SMOS L1 Prototype

Sun Brightness Temperature Self Estimation Study Report

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	Name	Function	Signature
Prepared by	J. C. Correia	Project Engineer	
	J. Freitas	Project Engineer	
Checked by	J. Freitas	Quality A. Manager	
Approved by	J. Barbosa	Project Manager	

DEIMOS Engenharia
Av. D. João II, Lote 1.17, Torre Zen, 10º
1998-023 Lisboa, PORTUGAL
Tel: +351 21 893 3017
Fax: +351 21 896 9099
E-mail: mailto:deimos@deimos.com.pt

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1. INTRODUCTION

1.1. Purpose and Scope

The purpose of this technical note is to report the results of the study of the accuracy of the Sun self-estimation and correction algorithm applied in the SMOS Level 1 Processor Prototype (L1PP).

This document was produced in the scope of the project "SMOS Level 1 Processor Prototype Development – Phase 3" project.

1.2. Acronyms and Abbreviations

For the list of acronyms, please refer to the "Directory of Acronyms and abbreviations" [RD.1].

1.3. Applicable and Reference Documents

1.3.1. Applicable Documents

Ref.	Code	Title	Issue
AD.1	SO-SOW-CASA-PLM-0385	Level 1 Processor Prototype Development Phase 3 and Support Activities. Statement of Work	***01***
AD.2	SO-RS-ESA-PLM-0003	SMOS System Requirements Document	***3.0***
AD.3	SO-IS-DME-L1PP-0002	SMOS L1 Product Format Specification	***2.1***
AD.4	SO-IS-DME-L1PP-0003	SMOS L1 Auxiliary Data Format Specification	***2.1***
AD.5	SO-DS-DME-L1PP-0011	SMOS L1 Algorithm Theoretical Baseline	***2.7***
AD.6	SPS-TN-GMV-PL-0003	SMOS End-to-End Performance Simulator (SEPS) Architectural and Detailed Design Document	***5.0***

Table 1: Applicable Documents.

1.3.2. Reference Documents

Ref.	Code/Author	Title	Issue
RD.1	SO-LI-CASA-PLM-0094	Directory of Acronyms and abbreviations	
RD.2	SO-DS-DME-L1PP-0008	SMOS L1a to L1b Detailed Processing Model	2.4
RD.3	A. Camps et al	*"Impact and Compensation of Diffuse Sun Scattering in 2D Aperture Synthesis Radiometers Imagery"*, IGARSS	2005
RD.4	A. Camps et al	*"Sun Effects in 2-D Aperture Synthesis Radiometry Imaging and their Cancellation"*, IEEE transactions on geoscience and remote sensing Vol. 42, No. 6	June 2004
RD.5	A. Camps et al	*"The processing of hexagonally sampled signals with standard rectangular techniques: application to 2-D large aperture synthesis interferometric radiometers"*, IEEE Trans. geosc. and remote sensing, Vol. 35, No.1, pp. 183-190.	Jan. 1997
RD.6	A. Camps	*"Application of Interferometric Radiometry to Earth Observation"*, PhD Dissertation, Universitat Politècnica de Catalunya	November 1996
RD.7	SMOSP3-UPC-TN-0002 v 1.0	*"Sun Self-estimation Algorithm"*[1]	May 2007
RD.8	SMOSP3-UPC-TN-0002 v 1.0	*"Sun Self-estimation Algorithm: Simulation Results"*	July 2007
RD.9	SO-TN-DME-L1PP-0156	*Impact of Solar Flare Occurrence in the SMOS L1 Data Processing*	1.0

Table 2: Reference Documents.

[1] Document available at the L1PP project webpage: http://www.smos.com.pt/project_results.html

2. Study Overview

During the image reconstruction process of the SMOS Level 1 Processing, one of the main effects that need to be taken into account is the contamination of the images due to the Sun appearing in the FOV of the MIRAS instrument. In order to address this issue, UPC has defined an algorithm to estimate the Sun brightness temperature and then remove the direct Sun effect on the MIRAS brightness temperatures maps [RD.4] and [RD.2], algorithm which was later adapted to the Level 1 Processor Prototype (L1PP), as defined in [RD.7].

The objective of this study was to assess the accuracy of this algorithm. This was done by defining several scenarios and then measuring the errors associated with the correction algorithm implemented in the image reconstruction process and assessing the efficiency of it.

This study was based in simulations performed using two tools:

- The SMOS End-to-End Performance Simulator- Ground Segment (SEPS-GS) – used mainly for simulating the MIRAS instrument and generating L0 data (although it also provides a Reconstruction module which allows to generate L1 data);
- The Level 1 Processor Prototype (L1PP) – used for validating the accuracy of the sun removal algorithm by processing SEPS-GS L0 products and applying the image reconstruction + sun correction algorithms to it.

The study was carried out by following the steps presented below:

- Definition of different test scenarios;
- Analysis of the output images and errors;
- Report and discussion of the results.

The simulations performed with SEPS-GS were done using three different scenarios:

1. The first one with nominal sun effects simulated;
2. The second one with “solar flares” simulated[2];
3. The third one with no sun effects simulated at all.

All the parameters that do not have an influence in the Sun generation and reconstruction were defined as the default parameters of SEPS-GS.

Finally, in order to assess L1PP performance on the correction of the Sun effects, the L0 products produced by the previous simulations were ingested and processed by L1PP and the efficiency of the sun correction on the produced L1 products was analysed.

[2] The “solar flares” were simulated by considering a Sun brightness temperature 10 times higher than what would be expected in the nominal case. For more information regarding the effects of the solar flares on the SMOS L1 processing, please refer to [RD.9].

3. Simulations results

The following sections present the results for the different scenarios:

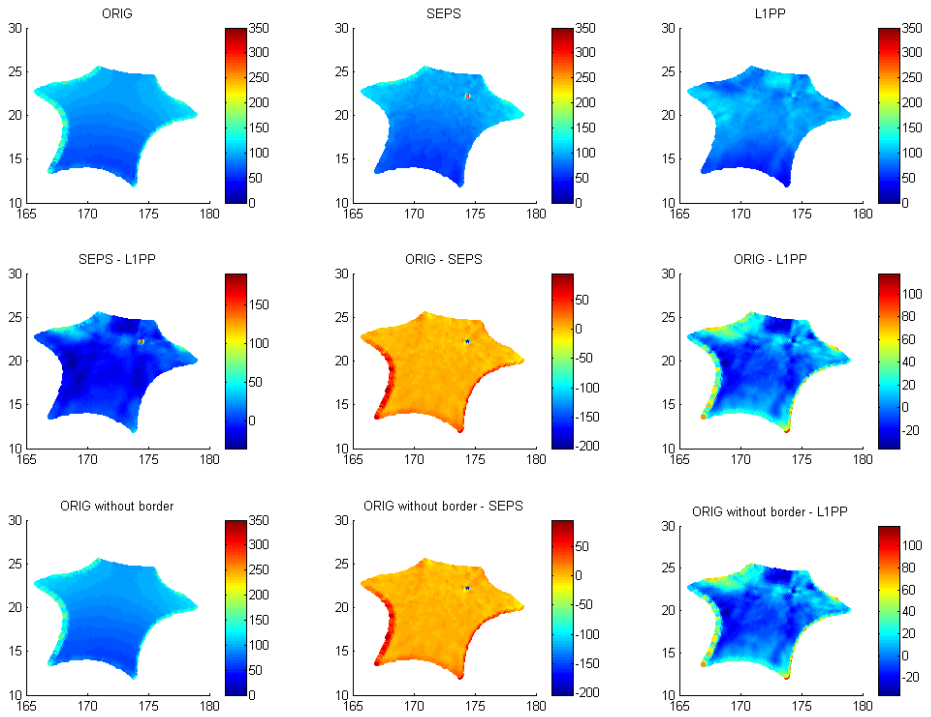
- Accuracy of the sun BT estimation (comparison between the SEPS-GS simulated and the L1PP estimated Sun BT);
- Accuracy, Scene Bias and Minimum/Maximum error in the EAF-FOV excluding the borders pixels;
- Images comparing the L1PP reconstruction with the SEPS reconstruction and SEPS original image.

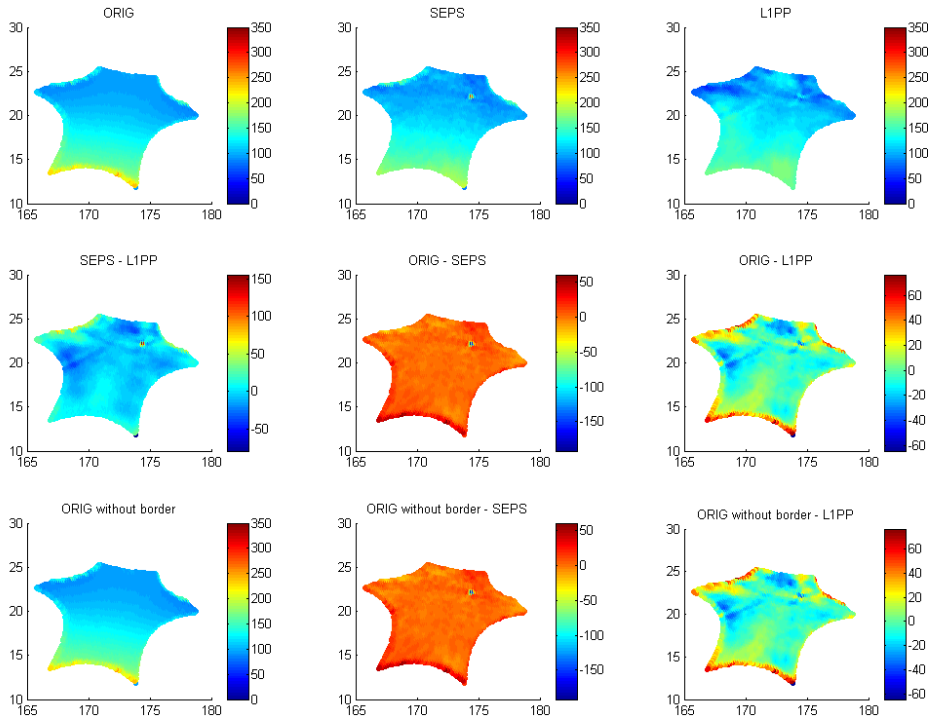
3.1. Scenario 01 – nominal sun

Table 3: Scenario 01 - Accuracy of the Sun BT Estimation.

	SEPS Simulation	L1PP Estimation	L1PP Error (%)
Scene 01 – H Pol	96 791,84 K	87 605,81 K	-9,49%
Scene 02 – V Pol	96 791,84 K	91 190,06 K	-5,79%
Scene 03 – H Pol	96 791,84 K	89 191,89 K	-7,85%
Scene 04 – V Pol	96 791,84 K	89 314,14 K	-7,73%
		Average absolute error	**7,71%**

		L1PP vs SEPS original	L1PP vs SEPS reconstruction
Scene 1	**TB accuracy in EAF-FOV**	9.086408K	8.219379K
	Scene Bias in EAF-FOV	5.025447K	8.252428K
	Maximum error in EAF-FOV	31.041794K	15.763932K
	Minimum error in EAF-FOV	-36.113603K	-35.777723K
Scene 2	**TB accuracy in EAF-FOV**	7.564702K	10.075787K
	Scene Bias in EAF-FOV	3.538973K	2.752474K
	Maximum error in EAF-FOV	14.504140K	55.613748K
	Minimum error in EAF-FOV	-38.542831K	-34.955336K

Scene	Comparisons
01	

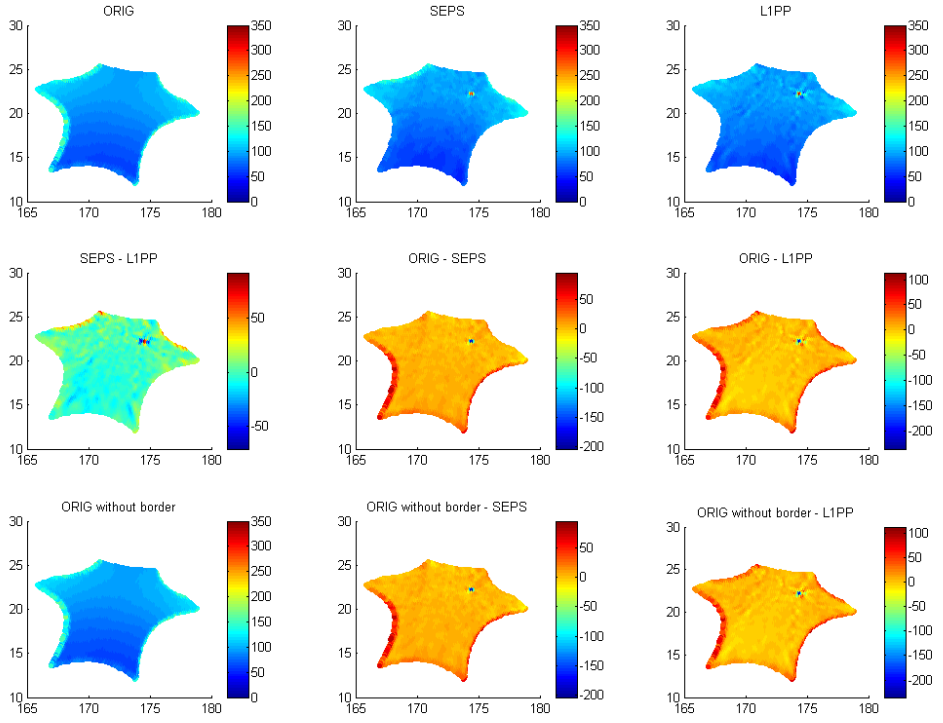
Scene	Comparisons
02	

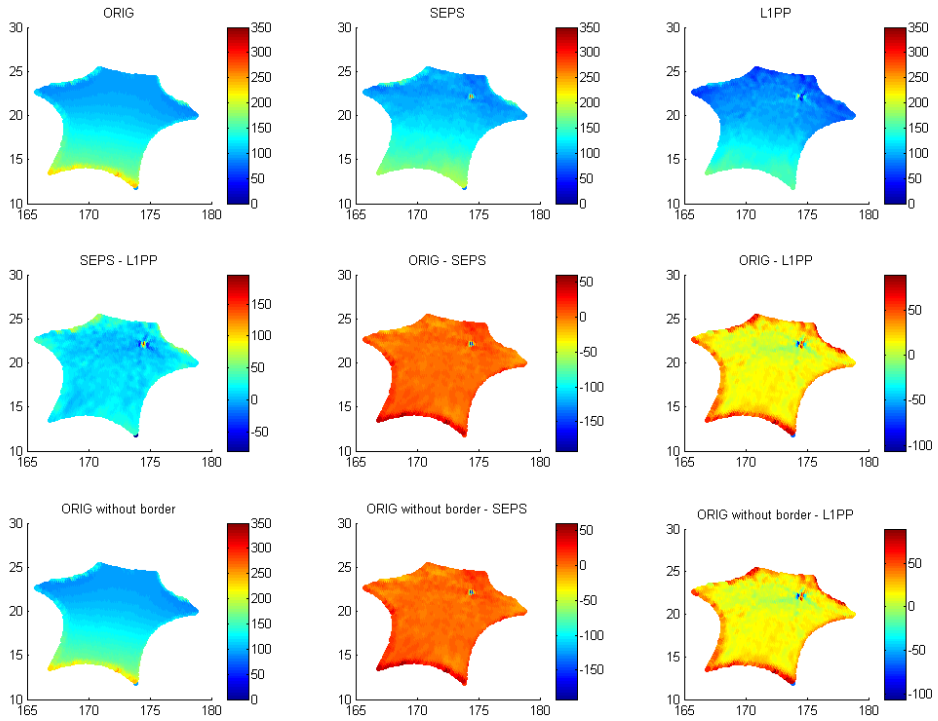
3.2. Scenario 02 – solar flare

Table 4: Scenario 02 - Accuracy of the Sun BT Estimation

	SEPS Simulation	L1PP Estimation	L1PP Error (%)
Scene 01 – H Pol	967 918,39 K	859 564,8 K	-11.19%
Scene 02 – V Pol	967 918,39 K	909 991,9 K	-5.98%
Scene 03 – H Pol	967 918,39 K	858 269,3 K	-11.33%
Scene 04 – V Pol	967 918,39 K	913 529,3 K	-5.62%
		Average absolute error	**8.53%**

		L1PP vs SEPS original	L1PP vs SEPS reconstruction
Scene 1	TB accuracy in EAF-FOV	4.512736K	4.768172K
	Scene Bias in EAF-FOV	1.473487K	4.700468K
	Maximum error in EAF-FOV	40.163498K	13.738441K
	Minimum error in EAF-FOV	-25.811456K	-21.671604K
Scene 2	TB accuracy in EAF-FOV	7.173904K	5.478096K
	Scene Bias in EAF-FOV	-14.125990K	-13.339492K
	Maximum error in EAF-FOV	69.305215K	35.423985K
	Minimum error in EAF-FOV	-10.620084K	-7.380219K

Scene	Comparisons
01	

Scene	Comparisons
02	

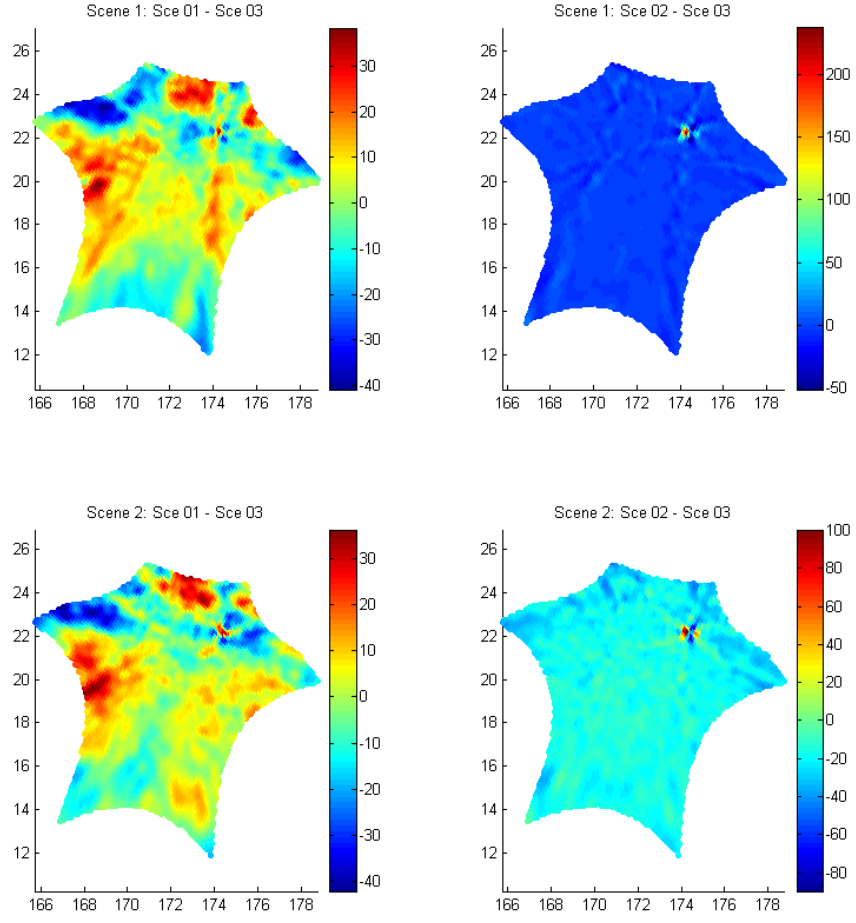
3.3. Scenario 03 – no sun effects

		L1PP vs SEPS original	L1PP vs SEPS reconstruction
Scene 1	TB accuracy in EAF-FOV	3.233464K	3.891419K
	Scene Bias in EAF-FOV	1.507845K	4.734826K
	Maximum error in EAF-FOV	37.142327K	22.076861K
	Minimum error in EAF-FOV	-9.734516K	-15.297829K
Scene 2	TB accuracy in EAF-FOV	6.285828K	4.703705K
	Scene Bias in EAF-FOV	0.731004K	1.517503K
	Maximum error in EAF-FOV	55.364571K	12.435857K

	L1PP vs SEPS original	L1PP vs SEPS reconstruction
Minimum error in EAF-FOV	-15.194235K	18.126436K

The sun effects that are not properly removed may be identified by subtracting, from the images of the previous scenarios, the image of a scenario produced with no sun effects simulated:

L1PP reconstructed results of Scenarios 01/02 minus Scenario 03 (sun effects remaining after the correction)



4. CONCLUSIONS

The study described in this technical note has lead to the following conclusions:

- There is a systematic negative error on the sun BT estimation, which may indicate an implementation error on L1PP. However, the studies performed by UPC do not indicate the same behaviour [RD.8];
- The simulations of the solar flares confirm that the images are much more affected when a flare occurs (even if the relative error of the BT estimation is similar with or without flare (7.7% 8.5%, respectively). The amplitude of the error when we have a flare is bigger, having a bigger impact on the reconstructed image. Therefore, the suggestion of flagging the flares occurrence proposed in [RD.9] shall be followed.