

Introduction

The single payload for the Soil Moisture and Ocean Salinity (SMOS) mission is the Microwave Imaging Radiometer by Aperture Synthesis (MIRAS). It is a Y-shaped interferometer formed by 69 equally spaced antennas operating in the L-band. Each pair of antennas forms a baseline that observes a specific signal, i.e., a visibility.

The visibilities gathered by all baselines are transformed to brightness temperatures through the use of a linear operation system, $T = J^+V$, where J^+ is the pseudo-inverse of the System Response Function.

The Level 1 Prototype Processor (L1PP) is a bridge between the data that MIRAS gathers and the Level 2 Algorithms to retrieve Soil Moisture from geolocated data of brightness temperatures.

It has been proposed to improve the radiometric accuracy of the retrieved maps by taking into account the variance-covariance matrix of the radiometric noise affecting the data.

This poster shows the results obtained during the SMOS Commissioning Phase using the Baseline Weights Algorithm implemented in L1PP and the Weighting Matrices derived with in-orbit data.

Computing the Weights

Estimation Over Open Ocean

It has been agreed that the weights to be applied should be derived from an Open Ocean Zone

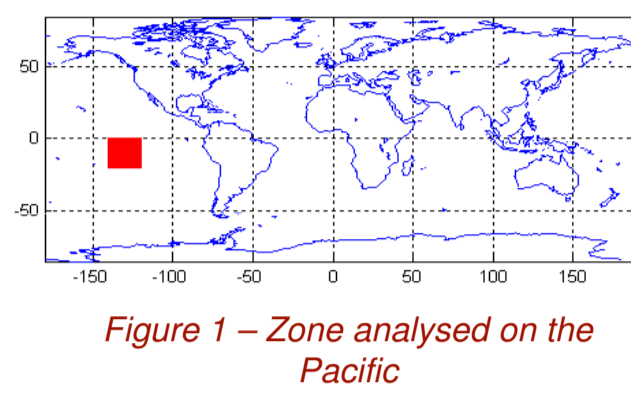


Figure 1 – Zone analysed on the Pacific

Due to the number of overpasses it is possible to compute the radiometric noise levels affecting M-baselines^(a) and L-baselines^(b)

(a) Baselines formed by a NIR and a LICEF (b) Baselines formed by two LICEFs

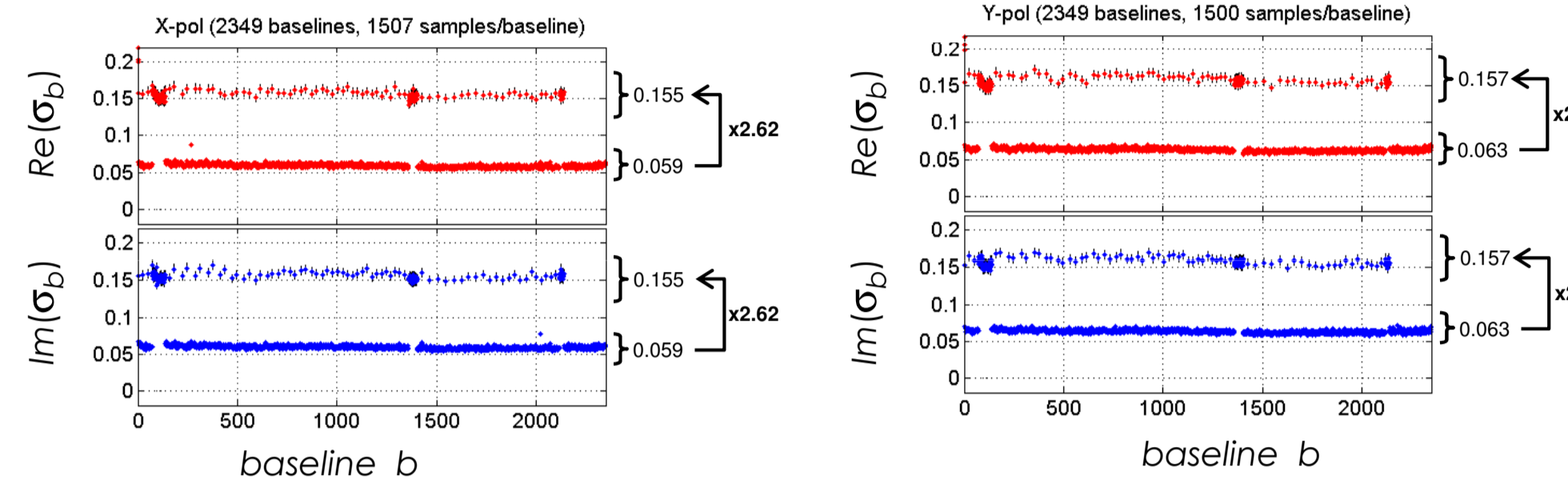


Figure 2 – Standard deviations σ_r of the real (red) and imaginary (blue) parts of the 2343 complex visibilities from the selected Pacific zone – Computed from data acquired in May 2010 (Left: H-pol, Right: V-pol)

M-Baselines have higher radiometric noise than the L-Baselines

Building the Weighting Matrices

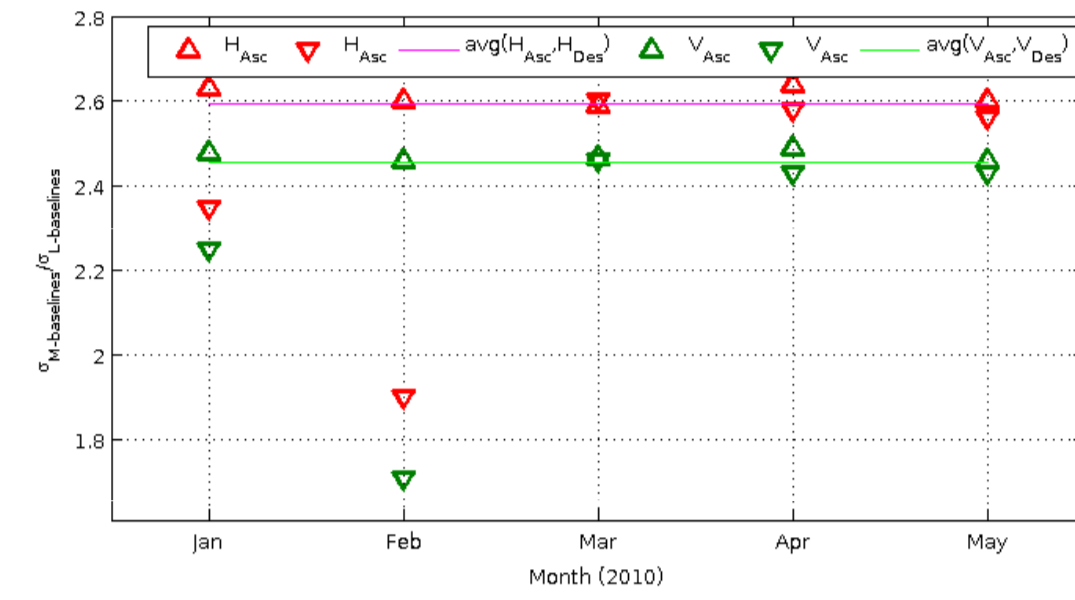


Figure 3 – Evolution of the ratio of Radiometric Noise levels between M- and L-Baselines

□ Ratios are very stable for Ascending (Asc) Orbits (*)
(*) Jan and Feb values reflect the instability on Operational Processors in beginning of IOCP
□ Averaging between Asc and Descending (Des) Orbits, the weighting matrices can be computed as $w_b = 1/R$

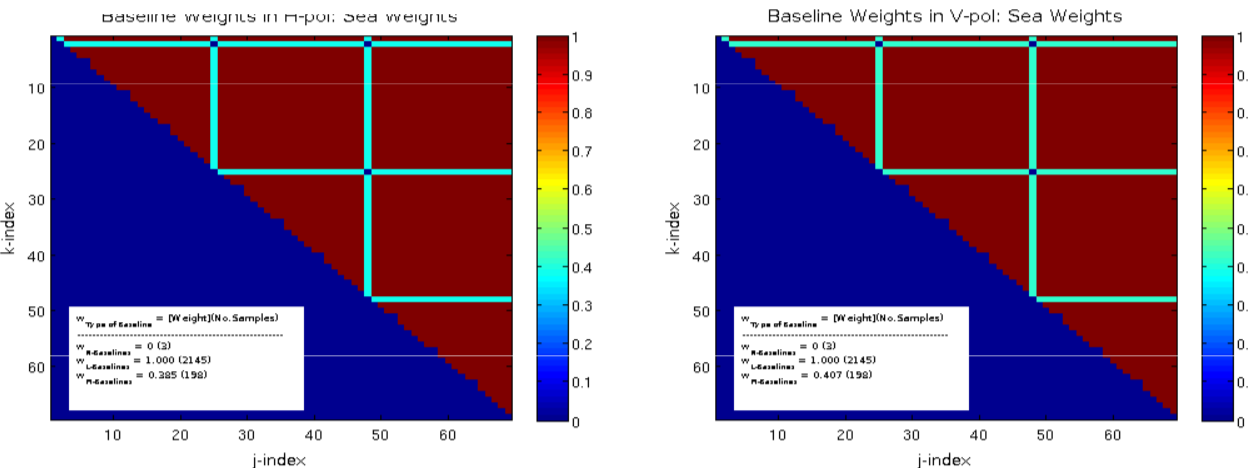


Figure 4 – Baseline Weight matrices to be applied to the visibilities (Left: H-pol, Right: V-pol)

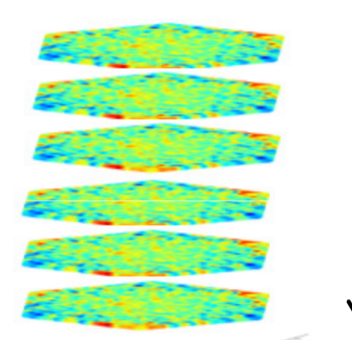
Radiometric Sensitivities computed with L1PP

The Radiometric Sensitivity is the best statistic that allows Level 1 to assess on the improvements brought by the Baseline Weights Algorithm. This assessment comprises several steps:

1. Generate J^+ Matrices with different weighting matrices (No Weights applied and using Sea Weights) and use them to process the same orbit

2. Using L1b data, compute an average scene (using > 300 snapshots)^(*) obtaining a Time Averaged Scene, $\bar{T}^p(\xi, \eta)$.

(*) For the results presented 512 snapshots per pol were used



3. Using the Time Averaged Scene, the empirical Radiometric Sensitivity is computed as shown in Eq. (1)

$$\bar{\sigma}^p(\xi, \eta) = \sqrt{\frac{1}{N} \sum_{n=1}^N T_n^p(\xi, \eta)^2} - \bar{T}^p(\xi, \eta)^2 \quad \text{Eq. (1)}$$

4. Compare the Time Average Scene and Radiometric Sensitivities derived from the orbits processed

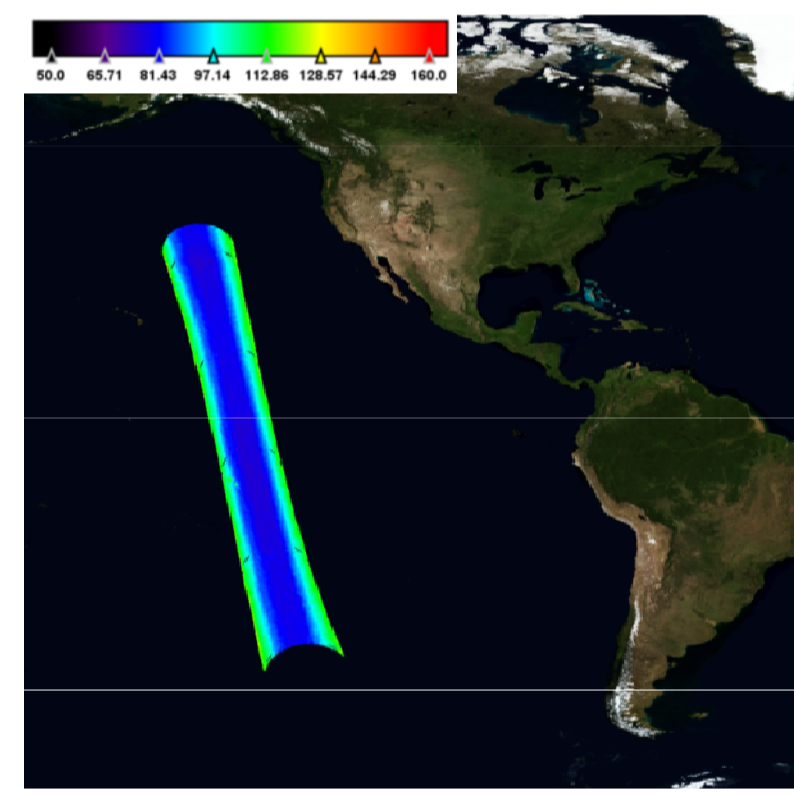


Figure 5 – Segment of Pacific orbit acquired on 10-Mar-2010, at 14:59:15 (H-pol image)

$$\Delta(\bar{T}_{SeaWeights}(\xi, \eta) - \bar{T}_{NoWeights}(\xi, \eta))(H-pol) = 0.054 \pm 0.48 \text{ K (in the AF-FOV)}$$

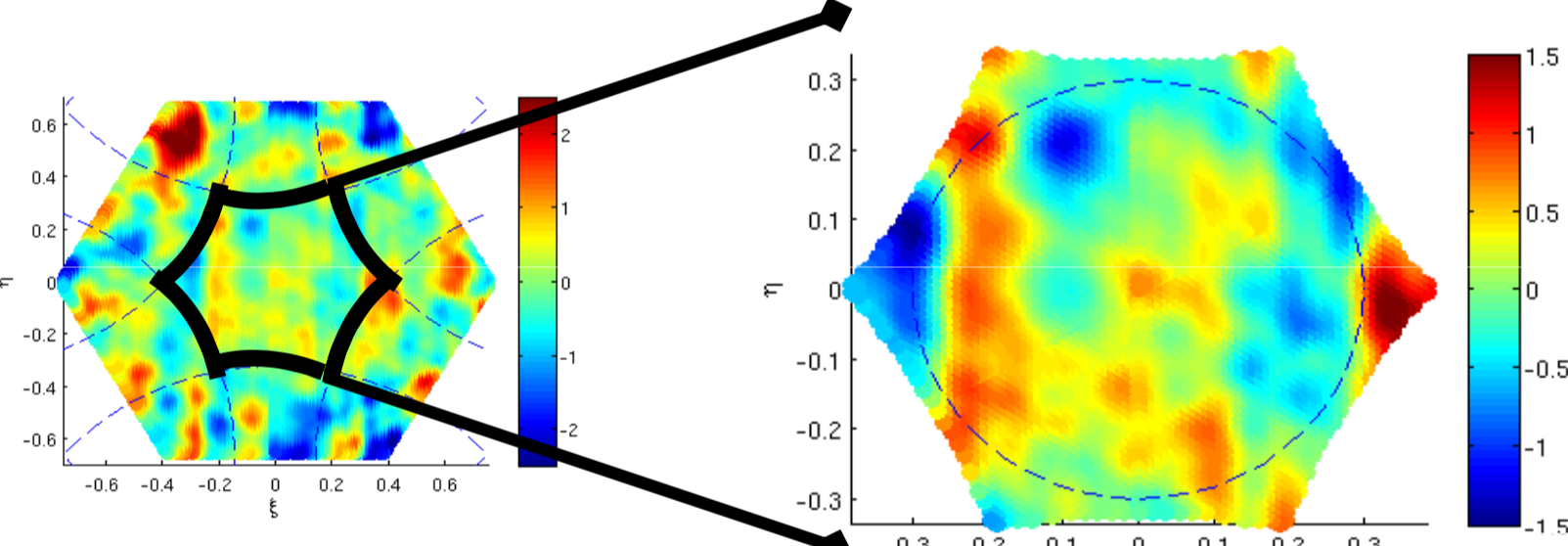


Figure 5 – Differences between Level 1b Time Average Temperature computed with 512 snapshots processed using Sea weights and with No Weights applied. (Left: Hexagon, Right: Zoom in the Alias Free Field of View (AF-FOV), Images in H-pol)

Result #1

The Time Averaged Scene is not affected by weighting down some baselines in the image reconstruction. The standard deviation corresponds to a change of < 1% in the temperature of the scenes. This is also valid for V-pol

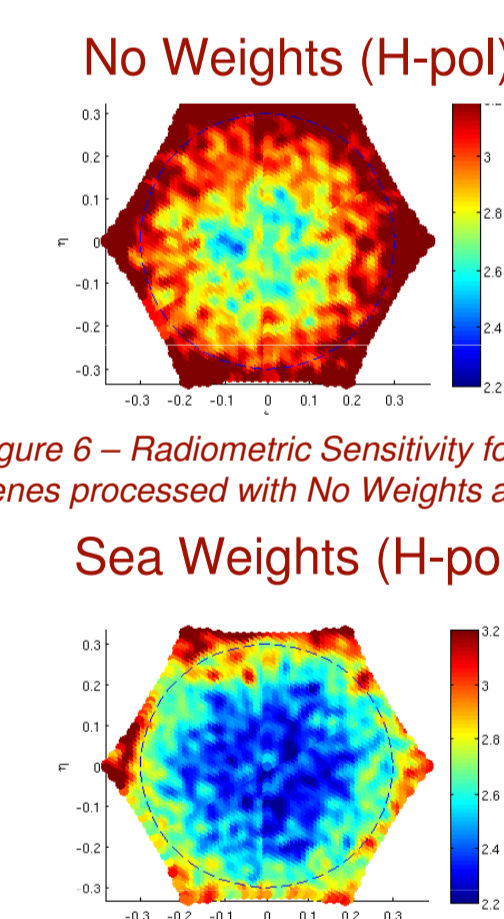


Figure 6 – Radiometric Sensitivity for 512 scenes processed with No Weights applied

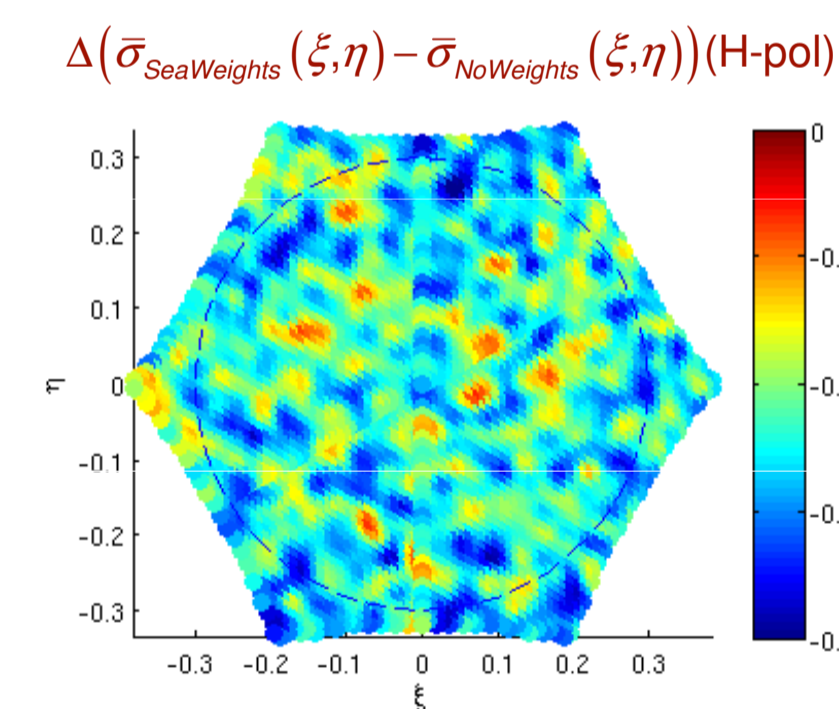


Figure 8 – Impact on the Radiometric Sensitivity when using Sea Weights.

Table 1 - Radiometric Sensitivity figures for two weighting options and their differences (@ Circle $r = 0.3$)	H-pol			V-pol			Re(HV)		Im(HV)	
	No Weights (1)	Sea Weights (2)	Δ [(2) - (1)]	No Weights (1)	Sea Weights (2)	Δ [(2) - (1)]	No Weights (1)	Sea Weights (2)	No Weights (1)	Sea Weights (2)
Boresight [K]	2.70	2.52	-0.18	2.63	2.46	-0.17	2.45	2.22	2.70	2.46
Average [K]	2.76	2.53	-0.24	2.93	2.72	-0.21	2.68	2.44	2.68	2.44
Std.Deviation [K]	-	-	0.05	-	-	0.05	-	-	0.05	-
Minimum [K]	2.29	2.09	-0.44	2.39	2.27	-0.39	2.35	2.12	2.33	2.07
Maximum [K]	3.37	3.14	-0.07	3.49	3.26	-0.03	3.14	2.85	3.12	2.79

Result #2

The Radiometric Sensitivity is improved by ~0.2 K in all polarisations.

Impact on Soil Moisture Retrieval

Detecting the impact of the above ~0.2 K radiometric sensitivity improvement on the Soil Moisture retrieval is a challenge

Challenging because:

- The SMOS radiometric accuracy 2.5K to 5K allows to retrieve the absolute soil moisture with an error less than 0.04 [m³/m³]
↳ The 0.2 K of improved sensitivity is small in comparison.
- But retrieval errors are expected to be dominated by the errors on the surface knowledge
↳ Landcover classification: fractions, especially water bodies
↳ Fixed parameters: sand, clay, vegetation or forecasted values
- The algorithms implemented in the L2 processor are still not completely calibrated and validated and still need to improve.

but with a strict control

Special SML2PP Setup	Focused DGG Analysis
stabilize the retrieval	minimize the impact of surface errors
<ul style="list-style-type: none"> SML2PP V3.08 in ESL mode No post analysis filtering SM & Tau free parameters only Hardened convergence criteria 	<ul style="list-style-type: none"> DT12 only ⇒ nominal model FNO > 95% ⇒ uniform surface Very low RFI ⇒ P < 0.01

Result #3

- No visible improvement for SM and Tau retrieval
- χ^2 is slightly improved for the Sea Weights option by ~0.1 absolute ⇒ ~3.5% relative ⇒ ~0.35 K

SM – Tau – χ^2 – Retrieval comparison Sea Weights versus No Weight

Australian rainy condition – Descending – Full Polarization – 20100212T072424 – L1PP L1C V330

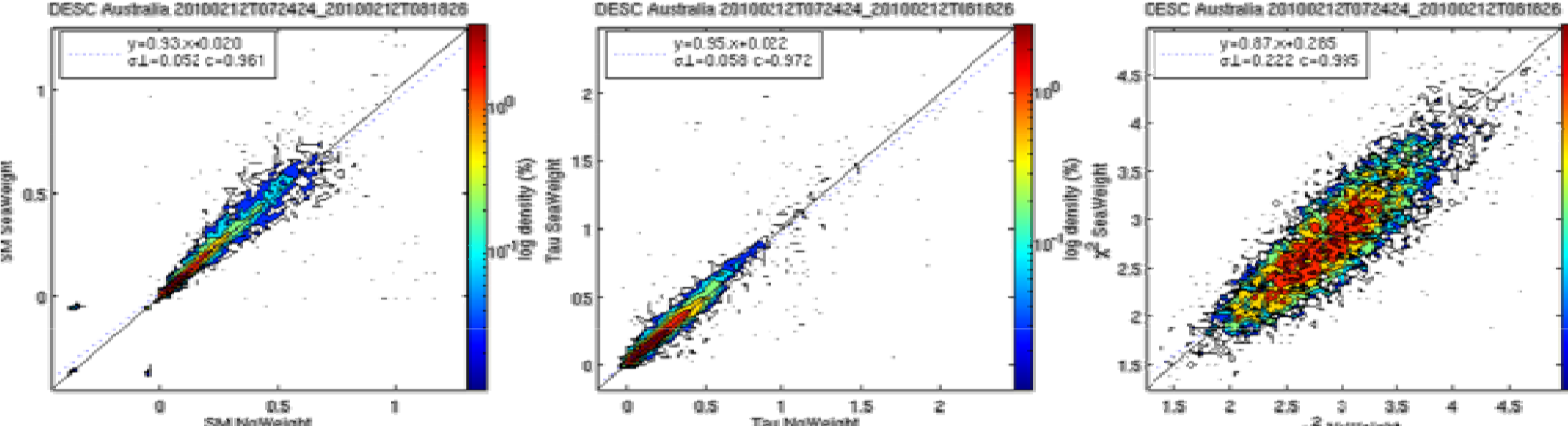


Figure 9a – Log density Soil Moisture scatter plot

Figure 10a – Log density Tau scatter plot

Figure 11a – Log density χ^2 scatter plot

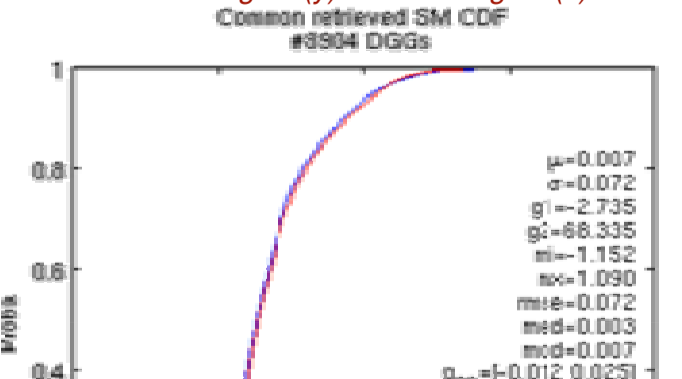


Figure 9b – CDF of Soil Moisture

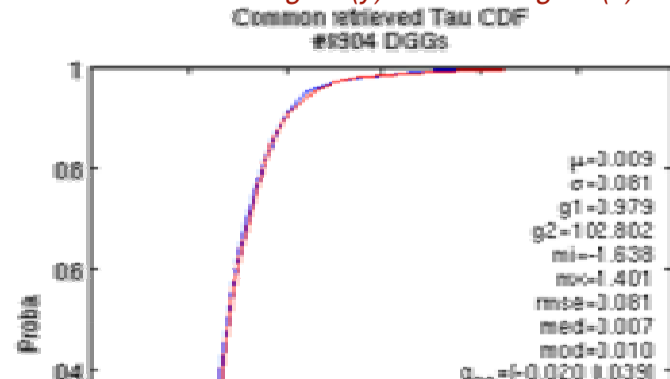


Figure 10b – CDF of Optical Thickness

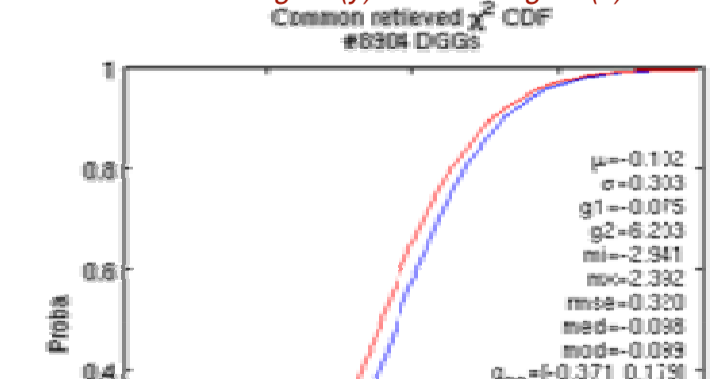


Figure 11b – CDF of χ^2

Conclusions:

The Baseline Weighting Algorithm has been designed to lower the noise levels in the reconstructed BTs of the L1 processing chain.

After an initial theoretical appraisal of the method, baseline weights were derived from in-orbit data and different weights are needed for baselines formed by NIR and LICEF receivers. The impact on the final BT has been accessed and, not only the final BT is not affected, the radiometric

sensitivity is improved by 0.2K.

Performing the study at L2 processing level has proven that SM retrieved values are not affected but that the χ^2 of the retrieved values is reduced as much as 0.35K.

The Baselines Weights are being computed on a monthly basis and are periodically updated in the processing chain. It is expected that the final improvements will be even larger as the mission continues.