Inter-Comparison of Aquarius and SMOS Brightness Temperature Observations

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Overview

- Introduction
- Objectives
- Methodology
- Comparison results for areas with concurrent Aquarius and SMOS observations
- Vicarious targets

Introduction

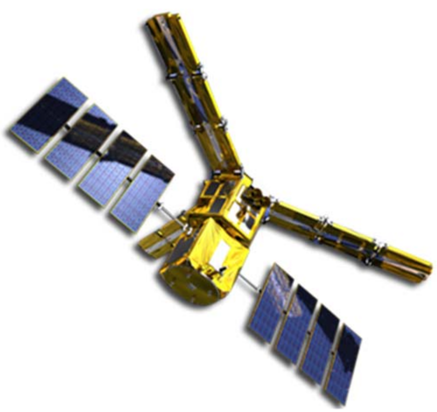
- Verifying the calibration of the Aquarius data over the entire dynamic range is necessary.
- Land brightness temperatures over land fall in a completely different range of response and it is prudent to verify that the primary calibration extends to these levels.
- It is a challenge to validate TB over land using models because there are more factors that contribute to TB and the footprints are more heterogeneous than the oceans.

Approach

- Use SMOS as a tool in assessing the calibration of the Aquarius radiometer over land
- On orbit inter-comparison of two L-band radiometers
- Need for consistent observations:
  - Aquarius and SMOS provide an opportunity to check each others calibration
  - Critical to develop a long-term climatic data record of L-band brightness temperature observations
  - A physical algorithm for development of a long term environmental data record that spans multiple L-band missions requires consistent input observations

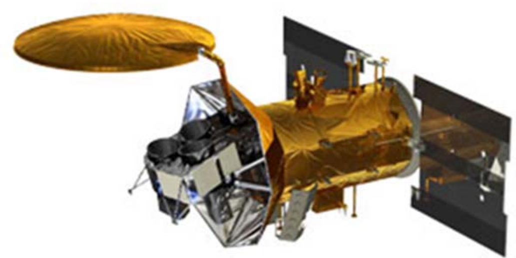
SMOS

- Launched Nov 2009
- 2D-synthetic aperture
  - ✓ Multiple incidence angles at every location [0-65]
- Sun Synchronous orbit with an ascending orbit of 6:00 AM
- Spatial resolution 40 km
- Swath – 1400 km
- 3 day global coverage



Aquarius

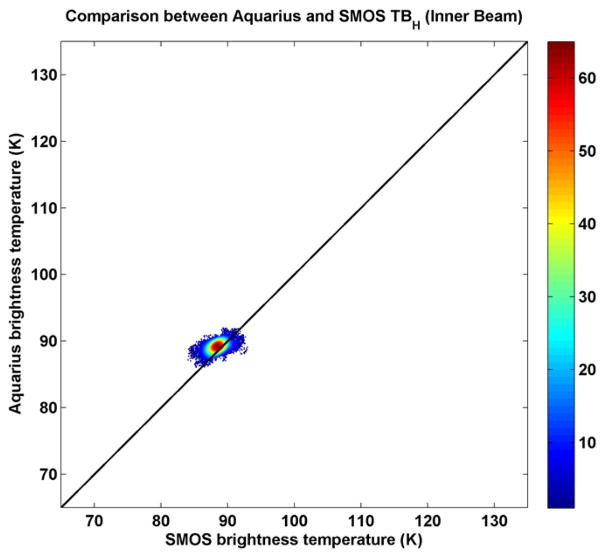
- Launched June 2011
- Real aperture
  - ✓ Three incidence angles of 29.36, 38.49, 46.29
- Sun Synchronous orbit with an descending orbit of 6:00 AM
- Spatial resolution 100 km
- Swath – 350 km
- 7 day global coverage

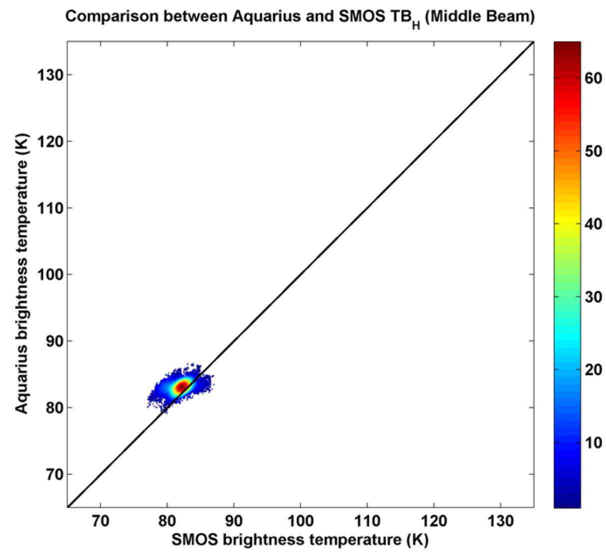


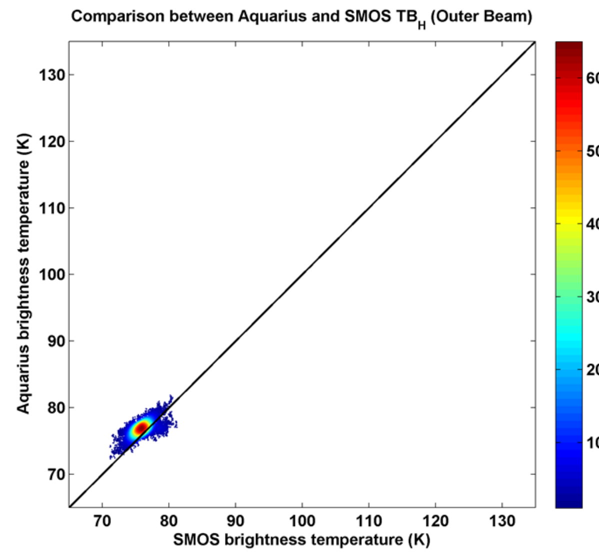
Methodology

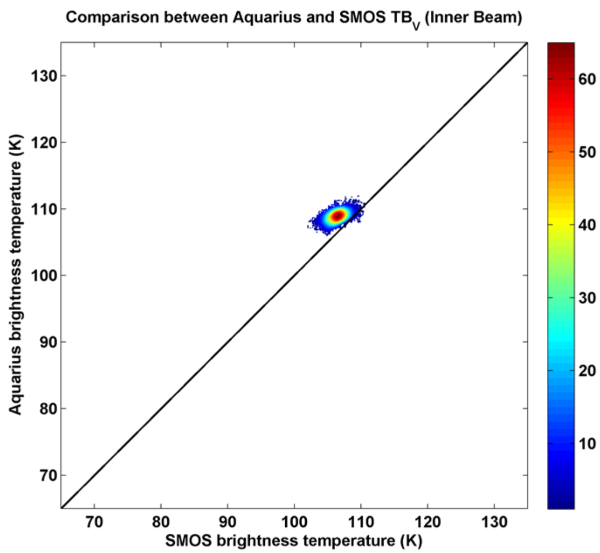
- Approach: Use SMOS as a tool in assessing the calibration of the Aquarius radiometer over land (under the assumption that SMOS is a well calibrated L-band radiometer)
- Concurrent observations in both time (within 30 min → eliminates effect of change in physical temperature) and space (same location)
- Aquarius and SMOS inter-comparison notes
  - Aquarius evaluation Version 2.0
  - Period of record : August 25, 2011 – December 31, 2012
  - Land and ocean
  - Concurrent SMOS and Aquarius observations within 30 min
  - Same incidence angle (after re-processing SMOS data)
  - Only alias free portions of SMOS observations
  - Multiple SMOS DGG locations within a single Aquarius footprint
  - Min number of SMOS observations per Aquarius footprint required– 20 (to minimize partial Aquarius footprint coverage)
  - Std. Dev. of SMOS data averaged < 5 K (land) and 1 K (ocean) (to minimize footprint variability; also results in screening RFI)
  - Differences in azimuth angle and orientation of the footprints ignored

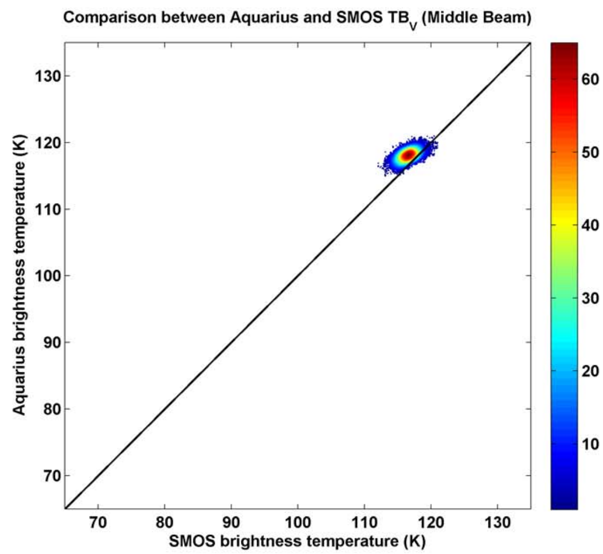
Comparison between Aquarius and SMOS (ocean)

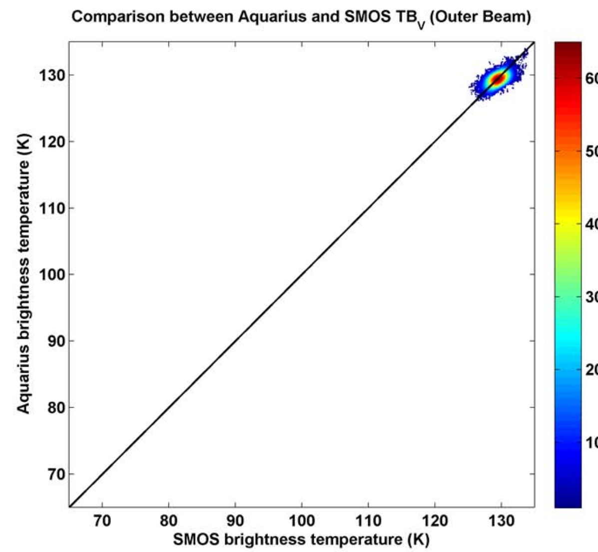










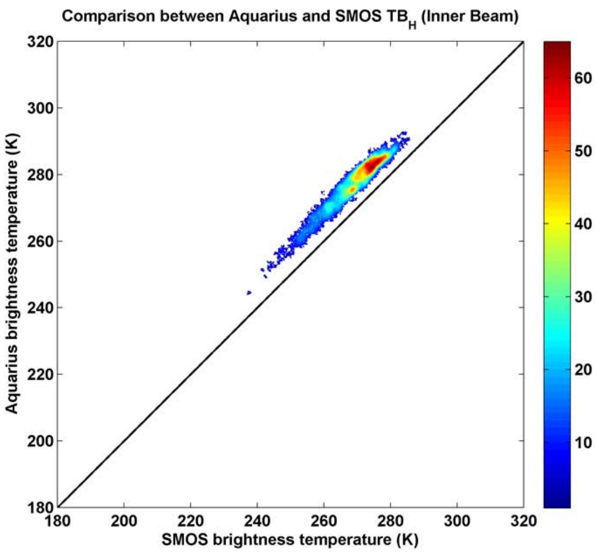


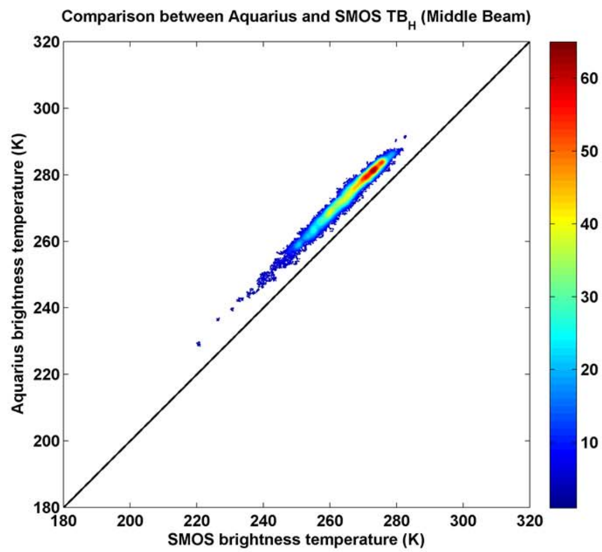
Comparison between Aquarius and SMOS over Ocean

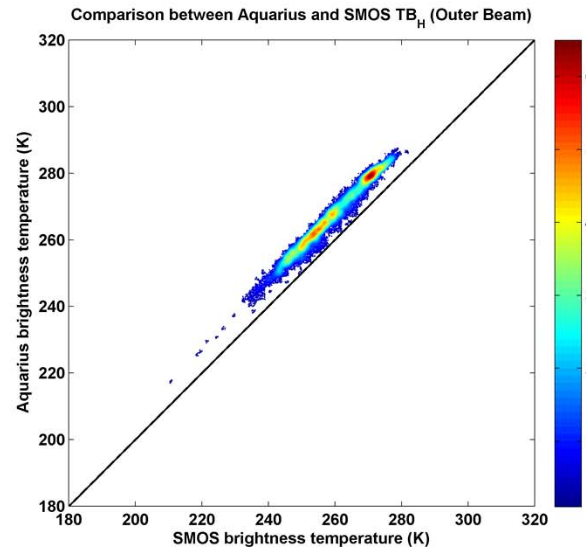
Summary Statistics

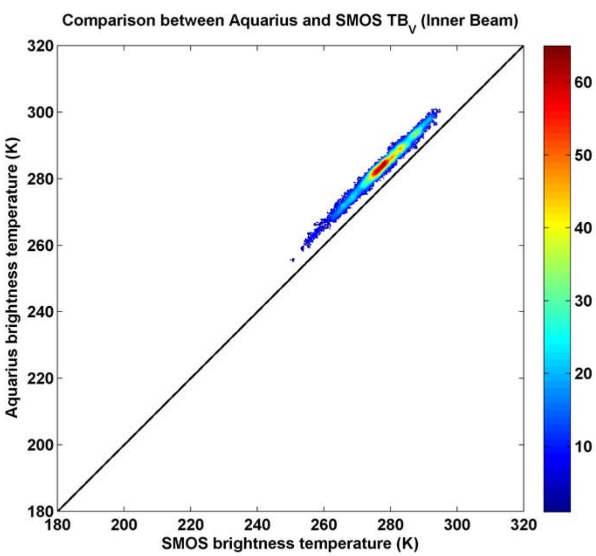
		RMSD (K)	Bias [Aq-SMOS] (K)
H pol	Inner (29.36°)	1.29	0.76
	Middle (38.49°)	1.77	1.20
	Outer (46.29°)	1.35	0.98
V pol	Inner (29.36°)	2.71	2.50
	Middle (38.49°)	1.82	1.53
	Outer (46.29°)	0.90	-0.08

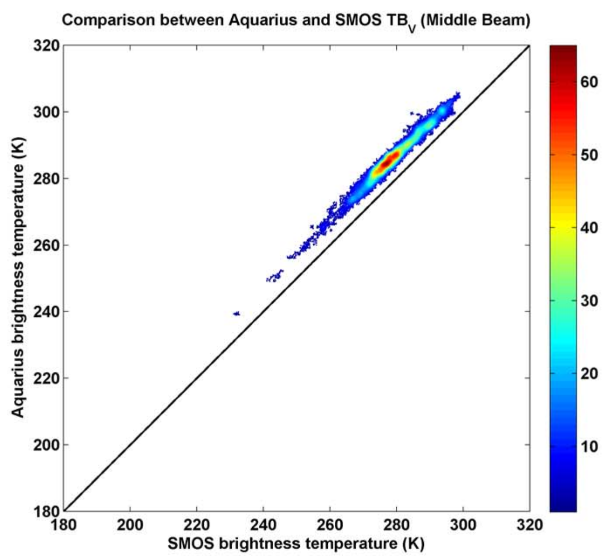
Comparison between Aquarius and SMOS (land)

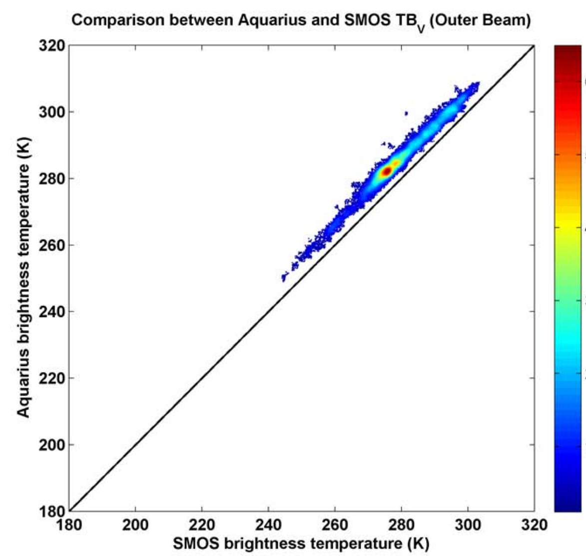












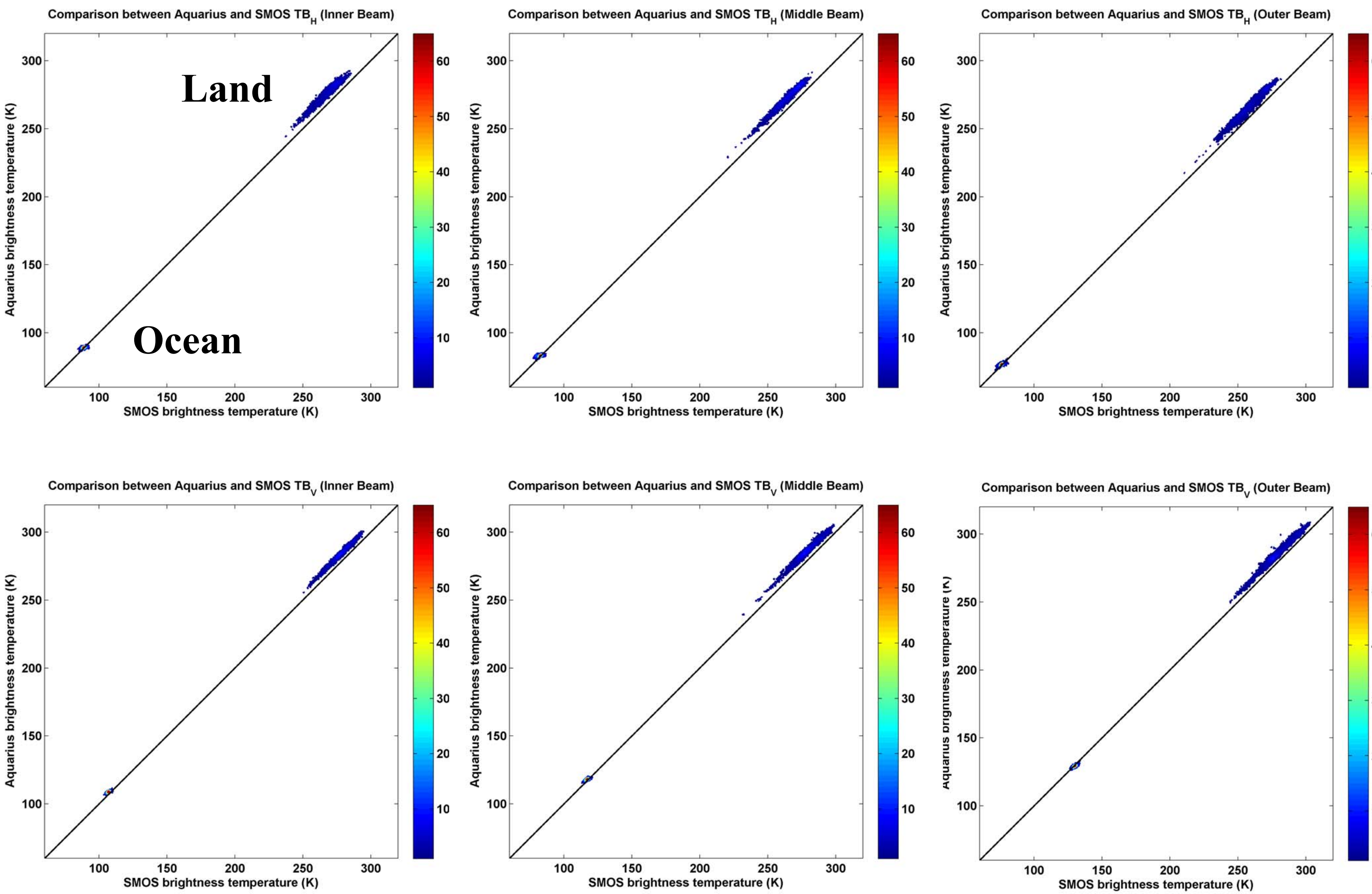
Comparison between Aquarius and SMOS over Land

Summary Statistics

		RMSD (K)	R	Bias [Aq-SMOS] (K)
H pol	Inner (29.36°)	8.60	0.9687	8.34
	Middle (38.49°)	8.49	0.9860	8.35
	Outer (46.29°)	8.12	0.9830	7.88
V pol	Inner (29.36°)	6.27	0.9892	6.15
	Middle (38.49°)	7.37	0.9854	7.20
	Outer (46.29°)	6.53	0.9882	6.29

TB	**ΔTB**
240-280 K	8 K (H)
260-300 K	6-7 K (V)

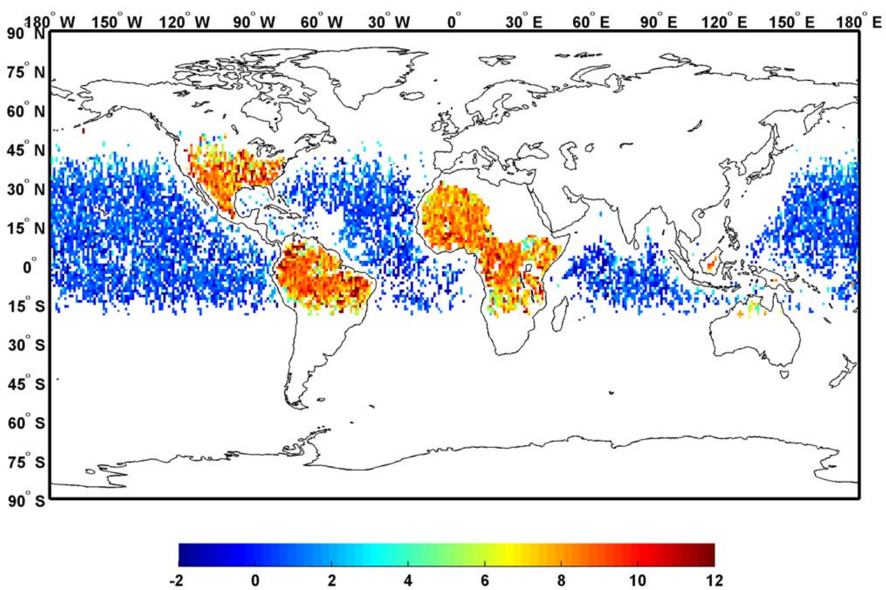
Comparison between Aquarius and SMOS



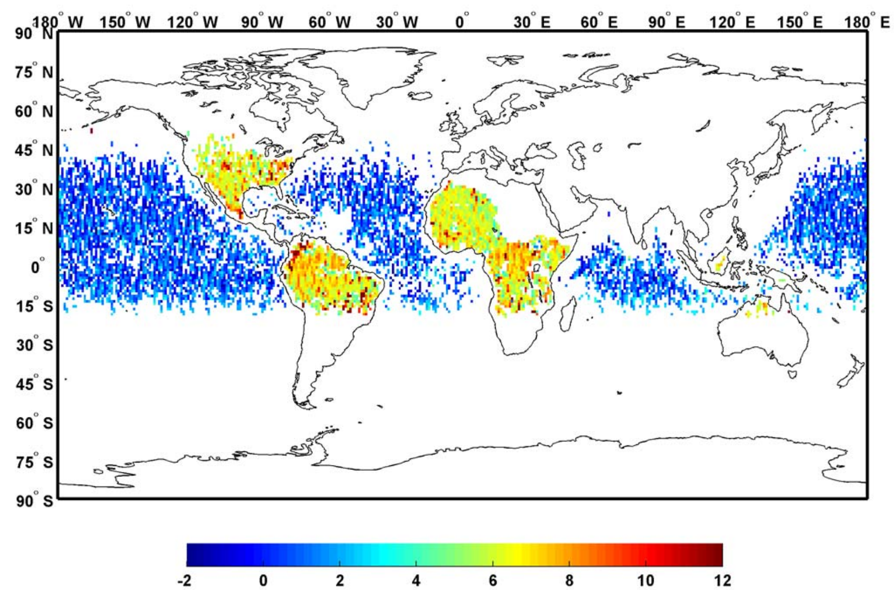
Comparison between Aquarius and SMOS

- Scatter possibly due to:
  - RFI (possible RFI in SMOS/Aquarius)
  - Heterogeneous footprint
  - Different azimuth angles
  - Noise in SMOS and Aquarius data
- Intercomparison results:
  - SMOS and Aquarius compare well over oceans
  - Very high correlation between SMOS and Aquarius observations
  - Systematic difference in gain and offset for all channels
  - H-pol bias greater than V-pol bias for all beams
  - Expecting improvements in future versions

Δ Tb_H between Aquarius and SMOS (All Beams)



Δ Tb_V between Aquarius and SMOS (All Beams)

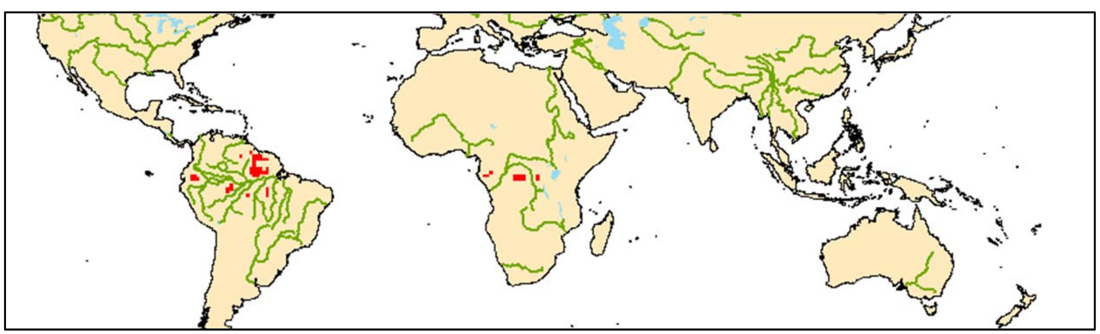


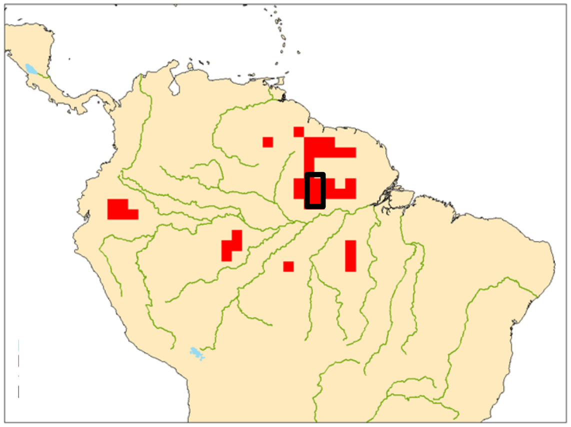
Vicarious Calibration Targets

- Amazon
  - Hot target
- Dome-C
  - Stable cold target in Antarctica
    - ESA has done extensive studies over this location.
    - Multi-year field experiment with a ground based radiometer (RADOMEX)

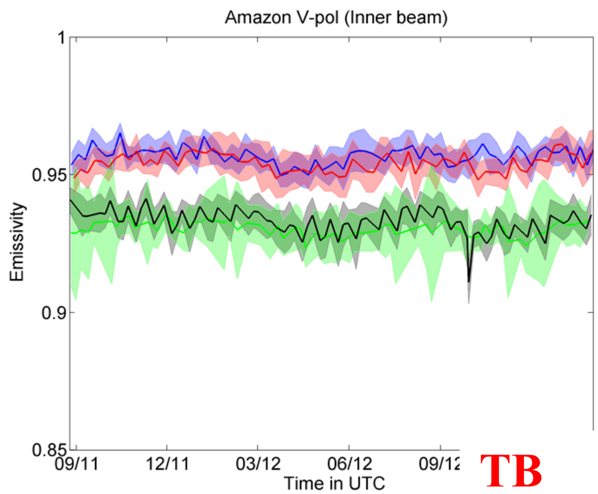
Amazon

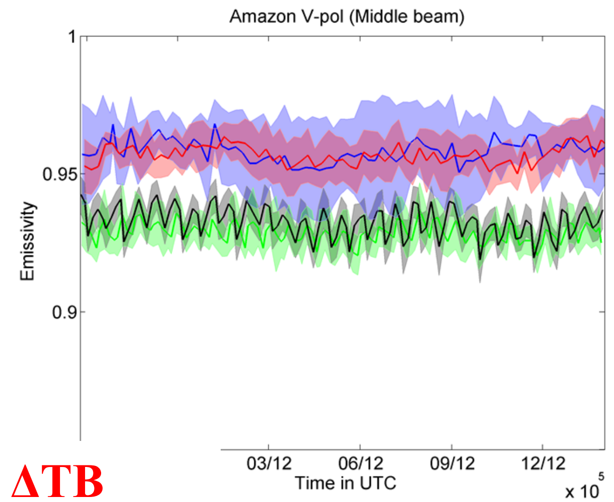
- Max e (emissivity)
- e is independent of incidence angle and polarization (can be investigated using SMOS)
- Low St Dev of e (signal is almost saturated and surface effects are minimal)
- SMOS observations at 10 different incidence angles ranging from 20-50 degrees used to identify candidate areas
- St. Dev. less than 0.02 for all angles
- Difference in mean for all angles and polarizations less than 0.02 [Mean(e_i) - Mean(e_j) <0.02]



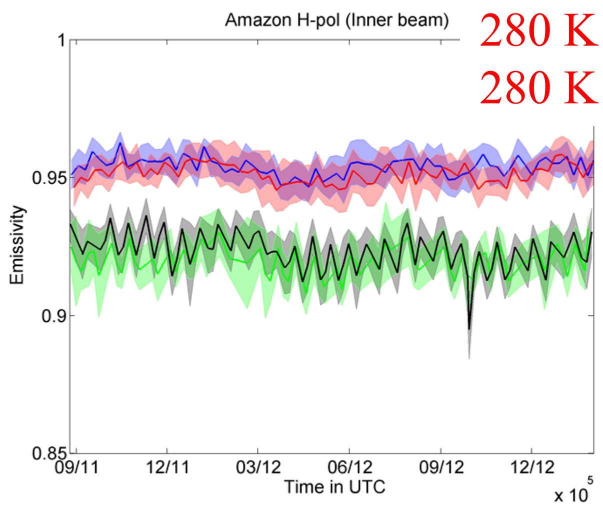


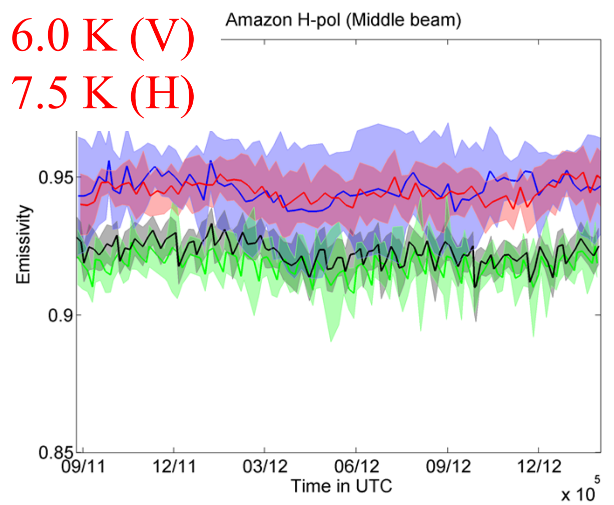
Aquarius (Asc) **Aquarius (Dsc)** **SMOS (Asc)** **SMOS (Dsc)**





TB	Δe	ΔTB
280 K	0.015	6.0 K (V)
280 K	0.025	7.5 K (H)





- Surface temperature effects eliminated by the use of land surface emissivity (NCEP surface temperature)
- Very little difference in Asc and Dsc observations over Amazon
- H and V pol observations are similar
- TB and emissivity does not change with incidence angle for both h- and v-pol
- Variability – Aquarius has higher stability (lower St. Dev.)
- Consistent difference between Aquarius and SMOS observations

Amazon

Vicarious Targets

- Amazon
  - Hot target
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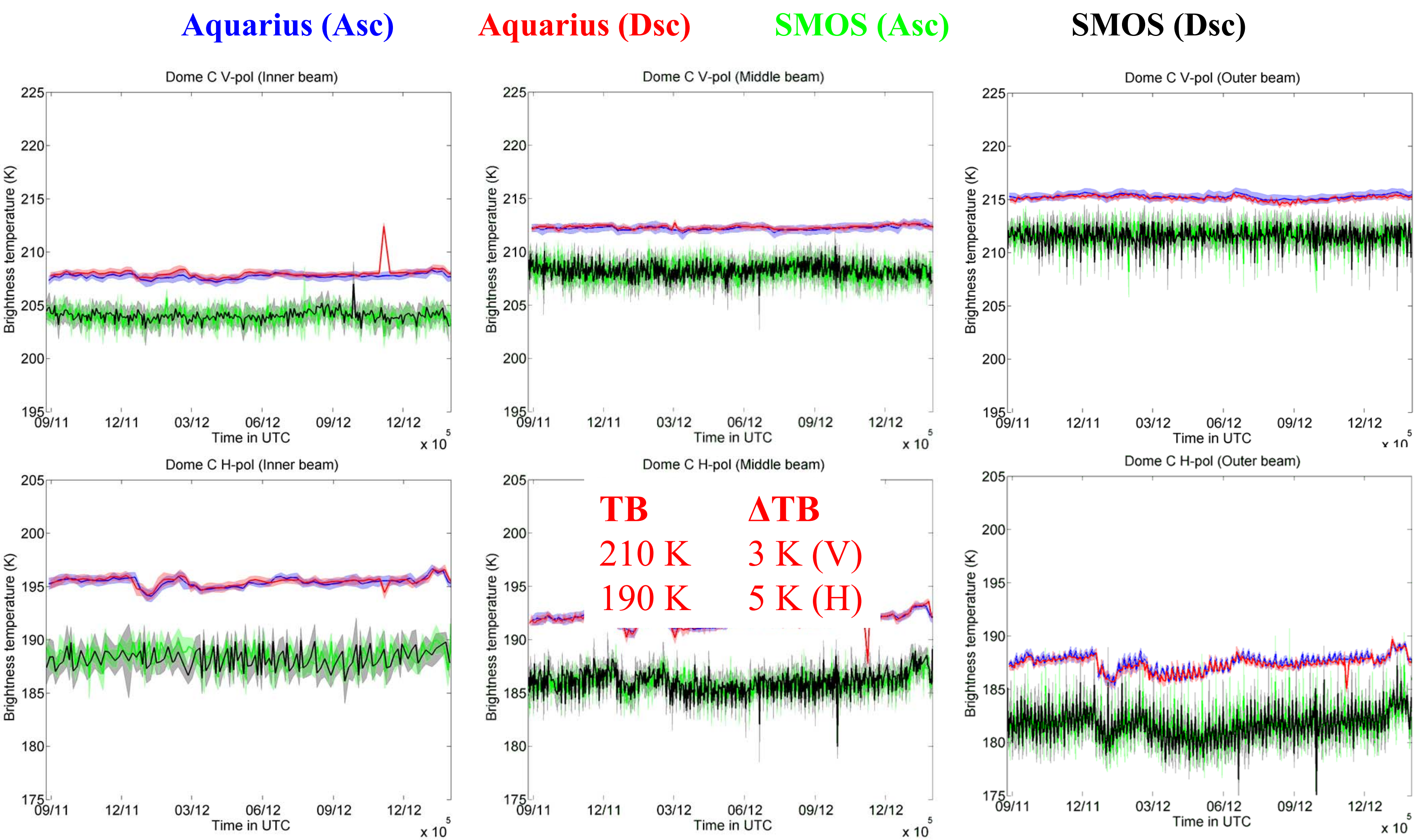

- Very little difference in Asc and Dsc observations over Dome-C
- Variability – Aquarius has higher stability (lower St. Dev.)
- V pol observations higher than h pol for both satellites
- TB increases with incidence angle for v-pol and vice versa for h-pol
- Bias between Aquarius and SMOS observations

Dome-C

Summary

- Scatter due to:
  - RFI (possible RFI in SMOS/Aquarius)
  - Heterogeneous footprint
  - Different azimuth angles
  - Noise in SMOS and Aquarius observations
- Aquarius observations compare well with SMOS observations over oceans (smaller differences of 1-2 K)
- How these TB differences translate to differences in SSS is not clear
- Aquarius observations very stable over Dome-C
- SMOS observations lower than Aquarius observations for all channels over land (6-8 K difference between SMOS and Aquarius)
- Possibly due to Aquarius radiometer calibration (spill-over ratio)
- Anticipated to be fixed in future versions of Aquarius data
- Important to develop a consistent calibration across all L-band mission SMOS, Aquarius and SMAP

Multi-platform Dome-C observations