(A)ATSR Land Surface Temperature (LST) Product (UOL_LST_L2) Level 2 User Guide

v 1.0
# Version History

<table>
<thead>
<tr>
<th>Version</th>
<th>Date</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.9</td>
<td>03/12/2013</td>
<td>Initial version for evaluation</td>
</tr>
<tr>
<td>1.0</td>
<td>17/12/2013</td>
<td>ESA QC recommendations applied</td>
</tr>
</tbody>
</table>
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1 Introduction

The purpose of this document is to describe the content and use of the reprocessed Level-2 University of Leicester Land Surface Temperature (LST) product (UOL_LST_L2) for the Along Track Scanning Radiometers (ATSRs). The product provides (A)ATSR-based LST and its associated uncertainty, as well as additional auxiliary information, which was used as part of the retrieval algorithm.

The algorithm applied for computing LST is based on the methodology originally developed by [1] in that it uses a split-window approach with model-derived regression coefficients which implicitly include the effects of emissivity. However, the updated methodology that was used for this reprocessing applies significantly improved auxiliary datasets for land cover, green vegetation fraction, and total column water vapour and as such is able to reduce or eliminate a wide variety of issues that were observed with the original LST product. Further details about the algorithm used for producing this dataset can be found in [2].

The resulting data product has been extensively validated by [3, 4] using the LST validation methodology described in [5].

2 Product Description

The following sections describe the overall scope of the data product, introduce the file naming convention and its elements, and briefly describe the actual file contents.

2.1 Scope

The product primarily provides data on LST and its associated uncertainty. It further provides auxiliary information that has been used for the LST retrieval, such as land cover type, fractional vegetation cover, total column water vapour, normalized difference vegetation index (NDVI), and quality control flags. Within some daily subdirectories there exists an additional folder called "segregated". Orbits within these folders have been processed to UOL_LST_L2 but have been separated due to the non-nominal nature of the input level-1b data (for more details see the Envisat AATSR Performance Report (IDEAS-VEG-OQC-REP-1143), which is available from the ESA Document Library: https://earth.esa.int/web/guest/document-library).
2.2 Filename Convention

The filename of the product follows the generic Envisat filename convention [6], which consists of the following elements:

\[
\text{<product}_\text{ID}> \ <\text{processing}_\text{stage}_\text{flag}> \ <\text{originator}_\text{ID}> \ <\text{start}_\text{day}> \ <"\_"> \ <\text{start}_\text{time}> \ <"\_"> \ <\text{duration}> \ <\text{phase}> \ <\text{cycle}> \ <"\_"> \ <\text{relative}_\text{orbit}> \ <"\_"> \ <\text{absolute}_\text{orbit}> \ <"\_"> \ <\text{counter}> \ <"\_"> <\text{extension}>
\]

The elements are described based on the following example filename

\text{ATS\_LST\_2PUUOL20060718\_102137\_000065272049\_00308\_22907\_6417.nc}

<table>
<thead>
<tr>
<th>Element</th>
<th>Example</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;product_ID&gt;</td>
<td>ATS_LST_2P</td>
<td>10-character string identifying sensor – AT1, AT2, ATS – for ATSR-1, ATSR-2, AATSR respectively, processing level, and type of product</td>
</tr>
<tr>
<td>&lt;processing_stage_flag&gt;</td>
<td>U</td>
<td>Identifier for the processing stage (U = 3rd reprocessing)</td>
</tr>
<tr>
<td>&lt;originator_ID&gt;</td>
<td>UOL</td>
<td>Identifier of the production facility (UOL = University of Leicester)</td>
</tr>
<tr>
<td>&lt;start_day&gt;</td>
<td>20060718</td>
<td>The start day of the product based on the start time of the first data set record. Given in YYYYMMDD</td>
</tr>
<tr>
<td>&lt;start_time&gt;</td>
<td>102137</td>
<td>The start time of the product from the UTC time of the first data set record, given in HHMMSS</td>
</tr>
<tr>
<td>&lt;duration&gt;</td>
<td>00006527</td>
<td>Time coverage of the product expressed in seconds</td>
</tr>
<tr>
<td>&lt;phase&gt;</td>
<td>2</td>
<td>Mission phase identifier</td>
</tr>
<tr>
<td>&lt;cycle&gt;</td>
<td>049</td>
<td>Cycle number within the mission phase</td>
</tr>
<tr>
<td>&lt;relative_orbit&gt;</td>
<td>00308</td>
<td>Relative orbit number</td>
</tr>
<tr>
<td>&lt;absolute_orbit&gt;</td>
<td>22907</td>
<td>Absolute orbit number</td>
</tr>
<tr>
<td>&lt;counter&gt;</td>
<td>6417</td>
<td>Numerical wrap-around counter for quick file identification</td>
</tr>
<tr>
<td>&lt;extension&gt;</td>
<td>.nc</td>
<td>File name extension</td>
</tr>
</tbody>
</table>
2.3 File contents

The data is provided in netCDF-4 classic format [7] using the CF-1.4 metadata convention [8]. This netCDF format is a self-describing, portable, scalable, appendable, sharable, archivable, and machine-independent data format. It is supported by all major data analysis and visualisation packages, such as for example IDL, Matlab, R, BEAM, Panoply, etc., and programming interfaces exist for a wide variety of other programming languages.

The data is provided as individual variables in the netCDF file. The existing variables are:

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ref_time</td>
<td>Provides the reference time at start of orbit given in in seconds since 1981-01-01 00:00:00 UTC.</td>
</tr>
<tr>
<td>Lat</td>
<td>Gives the latitude coordinate of the pixel centre in decimal degrees north.</td>
</tr>
<tr>
<td>Lon</td>
<td>Gives the longitude coordinate of the pixel centre in decimal degrees east.</td>
</tr>
<tr>
<td>Dtime</td>
<td>Provides the time difference between observation time and the reference time. Units are milliseconds. Thus, ref_time plus dtime gives milliseconds after 1981-01-01 00:00:00 UTC.</td>
</tr>
<tr>
<td>Lcc</td>
<td>Provides the land cover classification in 27 classes using a modified Globcover classification scheme specifically developed for the (A)ATSR LST product algorithm. See Table 1 in the Appendix for more information.</td>
</tr>
<tr>
<td>Fv</td>
<td>Gives the fractional vegetation cover used for estimating LST. The dataset is derived from the GEOLAND-2 FCOVER dataset, which has been gap-filled using climatology.</td>
</tr>
<tr>
<td>Tcwv</td>
<td>Provides the total column water vapour data used for estimating (A)ATSR LST. This data is based on the ECMWF ERA-Interim dataset.</td>
</tr>
<tr>
<td>LST</td>
<td>Gives the Land Surface Temperature in K</td>
</tr>
<tr>
<td>LST_uncertainty</td>
<td>Provides the uncertainty in LST, given in K. The given uncertainty estimate is a combination of individual uncertainties due to radiometric noise, fractional vegetation cover, atmospheric water vapour, geolocation, the coefficient fitting process, and systematic uncertainty due to the radiative transfer modelling.</td>
</tr>
<tr>
<td>NDVI</td>
<td>Provides the Normalized Difference Vegetation Index (NDVI) derived</td>
</tr>
</tbody>
</table>
from the 0.66μm and 0.87μm (A)ATSR channels. This is only derived for daytime retrievals where the solar zenith angle is less than 85°. Note: NDVI cannot be derived for ATSR-1.

### QC

Gives quality control flags for each pixel. The individual flags are:

1 = night:
   where the solar zenith angle is less than 0°

2 = land including inland and coastal water:
   where the land cover classification is between 1 and 27. The coastal water is defined as within 10km of the shoreline.

4 = V1 mask identifies cloud:
   standard ESA cloud mask – this is taken directly from bit 1 of the Level 1b cloud word

8 = V2 mask identifies cloud
   aggregation of individual ESA cloud mask with dynamic thresholds

16 = V3 mask identifies cloud
   Probabilistic approach utilising simulated radiances at ATSR tie points

32 = snow
   Combination of two snow masking approaches [9, 10]. Where a pixel is identified as snow LST is retrieved as per land cover classification no. 27 (Table 1)

The cloud masks are described in detail in [11]

All variables except `ref_time` have the dimensions `time × nj × ni`, where `time` is the number of different time slots (for the ATSRs this is always set as 1), `nj` is the number of pixels in the along-track direction and `ni` is the number of pixels in the across-track direction; `ref_time` has the dimension of `time` only.

In addition to the actual data, the product files include both global metadata and metadata for the individual variables, which are both described in detail in the following section.

### 3 Metadata

The following sections describe the metadata attributes that are provided with each netCDF file, both as global metadata attributes and attributes for individual variables.
3.1 Global attributes

Global metadata describe the whole file with regard to general information about conventions, data producer, contact information etc. Examples for the information provided in each of the used attributes can be found in Section 5.3 in the Appendix.

The following global attributes are provided with each file:

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventions</td>
<td>Refers to the metadata convention used in the file. The Climate and Forecasting (CF) metadata convention is used here and its version is given</td>
</tr>
<tr>
<td>title</td>
<td>Title of the data product</td>
</tr>
<tr>
<td>summary</td>
<td>Summarizes the primary content of the data product</td>
</tr>
<tr>
<td>references</td>
<td>Provides a reference to cite for data users</td>
</tr>
<tr>
<td>institution</td>
<td>Gives the name of the entity at which the data product was created</td>
</tr>
<tr>
<td>history</td>
<td>Provides information about how the product was created</td>
</tr>
<tr>
<td>comment</td>
<td>Provides additional information that does not fit any of the other attributes</td>
</tr>
<tr>
<td>license</td>
<td>Provides guidance on the data use policy</td>
</tr>
<tr>
<td>date_created</td>
<td>Gives the date on which the product was created. Given as DD-MM-YYYY HH:MM:SS±HHMM, where ±HHMM is the time zone relative to UTC</td>
</tr>
<tr>
<td>product_version</td>
<td>Provides the version of the data product</td>
</tr>
<tr>
<td>netcdf_version_id</td>
<td>Gives the version of the used netCDF format and its creation date</td>
</tr>
<tr>
<td>spatial_resolution</td>
<td>Provides the data products' spatial resolution at nadir</td>
</tr>
<tr>
<td>start_time</td>
<td>Provides the start time of the product – this is the start of the orbit. Given as YYYY-MM-DD HH:MM:SS. Z is the time zone relative to UTC</td>
</tr>
<tr>
<td>time_coverage_start</td>
<td>Provides the start time of the total coverage of the data for the whole Envisat mission. Given as YYYY-MM-DD HH:MM:SS. Z is the time zone relative to UTC</td>
</tr>
<tr>
<td>stop_time</td>
<td>Provides the end time of the product – this is the end time of the orbit. Given as YYYY-MM-DD HH:MM:SS. Z is the time zone relative to UTC</td>
</tr>
<tr>
<td>time_coverage_end</td>
<td>Provides the end time of the total coverage of the data for the whole Envisat mission. Given as YYYY-MM-DD HH:MM:SS. Z is the time zone relative to UTC</td>
</tr>
</tbody>
</table>
the whole Envisat mission. Given as YYYY-MM-DD
HH:MM:SSZ. Z is the time zone relative to UTC

| northernmost_latitude | Provides the northernmost geographical extent of the data product. Given as decimal degrees, positive numbers are north of the equator |
| southernmost_latitude | Provides the southernmost geographical extent of the data product. Given as decimal degrees, positive numbers are north of the equator |
| easternmost_longitude | Provides the easternmost geographical extent of the data product. Given as decimal degrees, positive numbers are east of the Greenwich meridian |
| westernmost_longitude | Provides the westernmost geographical extent of the data product. Given as decimal degrees, positive numbers are east of the Greenwich meridian |
| Source | Provides information about the source data on which the product is based on |
| Platform | Provides the name of the orbiting platform/satellite |
| Sensor | Provides the name of the used sensor/instrument |
| acknowledgment | Provides information about the funding agencies |
| creator_name | Gives the name of the creator of the file |
| creator_email | Gives the E-mail address of the creator of the file |
| creator_url | Provides the link to a website related to the product |

3.2 Variable Metadata

Each individual variable in the products' netCDF files has its own metadata.

The following attributes are common for most variables (unless not applicable for a particular variable):

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>long_name</td>
<td>A free-text descriptive name for the variable</td>
</tr>
<tr>
<td>standard_name</td>
<td>The standard name for the variable as defined by CF conventions</td>
</tr>
<tr>
<td>units</td>
<td>Text description of the units the data is stored in.</td>
</tr>
<tr>
<td>_FillValue</td>
<td>A value used to indicate array elements which contain invalid or missing data</td>
</tr>
<tr>
<td>scale_factor</td>
<td>Used to pack data into a smaller datatype. The original data can be recovered using: value = (scale_factor * packed_data) + add_offset</td>
</tr>
<tr>
<td>add_offset</td>
<td></td>
</tr>
</tbody>
</table>
valid_min  The minimum valid value for the variable in its packed form
valid_max  The maximum valid value for the variable in its packed form
coordinates  Describes the coordinate system in which the data is given
source  Published or web-based reference describing the origins of any third-party auxiliary data
comment  Other information about the variable or methods used to generate it

Some variables contain additional metadata attributes that are only relevant for this specific variable:

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Variable(s)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>flag_meanings</td>
<td>lcc, QC</td>
<td>Describes the scientific meaning behind the flags given in the variable</td>
</tr>
<tr>
<td>flag_values</td>
<td>lcc</td>
<td>Only used for land cover. They take the values 1s, 2s, 3s .... 27s. These correspond to the equivalent flag meanings.</td>
</tr>
<tr>
<td>flag_masks</td>
<td>QC</td>
<td>Only used for quality control. They take the values 1s, 2s, 4s, 8s, 16s, 32s. These correspond to the equivalent flag meanings.</td>
</tr>
</tbody>
</table>

**Recommended Approach**

Data in the LST variable has been quality checked with regards to input Level 1b data, with only valid data stored - all invalid data is assigned with the _FillValue. In addition, valid LST data is only available where QC bit value of 2 is set (land including inland and coastal water).

With respect to utilisation of LST of best quality then it is recommended to apply the V3 cloud mask (where QC bit value of 16 is set). Furthermore, LST where the corresponding LST_uncertainty is greater than 2.0 K should be treated with more caution.

**References**


4 Glossary

AATSR       Advanced Along Track Scanning Radiometer
ATSR-1      Along Track Scanning Radiometer-1
ATSR-2      Along Track Scanning Radiometer-2
CF          Climate and Forecast metadata convention
LST         Land Surface Temperature
NDVI        Normalized Difference Vegetation Index
netCDF      Network Common Data Form
UTC         Coordinated Universal Time
5 Appendices

5.1 Examples of product datasets

Figure 1: Example for the Globcover-based land cover classification custom-produced for the generation of the (A)ATSR LST product.
Figure 2: Example for the fractional vegetation cover datasets used for producing the (A)ATSR LST product
Figure 3: Example for the total column water vapour dataset used for producing the (A)ATSR LST product.
Figure 4: Example for the LST uncertainty derived from (A)ATSR
Figure 5: Example for the Normalized Difference Vegetation (NDVI) dataset derived from ATSR-2 or AATSR channels
Figure 6: Example for the V3 cloud mask dataset contained within the product
### 5.2 Custom land cover classification

Table 1- (A)ATSR LST land cover classification version 2 (ALB2) derived from the Globcover classification [2]

<table>
<thead>
<tr>
<th>No.</th>
<th>Legend</th>
<th>Based on</th>
<th>Fraction of land surface [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Water bodies of sea (&gt;10km away from coast)</td>
<td>GC210 (GC0)</td>
<td>N/A</td>
</tr>
<tr>
<td>1</td>
<td>Post-flooding or irrigated croplands</td>
<td>GC11</td>
<td>0.92</td>
</tr>
<tr>
<td>2</td>
<td>Rainfed croplands</td>
<td>GC14</td>
<td>3.68</td>
</tr>
<tr>
<td>3</td>
<td>Mosaic Cropland (50-70%) / Vegetation (grassland, shrubland, forest) (20-50%)</td>
<td>GC20</td>
<td>3.03</td>
</tr>
<tr>
<td>4</td>
<td>Mosaic Vegetation (grassland, shrubland, forest) (50-70%) / Cropland (20-50%)</td>
<td>GC30</td>
<td>4.01</td>
</tr>
<tr>
<td>5</td>
<td>Closed to open (&gt;15%) broadleaved evergreen and/or semi-deciduous forest (&gt;5m)</td>
<td>GC40</td>
<td>4.72</td>
</tr>
<tr>
<td>6</td>
<td>Closed (&gt;40%) broadleaved deciduous forest (&gt;5m)</td>
<td>GC50</td>
<td>3.09</td>
</tr>
<tr>
<td>7</td>
<td>Open (15-40%) broadleaved deciduous forest (&gt;5m)</td>
<td>GC60</td>
<td>1.16</td>
</tr>
<tr>
<td>8</td>
<td>Closed (&gt;40%) needleleaved evergreen forest (&gt;5m)</td>
<td>GC70</td>
<td>1.50</td>
</tr>
<tr>
<td>9</td>
<td>Open (15-40%) needleleaved deciduous or evergreen forest (&gt;5m)</td>
<td>GC90</td>
<td>7.38</td>
</tr>
<tr>
<td>10</td>
<td>Closed to open (&gt;15%) mixed broadleaved and needleleaved forest (&gt;5m)</td>
<td>GC100</td>
<td>1.47</td>
</tr>
<tr>
<td>11</td>
<td>Mosaic Forest/Shrubland (50-70%) / Grassland (20-50%)</td>
<td>GC110</td>
<td>2.98</td>
</tr>
<tr>
<td>12</td>
<td>Mosaic Grassland (50-70%) / Forest/Shrubland (20-50%)</td>
<td>GC120</td>
<td>1.86</td>
</tr>
<tr>
<td>13</td>
<td>Closed to open (&gt;15%) shrubland (&lt;5m)</td>
<td>GC130</td>
<td>3.90</td>
</tr>
<tr>
<td>14</td>
<td>Closed to open (&gt;15%) grassland</td>
<td>GC140</td>
<td>3.98</td>
</tr>
<tr>
<td>15</td>
<td>Sparse (&gt;15%) vegetation (woody vegetation, shrubs, grassland)</td>
<td>GC150</td>
<td>9.32</td>
</tr>
<tr>
<td>16</td>
<td>Closed (&gt;40%) broadleaved forest regularly flooded - Fresh water</td>
<td>GC160</td>
<td>0.28</td>
</tr>
<tr>
<td>17</td>
<td>Closed (&gt;40%) broadleaved semi-deciduous and/or evergreen forest regularly flooded - Saline water</td>
<td>GC170</td>
<td>0.04</td>
</tr>
<tr>
<td>18</td>
<td>Closed to open (&gt;15%) vegetation (grassland, shrubland, woody vegetation) on regularly flooded or waterlogged soil - Fresh, brackish or saline water</td>
<td>GC180</td>
<td>0.55</td>
</tr>
<tr>
<td>19</td>
<td>Artificial surfaces and associated areas (urban areas &gt;50%)</td>
<td>GC190</td>
<td>0.15</td>
</tr>
<tr>
<td>20</td>
<td>Bare areas of soil types not contained in biomes 21 – 25</td>
<td>GC200 and other USDA soil types</td>
<td>2.35</td>
</tr>
<tr>
<td>21</td>
<td>Bare areas of soil type &quot;Entisols – Orthents&quot;</td>
<td>GC200 / USDA-99</td>
<td>3.10</td>
</tr>
<tr>
<td>22</td>
<td>Bare areas of soil type &quot;Shifting sand&quot;</td>
<td>GC200 / USDA-1</td>
<td>1.38</td>
</tr>
<tr>
<td>23</td>
<td>Bare areas of soil type &quot;Aridisols - Calidds&quot;</td>
<td>GC200 / USDA-55</td>
<td>1.22</td>
</tr>
<tr>
<td>24</td>
<td>Bare areas of soil type &quot;Aridisols - Cambids&quot;</td>
<td>GC200 / USDA-56</td>
<td>0.52</td>
</tr>
<tr>
<td>25</td>
<td>Bare areas of soil type &quot;Gelisols - Orthels&quot;</td>
<td>GC200 / USDA-7</td>
<td>0.49</td>
</tr>
<tr>
<td>26</td>
<td>Water bodies (inland lakes, rivers, sea: max 10km away from coast)</td>
<td>GC210</td>
<td>6.05</td>
</tr>
</tbody>
</table>
5.3 Example output

```c
netcdf ATS_LST_2PUUOL20060718_102137_000065272049_00308_22907_6417 {

dimensions:
  time = 1 ;
  nj = 43520 ;
  ni = 512 ;

variables:
  int64 ref_time(time) ;
    ref_time:long_name  =  "reference_time" ;
    ref_time:standard_name = "time" ;
    ref_time:units = "seconds" ;
    ref_time:comment = "reference time in seconds at start of orbit since 1981-01-01 00:00:00" ;
  float lat(time, nj, ni) ;
    lat:long_name = "centre latitude" ;
    lat:standard_name = "latitude" ;
    lat:units = "degrees_north" ;
    lat:_FillValue = -32768.f ;
    lat:valid_min = -90.f ;
    lat:valid_max = 90.f ;
    lat:coordinates = "lon lat" ;
    lat:comment = "latitude coordinate of pixel centre" ;
  float lon(time, nj, ni) ;
    lon:long_name = "centre longitude" ;
    lon:standard_name = "longitude" ;
    lon:units = "degrees_east" ;
    lon:_FillValue = -32768.f ;
    lon:valid_min = -180.f ;
    lon:valid_max = 180.f ;
    lon:coordinates = "lon lat" ;
    lon:comment = "longitude coordinate of pixel centre" ;
  int dtime(time, nj, ni) ;
    dtime:long_name = "time difference from reference time" ;
    dtime:standard_name = "time" ;
    dtime:units = "milliseconds" ;
    dtime:_FillValue = -32768 ;
    dtime:valid_min = 0 ;
    dtime:valid_max = 6527850 ;
    dtime:coordinates = "lon lat" ;
}
```
dt ime:comment = "reference time plus dtime gives milliseconds after 00:00:00 UTC January 1, 1981";
short l cc(time, nj, ni);
  l cc:long_name = "land cover classification";
  l cc:units = "1";
  l cc:FillValue = -32768s;
  l cc:valid_min = 1s;
  l cc:valid_max = 27s;
  l cc:coordinates = "lon lat";
  l cc:comment = "land cover classification modified from the original Globcover classification for use with the Advanced Along Track Scanning Radiometer land surface temperature product";
  l cc:source = "Globcover: http://due.esrin.esa.int/globcover/";
  l cc:flag_meanings = "Post-flooding_or_irrigated_croplands, Rainfed_croplands, Mosaic_Cropland_/\_Vegetation, Mosaic_Vegetation_/\_Cropland, Closed_to_open_broadleaved-evergreen_and/or_semi-deciduous_forest, Closed_broadleaved_deciduous_forest, Open_broadleaved_deciduous_forest, Closed_needleleaved_deciduous_or-evergreen_forest, Closed_to_open_broadleaved_and_needleleaved_forest, Mosaic_Forest/Shrubland_/\_Grassland, Mosaic_Grassland_/\_Forest/Shrubland, Closed_to_open_shrubland, Closed_to_open_grassland, Sparse_vegetation, Closed_broadleaved_forest_regu larly_flooded_-_Fresh, Closed_broadleaved_semi-deciduous_and/or-evergreen_forest_regu larly_flooded_-_Saline, Closed_to_open_vegetation_on_regu larly_flooded_or_waterlogged_soil, Artificial_surfaces_and_associated_areas, Bare_soil_General, Bare_soil_Entisols\_u2013_Orthents, Bare_soil_Shifting_sand, Bare_soil_Aridisols_-_Calcids, Bare_soil_Aridisols_-_Cambids, Bare_soil_Gelisols_-_Orthels, Water_bodies, Permanent_snow_and_ice";
  l cc:flag_values = 1s, 2s, 3s, 4s, 5s, 6s, 7s, 8s, 9s, 10s, 11s, 12s, 13s, 14s, 15s, 16s, 17s, 18s, 19s, 20s, 21s, 22s, 23s, 24s, 25s, 26s, 27s;
short fv(time, nj, ni);
  fv:long_name = "fractional vegetation cover";
  fv:standard_name = "vegetation_area_fraction";
  fv:units = "1";
  fv:FillValue = -32768s;
  fv:add_offset = 0.f;
  fv:scale_factor = 0.004f;
  fv:valid_min = 0s;
  fv:valid_max = 250s;
  fv:coordinates = "lon lat";
  fv:comment = "fractional vegetation cover from the GEOLAND-2 FCOVER dataset for use with the Advanced Along Track Scanning Radiometer land surface temperature product. The original 10-day datafiles are gap-filled from climatology";
  fv:source = "GEOLAND-2 FCOVER dataset: http://www.geoland2.eu/";
short tcwv(time, nj, ni) ;
tcwv:long_name = "total column water vapour";
tcwv:standard_name = "atmosphere_mass_content_of_water_vapor";
tcwv:units = "kg m-2";
tcwv:_FillValue = -32768s;
tcwv:add_offset = 0.f;
tcwv:scale_factor = 0.004f;
tcwv:valid_min = 0s;
tcwv:valid_max = 2000s;
tcwv:coordinates = "lon lat";
tcwv:comment = "total column water vapour from the European Centre for Medium Weather Forecasting ERA-Interim dataset for use with the Advanced Along Track Scanning Radiometer land surface temperature product";
tcwv:source = "ECMWF ERA-Interim dataset: http://www.ecmwf.int/";
short LST(time, nj, ni);
LST:long_name = "land surface temperature";
LST:standard_name = "surface_temperature";
LST:units = "K";
LST:_FillValue = -32768s;
LST:add_offset = 273.15f;
LST:scale_factor = 0.01f;
LST:valid_min = -7315s;
LST:valid_max = 6685s;
LST:coordinates = "lon lat";
LST:comment = "Advanced Along Track Scanning Radiometer pixel land surface temperature product";
short LST_uncertainty(time, nj, ni);
LST_uncertainty:long_name = "land surface temperature uncertainty";
LST_uncertainty:units = "K";
LST_uncertainty:_FillValue = -32768s;
LST_uncertainty:add_offset = 0.f;
LST_uncertainty:scale_factor = 0.001f;
LST_uncertainty:valid_min = 0s;
LST_uncertainty:valid_max = 10000s;
LST_uncertainty:coordinates = "lon lat";
LST_uncertainty:comment = "Advanced Along Track Scanning Radiometer land surface temperature pixel uncertainty";
short NDVI(time, nj, ni);
NDVI:long_name = "normalised difference vegetation index";
NDVI:standard_name = "normalized_difference_vegetation_index";
NDVI:units = "1";
NDVI:_FillValue = -32768s;
NDVI:add_offset = 0.f;
NDVI:scale_factor = 0.004f;
NDVI:valid_min = 0s;
NDVI:valid_max = 250s;
NDVI:coordinates = "lon lat";
NDVI:comment = "normalised difference vegetation index derived from the Advanced Along Track Scanning Radiometer";
short QC(time, nj, ni);
QC:long_name = "quality control flags";
QC:units = "1";
QC:_FillValue = -32768s;
QC:valid_min = 0;
QC:valid_max = 63;
QC:coordinates = "lon lat";
QC:comment = "quality control flags corresponding to the Advanced Along Track Scanning Radiometer land surface temperature product";
QC:flag_meanings = "night land_including_inland_coastal_water cloudy_V1_mask cloudy_V2_mask cloudy_V3_mask snow";
QC:flag_masks = 1s, 2s, 4s, 8s, 16s, 32s;

// global attributes:
:Conventions = "CF-1.4";
:title = "Land Surface Temperature from Advanced Along Track Scanning Radiometer";
:summary = "This file contains land surface temperature (LST) data estimated from Advanced Along Track Scanning Radiometer (AATSR) observations. By using these data, you agree to cite the papers given in the references metadata field in any publications derived from them";
:references = "Ghent D., Land Surface Temperature Validation and Algorithm Verification (Report to European Space Agency). 2012(UL-NILU-ESA-LST-VAV)";
:institution = "University of Leicester";
:history = "Created using software developed at University of Leicester";
:comment = "These data were produced at the UK CEMS facility using software developed at The University of Leicester";
:license = "Data use is free and open";
:date_created = "30-10-2013 16:08:25+0000";
:product_version = "1.0";
:netcdf_version_id = "4.1.1 of Dec 27 2010 21:12:42";
:spatial_resolution = "1 km";
:time_coverage_start = "2002-07-22 23:37:42Z";
:stop_time = "2006-07-18 12:10:24Z";
:time_coverage_end = "2012-04-08 10:58:27Z";
:northernmost_latitude = 90.f;
:southernmost_latitude = -90.f;
:easternmost_longitude = 180.f;
:westernmost_longitude = -180.f;
:source = "ATS_TOA_1P";
:platform = "Envisat";
:sensor = "AATSR";