Ocean Surface Salinity from SMAP: Continuing the Legacy of Aquarius

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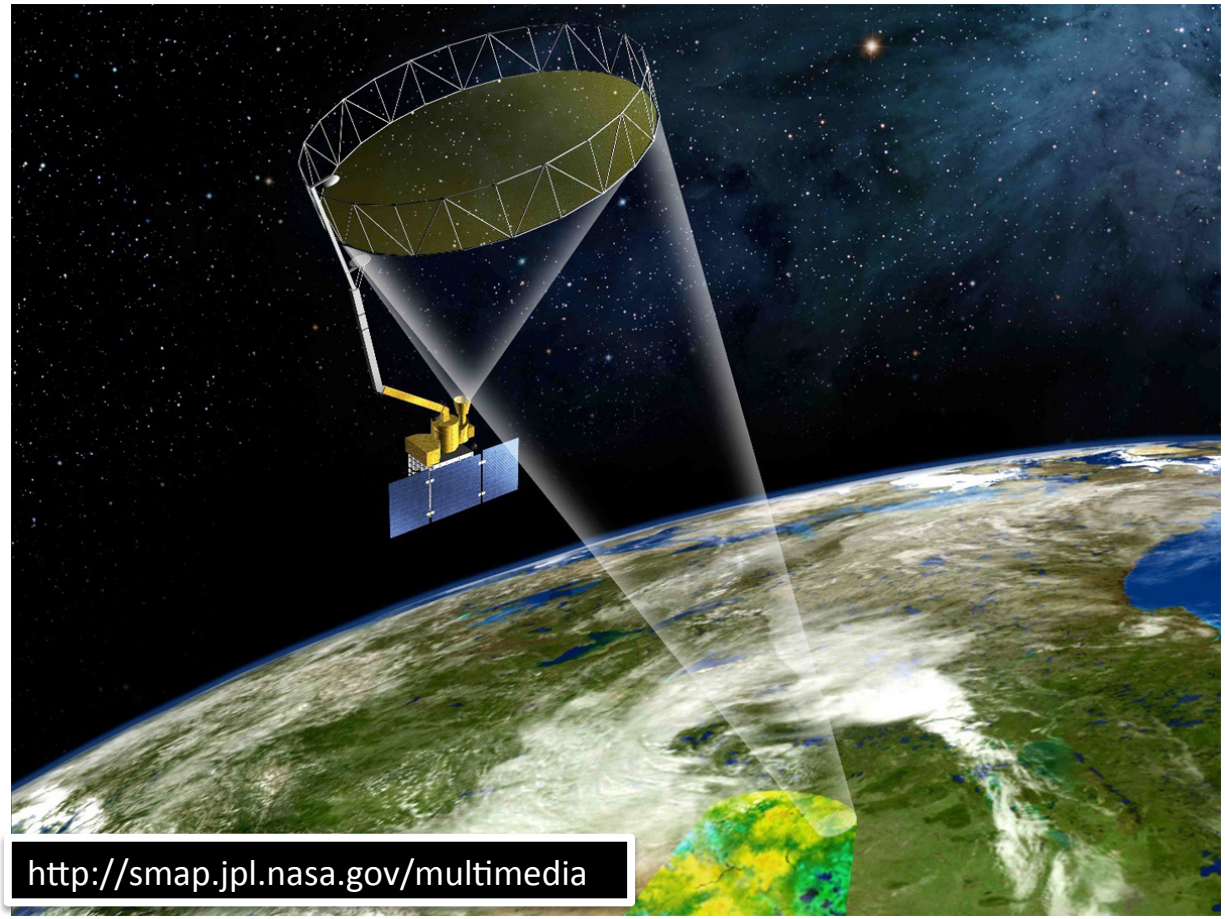
Outline

- Overview of SMAP Instrument
- SMAP Salinity Retrieval Algorithm
- First Light Image of SMAP Salinity
- Problems and Concerns
- Planned Data Release

SMAP

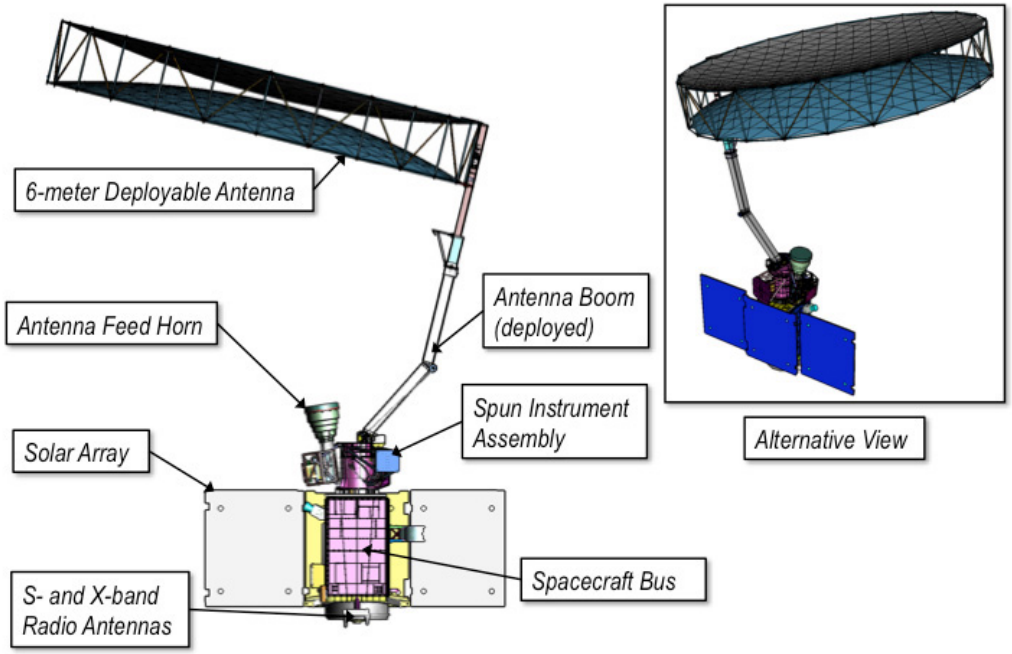
Soil **M**oisture **A**ctive **P**assive



Orbit Altitude: 685 km. Inclination: 98 deg.
Local ascending/descending time: 6 PM/AM.
8-day repeat orbit.

SMAP

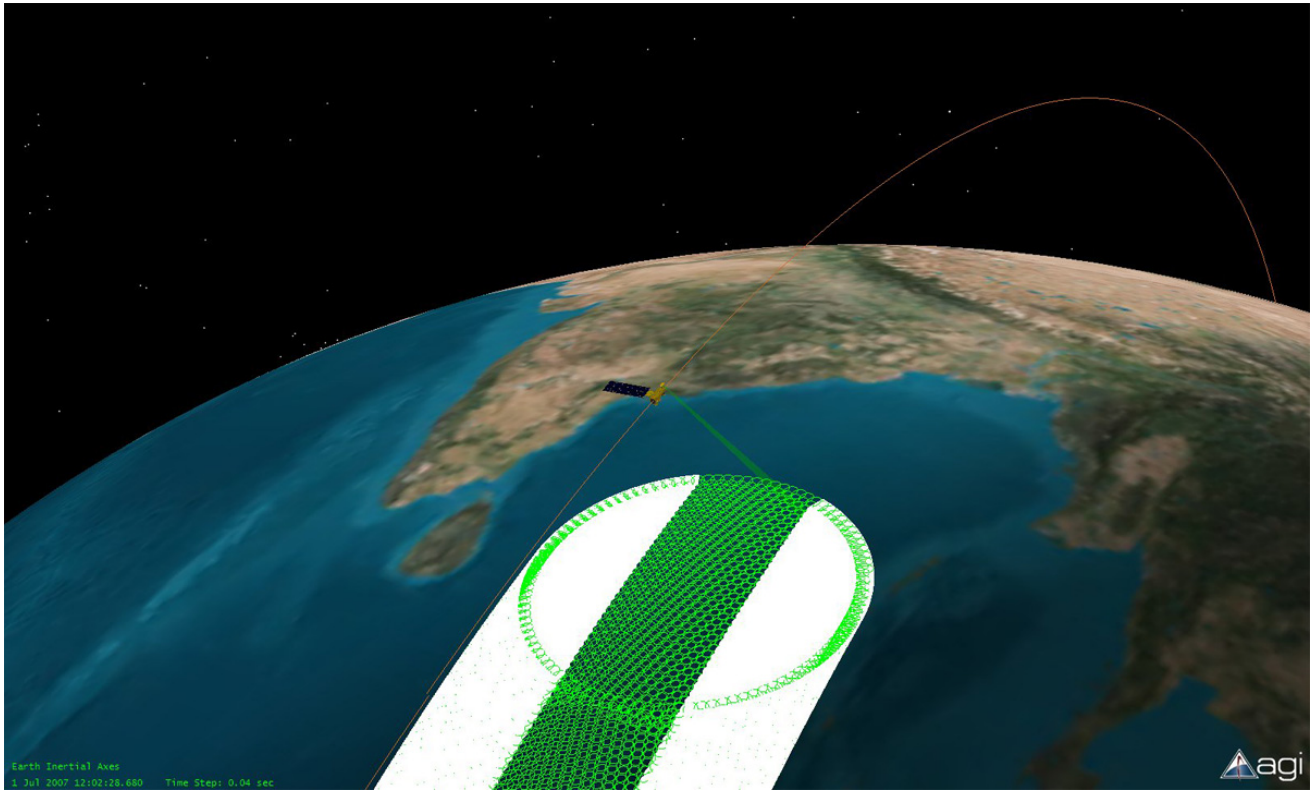
Instrument



6-meter mesh antenna.
Conical scanning @ 14.6 rpm. Scan time: 4.1 sec
Earth Incidence Angle: 40°.
Radiometer: Center frequency: 1.41 GHz ~~+ Radar.~~
Taking observations since April 2015.

SMAP

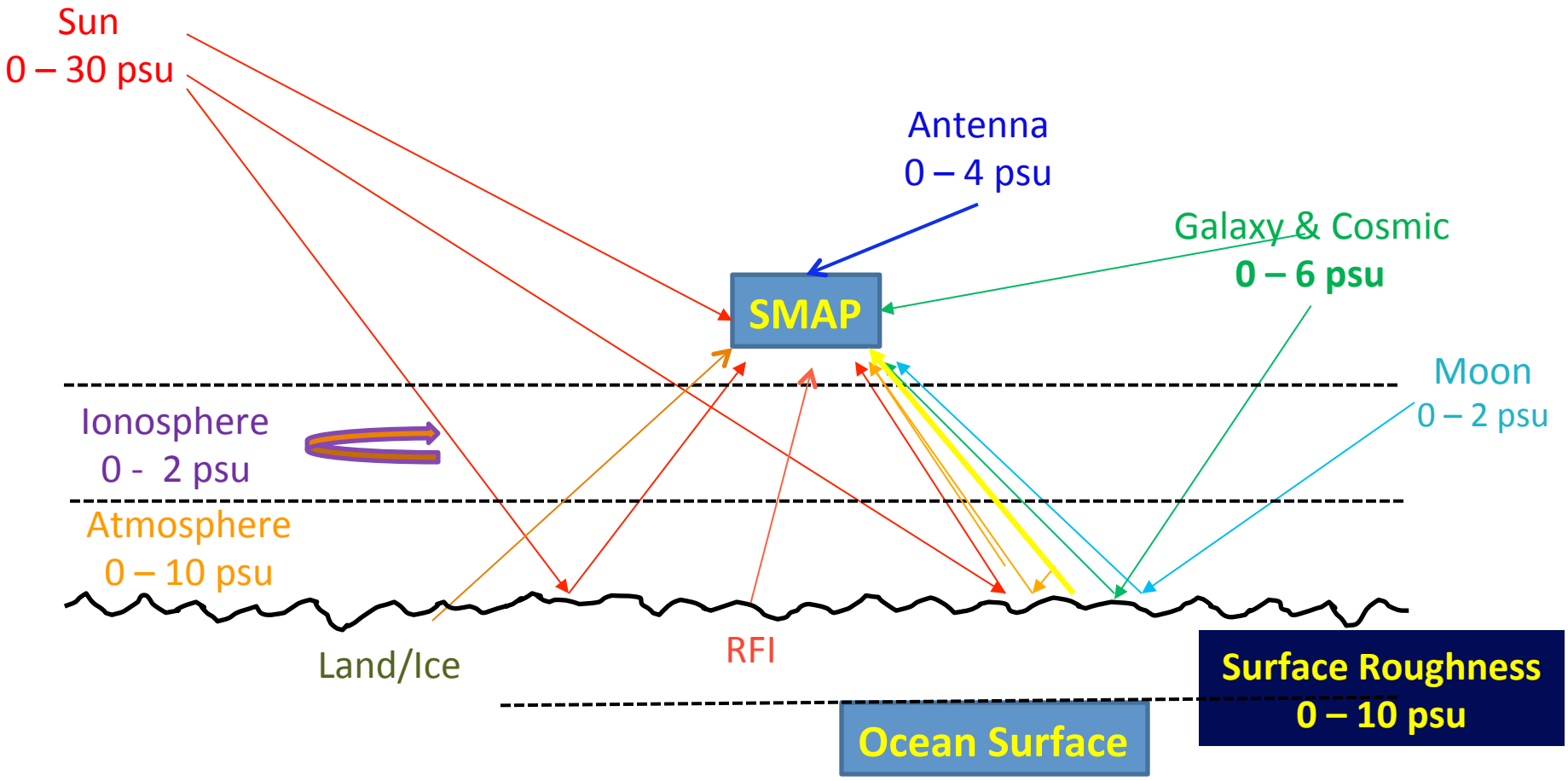
Swath and Footprint



Full 360^{o} scan views the Earth. 1000 km wide swath.
3-dB (half power) footprint size: 40 km.
Time for sampling 1 footprint: 17 msec.

SMAP Salinity Retrieval Algorithm Challenge

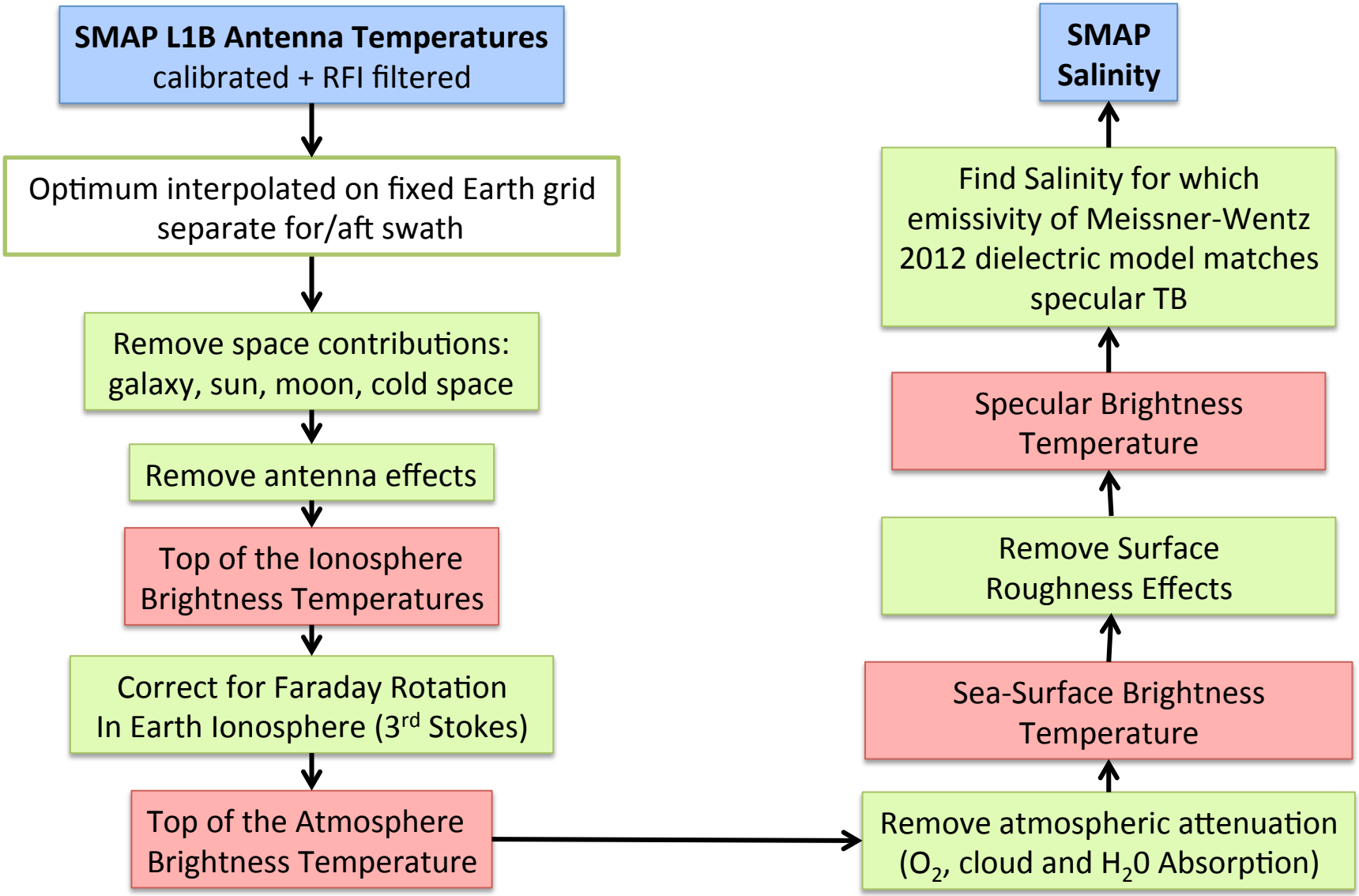
Removal of Many Large Spurious Signals



Needs to be done to 0.2 psu = 0.1 Kelvin accuracy

SMAP Level 2 Salinity Retrieval

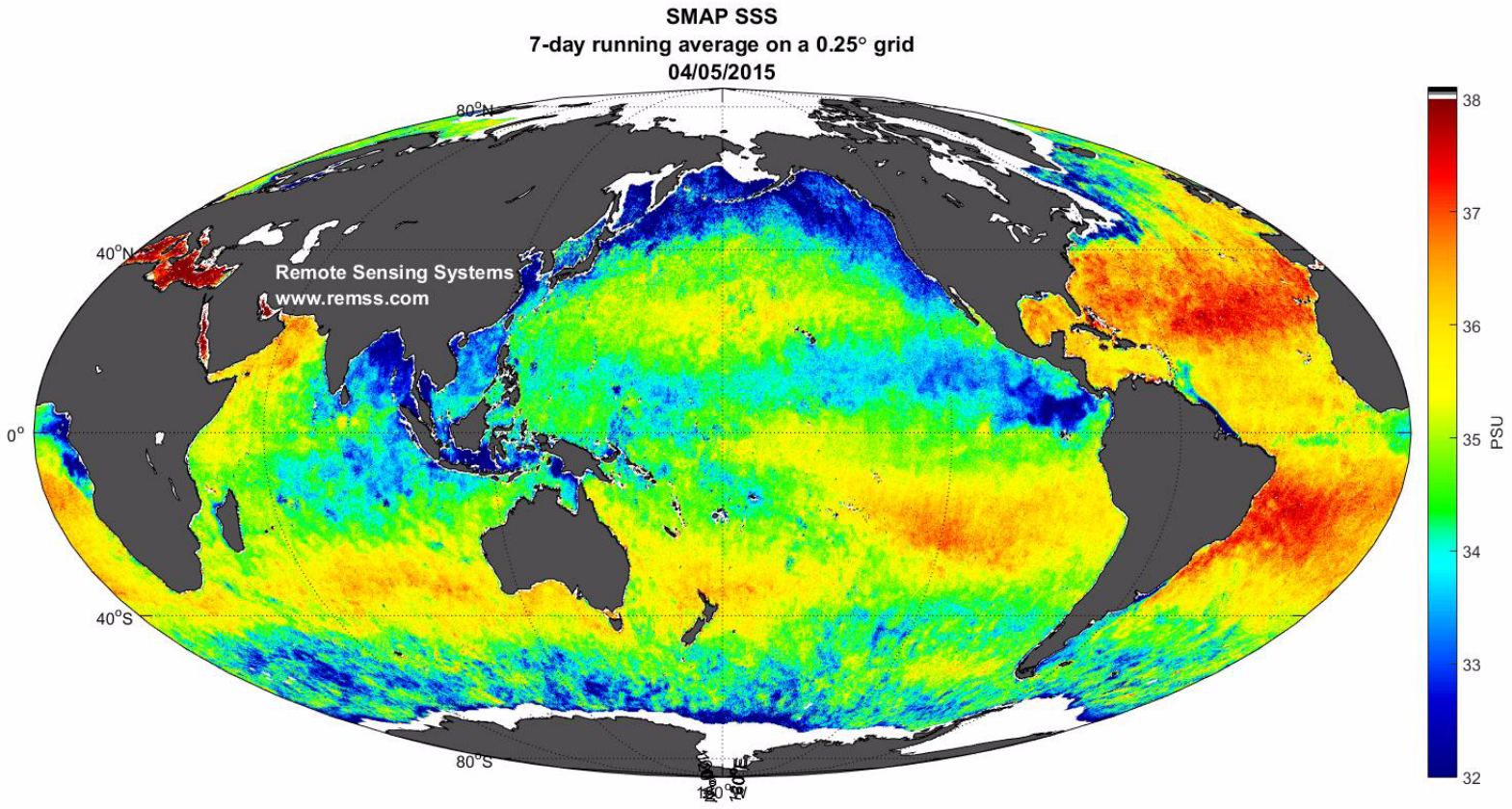
Basic Steps



SMAP Salinity

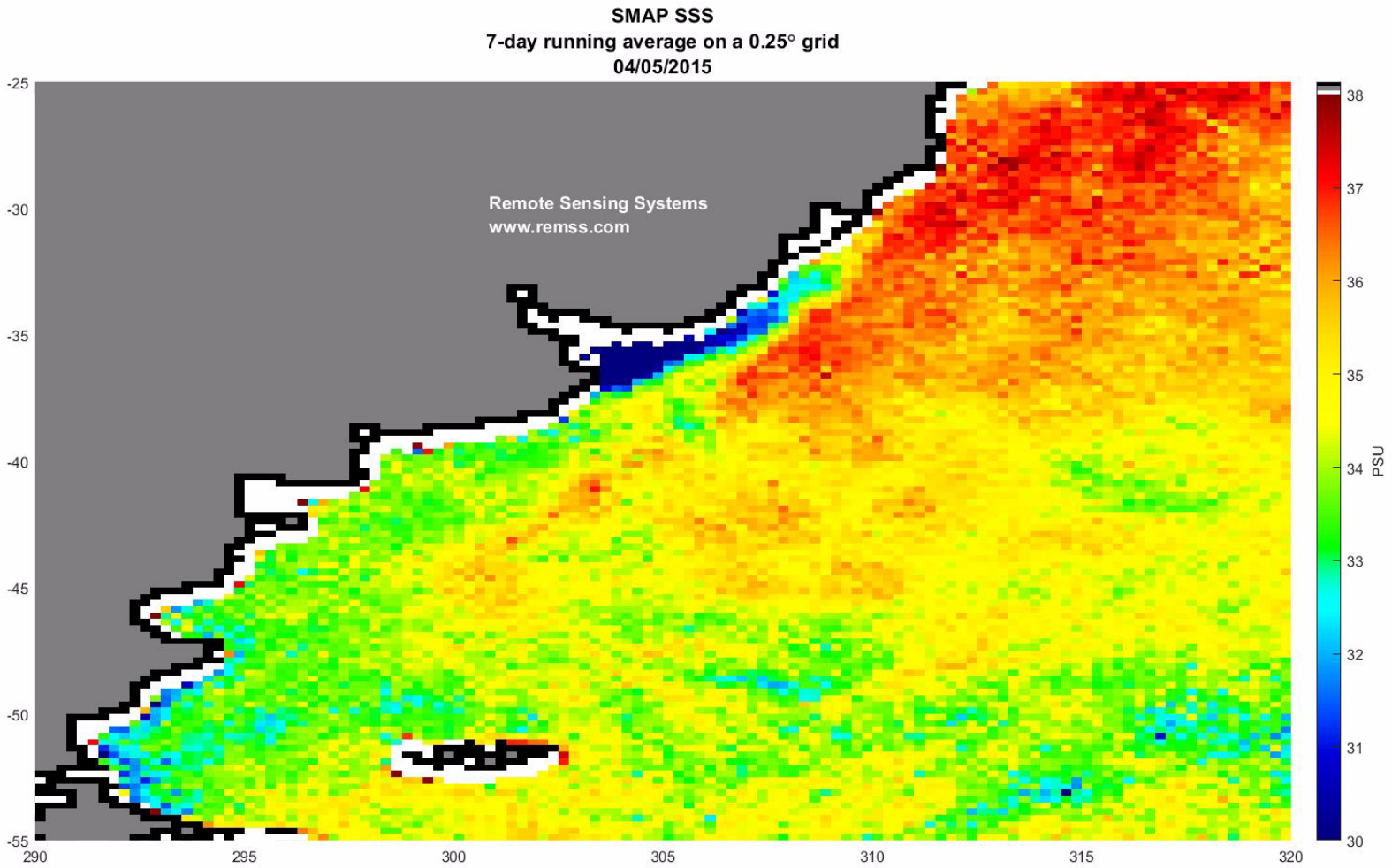
Remote Sensing Systems
www.remss.com

First Light Image: Running 8-day average



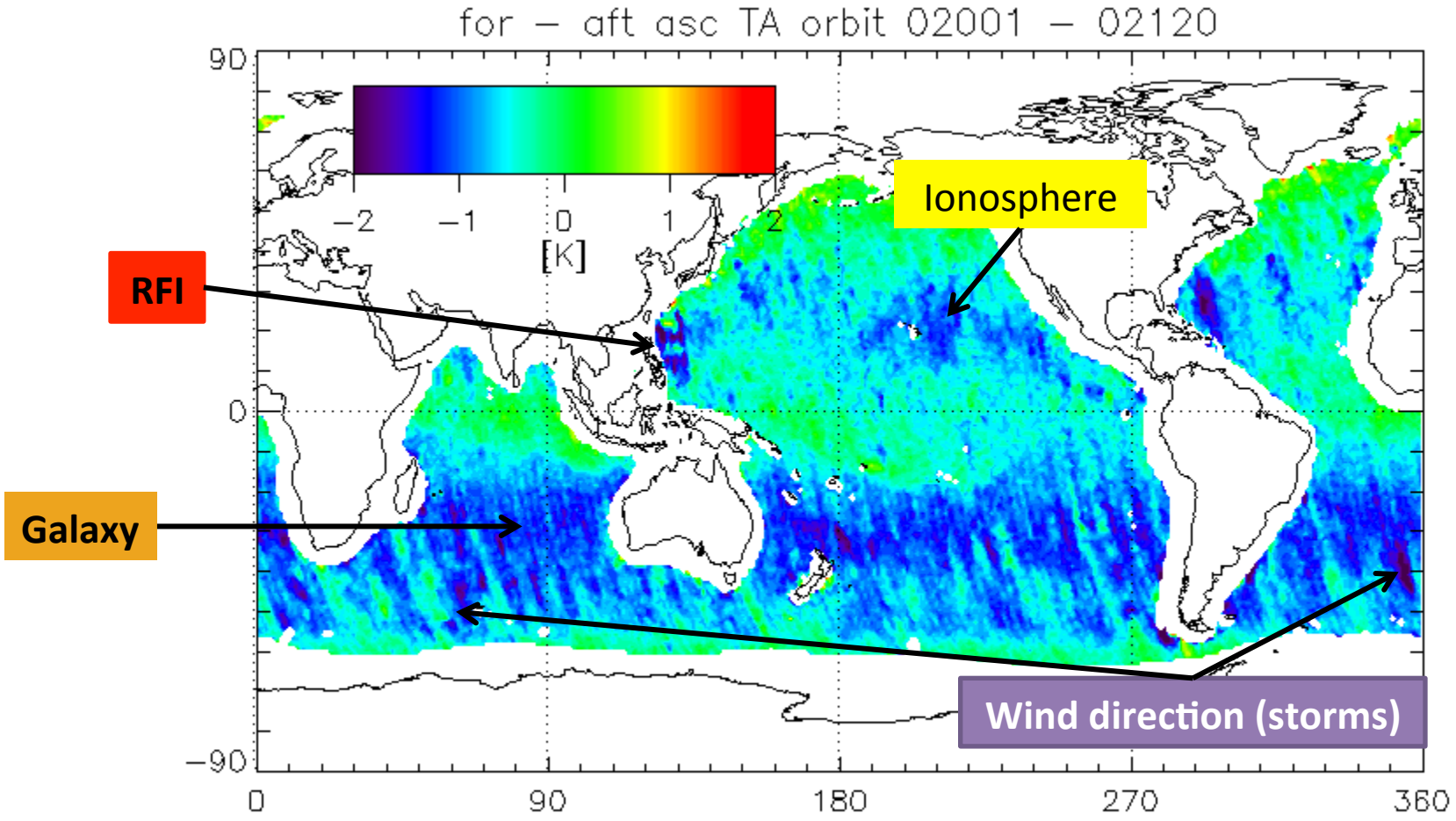
SMAP Salinity

Argentina: Running 8-day average



Forward – Backward Look

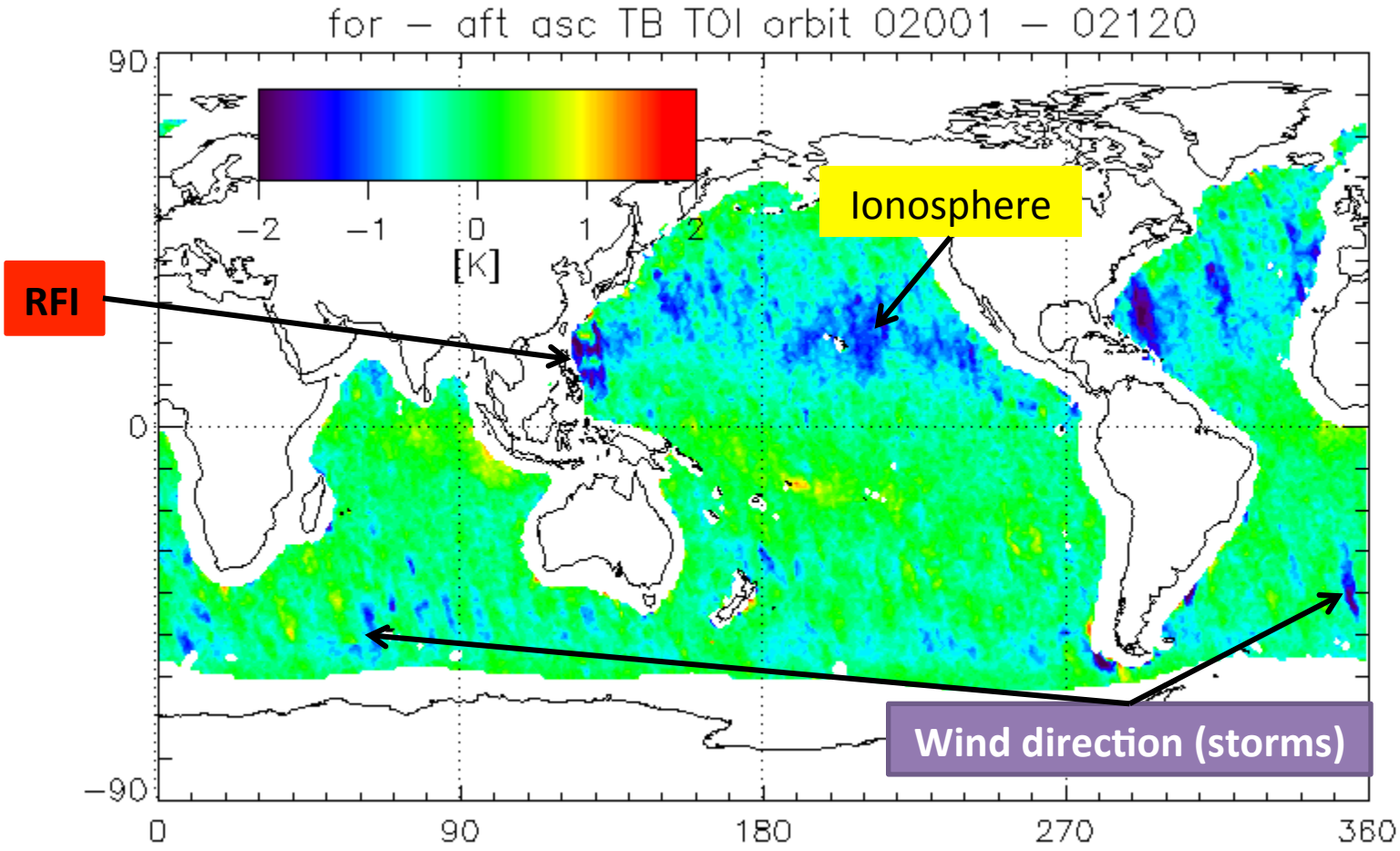
allows assessment of removal of spurious signals if they depend on looking direction without any external reference salinity field



1 Kelvin = 2 psu

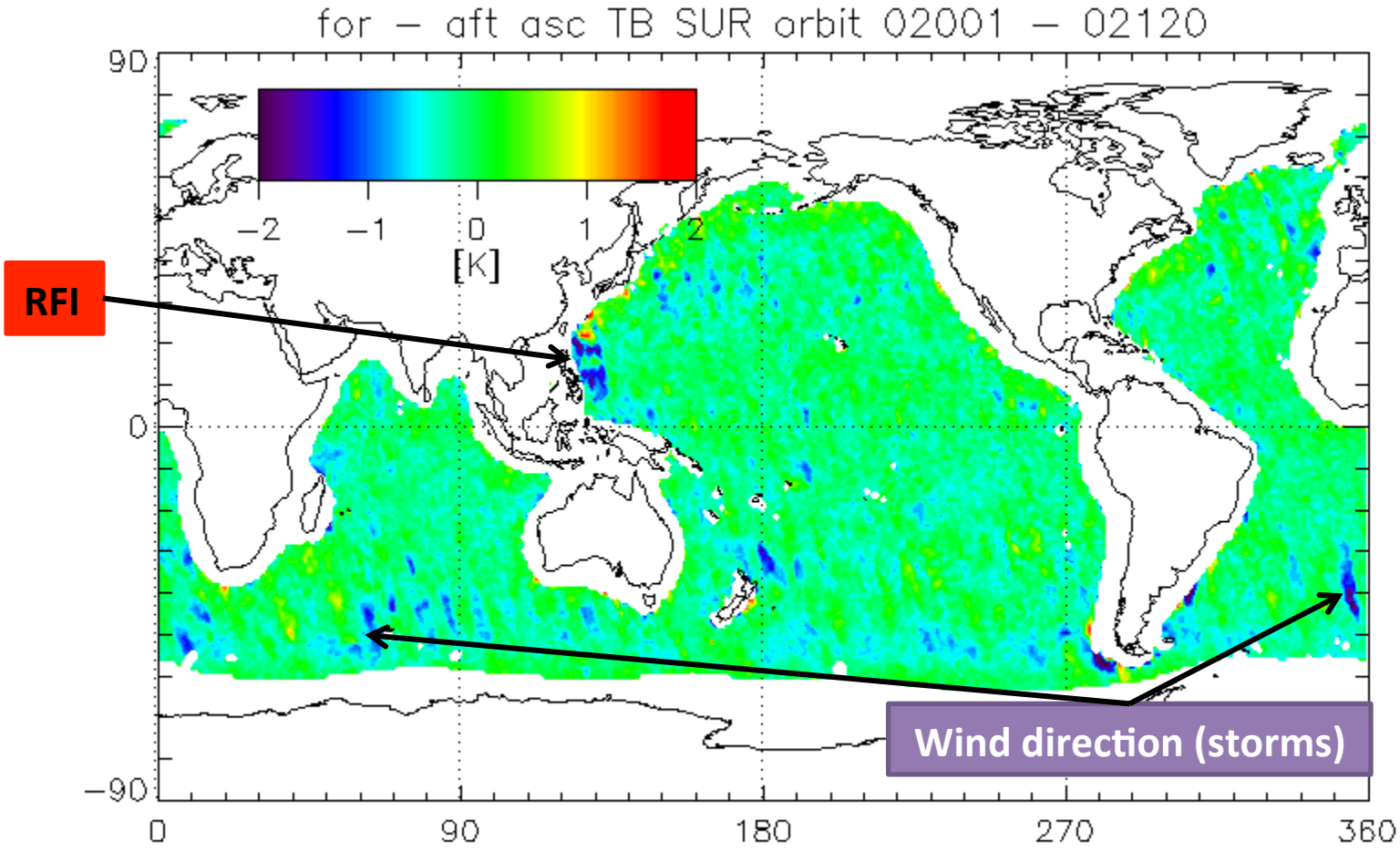
Forward – Backward Look

after removing galactic reflection



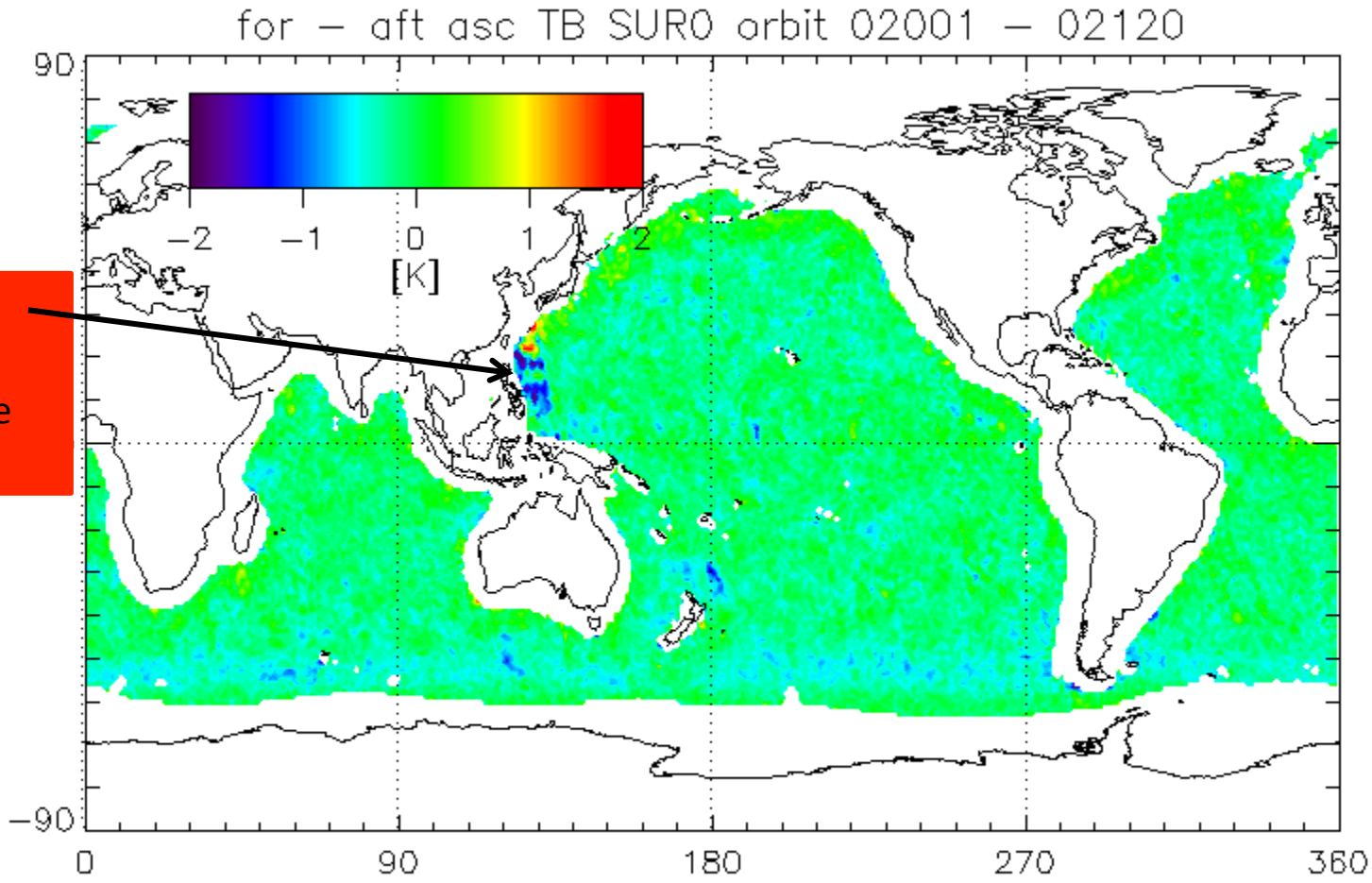
Forward – Backward Look

after removing Faraday Rotation in Earth Ionosphere



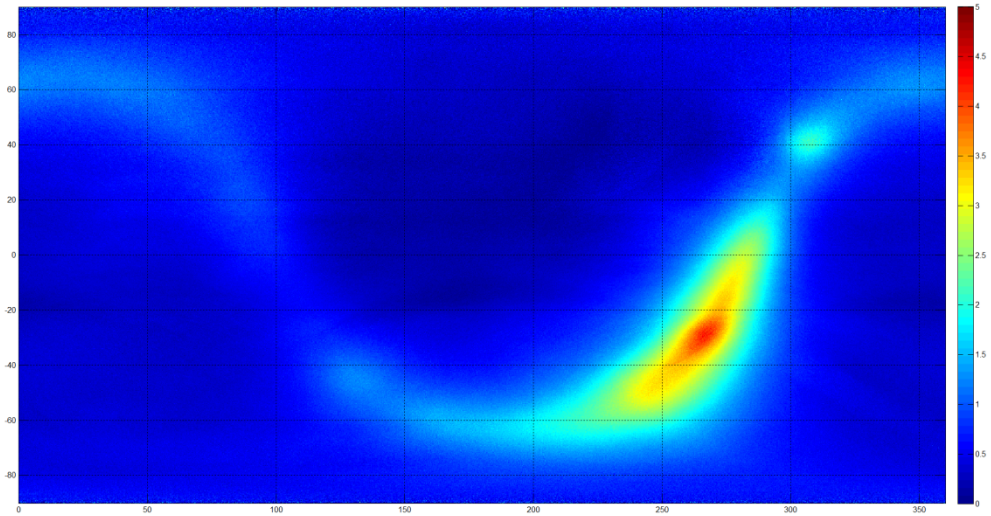
Forward – Backward Look

after removing wind direction component of surface emissivity

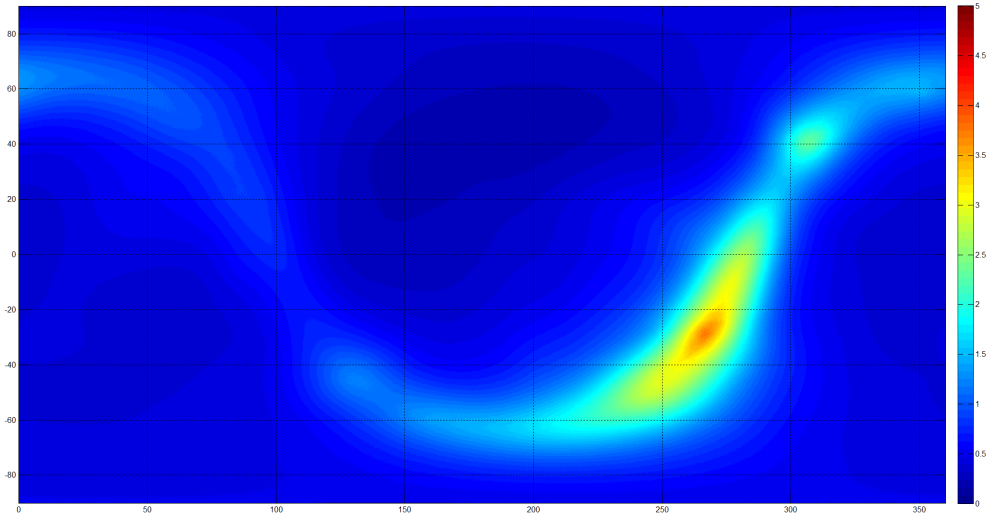


RFI sneaking through the filter

Galactic Map from SMAP For - Aft



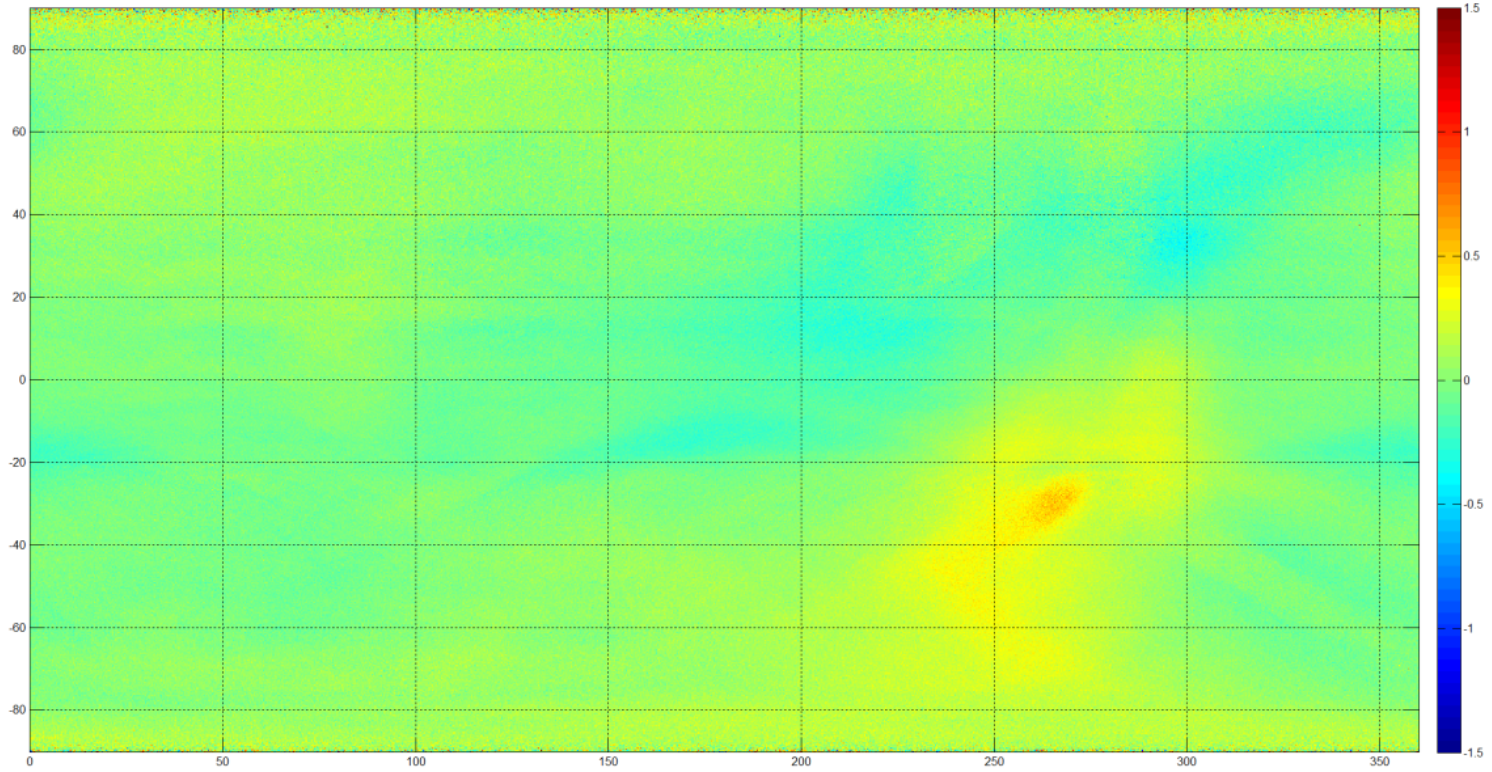
Empirical SMAP galactic map from
For – aft look
after correcting for Faraday Rotation and wind direction



Galactic map that is used in Aquarius V4.0 (adapted to SMAP configuration, no symmetrizatiojn).

To obtained best match with empirical SMAP galactic map, we have increased the roughness by adding 2 m/s to wind speed.

Galactic Map from SMAP For - Aft



Difference between SMAP for – aft galactic map and galactic map that is used in Aquarius processing (after adding 2 m/s to wind speed).

There is pretty remarkable agreement.

The result suggests that the roughness (slope variance) in the geometric optics model needs to be increased slightly and possible some scaling of the strong galactic sources.

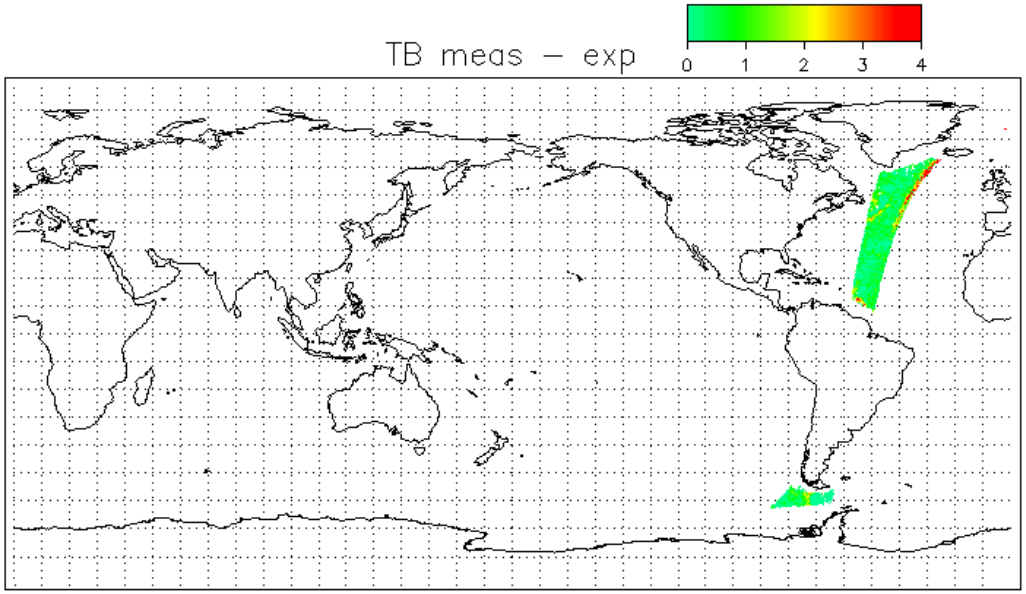
Expected Accuracy of SMAP SSS

- SMAP resolution 40 km versus Aquarius 100 – 150 km.
  - We can expect to get closer to land with SMAP than with Aquarius.
- SMAP sampling time 17 msec versus Aquarius 1.44 sec.
  - Observation of single SMAP footprint (Level 2) about 9 times noisier than Aquarius.
  - SMAP Level 2 data accuracy is about 1.5 psu.
  - However the wide swath + 2-look allows sufficient samples so that at monthly averages can be beat down the **random noise** close to the 0.2 psu level without compromising the resolution.
  - As with Aquarius the **driver in the performance** are the **systematic errors**.
- Calibration accuracy.
  - SMAP was solely designed for land applications (soil moisture, freeze-thaw state).
  - Radiometric accuracy requirement: **1.3 Kelvin.**
  - **To measure ocean salinity at 0.2 psu accuracy we need it accurate to 0.1 Kelvin.**
  - **There is a big additional calibration effort necessary in addition to what is provided by the SMAP radiometer team in order to achieve that level of calibration accuracy.**

Surface Roughness Correction

- No Radar (correction for surface roughness)
- Use wind speeds from WindSat and SSMIS F17
- Same ascending node time as SMAP (good overlap)
- Unavailable in rain (use NCEP wind speeds).

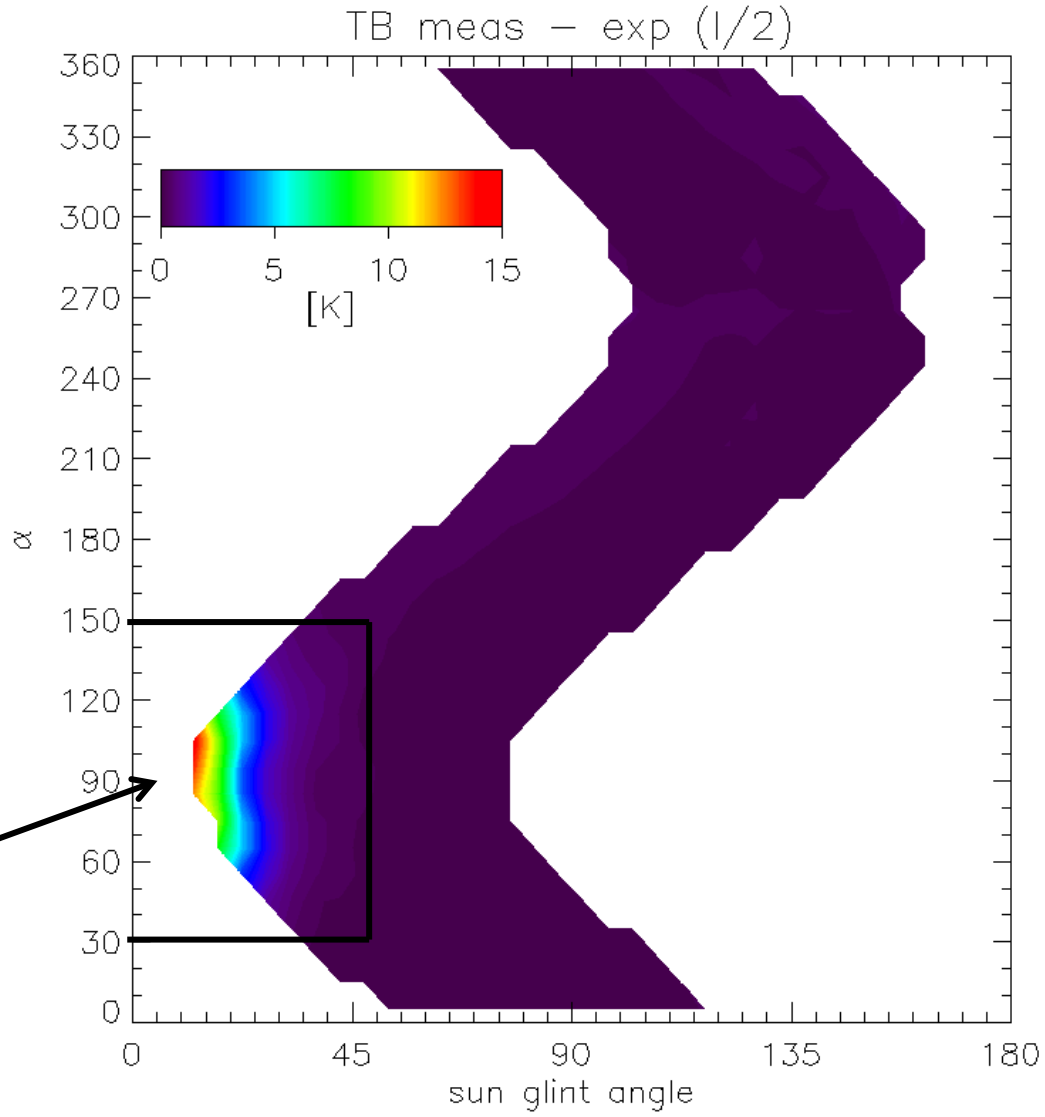
Sun Glitter



- Aquarius was staring away from the sun. SMAP performs full scan.
- SMAP sees sun reflection (glint) from the ocean surface
- Can be large (exceeding 15 K = 30 psu)
- Difficult to model
  - Solar radiation at L-band is strong and variable (1 Mio Kelvin)
  - Signal enters through sidelobes of the antenna.
  - Signal depends on surface roughness (not well modelled)

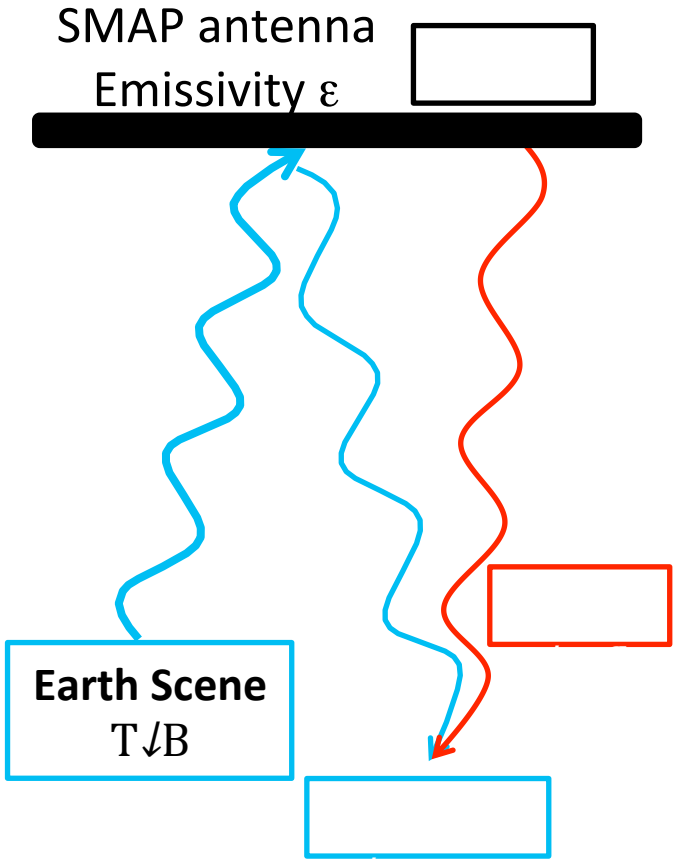
Sun Glitter

Flag



10% data flagged

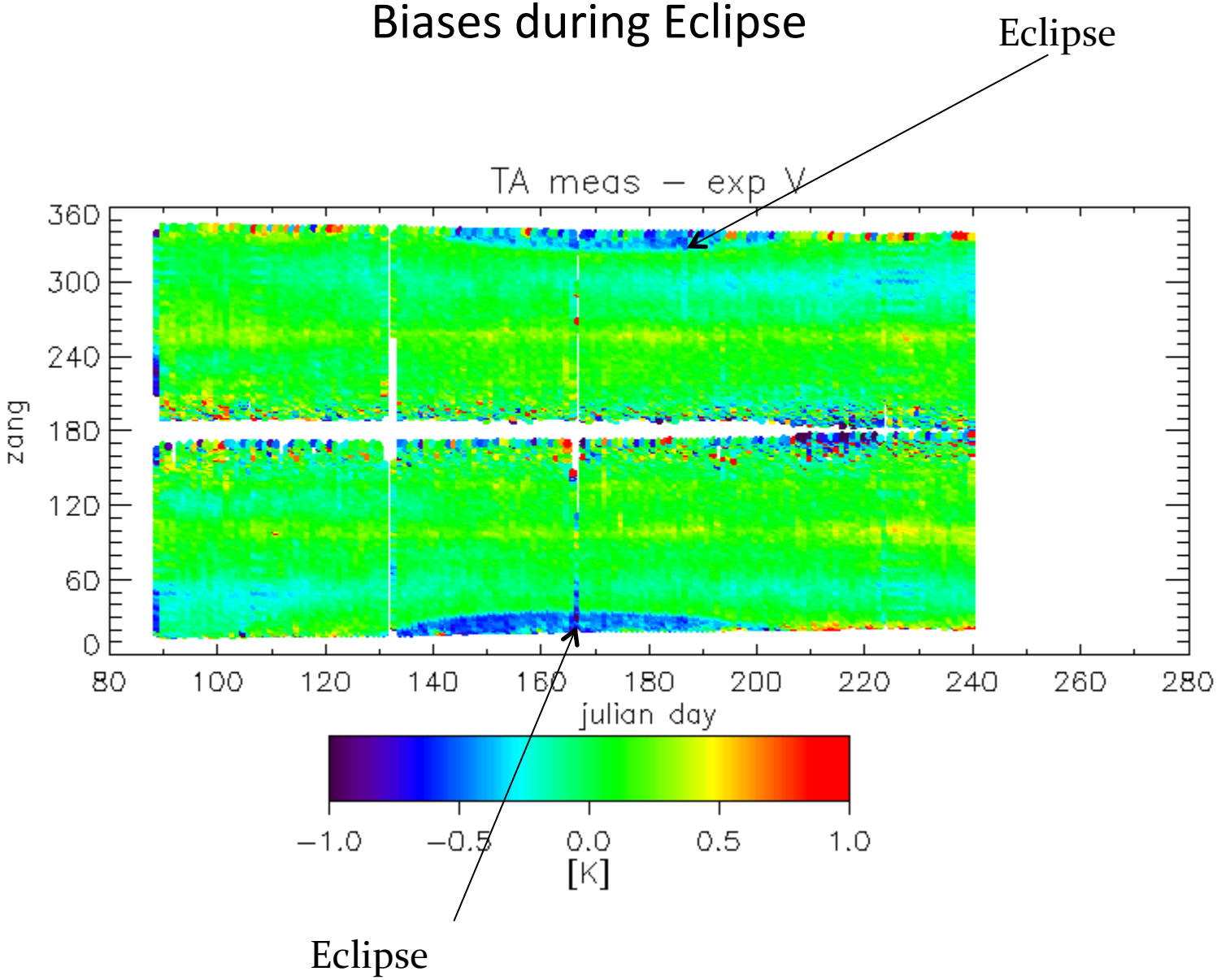
Emissive Antenna



- The SMAP reflector mesh is lossy (emission) at L-band
- **Emissivity about 1%, which is 4 times larger than pre-launch value!**
- Antenna temperature (TA) dependent on its physical temperature T_{refl}
  - Large biases between the ascending and descending orbits (up to 1 psu).
  - During summer eclipse large spurious cold biases in the Southern Ocean (up to 2 psu).
- **No measurement of physical temperature of SMAP antenna**
  - Only thermal model data are available
  - Thermal model appears to be inaccurate when S/C goes into eclipse (50 K temperature change).

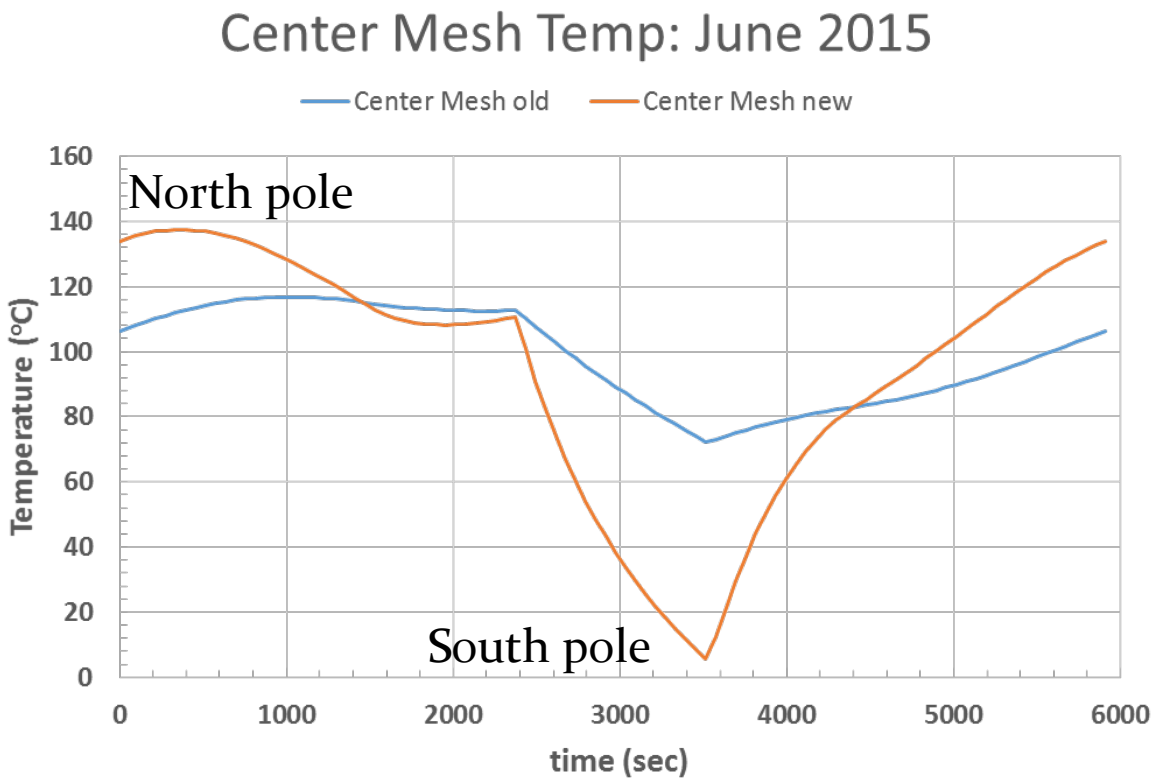
Emissive Antenna

Biases during Eclipse



Reflector Temperature Model

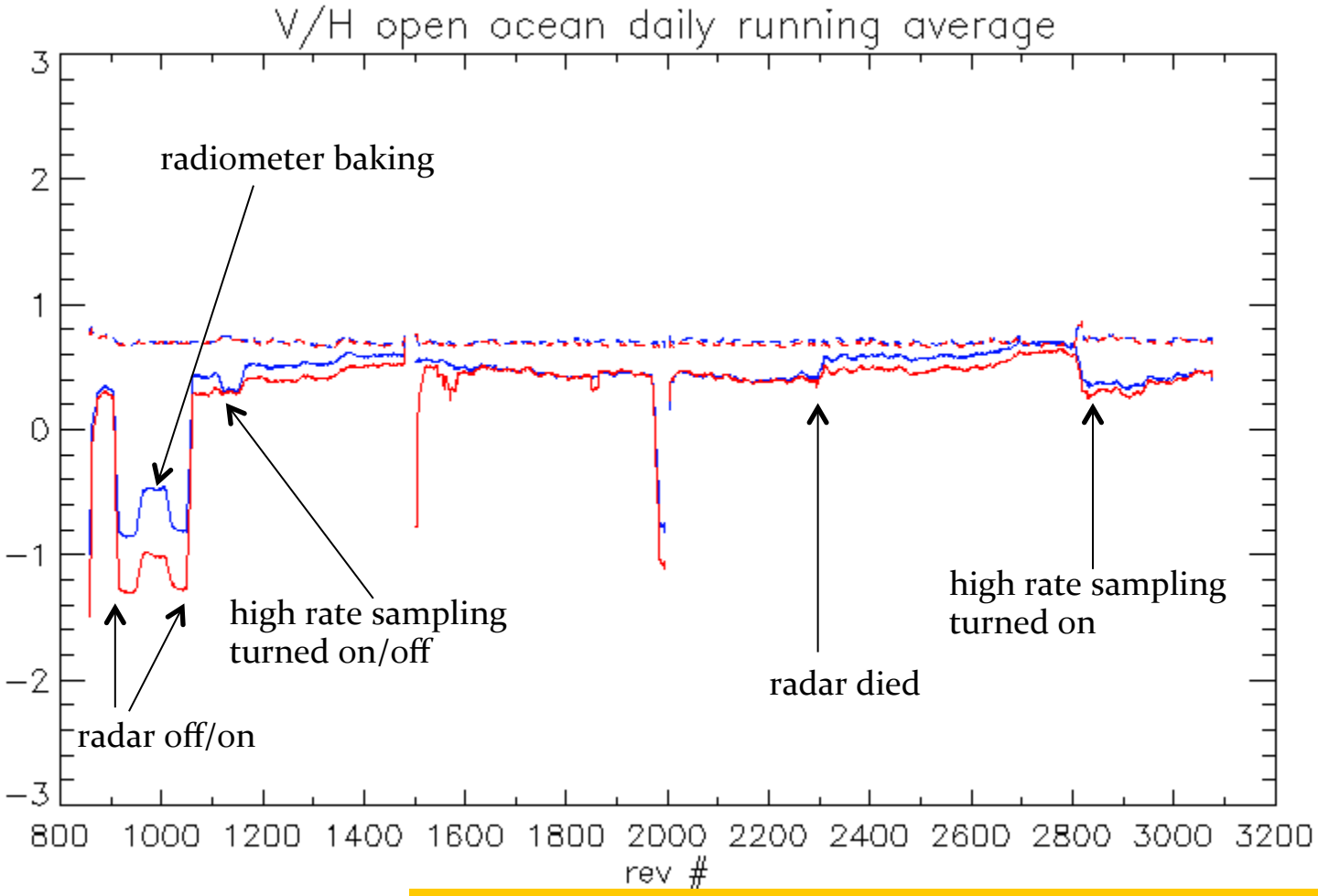
- Orbit/eclipse dependent error
- JPL thermal team discovered misspecification of mesh density in thermal model
- Thermal model is currently rerun



from J. Piepmeier

Jumps in Calibration

Count to TA Algorithm



V H
full lines: bias
dashed lines: standard deviation

SMAP Beta Version L1B TA
needs to be fixed "by hand"
supposed to improve with Validated Data Release

Processing Status and Outlook

- Undergoing effort to track down and remove those spurious calibration biases.
- Beta Release (V1.0) : November 2015
  - Available through RSS web site
  - Level 3 products only (3-day, weekly, monthly)
  - 40 km resolution
- Validated Release (V2.0): early 2016
  - Level 2 (swath data, OI interpolated on fixed Earth grid)
  - Containing all intermediate products starting form TA
  - Level 3: temporal averages (3-day, weekly monthly)
  - 40 km resolution
  - Available through PO.DAAC