>
<th>Name</th>
<th>Verification Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>L2-INT-120</td>
<td>nadr_band_edge_solar_elevation(i, k)</td>
<td>1 part in 1e6</td>
</tr>
<tr>
<td>L2-INT-140</td>
<td>fwrfd_band_edge_solar_elevation(i, k)</td>
<td>1 part in 1e6</td>
</tr>
<tr>
<td>L2-INT-124</td>
<td>nadr_band_centre_solar_elevation(i, k')</td>
<td>1 part in 1e6</td>
</tr>
<tr>
<td>L2-INT-144</td>
<td>fwrfd_band_centre_solar_elevation(i, k')</td>
<td>1 part in 1e6</td>
</tr>
<tr>
<td>L2-INT-160</td>
<td>image latitude</td>
<td>1 part in 1e6</td>
</tr>
<tr>
<td>L2-INT-161</td>
<td>image longitude</td>
<td>1 part in 1e6</td>
</tr>
</tbody>
</table>
Table 4-2-1. Level 2 Breakpoints

Note: In the table above, ‘Generally exact’ relates to flags or quantities of type integer, and indicates that test results should agree exactly with the reference processor in the majority of cases, but that a small number (TBD) of discrepancies may acceptable owing to differences in machine precision.

The following tables describe the formats specified for the breakpoint outputs.

### Table 4-2-2: Break Point #1 Record: nadir solar and viewing angles

<table>
<thead>
<tr>
<th>Parameter ID</th>
<th>Start byte</th>
<th>End byte</th>
<th>Field Description</th>
<th>Type</th>
<th>Units</th>
<th>Field size</th>
<th>Fields</th>
</tr>
</thead>
<tbody>
<tr>
<td>none</td>
<td>0</td>
<td>3</td>
<td>image row index (i)</td>
<td>sl</td>
<td>n/a</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>L2-INT-120</td>
<td>4</td>
<td>47</td>
<td>nadir_band_edge_solar_elevation(i, k)</td>
<td>float</td>
<td>degrees</td>
<td>4</td>
<td>11</td>
</tr>
<tr>
<td>L2-INT-124</td>
<td>48</td>
<td>87</td>
<td>nadir_band_centre_solar_elevation(i, k)</td>
<td>float</td>
<td>degrees</td>
<td>4</td>
<td>10</td>
</tr>
<tr>
<td>L2-INT-140</td>
<td>88</td>
<td>131</td>
<td>fwdrd_band_edge_solar_elevation(i, k)</td>
<td>float</td>
<td>degrees</td>
<td>4</td>
<td>11</td>
</tr>
<tr>
<td>L2-INT-144</td>
<td>132</td>
<td>171</td>
<td>fwdrd_band_centre_solar_elevation(i, k)</td>
<td>float</td>
<td>degrees</td>
<td>4</td>
<td>10</td>
</tr>
</tbody>
</table>

### Table 4-2-3: Break Point #2 Record: nadir view instrument pixel numbers

<table>
<thead>
<tr>
<th>Parameter ID</th>
<th>Start byte</th>
<th>End byte</th>
<th>Field Description</th>
<th>Type</th>
<th>Units</th>
<th>Field size</th>
<th>Fields</th>
</tr>
</thead>
<tbody>
<tr>
<td>none</td>
<td>0</td>
<td>3</td>
<td>image row index (i)</td>
<td>sl</td>
<td>n/a</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>L2-INT-160</td>
<td>4</td>
<td>2051</td>
<td>image_latitude(i, j)</td>
<td>float</td>
<td>degrees</td>
<td>4</td>
<td>512</td>
</tr>
<tr>
<td>L2-INT-161</td>
<td>2052</td>
<td>4099</td>
<td>image_longitude(i, j)</td>
<td>float</td>
<td>degrees</td>
<td>4</td>
<td>512</td>
</tr>
</tbody>
</table>

### Table 4-2-4: Break Point #3 Record: Gridded product record

<table>
<thead>
<tr>
<th>Parameter ID</th>
<th>Start byte</th>
<th>End byte</th>
<th>Field Description</th>
<th>Type</th>
<th>Units</th>
<th>Field size</th>
<th>Fields</th>
<th>Verification Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>none</td>
<td>0</td>
<td>3</td>
<td>image row index (i)</td>
<td>sl</td>
<td>n/a</td>
<td>4</td>
<td>1</td>
<td>exact</td>
</tr>
<tr>
<td>L2-INT-272</td>
<td>4</td>
<td>1027</td>
<td>confidence words</td>
<td>us</td>
<td>flags</td>
<td>2</td>
<td>512</td>
<td>generally exact</td>
</tr>
<tr>
<td>L2-INT-270</td>
<td>1028</td>
<td>2051</td>
<td>nadir field prior to SST smoothing</td>
<td>ss</td>
<td>K/100</td>
<td>2</td>
<td>512</td>
<td>0.01 K</td>
</tr>
<tr>
<td>L2-INT-271</td>
<td>2052</td>
<td>3075</td>
<td>combined field prior to SST smoothing</td>
<td>ss</td>
<td>K/100</td>
<td>2</td>
<td>512</td>
<td>0.01 K</td>
</tr>
</tbody>
</table>

Note 1. The GSST product is switchable, so that the contents of these MDS fields depend on the setting of the cloud land flags. The confidence word is included in the above records so that the product is interpretable. The units of these quantities depend on the flag settings; values quoted are for cloud-free sea data.

### Table 4-2-5: Break point #4 Record, AST Sea Record, 30 arc minute cell

<table>
<thead>
<tr>
<th>Field No.</th>
<th>Start byte</th>
<th>End byte</th>
<th>View</th>
<th>Field Description</th>
<th>Type</th>
<th>Units</th>
<th>Field size</th>
<th>Fields</th>
<th>Verification Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>L2-INT-30</td>
<td>0</td>
<td>7</td>
<td>n/a</td>
<td>cell UTC</td>
<td>double</td>
<td>days</td>
<td>3</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>L2-INT-47</td>
<td>8</td>
<td>11</td>
<td>n/a</td>
<td>cell latitude</td>
<td>sl</td>
<td>μdeg</td>
<td>4</td>
<td>100</td>
<td>μdeg</td>
</tr>
<tr>
<td>L2-INT-48</td>
<td>12</td>
<td>15</td>
<td>n/a</td>
<td>cell longitude</td>
<td>sl</td>
<td>μdeg</td>
<td>4</td>
<td>100</td>
<td>μdeg</td>
</tr>
<tr>
<td>L2-INT-344</td>
<td>16</td>
<td>19</td>
<td>N</td>
<td>total of clear sea pixels, nadir view</td>
<td>sl</td>
<td>none</td>
<td>4</td>
<td>1</td>
<td>exact</td>
</tr>
<tr>
<td>L2-INT-345</td>
<td>20</td>
<td>23</td>
<td>F</td>
<td>total of clear sea pixels, forward view</td>
<td>sl</td>
<td>none</td>
<td>4</td>
<td>1</td>
<td>exact</td>
</tr>
<tr>
<td>L2-INT-346</td>
<td>24</td>
<td>27</td>
<td>N</td>
<td>total of cloudy sea pixels, nadir view</td>
<td>sl</td>
<td>none</td>
<td>4</td>
<td>1</td>
<td>exact</td>
</tr>
<tr>
<td>Field No.</td>
<td>Start byte</td>
<td>End byte</td>
<td>View</td>
<td>Field Description</td>
<td>Type</td>
<td>Units</td>
<td>Field Size</td>
<td>Fields</td>
<td>Verification Accuracy</td>
</tr>
<tr>
<td>----------</td>
<td>------------</td>
<td>----------</td>
<td>------</td>
<td>-------------------</td>
<td>------</td>
<td>-------</td>
<td>------------</td>
<td>--------</td>
<td>-----------------------</td>
</tr>
<tr>
<td>L2-INT-30</td>
<td>0</td>
<td>7</td>
<td>n/a</td>
<td>cell UTC</td>
<td>double</td>
<td>days</td>
<td>9</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>L2-INT-47</td>
<td>8</td>
<td>11</td>
<td>n/a</td>
<td>cell latitude</td>
<td>sl</td>
<td>µdeg</td>
<td>1</td>
<td>100 udeg</td>
<td></td>
</tr>
<tr>
<td>L2-INT-48</td>
<td>12</td>
<td>15</td>
<td>n/a</td>
<td>cell longitude</td>
<td>sl</td>
<td>µdeg</td>
<td>1</td>
<td>100 udeg</td>
<td></td>
</tr>
<tr>
<td>L2-INT-328</td>
<td>16</td>
<td>19</td>
<td>N</td>
<td>total of clear land pixels, nadir view</td>
<td>sl</td>
<td>none</td>
<td>4</td>
<td>1</td>
<td>exact</td>
</tr>
<tr>
<td>L2-INT-329</td>
<td>20</td>
<td>23</td>
<td>F</td>
<td>total of clear land pixels, forward view</td>
<td>sl</td>
<td>none</td>
<td>4</td>
<td>1</td>
<td>exact</td>
</tr>
<tr>
<td>L2-INT-330</td>
<td>24</td>
<td>27</td>
<td>N</td>
<td>total of cloudy land pixels, nadir view</td>
<td>sl</td>
<td>none</td>
<td>4</td>
<td>1</td>
<td>exact</td>
</tr>
<tr>
<td>L2-INT-331</td>
<td>28</td>
<td>31</td>
<td>F</td>
<td>total of cloudy land pixels, forward view</td>
<td>sl</td>
<td>none</td>
<td>4</td>
<td>1</td>
<td>exact</td>
</tr>
<tr>
<td>L2-INT-332</td>
<td>32</td>
<td>2031</td>
<td>F</td>
<td>nadir histogram (land cell)</td>
<td>ss</td>
<td>none</td>
<td>2</td>
<td>1000</td>
<td>exact</td>
</tr>
<tr>
<td>L2-INT-333</td>
<td>2032</td>
<td>2031</td>
<td>F</td>
<td>forward histogram (land cell)</td>
<td>ss</td>
<td>none</td>
<td>2</td>
<td>1000</td>
<td>exact</td>
</tr>
<tr>
<td>L2-INT-40</td>
<td>4032</td>
<td>4045</td>
<td>N</td>
<td>Total clear pixels over land in cell, ch = 1,...?</td>
<td>ss</td>
<td>none</td>
<td>2</td>
<td>7</td>
<td>exact</td>
</tr>
<tr>
<td>L2-INT-40</td>
<td>4046</td>
<td>4059</td>
<td>N</td>
<td>Total cloudy pixels over land in cell, ch = 1,...?</td>
<td>ss</td>
<td>none</td>
<td>2</td>
<td>7</td>
<td>exact</td>
</tr>
<tr>
<td>L2-INT-40</td>
<td>4060</td>
<td>4073</td>
<td>F</td>
<td>Total clear pixels over sea in cell, ch = 1,...?</td>
<td>ss</td>
<td>none</td>
<td>2</td>
<td>7</td>
<td>exact</td>
</tr>
<tr>
<td>L2-INT-40</td>
<td>4074</td>
<td>4087</td>
<td>F</td>
<td>Total cloudy pixels over sea in cell, ch = 1,...?</td>
<td>ss</td>
<td>none</td>
<td>2</td>
<td>7</td>
<td>exact</td>
</tr>
</tbody>
</table>

**Table 4-2-6:** Break point #5 Record, AST Land Record, 30 arc minute cell
### Table 4-2-7: Break point #6 Record, AST Sea Record, 10 arc minute cell

<table>
<thead>
<tr>
<th>Field No.</th>
<th>Start byte</th>
<th>End byte</th>
<th>View</th>
<th>Field Description</th>
<th>Type</th>
<th>Units</th>
<th>Size</th>
<th>Fields</th>
<th>Verification Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>L2-INT-31</td>
<td>0</td>
<td>11</td>
<td>n/a</td>
<td>sub-cell UTC</td>
<td>double</td>
<td>days</td>
<td>9</td>
<td>1</td>
<td>exact</td>
</tr>
<tr>
<td>L2-INT-49</td>
<td>12</td>
<td>12</td>
<td>n/a</td>
<td>nadir view day/night flag</td>
<td>ss</td>
<td>flag</td>
<td>2</td>
<td>1</td>
<td>exact</td>
</tr>
<tr>
<td>L2-INT-50</td>
<td>13</td>
<td>15</td>
<td>n/a</td>
<td>forward view day/night flag</td>
<td>ss</td>
<td>flag</td>
<td>2</td>
<td>1</td>
<td>exact</td>
</tr>
<tr>
<td>L2-INT-45</td>
<td>16</td>
<td>19</td>
<td>n/a</td>
<td>nadir solar elevation for sub-cell</td>
<td>float</td>
<td>degrees</td>
<td>4</td>
<td>1</td>
<td>1 part in 1e6</td>
</tr>
<tr>
<td>L2-INT-46</td>
<td>20</td>
<td>23</td>
<td>n/a</td>
<td>fwdrd solar elevation for sub-cell</td>
<td>float</td>
<td>degrees</td>
<td>4</td>
<td>1</td>
<td>1 part in 1e6</td>
</tr>
<tr>
<td>L2-INT-32</td>
<td>24</td>
<td>25</td>
<td>n/a</td>
<td>sub-cell latitude</td>
<td>sl</td>
<td>μdeg</td>
<td>4</td>
<td>1</td>
<td>100 μdeg</td>
</tr>
<tr>
<td>L2-INT-33</td>
<td>26</td>
<td>27</td>
<td>N</td>
<td>sub-cell longitude</td>
<td>sl</td>
<td>μdeg</td>
<td>4</td>
<td>1</td>
<td>100 μdeg</td>
</tr>
<tr>
<td>L2-INT-34</td>
<td>28</td>
<td>29</td>
<td>N</td>
<td>sub-cell across-track band</td>
<td>sl</td>
<td>none</td>
<td>2</td>
<td>1</td>
<td>exact</td>
</tr>
<tr>
<td>L2-INT-36</td>
<td>30</td>
<td>31</td>
<td>N</td>
<td>sub-cell total, ch = 1, ..., 7, clear pixels, nadir view</td>
<td>sl</td>
<td>n/a</td>
<td>4</td>
<td>7</td>
<td>500 lsb</td>
</tr>
<tr>
<td>L2-INT-36</td>
<td>58</td>
<td>85</td>
<td>N</td>
<td>sub-cell total, ch = 1, ..., 7, cloudy pixels, nadir view</td>
<td>sl</td>
<td>n/a</td>
<td>4</td>
<td>7</td>
<td>500 lsb</td>
</tr>
<tr>
<td>L2-INT-36</td>
<td>86</td>
<td>113</td>
<td>F</td>
<td>sub-cell total, ch = 1, ..., 7, clear pixels, forward view</td>
<td>sl</td>
<td>n/a</td>
<td>4</td>
<td>7</td>
<td>500 lsb</td>
</tr>
<tr>
<td>L2-INT-36</td>
<td>114</td>
<td>141</td>
<td>F</td>
<td>sub-cell total, ch = 1, ..., 7, cloudy pixels, fwdrd view</td>
<td>sl</td>
<td>n/a</td>
<td>4</td>
<td>7</td>
<td>500 lsb</td>
</tr>
<tr>
<td>L2-INT-37</td>
<td>142</td>
<td>155</td>
<td>N</td>
<td>sub-cell valid pixel count, ch = 1, ..., 7, clear pixels</td>
<td>ss</td>
<td>none</td>
<td>2</td>
<td>7</td>
<td>exact</td>
</tr>
<tr>
<td>L2-INT-37</td>
<td>156</td>
<td>169</td>
<td>N</td>
<td>sub-cell valid pixel count, ch = 1, ..., 7, cloudy pixels</td>
<td>ss</td>
<td>none</td>
<td>2</td>
<td>7</td>
<td>exact</td>
</tr>
<tr>
<td>L2-INT-37</td>
<td>170</td>
<td>183</td>
<td>F</td>
<td>sub-cell valid pixel count, ch = 1, ..., 7, clear pixels</td>
<td>ss</td>
<td>none</td>
<td>2</td>
<td>7</td>
<td>exact</td>
</tr>
<tr>
<td>L2-INT-37</td>
<td>184</td>
<td>197</td>
<td>F</td>
<td>sub-cell valid pixel count, ch = 1, ..., 7, cloudy pixels</td>
<td>ss</td>
<td>none</td>
<td>2</td>
<td>7</td>
<td>exact</td>
</tr>
<tr>
<td>L2-INT-35</td>
<td>198</td>
<td>199</td>
<td>N</td>
<td>cumulative across-track band sum</td>
<td>ss</td>
<td>none</td>
<td>4</td>
<td>1</td>
<td>1 lsb</td>
</tr>
<tr>
<td>L2-INT-35</td>
<td>200</td>
<td>201</td>
<td>N</td>
<td>cumulative across-track band sum</td>
<td>ss</td>
<td>none</td>
<td>2</td>
<td>1</td>
<td>1 lsb</td>
</tr>
<tr>
<td>L2-INT-35</td>
<td>202</td>
<td>203</td>
<td>N</td>
<td>mean across-track band number</td>
<td>ss</td>
<td>none</td>
<td>2</td>
<td>1</td>
<td>1 lsb</td>
</tr>
</tbody>
</table>

### Table 4-2-8: Break point #7 Record, AST Land, 10 arc minute cell

<table>
<thead>
<tr>
<th>Field No.</th>
<th>Start byte</th>
<th>End byte</th>
<th>View</th>
<th>Field Description</th>
<th>Type</th>
<th>Units</th>
<th>Field Size</th>
<th>Fields</th>
<th>Verification Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>L2-INT-31</td>
<td>0</td>
<td>7</td>
<td>n/a</td>
<td>sub-cell UTC</td>
<td>double</td>
<td>days</td>
<td>9</td>
<td>1</td>
<td>exact</td>
</tr>
<tr>
<td>L2-INT-49</td>
<td>8</td>
<td>9</td>
<td>N</td>
<td>nadir view day/night flag</td>
<td>ss</td>
<td>flag</td>
<td>2</td>
<td>1</td>
<td>exact</td>
</tr>
<tr>
<td>L2-INT-50</td>
<td>10</td>
<td>11</td>
<td>F</td>
<td>forward view day/night flag</td>
<td>ss</td>
<td>flag</td>
<td>2</td>
<td>1</td>
<td>exact</td>
</tr>
<tr>
<td>L2-INT-45</td>
<td>12</td>
<td>15</td>
<td>N</td>
<td>nadir solar elevation for sub-cell</td>
<td>float</td>
<td>degrees</td>
<td>4</td>
<td>1</td>
<td>1 part in 1e6</td>
</tr>
<tr>
<td>L2-INT-46</td>
<td>16</td>
<td>19</td>
<td>F</td>
<td>fwdrd solar elevation for sub-cell</td>
<td>float</td>
<td>degrees</td>
<td>4</td>
<td>1</td>
<td>1 part in 1e6</td>
</tr>
<tr>
<td>L2-INT-32</td>
<td>20</td>
<td>23</td>
<td>N</td>
<td>sub-cell latitude</td>
<td>sl</td>
<td>μdeg</td>
<td>4</td>
<td>1</td>
<td>100 μdeg</td>
</tr>
<tr>
<td>L2-INT-33</td>
<td>24</td>
<td>27</td>
<td>N</td>
<td>sub-cell longitude</td>
<td>sl</td>
<td>μdeg</td>
<td>4</td>
<td>1</td>
<td>100 μdeg</td>
</tr>
<tr>
<td>L2-INT-34</td>
<td>28</td>
<td>29</td>
<td>N</td>
<td>sub-cell across-track band</td>
<td>ss</td>
<td>none</td>
<td>2</td>
<td>1</td>
<td>exact</td>
</tr>
<tr>
<td>L2-INT-36</td>
<td>30</td>
<td>31</td>
<td>N</td>
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<td>500 lsb</td>
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<tr>
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<td>113</td>
<td>F</td>
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<td>sl</td>
<td>n/a</td>
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<td>7</td>
<td>500 lsb</td>
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<td>141</td>
<td>F</td>
<td>sub-cell total, ch = 1, ..., 7, cloudy pixels, fwdrd view</td>
<td>sl</td>
<td>n/a</td>
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<td>500 lsb</td>
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<td>155</td>
<td>N</td>
<td>sub-cell valid pixel count, ch = 1, ..., 7, clear pixels</td>
<td>ss</td>
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<td>2</td>
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<td>197</td>
<td>F</td>
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<td>L2-INT-35</td>
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<td>cumulative across-track band sum</td>
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<td>1 lsb</td>
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<td>200</td>
<td>201</td>
<td>N</td>
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<td>1 lsb</td>
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## Table 4-2-9: Break point #8 Record, AST Sea Record, 50 km cell

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<th>Type</th>
<th>Units</th>
<th>Field Size</th>
<th>Fields</th>
<th>Verification Accuracy</th>
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<td>double</td>
<td>days</td>
<td>8</td>
<td>1</td>
<td>exact</td>
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<tr>
<td>L2-INT-77</td>
<td>8</td>
<td>11</td>
<td>n/a</td>
<td>cell latitude</td>
<td>sl</td>
<td>deg</td>
<td>4</td>
<td>1</td>
<td>100 udeg</td>
</tr>
<tr>
<td>L2-INT-78</td>
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<td>15</td>
<td>n/a</td>
<td>cell longitude</td>
<td>sl</td>
<td>deg</td>
<td>4</td>
<td>1</td>
<td>100 udeg</td>
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<td>sl</td>
<td>deg</td>
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<td>1</td>
<td>exact</td>
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<td>F</td>
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<td>sl</td>
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<td>1000</td>
<td>exact</td>
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<td>4045</td>
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<td>total clear pixels over sea in cell, ch = 1, ...7</td>
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<td>none</td>
<td>2</td>
<td>7</td>
<td>exact</td>
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<td>7</td>
<td>exact</td>
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<td>4073</td>
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<td>ss</td>
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<td>7</td>
<td>exact</td>
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<td>AST-MDS13-73</td>
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<td>4093</td>
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<td>ss</td>
<td>K/100</td>
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<td>1</td>
<td>0.01 K</td>
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<td>AST-MDS13-75</td>
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<td>4095</td>
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<td>Corresponding 3.7 micron BT, nadir view</td>
<td>ss</td>
<td>K/100</td>
<td>2</td>
<td>1</td>
<td>0.01 K</td>
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<td>4097</td>
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<td>ss</td>
<td>%/100</td>
<td>2</td>
<td>1</td>
<td>0.01 %</td>
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<td>ss</td>
<td>%/100</td>
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<td>ss</td>
<td>%/100</td>
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<td>%/100</td>
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<td>1</td>
<td>0.01 %</td>
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<td>4107</td>
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<td>ss</td>
<td>K/100</td>
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<td>1</td>
<td>0.01 K</td>
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<td>4109</td>
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<td>K/100</td>
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## Table 4-2-10: Break point #9 Record, AST Land Record, 50 km cell

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<th>Units</th>
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<td>1</td>
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<td>n/a</td>
<td>cell latitude</td>
<td>sl</td>
<td>deg</td>
<td>4</td>
<td>1</td>
<td>100 udeg</td>
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<td>15</td>
<td>n/a</td>
<td>cell longitude</td>
<td>sl</td>
<td>deg</td>
<td>4</td>
<td>1</td>
<td>100 udeg</td>
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<td>sl</td>
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<td>1</td>
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<td>23</td>
<td>F</td>
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<td>sl</td>
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<td>1</td>
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<td>1000</td>
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<td>7</td>
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</tr>
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<td>ss</td>
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<td>2</td>
<td>7</td>
<td>exact</td>
</tr>
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<td>L2-INT-70</td>
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<td>4073</td>
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<td>total clear pixels over land in cell, ch = 1, ...7</td>
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Table 4-2-11: Break point #10 Record, AST Sea Record, 17 km cell

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<td>1</td>
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<td>n/a</td>
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<td>ss</td>
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<td>1</td>
<td>exact</td>
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<td>15</td>
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<td>forward view day/night flag</td>
<td>ss</td>
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<td>1</td>
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<td>23</td>
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<td>frwrd solar elevation for sub-cell</td>
<td>float</td>
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<td>n/a</td>
<td>4</td>
<td>7</td>
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<td>201</td>
<td>N</td>
<td>sub-cell filled pixel count, cloudy pixels, nadir view</td>
<td>ss</td>
<td>none</td>
<td>2</td>
<td>1</td>
<td>exact</td>
</tr>
<tr>
<td>L2-INT-455</td>
<td>202</td>
<td>203</td>
<td>F</td>
<td>sub-cell filled pixel count, clear pixels, forward view</td>
<td>ss</td>
<td>none</td>
<td>2</td>
<td>1</td>
<td>exact</td>
</tr>
<tr>
<td>L2-INT-455</td>
<td>204</td>
<td>205</td>
<td>F</td>
<td>sub-cell filled pixel count, cloudy pixels, forward view</td>
<td>ss</td>
<td>none</td>
<td>2</td>
<td>1</td>
<td>exact</td>
</tr>
<tr>
<td>L2-INT-456</td>
<td>206</td>
<td>209</td>
<td>N</td>
<td>cumulative across-track band sum</td>
<td>sl</td>
<td>none</td>
<td>4</td>
<td>1</td>
<td>1 lsb</td>
</tr>
<tr>
<td>L2-INT-457</td>
<td>210</td>
<td>211</td>
<td>N</td>
<td>mean across-track band number</td>
<td>ss</td>
<td>none</td>
<td>2</td>
<td>1</td>
<td>1 lsb</td>
</tr>
</tbody>
</table>

Table 4-2-12: Break point #11 Record, AST Land, 17 km cell

<table>
<thead>
<tr>
<th>Field No.</th>
<th>Start byte</th>
<th>End byte</th>
<th>View</th>
<th>Field Description</th>
<th>Type</th>
<th>Units</th>
<th>Field Size</th>
<th>Fields</th>
<th>Verification Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>L2-INT-21</td>
<td>0</td>
<td>7</td>
<td>n/a</td>
<td>utc(cell)/sub-cell UTC</td>
<td>double</td>
<td>days</td>
<td>8</td>
<td>1</td>
<td>exact</td>
</tr>
<tr>
<td>L2-INT-79</td>
<td>8</td>
<td>9</td>
<td>N</td>
<td>nadir view day/night flag</td>
<td>ss</td>
<td>flag</td>
<td>2</td>
<td>1</td>
<td>exact</td>
</tr>
<tr>
<td>L2-INT-80</td>
<td>10</td>
<td>11</td>
<td>F</td>
<td>forward view day/night flag</td>
<td>ss</td>
<td>flag</td>
<td>2</td>
<td>1</td>
<td>exact</td>
</tr>
</tbody>
</table>
4.2 Module Definition: Input Annotation Data Sets

4.2.1 Functional Description

The Annotation Data Sets of the GBTR product that are required for Level 2 Processing are read into memory, and converted into appropriate units where necessary. Data are required from data sets ADS #3 (grid pixel latitude and longitude), and ADS #5, #6 (solar angles). In addition data sets ADS #1, ADS #2 and ADS #4 are needed for AST record time tagging.

4.2.2 Interface Definition

<table>
<thead>
<tr>
<th>Parameter ID</th>
<th>Field</th>
<th>Name</th>
<th>Type</th>
<th>Units</th>
<th>Field size</th>
<th>Fields</th>
</tr>
</thead>
<tbody>
<tr>
<td>GBTR-ADS1-1</td>
<td>sl</td>
<td>Nadir UTC time in MJD format</td>
<td>sl 2*ul</td>
<td>MJD</td>
<td>12</td>
<td>1</td>
</tr>
<tr>
<td>GBTR-ADS1-2</td>
<td>sc</td>
<td>Attachment flag (always zero for this ADS)</td>
<td>sc  n/a</td>
<td></td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>GBTR-ADS1-3</td>
<td>3*uc</td>
<td>Spare (null characters)</td>
<td>3*uc n/a</td>
<td></td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>GBTR-ADS1-4</td>
<td>si</td>
<td>image scan y coordinate</td>
<td>si m</td>
<td></td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>GBTR-ADS1-5</td>
<td>us</td>
<td>instrument scan number, nadir view</td>
<td>us none</td>
<td></td>
<td>2</td>
<td>512</td>
</tr>
<tr>
<td>GBTR-ADS2-1</td>
<td>us</td>
<td>pixel number, nadir view</td>
<td>us none</td>
<td></td>
<td>2</td>
<td>512</td>
</tr>
<tr>
<td>GBTR-ADS2-2</td>
<td>sc</td>
<td>Attachment flag (always zero for this ADS)</td>
<td>sc  n/a</td>
<td></td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>GBTR-ADS2-3</td>
<td>3*uc</td>
<td>Spare (null characters)</td>
<td>3*uc n/a</td>
<td></td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>GBTR-ADS2-4</td>
<td>si</td>
<td>image scan y coordinate</td>
<td>si m</td>
<td></td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>GBTR-ADS2-5</td>
<td>us</td>
<td>instrument scan number, forward view</td>
<td>us none</td>
<td></td>
<td>2</td>
<td>512</td>
</tr>
<tr>
<td>GBTR-ADS2-6</td>
<td>us</td>
<td>pixel number, forward view</td>
<td>us none</td>
<td></td>
<td>2</td>
<td>512</td>
</tr>
<tr>
<td>GBTR-ADS3-1</td>
<td>sl</td>
<td>Nadir UTC time in MJD format</td>
<td>sl 2*ul</td>
<td>MJD</td>
<td>12</td>
<td>1</td>
</tr>
<tr>
<td>GBTR-ADS3-2</td>
<td>sc</td>
<td>Attachment flag (always zero for this ADS)</td>
<td>sc  n/a</td>
<td></td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>GBTR-ADS3-3</td>
<td>3*uc</td>
<td>Spare (null characters)</td>
<td>3*uc n/a</td>
<td></td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>GBTR-ADS3-4</td>
<td>si</td>
<td>image scan y coordinate</td>
<td>si m</td>
<td></td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>GBTR-ADS3-5</td>
<td>sl</td>
<td>tie point latitudes</td>
<td>sl µdeg</td>
<td></td>
<td>4</td>
<td>23</td>
</tr>
<tr>
<td>GBTR-ADS3-6</td>
<td>sl</td>
<td>tie point longitudes</td>
<td>sl µdeg</td>
<td></td>
<td>4</td>
<td>23</td>
</tr>
<tr>
<td>GBTR-ADS3-7</td>
<td>latitude corrections, nadir view</td>
<td>sl</td>
<td>µdeg</td>
<td>4</td>
<td>23</td>
<td></td>
</tr>
<tr>
<td>GBTR-ADS3-8</td>
<td>latitude corrections, nadir view</td>
<td>sl</td>
<td>µdeg</td>
<td>4</td>
<td>23</td>
<td></td>
</tr>
<tr>
<td>GBTR-ADS3-9</td>
<td>latitude corrections, forward view</td>
<td>sl</td>
<td>µdeg</td>
<td>4</td>
<td>23</td>
<td></td>
</tr>
<tr>
<td>GBTR-ADS3-10</td>
<td>latitude corrections, forward view</td>
<td>sl</td>
<td>µdeg</td>
<td>4</td>
<td>23</td>
<td></td>
</tr>
<tr>
<td>GBTR-ADS3-11</td>
<td>Topographic Altitude</td>
<td>ss</td>
<td>metres</td>
<td>2</td>
<td>23</td>
<td></td>
</tr>
<tr>
<td>GBTR-ADS4-1</td>
<td>Scan UTC time in MJD format</td>
<td>sl, 2*uc</td>
<td>MJD</td>
<td>12</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>GBTR-ADS4-2</td>
<td>Attachment flag (always zero for this ADS)</td>
<td>sc</td>
<td>n/a</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>GBTR-ADS4-3</td>
<td>Spare (null characters)</td>
<td>3*uc</td>
<td>n/a</td>
<td>3</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>GBTR-ADS4-4</td>
<td>instrument scan number</td>
<td>us</td>
<td>none</td>
<td>2</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>GBTR-ADS4-5</td>
<td>tie pixel x coordinate</td>
<td>sl</td>
<td>m</td>
<td>4</td>
<td>94</td>
<td></td>
</tr>
<tr>
<td>GBTR-ADS4-6</td>
<td>tie pixel y coordinate</td>
<td>sl</td>
<td>m</td>
<td>4</td>
<td>94</td>
<td></td>
</tr>
<tr>
<td>GBTR-ADS5-1</td>
<td>Nadir UTC time in MJD format</td>
<td>sl, 2*uc</td>
<td>MJD</td>
<td>12</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>GBTR-ADS5-2</td>
<td>Attachment flag (always zero for this ADS)</td>
<td>sc</td>
<td>n/a</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>GBTR-ADS5-3</td>
<td>Spare (null characters)</td>
<td>3*uc</td>
<td>n/a</td>
<td>3</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>GBTR-ADS5-4</td>
<td>image scan y coordinate</td>
<td>sl</td>
<td>m</td>
<td>4</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>GBTR-ADS5-5</td>
<td>tie point solar elevation, nadir view</td>
<td>sl</td>
<td>mdeg</td>
<td>4</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>GBTR-ADS5-6</td>
<td>tie point satellite elevation, nadir view</td>
<td>sl</td>
<td>mdeg</td>
<td>4</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>GBTR-ADS5-7</td>
<td>tie point solar azimuth, nadir view</td>
<td>sl</td>
<td>mdeg</td>
<td>4</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>GBTR-ADS5-8</td>
<td>tie point satellite azimuth, nadir view</td>
<td>sl</td>
<td>mdeg</td>
<td>4</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>GBTR-ADS6-1</td>
<td>Nadir UTC time in MJD format</td>
<td>sl, 2*uc</td>
<td>MJD</td>
<td>12</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>GBTR-ADS6-2</td>
<td>Attachment flag (always zero for this ADS)</td>
<td>sc</td>
<td>n/a</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>GBTR-ADS6-3</td>
<td>Spare (null characters)</td>
<td>3*uc</td>
<td>n/a</td>
<td>3</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>GBTR-ADS6-4</td>
<td>image scan y coordinate</td>
<td>sl</td>
<td>m</td>
<td>4</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>GBTR-ADS6-5</td>
<td>tie point solar elevation, forward view</td>
<td>sl</td>
<td>mdeg</td>
<td>4</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>GBTR-ADS6-6</td>
<td>tie point satellite elevation, forward view</td>
<td>sl</td>
<td>mdeg</td>
<td>4</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>GBTR-ADS6-7</td>
<td>tie point solar azimuth, forward view</td>
<td>sl</td>
<td>mdeg</td>
<td>4</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>GBTR-ADS6-8</td>
<td>tie point satellite azimuth, forward view</td>
<td>sl</td>
<td>mdeg</td>
<td>4</td>
<td>11</td>
<td></td>
</tr>
</tbody>
</table>

Table 4-2-1: Input Data Table - Input Annotation Data Sets

<table>
<thead>
<tr>
<th>Parameter ID</th>
<th>Variable</th>
<th>Name</th>
<th>Type</th>
<th>Units</th>
<th>Field size</th>
<th>Fields</th>
</tr>
</thead>
<tbody>
<tr>
<td>L2-INT-18</td>
<td>MJD(T4)</td>
<td>Scan UTC in MJD Format</td>
<td>4*sl</td>
<td>MJD</td>
<td>16 per sg</td>
<td></td>
</tr>
<tr>
<td>L2-INT-23</td>
<td>MJD(DP)[1]</td>
<td>Scan UTC in processing format</td>
<td>double</td>
<td>days</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>L2-INT-24</td>
<td>MJD(DP)[2]</td>
<td>Scan delta UT1 (dummy)</td>
<td>double</td>
<td></td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>L2-INT-26</td>
<td>time(sg)</td>
<td>scan UTC</td>
<td>double</td>
<td>days</td>
<td>8 per sg</td>
<td></td>
</tr>
<tr>
<td>L2-INT-27</td>
<td>scan(sg)</td>
<td>scan number corresponding to time(sg)</td>
<td>us</td>
<td>none</td>
<td>2 per sg</td>
<td></td>
</tr>
<tr>
<td>L2-INT-134</td>
<td>scn_nadir(g, j)</td>
<td>nadir view instrument scan number</td>
<td>us</td>
<td>none</td>
<td>4 j = 0, 511</td>
<td></td>
</tr>
<tr>
<td>L2-INT-135</td>
<td>pxl_nadir(g, j)</td>
<td>nadir view instrument pixel number</td>
<td>us</td>
<td>none</td>
<td>4 j = 0, 511</td>
<td></td>
</tr>
<tr>
<td>L2-INT-154</td>
<td>scn_fwd(g, j)</td>
<td>forward view instrument scan number</td>
<td>us</td>
<td>none</td>
<td>4 j = 0, 511</td>
<td></td>
</tr>
<tr>
<td>L2-INT-155</td>
<td>pxl_fwd(g, j)</td>
<td>forward view instrument pixel number</td>
<td>us</td>
<td>none</td>
<td>4 j = 0, 511</td>
<td></td>
</tr>
<tr>
<td>local lg</td>
<td>index to instrument scan granules</td>
<td>sl</td>
<td>none</td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>local j</td>
<td>index to image pixels (j' = 0, 511)</td>
<td>sl</td>
<td>none</td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>local j'</td>
<td>index to tie point pixels (j' = 0, 22)</td>
<td>sl</td>
<td>none</td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L2-INT-1</td>
<td>oWl[g, j]</td>
<td>Tie point latitude</td>
<td>float</td>
<td>deg.</td>
<td>4 j = 0, 22</td>
<td></td>
</tr>
<tr>
<td>L2-INT-2</td>
<td>oWl[g, j]</td>
<td>Tie point longitude</td>
<td>float</td>
<td>deg.</td>
<td>4 j = 0, 22</td>
<td></td>
</tr>
<tr>
<td>local k</td>
<td>Index to across-track band (k = 0, 10)</td>
<td>sl</td>
<td>none</td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L2-INT-3</td>
<td>pxl[g, k]</td>
<td>tie scan solar elevation, nadir</td>
<td>float</td>
<td>deg.</td>
<td>4 k = 0, 10</td>
<td></td>
</tr>
<tr>
<td>L2-INT-4</td>
<td>Axi[g, k]</td>
<td>tie scan solar azimuth, nadir</td>
<td>float</td>
<td>deg.</td>
<td>4 k = 0, 10</td>
<td></td>
</tr>
<tr>
<td>L2-INT-5</td>
<td>pxl[g, k]</td>
<td>tie scan solar elevation, forward</td>
<td>float</td>
<td>deg.</td>
<td>4 k = 0, 10</td>
<td></td>
</tr>
<tr>
<td>L2-INT-6</td>
<td>Axi[g, k]</td>
<td>tie scan solar azimuth, forward</td>
<td>float</td>
<td>deg.</td>
<td>4 k = 0, 10</td>
<td></td>
</tr>
<tr>
<td>L2-INT-13</td>
<td>vxi[g, k]</td>
<td>tie scan satellite elevation, nadir</td>
<td>float</td>
<td>deg.</td>
<td>4 k = 0, 10</td>
<td></td>
</tr>
<tr>
<td>L2-INT-15</td>
<td>vxi[g, k]</td>
<td>tie scan satellite elevation, forward</td>
<td>float</td>
<td>deg.</td>
<td>4 k = 0, 10</td>
<td></td>
</tr>
<tr>
<td>local UTC</td>
<td>Scan UTC Time (byproduct not required)</td>
<td>char</td>
<td>n/a</td>
<td>27</td>
<td></td>
<td></td>
</tr>
<tr>
<td>local DUT1E</td>
<td>delta UT1 for scan (byproduct not required)</td>
<td>char</td>
<td>n/a</td>
<td>8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L2-INT-25</td>
<td>status</td>
<td>status flag</td>
<td>sl</td>
<td>n/a</td>
<td>4</td>
<td></td>
</tr>
</tbody>
</table>

Table 4-2-2: Internal Data Table - Input Annotation Data Sets
4.2.3 Detailed Structure

Step 4.2.1 Read ADS records.

The required ADS records as tabulated above are read in. Angular variables are converted from the external format (fixed point in units of millidegrees for solar angles, microdegrees for lat/long) to floating point format in degrees.

For the first record of each data set the record (image scan) counter $ig$ is initialised to 0. Increment by 1 for each subsequent record.

**ADS #1 and #2.** For each record $ig$ and for each $j = 0, 511$

\[
\begin{align*}
scn_{\text{nadir}}(ig, j) &= [\text{GBTR-ADS1-5}](ig, j) \\
pxl_{\text{nadir}}(ig, j) &= [\text{GBTR-ADS1-6}](ig, j) \\
scn_{\text{frwrd}}(ig, j) &= [\text{GBTR-ADS2-5}](ig, j) \\
pxl_{\text{frwrd}}(ig, j) &= [\text{GBTR-ADS2-6}](ig, j)
\end{align*}
\]

**ADS #3:** For each record $ig$ and for each $j' = 0, 22$

\[
\begin{align*}
\varphi_{g}(ig, j) &= 0.000001[\text{GBTR-ADS3-5}](ig, j') \\
\lambda_{g}(ig, j) &= 0.000001[\text{GBTR-ADS3-6}](ig, j')
\end{align*}
\]

**ADS #5 and #6.** For each record $ig$ and for each $k = 0, 10$

\[
\begin{align*}
\beta^{\nu}(ig, k) &= 0.001 \times [\text{GBTR-ADS5-5}](ig, k) \\
A^{\nu}(ig, k) &= 0.001 \times [\text{GBTR-ADS5-7}](ig, k) \\
\beta^{\lambda}(ig, k) &= 0.001 \times [\text{GBTR-ADS6-5}](ig, k) \\
A^{\lambda}(ig, k) &= 0.001 \times [\text{GBTR-ADS6-7}](ig, k) \\
\gamma^{\nu}(ig, k) &= 0.001 \times [\text{GBTR-ADS5-6}](ig, k) \\
\gamma^{\lambda}(ig, k) &= 0.001 \times [\text{GBTR-ADS6-6}](ig, k)
\end{align*}
\]

(Req 4.2-1)

(The satellite azimuth is not required for level 2 processing as currently defined, but the satellite elevation is required for land surface temperature processing.)

**ADS #4:** For the first record of each data set the record (instrument scan) counter $sg$ is initialised to 0. Increment by 1 for each subsequent record.

For each record $sg$ copy the three (long integer) words of the UTC scan time field into the first three elements of the corresponding array, noting that the second and third elements are to be converted from ul to sl:

\[
[MJDT[0:2]/(1:3)](sg) = [\text{GBTR-ADS4-1}]
\]

(Req 4.2-2)

(Only the instrument scan times are required for Level 2 processing.)

**Step 4.2.2 Convert Scan UT from Transport to Processing Format.**
The CFI time conversion subroutine must now be used to convert each instrument scan time from transport to processing format. This is necessary so that the scan time can be interpolated freely within granules.

The subroutine `pl_tmjd` from the time conversion library is used to convert the scan time from transport format to processing format. The time in external (character string) format is produced as an (unwanted) byproduct.

Initialise MJDT[3]/(4) = 0.0

\[ \text{status} = \text{pl_tmjd}(\text{MJDT}, \text{MJD}, \text{UTCE}, \text{DUT1E}) \]

Check that the value of `status` is zero; if it is not, an input error has occurred. If it is,

\[ \text{time}(\text{sg}) = \text{MJD}[0]/(1) \]  

(Req 4.2-3)

Also save the corresponding scan number from the same record:

\[ \text{scan}(\text{sg}) = [\text{GBTR-ADS4-4}](\text{sg}) \]  

(Req 4.2-4)

### 4.3 Module Definition: Assemble Regridded Brightness Temperature Arrays

#### 4.3.1 Functional Description

This module reads in grid co-ordinates and 7 channel brightness temperatures / reflectances for forward and nadir views from the appropriate MDS of the GBTR product and arranges them in the required memory configuration.

#### 4.3.2 Interface Definition

The module input data is read from the GBTR parameters listed in Table 4.3.1: Input Data Table - Assemble Regridded Brightness Temperature Arrays, output is internal.

<table>
<thead>
<tr>
<th>Parameter ID</th>
<th>Variable</th>
<th>Name</th>
<th>Type</th>
<th>Units</th>
<th>Field size</th>
<th>Fields</th>
</tr>
</thead>
<tbody>
<tr>
<td>GBTR-MDS1-1</td>
<td>Nadir UTC time in MJD format</td>
<td>sl, 2*ul</td>
<td>MJD</td>
<td>12</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>GBTR-MDS1-2</td>
<td>Record Quality Indicator</td>
<td>sc</td>
<td>n/a</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>GBTR-MDS1-3</td>
<td>Spare (null characters)</td>
<td>3*uc</td>
<td>n/a</td>
<td>3</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>GBTR-MDS1-4</td>
<td>image scan y coordinate</td>
<td>sl</td>
<td>m</td>
<td>4</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>GBTR-MDS1-5</td>
<td>nadir BT pixels 12 micron channel</td>
<td>ss</td>
<td>0.01K</td>
<td>2</td>
<td>512</td>
<td></td>
</tr>
<tr>
<td>GBTR-MDS2-1</td>
<td>Nadir UTC time in MJD format</td>
<td>sl, 2*ul</td>
<td>MJD</td>
<td>12</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>GBTR-MDS2-2</td>
<td>Record Quality Indicator</td>
<td>sc</td>
<td>n/a</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>GBTR-MDS2-3</td>
<td>Spare (null characters)</td>
<td>3*uc</td>
<td>n/a</td>
<td>3</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>GBTR-MDS2-4</td>
<td>image scan y coordinate</td>
<td>sl</td>
<td>m</td>
<td>4</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>GBTR-MDS2-5</td>
<td>nadir BT pixels 11 micron channel</td>
<td>ss</td>
<td>0.01K</td>
<td>2</td>
<td>512</td>
<td></td>
</tr>
<tr>
<td>GBTR-MDS3-1</td>
<td>Nadir UTC time in MJD format</td>
<td>sl, 2*ul</td>
<td>MJD</td>
<td>12</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>GBTR-MDS3-2</td>
<td>Record Quality Indicator</td>
<td>sc</td>
<td>n/a</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>GBTR-MDS3-3</td>
<td>Spare (null characters)</td>
<td>3*uc</td>
<td>n/a</td>
<td>3</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>GBTR-MDS3-4</td>
<td>image scan y coordinate</td>
<td>sl</td>
<td>m</td>
<td>4</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>GBTR-MDS3-5</td>
<td>nadir BT pixels 3.7 micron channel</td>
<td>ss</td>
<td>0.01K</td>
<td>2</td>
<td>512</td>
<td></td>
</tr>
<tr>
<td>GBTR-MDS4-1</td>
<td>Nadir UTC time in MJD format</td>
<td>sl, 2*ul</td>
<td>MJD</td>
<td>12</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>GBTR-MDS4-2</td>
<td>Record Quality Indicator</td>
<td>sc</td>
<td>n/a</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>GBTR-MDS4-3</td>
<td>Spare (null characters)</td>
<td>3*uc</td>
<td>n/a</td>
<td>3</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>GBTR-MDS4-4</td>
<td>image scan y coordinate</td>
<td>sl</td>
<td>m</td>
<td>4</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>
### Table 4.3.1: Input Data Table - Assemble Regridded Brightness Temperature Arrays

<table>
<thead>
<tr>
<th>Parameter ID</th>
<th>Variable</th>
<th>Name</th>
<th>Type</th>
<th>Units</th>
<th>Field size</th>
<th>Fields</th>
</tr>
</thead>
<tbody>
<tr>
<td>L2-INT-10</td>
<td>yi(j)</td>
<td>image scan y co-ordinate</td>
<td>sl, m</td>
<td></td>
<td>2</td>
<td>j = 0, 511</td>
</tr>
<tr>
<td>L2-INT-101</td>
<td>[i(1, n, l, j)]</td>
<td>12 µm nadir Brightness Temperature</td>
<td>ss array</td>
<td>0.01 K</td>
<td>2</td>
<td>j = 0, 511</td>
</tr>
<tr>
<td>L2-INT-102</td>
<td>[i(2, n, l, j)]</td>
<td>11 µm nadir Brightness Temperature</td>
<td>ss array</td>
<td>0.01 K</td>
<td>2</td>
<td>j = 0, 511</td>
</tr>
<tr>
<td>L2-INT-103</td>
<td>[i(3, n, l, j)]</td>
<td>3.7 µm nadir Brightness Temperature</td>
<td>ss array</td>
<td>0.01 K</td>
<td>2</td>
<td>j = 0, 511</td>
</tr>
<tr>
<td>L2-INT-104</td>
<td>[i(4, n, l, j)]</td>
<td>1.6 µm nadir Brightness Temperature</td>
<td>ss array</td>
<td>0.01 %</td>
<td>2</td>
<td>j = 0, 511</td>
</tr>
<tr>
<td>L2-INT-105</td>
<td>[i(5, n, l, j)]</td>
<td>0.870 µm nadir Reflectance</td>
<td>ss array</td>
<td>0.01 %</td>
<td>2</td>
<td>j = 0, 511</td>
</tr>
<tr>
<td>L2-INT-106</td>
<td>[i(6, n, l, j)]</td>
<td>0.670 µm nadir Reflectance</td>
<td>ss array</td>
<td>0.01 %</td>
<td>2</td>
<td>j = 0, 511</td>
</tr>
<tr>
<td>L2-INT-107</td>
<td>[i(7, n, l, j)]</td>
<td>0.555 µm nadir Reflectance</td>
<td>ss array</td>
<td>0.01 %</td>
<td>2</td>
<td>j = 0, 511</td>
</tr>
<tr>
<td>L2-INT-111</td>
<td>[i(1, f, i, j)]</td>
<td>12 µm forward Brightness Temperature</td>
<td>ss array</td>
<td>0.01 K</td>
<td>2</td>
<td>j = 0, 511</td>
</tr>
<tr>
<td>L2-INT-112</td>
<td>[i(2, f, i, j)]</td>
<td>11 µm forward Brightness Temperature</td>
<td>ss array</td>
<td>0.01 K</td>
<td>2</td>
<td>j = 0, 511</td>
</tr>
<tr>
<td>L2-INT-113</td>
<td>[i(3, f, i, j)]</td>
<td>3.7 µm forward Brightness Temperature</td>
<td>ss array</td>
<td>0.01 K</td>
<td>2</td>
<td>j = 0, 511</td>
</tr>
<tr>
<td>L2-INT-114</td>
<td>[i(4, f, i, j)]</td>
<td>1.8 µm forward Brightness Temperature</td>
<td>ss array</td>
<td>0.01 %</td>
<td>2</td>
<td>j = 0, 511</td>
</tr>
<tr>
<td>L2-INT-115</td>
<td>[i(5, f, i, j)]</td>
<td>0.870 µm forward Reflectance</td>
<td>ss array</td>
<td>0.01 %</td>
<td>2</td>
<td>j = 0, 511</td>
</tr>
<tr>
<td>L2-INT-116</td>
<td>[i(6, f, i, j)]</td>
<td>0.670 µm forward Reflectance</td>
<td>ss array</td>
<td>0.01 %</td>
<td>2</td>
<td>j = 0, 511</td>
</tr>
<tr>
<td>L2-INT-117</td>
<td>[i(7, f, i, j)]</td>
<td>0.555 µm forward Reflectance</td>
<td>ss array</td>
<td>0.01 %</td>
<td>2</td>
<td>j = 0, 511</td>
</tr>
<tr>
<td>L2-INT-171</td>
<td>gbtr_confidence_nadir(i,j)</td>
<td>ss array</td>
<td>flags</td>
<td>j = 0, 511</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L2-INT-172</td>
<td>gbtr_confidence_fwrd(i,j)</td>
<td>ss array</td>
<td>flag</td>
<td>j = 0, 511</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L2-INT-200</td>
<td>nadir_blanking_pulse(i,j)</td>
<td>ss array</td>
<td>flag</td>
<td>j = 0, 511</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L2-INT-201</td>
<td>nadir_cosmetic(i,j)</td>
<td>ss array</td>
<td>flag</td>
<td>j = 0, 511</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L2-INT-202</td>
<td>nadir_scan_absent(i,j)</td>
<td>ss array</td>
<td>flag</td>
<td>j = 0, 511</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L2-INT-203</td>
<td>nadir_pixel_absent(i,j)</td>
<td>ss array</td>
<td>flag</td>
<td>j = 0, 511</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L2-INT-204</td>
<td>nadir_packet_validation_error(i,j)</td>
<td>ss array</td>
<td>flag</td>
<td>j = 0, 511</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L2-INT-205</td>
<td>nadir_zero_count(i,j)</td>
<td>ss array</td>
<td>flag</td>
<td>j = 0, 511</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L2-INT-206</td>
<td>nadir_saturation(i,j)</td>
<td>ss array</td>
<td>flag</td>
<td>j = 0, 511</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L2-INT-207</td>
<td>nadir_cal_out_of_range(i,j)</td>
<td>ss array</td>
<td>flag</td>
<td>j = 0, 511</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L2-INT-208</td>
<td>nadir_calibration_unavailable(i,j)</td>
<td>ss array</td>
<td>flag</td>
<td>j = 0, 511</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L2-INT-209</td>
<td>nadir_unfilled_pixel(i,j)</td>
<td>ss array</td>
<td>flag</td>
<td>j = 0, 511</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L2-INT-216</td>
<td>fwrd_blanking_pulse(i,j)</td>
<td>ss array</td>
<td>flag</td>
<td>j = 0, 511</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L2-INT-217</td>
<td>fwrd_cosmetic(i,j)</td>
<td>ss array</td>
<td>flag</td>
<td>j = 0, 511</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L2-INT-218</td>
<td>fwrd_scan_absent(i,j)</td>
<td>ss array</td>
<td>flag</td>
<td>j = 0, 511</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L2-INT-219</td>
<td>fwrd_pixel_absent(i,j)</td>
<td>ss array</td>
<td>flag</td>
<td>j = 0, 511</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L2-INT-220</td>
<td>fwrd_packet_validation_error(i,j)</td>
<td>ss array</td>
<td>flag</td>
<td>j = 0, 511</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L2-INT-221</td>
<td>fwrd_zero_count(i,j)</td>
<td>ss array</td>
<td>flag</td>
<td>j = 0, 511</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L2-INT-222</td>
<td>fwrd_saturation(i,j)</td>
<td>ss array</td>
<td>flag</td>
<td>j = 0, 511</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L2-INT-223</td>
<td>fwrd_cal_out_of_range(i,j)</td>
<td>ss array</td>
<td>flag</td>
<td>j = 0, 511</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L2-INT-224</td>
<td>fwrd_calibration_unavailable(i,j)</td>
<td>ss array</td>
<td>flag</td>
<td>j = 0, 511</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L2-INT-225</td>
<td>fwrd_unfilled_pixel(i,j)</td>
<td>ss array</td>
<td>flag</td>
<td>j = 0, 511</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L2-INT-234</td>
<td>nadir_sunglint(i,j)</td>
<td>ss array</td>
<td>flag</td>
<td>j = 0, 511</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L2-INT-235</td>
<td>nadir_v16_histogram_test(i,j)</td>
<td>ss array</td>
<td>flag</td>
<td>j = 0, 511</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L2-INT-236</td>
<td>nadir_v16_spatial_coherence_test(i,j)</td>
<td>ss array</td>
<td>flag</td>
<td>j = 0, 511</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L2-INT-237</td>
<td>nadir_ir11_spatial_coherence_test(i,j)</td>
<td>ss array</td>
<td>flag</td>
<td>j = 0, 511</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L2-INT-238</td>
<td>nadir_ir12_gross_cloud_test(i,j)</td>
<td>ss array</td>
<td>flag</td>
<td>j = 0, 511</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L2-INT-239</td>
<td>nadir_ir11_ir12_thin_cirrus_test(i,j)</td>
<td>ss array</td>
<td>flag</td>
<td>j = 0, 511</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L2-INT-240</td>
<td>nadir_ir37_ir12med_high_level_test(i,j)</td>
<td>ss array</td>
<td>flag</td>
<td>j = 0, 511</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L2-INT-241</td>
<td>nadir_ir11_ir37_fog_low_stratus_test(i,j)</td>
<td>ss array</td>
<td>flag</td>
<td>j = 0, 511</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L2-INT-242</td>
<td>nadir_ir11_ir12_view_diff_test(i,j)</td>
<td>ss array</td>
<td>flag</td>
<td>j = 0, 511</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L2-INT-243</td>
<td>nadir_ir37_ir11_view_diff_test(i,j)</td>
<td>ss array</td>
<td>flag</td>
<td>j = 0, 511</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L2-INT-244</td>
<td>nadir_ir11_ir12_histogram_test(i,j)</td>
<td>ss array</td>
<td>flag</td>
<td>j = 0, 511</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L2-INT-246</td>
<td>fwrd_land(i,j)</td>
<td>ss array</td>
<td>flag</td>
<td>j = 0, 511</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L2-INT-249</td>
<td>fwrd_cloud(i,j)</td>
<td>ss array</td>
<td>flag</td>
<td>j = 0, 511</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L2-INT-250</td>
<td>fwrd_sunglint(i,j)</td>
<td>ss array</td>
<td>flag</td>
<td>j = 0, 511</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L2-INT-251</td>
<td>fwrd_v16_histogram_test(i,j)</td>
<td>ss array</td>
<td>flag</td>
<td>j = 0, 511</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L2-INT-252</td>
<td>fwrd_v16_spatial_coherence_test(i,j)</td>
<td>ss array</td>
<td>flag</td>
<td>j = 0, 511</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L2-INT-253</td>
<td>fwrd_ir12_spatial_coherence_test(i,j)</td>
<td>ss array</td>
<td>flag</td>
<td>j = 0, 511</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L2-INT-254</td>
<td>fwrd_ir12_gross_cloud_test(i,j)</td>
<td>ss array</td>
<td>flag</td>
<td>j = 0, 511</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L2-INT-255</td>
<td>fwrd_ir11_ir12_thin_cirrus_test(i,j)</td>
<td>ss array</td>
<td>flag</td>
<td>j = 0, 511</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L2-INT-256</td>
<td>fwrd_ir37_ir12med_high_level_test(i,j)</td>
<td>ss array</td>
<td>flag</td>
<td>j = 0, 511</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L2-INT-257</td>
<td>fwrd_ir11_ir37_fog_low_stratus_test(i,j)</td>
<td>ss array</td>
<td>flag</td>
<td>j = 0, 511</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L2-INT-258</td>
<td>fwrd_ir11_ir12_view_diff_test(i,j)</td>
<td>ss array</td>
<td>flag</td>
<td>j = 0, 511</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L2-INT-259</td>
<td>fwrd_ir37_ir11_view_diff_test(i,j)</td>
<td>ss array</td>
<td>flag</td>
<td>j = 0, 511</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L2-INT-260</td>
<td>fwrd_ir11_ir12_histogram_test(i,j)</td>
<td>ss array</td>
<td>flag</td>
<td>j = 0, 511</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Local:

| local | i | row (scan index) | integer | none | 4 1 |
| local | j | pixel index (j = 0, 511) | integer | none | 4 1 |

L2-INT-100 | nadir_fill_state(i,j) | byte | none | j = 0, 511 |
L2-INT-110 | fwrd_fill_state(i,j) | byte | none | j = 0, 511 |
constant | NATURAL_PIXEL (= 0) | byte | none | 1 1 |
constant | COSMETIC_PIXEL (= 1) | byte | none | 1 1 |
constant | UNFILLED_PIXEL (= 2) | byte | none | 1 1 |

Table 4.3.2: Internal Data Table - Assemble Regridded Brightness Temperature Arrays
4.3.3 Detailed Structure

4.3.3.1 Initialise Arrays

An internal data array needs to be constructed and initialised for each of the following parameters (the arrays are defined in Table 4-3-2):

- 12µ channel nadir brightness temperature
- 11µ channel nadir brightness temperature
- 3.7µ channel nadir brightness temperature
- 1.6µ channel nadir reflectance
- 0.870µ channel nadir reflectance
- 0.670µ channel nadir reflectance
- 0.555µ channel nadir reflectance
- 12µ channel forward brightness temperature
- 11µ channel forward brightness temperature
- 3.7µ channel forward brightness temperature
- 1.6µ channel forward reflectance
- 0.870µ channel forward reflectance
- 0.670µ channel forward reflectance
- 0.555µ channel forward reflectance
- nadir look confidence words
- forward look confidence words
- nadir look land / cloud flags
- forward look land / cloud flags

4.3.3.2 Input MDS records

For the first record, initialise a record counter \( i = 0 \).

For each subsequent record, increment \( i \) by 1.

Step 4.3.1 Read Measurement Data Sets #1 - 7.

These measurement data sets represent the nadir view channel brightness/reflectance values. For each channel \( ch = 1, 7 \) and for each image scan \( i \):

\[
\text{FOR each pixel } j = 0, 511, \quad I(ch, n; i, j) = [\text{GBTR-MDS}<ch>5](i, j) \quad (\text{Req } 4.3-1)
\]

No type conversion is required here.

Step 4.3.2 Read Measurement Data Sets #8 - 14.
These measurement data sets represent the forward view channel brightness/reflectance values. For each channel $ch = 1, 7$ and for each image scan $i$:

\[
\text{FOR each pixel } j = 0, 511, \\
\text{[GST-S-MDS}<7 + ch>_5](i, j) = I(ch, f; i, j) \quad \text{(Req 4.3-2)}
\]

No type conversion is required here.

**Step 4.3.3 Read Measurement Data Sets #15, 16.**

These measurement data sets represent the nadir and forward view confidence words respectively. For each image scan $i$, read in the records of confidence words:

\[
\text{FOR each pixel } j = 0, 511, \\
\text{gbtr\_confidence\_nadir}(i, j) = \text{[GBTR-MDS15-5]}(i, j) \\
\text{FOR each pixel } j = 0, 511, \\
\text{gbtr\_confidence\_frwrd}(i, j) = \text{[GBTR-MDS16-5]}(i, j) \quad \text{(Req 4.3-3)}
\]

Extract the individual flags from the confidence words for each pixel $j = 0, 511$. For each confidence flag, the truth value ($1 = \text{TRUE}; 0 = \text{FALSE}$) of the flag is to be set according to the corresponding bit of the confidence word as follows:

\[
\begin{align*}
\text{<view>\_blanking\_pulse}(i, j) &= \text{[gbtr\_confidence\_<view>]}(i, j)(\text{bit 0}) \\
\text{<view>\_cosmetic}(i, j) &= \text{[gbtr\_confidence\_<view>]}(i, j)(\text{bit 1}) \\
\text{<view>\_scan\_absent}(i, j) &= \text{[gbtr\_confidence\_<view>]}(i, j)(\text{bit 2}) \\
\text{<view>\_pixel\_absent}(i, j) &= \text{[gbtr\_confidence\_<view>]}(i, j)(\text{bit 3}) \\
\text{<view>\_packet\_validation\_error}(i, j) &= \text{[gbtr\_confidence\_<view>]}(i, j)(\text{bit 4}) \\
\text{<view>\_zero\_count}(i, j) &= \text{[gbtr\_confidence\_<view>]}(i, j)(\text{bit 5}) \\
\text{<view>\_saturation}(i, j) &= \text{[gbtr\_confidence\_<view>]}(i, j)(\text{bit 6}) \\
\text{<view>\_cal\_out\_of\_range}(i, j) &= \text{[gbtr\_confidence\_<view>]}(i, j)(\text{bit 7}) \\
\text{<view>\_cal\_out\_of\_range}(i, j) &= \text{[gbtr\_confidence\_<view>]}(i, j)(\text{bit 8}) \\
\text{<view>\_unfilled\_pixel}(i, j) &= \text{[gbtr\_confidence\_<view>]}(i, j)(\text{bit 9})
\end{align*}
\]

where in each case

\[
\text{<view> = <nadir | frwrd}> \quad \text{(Req 4.3-4)}
\]

Set the fill state bytes for each pixel $j = 0, 511$ according to the settings of the relevant the confidence flags as follows:

\[
\begin{align*}
\text{<view>\_fill\_state}(i, j) &= \text{UNFILLED\_PIXEL IF <view>\_unfilled\_pixel}(i, j) \text{ is TRUE;} \\
\text{<view>\_fill\_state}(i, j) &= \text{COSMETIC\_PIXEL IF <view>\_cosmetic}(i, j) \text{ is TRUE;} \\
\text{<view>\_fill\_state}(i, j) &= \text{NATURAL\_PIXEL otherwise,}
\end{align*}
\]

where in each case

\[
\text{<view> = <nadir | frwrd}> \quad \text{(Req 4.3-5)}
\]

**Step 4.3.4 Read Measurement Data Sets #17, 18.**

These measurement data sets represent the nadir and forward view cloud/land flag words respectively. For each image scan $i$, read in the records of cloud flag words:

\[
\begin{align*}
\text{FOR each pixel } j = 0, 511 \\
\text{gbtr\_cloud\_state\_nadir}(i, j) &= \text{[GBTR-MDS17-5]}(i, j) \\
\text{FOR each pixel } j = 0, 511
\end{align*}
\]
gbtr_cloud_state_frwrd(i, j) = [GBTR-MDS18-5](i, j)  \text{ (Req 4.3-6)}

Extract the land and cloud state flags for each pixel j = 0, 511:

For each cloud/land state flag, the truth value (1 = TRUE; 0 = FALSE) of the flag is to be set according to the corresponding bit of the cloud state word as follows:

\begin{align*}
\text{<view>_land}(i, j) &= \text{[gbtr_cloud_state_<view>(i, j)](bit 0)} \\
\text{<view>_cloud}(i, j) &= \text{[gbtr_cloud_state_<view>(i, j)](bit 1)} \\
\text{<view>_sunglint}(i, j) &= \text{[gbtr_cloud_state_<view>(i, j)](bit 2)} \\
\text{<view>_v16_histogram_test}(i, j) &= \text{[gbtr_cloud_state_<view>(i, j)](bit 3)} \\
\text{<view>_v16_spatial_coherence_test}(i, j) &= \text{[gbtr_cloud_state_<view>(i, j)](bit 4)} \\
\text{<view>_ir11_spatial_coherence_test}(i, j) &= \text{[gbtr_cloud_state_<view>(i, j)](bit 5)} \\
\text{<view>_ir12_gross_cloud_test}(i, j) &= \text{[gbtr_cloud_state_<view>(i, j)](bit 6)} \\
\text{<view>_ir11_ir12_thin_cirrus_test}(i, j) &= \text{[gbtr_cloud_state_<view>(i, j)](bit 7)} \\
\text{<view>_ir37_ir12med_high_level_test}(i, j) &= \text{[gbtr_cloud_state_<view>(i, j)](bit 8)} \\
\text{<view>_ir11_ir37_fog_low_stratus_test}(i, j) &= \text{[gbtr_cloud_state_<view>(i, j)](bit 9)} \\
\text{<view>_ir11_ir12_view_diff_test}(i, j) &= \text{[gbtr_cloud_state_<view>(i, j)](bit 10)} \\
\text{<view>_ir37_ir11_view_diff_test}(i, j) &= \text{[gbtr_cloud_state_<view>(i, j)](bit 11)} \\
\text{<view>_ir11_ir12_histogram_test}(i, j) &= \text{[gbtr_cloud_state_<view>(i, j)](bit 12)}
\end{align*}

where in each case

\[<view> = <\text{nadir} > | <\text{frwrd}> \quad \text{(Req 4.3-7)}\]

4.4 Module Definition: Interpolate Solar Angles

4.4.1 Functional Description

The solar azimuth and elevation and satellite azimuth and elevation, all measured at the pixel, are available for a series of uniformly spaced tie point pixels in ADS #5 for the nadir view and in ADS #6 for the forward view images. The present module derives those angles that are required for level 2 processing at every scan, and at the mid-points of the bands, by linear interpolation, between these tie points. Only the solar elevation is required for most Level 2 processing, but the satellite elevation is required for LST retrieval. (If it were necessary to derive interpolated azimuths as well, account would need to be taken of the possibility of a discontinuity as the azimuth passes through 180°.)

4.4.2 Interface Definition

<table>
<thead>
<tr>
<th>Parameter ID</th>
<th>Variable</th>
<th>Name</th>
<th>Type</th>
<th>Units</th>
<th>Field size</th>
<th>Fields</th>
</tr>
</thead>
<tbody>
<tr>
<td>L2-AUX3-9</td>
<td>NGRANULE</td>
<td>interval between ADS records (Granule size)</td>
<td>sl</td>
<td>none</td>
<td>4</td>
<td>1</td>
</tr>
</tbody>
</table>
Table 4.4.1: Input Data Table - Interpolate Solar Angles

<table>
<thead>
<tr>
<th>Parameter ID</th>
<th>Variable</th>
<th>Name</th>
<th>Type</th>
<th>Units</th>
<th>Field size</th>
<th>Fields</th>
</tr>
</thead>
<tbody>
<tr>
<td>local k</td>
<td>k</td>
<td>index to across-track band edge samples (k = 0, 10)</td>
<td>sl</td>
<td>none</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>local k'</td>
<td>k'</td>
<td>index to across-track band centre samples (k' = 0, 9)</td>
<td>sl</td>
<td>none</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>L2-INT-3</td>
<td>ig(k)</td>
<td>tie point solar elevation nadir</td>
<td>float</td>
<td>deg.</td>
<td>4</td>
<td>k = 0, 10</td>
</tr>
<tr>
<td>L2-INT-5</td>
<td>ig(k)</td>
<td>tie point solar elevation frwrd</td>
<td>float</td>
<td>deg.</td>
<td>4</td>
<td>k = 0, 10</td>
</tr>
<tr>
<td>local ig</td>
<td>g</td>
<td>index to (tie) rows</td>
<td>sl</td>
<td>none</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>local ig</td>
<td>i</td>
<td>index to image rows (scans)</td>
<td>sl</td>
<td>none</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>L2-INT-120</td>
<td>ig(k)</td>
<td>nadir band edge solar elevation(i, k)</td>
<td>float</td>
<td>degrees</td>
<td>4</td>
<td>k = 0, 10</td>
</tr>
<tr>
<td>L2-INT-121</td>
<td>ig(k)</td>
<td>nadir band edge satellite elevation(i, k)</td>
<td>float</td>
<td>degrees</td>
<td>4</td>
<td>k = 0, 10</td>
</tr>
<tr>
<td>L2-INT-140</td>
<td>ig(k)</td>
<td>frwrd band edge solar elevation(i, k)</td>
<td>float</td>
<td>degrees</td>
<td>4</td>
<td>k = 0, 10</td>
</tr>
<tr>
<td>L2-INT-141</td>
<td>ig(k)</td>
<td>frwrd band edge satellite elevation(i, k)</td>
<td>float</td>
<td>degrees</td>
<td>4</td>
<td>k = 0, 10</td>
</tr>
<tr>
<td>L2-INT-124</td>
<td>k'</td>
<td>nadir band centre solar elevation(i, k')</td>
<td>float</td>
<td>degrees</td>
<td>4</td>
<td>k' = 0, 9</td>
</tr>
<tr>
<td>L2-INT-125</td>
<td>k'</td>
<td>nadir band centre satellite elevation(i, k')</td>
<td>float</td>
<td>degrees</td>
<td>4</td>
<td>k' = 0, 9</td>
</tr>
<tr>
<td>L2-INT-144</td>
<td>k'</td>
<td>frwrd band centre solar elevation(i, k')</td>
<td>float</td>
<td>degrees</td>
<td>4</td>
<td>k' = 0, 9</td>
</tr>
<tr>
<td>L2-INT-145</td>
<td>k'</td>
<td>frwrd band centre satellite elevation(i, k')</td>
<td>float</td>
<td>degrees</td>
<td>4</td>
<td>k' = 0, 9</td>
</tr>
</tbody>
</table>

Table 4.4.2: Internal Data Table - Interpolate Solar Angles

4.4.3 Detailed Structure

Intermediate values are now calculated by linear interpolation. The nadir and forward scans are treated separately. Level 1b processing will have ensured that each ADS record corresponds to a single image row with

\[ i = ig \cdot NGRANULE \]

where \( i \) indexes the image scans, and \( ig \) is an index to the ADS records, both counting from 0.

The elevation values read in from the ADS records may contain exception values (-999). If a solar elevation of -999.0 appears at either end of an interpolation interval, the interpolated values in the interval should all be set to -999.0. This ensures that the interpolated values are consistent with the values derived at Level 1B in the presence of exception values.

(Implementation note: this may be achieved by initialising the arrays <view>_band_edge_solar_elevation and <view>_band_centre_solar_elevation to -999.0)

Step 4.4.1. Interpolate band edge solar angles.

The solar elevations for the intermediate rows can be determined by linear interpolation as follows:

for each \( k = 0, 1, ..., 10 \) and for \( j = 0, 1, ... NGRANULE - 1 \)

calculate

\[ w = j / NGRANULE \]

\[ i = ig \cdot NGRANULE + j \]

If [L2-INT-3](ig, k) equals -999.0 or [L2-INT-3](ig + 1, k) equals -999.0 (these are the nadir view tie point solar elevations at the two ends of the interpolation interval) then set
nadir_band_edge_solar_elevation(i, k) = -999.0
otherwise
nadir_band_edge_solar_elevation(i, k) = \beta^a(ig, k) + w \cdot \left\{ \beta^a(ig + 1, k) - \beta^a(ig, k) \right\}

If [L2-INT-5](ig, k) equals -999.0 or [L2-INT-5](ig + 1, k) equals -999.0 (these are the forward view tie point solar elevations at the two ends of the interpolation interval) then set
frwrd_band_edge_solar_elevation(i, k) = -999.0
otherwise
frwrd_band_edge_solar_elevation(i, k) = \beta^f(ig, k) + w \cdot \left\{ \beta^f(ig + 1, k) - \beta^f(ig, k) \right\}

(Req 4.4-1)

Step 4.4.2. Interpolate band centre solar angles.

The band centre values are then given as follows.
If <view>_band_edge_solar_elevation(i, k') equals -999.0 or <view>_band_edge_solar_elevation(i, k' + 1) equals -999.0 then
<view>_band_centre_solar_elevation(i, k') = -999.0
otherwise
<view>_band_centre_solar_elevation(i, k') = 0.5 \left\{ <view>_band_edge_solar_elevation(i, k') + <view>_band_edge_solar_elevation(i, k' + 1) \right\}
for k' = 0, 9.

(Req 4.4-2)

Step 4.4.3. Interpolate band edge satellite angles.

The satellite elevations for the intermediate rows are determined by linear interpolation in the same way as the solar elevations, but with [L2-INT-13] in place of [L2-INT-3] and with [L2-INT-15] in place of [L2-INT-5].
for each k = 0, 1, ..., 10 and for j = 0, 1, ... NGRANULE - 1
calculate
w = j / NGRANULE
i = ig \cdot NGRANULE + j

If [L2-INT-13](ig, k) equals -999.0 or [L2-INT-13](ig + 1, k) equals -999.0 then set
nadir_band_edge_satellite_elevation(i, k) = -999.0
otherwise
nadir_band_edge_satellite_elevation(i, k) = \gamma^a(ig, k) + w \cdot \left\{ \gamma^a(ig + 1, k) - \gamma^a(ig, k) \right\}
If \([L2-INT-15](ig, k)\) equals -999.0 or \([L2-INT-15](ig + 1, k)\) equals -999.0 then set 
\[frwrd\_band\_edge\_satellite\_elevation(i, k) = -999.0\]
otherwise 
\[frwrd\_band\_edge\_satellite\_elevation(i, k) = \gamma^f (ig, k) + w \cdot \left\{ \gamma^f (ig + 1, k) - \gamma^f (ig, k) \right\}\]

\((\text{Req } 4.4-3)\)

**Step 4.4.4. Interpolate band centre satellite angles.**

The band centre values are then given as follows.

If \(<view>_\_band\_edge\_satellite\_elevation(i, k')\) equals -999.0 or 
\(<view>_\_band\_edge\_satellite\_elevation(i, k' + 1)\) equals -999.0 then 
\(<view>_\_band\_centre\_satellite\_elevation(i, k') = -999.0\)
otherwise
\[<view>_\_band\_centre\_satellite\_elevation(i, k') = 0.5\left\{<view>_\_band\_edge\_satellite\_elevation(i, k') + <view>_\_band\_edge\_satellite\_elevation(i, k' + 1)\right\}\]

for \(k' = 0, 9\).

\((\text{Req } 4.4-4)\)

**4.5 Module Definition: Interpolate Image Pixel Position**

**4.5.1 Functional Description**

The (geodetic) latitudes and longitudes of a series of uniformly space tie point pixels are available in ADS #3. This module derives the latitude and longitude of each of image pixel by linear interpolation, in two dimensions, between these tie points. In the case of longitude account must be taken of the possibility that the 180 degree meridian intersects the image scan.

**4.5.2 Interface Definition**

<table>
<thead>
<tr>
<th>Parameter ID</th>
<th>Variable</th>
<th>Name</th>
<th>Type</th>
<th>Units</th>
<th>Field size</th>
<th>Fields</th>
</tr>
</thead>
<tbody>
<tr>
<td>GBTR-ADS3-1</td>
<td></td>
<td>UTC nadir time 1</td>
<td>sl</td>
<td>days</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>GBTR-ADS3-2</td>
<td></td>
<td>UTC nadir time 2</td>
<td>ul</td>
<td>s</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>GBTR-ADS3-3</td>
<td></td>
<td>UTC nadir time 3</td>
<td>ul</td>
<td>micros</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>GBTR-ADS3-4</td>
<td></td>
<td>image scan y coordinate</td>
<td>sl</td>
<td>km</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>GBTR-ADS3-5</td>
<td></td>
<td>tie point latitudes</td>
<td>sl</td>
<td>mdeg</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>GBTR-ADS3-6</td>
<td></td>
<td>tie point longitudes</td>
<td>sl</td>
<td>mdeg</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>GBTR-ADS3-7</td>
<td></td>
<td>latitude corrections</td>
<td>ss</td>
<td>mdeg</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>GBTR-ADS3-8</td>
<td></td>
<td>longitude corrections</td>
<td>ss</td>
<td>mdeg</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>GBTR-ADS3-9</td>
<td></td>
<td>Topographic Altitude</td>
<td>ss</td>
<td>metres</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>L2-AUX3-9</td>
<td>NGRANULE</td>
<td>interval between ADS records (Granule size)</td>
<td>sl</td>
<td>none</td>
<td></td>
<td>4</td>
</tr>
</tbody>
</table>

Table 4.5-1: Input Data Table - Interpolate Image Pixel Position
### Table 4.5-2: Internal Data Table - Interpolate Image Pixel Position

#### 4.5.3 Detailed Structure

**Step 4.5.1. Interpolate pixel latitudes.**

Given an image scan and pixel number $i, j$ define

$$i_g = \text{integer part of } i / \text{NGRANULE}$$

$$w_y = (i / \text{NGRANULE}) - i_g$$

$$j_g = \text{integer part of } (j + 19)/25$$

$$w_x = (j + 19) / 25 - j_g$$

Interpolate the geocentric latitudes as follows:

$$\varphi(i, j) = \varphi_1 + w_y \{ \varphi_2 - \varphi_1 \}$$

where

$$\varphi_1 = \varphi_g(i_g, j_g) + w_x \{ \varphi_g(i_g, j_g + 1) - \varphi_g(i_g, j_g) \}$$

and

$$\varphi_2 = \varphi_g(i_g + 1, j_g) + w_x \{ \varphi_g(i_g + 1, j_g + 1) - \varphi_g(i_g + 1, j_g) \}$$

*Req 4.5-1*

**Step 4.5.2. Interpolate pixel longitudes**

Longitude is treated similarly unless the meridian is present:

$$\lambda(i, j) = \lambda_1 + w_y \{ \lambda_2 - \lambda_1 \}$$

where

$$\lambda_1 = \lambda_g(i_g, j_g) + w_x \{ \lambda_g(i_g, j_g + 1) - \lambda_g(i_g, j_g) \}$$

---

and
\[ \lambda_2 = \lambda_g(i_g + 1, j_g) + w_x \left\{ \lambda_g(i_g + 1, j_g + 1) - \lambda_g(i_g + 1, j_g) \right\} \]

A test for the presence of the meridian is that
\[ (\lambda_{\text{max}} - \lambda_{\text{min}}) > 180.0 \]
where \( \lambda_{\text{max}} \) and \( \lambda_{\text{min}} \) are respectively the greatest and least of
\[ \lambda_g(i_g, 0), \lambda_g(i_g, 22), \lambda_g(i_g + 1, 0), \lambda_g(i_g + 1, 22). \]

In this case 360.0 is added to each of the grid longitudes that is initially negative before it is substituted in the above equations. The resultant interpolated longitude is translated into the range -180.0 to 180.0 degrees by subtracting 360.0 if its value exceeds 180.0.

### 4.6 Module Definition: Gridded SST / Vegetation Retrieval

#### 4.6.1 Functional Description

To derive the sea surface temperature (SST) or, over land, the land surface temperature (LST) and vegetation index (NDVI), at 1 km resolution, using cloud free data.

The derivation of SSTs uses the 11 and 12 micron channels for day time data and for night time data the 11, 12 and 3.7 micron channels. For each 1 km resolution element two results are obtained, one using the combined nadir and forward views and the other using the nadir view alone.

The SSTs are calculated using preset retrieval coefficients. These coefficients are provided for both nadir only and combined view SSTs and are a function of latitude and viewing angle.

Smoothing is applied by smoothing the difference between the calculated SST and the 11 micron brightness temperature. The effect is to smooth the atmospheric correction.

The LST is calculated using an algorithm developed by Prata and described in Reference RD3. This algorithm is similar to that used for the nadir only SST retrieval, in that it uses the 11 and 12 micron nadir view brightness temperatures in conjunction with pre-defined retrieval coefficients. However, the selection of the retrieval coefficients is more complicated than for the SST retrieval. The coefficients depend on a surface classification and on a seasonal vegetation index, both of which are defined in the form of maps at 0.5 degree resolution, and they also depend weakly on the precipitable water vapour content derived from climatological data. The surface class, vegetation index and precipitable water vapour are supplied as auxiliary data sets in the LST Retrieval Coefficient Data Product. Different coefficients may be supplied for day and night retrievals. Note that smoothing is not applied to the LST values in the present algorithm.

The NVDIs are calculated using the nadir .67 and .87 micron channels and the results are returned in the combined image land pixels.

In cloudy conditions the cloud top temperature is returned in the nadir image field and the cloud top height in the combined view image field.
4.6.2 Interface Definition

<table>
<thead>
<tr>
<th>Parameter ID</th>
<th>Variable</th>
<th>Name</th>
<th>Type</th>
<th>Units</th>
<th>Field size</th>
<th>Fields</th>
</tr>
</thead>
<tbody>
<tr>
<td>L2-AUX1-1</td>
<td>a[i, j]</td>
<td>sst_retrieval_a[i, j]</td>
<td>float</td>
<td>K/100</td>
<td>4</td>
<td>114</td>
</tr>
<tr>
<td>L2-AUX1-2</td>
<td>a[i, j]</td>
<td>sst_retrieval_a[i, j]</td>
<td>float</td>
<td>none</td>
<td>4</td>
<td>114</td>
</tr>
<tr>
<td>L2-AUX1-3</td>
<td>a[i, j]</td>
<td>sst_retrieval_a[i, j]</td>
<td>float</td>
<td>none</td>
<td>4</td>
<td>114</td>
</tr>
<tr>
<td>L2-AUX1-4</td>
<td>b[i, j]</td>
<td>sst_retrieval_b[i, j]</td>
<td>float</td>
<td>K/100</td>
<td>4</td>
<td>114</td>
</tr>
<tr>
<td>L2-AUX1-5</td>
<td>b[i, j]</td>
<td>sst_retrieval_b[i, j]</td>
<td>float</td>
<td>none</td>
<td>4</td>
<td>114</td>
</tr>
<tr>
<td>L2-AUX1-6</td>
<td>b[i, j]</td>
<td>sst_retrieval_b[i, j]</td>
<td>float</td>
<td>none</td>
<td>4</td>
<td>114</td>
</tr>
<tr>
<td>L2-AUX1-7</td>
<td>b[i, j]</td>
<td>sst_retrieval_b[i, j]</td>
<td>float</td>
<td>none</td>
<td>4</td>
<td>114</td>
</tr>
<tr>
<td>L2-AUX1-8</td>
<td>c[i, j]</td>
<td>sst_retrieval_c[i, j]</td>
<td>float</td>
<td>K/100</td>
<td>4</td>
<td>114</td>
</tr>
<tr>
<td>L2-AUX1-9</td>
<td>c[i, j]</td>
<td>sst_retrieval_c[i, j]</td>
<td>float</td>
<td>none</td>
<td>4</td>
<td>114</td>
</tr>
<tr>
<td>L2-AUX1-10</td>
<td>c[i, j]</td>
<td>sst_retrieval_c[i, j]</td>
<td>float</td>
<td>none</td>
<td>4</td>
<td>114</td>
</tr>
<tr>
<td>L2-AUX1-11</td>
<td>c[i, j]</td>
<td>sst_retrieval_c[i, j]</td>
<td>float</td>
<td>none</td>
<td>4</td>
<td>114</td>
</tr>
<tr>
<td>L2-AUX1-12</td>
<td>c[i, j]</td>
<td>sst_retrieval_c[i, j]</td>
<td>float</td>
<td>none</td>
<td>4</td>
<td>114</td>
</tr>
<tr>
<td>L2-AUX1-13</td>
<td>d[i, j]</td>
<td>sst_retrieval_d[i, j]</td>
<td>float</td>
<td>K/100</td>
<td>4</td>
<td>114</td>
</tr>
<tr>
<td>L2-AUX1-14</td>
<td>d[i, j]</td>
<td>sst_retrieval_d[i, j]</td>
<td>float</td>
<td>none</td>
<td>4</td>
<td>114</td>
</tr>
<tr>
<td>L2-AUX1-15</td>
<td>d[i, j]</td>
<td>sst_retrieval_d[i, j]</td>
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<td>none</td>
<td>4</td>
<td>114</td>
</tr>
<tr>
<td>L2-AUX1-16</td>
<td>d[i, j]</td>
<td>sst_retrieval_d[i, j]</td>
<td>float</td>
<td>none</td>
<td>4</td>
<td>114</td>
</tr>
<tr>
<td>L2-AUX1-17</td>
<td>d[i, j]</td>
<td>sst_retrieval_d[i, j]</td>
<td>float</td>
<td>none</td>
<td>4</td>
<td>114</td>
</tr>
<tr>
<td>L2-AUX1-18</td>
<td>d[i, j]</td>
<td>sst_retrieval_d[i, j]</td>
<td>float</td>
<td>none</td>
<td>4</td>
<td>114</td>
</tr>
<tr>
<td>L2-AUX1-19</td>
<td>d[i, j]</td>
<td>sst_retrieval_d[i, j]</td>
<td>float</td>
<td>none</td>
<td>4</td>
<td>114</td>
</tr>
<tr>
<td>L2-AUX6-1</td>
<td>j</td>
<td>pixel index (j)</td>
<td>float</td>
<td>none</td>
<td>2</td>
<td>512</td>
</tr>
<tr>
<td>L2-AUX6-2</td>
<td>j</td>
<td>pixel index (j)</td>
<td>float</td>
<td>none</td>
<td>2</td>
<td>512</td>
</tr>
<tr>
<td>L2-AUX3-11</td>
<td>TROPICAL_INDEX</td>
<td>float</td>
<td>deg</td>
<td>4</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>L2-AUX3-12</td>
<td>TEMPERATE_INDEX</td>
<td>float</td>
<td>deg</td>
<td>4</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>L2-AUX3-13</td>
<td>POLAR_INDEX</td>
<td>float</td>
<td>deg</td>
<td>4</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>L2-AUX3-17</td>
<td>smooth_fac</td>
<td>float</td>
<td>none</td>
<td>2</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

The following parameters are required by the Land Surface Temperature algorithm.

<table>
<thead>
<tr>
<th>Parameter ID</th>
<th>Variable</th>
<th>Name</th>
<th>Type</th>
<th>Units</th>
<th>Field size</th>
<th>Fields</th>
</tr>
</thead>
<tbody>
<tr>
<td>L2-AUX10-1</td>
<td>d</td>
<td>Water vapour factor for LST retrieval</td>
<td>float</td>
<td>none</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>L2-AUX10-2</td>
<td>m</td>
<td>Angle factor for LST retrieval</td>
<td>float</td>
<td>none</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>L2-AUX10-3</td>
<td>N_CLASS</td>
<td>Number of vegetation classes for LST</td>
<td>float</td>
<td>none</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>L2-AUX5-1</td>
<td>Coefficient A0</td>
<td>Coefficient A0</td>
<td>float</td>
<td>K</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>L2-AUX5-2</td>
<td>Coefficient A1</td>
<td>Coefficient A1</td>
<td>float</td>
<td>K</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>L2-AUX5-3</td>
<td>Coefficient A2</td>
<td>Coefficient A2</td>
<td>float</td>
<td>K</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>L2-AUX5-4</td>
<td>Coefficient A3</td>
<td>Coefficient A3</td>
<td>float</td>
<td>K</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>L2-AUX5-5</td>
<td>Coefficient A4</td>
<td>Coefficient A4</td>
<td>float</td>
<td>K</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>L2-AUX5-6</td>
<td>Coefficient A5</td>
<td>Coefficient A5</td>
<td>float</td>
<td>K</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>L2-AUX6-1</td>
<td>vegetation class index</td>
<td>vegetation class index</td>
<td>float</td>
<td>n/a</td>
<td>2</td>
<td>720</td>
</tr>
<tr>
<td>L2-AUX7-1</td>
<td>vegetation fraction</td>
<td>vegetation fraction</td>
<td>float</td>
<td>0.001</td>
<td>2</td>
<td>720</td>
</tr>
<tr>
<td>L2-AUX8-1</td>
<td>Precipitable water</td>
<td>Precipitable water</td>
<td>float</td>
<td>0.01 mm</td>
<td>2</td>
<td>720</td>
</tr>
<tr>
<td>L2-AUX9-1</td>
<td>Topographic Variance Flag</td>
<td>Topographic Variance Flag</td>
<td>float</td>
<td>n/a</td>
<td>2</td>
<td>720</td>
</tr>
</tbody>
</table>

Table 4-6-1: Input Data including SST Retrieval Coefficients.

<table>
<thead>
<tr>
<th>Parameter ID</th>
<th>Variable</th>
<th>Name</th>
<th>Type</th>
<th>Units</th>
<th>Field size</th>
<th>Fields</th>
</tr>
</thead>
<tbody>
<tr>
<td>local</td>
<td>a[i, j]</td>
<td>averaged sst retrieval a coefficients</td>
<td>float</td>
<td>mixed</td>
<td>4</td>
<td>342</td>
</tr>
<tr>
<td>local</td>
<td>b[i, j]</td>
<td>averaged sst retrieval b coefficients</td>
<td>float</td>
<td>mixed</td>
<td>4</td>
<td>456</td>
</tr>
<tr>
<td>local</td>
<td>c[i, j]</td>
<td>averaged sst retrieval c coefficients</td>
<td>float</td>
<td>mixed</td>
<td>4</td>
<td>570</td>
</tr>
<tr>
<td>local</td>
<td>d[i, j]</td>
<td>averaged sst retrieval d coefficients</td>
<td>float</td>
<td>mixed</td>
<td>4</td>
<td>798</td>
</tr>
<tr>
<td>L2-INT-101</td>
<td>l[i, j]</td>
<td>nadir iRGB Brightness Temp.</td>
<td>float</td>
<td>0.01 K</td>
<td>2</td>
<td>j = 0, 511</td>
</tr>
<tr>
<td>L2-INT-102</td>
<td>l[i, j]</td>
<td>nadir iRGB Brightness Temp.</td>
<td>float</td>
<td>0.01 K</td>
<td>2</td>
<td>j = 0, 511</td>
</tr>
<tr>
<td>L2-INT-103</td>
<td>l[i, j]</td>
<td>nadir iRGB Brightness Temp.</td>
<td>float</td>
<td>0.01 K</td>
<td>2</td>
<td>j = 0, 511</td>
</tr>
<tr>
<td>L2-INT-111</td>
<td>l[i, j]</td>
<td>forward iRGB Brightness Temp.</td>
<td>float</td>
<td>0.01 K</td>
<td>2</td>
<td>j = 0, 511</td>
</tr>
</tbody>
</table>
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Page 36 of 141

L2-INT-112  llr11(i, f, j)  forward ir11 Brightness Temp.  ss  0.01 K  2  j = 0, 511
L2-INT-113  llr17(i, f, j)  forward ir37 Brightness Temp.  ss  0.01 K  2  j = 0, 511
L2-INT-105  llr870(n, i, j)  regridded nadir v870 Reflectance  ss  %/100  2  j = 0, 511
L2-INT-106  llr870(n, i, j)  regridded nadir v870 Reflectance  ss  %/100  2  j = 0, 511
L2-INT-115  llr870(f, i, j)  regridded forward v870 Reflectance  ss  %/100  2  j = 0, 511
L2-INT-116  llr870(f, i, j)  regridded forward v870 Reflectance  ss  %/100  2  j = 0, 511
L2-INT-100  nadir_fill_state(i, j)  byte  n/a  1  j = 0, 511
L2-INT-110  foward_fill_state(i, j)  byte  n/a  1  j = 0, 511
L2-INT-160  vo(i, j)  image_latitude(i, j)  float  degrees  4  j = 0, 511
L2-INT-121  nadir_band_edge_satellite_elevation(i, k)  float  degrees  4  k = 0, 10
L2-INT-124  nadir_band_centre_solar_elevation(i, k)  float  degrees  4  k = 0, 9
L2-INT-141  foward_band_edge_satellite_elevation(i, k)  float  degrees  4  k = 0, 10
L2-INT-144  foward_band_centre_solar_elevation(i, k)  float  degrees  4  k = 0, 9
L2-INT-232  nadir_land(i, j)  nadir land flag  ss  n/a  2  j = 0, 511
L2-INT-233  nadir_cloud(i, j)  nadir cloud flag  ss  n/a  2  j = 0, 511
L2-INT-235  nadir_v16_histogram_test(i, j)  ss array  flag  2  j = 0, 511
L2-INT-236  nadir_v16_spatial_coherence_test(i, j)  ss array  flag  2  j = 0, 511
L2-INT-242  nadir_ir11_ir12_view_diff_test(i, j)  ss array  flag  2  j = 0, 511
L2-INT-244  nadir_ir11_ir12_histogram_test(i, j)  ss array  flag  2  j = 0, 511
L2-INT-248  foward_land(i, j)  foward land flag  ss  n/a  2  j = 0, 511
L2-INT-249  foward_cloud(i, j)  foward cloud flag  ss  n/a  2  j = 0, 511
L2-INT-251  foward_v16_histogram_test(i, j)  ss array  flag  2  j = 0, 511
L2-INT-252  foward_v16_spatial_coherence_test(i, j)  ss array  flag  2  j = 0, 511
L2-INT-256  foward_ir11_ir12_view_diff_test(i, j)  ss array  flag  2  j = 0, 511
L2-INT-260  foward_ir11_ir12_histogram_test(i, j)  ss array  flag  2  j = 0, 511
L2-INT-60  band(i)  number of across track band (or strip)  sl  none  4  j = 0, 511
L2-INT-61  map(i)  across-track mapping  sl  none  4  j = 0, 512
local  i  index to image scans  sl  none  4  1
local  j  index to image pixels, j = 0, 1, ...511  sl  none  4  1
local  k  index to across-track bands  sl  none  4  1
local  zone  latitude zone index, zone = 0, 1, 2  sl  none  4  1
local  T0  tropical sst  float  deg.  4  1
local  T1  temperate sst  float  deg.  4  1
local  T2  polar sst  float  deg.  4  1
local  w  interpolation weight  float  none  4  1
local  smoothed_gst_image(i, j)  ss  0.01 K  2  j = 0, 511
L2-INT-270  nadir_image_field(i, j)  ss  0.01 K  2  j = 0, 511
L2-INT-271  combined_image_field(i, j)  ss  mixed  2  j = 0, 511
L2-INT-280  nadir_image_valid(i, j)  flag  n/a  2  j = 0, 511
L2-INT-281  nadir_only_sst_uses_ir37(i, j)  flag  n/a  2  j = 0, 511
L2-INT-282  combined_image_valid(i, j)  flag  n/a  2  j = 0, 511
L2-INT-283  combined_view_sst_uses_ir37(i, j)  flag  n/a  2  j = 0, 511
L2-INT-284  land(i, j)  flag  n/a  2  j = 0, 511
L2-INT-285  nadir_view_cloudy(i, j)  flag  n/a  2  j = 0, 511
L2-INT-286  nadir_view_blanking_pulse(i, j)  flag  n/a  2  j = 0, 511
L2-INT-287  nadir_view_cosmetico(i, j)  flag  n/a  2  j = 0, 511
L2-INT-288  foward_view_cloudy(i, j)  flag  n/a  2  j = 0, 511
L2-INT-289  foward_view_blanking_pulse(i, j)  flag  n/a  2  j = 0, 511
L2-INT-290  foward_view_cosmetico(i, j)  flag  n/a  2  j = 0, 511
L2-INT-291  gstv16_cloud_test(i, j)  flag  n/a  2  j = 0, 511
L2-INT-292  gstv16_nadir_cloud_test(i, j)  flag  n/a  2  j = 0, 511
L2-INT-293  gstv11_histogram_test(i, j)  flag  n/a  2  j = 0, 511
L2-INT-294  topographic_varianco(i, j)  flag  n/a  2  j = 0, 511
L2-INT-295  extended_land(i, j)  flag  n/a  2  j = 0, 511
L2-INT-26  time(sq)  scan UTC  double  days  6  per sg
L2-INT-161  zi(i, j)  image_longitude(i, j)  float  deg.  4  j = 0, 511
**4.6.3 Detailed Structure**

**Step 4.6.1 Read in the retrieval coefficients.**

**Step 4.6.1.1 Read in the SST retrieval coefficients.**

This is done once at initialisation. Retrieval coefficients are specified for tropical, temperate and polar latitudes and for 38 bands or strips running parallel to the ground track, on each side, corresponding to different viewing angles. Also different sets are needed for day/night and for nadir only/combined view retrievals, as follows.

<table>
<thead>
<tr>
<th>Latitude zone</th>
<th>tropical</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>temperate</td>
</tr>
<tr>
<td>1</td>
<td>polar</td>
</tr>
</tbody>
</table>

Set

- **a** nadir only: day
- **b** nadir only: night
- **c** combined view: day
- **d** combined view: night

First the mapping array must be read in. Open the data set L2-AUX6 and set

\[
\text{map}(j) = [\text{L2-AUX6-2}](j), \ j = 0, 511
\]
Open the file of retrieval coefficients L2-AUX1.

The 'a' coefficient set are read in as follows.
- \( zone = 0, 1, 2 \) (outer loop)
- Across-track band \( k = 0 \) to \( 37 \) (inner loop)
  - \( a(zone, k, 0) = [L2-AUX1-1](zone, k) \)
  - \( a(zone, k, 1) = [L2-AUX1-2](zone, k) \)
  - \( a(zone, k, 2) = [L2-AUX1-3](zone, k) \)

Similarly read in the b, c and d sets of coefficients.
- \( b(zone, k, 0:3) = L2-AUX1<-4 - 7>](zone, k) \)
- \( c(zone, k, 0:4) = L2-AUX1<-8 - 12>](zone, k) \)
- \( d(zone, k, 0:6) = L2-AUX1<-13 - 19>](zone, k) \)

**Step 4.6.1.2 Read in coefficients and auxiliary tables for LST retrieval.**

**Step 4.6.1.2.1 Read in coefficients.**

For each of the \( N_{CLASS} \) vegetation classes there are two records, for vegetation and for bare soil. Open the file of retrieval coefficients L2-AUX5.

The LST coefficient set is read in as follows.
- for \( class = 0, N_{CLASS} - 1 \) (outer loop)
  - for \( i = 0, 1 \) (inner loop)
    - \( coeff(class, i, 0, 0) = [L2-AUX5-1] \)
    - \( coeff(class, i, 0, 1) = [L2-AUX5-2] \)
    - \( coeff(class, i, 0, 2) = [L2-AUX5-3] \)
    - \( coeff(class, i, 1, 0) = [L2-AUX5-4] \)
    - \( coeff(class, i, 1, 1) = [L2-AUX5-5] \)
    - \( coeff(class, i, 1, 2) = [L2-AUX5-6] \)

(Note: \( i = 0 \) are vegetation coefficients; \( i = 1 \) are coefficients for bare soil.)

**Step 4.6.1.2.2 Determine month index.**

Using a suitable calendar function, determine the month \((month = 0, \ldots 11)\) in which the data were collected from the scan time of start of data \( time(0)=[L2-INT-26](0)\):

\[ month = month(time(0)) \]

**Step 4.6.1.2.3 Read in auxiliary files.**

Note that in the cases of data sets L2-AUX7 and L2-AUX8 only one plane of data, that corresponding to the current month, is required in memory for a given run of the processor.

Read in Vegetation Class Index: Open the vegetation class file L2-AUX6.

- for each latitude index \( i = 0, 359 \)
  - \( vegetation_class(i, j) = [L2-AUX6-1](j) \) for all \( j \) of record \( i \).

Read in Vegetation Fraction Table: Open the file of vegetation fraction data L2-AUX7.
for each latitude index $i = 0, 359$
    select record $(360 \times \text{month} + i)$
    \[ \text{vegetation} \_\text{fraction}(i, j) = [L2\text{-AUX7-1}(j)] \text{ for all } j \text{ of selected record.} \]

Read in Precipitable Water Data: Open the file of precipitable water data L2-AUX8.
for each latitude index $i = 0, 359$
    select record $(360 \times \text{month} + i)$
    \[ \text{precipitable} \_\text{water}(i, j) = [L2\text{-AUX8-1}(j)] \text{ for all } j \text{ of selected record.} \]

Read in Topographic Variance Flag: Open the file of topographic variance flags L2-AUX9.
for each latitude index $i = 0, 359$
    \[ \text{topographic} \_\text{flag}(i, j) = [L2\text{-AUX9-1}(j)] \text{ for all } j \text{ of record } i. \]

**Step 4.6.2 Calculate across-track band number.**

The across-track band number for each pixel in the regridded image is given by

\[
\begin{align*}
\text{band}(j) &= 0 \text{ IF } j < 6 \\
\text{band}(j) &= \text{integer part of } (j - 6) / 50 \text{ IF } 6 \leq j < 506 \\
\text{band}(j) &= 9 \text{ IF } j \geq 506
\end{align*}
\]

where $j$ is the pixel across track index.  

(Req 4.6-1)

**Step 4.6.3 Clear the gsst confidence flags.**

The GSST confidence flags L2-INT-280 and L2-INT-282 are set to indicate data invalid for each pixel in the GSST arrays.

\[
\begin{align*}
\text{nadir} \_\text{image} \_\text{valid}(i, j) &= \text{FALSE} \\
\text{combined} \_\text{image} \_\text{valid}(i, j) &= \text{FALSE}
\end{align*}
\]

(Req 4.6-2)

(Implementation note: it may be convenient to initialise all the GSST confidence flags L2-INT-280 to L2-INT-293 inclusive at this point, although it is not logically necessary in terms of the way the algorithms are formulated in the following.)

**Step 4.6.4 Derive nadir only sea-surface temperature image.**

Each pixel $(i, j)$ in the nadir image field is processed as follows.

The latitude and longitude indices are extracted and used to identify the surface classification. The objective here is to identify those pixels that are flagged as sea pixels but represent inland lakes. The extended land flag is set if the pixel is either a land pixel or an inland lake: extended_land = (land OR {(NOT land) AND class = 14})

If $\text{nadir} \_\text{land}(i, j) = \text{FALSE}$ then

\[
\begin{align*}
\text{lat} \_\text{index} &= \text{integer part of } [(\text{image} \_\text{latitude}(i, j) + 90.0) \times 2.0] \\
\text{lon} \_\text{index} &= \text{integer part of } [(\text{image} \_\text{longitude}(i, j) + 180.0) \times 2.0] \\
\text{class} &= \text{vegetation} \_\text{class}(\text{lat} \_\text{index}, \text{lon} \_\text{index}) \\
\text{extended} \_\text{land}(i, j) &= (\text{class} = 14)
\end{align*}
\]

else

\[
\text{extended} \_\text{land}(i, j) = \text{nadir} \_\text{land}(i, j)
\]
IF over cloud and the extended land flag is not set, and the 11 micron brightness temperature is valid then the 11 micron brightness temperature is used as an estimate of cloud top temperature ie.

\[
\text{if } \text{nadir\_cloud}(i, j) \text{ AND NOT extended\_land}(i, j) = \text{TRUE} \\
\text{AND } I(ir11, n; i, j) > 0 \\
\text{then} \\
\text{nadir\_image\_field}(i, j) = I(ir11, n; i, j) \\
\text{nadir\_image\_valid}(i, j) = \text{TRUE} \\
\text{(Req 4.6-3)}
\]

IF the extended land flag is set then execute Step 4.6.9 below to derive the land surface temperature:

\[
\text{IF } \text{extended\_land}(i, j) = \text{TRUE} \\
\text{THEN execute Step 4.6.9} \\
\text{(Req 4.6-4)}
\]

ELSE the pixel is over open sea and NOT cloudy. Determine the nadir-only sea surface temperature SST as follows and assign it to nadir\_image\_field(i, j).

**Step 4.6.4.1**

IF the absolute value of the pixel latitude \(\phi(i, j)\) is less than TROPICAL\_INDEX retrieve the tropical sea surface temperature (using step 4.6.4.5 below).

**Step 4.6.4.2**

ELSE IF the absolute value of the pixel latitude is less than TEMPERATE\_INDEX but is not less than TROPICAL\_INDEX, two retrievals are made using the retrieval coefficients for both the tropical and mid-latitude zones. If these two retrievals are tropical\_sst and temperate\_sst respectively, the final value for the retrieved sst is given by linear interpolation between them, as follows:

\[
w = \frac{(abs(\phi(i,j)) - TROPICAL\_INDEX)}{(TEMPERATE\_INDEX - TROPICAL\_INDEX)}
\]

\[
SST = \text{tropical\_sst} + w \times (\text{temperate\_sst} - \text{tropical\_sst})
\]

**Step 4.6.4.3**

ELSE IF the absolute value of the pixel latitude is less than POLAR\_INDEX but not less than TEMPERATE\_INDEX, two retrievals are made using the retrieval coefficients for the high-latitude and mid-latitude regions. If these two retrievals are polar\_sst and temperate\_sst respectively, the final value for the retrieved sst is given by

\[
w = \frac{(abs(\phi(i,j)) - TEMPERATE\_INDEX)}{(POLAR\_INDEX - TEMPERATE\_INDEX)}
\]

\[
SST = \text{temperate\_sst} + w \times (\text{polar\_sst} - \text{temperate\_sst})
\]

**Step 4.6.4.4**

ELSE retrieve the polar sea surface temperature using step 4.6.4.5 below.

**Step 4.6.4.5. Retrieve nadir only SST**
This step is executed whenever an SST retrieval is called for in Steps 4.6.4.1 to 4.6.4.4. Retrievals use the 11, 12 and 3.7 micron brightness temperatures.

The latitude zone, 0 for tropical, 1 for temperate, 2 for polar.

The across-track band mapping index \( k = \text{map} (j), k = 0 \) to 37.

The nadir view solar elevation angle.

Negative data values indicate invalid data. If either the 11 or 12 micron brightness temperatures are invalid then the calculation is abandoned and the nadir_image_valid flag remains FALSE. Otherwise the calculation can proceed as follows.

Check the nadir solar elevation angle and if the pixel is in night-time (nadir band centre solar elevation\( (i, k) \) is \(< 0. \)) and the 3.7 micron brightness temperature is valid use the 3.7 micron channel with the \( b \) coefficient set.

\[
sst = \begin{align*}
b(z, k, 0) & \times 100. + \\
b(z, k, 1) & \times I(ir11, n, i, j) + \\
b(z, k, 2) & \times I(ir12, n, i, j) + \\
b(z, k, 3) & \times I(ir37, n, i, j) \\
nadir_only_sst_uses_ir37(i, j) & = \text{TRUE} \\
nadir_image_valid(i, j) & = \text{TRUE}. \\
\end{align*}
\]

(Req 4.6-7)

If NOT using 3.7 micron channel THEN a 2-channel retrieval is performed and the \( a \) coefficient set is required.

\[
sst = \begin{align*}
a(z, k, 0) & \times 100. + \\
a(z, k, 1) & \times I(ir11, n, i, j) + \\
a(z, k, 2) & \times I(ir12, n, i, j) \\
nadir_only_sst_uses_ir37(i, j) & = \text{FALSE} \\
nadir_image_valid(i, j) & = \text{TRUE}. \\
\end{align*}
\]

(Req 4.6-8)

**Step 4.6.5 Derive combined view sea-surface temperature image**

Each pixel \((i, j)\) in the image field is processed as follows.

IF the nadir cloud flag [L2-INT-233] for the pixel is set (nadir_cloud\((i, j) = \text{TRUE}\)) and the extended land flag \( \text{extended_land}(i, j) \) is NOT set THEN set

\[
\begin{align*}
\text{combined_image_field}(i, j) &= 0 \\
\text{combined_image_valid}(i, j) &= \text{FALSE} \\
\end{align*}
\]

(Req 4.6-8.1)

(Note: for cloudy pixels, the combined image field is reserved for the cloud top height. However, the algorithm for determining cloud top height is not yet defined, and so the combined image field is currently set to to zero in this case. The eventual algorithm is expected to make use of a look-up table of temperature versus height.)

IF over land \((\text{extended_land}(i, j) = \text{TRUE})\) THEN calculate the NDVI for the pixel (step 4.6.6).

Otherwise the pixel is not cloudy and over sea. Determine the combined view SST as follows and assign it to \( \text{combined_image_field}(i, j) \).
Step 4.6.5.1

IF the absolute value of the pixel latitude is LESS THAN TROPICAL_INDEX retrieve the combined view tropical sea surface temperature. Combined view temperature is derived according to step 4.6.5.5 below.

Step 4.6.5.2

ELSE if the absolute value of the pixel latitude is LESS THAN TEMPERATE_INDEX but is NOT LESS THAN TROPICAL_INDEX, two retrievals are made using the retrieval coefficients for both the tropical and mid-latitude zones. IF these two retrievals are tropical_sst and temperate_sst respectively, the final value for the retrieved sst is given by linear interpolation as follows:

\[
\begin{align*}
    w &= \frac{\text{abs}(\varphi(i, j)) - \text{TROPICAL\_INDEX}}{\text{TEMPERATE\_INDEX} - \text{TROPICAL\_INDEX}} \\
    \text{sst} &= \text{tropical\_sst} + w \times (\text{temperate\_sst} - \text{tropical\_sst})
\end{align*}
\]

(Req 4.6-9)

Step 4.6.5.3

ELSE IF the absolute value of the latitude [L2-INT-160] is less than POLAR_INDEX but not less than TEMPERATE_INDEX, two retrievals are made using the retrieval coefficients for the high-latitude and mid-latitude regions. IF these two retrievals are polar_sst and temperate_sst respectively, the final value for the retrieved sst is given by

\[
\begin{align*}
    w &= \frac{\text{abs}(\varphi(i, j)) - \text{TEMPERATE\_INDEX}}{\text{POLAR\_INDEX} - \text{TEMPERATE\_INDEX}} \\
    \text{sst} &= \text{temperate\_sst} + w \times (\text{polar\_sst} - \text{temperate\_sst})
\end{align*}
\]

(Req 4.6-10)

Step 4.6.5.4

ELSE retrieve the polar combined view sea-surface temperature using step 4.6.5.5 below.

Step 4.6.5.5 Combined view retrieval

This step is executed whenever an SST retrieval is called for in Steps 4.6.5.1 to 4.6.5.4. Combined view retrievals use the nadir and forward 11, 12 and 3.7 micron brightness temperatures; the latitude zone = 0 for tropical, 1 for temperate, 2 for polar; the across track band mapping index number k = 0 to 37; and the nadir and forward view solar elevation angles.

If the 11 or 12 micron brightness temperatures in either the nadir or forward view are invalid then the calculation is abandoned and the combined_image_valid flag remains FALSE. Otherwise the calculation can proceed as follows.

Use the 3.7 micron channel if the data is valid and the pixel is in night-time in both nadir and forward views, ie
\[ I(n_{i, j}) > 0 \quad \text{AND} \quad I(f_{i, j}) > 0 \quad \text{AND} \quad \text{nadir\_band\_centre\_solar\_elevation}(i, k) < 0 \quad \text{AND} \quad \text{frwrd\_band\_centre\_solar\_elevation}(i, k) < 0. \]

In this case use the \( d \) coefficient set.

\[
\begin{align*}
\text{sst} & = d(zone, k, 0) * 100. + \\
d(zone, k, 1) & * I(ir11, n, i, j) + \\
d(zone, k, 2) & * I(ir12, n, i, j) + \\
d(zone, k, 3) & * I(ir37, n, i, j) + \\
d(zone, k, 4) & * I(ir11, f, i, j) + \\
d(zone, k, 5) & * I(ir12, f, i, j) + \\
d(zone, k, 6) & * I(ir37, f, i, j)
\end{align*}
\]

\[
\text{combined\_view\_uses\_ir37}(i, j) = \text{TRUE}. \\
\text{combined\_image\_valid}(i, j) = \text{NOT frwrd\_cloud}(i, j).
\]

(Req 4.6-11)

If not using 3.7 micron channel the \( c \) coefficient set is required.

\[
\begin{align*}
\text{sst} & = c(zone, k, 0) * 100. + \\
c(zone, k, 1) & * I(ir11, n, i, j) + \\
c(zone, k, 2) & * I(ir12, n, i, j) + \\
c(zone, k, 3) & * I(ir11, f, i, j) + \\
c(zone, k, 4) & * I(ir12, f, i, j)
\end{align*}
\]

\[
\text{combined\_view\_uses\_ir37}(i, j) = \text{FALSE}. \\
\text{combined\_image\_valid}(i, j) = \text{NOT frwrd\_cloud}(i, j).
\]

(Req 4.6-12)

**Step 4.6.6 Calculate the NDVI.**

The NDVI is calculated for extended land pixels where the nadir view is not cloudy and both the .87 micron and .67 micron channels contain valid data.

\[
\begin{align*}
\text{extended\_land}(i, j) & = \text{TRUE} \quad \text{AND} \\
\text{nadir\_cloud}(i, j) & = \text{FALSE} \quad \text{AND} \\
I(v870, n, i, j) & > 0 \quad \text{AND} \\
I(v670, n, i, j) & > 0
\end{align*}
\]

Then

\[
\text{NDVI}(i, j) = \frac{I(v870, n, i, j) - I(v670, n, i, j)}{I(v870, n, i, j) + I(v670, n, i, j)}
\]

and

\[
\text{combined\_image\_valid}(i, j) = \text{TRUE}
\]

(Req 4.6-13)

Otherwise set

\[
\text{NDVI}(i, j) = -19999
\]

\[
\text{combined\_image\_valid}(i, j) = \text{FALSE}
\]

**Step 4.6.7 Confidence flags**

The following gsst confidence flags are set as appropriate:
land(i, j) = extended_land(i, j)
nadir_view_cloudy(i, j) = nadir_cloud(i, j)
nadir_view_blanking(i, j) = nadir_blanking_pulse(i, j)
nadir_view_cosmetic(i, j) = nadir_cosmetic(i, j)
frwrd_view_cloudy(i, j) = frwrd_cloud(i, j)
frwrd_view_blanking(i, j) = frwrd_blanking_pulse(i, j)
frwrd_view_cosmetic(i, j) = frwrd_cosmetic(i, j)

The following gsst confidence flags will have been set if the relevant calculations have been performed.

nadir_image_valid(i, j)
nadir_only_uses_ir37(i, j)
combined_image_valid(i, j)
combined_view_uses_ir37(i, j)

The following additional cloud flags are set on the basis of the input (GBTR) cloud flags:

If (NOT extended_land(i, j)) then

gsst_v16_cloud_test(i, j) = {nadir_v16_histogram_test(i, j) or
frwrd_v16_histogram_test(i, j) or
frwrd_v16_spatial_coherence_test(i, j) or
nadir_v16_spatial_coherence_test(i, j)}
gsst_nadir_frwrd_cloud_test(i, j) = nadir_ir11_ir12_view_diff_test(i, j)
gsst_ir11_histogram_test(i, j) = {nadir_ir11_ir12_histogram_test(i, j) or
frwrd_ir11_ir12_histogram_test(i, j)}

If the extended land flag is set, these flags will have been set in Step 4.6.9.

Step 4.6.8 Smoothing

Smoothing is applied to both the nadir and combined view SST images. The quantity that is smoothed is the atmospheric correction, defined as the difference between the derived sea-surface temperature and the 11 micron brightness temperature. The smoothing method is a Smooth_fac by Smooth_fac boxcar with checks for valid data and array bounds.

The 11 micron brightness temperature is then added to obtain the final smoothed SST.

Step 4.6.8.1 Smooth Nadir Image

For each pixel i, j in the nadir image the smoothed value is calculated as follows.

First initialize the output array element to the data invalid value.

\[
\text{smoothed_gsst_image}(i, j) = -1.
\]

If the pixel contains a valid SST value ie:

\[
\text{nadir_image_valid}(i, j) = \text{TRUE} \quad \text{AND} \\
\text{nadir_view_cloudy}(i, j) = \text{FALSE} \quad \text{AND} \\
\text{extended_land}(i, j) = \text{FALSE}
\]

then calculate the average atmospheric correction using all the valid SST values in a smooth_fac by Smooth_fac pixel box centred on this pixel. \(ib = i - 1 \ \text{to} \ \ i + 1, \ \text{and} \ \ jb = j - 1 \ \text{to} \ \ j + 1\).

The pixel (ib, jb) in the box has a valid SST value if
If there is at least one valid pixel in the box use these valid pixels to calculate the average value of
nadir_image_field(ib, jb) - I(ir11, n; ib, jb)
then add I(ir11, n; i, j) to the average and store the result in

\[
\text{smoothed_gsst_image}(i, j) = \frac{\sum \text{nadir_image_field} - \sum I\text{(ir11, n; ib, jb)}}{\text{number of valid pixels}} + I\text{(ir11, n; i, j)}
\]

When all the averages have been calculated the valid values in the smoothed image can be copied to the image field array.

\[
\text{IF smoothed_gsst_image}(i, j) > 0 \quad \text{THEN} \\
\text{nadir_image_field}(i, j) = \text{smoothed_gsst_image}(i, j)
\]

**Step 4.6.8.2 Smooth Combined Image**

The process is repeated for the combined image field. For each pixel i, j in the combined image the smoothed value is calculated as follows. First initialize the output array element to the data invalid value.

\[
\text{smoothed_gsst_image}(i, j) = -1.
\]

If the pixel contains a valid SST value ie:
combined_image_valid(i, j) = TRUE AND
nadir_view_cloudy(i, j) = FALSE AND
extended_land(i, j) = FALSE

then calculate the average atmospheric correction using all the valid SST values in a smooth_fac by Smooth_fac pixel box centred on this pixel. ib = i - 1 to i + 1, and jb = j - 1 to j + 1.

The pixel (ib, jb) in the box has a valid SST value if

\[
\begin{align*}
\text{jb} & \geq 0 \quad \text{AND} \quad \text{jb} < 512 \quad \text{AND} \\
\text{ib} & \geq 0 \quad \text{AND} \quad \text{ib} < \text{nadir_image_size} \quad \text{AND} \\
\text{combined_image_valid}(ib, jb) & = \text{TRUE} \quad \text{AND} \\
\text{nadir_view_cloudy}(ib, jb) & = \text{FALSE} \quad \text{AND} \\
\text{extended_land}(ib, jb) & = \text{FALSE}
\end{align*}
\]

If there is at least one valid pixel in the box use these valid pixels to calculate the average value of
nadir_image_field(ib, jb) - I(ir11, n; ib, jb)
then add I(ir11, n; i, j) to the average and store the result in

\[
\text{smoothed_gsst_image}(i, j) = \frac{\sum \text{nadir_image_field} - \sum I\text{(ir11, n; ib, jb)}}{\text{number of valid pixels}} + I\text{(ir11, n; i, j)}
\]

When all the averages have been calculated the valid values in the smoothed image can be copied to the image field array.
IF smoothed_gsst_image(i, j) > 0  THEN
    combined_image_field(i, j) = smoothed_gsst_image(i, j)

(Req 4.6-21)

Step 4.6.9 Derive Land Surface Temperature Image.

LST retrievals use the nadir view 11 and 12 micron channels in conjunction with retrieval coefficients derived from the tables.

If either the 11 or 12 micron brightness temperature in the nadir view is invalid, the calculation for that pixel is abandoned and the nadir_image_valid flag remains FALSE. In this case set

nadir_image_field(i, j) = I(ir11, n; i, j).

(Req 4.6-22)

Otherwise the calculation proceeds as follows.

Step 4.6.9.1 Determine latitude and longitude indices

lat_index = integer part of [(image_latitude(i, j) + 90.0) × 2.0]
lon_index = integer part of [(image_longitude(i, j) + 180.0) × 2.0]

(Req 4.6-23)

disp_lat_index = integer part of [360 + (image_latitude(i, j) + 90.0) × 2.0 - 0.5] (modulo 360)
disp_lon_index = integer part of [720 + (image_longitude(i, j) + 180.0) × 2.0 - 0.5] (modulo 720)

(Req 4.6-24)

Step 4.6.9.2 Determine solar elevation and day/night flag

sun_elev = nadir_band_centre_solar_elevation(i, band(j))

If sun_elev > 0.0 then
    night = 0 otherwise night = 1

(Req 4.6-25)

Step 4.6.9.3 Determine satellite elevation and non-linear exponent

A linear interpolation may be used to determine the satellite elevation.

w = float(j - 6)/50.0 - band(j)

sat_elev = (1.0 - w) × nadir_band_edge_satellite_elevation(i, band(j)) +
          w × nadir_band_edge_satellite_elevation(i, band(j) + 1)

(Req 4.6-26)

if I(ir11, n; i, j) > I(ir12, n; i, j) then
    n = 1.0 / cos(π × (90 - sat_elev) / (m × 180.0))
else
    n = 1.0

(Req 4.6-27)

Note that m is [L2-AUX10-2] and n is [L2-INT-480].

Step 4.6.9.4 Determine coefficients

f = 0.001 × vegetation_fraction(lat_index, lon_index)
Interpolation of precipitable water:

\[ pw_{00} = \text{precipitable\_water}(\text{disp\_lat\_index}, \text{disp\_lon\_index}) \]
\[ pw_{01} = \text{precipitable\_water}(\text{disp\_lat\_index} + 1, \text{disp\_lon\_index}) \]
\[ pw_{10} = \text{precipitable\_water}(\text{disp\_lat\_index}, [\text{disp\_lon\_index} + 1](\text{modulo} \ 720)) \]
\[ pw_{11} = \text{precipitable\_water}(\text{disp\_lat\_index} + 1, [\text{disp\_lon\_index} + 1](\text{modulo} \ 720)) \]

\[ q = \text{fractional\ part\ of}\ [(\text{image\_latitude}(i, j) + 90.0) \times 2.0 + 0.5] \]
\[ p = \text{fractional\ part\ of}\ [(\text{image\_longitude}(i, j) + 180.0) \times 2.0 + 0.5] \]
\[ pw = 0.001 \times ((1 - p)(1 - q)pw_{00} + (1 - p)q \times pw_{01} + p(1 - q)pw_{10} + pq \times pw_{11}) \]

\[ \text{class} = \text{vegetation\_class}(\text{lat\_index}, \text{lon\_index}) - 1 \]

If \( \text{class} < 0 \) or \( \text{class} > \text{NCLASS} - 1 \) then the index is out of range; the calculation for this pixel is abandoned and the nadir\_image\_valid flag remains false. In this case set
\[ \text{nadir\_image\_field}(i, j) = I(ir11, n; i, j). \]

Otherwise:

For \( k = 0, 2 \)
\[ a(k) = f \times \text{coeff}(\text{class}, 0, \text{night}, k) + (1.0 - f) \times \text{coeff}(\text{class}, 1, \text{night}, k) \]

If \( (\text{class} + 1) = 14 \) this is an inland lake pixel. The exponent \( n \) and the precipitable water correction are not used. In this case set
\[ n = 1.0. \]

Otherwise, if \( (\text{class} + 1) \neq 14 \) correct \( a(0) \) as follows:
\[ a(0) = a(0) + d \times (\text{cosec}(\pi \times \text{sat\_elev} / 180.0) - 1.0) \times pw \]

Note that \( d \) is \([\text{L2}\text{-AUX10-1}]\).

**Step 4.6.9.5 Calculate the land surface temperature.**

\[ \text{lst} = 100. \times (a(0) + a(1) \times (0.01 \times (I(ir11, n; i, j) - I(ir12, n; i, j))^{*n}) + (a(1) + a(2)) \times (I(ir12, n; i, j) - 27315) + 27315 \]

\[ \text{topographic\_variance}(i, j) = \text{topographic\_flag}(\text{lat\_index}, \text{lon\_index}) \]

(Note that this is a two-bit flag.)
Trap for lst out of range:

If $lst \geq 32767.5$ then

\[
\text{nadir\_image\_field}(i, j) = 32767 \\
\text{nadir\_image\_valid}(i, j) = \text{FALSE}.
\]

else

\[
\text{nadir\_image\_field}(i, j) = \text{integer part of } (lst + 0.5) \\
\text{nadir\_image\_valid}(i, j) = \text{TRUE}.
\]

\[\text{(Req 4.6-38)}\]

\[\text{(Req 4.6-39)}\]

**Step 4.6.9.6 Update ‘marginal cloud’ flags**

For land pixels, the ‘cloud test’ flags have a different meaning. Note that for true land (excluding lake) pixels, these flags should be clear because the relevant tests are not applied to land pixels at Level 1B.

\[
\text{gsst\_v16\_cloud\_test}(i, j) = \text{nadir\_cloud}(i, j) \\
\text{gsst\_nadir\_frwrd\_cloud\_test}(i, j) = \text{NOT land}(i, j) \\
\text{gsst\_ir11\_histogram\_test}(i, j) = \text{FALSE}
\]

\[\text{(Req 4.6-40)}\]

The first of these is the actual ‘marginal cloud’ flag; it is set if the LST has been computed even though the nadir view pixel was flagged as cloudy. The second acts in practice as a lake flag, while the third is cleared (it will only have been set over an inland lake) for the avoidance of ambiguity.

**Implementation Note: Land Surface temperature**

**Layout of auxiliary files**

In this document the latitude and longitude of a pixel $[i, j]$ are represented by $\phi(i, j), \lambda(i, j)$ respectively, with the conventions that

\[-90.0 \leq \phi \leq +90.0 \text{ and} \]
\[-180.0 \leq \lambda < 180.0 \]

It will be convenient in the following to redefine the origin of latitude and longitude so that both are positive. We thus define the shifted co-ordinates

\[
\hat{\phi} = \phi + 90.0 \\
\hat{\lambda} = \lambda + 180.0
\]

The auxiliary files define the surface class and vegetation fraction with a resolution of 0.5 degrees. Thus for each cell of 0.5 degrees in latitude by 0.5 degrees in longitude a surface class and vegetation fraction are defined, that are taken to apply to the whole cell.

Suppose that each cell is identified by the co-ordinates of its origin, defined to be its lower left-hand (i.e. south-west) corner. The cells form a two dimensional array indexed by latitude and longitude indices $\text{lat\_index}$ and $\text{lon\_index}$, such that the origin of the cell indexed by $\text{lat\_index}$ and $\text{lon\_index}$ is

\[
\hat{\phi}_0 = \text{lat\_index} \times \Delta \phi \\
\hat{\lambda}_0 = \text{lon\_index} \times \Delta \lambda
\]
where $\Delta \varphi, \Delta \lambda$ are the cell dimensions in latitude and longitude respectively. It follows that a pixel $(i, j)$ at latitude $\varphi(i, j)$, longitude $\lambda(i, j)$ falls within the cell identified by

\[
\text{lat\_index} = \text{int}\left[ \frac{\varphi}{\Delta \varphi} \right] = \text{int}\left[ \frac{\varphi(i, j) + 90.0}{\Delta \varphi} \right],
\]

\[
\text{lon\_index} = \text{int}\left[ \frac{\lambda}{\Delta \lambda} \right] = \text{int}\left[ \frac{\lambda(i, j) + 180.0}{\Delta \lambda} \right].
\]

where $\text{int}[x]$ represents the integer part of $x$. In the present case

\[\Delta \varphi = \Delta \lambda = 0.5\text{ degrees},\]

and so (compare Req 4.6-23)

\[
\text{lat\_index} = \text{int}[2\varphi(i, j) + 180.0],
\]

\[
\text{lon\_index} = \text{int}[2\lambda(i, j) + 360.0].
\]

For example, the cell at 58N, 7E extends over the latitude range 58.0 to 58.5 and the longitude range 7.0 to 7.5, and is indexed by lat\_index = 296, lon\_index = 374. The surface class for the cell will be found in the array element $\text{vegetation\_class(lat\_index, lon\_index)}$.

However, the precipitable water value is assumed to refer to the centre of the cell. Thus the precipitable water value associated with the cell [296][374] refers to the point at latitude 58.25 N, longitude 7.25 E. This shift must be taken into account in the interpolation of precipitable water. The centre points of the cells are the grid points for the bilinear interpolation of the precipitable water $pw$.

**Interpolation of precipitable water**

The water vapour sample corresponding to the cell whose origin is $\hat{\varphi}_0, \hat{\lambda}_0$ refers to the point whose shifted co-ordinates are $\varphi_0 + \Delta \varphi/2, \lambda_0 + \Delta \lambda/2$, and so the water vapour samples form a grid whose origin is at the point $\Delta \varphi/2, \Delta \lambda/2$. The precipitable water is interpolated to the position of the pixel using a bilinear interpolation between the four points of this grid that surround the pixel. These are the corner points of a quadrilateral enclosing the pixel. The origin of this quadrilateral is

\[
\hat{\varphi}_0 = \text{int}\left[ \frac{\varphi - \Delta \varphi/2}{\Delta \varphi} \right] \Delta \varphi + \Delta \varphi/2,
\]

\[
\hat{\lambda}_0 = \text{int}\left[ \frac{\lambda - \Delta \lambda/2}{\Delta \lambda} \right] \Delta \lambda + \Delta \lambda/2,
\]

and it clearly falls within the cell whose indices are

\[
\text{disp\_lat\_index} = \text{int}\left[ \frac{\varphi - \Delta \varphi/2}{\Delta \varphi} \right],
\]

\[
\text{disp\_lon\_index} = \text{int}\left[ \frac{\lambda - \Delta \lambda/2}{\Delta \lambda} \right].
\]
This pair of equations with $\Delta \phi = \Delta \lambda = 0.5$ is equivalent to the pair of equations Req 4.6-24 except that we have modified the latter so that they always give a positive result. The indices of the four sample points that enter into the interpolation are (ignoring wrap-around)

\begin{align*}
\text{disp}_\text{lat}_\text{index}, \text{disp}_\text{lon}_\text{index} \\
\text{disp}_\text{lat}_\text{index}, \text{disp}_\text{lon}_\text{index} + 1 \\
\text{disp}_\text{lat}_\text{index} + 1, \text{disp}_\text{lon}_\text{index} \\
\text{disp}_\text{lat}_\text{index} + 1, \text{disp}_\text{lon}_\text{index} + 1
\end{align*}

The relationship of $\text{disp}_\text{lat}_\text{index}, \text{disp}_\text{lon}_\text{index}$ to $\text{lat}_\text{index}, \text{lon}_\text{index}$ depends in which quadrant of the cell the pixel lies. In the case that $\Delta \phi = \Delta \lambda = 0.5$, the fractional co-ordinates of the pixel relative to the origin of the cell in which it falls are $\text{cell}_\text{lat}_\text{coord}, \text{cell}_\text{long}_\text{coord}$ given by

\begin{align*}
\text{cell}_\text{lat}_\text{coord} &= (2\phi(i, j) + 180.0) - \text{lat}_\text{index} \\
\text{cell}_\text{long}_\text{coord} &= (2\lambda(i, j) + 360.0) - \text{lon}_\text{index}
\end{align*}

Both $\text{cell}_\text{lat}_\text{coord}, \text{cell}_\text{long}_\text{coord}$ lie in the range $[0, 1]$. Then it follows from the equations for $\text{disp}_\text{lat}_\text{index}, \text{disp}_\text{lon}_\text{index}$ that the indices (in the precipitable water array) of the origin of the interpolation quadrilateral are as follows:

- If $\text{cell}_\text{lat}_\text{coord} < 0.5$ then $\text{disp}_\text{lat}_\text{index} = \text{lat}_\text{index} - 1$ else $\text{disp}_\text{lat}_\text{index} = \text{lat}_\text{index}$
- If $\text{cell}_\text{long}_\text{coord} < 0.5$ then $\text{disp}_\text{lon}_\text{index} = \text{lon}_\text{index} - 1$ else $\text{disp}_\text{lon}_\text{index} = \text{lon}_\text{index}$.

The approach to the precipitable water interpolation actually adopted in the Reference Processor is as follows. The same set of $\text{pw}$ sample values can be used for a succession of pixels, and an auxiliary 3 by 3 array is defined, to hold the precipitable water values of the current cell ($\text{lat}_\text{index}, \text{lon}_\text{index}$) and its eight neighbours. If this array is $\text{pw}_\text{coeff}(iy, jx)$ then the array element $\text{pw}_\text{coeff}(1, 1)$ contains the current cell value, and generally for $iy = 0, 1, 2$ and $jx = 0, 1, 2$:

\[ \text{pw}_\text{coeff}(iy, jx) = \text{precipitable}_\text{water}(\text{lat}_\text{index} + iy - 1, [\text{lon}_\text{index} + jx - 1](\text{modulo} 720)) \]

The fractional co-ordinates of the pixel within the cell are $\text{cell}_\text{lat}_\text{coord}, \text{cell}_\text{long}_\text{coord}$ as above, both in the range $[0, 1]$. Then the indices in this array of origin of the interpolation quadrilateral are as follows:

- If $\text{cell}_\text{lat}_\text{coord} < 0.5$ then $iy = 0$ else $iy = 1$
- If $\text{cell}_\text{long}_\text{coord} < 0.5$ then $jx = 0$ else $jx = 1$

It is easy to verify that this is equivalent to the formulation in terms of $\text{disp}_\text{lat}_\text{index}, \text{disp}_\text{lon}_\text{index}$ given above. We then have

\begin{align*}
\text{pw00} &= \text{pw}_\text{coeff}(iy, jx) \\
\text{pw01} &= \text{pw}_\text{coeff}(iy + 1, jx) \\
\text{pw10} &= \text{pw}_\text{coeff}(iy, jx + 1)
\end{align*}
Thus the procedure is as follows. For each pixel, its latitude and longitude are computed, and the indices \( \text{lat\_index}, \text{lon\_index} \) of the cell in which it falls are calculated. If this is the first pixel, or if the computed cell indices differ from those of the last pixel (so it falls in a new cell), the precipitable water values of the centre cell and of its eight neighbours are copied into the 3 by 3 array. The interpolation then proceeds as above.

### 4.7 Module Definition: Output GSST Records

#### 4.7.1 Functional Description

The GSST product is written to the output medium. First the SPH and ADS records are output, then for each image line, an MDS record is assembled and written.

#### 4.7.2 Interface Definition

<table>
<thead>
<tr>
<th>Parameter ID</th>
<th>Variable</th>
<th>Name</th>
<th>Type</th>
<th>Units</th>
<th>Field size</th>
<th>Fields</th>
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<tbody>
<tr>
<td>GBTR-ADS1-1</td>
<td>Nadir UTC time in MJD format</td>
<td>sl, 2*ul</td>
<td>MJD</td>
<td>12</td>
<td>1</td>
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<td>L2-INT-287</td>
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</tr>
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<td>L2-INT-288</td>
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<td>L2-INT-289</td>
<td>fwd_view_blanking_pulse(i, j)</td>
<td>flag</td>
<td>n/a</td>
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<td>L2-INT-292</td>
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### Table 4.7.2: Internal Data Table - Output GSST Records

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<th>Parameter ID</th>
<th>Variable Name</th>
<th>Type</th>
<th>Units</th>
<th>Field size</th>
<th>Fields</th>
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<td>GSST-MDS1-1</td>
<td>Nadir UTC time in MJD format</td>
<td>sl, 2*ul</td>
<td>MJD</td>
<td>12</td>
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<td>confidence words</td>
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</tr>
<tr>
<td>GSST-ADS2-3</td>
<td>Spare (null characters)</td>
<td>3*uc</td>
<td>n/a</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>GSST-ADS2-4</td>
<td>image scan y coordinate</td>
<td>sl</td>
<td>m</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>GSST-ADS2-5</td>
<td>instrument scan number, forward view</td>
<td>us</td>
<td>none</td>
<td>2</td>
<td>512</td>
</tr>
<tr>
<td>GSST-ADS2-6</td>
<td>pixel number, forward view</td>
<td>us</td>
<td>none</td>
<td>2</td>
<td>512</td>
</tr>
<tr>
<td>GSST-ADS3-1</td>
<td>Nadir UTC time in MJD format</td>
<td>sl, 2*ul</td>
<td>MJD</td>
<td>12</td>
<td>1</td>
</tr>
<tr>
<td>GSST-ADS3-2</td>
<td>Attachment flag (always zero for this ADS)</td>
<td>sc</td>
<td>n/a</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>
### Table 4.7-3: Output Data Table - Output GSST Records

<table>
<thead>
<tr>
<th>ADS Number</th>
<th>Description</th>
<th>Type</th>
<th>Length</th>
<th>Units</th>
<th>Row Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>GSST-ADS3-3</td>
<td>Spare (null characters)</td>
<td>3*uc</td>
<td>n/a</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>GSST-ADS3-4</td>
<td>Image scan y coordinate</td>
<td>sl</td>
<td>m</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>GSST-ADS3-5</td>
<td>Tie point latitude</td>
<td>sl</td>
<td>mdeg</td>
<td>4</td>
<td>23</td>
</tr>
<tr>
<td>GSST-ADS3-6</td>
<td>Tie point longitude</td>
<td>sl</td>
<td>mdeg</td>
<td>4</td>
<td>23</td>
</tr>
<tr>
<td>GSST-ADS3-7</td>
<td>Latitude corrections</td>
<td>ss</td>
<td>mdeg</td>
<td>2</td>
<td>23</td>
</tr>
<tr>
<td>GSST-ADS3-8</td>
<td>Longitude corrections</td>
<td>ss</td>
<td>mdeg</td>
<td>2</td>
<td>23</td>
</tr>
<tr>
<td>GSST-ADS3-9</td>
<td>Topographic Altitude</td>
<td>ss</td>
<td>metres</td>
<td>2</td>
<td>23</td>
</tr>
<tr>
<td>GSST-ADS4-1</td>
<td>Scan UTC time in MJD format</td>
<td>sl, 2*ul</td>
<td>MJD</td>
<td>12</td>
<td>1</td>
</tr>
<tr>
<td>GSST-ADS4-2</td>
<td>Attachment flag (always zero for this ADS)</td>
<td>sc</td>
<td>n/a</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>GSST-ADS4-3</td>
<td>Spare (null characters)</td>
<td>3*uc</td>
<td>n/a</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>GSST-ADS4-4</td>
<td>Instrument scan number</td>
<td>us</td>
<td>none</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>GSST-ADS4-5</td>
<td>Tie pixel x coordinate</td>
<td>sl</td>
<td>m</td>
<td>4</td>
<td>94</td>
</tr>
<tr>
<td>GSST-ADS4-6</td>
<td>Tie pixel y coordinate</td>
<td>sl</td>
<td>m</td>
<td>4</td>
<td>94</td>
</tr>
<tr>
<td>GSST-ADS5-1</td>
<td>Nadir UTC time in MJD format</td>
<td>sl, 2*ul</td>
<td>MJD</td>
<td>12</td>
<td>1</td>
</tr>
<tr>
<td>GSST-ADS5-2</td>
<td>Attachment flag (always zero for this ADS)</td>
<td>sc</td>
<td>n/a</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>GSST-ADS5-3</td>
<td>Spare (null characters)</td>
<td>3*uc</td>
<td>n/a</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>GSST-ADS5-4</td>
<td>Image scan y coordinate</td>
<td>sl</td>
<td>m</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>GSST-ADS5-5</td>
<td>Tie point solar elevation, nadir view</td>
<td>sl</td>
<td>mdeg</td>
<td>4</td>
<td>11</td>
</tr>
<tr>
<td>GSST-ADS5-6</td>
<td>Tie point satellite elevation, nadir view</td>
<td>sl</td>
<td>mdeg</td>
<td>4</td>
<td>11</td>
</tr>
<tr>
<td>GSST-ADS5-7</td>
<td>Tie point solar azimuth, nadir view</td>
<td>sl</td>
<td>mdeg</td>
<td>4</td>
<td>11</td>
</tr>
<tr>
<td>GSST-ADS5-8</td>
<td>Tie point satellite azimuth, nadir view</td>
<td>sl</td>
<td>mdeg</td>
<td>4</td>
<td>11</td>
</tr>
<tr>
<td>GSST-ADS6-1</td>
<td>Nadir UTC time in MJD format</td>
<td>sl, 2*ul</td>
<td>MJD</td>
<td>12</td>
<td>1</td>
</tr>
<tr>
<td>GSST-ADS6-2</td>
<td>Attachment flag (always zero for this ADS)</td>
<td>sc</td>
<td>n/a</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>GSST-ADS6-3</td>
<td>Spare (null characters)</td>
<td>3*uc</td>
<td>n/a</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>GSST-ADS6-4</td>
<td>Image scan y coordinate</td>
<td>sl</td>
<td>m</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>GSST-ADS6-5</td>
<td>Tie point solar elevation, forward view</td>
<td>sl</td>
<td>mdeg</td>
<td>4</td>
<td>11</td>
</tr>
<tr>
<td>GSST-ADS6-6</td>
<td>Tie point satellite elevation, forward view</td>
<td>sl</td>
<td>mdeg</td>
<td>4</td>
<td>11</td>
</tr>
<tr>
<td>GSST-ADS6-7</td>
<td>Tie point solar azimuth, forward view</td>
<td>sl</td>
<td>mdeg</td>
<td>4</td>
<td>11</td>
</tr>
<tr>
<td>GSST-ADS6-8</td>
<td>Tie point satellite azimuth, forward view</td>
<td>sl</td>
<td>mdeg</td>
<td>4</td>
<td>11</td>
</tr>
</tbody>
</table>

Note 1. The GSST product is switchable, so that the contents of these MDS fields depend on the setting of the forward and nadir cloud flags and the land flag. The units and range of these quantities consequently depend on the flag settings.

### 4.7.3 Detailed Structure

#### Step 4.7.1 SPH record.

The SPH record is identical to that of the input (Level 1b) product. The SPH (excluding the Data Set Descriptors) should be read and copied unchanged to the output header. Suitable DSD records for the ADS and MDS defined below should be prepared and appended to the SPH of the level 2 product.

(Req 4.7-1)

#### Step 4.7.2 Ancillary Data sets.

The Ancillary Data sets ADS #0 to ADS #6 inclusive are identical to the corresponding Data Sets of the Level 1b product, with the exception of four fields of the SQ ADS (ADS #0); see Step 4.7.2.1 below. For each of GSST-ADS<n>, n = 1, 2, ...6, the corresponding records of GBTR-ADS<n> should be read and copied unchanged to the output data set GSST-ADS<n>.

(Req 4.7-2)

#### Step 4.7.2.1 Summary Quality ADS (ADS #0).

The Summary Quality ADS, ADS #0, shall be identical to the input Summary Quality ADS from the Level 1b (GBTR) Product, but with the addition of the new quantities [GSST-
ADS0-10], [GSST-ADS0-11], [GSST-ADS0-12] and [GSST-ADS0-13] (see [RD2] Table 6-4).

Initialise counters:
n=0
n_cloud = 0
n_land = 0
n_sea = 0
n_ndvi_inv = 0
n_nadir_inv = 0
n_dual_inv = 0

Let ig be the index corresponding to the current ADS record. The quantities in the record indexed by ig relate to image rows indexed by
i = 512 * ig + k, k=0, 511. Then for each output record ig:
for k = 0, 511
  i = 511 * ig + k
for j = 0, 511
(Sums over 512 * 512 pixels:)
if (not unfilled) then
  n = n + 1
  n_cloud = n_cloud + nadir_view_cloudy(i, j)
  if (land(i, j) AND !nadir_view_cloudy(i, j)) then
    n_land = n_land + 1
  end if
  if (land(i, j) AND !nadir_view_cloudy(i, j) AND !combined_image_valid(i, j)) then
    n_ndvi_inv = n_ndvi_inv + 1
  end if
  if (!land(i, j)) AND !nadir_view_cloudy(i, j)) then
    n_sea = n_sea + 1
  end if
  if (!land(i, j) AND !nadir_view_cloudy(i, j) AND !nadir_image_valid(i, j)) then
    n_nadir_inv = n_nadir_inv + 1
  end if
  if (!land(i, j) AND !nadir_view_cloudy(i, j) AND !combined_image_valid(i, j)) then
    n_dual_inv = n_dual_inv + 1
  end if
endif
end for (loop over j)
end for (loop over k)

Each sum above is the number of pixels in the image segment that have the specified property.

(percentage of cloudy pixels:)
[GSST-ADS0-10](ig) = (if n = 0 then 0
else 100.*n_cloud/float(n))

(percentage of NDVI invalid:)
[GSST-ADS0-11](ig) = (if n_land = 0 then 0
else 100.*n_ndvi_inv/float(n_land))

(percentage of SST (nadir view) invalid:)
[GSST-ADS0-12](ig) = (if n_sea = 0 then 0
else 100.*n_nadir_inv/float(n_sea))
(percentage of SST (dual view) invalid):
\[
[\text{GSST-ADS0-13}]_{(ig)} = \begin{cases} 
0 & \text{if } \text{n}_\text{sea} = 0 \\
100.0 \times \text{n}_\text{dual}_\text{inv}/\text{float}(\text{n}_\text{sea}) & \text{else} 
\end{cases}
\]

**Step 4.7.3 Measurement Data Set.**

The GSST product includes only one measurement data set. This is to be assembled as follows. For each image scan i:

\[
[\text{GSST-MDS1-1}]_{(i)} = [\text{GBTR-MDS1-1}]_{(i)}
\]

\[
[\text{GSST-MDS1-2}]_{(i)} = [\text{GBTR-MDS1-2}]_{(i)}
\]

\[
[\text{GSST-MDS1-3}]_{(i)} = [\text{GBTR-MDS1-3}]_{(i)}
\]

\[
[\text{GSST-MDS1-4}]_{(i)} = [\text{GBTR-MDS1-4}]_{(i)}
\]

Assemble confidence words for each pixel \( j = 0, 511 \):

For each GSST confidence flag, the corresponding bit of the gsst confidence word is to be set according to the truth value (1 = TRUE; 0 = FALSE) of the flag as follows:

\[
[\text{gsst}_\text{confidence}(i, j)]_{(\text{bit 0})} = \text{nadir}_\text{only}_\text{sst}_\text{valid}(i, j)
\]

\[
[\text{gsst}_\text{confidence}(i, j)]_{(\text{bit 1})} = \text{nadir}_\text{only}_\text{sst}_\text{uses}_\text{ir37}(i, j)
\]

\[
[\text{gsst}_\text{confidence}(i, j)]_{(\text{bit 2})} = \text{dual}_\text{view}_\text{sst}_\text{valid}(i, j)
\]

\[
[\text{gsst}_\text{confidence}(i, j)]_{(\text{bit 3})} = \text{dual}_\text{view}_\text{sst}_\text{uses}_\text{ir37}(i, j)
\]

\[
[\text{gsst}_\text{confidence}(i, j)]_{(\text{bit 4})} = \text{land}(i, j)
\]

\[
[\text{gsst}_\text{confidence}(i, j)]_{(\text{bit 5})} = \text{nadir}_\text{view}_\text{cloudy}(i, j)
\]

\[
[\text{gsst}_\text{confidence}(i, j)]_{(\text{bit 6})} = \text{nadir}_\text{view}_\text{blanking}_\text{pulse}(i, j)
\]

\[
[\text{gsst}_\text{confidence}(i, j)]_{(\text{bit 7})} = \text{nadir}_\text{view}_\text{cosmetic}(i, j)
\]

\[
[\text{gsst}_\text{confidence}(i, j)]_{(\text{bit 8})} = \text{frwrd}_\text{view}_\text{cloudy}(i, j)
\]

\[
[\text{gsst}_\text{confidence}(i, j)]_{(\text{bit 9})} = \text{frwrd}_\text{view}_\text{blanking}_\text{pulse}(i, j)
\]

\[
[\text{gsst}_\text{confidence}(i, j)]_{(\text{bit 10})} = \text{frwrd}_\text{view}_\text{cosmetic}(i, j)
\]

\[
[\text{gsst}_\text{confidence}(i, j)]_{(\text{bit 11})} = \text{v16}_\text{cloud}_\text{test}(i, j)
\]

\[
[\text{gsst}_\text{confidence}(i, j)]_{(\text{bit 12})} = \text{nadir}_\text{frwrd}_\text{cloud}_\text{test}(i, j)
\]

\[
[\text{gsst}_\text{confidence}(i, j)]_{(\text{bit 13})} = \text{ir11}_\text{hist}_\text{cloud}_\text{test}(i, j)
\]

\[
[\text{gsst}_\text{confidence}(i, j)]_{(\text{bit 14})} = [\text{topographic}_\text{variance}(i, j)]_{(\text{bit 0})}
\]

\[
[\text{gsst}_\text{confidence}(i, j)]_{(\text{bit 15})} = [\text{topographic}_\text{variance}(i, j)]_{(\text{bit 1})}
\]

\[
[\text{GSST-MDS1-5}]_{(i, j)} = \text{gsst}_\text{confidence}(i, j)
\]

For each pixel \( j = 0, 511 \) \([\text{GSST-MDS1-6}]_{(i, j)} = \text{nadir}_\text{only}_\text{gsst}_\text{image}(i, j)\)

For each pixel \( j = 0, 511 \) \([\text{GSST-MDS1-7}]_{(i, j)} = \text{dual}_\text{view}_\text{gsst}_\text{image}(i, j)\)

(Req 4.7-3)
4.8 Module Definition: Spatial Averaging (Half Degree Cell)

4.8.1 Functional Description

For the averaged products in half-degree cells, the globe is divided into cells 0.5° in latitude by 0.5° in longitude, and these cells are further subdivided into 9 sub-cells extending 10 arcmin in latitude by 10 arcmin in longitude. For each channel, the average brightness temperature (for the infra-red channels) or reflectance (for the visible channels) is averaged over all pixels of each type that fall within each sub-cell, to give distributions of a brightness temperature and radiance at 10 arc minute resolution. Averages are performed for the forward and nadir views separately, and a separate average is performed for each surface type (land and sea) and cloud state (clear or cloudy). There are thus 4 averages per channel per view. The mean across-track band number in each cell is also derived, for use by the averaged SST algorithm.

4.8.2 Interface Definition

Table 4.8.1: Input Data Table - Spatial Averaging (Half Degree Cell)
| L2-INT-144 | `fwdr_band_centre_solar_elevation(i, k)` | float | degrees | 4 | \(k = 0, 9\) |
| L2-INT-134 | `scn_nadir(i, j)` | nadir view instrument scan number | us | none | 4 | \(j = 0, 511\) |
| L2-INT-135 | `pxl_fwrd(i, j)` | forward view instrument pixel number | us | none | 4 | \(j = 0, 511\) |
| L2-INT-155 | `band(j)` | across-track band number | si | none | 4 | \(j = 0, 511\) |
| L2-INT-30 | `utc(cell)` | cell UTC | double | days | 8 | per cell |
| L2-INT-49 | `fwdr_day(k, cell)` | forward view day/night flag | ss | flag | 2 | \(k = 0, 8\) |
| L2-INT-50 | `nadir_solar_elevation(k, cell)` | nadir solar elevation for sub-cell | float | degrees | 4 | \(k = 0, 8\) |
| L2-INT-47 | `cell_lat(cell)` | cell latitude | si | \(\mu\)deg | 4 | per cell |
| L2-INT-48 | `cell_long(cell)` | cell longitude | si | \(\mu\)deg | 4 | per cell |
| L2-INT-32 | `sub_cell_lat(k, cell)` | sub-cell latitude | si | \(\mu\)deg | 4 | \(k = 0, 8\) |
| L2-INT-33 | `sub_cell_long(k, cell)` | sub-cell longitude | si | \(\mu\)deg | 4 | \(k = 0, 8\) |
| L2-INT-95 | `sub_cell_valid_pixel_count(ch, k, cell)` | sub-cell valid pixel count | ss | none | 2 |
| L2-INT-43 | `\sigma(ch, v, sf, cl, cell)` | standard deviation of the cell average | float | 0.001K or 0.01% | 4 |
| L2-INT-41 | `A(ch, v, sf, cl, cell)` | cell brightness temperature average (for visible channels ch = 4, 5, 6, 7) | ss | 0.01% | 2 |
| L2-INT-35 | `n(x, sf, k, cell)` | sub-cell filled pixel count | ss | none | 2 |
| L2-INT-37 | `mean_band(k, cell)` | mean across-track band number | ss | none | 2 |
| L2-INT-38 | `A(ch, v, sf, cl, cell)` | sub-cell brightness temperature average (for infra-channels ch = 1, 2, 3) | si | 0.001K | 4 |
| L2-INT-40 | `M(ch, v, sf, cl, cell)` | cell pixel count, ch = 1, ..., 7 | ss | none | 2 |
| L2-INT-42 | `A(ch, v, sf, cl, cell)` | cell reflectance average (for visible channels ch = 4, 5, 6, 7) | ss | 0.01% | 2 |
| L2-INT-36 | `sub_cell_total(ch, k, cell)` | sub-cell total, ch = 1, ..., 7 | si | n/a | 4 |
| L2-INT-37 | `M(ch, v, sf, cl, cell)` | sub-cell valid pixel count, ch = 1, ..., 7 | ss | none | 2 |
| L2-INT-38 | `A(ch, v, sf, cl, cell)` | sub-cell brightness temperature average (for infra-channels ch = 1, 2, 3) | si | 0.001K | 4 |
| L2-INT-39 | `M(ch, v, sf, cl, cell)` | sub-cell brightness temperature average (for visible channels ch = 4, 5, 6, 7) | si | 0.001K | 4 |
| L2-INT-34 | `sub_cell_band(k, cell)` | sub-cell across-track band | ss | none | 2 |
| L2-INT-36 | `M(ch, v, sf, cl, cell)` | sub-cell total, ch = 1, ..., 7 | si | n/a | 4 |
Numbering scheme will be adopted for the purpose of indexing and identifying the AATSR channels, the following conventional state index sums, depending on surface type and cloud flag as follows:

For the averaged channel values there are for each channel and for each view four cumulative sums, depending on surface type and cloud flag as follows:

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Index (ch)</th>
</tr>
</thead>
<tbody>
<tr>
<td>12 micron</td>
<td>ir12</td>
</tr>
</tbody>
</table>

As previously noted, the globe is divided into cells 0.5° in latitude by 0.5° in longitude. Each cell can be identified by two numbers defined to be non-negative; the latitude index given by 2*(latitude + 90) and a longitude index 2*(longitude + 180). All internal variables associated with the averaged product algorithms are duplicated for each cell, and should be imagined to be virtually present in memory at all times for the purpose of algorithm definition. How this is to be implemented is not specified here.

Each cell is further subdivided into 9 sub-cells each extending 10 arc minutes in latitude by 10 arc minutes in longitude. The sub-cells within each cell are identified by an index in the range 0 to 8 as follows:

<table>
<thead>
<tr>
<th>index</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>4</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>2</td>
<td></td>
</tr>
</tbody>
</table>

For the averaged channel values there are for each channel and for each view four cumulative sums, depending on surface type and cloud flag as follows:

<table>
<thead>
<tr>
<th>Surface Type</th>
<th>Symbol</th>
<th>Index (ch)</th>
</tr>
</thead>
<tbody>
<tr>
<td>sea, clear</td>
<td>sea</td>
<td></td>
</tr>
<tr>
<td>land, clear</td>
<td>land</td>
<td></td>
</tr>
<tr>
<td>sea, cloud</td>
<td></td>
<td></td>
</tr>
<tr>
<td>land, cloud</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

To simplify the notation we define a surface type index $sf = 0$ (sea) or 1 (land) and a cloud state index $cl = 0$ (clear) or 1 (cloud).

For the purpose of indexing and identifying the AATSR channels, the following conventional numbering scheme will be adopted.

### Table: 4.8.2 Internal Data Table - Spatial Averaging (Half Degree Cell)

<table>
<thead>
<tr>
<th>L2-INT-301</th>
<th>N_land(n; k, cell)</th>
<th>total filled pixels over land for subcell</th>
<th>ss</th>
<th>none</th>
<th>2</th>
<th>k = 0, 8</th>
</tr>
</thead>
<tbody>
<tr>
<td>L2-INT-302</td>
<td>N_sea(n; k, cell)</td>
<td>total of filled pixels over sea for subcell</td>
<td>ss</td>
<td>none</td>
<td>2</td>
<td>k = 0, 8</td>
</tr>
<tr>
<td>L2-INT-303</td>
<td>N_total(n; k, cell)</td>
<td>total of filled pixels for subcell, nadir view</td>
<td>ss</td>
<td>none</td>
<td>2</td>
<td>k = 0, 8</td>
</tr>
<tr>
<td>L2-INT-304</td>
<td>pcs(n; k, cell)</td>
<td>percentage of cloudy pixels over sea</td>
<td>ss</td>
<td>0.01%</td>
<td>2</td>
<td>k = 0, 8</td>
</tr>
<tr>
<td>L2-INT-305</td>
<td>pcl(n; k, cell)</td>
<td>percentage of cloudy pixels over land</td>
<td>ss</td>
<td>0.01%</td>
<td>2</td>
<td>k = 0, 8</td>
</tr>
<tr>
<td>L2-INT-306</td>
<td>N_land(n; cell)</td>
<td>total filled pixels over land for cell</td>
<td>ss</td>
<td>none</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>L2-INT-307</td>
<td>N_sea(n; cell)</td>
<td>total of filled pixels over sea for cell</td>
<td>ss</td>
<td>none</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>L2-INT-308</td>
<td>N_total(n; cell)</td>
<td>total of filled pixels for cell, nadir view</td>
<td>ss</td>
<td>none</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>L2-INT-309</td>
<td>pcs(n; cell)</td>
<td>percentage of cloudy pixels over sea</td>
<td>ss</td>
<td>0.01%</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>L2-INT-310</td>
<td>pcl(n; cell)</td>
<td>percentage of cloudy pixels over land</td>
<td>ss</td>
<td>0.01%</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>L2-INT-311</td>
<td>N_land(f; k, cell)</td>
<td>total filled pixels over land for sub-cell</td>
<td>ss</td>
<td>none</td>
<td>2</td>
<td>k = 0, 8</td>
</tr>
<tr>
<td>L2-INT-312</td>
<td>N_sea(f; k, cell)</td>
<td>total of filled pixels over sea for subcell</td>
<td>ss</td>
<td>none</td>
<td>2</td>
<td>k = 0, 8</td>
</tr>
<tr>
<td>L2-INT-313</td>
<td>N_total(f; k, cell)</td>
<td>total of filled pixels for subcell, frwd view</td>
<td>ss</td>
<td>none</td>
<td>2</td>
<td>k = 0, 8</td>
</tr>
<tr>
<td>L2-INT-314</td>
<td>pcs(f; k, cell)</td>
<td>percentage of cloudy pixels over sea</td>
<td>ss</td>
<td>0.01%</td>
<td>2</td>
<td>k = 0, 8</td>
</tr>
<tr>
<td>L2-INT-315</td>
<td>pcl(f; k, cell)</td>
<td>percentage of cloudy pixels over land</td>
<td>ss</td>
<td>0.01%</td>
<td>2</td>
<td>k = 0, 8</td>
</tr>
<tr>
<td>L2-INT-316</td>
<td>N_land(f; cell)</td>
<td>total filled pixels over land for cell</td>
<td>ss</td>
<td>none</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>L2-INT-317</td>
<td>N_sea(f; cell)</td>
<td>total of filled pixels over sea for cell</td>
<td>ss</td>
<td>none</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>L2-INT-318</td>
<td>N_total(f; cell)</td>
<td>total of filled pixels for cell, frwd view</td>
<td>ss</td>
<td>none</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>L2-INT-319</td>
<td>pcs(f; cell)</td>
<td>percentage of cloudy pixels over sea</td>
<td>ss</td>
<td>0.01%</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>L2-INT-320</td>
<td>pcl(f; cell)</td>
<td>percentage of cloudy pixels over land</td>
<td>ss</td>
<td>0.01%</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>L2-INT-321</td>
<td>sub_cell_index(k, cell)</td>
<td>Along-track index representative of sub-cell</td>
<td>sl</td>
<td>none</td>
<td>4</td>
<td>k = 0, 8</td>
</tr>
</tbody>
</table>
Each average is defined by a sum of the form

\[ A(ch,v;sf,cl,k,c) = \frac{\sum I(ch,v;i,j)}{M(ch,v;sf,cl,k,c)} \]

where \( v \) indicates the view, either \( f \) (forward) or \( n \) (nadir) and where the sum is over all valid pixels which fall within the cell, are filled (or not unfilled), and have the correct cloud/surface type flag. That is, the sum is over all values of \( i \) and \( j \) such that all four of the following conditions are satisfied;

the co-ordinates of the pixel indexed by \( i \) and \( j \) fall within the sub-cell;

\(<view>_fill_{state}(i,j)\) is NOT UNFILLED_PIXEL;

\( I(ch,v;i,j)\) is valid surface type, cloud state, flags at \( i \) and \( j \) have the correct value.

A total of 56 sums and averages are calculated. A separate group of totals are calculated for each channel and view (nadir and forward), there being 14 channel/view combinations. For each combination of channel and view four totals are maintained, and 4 averages computed, corresponding to the four combinations of the cloud state and surface type flags.

In addition, the mean of the across-track band number is calculated for the clear sea pixels, for use in the Averaged SST determination, and a count of the numbers of pixels in each category is to be maintained.

**Step 4.8.1 Derive channel totals for each cell**

For each image scan \( i \):

perform steps 4.8.1.1 to 4.8.1.7 for each pixel in the scan (pixel index \( j = 0, 511 \) unless the pixel is unfilled in both images).

**Step 4.8.1.1 Identify cell number, subcell index and pixel state**

\[ cell_{latitude} = (image_{latitude}(i,j) + 90) \times 2 \]

\[ cell_{longitude} = (image_{longitude}(i,j) + 180) \times 2 \]

\[ cell_{latitude\_index} = \text{integer part of } cell_{latitude} \]

\[ cell_{longitude\_index} = \text{integer part of } cell_{longitude} \]

Define the cell number \( cell \) as a function of \( cell_{latitude\_index} \) and \( cell_{longitude\_index} \). The relationship between these quantities may be implementation-dependent; \( cell \) is required as an identifier.

The sub-cell index \( k \) is given by

\[ k = 3 \times (\text{fractional part of } cell_{latitude}) + 3 \times (\text{fractional part of } cell_{longitude}) \]
where the inclusion of a quantity in square brackets implies that the integer part is to be taken.

If the pixel identified by \((i, j)\) is the first pixel to fall within the cell \(cell\), ensure that all counters and cumulative sums are initialised to zero as follows for each \(ch = 1, 7, v = \text{nadir, frwrd, sf} = 0, 1, cl = 0, 1:\)

\[
S(ch, v; sf, cl, k, cell) = 0.0 \\
M(ch, v; sf, cl, k, cell) = 0 \\
N(v; sf, cl; k, cell) = 0 \\
band\_sum(k, cell) = 0, \text{ for each } k = 0, 8 \\
across\_track\_sum(sf; k, cell) = 0 \text{ for each } k = 0, 8.
\]

Also initialise the latitude and longitude of the sub-cells to exceptional values (in case the cell is intersected by the swath edge, and no pixels fall within a sub-cell):

\[
\text{sub\_cell\_lat}(k, cell) = -399999999, \\
\text{sub\_cell\_long}(k, cell) = -399999999, \text{ for each } k = 0, 8.
\]

If the pixel identified by \((i, j)\) is the first pixel to fall within this cell, assemble the cell geolocation and allied information as follows:

The time tag associated with the cell [L2-INT-30] is the instrument scan time of the nadir pixel which first falls within the cell. It is derived from the scan number associated with the pixel, and with the scan times from ADS #4.

First we identify the instrument scan number associated with the pixel (i.e. the number of the scan from which the pixel was regridded). This comes from ADS#1. Given \(i, j\) of the pixel compute

\[
ig = \text{integer part of } (i/\text{NGRANULE})
\]

and extract

\[
s = \text{scn\_nadir}(ig, j) + (i - \text{NGRANULE}\times ig) \\
= \text{[L2-INT-134]}(ig, j) + (i - \text{NGRANULE}\times ig) \\
sg = \text{integer part of } \left( \left( s - \text{scan}(0) / \text{NGRANULE} \right) \right)
\]

[Note scan(0) = [L2-INT-27](0) = instrument scan number of the first record of ADS #4.)

If \(sg < 0\), set \(sg = 0\).

If \(sg \geq sg\_max\), where \(sg\_max\) is the number of the last record in ADS #4, so that \(time(sg + 1)\) and \(scan(sg + 1)\) do not exist, set

\[
sg = sg\_max - 1.
\]

This is the index of the scan time from ADS#4 from which the time tag is taken. It has already been converted to processing format in Step 4.2.2. The converted time is

\[
t0 = time(sg)
\]

The time \(t1\) is derived similarly from the time tag of the subsequent record \(sg + 1\).

\[
t1 = time(sg + 1)
\]
Linear interpolation is then used to derive the UTC in processing format.

\[ \text{utc}(\text{cell}) = t_0 + (t_1 - t_0)(s - sg*NGRANULE)/(\text{scan}(sg + 1) - \text{scan}(sg)) \]

(Note that the denominator \((\text{scan}(sg + 1) - \text{scan}(sg))\) is equal to \(NGRANULE\) unless \(sg = sg_{\text{max}} - 1\).)

\[ \text{cell}_{\text{lat}}(\text{cell}) = (\text{cell}_{\text{latitude}\_\text{index}} - 180)*500000 \]
\[ \text{cell}_{\text{long}}(\text{cell}) = (\text{cell}_{\text{longitude}\_\text{index}} - 360)*500000 \]

Similarly if the pixel identified by \((i, j)\) is the first pixel to fall within the sub-cell \(k\), assemble the sub-cell time tag and geolocation information as follows. First derive the UTC in processing format, \(\text{utc}(k, \text{cell})\), from \(i\) and \(j\) in exactly the same way as described above for the cell. Then

\[ \text{sub}_{\text{cell}}_{\text{lat}}(k, \text{cell}) = \text{integer part of } (3*\text{cell}_{\text{latitude}} - 540)*500000/3 \]
\[ \text{sub}_{\text{cell}}_{\text{long}}(k, \text{cell}) = \text{integer part of } (3*\text{cell}_{\text{longitude}} - 1080)*500000/3 \]
\[ \text{sub}_{\text{cell}}_{\text{band}}(k, \text{cell}) = \text{band}(j) \]
\[ \text{sub}_{\text{cell}}_{\text{index}}(k, \text{cell}) = i \]

(This is used in the LST calculation, Section 4.10.)

\[ \text{nadir}_{\text{sol}}_{\text{e}}(k, \text{cell}) = \text{nadir}_{\text{band}}_{\text{centre}}_{\text{sol}}_{\text{e}}(i, \text{band}(j)) \]
\[ \text{frwrd}_{\text{sol}}_{\text{e}}(k, \text{cell}) = \text{frwrd}_{\text{band}}_{\text{centre}}_{\text{sol}}_{\text{e}}(i, \text{band}(j)) \]

If \(<\text{view}>_{\text{band}}_{\text{centre}}_{\text{sol}}_{\text{e}}(i, \text{band}(j)) > 0.0 \) then

\[ <\text{view}>_{\text{day}}(k, \text{cell}) = \text{TRUE} \]
otherwise

\[ <\text{view}>_{\text{day}}(k, \text{cell}) = \text{FALSE} \]

where \(<\text{view}> = <\text{frwrd}|\text{nadir}>\) (Req 4.8-1)

**Step 4.8.1.2 Process nadir Pixels**

Perform steps 4.8.1.3 and 4.8.1.4 to process the nadir pixels unless the nadir pixel is unfilled (i.e. unless \(\text{nadir}_{\text{fill}}_{\text{state}}(i, j) = \text{UNFILLED\_PIXEL}\)).

**Step 4.8.1.3 Identify the surface type and cloud state associated with the nadir pixel:**

\[ sf = 0 \text{ if nadir view land flag } [L2\text{-INT-232}](i, j) = \text{FALSE} \]
\[ sf = 1 \text{ if nadir view land flag } [L2\text{-INT-232}](i, j) = \text{TRUE} \]
\[ cl = 0 \text{ if nadir view cloud flag } [L2\text{-INT-233}](i, j) = \text{FALSE} \]
\[ cl = 1 \text{ if nadir view cloud flag } [L2\text{-INT-233}](i, j) = \text{TRUE} \]

Increment the pixel counters associated with the cloud state and surface type just determined:

\[ N(r,sf,cl,k,cell) \leftarrow N(r,sf,cl,k,cell) + 1 \]

If \(cl = 0\) then increment the cumulative across-track index as follows:
\textit{across\_track\_sum(sf; k, cell)} \leftarrow \textit{across\_track\_sum(sf; k, cell)} + j

\textbf{Step 4.8.1.4 Update nadir view channel totals}

For each channel of the nadir view \textit{ch} perform this step if the corresponding nadir pixel is valid (that is, if \(I(ch, n; i, j) > 0\)):

\[
S(ch, n; sf, cl, k, cell) \leftarrow S(ch, n; sf, cl, k, cell) + I(ch, n; i, j)
\]

\[
M(ch, n; sf, cl, k, cell) \leftarrow M(ch, n; sf, cl, k, cell) + 1
\]

\textbf{Step 4.8.1.5 Process forward Pixels:}

Perform steps 4.8.3.1.6 and 4.8.3.1.7 to process the forward pixels unless the forward pixel is unfilled (i.e. unless \textit{frwrd\_fill\_state}(i, j) = UNFILLED\_PIXEL).

\textbf{Step 4.8.1.6 Identify the surface type and cloud state associated with the forward pixel:}

\(sf = 0\) IF forward view land flag [L2-INT-248](i, j) = FALSE
\(sf = 1\) IF forward view land flag [L2-INT-248](i, j) = TRUE
\(cl = 0\) IF forward view cloud flag [L2-INT-249](i, j) = FALSE
\(cl = 1\) IF forward view cloud flag [L2-INT-249](i, j) = TRUE

Increment the pixel counters associated with the cloud state and surface type just determined:

\[
N(f; sf, cl, k, cell) \leftarrow N(f; sf, cl, k, cell) + 1
\]

\textbf{Step 4.8.1.7 Update forward view channel totals}

For each channel of the forward view, perform the following steps if the corresponding forward pixel is valid (that is, if \(I(ch, f; i, j) > 0\)):

\[
S(ch, f; sf, cl, k, cell) \leftarrow S(ch, f; sf, cl, k, cell) + I(ch, f; i, j)
\]

\[
M(ch, f; sf, cl, k, cell) \leftarrow M(ch, f; sf, cl, k, cell) + 1
\]

\textbf{Step 4.8.2 Derive average values}

When no more pixels remain to be added to the cell, or at the end of the data set, compute the averages. The following equation is evaluated for each channel \((ch = \text{ir12}, \text{ir11}, \text{ir37}, \text{v16}, \text{v870}, \text{v670}, \text{v555})\), for each view \(v = n, f\), for surface type \(sf = 0, 1\) and for cloud state \(cl = 0, 1\).

If \(M(ch, v; sf, cl, k, cell) > 0\)

\[
A(ch, v; sf, cl, k, cell) = 10.0 \cdot S(ch, v; sf, cl, k, cell) / \text{float}(M(ch, v; sf, cl, k, cell))
\]

(note the conversion to units of 0.001 K) otherwise set

\[
A(ch, v; sf, cl, k, cell) = -1.0
\]

The mean in the larger (30 arc minute) cell is given by
\[ \tilde{A}(ch, v; sf, cl, cell) = \frac{1}{\mu} \sum_k A(ch, v; sf, cl, k, cell) \text{ if } \mu > 0 \]
\[ \tilde{A}(ch, v; sf, cl, cell) = -1 \text{ if } \mu = 0 \]
where the sum is over all \( k \in \{0 \leq k \leq 8\} \) having a valid subcell mean \( A \) and \( \mu \) is the number of such valid means. The number of pixels that contribute to the mean is similarly
\[ \tilde{M}(ch, v; sf, cl, cell) = \sum_k M(ch, v; sf, cl, k, cell) \]
The standard deviation of the mean is
\[ \sigma(ch, v; sf, cl, cell) = \left\{ \frac{1}{\mu - 1} \sum_k (A(ch, v; sf, cl, k, cell) - \tilde{A}(ch, v; sf, cl, cell))^2 \right\}^{1/2} \]
provided \( \mu > 1 \), otherwise set the standard deviation to \(-1\). In all cases the sum is over subcells having valid means (i.e. the number of contributing pixels \( M \) is positive).

\( \text{Step 4.8.3 Derive Pixel Threshold Failure Flags Words (10 arcminute cells)} \)

For cell \( cell \) and for each sub-cell \( k = 0, 9 \):
For surface type \( sf = 0, 1 \) and for the nadir view \( v = n \):
\[ [PFF(n; sf; k, cell)](\text{bit } 0) = 1 \text{ if } M(\text{ir12, n; sf, 0, k, cell}) < \text{[L2-AUX3-1]}, \text{ otherwise } 0 \]
[PFF(n, sf; k, cell)](bit 1) = 1 if \( M(ir11, n; sf, 0, k, cell) < [L2-AUX3-1] \), otherwise 0

[PFF(n, sf; k, cell)](bit 2) = 1 if \( M(ir37, n; sf, 0, k, cell) < [L2-AUX3-1] \), otherwise 0

[PFF(n, sf; k, cell)](bit 3) = 1 if \( M(v16, n; sf, 0, k, cell) < [L2-AUX3-1] \), otherwise 0

[PFF(n, sf; k, cell)](bit 4) = 1 if \( M(v870, n; sf, 0, k, cell) < [L2-AUX3-1] \), otherwise 0

[PFF(n, sf; k, cell)](bit 5) = 1 if \( M(v670, n; sf, 0, k, cell) < [L2-AUX3-1] \), otherwise 0

[PFF(n, sf; k, cell)](bit 6) = 1 if \( M(v555, n; sf, 0, k, cell) < [L2-AUX3-1] \), otherwise 0

[PFF(n, sf; k, cell)](bit 7) = 1 if \( M(ir12, n; sf, 1, k, cell) < [L2-AUX3-1] \), otherwise 0

[PFF(n, sf; k, cell)](bit 8) = 1 if \( M(ir37, n; sf, 1, k, cell) < [L2-AUX3-1] \), otherwise 0

[PFF(n, sf; k, cell)](bit 9) = 1 if \( M(v16, n; sf, 1, k, cell) < [L2-AUX3-1] \), otherwise 0

[PFF(n, sf; k, cell)](bit 10) = 1 if \( M(v870, n; sf, 1, k, cell) < [L2-AUX3-1] \), otherwise 0

[PFF(n, sf; k, cell)](bit 11) = 1 if \( M(v670, n; sf, 1, k, cell) < [L2-AUX3-1] \), otherwise 0

[PFF(n, sf; k, cell)](bit 12) = 1 if \( M(v555, n; sf, 1, k, cell) < [L2-AUX3-1] \), otherwise 0

[PFF(n, sf; k, cell)](bit 13) = 1 if \( n= \text{nadir}_{\text{day}}(k, cell) \) = TRUE, otherwise 0

[PFF(n, sf; k, cell)](bit 14) = 1 if \( n= \text{frwrd}_{\text{day}}(k, cell) \) = TRUE, otherwise 0

[PFF(n, sf; k, cell)](bit 15) = 0

Similarly for surface type \( sf = 0, 1 \) and for the forward view \( v = f \)

Calculate the corresponding word \( PFF(f, sf; k, cell) \):

Set bits 0 to 13 inclusive as above, substituting the view index \( f \) in place of \( n \), and substituting the forward threshold value \([L2-AUX3-2]\) in place of \([L2-AUX3-1]\).

\[ PFF(f, sf; k, cell)](bit 14) = 1 \text{ if } frwrd_{\text{day}}(k, cell) = \text{TRUE}, \text{ otherwise } 0 \]

\[ PFF(f, sf; k, cell)](bit 15) = 0 \]

(Req 4.8-6)

Step 4.8.4 Derive Pixel Threshold Failure Flags Words (30 arcminute cells)

For cell \( cell \):

For surface type \( sf = 0, 1 \) and for the nadir view \( v = n \):

\[ PFF(n, sf; cell)](bit 0) = 1 \text{ if } \hat{M} (ir12, n; sf, 0, cell) < [L2-AUX3-3], \text{ otherwise } 0 \]

\[ PFF(n, sf; cell)](bit 1) = 1 \text{ if } \hat{M} (ir11, n; sf, 0, cell) < [L2-AUX3-3], \text{ otherwise } 0 \]

\[ PFF(n, sf; cell)](bit 2) = 1 \text{ if } \hat{M} (ir37, n; sf, 0, cell) < [L2-AUX3-3], \text{ otherwise } 0 \]

\[ PFF(n, sf; cell)](bit 3) = 1 \text{ if } \hat{M} (v16, n; sf, 0, cell) < [L2-AUX3-3], \text{ otherwise } 0 \]

\[ PFF(n, sf; cell)](bit 4) = 1 \text{ if } \hat{M} (v870, n; sf, 0, cell) < [L2-AUX3-3], \text{ otherwise } 0 \]

\[ PFF(n, sf; cell)](bit 5) = 1 \text{ if } \hat{M} (v670, n; sf, 0, cell) < [L2-AUX3-3], \text{ otherwise } 0 \]
\[ PFF(n, sf; cell) \text{ (bit 6)} = 1 \text{ if } \tilde{M}(v555, n; sf, 0, cell) < [L2-AUX3-3], \text{ otherwise 0} \]
\[ PFF(n, sf; cell) \text{ (bit 7)} = 1 \text{ if } \tilde{M}(ir12, n; sf, 1, cell) < [L2-AUX3-3], \text{ otherwise 0} \]
\[ PFF(n, sf; cell) \text{ (bit 8)} = 1 \text{ if } \tilde{M}(ir11, n; sf, 1, cell) < [L2-AUX3-3], \text{ otherwise 0} \]
\[ PFF(n, sf; cell) \text{ (bit 9)} = 1 \text{ if } \tilde{M}(ir37, n; sf, 1, cell) < [L2-AUX3-3], \text{ otherwise 0} \]
\[ PFF(n, sf; cell) \text{ (bit 10)} = 1 \text{ if } \tilde{M}(v16, n; sf, 1, cell) < [L2-AUX3-3], \text{ otherwise 0} \]
\[ PFF(n, sf; cell) \text{ (bit 11)} = 1 \text{ if } \tilde{M}(v870, n; sf, 1, cell) < [L2-AUX3-3], \text{ otherwise 0} \]
\[ PFF(n, sf; cell) \text{ (bit 12)} = 1 \text{ if } \tilde{M}(v670, n; sf, 1, cell) < [L2-AUX3-3], \text{ otherwise 0} \]
\[ PFF(n, sf; cell) \text{ (bit 13)} = 1 \text{ if } \tilde{M}(v555, n; sf, 1, cell) < [L2-AUX3-3], \text{ otherwise 0} \]
\[ PFF(n, sf; cell) \text{ (bit 14)} = 1 \text{ if } \text{nadir}_\text{day}(k, cell) = \text{TRUE} \text{ for some } k, \text{ otherwise 0} \]
\[ PFF(n, sf; cell) \text{ (bit 15)} = 0 \]  
(Req 4.8-8)

Similarly for surface type \( sf = 0, 1 \) and for the forward view \( v = f \)

Calculate the corresponding word \( PFF(f, sf; cell) \):

Set bits 0 to 13 inclusive as above, substituting the view index \( f \) in place of \( n \), and substituting the forward threshold value \([L2-AUX3-4] \) in place of \([L2-AUX3-3] \).

\[ PFF(f, sf; k, cell) \text{ (bit 14)} = 1 \text{ if } \text{frwrd}_\text{day}(k, cell) = \text{TRUE} \text{ for some } k, \text{ otherwise 0} \]
\[ PFF(f, sf; k, cell) \text{ (bit 15)} = 0 \]

**Step 4.8.5. Derive pixel counts for cell**

For each cell \( cell \) and for each view \( v = n, f \):

For each subcell \( k = 0, 8 \):

Total of filled pixels over land:
\[
N_{\text{land}}(v; k, cell) = N(v; 1, 0, k, cell) + N(v; 1, 1, k, cell) \]  
(Req 4.8-9)

Total of filled pixels over sea:
\[
N_{\text{sea}}(v; k, cell) = N(v; 0, 0, k, cell) + N(v; 0, 1, k, cell) \]  
(Req 4.8-10)

Total of filled pixels:
\[
N_{\text{total}}(v; k, cell) = N_{\text{land}}(v; k, cell) + N_{\text{sea}}(v; k, cell) \]  
(Req 4.8-11)

Derive cloudy pixel percentages for each subcell:
\[
\text{pcs}(v; k, cell) = 10000 \times \frac{N(v; 0, 1, k, cell)}{N_{\text{sea}}(v; k, cell)} \]
\[
\text{pcl}(v; k, cell) = 10000 \times \frac{N(v; 1, 1, k, cell)}{N_{\text{land}}(v; k, cell)} \]  
(Req 4.8-12)
Derive aggregate counts:

Total of filled pixels over land:

\[ N_{\text{land}}(v; \text{cell}) = \sum_{k=0}^{8} N_{\text{land}}(v; k, \text{cell}) \]  

(Req 4.8-13)

Total of filled pixels over sea:

\[ N_{\text{sea}}(v; \text{cell}) = \sum_{k=0}^{8} N_{\text{sea}}(v; k, \text{cell}) \]  

(Req 4.8-14)

Total of filled pixels:

\[ N_{\text{total}}(v; \text{cell}) = N_{\text{land}}(v; \text{cell}) + N_{\text{sea}}(v; \text{cell}) \]  

(Req 4.8-15)

Derive cloudy pixel percentages for the cell:

\[ \text{pcs}(v; \text{cell}) = 10000 \times \left( \sum_{k=0}^{8} N(v; 0, 1, k, \text{cell}) \right) / N_{\text{sea}}(v; \text{cell}) \]  

(Req 4.8-16)

\[ \text{pcl}(v; \text{cell}) = 10000 \times \left( \sum_{k=0}^{8} N(v; 1, 1, k, \text{cell}) \right) / N_{\text{land}}(v; \text{cell}) \]  

(Req 4.8-16)

end for (cell, v)

4.9 Module Definition: Averaged SST Retrieval (Half Degree Cell)

4.9.1 Functional Description

This module derives the averaged SST from the averaged brightness temperatures determined using the module described in Section 4.8 above.

4.9.2 Interface Definition

Averaged SST Retrieval Coefficients

<table>
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<tr>
<th>Parameter ID</th>
<th>Variable</th>
<th>Name</th>
<th>Type</th>
<th>Units</th>
<th>Field size</th>
<th>Fields</th>
</tr>
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<tbody>
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<td>a[0][0]</td>
<td>averaged sst retrieval a[3][3][0]</td>
<td>float</td>
<td>0.01K</td>
<td>4</td>
<td>114</td>
</tr>
<tr>
<td>L2-AUX2-2</td>
<td>a[0][1]</td>
<td>averaged sst retrieval a[3][3][1]</td>
<td>float</td>
<td>none</td>
<td>4</td>
<td>114</td>
</tr>
<tr>
<td>L2-AUX2-3</td>
<td>a[0][2]</td>
<td>averaged sst retrieval a[3][3][2]</td>
<td>float</td>
<td>none</td>
<td>4</td>
<td>114</td>
</tr>
<tr>
<td>L2-AUX2-4</td>
<td>b[0][0]</td>
<td>averaged sst retrieval b[3][3][0]</td>
<td>float</td>
<td>0.01K</td>
<td>4</td>
<td>114</td>
</tr>
<tr>
<td>L2-AUX2-5</td>
<td>b[0][1]</td>
<td>averaged sst retrieval b[3][3][1]</td>
<td>float</td>
<td>none</td>
<td>4</td>
<td>114</td>
</tr>
<tr>
<td>L2-AUX2-6</td>
<td>b[0][2]</td>
<td>averaged sst retrieval b[3][3][2]</td>
<td>float</td>
<td>none</td>
<td>4</td>
<td>114</td>
</tr>
<tr>
<td>L2-AUX2-7</td>
<td>b[0][3]</td>
<td>averaged sst retrieval b[3][3][3]</td>
<td>float</td>
<td>none</td>
<td>4</td>
<td>114</td>
</tr>
<tr>
<td>L2-AUX2-8</td>
<td>c[0][0]</td>
<td>averaged sst retrieval c[3][3][0]</td>
<td>float</td>
<td>0.01K</td>
<td>4</td>
<td>114</td>
</tr>
<tr>
<td>L2-AUX2-9</td>
<td>c[0][1]</td>
<td>averaged sst retrieval c[3][3][1]</td>
<td>float</td>
<td>none</td>
<td>4</td>
<td>114</td>
</tr>
<tr>
<td>L2-AUX2-10</td>
<td>c[0][2]</td>
<td>averaged sst retrieval c[3][3][2]</td>
<td>float</td>
<td>none</td>
<td>4</td>
<td>114</td>
</tr>
</tbody>
</table>

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AATSR Product Algorithm Detailed Documentation
### Table 4-9-1: Input Data Table - Averaged SST Retrieval Coefficients

<table>
<thead>
<tr>
<th>Parameter ID</th>
<th>Variable</th>
<th>Name</th>
<th>Type</th>
<th>Units</th>
<th>Field size</th>
<th>Fields</th>
</tr>
</thead>
<tbody>
<tr>
<td>L2-INT-30</td>
<td>utc(k, cell)</td>
<td>cell UTC</td>
<td>double</td>
<td>days</td>
<td>8</td>
<td>per cell</td>
</tr>
<tr>
<td>L2-INT-31</td>
<td>utc(k, cell)</td>
<td>sub-cell UTC</td>
<td>double</td>
<td>days</td>
<td>8</td>
<td>k = 0, 8</td>
</tr>
<tr>
<td>L2-INT-32</td>
<td>sub_cell_lat(k, cell)</td>
<td>sub-cell latitude</td>
<td>si</td>
<td>µdeg</td>
<td>4</td>
<td>k = 0, 8</td>
</tr>
<tr>
<td>L2-INT-33</td>
<td>sub_cell_long(k, cell)</td>
<td>sub-cell longitude</td>
<td>si</td>
<td>µdeg</td>
<td>4</td>
<td>k = 0, 8</td>
</tr>
<tr>
<td>L2-INT-37</td>
<td>mean_band(k, cell)</td>
<td>mean across-track band number</td>
<td>ss</td>
<td>none</td>
<td>2</td>
<td>k = 0, 8</td>
</tr>
<tr>
<td>L2-INT-36</td>
<td>s(ch, v, sf, cl, k, cell)</td>
<td>sub-cell total, ch = 1, ..., 7</td>
<td>si</td>
<td>n/a</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>L2-INT-38</td>
<td>M(ch, v, sf, cl, k, cell)</td>
<td>sub-cell pixel count, ch = 1, ..., 7</td>
<td>ss</td>
<td>none</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>L2-INT-40</td>
<td>A(ch, v, sf, cl, k, cell)</td>
<td>sub-cell brightness temperature average (for infra-red channels ch = 1, 2, 3)</td>
<td>ss</td>
<td>0.01K</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>L2-INT-41</td>
<td>A(ch, v, sf, cl, k, cell)</td>
<td>cell brightness temperature average (for infra-red channels ch = 1, 2, 3)</td>
<td>ss</td>
<td>0.01K</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>L2-INT-43</td>
<td>r(ch, v, sf, cl, k, cell)</td>
<td>standard deviation of the cell average</td>
<td>float</td>
<td>0.01K or 0.01%</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>L2-INT-49</td>
<td>nadir_day(k, cell)</td>
<td>nadir view sub-cell day/night flag</td>
<td>ss</td>
<td>flag</td>
<td>2</td>
<td>k = 0, 8</td>
</tr>
<tr>
<td>L2-INT-50</td>
<td>fwdrd_day(k, cell)</td>
<td>forward view sub-cell day/night flag</td>
<td>ss</td>
<td>flag</td>
<td>2</td>
<td>k = 0, 8</td>
</tr>
<tr>
<td>L2-INT-45</td>
<td>nadir_solar_el(k, cell)</td>
<td>nadir solar elevation for sub-cell</td>
<td>float</td>
<td>degrees</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>L2-INT-46</td>
<td>fwdrd_solar_el(k, cell)</td>
<td>fwdrd solar elevation for sub-cell</td>
<td>float</td>
<td>degrees</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>local</td>
<td>index to latitude zone: i = 0, 1, 2</td>
<td>si</td>
<td>none</td>
<td>4</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>local</td>
<td>index to across-track bands j = 0, 9</td>
<td>si</td>
<td>none</td>
<td>4</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>local</td>
<td>q</td>
<td>index to coefficient set</td>
<td>si</td>
<td>none</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>L2-INT-359</td>
<td>across_track_mean(sf, k, cell)</td>
<td>mean across-track pixel index, subcell k</td>
<td>ss</td>
<td>none</td>
<td>2</td>
<td>k = 0, 8</td>
</tr>
<tr>
<td>L2-INT-360</td>
<td>a(i, j, q)</td>
<td>averaged sst retrieval a coefficients</td>
<td>float</td>
<td>mixed</td>
<td>4</td>
<td>342</td>
</tr>
<tr>
<td>L2-INT-361</td>
<td>b(i, j, q)</td>
<td>averaged sst retrieval b coefficients</td>
<td>float</td>
<td>mixed</td>
<td>4</td>
<td>456</td>
</tr>
<tr>
<td>L2-INT-362</td>
<td>c(i, j, q)</td>
<td>averaged sst retrieval c coefficients</td>
<td>float</td>
<td>mixed</td>
<td>4</td>
<td>570</td>
</tr>
<tr>
<td>L2-INT-363</td>
<td>d(i, j, q)</td>
<td>averaged sst retrieval d coefficients</td>
<td>float</td>
<td>mixed</td>
<td>4</td>
<td>736</td>
</tr>
<tr>
<td>L2-INT-366</td>
<td>nadir_pixeluses(ch, k, cell)</td>
<td>nadir_pixeluses(ch, k, cell)</td>
<td>ss</td>
<td>flag</td>
<td>2</td>
<td>k = 0, 8</td>
</tr>
<tr>
<td>L2-INT-367</td>
<td>sst_mean_pixel(sf, cell)</td>
<td>mean across-track pixel index, cell</td>
<td>ss</td>
<td>none</td>
<td>2</td>
<td>per cell</td>
</tr>
<tr>
<td>local</td>
<td>latitude</td>
<td>temporary latitude</td>
<td>float</td>
<td>degrees</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>L2-INT-53</td>
<td>T_nadir(cell)</td>
<td>nadir view sst</td>
<td>ss</td>
<td>0.01K</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>L2-INT-54</td>
<td>T_nadir(k, cell)</td>
<td>nadir view sst</td>
<td>ss</td>
<td>0.01K</td>
<td>2</td>
<td>k = 0, 8</td>
</tr>
<tr>
<td>L2-INT-55</td>
<td>T_dual(cell)</td>
<td>dual view sst</td>
<td>ss</td>
<td>0.01K</td>
<td>2</td>
<td></td>
</tr>
</tbody>
</table>
Both dual-view and nadir only sea surface temperatures are derived.

In the processing, each half-degree cell is represented by a structure containing, or is associated with, the necessary intermediate and output variables including the averaged brightness temperatures for each 10 arc-minute cell contained within the larger cell. All cells should be virtually present in memory, but how this is achieved is a matter for the implementer.

Note on notation: In the following we adopt the following abbreviated notation for the average brightness temperatures.

\[
T_{\text{ch, n} K \text{ cell}} = \frac{S(\text{ch, n}; 0,0,k,\text{cell})}{M(\text{ch, n}; 0,0,k,\text{cell})}
\]

\[
T_{\text{ch, f} \text{ frwd}} = \frac{S(\text{ch, f}; 0,0,k,\text{cell})}{M(\text{ch, f}; 0,0,k,\text{cell})}
\]

where \( ch \) indicates one of the seven channels. This notation is adopted to reduce the proliferation of indices; note that where it is used, a dependence on \( k \) and \( \text{cell} \) is implied. Note also that the above quantities must be computed using a floating point computation, although \( S \) and \( M \) are of type integer, to ensure that sufficient precision is maintained. Substitution of the quantities \( A(ch, f; 0, 0, k, \text{cell}) \) would not ensure this.

This processing is applied to cells when the processing of Step 4.8.1 is complete; i.e. no more pixels remain to be added to the cell.

The processing to derive averaged SST is done as follows:

**Step 4.9.1 Read look-up tables.**

On first entry, input the look-up tables of averaged SST retrieval coefficients.

This is done once at initialisation. Retrieval coefficients are specified for three latitude zones (tropical, temperate and polar) and for 38 bands or strips running parallel to the ground track, and corresponding to different viewing angles. Distinct sets of coefficients are supplied for day/night and for nadir only/dual view retrievals, as follows.
Before reading the retrieval coefficients ensure that the mapping array \( map(j) \) \([L2-INT-61]\) is available. This has been read in during Step 4.6.1. If it is desired to re-input it independently in this module then proceed as before. Open the data set L2-AUX6 and set \( map(j) = [L2-AUX6-2]_j, j = 0, 511 \) (Note that \([L2-AUX6-1]_j = j, j = 0, 511\).)

Open the file of retrieval coefficients to access data set L2-AUX2.

For each latitude zone \( i = 0, 1, 2 \) (outer loop) and for each across-track band \( j = 0 \) to 37 (inner loop);

Read in next record of file.

Extract the \( a \) coefficients \([L2-INT-360]\) as follows
\[
\begin{align*}
    a(i, j, 0) &= [L2-AUX2-1]_j, \\
    a(i, j, 1) &= [L2-AUX2-2]_j, \\
    a(i, j, 2) &= [L2-AUX2-3]_j
\end{align*}
\]

Similarly extract in the \( b \), \( c \) and \( d \) sets of coefficients:
\[
\begin{align*}
    b(i, j, q) &= [L2-AUX2-<4 + q>], q = 0, 1, 2, 3; \\
    c(i, j, q) &= [L2-AUX2-<8 + q>], q = 0, 1, 2, 3, 4; \\
    d(i, j, q) &= [L2-AUX2-<13 + q>], q = 0, 1, 2, 3, 4, 5, 6.
\end{align*}
\]

(Req 4.9-1)

**Step 4.9.2 Nadir view average.**

Calculate the nadir view averaged SST value for each of the 10-arcmin cells. Note that in the following, if the flags \( nadir_asst_uses_ir37 \), \( dual_asst_uses_ir37 \) are initialised to the value \( FALSE \), then Reqs. 4-9-2a, 4-9-9a are logically redundant.

**Step 4.9.2.1**

Determine the minimum number of pixels required for the cell, for the nadir view, using the latitude value representative of the cell. This is (in degrees)
\[
latitude = sub\_cell\_lat(k, cell) * 10^6
\]

The latitude dependent threshold is
\[
minpn = 340 * \text{Nadir\_Pixels\_Threshold} * \cos ((\pi/180.)*\text{latitude}) + 1.
\]

If \( M(ir12, n; 0, 0, k, cell) \geq minpn \) and \( M(ir11, n; 0, 0, k, cell) \geq minpn \) proceed to calculate the retrieved sst as below, otherwise set
\[
T_{nadir}(k, cell) = -1.0
\]

(Req 4.9-2)

\( nadir\_asst\_uses\_ir37(k, cell) = FALSE \)

(Req 4-9-2a)

**Step 4.9.2.2**
For night-time data, if \( \text{nadir}_\text{day}(k, \text{cell}) = \text{FALSE} \), test whether the ratio of pixels with valid 3.7 \( \mu \)m data is greater or less than the threshold value and use the appropriate (three or two channel) SST algorithm. The 3.7 micron channel is valid, so the three-channel algorithm can be used, if

\[
\text{float}\{M(\text{ir37}, n; 0, 0, k, \text{cell})\} / \text{float}\{M(\text{ir11}, n; 0, 0, k, \text{cell})\} \geq \text{IR37}_\text{THRESH}.
\]

Otherwise use the two-channel algorithm. The two-channel algorithm is always used for day-time data, that is, if \( \text{nadir}_\text{day}(k, \text{cell}) = \text{TRUE} \).

**Step 4.9.2.3**

Calculate the averaged SST using the nadir-view retrieval coefficients for the appropriate across-track band given by \( j = \text{map}(\text{across}\_\text{track\_mean}(0; k, \text{cell})) \) and for the two or three channel algorithm as appropriate, for each latitude zone \( i = 0, 1, 2 \):

**Step 4.9.2.3.1**

Perform this step if the 3.7 micron channel is not available for use.

The equations for use with the nadir view are

\[
T_{\text{sst}, i}^{\text{nadir}} = 100.0a_0 + a_1T_{\text{ir11}}^{\text{nadir}} + a_2T_{\text{ir12}}^{\text{nadir}}
\]

where

\[
a_q = a(i, j, q) \quad \text{(Req 4.9-3)}
\]

(Here and elsewhere in this module the factor of 100 is to ensure consistency of units between the brightness temperatures, in units of 0.01K, and the leading coefficient, in K.)

Set

\[
\text{nadir}_\text{asst}_\text{uses}_\text{ir37}(k, \text{cell}) = \text{FALSE} \quad \text{(Req 4.9-3.1)}
\]

**Step 4.9.2.3.2**

Perform this step IF the 3.7 micron channel is to be used.

The equations for use with the nadir view are

\[
T_{\text{sst}, i}^{\text{nadir}} = 100.0b_0 + b_1T_{\text{ir11}}^{\text{nadir}} + b_2T_{\text{ir12}}^{\text{nadir}} + b_3T_{\text{ir37}}^{\text{nadir}}
\]

where

\[
b_q = b(i, j, q) \quad \text{(Req 4.9-4)}
\]

(As before, the factor of 100 is to ensure consistency of units.)

Set

\[
\text{nadir}_\text{asst}_\text{uses}_\text{ir37}(k, \text{cell}) = \text{TRUE} \quad \text{(Req 4.9-4.1)}
\]
Step 4.9.2.4

Return latitude-corrected SST (with linear interpolation).

If the cell is in the polar or tropical zone, return the corresponding retrieval. If the cell is in the temperate zone, use linear interpolation with respect to latitude to derive the averaged SST from the values for the temperate zone and the appropriate adjacent zone.

IF \( \text{abs(latitude)} < \text{TROPICAL\_INDEX} \) then

\[
T_{\text{nadir}}(k,\text{cell}) = T_{\text{nadir,0}}
\]

(Req 4.9-5)

IF \( \text{TROPICAL\_INDEX} \leq \text{abs(latitude)} < \text{TEMPERATE\_INDEX} \), the final value for the retrieved sst is given by

\[
T_{\text{nadir}}(k,\text{cell}) = T_{\text{nadir,0}} + w \cdot (T_{\text{nadir,1}} - T_{\text{nadir,0}})
\]

(Req 4.9-6)

where

\[w = \frac{(\text{abs(latitude)} - \text{TROPICAL\_INDEX})}{(\text{TEMPERATE\_INDEX} - \text{TROPICAL\_INDEX})}\]

IF the \( \text{TEMPERATE\_INDEX} \leq \text{abs(latitude)} < \text{POLAR\_INDEX} \) the but NOT LESS than, the final value for the retrieved sst is given by

\[
T_{\text{nadir}}(k,\text{cell}) = T_{\text{nadir,1}} + w \cdot (T_{\text{nadir,2}} - T_{\text{nadir,1}})
\]

(Req 4.9-7)

where

\[w = \frac{(\text{abs(latitude)} - \text{TEMPERATE\_INDEX})}{(\text{POLAR\_INDEX} - \text{TEMPERATE\_INDEX})}\]

IF POLAR\_INDEX \( \leq \text{abs(latitude)} \)

\[
T_{\text{nadir}}(k,\text{cell}) = T_{\text{nadir,2}}
\]

(Req 4.9-8)

Step 4.9.3 Dual view average.

Calculate the dual view averaged SST value for the 10-arcmin cells.

Step 4.9.3.1

Determine the minimum numbers of pixels required for the cell, for both views, using the latitude value representative of the cell. The latitude dependent threshold for the nadir view is \( \text{minpn} \) calculated as above. That for the forward view is.

\[\text{minpf} = 340 \times \text{FRWRD\_PIXELS\_THRESH} \times \cos ((\pi/180.)*\text{latitude}) + 1.\]

IF the number of valid pixels in the either view is LESS THAN the threshold value calculated, move to the next 10-arcmin cell.
IF

\[ M(ir12, n; 0, 0, k, cell) \geq \text{minpn} \] and \[ M(ir11, n; 0, 0, k, cell) \geq \text{minpn} \]

AND

\[ M(ir12, f; 0, 0, k, cell) \geq \text{minpf} \] and \[ M(ir11, f; 0, 0, k, cell) \geq \text{minpf} \]

proceed to calculate the retrieved SST as below, otherwise set

\[ T_{\text{dual}}(k, cell) = -1. \] (Req 4.9-9)

\[ \text{dual\_asst\_uses\_ir37}(k, cell) = \text{FALSE} \] (Req 4-9-9a)

**Step 4.9.3.2**

For night-time data, defined by the condition

\[ \text{(nadir\_day}(k, cell) = \text{FALSE and frwrd\_day}(k, cell) = \text{FALSE}), \]

test whether the ratio of pixels with valid 3.7 µm data in each view is greater or less than the threshold value and use the appropriate (two or three channel) SST algorithm. The 3.7 micron channel is valid if

\[
\frac{\text{float}\{M(ir37, n; 0, 0, k, cell) + M(ir37, f; 0, 0, k, cell)\}}{\text{float}\{M(ir11, n; 0, 0, k, cell) + M(ir11, f; 0, 0, k, cell)\}} \geq \text{IR37\_THRESH}. 
\]

Otherwise use the two-channel algorithm. The two-channel algorithm is always used for day-time data, defined by the condition

\[ \text{(nadir\_day}(k, cell) = \text{TRUE or frwrd\_day}(k, cell) = \text{TRUE}). \] (Req 4.9-10)

**Step 4.9.3.3**

Calculate the averaged SST using the dual-view retrieval coefficients for the appropriate across-track band given by \[ j = \text{map}(\text{across\_track\_mean}(0; k, cell)) \] and for the two or three channel algorithm as appropriate, for each latitude zone.

(Req 4.9-11)

**Step 4.9.3.3.1**

Perform this step if the 3.7 micron channel is not available for use.

The algorithm using both views is given by

\[ T_{\text{dual}}^{\text{sst}, i} = 100.0c_0 + c_1T_{ir11}^{\text{nadir}} + c_2T_{ir12}^{\text{nadir}} + c_3T_{ir11}^{\text{frwrd}} + c_4T_{ir12}^{\text{frwrd}} \] (Req 4.9-12)

where

\[ c_q = c(i, j, q). \]

Set

\[ \text{dual\_asst\_uses\_ir37}(k, cell) = \text{FALSE} \] (Req 4.9-12.1)
Step 4.9.3.2

Perform this step if the 3.7 micron channel is to be used.

\[
T_{\text{sstr},i}^{\text{dual}} = 100.0d_0 + d_1^{\text{nadir}} + d_2^{\text{nadir}} + d_3^{\text{frwrd}} + d_4^{\text{frwrd}} + d_5^{\text{frwrd}} + d_6^{\text{frwrd}}
\]

(Req 4.9-13)

where

\[d_q = d(i, j, q)\].

Set

\[\text{dual\_asst\_uses\_ir37}(k, \text{cell}) = \text{TRUE}\]

(Req 4.9-13.1)

Step 4.9.3.4

Return latitude-corrected SST (with linear interpolation).

IF \(\text{abs(latitude)} < \text{TROPICAL\_INDEX}\) THEN

\[T_{\text{dual}}(k, \text{cell}) = T_{\text{sstr},0}^{\text{dual}}\]

(Req 4.9-14)

IF \(\text{TROPICAL\_INDEX} \leq \text{abs(latitude)} < \text{TEMPERATE\_INDEX}\), the final value for the retrieved sst is given by

\[T_{\text{dual}}(k, \text{cell}) = T_{\text{sstr},0}^{\text{dual}} + w \cdot (T_{\text{sstr},1}^{\text{dual}} - T_{\text{sstr},0}^{\text{dual}})\]

(Req 4.9-15)

where

\[w = \frac{(\text{abs(latitude)} - \text{TROPICAL\_INDEX})}{(\text{TEMPERATE\_INDEX} - \text{TROPICAL\_INDEX})}\]

IF \(\text{TEMPERATE\_INDEX} \leq \text{abs(latitude)} < \text{POLAR\_INDEX}\) the final value for the retrieved sst is given by

\[T_{\text{dual}}(k, \text{cell}) = T_{\text{sstr},1}^{\text{dual}} + w \cdot (T_{\text{sstr},2}^{\text{dual}} - T_{\text{sstr},1}^{\text{dual}})\]

(Req 4.9-16)

where

\[w = \frac{(\text{abs(latitude)} - \text{TEMPERATE\_INDEX})}{(\text{POLAR\_INDEX} - \text{TEMPERATE\_INDEX})}\]

IF \(\text{POLAR\_INDEX} \leq \text{abs(latitude)}\)

\[T_{\text{dual}}(k, \text{cell}) = T_{\text{sstr},2}^{\text{dual}}\]

(Req 4.9-17)

Step 4.9.4
For up to nine 10-arcmin cells within the half-degree cell, derive the mean nadir view SST for the half-degree cell, and the standard deviation of the 10-arcmin SST values. Repeat for the dual-view retrieval. That is

\[ T_{\text{nadir}}(\text{cell}) = \frac{1}{\mu_1} \sum_{k} T_{\text{nadir}}(k, \text{cell}) \]

\[ T_{\text{dual}}(\text{cell}) = \frac{1}{\mu_2} \sum_{k} T_{\text{dual}}(k, \text{cell}) \]  

(Req 4.9-18)

where in each case the sum is over all values of \( k \) for which the respective sub-cell temperature is valid (i.e. has a positive value), and where \( \mu_1 \) and \( \mu_2 \) are the numbers of such valid temperatures in the nadir and forward views, respectively. If either of the values \( \mu_1 \) or \( \mu_2 \) is zero, set the corresponding temperature to –1.

The mean across-track pixel number to be associated with the 30 arc minute SST is [L2-INT-369]

\[ \text{sst\_mean\_pixel}(0; \text{cell}) = \frac{1}{\mu_1} \sum_{k} \text{across\_track\_mean}(0; k, \text{cell}) \text{ if } \mu_1 > 0 \]

\[ \text{sst\_mean\_pixel}(0; \text{cell}) = -1 \text{ if } \mu_1 = 0 \]

where the sum is over all \( k \in \{0 \leq k \leq 8\} \) for which corresponding SST \( T_{\text{nadir}}(k, \text{cell}) \) is valid (not equal to –1.)

**Step 4.9.5 Prepare the confidence flag words for the cell.**

The confidence flag word for the sub-cell indexed by \((k, \text{cell})\) should be prepared as follows:

Set bit 0 if 3-channel algorithm was used at Step 4.9.2.2.2, i.e. if \( \text{nadir\_asst\_uses\_ir37}(k, \text{cell}) = \text{TRUE} \), otherwise clear bit.

Set bit 1 if 3-channel algorithm was used at Step 4.9.2.3.2, i.e. if \( \text{dual\_asst\_uses\_ir37}(k, \text{cell}) = \text{TRUE} \), otherwise clear bit.

Set bit 2 if \( \text{nadir\_day}(k, \text{cell}) \) from §4.8.3 is TRUE, otherwise clear bit.

Set bit 3 if \( \text{frwrd\_day}(k, \text{cell}) \) from §4.8.3 is TRUE, otherwise clear bit.

The confidence flag word for the half-degree cell indexed by \text{cell} - to go in AST MDS#1 - will be derived by ORing together the words for those sub-cells \((k, \text{cell})\), \( k = 0, \ldots, 8 \), for which a valid temperature was derived.

(Req 4.9-19)

4.10 Module Definition: Averaged LST and NDVI Retrieval (Half Degree Cell)

4.10.1 Functional Description

The Land Surface Temperature (LST) and Normalised Difference Vegetation Index (NDVI) are calculated for each sub-cell for which average reflectances over land have been
calculated. The averaged LST and NDVI over all the subcells, and their standard deviation, are also computed.

4.10.2 Interface Definition

<table>
<thead>
<tr>
<th>Parameter ID</th>
<th>Variable Name</th>
<th>Type</th>
<th>Units</th>
<th>Field size</th>
<th>Fields</th>
</tr>
</thead>
<tbody>
<tr>
<td>L2-AUX3-14</td>
<td>NADIR_PIXELS THRESH</td>
<td>float</td>
<td>none</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>L2-AUX5-1</td>
<td>Coefficient A0 (day-time) for LST</td>
<td>float</td>
<td>K</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>L2-AUX5-2</td>
<td>Coefficient A1 (day-time) for LST</td>
<td>float</td>
<td>none</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>L2-AUX5-3</td>
<td>Coefficient A2 (day-time) for LST</td>
<td>float</td>
<td>none</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>L2-AUX5-4</td>
<td>Coefficient A0 (night-time) for LST</td>
<td>float</td>
<td>K</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>L2-AUX5-5</td>
<td>Coefficient A1 (night-time) for LST</td>
<td>float</td>
<td>none</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>L2-AUX5-6</td>
<td>Coefficient A2 (night-time) for LST</td>
<td>float</td>
<td>none</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>L2-AUX6-1</td>
<td>Vegetation class index [360][720] for LST</td>
<td>ss</td>
<td>n/a</td>
<td>2</td>
<td>720</td>
</tr>
<tr>
<td>L2-AUX7-1</td>
<td>Vegetation fraction[12][360][720]</td>
<td>ss</td>
<td>0.001</td>
<td>2</td>
<td>720</td>
</tr>
<tr>
<td>L2-AUX8-1</td>
<td>Precipitable water[12][360][720]</td>
<td>ss</td>
<td>0.01 mm</td>
<td>2</td>
<td>720</td>
</tr>
<tr>
<td>L2-AUX9-1</td>
<td>Topographic Variance Flag[360][720]</td>
<td>ss</td>
<td>n/a</td>
<td>2</td>
<td>720</td>
</tr>
<tr>
<td>L2-AUX10-1</td>
<td>d</td>
<td>Water vapour factor for LST retrieval</td>
<td>float</td>
<td>none</td>
<td>4</td>
</tr>
<tr>
<td>L2-AUX10-2</td>
<td>m</td>
<td>Angle factor for LST retrieval</td>
<td>ss</td>
<td>none</td>
<td>2</td>
</tr>
<tr>
<td>L2-AUX10-3</td>
<td>number of vegetation classes for LST</td>
<td>ss</td>
<td>none</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 4.10-1: Input Data Table - LST Retrieval LUTs and auxiliary parameters

<table>
<thead>
<tr>
<th>Parameter ID</th>
<th>Variable Name</th>
<th>Type</th>
<th>Units</th>
<th>Field size</th>
<th>Fields</th>
</tr>
</thead>
<tbody>
<tr>
<td>L2-AUX10-1</td>
<td>d</td>
<td>Water vapour factor for LST retrieval</td>
<td>float</td>
<td>none</td>
<td>4</td>
</tr>
<tr>
<td>L2-AUX10-2</td>
<td>m</td>
<td>Angle factor for LST retrieval</td>
<td>ss</td>
<td>none</td>
<td>2</td>
</tr>
<tr>
<td>L2-AUX10-3</td>
<td>N_CLASS</td>
<td>Number of vegetation classes for LST</td>
<td>ss</td>
<td>none</td>
<td>2</td>
</tr>
</tbody>
</table>

The following parameters are required by the Land Surface Temperature algorithm:

<table>
<thead>
<tr>
<th>Field</th>
<th>Name</th>
<th>Type</th>
<th>Units</th>
<th>Field size</th>
<th>Fields</th>
</tr>
</thead>
<tbody>
<tr>
<td>time (sg)</td>
<td>scan UTC</td>
<td>double</td>
<td>days</td>
<td>8</td>
<td>per cell</td>
</tr>
<tr>
<td>cell_lat(cell)</td>
<td>cell latitude</td>
<td>sl</td>
<td>deg</td>
<td>4</td>
<td>per cell</td>
</tr>
<tr>
<td>cell_long(cell)</td>
<td>cell longitude</td>
<td>sl</td>
<td>deg</td>
<td>4</td>
<td>per cell</td>
</tr>
<tr>
<td>vegetation_class(lat_index, lon_index)</td>
<td>vegetation class index</td>
<td>ss</td>
<td>none</td>
<td>2</td>
<td>360 x 720</td>
</tr>
<tr>
<td>vegetation_fraction(lat_index, lon_index)</td>
<td>vegetation fraction index</td>
<td>ss</td>
<td>0.001</td>
<td>4</td>
<td>360 x 720</td>
</tr>
<tr>
<td>precipitable_water(lat_index, lon_index)</td>
<td>precipitable water index</td>
<td>ss</td>
<td>0.01 mm</td>
<td>2</td>
<td>360 x 720</td>
</tr>
<tr>
<td>Topographic_flag(lat_index, lon_index)</td>
<td>Topographic flag index</td>
<td>ss</td>
<td>none</td>
<td>2</td>
<td>360 x 720</td>
</tr>
<tr>
<td>lat_index</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>lon_index</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Index to month: month = 0, 11</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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AATSR Product Algorithm Detailed Documentation
4.10.3 Detailed Structure

The following processing is applied to cells when the processing of Step 4.8.1 is complete; i.e. no more pixels remain to be added to the cell.

Step 4.10.1 Calculate subcell NDVIs.

NDVI is defined by

\[
NDVI(k, cell) = 10000 \frac{A(v870, n; 1, 0, k, cell) - A(v670, n; 1, 0, k, cell)}{A(v870, n; 1, 0, k, cell) + A(v670, n; 1, 0, k, cell)}
\]

(Req 4.10-1)

provided both values are valid (not exceptional). Otherwise set

\[
NDVI(k, cell) = -19999.
\]
The number of pixels contributing to the sub-cell mean, \( N_1(k, \text{cell}) \), provided as a confidence indicator, is the smaller of \( M(v870, n; 1, 0, k, \text{cell}) \) and \( M(v670, n; 1, 0, k, \text{cell}) \).

**Step 4.10.2 Calculate cell NDVI.**

The mean in the larger (30 arc minute) cell is given by

\[
\langle \text{NDVI} \rangle(\text{cell}) = \frac{1}{\mu} \sum_k \text{NDVI}(k, \text{cell})
\]

where the sum is over all \( k \in \{0 \leq k \leq 8\} \) having a valid sub-cell mean \( \text{NDVI} \) and \( \mu \) is the number of such valid means. The number of pixels that contribute to the mean is similarly the smaller of \( \tilde{M}(v870, n;1,0,\text{cell}), \tilde{M}(v670, n;1,0,\text{cell}) \).

The standard deviation of the mean is

\[
\sigma(\text{NDVI}; \text{cell}) = \left\{ \frac{1}{\mu - 1} \sum_k (\text{NDVI}(k, \text{cell}) - \langle \text{NDVI} \rangle(\text{cell}))^2 \right\}^{1/2}
\]

in all cases the sum is over sub-cells having valid means.

If the number of valid subcell means \( \mu \) is zero, set

\[ <\text{NDVI}> (\text{cell}) = -19999. \]

If the number of valid subcell means \( \mu \leq 1 \), so that a valid standard deviation cannot be calculated, set

\[ \sigma(\text{NDVI}; \text{cell}) = -19999. \]

**Step 4.10.3 Read in coefficients and auxiliary tables for LST retrieval.**

The coefficients for LST retrieval are identical to those used for the full resolution product, as read in by Step 4.6.1.2 (Section 4.6.3). If these coefficients are still available in the processor, there is no need to repeat the following steps.

**Step 4.10.3.1 Read in coefficients**

For each of the \( N_{\text{CLASS}} \) vegetation classes there are two records, for vegetation and for bare soil. Open the file of retrieval coefficients L2-AUX5.

The LST coefficient set is read in as follows.

for \( \text{class} = 0, N_{\text{CLASS}} - 1 \) (outer loop)
for \( i = 0, 1 \) (inner loop)

\[
\text{coeff}(\text{class}, i, 0, 0) = [L2-AUX5-1]
\]
\[
\text{coeff}(\text{class}, i, 0, 1) = [L2-AUX5-2]
\]
\[
\text{coeff}(\text{class}, i, 0, 2) = [L2-AUX5-3]
\]
\[
\text{coeff}(\text{class}, i, 1, 0) = [L2-AUX5-4]
\]
coeff(class, i, 1, 1) = [L2-AUX5-5]
coeff(class, i, 1, 2) = [L2-AUX5-6]

(Req 4.10-5)

Step 4.10.3.2 Determine month index
Using a suitable calendar function, determine the month (month = 0, … 11) in which the data were collected from the scan time of start of data time(0)=[L2-INT-26](0):

month = month(time(0))

(Req 4.10-6)

Step 4.10.3.3 Read in auxiliary files
Note that in the cases of data sets L2-AUX7 and L2-AUX8 only one plane of data, that corresponding to the current month, is required in memory for a given run of the processor.

Read in Vegetation Class Index: Open the vegetation class file L2-AUX6.
for each latitude index i = 0, 359
vegetation_class(i, j) = [L2-AUX6-1](j) for all j of record i.

(Req 4.10-7)

Read in Vegetation Fraction Table: Open the file of vegetation fraction data L2-AUX7.
for each latitude index i = 0, 359
select record (360 × month + i)
vegetation_fraction(i, j) = [L2-AUX7-1](j) for all j of selected record.

(Req 4.10-8)

Read in Precipitable Water Data: Open the file of precipitable water data L2-AUX8.
for each latitude index i = 0, 359
select record (360 × month + i)
precipitable_water(i, j) = [L2-AUX8-1](j) for all j of selected record.

(Req 4.10-9)

Read in Topographic Variance Flag: Open the file of topographic variance flags L2-AUX9.
for each latitude index i = 0, 359
topographic_flag(i, j) = [L2-AUX9-1](j) for all j of record i.

(Req 4.10-10)

Step 4.10.4 Derive Land Surface Temperature for sub-cells
LST retrieval uses the nadir view 11 and 12 micron channels in conjunction with retrieval coefficients derived from the tables.

Note that as in Section 4.9 we adopt an abbreviated notation for the average brightness temperatures in this section.

\[
T_{nadir}^{ch, sf} = \frac{\text{float}(S(ch, n; sf, 0, k, cell))}{\text{float}(M(ch, n; sf, 0, k, cell))}
\]

where \( ch \) indicates one of the long-wavelength infra-red channels, and where \( sf \) is the surface type flag. This notation is slightly more complex than that used in Section 4.9 because it is
necessary to distinguish between land and sea averages. Where this notation it is used, a
dependence on $k$ and cell is implied. As in Section 4.9, these quantities must be computed
using a floating point computation, although $S$ and $M$ are of type integer, to ensure that
sufficient precision is maintained.

The calculation proceeds as follows for each cell in turn.

**Step 4.10.4.1 Determine latitude and longitude indices**

$\text{lat\_index} = \left[\frac{\text{cell\_lat(}cell\text{)}}{500000}\right] + 180$

$\text{lon\_index} = \left[\frac{\text{cell\_lon(}cell\text{)}}{500000}\right] + 360$

(Req 4.10-11)

Note: Because $\text{cell\_lat}$ and $\text{cell\_long}$ are defined (Step 4.8.1.1) as integer multiples of
500000, the above integer divisions should be exact, and the values of $\text{lat\_index}$ and
$\text{lon\_index}$ should equal the values of cell$\_\text{latitude\_index}$ and cell$\_\text{longitude\_index}$
respectively that were computed locally for the same cell in Step 4.8.1.1.

Extract the vegetation class for the cell:

$\text{class} = \text{vegetation\_class(}\text{lat\_index, lon\_index}\text{)}$

(Req 4.10-12)

**Step 4.10.4.2 Test for valid data**

For each sub-cell $k = 0, \ldots, 8$, if either the 11 or 12 micron brightness temperature in the nadir
view is invalid, the calculation is abandoned, and the LST is set to -1. The criterion for
invalid data is the same as that used for the SST processing, as follows.

Determine the minimum number of pixels required for the cell, for the nadir view, using the
latitude of the cell. This is (in degrees)

$\text{latitude} = \text{sub\_cell\_lat(}k, cell\text{)} \times 10^{-6}$

The latitude dependent threshold is

$\text{minpn} = 340 \times \text{NADIR\_PIXELS\_THRESH} \times \cos((\pi/180)\times\text{latitude}) + 1.$

(Req 4.10-13)

Identify whether the land or ‘sea’ brightness temperatures are required. Inland lakes are
flagged as sea in the current land/sea data-base, so must be treated accordingly.

If $\text{class} = 14$ then $\text{sf} = 0$ (sea) otherwise $\text{sf} = 1$ (land).

If $M(\text{ir12, n; sf, 0, k, cell}) \geq \text{minpn}$ and $M(\text{ir11, n; sf, 0, k, cell}) \geq \text{minpn}$ proceed to calculate
the retrieved LST as below, otherwise set

$T_{\text{land}}(k, cell) = -1.0$

(Req 4.10-14)

If the 11 and 12 micron nadir brightness temperatures are valid, Steps 4.10.4.3 to 4.10.4.5 are
to be repeated for each sub-cell $k = 0, \ldots, 8$ in the cell.

**Step 4.10.4.3 Determine day/night flag, satellite elevation and non-linear exponent**
If $\text{nadir\_day}(k, \text{cell}) = \text{TRUE}$ then
\[
\text{night} = 0 \ \text{else} \ \text{night} = 1
\]  
(Req 4.10-15)

A linear interpolation is used to determine the satellite elevation:
\[
\begin{align*}
\text{sat\_elev} &= (1.0 - w) \times \text{nadir\_band\_edge\_satellite\_elevation}(i, \text{band}(j)) + \\
&\quad w \times \text{nadir\_band\_edge\_satellite\_elevation}(i, \text{band}(j) + 1)
\end{align*}
\]  
(Req 4.10-16)

Calculate the non-linear exponent:
\[
\text{n} = 1.0 / \cos(\pi \times (90 - \text{sat\_elev}) / (m \times 180.0))
\]  
(Req 4.10-17)

Note that $m$ is [L2-AUX10-2] and $n$ is [L2-INT-480].

**Step 4.10.4.4 Determine coefficients**

\[
f = 0.001 \times \text{vegetation\_fraction}(\text{lat\_index}, \text{lon\_index})
\]  
(Req 4.10-18)

\[
\text{ky} = \text{integer\ part\ of} \ [k/3]
\]

\[
\text{kx} = k - 3*\text{ky}
\]  
(Req 4.10-19)

If $\text{ky} = 0$ and $\text{lat\_index} > 0$ then $\text{disp\_lat\_index} = \text{lat\_index} - 1$
\[
\text{else} \ \text{disp\_lat\_index} = \text{lat\_index}
\]

If $\text{kx} = 0$ then $\text{disp\_lon\_index} = [720 + \text{lon\_index} - 1](\text{modulo} 720)$
\[
\text{else} \ \text{disp\_lon\_index} = \text{lon\_index}
\]  
(Req 4.10-20)

Interpolate precipitable water:
\[
\text{pw}00 = \text{precipitable\_water}(\text{disp\_lat\_index}, \text{disp\_lon\_index})
\]

\[
\text{pw}01 = \text{precipitable\_water}(\text{disp\_lat\_index}+1, \text{disp\_lon\_index})
\]

\[
\text{pw}10 = \text{precipitable\_water}(\text{disp\_lat\_index}, [\text{disp\_lon\_index}+1](\text{modulo} 720))
\]

\[
\text{pw}11 = \text{precipitable\_water}(\text{disp\_lat\_index}+1, [\text{disp\_lon\_index}+1](\text{modulo} 720))
\]  
(Req 4.10-21)

If $\text{ky} = 0$ then $q = (2.0 / 3.0)$ else $q = (\text{ky} - 1) / 3.0$

If $\text{kx} = 0$ then $p = (2.0 / 3.0)$ else $p = (\text{kx} - 1) / 3.0$

\[
\text{pw} = 0.001 \times ((1 - p)(1 - q)\text{pw}00 + (1 - p)q \times \text{pw}01 + p(1 - q)\text{pw}10 + pq \times \text{pw}11)
\]  
(Req 4.10-22)

\[
\text{class} = \text{vegetation\_class}(\text{lat\_index}, \text{lon\_index}) - 1
\]
If \( \text{class} < 0 \) or \( \text{class} > NCLASS - 1 \) then the index is out of range; the calculation for this sub-cell is abandoned and the nadir field should be set to an exception value of -1.0:

\[
T_{\text{land}}(k, \text{cell}) = -1.0
\]

Otherwise

for \( k = 0, 2 \)

\[
a(k) = f \times \text{coeff}(\text{class}, 0, \text{night}, k) + (1.0 - f) \times \text{coeff}(\text{class}, 1, \text{night}, k)
\]

If \( (\text{class} + 1) = 14 \) this cell is flagged as an inland lake in the vegetation class database. The exponent \( n \) and the precipitable water correction are not used, and the correct brightness temperature average to be used is that for pixels flagged as sea. Set \( n = 1.0 \).

Otherwise if \( (\text{class} + 1) \neq 14 \) correct \( a(0) \) as follows:

\[
a(0) = a(0) + d \times (\text{cosec}(\pi \times \text{sat_elev} / 180.0) - 1.0) \times \text{pw}
\]

(Req 4.10-26)

Step 4.10.4.5 Calculate the land surface temperature.

Note that the surface flag index \( sf_i \) retains the value assigned in Step 4.10.4.2.

If \( T_{\text{nadir}}^{\text{dir}}_{ir1, sf} > T_{\text{nadir}}^{\text{dir}}_{ir1, sf} \) then

\[
\text{lst} = 100. \times (a(0) + a(1) \times (T_{\text{nadir}}^{\text{dir}}_{ir1, sf} - T_{\text{nadir}}^{\text{dir}}_{ir1, sf}))^{n} + (a(1) + a(2)) \times (T_{\text{nadir}}^{\text{dir}}_{ir1, sf} - 27315) + 27315
\]

(Req 4.10-27)

else

\[
\text{lst} = 100. \times a(0) + a(1) \times (T_{\text{nadir}}^{\text{dir}}_{ir1, sf} - T_{\text{nadir}}^{\text{dir}}_{ir1, sf}) + (a(1) + a(2)) \times (T_{\text{nadir}}^{\text{dir}}_{ir1, sf} - 27315) + 27315
\]

(Req 4.10-28)

Set appropriate bits on AST confidence word \( \text{ast_conf}(1; k, \text{cell}) \):

Set bit 2 if \( \text{nadir_day}(k, \text{cell}) \) from §4.8.3 is TRUE, otherwise clear bit.

(Req 4.10-29)

Set bit 3 if \( \text{frwrd_day}(k, \text{cell}) \) from §4.8.3 is TRUE, otherwise clear bit.

(Req 4.10-30)

Set bits 4 and 5 to the topographic variance flags:

\[ [\text{ast_conf}(1; k, \text{cell})](\text{bits 4:5}) = \text{topographic_flag}(\text{lat_index}, \text{lon_index}) \]
(Note that this is a two-bit flag.)

Trap for LST out of range:

If $lst \geq 32767.5$ then

$$T\text{\_land}(k, cell) = -1$$

else

$$T\text{\_land}(k, cell) = \text{integer part of } (lst + 0.5)$$

Step 4.10.5 Calculate 30 arc min average

For up to nine 10-arcmin cells within the half-degree cell, derive the mean LST [L2-INT-493] for the half-degree cell, and the standard deviation [L2-INT-494] of the 10-arcmin LST values.

$$T\text{\_land}(cell) = \frac{1}{\mu} \sum_k T\text{\_land}(k, cell)$$

where the sum is over all values of $k$ for which the respective sub-cell LST is valid (i.e. has a positive value), and where $\mu$ is the number of valid temperatures. If $\mu$ is zero, set the corresponding temperature to $-1$. To calculate the standard deviation [L2-INT-494] use an expression analogous to Req 4.10-3.

The mean across-track pixel number to be associated with the 30 arc minute LST is [L2-INT-369]

$$\text{sst\_mean\_pixel}(1; cell) = \frac{1}{\mu} \sum_k \text{across\_track\_mean}(1; k, cell) \text{ if } \mu > 0$$

$$\text{sst\_mean\_pixel}(1; cell) = -1 \text{ if } \mu = 0$$

where the sum is over all $k \in \{0 \leq k \leq 8\}$ for which corresponding LST $T\text{\_land}(k, cell)$ is valid (not equal to $-1$).

Derive the confidence flag word $\text{ast\_conf}(1; cell)$ for the half-degree cell indexed by $cell$ by ORing together the words for those sub-cells $(k, cell)$, $k = 0, \ldots, 8$, for which a valid temperature was derived. (Note that the topographic variance bits will be the same for all sub-cells in the cell.)

4.11 Module Definition: Spatially Averaged Cloud Parameters (Half Degree Cell)

4.11.1 Functional Description

This module is to provide physical information on the cloud state additional to the results of the cloud flagging provided by the cloud clearing algorithms. The product is based on the same half-degree cells defined above. The frequency distribution of brightness temperature for the cloudy pixels within the cell is given together with representative parameters and an
estimate of the cloud-top temperature. The latter is interpreted as the mean brightness temperature of the coldest 25% of the cloudy pixels in the cell.

For each half-degree cell, information is given for the nadir and forward views separately. The information consists of the number of cloudy and cloud-free pixels falling within the cell, a histogram of the 11 micron brightness temperatures of the cloudy pixels, and various statistical parameters derived from the histogram. The 11 micron channel is used as the basis of the product following the practice of ATSR and ATSR-2.

The product is generated as follows. Two histograms are generated of the frequency distribution of 11 micron brightness temperature, for cloudy pixels over sea and land respectively. The histograms represent the brightness temperature at 0.1 K resolution between 190 K and 290 K. Thus each contains 1000 bins where the first bin contains the number of pixels with temperatures in the range 190.0 to 190.1 K, and the last bin contains the number of pixels with temperatures in the range 289.9 to 290.0 K. The cloud state of each filled pixel falling within the cell is inspected. If it is clear, a count of the number of clear pixels is incremented; if it is cloudy, the 11 micron channel BT is inspected and the count in the appropriate histogram bin is incremented. Note that cosmetic fill pixels are included in the processing.

As each pixel is inspected, a test is made to determine whether its 11 micron BT is lower than the lowest value previously encountered, and if so to store the location of the pixel. Then when the histogram is complete the identity of the minimum pixel will be known, and can be used to extract its channel values.

Once the histogram is complete for a given cell, that is once all the pixels falling within the cell have been inspected, the cloud temperature and coverage results are derived from it. Firstly the total number of cloudy pixels detected is computed by summing the histogram samples. If this total is less than 20 no further derivations are performed. If 20 or more cloudy pixels have been identified and included in the histogram, the mean 11 micron brightness temperature and its standard deviation are calculated from the histogram.

The histogram is searched for the lowest temperature represented by the histogram. This is the temperature corresponding to the first non-zero bin of the histogram. Next, the cloud-top temperature is estimated. The histogram bin containing the 25th percentile is identified; this is the first bin (as the histogram is searched in the direction of ascending temperature) for which the cumulative total of the bins up to and including itself exceeds 25% of the total number of cloudy pixels. The mean temperature represented by the bins up to and including this bin is calculated.

[Note that the cloud top temperature so derived may represent the mean of slightly more than 25% of the cloudy pixels, since the cumulative total including the 25th percentile bin may exceed 25%.]

Finally the percentage cloud cover is calculated from the ratio of cloudy pixels to total pixels.

### 4.11.2 Interface Definition

<table>
<thead>
<tr>
<th>Parameter ID</th>
<th>Variable Name</th>
<th>Type</th>
<th>Units</th>
<th>Field size</th>
<th>Fields</th>
</tr>
</thead>
</table>

Commercial In Confidence
AATSR Product Algorithm Detailed Documentation
| L2-INT-101 | lir12, n, i, j | regridded nadir l12 Brightness Temperature | ss | 0.01K | 2 | j = 0, 511 |
| L2-INT-102 | lir11, n, i, j | regridded nadir l11 Brightness Temperature | ss | 0.01K | 2 | j = 0, 511 |
| L2-INT-103 | lir37, n, i, j | regridded nadir l37 Brightness Temperature | ss | 0.01K | 2 | j = 0, 511 |
| L2-INT-104 | lirv16, n, i, j | regridded nadir l16 Reflectance | ss | 0.01% | 2 | j = 0, 511 |
| L2-INT-105 | lirv870, n, i, j | regridded nadir v870 Reflectance | ss | 0.01% | 2 | j = 0, 511 |
| L2-INT-106 | lirv670, n, i, j | regridded nadir v670 Reflectance | ss | 0.01% | 2 | j = 0, 511 |
| L2-INT-107 | lirv655, n, i, j | regridded nadir v655 Reflectance | ss | 0.01% | 2 | j = 0, 511 |
| L2-INT-111 | lir12, f, i, j | regridded forward l12 Brightness Temperature | ss | 0.01K | 2 | j = 0, 511 |
| L2-INT-112 | lir11, f, i, j | regridded forward l11 Brightness Temperature | ss | 0.01K | 2 | j = 0, 511 |
| L2-INT-113 | lir37, f, i, j | regridded forward l37 Brightness Temperature | ss | 0.01K | 2 | j = 0, 511 |
| L2-INT-114 | lirv16, f, i, j | regridded forward v16 Reflectance | ss | 0.01% | 2 | j = 0, 511 |
| L2-INT-115 | lirv870, f, i, j | regridded forward v870 Reflectance | ss | 0.01% | 2 | j = 0, 511 |
| L2-INT-116 | lirv670, f, i, j | regridded forward v670 Reflectance | ss | 0.01% | 2 | j = 0, 511 |
| L2-INT-117 | lirv655, f, i, j | regridded forward v655 Reflectance | ss | 0.01% | 2 | j = 0, 511 |
| L2-INT-100 | nadir_fill_state(i, j) | nadir fill state indicator | byte | none | 1 | j = 0, 511 |
| L2-INT-110 | fwd_fill_state(i, j) | fwd fill state indicator | byte | none | 1 | j = 0, 511 |
| L2-INT-232 | nadir_land(i, j) | nadir land/sea flag | ss | array flag | 2 | j = 0, 511 |
| L2-INT-233 | nadir_cloudy(i, j) | nadir cloudy flag | ss | array flag | 2 | j = 0, 511 |
| L2-INT-246 | fwd_land(i, j) | forward land/sea flag | ss | array flag | 2 | j = 0, 511 |
| L2-INT-249 | fwd_land_cloudy(i, j) | forward land/sea flag | ss | array flag | 2 | j = 0, 511 |
| L2-INT-160 | image_latitude(i, j) | image pixel latitude | float | degrees | 4 |
| L2-INT-161 | image_longitude(i, j) | image pixel longitude | float | degrees | 4 |
| local | k | histogram bin counter k = 0, 999 | sl | none | 4 |
| local | K | 25th percentile count | ss | none | 2 |
| cell | cell number | sl | none | 4 |
| Brightness temperature or reflectance, as appropriate, of channel ch, view v, for cloudy pixel having minimum 11 micron BT over surface type sf. | | ss | 0.01K or 0.01% | 2 |
| L2-INT-325 | across_track_band | across-track band | ss | none | 2 | per cell |
| L2-INT-328 | nadir_clear_land | total of clear land pixels, nadir view | sl | none | 4 | per cell |
| L2-INT-329 | fwd_clear_land | total of clear land pixels, forward view | sl | none | 4 | per cell |
| L2-INT-330 | nadir_cloudy_land | total of cloudy land pixels, nadir view | sl | none | 4 | per cell |
| L2-INT-331 | fwd_cloudy_land | total of cloudy land pixels, forward view | sl | none | 4 | per cell |
| L2-INT-332 | nadir_hist_land(k) | nadir histogram (land cell) | ss | none | 2 | 1000 |
| L2-INT-333 | fwd_hist_land(k) | forward histogram (land cell) | ss | none | 2 | 1000 |
| L2-INT-335 | bt_cloud_top | cloud top temperature (over land) | ss | 0.01K | 2 | per cell |
| L2-INT-336 | bt_percent_cloudy | percentage cloudy pixels (over land) | ss | 0.01% | 2 | per cell |
| L2-INT-337 | bt_cloud_top | cloud top temperature (over land) | ss | 0.01K | 2 | per cell |
| L2-INT-338 | bt_percent_cloudy | percentage cloudy pixels (over land) | ss | 0.01% | 2 | per cell |
| L2-INT-344 | nadir_clear_sea | total of clear sea pixels, nadir view | sl | none | 4 | per cell |
| L2-INT-345 | fwd_clear_sea | total of clear sea pixels, forward view | sl | none | 4 | per cell |
| L2-INT-346 | nadir_cloudy_sea | total of cloudy sea pixels, nadir view | sl | none | 4 | per cell |
| L2-INT-347 | fwd_cloudy_sea | total of cloudy sea pixels, forward view | sl | none | 4 | per cell |
| L2-INT-348 | nadir_hist_sea(k) | nadir histogram (sea cell) | ss | none | 2 | 1000 |
| L2-INT-349 | fwd_hist_sea(k) | forward histogram (sea cell) | ss | none | 2 | 1000 |
| L2-INT-351 | bt_cloud_top | cloud top temperature (over sea) | ss | 0.01K | 2 | per cell |
| L2-INT-352 | bt_percent_cloudy | percentage cloudy pixels (over sea) | ss | 0.01% | 2 | per cell |
| L2-INT-353 | bt_cloud_top | cloud top temperature (over sea) | ss | 0.01K | 2 | per cell |
| L2-INT-354 | bt_percent_cloudy | percentage cloudy pixels (over sea) | ss | 0.01% | 2 | per cell |
Table 4-11-1: Internal Data Table - Spatially Averaged Cloud Parameters (Half Degree Cell)

4.11.3 Detailed Structure

Step 4.11.1 Derive histogram for each cell.

Each image row \( i \) and pixel \( j \) is used as follows.

Step 4.11.1.1 Identify cell number.

Identify the half-degree cell number \( \text{cell} \) within which the pixel indexed by \( i \) and \( j \) falls exactly as in Section 4.8.3, Step 4.8.1.1

IF this is the first pixel to fall within a given cell, clear the histogram arrays:

\[
<\text{view}>_{\text{histogram}}_<\text{surface}>(\text{cell}, k) = 0 \text{ for all } k = 0, 999,
\]

initialise the clear pixel counters

\[
<\text{view}>_{\text{clear}}_<\text{surface}> = 0,
\]

AND initialise associated variables for each channel \( \text{ch} \):

\[
I_{\min}(\text{ch}, v, sf; \text{cell}) = 29000 \text{ if } \text{ch} = \text{ir12}, \text{ir11}, \text{ir37}
\]

\[
I_{\min}(\text{ch}, v, sf; \text{cell}) = 10000 \text{ if } \text{ch} = v16, v870, v670, v555
\]

FOR each view \( <v> = \text{nadir}, \text{frwrd}, \text{and for each surface type } <sf> = \text{land, sea}.\)

(Req 4.11-1)

Step 4.11.1.2 Process the image pixel.

Process the image pixel at \( i, j \) for both nadir and forward views, as follows,

(a) IF the pixel is unfilled, do nothing.

(b) IF the pixel is over sea, and is clear, increment \( <\text{view}>_{\text{clear}}_<\text{sea} \).

(c) IF the pixel is over sea, and is cloudy, check the 11 micron brightness temperature. If the 11 micron brightness temperature

\[
T_{11} = I(ir11, v; i, j)
\]

is valid, and if \( 19000 \leq T_{11} < 29000 \), increment the element of the histogram array

\[
<\text{view}>_{\text{histogram}}_<\text{sea}(\text{cell}, k) \text{ specified by index}
\]

\[
k = \text{integer part of } (T_{11}/10 - 1900)
\]

IF \( T_{11} < I_{\min}(\text{ir11}, v, sf; \text{cell}) \) THEN set

\[
I_{\min}(\text{ch}, v, sf; \text{cell}) = I(ch, v; i, j)
\]

for each channel \( \text{ch} \).

(d) IF the pixel is over land, treat similarly but increment the land counters and histogram arrays \( <\text{view}>_{\text{clear}}_<\text{land} \) and \( <\text{view}>_{\text{histogram}}_<\text{sea}(\text{cell}, k) \) in place of the corresponding sea variables.

(Req 4.11-2)
Step 4.11.2 Process histograms.

In this step the following notation is used.

\[ N_{v, sf}^{\text{cloud}}(cell) \] \hspace{1cm} <view>_cloudy_<surface>

\[ F_{v, sf}(cell; k) \] \hspace{1cm} <view>_hist_<surface>(cell, k)

where <view> = nadir | frwrd

and <surface> = sea | land

\[ T_{v, sf}^{ct}(cell) \] \hspace{1cm} [bt_cloud_top](v, sf)

When all four histograms are complete, find the number of cloudy pixels in each. For each view \( v = n, f \) and for each surface type \( sf \):

\[ N_{v, sf}^{\text{cloud}}(cell) = \sum_{k=0}^{999} F_{v, sf}(cell; k) \] (Req 4.11-3)

If the number of cloudy pixels found is less than 20, proceed to the next cell. Otherwise proceed as follows:

Calculate the position of the 25th percentile

\[ K = N_{v, sf}^{\text{cloud}}(cell) / 4 \] (Req 4.11-4)

and find the index \( k \) such that

\[ \sum_{k=0}^{k'-1} F_{v, sf}(cell; k) < K \leq \sum_{k=0}^{k'} F_{v, sf}(cell; k) \] (Req 4.11-5)

Then the cloud-top temperature is given by

\[ T_{v, sf}^{ct}(cell) = 19000 + 10 \cdot \sum_{k=0}^{k'} (k + 0.5) \cdot F_{v, sf}(cell; k) / \sum_{k=0}^{k'} F_{v, sf}(cell; k) \] (Req 4.11-6)

and the percentage of cloudy pixels for each view and surface type is given by

\[ \text{bt_percent_cloudy} = 10000 \cdot \frac{N_{v, sf}^{\text{cloud}}(cell)}{N_{v, sf}^{\text{cell}}(cell) + <view>_clear_<surface>(cell)} \] (Req 4.11-7)

4.12 Module Definition: Spatial Averaging (50 km Cell)

4.12.1 Functional Description

For the averaged products in 50 km cells, the swath is divided into cells nominally 50 km square, and these cells are further subdivided into 9 square sub-cells of nominal dimension 17 km. For each channel, the average brightness temperature (for the infra-red channels) or radiance (for the visible channels) is averaged over all pixels of each type that fall within
each sub-cell, to give distributions of a brightness temperature and radiance at 17 km nominal resolution. Averages are performed for the forward and nadir views separately, and a separate average is performed for each surface type (land and sea) and cloud state (clear or cloudy). There are thus 4 averages per channel per view. The mean across each sub-cell is calculated to give distributions of brightness temperature and radiance at 17 km nominal resolution.

4.12.2 Interface Definition

### Table 4.12-1: Input Data Table - Spatial Averaging, 50 km cell.

<table>
<thead>
<tr>
<th>Parameter ID</th>
<th>Variable</th>
<th>Name</th>
<th>Type</th>
<th>Units</th>
<th>Field size</th>
<th>Fields</th>
</tr>
</thead>
<tbody>
<tr>
<td>L2-AUX3-9</td>
<td>NGRANULE</td>
<td>Granule Size</td>
<td>sl</td>
<td>none</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>L2-AUX3-10</td>
<td>AX, AY</td>
<td>AST Cell dimension</td>
<td>sl</td>
<td>none</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>L2-AUX3-5</td>
<td>Threshold for ABT flag, 17 km cell nadir view</td>
<td>sl</td>
<td>n/a</td>
<td>4</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>L2-AUX3-6</td>
<td>Threshold for ABT flag, 17 km cell forward view</td>
<td>sl</td>
<td>n/a</td>
<td>4</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>L2-AUX3-7</td>
<td>Threshold for ABT flag, 50 km cell nadir view</td>
<td>sl</td>
<td>n/a</td>
<td>4</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>L2-AUX3-8</td>
<td>Threshold for ABT flag, 50 km cell forward view</td>
<td>sl</td>
<td>n/a</td>
<td>4</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>L2-AUX3-18</td>
<td>MAX CELLS X</td>
<td>Number of 50 km cells across-track</td>
<td>ss</td>
<td>none</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>L2-AUX3-19</td>
<td>MAX CELLS Y</td>
<td>Number of 50 km cells along-track</td>
<td>ss</td>
<td>none</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>L2-AUX3-20</td>
<td>MX, j</td>
<td>Across-track origin of 50 km cells</td>
<td>sl</td>
<td>none</td>
<td>4</td>
<td>1</td>
</tr>
</tbody>
</table>

### Table 4.12-2: Input Data Table - Spatial Averaging, 50 km cell.

<table>
<thead>
<tr>
<th>Parameter ID</th>
<th>Variable</th>
<th>Name</th>
<th>Type</th>
<th>Units</th>
<th>Field size</th>
<th>Fields</th>
</tr>
</thead>
<tbody>
<tr>
<td>L2-INT-101</td>
<td>4(1, n, i, j)</td>
<td>nadir ir12 Brightness Temperature</td>
<td>ss</td>
<td>0.01K</td>
<td>2</td>
<td>j = 0, 511</td>
</tr>
<tr>
<td>L2-INT-102</td>
<td>4(2, n, i, j)</td>
<td>nadir ir11 Brightness Temperature</td>
<td>ss</td>
<td>0.01K</td>
<td>2</td>
<td>j = 0, 511</td>
</tr>
<tr>
<td>L2-INT-103</td>
<td>4(3, n, i, j)</td>
<td>nadir ir37 Brightness Temperature</td>
<td>ss</td>
<td>0.01K</td>
<td>2</td>
<td>j = 0, 511</td>
</tr>
<tr>
<td>L2-INT-104</td>
<td>4(4, n, i, j)</td>
<td>nadir v16 Reflectance</td>
<td>ss</td>
<td>0.01%</td>
<td>2</td>
<td>j = 0, 511</td>
</tr>
<tr>
<td>L2-INT-105</td>
<td>4(5, n, i, j)</td>
<td>nadir v870 Reflectance</td>
<td>ss</td>
<td>0.01%</td>
<td>2</td>
<td>j = 0, 511</td>
</tr>
<tr>
<td>L2-INT-106</td>
<td>4(6, n, i, j)</td>
<td>nadir v670 Reflectance</td>
<td>ss</td>
<td>0.01%</td>
<td>2</td>
<td>j = 0, 511</td>
</tr>
<tr>
<td>L2-INT-107</td>
<td>4(7, n, i, j)</td>
<td>nadir v555 Reflectance</td>
<td>ss</td>
<td>0.01%</td>
<td>2</td>
<td>j = 0, 511</td>
</tr>
<tr>
<td>L2-INT-111</td>
<td>4(1, f, i, j)</td>
<td>forward ir12 Brightness Temperature</td>
<td>ss</td>
<td>0.01K</td>
<td>2</td>
<td>j = 0, 511</td>
</tr>
<tr>
<td>L2-INT-112</td>
<td>4(2, f, i, j)</td>
<td>forward ir11 Brightness Temperature</td>
<td>ss</td>
<td>0.01K</td>
<td>2</td>
<td>j = 0, 511</td>
</tr>
<tr>
<td>L2-INT-113</td>
<td>4(3, f, i, j)</td>
<td>forward ir37 Brightness Temperature</td>
<td>ss</td>
<td>0.01K</td>
<td>2</td>
<td>j = 0, 511</td>
</tr>
<tr>
<td>L2-INT-114</td>
<td>4(4, f, i, j)</td>
<td>forward v16 Reflectance</td>
<td>ss</td>
<td>0.01%</td>
<td>2</td>
<td>j = 0, 511</td>
</tr>
<tr>
<td>L2-INT-115</td>
<td>4(5, f, i, j)</td>
<td>forward v870 Reflectance</td>
<td>ss</td>
<td>0.01%</td>
<td>2</td>
<td>j = 0, 511</td>
</tr>
<tr>
<td>L2-INT-116</td>
<td>4(6, f, i, j)</td>
<td>forward v670 Reflectance</td>
<td>ss</td>
<td>0.01%</td>
<td>2</td>
<td>j = 0, 511</td>
</tr>
<tr>
<td>L2-INT-117</td>
<td>4(7, f, i, j)</td>
<td>forward v555 Reflectance</td>
<td>ss</td>
<td>0.01%</td>
<td>2</td>
<td>j = 0, 511</td>
</tr>
<tr>
<td>L2-INT-119</td>
<td>forward_fill_state(i, j)</td>
<td>nadir fill state indicator</td>
<td>byte</td>
<td>none</td>
<td>1</td>
<td>j = 0, 511</td>
</tr>
<tr>
<td>L2-INT-120</td>
<td>forward_fill_state(i, j)</td>
<td>forward fill state indicator</td>
<td>byte</td>
<td>none</td>
<td>1</td>
<td>j = 0, 511</td>
</tr>
<tr>
<td>L2-INT-121</td>
<td>nadir_land(i, j)</td>
<td>nadir view land flag</td>
<td>ss</td>
<td>array</td>
<td>flag</td>
<td>j = 0, 511</td>
</tr>
<tr>
<td>L2-INT-123</td>
<td>nadir_cloud(i, j)</td>
<td>nadir view cloud flag</td>
<td>ss</td>
<td>array</td>
<td>flag</td>
<td>j = 0, 511</td>
</tr>
<tr>
<td>L2-INT-124</td>
<td>fwdrd_land(i, j)</td>
<td>forward view land flag</td>
<td>ss</td>
<td>array</td>
<td>flag</td>
<td>j = 0, 511</td>
</tr>
<tr>
<td>L2-INT-125</td>
<td>fwdrd_cloud(i, j)</td>
<td>forward view cloud flag</td>
<td>ss</td>
<td>array</td>
<td>flag</td>
<td>j = 0, 511</td>
</tr>
<tr>
<td>L2-INT-126</td>
<td>image_latitude(i, j)</td>
<td>image pixel latitude</td>
<td>float degrees</td>
<td>4</td>
<td>j = 0, 511</td>
<td></td>
</tr>
<tr>
<td>L2-INT-127</td>
<td>image_longitude(i, j)</td>
<td>image pixel longitude</td>
<td>float degrees</td>
<td>4</td>
<td>j = 0, 511</td>
<td></td>
</tr>
<tr>
<td>L2-INT-128</td>
<td>nadir_band_centre_solar_elevation(i, k')</td>
<td>nadir band centre solar elevation(i, k')</td>
<td>float degrees</td>
<td>4</td>
<td>k' = 0, 9</td>
<td></td>
</tr>
<tr>
<td>L2-INT-129</td>
<td>fwdrd_band_centre_solar_elevation(i, k')</td>
<td>forward band centre solar elevation(i, k')</td>
<td>float degrees</td>
<td>4</td>
<td>k' = 0, 9</td>
<td></td>
</tr>
<tr>
<td>L2-INT-130</td>
<td>cell_latitude</td>
<td>pixel latitude transformed to cell units</td>
<td>float</td>
<td>cell</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>L2-INT-131</td>
<td>cell_longitude</td>
<td>pixel longitude transformed to cell units</td>
<td>float</td>
<td>cell</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>L2-INT-25</td>
<td>time[s]</td>
<td>scan UTC</td>
<td>double</td>
<td>days</td>
<td>8 per sg</td>
<td></td>
</tr>
<tr>
<td>L2-INT-132</td>
<td>scan_nadirflag(i, j)</td>
<td>nadir view instrument scan number</td>
<td>us</td>
<td>none</td>
<td>4</td>
<td>j = 0, 511</td>
</tr>
<tr>
<td>L2-INT-133</td>
<td>pxl_nadirflag(i, j)</td>
<td>nadir view instrument pixel number</td>
<td>us</td>
<td>none</td>
<td>4</td>
<td>j = 0, 511</td>
</tr>
<tr>
<td>L2-INT-134</td>
<td>scan_fwd flag(i, j)</td>
<td>forward view instrument scan number</td>
<td>us</td>
<td>none</td>
<td>4</td>
<td>j = 0, 511</td>
</tr>
</tbody>
</table>

| L2-INT-155 | pxl_fwrd(g, j) | forward instrument pixel number | us | none | 4 | j = 0, 511 |
| L2-INT-600 | band(i) | across-track band number | sl | none | 4 | 512 |
| local | i | image scan index | sl | none | 4 |
| local | j | pixel index | sl | none | 4 |
| local | ch | channel identifier | sl | none | 4 |
| v | view identifier (nadir / forward) | sl | none | 4 |
| sf | surface type identifier | sl | none | 4 |
| cl | cloud state identifier | sl | none | 4 |
| local | s | index to instrument scans | sl | none | 4 |
| local | sg | index to ADS #4 records | sl | none | 4 |
| local | k | sub-cell number | sl | none | 4 |
| local | l | 50 km cell index | sl | none | 4 |
| local | m | 50 km cell index | sl | none | 4 |
| L2-INT-20 | utcl(m, l) | 50 km cell UTC | double | days | 8 | per cell |
| L2-INT-21 | utccl(k, l, m) | 57 km sub-cell UTC | double | days | 8 | k = 0, 8 |
| L2-INT-62 | sub_cell_lat(k, l, m) | sub-cell latitude (17 km) | sl | µdeg | 4 |
| L2-INT-63 | sub_cell_long(k, l, m) | sub-cell longitude | sl | µdeg | 4 |
| L2-INT-64 | sub_cell_band(k, l, m) | sub-cell across-track band | ss | none | 2 |
| L2-INT-75 | nadir_solar_el(k, l, m) | nadir solar elevation for sub-cell | float | degrees | 4 |
| L2-INT-76 | fwdr_solar_el(k, l, m) | fwdr solar elevation for sub-cell | float | degrees | 4 |
| L2-INT-77 | cell_lat(k, l) | cell latitude (50 km) | sl | µdeg | 4 |
| L2-INT-78 | cell_long(l, m) | cell longitude (50 km) | sl | µdeg | 4 |
| L2-INT-79 | nadir_day(k, l, m) | nadir view sub-cell day/night flag | ss | flag | 2 | k = 0, 8 |
| L2-INT-80 | fwdr_day(k, l, m) | forward view sub-cell day/night flag | ss | flag | 2 | k = 0, 8 |
| L2-INT-66 | S(ch, v; sf, cl, k, l, m) | sub-cell total ch = 1, ..., 7 | si | n/a | 4 |
| L2-INT-67 | M(ch, v; sf, cl, k, l, m) | ch = 1, 2, 3, 4, 5, 6, 7 | ss | none | 2 |
| L2-INT-68 | A(ch, v; sf, cl, k, l, m) | sub-cell brightness temperature average (For infra-red channels ch = 1, 2, 3) | si | 0.001K | 4 |
| L2-INT-69 | A(ch, v; sf, cl, k, l, m) | sub-cell reflectance average (For visible channels ch = 4, 5, 6, 7) | ss | 0.01% | 2 |
| L2-INT-70 | M(ch, v; sf, cl, l, m) | 50 km cell pixel count, ch = 1, ..., 7 | ss | none | 2 |
| L2-INT-71 | A(ch, v; sf, cl, l, m) | 50 km cell brightness temperature average (For infra-red channels ch = 1, 2, 3) | si | 0.001K | 4 |
| L2-INT-72 | A(ch, v; sf, cl, l, m) | 50 km cell reflectance average (For visible channels ch = 4, 5, 6, 7) | ss | 0.01% | 2 |
| L2-INT-73 | σ(ch, v; sf, cl, l, m) | standard deviation of the 50 km cell average | float | 0.001K or 0.01% | 4 |
| L2-INT-455 | Nv; sf, cl, k, l, m | sub-cell filled pixel count | ss | none | 2 |
| L2-INT-456 | band_sum(k, l, m) | cumulative across-track band sum | si | none | 4 |
| L2-INT-457 | mean_band(k, l, m) | mean across-track band number | ss | none | 2 |
| L2-INT-458 | across_track_sum(sf, k, l, m) | cumulative sum of across-track pixel index | ss | none | 2 |
| L2-INT-459 | across_track_pixel(sf, k, l, m) | mean across-track pixel index, subcell k | ss | none | 2 |
| L2-INT-468 | across_track_mean(sf, k, l, m) | mean across-track pixel index, cell l, m | ss | none | 2 |
| local | µ | number of sub-cells contributing to mean | sl | none | 4 |
| L2-INT-81 | PFF(v; sf, k, l, m) | Pixel threshold failure flags word, 30 arc minute cell | ss | flags | 2 |
| L2-INT-82 | PFF(v; sf, k, l, m) | Pixel threshold failure flags word, 10 arc minute sub-cell | ss | flags | 2 |
| L2-INT-401 | N_land; n; k, l, m | total filled pixels over land for subcell | ss | none | 2 | k = 0, 8 |
| L2-INT-402 | N_sea; n; k, l, m | total of filled pixels over sea for subcell | ss | none | 2 | k = 0, 8 |
| L2-INT-403 | N_total; n; k, l, m | total of filled pixels for subcell, nadir view | ss | none | 2 | k = 0, 8 |
| L2-INT-404 | pcs(n; k, l, m) | percentage of cloudy pixels over sea | ss | 0.01% | 2 | k = 0, 8 |
| L2-INT-405 | pol(n; k, l, m) | percentage of cloudy pixels over land | ss | 0.01% | 2 | k = 0, 8 |
| L2-INT-406 | N_total; n; k, l, m | total filled pixels over land for cell | ss | none | 2 |
| L2-INT-407 | N_sea; n; k, l, m | total of filled pixels over sea for cell | ss | none | 2 |
| L2-INT-408 | N_total; n; k, l, m | total of filled pixels for cell, nadir view | ss | none | 2 |
4.12.3 Detailed Structure

Each 50 km cell can be identified by a pair of indices \( l \) and \( m \) that are proportional, respectively, to the \( y \) and \( x \) co-ordinates of the lower left-hand corner of the cell. Thus if these co-ordinates are \( X \) and \( Y \), then

\[
X = (m - 5) \Delta X; \quad (m = 0, 1, \ldots, MAX_CELLS_X - 1)
\]

\[
Y = l \Delta Y; \quad (l = 0, 1, \ldots, MAX_CELLS_Y - 1)
\]

where \( \Delta X \) and \( \Delta Y \) are the dimensions of the cell. All internal variables associated with the averaged product algorithms are duplicated for each cell, and should be imagined to be virtually present in memory at all times for the purpose of algorithm definition.

Each cell is further subdivided into 9 sub-cells of dimensions \( (\Delta X/3) \) and \( (\Delta Y/3) \). The sub-cells within each cell are identified by an index \( k \) in the range 0 to 8 as follows:

<table>
<thead>
<tr>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

For the averaged channel values there are for each channel and for each view four cumulative sums, depending on surface type and cloud flag as follows:

- **sea, clear**
- **sea, cloud**
- **land, clear**
- **land, cloud**

We define a surface type flag = 0 (sea) or 1 (land) and a cloud state flag = 0 (clear) or 1 (cloud). For the purpose of indexing and identifying the AATSR channels, the following conventional numbering scheme will be adopted.

<table>
<thead>
<tr>
<th>Channel</th>
<th>Symbol</th>
<th>Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>12 micron</td>
<td>( \text{ir12} )</td>
<td>1</td>
</tr>
<tr>
<td>11 micron</td>
<td>( \text{ir11} )</td>
<td>2</td>
</tr>
<tr>
<td>3.7 micron</td>
<td>( \text{ir37} )</td>
<td>3</td>
</tr>
<tr>
<td>1.6 micron</td>
<td>( \text{v16} )</td>
<td>4</td>
</tr>
</tbody>
</table>

Table 4.12-2: Internal Data Table - Spatial Averaging, 50 km cell.
Each average is defined by a sum of the form

\[ A(ch, v; sf, cl, k, l, m) = \left( \sum I(ch, v; i, j) \right) / M(ch, v; sf, cl, k, l, m) \]

where the sum is over all valid pixels which fall within the cell, are filled (or not unfilled), are valid and have the correct cloud/surface type flag. That is, the sum is over all values of \( i \) and \( j \) such that all four of the following conditions are satisfied;

- the pixel indexed by \( i \) and \( j \) falls within the sub-cell;
- \( \text{pixel\_fill\_state}(i, j) \) is not unfilled;
- \( I(ch, v; i, j) \) is valid
- surface type, cloud state, flags at \( i \) and \( j \) have the correct value.

A total of 56 sums and averages are calculated. A separate group of totals are calculated for each channel and view (nadir and forward), there being 14 channel/view combinations. For each combination of channel and view four totals are maintained, and 4 averages computed, corresponding to the four combinations of the cloud state and surface type flags.

for \( l = 0, 1, \ldots \) while not end of data
for \( m = 0, \text{MAX\_CELLS\_X} - 1 \)

**Step 4.12.1 Derive channel totals for each cell**

Perform steps 4.12.1.1 to 4.12.1.7 for each pixel that falls within the cell identified by indices \( l, m \) unless the pixel is unfilled in both images:

for \( i' = 0, \Delta Y - 1 \)
for \( j' = 0, \Delta X - 1 \)
\[
\begin{align*}
  i &= \Delta Y \cdot l + i' \\
  j &= \Delta X \cdot m + j_0 + j'
\end{align*}
\]

(Req 4.12-1)

**Step 4.12.1.1 Identify cell and subcell indices and pixel state**

Identify the \( i, j \) co-ordinates of the lower left corner of the cell; these are the minimum values of \( i, j \) that are still greater than \( l\Delta Y, m\Delta X + MX \) respectively.

\[
\begin{align*}
  \text{cell\_lat}(l, m) &= 1000000. \times \text{image\_latitude}(i, j) \\
  \text{cell\_long}(l, m) &= 1000000. \times \text{image\_longitude}(i, j)
\end{align*}
\]

evaluated at those values of \( i, j \).

The sub-cell index \( k \) is given by

\[ k = 3 \times [i'/\Delta Y] + [j'/\Delta X] \]

where the inclusion of a quantity in square brackets implies that the integer part is to be taken.
If the pixel identified by \((i, j)\) is the first pixel (i.e. the leftmost) to fall within the cell \(l, m\), ensure that all counters and cumulative sums are initialised to zero as follows:

\[
S(ch, v; sf, cl, k, l, m) = 0.0 \\
M(ch, v; sf, cl, k, l, m) = 0 \\
N(v; sf, cl; k, l, m) = 0 \\
band\_sum(k, l, m) = 0 \\
across\_track\_sum(sf; k, l, m) = 0 \text{ for each } k = 0, 8.
\]

If the pixel identified by \((i, j)\) is the first pixel to fall within this sub-cell, assemble the cell geolocation and allied information as follows:

The time tag associated with the sub-cell \([L2\text{-INT-21}]\) is derived from the scan number associated with the pixel \(i, j\), and with the scan times from ADS #4. Starting from the indices \(i, j\), derive the UTC time of the pixel in exactly the same way as described for the derivation of \(utc(cell)\) in Section 4.8.4 (Step 4.8.1.1), and assign it to \(utc(k, l, m)\) \([L2\text{-INT-21}]\).

If \(k = 0\) assign \([L2\text{-INT-20}]\)

\[utc(l, m) = utc(k, l, m).\]

Assign the cell positional information:

\[
sub\_cell\_lat(k, l, m) = 1000000. * \text{image\_latitude}(i, j) \\
sub\_cell\_long(k, l, m) = 1000000. * \text{image\_longitude}(i, j) \\
sub\_cell\_band(k, l, m) = \text{band}(j) \\
sub\_cell\_index(k, l, m) = i + [\Delta Y/6]
\]

(This is used in the LST calculation, Section 4.14. Note that in practice \([\Delta Y/6]\) equals 8, which is half the sub-cell dimension. The resulting along-track index refers to the mid-point of the sub-cell.)

\[
nadir\_solar\_el(k, l, m) = \text{nadir\_band\_centre\_solar\_elevation}(i, \text{band}(j)) \\
frwrd\_solar\_el(k, l, m) = \text{frwrd\_band\_centre\_solar\_elevation}(i, \text{band}(j)) \\
mean\_band(k, l, m) = \text{band}(j + \Delta X/6)
\]

If \(<view>\_\text{band\_centre\_solar\_elevation}(i, \text{band}(j)) > 0.0\) then

\(<view>\_\text{day}(k, l, m) = \text{TRUE}\)

otherwise

\(<view>\_\text{day}(k, l, m) = \text{FALSE}\)

where \(<view> = \langle\text{nadir} | \text{frwrd}\rangle\).

(Req 4.12-1)

**Step 4.12.1.2 Process nadir Pixels**
Perform steps 4.12.3.1.3 and 4.12.3.1.4 to process the nadir pixels unless the nadir pixel is unfilled (i.e. unless \( \text{nadir\_fill\_state}(i, j) = \text{UNFILLED\_PIXEL} \)) or \( m \) (computed as above) is out of range.

**Step 4.12.1.3 Identify the surface type and cloud state associated with the nadir pixel:**

\[
\begin{align*}
sf &= 0 \text{ if nadir view land flag } [L2-INT-232](i, j) = \text{FALSE} \\
sf &= 1 \text{ if nadir view land flag } [L2-INT-232](i, j) = \text{TRUE} \\
cl &= 0 \text{ if nadir view cloud flag } [L2-INT-233](i, j) = \text{FALSE} \\
cl &= 1 \text{ if nadir view cloud flag } [L2-INT-233](i, j) = \text{TRUE}.
\end{align*}
\]

Increment the pixel counters associated with the cloud state and surface type just determined:

\[
N(n; sf, cl, k, l, m) \leftarrow N(n; sf, cl, k, l, m) + 1
\]

If \( cl = 0 \) then increment the cumulative across-track index as follows:

\[
\text{across\_track\_sum}(sf; k, l, m) \leftarrow \text{across\_track\_sum}(sf; k, l, m) + j
\]

**Step 4.12.1.4 Update nadir view channel totals**

For each channel of the nadir view \( ch \) perform this step if the corresponding nadir pixel is valid:

\[
S(ch, n; sf, cl, k, l, m) \leftarrow S(ch, n; sf, cl, k, l, m) + I(ch, n; i, j) \\
M(ch, n; sf, cl, k, l, m) \leftarrow M(ch, n; sf, cl, k, l, m) + 1
\]

**Step 4.12.1.5 Process forward Pixels:**

Perform steps 4.12.3.1.6 and 4.12.3.1.7 to process the forward pixels unless the forward pixel is unfilled (i.e. unless \( \text{frwrd\_fill\_state}(i, j) = \text{UNFILLED\_PIXEL} \)).

**Step 4.12.1.6 Identify the surface type and cloud state associated with the forward pixel:**

\[
\begin{align*}
sf &= 0 \text{ if frwrd cloud state land flag } [L2-INT-248](i, j) = \text{FALSE} \\
sf &= 1 \text{ if frwrd cloud state land flag } [L2-INT-248](i, j) = \text{TRUE} \\
cl &= 0 \text{ if frwrd cloud state cloud flag } [L2-INT-249](i, j) = \text{FALSE} \\
cl &= 1 \text{ if frwrd cloud state cloud flag } [L2-INT-249](i, j) = \text{TRUE}.
\end{align*}
\]

Increment the pixel counters associated with the cloud state and surface type just determined:

\[
N(f; sf, cl, k, l, m) \leftarrow N(f; sf, cl, k, l, m) + 1
\]

**Step 4.12.1.7 Update forward view channel totals**

For each channel of the forward view, perform the following steps if the corresponding forward pixel is valid:

\[
S(ch, f; sf, cl, k, l, m) \leftarrow S(ch, f; sf, cl, k, l, m) + I(ch, f; i, j) \\
M(ch, f; sf, cl, k, l, m) \leftarrow M(ch, f; sf, cl, k, l, m) + 1
\]
end for (loop over j’)
end for (loop over i’)

**Step 4.12.2 Derive average values.**

When no more pixels remain to be added to the cell, or at the end of the data set, compute the averages. The following equation is evaluated for each channel \(ch = \text{ir12, ir11, ir37, v16, v870, v670, v555}\), for each view \(v = n, f\), for surface type \(sf = 0, 1\) and for cloud state \(cl = 0, 1\)

If \(M\{ch, v; sf, cl, k, l, m\} > 0\)

\[
A(ch, v; sf, cl, k, l, m) = 10 \cdot S(ch, v; sf, cl, k, l, m) / M(ch, v; sf, cl, k, l, m)
\]

(note the conversion to units of 0.001 K) otherwise set

\[
A(ch, v; sf, cl, k, l, m) = -1.0
\]

The mean in the larger (50 km) cell is given by

\[
\bar{A}(ch, v; sf, cl, l, m) = \frac{1}{\mu} \sum_k A(ch, v; sf, cl, k, l, m) \text{ if } \mu > 0
\]

\[
\bar{A}(ch, v; sf, cl, l, m) = -1 \text{ if } \mu = 0
\]

where the sum is over all \(k \in \{0 \leq k \leq 8\}\) having a valid subcell mean \(A\) and \(\mu\) is the number of such valid means. The number of pixels that contribute to the mean is similarly

\[
\bar{M}(ch, v; sf, cl, l, m) = \sum_k M(ch, v; sf, cl, k, l, m)
\]

The standard deviation of the mean is

\[
\sigma(ch, v; sf, cl, l, m) = \left\{ \frac{1}{\mu - 1} \sum_k (A(ch, v; sf, cl, k, l, m) - \bar{A}(ch, v; sf, cl, l, m))^2 \right\}^{1/2}
\]

provided \(\mu > 1\), otherwise set the standard deviation to -1. In all cases the sum is over sub-cells having valid means (i.e the number of contributing pixels \(M\) is positive).

(Req 4.12-3)

The mean across-track pixel number [L2-INT-459] is calculated for each sub-cell \(k = 0, 8\) and for each surface type \(sf = 0, 1\):

If \(N(n; sf, 0, k, l, m) > 0\) then set

\[
\text{across_track_mean}(sf, k, l, m) = \text{integer part of} \left( \frac{\text{across_track_sum}(sf; k, l, m)}{N(n; sf, 0, k, l, m)} \right)
\]

otherwise set

\[
\text{across_track_mean}(sf, k, l, m) = -1
\]

The mean to be associated with the 30 arc minute cell is [L2-INT-468]
across_track_mean(sf; l, m) = \frac{1}{\mu} \sum_k across_track_mean(sf; k, l, m) \text{ if } \mu > 0

across_track_mean(sf; l, m) = -1 \text{ if } \mu = 0

where the sum is over all \( k \in \{0 \leq k \leq 8\} \) for which the number of contributing pixels

\( N(n; sf, 0, k, l, m) > 0 \)

and \( \mu \) is the number of valid \( k \).

(Req 4.12-3.1)

Step 4.12.3 Derive Pixel Threshold Failure Flags Words (17 km cell)

For cell \( l, m \) and for each sub-cell \( k = 0, 9 \):

For surface type \( sf = 0, 1 \) and for the nadir view \( v = n \):

\[
\begin{align*}
[PFF(n, sf; k, l, m)](bit 0) &= 1 \text{ if } M(ir12, n; sf, 0, k, l, m) < [L2-AUX3-5], \text{ otherwise } 0 \\
[PFF(n, sf; k, l, m)](bit 1) &= 1 \text{ if } M(ir11, n; sf, 0, k, l, m) < [L2-AUX3-5], \text{ otherwise } 0 \\
[PFF(n, sf; k, l, m)](bit 2) &= 1 \text{ if } M(ir37, n; sf, 0, k, l, m) < [L2-AUX3-5], \text{ otherwise } 0 \\
[PFF(n, sf; k, l, m)](bit 3) &= 1 \text{ if } M(v16, n; sf, 0, k, l, m) < [L2-AUX3-5], \text{ otherwise } 0 \\
[PFF(n, sf; k, l, m)](bit 4) &= 1 \text{ if } M(v870, n; sf, 0, k, l, m) < [L2-AUX3-5], \text{ otherwise } 0 \\
[PFF(n, sf; k, l, m)](bit 5) &= 1 \text{ if } M(v670, n; sf, 0, k, l, m) < [L2-AUX3-5], \text{ otherwise } 0 \\
[PFF(n, sf; k, l, m)](bit 6) &= 1 \text{ if } M(v555, n; sf, 0, k, l, m) < [L2-AUX3-5], \text{ otherwise } 0 \\
[PFF(n, sf; k, l, m)](bit 7) &= 1 \text{ if } M(ir12, n; sf, 1, k, l, m) < [L2-AUX3-5], \text{ otherwise } 0 \\
[PFF(n, sf; k, l, m)](bit 8) &= 1 \text{ if } M(ir11, n; sf, 1, k, l, m) < [L2-AUX3-5], \text{ otherwise } 0 \\
[PFF(n, sf; k, l, m)](bit 9) &= 1 \text{ if } M(ir37, n; sf, 1, k, l, m) < [L2-AUX3-5], \text{ otherwise } 0 \\
[PFF(n, sf; k, l, m)](bit 10) &= 1 \text{ if } M(v16, n; sf, 1, k, l, m) < [L2-AUX3-5], \text{ otherwise } 0 \\
[PFF(n, sf; k, l, m)](bit 11) &= 1 \text{ if } M(v870, n; sf, 1, k, l, m) < [L2-AUX3-5], \text{ otherwise } 0 \\
[PFF(n, sf; k, l, m)](bit 12) &= 1 \text{ if } M(v670, n; sf, 1, k, l, m) < [L2-AUX3-5], \text{ otherwise } 0 \\
[PFF(n, sf; k, l, m)](bit 13) &= 1 \text{ if } M(v555, n; sf, 1, k, l, m) < [L2-AUX3-5], \text{ otherwise } 0 \\
[PFF(n, sf; k, l, m)](bit 14) &= 1 \text{ if } \text{nadir_day}(k, l, m) = \text{TRUE}, \text{ otherwise } 0 \\
[PFF(n, sf; k, l, m)](bit 15) &= 0
\end{align*}
\]

(Req 4.12-4)

Similarly for surface type \( sf = 0, 1 \) and for the forward view \( v = f \)

Calculate the corresponding word \( PFF(f, sf; k, l, m) \):

Set bits 0 to 13 inclusive as above, substituting the view index \( f \) in place of \( n \), and substituting the forward threshold value \([L2-AUX3-6]\) in place of \([L2-AUX3-5]\).

\[
[PFF(f, sf; k, l, m)](bit 14) = 1 \text{ if } \text{frwrd_day}(k, l, m) = \text{TRUE}, \text{ otherwise } 0
\]
Step 4.12.4 Derive Pixel Threshold Failure Flags Words (50 km cells)

For each cell \(l, m\):

For surface type \(sf = 0, 1\) and for the nadir view \(v = n\):

\[
PFF(n, sf; l, m)(\text{bit } 0) = 1 \text{ if } 
\tilde{M}(ir_{12}, n; sf, 0, l, m) < [L2-AUX3-7], \text{ otherwise } 0
\]

\[
PFF(n, sf; l, m)(\text{bit } 1) = 1 \text{ if } 
\tilde{M}(ir_{11}, n; sf, 0, l, m) < [L2-AUX3-7], \text{ otherwise } 0
\]

\[
PFF(n, sf; l, m)(\text{bit } 2) = 1 \text{ if } 
\tilde{M}(ir_{37}, n; sf, 0, l, m) < [L2-AUX3-7], \text{ otherwise } 0
\]

\[
PFF(n, sf; l, m)(\text{bit } 3) = 1 \text{ if } 
\tilde{M}(v_{16}, n; sf, 0, l, m) < [L2-AUX3-7], \text{ otherwise } 0
\]

\[
PFF(n, sf; l, m)(\text{bit } 4) = 1 \text{ if } 
\tilde{M}(v_{870}, n; sf, 0, l, m) < [L2-AUX3-7], \text{ otherwise } 0
\]

\[
PFF(n, sf; l, m)(\text{bit } 5) = 1 \text{ if } 
\tilde{M}(v_{670}, n; sf, 0, l, m) < [L2-AUX3-7], \text{ otherwise } 0
\]

\[
PFF(n, sf; l, m)(\text{bit } 6) = 1 \text{ if } 
\tilde{M}(v_{555}, n; sf, 0, l, m) < [L2-AUX3-7], \text{ otherwise } 0
\]

\[
PFF(n, sf; l, m)(\text{bit } 7) = 1 \text{ if } 
\tilde{M}(v_{12}, n; sf, 1, l, m) < [L2-AUX3-7], \text{ otherwise } 0
\]

\[
PFF(n, sf; l, m)(\text{bit } 8) = 1 \text{ if } 
\tilde{M}(v_{870}, n; sf, 1, l, m) < [L2-AUX3-7], \text{ otherwise } 0
\]

\[
PFF(n, sf; l, m)(\text{bit } 9) = 1 \text{ if } 
\tilde{M}(v_{670}, n; sf, 1, l, m) < [L2-AUX3-7], \text{ otherwise } 0
\]

\[
PFF(n, sf; l, m)(\text{bit } 10) = 1 \text{ if } 
\tilde{M}(v_{16}, n; sf, 1, l, m) < [L2-AUX3-7], \text{ otherwise } 0
\]

\[
PFF(n, sf; l, m)(\text{bit } 11) = 1 \text{ if } 
\tilde{M}(v_{870}, n; sf, 1, l, m) < [L2-AUX3-7], \text{ otherwise } 0
\]

\[
PFF(n, sf; l, m)(\text{bit } 12) = 1 \text{ if } 
\tilde{M}(v_{670}, n; sf, 1, l, m) < [L2-AUX3-7], \text{ otherwise } 0
\]

\[
PFF(n, sf; l, m)(\text{bit } 13) = 1 \text{ if } 
\tilde{M}(v_{555}, n; sf, 1, l, m) < [L2-AUX3-7], \text{ otherwise } 0
\]

\[
PFF(n, sf; l, m)(\text{bit } 14) = 1 \text{ if } \text{nadir\_day}(k, l, m) = \text{TRUE for some } k, \text{ otherwise } 0
\]

\[
PFF(n, sf; l, m)(\text{bit } 15) = 0
\]

(Req 4.12-5)

Similarly for surface type \(sf = 0, 1\) and for the forward view \(v = f\)

Calculate the corresponding word \(PFF(f, sf; l, m)\):

Set bits 0 to 13 inclusive as above, substituting the view index \(f\) in place of \(n\), and substituting the forward threshold value \([L2-AUX3-8]\) in place of \([L2-AUX3-7]\).

\[
PFF(f, sf; k, l, m)(\text{bit } 14) = 1 \text{ if } \text{frwrd\_day}(k, l, m) = \text{TRUE for some } k, \text{ otherwise } 0
\]

\[
PFF(f, sf; k, l, m)(\text{bit } 15) = 0
\]

(Req 4.12-6)

Step 4.12.5. Derive pixel counts for cell

For each cell \(l, m\) and for each view \(v = n, f\):

For each subcell \(k = 0, 8\):
Total of filled pixels over land:
\[ N_{\text{land}}(v; k, l, m) = N(v; 1, 0, k, l, m) + N(v; 1, 1, k, l, m) \]  
(Req 4.12-7)

Total of filled pixels over sea:
\[ N_{\text{sea}}(v; k, l, m) = N(v; 0, 0, k, l, m) + N(v; 0, 1, k, l, m) \]  
(Req 4.12-8)

Total of filled pixels:
\[ N_{\text{total}}(v; k, l, m) = N_{\text{land}}(v; k, l, m) + N_{\text{sea}}(v; k, l, m) \]  
(Req 4.12-9)

Derive cloudy pixel percentages for each sub-cell:
\[ \text{pcs}(v; k, l, m) = 10000 \times \frac{N(v; 0, 1, k, l, m)}{N_{\text{sea}}(v; k, l, m)} \]
\[ \text{pcl}(v; k, l, m) = 10000 \times \frac{N(v; 1, 1, k, l, m)}{N_{\text{land}}(v; k, l, m)} \]  
(Req 4.12-10)

end for \((k)\)

Derive aggregate counts:
Total of filled pixels over land:
\[ N_{\text{land}}(v; l, m) = \sum_{k=0}^{8} N_{\text{land}}(v; k, l, m) \]  
(Req 4.12-11)

Total of filled pixels over sea:
\[ N_{\text{sea}}(v; l, m) = \sum_{k=0}^{8} N_{\text{sea}}(v; k, l, m) \]  
(Req 4.12-12)

Total of filled pixels:
\[ N_{\text{total}}(v; l, m) = N_{\text{land}}(v; l, m) + N_{\text{sea}}(v; l, m) \]  
(Req 4.12-13)

Derive cloudy pixel percentages for the cell:
\[ \text{pcs}(v; l, m) = 10000 \times \left( \sum_{k=0}^{8} \frac{N(v; 0, 1, k, l, m)}{N_{\text{sea}}(v; l, m)} \right) \]
\[ \text{pcl}(v; l, m) = 10000 \times \left( \sum_{k=0}^{8} \frac{N(v; 1, 1, k, l, m)}{N_{\text{land}}(v; l, m)} \right) \]  
(Req 4.12-14)

end for \((l, m, v)\)
4.13 Module Definition: Averaged SST Retrieval (50 km Cell)

4.13.1 Functional Description

This module derives the averaged SST from the averaged brightness temperatures determined using the module described in Section 4.12 above.

4.13.2 Interface Definition

<table>
<thead>
<tr>
<th>Parameter ID</th>
<th>Variable</th>
<th>Name</th>
<th>Type</th>
<th>Units</th>
<th>Field size</th>
<th>Fields</th>
</tr>
</thead>
<tbody>
<tr>
<td>L2-AUX2-1</td>
<td>a[0][0]</td>
<td>averaged sst retrieval</td>
<td>float</td>
<td>K/100</td>
<td>4</td>
<td>114</td>
</tr>
<tr>
<td>L2-AUX2-2</td>
<td>a[0][1]</td>
<td>averaged sst retrieval</td>
<td>float</td>
<td>none</td>
<td>4</td>
<td>114</td>
</tr>
<tr>
<td>L2-AUX2-3</td>
<td>a[0][2]</td>
<td>averaged sst retrieval</td>
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<td>none</td>
<td>4</td>
<td>114</td>
</tr>
<tr>
<td>L2-AUX2-4</td>
<td>b[0][0]</td>
<td>averaged sst retrieval</td>
<td>float</td>
<td>K/100</td>
<td>4</td>
<td>114</td>
</tr>
<tr>
<td>L2-AUX2-5</td>
<td>b[0][1]</td>
<td>averaged sst retrieval</td>
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<td>none</td>
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</tr>
<tr>
<td>L2-AUX2-6</td>
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<td>none</td>
<td>4</td>
<td>114</td>
</tr>
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<td>4</td>
<td>114</td>
</tr>
<tr>
<td>L2-AUX2-8</td>
<td>c[0][0]</td>
<td>averaged sst retrieval</td>
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<td>4</td>
<td>114</td>
</tr>
<tr>
<td>L2-AUX2-9</td>
<td>c[0][1]</td>
<td>averaged sst retrieval</td>
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<td>none</td>
<td>4</td>
<td>114</td>
</tr>
<tr>
<td>L2-AUX2-10</td>
<td>c[0][2]</td>
<td>averaged sst retrieval</td>
<td>float</td>
<td>none</td>
<td>4</td>
<td>114</td>
</tr>
<tr>
<td>L2-AUX2-11</td>
<td>c[0][3]</td>
<td>averaged sst retrieval</td>
<td>float</td>
<td>none</td>
<td>4</td>
<td>114</td>
</tr>
<tr>
<td>L2-AUX2-12</td>
<td>c[0][4]</td>
<td>averaged sst retrieval</td>
<td>float</td>
<td>none</td>
<td>4</td>
<td>114</td>
</tr>
<tr>
<td>L2-AUX2-13</td>
<td>d[0][0]</td>
<td>averaged sst retrieval</td>
<td>float</td>
<td>K/100</td>
<td>4</td>
<td>114</td>
</tr>
<tr>
<td>L2-AUX2-14</td>
<td>d[0][1]</td>
<td>averaged sst retrieval</td>
<td>float</td>
<td>none</td>
<td>4</td>
<td>114</td>
</tr>
<tr>
<td>L2-AUX2-15</td>
<td>d[0][2]</td>
<td>averaged sst retrieval</td>
<td>float</td>
<td>none</td>
<td>4</td>
<td>114</td>
</tr>
<tr>
<td>L2-AUX2-16</td>
<td>d[0][3]</td>
<td>averaged sst retrieval</td>
<td>float</td>
<td>none</td>
<td>4</td>
<td>114</td>
</tr>
<tr>
<td>L2-AUX2-17</td>
<td>d[0][4]</td>
<td>averaged sst retrieval</td>
<td>float</td>
<td>none</td>
<td>4</td>
<td>114</td>
</tr>
<tr>
<td>L2-AUX2-18</td>
<td>d[0][5]</td>
<td>averaged sst retrieval</td>
<td>float</td>
<td>none</td>
<td>4</td>
<td>114</td>
</tr>
<tr>
<td>L2-AUX2-19</td>
<td>d[0][6]</td>
<td>averaged sst retrieval</td>
<td>float</td>
<td>none</td>
<td>4</td>
<td>114</td>
</tr>
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<td>L2-AUX6-1</td>
<td>j</td>
<td>pixel index</td>
<td>ss</td>
<td>none</td>
<td>2</td>
<td>512</td>
</tr>
<tr>
<td>L2-AUX6-2</td>
<td>map(j)</td>
<td>Across-track band index</td>
<td>ss</td>
<td>none</td>
<td>2</td>
<td>512</td>
</tr>
<tr>
<td>L2-AUX3-10</td>
<td>ast</td>
<td>AST Cell dimension</td>
<td>sl</td>
<td>none</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>L2-AUX3-11</td>
<td>trop</td>
<td>TROPICAL_INDEX</td>
<td>float</td>
<td>degrees</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>L2-AUX3-12</td>
<td>tem</td>
<td>TEMPERATE_INDEX</td>
<td>float</td>
<td>degrees</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>L2-AUX3-13</td>
<td>pol</td>
<td>POLAR_INDEX</td>
<td>float</td>
<td>degrees</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>L2-AUX3-14</td>
<td>nad</td>
<td>NADIR_PIXELS_THRESH</td>
<td>sl</td>
<td>none</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>L2-AUX3-15</td>
<td>frw</td>
<td>FRWRD_PIXELS_THRESH</td>
<td>sl</td>
<td>none</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>L2-AUX3-16</td>
<td>r3</td>
<td>IR37_THRESH</td>
<td>float</td>
<td>none</td>
<td>4</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 4.13.1: Input Data Table - Averaged SST Retrieval
Note on notation: In the following we adopt the following abbreviated notation for the associated with, the necessary intermediate and output variables including the averaged sst retrieval coefficients.

| L2-INT-73 | \( \sigma( ch; v, sf, cl, l, m) \) | standard deviation of the cell average | float | 0.01K or 0.01% | 4 |
| L2-INT-79 | nadir_day(k, l, m) | nadir view sub-cell day/night flag | ss | flag | 2 | k = 0, 8 |
| L2-INT-80 | fward_day(k, l, m) | forward view sub-cell day/night flag | ss | flag | 2 | k = 0, 8 |
| L2-INT-81 | b(i, j, q) | averaged sst retrieval a coefficients | float | mixed | 4 | 342 |
| L2-INT-82 | c(i, j, q) | averaged sst retrieval b coefficients | float | mixed | 4 | 456 |
| L2-INT-83 | d(i, j, q) | averaged sst retrieval c coefficients | float | mixed | 4 | 570 |
| L2-INT-87 | \( \sigma_{nadir}(ASST; l, m) \) | standard deviation of nadir view ASST | ss | flag | 2 | k = 0, 8 |

Table 4.13-2: Internal Data Table - Averaged SST Retrieval

### 4.13.3 Detailed Structure

Both dual-view and nadir only sea surface temperatures are derived.

In the processing, each half-degree cell is represented by a structure containing, or is associated with, the necessary intermediate and output variables including the averaged brightness temperatures for each 10 arc-minute cell contained within the larger cell. All cells should be virtually present in memory, but how this is achieved is a matter for the implementer.

Note on notation: In the following we adopt the following abbreviated notation for the average brightness temperatures.

\[
\tau_{ch}^{\text{nadir}} = \frac{\text{float}(S(ch,n;0,0,k,l,m))}{\text{float}(M(ch,n;0,0,k,l,m))}
\]
where \( ch \) indicates one of the seven channels. This notation is adopted to reduce the proliferation of indices; note that where it is used, a dependence on \( k, l \) and \( m \) is implied. Note also that the above quantities must be computed using a floating point computation, although \( S \) and \( M \) are of type integer, to ensure that sufficient precision is maintained. Substitution of the quantities \( A(ch, f; 0, 0, k, l, m) \) would not ensure this.

Processing is applied to cells for which the processing of Step 4.12.1 is complete; i.e. no more pixels remain to be added to the cell.

The processing to derive averaged SST is done as follows:

**Step 4.13.1 Read look-up tables.**

On first entry, input the look-up tables of averaged SST retrieval coefficients.

This is done once at initialisation. Retrieval coefficients are specified for three latitude zones (tropical, temperate and polar) and for 38 bands or strips running parallel to the ground track, and corresponding to different viewing angles. Distinct sets of coefficients are supplied for day/night and for nadir only/dual view retrievals, as follows.

<table>
<thead>
<tr>
<th>Index</th>
<th>Zone</th>
<th>Set</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>tropical</td>
<td>a</td>
<td>nadir only, day</td>
</tr>
<tr>
<td>1</td>
<td>temperate</td>
<td>b</td>
<td>nadir only, night</td>
</tr>
<tr>
<td>2</td>
<td>polar</td>
<td>c</td>
<td>dual view, day</td>
</tr>
<tr>
<td></td>
<td></td>
<td>d</td>
<td>dual view, night</td>
</tr>
</tbody>
</table>

Before reading the retrieval coefficients ensure that the mapping array \( map(j) \) \([L2-INT-61]\) is available. This has been read in during Step 4.6.1. If it is desired to re-input it independently in this module then proceed as before: Open the data set \( L2-AUX6 \) and set

\[ map(j) = [L2-AUX6-2](j), j = 0, 511 \]

(Note that \([L2-AUX6-1](j) = j, j = 0, 511\).)

Open the file of retrieval coefficients to access data set \( L2-AUX2 \).

For each latitude zone \( i = 0, 1, 2 \) (outer loop) and for each across-track band \( j = 0 \) to 37 (inner loop);

Read in next record of file.

Extract the \( a \) coefficients \([L2-INT-460]\) as follows

\[ a(i, j, 0) = [L2-AUX2-1] \]
\[ a(i, j, 1) = [L2-AUX2-2] \]
\[ a(i, j, 2) = [L2-AUX2-3] \]

Similarly extract in the \( b, c \) and \( d \) sets of coefficients:

\[ b(i, j, q) = [L2-AUX2-<4 + q>], q = 0, 1, 2, 3; \]
\[ c(i, j, q) = [L2-AUX2-<8 + q>], q = 0, 1, 2, 3 4; \]
\[ d(i, j, q) = [L2-AUX2-<13 + q>], q = 0, 1, 2, 3, 4, 5, 6. \]

(Note that if the retrieval coefficients have already been read in at Step 4.9.1 and are still available, they need not be read again. Instead the values \([L2-INT-460]\) to \([L2-INT-363]\) may...
be equated to [L2-INT-360] to [L2-INT-363] respectively. There is only one set of averaged retrieval coefficients.)

(Req 4.13-1)

Step 4.13.2 Nadir view average.

Calculate the nadir view averaged SST value for each of the 10-arcmin cells. Note that in the following, if the flags \textit{nadir\_asst\_uses\_ir37}, \textit{dual\_asst\_uses\_ir37} are initialised to the value \textit{FALSE}, then Reqs. 4-13-2a, 4-13-9a are logically redundant.

Step 4.13.2.1

Determine the minimum number of pixels required for the cell, for the nadir. This is

\[ \text{minpn} = 340 \times \text{NADIR\_PIXELS\_THRESH} + 1. \]

(No latitude dependence is required here as sub-cell size is independent of latitude.)

If \( M(\text{ir12}, n; 0, 0, k, l, m) \geq \text{minpn} \) and \( M(\text{ir11}, n; 0, 0, k, l, m) \geq \text{minpn} \) proceed to calculate the retrieved sst as below, otherwise set

\[ T_{\text{nadir}}(k, l, m) = -1.0 \]

\[ \text{nadir\_asst\_uses\_ir37}(k, l, m) = \text{FALSE} \]

(Req 4.13-2)

(Req 4-13-2a)

Step 4.13.2.2

For night-time data, if \( \text{nadir\_day}(k, l, m) = \text{FALSE} \), test whether the ratio of pixels with valid 3.7 µm data is greater or less than the threshold value and use the appropriate (two or three channel) SST algorithm. The 3.7 micron channel is valid if

\[ \text{float}\{M(\text{ir37}, n; 0, 0, k, l, m)\} / \text{float}\{M(\text{ir11}, n; 0, 0, k, l, m)\} \geq \text{IR37\_THRESH}. \]

Otherwise use the two-channel algorithm. The two-channel algorithm is always used for day-time data, that is, if \( \text{nadir\_day}(k, l, m) = \text{TRUE} \).

Step 4.13.2.3

Calculate the averaged SST using the nadir-view retrieval coefficients for the appropriate across-track band given by \( j = \text{map}(\text{across\_track\_mean}(0; k, l, m)) \) and for the two or three channel algorithm as appropriate, for each latitude zone \( i = 0, 1, 2 \):

Step 4.13.2.3.1

Perform this step if the 3.7 micron channel is not available for use.

The equation for use with the nadir view is

\[ T_{\text{nadir}}^{\text{sst}, i} = 100.0a_0 + a_1T_{\text{nadir}}^{\text{ir11}} + a_2T_{\text{nadir}}^{\text{ir12}} \]

where

\[ a_q = a(i, j, q). \]

(Req 4.13-3)
(Here and elsewhere in this module the factor of 100 is to ensure consistency of units between the brightness temperatures, in units of 0.01K, and the leading coefficient, in K.)

Set
\[ \text{nadir\_asst\_uses\_ir37}(k, l, m) = \text{FALSE} \]  

(Req 4.13-3.1)

**Step 4.13.2.3.2**

Perform this step if the 3.7 micron channel is to be used.

The equation for use with the nadir view is
\[ T_{\text{nadir}}^{s} = 100.0b_0 + b_1 T_{\text{ir}11}^{\text{nadir}} + b_2 T_{\text{ir}12}^{\text{nadir}} + b_3 T_{\text{ir}37}^{\text{nadir}} \]

where
\[ b_q = b(i, j, q). \]  

(Req 4.13-4)

(As before, the factor of 100 is to ensure consistency of units.)

Set
\[ \text{nadir\_asst\_uses\_ir37}(k, l, m) = \text{TRUE} \]  

(Req 4.13-4.1)

**Step 4.13.2.4**

Return latitude-corrected SST (with linear interpolation).

If the cell is in the polar or tropical zone, return the corresponding retrieval. If the cell is in the temperate zone, use linear interpolation with respect to latitude to derive the averaged SST from the values for the temperate zone and the appropriate adjacent zone.

If \( \text{abs(latitude)} < \text{TROPICAL\_INDEX} \) then
\[ T_{\text{nadir}}(k, l, m) = T_{\text{sst},0}^{\text{nadir}} \]  

(Req 4.13-5)

If \( \text{TROPICAL\_INDEX} \leq \text{abs(latitude)} < \text{TEMPERATE\_INDEX} \), the final value for the retrieved \( \text{sst} \) is given by
\[ T_{\text{nadir}}(k, l, m) = T_{\text{sst},0}^{\text{nadir}} + w \cdot (T_{\text{sst},1}^{\text{nadir}} - T_{\text{sst},0}^{\text{nadir}}) \]  

(Req 4.13-6)

where
\[ w = \frac{(\text{abs(latitude)} - \text{TROPICAL\_INDEX})}{(\text{TEMPERATE\_INDEX} - \text{TROPICAL\_INDEX})} \]

If the \( \text{TEMPERATE\_INDEX} \leq \text{abs(latitude)} < \text{POLAR\_INDEX} \), but not less than, the final value for the retrieved \( \text{sst} \) is given by
\[ T_{\text{nadir}}(k, l, m) = T_{\text{sst},1}^{\text{nadir}} + w \cdot (T_{\text{sst},2}^{\text{nadir}} - T_{\text{sst},1}^{\text{nadir}}) \]  

(Req 4.13-7)

where
\[ w = \frac{(\text{abs(latitude)} - \text{TEMPERATE\_INDEX})}{(\text{POLAR\_INDEX} - \text{TEMPERATE\_INDEX})} \]

If \( \text{POLAR\_INDEX} \leq \text{abs(latitude)} \)

\[ T_{\text{nadir}}(k,l,m) = T_{\text{sst,2}} \]

(Req 4.13-8)

**Step 4.13.3 Dual view average.**

Calculate the dual view averaged SST value for the 10-arcmin cells.

**Step 4.13.3.1**

Determine the minimum numbers of pixels required for the cell, for both. The threshold for the nadir view is \( \text{minpn} \) calculated as above. That for the forward view is

\[ \text{minpf} = 340 \times \text{FRWRD\_PIXELS\_THRESH} + 1. \]

If the number of valid pixels in the either view is less than the threshold value calculated, move to the next 17 km cell.

If

\[ M(ir_{12}, n; 0, 0, k, l, m) \geq \text{minpn} \text{ and } M(ir_{11}, n; 0, 0, k, l, m) \geq \text{minpn} \]

and

\[ M(ir_{12}, f; 0, 0, k, l, m) \geq \text{minpf} \text{ and } M(ir_{11}, f; 0, 0, k, l, m) \geq \text{minpf} \]

proceed to calculate the retrieved sst as below, otherwise set

\[ T_{\text{dual}}(k, l, m) = -1. \]

(Req 4.13-9)

\[ \text{dual\_asst\_uses\_ir37}(k, l, m) = \text{FALSE} \]

(Req 4-13-9a)

**Step 4.13.3.2**

For night-time data, defined by the condition

\( \text{nadir\_day}(k, l, m) = \text{FALSE} \text{ and } \text{frwrd\_day}(k, l, m) = \text{FALSE} \),

test whether the ratio of pixels with valid 3.7 µm data in the two views is greater or less than the threshold value and use the appropriate (two or three channel) SST algorithm. The 3.7 micron channel is valid if

\[ \text{float}\{M(ir_{37}, n; 0, 0, k, l, m) + M(ir_{37}, f; 0, 0, k, l, m)\} / \text{float}\{M(ir_{11}, n; 0, 0, k, l, m) + M(ir_{11}, f; 0, 0, k, l, m)\} \geq \text{IR37\_THRESH}. \]

Otherwise use the two-channel algorithm. The two-channel algorithm is always used for day-time data, defined by the condition

\( \text{nadir\_day}(k, l, m) = \text{TRUE} \text{ or } \text{frwrd\_day}(k, l, m) = \text{TRUE} \).

(Req 4.13-10)

**Step 4.13.3.3**
Calculate the averaged SST using the dual-view retrieval coefficients for the appropriate across-track band given by $j = \text{map(across\_track\_mean(0; k, l, m)}$ and for the two or three channel algorithm as appropriate, for each latitude zone.

(Req 4.13-11)

Step 4.13.3.3.1

Perform this step if the 3.7 micron channel is not available for use.

The algorithm using both views is given by

$$T_{\text{sst},i}^{\text{dual}} = 100.0c_0 + c_1T_{\mu_1}^{\text{nadir}} + c_2T_{\mu_2}^{\text{nadir}} + c_3T_{\mu_3}^{\text{frwrd}} + c_4T_{\mu_3}^{\text{frwrd}}$$  (Req 4.13-12)

where

$$c_q = c(i, j, q).$$

Set

$$\text{dual\_asst\_uses\_ir37}(k, l, m) = \text{FALSE}$$

(Req 4.13-12.1)

Step 4.13.3.3.2

Perform this step if the 3.7 micron channel is to be used.

$$T_{\text{sst},i}^{\text{dual}} = 100.0d_0 + d_1T_{\mu_1}^{\text{nadir}} + d_2T_{\mu_2}^{\text{nadir}} + d_3T_{\mu_3}^{\text{frwrd}} + d_4T_{\mu_3}^{\text{frwrd}} + d_5T_{\mu_3}^{\text{frwrd}}$$  (Req 4.13-13)

where

$$d_q = d(i, j, q).$$

Set

$$\text{dual\_asst\_uses\_ir37}(k, l, m) = \text{TRUE}$$

(Req 4.13-13.1)

Step 4.13.3.4

Return latitude-corrected SST (with linear interpolation).

If $\text{abs(latitude)} < \text{TROPICAL\_INDEX}$ then

$$T_{\text{-_ dual}}(k, l, m) = T_{\text{sst,0}}^{\text{dual}}$$  (Req 4.13-14)

If $\text{TROPICAL\_INDEX} \leq \text{abs(latitude)} < \text{TEMPERATE\_INDEX}$, the final value for the retrieved sst is given by

$$T_{\text{-_ dual}}(k, l, m) = T_{\text{sst,0}}^{\text{dual}} + w \cdot (T_{\text{sst,1}}^{\text{dual}} - T_{\text{sst,0}}^{\text{dual}})$$  (Req 4.13-15)

where

$$w = \frac{(\text{abs(latitude)} - \text{TROPICAL\_INDEX})}{(\text{TEMPERATE\_INDEX} - \text{TROPICAL\_INDEX})}$$
If the TEMPERATE_INDEX ≤ abs(latitude) < POLAR_INDEX the but not less than, the final value for the retrieved SST is given by

\[ T_{\text{dual}}(k,l,m) = T_{\text{sst,1}}^{\text{dual}} + w \cdot (T_{\text{sst,2}}^{\text{dual}} - T_{\text{sst,1}}^{\text{dual}}) \]  

(Req 4.13-16)

where

\[ w = \frac{(\text{abs(latitude)} - \text{TEMPERATE_INDEX})}{(\text{POLAR_INDEX} - \text{TEMPERATE_INDEX})} \]

If POLAR_INDEX ≤ abs(latitude)

\[ T_{\text{dual}}(k,l,m) = T_{\text{sst,2}}^{\text{dual}} \]  

(Req 4.13-17)

**Step 4.13.4**

From up to nine 17 km cells within the 50 km cell, derive the mean nadir view SST for the 50 km cell, and the standard deviation of the 17 km SST values. Repeat for the dual-view retrieval. That is

\[ T_{\text{nadir}}(l,m) = \frac{1}{\mu_1} \sum_k T_{\text{nadir}}(k,l,m) \]

\[ T_{\text{dual}}(l,m) = \frac{1}{\mu_2} \sum_k T_{\text{dual}}(k,l,m) \]  

(Req 4.13-18)

where in each case the sum is over all values of k for which the respective sub-cell temperature is valid (i.e. has a positive value), and where \( \mu_1 \) and \( \mu_2 \) are the numbers of such valid temperatures in the nadir and forward views respectively. If either of the values \( \mu_1 \) or \( \mu_2 \) is zero, set the corresponding temperature to \(-1\).

The mean across-track pixel number to be associated with the 50 km SST is \([L2-INT-469]\)

\[ sst\_mean\_pixel(0; l, m) = \frac{1}{\mu_1} \sum_k \text{across}\_track\_mean(0; k, l, m) \text{ if } \mu_1 > 0 \]

\[ sst\_mean\_pixel(0; l, m) = -1 \text{ if } \mu_1 = 0 \]

where the sum is over all \( k \in \{0 \leq k \leq 8\} \) for which corresponding SST \( T_{\text{nadir}}(k, l, m) \) is valid (not equal to \(-1\)).

**Step 4.13.5 Prepare the confidence flag word for the cell.**

The confidence flag word for the sub-cell indexed by \( (k, l, m) \) should be prepared as follows:

- Set bit 0 if 3-channel algorithm was used at Step 4.13.2.2.2, i.e. if \( \text{nadir\_asst\_uses\_ir37}(k, l, m) = \text{TRUE} \), otherwise clear bit.

- Set bit 1 if 3-channel algorithm was used at Step 4.13.2.3.2, i.e. if \( \text{dual\_asst\_uses\_ir37}(k, l, m) = \text{TRUE} \), otherwise clear bit.

- Set bit 2 if \( \text{nadir\_day}(k, l, m) \) from §4.12.3 is TRUE, otherwise clear bit.
Set bit 3 if \( frwd\_day(k, l, m) \) from §4.12.3 is TRUE, otherwise clear bit.

The confidence flag word for the half-degree cell indexed by \( l, m \) will be derived by ORing together the words for those sub-cells \((k, l, m), k = 0, \ldots, 8\), for which a valid temperature was derived.

(Req 4.13-19)

### 4.14 Module Definition: Averaged LST and NDVI Retrieval (50 km Cell)

#### 4.14.1 Functional Description

The Land Surface Temperature (LST) and Normalised Difference Vegetation Index (NDVI) are calculated for each sub-cell for which average reflectances over land have been calculated. The averaged LST and NDVI over all the subcells, and their standard deviation, are also computed.

#### 4.14.2 Interface Definition

<table>
<thead>
<tr>
<th>Parameter ID</th>
<th>Variable</th>
<th>Name</th>
<th>Type</th>
<th>Units</th>
<th>Field size</th>
<th>Fields</th>
</tr>
</thead>
<tbody>
<tr>
<td>L2-AUX3-14</td>
<td>NADIR_PIXELS_THRESH</td>
<td>float</td>
<td>none</td>
<td>4</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>L2-AUX5-1</td>
<td>Coefficient A0 (day-time) for LST</td>
<td>float</td>
<td>K</td>
<td>4</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>L2-AUX5-2</td>
<td>Coefficient A1 (day-time) for LST</td>
<td>float</td>
<td>none</td>
<td>4</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>L2-AUX5-3</td>
<td>Coefficient A2 (day-time) for LST</td>
<td>float</td>
<td>none</td>
<td>4</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>L2-AUX5-4</td>
<td>Coefficient A0 (night-time) for LST</td>
<td>float</td>
<td>K</td>
<td>4</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>L2-AUX5-5</td>
<td>Coefficient A1 (night-time) for LST</td>
<td>float</td>
<td>none</td>
<td>4</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>L2-AUX5-6</td>
<td>Coefficient A2 (night-time) for LST</td>
<td>float</td>
<td>none</td>
<td>4</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>L2-AUX6-1</td>
<td>Vegetation class index ([360][720]) for LST</td>
<td>ss</td>
<td>n/a</td>
<td>2</td>
<td>720</td>
<td></td>
</tr>
<tr>
<td>L2-AUX7-1</td>
<td>Vegetation fraction([12][360][720])</td>
<td>ss</td>
<td>0.001</td>
<td>2</td>
<td>720</td>
<td></td>
</tr>
<tr>
<td>L2-AUX8-1</td>
<td>Precipitable water([12][360][720])</td>
<td>ss</td>
<td>0.01 mm</td>
<td>2</td>
<td>720</td>
<td></td>
</tr>
<tr>
<td>L2-AUX9-1</td>
<td>Topographic Variance Flag([360][720])</td>
<td>ss</td>
<td>n/a</td>
<td>2</td>
<td>720</td>
<td></td>
</tr>
<tr>
<td>L2-AUX10-1</td>
<td>( d ) Water vapour factor for LST retrieval</td>
<td>float</td>
<td>none</td>
<td>4</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>L2-AUX10-2</td>
<td>( m ) Angle factor for LST retrieval</td>
<td>ss</td>
<td>none</td>
<td>2</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>L2-AUX10-3</td>
<td>N_CLASS Number of vegetation classes for LST</td>
<td>ss</td>
<td>none</td>
<td>2</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

**Table 4.14-1: Input Data Table - LST Retrieval LUTs and auxiliary parameters**

<table>
<thead>
<tr>
<th>Parameter ID</th>
<th>Variable</th>
<th>Name</th>
<th>Type</th>
<th>Units</th>
<th>Field size</th>
<th>Fields</th>
</tr>
</thead>
<tbody>
<tr>
<td>k</td>
<td>sub-cell number ( k = 0, \ldots, 8 )</td>
<td>si</td>
<td>none</td>
<td>4</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>l</td>
<td>along-track 50 km cell index</td>
<td>si</td>
<td>none</td>
<td>4</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>m</td>
<td>across-track 50 km cell index</td>
<td>si</td>
<td>none</td>
<td>4</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>L2-INT-69</td>
<td>( A(v870, n; 0, k, l, m) ) sub-cell reflectance average, 0.87 micron channel, nadir view, clear, land</td>
<td>ss</td>
<td>0.01%</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L2-INT-67</td>
<td>( M(v870, n; 0, 0, k, l, m) ) sub-cell pixel count, 0.87 micron channel, nadir view, clear, land</td>
<td>ss</td>
<td>none</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L2-INT-69</td>
<td>( A(v670, n; 0, k, l, m) ) sub-cell reflectance average, 0.670 micron channel, nadir view, clear, land</td>
<td>ss</td>
<td>0.01%</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L2-INT-67</td>
<td>( M(v670, n; 0, 0, k, l, m) ) sub-cell pixel count, 0.670 micron channel, nadir view, clear, land</td>
<td>ss</td>
<td>none</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L2-INT-95</td>
<td>( \text{NDVI}(k, l, m) ) Averaged NDVI in 10-arcmin cells</td>
<td>ss</td>
<td>0.0001</td>
<td>2</td>
<td>( k = 0, 8 )</td>
<td></td>
</tr>
<tr>
<td>L2-INT-96</td>
<td>( &lt;\text{NDVI}(l, m) ) mean NDVI</td>
<td>ss</td>
<td>0.0001</td>
<td>2</td>
<td>per cell</td>
<td></td>
</tr>
<tr>
<td>L2-INT-97</td>
<td>( \sigma(\text{NDVI}, l, m) ) standard deviation of NDVI</td>
<td>ss</td>
<td>0.0001</td>
<td>2</td>
<td>per cell</td>
<td></td>
</tr>
<tr>
<td>local ( \mu )</td>
<td>number of sub-cells contributing to cell mean</td>
<td>si</td>
<td>none</td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L2-INT-98</td>
<td>( N(l, m) ) Number of pixels in NDVI average, half degree cell</td>
<td>us</td>
<td>none</td>
<td>2</td>
<td>per cell</td>
<td></td>
</tr>
<tr>
<td>L2-INT-99</td>
<td>N(k, l, m)</td>
<td>Number of pixels in NDVI average, 10 arc min cells</td>
<td>us</td>
<td>none</td>
<td>2</td>
<td>k = 0, 8</td>
</tr>
<tr>
<td>L2-INT-464</td>
<td>ast_conf(1; k, l, m)</td>
<td>AST confidence word for land sub-cell</td>
<td>sl</td>
<td>flags</td>
<td>4</td>
<td>k = 0, 8</td>
</tr>
<tr>
<td>L2-INT-465</td>
<td>ast_conf(1; l, m)</td>
<td>AST confidence word for land cell l, m</td>
<td>sl</td>
<td>flags</td>
<td>4</td>
<td>per cell</td>
</tr>
</tbody>
</table>

The following parameters are required by the Land Surface Temperature algorithm:

| L2-INT-26 | time(sg) | scan UTC | double | days | 8 | per sg |
| L2-INT-77 | cell_lat[i], m | cell latitude (50 km) | sl | μdeg | 4 | per cell |
| L2-INT-78 | cell_long[i], m | cell longitude (50 km) | sl | μdeg | 4 | per cell |
| L2-INT-470 | vegetation_fraction(lat_index, lon_index) | vegetation fraction | ss | none | 2 | 360 × 720 |
| L2-INT-471 | precipitable_water(lat_index, lon_index) | Precipitable Water | ss | 0.001 | 4 | 360 × 720 |
| L2-INT-472 | Topographic_flag(lat_index, lon_index) | Topographic Flag | ss | none | 2 | 360 × 720 |
| L2-INT-474 | lat_index | Latitude index | sl | none | 4 | 1 |
| L2-INT-475 | lon_index | Longitude index | lon_index | sl | none | 4 | 1 |
| L2-INT-489 | disp_lat_index | Displaced latitude index | = 0, …359 | sl | none | 4 | 1 |
| L2-INT-490 | disp_lon_index | Displaced longitude index | = 0, 719 | sl | none | 4 | 1 |
| L2-INT-476 | month | Index to month: month = 0, 11 | sl | none | 4 | 1 |
| L2-INT-477 | sun_elev | Solar elevation at land pixel | float | degrees | 4 | 1 |
| L2-INT-478 | sat_elev | Satellite elevation at land pixel | float | degrees | 4 | 1 |
| L2-INT-479 | night | Daynight flag | sl | none | 2 | 1 |
| L2-INT-480 | n | Non-linear exponent | float | none | 4 | 1 |
| L2-INT-481 | f | Vegetation fraction at pixel | float | none | 4 | 1 |
| L2-INT-482 | pw | Precipitable water at pixel | float | cm | 4 | 1 |
| L2-INT-482 | coeff(class, i, j, 0) | Sub-array of coefficients A0 | float | 0.01K | 4 | 64 |
| L2-INT-484 | coeff(class, i, j, 1) | Sub-array of coefficients A1 | float | none | 4 | 64 |
| L2-INT-485 | coeff(class, i, j, 2) | Sub-array of coefficients A2 | float | none | 4 | 64 |
| L2-INT-486 | w | Interpolation weight | float | none | 4 | 1 |
| L2-INT-487 | a(k) | Retrieval coefficients for pixel | float | mixed | 4 | 1 |
| L2-INT-486 | lst | Land surface temperature at pixel | float | 0.01K | 4 | 1 |
| Local | lst | Land surface temperature at pixel | float | 0.01K | 4 | 1 |
| Local | pw00 | Precipitable water sample value | ss | 0.01 mm | 2 | 1 |
| Local | pw01 | Precipitable water sample value | ss | 0.01 mm | 2 | 1 |
| Local | pw10 | Precipitable water sample value | ss | 0.01 mm | 2 | 1 |
| Local | pw11 | Precipitable water sample value | ss | 0.01 mm | 2 | 1 |
| Local | q | Latitude argument for bilinear interpolation | float | none | 4 | 1 |
| Local | p | Longitudinal argument for bilinear interpolation | float | none | 4 | 1 |
| Local | class | Index to table of coefficients | sl | none | 4 | 1 |
| Local | latitude | Temporary latitude value | float | Degrees | 4 | 1 |
| Local | minpn | Minimum nadir pixels | float | none | 4 | 1 |
| Local | xx | Sub-cell index in longitude | sl | none | 4 | 1 |
| Local | ky | Sub-cell index in latitude | sl | none | 4 | 1 |
| L2-INT-62 | sub_cell_lat(k, l, m) | Sub-cell latitude (17 km) | sl | μdeg | 4 | k = 0, 8 |
| L2-INT-79 | nadir_day(k, l, m) | nadir view day/night flag (17 km) | ss | flag | 2 | k = 0, 8 |
| L2-INT-80 | forward_day(k, l, m) | forward view day/night flag (17 km) | ss | flag | 2 | k = 0, 8 |
| L2-INT-60 | band(i) | Number of across track band (or strip) | sl | none | 4 | j = 0, 511 |
| L2-INT-121 | across_track_mean(of, k, l, m) | mean across-track pixel index, subcell k | ss | none | 2 | k = 0, 8 |
| L2-INT-459 | sub_cell_index(k, l, m) | Along-track index representative of sub-cell | sl | none | 4 | k = 0, 8 |
| L2-INT-496 | T_land(k, l, m) | Land surface temperature in sub-cell | ss | 0.01 K | 4 | k = 0, 8 |
| L2-INT-497 | T_land(i, m) | Averaged land surface temperature in cell | ss | 0.01 K | 4 | per cell |
| L2-INT-498 | σ_land(i, m) | Standard deviation of Averaged LST | ss | 0.01 K | 4 | per cell |
| L2-INT-484 | ast_conf(k, l, m) | AST confidence word for sub-cell | sl | flags | 4 | k = 0, 8 |
| L2-INT-465 | ast_conf(i, l, m) | AST confidence word for cell | sl | flags | 4 | per cell |
| L2-INT-469 | stl_mean_pixel(of, i, m) | Mean across-track pixel index, cell | ss | none | 2 | per cell |

**Table 4.14-2: Internal Data Table - Averaged NDVI Retrieval**
4.14.3 Detailed Structure

The following processing is applied to cells after the processing of Step 4.12.1 is complete; i.e. no more pixels remain to be added to the cell.

**Step 4.14.1 Calculate subcell NDVIs.**

NDVI is defined by

\[ \text{NDVI}(k, l, m) = 10000 \frac{A(v870, n;1,0, k, l, m) - A(v670, n;1,0, k, l, m)}{A(v870, n;1,0, k, l, m) + A(v670, n;1,0, k, l, m)} \]

provided both values are valid (not exceptional). Otherwise

\[ \text{NDVI}(k, l, m) = -19999. \]

The number of pixels contributing to the sub-cell mean, \( N1(k, l, m) \), provided as a confidence indicator, is the smaller of \( M(v870, n; 1, 0, k, l, m) \) and \( M(v670, n; 1, 0, k, l, m) \).

**Step 4.14.2 Calculate cell NDVI.**

The mean in the larger (50 km) cell is given by

\[ \langle \text{NDVI} \rangle(l,m) = \frac{1}{\mu} \sum_k \text{NDVI}(k,l,m) \]

where the sum is over all \( k \in \{0 \leq k \leq 8\} \) having a valid subcell mean \( \text{NDVI} \) and \( \mu \) is the number of such valid means. The number of pixels that contribute to the mean is similarly the smaller of \( M(v870, n; 1, 0, l, m) \) and \( M(v670, n; 1, 0, l, m) \).

The standard deviation of the mean is

\[ \sigma(\text{NDVI};l,m) = \left\{ \frac{1}{\mu - 1} \sum_k \left( \text{NDVI}(k,l,m) - \langle \text{NDVI} \rangle(l,m) \right)^2 \right\}^{1/2} \]

in all cases the sum is over sub-cells having valid means.

If the number of valid subcell means \( \mu \) is zero, set

\[ <\text{NDVI}> (l, m) = -19999. \]

If the number of valid subcell means \( \mu \leq 1 \), so that a valid standard deviation cannot be calculated, set set

\[ \sigma(\text{NDVI};l,m) = -19999. \]

**Step 4.14.3 Read in coefficients and auxiliary tables for LST retrieval.**

The coefficients for LST retrieval are identical to those used for the full resolution product, as read in in Step 4.6.1.2 (Section 4.6.3). If these coefficients are still available in the processor, there is no need to repeat the following steps.
Step 4.14.3.1 Read in coefficients

For each of the \( N_{\text{CLASS}} \) vegetation classes there are two records, for vegetation and for bare soil. Open the file of retrieval coefficients L2-AUX5.

The LST coefficient set is read in as follows.

for \( class = 0, N_{\text{CLASS}} - 1 \) (outer loop)
for \( i = 0, 1 \) (inner loop)

\[
\begin{align*}
\text{coeff}(class, i, 0, 0) &= [\text{L2-AUX5-1}] \\
\text{coeff}(class, i, 0, 1) &= [\text{L2-AUX5-2}] \\
\text{coeff}(class, i, 0, 2) &= [\text{L2-AUX5-3}] \\
\text{coeff}(class, i, 1, 0) &= [\text{L2-AUX5-4}] \\
\text{coeff}(class, i, 1, 1) &= [\text{L2-AUX5-5}] \\
\text{coeff}(class, i, 1, 2) &= [\text{L2-AUX5-6}]
\end{align*}
\]

(Req 4.14-5)

Step 4.14.3.2 Determine month index

Using a suitable calendar function, determine the month \((month = 0, \ldots 11)\) in which the data was collected from the scan time of start of data \(\text{time}(0) = [\text{L2-INT-26}](0)\):

\[
\text{month} = \text{month}(\text{time}(0))
\]

(Req 4.14-6)

Step 4.14.3.3 Read in auxiliary files

Note that in the cases of data sets L2-AUX7 and L2-AUX8 only one plane of data, that corresponding to the current month, is required in memory for a given run of the processor.

Read in Vegetation Class Index: Open the vegetation class file L2-AUX6.

for each latitude index \( i = 0, 359 \)

\[
\text{vegetation_class}(i, j) = [\text{L2-AUX6-1}](j) \text{ for all } j \text{ of record } i.
\]

(Req 4.14-7)

Read in Vegetation Fraction Table: Open the file of vegetation fraction data L2-AUX7.

for each latitude index \( i = 0, 359 \)

select record \((360 \times \text{month} + i)\)

\[
\text{vegetation_fraction}(i, j) = [\text{L2-AUX7-1}](j) \text{ for all } j \text{ of selected record}.
\]

(Req 4.14-8)

Read in Precipitable Water Data: Open the file of precipitable water data L2-AUX8.

for each latitude index \( i = 0, 359 \)

select record \((360 \times \text{month} + i)\)

\[
\text{precipitable_water}(i, j) = [\text{L2-AUX8-1}](j) \text{ for all } j \text{ of selected record}.
\]

(Req 4.14-9)

Read in Topographic Variance Flag: Open the file of topographic variance flags L2-AUX9.

for each latitude index \( i = 0, 359 \)

\[
\text{topographic_flag}(i, j) = [\text{L2-AUX9-1}](j) \text{ for all } j \text{ of record } i.
\]

(Req 4.14-10)
Step 4.14.4 Derive Land Surface Temperature for sub-cells

LST retrievals use the nadir view 11 and 12 micron channels in conjunction with retrieval coefficients derived from the tables.

Note that as in Section 4.13 we adopt an abbreviated notation for the average brightness temperatures in this section.

\[ T_{\text{nadir}}^{ch, sf} = \frac{\text{float}(S(ch, n; sf, 0, k, cell))}{\text{float}(M(ch, n; sf, 0, k, cell))} \]

where \( ch \) indicates one of the long-wavelength infra-red channels, and where \( sf \) is the surface type flag. This notation is slightly more complex than that used in Section 4.13 because it is necessary to distinguish between land and sea averages. Where this notation is used, a dependence on \( k \) and \( l, m \) is implied. As in section 4.13, these quantities must be computed using a floating point computation, although \( S \) and \( M \) are of type integer, to ensure that sufficient precision is maintained.

The calculation proceeds as follows for each cell in turn. Steps 4.14.4.1 to 4.14.4.5 are repeated for each sub-cell \( k = 0, \ldots 8 \) of the cell.

Step 4.14.4.1 Determine latitude and longitude indices

For the current sub-cell \( k \), calculate

\[
\begin{align*}
\text{lat\_index} &= \text{integer part of } \left[ \text{cell}_{\text{lat}}(l, m)/500000.0 \right] + 180 \\
\text{lon\_index} &= \text{integer part of } \left[ \text{cell}_{\text{lon}}(l, m)/500000.0 \right] + 360 \\
\text{disp\_lat\_index} &= \text{integer part of } \left[ 360 + \left( \text{cell}_{\text{lat}}(l, m)/500000.0 + 180.0 \right) - 0.5 \right] \text{ (modulo 360)} \\
\text{disp\_lon\_index} &= \text{integer part of } \left[ 720 + \left( \text{cell}_{\text{lon}}(l, m)/500000.0 + 360.0 \right) - 0.5 \right] \text{ (modulo 720)}
\end{align*}
\]

(Req 4.14-11)

(Req 4.14-12)

Extract the vegetation class for the cell:

\[ \text{class} = \text{vegetation\_class(lat\_index, lon\_index)} \]

(Req 4.14-13)

Step 4.14.4.2 Test for valid data

For each sub-cell \( k = 0, \ldots 8 \), if either the 11 or 12 micron brightness temperature in the nadir view is invalid, the calculation is abandoned, and the LST is set to -1. The criterion for invalid data is the same as that used for the SST processing, as follows.

Determine the minimum number of pixels required for the cell, for the nadir view.

\[ \text{minpn} = 340 \times \text{NADIR\_PIXELS\_THRESH} + 1.0 \]

(Req 4.14-14)

Identify whether the land or ‘sea’ brightness temperatures are required. Inland lakes are flagged as sea in the current land/sea data-base, so must be treated accordingly.

If \( \text{class} = 14 \) then \( sf = 0 \) (sea) otherwise \( sf = 1 \) (land).
If $M(ir_{12}, n; sf, 0, k, l, m) \geq minpn$ and $M(ir_{11}, n; sf, 0, k, l, m) \geq minpn$ proceed to calculate the retrieved LST as below, otherwise set

$$T_{land}(k, l, m) = -1.0$$

(Req 4.14-15)

If the 11 and 12 micron nadir brightness temperatures are valid, Steps 4.14.4.3 to 4.14.4.5 are to be repeated for each sub-cell $k = 0, \ldots 8$ in the cell.

**Step 4.14.4.3 Determine day/night flag, satellite elevation and non-linear exponent**

If $view\_day(k, l, m) = TRUE$ then

$$night = 0 \text{ otherwise } night = 1$$

(Req 4.14-16)

A linear interpolation is used to determine the satellite elevation.

$$j = across\_track\_mean(1, k, l, m)$$
$$w = float(j - 6)/50.0 - band(j)$$
$$i = sub\_cell\_index(k, l, m)$$

$$sat\_elev = (1.0 - w) \times \text{nadir\_band\_edge\_satellite\_elevation}(i, band(j)) +$$
$$w \times \text{nadir\_band\_edge\_satellite\_elevation}(i, band(j) + 1)$$

(Req 4.14-17)

Calculate the non-linear exponent:

$$n = 1.0 / \cos(\pi \times (90 - sat\_elev) / (m \times 180.0))$$

(Req 4.14-18)

Note that $m$ is [L2-AUX10-2] and $n$ is [L2-INT-480].

**Step 4.14.4.4 Determine coefficients**

$$f = 0.001 \times vegetation\_fraction(lat\_index, lon\_index)$$

(Req 4.14-19)

Interpolate precipitable water:

$$pw00 = \text{precipitable\_water}(disp\_lat\_index, disp\_lon\_index)$$
$$pw01 = \text{precipitable\_water}(disp\_lat\_index+1, disp\_lon\_index)$$
$$pw10 = \text{precipitable\_water}(disp\_lat\_index, [disp\_lon\_index+1](modulo 720))$$
$$pw11 = \text{precipitable\_water}(disp\_lat\_index+1, [disp\_lon\_index+1](modulo 720))$$

(Req 4.14-20)

$$q = \text{fractional part of } [(cell\_lat(l, m)/500000.0) + 180.0 + 0.5]$$
$$p = \text{fractional part of } [(cell\_lon(l, m)/500000.0) + 360.0 + 0.5]$$

$$pw = 0.001 \times ((1 - p)(1 - q)pw00 + (1 - p)q \times pw01 + p(1 - q)pw10 + pq \times pw11)$$

(Req 4.14-21)

$$\text{class} = \text{vegetation\_class(lat\_index, lon\_index)} - 1$$
Step 4.14.4.5 Calculate the land surface temperature.

Note that the surface flag index retains the value assigned in Step 4.14.2.

If \( n \) is out of range then set the land field to an exception value of -1.0.

If \( \text{class} \leq 0 \) or \( \text{class} > \text{NCLASS} - 1 \), then the index is out of range; the calculation for this sub-cell is abandoned and the nadir field should be set to an exception value of 1.0.

\[
T_{\text{land}}(k, l, m) = \begin{cases} 
100 \times (a(0) + d(0) \times (T_{\text{nadir}} - T_{\text{min}})) + 27315 & \text{if } T_{\text{nadir}} > T_{\text{min}} \\
100 \times (a(0) + d(0) \times (T_{\text{nadir}} - T_{\text{min}})) + 27315 + 27315 & \text{otherwise} 
\end{cases}
\]

Otherwise if \( \text{class} > 14 \), this cell is flagged as an inland lake in the vegetation class database. The exponent \( n \) and the precipitable water correction are not used, and the correct brightness temperature average to be used is that for pixels flagged as sea. Set \( n = 1.0 \).

Otherwise if \( \text{class} + 1 \neq 14 \), correct \( a(0) \) as follows:

\[
a(0) = a(0) + d \times (\cot(\pi \times \text{sat}_elev} / 180.0) - 1.0) \times \text{pw}
\]

Note that \( d \) is \([L2 - AUX10 - 1] \).

Step 4.14.4.6 Calculate the land surface temperature.

Note that the surface flag index retains the value assigned in Step 4.14.2.

If \( \text{nadir}_{\text{sfir}}(k, l, m) \) from §4.12.3 is TRUE, otherwise clear bit.

Set bit 2 if \( \text{nadir}_{\text{day}}(k, l, m) \) from §4.12.3 is TRUE, otherwise clear bit.

Set appropriate bits on AST confidence word \( \text{ast}_{\text{conf}}(1; k, l, m) \):

Set bit 3 if \( \text{frwrd}_{\text{day}}(k, l, m) \) from §4.12.3 is TRUE, otherwise clear bit.

Set bits 4 and 5 to the topographic variance flags:

\[
[a_{\text{conf}}(1; k, l, m)](\text{bits } 4:5) = \text{topographic flag}(\text{lat_index, lon_index})
\]
(Note that this is a two-bit flag.)

Trap for lst out of range:

If \( \text{lst} \geq 32767.5 \) then

\[
T_{\text{land}}(k, l, m) = -1
\]

Else

\[
T_{\text{land}}(k, l, m) = \text{integer part of } (\text{lst} + 0.5)
\]

**(Step 4.14.5 Calculate 50 km average)**

For up to nine 17 km cells within the 50 km cell, derive the mean LST \([L2\text{-INT}-497]\) for the 50 km cell, and the standard deviation \([L2\text{-INT}-498]\) of the 17 km LST values.

\[
T_{\text{land}}(l, m) = \frac{1}{\mu} \sum_{k} T_{\text{land}}(k, l, m)
\]

where the sum is over all values of \( k \) for which the respective sub-cell LST is valid (i.e. has a positive value), and where \( \mu \) is the number of valid temperatures. If \( \mu \) is zero, set the corresponding temperature to \(-1\). To calculate the standard deviation \([L2\text{-INT}-498]\) use an expression analogous to Req 4.14-3.

The mean across-track pixel number to be associated with the 30 arc minute LST is \([L2\text{-INT}-469]\)

\[
sst_{\text{mean\_pixel}}(1; l, m) = \frac{1}{\mu} \sum_{k} \text{across\_track\_mean}(1; k, l, m) \quad \text{if } \mu > 0
\]

\[
sst_{\text{mean\_pixel}}(1; l, m) = -1 \quad \text{if } \mu = 0
\]

where the sum is over all \( k \in \{0 \leq k \leq 8\} \) for which corresponding LST \( T_{\text{land}}(k, l, m) \) is valid (not equal to \(-1\)).

Derive the confidence flag word \( \text{ast\_conf}(1; l, m) \) for the 50 km cell indexed by \( l, m \) by ORing together the words for those sub-cells \((k, l, m), k = 0, \ldots 8\), for which a valid temperature was derived.

**(Req 4.14-34)**

### 4.15 Module Definition: Spatially Averaged Cloud Parameters (50 km Cell)

#### 4.15.1 Functional Description

This module is to provide physical information on the cloud state additional to the results of the cloud flagging provided by the cloud clearing algorithms. The product is based on the same half-degree cells defined above. The frequency distribution of brightness temperature for the cloudy pixels within the cell is given together with representative parameters and an estimate of the cloud-top temperature. The latter is interpreted as the mean brightness temperature of the coldest 25% of the cloudy pixels in the cell.
For each half-degree cell, information is given for the nadir and forward views separately. The information consists of the number of cloudy and cloud-free pixels falling within the cell, a histogram of the 11 micron brightness temperatures of the cloudy pixels, and various statistical parameters derived from the histogram. The 11 micron channel is used as the basis of the product following the practice of ATSR and ATSR-2.

The product is generated as follows. Two histograms are generated of the frequency distribution of 11 micron brightness temperature, for cloudy pixels over sea and land respectively. The histograms represent the brightness temperature at 0.1 K resolution between 190 K and 290 K. Thus each contains 1000 bins where the first bin contains the number of pixels with temperatures in the range 190.0 to 190.1 K, and the last bin contains the number of pixels with temperatures in the range 289.9 to 290.0 K. The cloud state of each filled pixel falling within the cell is inspected. If it is clear, a count of the number of clear pixels is incremented; if it is cloudy, the 11 micron channel BT is inspected and the count in the appropriate histogram bin is incremented. Note that cosmetic fill pixels are included in the processing.

As each pixel is inspected, a test is made to determine whether its 11 micron BT is lower than the lowest value previously encountered, and if so to store the location of the pixel. Then when the histogram is complete the identity of the minimum pixel will be known, and can be used to extract its channel values.

Once the histogram is complete for a given cell, that is once all the pixels falling within the cell have been inspected, the cloud temperature and coverage results are derived from it. Firstly the total number of cloudy pixels detected is computed by summing the histogram samples. If this total is less than 20 no further derivations are performed. If 20 or more cloudy pixels have been identified and included in the histogram, the mean 11 micron brightness temperature and its standard deviation are calculated from the histogram.

The histogram is searched for the lowest temperature represented by the histogram. This is the temperature corresponding to the first non-zero bin of the histogram. Next, the cloud-top temperature is estimated. The histogram bin containing the 25th percentile is identified; this is the first bin (as the histogram is searched in the direction of ascending temperature) for which the cumulative total of the bins up to and including itself exceeds 25% of the total number of cloudy pixels. The mean temperature represented by the bins up to and including this bin is calculated.

[Note that the cloud top temperature so derived may represent the mean of slightly more than 25% of the cloudy pixels, since the cumulative total including the 25th percentile bin may exceed 25%.

Finally the percentage cloud cover is calculated from the ratio of cloudy pixels to total pixels.

### 4.15.2 Interface Definition

<table>
<thead>
<tr>
<th>Parameter ID</th>
<th>Variable</th>
<th>Name</th>
<th>Type</th>
<th>Units</th>
<th>Field size</th>
<th>Fields</th>
</tr>
</thead>
<tbody>
<tr>
<td>L2-AUX3-10</td>
<td>AST Cell dimension</td>
<td>si</td>
<td>none</td>
<td>4</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

Table 4-15-1: Input Data Table - Spatially Averaged Cloud Parameters (50 km Cell)
### ENVISAT PAYLOAD DATA SEGMENT

#### Commercial in Confidence

**AATSR Expert Support Laboratory**

<table>
<thead>
<tr>
<th>Parameter ID</th>
<th>Variable</th>
<th>Name Description</th>
<th>Type</th>
<th>Units</th>
<th>Field Size</th>
<th>Fields</th>
</tr>
</thead>
<tbody>
<tr>
<td>L2-INT-101</td>
<td>llir12, n, i, j</td>
<td>regridded nadir ir12 Brightness Temperature</td>
<td>ss</td>
<td>0.01K</td>
<td>2</td>
<td>j = 0, 511</td>
</tr>
<tr>
<td>L2-INT-102</td>
<td>llir11, n, i, j</td>
<td>regridded nadir ir11 Brightness Temperature</td>
<td>ss</td>
<td>0.01K</td>
<td>2</td>
<td>j = 0, 511</td>
</tr>
<tr>
<td>L2-INT-103</td>
<td>llir07, n, i, j</td>
<td>regridded nadir ir07 Brightness Temperature</td>
<td>ss</td>
<td>0.01K</td>
<td>2</td>
<td>j = 0, 511</td>
</tr>
<tr>
<td>L2-INT-104</td>
<td>llv16, n, i, j</td>
<td>regridded nadir v16 Reflectance</td>
<td>ss</td>
<td>0.01%</td>
<td>2</td>
<td>j = 0, 511</td>
</tr>
<tr>
<td>L2-INT-105</td>
<td>llv070, n, i, j</td>
<td>regridded nadir v070 Reflectance</td>
<td>ss</td>
<td>0.01%</td>
<td>2</td>
<td>j = 0, 511</td>
</tr>
<tr>
<td>L2-INT-106</td>
<td>llv070, n, i, j</td>
<td>regridded nadir v070 Reflectance</td>
<td>ss</td>
<td>0.01%</td>
<td>2</td>
<td>j = 0, 511</td>
</tr>
<tr>
<td>L2-INT-107</td>
<td>llv055, n, i, j</td>
<td>regridded nadir v055 Reflectance</td>
<td>ss</td>
<td>0.01%</td>
<td>2</td>
<td>j = 0, 511</td>
</tr>
<tr>
<td>L2-INT-111</td>
<td>llir12, f, i, j</td>
<td>regridded forward ir12 Brightness Temperature</td>
<td>ss</td>
<td>0.01K</td>
<td>2</td>
<td>j = 0, 511</td>
</tr>
<tr>
<td>L2-INT-112</td>
<td>llir11, f, i, j</td>
<td>regridded forward ir11 Brightness Temperature</td>
<td>ss</td>
<td>0.01K</td>
<td>2</td>
<td>j = 0, 511</td>
</tr>
<tr>
<td>L2-INT-113</td>
<td>llir07, f, i, j</td>
<td>regridded forward ir07 Brightness Temperature</td>
<td>ss</td>
<td>0.01K</td>
<td>2</td>
<td>j = 0, 511</td>
</tr>
<tr>
<td>L2-INT-114</td>
<td>llv16, f, i, j</td>
<td>regridded forward v16 Reflectance</td>
<td>ss</td>
<td>0.01%</td>
<td>2</td>
<td>j = 0, 511</td>
</tr>
<tr>
<td>L2-INT-115</td>
<td>llv070, f, i, j</td>
<td>regridded forward v070 Reflectance</td>
<td>ss</td>
<td>0.01%</td>
<td>2</td>
<td>j = 0, 511</td>
</tr>
<tr>
<td>L2-INT-116</td>
<td>llv055, f, i, j</td>
<td>regridded forward v055 Reflectance</td>
<td>ss</td>
<td>0.01%</td>
<td>2</td>
<td>j = 0, 511</td>
</tr>
<tr>
<td>L2-INT-100</td>
<td>nadir_f1_state(i, j)</td>
<td>nadir fill state indicator</td>
<td>byte</td>
<td>none</td>
<td>1</td>
<td>j = 0, 511</td>
</tr>
<tr>
<td>L2-INT-110</td>
<td>fwdr_f1_state(i, j)</td>
<td>forward fill state indicator</td>
<td>byte</td>
<td>none</td>
<td>1</td>
<td>j = 0, 511</td>
</tr>
<tr>
<td>L2-INT-232</td>
<td>nadr_land(i, j)</td>
<td>nadir land/sea flag</td>
<td>ss</td>
<td>array</td>
<td>flag 2</td>
<td>j = 0, 511</td>
</tr>
<tr>
<td>L2-INT-233</td>
<td>nadr_cloud(i, j)</td>
<td>nadir cloud state flag</td>
<td>ss</td>
<td>array</td>
<td>flag 2</td>
<td>j = 0, 511</td>
</tr>
<tr>
<td>L2-INT-248</td>
<td>fwdr_land(i, j)</td>
<td>forward land/sea flag</td>
<td>ss</td>
<td>array</td>
<td>flag 2</td>
<td>j = 0, 511</td>
</tr>
<tr>
<td>L2-INT-249</td>
<td>fwdr_cloud(i, j)</td>
<td>forward cloud state flag</td>
<td>ss</td>
<td>array</td>
<td>flag 2</td>
<td>j = 0, 511</td>
</tr>
<tr>
<td>L2-INT-160</td>
<td>image_lat(i, j)</td>
<td>image pixel latitude</td>
<td>float</td>
<td>degrees</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>L2-INT-161</td>
<td>image_long(i, j)</td>
<td>image pixel longitude</td>
<td>float</td>
<td>degrees</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>local K</td>
<td>k</td>
<td>histogram bin counter k = 0, 999</td>
<td>sl</td>
<td>none</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>local cell</td>
<td>cell</td>
<td>cell number</td>
<td>sl</td>
<td>none</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>(min(ch, v, sf, i, m)</td>
<td>brightness_temperature or reflectance, as appropriate, of channel ch, view v, for cloudy pixel having minimum 11 micron BT over surface type sf.</td>
<td>ss</td>
<td>0.01 K or 0.01%</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L2-INT-425</td>
<td>across_track_band</td>
<td>across-track band</td>
<td>ss</td>
<td>none</td>
<td>2</td>
<td>per cell</td>
</tr>
<tr>
<td>L2-INT-428</td>
<td>nadir_clear_land</td>
<td>total of clear land pixels, nadir view</td>
<td>sl</td>
<td>none</td>
<td>4</td>
<td>per cell</td>
</tr>
<tr>
<td>L2-INT-429</td>
<td>fwdr_clear_land</td>
<td>total of clear land pixels, forward view</td>
<td>sl</td>
<td>none</td>
<td>4</td>
<td>per cell</td>
</tr>
<tr>
<td>L2-INT-430</td>
<td>nadir_cloudy_land</td>
<td>total of cloudy land pixels, nadir view</td>
<td>sl</td>
<td>none</td>
<td>4</td>
<td>per cell</td>
</tr>
<tr>
<td>L2-INT-431</td>
<td>fwdr_cloudy_land</td>
<td>total of cloudy land pixels, forward view</td>
<td>sl</td>
<td>none</td>
<td>4</td>
<td>per cell</td>
</tr>
<tr>
<td>L2-INT-432</td>
<td>nadir_hist_land(k)</td>
<td>nadir histogram (land cell)</td>
<td>ss</td>
<td>none</td>
<td>2</td>
<td>1000</td>
</tr>
<tr>
<td>L2-INT-433</td>
<td>fwdr_hist_land(k)</td>
<td>forward histogram (land cell)</td>
<td>ss</td>
<td>none</td>
<td>2</td>
<td>1000</td>
</tr>
<tr>
<td>L2-INT-436</td>
<td>bt_cloud_top</td>
<td>cloud top temperature (over land)</td>
<td>ss</td>
<td>0.01K</td>
<td>2</td>
<td>per cell</td>
</tr>
<tr>
<td>L2-INT-437</td>
<td>bt_percent_cloudy</td>
<td>percentage cloudy pixels (over land)</td>
<td>ss</td>
<td>0.01%</td>
<td>2</td>
<td>per cell</td>
</tr>
<tr>
<td>L2-INT-438</td>
<td>bt_clear_land</td>
<td>total of clear land pixels, nadir view</td>
<td>sl</td>
<td>none</td>
<td>4</td>
<td>per cell</td>
</tr>
<tr>
<td>L2-INT-444</td>
<td>nadir_clear_sea</td>
<td>total of clear sea pixels, nadir view</td>
<td>sl</td>
<td>none</td>
<td>4</td>
<td>per cell</td>
</tr>
<tr>
<td>L2-INT-445</td>
<td>fwdr_clear_sea</td>
<td>total of clear sea pixels, forward view</td>
<td>sl</td>
<td>none</td>
<td>4</td>
<td>per cell</td>
</tr>
<tr>
<td>L2-INT-446</td>
<td>nadir_cloudy_sea</td>
<td>total of cloudy sea pixels, nadir view</td>
<td>sl</td>
<td>none</td>
<td>4</td>
<td>per cell</td>
</tr>
<tr>
<td>L2-INT-447</td>
<td>fwdr_cloudy_sea</td>
<td>total of cloudy sea pixels, forward view</td>
<td>sl</td>
<td>none</td>
<td>4</td>
<td>per cell</td>
</tr>
<tr>
<td>L2-INT-448</td>
<td>nadir_hist_sea(k)</td>
<td>nadir histogram (sea cell)</td>
<td>ss</td>
<td>none</td>
<td>2</td>
<td>1000</td>
</tr>
<tr>
<td>L2-INT-449</td>
<td>fwdr_hist_sea(k)</td>
<td>forward histogram (sea cell)</td>
<td>ss</td>
<td>none</td>
<td>2</td>
<td>1000</td>
</tr>
<tr>
<td>L2-INT-451</td>
<td>bt_cloud_top</td>
<td>cloud top temperature (over sea)</td>
<td>ss</td>
<td>0.01K</td>
<td>2</td>
<td>per cell</td>
</tr>
<tr>
<td>L2-INT-452</td>
<td>bt_percent_cloudy</td>
<td>percentage cloudy pixels (over sea)</td>
<td>ss</td>
<td>0.01%</td>
<td>2</td>
<td>per cell</td>
</tr>
<tr>
<td>L2-INT-453</td>
<td>bt_cloud_top</td>
<td>cloud top temperature (over sea)</td>
<td>ss</td>
<td>0.01K</td>
<td>2</td>
<td>per cell</td>
</tr>
<tr>
<td>L2-INT-454</td>
<td>bt_percent_cloudy</td>
<td>percentage cloudy pixels (over sea)</td>
<td>ss</td>
<td>0.01%</td>
<td>2</td>
<td>per cell</td>
</tr>
</tbody>
</table>

4.15.3 Detailed Structure

Step 4.15.1 Derive histogram for each cell.

Each image row \(i\) and pixel \(j\) is used as follows.

Step 4.15.1.1 Identify cell number.

Identify the 50 km cell number \(l,m\) within which the pixel indexed by \(i\) and \(j\) falls exactly as in Section 4.8.3.1.1

If this is the first pixel to fall within a given cell, clear the histogram arrays:

\[
\text{<view>}_\text{histogram_<surface>}(l, m; k) = 0 \text{ for all } k = 0, 999
\]

initialise the clear pixel counters

\[
\text{<view>}_\text{clear_<surface>} = 0,
\]

and initialise associated variables for each channel \(ch\):

\[
I_{\text{min}}(ch, v, sf; l, m) = 29000
\]

for each view \(<v> = \text{nadir, frwd}\), and for each surface type \(<sf> = \text{land, sea}\).

(Req 4.15-1)

Step 4.15.1.2 Process the image pixel.

Process the image pixel at \(i, j\) for both nadir and forward views,

(a) If the pixel is unfilled, do nothing.
(b) If the pixel is over sea, and is clear, increment \(\text{<view>}_\text{clear_sea}\).
(c) If the pixel is over sea and is cloudy, check the 11 micron brightness temperature. If the 11 micron brightness temperature

\[
T_{11} = I(ir11, v; i, j)
\]

is valid, and if \(19000 \leq T_{11} < 29000\), increment the element of the histogram array

\[
\text{<view>}_\text{histogram_sea}(l, m; k)
\]

specified by index

\[
k = \text{integer part of } (T_{11}/10 - 19000)
\]

If \(T_{11} < I_{\text{min}}(ir11, v, sf; l, m)\) then set

\[
I_{\text{min}}(ch, v, sf; l, m) = I(ch, v; i, j)
\]

for each channel \(ch\).

(d) If the pixel is over land, treat similarly but increment the land counters and histogram arrays \(\text{<view>}_\text{clear_land}\) and \(\text{<view>}_\text{histogram_sea}(l, m; k)\) in place of the corresponding sea variables.

(Req 4.15-2)

Step 4.15.2 Process histograms.
In this step the following notation is used.

\[ N_{\text{cloud}}^{\text{v.sf}} (l,m) \]  
\[ F_{v.sf} (l,m,k) \]  
\[ T_{v.sf}^{ct} (l,m) \]  

When all four histograms are complete, find the number of cloudy pixels in each. For each view \( v = n, f \) and for each surface type \( \text{sf} \):

\[ N_{v.sf}^{\text{cloud}} (l,m) = \sum_{k=0}^{999} F_{v.sf} (l,m,k) \]  

(Req 4.15-3)

If the number of cloudy pixels found is less than 20, proceed to the next cell. Otherwise proceed as follows:

Calculate the position of the 25th percentile

\[ K = N_{v.sf}^{\text{cloud}} (l,m) / 4 \]  

(Req 4.15-4)

and find the index \( k \) (such that

\[ \sum_{k=0}^{k-1} F_{v.sf} (l,m,k) < K \leq \sum_{k=0}^{k'} F_{v.sf} (l,m,k) \]  

(Req 4.15-5)

Then the cloud-top temperature is given by

\[ T_{v.sf}^{ct} (l,m) = 19000 + 10 \cdot \left( \frac{\sum_{k=0}^{k'} (k + 0.5) \cdot F_{v.sf} (l,m,k)}{\sum_{k=0}^{k'} F_{v.sf} (l,m,k)} \right) \]  

(Req 4.15-6)

and the percentage of cloudy pixels for each view and surface type is given by

\[ \text{bt_percent_cloudy} = 10000 \cdot \frac{N_{v.sf}^{\text{cloud}} (l,m)}{N_{v.sf}^{\text{cell}} (l,m) + \langle \text{view}_\text{clear}_\text{surface} > (l,m)} \]  

(Req 4.15-7)

4.16 Module Definition: Output AST Product

4.16.1 Functional Description

The AST product is written to the output medium. First the MPH, and SPH are written, then the Measurement data sets.

4.16.2 Interface Definition

See IODD Tables and Internal Parameter List
4.16.3 Detailed Structure

Step 4.16.1 AST MDS #1: Sea Cell SST Record, 50 km cell

Record identified by cell indices \( l, m \).

First convert the cell UTC [L2-INT-20] to transport format for output, using the ESA CFI subroutine \( \text{pl}_\text{pmjd} \).

\[
\begin{align*}
\text{mjdp}[0]/(l) &= \text{utc}(l, m) \\
\text{mjdp}[1]/(l) &= 0.0 \quad \text{(dummy value since output not required)} \\
\text{status} &= \text{pl}_\text{pmjd}(\text{mjdt}, \text{mjdp}, \text{utce}, \text{dut1e})
\end{align*}
\]

\[
[\text{AST-MDS1-1}](l, m) = [\text{mjdt}[0:2]/(1:3)](l, m) \quad \text{(Req 4.16.1-1)}
\]

\[
[\text{AST-MDS1-2}](l, m) = -1 \text{ if } (N_\text{sea}(n; l, m) = 0 \text{ and } N_\text{sea}(f; l, m) = 0) = 0 \text{ otherwise} \quad \text{(Req 4.16.1-2)}
\]

\[
[\text{AST-MDS1-3}](l, m) = (3 \text{ zero bytes}) \quad \text{(Req 4.16.1-3)}
\]

\[
[\text{AST-MDS1-4}](l, m) = \text{cell_lat}(l, m) \quad \text{[L2-INT-77]} \quad \text{(Req 4.16.1-4)}
\]

\[
[\text{AST-MDS1-5}](l, m) = \text{cell_long}(l, m) \quad \text{[L2-INT-78]} \quad \text{(Req 4.16.1-5)}
\]

\[
[\text{AST-MDS1-6}](l, m) = \text{sst_mean_pixel}(0; l, m) \quad \text{[L2-INT-469]} \quad \text{(Req 4.16.1-6)}
\]

\[
[\text{AST-MDS1-7}](l, m) = T_\text{nadir}(l, m) \quad \text{(Req 4.16.1-7)}
\]

\[
[\text{AST-MDS1-8}](l, m) = \sigma_\text{nadir}(\text{ASST}; l, m) \quad \text{(Req 4.16.1-8)}
\]

\[
[\text{AST-MDS1-9}](l, m) = \text{the smaller of } \tilde{M} (\text{ir11}, n; 0, 0, l, m), \tilde{M} (\text{ir12}, n; 0, 0, l, m) \quad \text{(Req 4.16.1-9)}
\]

\[
[\text{AST-MDS1-10}](l, m) = T_\text{dual}(l, m) \quad \text{(Req 4.16.1-10)}
\]

\[
[\text{AST-MDS1-11}](l, m) = \sigma_\text{dual}(\text{ASST}; l, m) \quad \text{(Req 4.16.1-11)}
\]

\[
[\text{AST-MDS4-12}](\text{cell}) = \text{the smallest of } \tilde{M} (\text{ir11}, n; 0, 0, l, m), \tilde{M} (\text{ir12}, n; 0, 0, l, m), \tilde{M} (\text{ir12}, f; 0, 0, l, m) \quad \text{(Req 4.16.1-12)}
\]

\[
[\text{AST-MDS1-13}](l, m) = \text{ast_conf}(0; l, m) \quad \text{(Req 4.16.1-13)}
\]

Averaged cloud parameters (ACLOUD), nadir view:

\[
[\text{AST-MDS1-23}](l, m) = [\text{L2-INT-451}](l, m) \quad \text{(Req 4.16.1-23)}
\]

\[
[\text{AST-MDS1-24}](l, m) = [\text{L2-INT-452}](l, m) \quad \text{(Req 4.16.1-24)}
\]

Averaged cloud parameters (ACLOUD), forward view:

\[
[\text{AST-MDS1-32}](l, m) = [\text{L2-INT-453}](l, m) \quad \text{(Req 4.16.1-32)}
\]

\[
[\text{AST-MDS1-33}](l, m) = [\text{L2-INT-454}](l, m) \quad \text{(Req 4.16.1-33)}
\]

Step 4.16.2 AST MDS #2: Sea Cell SST record, 17 km cell:

Record identified by \((k, l, m)\)
First convert the cell UTC [L2-INT-21] to transport format for output, using the ESA CFI subroutine pl_pmjd.

\[
\begin{align*}
\text{mjd}[0] / (1) &= \text{utc}(k, l, m) \\
\text{mjd}[1] / (2) &= 0.0 \text{ (dummy value since output not required)} \\
\text{status} &= \text{pl_pmjd}(\text{mjd}[0], \text{mjd}[1], \text{utc}, \text{dute})
\end{align*}
\]

[AST-MDS2-1](k, l, m) = [mjd[0:2]/(1:3)](k, l, m) \hspace{1cm} \text{(Req 4.16.2-1)}

[AST-MDS2-2](k, l, m) = \begin{cases} 
-1 \text{ if } (N\_sea(n; k, l, m) = 0) \text{ and } N\_sea(f; k, l, m) = 0 \\
0 \text{ otherwise}
\end{cases} \hspace{1cm} \text{(Req 4.16.2-2)}

[AST-MDS2-3] (k, l, m) = (3 \text{ zero bytes}) \hspace{1cm} \text{(Req 4.16.2-3)}

[AST-MDS2-4](k, l, m) = \text{sub\_cell\_lat}(k, l, m) \hspace{1cm} \text{[L2-INT-62]} \hspace{1cm} \text{(Req 4.16.2-4)}

[AST-MDS2-5](k, l, m) = \text{sub\_cell\_long}(k, l, m) \hspace{1cm} \text{[L2-INT-63]} \hspace{1cm} \text{(Req 4.16.2-5)}

[AST-MDS2-6](k, l, m) = \text{across\_track\_mean}(0; k, l, m) \hspace{1cm} \text{[L2-INT-459]} \hspace{1cm} \text{(Req 4.16.2-6)}

[AST-MDS2-7](k, l, m) = T\_nadir(k, l, m) \hspace{1cm} \text{(Req 4.16.2-7)}

[AST-MDS2-8](k, l, m) = \text{the smaller of } M(ir11, n; 0, 0, k, l, m), M(ir12, n; 0, 0, k, l, m) \hspace{1cm} \text{(Req 4.16.2-8)}

[AST-MDS2-9](k, l, m) = T\_dual(k, l, m) \hspace{1cm} \text{(Req 4.16.2-9)}

[AST-MDS2-10](k, l, m) = \text{the smallest of } M(ir11, n; 0, 0, k, l, m), M(ir12, n; 0, 0, k, l, m), M(ir11, f; 0, 0, k, l, m), M(ir12, f; 0, 0, k, l, m) \hspace{1cm} \text{(Req 4.16.2-10)}

[AST-MDS2-11](k, l, m) = ast\_conf(0; k, l, m) \hspace{1cm} \text{(Req 4.16.2-11)}

**Step 4.16.3 AST MDS #3: Sea Cell SST record, 10 arc minute cell:**

Record identified by (k, cell)

First convert the cell UTC [L2-INT-31] to transport format for output, using the ESA CFI subroutine pl_pmjd.

\[
\begin{align*}
\text{mjd}[0] / (1) &= \text{utc}(k, \text{cell}) \\
\text{mjd}[1] / (2) &= 0.0 \text{ (dummy value since output not required)} \\
\text{status} &= \text{pl_pmjd}(\text{mjd}[0], \text{mjd}[1], \text{utc}, \text{dute})
\end{align*}
\]

[AST-MDS3-1](k, cell) = [mjd[0:2]/(1:3)](k, cell) \hspace{1cm} \text{(Req 4.16.3-1)}

[AST-MDS3-2](k, cell) = \begin{cases} 
-1 \text{ if } (N\_sea(n; k, cell) = 0) \text{ and } N\_sea(f; k, cell) = 0 \\
0 \text{ otherwise}
\end{cases} \hspace{1cm} \text{(Req 4.16.3-2)}

[AST-MDS3-3](k, cell) = (3 \text{ zero bytes}) \hspace{1cm} \text{(Req 4.16.3-3)}

[AST-MDS3-4](k, cell) = \text{sub\_cell\_lat}(k, cell) \hspace{1cm} \text{[L2-INT-32]} \hspace{1cm} \text{(Req 4.16.3-4)}

[AST-MDS3-5](k, cell) = \text{sub\_cell\_long}(k, cell) \hspace{1cm} \text{[L2-INT-33]} \hspace{1cm} \text{(Req 4.16.3-5)}

[AST-MDS3-6](k, cell) = \text{across\_track\_mean}(0; k, cell) \hspace{1cm} \text{[L2-INT-359]} \hspace{1cm} \text{(Req 4.16.3-6)}

[AST-MDS3-7](k, cell) = T\_nadir(k, cell) \hspace{1cm} \text{[L2-INT-54]} \hspace{1cm} \text{(Req 4.16.3-7)}

[AST-MDS3-8](k, cell) = \text{the smaller of } M(ir11, n; 0, 0, k, cell), M(ir12, n; 0, 0, k, cell) \hspace{1cm} \text{(Req 4.16.3-8)}
Step 4.16.4 AST MDS #4: Sea Cell SST Record, 30 arc minute cell

Record identified by cell number cell.

First convert the cell UTC [L2-INT-30] to transport format for output, using the ESA CFI subroutine pl_pmjd.

mjdp[0] = utc(cell)
mjdp[1] = 0.0 (dummy value since output not required)
status = pl_pmjd(mjdt, mjdp, utce, dut1e)

5.24.1.9 \( T_{\text{cell}} \) = \( \text{ast_conf}(0; \text{cell}) \) (Req 4.16.3-11)

5.24.1.10 \( T_{\text{cell}} \) = the small of \( M(\text{ir}11, n; 0, 0, \text{cell}) \), \( M(\text{ir}12, n; 0, 0, \text{cell}) \), \( M(\text{ir}11, f; 0, 0, \text{cell}) \), \( M(\text{ir}12, f; 0, 0, \text{cell}) \) (Req 4.16.3-10)

5.24.1.11 \( T_{\text{cell}} \) = \( \text{ast_conf}(0; \text{cell}) \) (Req 4.16.3-13)

5.24.1.12 \( T_{\text{cell}} \) = the smaller of \( \tilde{M} (\text{ir}11, n; 0, 0, \text{cell}) \), \( \tilde{M} (\text{ir}12, n; 0, 0, \text{cell}) \) (Req 4.16.4-9)

5.24.1.13 \( T_{\text{cell}} \) = \( \text{ast_conf}(0; \text{cell}) \) (Req 4.16.4-13)

Averaged cloud parameters (ACLOUD), nadir view:

5.24.1.23 \( [\text{cell}] = [L2-INT-351]\) (cell) (Req 4.16.4-23)

5.24.1.24 \( [\text{cell}] = [L2-INT-352]\) (cell) (Req 4.16.4-24)

Averaged cloud parameters (ACLOUD), forward view:

5.24.1.32 \( [\text{cell}] = [L2-INT-353]\) (cell) (Req 4.16.4-32)
Step 4.16.5 AST MDS #5: Land Cell LST/NDVI Record, 50 km cell

Record identified by cell indices $l, m$.

\[ \text{[AST-MDS5-1]}(l, m) = \text{[AST-MDS1-1]}(l, m) \]  
\[ \text{[AST-MDS5-2]}(l, m) = -1 \text{ if } (N_{\text{land}}(n; l, m) = 0 \text{ and } N_{\text{land}}(f; l, m) = 0) \]  
\[ = 0 \text{ otherwise} \]  
\[ \text{[AST-MDS5-3]}(l, m) = (3 \text{ zero bytes}) \]  
\[ \text{[AST-MDS5-4]}(l, m) = \text{cell_lat}(l, m) \] \[ \text{[AST-MDS5-5]}(l, m) = \text{cell_long}(l, m) \]  
\[ \text{[AST-MDS5-6]}(l, m) = \text{sst_mean_pixel}(1; l, m) \] \[ \text{[AST-MDS5-7]}(l, m) = T_{\text{land}}(l, m) \]  
\[ \text{[AST-MDS5-8]}(l, m) = \sigma_{\text{land}}(l, m) \]  
\[ \text{[AST-MDS5-9]}(l, m) = \text{the smaller of } \bar{M} (ir11, n; sf; 0, l, m), \]  
\[ \bar{M} (ir12, n; sf; 0, l, m) \]  

where $sf$ has the value assigned to it in step 4.14.2.

\[ \text{[AST-MDS5-10]}(l, m) = <\text{NDVI}>(l, m) \] \[ \text{[AST-MDS5-11]}(l, m) = \sigma(\text{NDVI}; l, m) \]  
\[ \text{[AST-MDS5-12]}(l, m) = N0(l, m) \]  
\[ \text{[AST-MDS5-13]}(l, m) = \text{ast_conf}(l; l, m) \]  

Averaged cloud parameters (ACLOUD), nadir view:

\[ \text{[AST-MDS5-23]}(l, m) = \text{[L2-INT-435]}(l, m) \]  
\[ \text{[AST-MDS5-24]}(l, m) = \text{[L2-INT-436]}(l, m) \]  

Averaged cloud parameters (ACLOUD), forward view:

\[ \text{[AST-MDS5-32]}(l, m) = \text{[L2-INT-437]}(l, m) \]  
\[ \text{[AST-MDS5-33]}(l, m) = \text{[L2-INT-438]}(l, m) \]  

Step 4.16.6 AST MDS #6: Land Cell LST/NDVI record, 17 km cell:

Record identified by $(k, l, m)$.

\[ \text{[AST-MDS6-1]}(k, l, m) = \text{[AST-MDS2-1]}(k, l, m) \]  
\[ \text{[AST-MDS6-2]}(k, l, m) = -1 \text{ if } (N_{\text{land}}(n; k, l, m) = 0 \text{ and } N_{\text{land}}(f; k, l, m) = 0) \]  
\[ = 0 \text{ otherwise} \]  
\[ \text{[AST-MDS6-3]}(k, l, m) = (3 \text{ zero bytes}) \]  
\[ \text{[AST-MDS6-4]}(k, l, m) = \text{sub_cell_lat}(k, l, m) \]  
\[ \text{[AST-MDS6-5]}(k, l, m) = \text{sub_cell_long}(k, l, m) \]
[AST-MDS6-6](k, l, m) = \textit{across\_track\_mean}(1; k, l, m) [L2-INT-459]  
\text{(Req 4.16.6-6)}

[AST-MDS6-7](k, l, m) = T_{\text{land}}(k, l, m) [L2-INT-496]  
\text{(Req 4.16.6-7.1)}

[AST-MDS6-8](k, l, m) = \text{the smaller of } M(ir11, n; sf, 0, k, l, m),  
M(ir12, n; sf, 0, k, l, m)  
\text{(Req 4.16.6-8.1)}

where \( sf \) has the value assigned to it in step 4.14.4.2.

[AST-MDS6-9](k, l, m) = \text{NDVI}(k, l, m) [L2-INT-95]  
\text{(Req 4.16.6-9)}

[AST-MDS6-10](k, l, m) = N1(k, l, m) [L2-INT-99]  
\text{(Req 4.16.6-10)}

[AST-MDS6-11](k, l, m) = \text{ast\_config}(1; k, l, m)  
\text{(Req 4.16.6-11)}

\textbf{Step 4.16.7 AST MDS #7: Land Cell LST/NVDI record, 10 arc minute cell:}

Record identified by (\( k, cell \))

[AST-MDS7-1](k, cell) = [AST-MDS3-1](k, cell)  
\text{(Req 4.16.7-1)}

[AST-MDS7-2](k, cell) = -1 if (\( N_{\text{land}}(n; k, cell) = 0 \) and \( N_{\text{land}}(f; k, cell) = 0 \))  
= 0 otherwise  
\text{(Req 4.16.7-2)}

[AST-MDS7-3](k, cell) = (3 zero bytes)  
\text{(Req 4.16.7-3)}

[AST-MDS7-4](k, cell) = \text{sub\_cell\_lat}(k, cell) [L2-INT-32]  
\text{(Req 4.16.7-4)}

[AST-MDS7-5](k, cell) = \text{sub\_cell\_long}(k, cell) [L2-INT-33]  
\text{(Req 4.16.7-5)}

[AST-MDS7-6](k, cell) = \text{across\_track\_mean}(1; k, cell) [L2-INT-359]  
\text{(Req 4.16.7-6)}

[AST-MDS7-7](k, cell) = T_{\text{land}}(k, cell) [L2-INT-492]  
\text{(Req 4.16.7-7.1)}

[AST-MDS7-8](k, cell) = \text{the smaller of } M(ir11, n; sf, 0, k, cell),  
M(ir12, n; sf, 0, k, cell)  
\text{(Req 4.16.7-8.1)}

where \( sf \) has the value assigned to it in step 4.10.4.2.

[AST-MDS7-9](k, cell) = \text{NDVI}(k, cell) [L2-INT-90]  
\text{(Req 4.16.7-9)}

[AST-MDS7-10](k, cell) = N1(k, cell) [L2-INT-94]  
\text{(Req 4.16.7-10)}

[AST-MDS7-11](k, cell) = \text{ast\_config}(1; k, cell)  
\text{(Req 4.16.7-11)}

\textbf{Step 4.16.8 AST MDS #8: Land Cell LST/NVDI Record, 30 arc minute cell}

Record identified by cell number \( cell \).

[AST-MDS8-1](cell) = [AST-MDS4-1](cell)  
\text{(Req 4.16.8-1)}

[AST-MDS8-2](cell) = -1 if (\( N_{\text{land}}(n; cell) = 0 \) and \( N_{\text{land}}(f; cell) = 0 \))  
= 0 otherwise  
\text{(Req 4.16.8-2)}

[AST-MDS8-3](cell) = (3 zero bytes)  
\text{(Req 4.16.8-3)}

[AST-MDS8-4](cell) = \text{cell\_lat}(cell) [L2-INT-47]  
\text{(Req 4.16.8-4)}

[AST-MDS8-5](cell) = \text{cell\_long}(cell) [L2-INT-48]  
\text{(Req 4.16.8-5)}

[AST-MDS8-6](cell) = \text{sst\_mean\_pixel}(1; cell) [L2-INT-369]  
\text{(Req 4.16.8-6.1)}
4.16

[AIR-SED-2](cell) = L_tir11(cell) [L2-INT-493]

[AST-MDS9](cell) = N_land(cell) [L2-INT-494]

[AST-MDS9-9](cell) = the smaller of \( \bar{M} \) (ir11, n; sf, 0, cell),
\( \bar{M} \) (ir12, n; sf, 0, cell)

where \( sf \) has the value assigned to it in step 4.10.4.2.

[AST-MDS9-10](cell) = <NDVI>(cell) [L2-INT-91]

[AST-MDS9-11](cell) = ast_NDVI(cell) [L2-INT-92]

[AST-MDS9-12](cell) = N0(cell) [L2-INT-93]

[AST-MDS9-13](cell) = ast_conf(1; cell)

Averaged cloud parameters (ACLOUD), nadir view:

[AST-MDS9-23](cell) = [L2-INT-335](cell)

[AST-MDS9-24](cell) = [L2-INT-336](cell)

Averaged cloud parameters (ACLOUD), forward view:

[AST-MDS9-32](cell) = [L2-INT-337](cell)

[AST-MDS9-33](cell) = [L2-INT-338](cell)

**Step 4.16.9 AST MDS#9: Land Cell BT/TOA Record, 50 km cell**

Record identified by cell number \( l, m \).

[AST-MDS9-1](l, m) = [AST-MDS1-1](l, m)

[AST-MDS9-2](l, m) = -1 if (N_land(n; l, m) = 0 and N_land(f; l, m) = 0)
\( = 0 \) otherwise

[AST-MDS9-3](l, m) = (3 zero bytes)

[AST-MDS9-4](l, m) = cell_latt(l, m) [L2-INT-77]

[AST-MDS9-5](l, m) = cell_longt(l, m) [L2-INT-78]

[AST-MDS9-6](l, m) = across_track_mean(1; l, m) [L2-INT-468]

[AST-MDS9-7](l, m) = N_total(n; l, m) [L2-INT-408]

[AST-MDS9-8](l, m) = N_land(n; l, m) [L2-INT-406]

[AST-MDS9-9](l, m) = pcl(n; l, m) [L2-INT-410]

[AST-MDS9-10](l, m) = Topographic latitude correction

[AST-MDS9-11](l, m) = Topographic longitude correction

Clear pixels, nadir.

[AST-MDS9-12](l, m) = \( \tilde{A} \) (ch, n; 1, 0, l, m)
Cloudy pixels, nadir:

\[ \text{AST-MDS9-<13} + 2.(\text{ch-1})> (l, m) = \sigma(\text{ch, n; 1, 0, l, m}) \] (Req 4.16.9-13)

Cloudy pixels, forward:

\[ \text{AST-MDS9-<26} + 2.(\text{ch-1})> (l, m) = \tilde{A} (\text{ch, n; 1, 1, l, m}) \] (Req 4.16.9-14)

\[ \text{AST-MDS9-<27} + 2.(\text{ch-1})> (l, m) = \sigma(\text{ch, n; 1, 1, l, m}) \] (Req 4.16.9-15)

\[ \text{AST-MDS9-40} (l, m) = PFF(n, \text{land; l, m}) \] [L2-INT-81] (Req 4.16.9-16)

Forward view:

\[ \text{AST-MDS9-41} (l, m) = N_{\text{total}}(f; l, m) \] [L2-INT-418] (Req 4.16.9-17)

\[ \text{AST-MDS9-42} (l, m) = N_{\text{land}}(f; l, m) \] [L2-INT-416] (Req 4.16.9-18)

\[ \text{AST-MDS9-43} (l, m) = pcl(f; l, m) \] [L2-INT-420] (Req 4.16.9-19)

\[ \text{AST-MDS9-44} (l, m) = \text{Topographic latitude correction} \] (Req 4.16.9-20)

\[ \text{AST-MDS9-45} (l, m) = \text{Topographic longitude correction} \] (Req 4.16.9-21)

Clear pixels, forward:

\[ \text{AST-MDS9-<46} + 2.(\text{ch-1})> (l, m) = \tilde{A} (\text{ch, f; 1, 0, l, m}) \] (Req 4.16.9-22)

\[ \text{AST-MDS9-<47} + 2.(\text{ch-1})> (l, m) = \sigma(\text{ch, f; 1, 0, l, m}) \] (Req 4.16.9-23)

Cloudy pixels, forward:

\[ \text{AST-MDS9-<60} + 2.(\text{ch-1})> (l, m) = \tilde{A} (\text{ch, f; 1, 1, l, m}) \] (Req 4.16.9-24)

\[ \text{AST-MDS9-<61} + 2.(\text{ch-1})> (l, m) = \sigma(\text{ch, f; 1, 1, l, m}) \] (Req 4.16.9-25)

\[ \text{AST-MDS9-74} (l, m) = PFF(f, \text{land; l, m}) \] [L2-INT-81] (Req 4.16.9-26)

\[ \text{AST-MDS9-75} (l, m) = NO(l, m) \] (Req 4.16.9-27)

\[ \text{AST-MDS9-76} (l, m) = (\text{ACLOUD}) \] Percentage of pixels over <surface type> (Req 4.16.9-28)

Averaged cloud parameters (ACLOUD), nadir view:

\[ \text{AST-MDS9-77} (l, m) = I_{\text{min}}(\text{ir}11, n, \text{land; l, m}) \] (Req 4.16.9-29)

\[ \text{AST-MDS9-78} (l, m) = I_{\text{min}}(\text{ir}12, n, \text{land; l, m}) \] (Req 4.16.9-30)

\[ \text{AST-MDS9-79} (l, m) = I_{\text{min}}(\text{ir}37, n, \text{land; l, m}) \] (Req 4.16.9-31)

\[ \text{AST-MDS9-80} (l, m) = I_{\text{min}}(\nu16, n, \text{land; l, m}) \] (Req 4.16.9-32)

\[ \text{AST-MDS9-81} (l, m) = I_{\text{min}}(\nu870, n, \text{land; l, m}) \] (Req 4.16.9-33)

\[ \text{AST-MDS9-82} (l, m) = I_{\text{min}}(\nu670, n, \text{land; l, m}) \] (Req 4.16.9-34)

\[ \text{AST-MDS9-83} (l, m) = I_{\text{min}}(\nu555, n, \text{land; l, m}) \] (Req 4.16.9-35)

Averaged cloud parameters (ACLOUD), forward view:

\[ \text{AST-MDS9-84} (l, m) = I_{\text{min}}(\text{ir}11, f, \text{land; l, m}) \] (Req 4.16.9-36)
Step 4.16.10 AST MDS#10: Land Cell BT/TOA Record, 17 km cell

Record identified by (k, l, m)

Clear pixels, nadir.

\[ \text{AST-MDS10-1} (k, l, m) = \text{AST-MDS2-1} (k, l, m) \]  
\[ \text{AST-MDS10-2} (k, l, m) = -1 \text{ if } (N_\text{land}(n; k, l, m) = 0 \text{ and } N_\text{land}(f; k, l, m) = 0) \]  
\[ = 0 \text{ otherwise} \]  
\[ \text{AST-MDS10-3} (k, l, m) = (3 \text{ zero bytes}) \]  
\[ \text{AST-MDS10-4} (k, l, m) = \text{sub_cell_lat}(k, l, m) \] [L2-INT-62]  
\[ \text{AST-MDS10-5} (k, l, m) = \text{sub_cell_long}(k, l, m) \] [L2-INT-63]  
\[ \text{AST-MDS10-6} (k, l, m) = \text{across_track_mean}(1; k, l, m) \] [L2-INT-459]  
\[ \text{AST-MDS10-7} (k, l, m) = N_\text{total}(n; k, l, m) \] [L2-INT-403]  
\[ \text{AST-MDS10-8} (k, l, m) = N_\text{land}(n; k, l, m) \] [L2-INT-401]  
\[ \text{AST-MDS10-9} (k, l, m) = \text{pcl}(n; k, l, m) \] [L2-INT-405]  
\[ \text{AST-MDS10-10} (l, m) = \text{Topographic latitude correction} \]  
\[ \text{AST-MDS10-11} (l, m) = \text{Topographic longitude correction} \]  
\[ \text{AST-MDS10-12 + (ch - 1)} (k, l, m) = A(\text{ch}, n; 1 0, k, l, m) \]  
Cloudy pixels, nadir.

\[ \text{AST-MDS10-19 + (ch - 1)} (k, l, m) = A(\text{ch}, n; 1, 1, k, l, m) \]  
\[ \text{AST-MDS10-26} (k, l, m) = PFF(n; \text{land}; k, l, m) \] [L2-INT-82]  

Forward view:

\[ \text{AST-MDS10-27} (k, l, m) = N_\text{total}(f; k, l, m) \] [L2-INT-413]  
\[ \text{AST-MDS10-28} (k, l, m) = N_\text{land}(f; k, l, m) \] [L2-INT-411]  
\[ \text{AST-MDS10-29} (k, l, m) = pcl(f; k, l, m) \] [L2-INT-415]  
\[ \text{AST-MDS10-30} (l, m) = \text{Topographic latitude correction} \]  
\[ \text{AST-MDS10-31} (l, m) = \text{Topographic longitude correction} \]  

Clear pixels, forward.
Step 4.16.11 AST MDS#11: Land Cell BT/TOA Record, 10 arc minute cell

Record identified by \(k, cell\)

\[\text{AST-MDS11-1}(k, cell) = \text{AST-MDS3-1}(k, cell)\]  
(Req 4.16.11-1)

\[\text{AST-MDS11-2}(k, cell) = -1 \text{ if } (N_{\text{land}}(n; k, cell) = 0 \text{ and } N_{\text{land}}(f; k, cell) = 0) \]
\[= \text{ 0 otherwise}\]  
(Req 4.16.11-2)

\[\text{AST-MDS11-3}(k, cell) = (3 \text{ zero bytes})\]  
(Req 4.16.11-3)

\[\text{AST-MDS11-4}(k, cell) = \text{sub}_cell_{lat}(k, cell) \text{ [L2-INT-32]}\]  
(Req 4.16.11-4)

\[\text{AST-MDS11-5}(k, cell) = \text{sub}_cell_{long}(k, cell) \text{ [L2-INT-33]}\]  
(Req 4.16.11-5)

\[\text{AST-MDS11-6}(k, cell) = \text{across}\_track_{mean}(1; k, cell) \text{ [L2-INT-359]}\]  
(Req 4.16.11-6)

\[\text{AST-MDS11-7}(k, cell) = N_{\text{total}}(n; k, cell) \text{ [L2-INT-303]}\]  
(Req 4.16.11-7)

\[\text{AST-MDS11-8}(k, cell) = N_{\text{land}}(n; k, cell) \text{ [L2-INT-301]}\]  
(Req 4.16.11-8)

\[\text{AST-MDS11-9}(k, cell) = pcl(n; k, cell) \text{ [L2-INT-305]}\]  
(Req 4.16.11-9)

\[\text{AST-MDS11-10}(k, cell) = \text{Topographic latitude correction}\]  
(Req 4.16.11-10)

\[\text{AST-MDS11-11}(k, cell) = \text{Topographic longitude correction}\]  
(Req 4.16.11-11)

Clear pixels, nadir.

\[\text{AST-MDS11-12 + (ch - 1)}(k, cell) = A(ch, n; 1, 0, k, cell)\]  
(Req 4.16.11-12)

Cloudy pixels, nadir.

\[\text{AST-MDS11-19 + (ch - 1)}(k, cell) = A(ch, n; 1, 1, k, cell)\]  
(Req 4.16.11-13)

\[\text{AST-MDS11-26}(k, cell) = PFF(n; land; k, cell) \text{ [L2-INT-52]}\]  
(Req 4.16.11-14)

Forward view:

\[\text{AST-MDS11-27}(k, cell) = N_{\text{total}}(f; k, cell) \text{ [L2-INT-313]}\]  
(Req 4.16.11-15)

\[\text{AST-MDS11-28}(k, cell) = N_{\text{land}}(f; k, cell) \text{ [L2-INT-311]}\]  
(Req 4.16.11-16)

\[\text{AST-MDS11-29}(k, cell) = pcl(f; k, cell) \text{ [L2-INT-315]}\]  
(Req 4.16.11-17)

\[\text{AST-MDS11-30}(k, cell) = \text{Topographic latitude correction}\]  
(Req 4.16.11-18)

\[\text{AST-MDS11-31}(k, cell) = \text{Topographic longitude correction}\]  
(Req 4.16.11-19)

Clear pixels, forward.

\[\text{AST-MDS11-32 + (ch - 1)}(k, cell) = A(ch, f; 1, 0, k, cell)\]  
(Req 4.16.11-20)

Cloudy pixels, forward.
Step 4.16.12 AST MDS#12: Land Cell BT/TOA Record, 30 arc minute cell

Record identified by cell number cell.

- [AST-MDS12-1](cell) = [AST-MDS4-1](cell) (Req 4.16.12-1)
- [AST-MDS12-2](cell) = -1 if (N_land(n; cell) = 0 and N_land(f; cell) = 0) = 0 otherwise (Req 4.16.12-2)
- [AST-MDS12-3](cell) = (3 zero bytes) (Req 4.16.12-3)
- [AST-MDS12-4](cell) = cell_lat(cell) [L2-INT-47] (Req 4.16.12-4)
- [AST-MDS12-5](cell) = cell_long(cell) [L2-INT-48] (Req 4.16.12-5)
- [AST-MDS12-6](cell) = across_track_mean(1; cell) [L2-INT-368] (Req 4.16.12-6)
- [AST-MDS12-7](cell) = N_total(n; cell) [L2-INT-308] (Req 4.16.12-7)
- [AST-MDS12-8](cell) = N_land(n; cell) [L2-INT-306] (Req 4.16.12-8)
- [AST-MDS12-9](cell) = pcl(n; cell) [L2-INT-310] (Req 4.16.12-9)
- [AST-MDS12-10](cell) = Topographic latitude correction (Req 4.16.12-10)
- [AST-MDS12-11](cell) = Topographic longitude correction (Req 4.16.12-11)

Clear pixels, nadir.

- [AST-MDS12-12 + 2.(ch - 1)>](cell) = \(\tilde{A}(ch, n; 1, 0, cell)\) (Req 4.16.12-12)
- [AST-MDS12-13 + 2.(ch - 1)>](cell) = \(\sigma(ch, n; 1, 0, cell)\) (Req 4.16.12-13)

Cloudy pixels, nadir.

- [AST-MDS12-14 + 2.(ch - 1)>](cell) = \(\tilde{A}(ch, n; 1, 1, cell)\) (Req 4.16.12-14)
- [AST-MDS12-15 + 2.(ch - 1)>](cell) = \(\sigma(ch, n; 1, 1, cell)\) (Req 4.16.12-15)
- [AST-MDS12-40](cell) = PFF(n, land; cell) [L2-INT-51] (Req 4.16.12-16)

Forward view:

- [AST-MDS12-41](cell) = N_total(f; cell) [L2-INT-318] (Req 4.16.12-17)
- [AST-MDS12-42](cell) = N_land(f; cell) [L2-INT-316] (Req 4.16.12-18)
- [AST-MDS12-43](cell) = pcl(f; cell) [L2-INT-320] (Req 4.16.12-19)
- [AST-MDS12-44](cell) = Topographic latitude correction (Req 4.16.12-20)
- [AST-MDS12-45](cell) = Topographic longitude correction (Req 4.16.12-21)

Clear pixels, forward.

- [AST-MDS12-22 + 2.(ch - 1)>](cell) = \(\tilde{A}(ch,f; 1, 0, cell)\) (Req 4.16.12-22)
- [AST-MDS12-23 + 2.(ch - 1)>](cell) = \(\sigma(ch, f; 1, 0, cell)\) (Req 4.16.12-23)
Cloudy pixels, forward.

\[
[\text{AST-MDS12-}{{< 60 + 2.}\times (ch - 1)}>](cell) = \tilde{A} \ (ch, f; \ 1, 1, \ cell) \quad \text{(Req 4.16.12-24)}
\]

\[
[\text{AST-MDS12-}{{< 61 + 2.}\times (ch - 1)}>](cell) = \sigma(ch, f; \ 1, 1, \ cell) \quad \text{(Req 4.16.12-25)}
\]

\[
[\text{AST-MDS12-74}](cell) = PFF(f, \ land; \ cell) \ [L2-INT-51]
\]

\[
[\text{AST-MDS12-75}](cell) = \text{N0}(cell) \quad \text{(Req 4.16.12-27)}
\]

\[
[\text{AST-MDS12-76}](cell) = (\text{ACLOUD}) \ \text{Percentage of pixels over <surface type>}
\]

\[
(\text{Req 4.16.12-28})
\]

Averaged cloud parameters (ACLOUD), nadir view:

\[
[\text{AST-MDS12-77}](cell) = I_{\min}(\text{ir11}, \ n, \ land; \ cell) \quad \text{(Req 4.16.12-29)}
\]

\[
[\text{AST-MDS12-78}](cell) = I_{\min}(\text{ir12}, \ n, \ land; \ cell) \quad \text{(Req 4.16.12-30)}
\]

\[
[\text{AST-MDS12-79}](cell) = I_{\min}(\text{ir37}, \ n, \ land; \ cell) \quad \text{(Req 4.16.12-31)}
\]

\[
[\text{AST-MDS12-80}](cell) = I_{\min}(v16, \ n, \ land; \ cell) \quad \text{(Req 4.16.12-32)}
\]

\[
[\text{AST-MDS12-81}](cell) = I_{\min}(v870, \ n, \ land; \ cell) \quad \text{(Req 4.16.12-33)}
\]

\[
[\text{AST-MDS12-82}](cell) = I_{\min}(v670, \ n, \ land; \ cell) \quad \text{(Req 4.16.12-34)}
\]

\[
[\text{AST-MDS12-83}](cell) = I_{\min}(v555, \ n, \ land; \ cell) \quad \text{(Req 4.16.12-35)}
\]

Averaged cloud parameters (ACLOUD), forward view:

\[
[\text{AST-MDS12-84}](cell) = I_{\min}(\text{ir11}, \ f, \ land; \ cell) \quad \text{(Req 4.16.12-36)}
\]

\[
[\text{AST-MDS12-85}](cell) = I_{\min}(\text{ir12}, \ f, \ land; \ cell) \quad \text{(Req 4.16.12-37)}
\]

\[
[\text{AST-MDS12-86}](cell) = I_{\min}(\text{ir37}, \ f, \ land; \ cell) \quad \text{(Req 4.16.12-38)}
\]

\[
[\text{AST-MDS12-87}](cell) = I_{\min}(v16, \ f, \ land; \ cell) \quad \text{(Req 4.16.12-39)}
\]

\[
[\text{AST-MDS12-88}](cell) = I_{\min}(v870, \ f, \ land; \ cell) \quad \text{(Req 4.16.12-40)}
\]

\[
[\text{AST-MDS12-89}](cell) = I_{\min}(v670, \ f, \ land; \ cell) \quad \text{(Req 4.16.12-41)}
\]

\[
[\text{AST-MDS12-90}](cell) = I_{\min}(v555, \ f, \ land; \ cell) \quad \text{(Req 4.16.12-42)}
\]

**Step 4.16.13 AST MDS#13: Sea Cell BT/TOA Record, 50 km cell**

Record identified by cell number \( l, m \).

\[
[\text{AST-MDS13-1}](l, m) = [\text{AST-MDS1-1}](l, m) \quad \text{(Req 4.16.13-1)}
\]

\[
[\text{AST-MDS13-2}](l, m) = \begin{cases} 1 \text{ if } (N_{\text{sea}}(n; l, m) = 0 \text{ and } N_{\text{sea}}(f; l, m) = 0) \\ 0 \text{ otherwise} \end{cases} \quad \text{(Req 4.16.13-2)}
\]

\[
[\text{AST-MDS13-3}](l, m) = (3 \text{ zero bytes}) \quad \text{(Req 4.16.13-3)}
\]

\[
[\text{AST-MDS13-4}](l, m) = \text{cell_lat}(l, m) \ [L2-INT-77] \quad \text{(Req 4.16.13-4)}
\]

\[
[\text{AST-MDS13-5}](l, m) = \text{cell_long}(l, m) \ [L2-INT-78] \quad \text{(Req 4.16.13-5)}
\]

\[
[\text{AST-MDS13-6}](l, m) = \text{across_track_mean}(0; l, m) \ [L2-INT-468] \quad \text{(Req 4.16.13-6)}
\]
Averaged cloud parameters (ACLOUD), nadir view:

\[ \text{AST-MDS13-7}(l, m) = N_{\text{total}}(n; l, m) \ [L2-\text{INT}-408] \]  
\[ \text{AST-MDS13-8}(l, m) = N_{\text{sea}}(n; l, m) \ [L2-\text{INT}-407] \]  
\[ \text{AST-MDS13-9}(l, m) = \text{pcs}(n; l, m) \ [L2-\text{INT}-409] \]  

Clear pixels, nadir.

\[ \text{AST-MDS13-<10 + 2.(ch - 1)>}(l, m) = \tilde{A}(ch, n; 0, 0, l, m) \]  
\[ \text{AST-MDS13-<11 + 2.(ch - 1)>}(l, m) = \sigma(ch, n; 0, 0, l, m) \]

Cloudy pixels, nadir.

\[ \text{AST-MDS13-<24 + 2.(ch - 1)>}(l, m) = \tilde{A}(ch, n; 0, 1, l, m) \]  
\[ \text{AST-MDS13-<25 + 2.(ch - 1)>}(l, m) = \sigma(ch, n; 0, 1, l, m) \]  
\[ \text{AST-MDS13-38}(l, m) = PFF(n, \text{sea}; l, m) \ [L2-\text{INT}-81] \]  

Forward view:

\[ \text{AST-MDS13-39}(l, m) = N_{\text{total}}(f; l, m) \ [L2-\text{INT}-418] \]  
\[ \text{AST-MDS13-40}(l, m) = N_{\text{sea}}(f; l, m) \ [L2-\text{INT}-417] \]  
\[ \text{AST-MDS13-41}(l, m) = \text{pcs}(f; l, m) \ [L2-\text{INT}-419] \]

Clear pixels, forward.

\[ \text{AST-MDS13-<42 + 2.(ch - 1)>}(l, m) = \tilde{A}(ch, f; 0, 0, l, m) \]  
\[ \text{AST-MDS13-<43 + 2.(ch - 1)>}(l, m) = \sigma(ch, f; 0, 0, l, m) \]

Cloudy pixels, forward.

\[ \text{AST-MDS13-<56 + 2.(ch - 1)>}(l, m) = \tilde{A}(ch, f; 0, 1, l, m) \]  
\[ \text{AST-MDS13-<57 + 2.(ch - 1)>}(l, m) = \sigma(ch, f; 0, 1, l, m) \]  
\[ \text{AST-MDS13-70}(l, m) = PFF(f, \text{sea}; l, m) \ [L2-\text{INT}-81] \]  

\[ \text{AST-MDS13-71}(l, m) = N0(l, m) \]  
\[ \text{AST-MDS13-72}(l, m) = (\text{ACLOUD}) \text{ Percentage of pixels over <surface type4} \]  

\[ \text{Averaged cloud parameters (ACLOUD), nadir view:} \]

\[ \text{AST-MDS13-73}(l, m) = I_{\text{min}}(\text{ir}11, n, \text{sea}; l, m) \]  
\[ \text{AST-MDS13-74}(l, m) = I_{\text{min}}(\text{ir}12, n, \text{sea}; l, m) \]  
\[ \text{AST-MDS13-75}(l, m) = I_{\text{min}}(\text{ir}37, n, \text{sea}; l, m) \]  
\[ \text{AST-MDS13-76}(l, m) = I_{\text{min}}(\text{v}16, n, \text{sea}; l, m) \]  
\[ \text{AST-MDS13-77}(l, m) = I_{\text{min}}(\text{v}870, n, \text{sea}; l, m) \]
Averaged cloud parameters (ACLOUD), forward view:

\[ \text{AVERAGED CLOUD PARAMETERS, FORWARD VIEW:} \]

\[ \begin{align*}
\text{AST-MDS13-80}(l, m) &= I_{\text{min}}(\nu 670, f, \text{sea}; l, m) \\
\text{AST-MDS13-81}(l, m) &= I_{\text{min}}(\nu 870, f, \text{sea}; l, m) \\
\text{AST-MDS13-82}(l, m) &= I_{\text{min}}(\nu 16, f, \text{sea}; l, m) \\
\text{AST-MDS13-83}(l, m) &= I_{\text{min}}(\nu 16, f, \text{sea}; l, m) \\
\text{AST-MDS13-84}(l, m) &= I_{\text{min}}(\nu 555, f, \text{sea}; l, m) \\
\text{AST-MDS13-85}(l, m) &= I_{\text{min}}(\nu 555, f, \text{sea}; l, m) \\
\text{AST-MDS13-86}(l, m) &= I_{\text{min}}(\nu 555, f, \text{sea}; l, m)
\end{align*} \]

**Step 4.16.14 AST MDS#14: Sea Cell BT/TOA Record, 17 km cell**

Record identified by \((k, l, m)\)

Clear pixels, nadir.

\[ \begin{align*}
\text{AST-MDS14-1}(k, l, m) &= [\text{AST-MDS2-1}(k, l, m) \\
\text{AST-MDS14-2}(k, l, m) &= -1 \text{ if } (N_{\text{sea}}(n; k, l, m) = 0 \text{ and } N_{\text{sea}}(f; k, l, m) = 0) \\
&= 0 \text{ otherwise} \\
\text{AST-MDS14-3}(k, l, m) &= (3 \text{ zero bytes}) \\
\text{AST-MDS14-4}(k, l, m) &= \text{sub_cell_lat}(k, l, m) [L2-INT-62] \\
\text{AST-MDS14-5}(k, l, m) &= \text{sub_cell_long}(k, l, m) [L2-INT-63] \\
\text{AST-MDS14-6}(k, l, m) &= \text{across_track_mean}(0; k, l, m) [L2-INT-459] \\
\text{AST-MDS14-7}(k, l, m) &= N_{\text{total}}(n; k, l, m) [L2-INT-403] \\
\text{AST-MDS14-8}(k, l, m) &= N_{\text{sea}}(n; k, l, m) [L2-INT-402] \\
\text{AST-MDS14-9}(k, l, m) &= \text{pcs}(n; k, l, m) [L2-INT-404] \\
\text{AST-MDS14-10}(k, l, m) &= A(\text{ch}, n; 0, 0, k, l, m)
\end{align*} \]

Cloudy pixels, nadir.

\[ \begin{align*}
\text{AST-MDS14-11}(k, l, m) &= A(\text{ch}, n; 0, 1, k, l, m) \\
\text{AST-MDS14-12}(k, l, m) &= \text{PCS}(n; k, l, m) [L2-INT-82]
\end{align*} \]

Forward view:

\[ \begin{align*}
\text{AST-MDS14-13}(k, l, m) &= N_{\text{total}}(f; k, l, m) [L2-INT-413] \\
\text{AST-MDS14-14}(k, l, m) &= N_{\text{sea}}(f; k, l, m) [L2-INT-412] \\
\text{AST-MDS14-15}(k, l, m) &= \text{PCS}(f; k, l, m) [L2-INT-414]
\end{align*} \]

Clear pixels, forward.
Step 4.16.15 AST MDS#15: Sea Cell BT/TOA Record, 10 arc minute cell

Record identified by \((k, \text{cell})\)

Clear pixels, nadir.

\[
\text{AST-MDS15-1}(k, \text{cell}) = \text{AST-MDS3-1}(k, \text{cell})
\]

(Req 4.16.15-1)

\[
\text{AST-MDS15-2}(k, \text{cell}) = -1 \text{ if } (N_{\text{sea}}(n; k, \text{cell}) = 0 \text{ and } N_{\text{sea}}(f; k, \text{cell}) = 0)
\]

\[
= 0 \text{ otherwise}
\]

(Req 4.16.15-2)

\[
\text{AST-MDS15-3}(k, \text{cell}) = (3 \text{ zero bytes})
\]

(Req 4.16.15-3)

\[
\text{AST-MDS15-4}(k, \text{cell}) = \text{sub}_\text{cell}\_lat(k, \text{cell}) \text{ [L2-INT-32]}
\]

(Req 4.16.15-4)

\[
\text{AST-MDS15-5}(k, \text{cell}) = \text{sub}_\text{cell}\_long(k, \text{cell}) \text{ [L2-INT-33]}
\]

(Req 4.16.15-5)

\[
\text{AST-MDS15-6}(k, \text{cell}) = \text{across\_track\_mean}(0; k, \text{cell}) \text{ [L2-INT-359]}
\]

(Req 4.16.15-6)

\[
\text{AST-MDS15-7}(k, \text{cell}) = N_{\text{total}}(n; k, \text{cell}) \text{ [L2-INT-303]}
\]

(Req 4.16.15-7)

\[
\text{AST-MDS15-8}(k, \text{cell}) = N_{\text{sea}}(n; k, \text{cell}) \text{ [L2-INT-302]}
\]

(Req 4.16.15-8)

\[
\text{AST-MDS15-9}(k, \text{cell}) = \text{pcs}(n; k, \text{cell}) \text{ [L2-INT-304]}
\]

(Req 4.16.15-9)

\[
\text{AST-MDS15}\<10 + (ch - 1)\>(k, \text{cell}) = A(ch, n; 0, 0, k, \text{cell})
\]

(Req 4.16.15-10)

Cloudy pixels, nadir.

\[
\text{AST-MDS15}\<17 + (ch - 1)\>(k, \text{cell}) = A(ch, n; 0, 1, k, \text{cell})
\]

(Req 4.16.15-11)

\[
\text{AST-MDS15-24}(k, \text{cell}) = \text{PFF}(n; \text{sea}; k, \text{cell}) \text{ [L2-INT-52]}
\]

(Req 4.16.15-12)

Forward view:

\[
\text{AST-MDS15-25}(k, \text{cell}) = N_{\text{total}}(f; k, \text{cell}) \text{ [L2-INT-313]}
\]

(Req 4.16.15-13)

\[
\text{AST-MDS15-26}(k, \text{cell}) = N_{\text{sea}}(f; k, \text{cell}) \text{ [L2-INT-312]}
\]

(Req 4.16.15-14)

\[
\text{AST-MDS15-27}(k, \text{cell}) = \text{pcs}(f; k, \text{cell}) \text{ [L2-INT-314]}
\]

(Req 4.16.15-15)

Clear pixels, forward.

\[
\text{AST-MDS15}\<28 + (ch - 1)\>(k, \text{cell}) = A(ch, f; 0, 0, k, \text{cell})
\]

(Req 4.16.15-16)

Cloudy pixels, forward.

\[
\text{AST-MDS15}\<35 + (ch - 1)\>(k, \text{cell}) = A(ch, f; 0, 1, k, \text{cell})
\]

(Req 4.16.15-17)

\[
\text{AST-MDS15-42}(k, \text{cell}) = \text{PFF}(f; \text{sea}; k, \text{cell}) \text{ [L2-INT-52]}
\]

(Req 4.16.15-18)

Step 4.16.16 AST MDS#16: Sea Cell BT/TOA Record, 30 arc minute cell

Record identified by cell number \text{cell}.
AST-MDS16-1](cell) = [AST-MDS4-1](cell)  
AST-MDS16-2](cell) = -1 if \((N_{sea}(n; cell) = 0 \text{ and } N_{sea}(f; cell) = 0)\)  
= 0 otherwise  
AST-MDS16-3](cell) = (3 zero bytes)  
AST-MDS16-4](cell) = cell_lat(cell) [L2-INT-47]  
AST-MDS16-5](cell) = cell_long(cell) [L2-INT-48]  
AST-MDS16-6](cell) = across_track_mean(0; cell) [L2-INT-368]  
AST-MDS16-7](cell) = N_total(n; cell) [L2-INT-308]  
AST-MDS16-8](cell) = N_sea(n; cell) [L2-INT-307]  
AST-MDS16-9](cell) = pcs(n; cell) [L2-INT-309]  
Clear pixels, nadir.
AST-MDS16-<10 + 2.(ch - 1)>](cell) = \(\tilde{A}(ch, n; 0, 0, cell)\)  
AST-MDS16-<11 + 2.(ch - 1)>](cell) = \(\sigma(ch, n; 0, 0, cell)\)  
Cloudy pixels, nadir.
AST-MDS16-<24 + 2.(ch - 1)>](cell) = \(\tilde{A}(ch, n; 0, 1, cell)\)  
AST-MDS16-<25 + 2.(ch - 1)>](cell) = \(\sigma(ch, n; 0, 1, cell)\)  
AST-MDS16-38](cell) = PFF(n, sea; cell) [L2-INT-5]  
Forward view:
AST-MDS16-39](cell) = N_total(f; cell) [L2-INT-318]  
AST-MDS16-40](cell) = N_sea(f; cell) [L2-INT-317]  
AST-MDS16-41](cell) = pcs(f; cell) [L2-INT-319]  
Clear pixels, forward.
AST-MDS16-<42 + 2.(ch - 1)>](cell) = \(\tilde{A}(ch,f; 0, 0, cell)\)  
AST-MDS16-<43 + 2.(ch - 1)>](cell) = \(\sigma(ch,f; 0, 0, cell)\)  
Cloudy pixels, forward.
AST-MDS16-<56 + 2.(ch - 1)>](cell) = \(\tilde{A}(ch, f; 0, 1, cell)\)  
AST-MDS16-<57 + 2.(ch - 1)>](cell) = \(\sigma(ch, f; 0, 1, cell)\)  
AST-MDS16-70](cell) = PFF(f, sea; cell) [L2-INT-51]  
AST-MDS16-71](cell) = N0(cell)  
AST-MDS16-72](cell) = (ACLOUD) Percentage of pixels over <surface type>  
(Req 4.16.16-1)  
(Req 4.16.16-2)  
(Req 4.16.16-3)  
(Req 4.16.16-4)  
(Req 4.16.16-5)  
(Req 4.16.16-6)  
(Req 4.16.16-7)  
(Req 4.16.16-8)  
(Req 4.16.16-9)  
(Req 4.16.16-10)  
(Req 4.16.16-11)  
(Req 4.16.16-12)  
(Req 4.16.16-13)  
(Req 4.16.16-14)  
(Req 4.16.16-15)  
(Req 4.16.16-16)  
(Req 4.16.16-17)  
(Req 4.16.16-18)  
(Req 4.16.16-19)  
(Req 4.16.16-20)  
(Req 4.16.16-21)  
(Req 4.16.16-22)  
(Req 4.16.16-23)  
(Req 4.16.16-24)
Averaged cloud parameters (ACLOUD), nadir view:

\[
\text{[AST-MDS16-73](cell)} = I_{\text{min}}(ir11, n, \text{sea}; \text{cell}) \quad \text{(Req 4.16.16-25)}
\]

\[
\text{[AST-MDS16-74](cell)} = I_{\text{min}}(ir12, n, \text{sea}; \text{cell}) \quad \text{(Req 4.16.16-26)}
\]

\[
\text{[AST-MDS16-75](cell)} = I_{\text{min}}(ir37, n, \text{sea}; \text{cell}) \quad \text{(Req 4.16.16-27)}
\]

\[
\text{[AST-MDS16-76](cell)} = I_{\text{min}}(v16, n, \text{sea}; \text{cell}) \quad \text{(Req 4.16.16-28)}
\]

\[
\text{[AST-MDS16-77](cell)} = I_{\text{min}}(v870, n, \text{sea}; \text{cell}) \quad \text{(Req 4.16.16-29)}
\]

\[
\text{[AST-MDS16-78](cell)} = I_{\text{min}}(v670, n, \text{sea}; \text{cell}) \quad \text{(Req 4.16.16-30)}
\]

\[
\text{[AST-MDS16-79](cell)} = I_{\text{min}}(v555, n, \text{sea}; \text{cell}) \quad \text{(Req 4.16.16-31)}
\]

Averaged cloud parameters (ACLOUD), forward view:

\[
\text{[AST-MDS16-80](cell)} = I_{\text{min}}(ir11, f, \text{sea}; \text{cell}) \quad \text{(Req 4.16.16-32)}
\]

\[
\text{[AST-MDS16-81](cell)} = I_{\text{min}}(ir12, f, \text{sea}; \text{cell}) \quad \text{(Req 4.16.16-33)}
\]

\[
\text{[AST-MDS16-82](cell)} = I_{\text{min}}(ir37, f, \text{sea}; \text{cell}) \quad \text{(Req 4.16.16-34)}
\]

\[
\text{[AST-MDS16-83](cell)} = I_{\text{min}}(v16, f, \text{sea}; \text{cell}) \quad \text{(Req 4.16.16-35)}
\]

\[
\text{[AST-MDS16-84](cell)} = I_{\text{min}}(v870, f, \text{sea}; \text{cell}) \quad \text{(Req 4.16.16-36)}
\]

\[
\text{[AST-MDS16-85](cell)} = I_{\text{min}}(v670, f, \text{sea}; \text{cell}) \quad \text{(Req 4.16.16-37)}
\]

\[
\text{[AST-MDS16-86](cell)} = I_{\text{min}}(v555, f, \text{sea}; \text{cell}) \quad \text{(Req 4.16.16-38)}
\]

4.17 Module Definition: Output ECMWF Product

4.17.1 Functional Description

The ECMWF Averaged SST Product is written to the output medium. First the MPH, and
SPH are written, then the Measurement d

4.17.2 Interface Definition

See IODD Tables and Internal Parameter List

4.17.3 Detailed Structure

Step 4.17.1 MPH Record

As per PO-RS-MDA-GS-2009

Step 4.17.2 SPH Record

The SPH is identical to that for the AST product but with DSDs as per PO-RS-MDA-GS-

Step 4.17.3 MDS#1

The contents of each Meteo product record comprise the contents of the MDS3 record that
corresponds to the same cell, together with the clear sea brightness temperatures from the
corresponding MDS15 record, ordered to ensure that 4 byte quantities are aligned on 4-byte
boundaries. It is assembled as follows.
Record identified by (k, cell)

\[[\text{ECM-MDS1-1}](k, \text{cell}) = [\text{AST-MDS3-1}](k, \text{cell})\]  (Req 4.17.1)

\[[\text{ECM-MDS1-2}](k, \text{cell}) = -1 \text{ if } (N_{\text{sea}}(n; k, \text{cell}) = 0 \text{ and } N_{\text{sea}}(f; k, \text{cell}) = 0) \]
\[= 0 \text{ otherwise} \]  (Req 4.17.2)

\[[\text{ECM-MDS1-3}](k, \text{cell}) = (3 \text{ zero bytes}) \]  (Req 4.17.3)

\[[\text{ECM-MDS1-4}](k, \text{cell}) = \text{sub}_{\text{cell}}_{\text{lat}}(k, \text{cell}) \]  [L2-INT-32]  (Req 4.17.4)

\[[\text{ECM-MDS1-5}](k, \text{cell}) = \text{sub}_{\text{cell}}_{\text{long}}(k, \text{cell}) \]  [L2-INT-33]  (Req 4.17.5)

\[[\text{ECM-MDS1-12}](k, \text{cell}) = A(\text{ir12}, n; 0, 0, k, \text{cell}) \]  (Req 4.17.6)

\[[\text{ECM-MDS1-13}](k, \text{cell}) = A(\text{ir11}, n; 0, 0, k, \text{cell}) \]  (Req 4.17.7)

\[[\text{ECM-MDS1-14}](k, \text{cell}) = A(\text{ir37}, n; 0, 0, k, \text{cell}) \]  (Req 4.17.8)

\[[\text{ECM-MDS1-15}](k, \text{cell}) = A(\text{ir12}, f; 0, 0, k, \text{cell}) \]  (Req 4.17.9)

\[[\text{ECM-MDS1-16}](k, \text{cell}) = A(\text{ir11}, f; 0, 0, k, \text{cell}) \]  (Req 4.17.10)

\[[\text{ECM-MDS1-17}](k, \text{cell}) = A(\text{ir37}, f; 0, 0, k, \text{cell}) \]  (Req 4.17.11)

\[[\text{ECM-MDS1-6}](k, \text{cell}) = \text{across}_{\text{track}}_{\text{mean}}(0; k, \text{cell}) \]  [L2-INT-359]  (Req 4.17.12)

\[[\text{ECM-MDS1-7}](k, \text{cell}) = \text{T}_{\text{nadir}}(k, \text{cell}) \]  [L2-INT-54]  (Req 4.17.13)

\[[\text{ECM-MDS1-8}](k, \text{cell}) = \text{the smaller of } M(\text{ir11}, n; 0, 0, k, \text{cell}), M(\text{ir12}, n; 0, 0, k, \text{cell}) \]  (Req 4.17.14)

\[[\text{ECM-MDS1-9}](k, \text{cell}) = \text{T}_{\text{dual}}(k, \text{cell}) \]  [L2-INT-56]  (Req 4.17.15)

\[[\text{ECM-MDS1-10}](k, \text{cell}) = \text{the smallest of } M(\text{ir11}, n; 0, 0, k, \text{cell}), M(\text{ir12}, n; 0, 0, k, \text{cell}), M(\text{ir11}, f; 0, 0, k, \text{cell}), M(\text{ir12}, f; 0, 0, k, \text{cell}) \]  (Req 4.17.16)

\[[\text{ECM-MDS1-11}](k, \text{cell}) = \text{ast}_{\text{conf}}(0; k, \text{cell}) \]  (Req 4.17.17)
## 5 Internal Parameter List

<table>
<thead>
<tr>
<th>Parameter ID</th>
<th>Variable</th>
<th>Name</th>
<th>Type</th>
<th>Units</th>
<th>Field Size</th>
<th>Fields</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>L2-INT-1</td>
<td>(w(\text{ch}, i))</td>
<td>Tie point latitude</td>
<td>float</td>
<td>deg.</td>
<td>4</td>
<td>(j = 0, 22)</td>
<td></td>
</tr>
<tr>
<td>L2-INT-2</td>
<td>(L(\text{ch}, i))</td>
<td>Tie point longitude</td>
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<td>deg.</td>
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<td></td>
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<tr>
<td>L2-INT-3</td>
<td>(\gamma(\text{ch}, \text{cell}))</td>
<td>tie scan satellite elevation, nadir</td>
<td>float</td>
<td>deg.</td>
<td>4</td>
<td>(k = 0, 10)</td>
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</tr>
<tr>
<td>L2-INT-4</td>
<td>(\beta(\text{ch}, \text{cell}))</td>
<td>tie scan solar azimuth, nadir</td>
<td>float</td>
<td>deg.</td>
<td>4</td>
<td>(k = 0, 10)</td>
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</tr>
<tr>
<td>L2-INT-5</td>
<td>(\alpha(\text{ch}, \text{cell}))</td>
<td>tie scan solar elevation, forward</td>
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<tr>
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<td>deg.</td>
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<td>(k = 0, 10)</td>
<td></td>
</tr>
<tr>
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<td>(\beta(\text{ch}, \text{cell}))</td>
<td>tie scan y co-ordinate</td>
<td>si</td>
<td>m</td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L2-INT-8</td>
<td>(y(i))</td>
<td>image scan y co-ordinate</td>
<td>si</td>
<td>m</td>
<td>4</td>
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<tr>
<td>L2-INT-9</td>
<td>(\text{UTC(l, m)})</td>
<td>Scan UTC in MJD Format</td>
<td>4*si</td>
<td>MJD</td>
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<td></td>
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<tr>
<td>L2-INT-10</td>
<td>(\text{UTC(m, l)})</td>
<td>50 km cell UTC</td>
<td>double</td>
<td>days</td>
<td>8</td>
<td>per cell</td>
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</tr>
<tr>
<td>L2-INT-11</td>
<td>(\text{UTC(k, l)})</td>
<td>17 km sub-cell UTC</td>
<td>double</td>
<td>days</td>
<td>8</td>
<td>(k = 0, 8)</td>
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</tr>
<tr>
<td>L2-INT-12</td>
<td>(\text{UTC(k, cell)})</td>
<td>cell UTC</td>
<td>double</td>
<td>days</td>
<td>8</td>
<td>per cell</td>
<td></td>
</tr>
<tr>
<td>L2-INT-13</td>
<td>(\text{UTC(k, cell)})</td>
<td>sub-cell UTC</td>
<td>double</td>
<td>days</td>
<td>8</td>
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<td>L2-INT-14</td>
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<tr>
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<td>si</td>
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<td>sub-cell area</td>
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<td>si</td>
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<tr>
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<td>(\mu)deg</td>
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<tr>
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<td>(\mu)deg</td>
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<td>si</td>
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<td>(\mu)deg</td>
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<td>sub-cell area</td>
<td>si</td>
<td>(\mu)deg</td>
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<td>(\mu)deg</td>
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<td>4</td>
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<td>sub-cell area</td>
<td>si</td>
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<td>si</td>
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<tr>
<td>L2-INT-37</td>
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<tr>
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<tr>
<td>L2-INT-41</td>
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<td>sub-cell area</td>
<td>si</td>
<td>(\mu)deg</td>
<td>4</td>
<td>(k = 0, 8)</td>
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<td>L2-INT-42</td>
<td>(\text{UTC(k, cell)})</td>
<td>sub-cell area</td>
<td>si</td>
<td>(\mu)deg</td>
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<td>(k = 0, 8)</td>
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<td>L2-INT-43</td>
<td>(\text{UTC(k, cell)})</td>
<td>sub-cell area</td>
<td>si</td>
<td>(\mu)deg</td>
<td>4</td>
<td>(k = 0, 8)</td>
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<td>L2-INT-44</td>
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<td>si</td>
<td>(\mu)deg</td>
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<td>L2-INT-45</td>
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<td>si</td>
<td>(\mu)deg</td>
<td>4</td>
<td>(k = 0, 8)</td>
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<td>L2-INT-46</td>
<td>(\text{UTC(k, cell)})</td>
<td>sub-cell area</td>
<td>si</td>
<td>(\mu)deg</td>
<td>4</td>
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<td>L2-INT-47</td>
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<td>L2-INT-50</td>
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<td>(\mu)deg</td>
<td>4</td>
<td>(k = 0, 8)</td>
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### Footnotes
- Commercial In Confidence
- AATSR Product Algorithm Detailed Documentation
<table>
<thead>
<tr>
<th>Parameter</th>
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<td>L2-INT-66</td>
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### ENVISAT PAYLOAD DATA SEGMENT

**Commercial in Confidence**

**AATSR Expert Support Laboratory**

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<td>L2-INT-101</td>
<td><code>lir12_n, n, i, j)</code></td>
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<td>L2-INT-102</td>
<td><code>lir11_n, n, i, j)</code></td>
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<td>L2-INT-103</td>
<td><code>lir37_n, n, i, j)</code></td>
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<td><code>lv16_n, n, i, j)</code></td>
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<td><code>lv870_n, n, i, j)</code></td>
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<td>L2-INT-106</td>
<td><code>lv670_n, n, i, j)</code></td>
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<td>L2-INT-107</td>
<td><code>lv555_n, n, i, j)</code></td>
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<td>L2-INT-110</td>
<td><code>frwrd_fill_state(i, j)</code></td>
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<td><code>lir37_f, f, i, j)</code></td>
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<td>L2-INT-116</td>
<td><code>lv670_f, f, i, j)</code></td>
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<tr>
<td>L2-INT-117</td>
<td><code>lv555_f, f, i, j)</code></td>
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</table>

### regridded nadir information:

| L2-INT-120 | `nadir.band_edge.satellite.elevation(i, k)` | float | degrees | 4 | k = 0, 10 |
| L2-INT-121 | `nadir.band_edge.solar.elevation(i, k)`    | float | degrees | 4 | k = 0, 10 |
| L2-INT-122 | `nadir.band.edge.solar.azimuth(i, k)`      | float | degrees | 4 | k = 0, 10 |
| L2-INT-123 | `nadir.band.edge.solar.azimuth(i, k)`      | float | degrees | 4 | k = 0, 10 |
| L2-INT-124 | `nadir.band_centre.solar.elevation(i, k')`  | float | degrees | 4 | k' = 0, 9 |
| L2-INT-125 | `nadir.band_centre.solar.elevation(i, k')`  | float | degrees | 4 | k' = 0, 9 |
| L2-INT-126 | `nadir.band_centre.solar.azimuth(i, k')`    | float | degrees | 4 | k' = 0, 9 |
| L2-INT-127 | `nadir.band_centre.solar.azimuth(i, k')`    | float | degrees | 4 | k' = 0, 9 |
| L2-INT-128 | `nadir.band_centre.scan.times(i, k')`      | double |
| L2-INT-134 | `scn_nadir(i, j)`                      | `nadir view instrument scan number` | us | none | j = 0, 511 |
| L2-INT-135 | `pxl_nadir(i, j)`                      | `nadir view instrument pixel number` | us | none | j = 0, 511 |

### Regridded forward information:

| L2-INT-140 | `frwrd.band_edge.solar.elevation(i, k)` | float | degrees | 4 | k = 0, 10 |
| L2-INT-141 | `frwrd.band_edge.solar.azimuth(i, k)`   | float | degrees | 4 | k = 0, 10 |
| L2-INT-142 | `frwrd.band.edge.solar.azimuth(i, k)`   | float | degrees | 4 | k = 0, 10 |
| L2-INT-143 | `frwrd.band.edge.solar.azimuth(i, k)`   | float | degrees | 4 | k = 0, 10 |
| L2-INT-144 | `frwrd.band_centre.solar.elevation(i, k')` | float | degrees | 4 | k' = 0, 9 |
| L2-INT-145 | `frwrd.band_centre.solar.elevation(i, k')` | float | degrees | 4 | k' = 0, 9 |
| L2-INT-146 | `frwrd.band_centre.solar.azimuth(i, k')` | float | degrees | 4 | k' = 0, 9 |
| L2-INT-147 | `frwrd.band_centre.solar.azimuth(i, k')` | float | degrees | 4 | k' = 0, 9 |
| L2-INT-148 | `frwrd.band_centre.scan.times[10]`      | double |
| L2-INT-149 | `min_aux_temps[6]`                      | float |
| L2-INT-150 | `max_aux_temps[6]`                      | float |
| L2-INT-151 | `platform_mode`                        | long int |
| L2-INT-152 | `pod`                                 | long int |
| L2-INT-154 | `scn_frwrd(i, j)`                      | `forward view instrument scan number` | us | none | j = 0, 511 |
| L2-INT-155 | `pxl_frwrd(i, j)`                      | `forward view instrument pixel number` | us | none | j = 0, 511 |
| L2-INT-160 | \( w(i, j) \) | image pixel latitude | float | deg. | 4 | \( j = 0, 511 \) |
| L2-INT-161 | \( \lambda(i, j) \) | image pixel longitude | float | deg. | 4 | \( j = 0, 511 \) |
| L2-INT-171 | GBTR confidence word, nadir view | ss flags | 2 | \( j = 0, 511 \) |
| L2-INT-172 | GBTR confidence word, forward view: | ss flags | 2 | 512 |
| L2-INT-173 | gbtr_cloud_state_nadir | GBTR cloud state flags, nadir view | ss flags | 2 | 512 |
| L2-INT-174 | gbtr_cloud_state_fwr d | GBTR cloud state flags, forward view | ss flags | 2 | 512 |

Unpacked GBTR Confidence flags (nadir):

| L2-INT-200 | nadir_blanking_pulse(i, j) | ss array flag | 2 | \( j = 0, 511 \) |
| L2-INT-201 | nadir_cosmetic(i, j) | ss array flag | 2 | \( j = 0, 511 \) |
| L2-INT-202 | nadir_scan_absent(i, j) | ss array flag | 2 | \( j = 0, 511 \) |
| L2-INT-203 | nadir_pixel_absent(i, j) | ss array flag | 2 | \( j = 0, 511 \) |
| L2-INT-204 | nadir_packet_validation_error(i, j) | ss array flag | 2 | \( j = 0, 511 \) |
| L2-INT-205 | nadir_zero_count(i, j) | ss array flag | 2 | \( j = 0, 511 \) |
| L2-INT-206 | nadir_saturation(i, j) | ss array flag | 2 | \( j = 0, 511 \) |
| L2-INT-207 | nadir_cal_out_of_range(i, j) | ss array flag | 2 | \( j = 0, 511 \) |
| L2-INT-208 | nadir_calibration_unavailable(i, j) | ss array flag | 2 | \( j = 0, 511 \) |
| L2-INT-209 | nadir_unfilled_pixel(i, j) | ss array flag | 2 | \( j = 0, 511 \) |

Unpacked GBTR Confidence flags (forward):

| L2-INT-216 | frwrd_blanking_pulse(i, j) | ss array flag | 2 | \( j = 0, 511 \) |
| L2-INT-217 | frwrd_cosmetic(i, j) | ss array flag | 2 | \( j = 0, 511 \) |
| L2-INT-218 | frwrd_scan_absent(i, j) | ss array flag | 2 | \( j = 0, 511 \) |
| L2-INT-219 | frwrd_pixel_absent(i, j) | ss array flag | 2 | \( j = 0, 511 \) |
| L2-INT-220 | frwrd_packet_validation_error(i, j) | ss array flag | 2 | \( j = 0, 511 \) |
| L2-INT-221 | frwrd_zero_count(i, j) | ss array flag | 2 | \( j = 0, 511 \) |
| L2-INT-222 | frwrd_saturation(i, j) | ss array flag | 2 | \( j = 0, 511 \) |
| L2-INT-223 | frwrd_cal_out_of_range(i, j) | ss array flag | 2 | \( j = 0, 511 \) |
| L2-INT-224 | frwrd_calibration_unavailable(i, j) | ss array flag | 2 | \( j = 0, 511 \) |
| L2-INT-225 | frwrd_unfilled_pixel(i, j) | ss array flag | 2 | \( j = 0, 511 \) |

Unpacked GBTR cloud/land flags (nadir):

| L2-INT-232 | nadir_land(i, j) | ss array flag | 2 | \( j = 0, 511 \) |
| L2-INT-233 | nadir_cloud(i, j) | ss array flag | 2 | \( j = 0, 511 \) |
| L2-INT-234 | nadir_sunglint(i, j) | ss array flag | 2 | \( j = 0, 511 \) |
| L2-INT-235 | nadir_v16_histogram_test(i, j) | ss array flag | 2 | \( j = 0, 511 \) |
| L2-INT-236 | nadir_v16 Spatial coherence test(i, j) | ss array flag | 2 | \( j = 0, 511 \) |
| L2-INT-237 | nadir_ir11 Spatial coherence test(i, j) | ss array flag | 2 | \( j = 0, 511 \) |
| L2-INT-238 | nadir Ir12 gross_cloud test(i, j) | ss array flag | 2 | \( j = 0, 511 \) |
| L2-INT-239 | nadir_ir11_12 thin_cirrus_test(i, j) | ss array flag | 2 | \( j = 0, 511 \) |
| L2-INT-240 | nadir_ir37 Ir12med_high_level_test(i, j) | ss array flag | 2 | \( j = 0, 511 \) |
| L2-INT-241 | nadir_ir11 Ir37 fog_low_stratus_test(i, j) | ss array flag | 2 | \( j = 0, 511 \) |
| L2-INT-242 | nadir_ir11 Ir12 view_diff test(i, j) | ss array flag | 2 | \( j = 0, 511 \) |
| L2-INT-243 | nadir_ir37 Ir11 view_diff test(i, j) | ss array flag | 2 | \( j = 0, 511 \) |
| L2-INT-244 | nadir_ir11 Ir12 histogram test(i, j) | ss array flag | 2 | \( j = 0, 511 \) |

Unpacked GBTR cloud/land flags (forward):

<p>| L2-INT-248 | frwrd_land(i, j) | ss array flag | 2 | ( j = 0, 511 ) |
| L2-INT-249 | frwrd_cloud(i, j) | ss array flag | 2 | ( j = 0, 511 ) |
| L2-INT-250 | frwrd_sunglint(i, j) | ss array flag | 2 | ( j = 0, 511 ) |
| L2-INT-251 | frwrd_v16_histogram_test(i, j) | ss array flag | 2 | ( j = 0, 511 ) |
| L2-INT-252 | frwrd_v16 Spatial coherence test(i, j) | ss array flag | 2 | ( j = 0, 511 ) |
| L2-INT-253 | frwrd_ir11 Spatial coherence test(i, j) | ss array flag | 2 | ( j = 0, 511 ) |
| L2-INT-254 | frwrd_ir12 gross_cloud test(i, j) | ss array flag | 2 | ( j = 0, 511 ) |
| L2-INT-255 | frwrd_ir11 Ir12 thin_cirrus_test(i, j) | ss array flag | 2 | ( j = 0, 511 ) |
| L2-INT-256 | frwrd_ir37 Ir12med high_level_test(i, j) | ss array flag | 2 | ( j = 0, 511 ) |
| L2-INT-257 | frwrd_ir11 Ir37 fog_low_stratus_test(i, j) | ss array flag | 2 | ( j = 0, 511 ) |</p>
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<th>Description</th>
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<td><code>fwrd_ir11_ir12_view_diff_test(i, j)</code></td>
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<td>L2-INT-259</td>
<td><code>fwrd_ir37_ir11_view_diff_test(i, j)</code></td>
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<td>L2-INT-260</td>
<td><code>fwrd_ir11_ir12_histogram_test(i, j)</code></td>
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<td>L2-INT-270</td>
<td><code>nadir_image_field(i, j)</code></td>
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<tr>
<td>L2-INT-271</td>
<td><code>combined_image_field(i, j)</code></td>
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<td>L2-INT-272</td>
<td><code>gsst-confidence_word(i, j)</code></td>
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<td><code>nadir_only_sst_valid(i, j)</code></td>
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<td><code>nadir_only_sst_valid(i, j)</code></td>
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<tr>
<td>L2-INT-282</td>
<td><code>combined_view_valid(i, j)</code></td>
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<tr>
<td>L2-INT-283</td>
<td><code>combined_view_valid(i, j)</code></td>
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<tr>
<td>L2-INT-284</td>
<td><code>land(i, j)</code></td>
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<tr>
<td>L2-INT-285</td>
<td><code>nadir_view_cloudy(i, j)</code></td>
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<tr>
<td>L2-INT-286</td>
<td><code>nadir_view_blanking_pulse(i, j)</code></td>
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<td>L2-INT-287</td>
<td><code>nadir_view_cloudy(i, j)</code></td>
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<td><code>fwrd_view_cloudy(i, j)</code></td>
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<td><code>fwrd_view_blanking_pulse(i, j)</code></td>
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<td>L2-INT-290</td>
<td><code>fwrd_view_cloudy(i, j)</code></td>
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<td>L2-INT-291</td>
<td><code>gsst_view_cloud(i, j)</code></td>
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<td><code>gsst_nadir_fwrd_cloud_test(i, j)</code></td>
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<td>L2-INT-293</td>
<td><code>gsst_ir11_histogram_test(i, j)</code></td>
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<td><code>topographic_variance(i, j)</code></td>
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<td>L2-INT-295</td>
<td><code>extended_land(i, j)</code></td>
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<td><code>N_land(n; k, cell)</code></td>
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<td><code>N_sea(n; k, cell)</code></td>
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<tr>
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<td><code>N_total(n; k, cell)</code></td>
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<tr>
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<td><code>pcs(n; cell)</code></td>
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<tr>
<td>L2-INT-305</td>
<td><code>pcl(n; k, cell)</code></td>
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<td><code>N_land(n; cell)</code></td>
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<td><code>N_sea(n; cell)</code></td>
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<td><code>N_total(n; cell)</code></td>
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<td><code>pcs(n; cell)</code></td>
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<td><code>pcl(n; cell)</code></td>
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<tr>
<td>L2-INT-311</td>
<td><code>N_land(f; k, cell)</code></td>
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<tr>
<td>L2-INT-312</td>
<td><code>N_sea(f; k, cell)</code></td>
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<tr>
<td>L2-INT-313</td>
<td><code>N_total(f; k, cell)</code></td>
</tr>
<tr>
<td>L2-INT-314</td>
<td><code>pcs(f; cell)</code></td>
</tr>
<tr>
<td>L2-INT-315</td>
<td><code>pcl(f; cell)</code></td>
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<tr>
<td>L2-INT-316</td>
<td><code>N_land(f; cell)</code></td>
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<tr>
<td>L2-INT-317</td>
<td><code>N_sea(f; cell)</code></td>
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<tr>
<td>L2-INT-318</td>
<td><code>N_total(f; cell)</code></td>
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<td>L2-INT-319</td>
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<td>L2-INT-320</td>
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<td><code>fwrd_clear_land</code></td>
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<td>L2-INT-331</td>
<td>fwdr_cloud land</td>
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<td>nadir_hist land</td>
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<tr>
<td>L2-INT-333</td>
<td>fwdr_hist land</td>
</tr>
<tr>
<td>L2-INT-334</td>
<td>(Parameter deleted)</td>
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<td>bt_cloud_top</td>
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<tr>
<td>L2-INT-336</td>
<td>bt_percent_cloudy</td>
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<tr>
<td>L2-INT-337</td>
<td>bt_cloud_top</td>
</tr>
<tr>
<td>L2-INT-338</td>
<td>bt_percent_cloudy</td>
</tr>
</tbody>
</table>

Nadir output quantities:

| L2-INT-334 | nadir clear sea | total of clear sea pixels, nadir view | sl | none | 4 | per cell |
| L2-INT-335 | fwdr_clear sea | total of clear sea pixels, forward view | sl | none | 4 | per cell |
| L2-INT-336 | fwdr_cloudy sea | total of cloudy sea pixels, nadir view | sl | none | 4 | per cell |
| L2-INT-337 | fwdr_cloudy sea | total of cloudy sea pixels, forward view | sl | none | 4 | per cell |
| L2-INT-338 | nadir_hist sea | nadir histogram (sea cell) | ss | none | 2 | 1000 |
| L2-INT-339 | fwdr_hist sea | forward histogram (sea cell) | ss | none | 2 | 1000 |
| L2-INT-340 | (Parameter deleted) | | | | |

Forward output quantities:

| L2-INT-335 | bt_cloud_top | cloud top temperature (over sea) | ss | 0.01K | 2 | per cell |
| L2-INT-336 | bt_percent_cloudy | percentage cloudy pixels (over sea) | ss | 0.01% | 2 | per cell |

Sea pixel histogram quantities:

| L2-INT-336 | band_sum(k, cell) | cumulative across-track band sum | sl | none | 4 | |
| L2-INT-341 | mean_band(k, cell) | mean across-track band number | ss | none | 2 | |

Cumulative across-track pixel index:

| L2-INT-337 | across_track_sum(sf; k, cell) | cumulative sum of across-track pixel index | sl | none | 4 | k = 0, 8 |
| L2-INT-338 | across_track_mean(sf; k, cell) | mean across-track pixel index, subcell k | ss | none | 2 | k = 0, 8 |
| L2-INT-339 | averaged SST retrieval a coefficients | float | mixed | 4 | 90 |
| L2-INT-340 | averaged SST retrieval b coefficients | float | mixed | 4 | 120 |
| L2-INT-341 | averaged SST retrieval c coefficients | float | mixed | 4 | 150 |

| L2-INT-342 | d(i, j, q) | mean across-track pixel index, cell | ss | none | 2 | per cell |
| L2-INT-343 | ast_conf(sf; k, cell) | AST confidence word for sub-cell | sl | flags | 4 | k = 0, 8 |
| L2-INT-344 | ast_conf(sf; cell) | AST confidence word for cell | sl | flags | 4 | per cell |
| L2-INT-345 | nadir_asst Uses_ir37(k, cell) | | ss | flag | 2 | k = 0, 8 |
| L2-INT-346 | dual_asst Uses_ir37(k, cell) | | ss | flag | 2 | k = 0, 8 |
| L2-INT-347 | across_track_mean(sf; cell) | mean across-track pixel index, cell | ss | none | 2 | per cell |
| L2-INT-348 | sst_mean_pixel(sf, cell) | mean across-track pixel index, cell | ss | none | 2 | per cell |

Cell and sub-cell counts for 50 km cells:

| L2-INT-349 | N_land(n; k, l, m) | total of filled pixels over land for subcell | ss | none | 2 | k = 0, 8 |
| L2-INT-350 | N_sea(n; k, l, m) | total of filled pixels over sea for subcell | ss | none | 2 | k = 0, 8 |
| L2-INT-351 | N_total(n; k, l, m) | total of filled pixels over land for subcell | ss | none | 2 | k = 0, 8 |
| L2-INT-352 | pcs(n; k, l, m) | percentage of cloudy pixels over sea | ss | 0.01% | 2 | k = 0, 8 |
| L2-INT-353 | pcd(n; k, l, m) | percentage of cloudy pixels over land | ss | 0.01% | 2 | k = 0, 8 |
| L2-INT-354 | N_land(n; l, m) | total of filled pixels over land for cell | ss | none | 2 | k = 0, 8 |
| L2-INT-355 | N_sea(n; l, m) | total of filled pixels over sea for cell | ss | none | 2 | k = 0, 8 |
| L2-INT-356 | N_total(n; l, m) | total of filled pixels for cell, nadir view | ss | none | 2 | |
| L2-INT-415 | pctl(k, l, m) | percentage of cloudy pixels over land | ss | 0.01% | 2 | k = 0, 8 |
| L2-INT-416 | N_land(f, l, m) | total filled pixels over land for cell | ss | none | 2 |
| L2-INT-417 | N_sea(f, l, m) | total of filled pixels over sea for cell | ss | none | 2 |
| L2-INT-418 | N_total(f, l, m) | total of filled pixels for cell, fwd view | ss | none | 2 |
| L2-INT-419 | pctl(f, l, m) | percentage of cloudy pixels over sea | ss | 0.01% | 2 |
| L2-INT-420 | pctl(l, l, m) | percentage of cloudy pixels over land | ss | 0.01% | 2 |
| L2-INT-421 | (Parameter deleted) |
| L2-INT-422 | (Parameter deleted) |
| L2-INT-423 | (Parameter deleted) |
| L2-INT-424 | (Parameter deleted) |
| L2-INT-425 | across_track_band | across-track band | ss | none | 2 | per cell |

**land pixel histogram quantities:**

| L2-INT-426 |
| L2-INT-427 |
| L2-INT-428 | nadir_clear_land | total of clear land pixels, nadir view | sl | none | 4 | per cell |
| L2-INT-429 | fwdrd_clear_land | total of clear land pixels, forward view | sl | none | 4 | per cell |
| L2-INT-430 | nadir_cloudy_land | total of cloudy land pixels, nadir view | sl | none | 4 | per cell |
| L2-INT-431 | fwdrd_cloudy_land | total of cloudy land pixels, forward view | sl | none | 4 | per cell |
| L2-INT-432 | nadir_hist_land | nadir histogram (land cell) | ss | none | 2 | 1000 |
| L2-INT-433 | fwdrd_hist_land | forward histogram (land cell) | ss | none | 2 | 1000 |
| L2-INT-434 | (Parameter deleted) |

**nadir output quantities:**

| L2-INT-435 | bt_cloud_top | cloud top temperature (over land) | ss | 0.01K | 2 | per cell |
| L2-INT-436 | bt_percent_cloudy | percentage cloudy pixels (over land) | ss | 0.01% | 2 | per cell |
| L2-INT-437 | bt_cloud_top | cloud top temperature (over land) | ss | 0.01K | 2 | per cell |
| L2-INT-438 | bt_percent_cloudy | percentage cloudy pixels (over land) | ss | 0.01% | 2 | per cell |

**sea pixel histogram quantities:**

| L2-INT-442 | (Parameter deleted) |
| L2-INT-443 | (Parameter deleted) |
| L2-INT-444 | nadir_clear_sea | total of clear sea pixels, nadir view | sl | none | 4 | per cell |
| L2-INT-445 | fwdrd_clear_sea | total of clear sea pixels, forward view | sl | none | 4 | per cell |
| L2-INT-446 | nadir_cloudy_sea | total of cloudy sea pixels, nadir view | sl | none | 4 | per cell |
| L2-INT-447 | fwdrd_cloudy_sea | total of cloudy sea pixels, forward view | sl | none | 4 | per cell |
| L2-INT-448 | nadir_hist_sea | nadir histogram (sea cell) | ss | none | 2 | 1000 |
| L2-INT-449 | fwdrd_hist_sea | forward histogram (sea cell) | ss | none | 2 | 1000 |
| L2-INT-450 | (Parameter deleted) |

**nadir output quantities:**

<p>| L2-INT-451 | bt_cloud_top | cloud top temperature (over sea) | ss | 0.01K | 2 | per cell |
| L2-INT-452 | bt_percent_cloudy | percentage cloudy pixels (over sea) | ss | 0.01% | 2 | per cell |
| L2-INT-453 | bt_cloud_top | cloud top temperature (over sea) | ss | 0.01K | 2 | per cell |
| L2-INT-454 | bt_percent_cloudy | percentage cloudy pixels (over sea) | ss | 0.01% | 2 | per cell |
| L2-INT-455 | Nv(sf, cl, k, l, m) | sub-cell filled pixel count | ss | none | 2 |
| L2-INT-456 | band_sum(k, l, m) | cumulative across-track band sum | sl | none | 4 |
| L2-INT-457 | mean_band(k, l, m) | mean across-track band number | ss | none | 2 |
| L2-INT-458 | across_track_sum(sf; k, l, m) | cumulative sum of across-track pixel index | sl | none | 4 | k = 0, 8 |
| L2-INT-459 | across_track_mean(sf; k, l, m) | mean across-track pixel index, subcell k | ss | none | 2 | k = 0, 8 |
| L2-INT-460 | a[i, l, q] | averaged sst retrieval a coefficients | float | mixed | 4 |
| L2-INT-461 | b[i, l, q] | averaged sst retrieval b coefficients | float | mixed | 4 |
| L2-INT-462 | c[i, j, q] | averaged sst retrieval c coefficients | float | mixed | 4 |
| L2-INT-463 | d[i, j, q] | averaged sst retrieval d coefficients | float | mixed | 4 |
| L2-INT-464 | ast_conf(sf; k, l, m) | AST confidence word for sub-cell | sl | flags | 4 | k = 0, 8 |
| L2-INT-465 | ast_conf(sf; l, m) | AST confidence word for cell l, m | sl | flags | 4 | per cell |
| L2-INT-466 | nadir_asst_use_x3(k, l, m) | ss | flag | 2 | k = 0, 8 |
| L2-INT-467 | dual_asst_use_y3(k, l, m) | ss | flag | 2 | k = 0, 8 |
| L2-INT-468 | across_track_mean(sf; l, m) | mean across-track pixel index, cell l, m | ss | none | 2 | per cell |</p>
<table>
<thead>
<tr>
<th>L2-INT-469</th>
<th>ss, mean_pixel(position) of LST in pixel, l, m</th>
<th>mean across-track pixel index, l, m</th>
<th>ss</th>
<th>none</th>
<th>2</th>
<th>per cell</th>
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<td>precipitable_water(lat_index, lon_index)</td>
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<td>2</td>
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</tr>
<tr>
<td>L2-INT-473</td>
<td>Topographic_flag(lat_index, lon_index)</td>
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<td>coeff(class, i, 0)</td>
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<tr>
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<td>4</td>
<td>per cell</td>
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<td>per cell</td>
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<td>4</td>
<td>k = 0, 8</td>
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<td>4</td>
<td>per cell</td>
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</tbody>
</table>

Table 5-1: Internal Parameter summary list