Table Generation Requirement Document (TGRD) for the

SMOS Level 2 Soil Moisture Processor Development Continuation Project

Contract Number: 4000125649/15/I-SBO

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Prepared for:

The European Space Agency (ESA)

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Contract Number: 4000125649/15/I-SBO

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Revision History

Version	ESL Internal Release No.	Date	Revised By	Description
0.1	1.0	23rd March, 2005	University of Reading	Initial release.
	1.1	26th April, 2005	University of Reading	Reformatted for new template
	1.2	13th May, 2005	University of Reading	Added ECMWF specifics, land cover data source justification, 3armonization corrections.
	2.0	1st July, 2005	University of Reading	Revised format, incorporated suggestions from 20th May 2005 meeting
	2.01	6th July, 2005	University of Reading	Added PRI ECMWF sections
	2.02	7th July 2005	University of Reading	Minor cosmetics
	3.0	4th August 2005	CBSA	Complete revision including remarks from PM3, harmonization with ATBD
	3.0b	27th October 2005	CBSA	Complete revision including remarks from PDR, harmonization with ATBD, (maybe include all remarks from PM4), CBSA internal name TGRD-V03C
0.2	3.0b	2nd November 2005	ARRAY	Merge the content of latest version from CBSA and check the AIs for TGRD according to PM4.

Version	ESL Internal Release No.	Date	Revised By	Description
	3.0b	14th–29th November 2005	ARRAY	Modify the content with the introduction of DFFG (Discret Flexible Fine Grid) definition and elimination of DFG. All tables for DFG are GONE!!
	None	Dec 16, 2005	ARRAY	Modify the content with reintroduction of DFFG_LAI_MAX, DFFG_LandCover_Class and splitting Current_Tau into two tables for independently LV and FO. Modify several UPF parameters according to PhR's notes on Dec. 12&16.
0.3	0.3a Note: ESL adopted the Array version convention at this point.	March 24, 2006	ARRAY	Modify the content with CDR RIDs. Merge the latest version from PhW into Array's version. Complete methods for generating Tables. Clean up the TBDs in the previous version. Introduce the Big_Water_Body_Flag table.
0.4		August 1, 2006	Array	Modify the content with MTR RIDs; Refine and complete methods for generating Tables; Clean the TBDs in the previous version; Introduce some essential parameters.
1.0		August 31, 2006	Array	Revised for QR1 based on Pre-QR1 comments
1.1		November 10, 2006	Array	Updates from QR1. Refer to smppd_ar0025.
1.2		June 8, 2007	Array	Update the values for some parameters in UPF and clarify descriptions within the generation method for DFFG LAI LUT. Refer to smppd_ar0036.
2.0		November 12, 2007	Array	Big Water Body LUT is obsolete and deleted; Soil Property LUT reference has been updated; Four new parameters have been added in UPF; Sky Radiation LUT has been updated according to the new input of Galaxy map. And the Appendix D has been modified accordingly; The Current LUTs have been modified with adding Latitude and Longitude for each DGG node. Refer to smppd_ar0045.

Version	ESL Internal Release No.	Date	Revised By	Description
2.1		February 15, 2008	Array	Post Core-V3 FAT updates as required by a) Core-V3-FAT RIDs b) PM11 Minutes Refer to smppd_ar0050.
2.2-draft		July 15, 2008	Array/ESL	1) Refining DGG Current file algorithms 2) adding the information on generation of ECMWF 3) edting the processing parameters 4) polishing the tables.
3.0		October 20, 2008		See smppd_ar0055 Version 2.2 was never released. The change bars in this version track changes since V2.1.
3.1		April 15, 2009	Array	Post Core V4 FAT Release. See smppd_ar0060.
3.2		September 15, 2009	Array	AUX_DFFFRA updates, AUX_DFF* extensions, See smppd_ar0069
4.0-draft		December 15, 2010	Array	1) Title page, introduction, and list of references were updated 2) Changes related to AUX_ECMWF for scaling SWVL1 based on CDF matching coefficient were made 3) New field (Operating_Mode) was added to AUX_CNFSMx (Table 45). 4) Parameters were tuned in AUX_CNFSMx based on Sept. 2010 release See smppd_ar0085. 5) The “Data Source format” row of Table 17 (LAI MAX) is updated to reflect recent changes in the content of AUX_DFFLMX.
4.0		January 18, 2011	Array	Addressed comments from FAT! See smppd_ar0085.
5.0-draft		June 30, 2011	Array	Changes related to AUX_CNFSMx (dynamic RFI detection) and Post Processor updates by Array. See smppd_ar0087.
5.0		July 28, 2011	Array	Addressed comments from FAT. See smppd_ar0087.
05.50-draft		November 30, 2011	Array	Draft release for L2SM v05.50. Refer to smppd_ar0100.

Version	ESL Internal Release No.	Date	Revised By	Description
05.50		December 21, 2011	Array	Final release for L2SM v05.50. Refer to smppd_ar0100.
06.00-draft		January 25, 2013	AM	Updates to SOIL_PROPERTIES to reflect the change from FAO scale to DFFG scale Updates to DGG Currents (TLV, TFO, ROU, RFI) to reflect the change in separation of ascensing/descending orbits and use of the L2OS UDP in RFI product.s. Added description for DFFG_SNOW. Updated Table 7, Table 8, and Table 63 to reflect related changes above. Updated Table 45, Table 47, and Table 48 according the IODD v4.0 [AAD 8]. In response to L2SM-PR-0063 value of SM1_Thld changed from 0.2 to 0.02 in Table 45.
06.00		March 1, 2013	AM	Updated to address JCD comments at FAT – see FAT minutes [AAD-14].
06.10		November 22, 2013	AM	Updated for release 06.10. Added AUX_DGGRFI_Window_Siz e to Table 50. Updated to address JCD comments at FAT and AI.04 – see FAT Minutes [AAD 15]. Modified Table 22 to indicate LAI updates.
06.11		March 26, 2014	AM	Updated information corresposnding to soil properties (AUX_DFFSOI) and sky map (AUX_GAL_SM). See Table 15 and Table 12 respectively.

Version	ESL Internal Release No.	Date	Revised By	Description
06.20		July 31, 2014	CW	2.2.2 Table 4: Updated issue of SRDs. 3.2.3.1 Table 24: Added Chi_2_LV_Asc and Chi_2_LV_Desc. Updated product size. 3.2.3.2 Table 25: Added Chi_2_FO_Asc and Chi_2_FO_Desc. Updated product size. 3.2.3.3 Table 26: Added Chi_2_HR_Asc and Chi_2_HR_Desc. Updated product size. 3.3.7 Table 50: Added TH_MVAL0_UC.
06.21		December 2, 2014	CW	3.3.6 Table 46: Updated values of A_card_max and $TH\_DQX_{A\_card}$. 3.2.3 Table 24: Updated value of TH_CUR_TAU_NAD_LV_VAL_PERIOD. 3.3.7 Table 50: Updated values of TH_CUR_TAU_NAD_LV_VAL_PERIOD and TH_MVAL0_UC.
06.22		March 2, 2015	CW	2.2.1 Table 1: Added [CRD 3] 3.3.5 Table 45: Updated NITM from 10 to 30 3.3.6 Table 46: Updated • TH_DQX_{SM} from 10 to 20 • $TH\_DQX\tau_{Nad}$ from 0.2 to 0.4 Appendix E: Updated to use ESA GlobCover Version 2.3 2009.

Version	ESL Internal Release No.	Date	Revised By	Description
06.50		April 21, 2017	CW	2.1.1 Table 1: Added [CRD 4] and [CRD 5] 2.2.2 Table 4: Updated issue and date of SRDs 3.1.3.1 Table 13: Updated for IGBP 3.1.3.4 Table 16: Updated for IGBP 3.2.2.2 Table 23: Updated Generation method 3.3.6 Table 46: Updated • TH_DQX_{SM} from 20 to 30 • FTI_NPE_Land_Cover_Class_Code from 6 to 15 • FWL_NPE_Land_Cover_Class_Code from 238 to 18 • $TH\_DQX\tau_{Nad}$ from 0.4 to 0.6 3.3.6 Table 47: Updated • TH_FLOOD from 20 mm/h to 0.65 m^3/m^3 • TH_CHI2_P_MAX from 0.95 to 1.1 3.3.7 Table 50: Added • TH_Curr_Min_DQXTLV • TH_Curr_Min_DQXTFO • TH_Curr_Min_DQXROU • Fixed_Tau_Nad_ASTD • Fixed_T_Surf_ASTD • Fixed_TT_H_ASTD • Fixed_RTT_ASTD • Fixed_OM_H_ASTD • Fixed_Diff_Omega_ASTD • Fixed_HR_ASTD • Chi_2_Rescale_factor • Chi_2_Rescale_offset Added [4] in C.3.4. Deleted Appendix Sections C.4.2, C.4.3 and Appendix E. Added Appendix F.

Version	ESL Internal Release No.	Date	Revised By	Description
06.51		June 6, 2017	CW	Updated to address comments on v06.50. 1.2 [12] and [13]: Corrected. 2.2.2 Table 4: Updated issue and date of SRDs. 3.2.3.5 Table 28: Updated description of probability flood flag. 3.3.6 Table 47: Updated "Comments" of TH_FLOOD. Appendix A.3: Deleted old paragraphs [2], [3], [5] and Tables 59 and 60. Added new [3]. Appendix E: Added [1]. Appendix F: Added [1].
07.00-draft		December 13, 2019	SW	Updated version for L2SM v700: Various edits to incorporate ARGANS Ltd. as new entity leading L2SM development and maintenance. Contract number change.
07.00-draft2		25th February 2020	MA	Updates over Table 15. DFFG_SOIL_PROPERTIES to include the new organic soil fraction. Correction of typos and format issues when possible.
07.00		April 30, 2020	SW	Add Dielectric_Model_Type 2, Bircher's & Mironov. Set new nominal configuration from QWG 30: TH_TAU_FN to 100.0 Bircher's model coefficients + values Sigma_IR_2 + value
07.01		July 31, 2020	MA	Update of AUX_DFFFRA water fraction computations. See section 3.1.3.1 and Appendix G.
07.02		August 28, 2020	MA	Update of ADs and RDs to reflect dates and versions for baseline v700.

Revision History by CBSA Modified table (see Section 1.1 [4] and[5])

Version	Date	Revised By	Sections	Description	Origin	Visa
1.0	23/03/2005	RU	All	Initial release.		
1.1	26/04/2005	RU	All	Reformatted for new template		
1.2	13/05/2005	RU	All	Added ECMWF specifics, land cover data source justification, harmonisation corrections.		
2.0	1/07/2005	RU	All	Revised format, incorporated suggestions from 20th May 2005 meeting		
2.01	6/07/2005	RU	All	Added PRI ECMWF sections		
2.02	7/07/2005	RU		Minor cosmetics		
3.0 Draft for PDR	4/08/2005	CBSA	All	complete revision including remarks from PM3, harmonization with ATBD		
3.0b	27/09/2005	CBSA				
3.0b	27/09/2005	CBSA	3.1.2.2	Update notations	PDR RID 15438	
3.0b	27/09/2005	CBSA	3.1.3.3	Update	PDR RID 15380	
3.0b	27/09/2005	CBSA	3.2.3.1	Update current_Tau content	ESL	
3.0b	27/09/2005	CBSA	3.2.3.2	Update current_HR content	ESL	
3.0b	27/09/2005	CBSA	3.2.3.3	Update current_RFI content	ESL	
3.0b	27/09/2005	CBSA	3.3.2.1	T6: add TH_SIZE, TH_ELON, C1_RFI, C2_RFI; rename TH_AVAR; delete C_WEF_0	ESL, AC17	
3.0b	27/09/2005	CBSA	3.3.2.2	T8: rename SAL, add CPA_1to3	ESL	
3.0b	27/09/2005	CBSA	3.3.2.3.1	Decision tree stage one: Add TH_INDS, _INDM, TH_TAU_F1 Add dec tree threshold values, FM0 key, denominator key, branch rank	ESL	
3.0b	27/09/2005	CBSA	3.3.2.3.1	Add table for selecting models and default vs retrieval option	ESL	
3.0b	27/09/2005	CBSA	3.3.2.3.2	Stage 2: Add TH_23 Update table for retrieval options	ESL	
3.0b	27/09/2005	CBSA	3.3.2.4	Add KDIA_MAX control parameter	ESL	
3.0b	27/09/2005	CBSA	3.3.2.5	Fill some range values	ESL	
3.0b	18/10/2005	RU	3.1.3.6	Moved DFG_WATER_FRACTION to Static section, filled in generation method	ESL	
3.0b	18/10/2005	RU	3.1.3.7	Added DFG_WATER_CHANNEL_CONNECTIO N	ESL	
3.0ab	15/03/2006	CBSA/ Yann, PhW, PhR	Multiple sections	Modified some contents and sections.	ESL	

Table of Contents

List of Figures

List of Tables

List of Appendices

1 INTRODUCTION

1.1 Identification/Scope

[1] This Table Generation Requirement Document (TGRD), identified as SO-TN-ARG-GS-4405 (ASC_SMPPD_005), describes the requirements and generation methods for the tabulated geo-physical parameters required for the Soil Moisture and Ocean Salinity (SMOS) Level 2 (L2) processing, in order to support the retrievals of the Soil Moisture and other user-defined land surface geo-physical properties. These tables are used by ARGANS Ltd (ARGANS) in the SMOS L2 Soil Moisture Processor maintenance and evolution for the European Space Agency (ESA).

[2] This update is performed under ESA Contract no. 4000125649/15/I-SBo.

[3] The processing of the SMOS data by the Level 2 processor requires the use of numerous geo-physical, reference frame transformations and data aggregation models. In order to optimize processing speed, when analytically and statistically acceptable, certain models can be replaced by tables with pre-computed parameters.

[4] This document was first developed by CBSA and was then transferred to ARGANS for update and maintenance. Therefore, two Revision History tables are provided:

a) "Revision History" maintained by ARGANS (first table) from March 2005 until now, and
b) "Revision History by CBSA Modified table" (second table), which captures the CBSA updates to this document in the period between March 2005 and March 2006.

[5] The "Revision History" maintained by ARGANS provides a column, namely "ESL Internal Release No.", which cross references the "Revision History by CBSA Modified table".

1.2 System Overview

[1] Launched on November 2, 2009, SMOS is the second Earth Explorer mission to be developed as part of ESA's Living Planet Programme. The SMOS mission objective is to further the development of climatological, meteorological and hydrological models by observing Soil Moisture (SM) over the landmasses and Sea-Surface Salinity (SSS) – also referred to as Ocean Salinity (OS) – over the oceans for a period of at least three years.

[2] As part of the SMOS ground segment requirements, a prototype Level 2 Soil Moisture processor is required to develop and validate scientific algorithms. Furthermore, a Level 2 Soil Moisture Core Processor is required as part of a Level 2 processor for SMOS data. The Level 2 processor, integrated within the SMOS Data Processing Ground Segment (DPGS), is capable of processing SMOS data into both soil moisture and sea surface salinity products.

[3] ARGANS, with support from SM Expert Scientific Laboratories (SM ESL), has been responsible for the development of the Level 2 SM Open Prototype, Level 2 SM Core processor, validation of algorithms used by these processors, and the required documentation. ARGANS and ESL are currently responsible for the maintenance and evolution of Level 2 SM algorithms and associated Level 2 processors.

[4] The SM ESL currently supporting ARGANS consists of:

- CESBIO and IPSL SA of France, together known as CBSA,
- University of Roma (Tor Vergata) of Italy, and
- Finish Meteorological Institute at Finland, also known as FMI,
- Swiss Federal Institute for Forest at Swizerland, also known asd WSL
- Gamma Remote Sensing AG at Swizerland, also known as GAMMA

[5] University of Reading participated in the initial development phase of the prototype but did not participate in subsequent phases due to resource limitation.

[6] Array initially was responsible for the development of a prototype SMOS Level 2 SM processor until 2018. Due to schedule constraints, the Level 2 Soil Moisture Operational Processor was re-oriented to include the prototype software in its core processing module. This activity, originally lead by GMV of Spain, required the use of INDRA's RW API package for reading and writing all input/output data products. The original prototype processor did not use the RW API.

[7] The SMOS Level 2 SM processors rely on the outputs of SMOS Level 2 SM pre- and post-processors. The pre-processors generate operational ECMWF and LAI products required for processing half orbit Level 1C products. The post-processors generate the so-called "DGG Current" files (AUX_DGG) required in the operational chain by the Level 2 SM operational processor.

[8] The post processors have been deployed in the DPGS and are triggered, in a time-driven fashion, on a daily basis. The reprocessing of SMOS data requires these processors to be run in a data-driven mode. The algorithms implemented in v03.07 and earlier versions of the post processors did not allow this capability. In March 2011, through a contract change notice, Array was given the responsibility to update the post processors in order to meet this requirement.

[9] On 2018, ARGANS took over the responsibility of the L2 SM data processor, after closure of Array's activities

[10] INDRA in Spain is currently responsible for the integration of the SMOS Level 2 Operational Processor with support from ARGANS of UK. ARGANS is also responsible for the development of the Level 2 Sea Surface Salinity Core Processor.

[11] The Level 2 processor has three instances in the DPGS: one in the Fast Processing Centre, one in the Reprocessing Centre, and one in the Reference Processing Facility.

[12] The Fast Processing Centre processes SMOS data to produce products in an automated operational environment a short time after data acquisition using the best available auxiliary data available.

[13] The Reprocessing Centre, collocated with SMOS DPGS in ESAC, reprocesses SMOS data on demand. A reprocessing is normally expected when new auxiliary data or improved algorithms become available.

[14] The Reference Processing Centre processes SMOS data in an interactive manner; it is used by experts to identify potential algorithmic issues and verify algorithmic updates.

[15] The Level 2 Soil Moisture Core Processor is integrated into all three instances of the Level 2 processor.

1.3 Document Overview

[1] This document is structured into the following sections:

- Section 1 includes general information on the scope and identification of this TGRD and sets out the notations and conventions used herein.
- Section 2 lists all documents referenced within this document.
- Section 3 contains Look-Up Tables (LUTs) of Specifications.
- The appendices describe the main auxiliary data sets: ECMWF, ECOCLIMAP and Soil texture data set, and the DFFG definition.
  Appendix A provides a synthesis of ECMWF auxiliary evolving data, ECOCLIMAP, and Soil texture.
  Appendix B contains the coherence and cross-reference between the TGRD and the Level 2 Product Specification [CAD 10].
  Appendix C contains the SMOS L2 Processor Discrete Flexible Fine Grid (DFFG) Definition.
  Appendix D contains the description of Table 7, the Sky Radiation (TBsk) Table
  Appendix E has been deleted.
  Appendix F contains two tables related to the use of IGBP in AUX_DFFFRA and AUX_LANDCL.

1.4 Notations and Conventions Used in This Document

1.4.1 Definitions

[1] Please refer to Section 1 of the Software Release Documents (SRDs) [AAD 7] and [AAD 9] to see the respective master list of definitions for the prototype and operational processors.

1.4.2 Acronyms and Abbreviations

[1] Please refer to Section 1 of the SRDs [AAD 7] and [AAD 9] to see the respective master list of acronyms and abbreviations for the prototype and operational processors.

1.4.3 Tables

[1] The tables in sections 3.1, 3.2 and 3.3 are presented according to their static or time-varying character. There are four categories of tables:

- Tables that describe maps on the SMOS Discrete Global Grid (**DGG**), which is the ISEA4-9 grid used for L1c products. Those tables are always prefixed with **DGG.**

- Tables that describe maps on fine grid, which is a regular equi-area grid that samples the latitude and longitude domain with an almost-equal Earth surface distance increment. This grid consists of a variable number of points that depend on the surface distance increment. Since this is the L2 working grid for computation of weighted fractions and reference values, it has been named the Discrete Flexible Fine Grid (**DFFG**). Those tables in this category are always prefixed with **DFFG**.

- The ECMWF table is a special case, where certain parameters are used at DGG scale while others are at DFFG scale.

- The remaining tables are general purpose and are therefore prefixed with neither DGG nor DFFG.

[2] Note 1: Only 30% of the maps within most of the tables are of interest for SM (land). Their true size can be largely reduced by using an appropriate computer representation (e.g. sparse matrix).

[3] Most of the maps "are obtained with their nominal format" at DFFG scale. The L2 processor itself should convert the nominal format into a suitable internal format and scale, e.g. from the DFFG to the DGG scale.

[4] Efforts have been and will continue to be made until total consistency is achieved between Section 3 of this TGRD and the corresponding ATBD [AAD 1] content.

2 REFERENCES

[1] Please refer to Section 2 of the SRDs [AAD 7] and [AAD 9] to obtain the issue number and date of each document applicable to the current version of the SMOS-SM prototype and L2 SM Core operational processors respectively.

2.1 Customer Documents

2.1.1 Customer Reference Documents

Table 1. Customer Reference Documents

ID	Title	DCN (Issue, Date)
[CRD 1]	Technical Note on Changes in LAI Pre-Processing V1	XSMS-GSEG-EOPG-TN-07-0028
[CRD 2]	Technical Note on Changes in ECMWF Pre-Processing V1	XSMS-GSEG-EOPG-TN-07-0029
[CRD 3]	Configuration and AUX_DFFFRA Updates for the Level 2 Soil Moisture Processor V620	SO-TN-CBSA-GS-0050 (Issue 1.0, February 17, 2015)
[CRD 4]	Technical Note: Using the IMS snow database in the SMOS soil moisture retrieval processor	SO-TN-CBSA-GS-040 (Issue 1.c, February 2015)
[CRD 5]	AUX_DFFFRA, AUX_CNFSM, AUX_LANDCL, AUX_ECMCDF updates for the SMOS Level 2 Soil Moisture Processor V650	SO-TN-CB-GS-057 (Issue 0.1, March 21, 2017)
[CRD 6]	Algorithms updates for the SML2PP v700	SO-TN-CBSA-GS-0071 (Issue 1.0, 29th March 2019)

2.1.2 Customer Applicable Documents

Table 2. Customer Applicable Documents

ID	Title	DCN (Issue, Date)
[CAD 1]	SMOS Level 2 Prototype – Soil Moisture – Statement of Work	SO-SOW-ESA-GS-1376
[CAD 2]	Space Engineering: Software – Part 1: Principles and requirements	ECSS-E-40 Part 1B
[CAD 3]	Space Engineering: Software engineering and Software product assurance; Part 2: Documents requirements definitions (DRDs)	ECSS-E-40 Part 2B
[CAD 4]	Tailoring of the ECSS-E-40 Part 1B, 28 Nov 2003 Software Engineering Standards	SO-TN-ESA-GS-1353
[CAD 5]	Guidelines for the Specifications of Ground Processing Algorithms	SO-TN-ESA-GS-1427
[CAD 6]	Earth Explorer Ground Segment File Format Standard	PE-TN-ESA-GS-0001

ID	Title	DCN (Issue, Date)
[CAD 7]	Earth Explorer Mission CFI Software Mission Conventions Document	CS-MA-DMS-GS-0001
[CAD 8]	SMOS Product Definition	SO-TN-ESA-GS-1250
[CAD 9]	SMOS Level 1 and Auxiliary Data Products Specifications	SO-TN-IDR-GS-0005
[CAD 10]	SMOS Level 2 and Auxiliary Data Products Specifications	SO-TN-IDR-GS-0006
[CAD 11]	SMOS LAI Pre-Processing	SO-TN-GMV-GS-4406
[CAD 12]	SMOS ECMWF Pre-Processing	SO-TN-GMV-GS-4405
[CAD 13]	SMOS L2 SM Post-Processing	SO-TN-GMV-GS-4408
[CAD 14]	SMOS Expert Support Laboratories for the period 2010-2014 – ESL Soil Moisture – Statement of Work	SO-SOW-ESA-GS-6646

2.2 ARGANS Documents

[1] Please note that ARGANS documents include Expert Support Laboratories (ESL) documents. In particular, the ATBD [AAD 1] is an ESL document.

2.2.1 ARGANS Reference Documents

Table 3. ARGANS Reference Documents

ID	Title	DCN (Issue, Date)
[ARD 1]	SMOS L2 Processor Discrete Flexible Fine Grid Definition	SO-TN-CBSA-GS-0011

2.2.2 ARGANS Applicable Documents

Table 4. ARGANS Applicable Documents

ID	Title	DCN (Issue, Date)
[AAD 1]	SMPPD Algorithm Theoretical Baseline Document (ATBD)	SO-TN-ARG-L2PP-0037
[AAD 2]	SMPPD Development Plan (DVP)	SO-PL-ARR-L2PP-0015
[AAD 3]	SMPPD System Quality Assurance Plan (SQAP)	SO-PL-ARR-L2PP-0030
[AAD 4]	SMPPD Quality System Plan – Lite (QSP-L)	ASC_SMPPD_016
[AAD 5]	Configuration Management Reference Guide (CMRG)	ASC00002
[AAD 6]	SMPPD Software Requirements Specification (SRS)	SO-RS-ARR-L2PP-0017
[AAD 7]	L2 SM Open Prototype Software Release Document (SRD)	SO-SD-ARR-GS-4408, Issue 06.51, Date June 6, 2017
[AAD 8]	SMPPD Input/Output Data Definition (IODD) Document	SO-ID-ARG-GS-4406

ID	Title	DCN (Issue, Date)
[AAD 9]	L2 SM Core Software Release Document (SRD)	SO-RP-ARG-GS-4405, Issue 07.03, 28 August 2020
[AAD 10]	Proposal for the SMOS Expert Support Laboratories for the period 2010- 2014 – ESL Soil Moisture	ARR-L2SMEP1-RS09-001
[AAD 11]	V5 FAT Minutes for the SMOS Level 2 SM Processor	N/A
[AAD 12]	Algorithm Theoretical Baseline Document (ATBD) for ECMWF SWVL1 Rescaling Implementation for Level 2 SM Processor	SO-TN-CBSA-GS-0027
[AAD 13]	SMOS L2 SM Post-Processing Algorithms	SO-TN-ARG-GS-4476
[AAD 14]	SMOS L2SM FAT Release 06.00 Minutes for the SMOS L2SM Exploitation Phase Project	SO-MN-ARR-GS-4498
[AAD 15]	SMOS L2SM FAT Release 06.10 Minutes for the SMOS L2SM Exploitation Phase Project	SO-MN-ARR-GS-4402

2.3 Other Reference Documents

Table 5. Other Reference Documents

ID	Description (Authors, Title, DCN, Issue, Date, Possible Source)
[ORD 1]	ECOLIMAP: A Global Database of Land Surface Parameters at 1km Resolution in Meteorological and Climate Models
[ORD 2]	Rome Masson V, Champeaux JL, Chauvin F, et al., FAO: 1988, Unesco soil map of the world. World soil Resources Report No 60
[ORD 3]	Robert J. Scholes, Eric Brown de Colstoun, ISLSCP II Global Gridded Soil Characteristics
[ORD 4]	Nasa Earth Science System Components Related to Mod15: Leaf Area Index and Fraction of Photosynthetically Active Radiation
[ORD 5]	MODIS Leaf Area Index (LAI) and Fraction of Photosynthetically Active Radiation Absorbed by Vegetation (FPAR) Product (MOD15) Algorithm Theoretical Basis Document
[ORD 6]	ECMWF DATA REQUIREMENTS for Level 2 SM Processor, SO-TN-CBSA-GS-0009
[ORD 7]	Niels Skou, Faraday Rotation and L-band Oceanographic Measurements
[ORD 8]	Laurent Coret Yann Kerr Philippe Richaume, FLAGGING THE TOPOGRAPHIC IMPACT ON THE SMOS SIGNAL, SO-TN-CBSA-GS-0012-1.b
[ORD 9]	Binding List Propagation Scheme for Preparing ECMWF GRIB for SML2PP Processor, SO-TN-CBSA-GS-0019, 1.0, 11/07/2008
[ORD 10]	GLOBCOVER, Products description and Validation Report. Prepared by Medias-France, UCL, BC, Infram, JRC, GOFC-GOLD, and ESA. 4/12/2008. , **Source data: © ESA / ESA GlobCover Project, led by MEDIAS-France Image: © ESA / ESA GlobCover Project, led by MEDIAS-France**
[ORD 11]	Das, N., 2013: Ancillary data report: Soil attributes, Soil Moisture Active Passive (SMAP) Project Science Document 44, Jet Propulsion Laboratory document JPL D-53058, California Institute of Technology, 16 pages.

3 TABLE SPECIFICATIONS

[1] The content of the tables provided in the following sections of the TGRD read as follows:

Table 6. Information Content of TGRD Tables

Information Label	Content
Description	Short description of variable
Data source	Sources of data required to generate the LUT
Justification	Reasons for choice of source variable over alternatives
Possible alternatives	Alternative options, if any, should the first-choice variable be unavailable
Availability / timeliness	Time lapse between when this source data is provided and the time to which it refers
Cost	Cost to acquire the data
Any contractual issues	Notification of whether or not the data need to be negotiated for, and, if so, the stage of the negotiations for them
Source data spatial sampling	Distance between source data items in space
Temporal sampling requirements	Frequency at which the source data is required (evolving data only)
Data source format	Identification of the formats of the data sources required to generate the LUT file
Generation method	Rationale or recommended method for generating the final variable (resampling, transformation, etc.) Whenever possible, other generation methods are identified for reprocessing purposes (more accurate).
LUT format	Identification of format and size of the LUT file
Quality check	Availability of simple checks on validity, such as range checks, or cross-checks against other variables
References	Availability of documentation on the source data

Table 7. Overview of TGRD Pre-Computed Tables

Section	Table Name	Description	Source	Sampling Requirements	Temporal Sampling	Generation Method	Quality Check	Notes
Instrument Model Tables								
3.1.1.1	MEAN_WEF	Array of weights used to compute the incidence angle independent mean WEF for a working area, related to a DGG node.	ESL	Distance in ρ_{Earth} < 1-E-2 meter	None	Analytical methods	N/A	Series of Rho_Earth dependant 1D vectors. Used at DFFG scale.
3.1.1.2	WEF	Array of weights used to compute the incidence angle dependent WEF for a working area, related to a given DGG node.	ESL	Distance in $\rho_{DC} \leq$ 1-E-5	None	Analytical methods	N/A	Series of Rho_DC dependant 1D vectors. Used at DFFG scale.
Miscellaneous Tables								
3.1.2.1	SKY_ RADIATION	Galactic radiation sources TB contribution	L1 Auxiliary data	< synthetic antenna pattern width (≈ 2.5°)	None	Build from available (0.25°) L1 Auxiliary data	N/A	Used at DGG scale. The map is equivalent to the one used for L2OS.
3.1.3.4	LAND_COVER_CLASSES	Landcover Class Code/ecosystems classes along with soil and vegetation properties	ECOCLIMAP ESL	Flexible	None	File or table directly provided by ESL	N/A	Used at DFFG scale
DFFG Tables								

Section	Table Name	Description	Source	Sampling Requirements	Temporal Sampling	Generation Method	Quality Check	Notes
3.1.3.1	DFFG_INFO	Provides detailed information for each DFFG cell, including fraction percentage, landcover class code of fraction	ESL	N/A	None	Generated based on ECOCLIMAP, Water Fraction, topography index, and other sources	Consistency check	At DFFG scale.
3.1.3.2	DFFG_XYZ	Provides X, Y, Z Earth reference coordinates in the Earth fixed frame for each DFFG cell	GETASSE30 DEM data set	N/A	None	Geographical coordinates conversion	N/A	At DFFG scale.
3.1.3.3	DFFG_SOIL_PROPERTIES	Fractions of clay, sand, and organic soil, information on soil bulk density, and soil temperature vertical interpolation parameters	JPL data (Das, N., 2013, [ORD 11]) ORCDRC SMOS HiLat (for organic soil) ESL	Flexible	None	Drop-in-the-bucket technique for sand, clay and bulk density from JPL maps ESL provided values for w0, bW0, XMVT and FC	N/A	At DFFG scale.
3.1.3.5	DFFG_LAI_MAX	Max annual LAI	ECOCLIMAP phenology or ESL source	Flexible	10 days	File or table directly provided by ESL	N/A	At DFFG scale.
DGG Tables								
3.1.4.1	DGG_INDEX	SMOS DGG nodes, including index information, latitude, longitude and altitude	ESA from SMOS Level 1	ISEA4-9, 15 km on average	None	Generated by Level 1 phase	N/A	OBSOLETE! No longer required in SML2PP! Altitude data is obtained from L1 C. Limited to land surfaces and coastal margins

Section	Table Name	Description	Source	Sampling Requirements	Temporal Sampling	Generation Method	Quality Check	Notes
3.1.4.2	DGG_XYZ	SMOS DGG node indexes to Earth reference coordinate (X,Y,Z)	SMOS L1 Auxiliary File	ISEA4-9, 15 km on average	None	Geographical coordinates conversion	N/A	At DGG scale
DGG Default Tables								
3.1.5.1	DGG_DEFAULT_FRACTIONS	The pre-computable MEAN_WEF fractions of decision tree classes all around the earth. This is a placeholder for now.	ESL	DGG ISEA4-9, 15 km on average	None	At DGG scale	N/A	Pre-computed fractions can be used in absence of non permanent cover types.

Table 8. Overview of TGRD Time-Updated Tables

Section	Table Name	Description	Source	Sampling Requirements	Temporal Sampling	Generation Method	Quality Check	Use and Notes
Tables Used at Both DFFG and DGG Scales								
3.2.1	ECMWF_FORECAST[1]	All SM+OS ECMWF products	ESA/ECMWF	0.225° × 0.225°	3 hours	Direct read	ECMWF docs	For surface models, atmosphere models and flags. The content is used at DFFG scale as well as DGG scale and by online mapping in DPM.
DFFG Tables								
3.2.2.1	DFFG_LAI	Leaf Area Index	MODIS MOD15	Flexible	Weekly or 10 days	Use MODIS product when available and not expired.	N/A	Generated at DFFG scale

[1] **Described in Appendix – A**

Section	Table Name	Description	Source	Sampling Requirements	Temporal Sampling	Generation Method	Quality Check	Use and Notes
						Use ECOCLIMAP phenology as backdrop.		
3.2.2.2	DFFG_SNOW	Snow Percentage	IMS (NOAA)	Flexible	Daily	Use IMS data when available.	N/A	Generate at DFFG scale
DGG Current Tables								
3.2.3.1	DGG_CURRENT_TAU_NADIR_LV	Every non-missing value is used as the Tau_Nadir_LV reference value for retrieval for Low Vegetation (LV) fractions (FNO, FWL) of every DGG.	SMOS L2	ISEA4-9	Every day	When SML2P retrieval of Tau_Nad_LV is possible and accurate, post-processing will update this table with the retrieved values. Updated after each UDP/DAP processing Forgetfullness time 3 days	Ground truth, time consis-tency	At DGG scale
3.2.3.2	DGG_CURRENT_TAU_NADIR_FO	Every non-missing value is used as the Tau_Nadir_FO reference value for retrieval for forest fraction FFO of every DGG.	SMOS L2	ISEA4-9	Every 4 weeks (Evolving slowly in general, period is varying)	When SML2P retrieval of Tau_Nadir_FO is possible and accurate, post-processing will update this table with the retrieved values. Updated after each UDP/DAP processing Forgetfullness time 365 days (or more) or on demand	Ground truth, time consis-tency	At DGG scale
3.2.3.3	DGG_CURRENT_ROUGHNESS_H	Every non-missing value is used as the roughness parameter HR reference value for retrieval.	SMOS L2	ISEA4-9	Every 4 weeks	When SML2P retrieval of the roughness parameter HR is possible and accurate, then post-processing will update	Ground truth, time consis-tency	At DGG scale

Section	Table Name	Description	Source	Sampling Requirements	Temporal Sampling	Generation Method	Quality Check	Use and Notes
						this table with the retrieved values. Updated after each UDP/DAP processing Forgetfullness time 30 days		
3.2.3.4	DGG_CURRENT_RFI	RFI flags	SMOS L1/L2	ISEA4-9	Every Day	When SML2P post-processing diagnostic analysis suspects RFI, it is recorded in this table Updated after each UDP/DAP processing	Ground truth, time consistency	At DGG scale
3.2.3.5	DGG_CURRENT_FLOOD	Flood flags	SMOS L2	ISEA4-9	Every Day	When SML2P post-processing diagnostic analysis suspects Flood, it is recorded and updated in this table	Ground truth, time consistency	At DGG scale

Table 9. Overview of TGRD User Parameter Tables

Section	Table Name	Description	Source	Sampling Requirements	Temporal sampling	Generation Method	Quality Check	Notes
3.3	USER_PARAMETERS	Constants. Includes Physical Constants which are true constants and others which may be changed after launch.	ESL	N/A	×	File or table provided directly by ESL	SMOS docs; Operational constants: tuning during the commissioning phase	To be modified based on the input from ESLs.

3.1 Pre-Computed Tables for the Duration of SMOS Mission

3.1.1 Instrument Model LUTs

[1] This section includes tables related both to the instrument (strictly speaking) and to the conversion of tables between various grids used by the SMOS processor.

3.1.1.1 WEF

Table 10. WEF

Description	Array of weights to be used to compute the actual WEF for a given working area. The WEF is used to compute aggregated fractions and reference values.
Data source	No external data required.
Justification	Vector of weights to apply to every DFFG area to compute fractions and TBs for Forward models.
Possible alternatives	Other functional shapes might be selected.
Availability/timeliness	N/A
Cost	None
Any contractual issues	None.
Source data spatial sampling	No external data is needed, for parameters see Generation method.
Source temporal sampling requirements	Static
Data source format	None
Generation method	1. Use the defaults WEF_RHO_SCALE = 0.00001 C_{WEF1}= 73.3, C_{WEF2} = 1.4936, C_{WEF3} = 524.5, $CWEF_4$ = 2.1030 WEF_RHO_N = floor (π / C_{WEF1}/ WEF_RHO_SCALE) +1 = 4286 2. Compute for i=0, 1, ..., WEF_RHO_N-1 $\rho_{DC} = \text{WEF\_RHO\_SCALE} \times i$ $WEF_A = [\text{sinc}(C_{WEF1} * \rho_{DC})] \wedge C_{WEF2} / [1 + C_{WEF3} * \rho_{DC} \wedge C_{WEF4}]$, if $(C_{WEF1} * \rho_{DC}) \leq \pi$; Otherwise $WEF_A = 0$. Wrap in Earth Explorer XML format
LUT format	Earth Explorer XML format standard The LUT includes: ▪ WEF_RHO_N, 2 bytes, default 4286 ▪ WEF_RHO_SCALE, 4 bytes, default 1E-5 ▪ WEF, vector of tabulated WEF values, total size WEF_RHO_N * 4 bytes Using the default parameters, the size is approximately ~17 KB.
Quality check	None
References	[AAD 1]

3.1.1.2 MEAN WEF

Table 11. MEAN_WEF

Description	Array of weights to be used to compute the actual MEAN WEF for a given working area. The MEAN WEF is used to compute aggregated mean fractions and prior reference values for forward models.
Data source	No external data required.
Justification	Vector of weights to apply to every DFFG area to compute mean fractions and reference values for further computing TBs and for using Forward models.
Possible alternatives	Other functional shape might be selected.
Availability/timeliness	N/A
Cost	None
Any contractual issues	None identified
Source data spatial sampling	No external data is needed, for parameters see Generation method.
Source temporal sampling requirements	Static
Data source format	None
Generation method	1. Use defaults WEF_RHO_SCALE = 0.00001 C_{WEF1}= 73.3 WEF_SIZE= 123 km C_{MWEF1}=40 km C_{MWEF2} =0.0027 MEANWEF_RHO_SCALE=WEF_RHO_SCALE* C_{WEF1} *C_{MWEF1}/π = 0.00001*73.3*40/π = 933.2846 E-5 in km MEANWEF_RHO_N = floor (WEF_SIZE/2/ MEANWEF_RHO_SCALE) +1 = floor (123/2/933.2846*100000) +1 = 6590 2. for i=0, 1,…, MEANWEF_RHO_N-1 ρ_{earth} = MEANWEF_RHO_SCALE × i if $\rho_{earth} \in [0, C_{MWEF1}]$ $\rho_{DC} = \rho_{earth}$ / MEANWEF_RHO_SCALE/WEF_RHO_SCALE; MEANWEF = C_{MWEF2}+$WEF_A(\rho_{DC})$; elseif ρ_{earth} <= WEF_SIZE/2 MEANWEF = C_{MWEF2}; else MEANWEF = 0; endif Where: • $WEF_A(\rho_{DC})$ is as defined in Table 10. WEF • $\rho_{earth} \in [0, 61.5]$, is the distance in km between DFFG and DGG. **W**rap in Earth Explorer XML format standard

LUT format	• Earth Explorer XML format standard • The LUT includes: ▪ MEANWEF_RHO_N, 2 bytes, default 6590. ▪ MEANWEF_RHO_SCALE, 4 bytes, default 933.2846 E-5 in km. ▪ MEANWEF, vector of tabulated WEF values, totall size MEANWEF_RHO_N * 4 bytes. With the default parameters, that leads to a size about 25.8 KB.
Quality check	None
References	[AAD 1]

3.1.2 Miscellaneous LUTs

3.1.2.1 SKY_RADIATION

Table 12. SKY_RADIATION

Description	The MEAN WEF (or center symmetric WEF) integreted brightness temperatures of the continuum radiation and cosmic background on discrete measurements of Sky brightness temperature in Right Ascension (alpha) and Declination (delta) grid.
Data source	The L1 galaxy map: SM_TEST_AUX_GALAXY_20070101T000000_20500101T000000_300_003_0
Justification	For correcting the sky contribution to the reconstruction process, the Sky Radiation TBs in this table will be used for each DGG at every view to do the correction for the computed TBs. The generated map is made equivalent to that of the L2OS for harmonization purposes.
Possible alternatives	None.
Availability/timeliness	Available
Cost:	None
Any contractual issues	None identified
Source data spatial sampling	0.25°x0.25°
Source temporal sampling requirements	Static in the period of time_info from Validity_Start to Validity_Stop.
Data source format	See [CAD 9].
Generation method	See Appendix D. *Reprocessing:* None.
LUT format	• Earth Explorer XML format standard • The LUT includes:

	▪ Time_ Validity_Start: 27 bytes, format:27*uc (yyyy-mm-ddThh:mm:ss.uuuuuu); ▪ Time_ Validity_Stop: 27 bytes, format:27*uc (yyyy-mm-ddThh:mm:ss.uuuuuu); ▪ Step_Size, 2 bytes, default 0.25°, in degree for both Alpha and Delta. ▪ Delta_Size: 721, with 2 bytes; ▪ Alpha_Size:1441, with 2 bytes; ▪ Sky_TBv, metrix 721*1441, each value in 4 bytes. ▪ Sky_TBh, metrix 721*1441, each value in 4 bytes. With the default parameters the size is about 8311748 bytes = 8.1169 MB.
Quality check	The data was checked against L2OS galactic map to ensure they are equivalent. The L2OS field “I_CSWeF” is the first stokes parameter (Th+Tv). If one plots “I_CSWeF –TBh - TBv”, the value should be close to 0. Check against valid ranges and use other sources to verify the values are meaningful for selected number of targets. Other quality checks based on various statistics will need to be established.
References	[CAD 9]; [AAD 1]: ATBD; [ORD 7]; Technical note: ‘**Generation of a sky map to be used in Lvl1 and Lvl2 processors’** from Steven Delwart and Nicolas Floury on July 05, 2007.

3.1.3 DFFG LUTs

The DFFG defines an almost equi-area grid system close to the reduced Gaussian ECMWF standard, which is parameterized by the length edge of the square equi-area.

3.1.3.1 DFFG_INFO

Table 13. DFFG_INFO

Description	According to the DFFG definition and specification, for each DFFG, this table provides the values of a subset of fractions, and the Landcover Class Code for each fraction. For detail information, refer to Appendix C.
Data source	▪ IGBP for Land Cover Class; ▪ SRTM+GTOPO30 for Topography Impact Index; ▪ Broxton IGBP for Land Cover; ▪ For water fractions, IGBP is used in conjunction with land/sea mask in ECOCLIMAP
Justification	To be used to compute TB and cost function.
Possible alternatives	None
Availability/timeliness	Available
Cost	None.
Any contractual issues:	None indentified
Source data spatial sampling	This table is meant to be ready for use at DFFG scale.
Source temporal sampling requirements	Same as the source availability

Data source format	As per IGBP, SRTM+GTOPO30, IGBP Broxton documents
Generation method	1. Header Header consists of the following 17 parameters: STEP_KM; DFFG_HEADER_ID; LAT_START; DELTA_LAT; LON_START; DELTA_LON; EARTH_SEMI_MAJOR_KM; EARTH_INV_FLATTENING; FLAGS; LAT_N; LAT_STEP_ANG; LON_V_N; LON_V_STEP_ANG; LAT_STEP_KM; LON_V_STEP_KM; V_CUMUL_N; TOTAL_N _CELLS; V_BM_CUMUL_N. For detail definitions refer to Appendix.C. 2. For each DFFG compute Fractions as follows: FNO; FFO; FWP; FWS; FEI are derived from IGBP using Aggregation rules as defined in Table 84 in Appendix F and Figure 9 in Appendix C. FTS and FTM are derived from SRTM and GTOPO30 as defined in [ORD 8]. 3. For each DFFG compute Landcover Reference Code as follows: For each of the 8 different fractions: FNO; FFO; FWL; FWP; FWS; FEB; FEI; FEU compute the Landcover Reference Code from the Broxton IGBP using Aggregation rules as defined in Table 84 in Appendix F and Figure 9 in Appendix C**.** Note that FWL, FEB and FEU are set to zero. 4. As for L2SM v7.0.0, a new method has been proposed to compute water fractions. It is described in Appendix G. Wrap in Earth Explorer XML standard.
LUT format	Earth Explorer XML fomat standard Total size: (variable, depends on the flexible size of DFFG) The table size is approximately: 81.6 KB+(10+8)×37 MB ≈ 666 MB
Quality check	Theoretical analysis
References	[ARD 1] [ORD 8] [CRD 5]

3.1.3.2 DFFG_XYZ

Table 14. DFFG_XYZ

Description	Provides (X, Y, Z) coordinates in the Earth reference system for each DFFG node.
Data source	GETASSE30
Justification	To be used to compute the director cosine distance Rho_DC between DGG and the DFFG for getting the WEF and/or MEAN WEF weighting values. We use GETASSE30 Digital Elevation Model (DEM) so the results are consistent with those of the DGG_XYZ.
Possible alternatives	Static
Availability/timeliness	Available

Cost	None. This data set is freely available (see reference at the end of this table).
Any contractual issues	None
Source data spatial sampling	This LUT uses a DEM together with DFFG lat/long information to compute the (x, y, z) coordinates. The DEM used is GETASSE30 which stands for **G**lobal **E**arth **T**opography **A**nd **S**ea **S**urface **E**levation at **30** arc second resolution along both latitude and logitude. GETASSE30 data set is a composite of four other DEM datasets: the SRTM30, ACE, Mean Sea Surface (MSS), and the EGM96 ellipsoid. The resulting GETASSE30 represents the Earth Topography and Sea Surface Elevation with respect to the WGS84 ellipsoid. The ACE dataset contains several highly negative elevation (- 700) close to arctic and antartica which are inherited by GETASSE30. All latitude/longitude values refer to the center of a pixel, not to one of its corners.
Source temporal sampling requirements	Static
Data source format	The GETASSE30 is organised as multiple tiles. There are 288 tiles, each tile covering a 15° by 15° area. A tile is named using its coordinates. For example, the tiles '45S045W.GETASSE30' where (45, 045) specifies the (lat, long) of the most South West corner. The file is in binary format, where each tile is stored as an 1800*1800 matrix of signed integer values (in meters). Each integer value is represented by 16-bit in big endian.
Generation method	1. Determine the altitude *h* of each DFFG from GETASSE30 by using nearest neighbour method. 2. Compute X, Y, and Z as follows: $X = (N+h)\cos(lat)\cos(lon)$ $Y = (N+h)\cos(lat)\sin(lon)$ $Z = ((1-e^2)N+h)\sin(lat)$ *N* is the ellipsoidal radius meridian curvature at the latitude, given by: $N = \frac{a}{\sqrt{1-e^2\sin^2(lat)}}$ *a*, the semi-major axis, 6378.137 km, *e*, the eccentricity of the earth reference ellipsoid e^2=[2/*earth_flat_coef*-(1/*earth_flat_coef*)^2]. *earth_flat_coef* = 298.257223563 is the inverse of earth ellipsoid model flattening coefficient. Wrap in Earth Explorer XML standard.
LUT format	Header section: same as in the table DFFG_INFO; Data section for each latitude line i_{DFFG}: DFFG_ XYZ(i_{FG}, j_{FG}) = (X, Y, Z) — 3*4byte. Total size is approximately 440 MB
Quality check	Theoretical analysis
References	[ARD 1] and http://www.brockmann-consult.de/beam/doc/help/visat/GETASSE30ElevationModel.html

3.1.3.3 DFFG_SOIL_PROPERTIES

Table 15. DFFG_SOIL_PROPERTIES

Description	Parameters for soil properties are provided as: • percentages [%] of sand and clay; • mass of dry soil per unit bulk volume (bulk density parameter ρ_b); • w_0 and b_{w0} (interpolating temperature coefficients) that depend on soil texture and structure; • XMVT, a transition moisture point, is a function of the sand, S, and the clay, C, fractions. It is for computing the HR(SM): roughness as a piecewise function of SM; • FC, the field moisture capacity, is also a function of the sand, S, and the clay, C, fractions. It is for computing the HR(SM): roughness as a piecewise function of SM. • RSOM, the ratio of organic matter within a DFFG cell; from 0.0 (no organic matter) to 1.0 (fully organic matter covered)
Data source	• JPL data set (see References below) for sand percentage, clay percentage and bulk density. This data set is intended for use in the future SMAP. • w_0 and b_{w0} (soil temperature vertical interpolation parameters) given by ESL. Currently, use default values for them, w_0=0.3, and b_{w0}=0.3. • XMVT and FC given by ESL. • ORCDRC SOM map from the ESA STSE HiLat study
Justification	Required for dielectric models and other parts of the algorithms.
Possible alternatives	FAO (C.A. Reynolds, T. J. Jackson, and W.J. Rawls. 1999. Estimated Available Water Content from the FAO Soil Map of the World, Global Soil Profile Databases, and Pedo-transfer Functions) WRB SOM map from the ESA STSE HiLat study.
Availability/timeliness	Available for sand, clay, bulk density and RSOM Default constant value available for w0, b_{w0}, XMVT and FC.
Cost	Free
Any contractual issues	None
Source data spatial sampling	The global sand, clay, and bulk density in EASE grid, 1 km resolution binary ".mat" files. The water bodies and 'no data' values are assigned -9999. The extent of latitude and longitude covered by the global composite database is 90° to -90° and -180° to 180°, respectively. The Antarctic continent is excluded from the composite database. SOM maps ~1km binary 0/255 mineral/organic mask.
Source temporal sampling requirements	Static
Data source format:	Global in EASE, 1 km resolution binary ".mat" files . SOM maps, TIFF equal angle 0.01°x0.01° near kilometric resolution at the equator.

<table>
<tr><td>Generation method</td><td>Resolution needed:
• Drop-in-the-bucket method for each DFFG cell. All data samples that fall within a grid cell are averaged together, taking account of the overlap size.
Computing:
Note:
The data is global and hence we need to avoid using invalid data from existing maps over the oceans. Therefore, tables are initialized with the following default values:
* everywhere ρ_b(i,j) == 0, its value is replaced by default value = 1.4.
* everywhere S (i,j) == 0 and C (i,j) == 0, we replace their values with default values, S =0.3 and C =0.4
* w0=0.3,bw0=0.3, xmvt=0 and FC=0.3 everywhere on earth even on ocean/water cells.

Use the JPL or SOM binary files as input to form the content of the DFFG cells of the final product as follows:
For each fraction (sand, caly, bulk density):
For each DFFG cell, X, in the AUX_DFFSOI
Determine which cells in the JPL file overlap with X (call the set of cells Y)
Compute the average for cells in Y, taking account of the overlap area and assign that to X
End for
End for

Reprocessing:
May need to update w0 and b_{w0} from the analysis of SMOS products after launch.</td></tr>
<tr><td>LUT format</td><td>Header section: same as in the table DFFG_INFO;
Global Header: offset and scaling factor on 4 bytes each, for ρ_b, w_0, bw_0, XMVT, and FC
Total size: ~ 500MB</td></tr>
<tr><td>Quality check</td><td>Theoretical analysis. The JPL data was re-gridded to DFFG format and was used for a number of global experiments. The soil moisture values and those of other geophysical L2 parameters were then analysed and the impact found to be acceptable. The results were compared against FAO (C.A. Reynolds, T. J. Jackson, and W.J. Rawls. 1999. Estimated Available Water Content from the FAO Soil Map of the World, Global Soil Profile Databases, and Pedo-transfer Functions).

SOM, as part of STSE HiLat project, RSOM used in SML2PP consistency check and evaluation SO-TN-CBSA-GS-0069 “Bircher organic soil dielectric constant empirical model_ESL pre-implementation tests for SML2PP V700, issue 1.0”</td></tr>
<tr><td>References</td><td>Das, N., 2013: Ancillary data report: Soil attributes, Soil Moisture Active Passive (SMAP) Project Science Document 44, Jet Propulsion Laboratory document JPL D-53058, California Institute of Technology, 16 pages.

Bircher, S., Kerr, Y.H. & Wigneron, J.-P. 2015. SMOSHiLat – Microwave L-band emissions from organic-rich soils in the northern cold climate zone and their impact on the SMOS soil moisture product (4000107338/12/I-G). European Space Agency. CESBIO report SO-SR-CB-CA-0001, 76 p</td></tr>
</table>

3.1.3.4 LAND_COVER_CLASSES

Table 16. LAND_COVER_CLASSES

Description	Parameters associated to the DFFG Landcover ecosystem description/code. There is a total of 18 valid Landcover classes. Note that IGBP class 0 has been converted to two new classes, namely Saline Water (Code 17) and Pure Water (Code 18). The processor expects Code 0 to be a place holder.
Data sources	IGBP for code-set; ESL expertise for associated parameters.
Justification	Each land cover class is linked with static properties used in L2PP in various ways: Decision tree aggregation key to allow building fractions relevant for decision tree; Soil roughness properties; Low vegetation properties; Forest properties; etc.
Possible alternatives	GLOBCOVER, MODIS MOD12Q1
Availability/timeliness	N/A
Cost:	None
Any contractual issues	None
Source data spatial sampling	N/A
Source temporal sampling requirements	Static
Data source format	See Table 85
Generation method	*Generating:* Source data file provided by ESL. Wrap in Earth Explorer XML standard. *Reprocessing:* Not on a regular basis. The parameterization values may be fine tuned in future.
LUT format	ASCII data file of ***N_LCC*** lines x 18 columns; Each line number is implicitly an IGBP landcover code. The associated properties are given in columns: • Name • Decision tree aggregation key (255 -> 8 basic complementary classes) • Surface roughness: HR • Surface roughness polarization coupling parameter: QR • Power law of cos (θ) for H pol NR_H • Power law of cos (θ) for V pol NR_V • Low vegetation & Forest: C_L (litter coefficient) • Low vegetation & Forest: BS_L (litter coefficient) • Low vegetation & Forest: a_L (litter coefficient) • Low vegetation & Forest: b_L (litter coefficient) • Low vegetation & Forest: b'_S or b'_F (LAI or LAI_max coefficient) • Low vegetation & Forest: b''_S or b''_F (LAI or LAI_max coefficient) • Low vegetation: ω_H **or** Forest: ω_F • Low vegetation: DIFF_ω • Low vegetation: TT_H (optical thickness coefficient H pol.) • Low vegetation: RTT (ratio of optical thickness coefficients) • Low vegetation & Forest: B_t (temperature coefficient) • Surface roughness (classic expression): HR_MIN • Uncertainty in reference values: DLCC Total size of this data is approximately 255(***N_LCC***)×2byte×18≈ 9 KB
Quality check	Theoretical analysis
References	ATBD [CRD 5]

3.1.3.5 DFFG_LAI_MAX

Table 17. DFFG_LAI_MAX

Description	LAI_MAX parameter for each DFFG node required by forest model.
Data source	ESL provided at 30” size cell; Or ECOCLIMAP SOFTWARE downloaded by http://www.cnrm.meteo.fr/gmme/PROJETS/ECOCLIMAP/page_ecoclimap.htm with “October 04 DATABASE”.
Justification	Required by forest model to compute optical depth. This is the maximum climatological LAI obtained during one year.
Possible alternatives	• ECOCLIMAP LAI phenology for the 221 ecosystems, but poor spatial variability as a quick initialization; • CYCLOPES global LAI (VGT sensor) @ 30”, 10 day (time coverage 1998-2003) to improve the table; • MODIS MOD15.
Availability/timeliness	Available.
Cost	ECOCLIMAP data set and software are free and provide by ESL.
Any contractual issues	None identified
Source data spatial sampling	Regular lat-lon sampled at 30 arcsecond.
Source temporal sampling requirements	Static
Data source format	Using ECOCLIMAP database and software two ASCII files are generated by the ESL: • lai.07.t02.001.intg: global lai_Fmax for mid-july period • lai.01.t02.001.intg: global lai_Fmax for mid-january period The file dimensions are: 21600 latitude rows * 43200 longitude columns. LAI values are given in sequence, starting from +90 latitude and -180 longtitude. For each 30" x 30" grid point a real number between [0, 255] is reported, providing 10*LAI value. A value in the range of [0, 60] corresponds to a valid LAI. A value of 255 indicates the LAI is not available for the surface in the ECOCLIMAP (water surface for example). Each “intg” file reports the product of the multiplication between the LAI_MAX from ECOCLIMAP with the fraction of the forest for the given 30”x30” cell. For instance, if LAI_MAX over Amazon is 60 but the fraction of forest over a given 30”x30” cell is “0.12”, then a value of “7.2” is reported for that cell.
Generation method	*Computing:* Resample the source LAI_MAX data at the DFFG scale using Aggregation rule as defined in Figure 9 in Appendix C. Wrap in Earth Explorer XML standard. *Reprocessing:* Not in regular basis.
LUT format	• Header contains offset and scaling factor. • Array 41 M of one byte. Total size is approximately 41 MB.
Quality check	Theoretical analysis

References	Masson V, Champeaux JL, Chauvin F, et al. 2003, A global database of land surface parameters at 1-km resolution in meteorological and climate models J CLIMATE 16 (9): 1261-1282 MAY 2003; http://www.cnrm.meteo.fr/gmme/PROJETS/ECOCLIMAP/page_ecoclimap.htm

3.1.4 DGG LUTs

3.1.4.1 DGG INDEX (Obsolete)

Table 18. DGG INDEX

Description	The SMOS Discrete Global Grid – Icosahedral Snyder Equal Area aperture 4 resolution 9 global Hexgonal grid (ISEA4-9). Contains the DGG index along with its latitude, longitude and altitude. This product was needed for altitude data for each DGG node. This data is being provided in the L1c. Therefore, DGG Index is no longer needed.
Data source	L1c auxiliary data file that describe DGG: Discrete Global Grid and GETASSE30 info for altitude information
Justification	Required in all processing for land surfaces
Possible alternatives	None
Availability / timeliness	Available
Cost	None
Any contractual issues	None
Source data spatial sampling	ISEA4-9, equi-area, interlace 15km on average.
Temporal sampling requirements	Static
Data source format	Earth Explorer XML standard
Generation method	*Computing:* Directly read *Reprocessing:* None
LUT format	Same as Data source
Quality check	Check the index, latitude, longitude, and altitude to make sure they are in valid range.
References	[CAD 9] See section 4.11

3.1.4.2 DGG_XYZ

Table 19. DGG_XYZ

Description	For each DGG node defined by its index, n_{DGG}, supplies the coordinates of DGG nodes in the Earth reference coordinate system (X,Y,Z)
Data source	L1c auxiliary data file that describe DGG: Discrete Global Grid
Justification:	Needed along with the spacecraft location and attitude to compute angular coordinates of DGG nodes to obtain DGG director cosines which are needed to get the WEF and MEAN_WEF
Possible alternatives	Compute on the fly.
Availability/timeliness	Available in L1c
Cost	None.
Any contractual issues	None.
Source data spatial sampling	ISEA4-9, equi-area, interlace 15km on average.

Source temporal sampling requirements	Static
Data source format	L1c auxiliary Discrete Global Grid file.
Generation method	1. Determine the *lat, long,* and altitude *h)* of each DGG from L1C Auxiliary data file. 2. Compute X, Y, and Z as follows: $X = (N+h)\cos(lat)\cos(lon)$ $Y = (N+h)\cos(lat)\sin(lon)$ $Z = ((1-e^2)N+h)\sin(lat)$ N is the ellipsoidal radius meridian curvature at the latitude, given by: $N = \frac{a}{\sqrt{1-e^2\sin^2(lat)}}$ *a,* the semi-major axis, 6378.137 km, *e,* the eccentricity of the earth reference ellipsoid e^2=[2/*earth_flat_coef*-(1/*earth_flat_coef*)^2]. *earth_flat_coef* = 298.257223563 is the inverse of earth ellipsoid model flattening coefficient. Wrap in Earth Explorer XML standard. *Reprocessing:* None
LUT format	Vector of records: • DGG Grid Point ID: 4 bytes • X: 4 bytes • Y: 4 bytes • Z: 4 bytes Total size of this data product is approximately 41 MB
Quality check	Check values of X, Y, and Z for a subset of nodes to make sure they are in valid range.
References	[ARD 1]

3.1.5 DGG DEFAULTS LUT

3.1.5.1 DGG_DEFAULT_FRACTIONS

This Table is just a placeholder for future usage or consideration. The L2PP does not use it.

Table 20. DGG_DEFAULT_FRACTIONS

Description	Mean fractions over DGG in the absence of non permanent cover features (snow, frozen, sea-ice)
Data source	ECMWF and DFFG_Info, and MEAN_ WEF.
Justification	Saves computation of mean fractions over 2/3 of cases and allows computation of TAU_NAD map
Possible alternatives	Compute on the fly in all cases
Availability/timeliness	Will be built from parent tables when available
Cost	None.
Any contractual issues	None
Source data spatial sampling:	ISEA4-9, equi-area, interlace 15km on average.
Source temporal sampling requirements	Static
Data source format	ECMWF and DFFG_Info, and MEAN_ WEF
Generation method	*Computing:* ▪ Relevant DFFG subsets for each DGG node are selected. ▪ Apply then the MEAN_WEF arrays to obtain 8 complementary fractions and 2 Topo-fractions, by using Aggregation rules as defined in Figure 9 in Appendix C. Wrap in Earth Explorer XML standard *Reprocessing:* Possible
LUT format	Header: offset=0, scaling factor $1/2^{16}$ Vector of records: • FNO: 2 bytes • FFO: 2 bytes • FWL: 2 bytes • FWO: 2 bytes • FEB: 2 bytes • FEI: 2 bytes • FEU: 2 bytes • FTS: 2 bytes • FTM: 2 bytes Vector length about 800000 DGG nodes over land. Size 800000 x 9 x 2 bytes ~14 MB
Quality check	Check against valid ranges and use other sources to verify the values are meaningful for selected number of targets. Other quality checks based on various statistics will need to be established.
References	[AAD 1] [ARD 1]

3.2 Time-Varying Tables

3.2.1 ECMWF_FORECAST

(see also **Appendix – A)**

[1] The ECMWF table is special for the following reasons:

- Its content will contain both SM- and OS-required ECMWF parameters. Only those parameters used for SML2PP are emphasized in this document.
- Some parameters are used at DFFG scale, whereas others are used at DGG scale.

Table 21. ECMWF_FORECAST

Description	This LUT provides parameters supported by ECMWF products. Forecasted values are required for surface models at DFFG scale and for atmosphere model at DGG scale. This LUT contains all the 1st priority parameters required by SML2PP and as specified in [ORD 6].
Data source	This data source is based on ECMWF operational archive on MARS server.
Justification	See [ORD 6]. The forward models used in SML2PP rely heavily on ECMWF products.
Possible alternatives	Other forecast centre products.
Availability/timeliness	ECMWF operational forecast archives every 12 hours.
Cost	To be identified by ESA.
Any contractual issues	To be identified by ESA.
Source data spatial sampling	At the SMOS launch time 0.225° x 0.225° (N400)
Source temporal sampling requirements	Forecasts sequence on 3 hourly basis steps. T0,T0+3,T0+6,T0+9, T0+ 12, T0+15
Data source format	Originally in GRIB format from ECMWF operational center (see [ORD 6]. .
Generation method	Full algorithm is described in the following documents: • [CAD 12]: GMV document providing details of algorithms for pre-processing ECMWF data in GRIB format. The output of this process is ECMWF in the DPGS format (i.e. ISEA DGG based format). This document needs to be updated based on [AAD 12]. • [CRD 2]: ESA technical note specifying changes requested to algorithms defined in [CAD 12]. • [ORD 9]: CBSA technical note used as input to [CRD 2]. This document titled: “Binding List Propagation Scheme for Preparing ECMWF GRIB for SML2PP” describes the use of binding lists for parameter propagations. • [AAD 12]: CBSA ATBD for rescaling SWVL1. This document describes how to derive a field, called RSWVL1, based on ECMWF SWVL1 and a set of coefficients provided in an auxiliary file in GRIB format (called AUX_ECMCDF). This is done by the pre-processor [CAD 12]. In the Level 2 SM processor the field RSWVL1 will be used wherever there is a reference to SWVL1. The [AAD 12] contains references to papers describing methods used to populate AUX_ECMCDF. *Reprocessing:* None.
LUT format	The Level 2 operational processor uses an ISEA based format where the ECMWF products are provided per DGG node (see [CAD 12] and [CAD 10] for further details).

Quality check	See [CAD 12].
References	[ORD 6], [CRD 2], [AAD 12], and [CAD 12].

3.2.2 DFFG LUTs

3.2.2.1 DFFG_LAI

Table 22. DFFG_LAI

Description	Map of Leaf Area Index at DFFG scale.
Data source	MODIS MOD15 Leaf Area Index product and ECOCLIMAP phenology.
Justification	Used for low vegetation and forest models.
Possible alternatives	Not known.
Availability/timeliness	Available.
Cost	To be identified by ESA.
Any contractual issues	To be identified by ESA.
Source data spatial sampling	Tiles of 10°x10° lat/lon (1200 rows x 1200 columns) 1km of resolution on a integerized sinusoidal projection.
Source temporal sampling requirements	MOD15 updates every 8 days.
Data source format	HDF-EOS

Generation method	*Detailed method:* The detailed method is described in the SMOS LAI Pre-Processing [CAD 11] document which takes precedence over the following high-level procedure. Since SMOS launch, there have been several operational issues with reception of MODIS data and its quality. Therefore, it was decided to abandon MODIS for the time being and use ECOCLIMAP phenology, which is designated as backup in the following paragraphs. 1. Identify the MODIS Tile in which the DFFG is located using the latitude and longitude information. 2. Identify all MODIS LAI cells within the Tile which overlap with the DFFG using the latitude, longitude and size information. 3. $DFFG\_LAI = \sum(LAI\_Cell_i * Overlap\_Area\_Cell_i)/\sum Overlap\_Area\_Cell_i$ where $Cell_i$ are cells identified to overlap with the DFFG cell in the step above. Additional changes have been requested to the generation of LAI product (see [CRD 1] for full details). Major changes include: • Including ECOCLIMAP phenology. The ECOCLIMAP phenology as fallback value was not included in the early versions of the pre-processor. This fallback is used in the event that no quality MODIS LAI is available. • The ECOCLIMAP LAI phenology data are aggregated at 4 km DFFG cell resolution from the original ECOCLIMAP resolution of 30 arc-second. These are weighted averages of LAI for low vegetation and forests as provided by ECOCLIMAP. • As a measure of product quality, for each DFFG cell, indicate the number of days elapsed since product was updated using a valid MODIS LAI. Note: Missing LAI values for MOD15 cells identified in Step 2 are filled in with the older LAI values up to a given period. If no such data is available, the LAI will be filled with a phenology included in ECOCLIMAP codes. Wrap in Earth Explorer XML standard. *Reprocessing:* Possible on a timely basis with LAI maps that correspond exactly to the SMOS swaths observations days.
LUT format	Header file for definition of DFFG and DFFG Zones; Header contains an offset and a scaling factor, where the values are to be obtained from MODIS LAI product. Array size is variable and depends on the equi-area DFFG size. With default size of DFFG, 4×0.927 km, total number of DFFGs on the Earth approximately: $10799 \times 5220 \approx 37$ M. Total size of this product is approximately 41 MB
Quality check	Check against valid ranges and use other sources to verify the index is meaningful for selected number of targets. In addition, quality checks can be made based on what percentage of the product is obtained from recent MODIS data.
References	See [CRD 1] and [CAD 11] and references provided there.

3.2.2.2 DFFG_SNOW

Table 23. DFFG SNOW

Description	Map of snow percentage at DFFG scale.
Data source	NOAA The Interactive Multisensor Snow and Ice Mapping System (IMS): http://nsidc.org/data/docs/noaa/g02156_ims_snow_ice_analysis/
Justification	Improve retrievals by more current information on snow coverage.
Possible alternatives	Currently ECMWF Snow Depth (SD) is used.
Availability/timeliness	Available only for the northern hemisphere. The IMS product may not be available over the weekends. Therefore, ESL need to first analyse the impact of possible gaps in availability before this product becomes operational.
Cost	To be identified by ESA.
Any contractual issues	To be identified by ESA.
Source data spatial sampling	Nominal resolution of 4 km (6144 x 6144 grid).
Source temporal sampling requirements	Daily.
Data source format	GeoTIFF and ASCII
Generation method	*Detailed method:* There is only one field per DFFG cell, namely SnowPercentage. One unsigned byte is used to encode information on snow. Valid percentages in the range [0, 100] are encoded as unsigned integers in [0, 200]. Initially set SnowPercentage = 255 for all DFFG cells. For each DFFG cell, determine the overlapping area of this cell and IMS cells with snow. Use this information to determine what percentage of the DFFG cell is covered by snow. Alternatively, bilinear interpolation can be used (see Section 3.2 in [CRD 4]). A 255 value for SnowPercentage indicates the value is missing. In this case the fallback option is the ECMWF SD *Reprocessing:* None.
LUT format	Header file for definition of DFFG and DFFG Zones; Total size of this product is approximately 40 MB
Quality check	Theoretical analysis.
References	None.

3.2.3 DGG CURRENT LUTs

3.2.3.1 DGG_CURRENT_TAU_NADIR_LV

Table 24. DGG_CURRENT_TAU_NADIR_LV

Description	Optical thickness of vegetation covers at nadir for Low Vegetation cover area/fractions.
Data source	DGG_CURRENT_TAU_NADIR_LV, SMOS L2 SM User Data Product, SMOS L1 Auxiliary data: Land/Sea Mask
Justification	For many DGG nodes, it is believed that retrieval will have a better quality compared to using a priori/reference optical thicknesses derived from LAI or LAI_MAX of LV fractions. This table is necessary to store this particular reference value if it is to be updated using SMOS L2 data.
Possible alternatives	None
Availability/timeliness	The file is expected to get updated at least daily using the SMOS L2 SM UDP.
Cost	None
Any contractual issues	None
Source data spatial sampling:	SMOS L2 SM UDP product: DGG based data.
Source temporal sampling requirements	Updated after each swath processing. Default DGGs validity period **TH_CUR_TAU_NAD_LV_VAL_PERIOD = 10 days**
Data source format	Earth Explorer XML
Generation method	The DGG_CURRENT_TAU_NADIR_LV is a global product. The fields associated to each DGG are initially set to default values. Subsequently this file is updated using information from L2 UDP. There are two sets of fields, one to keep information for ascending and one for descending passes. ***Initialization:*** 1. The first time this LUT is filled with the following default values for different fields: • Tau_Nad_LV_Asc (2 bytes) = 2^16-1 • DQX_Tau_Nadir_LV_Asc (1 byte) = 2^8 - 1 • DT_Branch_LV_Asc (1 byte) = 2^8 - 1 • Date_Stamp_LV_Asc (2 bytes) = 2^16 - 1 • Chi_2_LV_Asc (1 byte) = 2^8 - 1 • Tau_Nad_LV_Desc (2 bytes) = 2^16-1 • DQX_Tau_Nadir_LV_Desc (1 byte) = 2^8 - 1 • DT_Branch_LV_Desc (1 byte) = 2^8 - 1 • Date_Stamp_LV_Desc (2 bytes) = 2^16 - 1 • Chi_2_LV_Desc (1 byte) = 2^8 - 1 ***Subsequent updates:*** **A detailed and updated description of the algorithm is provided in the SMOS L2 SM Post-processing Algorithms document [AAD 13] which takes precedence over the procedures here.** Notes: • The generation method is applied by an external process at the end of each swath processed by SML2PP.

	• All external fields used to update DGG Current are provided in L2 SM UDP. • When this file is used as input to the L2 SM processor Tau_Nad_**LV_{Asc, Desc}**= 2^16-1 implies that other entries contain default or missing value. *Reprocessing:* None
LUT format	This LUT contains, for each DGG node, the grid point ID, Latitude and Longitude, Tau_Nadir_LV_{Asc, Desc}, DQX_Tau_Nadir_LV_{Asc, Desc}, Retrieval_Case_Branch_{Asc, Desc}, and a date stamp {Asc, Desc} that corresponds to the number of elapsed days from SMOS launch date. It also contains the retrieval fit quality index Chi_2_LV_ {Asc, Desc}. Header for offset and scaling factor: 4 bytes each for Tau_Nad**_LV_***, DQX_ Tau_Nad**_LV_*** Vector for each node: • Grid Point ID: 4 bytes • Latitude: 4 bytes • Longitude: 4 bytes • Tau_Nad**_LV_{Asc, Desc}**: 2 × 2 = 4 bytes • DQX_Tau_Nadir**_LV_{Asc, Desc}**: 2 × 1 = 2 byte • DT_Branch_LV**_{Asc, Desc}**: 2 × 1 = 2 Byte • Date_Stamp_LV**_{Asc, Desc}**: 2 × 2 = 4 bytes • Chi_2_LV_{Asc, Desc}: 2 x 1 = 2 bytes The size ~ 68 MB. For a full description see the Level 2 product specification [CAD 10].
Quality check	Check against valid ranges and use other sources to verify the index is meaningful for selected number of targets.
References	See [AAD 1] and [AAD 13].

3.2.3.2 DGG_CURRENT_TAU_NADIR_FO

Table 25. DGG_CURRENT_TAU_NADIR_FO

Description	Optical thickness of vegetation covers at nadir for Forest Fraction FFO.
Data source	SMOS L2 SM User Data Product, SMOS L1 Auxiliary data: Land/Sea Mask
Justification	For many DGG nodes, we think that retrieval will have a better quality compared to using a priori/reference optical thicknesses derived from LAI or LAI_MAX of FFO fraction. This table is necessary to store this particular reference value if it is to be updated using SMOS L2 data.
Possible alternatives	None
Availability/timeliness	Available as a part of global L2 processing
Cost	None
Any contractual issues	None
Source data spatial sampling	L2 SMOS products
Source temporal sampling requirements	Updated after each swath processing. Default DGGs validity period **TH_CUR_TAU_NAD_FO_VAL_PERIOD = 365 days (or more)**

<table>
<tr><td>Data source format</td><td>Earth Explorer XML.</td></tr>
<tr><td>Generation method</td><td>The DGG_CURRENT_TAU_NADIR_FO is a global product. The fields associated to each DGG are initially set to default values. Subsequently this file is updated using information from L2 UDP. There are two sets of fields, one to keep information for ascending and one for descending passes.

Initialization:
1. The first time this LUT is filled with the following default values for different fields:
• Tau_Nad_FO_Asc (2 bytes) = 2^16-1
• DQX_Tau_Nadir_FO_Asc (1 byte) = 2^8 - 1
• DT_Branch_FO_Asc (1 byte) = 2^8 - 1
• Date_Stamp_FO_Asc (2 bytes) = 2^16 - 1
• Chi_2_FO_Asc (1 byte) = 2^8 - 1
• Tau_Nad_FO_Desc (2 bytes) = 2^16-1
• DQX_Tau_Nadir_FO_Desc (1 byte) = 2^8 - 1
• DT_Branch_FO_Desc (1 byte) = 2^8 - 1
• Date_Stamp_FO_Desc (2 bytes) = 2^16 - 1
• Chi_2_FO_Desc (1 byte) = 2^8 -1

Subsequent updates:

A detailed description of the algorithm is provided in the SMOS L2 SM Post-processing Algorithm document [AAD 13] which takes precedence over the high-level procedure here.

Note:
• The generation method is applied by an external process at the end of each swath processed by SML2PP.
• In contrast to the DGG_CURRENT_TAU_NADIR_LV generation method, once we get a good (or better) estimate of Tau_Nadir_FO for a particular DGG, it will last for the rest of the mission (except for manual override. It means that at the beginning CUR_TAU_NAD_FO_VAL_PERIOD is set very high (e.g 365*5)
• When used as input to the L2 SM processor the Tau_Nad_FO == 2^16-1 indicates other entries contain default or missing values (not valid).

Reprocessing:
None</td></tr>
</table>

LUT format	This LUT contains, for each DGG node, the grid point ID, Latitude and Longitude, Tau_Nadir_FO_{Asc, Desc}, DQX_Tau_Nadir_FO_{Asc, Desc}, Retrieval_Case_Branch_{Asc, Desc}, and a date stamp{Asc, Desc} that corresponds to the number of elapsed days from SMOS launch date. Header for offset and scaling factor of 4 bytes each for Tau_Nad_FO, DQX_ Tau_Nad_FO Vector for each node: • Grid Point ID: 4 bytes • Latitude: 4 bytes • Longitude: 4 bytes • Tau_Nad_FO_{Asc, Desc}: 2 × 2 = 4 bytes • DQX_Tau_Nadir_FO_{Asc, Desc}: 2 × 1 = 2 byte • DT_Branch_FO_{Asc, Desc}: 2 × 1 = 2 Byte • Date_Stamp_FO_{Asc, Desc}: 2 × 2 = 4 bytes • Chi_2_FO_{Asc, Desc}: 2 x 1 = 2 bytes The size ~ 68 MB. For a full description see the Level 2 product specification [CAD 10].
Quality check	Check against valid ranges and use other sources to verify the index is meaningful for selected number of targets. Other quality checks based on various statistics will need to be established.
References	See [AAD 1] and [AAD 13].

3.2.3.3 DGG_CURRENT_ROUGHNESS_H

Table 26. DGG_CURRENT_ROUGHNESS_H

Description	This LUT contains for each DGG node, HR, DQX_HR, the associated DT aggregation class number and a date stamp.
Data source	SMOS L2 SM User Data Product, SMOS L1 Auxiliary data: Land/Sea Mask
Justification	For some DGG nodes, the roughness H parameter can be retrieved with a better quality compared to the roughness derived from LAND_COVER_CLASSES. This table is necessary to store this particular reference value if it is to be updated using SMOS L2 data.
Possible alternatives	None
Availability/timeliness	Available as a part of global L2 processing
Cost	None
Any contractual issues	None
Source data spatial sampling	L2 SMOS products
Source temporal sampling requirements	Updated after each swath processing. Default DGGs validity period **TH_CUR_HR_VAL_PERIOD = 30 days**
Data source format	Earth Explorer XML
Generation method	The DGG_CURRENT_ROUGHNESS_H is a global product. The fields associated to each DGG are initially set to default values. Subsequently this file is updated using information from L2 UDP. There are two sets of fields, one to keep information for ascending and one for descending passes. ***Initialization:*** 1. Identify the land DGG nodes with their Grid_Point_ID using the Land/Sea mask; 2. Initialize the following fields to the given default values:

	• HR_**Asc** (2 bytes) = 2^16-1 • DQX_**HR_Asc** (1 byte) = 2^8 - 1 • DT_Branch_**HR_Asc** (1 byte) = 2^8 - 1 • Date_Stamp_**HR_Asc** (2 bytes) = 2^16 - 1 • Chi_2_HR_Asc (1 byte) = 2^8 - 1 • HR_Desc (2 bytes) = 2^16-1 • DQX_**HR**_Desc (1 byte) = 2^8 - 1 • DT_Branch_**HR**_Desc (1 byte) = 2^8 - 1 • Date_Stamp_**HR**_Desc (2 bytes) = 2^16 - 1 • Chi_2_HR_Desc (1 byte) = 2^8 - 1 ***Subsequent updates:*** **A detailed description of the algorithm is provided in the SMOS L2 SM Post-processing Algorithm document [AAD 13] which takes precedence over the high level procedure here.** Notes: • The generation method is applied by an external process at the end of each swath processed by SML2PP. • The first time, this LUT is filled with missing values as shown in step 2) above. • When this file is used as input to the L2 SM processor HR_{Asc, Desc}:== 2^16-1 indicates, for a given DGG, that other entries contain default or missing value (not valid). *Reprocessing:* None on a timely basis
LUT format	Header for offset and scaling factor of 4 bytes each, for HR, DQX_HR Vector for each node: • Grid Point ID: 4 bytes • Latitude: 4 bytes • Longitude: 4 bytes • HR: 2 bytes • DQX_HR_{Asc, Desc}: 2 × 1 = 2 byte • DT_Branch_HR_{Asc, Desc}: 2 × 1 = 2 byte • Date_Stamp_HR_{Asc, Desc}: 2 × 2 = 4 bytes • Chi_2_HR_{Asc, Desc} = 2 x 1 = 2 bytes . The size ~ 68 MB. For a full description see the Level 2 product specification [CAD 10].
Quality check	Check against valid ranges and use other sources to verify the values are meaningful for selected number of targets. Other quality checks based on various statistics will need to be established.
References	See [AAD 1] and [AAD 13].

3.2.3.4 DGG_CURRENT_RFI

Table 27. DGG_CURRENT_RFI

Description	Radio Frequency Interferences
Data source	SMOS L2 SM and OS User Data Products,
Justification	Used to flag RFI events and/or to increase the radiometric uncertainties.
Possible alternatives	None
Availability/timeliness	Available as a part of global L2 processing
Cost	None
Any contractual issues	None
Source data spatial sampling	ISEA4-9, equi-area, interlace 15km on average.
Source temporal sampling requirements	Every day.
Data source format	Earth Explorer XML format
Generation method	*The DGG_CURRENT_RFI is a global product. The RFI associated fields for each DGG are initially set to default values. Subsequently this file is updated using information from L2 SM and OS UDPs.* There are two sets of fields, one to keep information for ascending and one for descending passes. ***Initial generation:*** 1. The first time this LUT is filled with the following default values for different fields: • N_SNAP_Asc = 1 • N_RFI_X_Asc = 0 • N_RFI_Y_Asc = 0 • N_SNAP_Desc = 1 • N_RFI_X_Desc = 0 • N_RFI_Y_Desc = 0 ***Subsequent updates:*** **A detailed description of the algorithm is provided in the SMOS L2 SM Post-processing Algorithm document [AAD 13] which takes precedence over the procedures here.** Notes: • The generation method is applied by an external process at the end of each swath processed by SML2PP. Reprocessing: Possible on a timely basis, if persitent RFI map can be drawn with the accumulation of statistics.
LUT format	Vector of records: • DGG Grid Point ID: 4 bytes • Latitude: 4 bytes • Longitude: 4 bytes • N_{SNAP} {Asc, Desc}: 2 × 4 = 8 bytes • NX_{RFI} {Asc, Desc}: 2 × 4 = 8 bytes • NY_{RFI} {Asc, Desc}: 2 × 4 = 8 bytes The size ~ 90 MB For a full description see the Level 2 product specification [CAD 10].

Quality check	Check against valid ranges and use other sources to verify the values are meaningful for selected number of targets. Other quality checks based on various statistics will need to be established.
References	[AAD 1]: section 3.5.2.1 and [AAD 13].

3.2.3.5 DGG_CURRENT_FLOOD

Table 28. DGG_CURRENT_FLOOD

Description	The probability of flood flag FL_Flood_Prob is to be set when the retrieved SM is greater than the threshold TH_FLOOD + the DQX of the retrieved SM. In the future, this simple computation may evolve to a better one by using information from the auxiliary DGG_CURRENT_FLOOD map.
Data source	SMOS L2 SM User Data Product, SMOS L1 Auxiliary data: Land/Sea Mask
Justification	Used to flag Flood events
Possible alternatives	None
Availability/timeliness	Available as a part of global L2 processing
Cost	None
Any contractual issues	None
Source data spatial sampling	L2 SMOS products
Source temporal sampling requirements	Every day. (TBC)
Data source format	Earth Explorer XML format
Generation method	*Rationale:* This external post-processing action requires to be developed; for now it is mainly a placeholder. In the future this map will contain some accumulated SMOS retrieved information associated with external risks information to provide a more accurate flag on flooding risk. *Reprocessing:* None
LUT format	Vector of records: • Land DGG Grid Point ID: 4 bytes • Latitude: 4 bytes • Longitude: 4 bytes • FL_{flood}: 1 bit The length of the vector is ~ 800000 on land; each DGG is set with 1 bit flag. The size: 800000 x 12 bytes ~ 9.4 MB For a full description see the Level 2 product specification [CAD 10].
Quality check	Check against valid ranges and use other sources to verify the values are meaningful for selected number of targets. Other quality checks based on various statistics will need to be established.
References	[AAD 1]: section 3.2.3.2.4 and [AAD 13]

3.3 User Parameter Tables

[1] The L2 processor will use many fixed parameters or values. Apart from the true constants (e.g. physical constants, such as ε_0, π, … and mission parameters) described in Section 3.3.1, certain parameters should be kept modifiable after launch in order to facilitate updates, fine tuning, improvements, etc. They are described in Section 3.3.2 and in the following subsections.

[2] The following subsections (3.3.x) and tables define and list all user parameters and their default values to be stored in **UPF. Except for physical constants, the UPF is contained in AUX_CNFSMx file (see** Table 61**)**. Although they define **a single unique table**, it has been split into these nominal subsections in order to facilitate verification.

[3] All tables whose parameters are set from auxiliary data (unless there a fall-back mechanism to provide default values is set up to handle the unavailability of data) have been excluded from this section.

[4] The first column (T) gives the type of user parameters:

CO: **Constant** – a parameter value that will remain constant during the life ime of the SMOS mission.

FB: **Fall Back** default – fixed-parameter default values that depend on auxiliary data availability issues. It is assumed that either the whole data file may prove to be missing or only some data within the file. Note that the parameters associated with static auxiliary files do not normally have fall back defauts since it is assumed that they are always available.

FT: **Fine Tuning** – fixed parameters for which the best values depend on a fine tuning of the data available after the validation phase.

FI: **Further Investigation** – fixed parameters for which the best values will require further investigation after launch of SMOS in order to be finalized.

Table 29. TABLE_TEMPLATE

Description	The **User Parameters File (UPF)** contains parameters values, range and units. Those values can change during SMOS mission.
Data source	ESL
Justification	Used in SML2P
Possible alternatives	N/A
Availability/timeliness	Available
Cost	None
Any contractual issues	None
Source data spatial sampling	N/A
Source temporal sampling requirements	N/A
Data source format	N/A
Generation method	*Rationale:* The values come from ESL expertise and/or scientific literature and are given in the following tables (Table 30 to Table 34). *Reprocessing:* None on a timely basis. Certainly yes, to update/improve/refine most of the values from the analysis of SMOS products after launch.
LUT format	This table is perfect to be stored as a pure Earth Explorer XML. It consists in a list of pairs (ident tag, properties list). The ident tag identifies the parameters and the property list their associated properties made up with the values given in columns (Name, Value, Range, Units).

Quality check	Verify consistency and notations, check gaps etc between ATBD and TGRD → Action to all
References	ATBD

3.3.1 PHYSICAL_CONSTANTS

[1] The following table includes true physical constants, such as the speed of light in vacuum, plus certain other variables appearing in the ATBD [AAD 1], which are assumed to be unchanging throughout the mission.

Table 30. PHYSICAL_CONSTANTS

T	Name	Value	Range	Units	Comments	ATBD ref
CO	π	3.14159265	N/A	[-]	PI	
CO	k_{BC}	5.67 x 10^{-8}	N/A	Watt.m^{-2}.K^{-4}	Boltzman constant	
CO	ε_0	8.854187817 x 10^{-12}	N/A	F.m^{-1}	Permittivity of vacuum	
CO	η_{FS}	377	N/A	ohm	Intrinsic impedance of free space	
CO	c	2.99792458E+08	N/A	m.s^{-1}	Speed of light in vacuum. Frequency / wavelength conversion	
CO	$\varepsilon_{w\infty}$	4.9	N/A	F.m^{-1}	High frequency limit of static water dielectric constant	
CO	Ω_E	0.2506846	N/A	°/mn	Angular speed of the Earth	
SMOS Mission-Specific Constants						
CO	f	1.4135	N/A	GHz	Central frequency of microwave sensor	
CO	λ	0.212092294304917	N/A	m	Wavelength of microwave sensor	
CO	BD_S	19	N/A	MHz	Equivalent SMOS bandwidth	
CO	TILT	33	N/A	°	Elevation angle of antenna plane	

3.3.2 Pre-processing

Table 31. Parameter List for Input and Pre-Processing

T	Name	Default	Range	Units	Comments	ATBD ref
Pre-processing Control						§ 3.2.2
FT	TH_SIZE	55	[30, 100]	Km	Spatial resolution size requirement	§ 3.2.2.1.4
FT	TH_ELON	1.5	[1.3, 2]	[-]	Spatial resolution elongation requirement	
FT	C_EAF	1	[1, 10]	[-]	Radiometric uncertainty multiplying factor for non-AF views	§ 3.2.2.1.6
FT	C_BORDER	2	[1, 10]	[-]	Radiometric uncertainty multiplying factor for BORDER views	
FT	C_SUN_TAILS	1	[1, 10]	[-]	Radiometric uncertainty multiplying factor for SUN_TAILS views	

T	Name	Default	Range	Units	Comments	ATBD ref
FT	C_SUN_GLINT_AREA	1	[1, 10]	[-]	Radiometric uncertainty multiplying factor for SUN_GLINT_AREA views	
FT	C1_RFI	6	[0, 10]	[-]	Coefficient for Radiometric uncertainty factor from RFI map	§ 3.2.2.1.6 Eq 70
FT	C2_RFI	1	[0,10]	[-]	Coefficient for Radiometric uncertainty factor from RFI map	
FT	Emissivity_Min	0.3	[0, 1]	[-]	Minimum/Maximum emissivity over a representative range of surfaces used in defining a valid range for TB and hence detection of RFI.	§ 3.2.2.1.5 ESL will provide the value.
FT	Emissivity_Max	1.0	[0, 1]	[-]		
FT	Tscene_Margin_Low	5.0	NA	[K]	A user supplied margin, accounting for various uncertainties in the scene temperature, and used in defining a valid lower/upper bound for TB. The bound is used for detection of RFI.	
FT	Tscene_Margin_High	5.0	NA	[K]		
FT	DTB_Scale	2.0	[0, 100]	[-]	A user supplied scale factor, accounting for the uncertainties associated with estimating DTB, and used in the computation of valid TB ranges in RFI detection.	
FT	TBxy_RE_MIN	-50	[-100, 0]	[K]	Antenna level TBxy range check: real part for full polarization (assuming ground 3rd Stokes = 0)	
FT	TBxy_RE_MAX	50	[0, 100]	[K]		
FT	TBxy_IM_MIN	-50	[-100, 0]	[K]	Antenna level TBxy range check: imagery part for full polarization (assuming ground 3rd Stokes = 0)	
FT	TBxy_IM_MAX	50	[0, 50]	[K]		
FT	TH_MR2_Cond	26.0	N/A	[-]	Threshold for test MR2 matrix conditioning for dual-pol	
FT	DTB_F	2.57	[2, 8]	[K]	Scaling factor used to compute MVAL0	§ 3.2.2.1.7 Eq 71
FT	C_{VAL}_2	0.5	[0.4, 1]	[-]	Coefficient used to compute MVAL0	
FT	C_{VAL}_4	0.6	[0.4, 1]	[-]	Coefficient used to compute MVAL0	
FT	MMIN0 TH_MMIN0	3	[5, 15]	[-]	Minimum threshold on the number of available TB after L1c pixel filtering.	§ 3.2.2.1.5
FT	M_AVAR (TH_AVAR)	20	N/A	[-]	Minimum number of views for applying RFI L2 test	§ 3.2.2.1.4
FT	CA_TBS1	5	N/A	K	Coefficient for RFI L2 test	§ 3.2.2.1.4
FT	CB_TBS1	4	N/A	[-]	Coefficient for RFI L2 test	
FT	TH_HOMOGENEOUS_1ST_STOKES	0.1275	[0, 1]	[-]	Threshold to control if the 1st stokes parameter test should be applied.	§ 3.2.2.1.5
FT	TH_RFI_ST4	50	[0, 300]	K	Threshold for detecting RFI using the 4th Stokes parameter.	§ 3.2.2.1.4

Table 32. WEF and Mean WEF Parameters

T	Name	Values	Range	Units	Comments	ATBD ref
FT	WEF_SIZE (WORKING_AREA)	123	N/A	[km]	Size of the squared fine grid area (in km) over which MEAN_WEF fractions, WEFfractions and reference parameter values are computed	§ 3.2.2.4.3 § 3.2.2.5
FT	DGG_Intercell_Distance	15	N/A	[km]	Distance between two adjacent DGG cells in km	

T	Name	Values	Range	Units	Comments	ATBD ref
WEF Approximation						§ 3.2.2.4.2
FT	C_WEF_1	73.30	N/A	[-]	Coefficient in WEF approximation	Eq 76
FT	C_WEF_2	1.4936	N/A	[-]	Coefficient in WEF approximation	
FT	C_WEF_3	524.5	N/A	[-]	Coefficient in WEF approximation	
FT	C_WEF_4	2.1030	N/A	[-]	Coefficient in WEF approximation	
MEAN WEF Approximation						§ 3.2.2.4.5
FT	C_MWEF_1	40	N/A	[km]	Parameter in MEAN_WEF approximation	Eq 77
FT	C_MWEF_2	0.0027	N/A	[-]	Parameter in MEAN_WEF approximation	

3.3.3 Radiative Models

3.3.3.1 Surface Layer

Table 33. Effective Temperature for Dobson Model

T	Name	Default	Range	Units	Comments	ATBD ref
All Surface Land Models						§ 3.1.2
FB	T_g	288	[250, 350]	[K]	Soil effective temperature. Auxiliary ECMWF data fall back default	§ 3.1.2.4 Eq 12 Eq 29 Eq 43

Table 34. Parameter List for Soil Nominal Model (MN)

T	Name	Default	Range	Units	Comments	ATBD ref
Soil (Dobson Model)						§ 3.1.2.2.1
FT	ρ_S	2.664	[0.5, 3]	[g/cm^3]	Soil particle density	Eq 13 Eq 14
FT	α	0.65	N/A	[-]	Dobson model empirical coefficients	
FB	SAL	0.65	[0, 50]	[ppt]	Soil salinity: be kept for future use	
FT	CPA_1	1.01	N/A	[F/m]$^{1/2}$	Coefficients for computing dielectric constant of solid particles ε_{pa}: $\varepsilon_{pa} = (CPA_1 + CPA_2 * \rho_s)^2 + CPA_3$	
FT	CPA_2	0.44	N/A	[F m^2/g]$^{1/2}$		
FT	CPA_3	-0.062	N/A	[F/m]		
FB	ε_{pa}	4.7	N/A	[F/m]	Dielectric content of solid particles	
FT	$SGEF_1$	-1.645	N/A	N/A	Coefficients for computing σ_{eff}: $\sigma_{eff} = SGEF_1 + SGEF_2\ \rho_b + SGEF_3\ S + SGEF_4\ C$	Eq 15
FT	$SGEF_2$	1.939	N/A	N/A		
FT	$SGEF_3$	-2.256	N/A	N/A		
FT	$SGEF_4$	1.594	N/A	N/A		
FT	$BERE_1$	1.2748	N/A	N/A	Coefficients for computing $\beta_{\varepsilon'}$: $\beta_{\varepsilon'} = BERE_1 + BERE_2\ S + BERE_3\ C$	Eq 15
FT	$BERE_2$	-0.519	N/A	N/A		
FT	$BERE_3$	-0.152	N/A	N/A		

T	Name	Default	Range	Units	Comments	ATBD ref
FT	$BEIM_1$	1.338	N/A	N/A	Coefficients for computing βε'': $\beta_{\varepsilon''} = BEIM_1 + BEIM_2\ S + BEIM_3\ C$	Eq 15
FT	$BEIM_2$	-0.603	N/A	N/A		
FT	$BEIM_3$	-0.166	N/A	N/A		
Soil (Mironov Model)						§ 3.1.2.2.2
FT	PERMIT0	8.854e-12	N/A	$F.m^{-1}$	Permittivity of free space	Eq 20
FT	EPWI0	4.9	N/A	$F.m^{-1}$	High frequency limit of static water dielectric constant $\varepsilon_{w\infty}$	Eq 20
FT	ND0	1.62847	N/A	N/A	Coefficients to compute refractive index of dry soil n_d	Eq 18
FT	ND1	-0.70803	N/A	N/A		
FT	ND2	0.4659	N/A	N/A		
FT	KD0	0.03945	N/A	N/A	Coefficients to compute normalized attenuation coefficient of dry soil k_d	Eq 18
FT	KD1	-0.03721	N/A	N/A		
FT	XMVT0	0.00625	N/A	N/A	Coefficients to compute maximum bound water fraction xm_{vt}	Eq 24
FT	XMVT1	0.33918	N/A	N/A		
FT	TF0	20	N/A	°C	Starting temperature	Eq 23
FT	E0PB0	79.82918	N/A	N/A	Coefficients to compute ε_{0b}	
FT	E0PB1	-85.36581	N/A	N/A		Eq 23
FT	E0PB2	32.70444	N/A	N/A		
FT	BVB0	-5.96311e-19	N/A	N/A	Coefficients to compute volumetric expansion coefficient β_b	Eq 23
FT	BVB1	-1.25999e-3	N/A	N/A		
FT	BVB2	1.83991e-3	N/A	N/A		
FT	BVB3	-9.77347e-4	N/A	N/A		
FT	BVB4	-1.39013e-7	N/A	N/A		
FT	BSGB0	0.0028	N/A	N/A	Coefficients to compute temperature incrementation coefficient for conductivity $\beta_{\sigma b}$	Eq 22
FT	BSGB1	2.37388e-2	N/A	N/A		
FT	BSGB2	-2.93876e-2	N/A	N/A		
FT	BSGB3	3.28954e-2	N/A	N/A		
FT	BSGB4	-2.00582e-2	N/A	N/A		
FT	DHBR0	1466.80741	N/A	N/A	Coefficeints to compute activation energy ΔH_b	Eq 21
FT	DHBR1	26.97032e2	N/A	N/A		
FT	DHBR2	-0.09803e4	N/A	N/A		
FT	DSRB0	0.88775	N/A	N/A	Coefficients to compute entropy of activation ΔS_b	Eq 21
FT	DSRB1	0.09697e2	N/A	N/A		
FT	DSRB2	-4.2622	N/A	N/A		
FT	TAUB0	48e-12	N/A	N/A	Coefficients to compute relaxation time τ_b	Eq 21
FT	SBT0	0.29721	N/A	N/A	Coefficients to compute ohmic conductivity σ_b	Eq 22
FT	SBT1	0.49	N/A			
FT	E0PU	100	N/A	N/A	Coefficients to compute dielectic constant ε_{uo}	Eq 23
FT	BVU0	1.10511e-4	N/A	N/A	Coefficients to compute volumetric expansion coefficient β_u	
FT	BVU1	-5.16834e-6	N/A	N/A		Eq 23
FT	BSGU0	0.00277	N/A	N/A	Coefficients to compute temperature incrementation coefficient for conductivity $\beta_{\sigma u}$	
FT	BSGU1	3.58315e-2	N/A	N/A		Eq 22
FT	DHUR0	2230.20237	N/A	N/A	Coefficients to compute activation energy ΔH_u	
FT	DHUR1	-0.39234e2	N/A	N/A		Eq 21
FT	DSUR0	3.6439	N/A	N/A	Coefficients to compute entropy of activation ΔS_u	Eq 21
FT	DSUR1	-0.00134e2	N/A	N/A		

T	Name	Default	Range	Units	Comments	ATBD ref
FT	TAUU0	48e-12	N/A	N/A	Coefficients to compute relaxation time τ_u	Eq 21
FT	SUT0	0.12799	N/A	N/A	Coefficients to compute ohmic conductivity σ_u	Eq 22
FT	SUT1	1.65164	N/A	N/A		
Effective Temperature of Soil						§ 3.1.2.4
FB	w_0	0.3	N/A	[m^3/m^3]	w_0 and b_{w0} are used to obtain the weighting coeff C_t for computing T_s. Those parameters depend mainly on the soil texture and structure. They are superseded by values in the DFFG_SOIL_PROPERTIES table when available.	Eq 27 Eq 28
FB	b_{w0}	0.65	N/A	[-]		
Soil (Bircher's Model)						§ 3.1.2.2.3
FT	C_SOM_Re_0	1.636	N/A	[F/m]	Real components of the constant coefficients for Bircher's organic soil dielectric constant model.	Eq 14
FT	C_SOM_Re_1	25.0	N/A	[F/m]		
FT	C_SOM_Re_2	18.81	N/A	[F/m]		
FT	C_SOM_Re_3	50.69	N/A	[F/m]		
FT	C_SOM_Im_0	0.1211	N/A	[F/m]	Imaginary components of the constant coefficients for Bircher's organic soil dielectric constant model.	
FT	C_SOM_Im_1	9.613	N/A	[F/m]		
FT	C_SOM_Im_2	-11.08	N/A	[F/m]		
FT	C_SOM_Im_3	10.61	N/A	[F/m]		

Table 35. Pure and Saline Water Model (MW)

T	Name	Value	Range	Units	Comments	ATBD ref
Dielectric Constant for Saline Water ε_{SW} , or Pure Water ε_{PW}						§ 3.1.3.1
FB	SST	288	[260, 320]	[K]	Water temperature (pure or saline). Fall back default of forecast SST	Eq 49a-50e
FT	SSS	35	[0, 40]	[ppt]	Water salinity (saline water)	
Dielectric (Klein & Swift Model)						§ 3.1.3.1
FT	OW_01	88.045	N/A	N/A	Klein and Swift	Eq 49a
FT	OW_02	-0.4147	N/A	N/A		
FT	OW_03	6.295×10^{-4}	N/A	N/A		
FT	OW_04	1.075×10^{-5}	N/A	N/A		
FT	OW_05	87.134	N/A	N/A	Klein and Swift	Eq 50b
FT	OW_06	-1.949×10^{-1}	N/A	N/A		
FT	OW_07	-1.276×10^{-2}	N/A	N/A		
FT	OW_08	2.491×10^{-4}	N/A	N/A		
FT	OW_09	1.000	N/A	N/A	Klein and Swift	Eq 50c
FT	OW_10	1.613×10^{-5}	N/A	N/A		
FT	OW_11	-3.656×10^{-3}	N/A	N/A		
FT	OW_12	3.210×10^{-5}	N/A	N/A		
FT	OW_13	-4.232×10^{-7}	N/A	N/A		
FT	OW_14	1.1109×10^{-10}	N/A	N/A	Stogryn	Eq 49b
FT	OW_15	-3.824×10^{-12}	N/A	N/A		
FT	OW_16	6.938×10^{-14}	N/A	N/A		
FT	OW_17	-5.096×10^{-16}	N/A	N/A		
FT	OW_18	1.000	N/A	N/A	Klein and Swift	Eq 50e
FT	OW_19	2.282×10^{-5}	N/A	N/A		

T	Name	Value	Range	Units	Comments	ATBD ref
FT	OW_20	-7.638×10^{-4}	N/A	N/A		
FT	OW_21	-7.760×10^{-6}	N/A	N/A		
FT	OW_22	1.105×10^{-8}	N/A	N/A		
FT	OW_23	0.18252	N/A	N/A	Weyl & Stogryn	Eq 48b
FT	OW_24	-1.4619×10^{-3}	N/A	N/A		
FT	OW_25	2.093×10^{-5}	N/A	N/A		
FT	OW_26	-1.282×10^{-7}	N/A	N/A		
FT	OW_27	2.033×10^{-2}	N/A	N/A	Weyl & Stogryn	Eq 48c
FT	OW_28	1.266×10^{-4}	N/A	N/A		
FT	OW_29	2.464×10^{-6}	N/A	N/A		
FT	OW_30	1.849×10^{-5}	N/A	N/A		
FT	OW_31	-2.551×10^{-7}	N/A	N/A		
FT	OW_32	2.551×10^{-8}	N/A	N/A		

Table 36. Parameter List for Dielectric Model (MD)

T	Name	Values	Range	Units	Comments	ATBD ref
Cardioid Model						§ 3.1.4.7
FT	U_card	0.1	$[0, \pi]$	[rd]	Angle parameter	Eq 54a
FT	B_card	0.8	N/A	[F/m]	A constant for cardioid model	Eq 54b
Dielectric Constants						§ 3.1.2 § 3.1.4
FI	ε_{sand}	2.53 - 0.05 i	N/A	[F/m]	Dielectric constant for dry sand.	§ 3.1.2.10.2 Eq 45
FI	ε_{Frz}	5 - i 0.5	N/A	[F/m]	Dielectric constant for frozen soil.	§ 3.1.4.2 Eq 52
FI	ε_{Ice}	3.17 - i ε_i"	N/A	[F/m]	Dielectric constant for ice. εi" is very small for pure ice Currently suggested ε_{ice}"= 0.1	§ 3.1.4.2 Eq 53
FI	$\varepsilon_{\mathrm{Urban}}$	5.7-i 0.074	N/A	[F/m]	Dielectric constant for urban area	§ 3.1.4.5
FI	$\varepsilon_{\mathrm{Rock}}$	5.7-i 0.074	N/A	[F/m]	Dielectric constant for barren areas	§ 3.1.4.1.2 Eq 51

3.3.3.2 Interface Surface Layer – Above Surface Layer

Table 37. Parameter List for Soil Surface Roughness Model

T	Name	Value	Range	Units	Comments	ATBD ref
Soil Fresnel Law						§ 3.1.2.2, § 3.1.3.1
FT	μ_s	1	N/A	N/A	Soil magnetic permeability	Eq 11
FT	μ_w	1.0	[0.99, 1.001]	Henry m-1	Water magnetic permeability (not equal to 1)	Eq 11
Surface roughness						§ 3.1.2.3
FT	CWP1	0.06774	N/A	N/A	Coefficient for computing roughnessHR(SM) as a piecewise function of SM	Eq 26a
FT	CWP2	- 0.00064	N/A	N/A	Coefficient for computing roughnessHR(SM) as a piecewise function of SM	Eq 26a
FT	CWP3	0.00478	N/A	N/A	Coefficient for computing roughnessHR(SM) as a piecewise function of SM	Eq 26a

FT	CXMVT 1	0.49	N/A	N/A	Coefficient for computing roughnessHR(SM) as a piecewise function of SM	Eq 26b
FT	CXMVT 2	0.165	N/A	N/A	Coefficient for computing roughnessHR(SM) as a piecewise function of SM	Eq 26b

3.3.3.3 Above Surface Layers

[1] Here we have to distinguish parameters default value and range for low vegetation (LV) and forest vegetation (FV). So the default column is separated in two sub-columns, LV and FV.

Table 38. Parameter List for Vegetation Model

T	Name	Default LV	Default FV	Range	Units	Comments	ATBD ref
Optical thickness of litter τ_{LH} and τ_{LV}							§ 3.1.2.7
FB	SM	0.3	N/A	[0, 0.5]	m^3/m^3	Soil Moisture to derive optical thickness of litter when soil+low veg is not regressed but used as default contribution. Fall back default to ECMWF SWVL unavailability	Eq 41c
General							§ 3.1.2.7-8
FB	T_c	288	288	[250, 350]	[K]	Effective vegetation temperature. Fall back default to ECMWF SKT unavailability.	$ 3.1.2.7 Eq 31a § 3.1.2.8 Eq 43

Table 39. Parameter List for Snow Model (SN)

T	Name	Values	Range	Units	Comments	ATBD ref
FI	SCR	0.015	[-]	m	Minimum snow mass that ensures complete coverage of an ECMWF grid box. Use to compute snow fraction.	$3.2.3.2.7
FI	Dielec_Const_Snow	Re →1.5 Im → -0.026	Re→[1, 3.4] Im → [-0.006, -0.08]	[F/m]	It will be required by computing the TB contribution from Snow fraction.	$3.1.4.3 $3.2.3.2.7

3.3.3.4 External Contributions

Table 40. List of Parameters for Atmosphere Model

T	Name	Values	Range	Units	Comments	ATBD ref
Atmosphere Forecast Parameter						§ 3.1.5.1.1
FB	T0	288	[230, 310]	[K]	Temperature at 2 meters Fall back default to ECMWF 2T unavailability	§ 3.1.5.1.2.2 Eq 59-61
FB	P0	1013	[400, 1100]	[hPa]	Surface pressure Fall back default to ECMWF SP unavailability	
FB	WVC	1	[0, 10]	$[kg/m^2]$	Total water vapor content Fall back default to ECMWF TWVC unavailability	
Atmosphere Optical Thickness τ_{atm}						§ 3.1.5.1.2.2
FT	k0_tau_O_2	5.12341e3	N/A	[neper]		Eq 60a

T	Name	Values	Range	Units	Comments	ATBD ref
FT	kT0_tau_O_2	-6.80605e1	N/A	[neper/K]	Oxygen optical thickness parameters fit	
FT	kP0_tau_O_2	2.42216e1	N/A	[neper/hPa]		
FT	kT02_tau_O2	1.70616e-1	N/A	[neper/K^2]		
FT	kP02_tau_O2	6.64682e-3	N/A	[neper/hPa^2]		
FT	kT0P0_tau_O2	-7.99404e-2	N/A	[neper/K/hPa]		
FT	k0_tau_H_2O	-113.724	N/A	[neper]	H_2O optical thickness parameters fit	Eq 61a
FT	k1_tau_H_2O	0.155378	N/A	[neper/hPa]		
FT	k2_tau_H20	2.87254	N/A	[neper m^2/kg]		
	Atmospheric Layer Equivalent Temperature T_{atm}					§ 3.1.5.1.2.2
FT	k0_DT_O_2	-3.16387e+0	N/A	[K]	Oxygen temperature contribution parameters fit	Eq 60b
FT	kT0_ DT_O2	+1.38628e-1	N/A	[]		
FT	kP0_ DT_O2	3.29731e-3	N/A	[K/hPa]		
FT	kT02_ DT_O2	-1.19886e-4	N/A	[1/K]		
FT	kP02_ DT_O2	1.66366e-6	N/A	[K/hPa^2]		
FT	kT0P0_ DT_O2	-9.90743e-6	N/A	[1/hPa]		
FT	k0_DT_H_2O	8.07567	N/A	[K]	H_2O temperature contribution parameters fit	Eq 61b
FT	k1_DT_H_2O	0.000516901	N/A	[K/hPa]		
FT	k2_DT_H20	0.0344319	N/A	[K m^2/kg]		
	Galactic Contribution Parameters					§ 3.1.5.2
FT	C0_GST0	100.46062	N/A	N/A	Ephemeris of Greenwich Sidereal Time Origin (00:00 UTC). Polynomial approximation: GST0=C0_GST0+C1_GST0xU0+ C2_GST0xU0^2+C4_GST0xU0^3	Eq 68
FT	C1_GST0	36000.77	N/A	N/A		
FT	C2_GST0	0.000388	N/A	N/A		
FT	C4_GST0	-2.6x10^{-8}	N/A	N/A		

3.3.4 Decision Tree

3.3.4.1 Decision Tree Stage One

Table 41. Decision Tree Fraction Thresholds

T	Name	Values	Range	Units	Comments	ATBD ref
	Thresholds for Selecting Classes					
FT	TH_TDRY	-12	N/A	°C	Threshold for dry NPE snow	§ 3.2.3.2.7
FT	TH_TWET	-2	N/A	°C	Threshold for wet NPE snow	
FT	TH_SAND	97	(≈95 or 97).	%	Threshold for sand	§ 3.1.2.10.2
	Thresholds for external conditions to update the DFFG pixel content					§ 3.2.3.2.2
FT	TH_PWATER_FRZ	271	[270, 273]	K	Threshold for frozen pure water	§ 3.2.3.2.2.3
FT	TH_SWATER_FRZ	270	[270, 273]	K	Threshold for frozen saline water	§ 3.2.3.2.2.4
FT	TH_SOIL_FRZ	270	[268, 274]	K	Threshold for frozen soil	§ 3.2.3.2.2.1
FT	TH_TAU_F1	0.05	[0, 1]	neper	Threshold for canopy opacity of (1-FFO) fraction to Obtaining the final aggregated radiometric fractions for WA_{DFFG}	§ 3.2.3.2.3
FT	TH_F1	61	N/A	%	Threshold for FFO fraction to deal with the Forest Winter case. Previously, it was TH_FF.	§ 3.2.3.2.3
FT	TH_TAU_FN	100.0	[0, 1]	neper	Threshold for canopy opacity of FFO fraction to determine if FNO+FFO retrieval is applied	§ 3.2.3.4.2

T	Name	Values	Range	Units	Comments	ATBD ref
FT	TH_VEG_FRZ	269	[265, 273]	K	Threshold for frozen vegetation	§ 3.2.3.2.2.7

T	Name	Values	Range	Units	Comments	ATBD ref
Decision Free Fraction Thresholds						§ 3.2.3.4-5
FT	NB_TH_DEC	16		[]	Number of fraction thresholds (= Nb branches – 1)	
FT	TH_W2	90	[0,100]	[%]	Threshold: applies to Open Water	
FT	TH_W2_N	FWO			Fraction FM0 key	
FT	TH_W2_D	0	na		Key for denominator = 0(all) or 1(FLA)	
FT	TH_W2_R	1			Rank of the branch of decision tree	
FT	TH_W1	60	[0,100]	[%]	Threshold: applies to Open Water	
FT	TH_W1_N	FWO			Fraction FM0 key	
FT	TH_W1_D	0	na		Key for denominator = 0(all) or 1(FLA)	
FT	TH_W1_R	2			Rank of the branch of decision tree	
FT	TH_TS	200	[0,100]	[%]	Threshold: applies to Topography (strong)	
FT	TH_TS_N	FTS			Fraction FM0 key	
FT	TH_TS_D	1	na		Key for denominator = 0(all) or 1(FLA)	
FT	TH_TS_R	3			Rank of the branch of decision tree	
FT	TH_TM	200	[0,100]	[%]	Threshold: applies to Topography (moderate)	
FT	TH_TM_N	FTM			Fraction FM0 key	
FT	TH_TM_D	1	na		Key for denominator = 0(all) or 1(FLA)v	
FT	TH_TM_R	4			Rank of the branch of decision tree	
FT	TH_S2W	98	[0,100]	[%]	Threshold: applies to non permanent (wet) snow	
FT	TH_S2W_N	FSW			Fraction FM0 key	
FT	TH_S2W_D	1	na		Key for denominator = 0(all) or 1(FLA)	
FT	TH_S2W_R	5			Rank of the branch of decision tree	
FT	TH_S2M	98	[0,100]	[%]	Threshold: applies to non permanent (mixed) snow	
FT	TH_S2M_N	FSM			Fraction FM0 key	
FT	TH_S2M_D	1	na		Key for denominator = 0(all) or 1(FLA)	
FT	TH_S2M_R	6			Rank of the branch of decision tree	
FT	TH_S1W	5	[0,100]	[%]	Threshold: applies to non permanent (wet) snow	
FT	TH_S1W_N	FSW			Fraction FM0 key	
FT	TH_S1W_D	1	na		Key for denominator = 0(all) or 1(FLA)	
FT	TH_S1W_R	7			Rank of the branch of decision tree	
FT	TH_S1M	5	[0,100]	[%]	Threshold: applies to non permanent (mixed) snow	
FT	TH_S1M_N	FSM			Fraction FM0 key	
FT	TH_S1M_D	1	na		Key for denominator = 0(all) or 1(FLA)	
FT	TH_S1M_R	8			Rank of the branch of decision tree	
FT	TH_R2	98	[0,100]	[%]	Threshold: applies to NPE frozen surface	
FT	TH_R2_N	FRZ			Fraction FM0 key	
FT	TH_R2_D	1	na		Key for denominator = 0(all) or 1(FLA)	
FT	TH_R2_R	9			Rank of the branch of decision tree	
FT	TH_R1	5	[0,100]	[%]	Threshold: applies to NPE frozen surface	
FT	TH_R1_N	FRZ			Fraction FM0 key	
FT	TH_R1_D	1	na		Key for denominator = 0(all) or 1(FLA)	
FT	TH_R1_R	10			Rank of the branch of decision tree	
FT	TH_F2	60	[0,100]	[%]	Threshold: applies to Forest	
FT	TH_F2_N	FFO			Fraction FM0 key	
FT	TH_F2_D	0	na		Key for denominator = 0(all) or 1(FLA)	
FT	TH_F2_R	11			Rank of the branch of decision tree	
FT	TH_NO	40	[0,100]	[%]	Threshold: applies to nominal soil + low vegetation	
FT	TH_NO_N	FNO			Fraction FM0 key	
FT	TH_NO_D	0	na		Key for denominator = 0(all) or 1(FLA)	
FT	TH_NO_R	12			Rank of the branch of decision tree	
FT	TH_WL	90	[0,100]	[%]	Threshold: applies to Wetlands	

T	Name	Values	Range	Units	Comments	ATBD ref
FT	TH_WL_N	FWL			Fraction FM0 key	
FT	TH_WL_D	1	na		Key for denominator = 0(all) or 1(FLA)	
FT	TH_WL_R	13			Rank of the branch of decision tree	
FT	TH_EB	80	[0,100]	[%]	Threshold: applies to barren surfaces	
FT	TH_EB_N	FEB			Fraction FM0 key	
FT	TH_EB_D	1	na		Key for denominator = 0(all) or 1(FLA)	
FT	TH_EB_R	14			Rank of the branch of decision tree	
FT	TH_TI	80	[0,100]	[%]	Threshold: applies to total ice	
FT	TH_TI_N	FTI			Fraction FM0 key	
FT	TH_TI_D	1	na		Key for denominator = 0(all) or 1(FLA)	
FT	TH_TI_R	15			Rank of the branch of decision tree	
FT	TH_UH	80	[0,100]	[%]	Threshold: applies to urban areas - high coverage.	
FT	TH_EU_N	FEU			Fraction FM0 key	
FT	TH_EU_D	1	N/A		Key for denominator = 0(all) or 1(FLA)	
FT	TH_EU_R	16			Rank of the branch of decision tree.	

Table 42. Decision Tree Model Selection

			Aggregated Fractions FM									
N°	Tree Branch	Content	FWP	FWS	FSN	FRZ	FFO	FNO	FWL	FEB	FTI	FEU
1	All open water	Forward model	**MWP**	**MWS**	MD	MD	MN	MN	MWP	MD	MD	MD
		Retrieved fraction	**1**	**1**	0	0	0	0	0	0	0	0
2	Heterogeneous OW	Forward model	**MD**	**MD**	**MD**	**MD**	**MD**	**MD**	**MD**	**MD**	**MD**	**MD**
		Retrieved fraction	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**
3	Strong topo pollution	Forward model	MWP	MWS	**MD**	**MD**	**MD**	**MD**	**MD**	**MD**	**MD**	**MD**
		Retrieved fraction	0	0	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**
4	Soft topo pollution	Forward model	MWP	MWS	**MD**	**MD**	**MD**	**MD**	**MD**	**MD**	**MD**	**MD**
		Retrieved fraction	0	0	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**
5	All wet snow	Forward model	MWP	MWS	**MD**	MD	MN	MN	MWP	MD	MD	MD
		Retrieved fraction	0	0	**1**	0	0	0	0	0	0	0
6	All mixed snow	Forward model	MWP	MWS	**MD**	**MD**	**MD**	**MD**	**MD**	**MD**	**MD**	**MD**
		Retrieved fraction	0	0	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**
7	Wet snow pollution	Forward model	MWP	MWS	**MD**	**MD**	**MD**	**MD**	**MD**	**MD**	**MD**	**MD**
		Retrieved fraction	0	0	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**
8	Mixed snow pollution	Forward model	MWP	MWS	**MD**	**MD**	**MD**	**MD**	**MD**	**MD**	**MD**	**MD**

			Aggregated Fractions FM									
N°	**Tree Branch**	**Content**	**FWP**	**FWS**	**FSN**	**FRZ**	**FFO**	**FNO**	**FWL**	**FEB**	**FTI**	**FEU**
		Retrieved fraction	0	0	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**
9	All frost	Forward model	MWP	MWS	MD	**MD**	MN	MN	MWP	MD	MD	MD
		Retrieved fraction	0	0	0	**1**	0	0	0	0	0	0
10	Frost pollution	Forward model	MWP	MWS	**MD**	**MD**	**MD**	**MD**	**MD**	**MD**	**MD**	**MD**
		Retrieved fraction	0	0	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**
11	Forest cover	Forward model	MWP	MWS	MD	MD	**MN**	MN	MWP	MD	MD	MD
		Retrieved fraction	0	0	0	0	**1**	0	0	0	0	0
12	Nominal soil cover	Forward model	MWP	MWS	MD	MD	MN	**MN**	MWP	MD	MD	MD
		Retrieved fraction	0	0	0	0	0	**1**	0	0	0	0
13	All wetlands	Forward model	MWP	MWS	MD	MD	MN	MN	**MWP**	MD	MD	MD
		Retrieved fraction	0	0	0	0	0	0	**1**	0	0	0
14	All barren	Forward model	MWP	MWS	MD	MD	MN	MN	MWP	**MD**	MD	MD
		Retrieved fraction	0	0	0	0	0	0	0	**1**	0	0
15	All ice	Forward model	MWP	MWS	MD	MD	MN	MN	MWP	MD	**MD**	MD
		Retrieved fraction	0	0	0	0	0	0	0	0	**1**	0
16	All urban	Forward model	MWP	MWS	MD	MD	MN	MN	MWP	MD	MD	**MD**
		Retrieved fraction	0	0	0	0	0	0	0	0	0	**1**
17	Heterogeneous	Forward model	MWP	MWS	**MD**	**MD**	**MD**	**MD**	**MD**	**MD**	**MD**	**MD**
		Retrieved fraction	0	0	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**

3.3.4.2 Decision Tree Stage Two

Table 43. Parameter List for Second Stage of Decision Tree

T	Name	Value	Range	Units	Comments	ATBD Ref
Decision Tree Stage 2 Retrieval Condition Thresholds						§ 3.2.3.6
FT	MMIN1	3.0	[1, 60]	[-]	No retrieval Minimun number of retrieved parameters	§ 3.2.3.6
FT	MMIN2	30	[1, 60]	[-]	Nominal number of retrieved parameters	
FT	MMIN3	250	[1, 60]	[-]	Maximum number of retrieved parameters. In this case, 250 is a value large enough to ensure that MVAL will never be higher. Maximum MVAL value after spatial filtering and considering a 100% homogeneous surface is around 55 – 65. If we had kept all the incidence angles, the maximum MVAL would have been around 120.	
FT	TH_23	0.005	[0.0001, 0.1]	neper	The value for this parameter controls whether Tau is selected for retrieval. By lowering this value, one increases the range of surface types for which Tau is retrieved. However, due to precisions used to represent LAI and other parameters, there is a limit on how low this parameter can be set.	Table 21
FT	TH_34	0.5	[0.4, 1.5]	neper	TAU_R threshold for selecting prior standard deviation values on free parameters	

Table 44. Prior Standard Deviations for Second Stage of Decision Tree

Parameter	Unit	Forward Models								
		MD 2	MD 3	MD 4	MN 2	MN 3	MN 4	MW 2	MW 3	MW 4
Free Parameters for Initial Vegetation Thickness inInterval [0 TH_23]										
σ0_TSURF	K	0	0	2.5	0	0	2.5	2.5	2.5	2.5
σ0_A_CARD	-	80.0	80.0	80.0						
σ0_SM	%				80.0	80.0	80.0			
σ0_HR	-	0	0.5	0.5	0	0.5	0.5			
σ0_TAU	-	0	0	0	0	0	0	0	0	0
σ0_TTH	-	0	0	0	0	0	0	0	0	0
σ0_RTT	-	0	0	0	0	0	0	0	0	0
σ0_OMH	-	0	0	0	0	0	0	0	0	0
σ0_DIFF_OM	-	0	0	0	0	0	0	0	0	0
Free Parameters for Initial Vegetation Thickness in Interval [TH_23 TH_34]										
σ0_TSURF	K	0	0	2.5	0	0	2.5	0	2.5	2.5
σ0_A_CARD	-	80.0	80.0	80.0						
σ0_SM	%				80.0	80.0	80.0			
σ0_HR	-	0	0	0	0	0	0			
σ0_TAU	-	0.1	0.5	0.5	0.1	0.5	0.5	0.1	0.5	0.5

Parameter	Unit	Forward Models								
		MD 2	MD 3	MD 4	MN 2	MN 3	MN 4	MW 2	MW 3	MW 4
σ0_TTH	-	0	0	1.0	0	0	1.0	0	0	1.0
σ0_RTT	-	0	0	2.0	0	0	2.0	0	0	2.0
σ0_OMH	-	0	0	0.1	0	0	0.1	0	0	0.1
σ0_DIFF_OM	-	0	0	0.1	0	0	0.1	0	0	0.1
Free Parameters for Initial Vegetation Thickness above TH_34										
σ0_TSURF	K	0	0	2.5	0	0	2.5	0	2.5	2.5
σ0_A_CARD	-	80.0	80.0	80.0						
σ0_SM	%				80.0	80.0	80.0			
σ0_HR	-	0	0	0	0	0	0			
σ0_TAU	-	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
σ0_TTH	-	0	0	0	0	0	0	0	0	0
σ0_RTT	-	0	0	0	0	0	0	0	0	0
σ0_OMH	-	0	0	0.1	0	0	0.1	0	0	0.1
σ0_DIFF_OM	-	0	0	0	0	0	0	0	0	0

3.3.5 Iterative Retrieval

Table 45. Parameter List for Iterative Retrieval Algorithm

T	Name	Value	Range	Units	Comments	ATBD Ref
Free Parameters Prior Values and DerivativeIincrement						§ 3.2.3.6
FB	SM	15	[0,60]	[%]	Soil moisture prior value. ECMWF fallback for SWVL1 value.	§ 3.1.2.2 Eq 13
FT	ΔSM	0.01	[0,50]	[%]	Soil moisture increment for computing derivatives (DPD)	§ 3.2.4.4.3 Table 23
FT	A_card	20	[0,50]	F/M	Default cardioid magnitude prior value. To be used with MDd retrieval.	§ 3.2.3.5
FT	ΔA_card	0.1	[0,50]	F/M	Cardioid magnitude increments for computing derivatives (DPD)	§ 3.2.4.4.3 Table 22
FT	$\Delta\tau_{NAD}$	0.01	[0,50]	[neper]	Tau nadir increment for computing derivatives (DPD)	§ 3.2.4.4.3 Table 22
FB	T_{SURF}	288	[260, 300]	[K]	Surface effective temperature parameter prior value. Fall back value for missing ECMWF STL1	§ 3.1.2.7 Eq 30
FT	ΔT_{SURF}	0.1	[0,50]	[K]	T_{SURF} increment for computing derivatives (DPD)	§ 3.2.4.4.3 Table 22
FT	ΔTT_H	0.05	[0,5]	[-]	TT_H increment for computing derivatives (DPD)	§ 3.2.4.4.3 Table 22
FT	Δ RTT	0.05	[0,50]		RTT increment for computing derivatives (DPD)	§ 3.2.4.4.3 Table 22
FT	Δ	0.1	[0,50]	[-]	ω_H increment for computing derivatives (DPD)	§ 3.2.4.4.3 Table 22
FT	Δ DIFFω	0.01	[-1,1]	[-]	DIFFω increment for computing derivatives (DPD)	§ 3.2.4.4.3 Table 22

T	Name	Value	Range	Units	Comments	ATBD Ref
FT	ΔHR	0.01	[0,3]	[-]	Roughness H_{SOIL} parameter increment for computing derivatives (DPD)	§ 3.2.4.4.3 Table 22
Global Algorithm Control						§ 3.2.4.4.3
FT	NITM	30	[5, 50]	[-]	Maximum number of iterations	Table 32
FT	KDIA	0.1	[0.05, 0.3]	[-]	Initial value of the diagonal increment (Levenberg-Marquardt)	
FT	KDIA_MAX	1.e5	[1, 3]	[-]	Maximum value allowed for the diagonal increment (Levenberg-Marquardt)	
FT	FDIA	0.1	[0.05, 0.3]	[-]	Dividing factor for KDIA (Levenberg-Marquardt)	
FT	FCV1	5e-3	[0.01, 0.3]	[-]	Convergence test on parameters variation	
FT	FCV2	0.05	[0.01, 0.3]	[-]	Convergence test on cost function minimum Not activated (This is not included in AUX_CNF)	
FT	FCOND	10^{15}	N/A	[-]	Test for matrix conditioning (Levenberg-Marquardt)	
FT	Use_TAU_L_In_Inv	0	{0, 1}	N/A	default="0" "1" means "use Tau litter in retrieval; "0" means "do NOT use Tau litter".	
Product Control Parameters						
FT	Standard_User_Mode	1	{0, 1}	N/A	Switch for suppressing negative retrieval values. “0” = ESL or Prototype mode which outputs retrieval results even if they are negative; “1” = Operational mode which adjusts “small” negative retrievals (default value)	
FT	C_R_A_Card	1.0	[0, 1] (TBC)	[-]	Coefficient, Cp, used to define the extended validity range for p = A_Card: [MINp – Cp*DQXp, MAXp + Cp *DQXp]	
FT	C_R_Diff_OM	1.0	[0, 1] (TBC)	[-]	Coefficient, Cp, used to define the extended validity range for p = Diff_OM: [MINp – Cp*DQXp, MAXp + Cp *DQXp]	
FT	C_R_HR	1.0	[0, 1] (TBC)	[-]	Coefficient, Cp, used to define the extended validity range for p = HR: [MINp – Cp*DQXp, MAXp + Cp *DQXp]	
FT	C_R_OMH	1.0	[0, 1] (TBC)	[-]	Coefficient, Cp, used to define the extended validity range for p = OMH: [MINp – Cp*DQXp, MAXp + Cp *DQXp]	
FT	C_R_RTT	1.0	[0, 1] (TBC)	[-]	Coefficient, Cp, used to define the extended validity range for p = RTT: [MINp – Cp*DQXp, MAXp + Cp *DQXp]	
FT	C_R_SM	1.0	[0, 1] (TBC)	[-]	Coefficient, Cp, used to define the extended validity range for p = SM: [MINp – Cp*DQXp, MAXp + Cp *DQXp]	
FT	C_R_Tau	1.0	[0, 1] (TBC)	[-]	Coefficient, Cp, used to define the extended validity range for p = Tau: [MINp – Cp*DQXp, MAXp + Cp *DQXp]	
FT	C_R_TSurf	1.0	[0, 1] (TBC)	[-]	Coefficient, Cp, used to define the extended validity range for p = TSurf: [MINp – Cp*DQXp, MAXp + Cp *DQXp]	
FT	C_R_TTH	1.0	[0, 1] (TBC)	[-]	Coefficient, Cp, used to define the extended validity range for p = TTH: [MINp – Cp*DQXp, MAXp + Cp *DQXp]	
FT	Use_AUX_DFFSNO	0.0	{0, 1}	N/A	Switch, controlling the use of AUX_DFFSNO. If set to 1 AUX_DFFSNO is expected. Default is 0 = OFF.	
FI	Generate_DAP	0	{0, 1}	N/A	Switch controlling the generation of DAP. If set to 1 DAP is generated. Default is 0 = OFF.	
FI	Operating_Mode	0	{0, 1, 2}	N/A	Switch controlling the “operating mode” of the processor, where 0 is the default mode (use full set of TBs), 1 is the “Dual-in-Full” mode (do not use TBXY in retrievals), and 2 is “Extended Dual-in-Full” mode (do not use any measurements from snapshots containing TBXY).	

T	Name	Value	Range	Units	Comments	ATBD Ref
	Dielectric_Model_Type	1	{0, 1, 2}	N/A	A switch used to select the dielectric model (0 for Dobson, 1 for Mironov, 2 for mixed Bircher's & Mironov)	
	Dielectric_Model_Sub_Type	1	{0, 1}	N/A	A switch used to select the behaviour of the dielectric model computation (0 for standard, 1 for symmetrised)	
	SM1_Thld	0.02	[0, 0.5]	m^3/m^3	Call the *prolonged* version of the dielectric model when SM is in [0, SM1_Thld], and normal case otherwise	

3.3.6 Post-Processing

Table 46. Quality Control and Diagnostics

T	Name	Value	Range	Units	Comments	ATBD Ref
					Dielectric Constant	§ 3.2.5.1
FT	SM_min	0		[%]	Soil moisture retrieval domain	
FT	SM_max	100		[%]		
FT	TH_DQX$_{SM}$	30		[]	Threshold for maximum acceptable DQX$_{SM}$ value	$ 3.2.5.1
FT	A_card_min	0		[]	Dielectric constant retrieval domain.	
FT	A_card_max	90000		[]		
FT	TH_DQX$_{A_card}$	1000		[]	Threshold for acceptable DQX$_{A_card}$ value	$ 3.2.5.1
					Temperature	§ 3.2.5.1
FT	T$_{SURF}$_min	230		[K]	Surface temperature retrieval domain	
FT	T$_{SURF}$_max	320		[K]		
FT	TH_DQX$_{TSURF}$	3		[]	Threshold for maximum acceptable DQX$_{TSurf}$ value	$ 3.2.5.1
					Roughness	§ 3.2.5.1
FT	HR_min	0			Hsoil retrieval domain	
FT	HR_max	3				
FT	TH_DQX$_{HR}$	0.9			Threshold for maximum acceptable DQX$_{Hsoil}$ value	$ 3.2.5.1
FT	HR_MIN_FSN_WET_OR_MIXED	0	[0, 5]	NA	Roughness Parameter (HRmin) of Wet or Mixed Snow (float)	TBD
FT	FTI_NPE_Land_Cover_Class_Code	15	[1, 255]		Code of the Land Cover Class defining parameters for the Ice Fraction resulting from Non-Permanent Effects (unsigned int)	TBD
FT	FWL_NPE_Land_Cover_Class_Code	18	[1, 255]		Code of the Land Cover Class defining parameters for the Wetlands resulting from Non-Permanent Effects (unsigned int).	TBD
					Vegetation	§ 3.2.5.1
FT	τ_{Nad}_min	0		[neper]	τ_{Nad} retrieval domain	
FT	τ_{Nad}_max	3		[neper]		
FT	TH_DQX$_{\tau Nad}$	0.6		[-]	Threshold for maximum acceptable DQX$_{\tau Nad}$ value	$ 3.2.5.1
FT	TT$_H$_min	0		[-]	TT$_H$ retrieval domain	
FT	TT$_H$_max	6		[-]		
FT	TH_DQX$_{TTH}$	1.5		[-]	Threshold for maximum acceptable DQX$_{TTH}$ value	$ 3.2.5.1
FT	RTT_max	10		[-]	RTT retrieval domain	
FT	RTT_min	0		[-]		
FT	TH_DQX$_{RTT}$	1.9		[-]	Threshold for maximum acceptable DQX$_{RTT}$ value	$ 3.2.5.1
FT	ω_H _min	0		[-]	ω_H retrieval domain	
FT	ω_H _max	0.2		[-]		
FT	TH_DQX$_{\omega H}$	0.1		[-]	Threshold for maximum acceptable DQX$_{\omega H}$ value	$ 3.2.5.1

T	Name	Value	Range	Units	Comments	ATBD Ref
FT	DIFF_ω_min	-0.2		[-]	DIFFω retrieval domain	
FT	DIFF_ω_max	0.2		[-]		
FT	TH_DQX$_{DIFFω}$	0.1		[-]	Threshold for maximum acceptable DQX$_{DIFFω}$ value	$ 3.2.5.1
General						§ 3.2.5.1
T	TH_FIT	4		[-]	Threshold for detecting outliers	§ 3.2.5.1

Table 47. PCD Quantities

T	Name	Value	Range	Units	Comments	ATBD Ref
PCD Additional Flag Thresholds						§ 3.2.5.5 § 3.4.4.1
FT	TH_SCENE_FEB	5	[0,100]	[%]	Presence of rocks	
FT	TH_SCENE_FTS	5	[0,100]	[%]	Presence of strong topography	
FT	TH_SCENE_FTM	10	[0,100]	[%]	Presence of moderate topography	
FT	TH_SCENE_FWO	5	[0,100]	[%]	Presence of open water	
FT	TH_SCENE_FSN	5	[0,100]	[%]	Presence of snow	
FT	TH_SCENE_FSW	5	[0,100]	[%]	Presence of wet snow. This threshold will be used in setting FL_SNOW_WET flag	
FT	TH_SCENE_FSD	5	[0,100]	[%]	Presence of dry snow. This threshold will be used in setting FL_SNOW_DRY flag	
FT	TH_SCENE_FFO	10	[0,100]	[%]	Presence of forest	
FT	TH_SCENE_TAU_FO	1	[0,3]		Large forest optical thickness	
FT	TH_SCENE_FNO	10	[0,100]	[%]	Presence of nominal soil	
FT	TH_SCENE_FRZ	5	[0,100]	[%]	Presence of frost	
FT	TH_SCENE_FWL	5	[0,100]	[%]	Presence of wetlands	
FT	TH_SCENE_FUL	10	[0,100]	[%]	Presence of limited urban area	
FT	TH_SCENE_FUH	30	[0,100]	[%]	Presence of large urban area	
FT	TH_SCENE_FTI	5	[0,100]	[%]	Presence of permanent ice/snow	
FT	TH_SAND	95	[0,100]	[%]	Presence of high sand fraction	
FT	TH_TEC	95	[0,100]	TECu	TEC threshold	
FT	TH_RAIN	10	[0,100]	[mm/h]	Rain intensity threshold for rain flag	
FT	TH_FLOOD	0.65	[0,100]	[m^3/m^3]	Soil moisture threshold for flood probability flag	
FT	TH_Snow	0	[0,100]	[%]	Snow threshold to decide if snow effect applies	
FT	TH_DRY_SNOW	10	[0,100]	[%]	Threshold for dry snow	
FT	TH_TAU_LITTER	0.1	[0, 1]	[neper]	Threshold for mean litter opacity, which is used in setting FL_Litter flag.	§ 3.2.5.5.3
FT	TH_PR	0.026	[0,0.04]	[-]	Threshold for vegetation interception event flag	§ 3.2.5.5.1
FT	TH_INTERCEP	0.02	[0,0.5]	m	ECMWF interception	§ 3.2.5.5.3
FT	TH_SEA_ICE	20%	[0,100]	[%]	Percentage of sea ice	§ 3.2.5.5.3
FT	TH_CHI2_P_MIN	0.05	[0, 1]	[-]	Threshold for χ^2 interpretation Interval for CHI_2_P interpretation Used to set/unset FCVAL flag	§ 3.2.5.5.2
FT	TH_CHI2_P_MAX	1.1	[0, 1]	[-]	Threshold for χ^2 interpretation Used to set/unset FCVAL flag	
DAP Additional Flag Thresholds						
FT	TH_SKY	5	[0, 100]	K	Threshold for sky TB contribution	§ 3.1.5.2.3.3

Table 48. Other Control Parameters

T	Name	Value	Range	Units	Comments	ATBD Ref
Above Surface Level (ASL) Modelled Brightness Temperature						
FT	THETA_B	42.5	[0,60]	[°]	Angle to generate modelled ASL brightness temperature for User Data Product	§ 3.2.5.3
FT	TH_Theta_B	0.01			Threshold angle used to define class of angles equivalent to Theta_B.	
FT	PR_INCI	42.5	[0,60]	[°]	Angle to generate modelled ASL brightness temperature for computing vegetation interception PR index	

Table 49. Overall Quality

T	Name	Value	Range	Units	Comments	ATBD Ref
GQX coefficients						
FT	GQX11	100	[0.25, 4]	N/A	Radiom ΔTB & prior	§ 3.2.2.5.3
FT	GQX21	1	[0.1, 20]	K	Instrument	§ 3.2.2.5.3
FT	GQX22	0	[0, 1]	Kkm^{-1}	Instrument X_SWATH term	§ 3.2.2.5.3
FT	GQX23	1	[0.5, 2]	K	Calibration	§ 3.2.2.5.3
FT	GQX24	0.2	[0, 2]	K	Reconstruction overall bias	§ 3.2.2.5.3
FT	GQX25	0.1	[0, 2]	K	Reconstruction Coast line flag	§ 3.2.2.5.3
FT	GQX26	0	[0, 100]	N/A	Reconstruction Corbella term	§ 3.2.2.5.3
FT	GQX31	0.05	[0.01, 0.2]	K	Goodness of fit	§ 3.2.2.5.3
FT	GQX32	10	[2, 50]	K	Outliers	§ 3.2.2.5.3
FT	GQX33	0.5	[0, 5]	K	SUN in front	§ 3.2.2.5.3
FT	GQX34	0.2	[0, 5]	K	Rain	§ 3.2.2.5.3
FT	GQX35	0.2	[0, 5]	K	TEC	§ 3.2.2.5.3
FT	GQX36	0.2	[0, 5]	K	Sky	§ 3.2.2.5.3
FT	GQX41	20	[0, 100]	K	Default fractions	§ 3.2.2.5.3
FT	GQX42	5	[0, 100]	K	FNO reference values	§ 3.2.2.5.3
FT	GQX43	0	[0, 100]	K	LITTER (**not activate**d)	§ 3.2.2.5.3
FT	GQX44	1	[0, 10]	K	Interception	§ 3.2.2.5.3
FT	GQX45	0.5	[0, 10]	K	Interception (aux)	§ 3.2.2.5.3
FT	GQX46	25	[0, 100]	K/%	FLOOD probability	§ 3.2.2.5.3
FT	GQX47	6	[0, 200]	K	Moderate topography	§ 3.2.2.5.3
FT	GQX48	20	[0, 200]	K	Strong topography	§ 3.2.2.5.3
FT	GQX49	1	[0, 20]	K	Evening orbit	§ 3.2.2.5.3
Coefficients for the CCX function						
FT	CCX0	1	[0.2, 5]	N/A	First coefficient	§ 3.2.2.5.3
FT	CCX1	+0.189962	[-1, 1]	$\%K^{-1}$	A constant	§ 3.2.2.5.3
FT	CCX2	+0.0122461	[-1, 1]	K^{-1}	SM factor	§ 3.2.2.5.3
FT	CCX3	+0.482144	[-1, 1]	$\%K^{-1}$ $neper^{-1}$	Tau factor	§ 3.2.2.5.3
FT	CCX4	-4.91387E-05	[-1, 1]	$\%^{-1}K^{-1}$	SM^2 factor	§ 3.2.2.5.3
FT	CCX5	+0.0512738	[-1, 1]	$\% K^{-1}neper^{-2}$	Tau^2 factor	§ 3.2.2.5.3
FT	CCX6	+0.00548654	[-10, 10]	$K^{-11}neper^{-1}$	SM*Tau factor	§ 3.2.2.5.3

3.3.7 Overall L2 Processing

[1] This table gives global values that control the whole L2 process (e.g. switches).

Table 50. Overall L2 Processing

T	Name	Values	Range	Units	Comments	Ref
FI	USE_CURRENT_RFI	1	{0,1}	N/A	Switch controlling the use of Current RFI (AUX_DGG_RFI) by the L2 SM processor: 0 means do not use; 1 means use Current RFI when values are valid. Its counterpart switch in ATBD [AAD 1] is USE_DEFLT_RFI.	
FI	USE_CURRENT_TAU_NAD_LV	1	{0,1}	N/A	Switch controlling the use of Current Tau for low vegetation (AUX_DGGTLV) by the L2 SM processor: 0 means do not ues; 1 means use the Current file when provided values are valid; Its counterpart switch in ATBD [AAD 1] is USE_DEFLT_TAU_NADIR_LV.	
FI	USE_CURRENT_TAU_NAD_FO	1	{0,1}	N/A	Switch controlling the use of CurrentTau for Forest cover (AUX_DGGTFO) by the L2 processor: 0 means do not use; 1 means use the Current File when provided values are valid. Its counterpart switch in ATBD [AAD 1] is USE_DEFLT_TAU_NADIR_FO.	
FI	USE_CURRENT_HR	1	{0,1}	N/A	Switch controlling the use of Current roughness parameter HR (AUX_DGGROU) by the L2 SM processor: 0 means do not use; 1 means use Current file when provided values are valid. Its counterpart switch in ATBD is USE_DEFLT_HR.	
FI	USE_CURRENT_FLOOD	0	{0, 1}	N/A	Switch intended for controlling the application of AUX_DGGFLO (DGG CURRENT FLOOD file) in the Level 2 SM retrieval process. A placeholder for now! 0: do not apply the Current flood information 1: apply the Current flood information.	
FT	TH_CUR_HR_VAL_PERIOD	30	[0, 30]	days	Controls maximum period of validity for HR entries in DGG_CURRENT_ROUGHNESS_H LUT	
FT	TH_CUR_TAU_NAD_FO_VAL_PERIOD	30	[0, 30]	days	Controls maximum period of validity for Tau_Nad_FO entries in DGG_CURRENT_Tau_Nad_FO LUT	
FT	TH_CUR_TAU_NAD_LV_VAL_PERIOD	10	[0, 30]	days	Controls maximum period of validity for Tau_Nad_LV entries in DGG_CURRENT_Tau_Nad_LV LUT	
FI	TH_CURRENT_RFI_V	1	[0, 1]	N/A	Threshold for current vertical RFI. If NV_RFI/N_SNAP > TH_CURRENT_RFI_V then FL_RFI_PRONE_V = 1, else, FL_RFI_PRONE_V = 0,	

T	Name	Values	Range	Units	Comments	Ref
FI	TH_CURRENT_RFI_H	1	[0, 1]	N/A	Threshold for current horizontal RFI. If NH_RFI/N_SNAP > TH_CURRENT_RFI_H then FL_RFI_PRONE_H = 1, else, FL_RFI_PRONE_H = 0.	
FT	Current_HR_ASTD	0.3	[0, 1]	N/A	An ASTD value to compute output DQX_HR. Usually its value is several times larger than its priory value.	
FT	Current_TAU_NADIR_ASTD	1.0	[0, 1]	neper	An ASTD value to compute output DQX_Tau_LV and DQX_Tau_FO. Usually its value is several times larger than its priory value.	
FI	MISSING_VAL	-999	[-]	N/A	Missing value is used by DGG Current LUTs and output options.	
FT	AUX_DGGRFI_Window_Size	13	7-15	Days	This parameter is used to select two AUX_DGGRFI input files in order to compute the RFI probability over a window of size (AUX_DGGRFI_Window_Size – 1). It is used by the L2SM processor and for orchestration of the post processors (i.e. supplying two AUX_DGGRFI files).	
FT	TH_MVAL0_UC	35	[0, 100]	N/A	Threshold used in setting flags that drive the update of AUX_DGGTLV, AUX_DGGTFO and AUX_DGGROU products.	
FI	Overall_Quaility_Threshold_low	0	[0, 100]	%	An L2 UDP/DAP with an overall quality below or equal to the value of this parameter is considered low quaitlity and therefore discarded.	
FI	Overall_Quaility_Threshold_high	66	[0, 100]	%	An L2 UDP/DAP with a quaiility higher or equal to the value of this parameter is considered of high quality. A quality which is not low or high is considered medium.	
FT	TH_Curr_Min_DQX TLV	0.01		neper	Minimum threshold for Tau_Cur_DQX in UDP when FL_Current_Tau_Nadir_LV in UDP is ON	
FT	TH_Curr_Min_DQX TFO	0.01		neper	Minimum threshold for Tau_Cur_DQX in UDP when FL_Current_Tau_Nadir_FO in UDP is ON	
FT	TH_Curr_Min_DQX ROU	0.02		N/A	Minimum threshold for HR_Cur_DQX in UDP when FL_Current_HR in UDP is ON	
FI	Fixed_Tau_Nad_ASTD	0.0		neper	Tau Nadir is a potentially free (i.e., to be retrieved) parameter. This is the ASTD value for it if it is fixed (i.e, not retrieved).	
FI	Fixed_T_Surf_ASTD	0.0		K	Surface temperature is a potentially free (i.e., to be retrieved) parameter. This is the ASTD value for it if it is fixed (i.e, not retrieved).	
FI	Fixed_TT_H_ASTD	0.0		N/A	TTH is a potentially free (i.e., to be retrieved) parameter. This is the ASTD value for it if it is fixed (i.e, not retrieved).	
FI	Fixed_RTT_ASTD	0.0		N/A	RTT is a potentially free (i.e., to be retrieved) parameter. This is the ASTD value for it if it is fixed (i.e, not retrieved).	
FI	Fixed_OM_H_ASTD	0.0		N/A	Scattering albedo H is a potentially free (i.e., to be retrieved) parameter. This is the ASTD value for it if it is fixed (i.e, not retrieved).	
FI	Fixed_Diff_Omega_ASTD	0.0		N/A	Difference of albedos is a potentially free (i.e., to be retrieved) parameter. This is the ASTD value for it if it is fixed (i.e, not retrieved).	
FI	Fixed_HR_ASTD	0.0		N/A	Surface roughness is a potentially free (i.e., to be retrieved) parameter. This is the ASTD value for it if it is fixed (i.e, not retrieved).	

T	Name	Values	Range	Units	Comments	Ref
FT	Chi_2_Rescale_factor	1.0		N/A	Rescale factor for Chi_2	
FT	Chi_2_Rescale_offset	0.0		N/A	Rescale offset for Chi_2	
FT	Sigma_IR_2	9.9225		N/A	Cost Function image reconstruction variance addition term	

Appendix A – ECMWF Auxiliary Evolving Data

[1] The proposed following synthesis of ECMWF products is built from the analysis of the information obtained from ECMWF and from the auxiliary table that resulted from the harmonization meeting.

[2] Direct outputs of forecast model products are considered the only ones that will produce a timely availability every 3 hours.

A.1 Data Availability

[1] The following tables list all ECMWF data required for SML2PP.

[2] The availability of those parameters has been checked against MARS request on forecast stream on a 3-hourly basis; thus, all of parameters (except TP) are available upon demand.

[3] There is still only one ambiguity with regard to the Total Precipitation (TP) parameter, which ESL failed to find in forecast and even analysis, although it is supposed to be there. For now, ESL replaces it (equivalently) by the sum of LSP and CP parameters but will continue investigating the matter since one parameter is better than two.

Table 51. SMOS L2 Auxiliary Evolving Data v.s. ECMWF Products[2]

#	Auxiliary Data	ECMWF Product @ Step	MARS Abbrev	GRIB CODE	Units	Comments	Bits
Common to Soil Moisture and Ocean Salinity							
1	Rain	**FC @ 3H**	**LSP**	**142**	**m**	**Large scale precipitation (accumulated)**	**16**
		FC @ 3H	**CP**	**143**	**m**	**Convective precipitation (accumulated)**	**16**
2	Pressure	**FC @ 3H**	**SP**	**134**	**Pa**	**Surface pressure**	**12**
3	Air temperature	**FC @ 3H**	**2T**	**167**	**K**	**2 meters temperature**	**12**
4	Atmosphere H2O	**FC @ 3H**	**TCWV**	**137**	**kg/m^2**	**Total column water vapor**	**12**
5	Inland water bodies temperature	**FC @ 3H**	**SSTK**	**34**	**K**	**Sea surface temperature (water bodies on continent)**	**16**
		FC @ 3H	**ISTL1**	**35**	**K**	**Ice surf. temperature level 1**	**12**
		FC @ 3H	**CI**	**31**	**m^2/m^2**	**Sea Ice cover**	**8**
Specific to Soil Moisture							
6	SM	**FC @ 3H**	**SWVL1**	**39**	**m^3/m^3**	**Volumetric soil water level 1**	**12**
		FC @ 3H	**SWVL2**	**40**	**m^3/m^3**	**Volumetric soil water level 2**	**12**
		FC @ 3H	**SWVL3**	**41**	**m^3/m^3**	**Volumetric soil water level 3**	**12**
		FC @ 3H	**SWVL4**	**42**	**m^3/m^3**	**Volumetric soil water level 4**	**12**
		FC @ 3H	**SRC**	**198**	**m**	**Skin reservoir content (water)**	**12**

[2] **Green rows** are 1st priority products: they are clearly identified to be required now.
Blue rows are 2nd priority products: they are clearly identified to be valuable but for future use.

#	Auxiliary Data	ECMWF Product @ Step	MARS Abbrev	GRIB CODE	Units	Comments	Bits
		FC @ 3H	RO	205	m	Run off (accumulated)	
7	Surface Temperature See note 1 See note 2	FC @ 3H	STL1	139	K	Soil temperature level 1	12
		FC @ 3H	STL2	170	K	Soil temperature level 2	12
		FC @ 3H	STL3	183	K	Soil temperature level 3	12
		FC @ 3H	STL4	236	K	Soil temperature level 4	12
		FC @ 3H	SKT	235	K	Skin temperature	12
8	snow cover	FC @ 3H	SMLT	45	m	Meter of water (accumulated)	16
		FC @ 3H	RSN	33	Kg/m^3	Snow Density	16
		FC @ 3H	SD	141	m	Snow depth (meter of water equivalent)	12
		FC @ 3H	TSN	238	K	Temperature of snow layer	12
9	frozen soils see note 3	To be merged with #7				Thresholds on STLx	

[4] *Notes concerning surface layers:* According to IFS documentation for the current CY28r1 model, (Part IV: Physical Processes => Chap 3: Turbulent Diffusion and Interactions with the Surface, and Chap. 7: Land Surface Parameterization) [ORD 6], the following clarifications may be useful in interpreting some of the above parameters:

1. The skin forms the interface between the soil and atmosphere. Over land, the skin temperature is in thermal contact with a four-layer soil expanse or with a single-layer snow mantle overlying the soil. The TESSEL (Tiled ECMWF Scheme for Surface Exchanges over Land) scheme defines up to 8 tile fractions that connect the lowest atmospheric model (10m) to the PBL (Planetary Boundary Layer). There are 6 fractions over land: bare ground, low and high vegetation, intercepted water, shaded and exposed snow; and 2 fractions over sea and freshwater bodies: open and frozen. Each individual tile fraction has its own properties defining separate heat and water fluxes used in an energy balance equation solved for the tile temperature.
   The average temperature (on tile fractions) is given by SKT. For vegetated surface, the average corresponds to the canopy temperature.
2. Sub-surface layers correspond to the following depths (m): layer 1 = [0, 0.07], layer 2 = [0.07, 0.21], layer 3 = [0.21, 0.72], and layer 4 = [0.72 1.89].
3. Frozen soil must be accounted for in resolving the soil equations. The formulation uses three states, starting from no ice present if $T>T_0+1$, to mixed if $T_0-3<T< T_0+1$, and finally to no free water if $T<T_0-3$. T_0 is the freezing point of pure water.

Table 52. ECMWF Products Use for SML2PP

#	MARS Abbrev	SML2PP Use
Common to Soil Moisture and Ocean Salinity		
1	LSP	Post-processing, retrieval analysis, diagnostic, vegetation interception
	CP	
2	SP	Retrieval, models, atmospheric contribution
3	2T	Retrieval, models, atmospheric contribution Retrieval, models, above surface effective temperature
4	TCWV	Retrieval, models, atmospheric contribution

#	MARS Abbrev	SML2PP Use
5	SSTK	Retrieval, decision tree, water body default contribution
	ISTL1	Retrieval, decision tree, water ice default contribution
	CI	**Retrieval, decision tree, sea ice model.**
Specific to Soil Moisture		
6	SWVL1 SWVL2 SWVL3 SWVL4	Retrieval, decision tree SM priors Post processing, retrieval analysis, diagnostic
	SRC	Retrieval, tau-omega model, vegetation interception Post-processing, retrieval analysis, diagnostic, vegetation interception
	RO	Post-processing, retrieval analysis, diagnostic, flake, flooding
7	STL1 STL2 STL3 STL4	Retrieval, decision tree priors, soil model, soil effective temperature
	SKT	Retrieval, decision tree priors, Tveg effective temperature (Tc)
8	SMLT RSN SD TSN	Retrieval, decision tree priors, snow model Post-processing, retrieval analysis, diagnostic
9	To be merged with #7	Retrieval, decision tree, frozen soil dielectric model

A.2 Requested Products Summary

[1] This section summarizes all the data needed by SML2PP. Those data consist of a list of GRIB codes from the **ECMCF local Table 128** within the associated ECMWF data stream source.

[2] We also give a first assessment of data size on the basis of the GRIB format that gives a packed encoding of the fields with a variable number of bits. That data size will be fully stated as soon as the required products are firmly consolidated, and a real MARS request has been issued.

[3] The data file size (in bits) is computed as follows:

$$data\_size = record\_size \times number\_of\_grid\_points \times number\_of\_step$$

Where:

record_size is the sum of all the number of bits associated with each required field,

- *number_of_grid_points* is the number of points of the considered ECMWF surface grid (N256, N320 or future N400). The size of the fixed part of the files, header, table, etc. is not addressed here since it is very marginal.
- *Number_of_steps* is the number of 3-hourly steps that are to be retrieved in the same file, which could be basically 4; the fifth being the first step of the next forecast time validity.

[4] **Note 1**: In the above computation, the size of the fixed part of the files (headers, tables) is not addressed since it represents a very small amount; a few hundred bytes at the most.

[5] **Note 2**: The files sizes given in the tables of Sections A.2.x are calculated for **one** step and for **four** steps. These two file sizes give us the trade-off between either getting all of the data in a single fetch (which could take too much time with respect to orbital timeliness of SMOS) or submitting multiple smaller requests to ensure that data are fetched in the most timely manner possible.

[6] Two options have been identified for consideration. The first is restricted to first-priority products (the **green colored** items from Table 51) and the volume of data is given in Section A.1. The second option extends the first option with second-priority products (the **blue colored** items from Table 51), and the corresponding volume of data is given in Section A.2.1. Section A.2.2 gives the total amount of data taking both first-priority products and second-priority products into consideration.

A.2.1 First Priority ECMWF Products

[1] This section presents the data volume of the first-priority ECMWF products. Those products are the **green colored** items from Table 51; they are now for the current algorithm schemes **with the highest urgency possible**.

Table 53. ECMWF Data Sources & First Priority Products GRIB Codes

ECMWF Data Source	GRIB Codes
Operational archive, Atmospheric model, Analysis	N/A
Operational archive, Atmospheric model, Forecast	34, 35, 39, 40, 134, 137, 139, 141, 142, 143, 167, 170, 183,198, 235, 236

Table 54. Assessment of GRIB Files Sizes for First Priority ECMWF Products

Total Record Size	208 bits				
Gaussian Grid	**Resolution**	**# Lig x # Col**	**# Points**	**Total for One Step**	**Total for 4 Steps**
TL511-N256	**0.351 °**	512x1024	524288	**13,00 MB**	**52,00 MB**
TL511-NR256	**0.351 °**	Varyingx1024	348528	**8,64 MB**	**34,57 MB**
TL639-N320	**0.28125 °**	640x1280	819200	**20,31 MB**	**81,25 MB**
TL639-NR320	**0.28125 °**	Varying x1280	540722	**13,41 MB**	**53,63 MB**
TLxxx-N350	**0.25714 °**	640x1280	980000	**24,30 MB**	**97,20 MB**
TLxxx-NR350	**0.25714 °**	Varying x1280	???	**N/A**	**N/A**
TL799-N400	**0.225 °**	800 x 1600	1280000	**31,74 MB**	**126,95 MB**
TL799-NR400	**0.225 °**	Varying x 1600	843532	**20,92 MB**	**83,66 MB**

A.2.2 Second Priority ECMWF Products

[1] This section gives the amount of data overload of the 2nd priority ECMWF products. Those products are the **blue colored** items from Table 51; they are not of absolute need now but are foreseen to be potentially used by algorithms before launch.

Table 55. ECMWF Data Sources & Second Priority Products GRIB Codes

ECMWF Data Source	GRIB Codes
Operational archive, Atmospheric model, Analysis	N/A
Operational archive, Atmospheric model, Forecast	33, 41, 41, 42, 45, 205, 228, 238

Table 56. Assessment of GRIB Files Sizes for Second Priority ECMWF Products

Total Record Size	96 bits				
Gaussian Grid	**Resolution**	**# Lig x # Col**	**# Points**	**Total for One Step**	**Total for 4 Steps**
TL511-N256	**0.351 °**	512x1024	524288	**6,00 MB**	**24,00 MB**
TL511-NR256	**0.351 °**	Varyingx1024	348528	**3,99 MB**	**15,95 MB**
TL639-N320	**0.28125 °**	640x1280	819200	**9,38 MB**	**37,50 MB**
TL639-NR320	**0.28125 °**	Varying x1280	540722	**6,19 MB**	**24,75 MB**
TLxxx-N350	**0.25714 °**	640x1280	980000	**11,22 MB**	**44,86 MB**
TLxxx-NR350	**0.25714 °**	Varying x1280	???	**N/A**	**N/A**
TL799-N400	**0.225 °**	800 x 1600	1280000	**14,65 MB**	**58,59 MB**
TL799-NR400	**0.225 °**	Varying x 1600	843532	**9,65 MB**	**38,61 MB**

A.2.3 Total ECMWF Products

[1] This section gives the total amount of data considering we keep both 1st priority ECMWF product and 2nd priority ECMWF products.

Table 57. ECMWF Data Sources and First + Second Priority Products GRIB Codes

ECMWF Data Source	GRIB Codes
Operational archive, Atmospheric model, Analysis	na.
Operational archive, Atmospheric model, Forecast	33, 34, 35, 39, 40, 41, 41, 42, 45, 134, 137, 139, 142, 143, 167, 170, 183, 198, 205, 228, 235, 236, 238

Table 58. Assessment of GRIB Files Sizes for First + Second Priority ECMWF Products

Total Record Size	304 bits				
Gaussian Grid	**Resolution**	**# Lig x # Col**	**# Points**	**Total for One Step**	**Total for 4 Steps**
TL511-N256	**0.351 °**	512x1024	524288	**19,00 MB**	**76,00 MB**
TL511-NR256	**0.351 °**	Varyingx1024	348528	**12,63 MB**	**50,52 MB**
TL639-N320	**0.28125 °**	640x1280	819200	**29,69 MB**	**118,75 MB**
TL639-NR320	**0.28125 °**	Varying x1280	540722	**19,60 MB**	**78,38 MB**
TLxxx-N350	**0.25714 °**	640x1280	980000	**35,51 MB**	**142,06 MB**
TLxxx-NR350	**0.25714 °**	Varying x1280	???	**N/A**	**N/A**
TL799-N400	**0.225 °**	800 x 1600	1280000	**46,39 MB**	**185,55 MB**
TL799-NR400	**0.225 °**	Varying x 1600	843532	**30,57 MB**	**122,28 MB**

A.3 ECOCLIMAP 2004

[1] The ECOCLIMAP 2004 raw data set is based on a regular lat-lon grid that defines 21600x43200 points. The grid step corresponds roughly to 1 km x 1 km at the equator, but the longitude step decreases rapidly with the increase of latitude (north or south). At a latitude φ, a cell of the grid has a size of 1 km x cos(φ) km, at 60° of latitude the size is 1 km x 0.5 km.

[2] The Ecoclimap data gives LAI (for year 2000 from the NDVI derived from the VEGETATION instrument) on the same grid and thus can serve as a fall back default in case of total (missing file) or partial (clouds) unavailability of LAI from evolving auxiliary data.

[3] From L2SM v06.50 onwards, ECOCLIMAP is not used in AUX_DFFFRA or AUX_LANDCL except for the land/sea mask in ECOCLIMAP which is used in AUX_DFFFRA to split the water class from IGBP into saline and pure.

Table 59. ECOCLIMAP File Sizes

Record size	8 bits					
Grid	Resolution	# Lig x # Col	# Points	Ecosystem Land Cover	LAI 1 Month	Total with 12 Months LAI
Regular Lat-Lon	**0.5° - 1km**	**21600x43200**	**933120000**	889.9 MB	889,9 MB	15.6 GB

A.4 Soil Texture Data Base

[1] The soil texture (sand and clay fraction) is taken from the Food and Agriculture Organization (FAO) information source at 10km of resolution [ORD 2].

Table 60. FAO Sand and Clay Fraction File Sizes

Record Size	8 bits					
Grid	Resolution	# Lig x # Col	# Points	Sand	Clay	Total
Regular Lat-Lon	**5° - 10km**	**2160x4320**	**93312000**	8.9 MB	8.9 MB	17.8 MB

Appendix B – The Coherence and Cross-Reference Between TGRD and Level 2 Product Specification

B.1 Coherence Between TGRD and Level 2 Product Specification

[1] The following table shows the conherence between the TGRD and Level 2 product specification [CAD 10].

Table 61. Mapping Table Between TGRD's LUTs and Level 2 Product Specification's ADP

#	TGRD LUT Name	Level 2 Product ADP Name
1	DFFG_INFO	AUX_DFFFRA
2	DFFG_XYZ	AUX_DFFXYZ
3	DFFG_LAI	AUX_DFFLAI
4	DFFG_LAI_MAX	AUX_DFFLMX
5	DGG_INDEX	AUX_DGG___ (OBSOLETE)
6	DGG_XYZ	AUX_DGGXYZ
7	DGG_CURRENT_TAU_NADIR_LV	AUX_DGGTLV
8	DGG_CURRENT_TAU_NADIR_FO	AUX_DGGTFO
9	DGG_CURRENT_ROUGHNESS_H	AUX_DGGROU
10	DGG_CURRENT_RFI	AUX_DGGRFI
11	ECMWF_FORECAST	AUX_ECMWF_
12	WEF	AUX_WEF___
13	MEAN_WEF	AUX_MN_WEF
14	DFFG_SOIL_PROPERTIES	AUX_DFFSOI
15	SKY_RADIATION	AUX_GAL_SM
16	LAND_COVER_CLASSES	AUX_LANDCL
17	USER_PARAMETERS: Table 30 PHYSICAL_CONSTANTS	None! This table is hard coded.
18	USER_PARAMETERS, UPF: Table 31 to Table 50	AUX_CNFSMD, AUX_CNFSMF
19	DGG_CURRENT_FLOOD	AUX_DGGFLO
20	DFFG_SNOW	AUX_DFFSNO

B.2 L2 Product Specification/TGRD Cross Reference for User Parameters

[1] Table 62 provides a cross reference between parameters in AUX_CNFSM_ (see [CAD 10]) and those in the current TGRD.

[2] Table 62 was first created based on Array's IODD [AAD 8] where all components of a variable name are specified in upper case. In INDRA's Level 2 Specification [CAD 10] only certain componenets including acronyms and abbreviations are specified in upper case, whereas for legal word components only the first letter is capitalized. Therefore, the variable names in the first column are not case sensitive. Furthermore while a check was made between selected fields in the TGRD and the AUX_CNFSM_ in [CAD 10], a complete consistency check between the two is an on-going task.

Table 62. Level 2 Spec/TGRD Cross-Reference

Variables in Level 2 Specification	Corresponding Variables in TGRD
A_CARD	A_card
A_CARD_MAX	A_card_max
A_CARD_MIN	A_card_min
B_W_0	b_{w0}
BSGB0	BSGB0
BSGB1	BSGB1
BSGB2	BSGB2
BSGB3	BSGB3
BSGB4	BSGB4
BSGU0	BSGU0
BSGU1	BSGU1
BVB0	BVB0
BVB1	BVB1
BVB2	BVB2
BVB3	BVB3
BVB4	BVB4
BVU0	BVU0
BVU1	BVU1
C_1_RFI	C1_RFI
C_1_TBS1	CA_TBS1
C_2_RFI	C2_RFI
C_2_TBS1	CB_TBS1
C_BETA_IM_1	$BEIM_1$
C_BETA_IM_2	$BEIM_2$
C_BETA_IM_3	$BEIM_3$
C_BETA_RE_1	$BERE_1$
C_BETA_RE_2	$BERE_2$
C_BETA_RE_3	$BERE_3$
C_BORDER	C_BORDER
C_CPA_1	CPA_1
C_CPA_2	CPA_2
C_CPA_3	CPA_3
C_DOBSON_EMP	α
C_EAF	C_EAF
C_GST0_0	C0_GST0
C_GST0_1	C1_GST0
C_GST0_2	C2_GST0
C_GST0_4	C4_GST0
C_MWEF_1	C_MWEF_1
C_MWEF_2	C_MWEF_2
C_OW_1	OW_01
C_OW_10	OW_10
C_OW_11	OW_11
C_OW_12	OW_12
C_OW_13	OW_13
C_OW_14	OW_14
C_OW_15	OW_15

Variables in Level 2 Specification	Corresponding Variables in TGRD
C_OW_16	OW_16
C_OW_17	OW_17
C_OW_18	OW_18
C_OW_19	OW_19
C_OW_2	OW_02
C_OW_20	OW_20
C_OW_21	OW_21
C_OW_22	OW_22
C_OW_23	OW_23
C_OW_24	OW_24
C_OW_25	OW_25
C_OW_26	OW_26
C_OW_27	OW_27
C_OW_28	OW_28
C_OW_29	OW_29
C_OW_3	OW_03
C_OW_30	OW_30
C_OW_31	OW_31
C_OW_32	OW_32
C_OW_4	OW_04
C_OW_5	OW_05
C_OW_6	OW_06
C_OW_7	OW_07
C_OW_8	OW_08
C_OW_9	OW_09
C_SIGMA_EFF_1	$SGEF_1$
C_SIGMA_EFF_2	$SGEF_2$
C_SIGMA_EFF_3	$SGEF_3$
C_SIGMA_EFF_4	$SGEF_4$
C_SUN_GLINT_AREA	C_SUN_GLINT_AREA
C_SUN_TAILS	C_SUN_TAILS
C_VAL_2	C_{VAL}_2
C_VAL_4	C_{VAL}_4
C_WEF_1	C_WEF_1
C_WEF_2	C_WEF_2
C_WEF_3	C_WEF_3
C_WEF_4	C_WEF_4
CARDIOID_B	B_card
CARDIOID_U	U_card
CCX0	CCX0
CCX1	CCX1
CCX2	CCX2
CCX3	CCX3
CCX4	CCX4
CCX5	CCX5
CCX6	CCX6
Current_HR_ASTD	Current_HR_ASTD
Current_TAU_NADIR_ASTD	Current_TAU_NADIR_ASTD
CWP_1	CWP1
CWP_2	CWP2

Variables in Level 2 Specification	Corresponding Variables in TGRD
CWP_3	CWP3
CXMVT_1	CXMVT1
CXMVT_2	CXMVT2
DENOMINATOR_KEY	(Decision Free Fraction Thresholds)
DGG_Intercell_Distance	DGG_Intercell_Distance
DHBR0	DHBR0
DHBR1	DHBR1
DHBR2	DHBR2
DHUR0	DHUR0
DHUR1	DHUR1
DIELEC_CONST_FRZ	ε_{Frz}
DIELEC_CONST_ICE	ε_{Ice}
DIELEC_CONST_PARTICLE	ε_{pa}
DIELEC_CONST_ROCK	$\varepsilon_{\mathrm{Rock}}$
DIELEC_CONST_SAND	ε_{sand}
DIELEC_CONST_SNOW	Dielec_Const_Snow
DIELEC_CONST_URBAN	$\varepsilon_{\mathrm{Urban}}$
Dielectric_Model_Sub_Type	Dielectric_Model_Sub_Type
Dielectric_Model_Type	Dielectric_Model_Type
DIFF_A_CARD	ΔA_card
DIFF_DIFF_OMEGA	Δ DIFFω
DIFF_HR	ΔHR
DIFF_OM_H	ΔOM_H
DIFF_OMEGA_MAX	DIFF_ω_max
DIFF_OMEGA_MIN	DIFF_ω_min
DIFF_RTT	Δ RTT
DIFF_SM	ΔSM
DIFF_T_PHYS	ΔT_{PHYS}
DIFF_TAU_NAD	$\Delta\tau_{\mathrm{NAD}}$
DIFF_TT_H	ΔTT_H
DSRB0	DSRB0
DSRB1	DSRB1
DSRB2	DSRB2
DSUR0	DSUR0
DSUR1	DSUR1
DTB_Scale	DTB_Scale
E0PB0	E0PB0
E0PB1	E0PB1
E0PB2	E0PB2
E0PU	E0PU
Emissivity_Max	Emissivity_Max
Emissivity_Min	Emissivity_Min
EPWI0	EPWI0
F_CON	FCOND
FCV1	FCV1
FDIA	FDIA
FORWARD_MODEL	(Decision Free Fraction Thresholds)

Variables in Level 2 Specification	Corresponding Variables in TGRD
FRACTION_KEY	(Decision Free Fraction Thresholds)
GG_COLUMN_MAX	gg_column_max
GG_LAT_STEP_SIZE	gg_lat_step_size
GG_LAT_STOP	gg_lat_stop
GG_LONG_START	gg_long_start
GG_LONG_STEP_SIZE	gg_long_step_size
GG_ROW_MAX	gg_row_max
GQX11	CQX11
GQX21	CQX21
GQX22	CQX22
GQX23	CQX23
GQX24	CQX24
GQX25	CQX25
GQX26	CQX26
GQX31	CQX31
GQX32	CQX32
GQX33	CQX33
GQX34	CQX34
GQX35	CQX35
GQX36	CQX36
GQX41	CQX41
GQX42	CQX42
GQX43	CQX43
GQX44	CQX44
GQX45	CQX45
GQX46	CQX46
GQX47	CQX47
GQX48	CQX48
GQX49	CQX49
HR_MAX	HR_MAX
HR_MIN	HR_MIN
K0_DT_H2O	K0_DT_H2O
K0_DT_O2	K0_DT_O2
K0_TAU_H2O	K0_TAU_H2O
K0_TAU_O2	K0_TAU_O2
K1_DT_H2O	K1_DT_H2O
K1_TAU_H2O	K1_TAU_H2O
K2_DT_H2O	K2_DT_H2O
K2_TAU_H2O	K2_TAU_H2O
KD0	KD0
KD1	KD1
KDIA	KDIA
KDIA_MAX	KDIA_MAX
KP0_DT_O2	KP0_DT_O2
KP0_TAU_O2	KP0_TAU_O2
KP02_DT_O2	KP02_DT_O2
KP02_TAU_O2	KP02_TAU_O2
KT0_DT_O2	KT0_DT_O2
KT0_TAU_O2	KT0_TAU_O2
KT02_DT_O2	KT02_DT_O2

Variables in Level 2 Specification	Corresponding Variables in TGRD
KT02_TAU_O2	KT02_TAU_O2
KT0P0_DT_O2	KT0P0_DT_O2
KT0P0_TAU_O2	KT0P0_TAU_O2
MAG_PERM_SOIL	μ_s
MAG_PERM_WATER	μ_w
MAX_ITERATIONS	NITM
MISSING_VAL	MISSING_VAL
N_REPEAT	NITM
ND0	ND0
ND1	ND1
ND2	ND2
Negative_Retrieval_Output	Negative_Retrieval_Output
NUM_AGGREGATED_FRACTIONS	(10) Table 40
NUM_MODES	(4) Table 40
NUM_OPACITY_OPTIONS	(3) Table 42
NUM_RETRIEVAL_OPTIONS	(3) Table 42
NUM_THRESHOLDS	NB_TH_DEC
OMEGA_H_MAX	ω_H _ max
OMEGA_H_MIN	ω_H _ min
P_SURF	P0
PERMIT0	PERMIT0
PR_INCI	PR_INCI
RANK	(Decision Free Fraction Thresholds)
RETRIEVED_FRACTION	(10) Table 40
RTT_MAX	RTT_MAX
RTT_MIN	RTT_MIN
SBT0	SBT0
SBT1	SBT1
SCR	SCR
SF_DTB	DTB_F
SIGMA_0_A_CARD	$\sigma_{0\_A\_CARD}$
SIGMA_0_DIFF_OM	$\sigma_{0\_DIFF\_OM}$
SIGMA_0_HR	σ_{0_HR}
SIGMA_0_OMH	σ_{0_OMH}
SIGMA_0_RTT	σ_{0_RTT}
SIGMA_0_SM	σ_{0_SM}
SIGMA_0_TAU	σ_{0_TAU}
SIGMA_0_TPHYS	σ_{0_TPHYS}
SIGMA_0_TTH	σ_{0_TTH}
SM	SM
SM_FV	SM_FV
SM_LV	SM_LV
SM_MAX	SM_max
SM_MIN	SM_min
SM1_Thld	SM1_Thld
SOIL_PARTICLE_DEN	ρ_s
SOIL_SALINITY	SAL
SSS	SSS
SST	SST

Variables in Level 2 Specification	Corresponding Variables in TGRD
SUT0	SUT0
SUT1	SUT1
T_2M	T0
T_C_FV	Tc_FV
T_C_LV	Tc_LV
T_G	T_g
T_PHYS	T_{PHYS}
T_PHYS_MAX	T_{PHYS}_max
T_PHYS_MIN	T_{PHYS}_min
TAU_NAD_MAX	τ_{Nad}_max
TAU_NAD_MIN	τ_{Nad}_min
TAUB0	TAUB0
TAUU0	TAUU0
TBXY_IM_MAX	TH_TBXY_IM_MAX
TBXY_IM_MIN	TH_TBXY_IM_MIN
TBXY_RE_MAX	TH_TBXY_RE_MAX
TBXY_RE_MIN	TH_TBXY_RE_MIN
TF0	TF0
TH_AVA_MIN	M_AVAR
TH_CHI_2_P_MAX	TH_CHI2_P_MAX
TH_CHI_2_P_MIN	TH_CHI2_P_MIN
TH_CUR_HR_VAL_PERIOD	TH_CUR_HR_VAL_PERIOD
TH_CUR_TAU_NAD_FO_VAL_PERIOD	TH_CUR_TAU_NAD_FO_VAL_PERIOD
TH_CUR_TAU_NAD_LV_VAL_PERIOD	TH_CUR_TAU_NAD_LV_VAL_PERIOD
TH_CURRENT_RFI_H	TH_CURRENT_RFI_H
TH_CURRENT_RFI_V	TH_CURRENT_RFI_V
TH_DQX_A_CARD	TH_DQX_{A_card}
TH_DQX_DIFF_OMEGA	TH_$DQX_{DIFF\omega}$
TH_DQX_HR	TH_DQX_{HR}
TH_DQX_OMEGA_H	TH_$DQX_{\omega H}$
TH_DQX_RTT	TH_DQX_{RTT}
TH_DQX_SM	TH_DQX_{SM}
TH_DQX_T_PHYS	TH_DQX_{TPHYS}
TH_DQX_TAU_NAD	TH_$DQX_{\tau Nad}$
TH_DQX_TT_H	TH_DQX_{TTH}
TH_DRY_SNOW	TH_DRY_SNOW
TH_ELONGATION	TH_ELON
TH_FIT	TH_FIT
TH_FLOOD	TH_FLOOD
TH_HR_MAX_DELAY	TH_LAG_HR
TH_INTERCEP	TH_INTERCEP
TH_MMIN0	MMIN0
TH_MMIN1	MMIN1
TH_MMIN2	MMIN2
TH_MMIN3	MMIN3
TH_MR2_Cond	TH_MR2_Cond
TH_NO	TH_NO
TH_PR	TH_PR
TH_PWATER_FRZ	TH_PWATER_FRZ

Variables in Level 2 Specification	Corresponding Variables in TGRD
TH_RAIN	TH_RAIN
TH_RFI_ST4	TH_RFI_ST4
TH_SAND	TH_SAND
TH_SCENE_FEB	TH_SCENE_FEB
TH_SCENE_FFO	TH_SCENE_FFO
TH_SCENE_FNO	TH_SCENE_FNO
TH_SCENE_FRZ	TH_SCENE_FRZ
TH_SCENE_FSD	TH_SCENE_FSD
TH_SCENE_FSM	TH_SCENE_FSM
TH_SCENE_FSW	TH_SCENE_FSW
TH_SCENE_FTI	TH_SCENE_FTI
TH_SCENE_FTM	TH_SCENE_FTM
TH_SCENE_FTS	TH_SCENE_FTS
TH_SCENE_FUH	TH_SCENE_FUH
TH_SCENE_FUL	TH_SCENE_FUL
TH_SCENE_FWL	TH_SCENE_FWL
TH_SCENE_FWO	TH_SCENE_FWO
TH_SCENE_TAU_FO	TH_SCENE_TAU_FO
TH_SEA_ICE	TH_SEA_ICE
TH_SIZE	TH_SIZE
TH_SKY	TH_SKY
TH_SOIL_FRZ	TH_SOIL_FRZ
TH_SWATER_FRZ	TH_SWATER_FRZ
TH_T_DRY	TH_TDRY
TH_T_WET	TH_TWET
TH_TAU_F1	TH_F1
TH_TAU_F2	TH_F2
TH_TAU_FN	TH_TAU_FN
TH_TAU_LITTER	TH_TAU_LITTER
TH_TAU_MAX_DELAY	TH_LAG_TAU_LV
TH_TAU_R_23	TH_23
TH_TAU_R_34	TH_34
TH_TAU_WINTER	TH_TAU_F1
TH_TBAM_MIN	TH_TBAM_MIN
TH_TEC	TH_TEC
TH_VEG_FRZ	TH_VEG_FRZ
THETA_B	THETA_B
Tscene_Margin_High	Tscene_Margin_High
Tscene_Margin_Low	Tscene_Margin_Low
TT_H_MAX	TT_H_max
TT_H_MIN	TT_H_min
USE_CURRENT_HR	USE_CURRENT_HR
USE_CURRENT_RFI	USE_V_RFI
USE_CURRENT_TAU_NAD_FO	USE_CURRENT_TAU_NAD_FO
USE_CURRENT_TAU_NAD_LV	USE_CURRENT_TAU_NAD_LV
Use_TAU_L_In_Inv	Use_TAU_L_In_Inv
W_0	w_0
WEF_SIZE	WEF_SIZE
WVC	WVC
XMVT0	XMVT0

Variables in Level 2 Specification	Corresponding Variables in TGRD
XMVT1	XMVT1

Appendix C – SMOS L2 Processor Discrete Flexible Fine Grid (DFFG) Definition

C.1 DFFG Concept

[1] The DFFG defines an almost equal-area grid system close to the reduced Gaussian ECMWF standard, which is **parameterized** by the length edge the squared equal-area. The description of the grid property is very similar to the way **reduced** Gaussian grid is described in the WMO GRIB standard though simplified to satisfy only our needs and, in our case, with a uniform sampling of latitude instead of a Gaussian one.

[2] Once a DFFG Header section is given, it defines completely the property of the grid. The grid is flexible in the sense that the DFFG Header section is fully defined on the basis of the latitude, longitude window and the length of cell edge. Thus, the size of the header is not fixed. This header describes a variable resolution grid system very close to an equal-area grid.

[3] One or several individual DFFG data sections are associated with the previous DFFG Header Section. Each data section describes the content and the format of the data (Level 2 Product Specification [CAD 10] of the data block). The information about fractions, reference values, XYZ, etc., are referenced in the DFFG data sections.

[4] Eventually a special bitmap section can be provided. This bitmap will describe the validity of DFFG cells. For example, for SMOS-SM it is not necessary to store any information in data sections at the middle of the ocean. Thus, the data sections will contain information only for a valid DFFG cell that will result in reducing the size by ≈70%.

[5] The DFFG scheme does not handle internally a partition of the Earth in multiple smaller zones. However, this can be easily achieved by considering several DFFG headers with specific windows that define the desired partition of the earth. Indeed, it may be useful to consider dealing with smaller DFFG Data sections to increase the efficiency in IO operations. This allows storing all the data for a zone in memory, which is not possible for global DFFG data section.

C.2 DFFG Header Section

C.2.1 Conventions

[1] In this grid system, the sampling of each cell in km is almost the same along longitude and along latitude. As the latitude increases from equator to poles, the length in km of a full circle of longitude and the number of cells decreases.

[2] The cells are ordered with decreasing latitude from LAT_STOP included to LAT_START excluded and increasing longitude from LON_START included to LON_STOP excluded.

[3] This window defines a closure of the paving of DFFG cells, i.e. all the cells' surfaces are inside this window and the boundary cells share one or two edges with the window's frontiers as shown in the following figures.

[4] The DFFG cells stream shown in Figure 1 maps exactly the stream of record in any Data Section file when no BitMap Section is used. We can conceptually consider that a numbered squared cell, in this figure, contains a specific record of data.

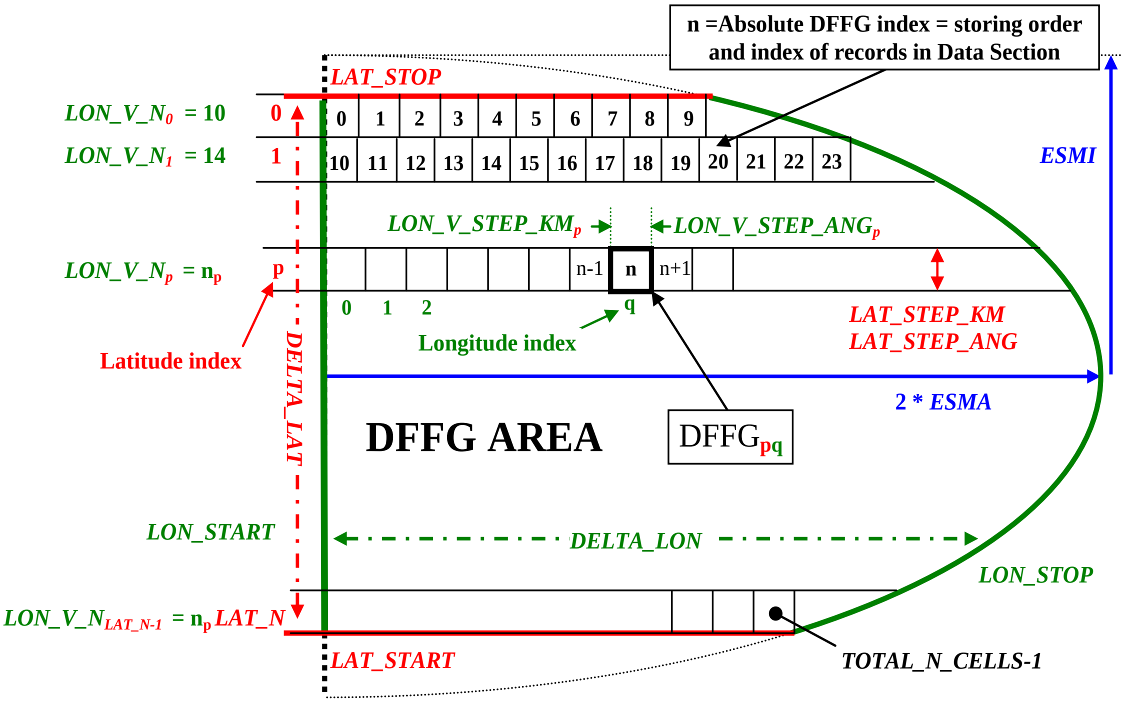


Figure 1. DFFG Main Characteristics

[5] The DFFG cells stream shown in Figure 2 does not map the stream of record in a Data Section file when a BitMap Section is used. As shown, only the subset of numbered cells does. In that case, the BitMap Section is addressed following the conventions illustrated in Figure 3, and all the other Data Section will be addressed following the conventions illustrated in Figure 4.

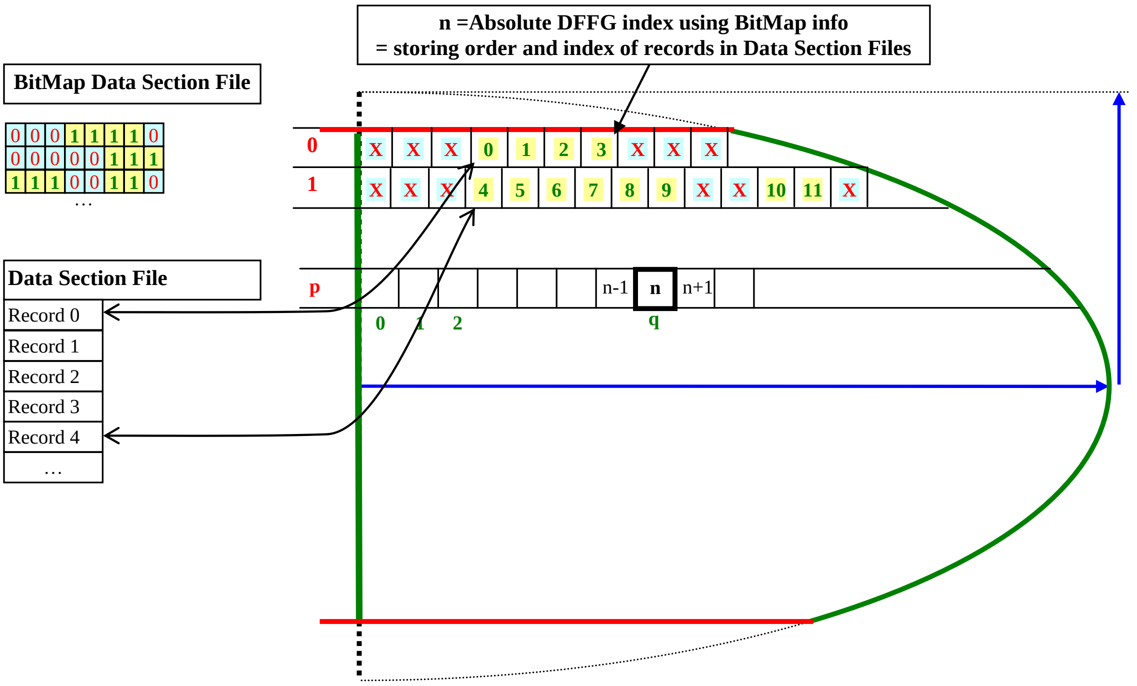


Figure 2. Absolute DFFG Index When Using a BitMap Section

Figure 3 illustrates how the DFFG paves the Earth for a complete coverage in longitudes and between -87° and +87° of latitude. STEP_KM has been chosen large (300 km) in order to have a clear figure.

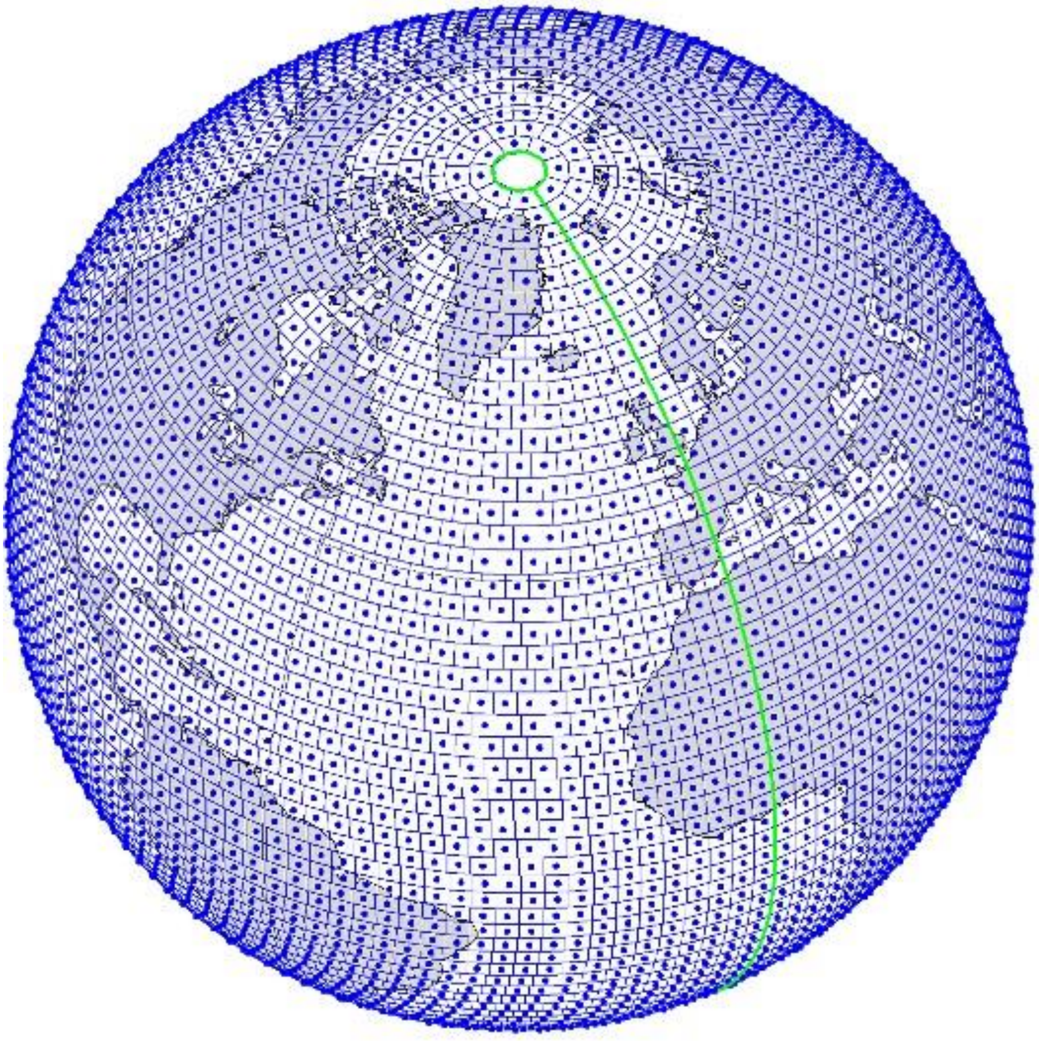


Figure 3. DFFG Cells Mapping of the Earth for STEP_KM = 300 km

C.2.2 Header Content

[1] The following table defines the header content that specifies the DFFG properties. Note that all the fields of this table are completely computable from the stand-alone knowledge of LAT_START, DELTA_LAT, START_LON, DELTA_LON, STEP_KM and the Earth ellipsoid properties, EARTH_SEMI_MAJOR_KM, EARTH_INV_FLATTENING.

[2] Longitudes and latitudes are geodetic coordinates with respect to the Earth reference ellipsoid.

[3] The other fields are not mandatory but bring valuable and very useful precomputed information to increase the efficiency for accessing data section blocks, computing grid conversion with a small extra cost in the header size.

- Yellow highlight are the only true mandatory fields.
- Green highlight are the minimum useful fields.
- Blue highlight brings more support to ease computation.

Table 63. DFFG Header

#	Field Name	Byte	T	dim	Comment	Unit
1	STEP_KM	4	F	1	Asked step size for the DFFG	km
2	DFFG_HEADER_ID	4	I	1	Any internal identity number. e.g a zone partition ID. 0xFFFFFFFF if unset.	na.
3	LAT_START	4	F	1	Global latitude window starting at LAT_START and DELTA_LAT wide.	deg
4	DELTA_LAT	4	F	1		deg
5	LON_START	4	F	1	Global longitude window starting at LON_START and DELTA_LON wide.	deg
6	DELTA_LON	4	F	1		deg
7	EARTH_SEMI_MAJOR_KM	4	F	1	Earth ellipsoid model semi major radius in km. Used to generate the Header content for longitude and latitude sampling. Default value: 6378.137 km (WGS84)	km
8	EARTH_INV_FLATTENING	4	F	1	Inverse of Earth ellipsoid model flattening coefficient. Used to generate the Header content for longitude and latitude sampling. Default value: 298.257223563 (WGS84)	na.
9	FLAGS	4	I	1	b0: 1: BitMap Data Section exists (see #19 & #20) b0: 0: BitMap Data Section does not exist (see #19 & #20) b1: 1: Green section exists (see #10 to #13) b1: 0: Green section does not exist (see #10 to #13) b2: 1: Blue section exist (see #14 to #20) b2: 0: Blue section does not exist (see #14 to #20) b3 B31: na.	na.
10	LAT_N	4	I	1	Number of latitudes (rows)	na.
11	LAT_STEP_ANG	4	F	1	Angular latitude step size along a longitude	Deg
12	LON_V_N	4	I	LAT_N	Vector of number of longitudes (columns) along each latitude. Reverse order: starts from LAT_START + DELTA_LAT down to LAT_START	na.
13	LON_V_STEP_ANG	4	F	LAT_N	Vector of longitudes angular step sizes along each latitude.	Deg

					Reverse order: starts from LAT_START + DELTA_LAT down to LAT_START	
14	LAT_STEP_KM	4	F	1	Latitude km step size along a longitude adjusted to fit the full latitude window due to LAT_N truncation.	Km
15	LON_V_STEP_KM	4	F	LAT_N	Vector of longitudes km steps size along each latitude adjusted to fit the full longitude window due to LON_V_N truncation. Reverse order: starts from LAT_START + DELTA_LAT down to LAT_START	Km
16	V_CUMUL_N	4	I	LAT_N	Vector of absolute number of cells from LAT_START + DELTA_LAT down to every latitude indices. Used to fast link any DFFG index (n, p) to absolute position in Data Section files.	na.
17	TOTAL_N_CELLS	4	I	1	Total number of cells contained in the DFFG. Basically, this is the sum of LON_V_N values	na.
18	V_BM_CUMUL_N	4	I	LAT_N	**Only present iff FLAGS=>b0 = 1 Implies that a DFFG Bitmap Data Section is available.** Vector of absolute number of **valid cells** from LAT_START + DELTA_LAT down to every latitude indices. Used to fast link any **valid cell index** (n, p) to its absolute position in Data Section files	na.
19	TOTAL_BM_N_CELLS	4	I	1	**Only present iff FLAGS=>b0 = 1 Implies that a DFFG Bitmap Data Section is available.** Total number of **valid cells** contained in the DFFG. Basically, this is the number of bit set to 1 in the DFFG Bitmap Data Section.	na.

C.2.3 Fields Computation

First let us define:

$$EARTH\_SEMI\_MINOR\_KM = \left\{ EARTH\_SEMI\_MAJOR\_KM \times \left(1 - \frac{1}{EARTH\_INV\_FLATTENING}\right)\right.$$

$$EARTH\_E^2 = \frac{EARTH\_SEMI\_MAJOR\_KM^2 - EARTH\_SEMI\_MINOR\_KM^2}{EARTH\_SEMI\_MAJOR\_KM^2}$$

$$\mathrm{LAT\_STOP} = LAT\_START + DELTA\_LAT$$

LONG_LEN is the length of ellipse arc meridian between LAT_START and LAT_STOP. It is an elliptic integral we approximate using an expansion series of $\sin^2(\varphi)$ power of the integrand part, and Wallis's integrals series. For the earth shape characteristics, the two first terms of this expansion leads to an accuracy of ≈ 600 m, and the three first to ≈ 4 m. The targeting capabilities of SMOS are expected to be ≈ 400 mso we will use the three first terms.

$$\beta(\varphi_1,\varphi_2) = EARTH\_SEMI\_MAJOR(1 - EARTH\_E^2)\int_{\varphi_1}^{\varphi_2}(1 - EARTH\_E^2 \sin^2(\varphi))^{\frac{3}{2}} d\varphi$$

$$\beta(\varphi_1,\varphi_2) \approx EARTH\_SEMI\_MAJOR \times (b_0(\varphi_2 - \varphi_1) + b_1 \sin(2\varphi)) with\, b_0 = 1 - \frac{1}{4} EARTH\_E^2 \; and \; b_1 = -\frac{3}{8} EARTH\_E^2$$

$$LON\_LEN \approx \beta\left(LAT\_STOP \frac{\pi}{180}\right) - \beta\left(LAT\_START \frac{\pi}{180}\right)$$

#10: LAT_N:

$LAT\_N = \text{round}\left(\frac{LON\_LEN}{STEP\_KM}\right)$: $\text{round}(v)$ is the truncation to the integer the closest to *v*. The purpose of $\text{round}(v)$ is to stay as close as possible from the required specification STEP_KM. So, STEP_KM² remains a good approximation of a DFFG cell area whatever the chosen resolution.

#11: LAT_STEP_ANG:

$LAT\_STEP\_ANG = \frac{DELTA\_LAT}{LAT\_N}$: is the angular step in degrees to be used with any row index.

It will introduce variations in the true meridian step length because of the earth ellipsoid shape. However, in the case of the Earth, the fattening coefficient is very small, and these variations introduce a negligible impact on the DFFG cell area variance.

#12: LON_V_N is a vector of LAT_N values such as $\forall p, p \in \{0, \Lambda\ , LAT\_N - 1\}$ then

$$LON\_V\_N_p = \text{round}\left(\begin{array}{l} DELTA\_LON \times \frac{\pi}{180} \times \frac{EARTH\_SEMI\_MAJOR\_KM}{LAT\_STEP\_KM} \times \\ \cos(LAT\_STOP - (p + \frac{1}{2}) \times LAT\_STEP\_ANG) \end{array} \right)$$

So, this vector goes from LAT_STOP to LAT_START.

#13: LON_V_STEP_ANG: is a vector of LAT_N values such as $\forall p, p \in \{0, \Lambda\ , LAT\_N - 1\}$ then

$$LON\_V\_STEP\_ANG_p = \frac{DELTA\_LON}{LON\_V\_N_p}$$

#14:LAT_STEP_KM:

$LAT\_STEP\_KM = \frac{LON\_LEN}{LAT\_N}$: is the adjusted step size in km to be used with any row index.

#15: LON_V_STEP_KM: is a vector of LAT_N values such as $\forall p, p \in \{0, \Lambda\ , LAT\_N - 1\}$ then

$$LON\_V\_STEP\_KM_p = \left\{ \begin{array}{l} LON\_V\_STEP\_ANG_p \times \frac{\pi}{180} \times EARTH\_SEMI\_MAJOR\_KM \times \\ \cos(LAT\_STOP - (p + \frac{1}{2}) \times LAT\_STEP\_ANG) \end{array} \right.$$

#16: LON_V_AREA_KM: is a vector of LAT_N values such as $\forall p, p \in \{0, \Lambda\ , LAT\_N - 1\}$ then

$$LON\_V\_AREA\_KM_p = LAT\_STEP\_KM * LON\_V\_STEP\_KM_p$$

#16: V_CUMUL_N: is a vector of LAT_N values such as $\forall p,\ p \in \{0, \Lambda\ , LAT\_N - 1\}$ then

$$V\_CUMUL\_N_0 = 0$$

$$V\_CUMUL\_N_p = V\_CUMUL\_N_{p-1} + LON\_V\_N_{p-1}$$

#17: TOTAL_N_CELLS:

$$TOTAL\_N\_CELLS = \begin{cases} \sum_{p=0}^{LAT\_N-1} LON\_V\_N_p \\ \text{or} \\ V\_CUMULATIVE_{LAT\_N-1} + LON\_V\_N_{LAT\_N-1} \end{cases}$$

#18: V_BM_CUMUL_N: we assume that a BitMap data section exists, then this is a vector of LAT_N values such as $\forall p,\ p \in \{0, \Lambda\ , LAT\_N - 1\}$ then

$$V\_CUMUL\_N_0 = 0$$

$$V\_CUMUL\_N_p = V\_CUMUL\_N_{p-1} + \sum_{k=0}^{LON\_V\_N_{p-1}} BitMap_{k+V\_CUMUL\_N_p}$$

#19: TOTAL_BM_N_CELLS:

$$TOTAL\_N\_CELLS = \begin{cases} \sum_{k=0}^{TOTAL\_N\_CELLS-1} BitMap_k \\ \text{or} \\ V\_BM\_CUMULATIVE_{LAT\_N-1} + \sum_{k=0}^{LON\_V\_N_{LAT\_N-1}} BitMap_{k+V\_CUMUL\_N_{LAT\_N-1}} \end{cases}$$

C.2.4 DFFG Use

Some useful conversions or accessors methods:

1. $DFFG_{p,q}$ cell index to the latitude longitude of the cell's centre:

   $$p \in \{0, \Lambda\ , LAT\_N - 1\}, q \in \{0, \Lambda\ , V\_LON\_N_p - 1\}$$

   $$Lat_{pq} = LAT\_STOP - \left(p + \tfrac{1}{2}\right) \times LAT\_STEP\_ANG$$

   $$Lon_{pq} = LON\_START + \left(q + \tfrac{1}{2}\right) \times LON\_STEP\_ANG_p$$

2. Longitude and latitude to the cell index $DFFG_{pq}$ having the closest centre:

   $$p = floor\left(\frac{LAT\_STOP - latitude}{LAT\_STEP\_ANG}\right),\ p \in \{0, \Lambda\ , LAT\_N - 1\}$$

   $$q = floor\left(\frac{longitude - LON\_START}{LON\_STEP\_ANG_p}\right),\ q \in \{0, \Lambda\ , LON\_V\_N_p - 1\}$$

   where $\mathrm{floor}(v)$ is the truncation to the nearest integers less than or equal to *v*.

   Note that this formula implies that valid latitudes belong to] LAT_START, LAT_STOP] and valid longitudes belong to [LON_START, LON_STOP[

3. $DFFG_{pq}$ cell index to its absolute index of cells $n_{p,q}$

$$n_{p,q} = \sum_{j=0}^{p-1} LON\_V\_N_j + q$$

or $n_{p,q} = V\_CUMUL\_N_p + q$

$$n_{p,q} \in \{0, \Lambda, TOTAL\_N\_CELLS - 1\}$$

4. Finding if a $DFFG_{pq}$ cell index is valid or not with the BitMap section

   Here we suppose that a BitMap data section exists and is defined according to Section C.2.1 (especially, it assumes that the flags are packed within 32 bits integer records)

   First, we compute $n_{p,q}$ with 3) and then apply the following formula:

$$nrec = n_{p,q} / 32$$

$$bitpos = 31 - (n_{p,q} \% 32)$$

$$VF_{p,q} = BitMap_{nrec} \,\&\, 2^{bitpos}$$

   Where, / is the integer division, % is the remaining of the integer division and & is the binary bit to bit AND.

   The value of the validity flag $VF_{p,q}$ is 1 if $DFFG_{pq}$ correspond to a valid cell, 0 otherwise.

5. $DFFG_{pq}$ cell index to the absolute index of valid cells $nv_{p,q}$

   First, we need to check with 4) that $DFFG_{pq}$ is a valid cell, and then we use the following formulas:

$$nv_{p,q} = \sum_{j=0}^{p-1} \sum_{k=0}^{q-1} BitMap_{p,k}$$

or $nv_{p,q} = V\_BM\_CUMUL\_N_p + \sum_{k=0}^{q-1} VF_{p,k}$

$$nv_{p,q} \in \{0, \Lambda, TOTAL\_BM\_N\_CELLS - 1\}$$

6. Longitude and latitude to the index number of cell *n* (resp. *nv*) (record in a file)
   use 2) to get *p* and *q*, then use 3) (resp. 5) to compute *n* (resp. *nv*)
7. Size of the header, for each part of the header:
   - A: 36 bytes
   - B: $8 \times (LAT\_N + 1)$ bytes
   - C: $8 \times (LAT\_N + 1)$ bytes (no BitMap)
   - C: $12 \times (LAT\_N + 1)$ bytes (with BitMap)
   - Total = $32 + 16 \times (LAT\_N + 1)$ bytes (no BitMap)
   - Total = $32 + 20 \times (LAT\_N + 1)$ bytes (with BitMap)

C.2.5 Partitioning the Earth in Zones

[1] In SML2PP, the L1c DGGs located up to ±87° latitude with the working area 123 km × 123 km for each of them (approximately equal to the Earth surface distance with 1° along longitude) are required to do retrieval processing. The surface area of the Earth that the DFFGs need to cover should be at least from latitude –89° to 89° and all the longitudes. If we treat the whole Earth surface area as only a 1 DFFG data block or Zone, every LUT for DFFG is relatively big or even

huge. Since the area of a DFFG tends to be small, about 4km by 4km or less, an enormous number of grid cells are needed.

[2] The retrieval at each DGG needs the L2PP to find its DFFGs and their parameters in many big DFFG LUTs for different auxiliary data. Since a huge DFFG Zone is captured in a single Data Set Record in the ADPs, and the BinX library scheme imposes the full Data Set Record to be read from the disk into computer memories as a whole, the size of the Data Set Record will be too large to fit in the memory of a single ordinary personal computer.

[3] Considering those effects, a workable and optimal approach is better to use multiple smaller DFFG Zones to cover the whole Earth surface area. With this approach, many smaller numbers of DFFGs in certain surface areas are mapped onto many smaller DFFG Zones. And for any DGG with its working area 123 km × 123 km, the L2PP can locate its DFFGs and associated auxiliary data from at most 3 connected smaller DFFG Zones.

[4] The Equator Equal-Area Partition (EEAP) method of partitioning has been considered and developed to partition the surface of the globe in a way that is appropriate for multiple smaller DFFG Zones. The following subsection provides the precise definition of EEAP.

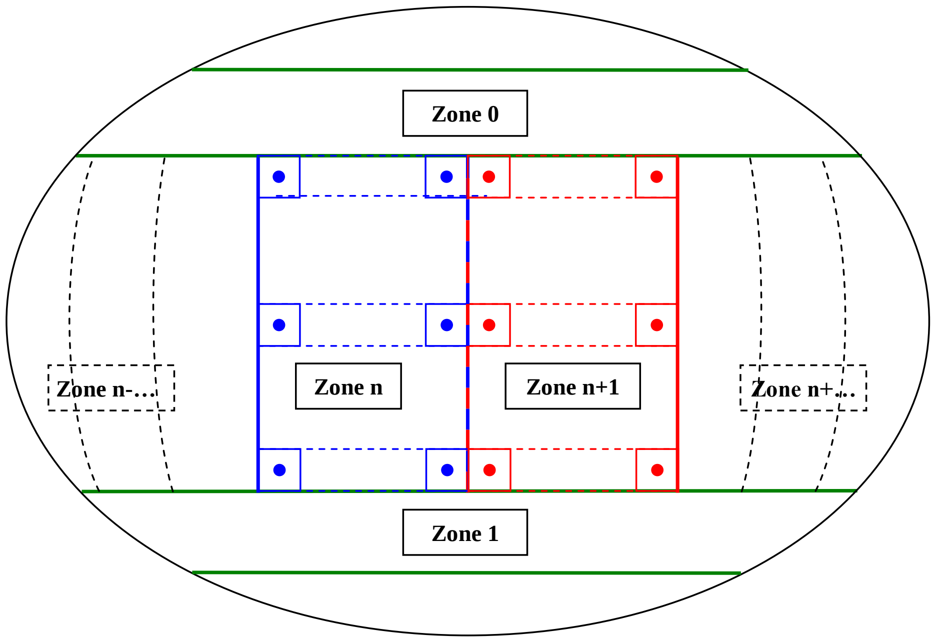


Figure 4. Using the ID to reference the EEAP zones of Earth

[5] Definition of Zones = windows to set in the DFFG headers:

- For Zone#0 area, start latitude is 75°, latitude width is 14°, start longitude is 0°, longitude width is 360°, ID = 0.
- For Zone#1 area, start latitude is –89°, latitude width is 14°, start longitude is 0°, longitude width is 360°, ID = 1.
- For Zone#2 area (to Zone#73 area, total 72 Zones, they are quite similar). They define a 5° longitude width windows.
- Let *n* be the number of one of these zones then start latitude is -75°, latitude width is 150°, start longitude is (n-2) *5°, longitude width is 5°, ID = n.

[6] A point located at the frontier between two zones follows the conventions:

- For longitudes, the point belongs to the eastward zone
- For latitudes, the point belongs to the southward zone.

[7] Note: from Zone#2 to #73:

- Every Zone has identical total number of DFFGs.
- For DFFGs with same latitude coordinates but in different zones, the area size of each of them is identical.
- Same number of DFFGs on the same longitude arc in different Zones.

[8] The following figure shows the global partition of EEAP zones (#0, #2 to #73) for a STEP_KM resolution of 150 km.

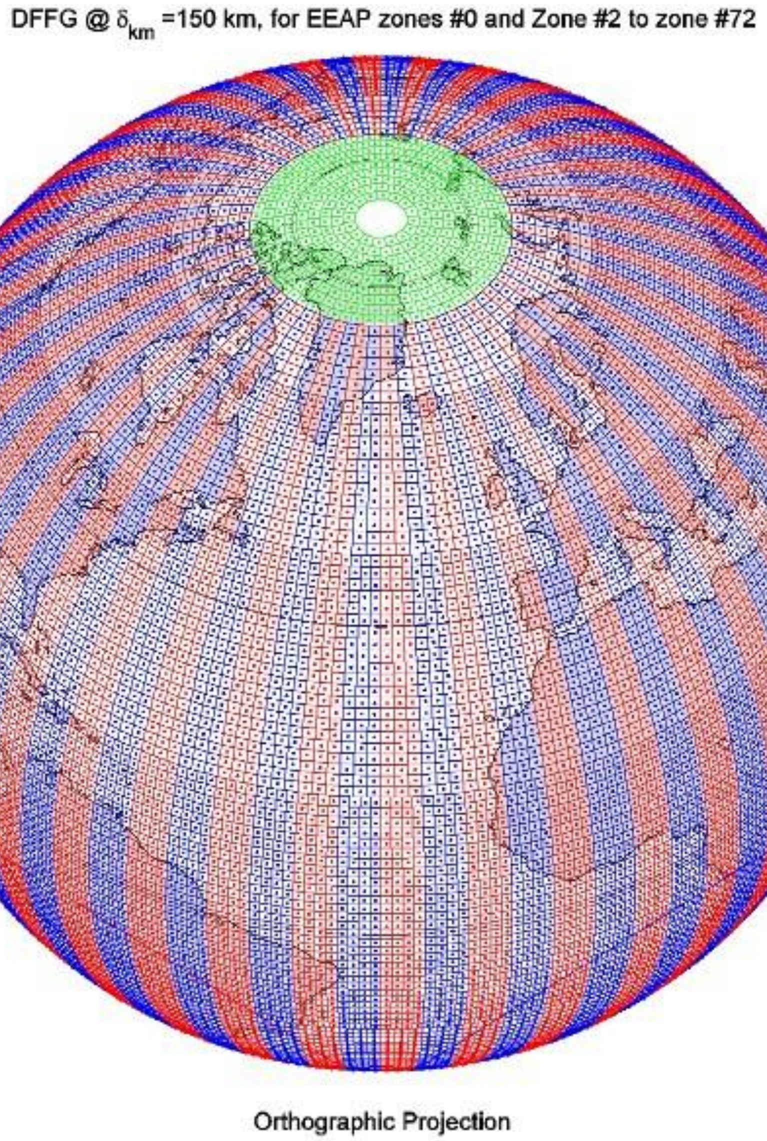


Figure 5. Global DFFG EEAP @ 5° for STEP_KM = 150 km

[9] The following figure shows a close-up of EEAP to illustrate how zones connect together and how the number of cells along the meridians decreases with the increasing latitudes.

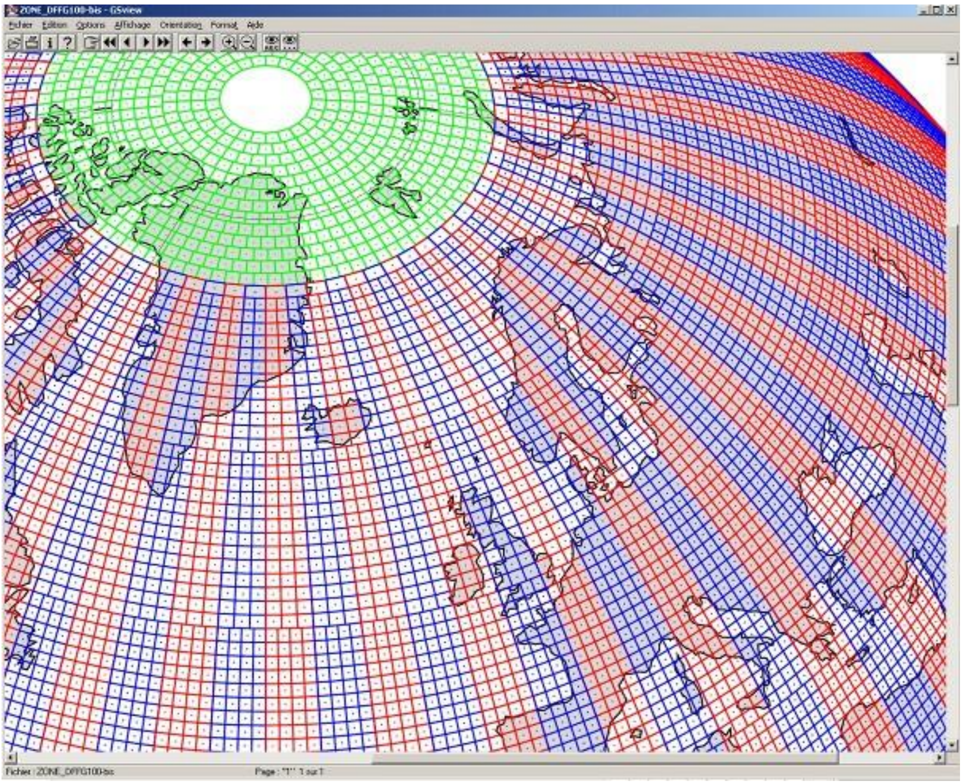


Figure 6. Close-up of EEAP @ 5° for STEP_KM = 100 km

C.2.6 Working Area and DFFG

[1] A working area (WA) for SMOS L2 is a square area that surrounds a DGG node where the L2 algorithms need and use the high-resolution surface information at DFFG scale.

[2] Given a DGG node location $(\varphi_{DGG}, \lambda_{DGG})$, this WA is defined by the DFFG index coordinates (p_{WA}, q_{WA}) of the cell that also define its centre. These are the coordinates of the closest DFFG cell centre to $(\varphi_{DGG}, \lambda_{DGG})$. WA is tangent to the Earth ellipsoid at (p_{WA}, q_{WA}) and aligned along the meridian and the parallel at this point.

[3] The size of this WA is defined by the number of DFFG rows and columns: The DFFG area is the smallest one that includes a square of WEF_SIZE km x WEF_SIZE km with an odd number of DFFG rows or columns. So, there is always a cell defining its centre.

[4] Because the DFFG defines an equal-area grid, the number of columns and the number of rows are equal, and they are constant whatever the location $(\varphi_{DGG}, \lambda_{DGG})$ is.

[5] For WEF_SIZE=123 km and for a DFFG with STEP_KM = 4 km, the DFFG working area contains 31 rows x 31 columns which define a true surface of 124 km x 124 km.

[6] Figure 7 shows the DFFG working area and the DFFG cell it contains for the L1c node ID=#32002432. The black dots in the displayed zone are the L1c DGG nodes; the red one with the black circle is the ID=#32002432 one.

[7] As one can see the equal-area specification implies an irregular spacing of the grid from a parallel to another. But each cell has practically the same surface.

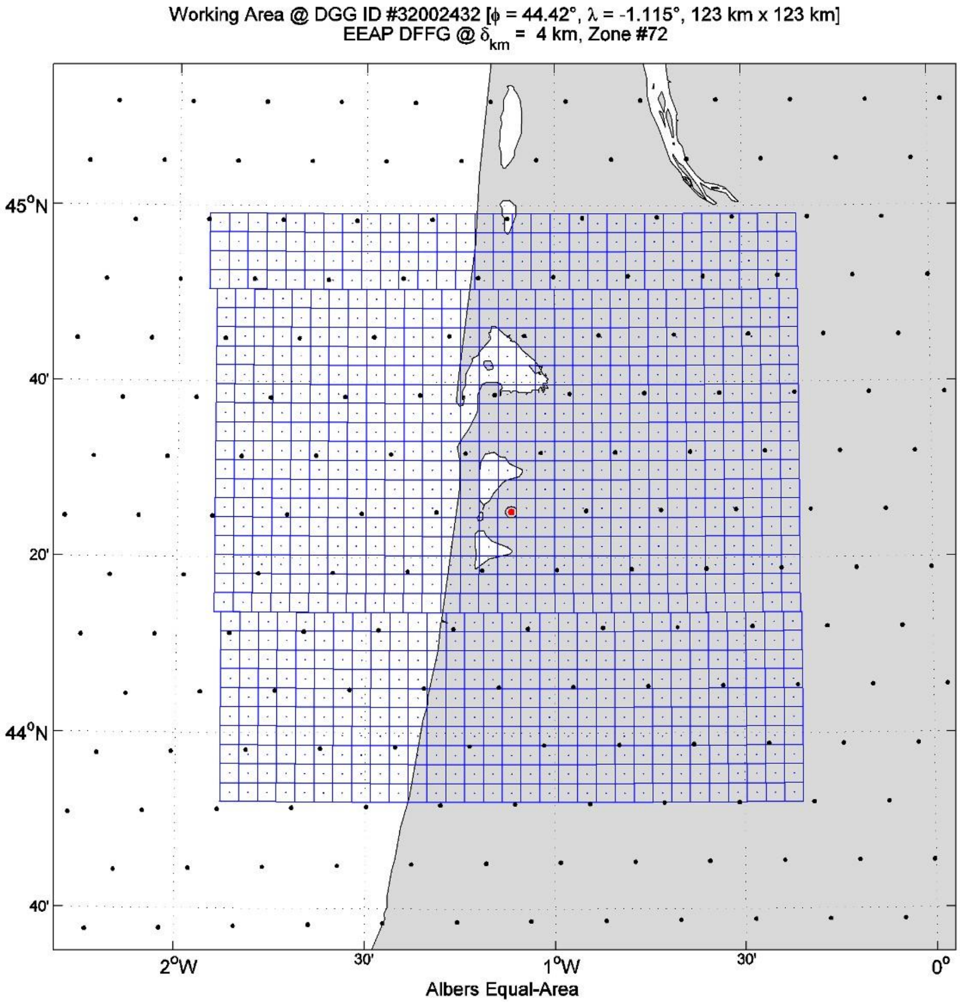


Figure 7. DFFG working area around L1c node at Arcachon (France)

[8] When using EEAP zone, the WA may overlap up to three zones. Figure 8 illustrates this configuration for $\varphi_{DGG} = 75°\,N$ and $\lambda_{DGG} = 20°\,E$ (black central dot) which is located at the common corner to the EEAP Zones #0, #69 and #70. Due to the EEAP specification, this particular point belongs to the eastward and southward zone which is Zone #70.

[9] Note that the specification of the DFFG and WSIZE being the same compared to the previous case (Figure 7) the working area in Figure 8 has the same number of rows and columns; as expected, the size of the working area is independent of its position of on the Earth, even at high latitude.

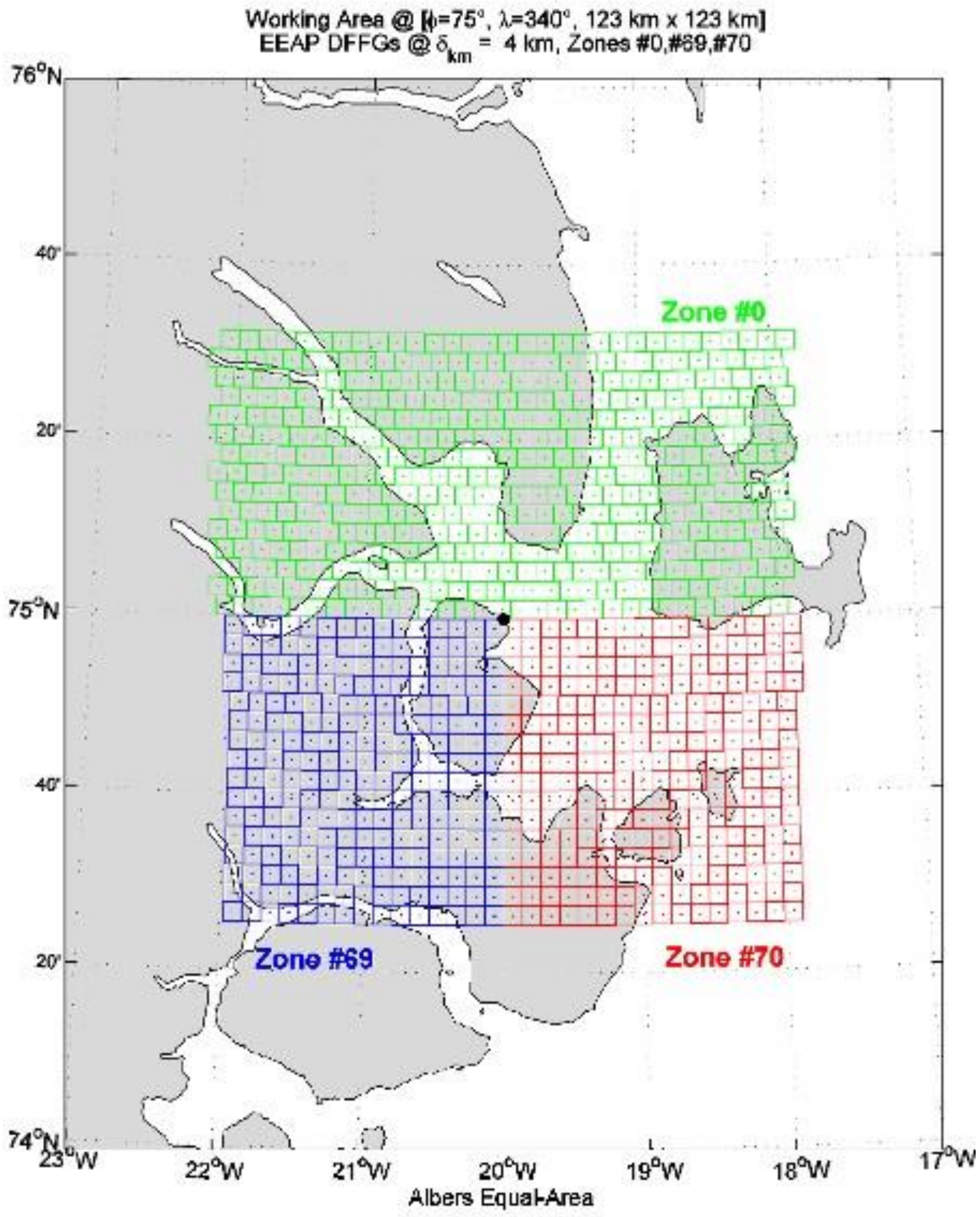


Figure 8. DFFG Working Area and EEAP Zones

C.2.7 DFFG Statistics

[1] The following tables give some statistics as a function of the adjusted step size in km (i.e. the true one) for global DFFG (window equal to [0°, 180°] for the longitude and [-87°, 87°] for the latitude) and for EEAP DFFG Zone #0, #1 and for Zone #2 to #72.

[2] The required step sizes have been chosen as a multiple of the length of 1/120th of degree at the equator = 1/120 * π/180 * 6378 km ≈ 0.927 km in order to be directly comparable with an equivalent equal-angle aggregation of the DFG. The list is given for 1, 2, 4, 8, 16, 32 times 0.927 km.

[3] The highlights correspond to the baseline option close to 4km x 4km.

C.2.7.1 Global DFFG

Table 64. Statistics for global DFFG: φ∈[-87°, 87°], λ∈[0°, 360°]

Step size km	Header size			Grid properties		Equal area	relative anomaly			
							spec		area	
	A B	B KB	C / CBM[3] KB	nb lat	Total nb cells	area km^2	μ (%)	σ (%)	μ (%)	σ (%)
0.927	32	162.8	162.8 / 244.2	20841	592094664	0.8605	1.2×10^{-3}	2.4×10^{-3}	-3.9×10^{-6}	2.4×10^{-3}
1.855	32	81.4	81.4 / 122.1	10421	148037937	3.4421	-8.4×10^{-3}	4.8×10^{-3}	-1.5×10^{-5}	4.8×10^{-3}
3.710	32	40.7	40.7 / 61.1	5210	37002439	13.7683	1.1×10^{-2}	9.6×10^{-3}	-2.8×10^{-5}	9.6×10^{-3}
7.421	32	20.4	20.4 / 30.5	2605	9250632	55.0733	1.1×10^{-2}	1.9×10^{-2}	1.8×10^{-4}	1.9×10^{-2}
14.842	32	10.2	10.2 / 15.3	1303	2314455	220.2933	-6.7×10^{-2}	3.7×10^{-2}	-6.4×10^{-4}	3.8×10^{-2}
29.707	32	5.1	5.1 / 7.6	651	577728	882.5251	9.0×10^{-2}	7.7×10^{-2}	2.6×10^{-3}	7.7×10^{-2}

[4] The relative anomalies correspond to:

- The anomaly of the DFFG with respect to the specification LAT_STEP_KM. It shows the relative mean and standard deviation of the adjusted equal area with respect to LAT_STEP_KM^2:

  $$let\ LON\_V\_AREA\_KM2_k = LAT\_STEP\_KM \times LON\_V\_STEP\_KM_k$$

  $$\mu_{spec} = \left(\frac{\overline{LON\_V\_AREA\_KM2}}{STEP\_KM^2} - 1 \right) \times 100$$

  $$\sigma_{spec} = \frac{std(LON\_V\_AREA\_KM2)}{STEP\_KM^2} \times 100$$

  If the required specification LAT_STEP_KM is met (on average), then $\mu_{spec} = 0\%$. Furthermore, if $\sigma_{spec} = 0\%$, then the required specification LAT_STEP_KM is met everywhere on the grid.

- The anomaly of the DFFG with respect to the specification to have equal-area cells. It shows the relative mean and standard deviation of the adjusted LON_V_STEP with respect to LAT_STEP_KM:

  $$\mu_{square} = \left(\frac{\overline{LON\_V\_STEP\_KM}}{LAT\_STEP\_KM} - 1 \right) \times 100 \text{ in } \%$$

  $$\sigma_{square} = \frac{std(LON\_V\_STEP\_KM)}{LAT\_STEP\_KM} \times 100 \text{ in}\%$$

If "squareness" is met (on average), then $\mu_{square} = 0\%$. Furthermore, if $\sigma_{square} = 0\%$, then "squareness" is met everywhere on the grid.

[5] As can be seen from Table 64, the anomalies (μ, σ) (resulting from rounding the number of cells and the cell size required to span the zoom area with an integer number of DFFG cells) for the specification STEP_KM and for the area are negligible.

[3] Without / with bitmap specific fields in blue header part

C.2.7.2 EEAP DFFG

[1] Fields interpret like the previous section.

Table 65. Statistics for DFFG EEAP Zone #0, Zone #1

Step size km	Header size			Grid properties		Equal area	relative anomaly			
							spec		area	
	A B	B KB	C / CBM KB	nb lat	Total nb cells	area km²	μ (%)	σ (%)	μ (%)	σ (%)
0.927	32	11.3	11.3 / 16.9	1444	10269217	0.8605	6.5×10^{-2}	5.2×10^{-3}	1.8×10^{-4}	5.2×10^{-3}
1.855	32	5.6	5.6 / 8.5	722	2566188	3.4421	6.5×10^{-2}	1.1×10^{-2}	4.6×10^{-4}	1.1×10^{-2}
3.710	32	2.8	2.8 / 4.2	361	640992	13.7683	6.4×10^{-2}	2.1×10^{-2}	-1.6×10^{-4}	2.1×10^{-2}
7.421	32	1.4	1.4 / 2.1	181	160858	55.0733	-4.9×10^{-1}	4.2×10^{-2}	2.0×10^{-3}	4.3×10^{-2}
14.842	32	0.7	0.7 / 1.1	90	39633	220.2933	6.2×10^{-1}	8.6×10^{-2}	-5.0×10^{-3}	8.6×10^{-2}
29.707	32	0.4	0.4 / 0.5	45	9838	882.5251	6.3×10^{-1}	1.7×10^{-1}	1.3×10^{-2}	1.7×10^{-1}

Table 66. Statistics for DFFG EEAP Zone #2 to Zone #72

Step size km	Header size			Grid properties		Equal area	relative anomaly			
							spec		area	
	A B	B KB	C / CBM KB	nb lat	Total nb cells	area km²	μ (%)	σ (%)	μ (%)	σ (%)
0.927	32	140.3	140.3 / 210.4	17952	7947860	0.8605	2.1×10^{-3}	8.1×10^{-2}	-1.3×10^{-4}	8.1×10^{-2}
1.855	32	70.1	70.1 / 105.2	8976	1986987	3.4421	1.9×10^{-3}	1.6×10^{-1}	-3.1×10^{-4}	1.6×10^{-1}
3.710	32	35.1	35.1 / 52.6	4488	496769	13.7683	-2.5×10^{-3}	3.2×10^{-1}	-4.7×10^{-3}	3.2×10^{-1}
7.421	32	17.5	17.5 / 26.3	2244	124204	55.0733	-2.8×10^{-3}	6.5×10^{-1}	-5.0×10^{-3}	6.5×10^{-1}
14.842	32	8.8	8.8 / 13.2	1122	31005	220.2933	1.2×10^{-1}	1.3×10^{0}	1.2×10-1	1.3×10^{0}
29.707	32	4.4	4.4 / 6.6	561	7774	882.5251	-5.3×10^{-2}	2.6×10^{0}	-5.5×10^{-2}	2.6×10^{0}

[2] The union of a partition set of DFFG headers will never be completely equivalent to a global DFFG; the union of zones cover exactly the same global surface, but the locations of the cell centres and the total number of cells will not be exactly the same due to the effects of truncation on smaller meridian arc lengths.

[3] Since arc-lengths are smaller the impact of truncations is greater compared to a global DFFG, as one could expect; they remain still very low. However, as the scale becomes coarser the area specification as well as the equal-area quality becomes also more variable within the whole grid to reach few percents for 30 km x 30 km. The solution to avoid this should be to link the EEAP partition size to the DFFG resolution: the bigger STEP_KM, the smaller data sections, thus the lesser number of necessary EEAP zones.

[4] The duplication of internal tables (such as LON_V_N, LON_STEP_ANG ….) implies that the cumulative size of the set of DFFG headers will be also much greater. However, the individual DFFG headers are small files and only few zones are required at the same time to handle a given SMOS swath, which is the purpose of EEAP especially for Data Sections.

[5] The total amount of data of Data Section is also affected. As the following tables show us, the sum of TOTAL_N_CELLS over the 73 EEAP zone is lesser by ~ 1.2 %.

Table 67. DFFG EEAP all zones TOTAL_N_CELLS vs. DFFG Global

All EEAP Zones		
Step (Km)	Total Nb cells	% Global DFFG
0,927	584836494	-1,2%
1,854	146208453	-1,2%
3,708	36552583	-1,2%
7,416	9140200	-1,2%
14,832	2280621	-1,5%
29,664	571630	-1,1%

C.2.8 Conclusions

1. For the baseline ≈ 4 km x 4 km and higher resolutions, we can consider that DFFG cells have a quasi constant area equal to $STEP\_KM^2$ everywhere in the grid.
2. If computation time constraint would require gaining a factor 4, the ≈ 8 km x 8 km resolution has still very high quality even for EEAP zone with a 5° width.
3. So, when we need to compute mean average of values weighted by the MEAN_WEF or the WEFs, it is not necessary to account for the surface of each DFFG cell.
4. The sizes of the headers are not very big, even for the smallest resolution.
   So we would recommend the use of all the information, A+B+C. In that case, the overall header size will be:

Table 68. Summary of Header Size as a Function of DFFG Cell Size

Step size km	0.927	1.855	3.710	7.421	14.842	29.707
Global DFFG Header size KB	325.7	162.9	81.5	40.8	20.4	10.2
Global DFFG Header size (BM[4]) KB	407.1	203.6	101.8	50.9	25.5	12.8
EEAP Zone #0,#1 DFFG Header size KB	22.6	11.3	5.7	2.9	1.5	0.8
EEAP Zone #0,#1 Header size (BM) KB	28.3	14.2	7.1	3.6	1.8	0.9
EEAP Zone #2 to #72 DFFG Header size KB	280.5	140.3	70.2	35.1	17.6	8.8
EEAP Zone #2 to #72 Header size (BM) KB	350.7	175.4	87.7	43.9	22.0	11.0

5. If we compare the number of the DFFG cells with the number of cells obtained from an equivalent but **equal-angle** aggregation of the DFG (aggregating 2, 4, 8, 16, and 32 lines and columns of DFG), then the number of DFFG **equal-area** cells is always smaller ≈ 65.7 % of the **equal-angle** aggregation one. This percentage almost independent of the resolution (step size).

C.3 DFFG Data Sections

[1] The header section defines the structure of the DFFG, the Data Sections define the structure and the content of records.

[2] DFFG Data Sections can be stored in single as well as multiple files.

[3] The description of a Data Section consists of two parts, a Data Section Header and a Data Section Block.

[4] With bitmap specific header fields

C.3.1 Data Section HEADER General Definition

[1] The Data Section Header is a small header located at the beginning of the Data Section files made up with a fixed size part (yellow fields #1 to #6) and a variable size part (green fields #7 and #8 repeated #6:NB_FIELDS times).

[2] The first purpose of this Data Section Header is to keep the logical link of the sections with the associated header, eventually a BitMap Section and the type of the Data Section. All this information will define precisely how the Data Section Block is structured.

[3] Its second purpose is to provide scaling information (offset and scaling factor) for each field of a record of Data Section Block. This scaling definition must follow the same order of the Data Section Block Record definition.

Table 69. Data Section Header

#	Field Name	Byte	T	dim	Comment	Unit
1	SECTION_ID	4	UI	1	Ident number of the Data Section 0XFFFFFFFF if unset.	na.
2	SECTION_TYPE	4	UI	1	Code defining the type of the Data Section: 0: Standard cells Data Section 1: Latidude Data Section 2: BitMap Data Section 0XFFFFFFFF if unset.	na.
3	REF_DFFG_ID	4	UI	1	Ident number of the associated DFFG Header. 0XFFFFFFFF if unset.	na.
4	REF_BITMAP_ID	4	UI	1	Ident number of the associated Bitmap Data Section 0XFFFFFFFF if unset.	na.
5	SECTION_NAME	1	C	40	Name of the Data Section	na.
6	NB_FIELDS	4	UI	1	Name of the Data Section	na.
7	OFFSET	4	F	1	These two fields are repeated NB_FIELDS time and provide the scaling to apply to each fields of Data block records.	na.
8	SCALING	4	F	1		na.

Note about Field #2:

- SECTION_TYPE = 0, Standard cells Data Section, indicates that the Data Section Block provides the records for each cell of the DFFG if REF_BITMAP_ID = 0XFFFFFFFF, or for the valid cells only described by the Data Section SECTION_ID equal to REF_ BITMAP_ID.
- SECTION_TYPE = 1, Latitude Data Section, indicates that the Data Section Block provides the records for each latitudes (rows) defined in the associated DFFG Header.
- SECTION_TYPE = 2, BitMap Data Section, indicates that the Data Section Block provides the records for the BitMap information of the DFFG.
- SECTION_TYPE = 3 to 0x7FFFFFFF are reserved.
- SECTION_TYPE = 0x80000000 to 0XFFFFFFFE are free to be used to handle users specific cases.

Note about Field #6: NB_FIELDS = 0 is authorized. In this case there is no scaling part and no scaling to apply to the data coming from records fields.

C.3.2 DATA SECTION BLOCK General Definition

[1] The Data Section Block consists in a sequential stream of fixed size records.
[2] A record is defined by the ordered list of the fields, formats and sizes that make up the record as shown in the template of the following table.

Table 70. DFFG Data Section Record Template

#	Field Name	Byte	T	Dim	Comment	Unit
1	Name	1	Type	Number of Type	Comment about the field	If relevant
2	…	…	…	…	…	…

[3] The number of records depends on the information given in the DFFG Data Section Header, associated DFFG Header Section and eventually BitMap Section:

- For SECTION_TYPE = 0 and REF_BITMAP_ID = 0XFFFFFFFF, Data Section Block contains DFFG Header TOTAL_N_CELLS records.
- For SECTION_TYPE = 0 and REF_BITMAP_ID ≠ 0XFFFFFFFF, Data Section Block contains DFFG Header TOTAL_BM_N_CELLS records.
- SECTION_TYPE = 1, Data Section Block contains DFFG Header LAT_N records.
- SECTION_TYPE = 2, Data Section Block contains DFFG Header TOTAL_N_CELLS records.

C.3.3 Bitmap Data SECTION Block

[1] The BitMap section can be considered a standard Data Section, where the following information is given for each DFFG cell.
[2] The Data Section Header SECTION_TYPE is always set to 2 and REF_BITMAP_ID = 0XFFFFFFFF and NB_FIELDS = 0 (no scaling).
[3] The Bitmap Section will contain exactly the same number of information than the number of cells described by the DFFG Header: TOTAL_N _CELLS.

Table 71. DFFG BitMap Data Record Content

#	Field Name	Bit	T	Dim	Comment		Unit
1	VALID	32	UI	1	Field bits b_{31}->b_0	B_{nn}=0: data block no present in data sections for the DFFG cell	-
						B_{nn}=1: data block present in data sections for the DFFG cell	

[4] This section is a continuous bit field but implemented as unsigned 32 bits words to gain efficiency. The mapping with the DFFG logical indexing follows this convention:

word #0:

Standard bits positions in a 32 bits word

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

Logical DFFG bit field positions

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31

word #1:

Standard bits positions in a 32 bits word

31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

Logical DFFG bit field positions

32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63

word #2: ……….

Table 72. DFFG BitMap Section size as a function of DFFG step size

Step size km	0.927	1.855	3.710	7.421	14.842	29.707
Global DFFG	70,6 MB	17,6 MB	4,4 MB	1,1 MB	282,5 KB	70,5 KB
EEAP DFFG Zone #0,#1	1,2 MB	313,3 KB	78,2 KB	19,6 KB	4,8 KB	1,2 KB
EEAP DFFG Zone #2 to #72	970,2 KB	242,6 KB	60,6 KB	15,2 KB	3,8 KB	972 B

C.3.4 DFFG Fraction Data Section BLOCK

[1] The following information is given for each DFFG cell.

[2] The first parts of the information, which we will need for each DFFG cell, are decision tree classes fractions related to FM0/FM fraction on static data.

[3] Note that some FM fractions are identical to FM0, but sometimes not, see the comment column.

[4] Note also that FWL, FEB and FEU are set to zero when IGBP is used to generate the fractions (see [CRD 5]).

Table 73. DFFG Fraction Data Section Record Content

#	Field Name	Byte	T	Dim	Comment		Unit
1	FNO	1	UI	1	FM0=FM		0.5 %
2	FFO	1	UI	1	FM0=FM		0.5 %
3	FWL	1	UI	1	FM0=FM		0.5 %
4	FWP	1	UI	1	FM	FM0 FWO = FWL+FWP	0.5 %
5	FWS	1	UI	1	FM		0.5 %
6	FEB	1	UI	1	FM0=FM		0.5 %
7	FEI	1	UI	1	FM	FM0 FTI = FEI+FSI dependent of dynamical FSI	0.5 %
8	FEU	1	UI	1	FM0=FM		0.5 %
9	FTS	1	UI	1	FM0	No FM for mountains (stacked over other fractions)	0.5 %
10	FTM	1	UI	1	FM0		0.5 %

Table 74. DFFG Fraction Data Section Block Size as a Function of DFFG Step Size

Step size km	0.927	1.855	3.710	7.421	14.842	29.707

Global DFFG Data Section size	5,5 GB	1,4 GB	352,9 MB	88,2 MB	22,1 MB	5,5 MB
EEAP DFFG Zone #0,#1	97,9 MB	24,5 MB	6,1 MB	1,5 MB	387,0 KB	96,1 KB
EEAP DFFG Zone #2 to #72	75,8 MB	18,9 MB	4,7 MB	1,2 MB	302,8 KB	75,9 KB

C.3.5 DFFG Reference Values Data Section BLOCK

[1] The following information is given for each DFFG cell.

[2] For each DFFG cell, the DFFG Fraction Data Section gives the fractions to use. For each of these fractions, models need to know the reference values to used to compute TB; for example, the b', b" to be used to compute the optical thickness when it is relevant.

[3] The two following options can be envisaged, the first is lighter (size of the data file) than the second, especially if the resolution increases.

[4] But the second is more accurate than the first if the resolution decreases and is also a little bit more flexible.

[5] The baseline is now to use a ≈ 4 km x 4 km because of timings, but in the future the computer power will increase and possibly give us the opportunity to use a ≈ 2 km x 2 km instead, and even the full resolution at ≈1 km x 1 km.

C.3.4.1 Lighter Size Option (Prefered option now)

[1] Each fraction is defined with DT class in the ECOCCIMAP code. The LAND_COVER_CLASSES LUT is reintroduced and used to fetch the surface parameters associated with the code as we did with the original approach with the DFG.

Table 75. DFFG Reference Value Data Section Record Content

#	Field Name	Byte	T	Dim	Comment	Unit
1	LANDCOVER_CNO	1	UI	1	Nominal Fraction	%
2	LANDCOVER_CFO	1	UI	1	Forest Fraction	%
3	LANDCOVER_CWL	1	UI	1	Wetland Fraction	%
4	LANDCOVER_CWP	1	UI	1	Purewater Fraction	%
5	LANDCOVER_CWS	1	UI	1	Saline Water Fraction	%
6	LANDCOVER_CEB	1	UI	1	Barren Area Fraction	%
7	LANDCOVER_CEI	1	UI	1	Permenent Ice Fraction	%
8	LANDCOVER_CEU	1	UI	1	Urban Area Fraction	%

Table 76. DFFG Reference Values Section Size as a Function of DFFG Step Size

Step size km	0.927	1.855	3.710	7.421	14.842	29.707
Global DFFG Data Section size	4,4 GB	1,1 GB	282,3 MB	70,6 MB	17,7 MB	4,4 MB
EEAP DFFG Zone #0,#	78,3 MB	19,6 MB	4,9 MB	1,2 MB	309,6 KB	76,9 KB
EEAP DFFG Zone #2 to #72	60,6 MB	15,2 MB	3,8 MB	970,3 KB	242,2 KB	60,7 KB

C.3.4.2 Heavier Size Option (Deprecated Option Now)

[1] For each fraction, we give the relevant list of parameters to be used. Hopefully not all parameters are necessary for each fraction. The following table recaps the LAND_COVER_CLASSES LUT parameters and gives for each fraction if the parameter is relevant for the model, y, or not relevant, n, or **?** if unsure at the moment.

[2] This Table needs to be verified and checked by all ESLs, before it is used.

Table 77. DFFG Reference Values Data Section Record Content

#	Field Name	Byte	T	Dim	HR	QR	NRH	NRV	CL	BSL	AL	BL	b’	b”	ω	DIFF ω	TTH	RTT	Bt
1	RNO	2	UI	15	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y
2	RFO	2	UI	14	y	y	y	y	y	y	y	y	$\tau_{F\,NAD}$		y	y	y	y	y
3	RWL	2	UI	15	y	y	y	y	y	y	y	y	y	y	y	y	y	y	y
4	RWP	2	UI	0	n	n	n	n	n	n	n	n	n	n	n	n	n	n	n
5	RWS	2	UI	0	n	n	y	n	n	n	n	n	n	n	n	n	n	n	n
6	REB	2	UI	4/15	y	y	Y	y	?	?	?	?	?	?	?	?	?	?	?
7	REI	2	UI	0/4	?	?	?	?	n	n	n	n	n	n	n	n	n	n	n
8	REU	2	UI	0/4	?	?	?	?	n	n	n	n	n	n	n	n	n	n	n

[3] For the time being Table 78 is the assessment of size considering the “y” in the above Table 77.

Table 78. DFFG Reference Values Section size as a Function of DFFG Step Size

Step size km	0.927	1.855	3.710	7.421	14.842	29.707
Data Section size	53.0 GB	13.3 GB	3.3 GB	848.6 MB	212.2 MB	53.0 MB

C.3.6 DFFG XYZ Data Sections BLOCKS

Table 79. DFFG XYZ Data Section Record Content

#	Field Name	Byte	T	Dim	Comment	Unit
1	X	4	F	1	X geocentric coordinates of the DFFG cell	m
2	Y	4	F	1	Y geocentric coordinates of the DFFG cell	m
3	Z	4	F	1	Z geocentric coordinates of the DFFG cell	m

Table 80. DFFG XYZ Data Section size as a Function of DFFG Step Size (Direct)

Step size km	0.927	1.855	3.710	7.421	14.842	29.707
Global DFFG Data Section size	6,6 GB	1,7 GB	423,5 MB	105,9 MB	26,5 MB	6,6 MB
EEAP DFFG Zone #0,#1	117,5 MB	29,4 MB	7,3 MB	1,8 MB	464,4 KB	115,3 KB
EEAP DFFG Zone #2 to #72	91,0 MB	22,7 MB	5,7 MB	1,4 MB	363,3 KB	91,1 KB

C.3.7 DFFG LAIMAX DaTA SECTION BLOCK

[1] The DFFG LAIMAX Data Section is a standard cells Data Section, with a Data Section Header SECTION_TYPE set to 0.

[2] The following information is given for each DFFG cell.

Table 81. DFFG LAIMAX Data Section Record Content

#	Field Name	Byte	T	Dim	Comment	Unit
1	LAIMAX	1	F	1	Maximum Leaf Area Index	-

[3] This section is scaled according to:

Table 82. DFFG B2XYZ Data Section Scaling Information

#	Field Name	Byte	T	dim	value	Unit
6	NB_FIELDS	4	UI	1	1	na.
7	OFFSET	4	F	1	0	na.
8	SCALING	4	F	1	0.1	na.

Table 83. DFFG LAIMAX Data Section Record as a Function of DFFG Step Size

Step size km	0.927	1.855	3.710	7.421	14.842	29.707
Global DFFG Data Section size	564,7 MB	141,2 MB	35,3 MB	8,8 MB	2,2 MB	564,2 KB
EEAP DFFG Zone #0,#1	9,8 MB	2,4 MB	626,0 KB	157,1 KB	38,7 KB	9,6 KB
EEAP DFFG Zone #2 to #72	7,6 MB	1,9 MB	485,1 KB	121,3 KB	30,3 KB	7,6 KB

C.4 Generating methods for DFFG Fraction Data Section

[1] To generate the FM/FM0 fractions for DFFG, there are four individual steps needed.

C.4.1 Generating Complementary Fractions

[1] The complementary DFFG fractions for FM/FM0 include FNO, FFO, FWL, FWP, FWS, FEB, FEI, FEU. They can be generated from the 30” Ecoclimap land cover classes (CNO, CFO, CWL, CWP, CWS, CEB, CEI, CEU, etc) with the aggregation rule, defined in Table 56 in Appendix A.

[2] In general, the generating/aggregation rules can be elaborated as:

- Use the aggregation rule in Appendix A to assign each ECOCLIMAP code to one of 8 decision tree classes.
- Use the aggregation/generating rules to obtain aggregated fractions in percentages for DFFG (~4km) scale from the DFG (30") scale in ECOCLIMAP.
- Use the domininat ECOCLIMAP Land Cover Class Code for the given fraction in the DFFG cell. If the fraction is 0, then set its associating ECOCLIMAP Land Cover Class Code to 0.

[3] Figure 9 illustrates the generating procedure. This is just an exmple; the figures may not be precise.

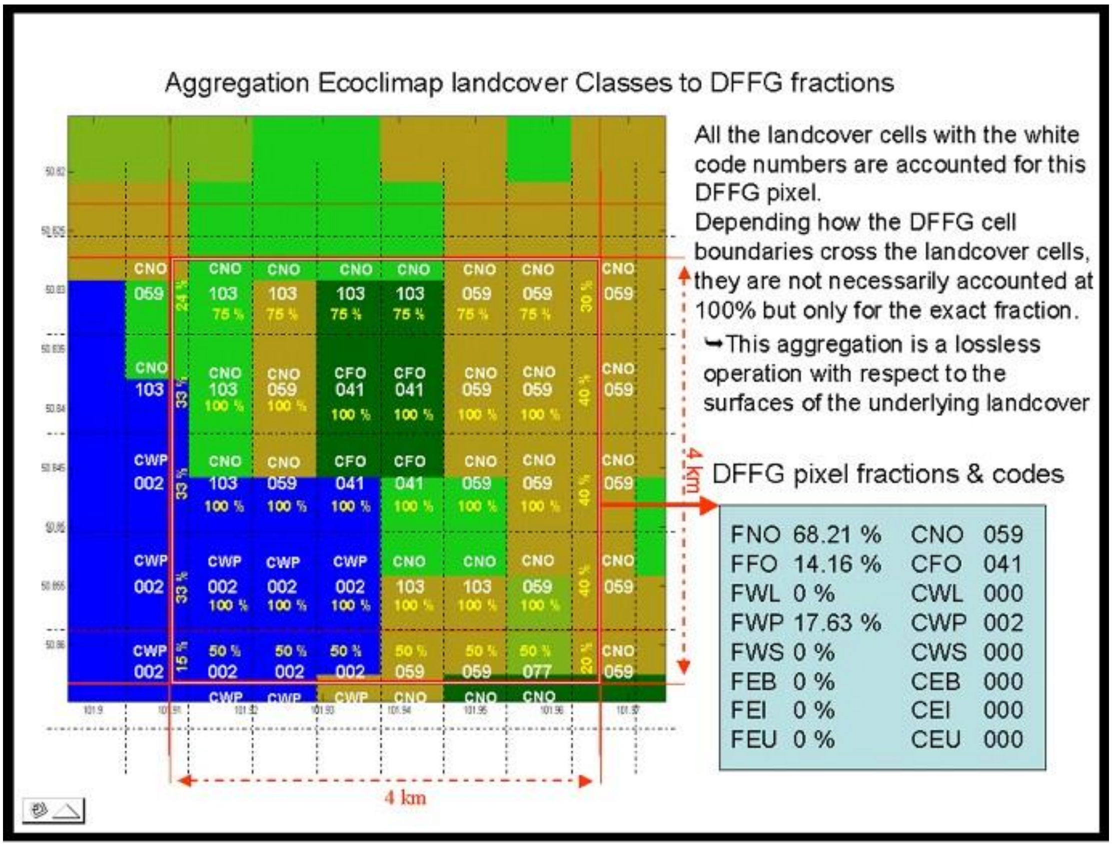


Figure 9. Procedure to Aggregate Ecoclimap Land Cover Classes to DFFG Complementary Fractions

C.4.2 Generating More Accurate Inland Water Fractions (DELETED)

C.4.3 Normalizing the Complementary Fractions (DELETED)

C.4.4 Generating Supplementary Fractions

C.4.4.1 Generating FTM, FTS Topography Fractions

[1] The supplementary fractions FTS and FTM for each DFFG cell can be generated independently (of other fractions) from the DEM (Digital Elevation Maps), more specifically the SRTM (Shuttle Radar Topographic mission) and GTOPO30 (Global TOPOgraphy) data.

C.4.4.1.1 Outline

[1] The computation of FTM and FTS fractions is done in two stages. In the first stage, the topography indices (which characterize the topography over a region) are derived from the DEM data. The computation of topography indices is based on the study [ORD 8 Flagging the Topographic Impact on the SMOS Signal]. This study derives a computation method for topography indices and establishes their thresholds for moderate and strong topography (TH_TOPO_IDX_TM, and

TH_TOPO_IDX_TS, respectively). In the second stage for each DFFG cell the percentage of its surface that falls within regions characterized by medium or strong topography (characterized as such through topography indices) is computed. These percentages represent the FTM and FTS fractions. The FTS fraction contribution is included in the FTM fraction [AAD 1].

[2] The proposed approach for topography [80], is to process a global DEM so as to have for every node a descriptor of the topography [AAD 1].

[3] The topography descriptor selected (topography index) is the ***a*** parameter of Variogram Parameters of Topography (VPT) [ORD 8].

[4] From the topography indices and the two thresholds, three topography levels can be identified, featuring weak (or non-existent), moderate, and strong topography. A mapped topography index above threshold TH_TOPO_IDX_TS (value 3.04 in the study) indicates a region of strong topography. An index above TH_TOPO_IDX_TM (value 2.17) indicates moderate / strong topography. For a given DFFG, a moderate topography fraction (FTM) and strong topography fraction (FTS) can be computed.

C.4.4.1.2 Detail

[1] Elevation data in SRTM is equiangular spaced at 3 arc second (approximately 90m resolution) and is available between 60 degrees latitude North and 60 degrees latitude South.

[2] Elevation data in GTOPO30 is also equiangular, spaced at 30 arc second (approx 900m resolution) and is available for the whole world.

[3] For Antarctica (covered by GTOPO30), however, the current algorithm of computing the ***a***-indices cannot be applied directly, because of the high distortion introduced in surface evaluation (and slopes) due to the equiangular data sampling. The special tile ANTARCPS (in polar projection) could be used.

C.4.4.1.2.1 FTM, FTS computation from SRTM data

[1] The topography index is the first coefficient, ***a***, of the model of the covariogram. More detail on the ***a***, ***b***, ***c*** coefficients and their meaning are given in [ORD 8].

[2] SRTM data is given in tiles of 5° longitude x 5° latitude and covers 360° longitude and 120° in latitude (from 60S to 60N). Therefore, there are 72 tiles in the longitude direction and 24 tiles in the latitude direction, as in figure below.

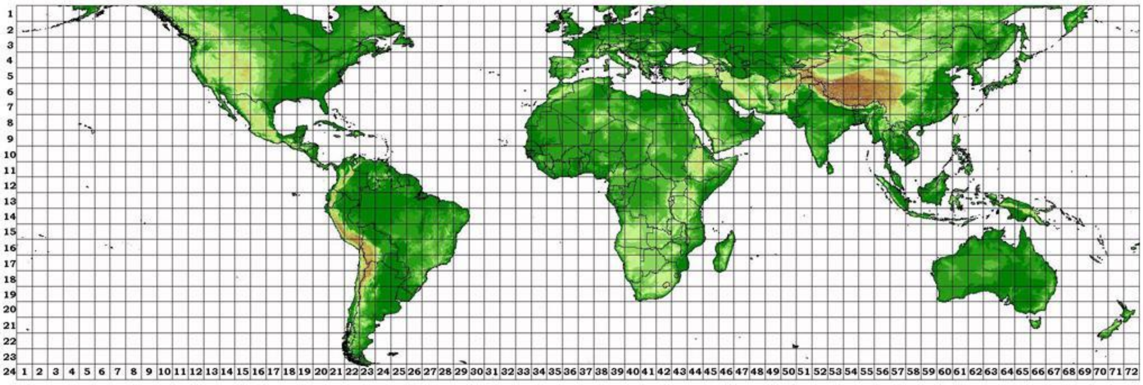


Figure 10. SRTM data partitioned in 5° lon x 5° lat tiles (72 x 24 tiles), between latitude 60N and 60S.

[3] By coincidence the 72 columns of SRTM tiles and their positioning in latitude coincide with DFFG zones 2-73. However, DFFG zones extend in latitude from 75N to 60S and the numbering differs (SRTM columns 1 to 36 correspond to DFFG zones 38 to 73, while SRTM columns 37 to 72 correspond to DFFG zones 1 to 36). Each SRTM tile has 6000 x 6000 samples.

[4] The topography indices, (or VPT coefficients 'a'), are computed for each 5°x5° SRTM tile using the variogram method. In order to estimate the VPTs, a region of 120 x 120 samples is needed (which correspond to 10.8km x 10.8km for SRTM, considering 90m for spatial resolution) [ORD-8].
NOTE: The SRTM spatial resolution in longitude changes as the latitude progresses from Equator toward north or south. However, 90m (equatorial resolution) is the resolution selected in [ORD 8] for the study over France (where at latitudes ~45-50N SRTM resolution in longitude is actually ~60m). The thresholds obtained in [ORD 8] were based on the 90m resolution.

[5] As in [ORD 8], for each SRTM tile (6000 x 6000 samples) there are obtained 50 x 50 'a' indices (or topography indices). (Note: in [ORD 8] there were 18000 x 18000 SRTM samples selected, from which resulted 150 x 150 'a' indices).

[6] The variogram is computed as follows:

$$V(k) = \frac{1}{4 \cdot N \cdot N}\left(\sum_{m=1}^{N}\sum_{n=1}^{N}\left(Im(m,n) - Im(m,n-k)\right)^2 + \sum_{m=1}^{N}\sum_{n=1}^{N}\left(Im(m,n) - Im(m-k,n)\right)^2\right)$$

with Im(m,n) denoting the (m,n) pixel of image, Im(m,n-k) = 0 for n-k <=0, Im (m-k,n) = 0 for m-k <= 0 and N = 40. NOTE: This variogram is computed by shifting the image once in the horizontal and once in the vertical direction. It corresponds to the function 'variogram' implemented in 'variogram.pro' [ORD 8].

[7] Sample maps of topography indices (50 x 50 over each 5°x5° SRTM tile) are presented below

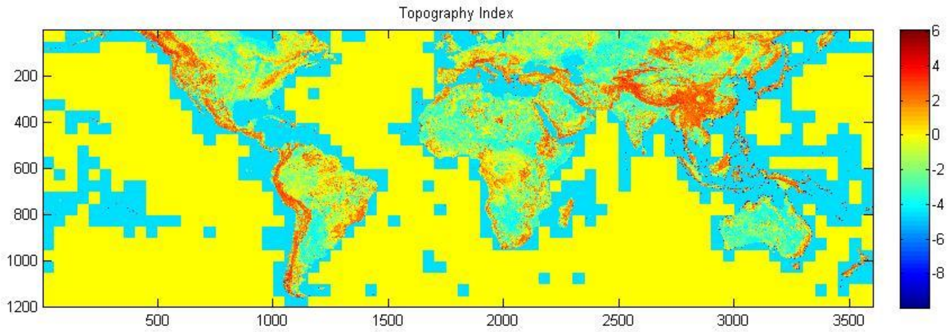


Figure 11. Topography indices for whole SRTM-covered region.

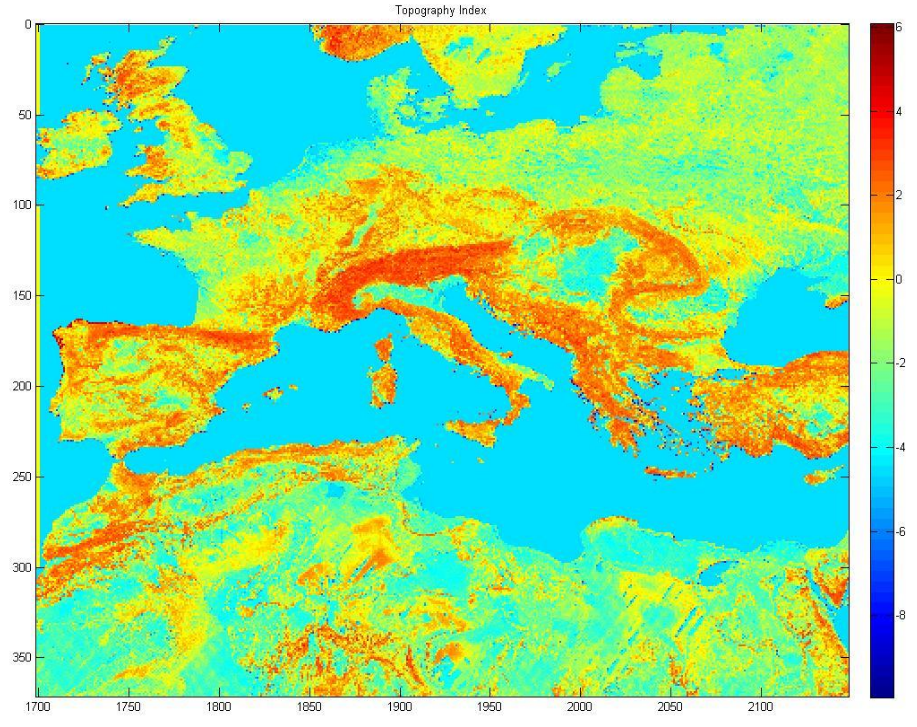


Figure 12. Topography indices for Europe.

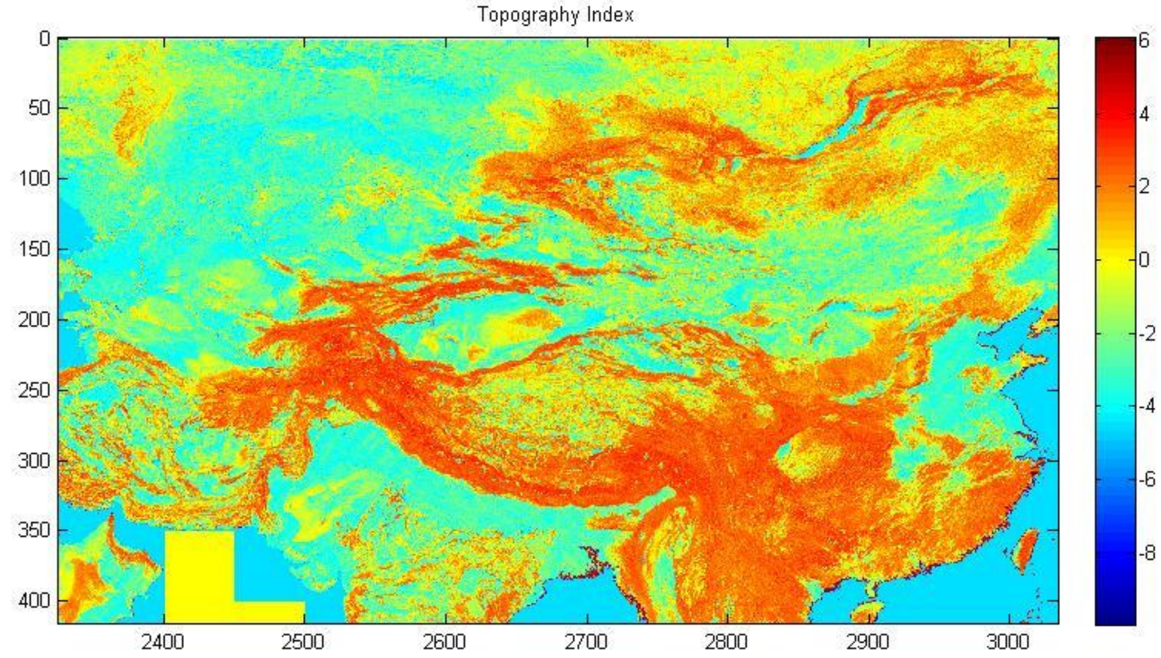


Figure 13. Topography indices for Asia, showing weak to moderate topography indices for the Tibetan plateau (although at high altitude ~4000m). (Note: slightly distorted due to equiangular data at 30N-40N latitude).

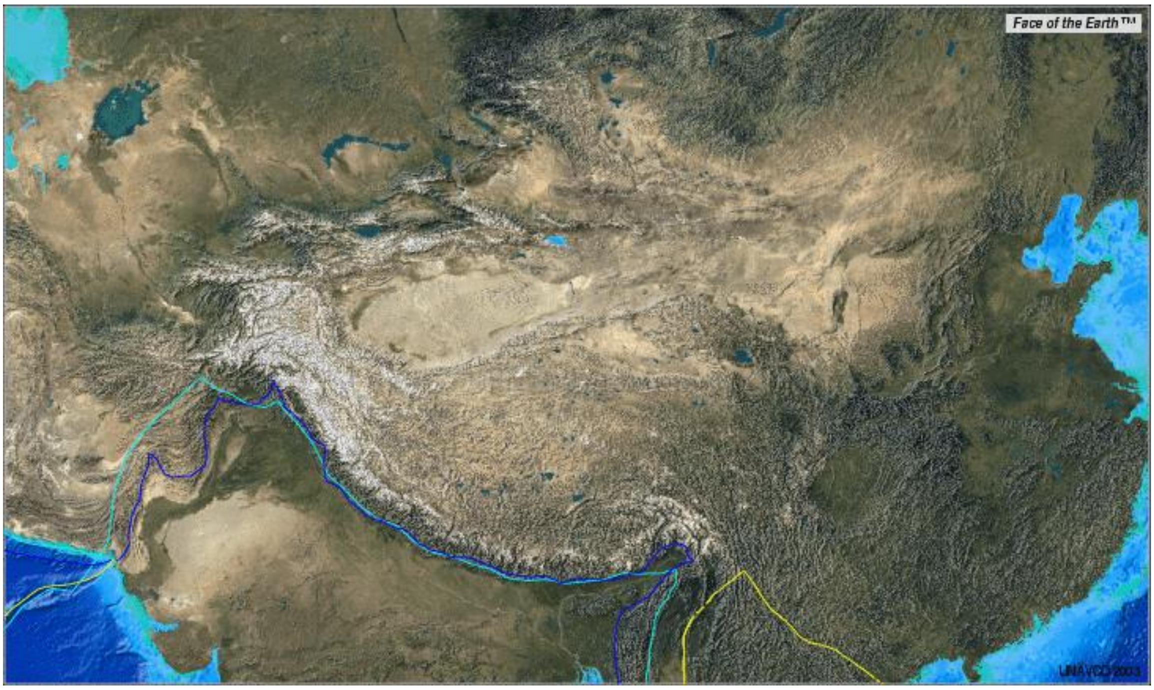


Figure 14. Physical image (satellite photo) of Tibetan plateau and Himalayan chain.

[8] Based on the precomputed indices and the selected thresholds (TH_TOPO_IDX_TM = 2.17 and TH_TOPO_IDX_TS = 3.04), the FTM and FTS fractions are computed at DFFG level. For each DFFG cell area, the percentage overlapped by surface corresponding to ***a*** > TH_TOPO_IDX_TM contributes to FTM, while the percentage overlapped by surface corresponding to ***a*** > TH_TOPO_IDX_TS contributes to both FTS and FTM.

[9] Sample contributions of topography indices regions to a DFFG cell, and FTM, FTS computation is presented in figure below

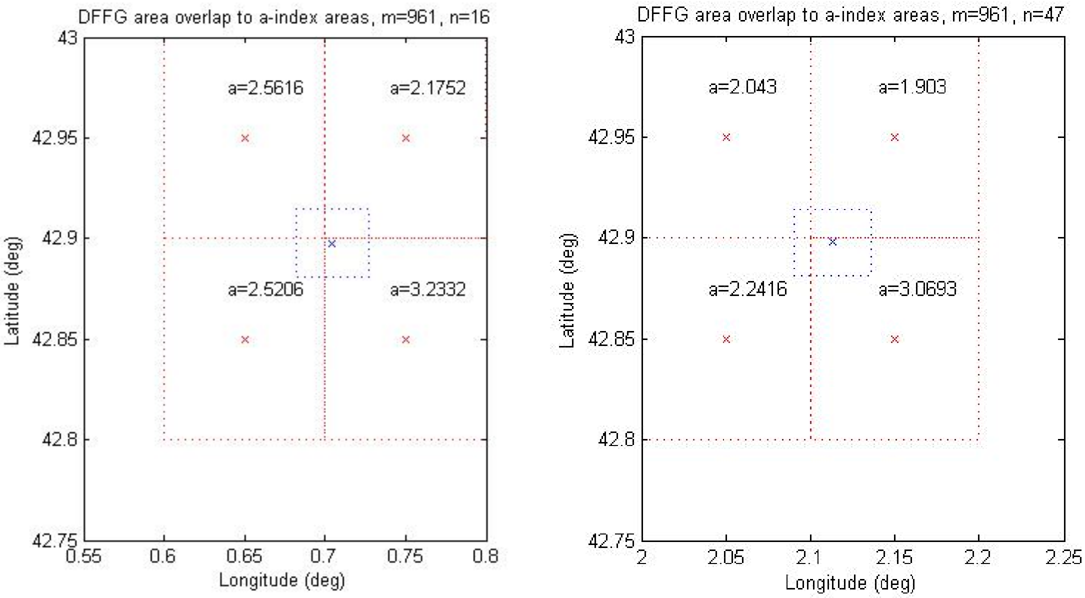


Figure 15. Computation of FTM, FTS for two DFFG cell (region marked with blue dots) using overlapping regions of topography indices (, regions marked with red dots).

For DFFG cell shown in above left figure (DFFG zone 2, latitude row 961, longitude column 16) FTM = 100 and FTS = 34.08, while for DFFG cell shown in above right figure, FTM = 56.80, and FTS = 45.44 (fractions in percentages). Note that FTM percentage includes FTS percentage

As topography indices are obtained on a equiangular grid (from the equiangular initial data), the DFFG cell region is computed in latitude-longitude as well, for surface area mapping. NOTE: for small regions as DFFG cells (less than. 4km x 4km) the surface percentages computed using lat-lon or surface distances are equivalent.

FTM and FTS percentages are computed as detailed below:

$$FTM(DFFG_{mn}) = 100 \sum_{A,\, A \cap DFFG(m,n) \neq \emptyset} \frac{A_{ij} \cap DFFG_{mn} \cdot (a_{ij} > TH\_TOPO\_IDX\_TM)}{\sum_{A,\, A \cap DFFG(m,n) \neq \emptyset} A_{ij} \cap DFFG_{mn}}$$

$$FTS(DFFG_{mn}) = 100 \sum_{A,\, A \cap DFFG(m,n) \neq \emptyset} \frac{A_{ij} \cap DFFG_{mn} \cdot (a_{ij} > TH\_TOPO\_IDX\_TS)}{\sum_{A,\, A \cap DFFG(m,n) \neq \emptyset} A_{ij} \cap DFFG_{mn}}$$

[10] FTS and FTM are written in units of 0.5 percentages in the DFFG fractions info file, to make use of the 256 unit range. Samples of FTM obtained over Asia (to be compared with Figure 7 and Figure 8) are presented in figures below (scale 0-200 for 0-100%):

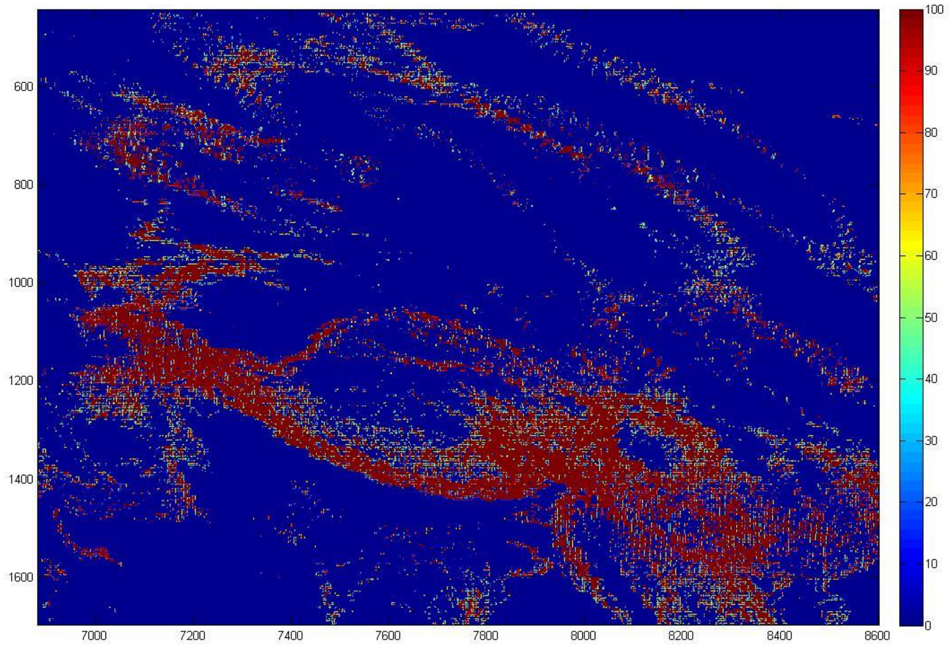


Figure 16. FTM fractions obtained from SRTM data over Asia, including Tibetan plateau. To be compared with Figure 15 and Figure 16.

NOTE: The chainsaw effect, seen on the upper right corner of figure showing FTM, FTS fractions, is due to the projection used for the DFFG data (DFFG rows shorten as latitude moves from Equator, and the effect is more visible than over Europe due to accumulated differences).

C.4.4.1.2.2 FTM, FTS computation from GTOPO30 data

[1] GTOPO30 DEM data is given between 60S and 90N latitude in tiles of 40° lon x 50° lat and covers the entire longitude domain (27 tiles, of 6000 x 4800 points). Southern part below 60S latitude is covered by 6 tiles of 60° lon x 30° lat (6 tiles of 3600 x 7200 points).

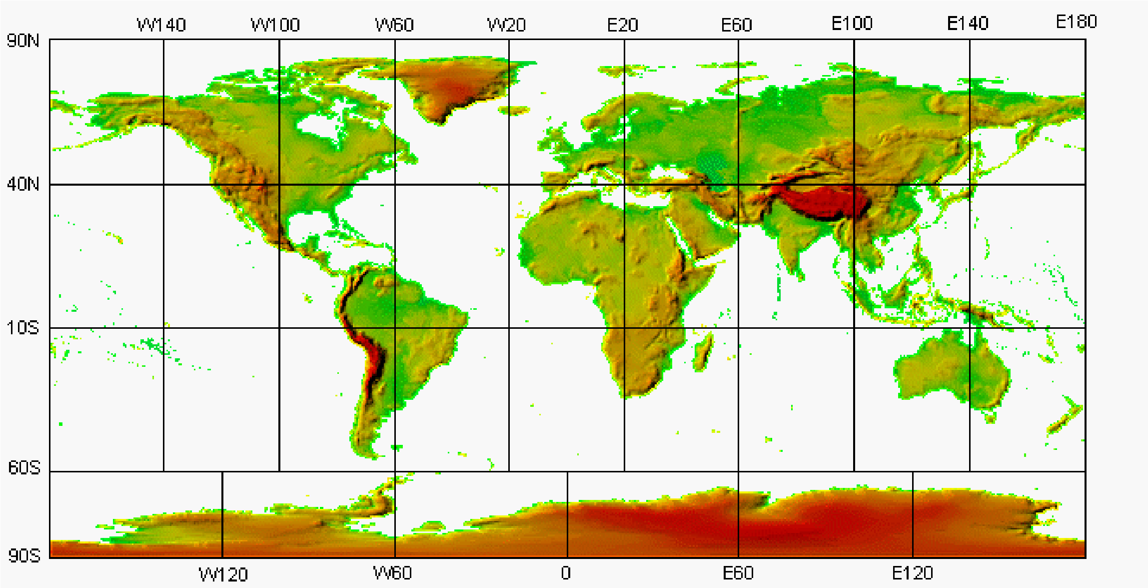


Figure 17. GTOPO30 DEM data partitioned in 27 + 6 tiles, covering entire Earth.

[2] GTOPO30 data is used to obtain the topography indices ***a*** between 60N-75N latitudes for all DFFG zones (2-73) and for the polar DFFG zone 0 (75N to 89N, over all longitudes).

[3] FTM and FTS over zone 1 are all set to zero.

[4] The GTOPO30 data, spaced at equal angles of 30 arc-second is spaced in distance at approximately 900m in latitude and approximately 900m in longitude at Equator. In order to compute the variogram over 40 points, the computation window of 120 x 120 points would result in an area of around 108km x 108km, which is too wide for a single topography characterization (light, medium or high). Moreover, the variogram over such a wide area does not have the shape looked for in [ORD 8].

[5] In order to obtain the topography from a higher density of samples, an interpolation with 4 was used, which results in data spaced at around 225m x 225m and obtains topography indices for surfaces of around 27km x 27km. Figure below shows the interpolation effect on DEM and variogram shape. Interpolation with 4 brings the topography index for a mountaneous area (e.g. Pyrinees into the strong topography region, > 3.04)

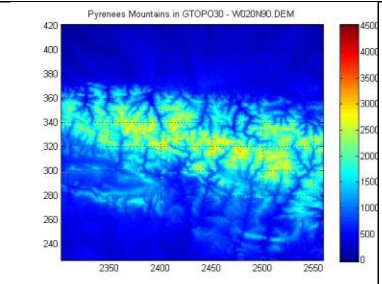
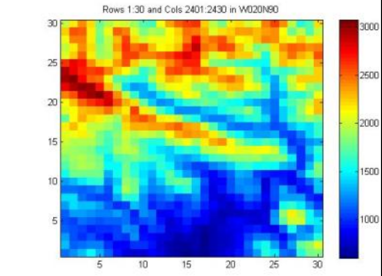
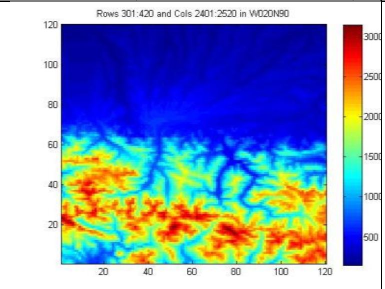
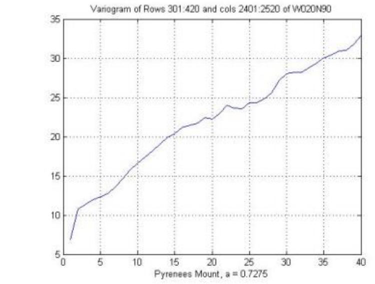
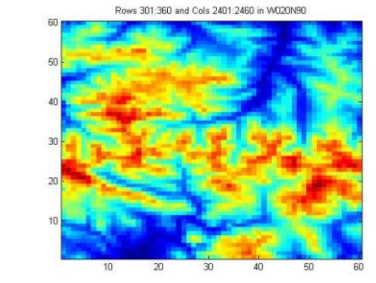
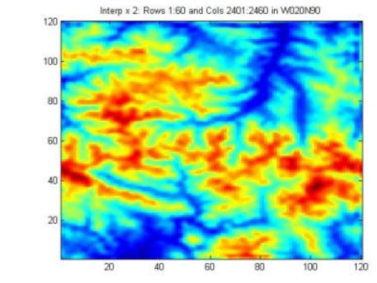
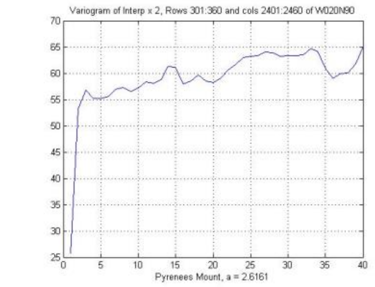
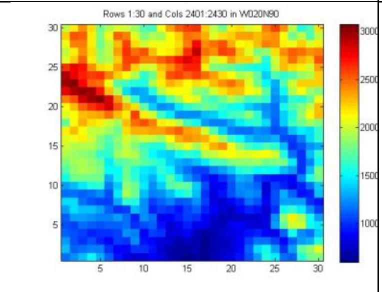
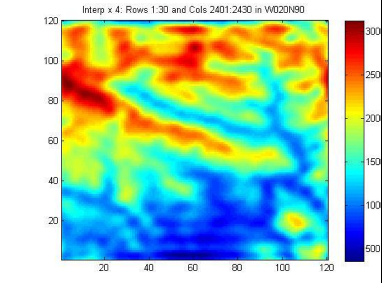
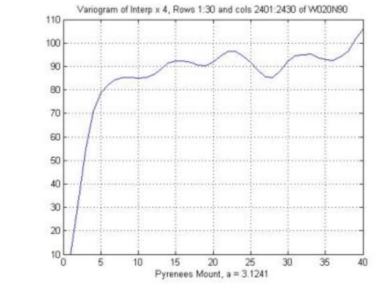
		On the left: sample area of interest in the Pyrinees mountains (27x27km). Outmost left: Pyrinees mountains in W020N90.
Pyrinees Mountains in W020N90	W020N90 (301:330, 2401:2430)	
At the GTOPO30 spacing a computation window of 120 x 120, (right column), may contain significant areas of mixed topography (e.g. mountain and piedmont). Variogram in rightmost column does not signal topography presence (low index).		
	W020N90 (301:420, 2401:2520)	Variogram, a = 0.7275
		
	Interpolation by 2	Variogram, a = 2.6161
		
	Interpolation by 4	Variogram, a = 3.1241

Figure 18. Sample of interpolation effect on the topography index computation from GTOPO30 data.

[6] Figure below shows topography indices obtained north of 60N from GTOPO30.

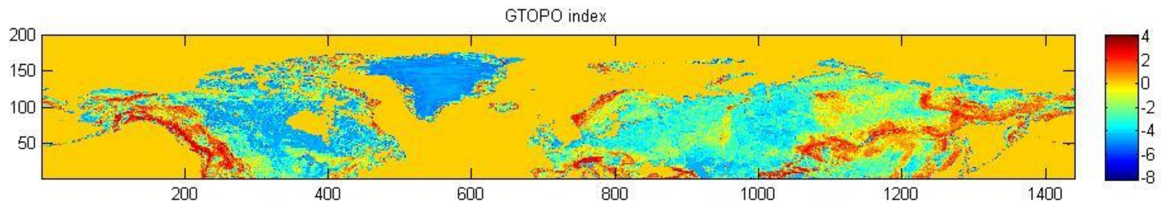


Figure 19. Topography indices computed from GTOPO30 data interpolated by a factor of 4.

[7] North of 60N latitude, due to the GTOPO30 data equiangular spacing and variogram computation on a fixed window, more than 4 regions characterized by the same topography index overlap a DFFG cell area, as shown in figure below (where over Groenland, a DFFG region overlaps 6 regions of 30x30 points obtained from GTOPO30:

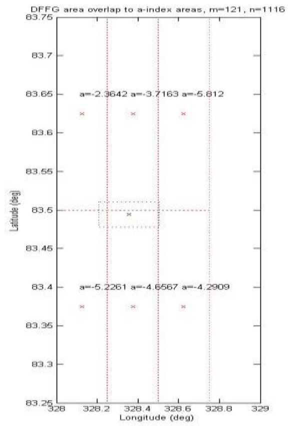


Figure 20. Sample overlapping between a DFFG cell (contour of blue dots) and regions of equal topography indices (contours of red dots) computed from GTOPO30

[8] Sample of FTM fractions obtained from GTOPO30 using the same formulas as for SRTM, (given above) are shown in the figure below (north of Europe, presented combined to the ones obtained from SRTM for comparison).

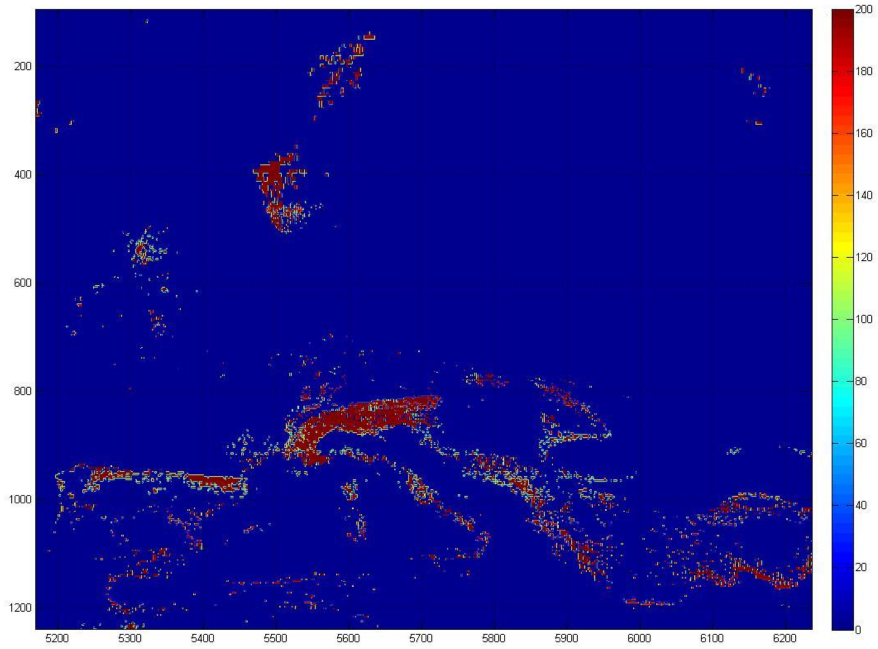


Figure 21. FTM fractions over Europe and up to 75 latitude North, obtained from SRTM and GTOPO30 data (with border between source data at rows 448,449). (Values multiplied by 2).

C.4.4.1.3 Possible improvements in FTM, FTS estimation

[1] Equivalence between topography indices (and implicitly their thresholds TH_TOPO_IDX_TM, TH_TOPO_IDX_TS) could be established dependent on the initial data they are derived from. (E.g. by computing indices for the same surface independently from overlapping SRTM and GTOPO30 data).

[2] SRTM and GTOPO30 data (both on equiangular grid) could be first interpolated/resampled on a equisurface grid and the variogram, a-indices to be computed on such interpolated/resampled data.

[3] Variogram computation can be improved by shifting center data within the computation window in both directions (i.e. left too, for horizontal shift and down too, for vertical shift).

[4] Topography for Antarctica could be computed from ANTARCPS polar projection file (separate file provided by the GTOPO30 provider).

Appendix D – Description of the Generation of the Sky Radiation (TB_{sk}) in, Table 12

D.1 Implementation of Generating Sky Radiation (TB_{sk})

[1] The implementation includes in general the following two steps:

1. Generate Sky TB_h and TB_v from the first Stokes and Second Stokes
According to the definition:

$$TB = \begin{bmatrix} I \\ Q \end{bmatrix} = \begin{bmatrix} TBv + TBh \\ TBv - TBh \end{bmatrix}$$

Then

TBv=(I+Q)/2
TBh=(I-Q)/2

Where, I is the first Stokes, Q is the second Stokes. These two are provided in the SMOS L1 Auxiliary Data as L-Band Galaxy Map Data Set Record. TBv is for vertical polarization Sky TB, and TBh is for horizontall polarization Sky TB.

According to the technical note '**Generation of a sky map to be used in Lvl1 and Lvl2 processors'** from Steven Delwart and Nicolas Floury on July 05, 2007, the input Sky map (v2.0) provides
Channel 1: I'=(I_H+I_V)/2 =(TBh+TBv)/2, half of the 1st Stokes
Channel 2: Q, 2 nd Stokes
Then

TBv=(2I'+Q)/2
TBh=(2I'-Q)/2

Each of them is with size 721x1441 associated with celestial sphere angular coordinate (δ, α) with step size 0.25°x0.25°.
An example Sky TBv/h is quite similar like the one showing in the following figure in ATBD [AAD 1].

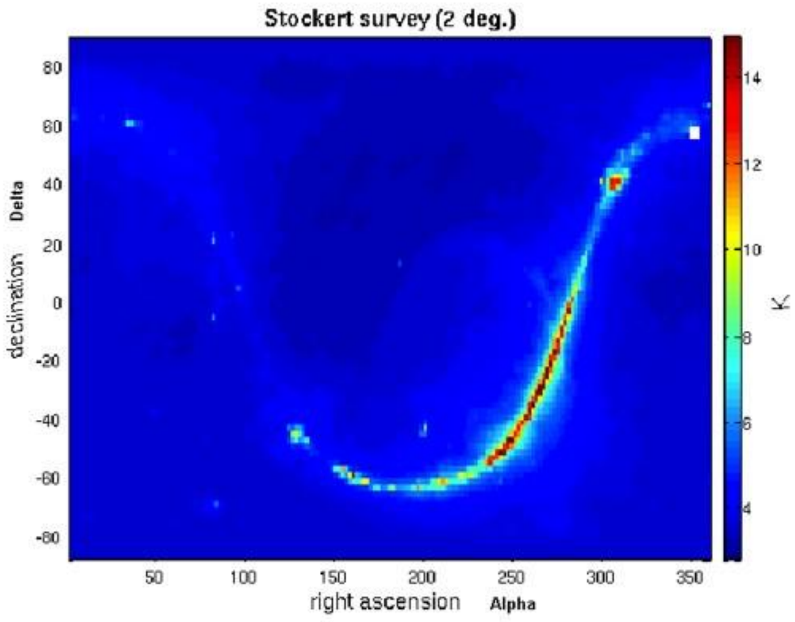


Figure 22. Stockert Map

2. Integration of Sky TB_h and TB_v over the Antenna Pattern

According to the ATBD [AAD 1], it is necessary to integrate the reflected brightness temperature over the antenna pattern to obtain the sky contribution to the signal exactly as for a ground element.

The antenna smoothes (integrates) the incident radiation, and, as a result, the values observed can be significantly different from the peak values. This is especially true in the vicinity of the galactic plane, which is relatively narrow.
When the antenna pattern is axially symmetric, it is possible to make the integration on δ and α and thence to precompute (in TGRD) customized galactic maps integrated over an average apodisation window after reflection on the surface. In our SMPPD, fortunately, the antenna pattern/WEF and MEAN WEF is just the conceptual case with center symmetric approximation.

The integration procedure for a DGG with a specific view is depicted in the following figure.

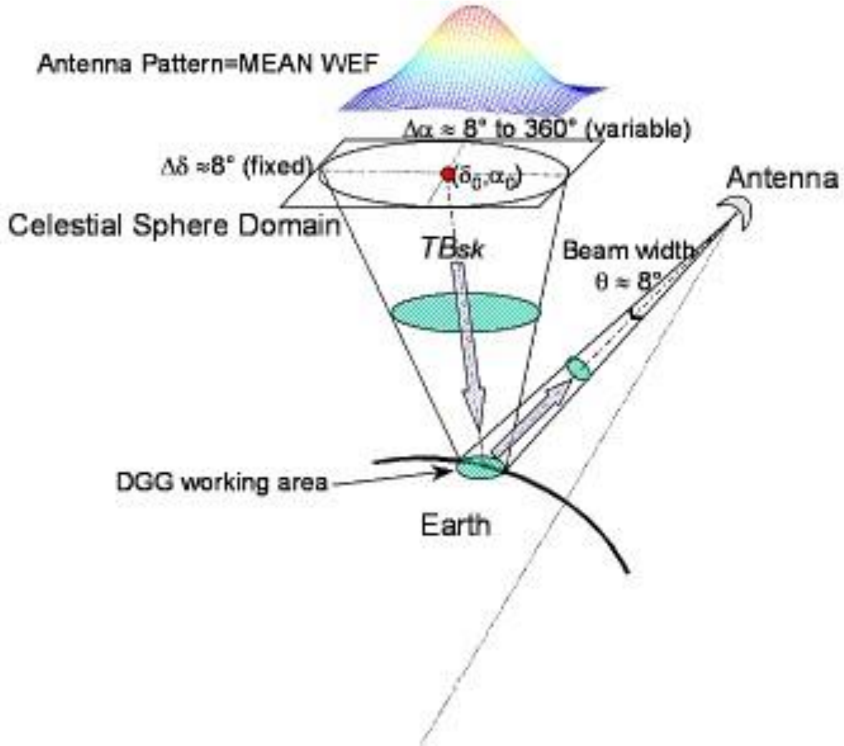


Figure 23. Integration Procedure for a DGG with a Specific View

According to the definition of MEAN WEF, the antenna beam width θ is about:

sin(θ/2)=WEF_SIZE/2*π/C_MWEF1/C_WEF1

Then

θ =2*asin(WEF_SIZE/2*π/C_MWEF1/C_WEF1)
=2*asin(123/2*π/40/73.3)*180/π
=7.5566°

According the technical comments from ESL, in the case of the sky radiation, what we need is not exactly the MEAN_WEF, because we do not need the "pedestal" part of the MEAN_WEF. The MEAN_WEF function for Sky Radiation is only limited to the main lobe. Finally, the antenna beam width width θ is adjusted from above with the following processing:

θ = 2* C_MWEF1/ WEF_SIZE *7.5566°=4.9149°

On the celestial sphere, the covering circle area centered on (δ_0,α_0) by the antenna beam width is approximately a Δδ≈5° circle in δ direction. But along α direction, the covering Δα depends on the δ_0. At δ_0=0°, Δα ≈5°, but at δ_0 around 90°, Δα is 360°.

The following two processing sub-steps are for the integration procedure to each Sky TBv/h(δ,α) at every celestial sphere coordinate (δ,α) to form TBsk_h/v(δ, α) at the point (δ, α):

a. According to the half beam width θ/2 of MEAN WEF, search all points around current point (δ,α). This step is based on the following criteria according to the Reference [87] in ATBD [AAD 1]. To determine Θ_i from the antenna bore sit at (δ,α) to the point (δ_i,α_i) around it, use the equation below:

$$\cos(\Theta_i) = \cos(\delta_0)\cos(\delta_i)\cos(\alpha_0 - \alpha_i) + \cos(\delta_0)\cos(\delta_i)$$

If the Θ_i is within [0, θ/2], the point (δ_i, α_i) is inside the antenna beam. And its value Sky ***$TB_{v/h}(\delta_i, \alpha_i)$*** will be used for further processing in **Step.b** below.

This step will also find the index of MEAN WEF for the point (δ_i,α_i) according to Θ_i and angle step of the MEAN WEF. Then the weighting factor value ***mean_wef(Θ_i)*** is obtained.

b. To derive the TBsk_h, and TBsk_v for each (δ, α) celestial sphere point:

This can be achieved easily with the result from **Step.a.**

Sum over all data points within the beam width, and at same do the normalization:

$$TBsk\_h(\delta,\alpha) = \frac{1}{\sum mean\_wef(\Theta_i)} \sum mean\_wef(\Theta_i) \cdot TB_h(\delta_i,\alpha_i)$$

$$TBsk\_v(\delta,\alpha) = \frac{1}{\sum mean\_wef(\Theta_i)} \sum mean\_wef(\Theta_i) \cdot TB_v(\delta_i,\alpha_i)$$

The TBsk_h (for H-pol) and TBsk_v (for V-pol) are the required values in Eq.9 in ATBD [AAD 1].

Appendix E – Updates to AUX_DFFFRA using ESA-Globcover (DELETED)

[1] This appendix was deleted in v06.50 because from L2SM v06.50 onwards, AUX_DFFFRA is generated based on “Simplified” IGBP. ESA-Globcover is no longer used.

Appendix F – Use of IGBP in AUX_DFFFRA and AUX_LANDCL

[1] This appendix was added in v06.50 because from L2SM v06.50 onwards, AUX_DFFFRA is generated based on “Simplified” IGBP.

[2] The following two tables are taken from [CRD 5]. Please refer to that document for more details.

Table 84. Aggregation of IGBP Land Cover Ecosystems to AUX_DFFFRA

LANDCOVER CODE	Name	DT aggreg class
0	Special Discard LC Marker	None:0
1	Evergreen Needle leaf Forest	CFO:2
2	Evergreen Broadleaf Forest	CFO:2
3	Deciduous Needle leaf Forest	CFO:2
4	Deciduous Broadleaf Forest	CFO:2
5	Mixed Forests	CFO:2
6	Closed Shrublands	CNO:1
7	Open Shrublands	CNO:1
8	Woody Savanas	CFO:2
9	Savanas	CNO:1
10	Grasslands	CNO:1
11	Permanent Wetland	CNO:1
12	Croplands	CNO:1
13	urban and Built-Up	CNO:1
14	Cropland/Natural Vegetation Mosaic	CNO:1
15	Snow and Ice	CEI:7
16	Barren or Sparsely Vegetated	CNO:1
17	Ocean water (Saline)	CWS:5
18	Open Water (Pure)	CWP:4

Table 85. AUX_LANDCL Content

LANDCOVER CODE	Name	DT aggreg class	HR	HR_MIN	QR	NR_H	NR_V	CL	BS_L	a_L	b_L	b'	b"	Omega_H	DIFF_Omega	TT_H	RTT	B_t	DLCC
0	Special Discard LC Marker	None:0	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999	-999
1	Evergreen Needle leaf Forest	CFO:2	0.3	0.3	0	2	0	0	0.3	2.33	0	0.11	0.03	0.06	0	1	1	1.5	0.1
2	Evergreen Broadleaf Forest	CFO:2	0.3	0.3	0	2	0	0	0.3	2.33	0	0.18	0	0.06	0	1	1	1.5	0.1
3	Deciduous Needle leaf Forest	CFO:2	0.3	0.3	0	2	0	0	0.3	2.33	0	0.11	0.03	0.06	0	1	1	1.5	0.1
4	Deciduous Broadleaf Forest	CFO:2	0.3	0.3	0	2	0	0	0.3	2.33	0	0.13	0.05	0.06	0	1	1	1.5	0.1
5	Mixed Forests	CFO:2	0.3	0.3	0	2	0	0	0.3	2.33	0	0.11	0.03	0.06	0	1	1	1.5	0.1
6	Closed Shrublands	CNO:1	1	0.05	0	2	0	0	0.3	2.33	0	0.06	0	0	0	1	1	1.7	0.1
7	Open Shrublands	CNO:1	1	0.05	0	2	0	0	0.3	2.33	0	0.06	0	0	0	1	1	1.7	0.1
8	Woody Savanas	CFO:2	0.3	0.3	0	2	0	0	0.3	2.33	0	0.18	0	0.06	0	1	1	1.5	0.1
9	Savanas	CNO:1	0.1	0.05	0	2	0	0	0.3	2.33	0	0.06	0	0	0	1	1	1.7	0.1
10	Grasslands	CNO:1	0.1	0.05	0	2	0	0	0.3	2.33	0	0.06	0	0	0	1	1	1.7	0.1
11	Permanent Wetland	CNO:1	0.1	0.05	0	2	0	0	0.3	2.33	0	0.06	0	0	0	1	1	1.7	0.1
12	Croplands	CNO:1	0.1	0.05	0	2	0	0	0.3	2.33	0	0.06	0	0	0	1	1	1.7	0.1
13	urban and Built-Up	CNO:1	0.1	0.05	0	2	0	0	0.3	2.33	0	0.06	0	0	0	1	1	1.7	0.1
14	Cropland/Natural Vegetation	CNO:1	0.1	0.05	0	2	0	0	0.3	2.33	0	0.06	0	0	0	1	1	1.7	0.1
15	Snow and Ice	CEI:7	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
16	Barren or Sparsely Vegetated	CNO:1	0.1	0.05	0	2	0	0	0.3	2.33	0	0.06	0	0	0	1	1	1.7	0.1
17	Opean water (Saline)	CWS:5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	Open Water (Pure)	CWP:4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix G – Updates to AUX_DFFFRA using ESA-CCI FWO

[1] This appendix was added in v7.0.1 because from L2SM v7.0.0 onwards, AUX_DFFFRA is generated now using CCI RADAR WB from CCI FWO.

Versions :

1. IGBPS DFFFRA V650 + CCIFWO 1km – exception cases based on default FNO/LC=10, FWP/LC=18
2. IGBPS DFFFRA V650 + CCIFWO 1km – exception cases based on closest valid DFFG
3. IGBPS DFFFRA V650 + CCIFWO native 150m - exception cases based on closest valid DFFG

Inputs for V3 (current):

- $DFFFRA^{ref}$: L2SM v650 AUX_DFFFRA ADF SM_TEST_AUX_DFFFRA_20050101T000000_20500101T000000_001_006_9
- FWO^{src} : aggregation of CCI RADAR WB 150m v4.0 product to DFFG cells (ftp://anon-ftp.ceda.ac.uk/neodc/esacci/land_cover/data/water_bodies/v4.0/ESACCI-LC-L4-WB-Map-150m-P13Y-2000-v4.0.tif)

The DFFFRA is defined by a set of N DFFG cells index DFFFRA= $\{k\}_{1\leq k\leq N}$
Each cell $DFFG_k$ contains the following data that consists in Fxx fractions of aggregated land-cover classes along with their dominant land-cover classes Cxx and superimposed strong and medium topography fractions FTS and FTM.

$$\overrightarrow{FLA}_k = (FNO_k, FFO_k, FEB_k, FEI_k, FEU_k)$$
$$\overrightarrow{CLA}_k = (CNO_k, CFO_k, CEB_k, CEI_k, CEU_k)$$
$$FLA_k = FNO_k + FFO_k + FEB_k + FEI_k + FEU_k$$
$$\overrightarrow{FWO}_k = (FWP_k, FWS_k, FWL_k)$$
$$\overrightarrow{CWO}_k = (CWP_k, CWS_k, CWL_k)$$
$$FLO_k = FWP_k + FWS_k + FWL_k$$
$$\forall k, FLO_k + FLA_k = 1$$

Replacing the water fractions of a reference $DFFFRA^{ref}$ by a source DFFG FWO^{src} to create target $DFFFRA^{tgt}$ can be viewed as a two steps procedure:

1. The 1st step consisting in drying $DFFFRA^{ref}$ DFFG cells to a $DFFFRA^{dry}$ containing no more water in DFFG cells.
2. The 2nd step consisting in flooding the $DFFFRA^{dry}$ DFFG cells with a DFFG FWO^{src} map having fractions from none FWO=0, to possibly partial 0<FWO<1, up to complete FWO=1.

Step 1: drying

The $DFFFRA^{ref}$ DFFG cells are partitioned into two sets, pure water body cells PWO having all their FLA equal to 0 and the complementary set NPW containing non-zero land fractions with FLA≠0.

$$PW^{ref} = \{k / FLA_k^{ref} = 0\}$$
$$NPW^{ref} = \{k / FLA_k^{ref} \neq 0\}$$

For DFFG cells belonging to NPW^{ref}:

$$\forall k \in NPW^{ref},\ (0{,}0{,}0) \rightarrow \overrightarrow{FWO}_k^{dry},\ \frac{\overrightarrow{FLA}_k^{ref}}{FLA_k^{ref}} \rightarrow \overrightarrow{FLA}_k^{dry}$$

For DFFG cell belonging to PW^{ref}, there is no existing land information to decide about the content about the dried cells and two options are possible:

1. A fast one by allocating 100% to a default land fraction e.g. FNO with a specific LC code e.g. grassland LC code 10.
2. A long one getting a copy of the closest cells (great circle distance) in the already dried set $\{\overrightarrow{FLA}_k^{dry}\}$.

The option 1 could generate some anomalies depending how far the source FWO^{src} are to the reference FWO^{ref}. The option 2 is always safer but longer as it involves many distances computations between grid points of an irregular and segmented grid. For best accuracy it is always the preferred option that can be described as following with $d(k,p)$ being the great circle distance between the two DFFG cells $DFFG_k$ and $DFFG_p$

$$\forall k \in PW,\ \ n = argmin_{p \in NPW}\big(d(k,p)\big),\ \overrightarrow{FLA}_n^{dry} \rightarrow \overrightarrow{FLA}_k^{dry},\ \overrightarrow{CLA}_n^{dry} \rightarrow \overrightarrow{CLA}_k^{dry}$$

Step 2: flooding

The second step involves the $DFFFRA^{dry}$, the $DFFFRA^{ref}$ and the $FWO^{src}$and is basically the opposite. The CCI RADAR water fractions product contains single fractions information i.e. it does not provide a category, pure water, saline water, or wetland. We will reuse, when existing, the relative contributions of (FWP, FWS, FWL) from the $DFFFRA^{ref}$ to dispatch the FWO^{src} i.e. for cells having FWO^{ref}≠0. For the other ones, those having FWO^{ref}=0, we perform an equivalent to option2 by fetching the closest FWO^{ref}≠0 to obtain (FWP, FWS, FWL).

We consider this time the DFFG cells partition into the set of the pure land cells PL^{ref} and the set of non pure land cells NPL^{ref}:

$$PL^{ref} = \{k / FLA_k^{ref} = 1\} = \{k / FWO_k^{ref} = 0\}$$
$$NPL^{ref} = \{k / FLA_k^{ref} \neq 1\} = \{k / FWO_k^{ref} \neq 0\}$$

Then:

$$\forall k \in DFFFRA^{dry},\ (1 - FWO_k^{src}) \times \overrightarrow{FLA}_k^{dry} \rightarrow \overrightarrow{FLA}_k^{tgt}$$
$$\forall k \in NPL^{ref},\ FWO_k^{src} \times \frac{\overrightarrow{FWO}_k^{ref}}{FWO_k^{ref}} \rightarrow \overrightarrow{FWO}_k^{tgt}$$
$$\forall k \in PL^{ref},\ p = argmin_{n \in NPL}\big(d(k,n)\big),\ FWO_k^{src} \times \frac{\overrightarrow{FWO}_p^{ref}}{FWO_p^{ref}} \rightarrow \overrightarrow{FWO}_k^{tgt}$$

Note: the topography FTS and FTM fractions remain untouched and are copied from $DFFFRA^{ref}$ to $DFFFRA^{tgt}$.