AMSU-A Level 1 Product Generation Specification

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Document Change Record

Issue / Revision	Date	DCN. No	Changed Pages / Paragraphs
Draft E	29/04/99		Based on the AVHRR/3 document
Draft F	23/07/99		CGSRR RIDs Implementation
Draft G	14/03/2000		Updates for CGS KO
			1.3 Applicable documents list update
			2.2 refinements
			2.3 refinements
			3.1 refinements of configured data bases
			3.2 refinements, introduction of quality control functions
			4.2 introduction of user configurability of calibration processing introduction of static parameter files removed relative azimuth angle (solar and satellite) introduced navigation tie points configurable, default every scan line and every sample
			4.4 introduction of quality control functions at product level and at scan line level introduction of online quality checks
			4.6 removed encoding and formatting of products
			Appendix B: introduced Configurable Auxiliary Database
			Appendix C: introduced Sample Auxiliary Database with calibration parameters and secondary calibration coefficients
Issue 2 Draft A	15/06/2000		Implementation of Mini-RIDs to Draft G
Issue 3 Draft A Internal draft	20/09/2000		Produced for Kick-off. Several issues still open. The Operations Concept section has been introduced (still preliminary in this issue). The AMSU-A Processor states have been identified: this is to be further refined. Explanatory text already in the document has been used to fill this section. Two new sections have been introduced to explicitly deal with Backlog Processing and Reprocessing (sections 3.2.2 and 3.2.3) Section 2 - Overview of the Processing Algorithms has been renamed Overview of the Instrument All SADT diagrams have been removed. Requirements are all included in Section 4 and have been grouped according to applicability (e.g., all requirements applying to Level 1b processing are included in subsections of the same section) Many comments have been added to the requirements to clarify their scope: this is to be checked by the scientists Science has been moved to a new section (Section 5 - Supporting Science) A new set of traceability matrices has been introduced (sections 3.5 and 4.11)
Issue 3 Draft A Internal draft			Wherever a TBD or TBC is encountered, have made an attempt to insert a note describing when and by whom the issue is expected to be resolved
Issue 3 Draft A Internal draft			All requirements starting with “The function shall....” have been re-phrased since there are no SADT functions any more

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			1 Completely altered to reflect restructuring Included the Document Evolution and Document Status sections describing the document's lifeline and status as well as the how TBCs and TBDs are to interpreted. Also the major issues still pending in Issue 3 Draft A are recorded, namely the full specification of the reprocessing and of the backlog processing as well as the algorithms in Section 5. Added a List of Acronyms (previously List of Abbreviations at the end of the document) Added the Definitions section.
			2 Largely altered to reflect restructuring
			2.1 removed
			2.2 renumbered to 2.1
			2.2.1 renumbered to 2.2
			2.2.2 renumbered to 2.3
			2.2.3 renumbered to 2.4
			2.3 content moved to Sections 3.2.1 and 3.2.4
			2.4 removed
			2.5 removed
			3 Completely altered to reflect restructuring
			3.1 restructured: DSADT diagram removed; list of dataflow converted to a table and moved to Section 3.3
			3.2 removed
			3.2.1 removed
			3.2.1.1 moved to Section 5.1.1 as to the Navigation Computation and to Section 5.1.2 as to the Calibration Coefficients Calculation.
			3.2.1.2 moved to Section 5.2
			3.2.1.3 moved to Section 3.4
			3.2.2 requirements re-numbered and moved to Section 4.1
			3.2.3 requirements re-numbered and moved to Section 4.2
			3.2.4 requirements re-numbered and moved to Section 4.3
			4 Completely altered to reflect restructuring
			4.1 SADT diagram removed; explanatory text moved to Section 4.4
			4.1.1 Requirements re-numbered and moved to Section 4.4.1
			4.1.2 Requirements re-numbered and moved to Section 4.4.2
			4.1.3 Requirements re-numbered and moved to Section 4.4.3
			4.2 SADT diagram removed; explanatory text moved to Section 4.5
			4.2 Item A) requirements re-numbered and moved to

Issue / Revision	Date	DCN. No	Changed Pages / Paragraphs
			Section 4.5.1
			4.2 Item B) requirements re-numbered and moved to Section 4.5.2
			4.2 Item C) requirements re-numbered and moved to Section 4.5.3
			4.2 Item D) requirements re-numbered and moved to Section 4.5.4
			4.2 Item E) requirements re-numbered and moved to Section 4.5.5
			4.2.1 SADT diagram removed; explanatory text moved to Section 4.5.6; requirements re-numbered and moved to Section 4.5.6
			4.2.1.1 SADT diagram removed; explanatory text removed. This section actually maps to Section 5.1.2.1
			4.2.1.1.1 moved to Section 5.1.2.1.1
			4.2.1.1.2 moved to Section 5.1.2.1.2
			4.2.1.1.3 moved to Section 5.1.2.1.3
			moved to Section 5.1.2.1.4
			moved to Section 5.1.2.1.5
			SADT diagram removed; explanatory text removed. This section actually maps to Section 5.1.2.2
			4.2.1.2.1 moved to Section 5.1.2.2.1
			4.2.1.2.2 moved to Section 5.1.2.2.2
			4.2.1.3 SADT diagram removed; explanatory text moved to section to Section 5.1.2.3
			4.2.1.4 SADT diagram removed; explanatory text moved to section to Section 5.1.2.4
			4.2.1.5 SADT diagram removed; explanatory text moved to section to Section 5.1.2.5
			4.2.2 SADT diagram removed; explanatory text moved to Section 5.1.1; requirements re-numbered and moved to Section 4.5.3
			4.2.2.1 moved to Section 5.1.1.1
			4.2.2.2 moved to Section 5.1.1.2
			4.2.2.3 moved to Section 5.1.1.3
			4.2.2.4 moved to Section 5.1.1.4
			4.2.2.5 moved to Section 5.1.1.5
			4.3 SADT diagram removed; explanatory text moved to Section 4.6; requirements re-numbered and moved to Section 4.6
			4.3.1 SADT diagram removed; explanatory text moved to Section 5.2
			4.3.1.1 moved to Section 5.2.1
			4.4 SADT diagram removed; explanatory text moved to Section 4.7
			4.4 Item A) requirements re-numbered and moved to Section 4.7.1

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			4.4 Item B) requirements re-numbered and moved to Section 4.7.2
			4.4 Item C) requirements re-numbered and moved to Section 4.7.3
			4.4 Item D) requirements re-numbered and moved to Section 4.7.4
			4.5 explanatory text moved to Section 4.8
			4.5 Item A) requirements re-numbered and moved to Section 4.8.1
			4.5 Item B) requirements re-numbered and moved to Section 4.8.2
			4.6 SADT diagram removed; explanatory text moved to Section 4.9
			4.6 Item A) Requirement ALG.A6.10 removed: all incoming data is assumed to be in EPS format, thus there is no need for specifying such requirement Requirement ALG.A6.20 re-numbered and moved to Section 4.9
			4.7 SADT diagram removed; explanatory text moved to Section 4.10 requirements re-numbered and moved to Section 4.10
			New TBDs/TBCs have been added. Some were implicit in the previous issue of the document; some others have been added
			Appendix A: The list of symbols has been checked: some mismatches have been identified but not yet corrected
Issue 3 Draft A Internal draft	13/10/2000		Second iteration of the restructuring process Change bars have not been used since this is still a draft document The wording “Side information” has been systematically replaced with “Auxiliary Data”. This is to be checked against the overall definition of Auxiliary Data.
			1.1 The Document Structure was wrongly cut and pasted from Issue 2 Draft A and did not mirror the new structure: now this is fixed Added a remark on the scope of the acceptance, which is limited to the requirements in Section 4. Section 3 and 5 are provided as guidelines.
			1.2 “in what document and issue” changed to “when and by whom”
			1.3 Updated Document Status
			1.4 Updated List of Acronyms
			Updated Definitions
			3. Completely reviewed

Issue / Revision	Date	DCN. No	Changed Pages / Paragraphs
			Added System Context figure Removed suspend/resume from the list of features the PGE is required to support Included introductory foreword Added note on timeliness requirements for the AMSU-A PGF, which are TBD by the Contractor Written the Backlog Processing Mode Completed the Reprocessing Mode Added the operational scenarios Added the Traceability Matrix
			4. Completely reviewed Re-numbered requirements Most requirements did not appear in the previous issue
Issue 3 Draft A	15.11.2000	DCN. SYS. DCN. 020	Re-structuring of the document
Issue 4 Revision 0	1.6.2001		1.2 Noted V1 second evolution.
			3 Removed trace table. Removed section describing 24/7 operation as that is already covered in CGSRD. Processor may or may not have had an opportunity to establish warm start parameter set. Cold start parameter set may also be appropriate under certain circumstances. Changed from “System Concept” to “System and Operations Concept.” Removed Use Case diagram. Restructured sections which heretofore separately considered the NRT backlog, and reprocessing modes, repeating many aspects, into a set of sections partitioned by processing level (0, 1a, 1b) with relevant remarks on NRT, Reprocessing, etc where necessary
Section 3.1, Section 3.2.1			Section 3.1, Section 3.2.1 Moved list of products and aspects of processing to section more appropriately concerned with what the PGF does than how components of the system work together.
Section 3.1.1			Section 3.1.1 Added section that provides a single reference on PGF states and transitions. This provides a clearer reference than the several separate sections that would have followed in prev. version.
			Section 3.1.2 Moved the section on major interfaces, which defines the system context, from its previous position near the end of this chapter to within the system context section
			Section 3.2 Changed name of section from operating modes to operations concept. Editorial changes to text. Dropped statement that each of the high-level states attainable is described for each mode. removed3 paras promising a detailed review of processing steps in each mode.

Issue / Revision	Date	DCN. No	Changed Pages / Paragraphs
			Removed note stating that operational situations were not part of the requirements. Removed “requirements section” (erstwhile Near-Real Time Mode section).Requirements like this belong in the req section. Removed disquisition on states in NRT mode. Removed header “Operational Scenarios in NRT Mode.” Changed name of Section 3.2.1.1 to “Level 0 Processing” from “NRT Level 0 Processing.” Removed routine L0 processing section as it is redundant. Removed routine L1a processing section as it is redundant. Removed routine L1b processing section as it is redundant. Removed the Stop Run and Abort Run scenarios as they are now redundant given “PGF States and Transitions” on page 12. Simplified operations in L0, 1a, and 1b processing. Noted that degraded operations are TBD.
			Section 3.2.1.1 Inserted phrase “The operations that take place in L0 processing are outlined in the list below. This list is not meant to be complete but to provide a context for understanding parts of the remainder of this document. Operations are not necessarily performed in the sequence shown.” Removed numbering, replaced with bullets. Noted “STOP and ABORT commands may be accepted at any time during the processing.”
			Section 3.2.1.2 Pulled this header up one level and stripped NRT and First Run from name. Numbered list now bulleted. Inserted “(It is foreseen that a user-configurable switch can be used to cause a set of cold-start parameters to be loaded instead of warm-start parameters, even if warm start parameters have been built up by previous runs of the processor. These would also be loaded if there were no warm-start parameters built up by the processor.)”
			Section 3.2.1.3 Pulled this header up one level and stripped NRT and First Run from name. Numbered list now bulleted.
			Section 3.2.1.4 “Supporting Functions” on page 16 Section moved from previous position near end of chapter
			Section 3.2.2 Removed discussion of split mission.
			Section 3.2.3“Backlog Processing Mode” on page 17 removed “The AMSU-A PGF shall switch to this mode

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			whenever the late arrival of any data needed for the processing does not allow to meet the timeliness constraints for the NRT Mode." Removed "The Backlog Processing Mode does not differ from the standard Near-Real Time Mode from the point of view of the processing." and replaced with "From the point of view of the PGF, processing is equivalent whether it is in backlog mode or in nominal mode. Thus the scenario for processing in Backlog mode is equivalent to that for Nominal mode (see above, Section 3.2.1.) Note in particular that the PGF may or may not have access to warm-start parameters, depending both on whether a sufficiently long history has been built up and whether the user-configurable switch (mentioned above) has been set to load warm- or cold start parameters." As the sections on states and scenarios were redundant (the states are as laid out in Section 3.1.1), they have been removed.
			Section 3.2.4 Removed "In particular, note that in the following sections the cases governing the 'first run' and 'routine run' operations have not been separately considered." Removed overview of states as it is redundant given the existence of "PGF States and Transitions" on page 12. Removed the sections on L0, L1a, and L1b processing that were "Operational Scenarios in Reprocessing Mode" as they are redundant. Added note that aux data are not necessarily those that would have been used during the original processing. Added note that a user-configurable switch can be set to allow the use of cold-start, or, if sufficient warm-start parameters have been built up, warm-start parameters in the processing, as appropriate.
			4. Removed landmark database See "AMSU-PGF-4.2-0010 MMI" on page 22. Removed section 4.13 – traceability matrices.
			4.9.1 Noted that functionality is described in section 5.2.
			5.2.2 Described functionality of derivation of limb-corrected brightness temperatures.
			Appendix B: AMSUA_L1_PGS_COF_ANTCOR, AMSU-A_L1_PGS_COF_LMBSEA, AMSU-A_L1_PGS_COF_LMBLND. Removed AMSU_A_L1_PGS_DAT_LANMAR K
Issue 5 Revision 0	12/11/2001		5. Added assumption on scan-line wise availability of information.

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			Added: Note on AMSU-A instrument and channel setup. Added: Scan line check for antenna position.
			Section 5.1.2.1 Section added to explain which parameters are needed from the calibration file.
			Section 5.1.2.4 Added: Averaging of first and second reading of the warm and cold target counts Antenna pointing checks for cold and warm target. Difference check between first and second calibration count reading. Check of line to line consistency of space and internal target counts.
			Section 5.1.2.2.2 Added: Check of PRT consistency on the scan line. Compute average PRT temperature. Check of line to line consistency of PRT temperatures.
			Section 5.3 Added: End of dump conditions and gap conditions.
Issue 5 Revision 1	04/06/2002	EUM.EPS. SYS. DCR. 02.110	Comments included from Algorithm Panel 15/03/2002 (cf. Minutes of meeting) Comments from internal review included (cf. Comment forms) Explicitly noted the derivation of surface type in 5.1. Comments from Nigel Atkinson (Met. Office; cf. Comment Forms)
			Requirement AMSU-PGF-4.1-0100 no longer refers to start/stop/abort. AMSU-PGF-4.1-0110, AMSU-PGF-4.1-0120, AMSU-PGF-4.1-0130 removed. Clarified term in AMSU-PGF-4.1- 0050 Requirement AMSU-PGF-4.1-0080 changed to: "The AMSU-A PGF shall be able to process any Auxiliary Data identified in this document as being used by it." AMSU-PGF-4.2-0040 Removed L1b reference. AMSU-PGF-4.2-0050 removed AMSU-PGF-4.4-0010 Added "from the full set of data supplied" Deleted requirement AMSU-PGF-4.4-0020 Removed AMSU-PGF-4.4-0030 Removed reference to AD 65 in AMSU-PGF-4.5-0030. AMSU-PGF-4.5-0060 removed. Eliminated point 5 from AMSU-PGF-4.7.1.1-0010
			Chapter 4. Deleted AMSU-PGF-4.7.1.1-0020 Deleted AMSU-PGF-4.7.1.1-0030 AMSU-PGF-4.7.1.1-0060 clarified and comment added. Ancillary data replaces auxiliary data in AMSU-PGF-4.7.1.2-0040 Removed point 2 in AMSU-PGF- 4.7.1.1-0070
			Removed point 2 in AMSU-PGF-4.7.2-0030 Replaced "subsequent navigation and calibration" with "subsequent processing" in AMSU-PGF-4.7.1.2-0050

Issue / Revision	Date	DCN. No	Changed Pages / Paragraphs
			Removed "generated" from AMSUPGF- 4.7.1.3-0020 AMSU-PGF-4.7.2-0010 Extended first point with "including quality information to be generated as specified in chapter 5" AMSU-PGF-4.7.2-0020 added a comment. Inserted the clause "in accordance with the specifications in Chapter 5"in AMSU-PGF-4.1-0010 Removed redundant text in 4.8. Changed "file" to "dataset" in AMSUPGF-4.8.1.1-0020 Removed application of coefficients from AMSU-PGF-4.8.1.1-0010 4.8.1.4-0010 removed. AMSU-PGF-4.8.1.5-0010 modified. AMSU-PGF-4.8.1.5-0020 and AMSUPGF-4.8.1.5-0030 extended to show maximum number of scan lines used. Removed AMSU-PGF-4.8.2.1-0040 Changed meant to mean in AMSUPGF-4.8.2.1-0160 Clarified comment in AMSU-PGF-4.8.2.3-0040 Removed point 4 from AMSU-PGF- 4.9.2-0010 Removed section 4.10 Requirement AMSU-PGF-4.6-0020 removed Corrected MHS to AMSU in AMSUPGF-4.12-0010
			5. Added Moon glint correction to Chapter 5. Modified Equation 17.
			Appendix A: Updated List of symbols
Issue 5 Revision 2	14 March 2003	EUM.EPS. SYS.DCR. 03.067	5. Added: “Except for the case of flags which are passed directly through from the level 0 data stream, where no other specification of the setting of a flag bit is identifiable from a combined reading and analysis of this document and the descriptions and/ or names of the flag bits in its associated PFS (AD40), the flag bits shall not be set, and where no other specification of the setting of a flag bit with a name or description in the PFS including the word 'some,' is identifiable in this document or its associated PFS, then the word 'some' in the bit name or description is to be taken to mean 'more than zero,' and where bits are indicated as not used in the PFS, these bits are not to be set”
Issue 5 Revision 3	6 April 2004	EUM.EPS. SYS.DCR. 04.030	Moon contamination chapter modified according to PLP's description, Added moon flag and threshold angles in the calibration data set description
Issue 5 Revision 4	15 May 2013	EPS Docet 228	Added description of NEdT calculation as a new Requirements section of document. New requirement is AMSUPGF-4.8.1.5-0040.
Version 6	17 Sep 2013		Document transcribed to Word Docx from Framemaker, retaining original Reference Number.

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1 INTRODUCTION

1.1 Purpose and Scope of Document

This Product Generation Specification (PGS) specifies the requirements for the Metop and NOAA AMSU-A Product Generation Function. This specification encompasses not only the required algorithm functions but also the identified supporting functions pertaining to the Product Generation Function.

Note: 'Reprocessing,' as used in this document, extends to several situations. One of these is the use of new versions of the software implementing the PGF to process data that has already been processed with an older version of the software. The document structure is as follows:

Section	*Contents*
1	This introduction.
2	Provides a short overview of the AMSU-A Instrument
3	Outlines the operational modes of the AMSU-A PGF. It also introduces the AMSU-A PGF as a component in a larger system.
4	Sets forth the requirements on the AMSU-A PGF.
5	Provides the scientific and mathematical information that supports the requirements.
Appendix A	Lists the symbols used in Section 5.
Appendix B	Lists the Configurable Auxiliary Data Sets used in the AMSU-A PGF
Appendix C	Provides an example of the format and content of the Configurable Auxiliary Data Sets.

1.2 Document Evolution

This document is the third evolution of the PGS as planned in the EPS Programme Core Ground Segment Statement of Work (EUM.EPS.GSE.SOW.99.0004) and identified as V2 therein.

1.3 Applicable Documents

The AMSU-A PGF is a constituent of the CGS, and unless otherwise specified, all the requirements in AD 3 Core Ground Segment Requirements Document (EPS/GGS/REQ/95327) apply. In case of conflict between the PGF requirements and Core Ground Segment Requirements Document requirements, the latter shall take precedence. For the definitions used in this document, including the reference frames to be used, see AD 2 EPS Mission Conventions Document EPS/GGS/SPE/990002), and AD 4 EPS Product Conventions Document (EPS/SYS/TEN/990007).

No.	*Document Title*	*EUMETSAT Reference*
AD 1	Product Processing Software to Product Generation Element I/F Requirement Document	EPS/GGS/IRD/980255
AD 2	EPS Mission Conventions Document	EPS/GGS/SPE/990002
AD 3	Core Ground Segment Requirements Document	EPS/GGS/REQ/95327
AD 4	EPS Product Conventions Document	EPS/SYS/TEN/990007

1.4 Reference Documents

No.	*Document Title*	*Reference*
RD 1	EPS Generic Product Format Specification	EPS/GGS/SPE/96167
RD 2	AMSU-A Level 1 Product Format Specification	EPS/MIS/SPE/97228
RD 3	EPS Auxiliary Data Inventory	EPS.SYS.LIS.00.002
RD 4	AVHRR/3 Level 1 Product Generation Specification	EUM.EPS.SYS.SPE.990004

1.5 Definitions of Terms Used

Term	*Definition*
Operational Situation	An operational state of the AMSU-A Instrument
Operational Mode	An operational state of the AMSU-A PGF
Auxiliary Data	This encompasses any non-AMSU-A data needed to carry out the PGF's tasks. Auxiliary Data includes but is not limited to the platform TM.
Configurable Auxiliary Data Sets	In the context of this document, these are the datasets listed in Appendix B that contain the set of user-configurable parameters for the AMSU-A processing.

1.6 Abbreviations and Acronyms Used in this Document

Term	*Definition*
BB	Blackbody
CFI	Customer Furnished Items
FD	Flight Dynamics
FFT	Fast Fourier Transform
FIR	Finite Impulse Response
GQA	Geometric Quality Analysis
LOS	Line-of-sight
LSB	Least Significant Bit
LUT	Look-Up-Table
M&C	Monitor and Control
MTF	Modulation Transfer Function
MTTR	Mean Time To Recovery
NIR	Near Infrared
NRT	Near Real Time
PGE	Product Generation Environment
PRT	Platinum Resistance Thermometer
RQA	Radiometric Quality Analysis
SQL	Start-Of-Line
SSP	Sub-Satellite-Point
TM	Telemetry and Monitoring
U-MARF	Unified Meteorological Archive and Retrieval Facility

1.7 Identification of Algorithm-Related Requirements

DES	Design Constraints
FUNCT	Functional Requirements
INT	Interface Requirements
MMI	Man-Machine Interface Requirements
PERF	Performance (including Accuracy) Requirements
RES	Resource Usage Requirements
RAMS	Reliability, Availability, Maintainability and Safety Requirements
TEST	Testing Requirements

The numbering of the requirements follows the following convention:

MHS-PGF-<SECTION NUMBER>-NNNN TYPES

where:

MHS identifies the instrument;
PGF stands for PGF requirement;
<SECTION NUMBER> is the complete section label (up to 6 levels of indentation);
NNNN is the number of the requirement (reset to 0010 at each section,);
TYPES indicate the relevant types of the requirement, according to the list above.

2 OVERVIEW OF THE INSTRUMENT

The basic definitions used in this document are specified in the EPS Mission Conventions Document (EPS/GGS/SPE/990002) [AD2] (which includes the reference frames to be used.) and the EPS Product Conventions Document (EPS/SYS/TEN/990007) [AD 4].

2.1 Instrument Description

The Advanced Microwave Sounding Unit-A (AMSU-A) and the complementary Microwave Humidity Sounder (MHS) are planned to fly on the METOP spacecraft and on NOAA N and N'. NOAA makes the AMSU-A instrument available. The MHS is procured and developed by EUMETSAT. These instruments, together with the High Resolution Infrared Radiation Sounder/4 (HIRS/4) form the Advanced TIROS Operational Vertical Sounder (ATOVS) instrument package.

The primary role of the microwave sounders is to provide temperature and humidity sounding under completely overcast conditions and to aid in cloud detection for the companion HIRS/4 sounding instrument. The temperature sounding mainly exploits the oxygen band at 50 GHz.

AMSU-A measures in 15 spectral bands described in Table 1. AMSU-A is divided into two separate units:

- AMSU-A2 with two channels at 23.8 GHz and 31.4 GHz
- AMSU-A1 with twelve channels in the range 50.3 GHz up to 57.290344 GHz plus one channel at 89.0 GHz.

The 12 oxygen-band channels (channels 3–14) will provide microwave temperature sounding for regions from the Earth's near surface up to about 42 kilometres or from 1000 millibars to 2 millibars. The extreme spectral windows (channels 1, 2 and 15) allow correction of the other measurements for surface emissivity, atmospheric liquid water and total precipitable water. These channels also provide information concerning precipitation, sea ice and snow coverage.

2.2 Spectral Characteristics of AMSU-A

The following provides the spectral characteristics of AMSU-A.

Channel	*Central Frequency*	*Pass Bands*	*Bandwidth (9MHz)*	*Temperature Sensitivity, (K)*	*Calibration accuracy (K)*	*Polarisation Angles Degrees (See Note)*
AMSU-A2						
1	23.8	1	270	0.3	2.0	90-ϴ
2	31.4	1	180	0.3	2.0	90-ϴ
AMSU-A1						
3	50.3	1	180	0.4	1.5	90-ϴ
4	52.8	1	400	0.25	1.5	90-ϴ
5	53.59 ± 0.115	2	170	0.25	1.5	q
6	54.40	1	400	0.25	1.5	q
7	54.94	1	400	0.25	1.5	90-ϴ
8	55.50	1	330	0.25	1.5	q
9	F_{LO} = 57.2903 44	1	330	0.25	1.5	q
10	F_{LO} ± 0.217	2	78	0.4	1.5	q
11	F_{LO} ± 0.3222 ± 0.048	4	36	0.4	1.5	q
12	F_{LO} ± 0.3222 ± 0.022	4	16	0.6	1.5	q
13	F_{LO} ± 0.3222 ± 0.010	4	8	0.8	1.5	q
14	F_{LO} ± 0.3222 ± 0.0045	4	3	1.2	1.5	q
15	89.0	1	6000	0.5	2.0	90-9

Table 1: Spectral characteristics of AMSU-A

> ***Note:*** The polarisation angle is defined as the angle from horizontal polarisation (electric field vector parallel to the satellite track) where θ is the scan angle from nadir. θ indicates horizontal polarisation and 90-θ indicates vertical polarisation.

The AMSU-A2 module has a single antenna assembly providing data for channels 1 and 2. AMSU-A1 has two separate antenna assemblies: A1-1, which provides data for channels 6,7, and 9-15; and A1-2 which provides data for channels 3,4,5, and 8.

Each antenna assembly contains a warm target with a different number of Platinum Resistance Thermometers (PRTs), and furnishes its own individual telemetry packet containing earth scene data and warm target and cold space calibration data as well as instrument state and temperature.

This is summarised in the Table 2: AMSU-A antenna package breakdown below.

Instrument Module	*AMSU-A1*		*AMSU-A2*
Antenna package	AMSU-A1-1	AMSU-A1-2	AMSU-A2
Channels	6,7,9-15	3,4,5,8	1.3
Number of warm target PRTs	5	5	7
Number of warm target views per scan line	2	2	2
Number of cold space views per scan line	2	2	2
Definition of instrument temperature	RF Shelf A1-1	RF Shelf A1-2	RF Shelf A2
Backup instrument temperature	RF Mux A1-1	RF Shelf A1-2	RF Mux A2
PLLO#1	all channels	all channels	all channels
PLLO#2	channels 9-14	none	None

Table 2: AMSU-A antenna package breakdown

2.3 Sampling Characteristics of AMSU-A

AMSU-A is an across track scanning system (see Table 4) with a scan range of ±48.33° with respect to the nadir direction. The instantaneous field of view (IFOV) of each channel is approximately 57.6 milliradians (3.3 degrees) leading to a circular instantaneous field of view size close to 47.63 km at nadir and a swath width of ±1026.31 km (at a sampling time of 200.0 ms) for a nominal altitude of 833 km. The sampling angular interval is close to 58.18 milliradians (3.3333 degrees). The distance between two consecutive scans is approximately equal to 52.69 km.

There are 30 Earth views, two views of the internal warm target, and two views of cold space per scan line for each channel. Each scan takes 8.0 seconds to complete.

Characteristics	*Value*	*Unit*
Scan type	step and dwell	
Scan direction	West to East (northbound)	
Scan rate (duration)	8.0	second
Sampling interval	200.0	ms
Sampling interval	3.3333	degree
Pixels/scan	30	
Swath	± 48.33	degree
Swath width	± 1026.31	km
IFOV	3.3	degree
IFOV shape	circular	
IFOV size (nadir)	47.63	km
IFOV size (edge) - across track	146.89	km
IFOV size (edge) - along track	78.79	km
Scan separation	52.69	km

Table 3: Scanning characteristics of AMSU-A

Figure 1 presents the location of the centre of the IFOV on-ground projections when the satellite is at the equator, in ascending track and for the full swath width.

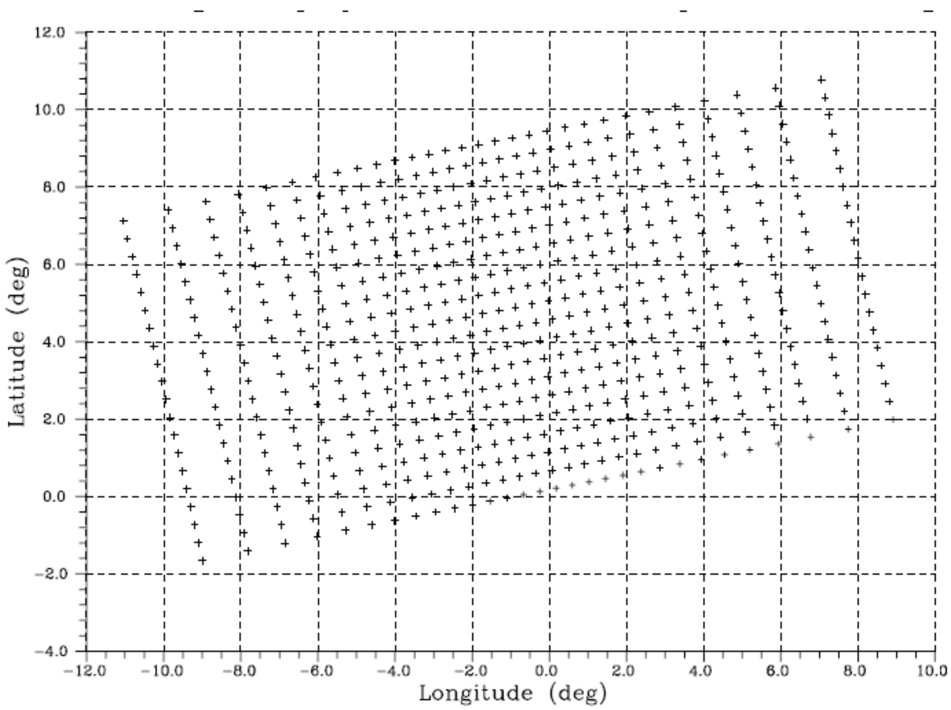

Figure 1: IFOV on-ground projections of AMSU-A at equator in ascending track

2.4 AMSU-A On-board NOAA KLM Satellites

AMSU-A is nearly identical to the instrument deployed on the NOAA KLM series of satellites, the main difference being the bandwidth. Table 5 below summarises the characteristics of AMSU-A on NOAA-KLM.

Channel	*Central Frequency*	*Pass Bands*	*Bandwidth (MHz)*	*Temperature Sensitivity, (K) Specification*	*Polarisation Angles Degrees (See Note)*
			AMSU-A2		
1	23.8 ± 0.0725	2	125	0.3	90-Θ
2	31.4 ± 0.050	2	80	0.3	90-Θ
			AMSU-A1		
3	50.3 ± 0.050	2	80	0.4	90-Θ
4	52.8 ± 0.105	2	190	0.25	90-Θ
5	53.596 ± 0.115	2	170	0.25	q
6	54.40 ± 0.105	2	190	0.25	q
7	54.94 ± 0.105	2	190	0.25	90-Θ
8	55.50 ± 0.0875	2	155	0.25	q
9	F_{LO} = 57.290344 ± 0.0875	4	155	0.25	q
10	F_{LO} ± 0.217	4	78	0.4	q
11	F_{LO} ± 0.3222 ± 0.048	4	36	0.4	q
12	F_{LO} ± 0.3222 ± 0.022	4	16	0.6	q
13	F_{LO} ± 0.3222 ± 0.010	4	8	0.8	q
14	F_{LO} ± 0.3222 ± 0.0045	4	3	1.2	q
15	89.0 ± 1.0	2	1000	0.5	90-9

Table 4: Spectral characteristics of NOAA KLM AMSU-A

Note: The polarisation angle is defined as the angle from horizontal polarisation (electric field vector parallel to the satellite track) where θ is the scan angle from nadir. θ indicates horizontal polarisation and 90-θ indicates vertical polarisation.

3 SYSTEM AND OPERATIONS CONCEPT

The AMSU-A PGF shall support all the modes of operations identified in AD 3 Core Ground Segment Requirements Document (EPS/GGS/REQ/95327). This section outlines the Operational Modes of the AMSU-A PGF.

3.1 System Context

Processing steps involved in product generation will be implemented by Product Processing Software (PPS). The System Context diagram for the AMSU-A PPS is shown in Figure 2.

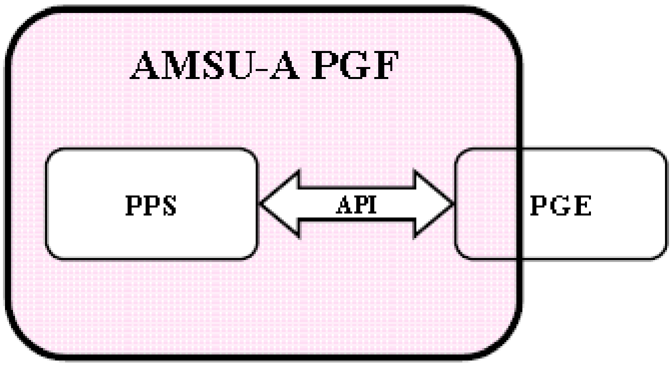

Figure 2: System Context

The PPS makes use of the API provided by the PGE as its only means of external communication. This isolates it from the environment.

The PPS makes use of the PGE services through a dedicated API [AD 1 Product Processing Software to Product Generation Element I/F Requirement Document (EPS/GGS/IRD/980255)].

The single use of the API makes the PPS portable between environments that provide the same API together with all the necessary functions to provide the API-services. The PPS requires the API-services provided by the PGE as a pre-requisite for its execution.

In addition, the PPS follows a number of rules established by the PGE on coding rules, invocation procedures, and program structure. The relevant requirements are specified in AD 3 Core Ground Segment Requirements Document (EPS/GGS/REQ/95327).

This document specifies further requirements on the PGE API.

The PGE provides the PPS with all basic functionality to enable it to perform its processing task.

Specifically, support in the following areas will be provided:

- Data flow control - to satisfy the PPS's data requests
- Operational software status and error reporting management
- Control parameters for PPS. This shall include environmental information that is required by the PPS (G/S-1/2, time, machine).
- PPS characterisation information management

The PGE will provide support services to, for example, replace and restrict the O/S services in order to isolate the PPS from the general computational environment and to provide other widely used functionality, such as:

- Orbit propagator function (including orbit and attitude interpolation)
- Earth location utilities (pointing, navigation, co-ordinate conversion)
- Conversion functions (time, location …)
- Interpolation functions (space, time)
- Mathematical utilities
- Statistical utilities
- Meteorological, Earth and geophysical models and utilities
- Geometric event prediction (celestial bodies position, day/night transition etc.)
- Access to a subset of satellite telemetry
- Access to a Digital Terrain Model.

3.1.1 Major Interfaces

The major external dataflows to/from the AMSU-A L1 PGF are listed in Table 5 and in Table 6. Table 7 lists the PGE services required.

Interface Label	*Interface Description*
AMSU-A Level 0 Data	Operational scan mode AMSU-A Level 0 data in a line by line manner such that there is no difference in the format regardless whether the data is provided by a MetOp or NOAA satellite. This data includes the instrument ancillary data. ***Note:*** In case the PGF operates in reprocessing mode, the information is received via the CGS function providing the reprocessing support. The data might also originate from one of the test tools if the PGF is being tested standalone.
AMSU-A Instrument Ancillary Data	Is similar to the Level 0 data except that this dataflow corresponds to the platform telemetry that might be required in addition to the Level 0 data. The dataflow typically contains all the relevant spacecraft/platform parameters and status flags required by the processing that are not included in the instrument Level 0 data.
Auxiliary data	Corresponds to all data that are required from the G/S and that are not present in the Platform Telemetry and the Level 0 data. These are typically all derived information (orbit, attitude, required derived/extracted platform parameters, …).
Config. Data Sets	User-configurable sets of data that, together with the version numbers of the processing software installed, define the processing. Examples include land-sea masks, land surface topography datasets, landmarks, instrument scan/time parameters, pre-flight and manufacturer provided calibration coefficients, and plausibility thresholds.

Table 5: AMSU-A L1 PGF Input Data Flows

Interface Label	**Interface Description**
AMSU-A Level 0 Product	Corresponds to the AMSU-A Level 0 products formatted as defined in [RD1] EPS Generic Product Format Specification (EPS/GGS/SPE/96167).
AMSU-A Level 1a Product	Corresponds to the AMSU-A Level 1a products formatted as defined in [RD2] AMSU-A Level 1 Product Format Specification (EPS/MIS/SPE/97228)
AMSU-A Level 1bProduct	Corresponds to the AMSU-A Level 1b products formatted as defined in [RD2] AMSU-A Level 1 Product Format Specification (EPS/MIS/SPE/97228)
Reporting/Quality Information	Reporting Information: information to be sent to the reporting function of the Core Ground Segment. ***Note:*** this can include information on input data, along with instrument, processing, and mission performance."Quality information: all information that is to be sent to the offline quality control function of the CGS. ***Note:*** The offline quality control function of the CGS is specified in AD 3.
Monitoring Information	Information on the status of the instrument, data, PGF, PGF platform, and links that is provided to the core ground segment monitoring and control function. This includes all events (including command acknowledgements) raised by the PGF.

Table 6: AMSU-A L1 PGF Output Data Flows

Interface Label	**Interface Description**
Generic PGE Services	Common functions used by PGFs of different processing chains to carry out aspects of product generation. Examples may include orbit/eclipse prediction, time functions, event and data handlers.
G/S Commands	This data stream corresponds to the transfer of commands generated by the G/S and controlling the operation of the PGF. ***Note***: these only influence the way the processing is done and are not related to any instrument/platform commands.
Configuration Switches	This corresponds to (a) switch(es), selecting (a) configured product generation option(s). This influences the selection of a method or a data set.

Table 7: AMSU-A L1 PGF Required Mechanisms and Controls

3.2 Operations Concept

Note that the AMSU-A PGF can be in the following Operational Modes:

- Near-Real Time Mode
- Backlog Processing Mode
- Reprocessing Mode

Although the PGF runs through the same basic states (Initial, Active, Emptying, and Stopped) regardless of mode, special attention is needed in the actual implementation–since subtle differences exist among the different modes. For example, the satellite data supplied to the PGF have different origins depending on the mode; the selection of the Auxiliary Data to use in the processing characterises the Reprocessing mode. Section 3.2.5 maps the AMSU-A PGF Operational Modes to the AMSU-A Instrument Operational Situations. This section is intended to clarify the relationship between the AMSU-A PGF and the AMSU-A Instrument.

Note: While the Operational Modes are part of the specification as per AD 3 Core Ground Segment Requirements Document (EPS/GGS/REQ/95327), the description of the "states" and of the "operational scenarios" is only provided as supporting information to the Contractor in order to clarify the PGF Requirements. In particular, operational scenarios do *not* specify the actual implementation.

3.2.1 AMSU-A Instrument Nominal Operational Situation

The Product Generation Function generates the Level 0, 1a, and 1b products for each of the Metop / NOAA spacecraft:

- AMSA_xxx_00_Mnn/AMSA_xxx_00_Nnn,
- AMSA_xxx_1a_Mnn/ AMSA_xxx_1a_Mnn,
- AMSA_xxx_1b_Mnn/ AMSA_xxx_1b_Nnn

The AMSU-A Level 1a processing includes the navigation of the AMSU-A pixels and the calculation of the calibration coefficients for all channels. This information is appended to the Level 1a data, but the calibration corrections are not applied.

The AMSU-A Level 1b processing includes the application of the calibration coefficients to the Earth view counts to retrieve calibrated radiances for the 15 channels.

For the purpose of the AMSU-A PGF, the following describes the nominal operations of the AMSU-A Instrument:

The AMSU-A instrument will be operated continuously and the 15 channels transmitted will be processed. All channels will be used continuously; this is the nominal Operational Situation.

Table 9 presents the behaviour of the PGF in some specific operational situations. In cases where some degradation of the product quality may be expected this is indicated.

3.2.1.1 Supporting Functions

The following list of generic functions is part of the AMSU-A PGF Specification although the PGE actually supports them. This section also presents the purpose of these functions.

- *Level 0 data & other input data check and validation*: this function is foreseen to provide the isolation of the algorithm & scientific function from the received Level 0 and input data by validating these before passing them on to the subsequent processing stages. Occurrences of abnormal situations will give rise to the corresponding events and log/reports. Although the general communication-level checks may be performed using generic PGE services, the validation of the level 0 dataflow is instrument-specific.

- *Instrument status/mode identification*: A function must also derive from the telemetry the actual mode and state of the instrument and log / report this information.
- *Usage of M and C services*: All functions of the product generation function make use of the generic M and C service of the PGE to receive commands from the CGS and to transfer log and monitoring information to the CGS.
- *Online quality control functions*: The purpose of the function is to provide all required statistics on the supported mission and product generation function performance regarding the product quality. ***Note***: Data supplied to online quality control can be generated during calibration, for example as a result of checks of counts and temperatures.
- *Generation and compiling of reporting information*: All sub-functions of the product generation function generate information that will be used for the generation of reports on the Instrument and Mission performance. A function of the product generation function compiles all the generated information and makes this reporting information available to the CGS for the purpose of routine or specific reporting.

3.2.2 Note on Degraded Operations

In case of failure of one or more channels, the PGF will process the remaining channels' data and produce degraded mode products which will be flagged accordingly. No interpolation and/or replacement of missing data with simulated data will be performed. The handling of the majority of these type of "foreseeable" anomalies is internal to the PGF and will not require specific commanding from the PGE.

3.2.3 Backlog Processing Mode

From the point of view of the PGF, processing is equivalent whether it is in backlog mode or in nominal mode. Thus, the scenario for processing in Backlog mode is equivalent to that for Nominal mode (see above, Section 3.2.1.)

3.2.4 Reprocessing Mode

Reprocessing covers the situations in which data that has previously been processed is processed again, either because the auxiliary data and/or configuration parameters have been changed, or because the software that implements the PGF has been changed.

3.2.4.1 PGF States In Reprocessing Mode

The following notes apply to reprocessing behaviour:

Because one of the reasons to reprocess data can be that the processing functionality has been upgraded, the auxiliary data are not necessarily the same as those that would have been used in the original processing.

3.2.5 Summary of the AMSU-A PGF Operational Modes

Table 8 summarises the Operational Situations the AMSU-A Instrument may go across versus the Operational Modes of the AMSU-A PGF. This information provides a guideline for the contractor.

Operational Situation	***Operational Mode***	***Expected Behaviour***	***Impact on Product***
Nominal NRT	Near-Real Time	Fully nominal product extraction	Nominal quality products
Nominal Backlog Processing	Backlog Processing	Fully nominal product extraction	Nominal quality products
Nominal Reprocessing	Reprocessing	Fully nominal product extraction but based on historical input data "re-injected" via the normal external interfaces. Possibility of modified algorithm version (for product improvement) or same algorithm version.	Nominal quality products
Manoeuvre	Near-Real Time Backlog Processing Reprocessing	Degraded processing if instrument is operating; else case of switched off instrument, therefore no processing.	Product manoeuvre flag set.
Missing Level 0 Data	Near-Real Time Backlog Processing Reprocessing	Expected Behaviour: 1. If no Level 0 data for a dump period is available then no Level 1 products are to be produced. 2. If parts of the Level 0 data for a dump period are missing then degraded L1 products are produced containing information on which parts are missing.	1. Not derived 2. Degraded and flagged as such.
Corrupted Level 0 data	Near-Real Time Backlog Processing Reprocessing	Processing identifies and flags the corrupted data. Processing continues as specified, output products are of degraded quality.	Degraded and flagged as such
Invalid or missing auxiliary data (and/or Instrument ancillary, platform TM, G/S aux data)	Near-Real Time Backlog Processing Reprocessing	The processing continues in degraded mode using either interpolated, previous or default side information (this is case-by-case as per requirements)	Degraded and flagged as such

Operational Situation	Operational Mode	Expected Behaviour	Impact on Product
Late arrival of data	Backlog Processing	**If Level 0 data is delayed:** Delayed processing in backlog mode. **If auxiliary data needed for the processing is available later than a user-configurable delay:** Late arrival is considered missing data. In this case, the operational practice would be to reprocess the data at a later stage to increase quality of archived Product	Nominal for backlog Processing and reprocessing. Degraded ad flagged as such in case of too late auxiliary data
Duplicate data	Near-Real Time Backlog Processing	Perform quality checks on the data and keep the first data set received. Discard the second data set received.	Nominal product quality
Wrong satellite/ instrument	Reprocessing Near-Real Time Backlog Processing	Data is discarded	No product derived
Missing Channels	Near-Real Time Backlog Processing Reprocessing	Processing uses a reduced algorithm (to the extent specified) and flags the results as degraded, otherwise the processing enters the relevant Degraded Operations Mode.	Degraded and flagged as such
Invalid Calibration Information	Near-Real Time Backlog Processing Reprocessing	No calibration update – older calibration results applied	Nominal if old calibration still within the specified accuracy

Table 8: Domain of application and behaviour in operational situations

4 REQUIREMENTS

The following requirements on the mission the AMSU-A L1 PGF is supporting.

This instrument-specific functionality is in addition to the generic functions identified in AD 3 Core Ground Segment Requirements Document (EPS/GGS/REQ/95327):

4.1 System Requirements

AMSU-PGF-4.1-0010	**FUNCT, INT**
The PGF shall generate Level 0/1a/1b products in accordance with the specifications in Chapter 5 from input data acquired by the following Instruments & Platforms configurations: 1. Metop-1/AMSU-A Instrument 2. Metop-2/AMSU-A Instrument 3. Metop-3/AMSU-A Instrument 4. NOAA-N/AMSU-A Instrument (N=18) 5. NOAA-N´/AMSU-A Instrument (N'=19)	

AMSU-PGF-4.1-0020	**INT**
The AMSU-A PGF shall generate Level 0/1a/1b products compliant with [RD2] AMSU-A Level 1 Product Format Specification (EPS/MIS/SPE/97228).	

AMSU-PGF-4.1-0030	**FUNCT, INT**
The AMSU-A PGF shall be able to process any AMSU-A Level 0/1a product compliant with [RD2] AMSU-A Level 1 Product Format Specification (EPS/MIS/SPE/97228).	

AMSU-PGF-4.1-0040	**FUNCT, INT**
The outputs of the PGF shall be formatted as per [RD2] AMSU-A Level 1 Product Format Specification (EPS/MIS/SPE/97228) and AD 3 Core Ground Segment Requirements Document (EPS/GGS/REQ/95327).	

AMSU-PGF-4.1-0050	**FUNCT, PERF**
The AMSU-A PGF shall process the AMSU-A Level 0 datastream and generate Level 0/1a/1b products of a nominal quality for all nominal Operational Situations of the AMSU-A Instrument.	

AMSU-PGF-4.1-0060	**FUNCT, PERF**
The PGF shall process the AMSU-A acquired data and generate Level 0/1a/1b products in a degraded manner in the following Operational Situations of the AMSU-A Instrument: 1. Continuous operation with missing channels 2. Continuous operation with pointing out of range ***Note:*** Out of range means that the error tolerance value in AMSU-A_L1_PGS_COF_CAL has been exceeded.	

AMSU-PGF-4.1-0070	**FUNCT, INT**
The AMSU-A PGF shall support the reception, acceptance and validation of any Auxiliary Data required in the Level 0/1a/1b processing. ***Note:*** This includes but is not limited to instrument TM, G/S auxiliary data, other products.	

AMSU-PGF-4.1-0080	**INT**
The AMSU-A PGF shall be able to process any Auxiliary Data identified in this document that is being used by it.	

AMSU-PGF-4.1-0090	
The AMSU-A PGF shall support the following Operational Modes in compliance with AD 3 Core Ground Segment Requirements Document (EPS/GGS/REQ/95327): 1. Near-Real Time Mode 2. Backlog Processing Mode 3. Reprocessing Mode	

AMSU-PGF-4.1-0100	**DES, INT**
The AMSU-A PGF shall use the PGE generic API as per AD 3 Core Ground Segment Requirements Document (EPS/GGS/REQ/95327) to interface with its environment. ***Note:*** This requirement means that the PGF is completely insulated from its software and hardware environment.	

4.2 MMI Requirements

This section comprises the MMI requirements applicable to the whole AMSU-A PGF. Further MMI requirements are set forth in the sections dedicated to Level 0/1a/1b processing.

AMSU-PGF-4.2-0010	**MMI**
The AMSU-A PGF shall allow the users to interactively configure the following data sets: 1. AMSU-A_L1_PGS_COF_CAL 2. AMSU-A_L1_PGS_COF_CALSEC 3. AMSU-A_L1_PGS_DAT_SFCTOP 4. AMSU-A_L1_PGS_DAT_NAV 5. AMSU-A_L1_PGS_DAT_ASTRO	

AMSU-PGF-4.2-0020	**FUNCT, MMI**
All Auxiliary Data files shall be kept under Configuration Control. As a minimum, the following features shall be provided: 1. a version number associated to each file, 2. a creation date associated to each version, 3. the name of the AMSU-A PGF user who created a given version, 4. an explanatory text associated to each version.	

AMSU-PGF-4.2-0030	**FUNCT, MMI**
It shall be possible to get the modification history of any Auxiliary Data file.	

AMSU-PGF-4.2-0040	**FUNCT, MMI**
Users shall be able to interactively select the AMSU-A Level 0/1a data/products, the configurable data sets and the Auxiliary Data sets to be used for reprocessing.	

4.3 Quality Control Requirements

This section specifies the PGF-wide requirements. Detailed Quality Control requirements are set forth for each level of processing in the dedicated sections.

AMSU-PGF-4.3-0010	**FUNCT, PERF**
There shall be quality indicators at product level according to the specification in [RD2] AMSU-A Level 1 Product Format Specification (EPS/MIS/SPE/97228).	

AMSU-PGF-4.3-0020	**FUNCT, PERF**
There shall be quality indicators at scan line level according to the specification in [RD2] AMSU-A Level 1 Product Format Specification (EPS/MIS/SPE/97228).	

4.4 Accuracy Requirements

This section covers the PGF-wide Accuracy Requirements. Further Accuracy Requirements are set forth for Level 1a/1b processing.

AMSU-PGF-4.4-0010	**PERF**
A product shall be considered complete if all the required data content as per [RD2] AMSU-A Level 1 Product Format Specification (EPS/MIS/SPE/97228), was produced nominally from the full set of data supplied and the complete product made available. ***Note:*** *Nominally* in this context means that no degradation of data quality was detected.	

4.5 Reliability Requirements

AMSU-PGF-4.5-0010	**DES**
The AMSU PGF shall be designed so that no error propagates within or outside the system.	

AMSU-PGF-4.5-0020	**FUNCT, RAMS, MMI**
The PGF shall monitor its performance and raise events of user-configurable severity on the occurrence of: 1. Any abnormal instrument behaviour; 2. Any occurrence and transition to/from a degraded mode of product generation; 3. Any non-nominal operation of the PGF; 4. Any occurrence likely to affect the product quality.	

AMSU-PGF-4.5-0030	**RAMS, DES**
The AMSU-A PGF shall be robust against non-nominal conditions in the external interfaces. In particular, the AMSU-A PGF shall detect and discard any data specified in and non-compliant with [RD2] AMSU-A Level 1 Product Format Specification (EPS/MIS/SPE/97228) and its applicable documents.	

AMSU-PGF-4.5-0040	**RAMS, DES**
The AMSU-A PGF shall be able to recover from non-nominal processing conditions. In particular, mathematical errors (division by zero) shall be detected and handled before they occur.	

AMSU-PGF-4.5-0050	**RAMS**
The AMSU-A PGF shall be robust against the potential loss of data. In particular, an explicit confirmation shall be required before deleting any data.	

4.6 Availability Requirements

AMSU-PGF-4.6-0010	**RAMS, DES**
The AMSU-A PGF shall have the capability to be operated on a 24 hours/7days basis for at least 28 days independently of the status of its environment. ***Note:*** This requirement means that corrupted, missing or duplicate data as well as any other environmental conditions shall not compromise the AMSU-A PGF availability.	

4.7 Level 0 Processing

In addition to the generic functionality identified in AD 3 Core Ground Segment Requirements Document (EPS/GGS/REQ/95327), instrument-specific acceptance and validation of the input data is required for the AMSU-A PGF.

The purpose is to accept the AMSU-A Level 0 data and to perform all checks required to validate the input data before passing them further on to the algorithmic functions. The instrument status shall be monitored and appropriate reporting statistics shall be produced.

Correlation of the AMSU-A Level 0 data with the Auxiliary Data is also required as well as extraction of the relevant information for the subsequent calibration & navigation processing.
Note: The following requirements apply to all the different Metop spacecraft as well as to the NOAA platforms.

4.7.1 Processing and Quality Control Requirements

AMSU-PGF-4.7.1-0010	**FUNCT, PERF, INT**
The following steps shall be performed for Level 0 processing: 1. Reception and Quality Control of the AMSU-A Level 0 data; 2. Reception and Quality Control of the Auxiliary Data; 3. Preparation of the Appended Information required to compile the AMSU-A Level 0 products.	

4.7.1.1 Level 0 Data Reception and Quality Control

The generic checks identified in AD 3 Core Ground Segment Requirements Document (EPS/GGS/REQ/95327) are followed by the verification against the expected instrument S/C configuration and a check for operational scan mode (other data is not processed). This is followed by coarse data quality control.

AMSU-PGF-4.7.1.1-0010	**FUNCT, INT, PERF**
At a minimum, AMSU-A Level 0 data shall be checked against the following: 1. S/C and Instrument identification against the expected configuration; 2. Instrument is in operational scan mode; 3. Time coherency (monotonic, increasing) of the AMSU-A Level 0 data; 4. Correct sequence of the received data;	

AMSU-PGF-4.7.1.1-0030	**FUNCT, PERF**
Should the AMSU-A Level 0 data be late with respect the maximum allowed reception delay, their processing shall be deferred and an event of user-configurable severity shall be raised.	

AMSU-PGF-4.7.1.1-0040	**FUNCT, PERF,**
There shall be a check of each AMSU-A scan line on scan numbering and the result shall be reported in a flag. ***Note:*** This means checking on increasing line numbering, derived from the scan line time (which should increase in scan time steps). A flag needs to be set on failure.	

AMSU-PGF-4.7.1.1-0050	**FUNCT, PERF**
There shall be a check on each AMSU-A scan line on the scan time and the result shall be reported in a flag.	

AMSU-PGF-4.7.1.1-0060	**FUNCT, PERF**
Quality control on the received AMSU-A Level 0 data shall be performed in order to detect at least data corruption resulting in contiguous sequences of same binary values, and consequently to send a user-configurable event to the CGS via the PGE interface, to send reporting information which will be available for inspection for at least two weeks to the CGS via the PGE interface, and to set a flag in the product. ***Note:*** The user-configurable event is intended to alert the operator to the situation as it presents itself; the reporting information is intended to be of use to operators and others reviewing the longer-term performance of EUMETSAT's product-generation capability, and the flag is intended to be used by the users of the product who need to be warned of degradation in product quality resulting from data corruption.	

AMSU-PGF-4.7.1.1-0070	**FUNCT, PERF**
The AMSU-A PGF shall process the AMSU-A Level 0 data and produce Level 0 Products in a degraded manner in the following cases: 1. Missing, corrupt, or duplicated instrument L0 or TM packets ***Note:*** Further requirements apply if any Auxiliary Data is missing, corrupt or duplicated.	

AMSU-PGF-4.7.1.1-0080	**FUNCT, PERF**
The AMSU-A PGF shall process the AMSU-A Level 0 data and produce Level 0 Products in a degraded manner in the following cases: 1. Missing, corrupt, or duplicated instrument L0 or TM packets ***Note:*** Further requirements apply if any Auxiliary Data is missing, corrupt or duplicated.	

AMSU-PGF-4.7.1.1-0090	**FUNCT, PERF**
AMSU-A Level 0 data detected as duplicated shall be discarded as per AD 3 Core Ground Segment Requirements Document (EPS/GGS/REQ/95327) as long as it was not used for processing. ***Note:*** This requirement means that duplicated data shall be discarded in NRT Mode and in Backlog Processing Mode and shall not be discarded in Reprocessing Mode. Also, the generic requirements on the robustness in case of potential loss of data apply.	

4.7.1.2 Auxiliary Data Reception and Quality Control

In the following requirements we will refer generically to "Auxiliary Data": this encompasses any non- AMSU-A data needed to carry out the PGF tasks.

AMSU-PGF-4.7.1.2-0010	**FUNCT, PERF**
The Auxiliary Data shall be checked at least for the following: 1. Validity; 2. Timeliness; 3. Completeness.	

AMSU-PGF-4.7.1.2-0020	**FUNCT, INT**
The Auxiliary Data sets shall be correlated to the AMSU-A Level 0 data to assess whether they can be used for processing the latter. At a minimum, the time correlation shall be performed.	

AMSU-PGF-4.7.1.2-0030	**FUNCT, PERF**
The PGF shall process the AMSU-A Level 0 data and produce Level 0 Products in a degraded manner if Auxiliary Data is missing, corrupt, or duplicated.	

AMSU-PGF-4.7.1.2-0040	**FUNCT**
The mode/state of the instrument/platform shall be extracted from the Ancillary Data.	

AMSU-PGF-4.7.1.2-0050	**FUNCT, MMI**
The subset of data extracted from the received Auxiliary Data for the subsequent processing shall be user-configurable.	

4.7.1.3 Level 0 Appended Information Generation

AMSU-PGF-4.7.1.3-0010	**FUNCT, INT**
AMSU Level 0 Appended Data shall be generated from the received AMSU-A Level 0 data and Auxiliary Data.	

AMSU-PGF-4.7.1.3-0020	**FUNCT, INT**
The AMSU-A Level 0 Appended Data shall be formatted in accordance with [RD2] AMSU-A Level 1 Product Format Specification.	

4.7.2 Reporting Requirements

AMSU-PGF-4.7.2-0010	FUNCT, MMI
Reports shall be generated on the received AMSU-A Level 0 data. These shall include at least the following: 1. Parameters describing their quality including quality information to be generated as specified in chapter 5; 2. Timeliness information; 3. Completeness information.	

AMSU-PGF-4.7.2-0020	FUNCT, MMI
Reports shall be generated on the received Auxiliary Data. These shall include at least: 1. Parameters describing their validity; 2. Timeliness information; 3. Completeness information. ***Note:*** "Timeliness information" means both a) information on how trustworthy the auxiliary datasest is at the time of instrument data acquisition, and b) how applicable the auxiliary dataset is to the time of instrument data acquisition: thus for example: a) an NWP forecast file covering the acquisition time made 5 hours previous to instrument data acquisition is more reliable than one covering the acquisition time made 18 hours previous to the instrument data acquisition, and b) an NWP forecast file for one hour after instrument data acquisition is more applicable then an NWP forecast file for two hours before the acquisition.	

AMSU-PGF-4.7.2-0030	FUNCT, MMI
In addition to the Near-Real Time data required to support the MMI functionality of the CGS in accordance with AD 3 Core Ground Segment Requirements Document (EPS/GGS/REQ/95327), the following instrument-specific data shall be generated for displaying: 1. Reduced resolution representation of the AMSU-A Level 0 data for all of the channels of the instrument, with superimposed indication of missing and corrupted data.	

4.8 Level 1a Processing

The AMSU-A Level 1a processing consists in computing the navigation data as well as the calibration data, using the information from the instrument on-board calibration scans, the Level 0 data and the information and parameters from the on-ground characterisation.

The processing of the appended calibration data is performed using the information from the instrument onboard calibration scans, the AMSU-A Level 0 data and the information/parameters from on-ground characterisation.

The first step is to validate the received on-board AMSU-A calibration information by verifying the consistency with previous calibration occurrences (if available). The purpose is to avoid corrupted calibration information to propagate through the whole PGF and the subsequent product extraction.

Finally, the AMSU-A Level 1a data and the appended AMSU-A Level 1a data are produced.

All the parameters used in the calibration processing shall be user-configurable since they are platform-specific or instrument-specific.

4.8.1 Processing Requirements

All extracted information required to perform the calibration processing is first validated; then all the calibration parameters needed for the creation of the AMSU-A Level 1a Appended Data are derived.

AMSU-PGF-4.8.1-0010	FUNCT, PERF, INT
The following steps shall be performed for Level 1a processing: 1. Processing of the On-Board Calibration Information; 2. Processing of the Navigation Information; 3. Processing of the validated AMSU-A Level 0 data to Level 1a data; 4. Preparation of all the Auxiliary Data required to compile the AMSU-A Level 1a products Appended Data as per [RD2] AMSU-A Level 1 Product Format Specification (EPS/MIS/SPE/97228); 5. Generation of the Calibration Information to be appended to Level 1a data for the subsequent Level 1b processing.	

AMSU-PGF-4.8.1-0020	FUNCT, PERF, MMI
All the parameters used in the calibration and navigation processing shall be user-configurable and platform- and instrument/channel-specific. ***Note:*** This requirement means that the granularity of the configuration parameters shall allow the setting of different values for each S/C and each instrument's channel for each parameter. Also, it requires that the users be able to configure all Level 1a processing parameters.	

4.8.1.1 Calibration Processing

AMSU-PGF-4.8.1.1-0010	FUNCT, PERF,
The calibration processing shall execute the following steps: 1. Computation of the Warm Target Radiance 2. Computation of the Cold Space Radiance 3. Averaging of the Warm Target and Cold Space Counts 4. Interpolation of the Non-Linearity Correction Coefficients 5. Computation and Application of the Calibration Coefficients ***Note:*** These steps are further specified in the following requirements, if necessary. Further details can be found in Section 5.1.2.2, Section 5.1.2.3, Section 5.1.2.4, Section 5.1.2.5 and Section 5.1.2.6	

AMSU-PGF-4.8.1.1-0020	FUNCT, INT, MMI
The static parameters, coefficients, instrument characteristics, gross limits, weighting factors etc. required to perform the calibration processing and the related quality checks, shall be included in the user-configurable dataset AMSU-A_L1_PGS_COF_CAL. ***Note:*** Appendix C provides an example of the structure and format of such file, However the structure and format are beyond the scope of this document and are not specified. Appendix C only provides a guideline for the Contractor.	

AMSU-PGF-4.8.1.1-0030	**FUNCT, PERF,**
The processing to compute the Warm Target Radiance shall follow the following steps: 1. Computation of the Reference Temperature 2. Computation of the Warm Target PRT Temperatures 3. Interpolation of the Warm Target Bias Correction 4. Computation of the Average Warm Target Temperatures 5. Computation of the Warm Target Radiance ***Note:*** Further details on each of those processing steps can be found in Section 5.1.2.2.1, Section 5.1.2.2.2, Section 5.1.2.2.3, Section 5.1.2.2.4 and Section 5.1.2.2.5 respectively.	

AMSU-PGF-4.8.1.1-0040	**FUNCT, PERF,**
The processing to compute the Cold Space Radiance shall execute the following steps: 1. Estimation of the Cold Space Temperature 2. Computation of the Cold Space Radiance ***Note:*** Further details on each of those processing steps can be found in Section 5.1.2.3.1 and Section 5.1.2.3.3 respectively.	

AMSU-PGF-4.8.1.1-0050	**FUNCT, PERF,**
The AMSU-A PGF shall support, in addition to the processing of data from the continuous part of a dump, the processing at the begin and the end of the dump. ***Note:*** Further details on handling of edge-of-dump conditions can be found in Section 5.3.	

AMSU-PGF-4.8.1.1-0060	**FUNCT, PERF,**
The AMSU-A PGF shall support, in addition to the processing of data from the continuous part of a dump, the processing before and after data gaps. ***Note:*** Further details on handling of edge-of-data-gap conditions can be found in Section 5.3.	

4.8.1.2 Navigation Processing

All information required to perform the calibration processing is first extracted; then all the calibration parameters needed for the creation of the AMSU-A Level 1a Appended Data are derived.

AMSU-PGF-4.8.1.2-0010	**FUNCT, PERF,**
The Navigation Processing shall execute the following steps: 1. Computation of the clock error; 2. Computation of the satellite orbit state and position; 3. Computation of the position for every pixel and every line; 4. Computation of the satellite and solar zenith angle and azimuth; 5. Computation of the Earth parameters ***Note:*** Further details on the actual processing can be found in Section 5.1.1 Further details on handling of edge-of-data-gap conditions can be found in Section 5.3.	

AMSU-PGF-4.8.1.2-0020	**DES, INT**
The generic orbit and attitude services of the PGE shall be used to perform the navigation processing.	

AMSU-PGF-4.8.1.2-0030	**FUNCT, PERF**
The full navigation processing shall be performed for a user-configurable density of pixels and lines, by default for every pixel and every line.	

AMSU-PGF-4.8.1.2-0040	**FUNCT, PERF**
The terrain elevation information at instrument pixel level shall be taken into account for navigation processing: ***Note:*** The terrain elevation information at instrument pixel level is provided in the data set AMSUA_L1_PGS_DAT_SFCTOP.	

4.8.1.3 Generation of the Level 1a Data

The AMSU-A Level 1a data are generated re-formatting the AMSU-A Level 0 data into the AMSU-A Level 1a data representation.

AMSU-PGF-4.8.1.3-0010	**FUNCT, PERF**
The AMSU-A Level 0 data shall be formatted into the AMSU-A Level 1a binary representation. The binary representation and format of the AMSU-A Level 1a data shall comply with [RD2] AMSU-A Level 1 Product Format Specification.	

4.8.1.4 Generation of the Level 1a Appended Data

The AMSU-A Level 1a Appended Data are based on the output of the calibration processing and the navigation processing. In addition, any relevant data from the validated platform, instrument and G/S auxiliary data that is required to complete the format of the AMSU-A Level 1a Appended Data are generated or extracted.

AMSU-PGF-4.8.1.4-0020	**FUNC, INT, MMI**
In addition to the Near-Real Time data required to support the MMI functionality of the CGS in accordance with AD 3 Core Ground Segment Requirements Document the following instrument-specific data shall be generated for displaying the following: 1. Identified mode and mode transitions of the instrument; 2. User-configurable subsets of the instrument telemetry 3. Multi-spectral images with flexible colour coding, including pseudo-colours and true colours	

4.8.1.5 Generation of the Calibration Information

The validated AMSU-A calibration data from the spacecraft, the instrument characteristics and the AMSUA Level 0 data shall be used to produce the calibration information for each AMSU-A channel.

The output is a set of calibration parameters, which are needed for the subsequent Level 1b processing and which are appended to the Level 1a counts.

In the AMSU-A Level 1a processing calibration coefficients are calculated for all AMSU-A channels. In the Level 1b processing, the calibration coefficients are used to convert the numerical counts returned by the instrument into radiance.

The calibration information is based on the in-flight measurements of a warm target and the cold space per scan line. Further details can be found in Section 5.1.2.

AMSU-PGF-4.8.1.5-0010	**FUNC, PERF**
The AMSU-A calibration parameters for each part of the Earth view data in the dump shall be generated using the scan line information from scan lines adjacent to the current scan line–specified in Chapter 5. ***Note:*** Further details on handling of edge-of-dump/data-gap conditions can be found in Section 5.3.	

AMSU-PGF-4.8.1.5-0020	**FUNC, PERF, MMI**
The function shall use a user-configurable averaged (default seven, maximum twenty) number of warm target counts for the estimation of the warm target count for the calibration estimation.	

AMSU-PGF-4.8.1.5-0030	FUNC, PERF, MMI
The function shall use a user-configurable averaged (default seven, maximum twenty) number of cold space counts for the estimation of the cold space count used for the calibration estimation.	

AMSU-PGF-4.8.1.5-0040	FUNC, PERF, MMI
The function shall calculate the values for the Noise Equivalent Delta T. It comprises the following steps: 1. Use the scan line calibration information to check the completeness and reliability of the space view, the warm target view counts and the black body thermistor temperature (PRT temperature). 2. Using the warm target counts, the cold space counts and the PRT temperature, this function shall calculate the Noise-Equivalent temperature for each of the 15 AMSU channels. 3. The information of the NEdT-values is written into the array NEDT_VALUE. 4. The actual NEdT value is checked against a predefined threshold. If it exceeds the threshold, a corresponding flag should be set in the 'CALIBRATION_QUALITY' bit field.	

4.8.2 Quality Control Requirements

Quality Control covers both the radiometric and the geometric quality assessment for the AMSU-A Instrument. The information produced shall be used to generate detailed quality statistics for analysis purposes. This information shall also be used for reporting on the mission performance/product accuracy.

In addition, the derived accuracy information shall be post processed and trend analysis shall be performed. Quality Control shall also support the interactive off-line analysis functionality. This MMI allows the analysis of all data received and produced by the PGF and the extracted quality information.

AMSU-PGF-4.8.2-0010	FUNC, PERF
All the input data to the calibration processing shall be validated at least with respect to: 1. the source of the data; 2. the data content; 3. the completeness of the information before being used to perform the calibration processing	

AMSU-PGF-4.8.2-0020	**FUNC, PERF**
This input data content validation shall include at least the checking of the time consistency with respect to the following: 1. previously validated calibration inputs, if these are available.	

AMSU-PGF-4.8.2-0030	**FUNC, PERF, MMI**
The input data for the calibration shall undergo a gross limit check to eliminate outliers. The limits shall be configurable in the data set AMSU-A_L1_PGS_COF_CAL. ***Note:*** Appendix C provides an example of the structure and format of such file, However the structure and format are beyond the scope of this document and are ***not*** specified. Appendix C only provides a guideline for the contractor.	

AMSU-PGF-4.8.2-0040	**FUNC, PERF**
The result of the calibration processing shall be checked for consistency with previously-generated calibration values for the same instrument/platform, if these are available.	

AMSU-PGF-4.8.2-0050	**FUNC, PERF**
The following occurrences shall raise an event of user-configurable severity: 1. Successful completion of the on-line calibration processing; 2. Successful completion of the AMSU-A Level 1a processing for the corresponding dump; 3. Any failure of the above validation checks.	

4.8.2.1 Radiometric Quality Control

The radiometric quality assessment consists of the production of a detailed set of radiometric characteristics of the data for each detector/channels, for different imaged scenes during the dump (Day/night sides, Calibration viewing).

AMSU-PGF-4.8.2.1-0010	**MMI**
The parameters defining the windows/locations used for the extraction of radiometric statistics shall be user-configurable.	

AMSU-PGF-4.8.2.1-0020	**FUNC, PERF**
The first calibration sequence in the data shall be determined.	

AMSU-PGF-4.8.2.1-0030	**FUNC, PERF, MMI**
There shall be a check on each scan line on the status of the instrument. As a minimum the derived status shall comprise: 1. scan OK 2. power off 3. not scanning	

AMSU-PGF-4.8.2.1-0035	**FUNC, PERF**
There shall be a distinction between the status of the instrument units A1-1, A1-2 and A2. The data of the “good” units shall be processed.	

AMSU-PGF-4.8.2.1-0050	**FUNC, PERF, MMI**
There shall be for each scan line a check on the space view antenna position. In case it is out of limits the respective scan line shall be flagged as “bad”. ***Note**:* The data set AMSU-A_L1_PGS_CAL_COF specifies the limits for the space view antenna quality check	

AMSU-PGF-4.8.2.1-0060	**FUNC, PERF**
For ‘bad’ scan lines the calibration coefficients shall not be computed, but replaced by the secondary calibration coefficients. ***Note:*** The secondary calibration coefficients are in the data set AMSU-A_L1_PGS_COF_CALSEC.	

AMSU-PGF-4.8.2.1-0070	FUNC, PERF
There shall be a gross limit check on the space and internal black body counts.	

AMSU-PGF-4.8.2.1-0080	FUNC, PERF
There shall be a check on the antenna pointing of the space view and of the internal black body.	

AMSU-PGF-4.8.2.1-0090	FUNC, PERF, MMI
There shall be a line-to-line consistency check of the space and internal target counts. ***Note:*** The difference limit is specified in the calibration data base AMSU-A_L1_PGS_ COF_CAL.	

AMSU-PGF-4.8.2.1-0100	PERF
There shall be a pair of consistent ‘good’ readings to start a valid calibration sequence.	

AMSU-PGF-4.8.2.1-0110	PERF
Isolated ‘good’ values in a ‘bad’ sequence shall be considered unreliable and shall be flagged as such.	

AMSU-PGF-4.8.2.1-0120	FUNC, PERF, MMI
In case of more than a user-configurable limit of inconsistent scan-lines the calibration sequence shall be restarted.	

AMSU-PGF-4.8.2.1-0130	FUNC, PERF
There shall be a consistency check on the PRT temperatures on a scan line.	

AMSU-PGF-4.8.2.1-0140	FUNC, PERF
There shall be a line-to-line consistency check on the PRT temperatures.	

AMSU-PGF-4.8.2.1-0150	FUNC, PERF
In case there are less than a user configurable number of 'bad' lines and the difference between successive 'good' values is less than a user configurable limit, the last or next 'good' value shall be taken as corrected value to fill the gaps.	

AMSU-PGF-4.8.2.1-0160	FUNC, PERF, MMI
If there are 'bad' values in a sequence to compute the mean target temperatures, the used valid values shall receive appropriate higher weighting, according to the calibration sequence.	

4.8.2.2 Geometric Quality Control

AMSU-PGF-4.8.2.2-0010	FUNC, PERF, MMI
There shall be for each scan line a check on the Earth view antenna position. If it is out of thresholds a flag will be set for the navigation, to allow to use good data ***Note:*** The data set AMSU-A_L1_PGS_COF_CAL provides the limits for the Earth view antenna quality check.	

4.8.2.3 Limit Checking

AMSU-PGF-4.8.2.3-0010	FUNC, PERF, MMI
All PRT counts shall be compared against pre-defined thresholds. ***Note:*** The thresholds for the PRT counts are provided in AMSU-A_L1_PGS_COF_CAL.	

AMSU-PGF-4.8.2.3-0010	FUNC, PERF, MMI
All PRT counts shall be compared against pre-defined thresholds. ***Note:*** The thresholds for the PRT counts are provided in AMSU-A_L1_PGS_COF_CAL.	

AMSU-PGF-4.8.2.3-0010	FUNC, PERF, MMI
All PRT counts shall be compared against pre-defined thresholds. ***Note:*** The thresholds for the PRT counts are provided in AMSU-A_L1_PGS_COF_CAL.	

AMSU-PGF-4.8.2.3-0010	FUNC, PERF, MMI
All PRT counts shall be compared against pre-defined thresholds. ***Note:*** The thresholds for the PRT counts are provided in AMSU-A_L1_PGS_COF_CAL.	

AMSU-PGF-4.8.2.3-0010	FUNC, PERF, MMI
All PRT counts shall be compared against pre-defined thresholds. ***Note:*** The thresholds for the PRT counts are provided in AMSU-A_L1_PGS_COF_CAL.	

4.8.3 Reporting Requirements

AMSU-PGF-4.8. 3-0010	FUNC, PERF,
The following reporting information on the performance of the calibration and AMSU Level 1a data, shall be produced: 1. Information on the on-board calibration events 2. Resulting calibration values; 3. Information on completeness and timeliness of the produced Level 1a data.	

4.8.4 Accuracy Requirements

AMSU-PGF-4.8.4-0010	**PERF**
The calibration algorithm shall be implemented such that brightness temperatures (Kelvin) values are not affected in their 10^{-2} digits by rounding.	

4.9 Level 1b Processing

From the received Level 1a data and the auxiliary data, the Level 1b data are produced via data transformation and representation conversion, i.e. the Earth view data counts are converted into physical quantities.

The appropriate Level 1b Appended Data is also produced as part of the Level 1b products

4.9.1 Processing Requirements

AMSU-PGF-4.9.1-0010	**FUNCT, PERF**
The Level 1b data shall be derived from the Level 1a data using the following information: 1. The Level 1a Appended Data, in particular the derived calibration parameters 2. The on-ground characterised data, made available as configurable data sets (for the non-linearity correction). ***Note:*** Further details can be found in Section 5.2	

4.9.2 Reporting and Quality Control

AMSU-PGF-4.9.2-0010	**FUNCT, PERF**
At least the following reporting information shall be produced: 1. Completeness of the Level 1b products; 2. Validity of the processing to Level 1b; 3. Timeliness of the Level 1b products;	

AMSU-PGF-4.9.2-0020	**FUNCT, PERF, INT**
The same set of radiometric statistics on the AMSU-A Level 1b data as for the AMSU-A Level 1a data shall be produced, for all the channels of the instrument and per detector of the instrument	

4.9.3 Accuracy Requirements

AMSU-PGF-4.9.3-0010	**PERF**
The application of the calibration to the pixels shall be performed with an accuracy of better than 0.6 LSB (Least Significant Bit) maximum and 0.3 LSB RMS. ***Note:*** The LSB corresponds to the LSB of the final Level 1b binary representation. ***Note:*** It is expected that the transformation would be based on a LUT transformation mapping the Level 1a representation to the Level 1b representation. To achieve this accuracy, the derivation of the LUT would need to be performed with floating point accuracy, followed by the rounding to the final binary representation.	

4.10 Reporting Statistics Requirements

All the reporting information produced by the PGF is gathered to generate the input data for the CGS reporting function. Both the reporting inputs and the full quality information are transferred to the G/S for centralised mission reporting and off-line analysis.

AMSU-PGF-4.10-0010	**FUNCT, MMI**
The PGF shall support the generation of monitoring information reports on the observed AMSU-A Instrument status and on the AMSU-A PGF status via the PGE services. Such information reports shall be displayed on screen and printed out on user request.	

AMSU-PGF-4.10-0020	**FUNCT, MMI**
The PGF shall monitor its internal status and shall include in its reports at least the following information: 1. Number of products generated since the last report 2. For each generated product, the time tags of the first and last scan line 3. For each generated product, the date and time of the end of processing 4. For each generated product, an overall quality indicator 5. Number of received scan lines since the last report 6. Number of corrupted, missing and duplicated scan lines since the last report 7. Progress of any on-going processing ***Note:*** "Progress" is intended as a percentage of completion: a linear interpolation is sufficient (number of scan lines processed / total number of scan lines).	

AMSU-PGF-4.10-0030	INT
All reporting shall be performed in accordance with AD 3 Core Ground Segment Requirements Document.	

AMSU-PGF-4.10-0040	FUNCT, INT, MMI
The PGF shall have the capability to select any of the following parameters in a user-configurable way for forwarding to the CGS for routine monitoring: 1. Any parameter derived from the contents of the pixel data contained in the AMSU-A Level 0 data stream (raw counts for a given pixel, calibrated radiance for a given pixel, averaging counts over a target view, gain value, offset value) 2. Any parameter of the PGF software itself 3. Any generated report.	

4.11 Testing Requirements

AMSU-PGF-4.11-0010	TEST
A complete and coherent set of simulated TEST data shall be developed to TEST the AMSU PGF. ***Note***: "Complete" means that all cases shall be simulated (missing, corrupted or duplicated scan lines; tuning of the quality control thresholds; manoeuvres; etc.). "Coherent" means that the appropriate auxiliary data shall also be produced.	

5 SUPPORTING SCIENCE

This section includes the description of the algorithms mentioned in Section 4.

In the following section, it is assumed that the AMSU-A information is made available per scan-line. In those sections, where the information of more than one scan-line is needed, it is assumed that the information is available in units of one scan line for those multiple scan-lines required. This is valid for both the Metop and the NOAA satellites.

Note: AMSU-A measurements are made with two separate instrument units, AMSU-A1 and AMSU-A2. AMSU-A1 has two reflectors, which are referenced to as AMSU-A1-1 and AMSU-A1-2. AMSU-A1-1 measures AMSU-A channels 6 - 7 and 9 - 15, whereas AMSU-A1-2 measures channels 3 - 5 and channel 8. AMSU-A2 measures channels 1 and 2.

From the decommutation process, information shall be available for AMSU-A1 and AMSU-A2:

- Whether the sync bytes are ok
- The instrument status for each of the instruments (A1 and A2)
- The space view position for both instruments (0,...,3).

A flag shall contain the respective information for each scan-line and indicate non-usable scan lines:

- In case an instrument is switched off or not scanning,
- In case the scan line is already flagged as bad

A warning shall be issued in case there is a non recommended space view selected (e.g. ne 0 in case of 0 in the data base),

There shall be a navigation status flag per scan-line, which is to be initialised.

There shall be a calibration status flag per scan-line which is to be initialised.

Except for the case of flags which are passed directly through from the level 0 datastream, where no other specification of the setting of a flag bit is identifiable from a combined reading and analysis of this document and the descriptions and/or names of the flag bits in its associated PFS (AD40), the flag bits shall not be set, and where no other specification of the setting of a flag bit with a name or description in the PFS including the word 'some,' is identifiable in this document or its associated PFS, then the word 'some' in the bit name or description is to be taken to mean 'more than zero,' and where bits are indicated as not used in the PFS, these bits are not to be set.

For each instrument the antenna pointing of the AMSU-A Earth views must be checked. The thresholds are given in the calibration parameter data set AMSU-A_L1_PGS_COF_CAL. The antenna pointing position is calculated using the antenna pointing counts Cant and the slope Mant and offset Iant for the counts to antenna position conversion. This is performed for each AMSU-A1-1, AMSU-A1-2 and AMSU-A2 according to the following:

$$P_{ant}(i,k) = M_{ant}(k) \cdot C_{ant}(i,k) + I_{ant}(k)$$

Equation 1

for each Earth view i and for each instrument k. There is a table of counts versus antenna position from the manufacturer. From that Mant(k) and Iant(k) will be derived and made available in a table. Antenna positions are defined relative to nadir at 0°, with positive angles corresponding to the sun-side, and the internal target view at 180°. For the purposes of the computation it is convenient to constrain the angles within the range –135° to +225°. Then the nominal antenna position has to be calculated, using the scan step angle, for AMSU it is 3.333333°:

$$\eta_{ant}(i) = \alpha_0 - (i-1) \cdot \alpha_{AMSU}$$

Equation 2

where is the scan angle for view 1 and is the nominal antenna position (scan angle) for Earth view position i. This nominal position is then checked against the error tolerance value taken from the calibration parameter data set AMSU-A_L1_PGS_COF_CAL. If:

$$\left|\eta_{ant}(i) - P_{ant}(i, k)\right| > \varepsilon_{ant}(k)$$

Equation 3

navigation status flag should be set to false. The scan-line flag should indicate that the Earth location process will be questionable.

5.1 Level 1a Processing

5.1.1 Navigation Processing

The purpose of this processing step is to compute the Earth location in geodetic co-ordinates (longitude, latitude) of each pixel which will be appended to the AMSU-A Level 1a and 1b data. The navigation function performs the creation of the Navigation data of each Earth observation pixel. A generic algorithm for the geolocation of pixels from scanning radiometers is specified in section 5.4.3.1 of the AVHRR Level 1 PGS (RD-21). Azimuth and zenith angles with reference to north direction and local vertical at the ground measurement location are computed, as well as solar zenith and azimuth angles. In detail:

- Solar zenith angle,
- Satellite zenith angle
- Solar azimuth angle
- Satellite azimuth angle
- Average Terrain elevation in the pixel and surface type (land/sea/coast).

The following functions are required:

1. time handling and processing function which performs the datation of the data using the OBT/UTC correlation data;
2. an orbit propagator, initialised either with a predicted state vector or with the on-board provided state vector;
3. a satellite attitude model to provide the attitude of the platform;
4. an instrument viewing model to express the location of the intersection of each optical ray of the considered field of view with the Earth ellipsoid;
5. an Earth model for the computation of the navigation;
6. a Digital Elevation Model to annotate pixels with surface altitude.

The respective reference frames of the Metop and NOAA S/C have to be used as per AD 2 EPS Mission Conventions Document.

5.1.1.1 Computation of the Clock Error Information

The satellite clock error estimate is required to correct the On Board Time before converting it to UTC. With this the along track error of the sub satellite point is corrected. The clock error is specified in AD 2 EPS Mission Conventions Document.

5.1.1.2 Computation of the Satellite Orbit State and Position

From the flight dynamics function the satellite position, velocity and attitude is obtained and interpolated at the time resolution specified in [RD2] AMSU-A Level 1 Product Format Specification (EPS/MIS/SPE/ 97228). In addition the orbit state vector is provided for the start time of the dump. The flight dynamics information is specified in AD 2 EPS Mission Conventions Document (EPS/GGS/SPE/990002).

5.1.1.3 Computation of the Position for Every Nth Pixel and Every Mth Line

With the instrument scan characteristics and the satellite position (orbit information) the latitude and longitude *nth* pixel from the start of every *mth* scan line is calculated. *n* and *m* are taken from the configurable navigation parameter data base
(AMSU-A_L1_PGS_DAT_NAV). The default values are $n=1$ and $m=1$.

5.1.1.4 Computation of the Satellite and Solar Zenith Angle and Azimuth

From astronomical information (AMSU-A_L1_PGS_DAT_ASTRO) and from the information obtained in Section 5.1.1.2 and Section 5.1.1.3 the satellite zenith angle, azimuth angle, the solar zenith angle and azimuth angle are calculated.

5.1.1.5 Computation of the Earth Parameters

From the Earth information database specified in AD 2 EPS Mission Conventions Document (EPS/GGS/SPE/990002) the average terrain elevation is calculated for the AMSU-A Fields of View. Together with terrain type information (land/sea/coast) this information is put into the appended part of the Level 1a and Level 1b Products.

5.1.2 Calibration Coefficients Calculation

The calibration coefficients to convert from Earth view counts to radiance for each of the AMSU-A channels are determined in-flight by viewing the on-board blackbody target and cold space. A calibration is performed at each scan line (8 seconds).

Earth scene radiances R_s, depend on the Earth scene counts C_s through the non linear relationship.

$$R_s = R_w + \frac{R_w - R_c}{\bar{C}_w - \bar{C}_c} \cdot (C_s - \bar{C}_w) + Q$$	***Equation 4***

The linear gain term G is given by:

$$G = \frac{\bar{C}_w - \bar{C}_c}{R_w - R_c}$$	***Equation 5***

is a function of the average warm target calibration measurement counts $\bar{C}_w$, the cold space calibration measurement counts $\bar{C}_c$, the warm target radiance R_w, and the radiance of cold space R_c. The warm target radiance is calculated from PRT measurements of the temperature of the warm target using the Planck function, and the cold space radiance is calculated from the temperature of cold space. The non-linear term Q is given by:

$$Q = u \cdot (R_w - R_c)^2 \cdot \frac{(C_s - \bar{C}_w) \cdot (C_s - \bar{C}_c)}{(\bar{C}_w - \bar{C}_c)^2} = u \cdot \frac{(C_s - \bar{C}_w) \cdot (C_s - \bar{C}_c)}{G^2}$$	***Equation 6***

where u is an instrument temperature dependent non-linearity coefficient characterised pre-launch. Each of these terms is described in more detail below in the following.

The following steps are to be performed:

- ***Compute the mean internal warm target temperature*** from several PRT output values, translated into temperature using pre-flight 3rd order polynomial coefficients, weighted by each PRT respective weight and with a warm load bias correction term added.

- ***Apply pre-computed corrections for each channel to the mean warm target temperature and the known fixed temperature of cold space***, then convert the resulting temperatures into radiance for each channel.
- ***Compute the mean instrument counts*** for the warm target and cold space measurements. For each scan line, apply a triangular convolution over seven consecutive scan lines in order to derive the mean warm target and cold space counts (with reduced noise).
- ***Compute the linear gain*** from the warm target and cold space radiances and the average warm target and cold space counts.
- ***Compute the non-linearity correction*** *term* using coefficients determined pre-flight at three instrument temperatures (interpolation at other temperatures performed from these values).
- ***Compute calibration coefficients*** to convert Earth view counts into radiance.

5.1.2.1 Get Information from Calibration Data Set

The user-configurable data set AMSU-A_L1_PGS_COF_CAL contains all information required for the calibration of the instrument. It is specific for each flight model and contains the following information:

AMSU generic information:

- Brightness temperature of space at AMSU frequencies in K
- 15 central wave numbers
- Band correction coefficients a,b for each channel.
- Nominal space and internal target viewing angles in ° (four pairs)
- Flag for moon contamination on/off
- Threshold angle for moon contamination

AMSU flight model specific information:

AMSU-A1 information:

- AMSU-A1 instrument ID
- Selected position for space view for calibration (0,..,3)
- Slope and offset for counts to antenna position in degrees, for AMSU A1-1 and AMSU A1-2
- Antenna position error allowed in degrees for calibration and Earth views, for AMSU-A1-1 and AMSU-A1-2
- Internal warm target PRT count to temperature (in K) conversion coefficients
- Weight coefficients for each of the five PRT, AMSU-A1-1 and AMSU-A1-2
- Reasonable PRT temperature limits (minimum, maximum, in K) for AMSU-A1-1 and AMSU-A1-2
- Maximum PRT temperature change (in K) allowed before rejecting for AMSU-A1-1 and AMSU-A1-2
- Minimum number of PRT readings acceptable for AMSU-A1-1 and AMSU-A1-2
- Number of scan lines to fill in bad PRT data for AMSU-A1-1 and AMSU-A1-2
- Number of scan lines to use in consistency checks of calibration views for AMSU-A1-1 and AMSUA1-2
- Instrument temperature sensor I, for AMSU-A1-1 and AMSU-A1-2, 0=RF shelf, 1=RF mux
- three Instrument RF shelf temperatures (in K), for AMSU-A1-1 and AMSU-A1-2, PLLO1
- three Instrument RF mux temperatures (in K), for AMSU-A1-1 and AMSU-A1-2, PLLO2

AMSU-A1 information:

- Instrument temperature RF Shelf PRT count to temperature (in K) conversion coefficients for AMSUA1-1 and AMSU-A1-2
- Instrument temperature RF mux PRT count to temperature (in K) conversion coefficients for AMSUA1-1 and AMSU-A1-2
- Warm load correction factor for each reference temperature, channel 3-15 and channels 9-14 PLLO2
- Cold space correction factors for each space view, channels 3-15 and channels 9-14 PLLO2
- Gross count limits (maximum and minimum) for the internal target counts
- Gross count limits (maximum and minimum) for the space view counts
- Maximum change in mean counts from previous scan allowed before rejecting
- Non linearity correction coefficients, three reference temperatures, channels 3-15 and 9-14 PLLO2
- Digital A conversion coefficients (4 coefficients, 45 parameters)
- Analogue conversion coefficients (2 coefficients, 27 parameters)

AMSU-A2 information:

- AMSU-A2 instrument ID
- Selected position for space view for calibration (0,..,3)
- Slope and offset for counts to antenna position in degrees.
- Antenna position error allowed in degrees for calibration and Earth views
- Internal warm target PRT count to temperature (in K) conversion coefficients
- Weight coefficients for each of the five PRT
- Reasonable PRT temperature limits (minimum, maximum, in K)
- Maximum PRT temperature change (in K) allowed before rejecting
- Minimum number of PRT readings acceptable
- Number of scan lines to fill in bad PRT data
- Number of scan lines to use in consistency checks of calibration views
- Instrument temperature sensor ID, 0=RF shelf, 1=RF mux
- Three Instrument RF shelf temperatures (in K)
- Three Instrument RF mux temperatures (in K)
- Instrument temperature RF Shelf PRT count to temperature (in K) conversion coefficients
- Instrument temperature RF mux PRT count to temperature (in K) conversion coefficients
- Warm load correction factor for each reference temperature, channel 1 and 2
- Cold space correction factors for each space view, channels 1 and 2
- Gross count limits (maximum and minimum) for the internal target counts
- Gross count limits (maximum and minimum) for the space view counts
- Maximum change in mean counts from previous scan allowed before rejecting
- Non-linearity correction coefficients, three reference temperatures, channels 1 and 2
- Digital A conversion coefficients (4 coefficients, 19 parameters)
- Analogue conversion coefficients (2 coefficients, 15 parameters)

The parameters listed above will be used in the subsequent calibration processing. They represent preflight measured and derived parameters to characterise the instrument and also thresholds, against which instrument measurements will have to be checked. The result of each of these checks shall be documented in a flag information, typically per scan line or pixel.

5.1.2.2 Computation of the Warm Target Radiance

5.1.2.2.1 Computation of the Instrument Reference Temperature

The readings of the warm target temperature are affected by the temperature of the instrument. To correct for these effects the instrument reference temperature needs to be calculated.

There is a different instrument reference temperature for each antenna assembly. For antenna A1-1 corresponding to channel 6,7, and 9-15, this reference temperature is the A1-1 RF Shelf temperature, and the backup value is the A1-1 RF Multiplexer temperature.

Likewise, the reference temperature for channels 3, 4, 5, and 8 is the A1-2 RF Shelf temperature with the A1-2 RF Multiplexer temperature as backup, and the reference temperature for channels 1 and 2 is the A2 RF Shelf temperature with the A2 RF Multiplexer temperature as backup.

These values are contained in the temperature sensor telemetry data. A user-configurable flag indicates whether the primary or backup temperature is used.

Each of these temperatures has associated third order polynomial coefficients contained in the Global Auxiliary data set to convert the instrument temperature counts H to units of temperature:

$$T_{inst} = \sum_{j=0}^{3} d_j \cdot H^j$$

Equation 7

The coefficients *dj* are provided for all instrument temperatures that are measured for monitoring purposes (from AMSU-A_L1_PGS_COF_CAL).

5.1.2.2.2 Computation of the Warm Target PRT Temperatures

The Planck function allows the calculation of the warm target radiances given estimates of their temperatures.

Each antenna assembly has a separate warm target whose temperature is measured with embedded Platinum Resistance Thermometers (PRTs). Each antenna assembly has a different number of PRTs: Five PRTs for AMSU-A1-1, five PRTs for AMSU-A1-2, and seven PRTs for AMSU-A2.

The PRT counts are contained in the temperature sensor telemetry packet along with other instrument monitoring temperatures.

Each PRT provides numerical counts $\tilde{C}_k$, which are translated into temperatures through a third-order polynomial with the pre-launch or in-flight determined coefficients $f_{k,j}$. where k indicates the PRT number of the respective instrument.

$$T_k = \sum_{j=0}^{3} f_{k,j} \cdot \tilde{C}_k^j \qquad \textit{Equation 8}$$

The PRT temperatures are then checked for consistency over a scan line and the mean temperature is computed. First "good" PRT values are selected:

- The PRT weight must be greater than 0;
- The PRT temperature must be within gross limits and the weight must be greater than 0,
- The PRT used for the calculation of the average PRT temperature must be within a range from the median.

Hence the check:

$$T_k \geq T_{k,min} \wedge T_k \leq T_{k,max} \qquad \textit{Equation 9}$$

selects good points for all weights greater than 0. Then there is a check of the good values against the median value:

$$\left| T_{k,good} - T_{median} \right| \leq \delta T_{PRT} \qquad \textit{Equation 10}$$

where $T_{k,good}$ are the PRT temperatures selected through the check above, T_{median} is the median of the good temperatures and δT_{PRT} is a threshold taken from the calibration data set. The average PRT temperature is then computed using the "good" PRT temperatures, which passed the median test according to:

$$T_{PRT,avg} = \frac{1}{N_{good}} \sum_{n=1}^{N_{good}} w_n \cdot T_{n,good} \qquad \textit{Equation 11}$$

where n is the index of the good PRT temperatures, which passed the median test, w_n is the weight of the good PRT, the temperature of which has passed the median test.

Finally the interline consistency is checked in a similar way as the check of the space and internal target counts. A defined number of scans may have the last good PRT value or the next good PRT value. The difference between successive good values must be less than a threshold taken from the calibration data set. In contrary to the test on the target counts bad values of the PRTs are corrected. Hence if:

$$\left|T_{PRT,\,avg}(i-1) - T_{PRT,\,avg}(i)\right| < \delta T_{PRT,\,avg}$$ ***Equation 12***

and

$$\left|T_{inst}(i-1) - T_{inst}(i)\right| < \delta T_{inst}$$ ***Equation 13***

where $\delta T_{PRT,avg}$ and δT_{inst} are the PRT and instrument temperature thresholds, and the PRT and instrument temperatures are considered for scan lines i-1 and i, the temperatures are flagged as good and used. If not, the respective temperatures are replaced with the previous good value. A flag is set for the PRT and instrument temperature status as well as for the scan-line quality.

5.1.2.2.3 Interpolate Warm Target Temperature Bias Correction

The warm target temperature bias correction term is a function of the instrument temperature T_{inst} and is different for the two phase locked loop oscillators PLLO#1 and PLLO#2, which stabilize the frequencies of the channels 9 - 14. It is characterised pre-launch at three instrument reference temperatures: minimum, nominal and maximum for each of the AMSU-A instrument channels (specified in AMSUA_L1_PGS_COF_CAL). These pre-launch bias correction terms are to be interpolated at the current instrument temperature.

Pre-flight Calibration for Warm Target Temperature Fixed Bias Corrections

Note: The following specification is not to be implemented. It provides additional explanation to support the understanding. The algorithm used for calculating the warm target fixed bias correction during thermal vacuum chamber testing of the flight model is described below.

A scene target with embedded PRTs is used to provide scene counts C_s in the calibration test. The scene target temperature is measured by the PRTs to give an average scene temperature T_s^{prt} using the same PRT equations:

$$T_{Sk}^{prt} = \sum_{j=0}^{3} f_{Sk,j} \cdot \tilde{C}_{Sk}^{j}$$	***Equation 14***

$$T_{S}^{prt} = \frac{\sum_{k=1}^{m} w_k Ts_k^{prt}}{\sum_{k=1}^{m} w_k}$$	***Equation 15***

with the corresponding conversion coefficients $f_{Sk,j}$, the scene target PRT counts C_{Sk}^{j}, the individual PRT temperatures T_{Sk}^{prt}, and the weights w_k. Warm target counts *Cw* , are taken as the average of two measurements of each target. The warm target radiometric temperature T_{W}^{rad} is then calculated from

$$T_{W}^{rad} = T_{S}^{prt} + (T_{S}^{prt} - T_c) \cdot \frac{C_w - C_s}{C_s - C_c}$$	***Equation 16***

for comparison with the actual temperature of the warm target measured by the PRTs *Tw* to determine the bias. This warm target temperature bias correction factor is then computed as the average over N (= 725) scan lines taken at three instrument shelf temperatures and provided in the instrument characteristics data set (AMSU-A_L1_PGS_COF_CAL), as follows:

$$\delta T_w = \frac{1}{N} \cdot \sum_{i=1}^{N} (T_{W}^{rad} - T_w)$$	***Equation 17***

5.1.2.2.4 Calculation of the Average Warm Target Temperature

All the PRT temperatures for a given antenna assembly are averaged to estimate the corresponding warm target temperature:

$$T_w = \frac{\sum_{k=1}^{m} w_k \cdot T_k}{\sum_{k=1}^{m} w_k} + \delta T_w$$

Equation 18

where δT_w is a warm load correction term and w_k is a weighting factor associated with each PRT (1 if the PRT is good; 0 if the PRT is bad), and *m* is the number of PRTs for the target (specified in AMSUA_ L1_PGS_COF_CAL).

5.1.2.2.5 Computation of the Warm Target Radiances

The radiance R_w emitted by the warm target with the band corrected temperature T'_w is calculated applying Planck's law:

$$R_w = B(T'_w)$$

Equation 19

The band-corrected temperature is calculated according to:

$$T_w' = a + bT_w$$

Equation 20

where *a* and *b* are the band correction coefficients.

Note: For NOAA-KLM, these corrections are small for all AMSU-A channels and the coefficients are set to 0 and 1.

The full Planck function is to be used. The radiance in $mW/(m^2 \text{ ster } cm^{-1})$ is expressed as a function of the wavenumber κ in cm^{-1} and the temperature T in Kelvin according to:

$$R = \frac{c_1 \kappa^3}{\exp\left(c_2 \cdot \frac{\kappa}{T}\right) - 1}$$

Equation 21

where c_1 and c_2 are the first and second constant of the Planck function and are to be taken from the data set of physical constants.

5.1.2.3 Computation of the Cold Space Radiance

5.1.2.3.1 Estimation of the Cold Space Temperature

The cold space temperature is directly estimated from:

$$T_c = 2.73 + \delta T_c \qquad \textit{Equation 22}$$

where δT_c is a cold space temperature fixed bias correction term available for each channel reflecting the contamination by radiation originating from the spacecraft and the Earth limb. An initial value is estimated from pre-launch calibration tests. Optimal values may be determined from post-launch data analysis to compensate for contamination due to stray radiation created by the spacecraft.

Pre-launch Characterisation of Cold Bias Corrections

Note: The following specification is not to be implemented. It provides additional explanation to support understanding of the product.

The linear part of the calibration function is defined as the first two terms of the calibration equation:

$$R_{sL} = R_w + (R_w - R_c) \cdot \frac{C_s - \overline{C}_w}{\overline{C}_w - \overline{C}_c} \qquad \textit{Equation 23}$$

approach R_{sL}. These $\Delta Rc = R_{sprt} - RsL$ are considered cold biases. They are used to derive the δT_c values.

5.1.2.3.2 Moon-Glint Correction

According to (Saunders et al., 2002) the moon, if visible in the cold space view of the AMSU-A and MHS instruments, can cause considerable problems in the calibration. In the case of MHS this can amount to several tens of K in Brightness temperatures. Hence, there is a need to correct for this effect. The several steps required for this correction are described in the following section.

5.1.2.3.2.1 Calculation of the moon angle

1. Calculate the geocentric right ascension $\alpha_{RA,\ moon}$ and declination δ_{moon} of the moon using standard astronomic formula or tables. This position needs to be accurate to 0.3 degrees or better (e.g. http://www.xylem.f2s.com/kepler/moon.html). It is acceptable to do the full calculation at the beginning and end of each dump, and interpolate for intermediate scan-lines to save computation time.

2. To establish whether the moon lies in the instrument space field of view it is necessary to compare the angular separation of the moon and the space field of view. This means the coordinates of the moon from a space fixed geocentric reference frame must be converted to the satellite field of view reference frame. This process requires several stages. Firstly, the moon coordinates are transformed from the space fixed reference frame to an earth fixed geocentric reference frame (with the x-axis pointing to the Greenwich Meridian, z-axis to the North pole and the y-axis comprising the right-hand set). To achieve this, the space fixed moon coordinates must be rotated about the z-axis by the hour angle. In this case, the hour angle is simply the sidereal time at the Greenwich meridian as an angle since the right ascension on the first point of Aries, is zero. The hour angle is simply how much sidereal time has passed since the first point of Aries, is zero. The hour angle is simply how much sidereal time has passed since the first point of Aries was on the Greenwich meridian. As a result, for each individual scan line *i*, we need to compute the local sidereal time t_{lst} according to the following:

$t_{lst}(i) = 100.46 + 0.98564735 \cdot j_{day} + h \cdot 15° + \lambda$	**Equation 24**

where j_{day} is the time in days since the epoch 12:00 at 1 January 2000, *h* is the hour of the day in GMT and λ is the longitude of the Greenwich meridian (zero degrees in this case). The earth-fixed coordinates of the moon for each scan line are then given by:

$\begin{bmatrix} x^{earth}_{moon} \\ y^{earth}_{moon} \\ z^{earth}_{moon} \end{bmatrix} = \begin{bmatrix} \cos\alpha_h & \sin\alpha_h & 0 \\ -\sin\alpha_h & \cos\alpha_h & 0 \\ 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} x^{space}_{moon} \\ y^{space}_{moon} \\ z^{space}_{moon} \end{bmatrix}$	**Equation 25**

3. Given the position of the satellite in the same earth-fixed reference frame, the position of the moon, *dr*, with respect to the satellite is as follows:

$$\underline{dr} = \begin{bmatrix} dx \\ dy \\ dz \end{bmatrix} = \underline{r}_{moon} - \underline{r}_{sat}$$

Equation 26

This vector must be transformed to the satellite frame of reference and then by to the actual field of view reference frame. The satellite reference frame [AD 2] is defined in by the right-hand geocentric axes with the z axis pointing away from the earth's centre, the y-axis points approximately in the direction of negative velocity and the x-axis making up the right-hand set.

4. To transform to the satellite frame of reference, a rotation about the z-axis by the satellite longitude, λ is required, followed by a rotation about the new x-axis by a 90 degree latitude, ϕ . The x-y axis then needs aligning such that the y-axis points in the direction of negative satellite velocity. The transformation to the satellite reference frame is summarised below:

$$\begin{bmatrix} dx' \\ dy' \\ dz' \end{bmatrix} = \begin{bmatrix} \cos\lambda & \sin\lambda & 0 \\ -\sin\lambda & \cos\lambda & 0 \\ 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} dx \\ dy \\ dz \end{bmatrix}$$

$$\begin{bmatrix} dx'' \\ dy'' \\ dz'' \end{bmatrix} = \begin{bmatrix} \cos\left(\frac{\pi}{2} - \phi\right) & 0 & -\sin\left(\frac{\pi}{2} - \phi\right) \\ 0 & 1 & 0 \\ \sin\left(\frac{\pi}{2} - \phi\right) & 0 & \cos\left(\frac{\pi}{2} - \phi\right) \end{bmatrix} \times \begin{bmatrix} dx' \\ dy' \\ dz' \end{bmatrix}$$

$$\begin{bmatrix} dx^{sat} \\ dy^{sat} \\ dz^{sat} \end{bmatrix} = \begin{bmatrix} \cos\left(\frac{\pi}{2} + \theta^{vel}\right) & \sin\left(\frac{\pi}{2} + \theta^{vel}\right) & 0 \\ -\sin\left(\frac{\pi}{2} + \theta^{vel}\right) & \cos\left(\frac{\pi}{2} + \theta^{vel}\right) & 0 \\ 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} dx'' \\ dy'' \\ dz'' \end{bmatrix}$$

Equation 27

where Θ^{vel} is the angle subtended by the x-y component velocity and the x-axis in the x-y plane in the intermediate dx'',dy'',dz'' frame (there should be no z component of velocity).

$$\theta^{vel} = \operatorname{atan}\left(\frac{v_y''}{v_x''}\right)$$	***Equation 28***

Note: The velocity vectors vx'' and vy'' must also be defined in the intermediate x'',y'',z'' frame. For example, if the satellite velocity is known in earth fixed geocentric co-ordinates, the velocity vectors must also be transformed in the same way that the moon position vector was transformed from (dx,dy,dz) to (dx'',dy'',dz'').

5. The satellite attitude must also be taken into account by transforming it to the satellite actual frame of reference. This involves three rotations about the x,y,z axes by the roll, pitch and yaw angles as defined in [AD 2]

6. The space field of view, δ_{FOV}, of AMSU-A1 and AMSU-A2 is nominally set to 6.666 degrees as measured anti-clockwise from the -x axis in the z-x plane of the satellite actual frame of reference. Other possibilities exist and so the actual position of the space field of view must be obtained from the satellite data itself for both AMSU-A1 and A2 for each scan line. To establish whether the moon is within the field of view, the angular separation between moon and each space view must be determined using standard trigonometry. To achieve this, the coordinate system is transformed such that the field of view direction is coincident with the –x axis and the dot product of the new –x axis and the moon position vector dr^{FOV} is calculated.

$$\begin{bmatrix} dx^{FOV} \\ dy^{FOV} \\ dz^{FOV} \end{bmatrix} = \begin{bmatrix} \cos\delta^{FOV} & 0 & \sin\delta^{FOV} \\ 0 & 1 & 0 \\ -\sin\delta^{FOV} & 0 & \cos\delta^{FOV} \end{bmatrix} \times \begin{bmatrix} dx^{sat} \\ dy^{sat} \\ dz^{sat} \end{bmatrix}$$	***Equation 29***

The angle subtended by the moon and the space field of view, $\Delta\Theta^{moon}$, is given by

$$\Delta\theta^{moon} = \operatorname{acos}\left(\frac{-\hat{\underline{x}} \bullet \underline{dr}^{FOV}}{\left\|-\hat{\underline{x}}\right\| \left\|\underline{dr}^{FOV}\right\|}\right)$$	***Equation 30***

where $-\hat{\underline{x}}$ is a unit vector.

7. Space view readings are considered contaminated if the moon is within a predefined angle of the space view. The condition for moon contamination is then

$$\Delta\theta^{moon} > \left(\frac{3.3^{\circ}}{2} + 0.25^{\circ} + 0.3^{\circ}\right)$$

Equation 31

where:

i. the instrument field of view = 3.3 degrees

ii. the angle subtended by the moon = 0.25 degrees

iii. the error in the moon calculation is, in the worst case, 0.3 degrees.

These values must be user configurable and may be changed.

8. An alternative method would be to use the satellite attitude information and the earth located two mid-swath samples (15 and 16 for AMSU-A) to calculate the angle subtended by the moon and the space field of view. However, care must be taken to allow for the forward motion of the spacecraft during the time elapsed between the acquisition of the mid-swath pixels and the space counts.

5.1.2.3.2.2 Correction of the data

For AMSU-A, there will be normally be at least two space-view samples remaining even after the test described in Step 1 in Section 5.1.2.3.2.1 above. In this case, the calibration proceeds as normal, apart from rejecting the contaminated samples. However, AMSU-A has only one space view angle, so it is necessary to correct or reject the data. The method recommended for correcting the data is as follows:

1. Interpolate the gain (G) for each channel, using good data either side of the moon-contaminated data. [This means retaining up to 10 min of calibration data in memory or performing a second pass over the data]. If no good data is available within a user configurable sized window either side of the contaminated regions (for example, within the current scan line), then the recovery fails.

2. Re-calculate the space counts using the new interpolated gain values and then calculate the calibration coefficients in the usual way.

3. Lines which are moon contaminated must be flagged as such by setting the following bits in the SCAN_LINE_QUALITY flag: Bit 24 must be set if the scan line was able to recover from contamination and be successfully calibrated. Regardless of the recovery status and the value of bit 24, bit 25 must always be set if the scan line is lunar contaminated. The angle subtended by the moon position vector and the centre of the space field of view must also be recorded in the Lunar Angle level 1 product.

Note the following conditions:

1. The AMSU-A correction must be done independently for AMSU-A1 and AMSU-A2, since their space-view angles may be different.

2. If the moon contamination occurs at the start or end of the data, a constant value for G will have to be assumed throughout the contaminated region.

This method assures that we continue to make full use of the warm target calibration data. Aside from increased space view counts during lunar contamination, changes in both the space and warm target counts occur each orbit due to the temperature fluctuations experienced by the receiver electronics. Since the warm target counts act as a first order pre-cursor to the space target counts, interpolation of the gain as opposed to the space counts directly gives slightly more accurate results.

5.1.2.3.3 Computation of the Cold Space Radiances

The next step converts the band corrected cold space temperature T'_c into a radiance by applying Planck's law:

$$R_c = B(T_c')$$ **Equation 32**

The band corrected temperature is calculated according to the following:

$$T_c' = a + bT_c$$ **Equation 33**

where *a* and *b* are the band correction coefficients.

Note: For NOAA-KLM, these corrections are small for all AMSU-A channels and the coefficients are set to 0 and 1.

5.1.2.4 Averaging the Warm Target and Cold Space Counts

At each scan, two measurements of the internal blackbody (warm) target C_w and of the cold space C_c, are performed and averaged. If the two measurements differ by more than a pre-set limit of blackbody (respectively cold space) count variation, the data from that scan line is not used. The initial limit is calculated from the pre-launch calibration data and is set to 4.5σ of this data set. The antenna position for the calibration targets is checked beforehand. As a first step, the antenna pointing to the internal warm target and the external cold space needs to be checked, in an analogue way to the check of the earth view antenna position. This step is performed for the three AMSU-A components: AMSU-A1-1, AMSU-A1-2, and AMSU-A2. The thresholds are given in the calibration parameter data set AMSU-A_L1_PGS_COF_CAL. The antenna pointing position is calculated using the antenna pointing counts $C_{x,ant}$ and the slope $M_{x,ant}$ and offset $I_{x,ant}$ for the counts to antenna position conversion. This is performed for AMSU-A1-1, AMSU-A1-2, and AMSU-A2 according to:

$$P_{x,\,ant}(k) = M_{x,\,ant}(k) \cdot C_{x,\,ant}(k) + I_{x,\,ant}(k)$$ ***Equation 34***

for each instrument k, where x stands for c(old) and w(arm) target. Then the selected spaceview position is then checked against the error tolerance value taken from the calibration parameter data set AMSUA_ L1_PGS_COF_CAL. If

$$\left|\eta_{c,\,ant} - P_{c,\,ant}(k)\right| > \varepsilon_{c,\,ant}(k)$$ ***Equation 35***

then a warning flag should be set for the space view. The scan-line flag should indicate that the cold space view antenna pointing is bad.

The same check is done on the internal warm target. against the error tolerance value taken from the calibration parameter data set AMSU-A_L1_PGS_COF_CAL. If:

$$\left|\eta_{w,\,ant} - P_{w,\,ant}(k)\right| > \varepsilon_{w,\,ant}(k)$$ ***Equation 36***

then a warning flag should be set for the internal target view. The scan-line flag should indicate that the internal warm target antenna pointing is bad.

As indicated above, there are two readings of the internal blackbody (warm) target counts and of the cold space count made: The first set $C_{x,1}$ is made prior to the integration interval, whereas the second reading $C_{x,2}$ is made approximately halfway through the integration period (x stands for *warm* and *cold* target, respectively).

First, there is a check of the difference between the samples made. It this difference is larger then a threshold– read from the calibration parameter data set AMSU-A_L1_PGS_COF_CAL–then the scan line should be flagged as bad. That being so, this still has to be checked.

$$\left|C_{x,\,1} - C_{x,\,2}\right| > \varepsilon_{x,\,12}$$ ***Equation 37***

If this is satisfactory, then the two readings are averaged to yield the warm and cold internal counts C_w and C_c for each instrument channel:

$$C_x = (C_{x,\,1} + C_{x,\,2})/2$$ ***Equation 38***

where x stands for w(arm) or c(old) target.

Finally, the line-to-line consistency of the space and internal target counts is checked. The difference between successive good values must be less than a threshold for each channel taken from the calibration data set AMSU-A_L1_PGS_COF_CAL. A pair of consistent readings is necessary to define the start of a good sequence, after which inconsistent readings are flagged as bad. If more than a defined number of scans elapses since the last good pair, the sequence will be restarted. Isolated valid readings are flagged as bad, since they are considered unreliable. Hence the check:

$$\left|C_{x,\,i-1} - C_{x,\,i}\right| \leq d$$

Equation 39

where x stands for both *cold* and *warm* target, i is the scan line in question, d is the user-configurable threshold for each channel, needs to be performed. If the threshold is exceeded, then a flag should be set to indicate inconsistent cold or warm target with the one of the previous line. The scan-line quality flag should indicate a bad channel.

In order to reduce the noise and provide calibration coefficients that vary smoothly with time, the instrument counts from *n* consecutive scan lines before and after the current scan line are used to compute the average counts, ($\bar{C}_w$ and $\bar{C}_c$). For *n = 3*, a triangular convolution function defined over the seven measurements is applied for each scan line:

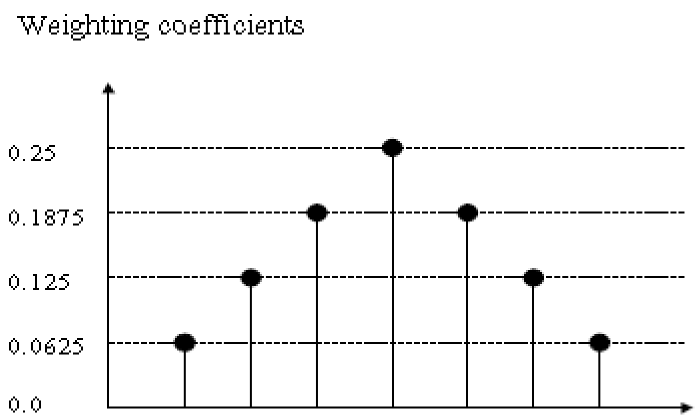

Figure 3: Weighting coefficients for the Warm Target/Cold Space Counts Convolution Function

The following equation determines the applied convolution:

$\overline{C}_x = \frac{1}{n+1} \cdot \sum_{i=-n}^{+n} \left(1 - \frac{\lvert i \rvert}{n+1}\right) \cdot C_x(t_i)$	***Equation 40***

where

- x stands for w (warm blackbody target) or c (cold space target),
- n is the number of scan lines over which the averaging is done, before and after the current scan-line
- t_i is the time of the scan lines before or after the current scan line, and
- $C_x(t_i)$ is the average of the two blackbody views or two cold space views for the scan line at time t_i.

If t_0 is the time of the current scan line, one can write $ti = t_0 + i \bullet \Delta t$, where Δt = 8 seconds for AMSU-A. The $2n+1$ values are equally distributed around the scan line to be calibrated ($n = 3$ for all AMSU-A antenna systems, 20 is the maximum value assumed). For the first and last n scan lines in a dump and around a scan line gap, the convolution is applied with a restricted number of scan lines.

5.1.2.5 Interpolation of the Non-Linearity Correction Coefficients

u is the non-linearity coefficient (see Equation 3), which is a function of instrument temperature

$u = u(T_{inst})$	***Equation 41***

u is characterised at three instrument temperatures (low, nominal and high) for each channel.

The value of u at the current instrument temperature will be linearly interpolated from these three values. The non-linearity coefficient u is provided for two reference temperatures: the instrument RF shelf temperature that is the primary temperature measurement, and the instrument RF MUX temperature that is the backup temperature measurement. Two sets of calibration coefficients corresponding to the two reference temperatures are provided.

5.1.2.6 Calculation and Application of Calibration Coefficients

The non-linear calibration function

$R_s = R_w + \frac{(C_s - \overline{C}_w)}{G} + Q$	***Equation 42***

can also be written

$R_s = a_0 + a_1 \cdot C_s + a_2 \cdot C_s^2$	***Equation 43***

where a_0, a_1 and a_2 are the calibration coefficients computed from G and u at each scan line: This calculation is done only if there are good target temperatures as well as a good instrument temperature.

$$\begin{cases} a_0 = R_w - \dfrac{\overline{C}_w}{G} + u \cdot \dfrac{\overline{C}_w \cdot \overline{C}_c}{G^2} \\ a_1 = \dfrac{1}{G} - u \cdot \dfrac{(\overline{C}_w + \overline{C}_c)}{G^2} \\ a_2 = \dfrac{u}{G^2} \end{cases}$$

Equation 44

The coefficients a_0, a_1 and a_2 in units of mW/ (m2 ster cm^{-1}), mW/ (m2 ster cm-1) / count, mW / (m^2 ster cm^{-1})/$count^2$ have to be scaled by 109, 1013 and 1019 to allow their storage in as integers in the Level 1 file.

Two sets of calibration coefficients corresponding to the two reference temperatures are provided.

$$a_{kprimary} = a_k(u(T_{instprimary}))$$

Equation 45

as specified above, k = 0,...,2. The coefficients $a_{ksecondary}$, k = 0,...,2 are interpolated for the instrument temperature T_{inst}. They were measured pre-flight in the thermal vacuum test at three instrument temperatures. The values are taken from the secondary calibration data set (AMSUA_ L1_PGS_COF_SECCAL).

These coefficients are output along with the raw counts in the Level 1a product.

Pre-launch Characterisation of Gain and System Noise

Note: The following specification is not to be implemented. It provides additional explanation to support the understanding.

Counts at zero radiance are computed during pre-launch calibration tests to determine the system noise. To compute the counts at zero radiance, R_{sL} is set to zero in the linear calibration equation and it is solved for C_s.

$$C_s^{int} = \overline{C}_w - G \cdot R_w$$

Equation 46

This value C_s^{int} may be used to monitor the zero offset level and hence the rough quality of the calibration coefficients and the system noise. Calibration tests for the AMSU-A instrument revealed that the gain *G*, is sensitive to instrument temperature.

5.1.2.7 Algorithm to Calculate the Noise Equivalent Temperature

The value for NEdT is calculated for each channel and each scan line. It is driven by the variability of the warm target view counts generated during the blackbody view of the antenna. Unlike the previously described procedure of the operational instrument calibration, the counts for the blackbody views and the space views are not averaged using a triangular-shaped sliding window. Instead, a simple non-weighted average over seven subsequent scan lines is used.

The first step of the NEdT calculation is therefore to used the scan line-averaged warm target views and cold target views (Equation 36) and the corresponding mean warm target temperature (Equation 28) to calculate the channel gain for a distinct scan line *i:*

$$G_i = \frac{C_{wi} + C_{ci}}{T_{PRTavg}(i) - 4}$$

Equation 47

Note that the gain given herein is related to temperature. Therefore it is different from the gain defined in Equation 2, which refers to radiances. The value of four (4) is an approximation of the temperature of space plus an offset due to some background radiation. The mean of the gain of seven (denoted with N in the following equations, with $N = 7$ subsequent scan lines is, therefore:

$$\overline{G} = \frac{1}{N} \sum_{i = imin}^{i = imax} G_i$$

Equation 48

The summation runs over seven subsequent scan lines from i_{min} to i_{max}. For the same scan lines, 14 warm target views (2 for each scan line) are averaged. Again, $N = 7$.

$$\langle C_w \rangle = \frac{1}{N} \sum_{i = imin}^{i = imax} C_{w,i}$$

Equation 49

The variability of these 14 warm target view counts is simply calculated by summing up the squared differences between an individual count and the mean value.

$$Var_w = \sum_{i=imin}^{i=imax} [(C_{w1.i} - \langle C_w \rangle)^2 + (C_{w2.i} - \langle C_w \rangle)^2]$$ ***Equation 50***

Consequently, the standard deviation of the warm target view counts is as follows, with $N = 7$.

$$\sigma_w = \sqrt{\frac{1}{2N} Var_w}$$ ***Equation 51***

Finally, one obtains the NEdT for a block of seven scan lines as follows.

$$NEDT = \frac{\sigma_w}{\overline{G}}$$ ***Equation 52***

In practice, NEdT is often averaged over a distinct number of subsequent scan lines (typically 100) in order to get a smoother estimate. This averaging procedure is not part of the operational processing.

5.2 Level 1b Processing

The calibration coefficients are applied to the Earth view counts and thus the engineering information converted into physical parameters.

The Level 1b processing includes the application of the calibration coefficients to the Earth view counts to retrieve the calibrated radiances for the 15 channels.

5.2.1 Radiance Computation

Radiances are computed according to the calibration equation for the calibration parameters (see Equation 18).

5.2.2 Limb-Corrected Brightness Temperature Derivations

This step is only to be performed for the data to be transferred to the AVHRR processing and for the stand-alone AMSU-A based retrieval.

This section specifies the preparation of the input data for the limb-adjustment step. Input to this function are the AMSU-A level 1b dataflow (antenna temperatures $T_b{}^{a}$), the topography file, the antenna-correction coefficients (if antenna correction is already done, there is no need), the limb-adjustment coefficients for sea and non-sea surfaces. Output from this step are antenna corrected, AMSU-A limb-adjusted brightness temperatures $T_b{}^{lbcor}$, on the same grid and Earth location as the level 1b information, and a land/sea mask for the AMSU-A grid.

A configuration parameter i4_antenna_correction is set to 0. If this configuration parameter is not set to 0, the first step to prepare the data is performed. The user configurable antenna correction coefficients $f_0{}^{i,n}$, $f_1{}^{i,n}$ and $f_2{}^{i,n}$ i = 1,...,30, n = 1,...,10 are read (AMSUA_L1_PGS_COF_ANTCOR in Appendix B). The antenna correction coefficients are then prepared according to the following short algorithm, where all indexing shall be user-configurable:

$$f_k{}^{i,15}=f_k{}^{i,10},\ k = 0,...,2 \text{ and } i = 1,30$$

$$f_k{}^{i,j} = f_k{}^{i,9},\ k = 0,...,2;\ i = 1,30 \text{ and } j = 10,...,14$$

$$f_k{}^{i,j} = f_k{}^{i,j}/100.,\ k = 0,...,2 \text{ and } i = 1,30 \text{ and } j = 1,...,15$$

If the antenna correction configuration parameter is not set to 0 then for all 15 AMSU-A channels the antenna correction is performed according to the following:

$$T_b^{a,cor,j} = \left(T_b^{a,j} - \eta(j) \times f_1^{i,j} \times 290. - f_2^{i,j} \times 2.73\right) / f_0^{i,j}$$

Equation 53

for all channels j = 1,...,15 and all scan angle positions i = 1,...,30.

η (j), j=1,...,15 is the AMSU-A channel number, is user configurable set of coefficients in AMSUA_L1_PGS_COF_ANTCOR in Appendix B.

The default settings are as follows:

η (1) = 0.01
η (2) = 0.08
η (3) = 0.03
η (4) = 0.04
η (5) = 0.04
η (6) = 0.03
η (7) = 0.03
η (8) = 0.04
η (9) = 0.04
η (10) = 0.04
η (11) = 0.04
η (12) = 0.04
η (13) = 0.04
η (14) = 0.04
η (15) = 0.11

Land/sea mask determination

The next step is to assure that for each AMSU-A pixel it is known whether it is over land or not over land. For this purpose either the information from previous AMSU-A level 1 processing steps can be used (Earth parameter calculation) and a land/sea mask be extracted, or the land/sea mask is extracted now. The choice doing this at this stage shall be made by a configuration parameter. The default shall be that the distinction between land/sea has already been determined,

If there is a need to determine the land/sea mask now, the terrain data (AMSUA_L1_PGS_DAT_SFCTOP) shall be read. For each geodetic location (latitude/longitude) of each AMSU-A pixel it shall be determined, whether it is a land, sea or coast pixel. Thus a land/sea mask for the AMSU-A FOVs is determined.

Limb-Adjustment function

The limb adjustment is the next step in the preparation of the AMSU-A data. Limb adjustment will be different for AMSU-A pixels located over water and for pixels located not over water. The first step is to make the user-configurable limb-correction coefficients are available for sea and for non-sea locations (AMSU-A_L1_PGS_COF_LMBSEA, AMSU-A_L1_PGS_COF_LMBLND). For each AMSU-A Channel *i* (1-15), the following coefficients and indices are read as detailed in the following page.

For pixels over land

Process	*Note*
Channel number *i*, number of indices for regression coefficients $N_{land}(i)$, $d_{mean,\ land}(i)$ $N_{land}(i)$ indices, which point to the Channels used for the regression (Channel 3 (i = 3), $N_{land}(i)=3$	*We may have to read three* ***indices:****, 3, 4 and 5, which means that for Channel 3 limb-corrected brightness temperatures, the AMSU-A Channels 3, 4 and 5 are used (see below).*
Then the coefficients are read for each scan position j (1 - 30):	
For each pixel *j* read: Channel number *i*, scan position *j*, $N_{land}(i)$ coefficents $c_{\ land}(i, j, _{nchan,land}(i,k))$, $N_{land}(i)$ mean temperatures $a_{mean,land}(i,j, _{nchan,land}(i,k))$, where $k = 1,...,$ $N_{land}(i)$ is the index pointing to the regression channel number used for the limb correction of channel *i,* and an error value $\delta T_{b,limb,land}(i,j)$, which is for information and indicates the estimated error of the limb correction.	

For pixels over sea

Process	*Note*
Channel number *i*, number of indices for regression coefficients $N_{\ sea}(i)$, $d_{\ mean,sea}(i)N_{\ sea}(i)$ indices, which point to the Channels used for the regression (Channel 3 (i = 3), $N_{sea}(i)=3,$	*We may have to read three* ***indices****, 3, 4 and 5, which means that for Channel 3 limb corrected brightness temperatures, the AMSU-A Channels 3, 4 and 5 are used (see below).*
Then the coefficients are read for each scan position *j (1 - 30)*:	
For each pixel *j* read: Channel number *i*, scan position *j*, $N_{sea}(i)$ coefficents $c_{sea}(i, j, n_{chan,sea}(i,k))$, $N_{sea}(i)$ mean temperatures $a_{mean,sea}(i,j,n_{\ chan,sea}(i,k))$, where $k = 1,...,N_{sea}(i)$ is the index pointing to the regression channel number used for the limb correction of channel *i,* and an error value $\delta T_{\ b,limb,sea}(i,j)$, which is for information and indicates the estimated error of the limb correction.	

The limb-adjustment is then performed for the data located over water according to

$$T_b^{lmbcor,j} = d_{mean,sea}(i) + \sum_{n_{chan,sea}(i,k)}^{N_{sea}(i)} \left\{ c_{sea}(i,j,n_{chan,sea}(i,k)) T_b^{a,cor}(n_{chan,sea}(i,k)) - a_{mean,sea}(i,j,n_{chan,sea}(i,k)) \right\}$$

Equation 54

The limb-adjustment over land is performed accordingly for the data located over land:

$$T_b^{lmbcor,j} = d_{mean,land}(i) + \sum_{n_{chan,land}(i,k)}^{N_{land}(i)} \left\{ c_{land}(i,j,n_{chan,land}(i,k)) T_b^{a,cor}(n_{chan,land}(i,k)) - a_{mean,land}(i,j,n_{chan,land}(i,k)) \right\}$$

Equation 55

At the end of this step, there will be limb-adjusted brightness temperatures for all 15 AMSU-A channels and for all scan angles, in addition to the output of the AMSU-A level 1b processing.

5.3 Handling of Edge-of-Dump/Data-Gap Conditions

The calibration procedure in the section above is applied at the edge of dump as well as at possible data. In the case of data gaps, the relative weights of Figure 4 are used, but any points that would fall in the gap are excluded, and the weights are re-normalised. The averaging of calibration counts and temperatures is then performed only for the remaining parts of the weighting triangle.

Logic applied: If *x* is the last line before the gap, for the (x-3)rd line, the full averaging procedure can be applied, and for the (x-2)nd line there is one weight less to apply, and as follows. The lines after the gap would have exactly the opposite logic.

At the dump boundary a buffer of 2n lines is kept, which have to be used for the calibration of the next dump, where the first line needs to be synchronised with the lines kept. The full averaging procedure is then to be applied. The first lines of the new dump have to be used to calibrate the last lines of the previous dump.

APPENDIX A: LIST OF EQUATION PARAMETERS

The following table presents the preliminary list of parameters, coefficients and intermediate values used to translate the Earth view counts into calibrated radiances for the MHS instrument.

The symbol and a short description are followed by the origin column, which provides the origin of the variable:

C	Computed
M	Earth view measurement data
Aux	Auxiliary data
Anc	Ancillary data

Variables are listed as follows:

1. Origin C, M, Aux and Anc in this order
2. Alphabetical order within origin; first common symbol characters then Greek characters

Symbol	Description	Origin
$\alpha_h(t)$	Moon hour angle	C
$\alpha_{RA,moon}$	Moon right ascension of the ascending node	C
δ_{moon}	Moon declination	C
δ^{FOV}	space field of view angle, as measured anti-clockwise from the -x axis in the z-x plane in the satellite frame of reference	C
$\Delta\theta_{moon}$	angle subtended by the moon and the space field of view	C
a_0	zero[th]-order coefficient for the computation of the calibrated radiance	C
a_1	first-order coefficient for the computation of the calibrated radiance	C
a_2	second-order coefficient for the computation of the calibrated radiance	C
$C_c(t_i)$	cold space counts (averaged over two views at scan time t_i)	C
$\bar{C}_c$	averaged cold space counts (weighted average of 7 scans)	C
C_s^{inst}	counts at zero radiance	C
$C_w(t_i)$	warm internal target counts (averaged over two views at scan time t_i)	C
dx, dy, dz	position vectors of the moon with respect to the satellite in earth fixed geocentric coordinates	C
dx', dy', dz'	position vectors of the moon with respect to the satellite – intermediate frame of reference	C
dx'', dy'', dz''	position vectors of the moon with respect to the satellite – intermediate frame of reference	C
dx^{sat}, dy^{sat}, dz^{sat}	position vectors of the moon with respect to the satellite in the satellite frame of reference	C
dx^{FOV}, dy^{FOV}, dz^{FOV}	position vectors of the moon with respect to the satellite as viewed by the space FOV (sometimes written dr^{FOV})	C
G	gain of the linear calibration law	C
j_{day}	Days since epoch (for moon glint correction)	C
λ	Longitude	C
Ngood	Number of good PRT	C

Symbol	Description	Origin
$\eta_{ant}(i)$	nominal antenna position	C
φ_{loc}	local azimuth of the Moon	C
Φ	Latitude	C
Q	non-linear correction term	C
R_c	computed radiance of the cold space target	C
R_s	calibrated radiances	C
R_{sL}	calibrated radiances (linear calibration approximation)	C
R_w	computed radiance of the warm internal target	C
$t_{lst}(i)$	local siderial time	C
$T_b^{a,corr,j}$	Antenna-corrected Brightness temperature	C
$T_b^{limbcorr,j}$	Limb-corrected Brightness temperature	C
T_c	estimated temperature of the cold space target	C
T_{inst}	instrument internal temperature	C
T_k	estimated temperature for PRT k	C
T_s^{prt}	average PRT temperature of the calibration scene target	C
$T_{PRT,avg}$	average PRT temperature calculated from good PRT temperatures	C
T_w	estimated temperature of the internal warm target	C
T'_w	modified estimated temperature of the internal warm target	C
T_w^{rad}	radiometric temperature of the black body	C
$T_{k,good}$	good PRT temperature	C
T_{median}	median of good PRT temperature	C
θ^{vel}	angle subtended by the satellite velocity vector and x axis in the intermediate dx'',dy'',dz'' frame of reference	C
$\underline{r}_{moon}$	Cartesian position vector of the moon in geocentric earth fixed coordinates	C
$\underline{r}_{sat}$	Cartesian position vector of the satellite in geocentric earth-fixed coordinates	C
vx'',vy'',vz''	Cartesian velocity vectors in the intermediate dx'',dy'',dz'' frame of reference	C
x^{earth}_{moon}, y^{earth}_{moon}, z^{earth}_{moon}	Cartesian position vectors of the moon in earth fixed geocentric coordinates	C
x^{space}_{moon}, y^{space}_{moon}, z^{space}_{moon}	Cartesian position vectors of the moon in space fixed geocentric coordinates	C
u	nonlinearity coefficient (function of instrument temperature)	C
C_c	cold space counts	M
C_s	earth view counts	M
C_w	warm internal target counts	M
$C_{x,1}$	Count of first reading	M

Symbol	Description	Origin
$C_{x,2}$	Count of second reading	M
$\tilde{C}_k$	PRT count of PRT k	M
$C_{ant}(i,k)$	Antenna position count of view i of instrument k	M
h	hour of the day in GMT	M
H	Instrument temperature counts	M
N	Number of lines over which warm target temperature bias was computed	M
a,b	Band correction coefficients	Aux
α_0	Scan angle for view 1	Aux
α_{AMSU}	Scan step angle for AMSU	Aux
c_{sea}	limb correction coefficient for sea pixels	Aux
C_{land}	limb correction coefficient for land and coast pixels	Aux
C_1	first constant of the Planck function	Aux
C_2	second constant of the Planck function	Aux
d_j	conversion coefficients for instrument reference temperature	Aux
$\varepsilon_{ant}(k)$	Pointing error tolerance value	Aux
$\varepsilon_{c,ant}(k)$	Pointing error tolerance value for space view	Aux
$\varepsilon_{w,ant}(k)$	Pointing error tolerance value for warm target	Aux
$\varepsilon_{x,12}$	Error tolerance value counts of first and second reading	Aux
$f_{k,j}$	polynomial coefficients for the computation of the PRT temperature	Aux
$f_k^{i,j}$	Antenna correction coefficients for stand-alone AMSU-A based retrieval	Aux
$I_{ant(k)}$	Antenna count intercept	Aux
k	warm target PRT index (k=1 to 5 for A1-1, A1-2; k=1 to 7 for A2)	Aux
$M_{ant}(k)$	Antenna count slope	Aux
$\eta(j)$	Coefficients for antenna correction in AMSU standalone retrieval	Aux
$n_{chan,land}$	index of the first channel used for limb correction over land for channel i and regression channel k	Aux
$n_{chan,sea}$	index of the first channel used for limb correction over sea for channel i and regression channel k	Aux
N_{land}	Number of indices for regression coefficients over land for Limb correction	Aux
N_{sea}	Number of indices for regression coefficients over sea for Limb correction	Aux
D	Distance of the Moon from the centre of the Earth	Aux
d	line to line consistency threshold	Aux
u_i	nonlinearity coefficients characterised pre-flight at 3 temperatures	Aux
w_k	PRT weights for the computation of the warm target temperature	Aux
R_e	Earth's radius	Aux
$T_{k,min}$	minimum meaningful PRT temperature	Aux
$T_{k,max}$	maximum meaningful PRT temperature	Aux

Symbol	*Description*	*Origin*
δT_{PRT}	PRT median check tolerance value	Aux
δT_{inst}	Instrument temperature threshold	Aux
$\delta T_{PRT,avg}$	PRT check tolerance value	Aux
δT_w	internal warm target temperature correction factor	Aux
δT_c	cold space temperature correction factor	Aux
$\Delta(v)$	spectral discretisation for the radiance computation	Aux
v_c	central wave number of each channel	Aux
v_1, v_2	lower and upper spectral limits of the channels	Aux
Φ *(LUT)*	instrument spectral response function (discretised)	Aux
$\tilde{C}_k$	warm target PRT counts for PRT k	Aux

Table 9: MHS preliminary list of variables

APPENDIX B: CONFIGURABLE AUXILIARY DATA SETS

Identifier	*Contents of Data Set*
AMSU-A_L1_PGS_COF_CAL	AMSU-A calibration parameters file, containing for all AMSU-A instruments central wave numbers, band correction coefficients, nominal space and internal target viewing angles, position of space view for calibration, antenna position errors permitted for calibration and Earth views, slope and intercept for counts to antenna position, count to temperature conversion coefficients, weight coefficients for each PRT, PRT temperature limits, number of scan lines to fill in bad PRT data, number of scan lines to use in consistency checks, instrument RF shelf temperatures, correction factors for warm and space load, gross counts limits, non-linearity correction coefficients, analogue conversion coefficients.
AMSU-A_L1_PGS_COF_CALSEC	Secondary calibration coefficients for three temperature ranges and all channels.
AMSU-A_L1_PGS_DAT_SFCTOP	Geographical land-surface topography distribution.
AMSU-A_L1_PGS_DAT_NAV	Configurable navigation parameters, interpolation width for pixel and lines tie points of navigation information.
AMSU-A_L1_PGS_DAT_ASTRO	Data base with Astronomical information.
AMSUA_L1_PGS_COF_ANTCOR	User-configurable antenna correction coefficients $f_0^{\,i,n}$, $f_1^{\,i,n}$ and $f_2^{\,i,n}$ i = 1,...,30, n = 1,...,10.
AMSU-A_L1_PGS_COF_LMBSEA	User-configurable limb-correction coefficients for sea.
AMSU-A_L1_PGS_COF_LMBLND	User-configurable limb-correction coefficients for non-sea locations.

APPENDIX C: SAMPLE AUXILIARY DATA SET

The following pages provide an example of the possible format of the configurable data sets. The actual format is to be determined by the contractor.

```
############################################################
### ###
### FILE OF AMSU-A CALIBRATION COEFFICIENTS ###
### ###
############################################################
04 ; version number (cal parameter id in 1B dataset)
1998 ; year of the version
180 ; day of year of the version. This version incorporates channel 7-15 swap
## Values for Fundamental Constants ##
## Speed of light m/s ##
299792458
## Planck constant J s ##
6.62606876e-34
## Boltzmann constant J/K ##
1.38065030e-23
## First & second radiation constants mW/(sqm.ster.cm^-4) & K/cm^-1 ##
1.191044e-05,1.438769
## Brightness temperature of space at AMSU frequencies degK ##
2.73
## 15 Central wavenumbers ##
0.793883,1.047391,1.677827,1.761218,1.787770,1.814589,1.832601,1.851281
1.911000,1.911000,1.911000,1.911000,1.911000,1.911000,2.968720
## Band Correction Coefficients a,b for each channel --
## used to modify TW to give an effective temperature T'W for use
## in the Planck function.
0,1
0,1
0,1
0,1
0,1
0,1
0,1
0,1
0,1
0,1
0,1
0,1
0,1
0,1
0,1
## Nominal space & internal target viewing angles
-83.333,180.0
-81.667,180.0
-80.000,180.0
-76.667,180.0
##############################################################################
## AMSU-A1 FM1 DATA ##
## ID of instrument
9#
Selected position of space view for calibration 0->3 #
0#
Slope and offset for counts to antenna posn in deg, A1-1 and A1-2 #
-0.021973, 31.15
-0.021973, 32.53
# Antenna Pos error allowed in deg for cal and Earth views, A1-1 and A1-2 #
1.3,0.33
1.3,0.33
# IWT PRT count to temperature in degK conversion coefficients #
```

```
254.1017,1.688320E-03, 6.241647E-09, 3.332807E-14
254.2879,1.687466E-03, 6.328255E-09, 3.201182E-14
254.0809,1.683857E-03, 6.409828E-09, 3.014064E-14
253.9888,1.683900E-03, 6.447313E-09, 2.948637E-14
254.1004,1.681304E-03, 6.553487E-09, 2.742913E-14
254.2758,1.685070E-03, 6.370184E-09, 3.068538E-14
254.9758,1.684902E-03, 6.415300E-09, 2.995926E-14
254.0380,1.686581E-03, 6.146616E-09, 3.541479E-14
254.1047,1.684485E-03, 6.262817E-09, 3.310585E-14
254.1422,1.685264E-03, 6.310010E-09, 3.142085E-14
# Weight coefficients for each PRT, A1-1 and A1-2 #
0,1,1,1,1
1,1,1,1,1
# Reasonable PRT temp limits in degK (min,max), A1-1 and A1-2 #
258.15,313.15
258.15,313.15
# Max PRT temp change in degK allowed before rejecting #
0.2
0.2
# Minimum number of PRT readings acceptable #
22#
Number of scan lines to fill in bad PRT data #
20
20
# Number of scan lines to use in consistency checks of cal views #
55#
Instrument temperature sensor ID, A1-1 and A1-2, 0=RF shelf, 1=RF mux
00#
3 Instrument RF shelf temperatures degK, A1-1, A1-2 and A1-1 PLLO2 #
270.54,291.18,311.24
270.56,291.18,311.91
270.03,289.10,311.92
# 3 Instrument RF mux temperatures degK, A1-1, A1-2 and A1-1 PLLO2 #
270.54,291.18,311.24
270.56,291.18,311.91
270.03,289.10,311.92
# Instrument temp RF Shelf PRT count to temperature in degK conversion coeffs
#
2.630331E+02, 1.747753E-03, 3.759031E-09, 1.140711E-14
2.630074E+02, 1.737507E-03, 4.300952E-09, 2.651179E-15
# Instrument temp RF Mux PRT count to temperature in degK conversion coeffs #
2.630722E+02, 1.747151E-03, 3.735050E-09, 1.132005E-14
2.629747E+02, 1.737891E-03, 4.241792E-09, 3.482516E-15
# Warm load corr factor for each ref temp, Chan 3-15 and 9-14 PLLO2. Swap 7-15
#
0.109,0.012,0.007,0.091,0.087,-.004,0.046,0.086,0.085,0.085,0.102,0.053,0.047,
0.001,0.072,0.077,0.049,0.064,0.024
0.109,0.012,0.007,0.091,0.087,-.004,0.046,0.086,0.085,0.085,0.102,0.053,0.047,
0.001,0.072,0.077,0.049,0.064,0.024
0.109,0.012,0.007,0.091,0.087,-.004,0.046,0.086,0.085,0.085,0.102,0.053,0.047,
0.001,0.072,0.077,0.049,0.064,0.024
# Cold space correction factors for each space view, Chan 3-15 and 9-14 PLLO2
#
1.19,1.22,1.28,1.49,1.33,1.25,1.43,1.43,1.43,1.43,1.43,1.43,0.91
1.43,1.43,1.43,1.43,1.43,1.43
1.19,1.22,1.28,1.49,1.33,1.25,1.43,1.43,1.43,1.43,1.43,1.43,0.91
1.43,1.43,1.43,1.43,1.43,1.43
1.19,1.22,1.28,1.49,1.33,1.25,1.43,1.43,1.43,1.43,1.43,1.43,0.91
1.43,1.43,1.43,1.43,1.43,1.43
1.19,1.22,1.28,1.49,1.33,1.25,1.43,1.43,1.43,1.43,1.43,1.43,0.91
1.43,1.43,1.43,1.43,1.43,1.43
# Gross count limits (minimum & maximum) for the internal target counts #
0,0,0,0,0,0,0,0,0,0,0,0,0
0,0,0,0,0,0
32768,32768,32768,32768,32768,32768,32768,32768,32768,32768,32768,32768,32768
32768,32768,32768,32768,32768,32768
```

```
# Gross count limits (minimum & maximum) for the space view counts #
0,0,0,0,0,0,0,0,0,0,0,0,0
0,0,0,0,0,0
32768,32768,32768,32768,32768,32768,32768,32768,32768,32768,32768,32768,32768
32768,32768,32768,32768,32768,32768
# Max change in mean counts from previous scan allowed before rejecting #
12,12,12,12,12,12,12,12,16,16,20,40,15
12,12,16,16,20,40
# Non-lin corr coefs, 3 ref temps, chan 3-15 & 9-14 PLLO2. Swap & modify 7-15
#
0.055511,0.444932,-0.027906,-0.010790,0.242849,-0.000369
-0.148429,-0.239106,0.075740,-0.082410,-0.353876,-0.371479,-0.000239
-0.155463,-0.170186,0.168389,-0.052939,-0.250147,-0.024656
0.080626,0.439102,-0.003414,0.087373,0.271828,-0.001171
-0.047238,-0.169687,0.020415,-0.025818,-0.284480,-0.022299,-0.005869
-0.085951,-0.130501,0.123357,0.011045,-0.136397,-0.010211
0.048428,0.269246,-0.013142,0.232594,0.495075,-0.009438
-0.022126,-0.029466,0.220561,0.139549,0.044524,0.021492,0.042835
0.049806,0.016424,0.174105,0.035468,0.001316,-0.063196
# Digital A conversion coefficients (4 coeffs, 45 parameters) #
2.630037E+02, 1.747464E-03, 3.611793E-09, 1.408073E-14
2.630755E+02, 1.737651E-03, 4.401445E-09, 1.651136E-15
2.629443E+02, 1.747953E-03, 3.692945E-09, 1.236913E-14
2.630390E+02, 1.739450E-03, 4.221214E-09, 3.747511E-15
2.630722E+02, 1.747151E-03, 3.735050E-09, 1.132005E-14
2.629747E+02, 1.737891E-03, 4.241792E-09, 3.482516E-15
2.630540E+02, 1.748261E-03, 3.730504E-09, 1.180654E-14
2.629409E+02, 1.736642E-03, 4.349951E-09, 1.296027E-15
2.630854E+02, 1.735083E-03, 4.282954E-09, 3.003631E-15
2.628903E+02, 1.750977E-03, 3.637912E-09, 1.331306E-14
2.630363E+02, 1.747121E-03, 3.651951E-09, 1.337592E-14
2.630474E+02, 1.734271E-03, 4.391040E-09, 1.000835E-15
2.632229E+02, 1.751721E-03, 3.622826E-09, 1.276853E-14
2.630344E+02, 1.734629E-03, 4.318891E-09, 2.309493E-15
2.630713E+02, 1.748204E-03, 3.651635E-09, 1.366764E-14
2.630320E+02, 1.739238E-03, 4.276768E-09, 3.156441E-15
2.631502E+02, 1.751596E-03, 3.733117E-09, 1.213597E-14
2.629138E+02, 1.737586E-03, 4.273391E-09, 3.773862E-15
2.629436E+02, 1.746811E-03, 3.715164E-09, 1.220530E-14
2.631028E+02, 1.740953E-03, 4.301377E-09, 2.778946E-15
2.630626E+02, 1.751180E-03, 3.709273E-09, 1.264067E-14
2.629497E+02, 1.739036E-03, 4.289452E-09, 3.000804E-15
2.630612E+02, 1.748672E-03, 3.651322E-09, 1.348387E-14
2.630224E+02, 1.734811E-03, 4.284050E-09, 3.032046E-15
2.635755E+02, 1.749622E-03, 3.732910E-09, 1.228633E-14
2.632024E+02, 1.739840E-03, 4.245337E-09, 3.929503E-15
2.629374E+02, 1.750283E-03, 3.678020E-09, 1.279883E-14
2.629866E+02, 1.739247E-03, 4.256647E-09, 3.939451E-15
2.630103E+02, 1.746012E-03, 3.718877E-09, 1.227157E-14
2.629475E+02, 1.738816E-03, 4.322414E-09, 2.640587E-15
2.629747E+02, 1.750096E-03, 3.720513E-09, 1.176121E-14
2.630440E+02, 1.736559E-03, 4.289366E-09, 3.027244E-15
2.630331E+02, 1.747753E-03, 3.759031E-09, 1.140711E-14
2.630074E+02, 1.737507E-03, 4.300952E-09, 2.651179E-15
2.630804E+02, 1.776352E-03, 4.423964E-09, 3.883034E-15
2.541017E+02, 1.688320E-03, 6.241647E-09, 3.332807E-14
2.542879E+02, 1.687466E-03, 6.328255E-09, 3.201182E-14
2.540809E+02, 1.683857E-03, 6.409828E-09, 3.014064E-14
2.539888E+02, 1.683900E-03, 6.447313E-09, 2.948637E-14
2.541004E+02, 1.681304E-03, 6.553487E-09, 2.742913E-14
2.542758E+02, 1.685070E-03, 6.370184E-09, 3.068538E-14
2.539758E+02, 1.684902E-03, 6.415300E-09, 2.995926E-14
2.540380E+02, 1.686581E-03, 6.146616E-09, 3.541479E-14
2.541047E+02, 1.684485E-03, 6.262817E-09, 3.310585E-14
2.541422E+02, 1.685264E-03, 6.310010E-09, 3.142085E-14
# Analogue conversion coefficients (2 coeffs, 27 parameters) #
0, 1.36054
```

```
0, 1.36054
0, 1.36054
0, 1.36054
0, 1.36054
0, 1.36054
-2.51, 0.5576
-15.55, 0.5408
0, 0.10
0, 0.10
-9.00, -0.04
-9.00, -0.04
0, 0.0368
0, 0.034
0, 0.0336
0, 0.0402
0, 0.1006
-9.00, -0.0388
0, 0.036
0, 0.0358
0, 0.0358
0, 0.0356
0, 0.0356
0, 0.0358
-14.80, 0.148
-14.80, 0.148
0, 0.033
##############################################################################
## AMSU-A2 PFM DATA ##
## ID of instrument
6#
Selected position of space view for calibration 0->3 #
0#
Slope and offset for counts to antenna posn in deg #
+0.021973, 55.89
# Antenna Pos error allowed in deg for cal and Earth views #
1.3,0.33
# IWT PRT count to temperature in degK conversion coefficients #
253.9989, 1.638866E-03, 6.007023E-09, 2.812463E-14
254.0397, 1.636785E-03, 6.027363E-09, 2.824335E-14
253.9349, 1.642202E-03, 5.981135E-09, 2.918848E-14
254.0187, 1.638825E-03, 6.018147E-09, 2.859953E-14
253.9916, 1.638811E-03, 6.048192E-09, 2.740716E-14
253.9744, 1.638622E-03, 6.003124E-09, 2.799640E-14
253.9943, 1.637949E-03, 6.066317E-09, 2.668021E-14
# Weight coefficients for each PRT #
1,1,1,1,1,1,1
# Reasonable PRT temp limits in degK (min,max) #
258.15,313.15
# Max PRT temp change in degK allowed before rejecting #
0.2
# Minimum number of PRT readings acceptable #
2#
Number of scan lines to fill in bad PRT data #
20
# Number of scan lines to use in consistency checks of cal views #
5#
Instrument temperature sensor ID, 0=RF shelf, 1=RF mux
0#
3 Instrument RF shelf temperatures degK #
266.55,284.65,302.85
# 3 Instrument RF mux temperatures degK #
266.55,284.65,302.85
# Instrument temp RF Shelf PRT count to temperature in degK conversion coeffs
#
2.628805E+02, 1.746935E-03, 3.662064E-09, 1.326031E-14
# Instrument temp RF Mux PRT count to temperature in degK conversion coeffs #
2.628583E+02, 1.738158E-03, 4.182846E-09, 4.551534E-15
```

```
# Warm load correction factor for each reference instrument temp, chan 1-2 #
-0.046,-0.230
-0.007,-0.133
# Cold space correction factors for each space view, chan 1-2 #
0.74,0.44
0.74,0.44
0.74,0.44
0.74,0.44
# Gross count limits (minimum & maximum) for the internal target counts #
0,0
32768,32768
# Gross count limits (minimum & maximum) for the space view counts #
0,0
32768,32768
# Max change in mean counts from previous scan allowed before rejecting #
12,12
# Non-linearity corrn coefficients for 3 instrument ref temps & chans 1-2 #
0.980173,-0.072332
1.128380,0.309354
1.109810,-0.050246
# Digital A conversion coefficients (4 coeffs, 19 parameters) #
2.628483E+02, 1.744870E-03, 3.656985E-09, 1.311605E-14
2.628909E+02, 1.745131E-03, 3.618670E-09, 1.371539E-14
2.628583E+02, 1.738158E-03, 4.182846E-09, 4.551534E-15
2.629412E+02, 1.745020E-03, 3.638992E-09, 1.317258E-14
2.630224E+02, 1.738089E-03, 4.475776E-09,-2.782349E-16
2.628308E+02, 1.745703E-03, 3.652799E-09, 1.288072E-14
2.628446E+02, 1.733296E-03, 4.214177E-09, 3.241416E-15
2.627900E+02, 1.734460E-03, 4.373190E-09, 1.175410E-15
2.627894E+02, 1.746871E-03, 3.604260E-09, 1.427609E-14
2.629737E+02, 1.734227E-03, 4.156827E-09, 4.614430E-15
2.628805E+02, 1.746935E-03, 3.662064E-09, 1.326031E-14
2.628441E+02, 1.736258E-03, 4.159231E-09, 5.129305E-15
2.539989E+02, 1.638866E-03, 6.007023E-09, 2.812463E-14
2.540397E+02, 1.636785E-03, 6.027363E-09, 2.824335E-14
2.539349E+02, 1.642202E-03, 5.981135E-09, 2.918848E-14
2.540187E+02, 1.638825E-03, 6.018147E-09, 2.859953E-14
2.539916E+02, 1.638811E-03, 6.048192E-09, 2.740716E-14
2.539744E+02, 1.638622E-03, 6.003124E-09, 2.799640E-14
2.539943E+02, 1.637949E-03, 6.066317E-09, 2.668021E-14
# Analogue conversion coefficients (2 coeffs, 15 parameters) #
0, 1.36054
0, 1.36054
0, 1.36054
0, 1.36054
-5.50, 0.917
-21.27, 0.8866
0, 0.10034
0, 0.09882
-9.00, -0.0406
-9.00, -0.03916
0, 0.03668
0, 0.0336
0, 0.0327
0, 0.04022
0, 0.0335
#############################################################################
## ID of
```

See **Secondary Calibration Coefficients** *on following page*

Secondary Calibration Coefficients

```
######################################################################
### ###
### FILE OF AMSU-A SECONDARY CALIBRATION COEFFICIENTS ###
### ###
######################################################################
01 ; version number
1996 ; year of the version
185 ; day of year of the version
##############################################################################
## AMSU-A1 F1 DATA ##
## ID of instrument
9#
Secondary coefficients u0, u1 and u2 for channels 3-15 #
# Low temperature #
1.0e-6,1.0e-6,1.0e-6,1.0e-6,1.0e-6,1.0e-6,1.0e-6,1.0e-6
1.0e-6,1.0e-6,1.0e-6,1.0e-6,1.0e-6
1.0e-10,1.0e-10,1.0e-10,1.0e-10,1.0e-10,1.0e-10,1.0e-10,1.0e-10
1.0e-10,1.0e-10,1.0e-10,1.0e-10,1.0e-10
1.0e-16,1.0e-16,1.0e-16,1.0e-16,1.0e-16,1.0e-16,1.0e-16,1.0e-16
1.0e-16,1.0e-16,1.0e-16,1.0e-16,1.0e-16
# Mid temperature #
1.0e-6,1.0e-6,1.0e-6,1.0e-6,1.0e-6,1.0e-6,1.0e-6,1.0e-6
1.0e-6,1.0e-6,1.0e-6,1.0e-6,1.0e-6
1.0e-10,1.0e-10,1.0e-10,1.0e-10,1.0e-10,1.0e-10,1.0e-10,1.0e-10
1.0e-10,1.0e-10,1.0e-10,1.0e-10,1.0e-10
1.0e-16,1.0e-16,1.0e-16,1.0e-16,1.0e-16,1.0e-16,1.0e-16,1.0e-16
1.0e-16,1.0e-16,1.0e-16,1.0e-16,1.0e-16
# High temperature #
1.0e-6,1.0e-6,1.0e-6,1.0e-6,1.0e-6,1.0e-6,1.0e-6,1.0e-6
1.0e-6,1.0e-6,1.0e-6,1.0e-6,1.0e-6
1.0e-10,1.0e-10,1.0e-10,1.0e-10,1.0e-10,1.0e-10,1.0e-10,1.0e-10
1.0e-10,1.0e-10,1.0e-10,1.0e-10,1.0e-10
1.0e-16,1.0e-16,1.0e-16,1.0e-16,1.0e-16,1.0e-16,1.0e-16,1.0e-16
1.0e-16,1.0e-16,1.0e-16,1.0e-16,1.0e-16
##############################################################################
## AMSU-A2 PFM DATA ##
## ID of instrument
6#
Secondary coefficients u0, u1 and u2 for channels 1-2 #
# Low temperature #
1.0e-6,1.0e-6
1.0e-10,1.0e-10
1.0e-16,1.0e-16
# Mid temperature #
1.0e-6,1.0e-6
1.0e-10,1.0e-10
1.0e-16,1.0e-16
# High temperature #
1.0e-6,1.0e-6
1.0e-10,1.0e-10
1.0e-16,1.0e-16
##############################################################################
## ID of instrument: 99 terminator
99
```