Dielectric constant retrieved from SMOS multiangular measurements: the cardioid model

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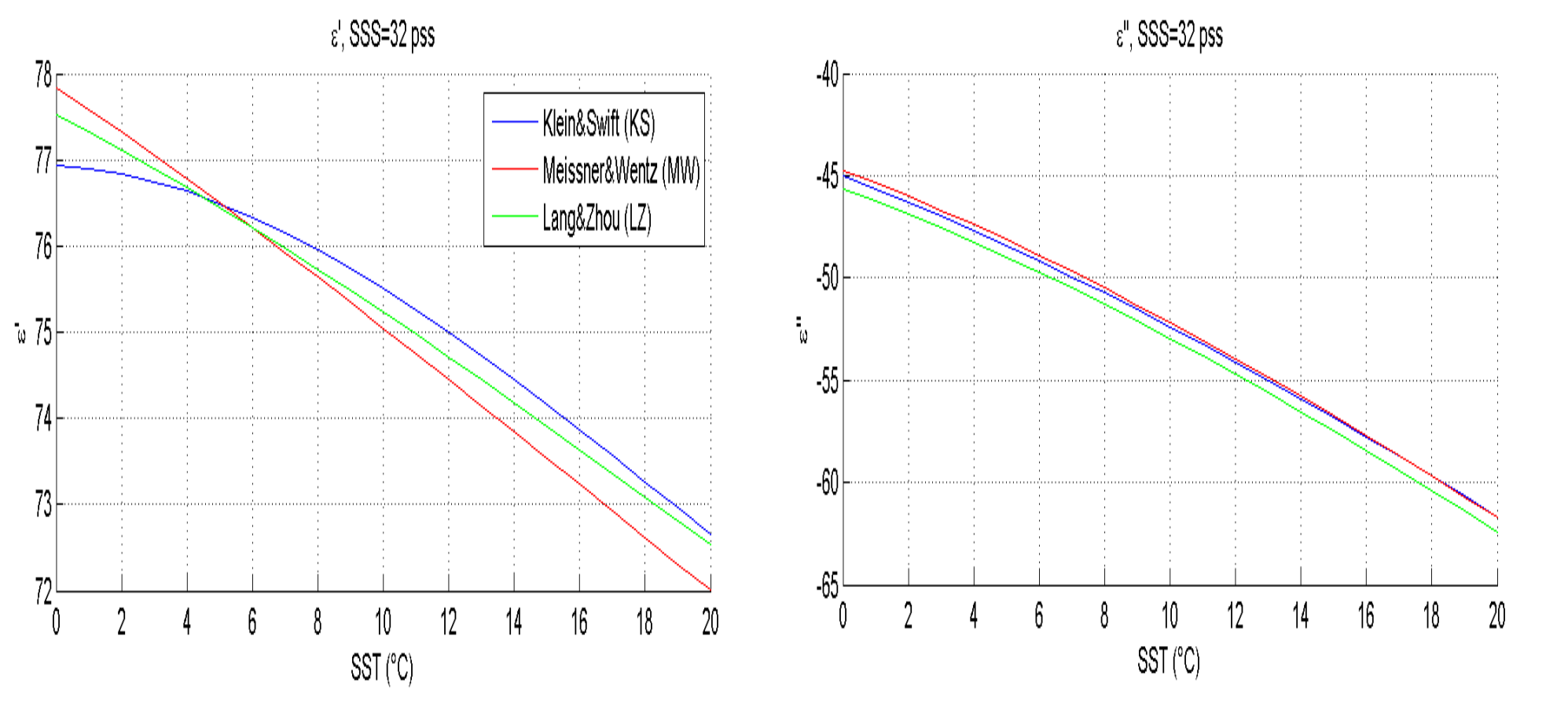
ABSTRACT. Sea surface salinity (SSS) retrieved from L-band radiometry strongly depends on the formulation chosen for modelling the dielectric constant ε of sea water. Recent laboratory measurements of Lang et al (2016) indicate some differences at very low and very high SST with respect to the ε models of Klein and Swift (1977) (KS) and Meissner and Wentz (2012) (MW), respectively used for processing the SMOS and Aquarius/SMAP data. In this poster, we compare information on ε retrieved from the angular variation of SMOS brightness temperatures (Tb) with KS and MW models and with interpolated Lang measurements. We find that in cold waters, SMOS measurements are closer to the latter than to the KS parametrization. In warm waters, further analysis involving SSS variations will be necessary to identify the causes for the large scattering.

1. BACKGROUND AND GOALS

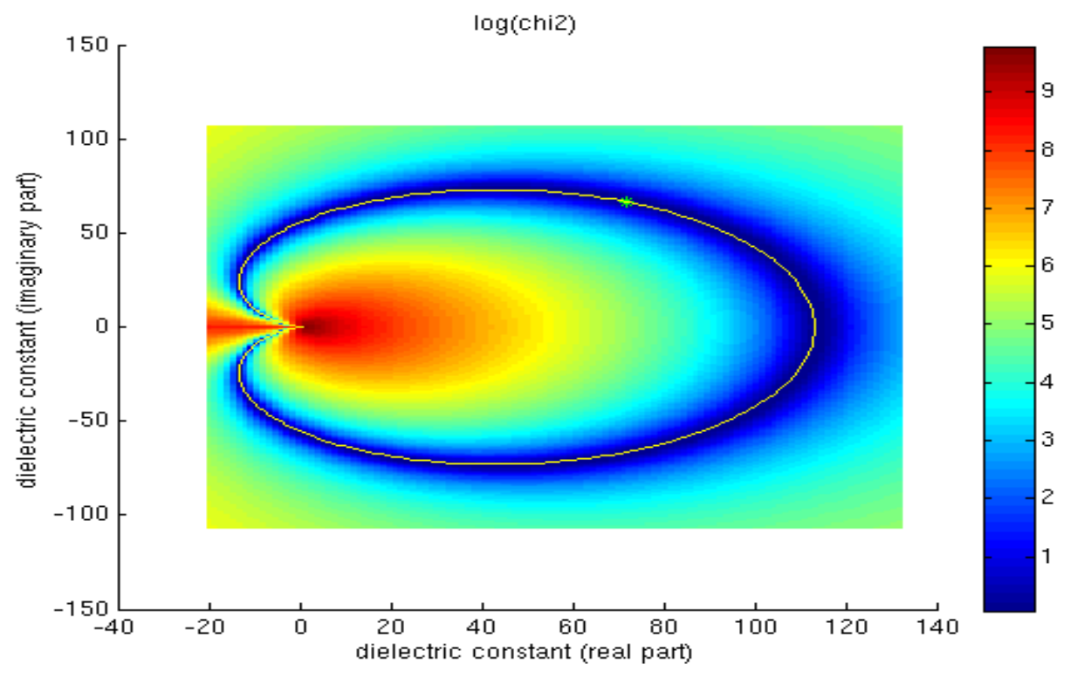
- Modelling the dielectric constant of sea water, ε, at L-band remains uncertain: recent laboratory measurements (Lang et al. (2016) suggest a dependency with sea surface temperature (SST) different from the previous ones (KS and MW models).
- Using a third-order polynomial fit of Lang et al. (2016) measurements that depends on sea surface salinity (SSS) and SST (Zhou et al., in rev. 2017) (LZ), we compare a pseudo-modulus of ε retrieved from SMOS Tbs, with the ones estimated with the three models, focusing on cold water regions.



Dielectric constant of sea water at L-band as derived from the three models for both the real part (ε ', left) and the imaginary part (ε '', right); SSS=32pss.

2. THE CARDIOID MODEL

Using the angular dependency of SMOS Tb, it is possible to retrieve information about ε (Waldteufel et al. (2004)). The simultaneous retrieval of the real (ε') and imaginary (ε'') part of ε from SMOS Tb is an ill posed problem: the cost function, rather than a single minimum, exhibits a minimum valley (see figure). The latter can be represented analytically using a modified cardioid model, providing a **way to retrieve, without any assumption on the dielectric model, a pseudo-modulus of ε**, the so-called Acard parameter:



Cost function (log values) obtained when retrieving (ε', ε'') for sea water, as plotted over the (ε', ε'') plane: the green cross indicates the true value of the dielectric constant. The yellow curve corresponds to a constant A_card with U_card varying between 0 and 360 °

$\varepsilon' = A\_card\,(1 + \cos(U\_card))\cos(U\_card) + B\_card$

$\varepsilon'' = A\_card\,(1 + \cos(U\_card))\sin(U\_card)$

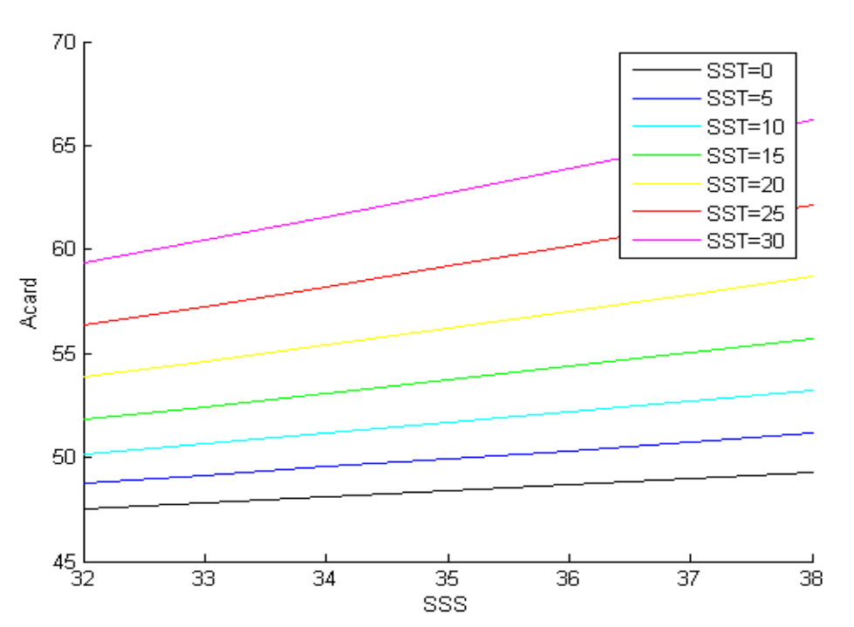
which is equivalent to:

$A\_card = m\_card^2 / (m\_card + \varepsilon' - B\_card)$

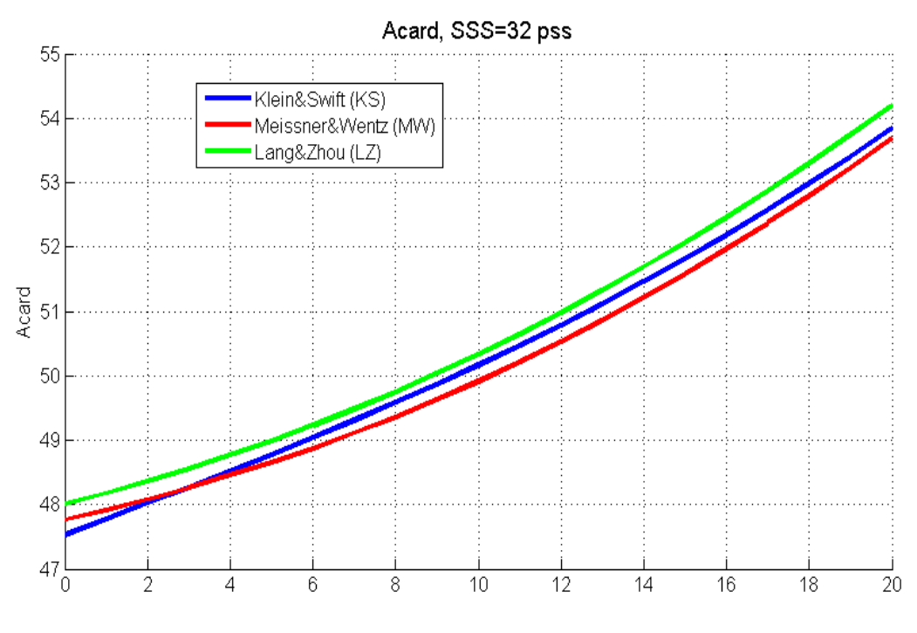
$U\_card = \tan^{-1}(\varepsilon''/(\varepsilon'-B\_card))$

with: $m\_card = ((\varepsilon'-B\_card)^2 + \varepsilon''^2)^{1/2}$

with $B\_card = 0.8$



Variation of Acard as a function of SSS and SST, as derived with the KS relationship.

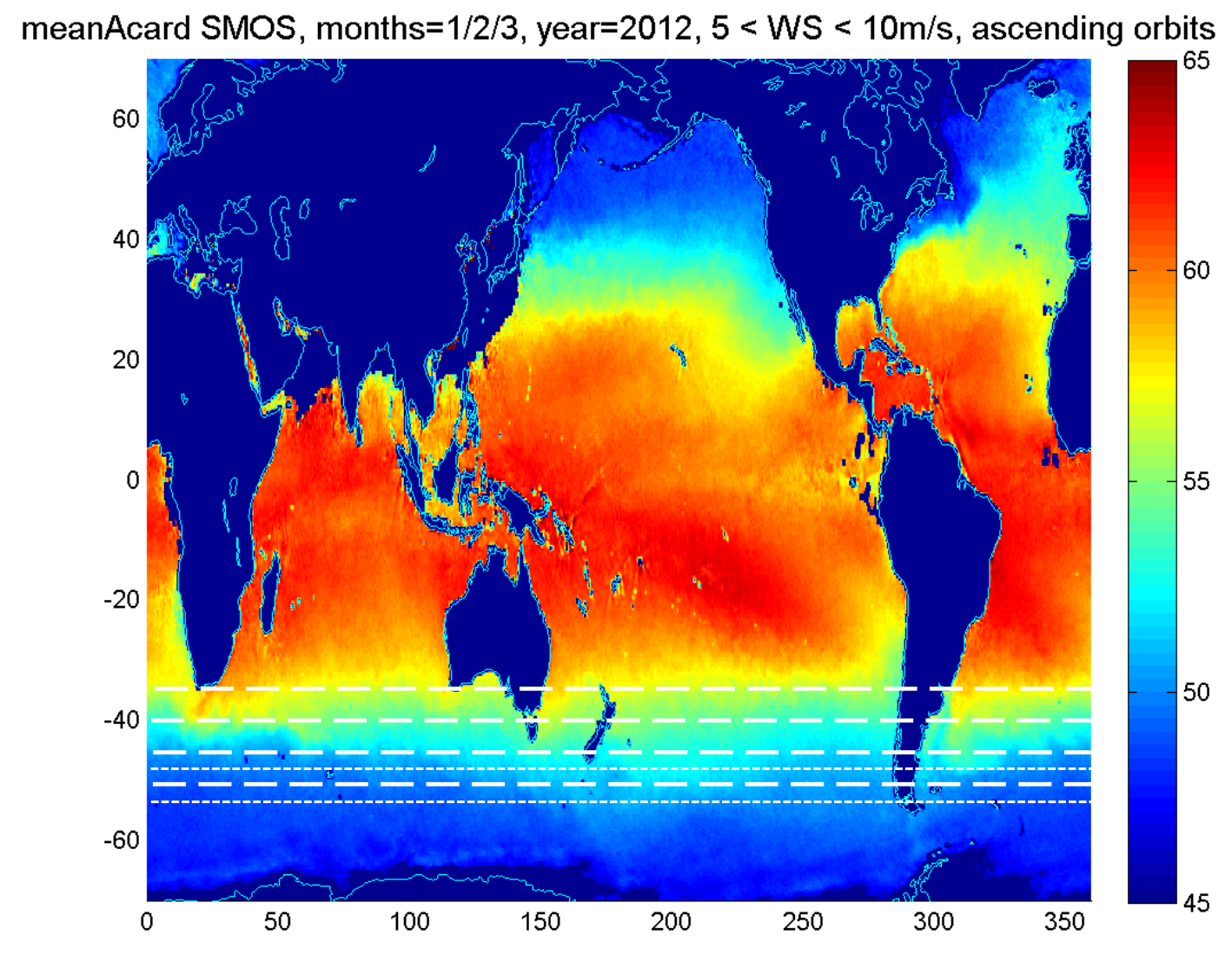


Variation of Acard as a function of SST, for SSS=32 pss, as derived with the KS, the MW and the Lang/Zhou formulations.

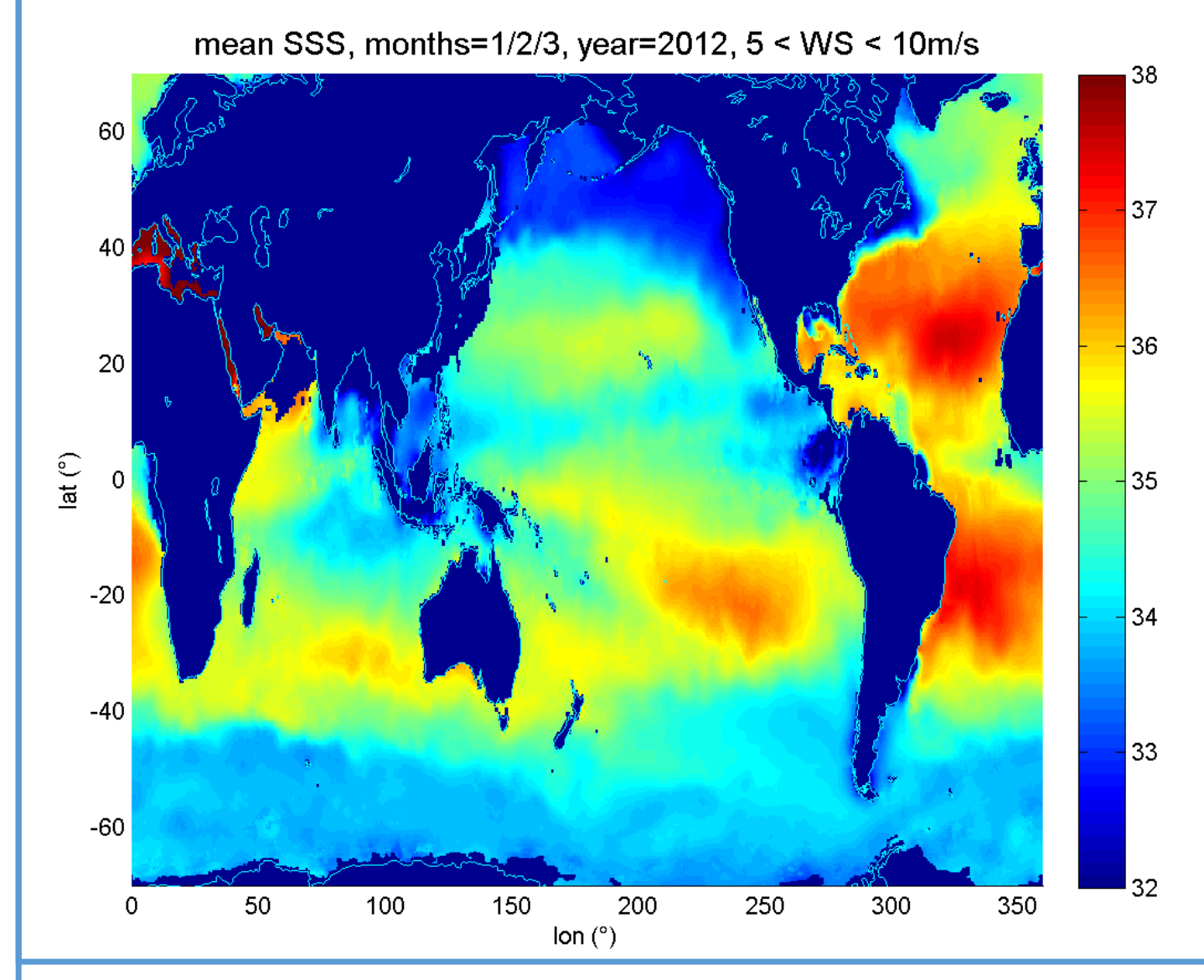
3. DATA AND METHOD

Compare SMOS Acard with Acard computed using KS, MW, and LZ ε models and with following SSS and SST fields:

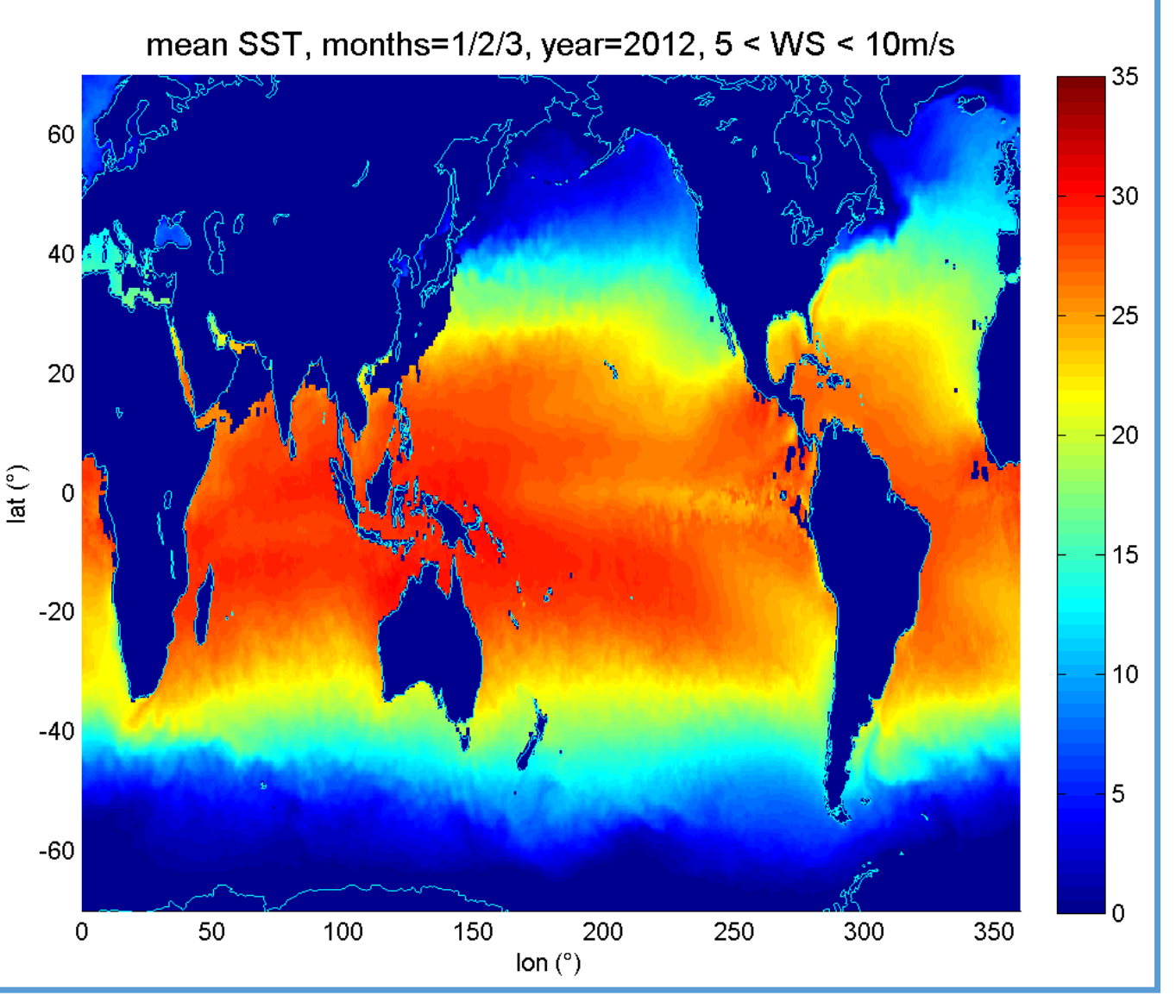
SMOS ACARD from ESA L2OS v662 - January, February, March 2012, ascending orbits (low galactic noise, low Faraday rotation, austral summer (minimum contamination of ice edge in the Southern Ocean)).



SSS: Argo OI (ISAS) (Gaillard et al. 2016)



SST: from SMOS-ECMWF (=OSTIA)

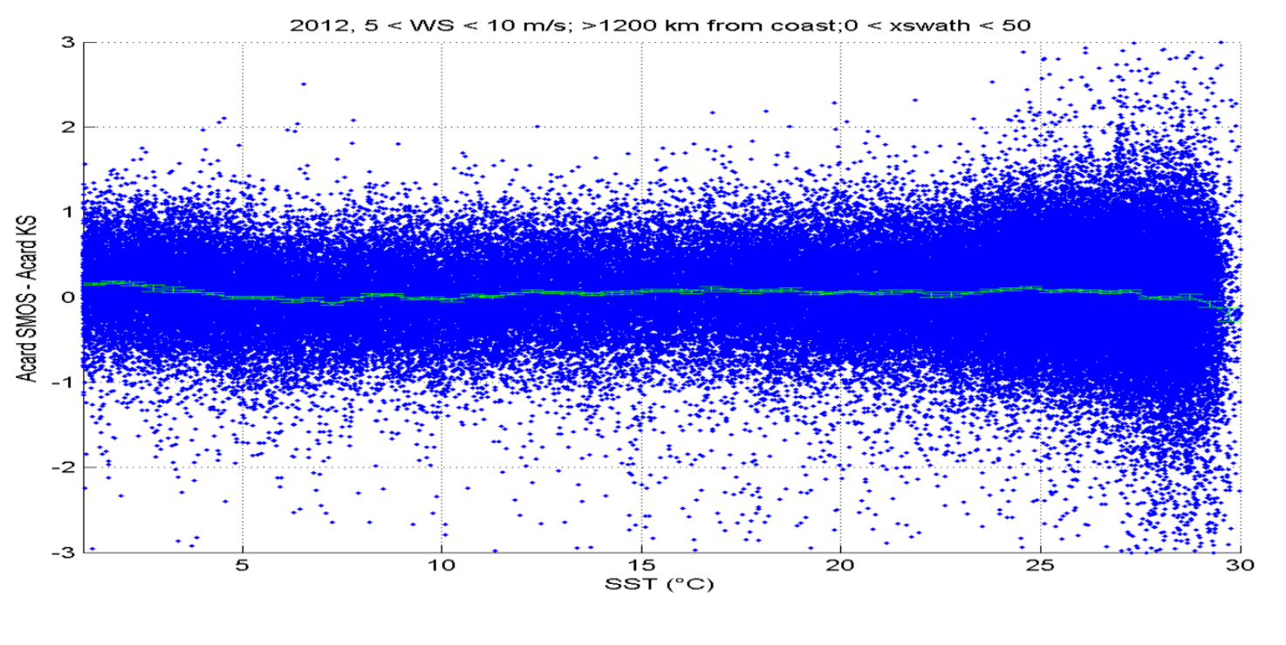


•Studied region: Southern Ocean at further than 1200km away from coasts. In order to get rid of systematic errors due to latitude dependent thermal effects on SMOS measurements, analysis is carried out over narrow latitudinal ranges (white lines) in the Southern Ocean taking advantage of large SST variations across oceanic fronts.

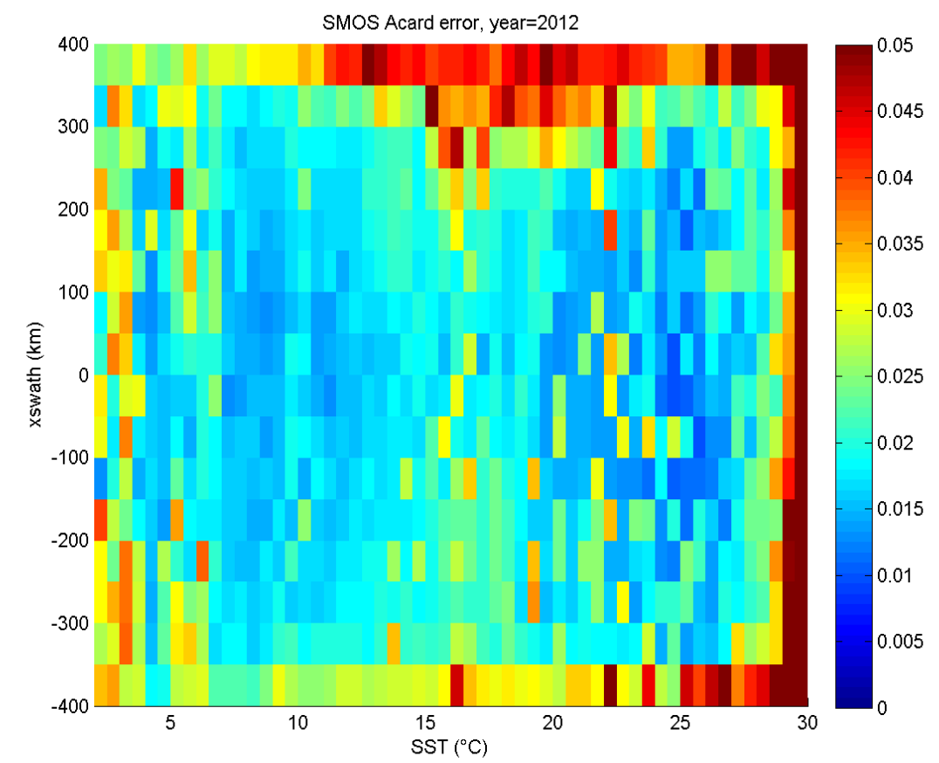
• Correct for across track ("xswath") signatures: 8 xswaths abscissas between -400 and 400 km corrected for mean difference with respect to central xswath.

• Distinct wind speed (WS) : [3m/s 5m/s], [5m/s 8m/s],[8m/s 10m/s] and [10m/s 15m/s]

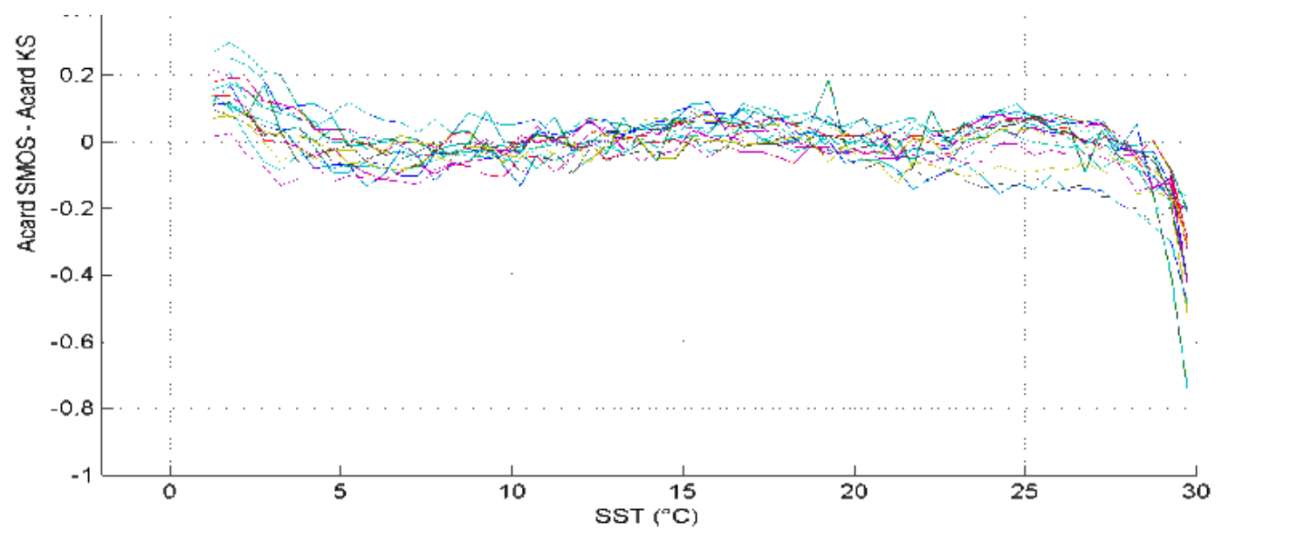
4. RESULTS AT GLOBAL SCALE



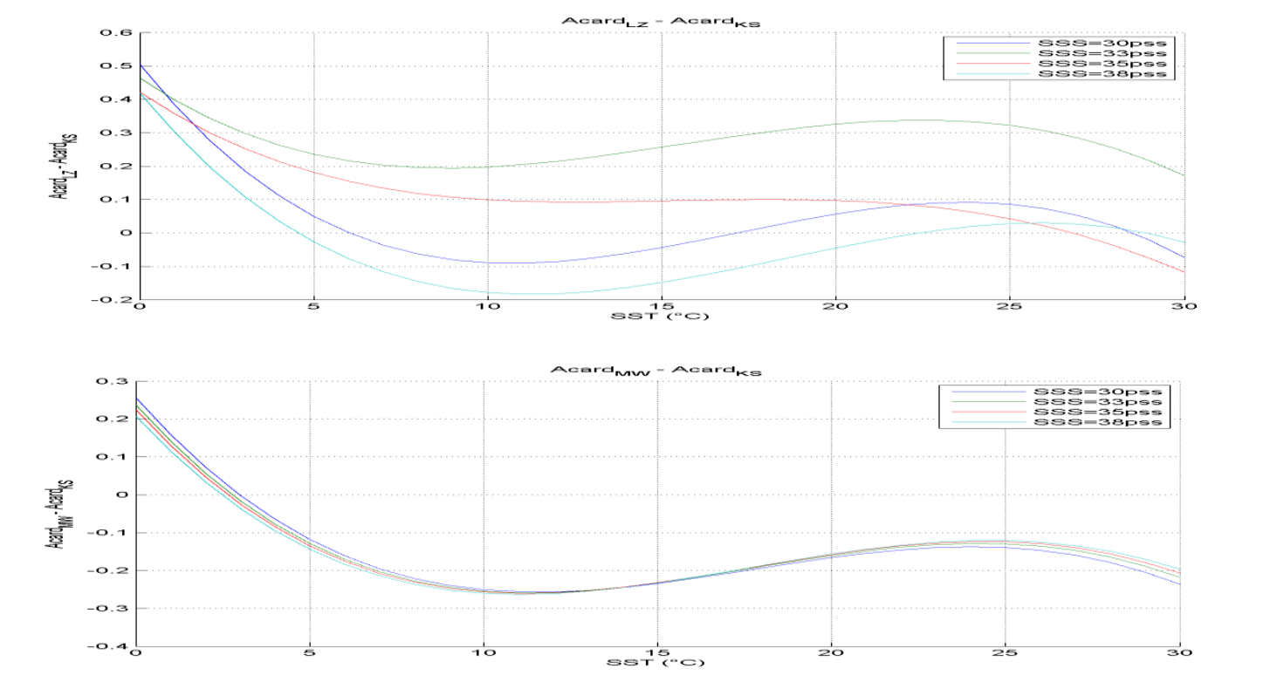
(SMOS Acard - KS Acard) for individual SMOS retrievals (blue dots) at the center of the swath- Binned averaged differences (green) with their (very small) associated error (std/ √N) - Jan-March 2012



Uncertainties on SMOS Acar averaged per SST classes (std/ √N) as a function of swath abscissa- Jan-March 2012



3-month means of (SMOS Acard - KS Acard) differences for each swath abscissa, and averaged per 0.5°C SST bins (uncertainties are shown on the figure on the left) - Jan-March 2012

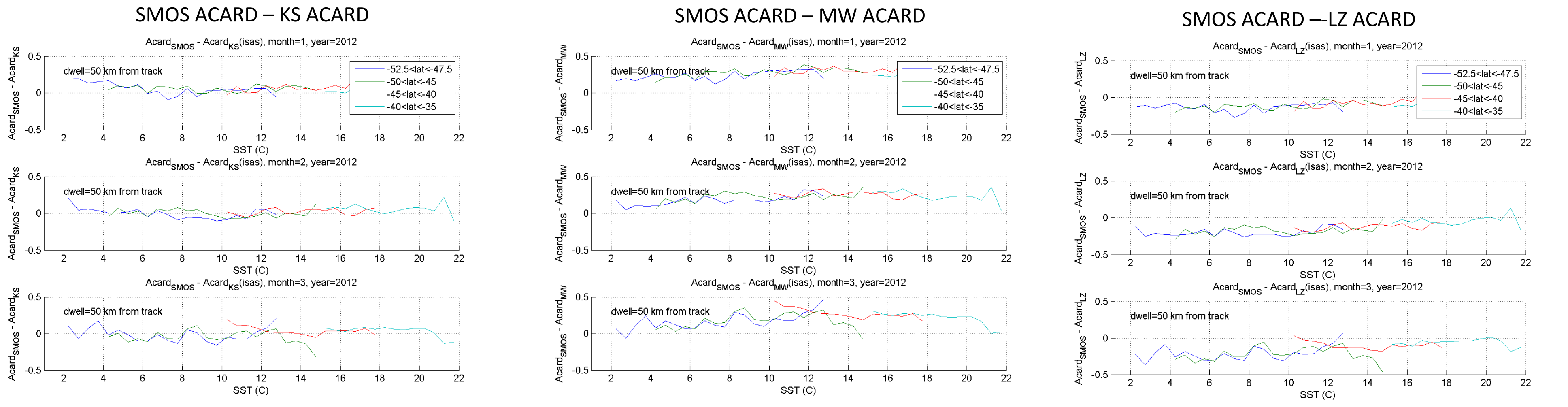


Differences in Acard between LZ and KS parametrisations (top) and between MW and KS models (bottom). The observed SMOS Acard-KS Acard (Figure above) in cold waters is close to LZ-KS Acard differences at SSS~33 pss .

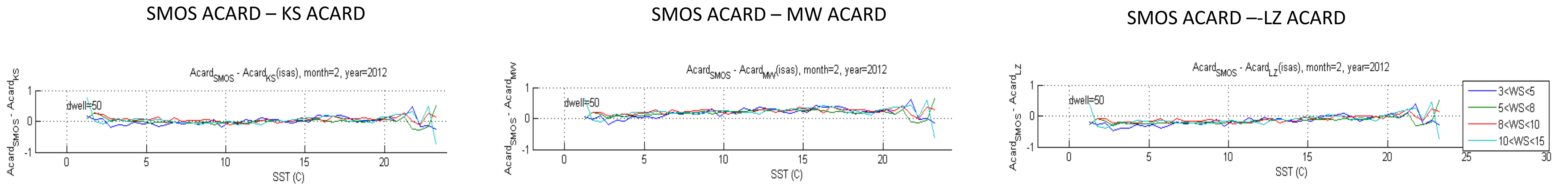
The (SMOS Acard – KS Acard) plot suggests that Acard is underestimated by the KS model in cold regions and overestimated in very warm regions, with orders of magnitude consistent with LZ-KS Acard differences. Noisy differences in warm regions are possibly due to large variations of SSS at a given SST. In the following we focus on cold regions characterized by SSS close to 33 pss.

5. RESULTS IN THE SOUTHERN OCEAN

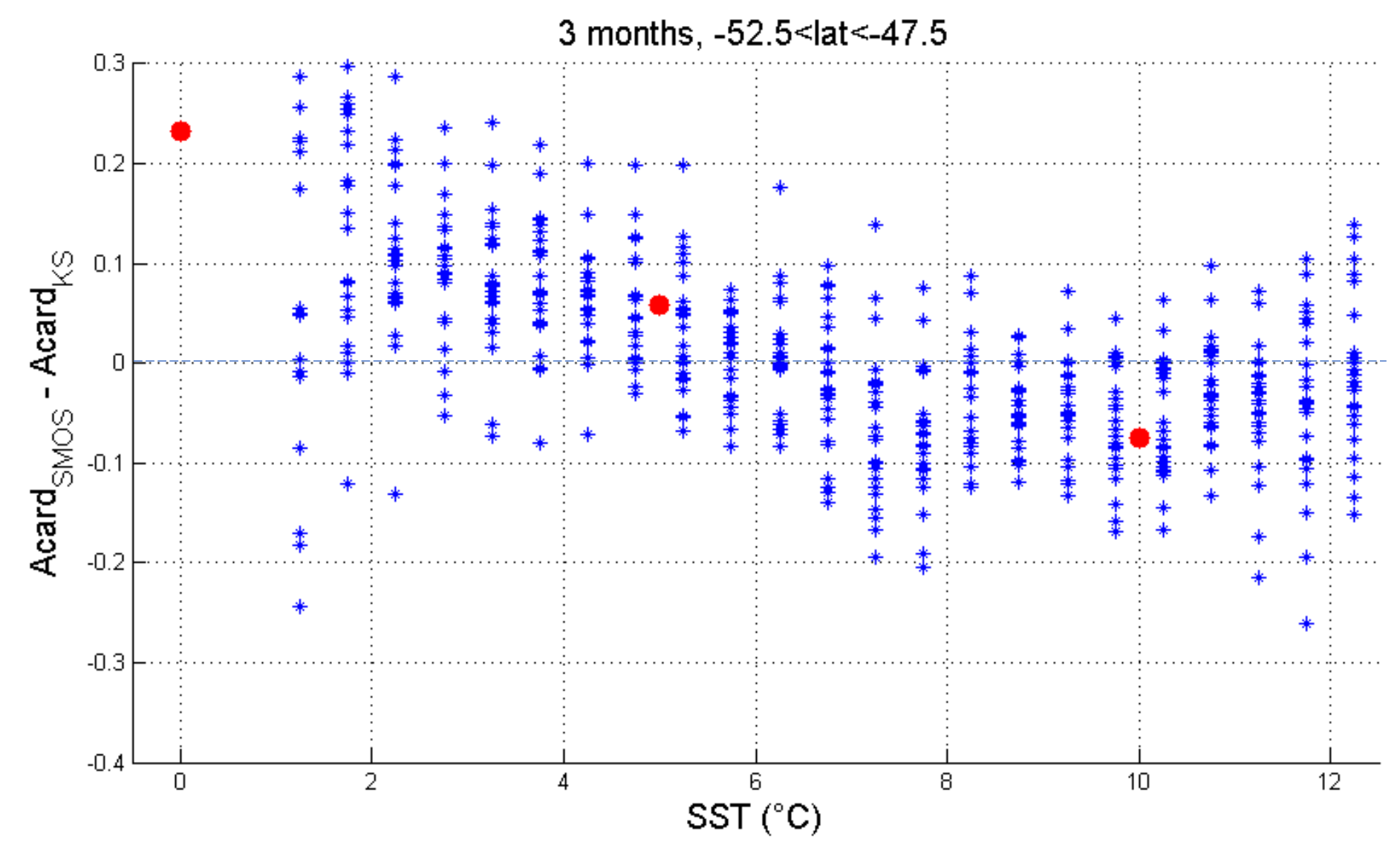
Acard mean differences, in latitudinal slices, are stable from one month to the other

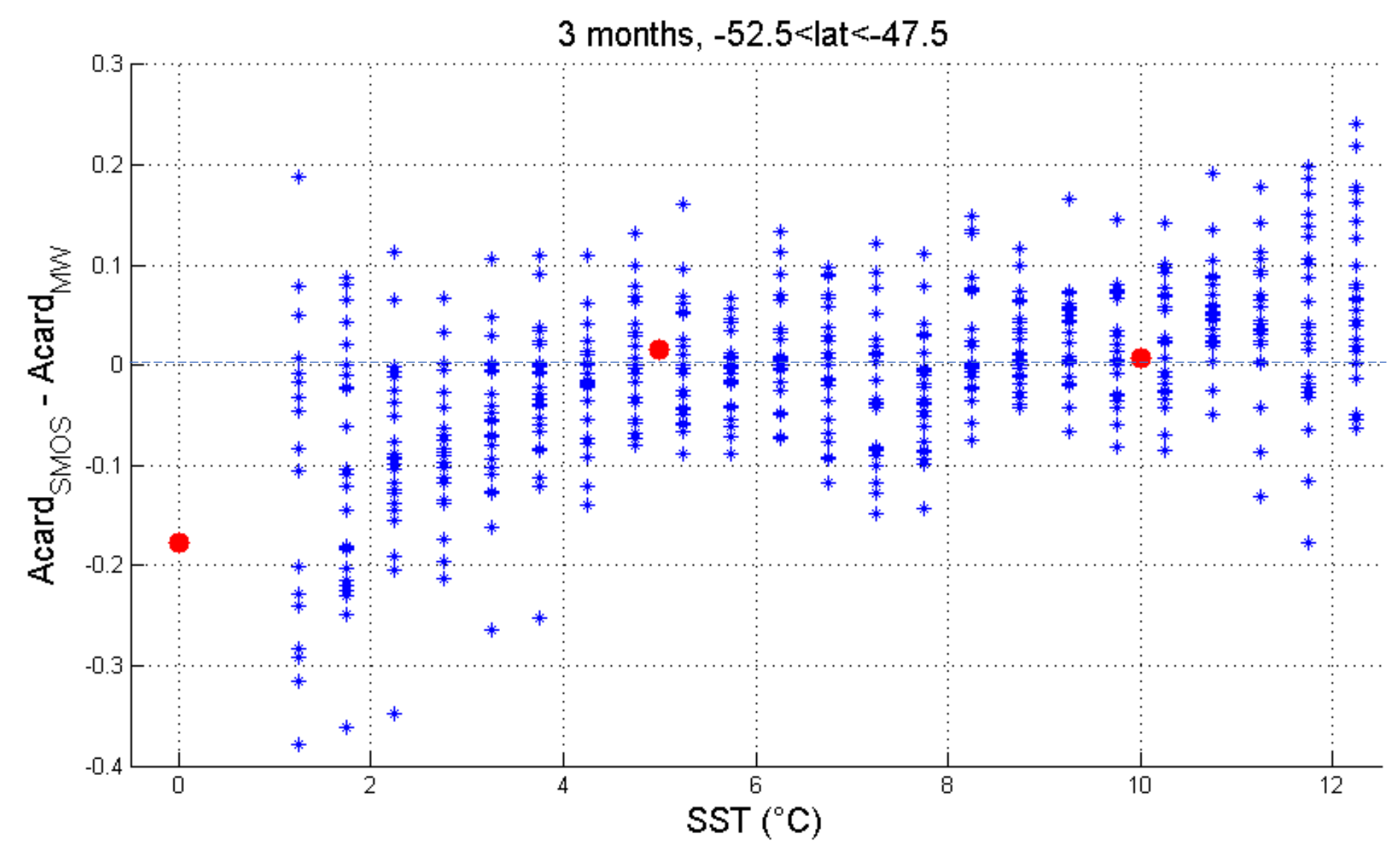


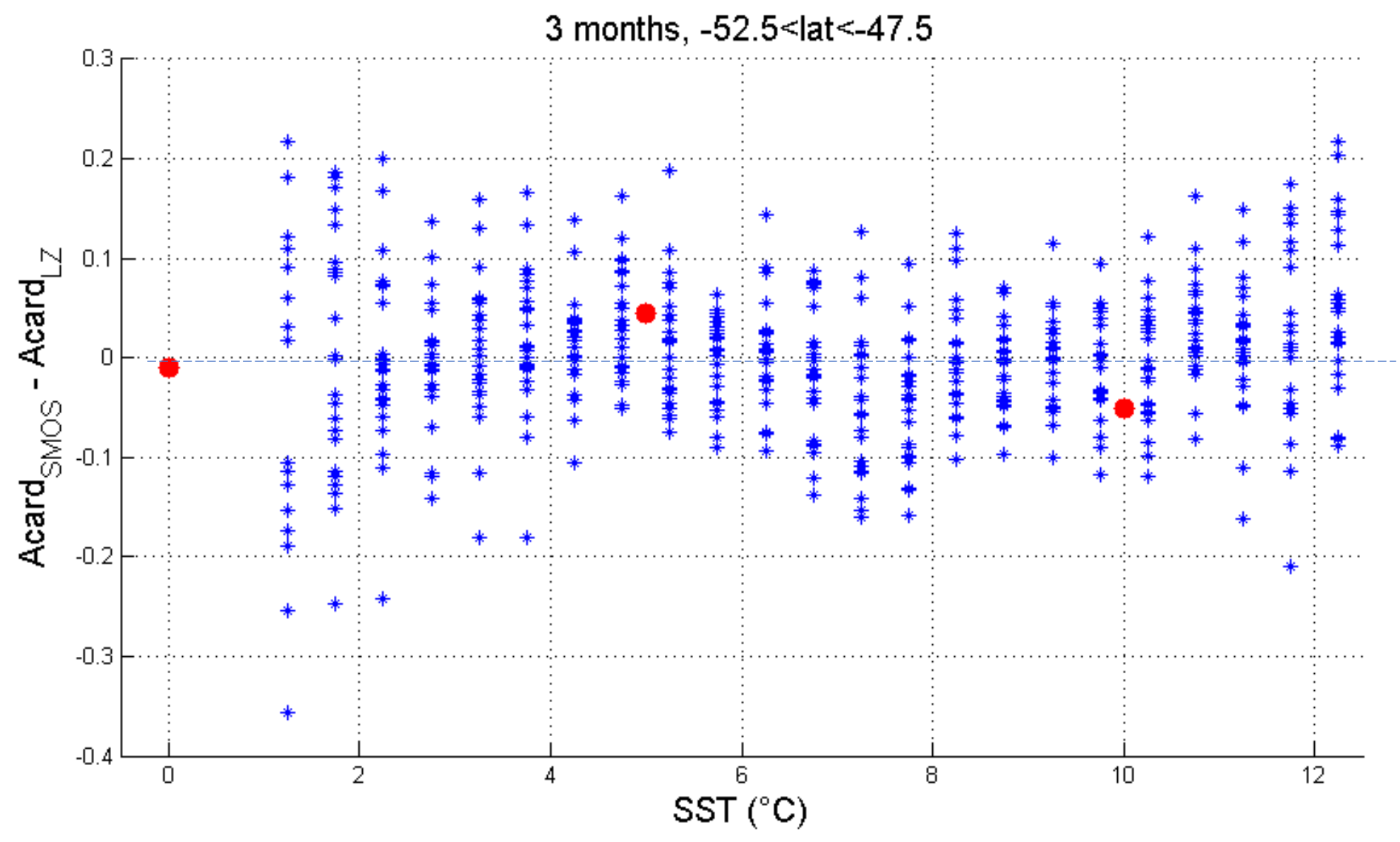
Acard mean differences do not depend on surface roughness correction (wind speed)



Acard mean differences for every swath abscissa exhibit very similar behavior with respect to the SST. Final results are obtained from 5<WS<10 m/s, 52°<lat<47°, 8 xswaths over 3 months and after correcting across-swath systematic error:







SMOS ACARD minus ACARD computed with (top left) KS, (top right) MW, (bottom left) LZ models. For each SST range, the 24 blue points correspond to 8 distances to the center of the swath and 3 months (NB: . Red points indicate Lang et al. measurements at 33pss. Southern Ocean between 52.5S and 47.5S

For SST <5°C, the recent LZ formulation agrees with Acard data, while underestimates (overestimates) are observed for KS (MW) models.
Future studies should focus on the low anomalies at 7.5°C and at warm SSTs.

REFERENCES

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