Towards an improved characterization of instrumental biases and galactic modeling for SMOS observations over the Ocean

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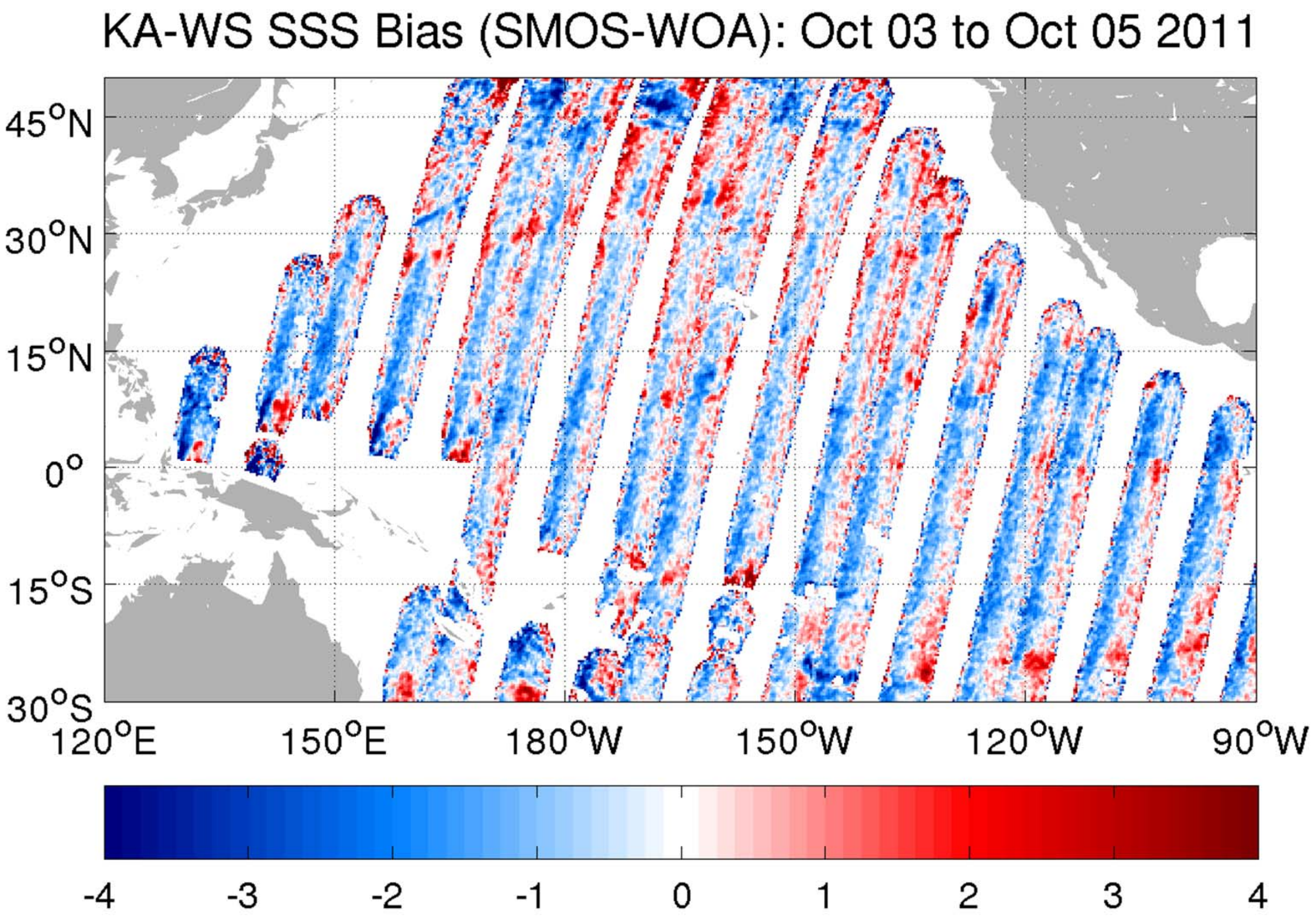
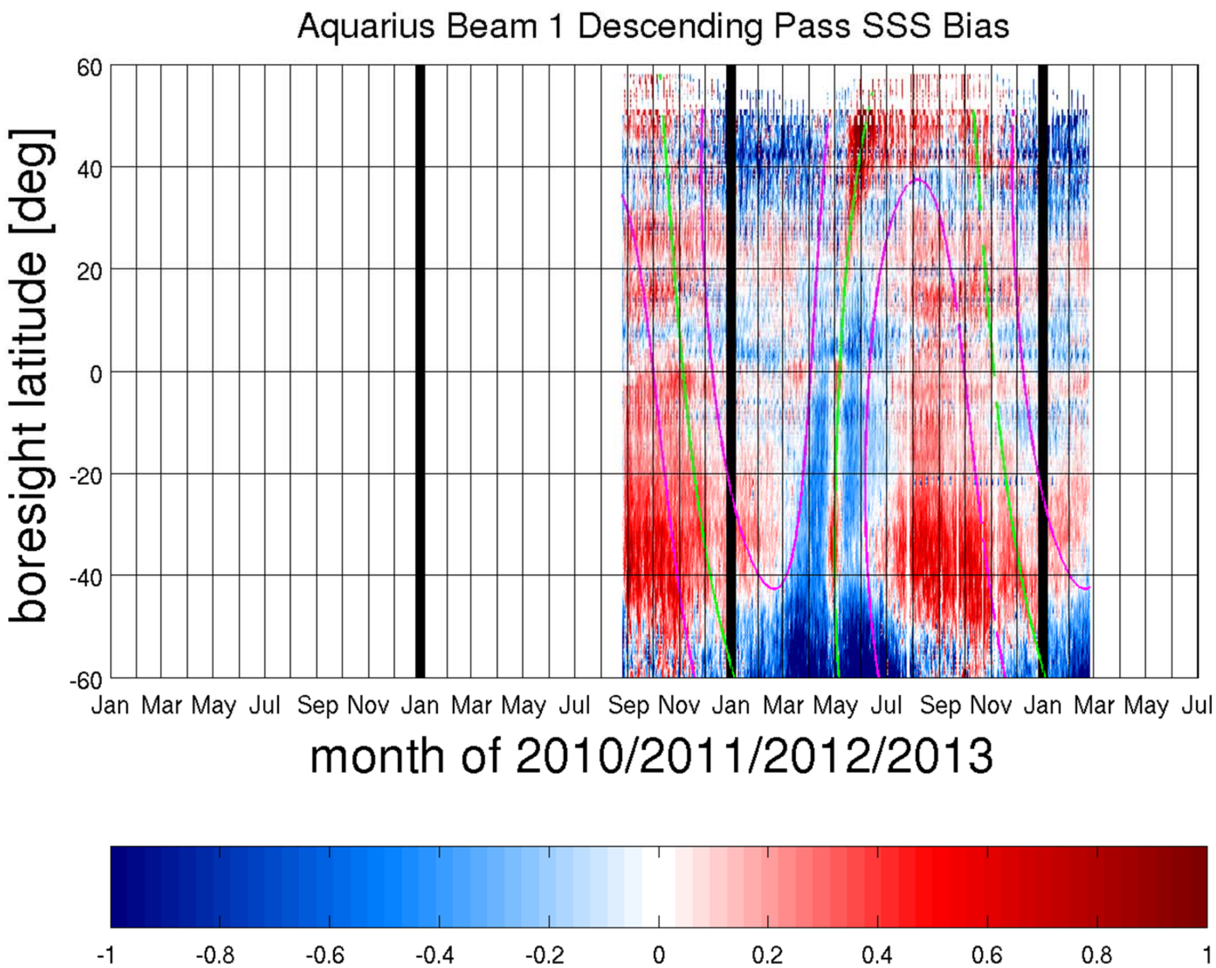
Introduction

Spatio-temporal systematic biases in SMOS salinities



Introduction

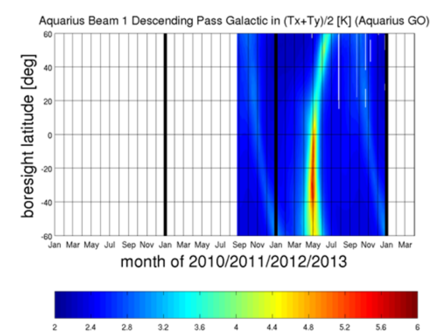
Spatio-temporal systematic biases in Aquarius salinities



Version 2.0

Inner beam

Descending passes



GEOMETRICAL OPTICS GALACTIC MODEL

Take high-frequency limit of the Kirchhoff approximation for scattering cross sections:

$$\tilde{\sigma} \approx \sigma_{00}^{hf} = \frac{1}{\pi} \frac{|\mathbf{T_0}|^2}{q_z^2} e^{-q_z^2 h_0^2} \left[\iint \left[e^{q_z^2 [\rho(x', y')]} - 1 \right] e^{-i(q_x x' + q_y y')} \, dx' \, dy'. \right]$$

Obtain expression in terms of slope probability distribution:

$$\sigma_{00}^{hf} = 4\pi \frac{|\mathbf{T_0}|^2}{q_z^4} P(-q_x/q_z, -q_y/q_z)$$

Assume Gaussian slope probability distribution. Then fit the slope variance (MSS):

$$P(S_u, S_c) = \frac{1}{2\pi\sigma_u\sigma_c} \exp\left\{ -\frac{\xi^2 + \eta^2}{2} \right\}$$

$$\begin{aligned} \eta &= S_u/\sigma \\ \xi &= S_c/\sigma. \end{aligned}$$

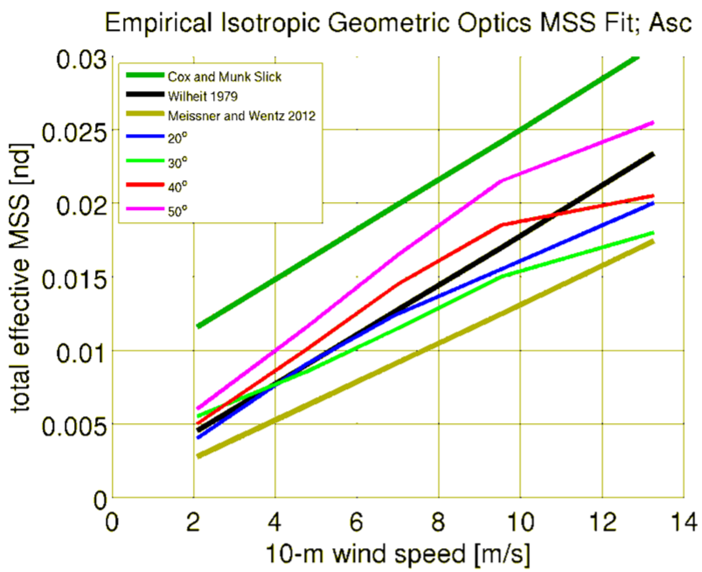
$$\begin{aligned} S_u &= \left(\hat{k}_{ix} + \hat{k}_{sx}\right) / \left(\hat{k}_{iz} + \hat{k}_{sz}\right) \\ S_c &= -\left(\hat{k}_{iy} + \hat{k}_{sy}\right) / \left(\hat{k}_{iz} + \hat{k}_{sz}\right) \end{aligned}$$

GO model adjustment on SMOS data

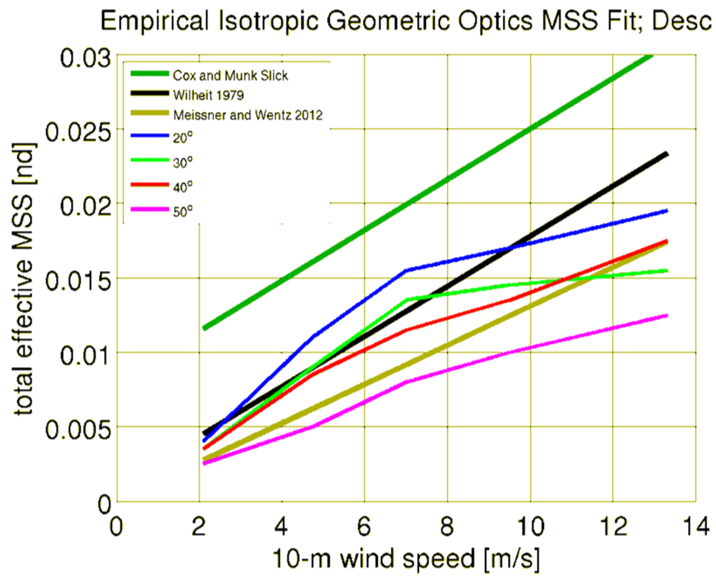
Geometrical optics fits to the data are different for ascending and descending passes:

The wind speed dependency of the slope variance exhibit different behavior with incidence angles.

Ascending

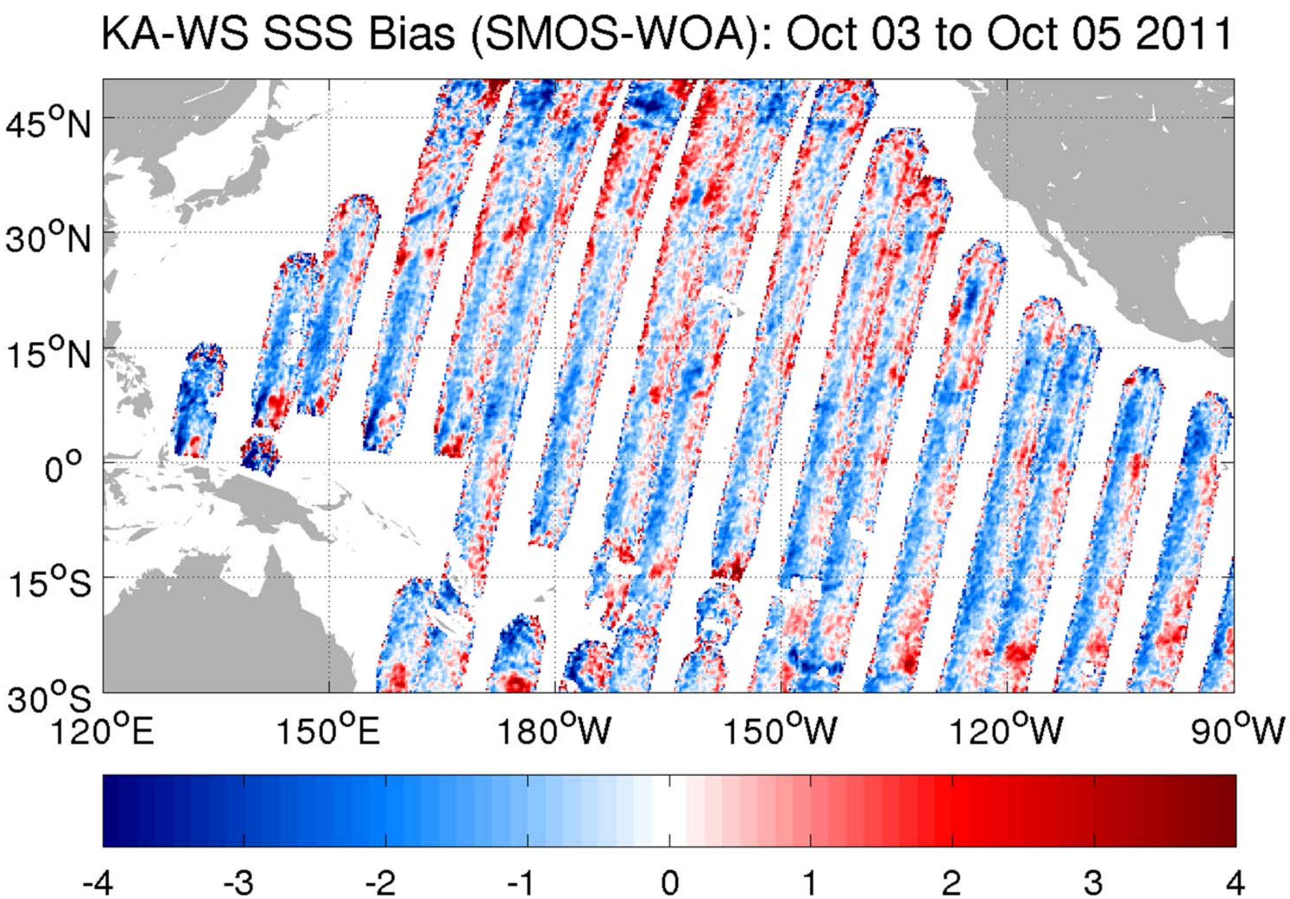


Descending



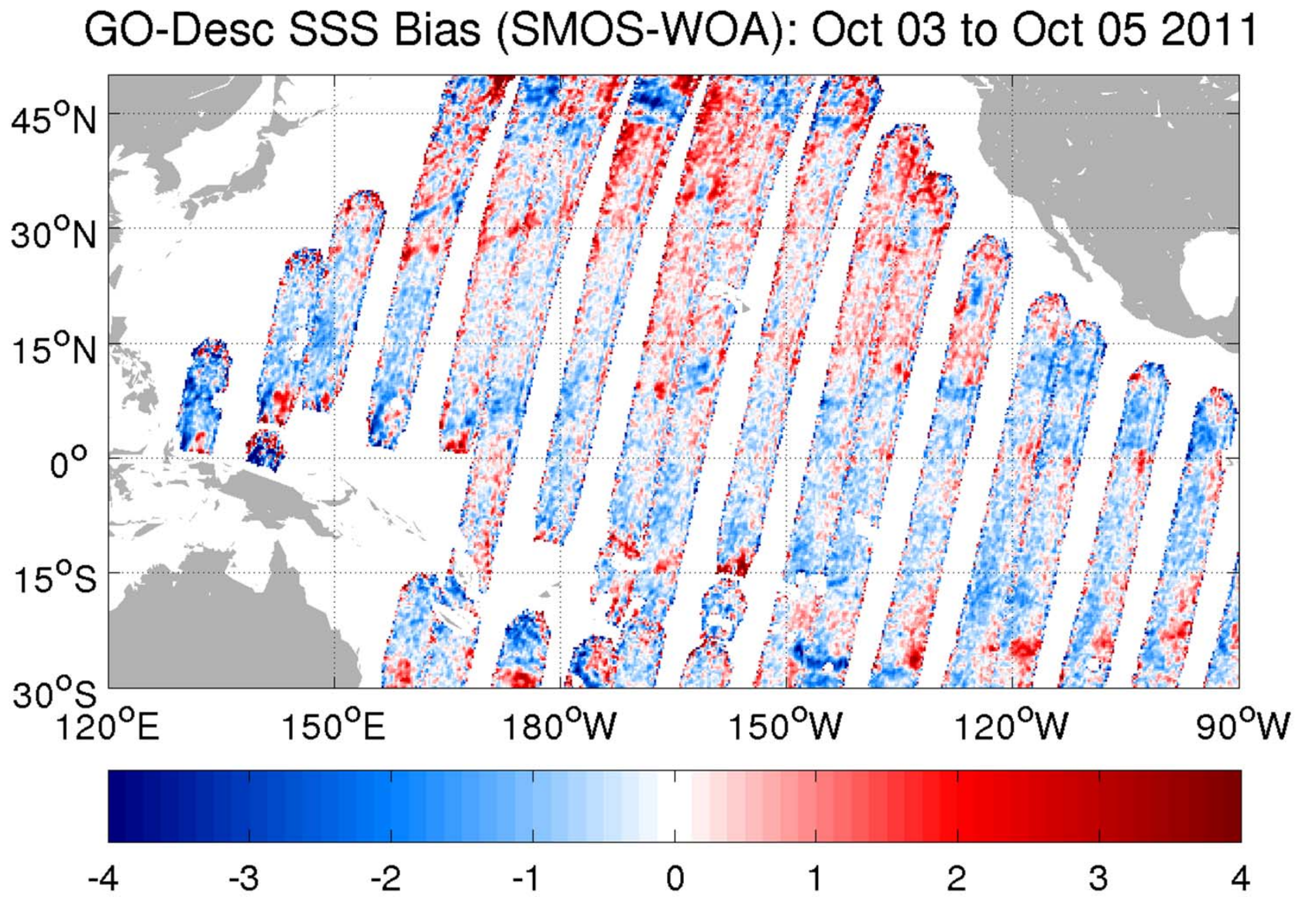
->2 different lookup tables are required for scattered celestial sky brightness corrections.

SMOS descending passes example
SSS bias using the **old** galatic model



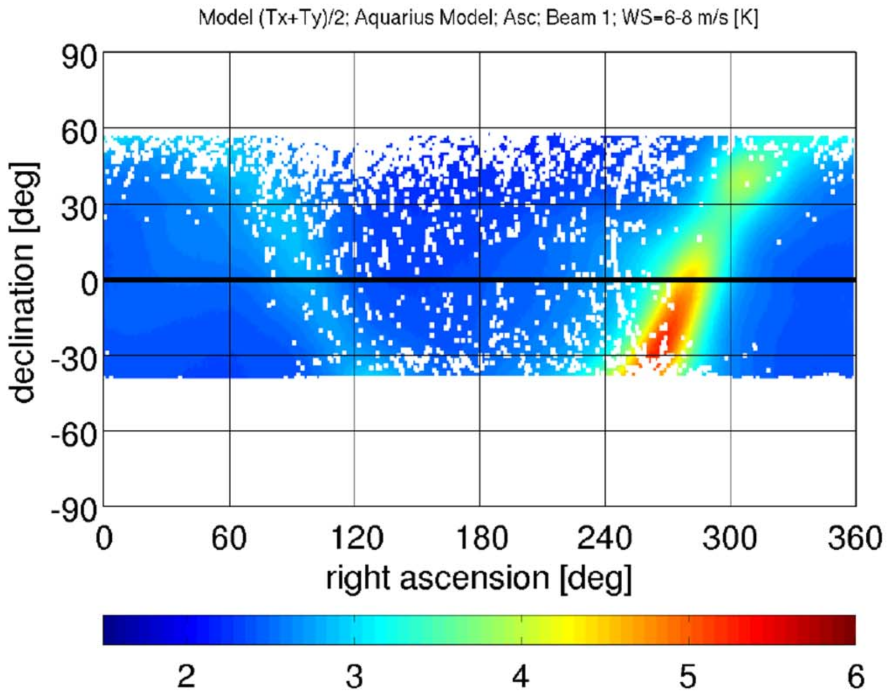
GO model impact

SMOS descending passes example
SSS bias using the **new** galatic model

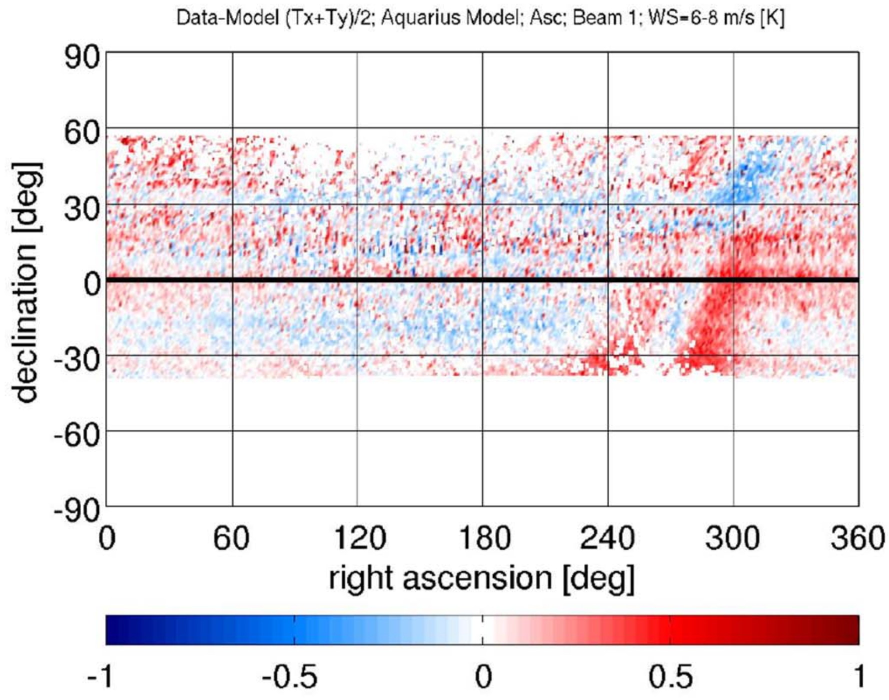


AQUARIUS inner beam (ascending passes only)

Model (including reflected 3 K floor)



Aquarius-Model

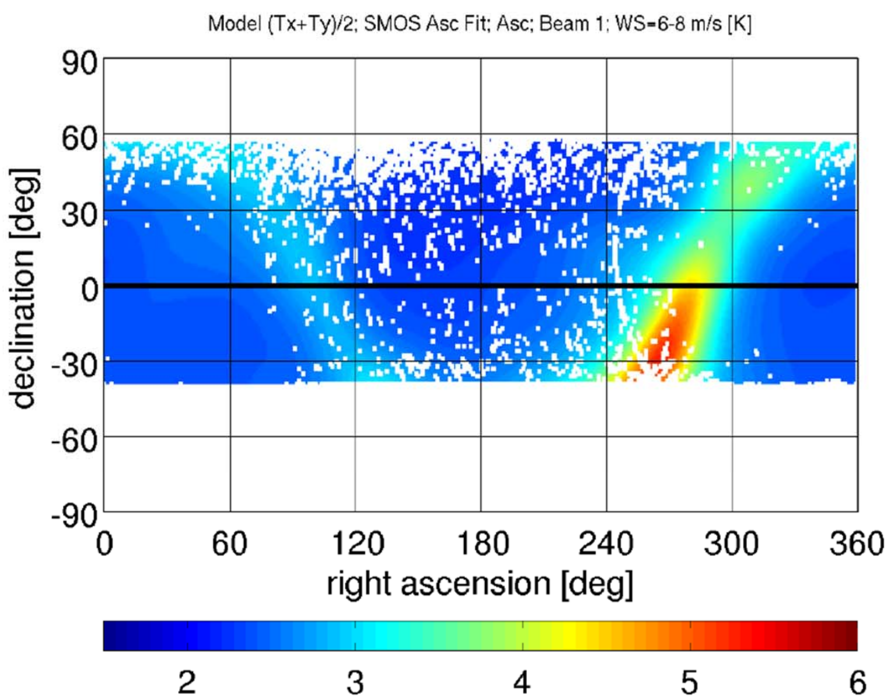


Aquarius galactic reflection model

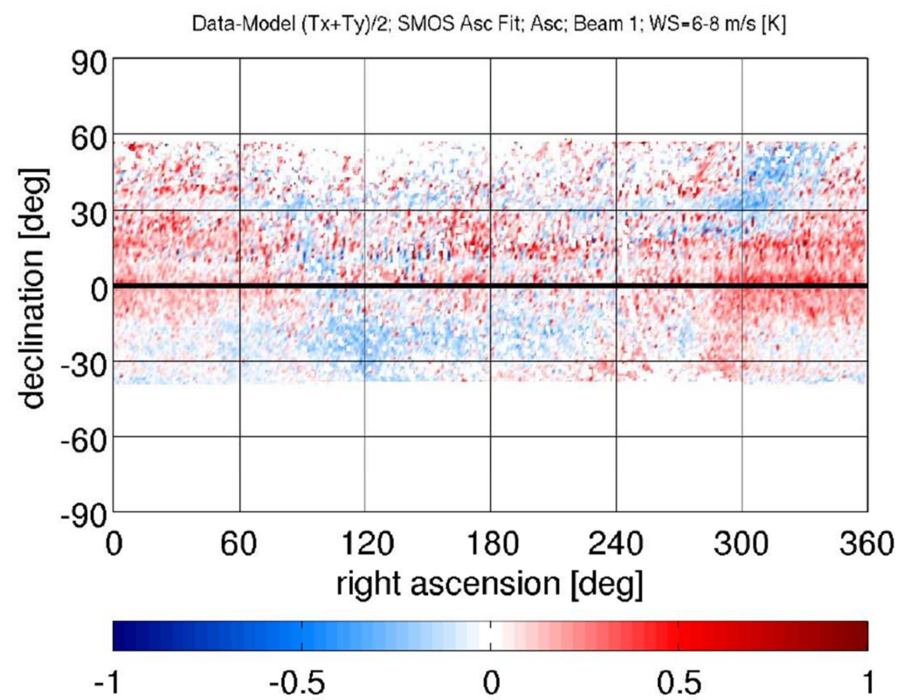
GO model impact

AQUARIUS inner beam (ascending passes only)

SMOS Asc. Pass Fit Model



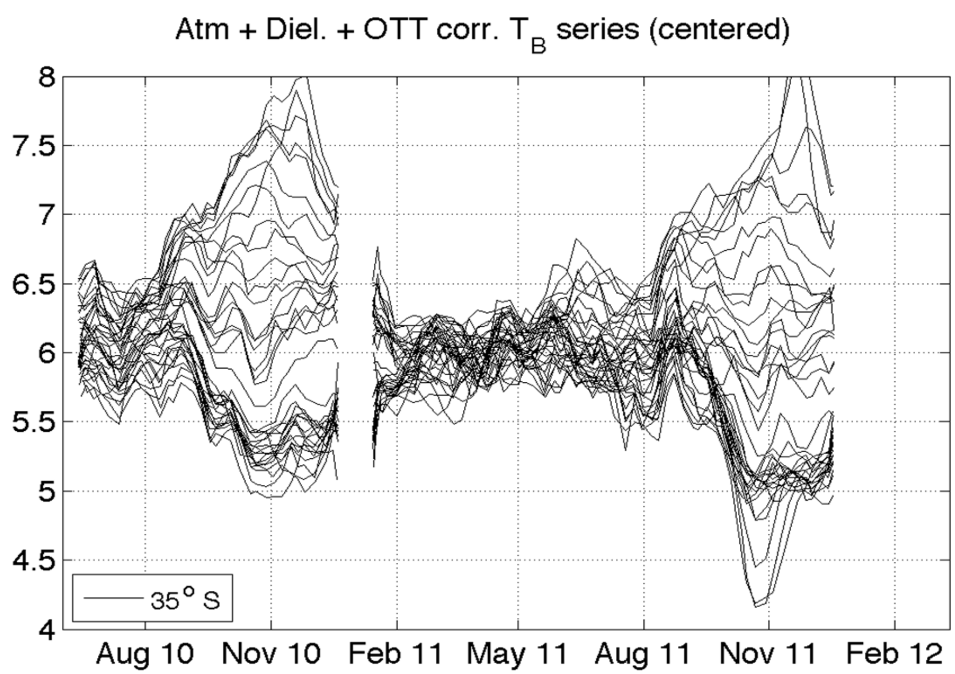
Aquarius-Model



SMOS ascending pass fit galactic reflection model

Remaining issues with the GO mss fit

1 - Potential phasing between biases and model errors



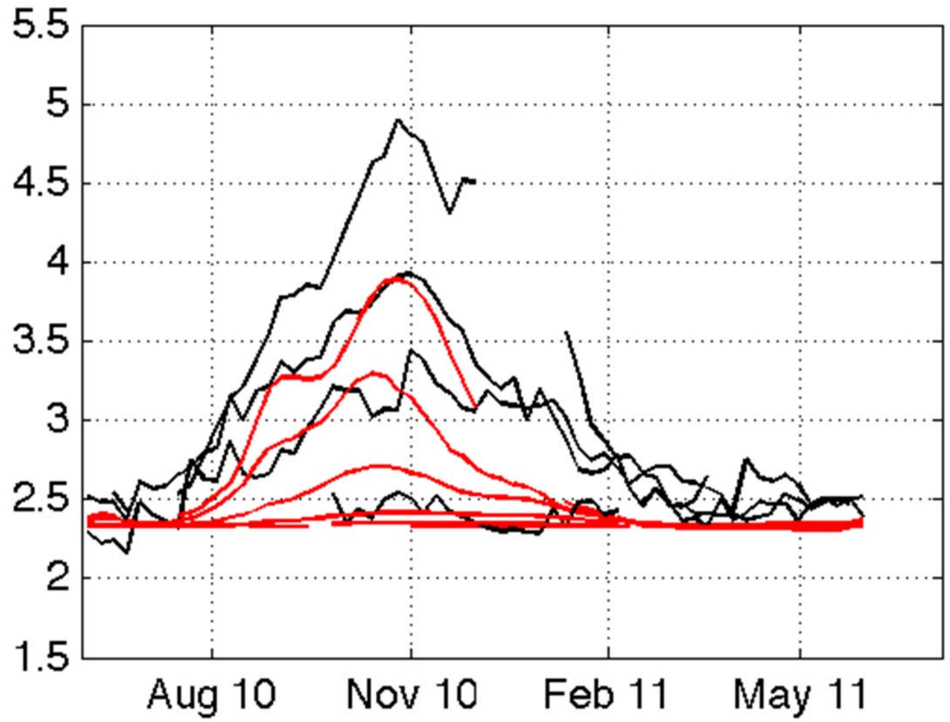
→ Need to **uncouple bias** estimation **and model** improvement tasks

Estimate biases from expected low model errors dataset

Update galactic model using a **corrected dataset**

Remaining issues with the GO mss fit

2 - Systematic underestimation at high incidence angle



→ Incomplete model physics (GO, Gaussian slope pdf ?)

Objective : *uncouple bias estimation and model improvement tasks*

- ✓ estimate the temporal "instrumental" bias from a specific dataset with low model errors (to build a corrected dataset)

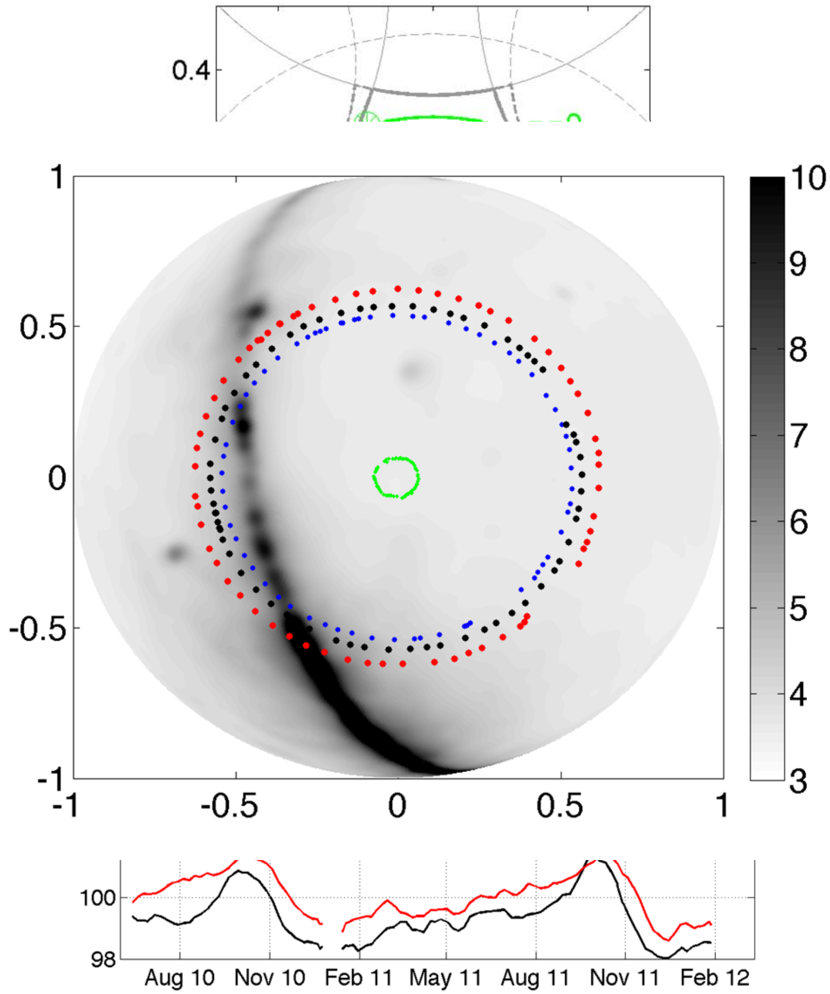
Strategy : *build T_B signals with reduced environmental variability*

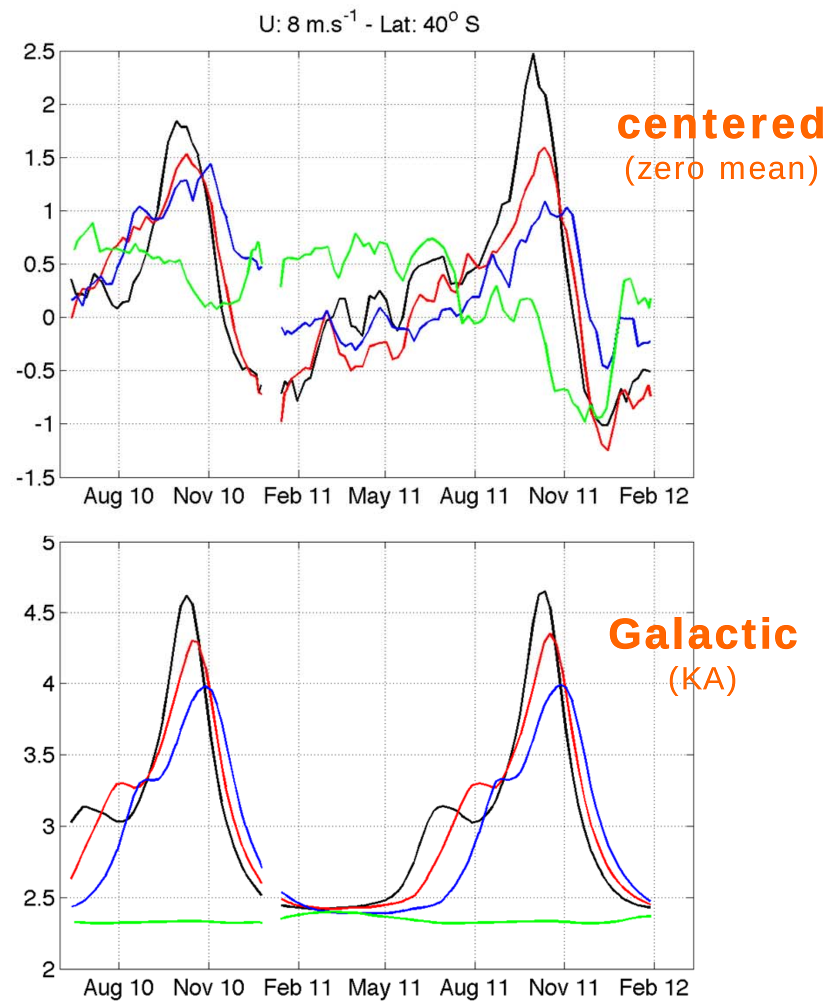
- ✓ low environmental (geophysical + foreign sources) variability
  - → expected to be constant *in a perfect world*
- ✓ Environmental variability is reduced through either data selection or correction based on reliable model components

Data

- ✓ 30-month time series (June'10 to Jan'13, Pacific) processed at BEC
- ✓ Noise reduction: 18-days and 5º x 80º averages, circular apodisation

1^{st} Stokes T_B time series : an example

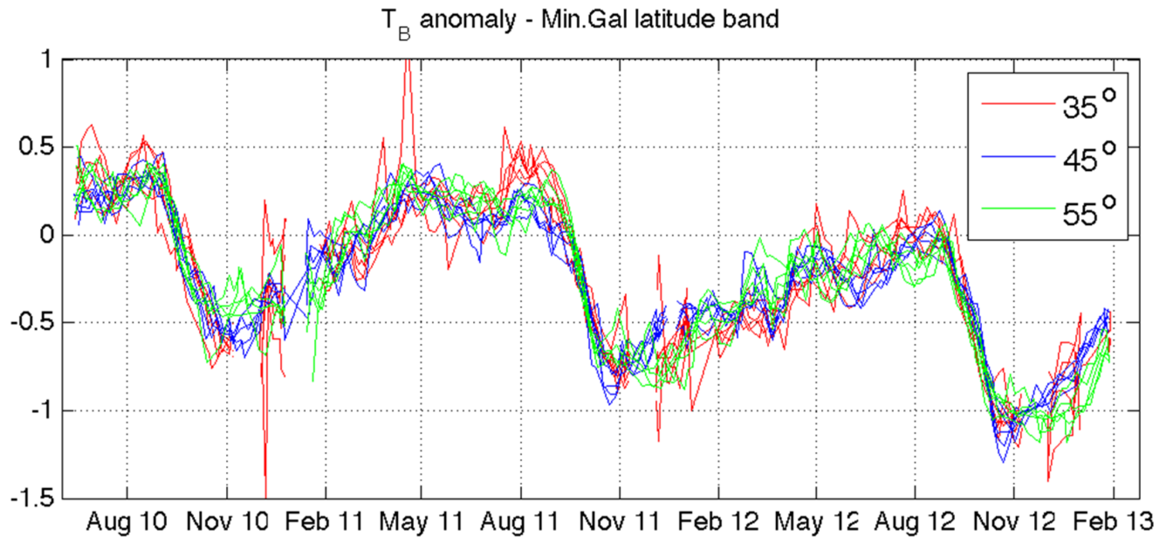


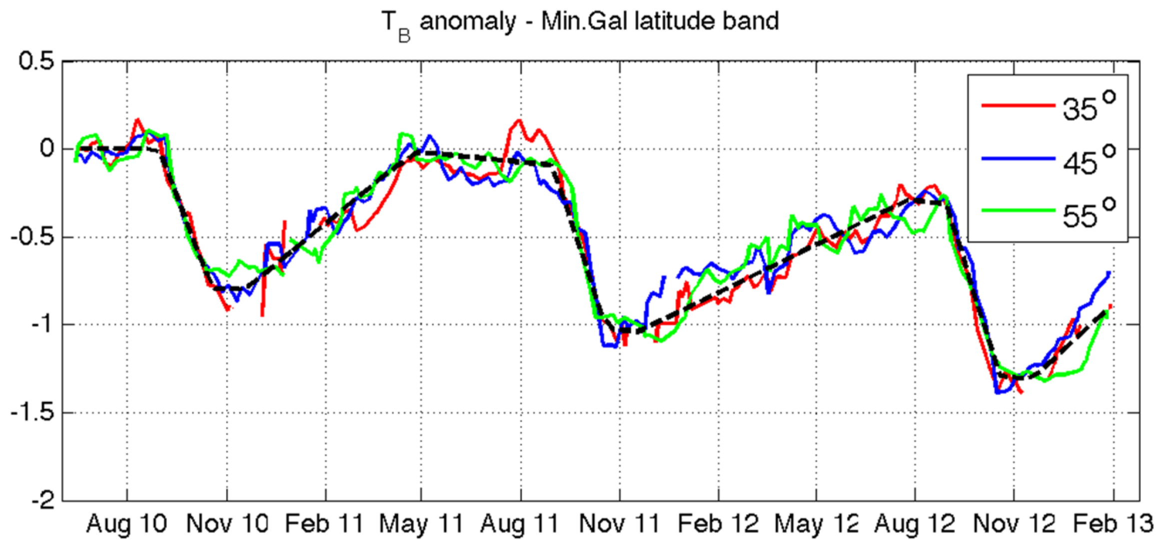


Variability reduction strategy

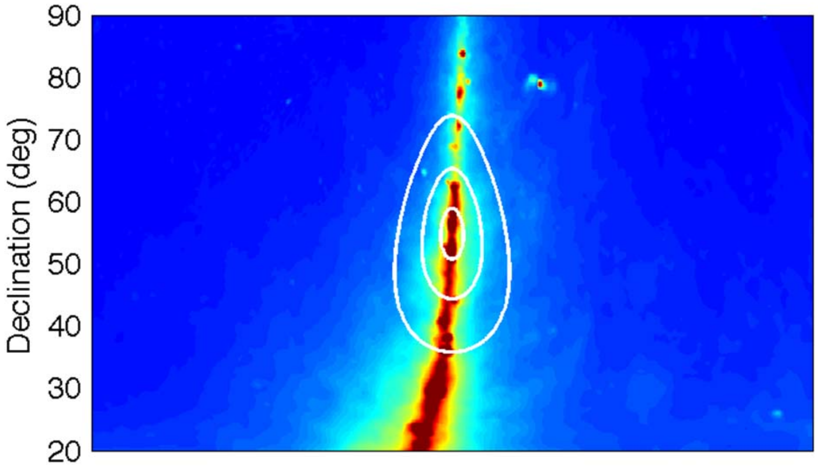
Variability source	Reduction approach
Faraday :	• use 1st Stokes parameter
Roughness :	• thin interval of wind speed values • thin bands of latitude (sea state)
Dielectric :	• cancel contribution using Klein-Swift model • latitude band with low SST seasonal variations
Atmosphere :	• cancel contribution using emission/attenuation model
Direct sun :	• remove sun alias and sun tails (0.06)
Celestial reflections :	• set of xi/eta points with very low annual variations (predicted by the KA)

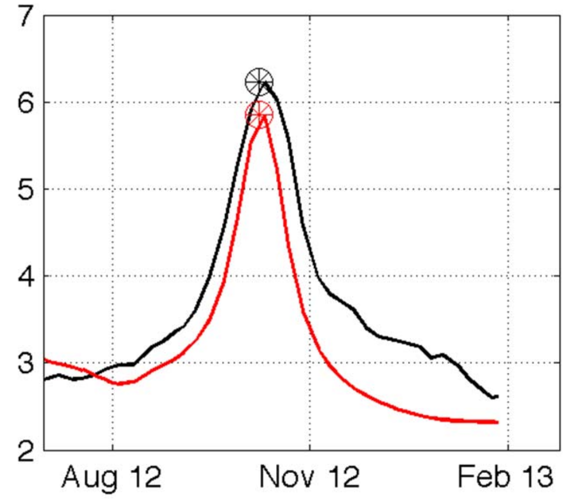
1 - phasing between biases and model errors

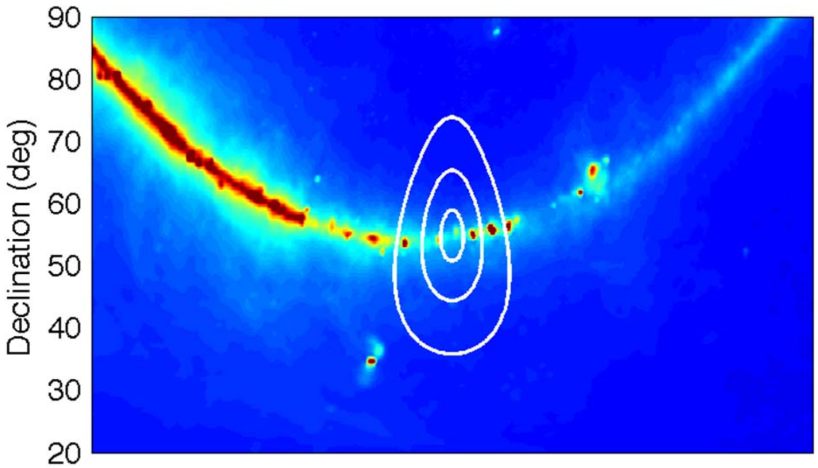


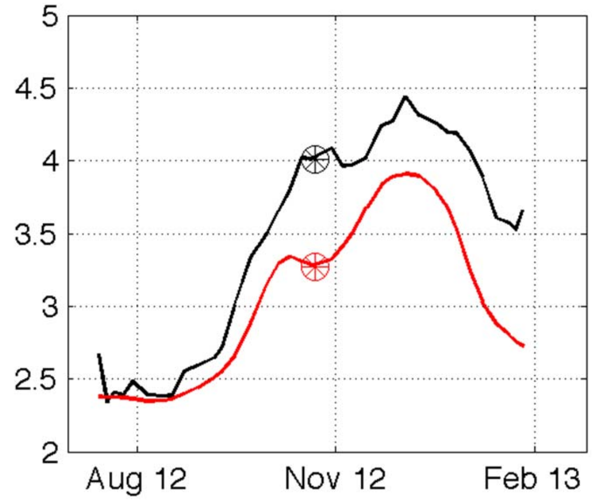


2 - Underestimation at high incidence angle

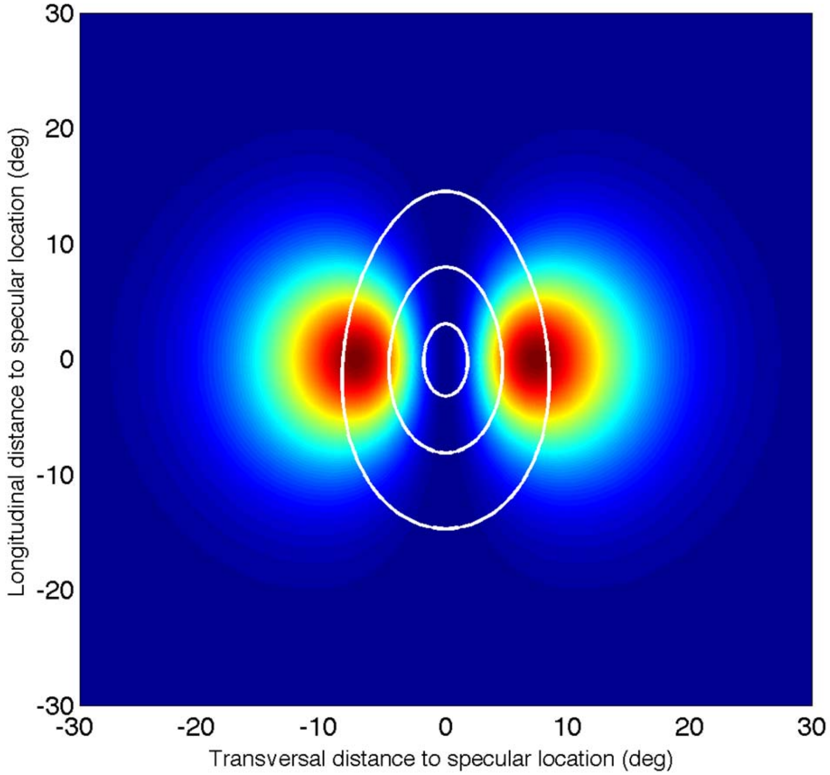


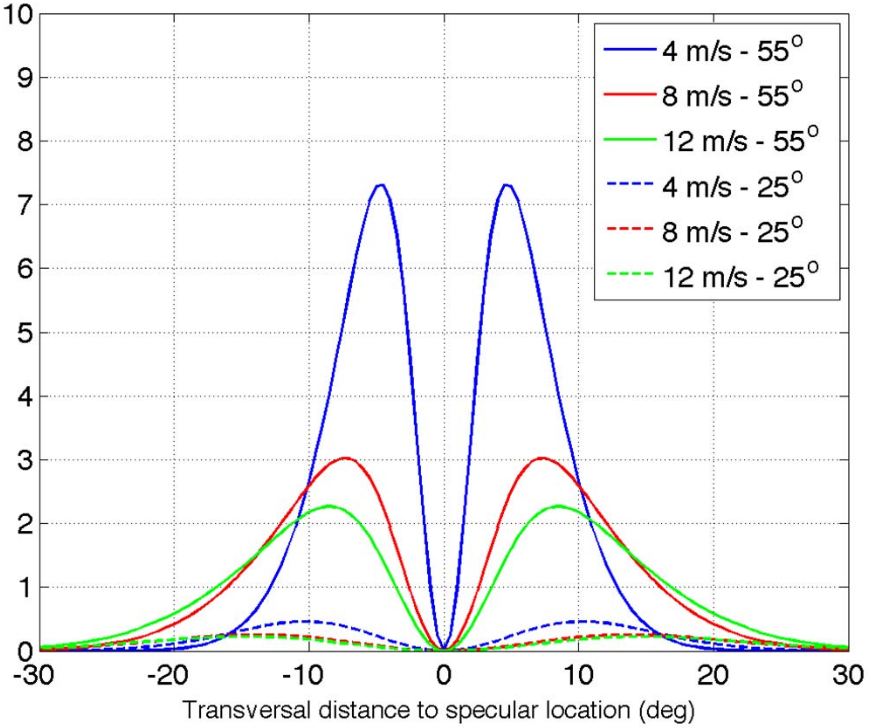






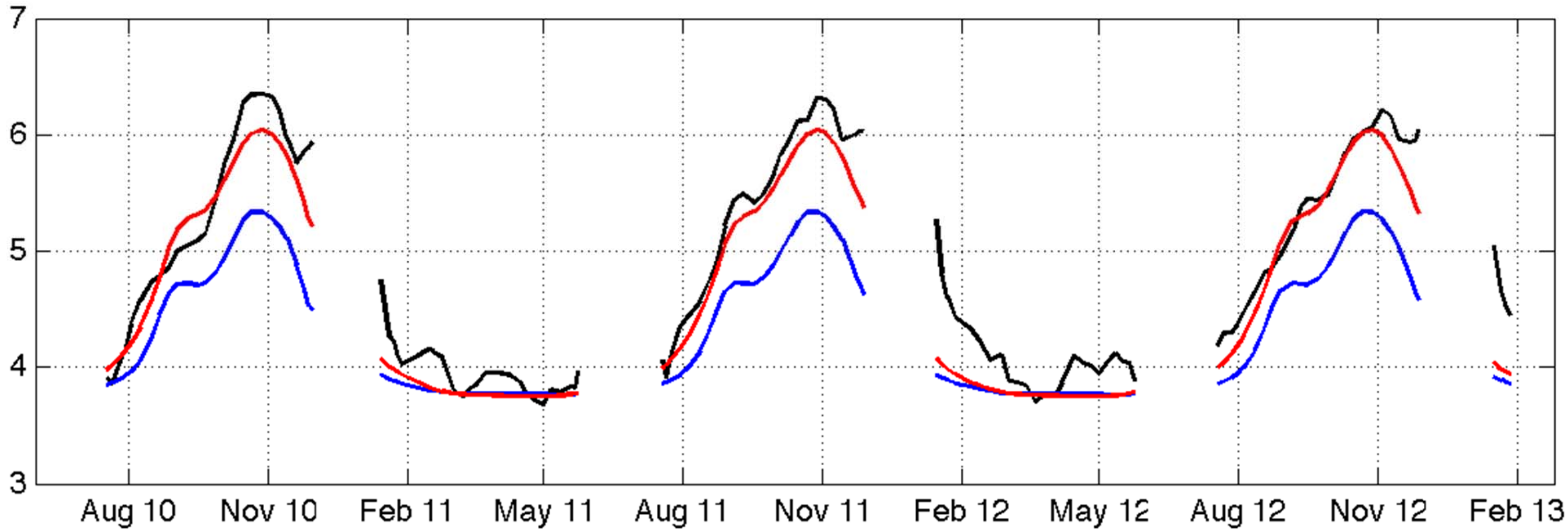
A fully empirical correction





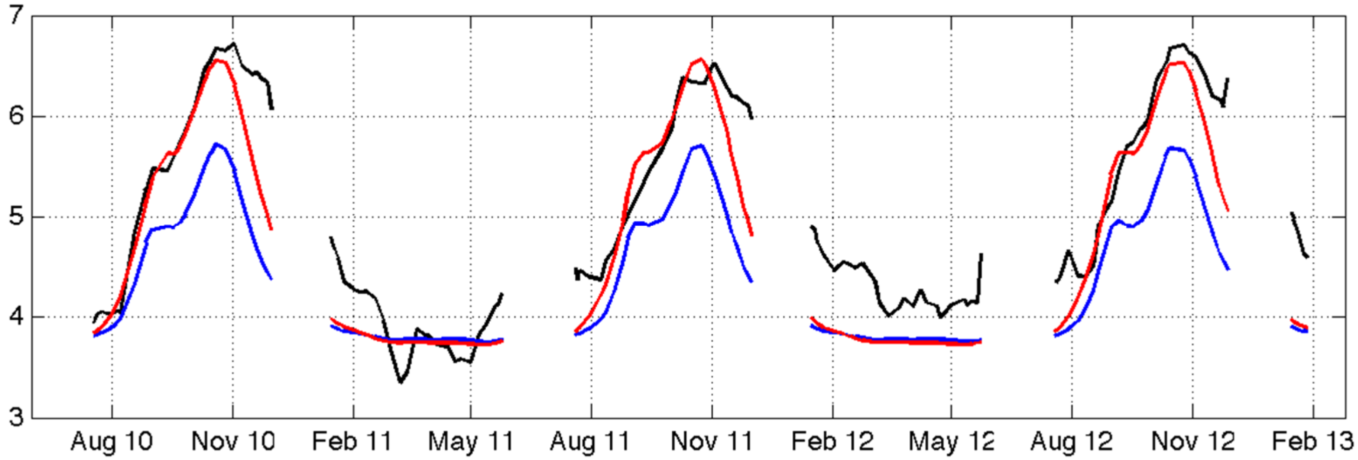
2 - Underestimation at high incidence angle

55º incidence, 8 m/s

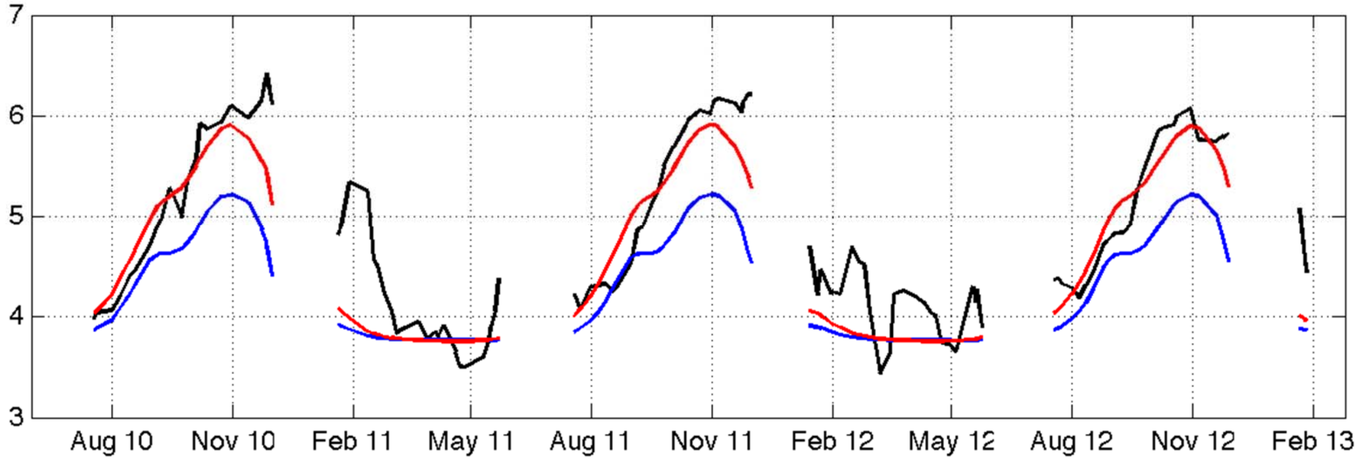


2 - Underestimation at high incidence angle

55° incidence, 4 m/s



55° incidence, 12 m/s



Summary

- Modeling the scattered celestial signal is of importance for salinity retrieval but also for accurate bias estimation
- The pre-launch Kirchhoff scattering model strongly underpredicts the scattered brightness near the galactic plane and overpredicts the brightness away from the galactic plane under most surface roughness conditions.
- A semi-empirical GO model approach has been developed. The slope variance fit changes with pass orientation and incidence angle. It improves the description of the scattering near the specular lobe.
- Inaccurate representation of scattering cross sections away from specular direction is evidenced. Particularly at high incidence angles.
- A preliminary empirical correction of the scattering cross sections further improves the modeling of the SMOS scattered celestial signal.

SMOS-Mission Oceanographic Data Exploitation

SMOS-MODE

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SMOS-MODE supports the **network** of SMOS ocean-related R&D

Next plenary meeting foreseen in **October 2013**

Additional institutions and countries are welcome!