Development of a Soil Moisture Product Using Aquarius/SAC-D Observations

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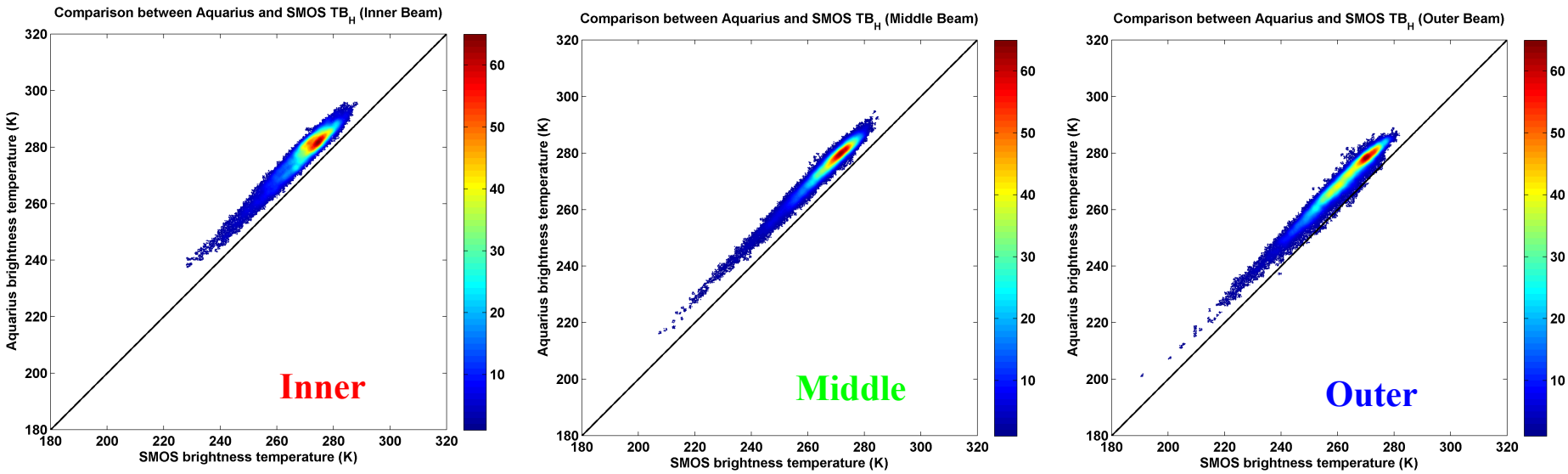
Overview

- Aquarius L-band brightness temperature over land
- Approach
- Soil moisture retrievals and validation
- Next steps

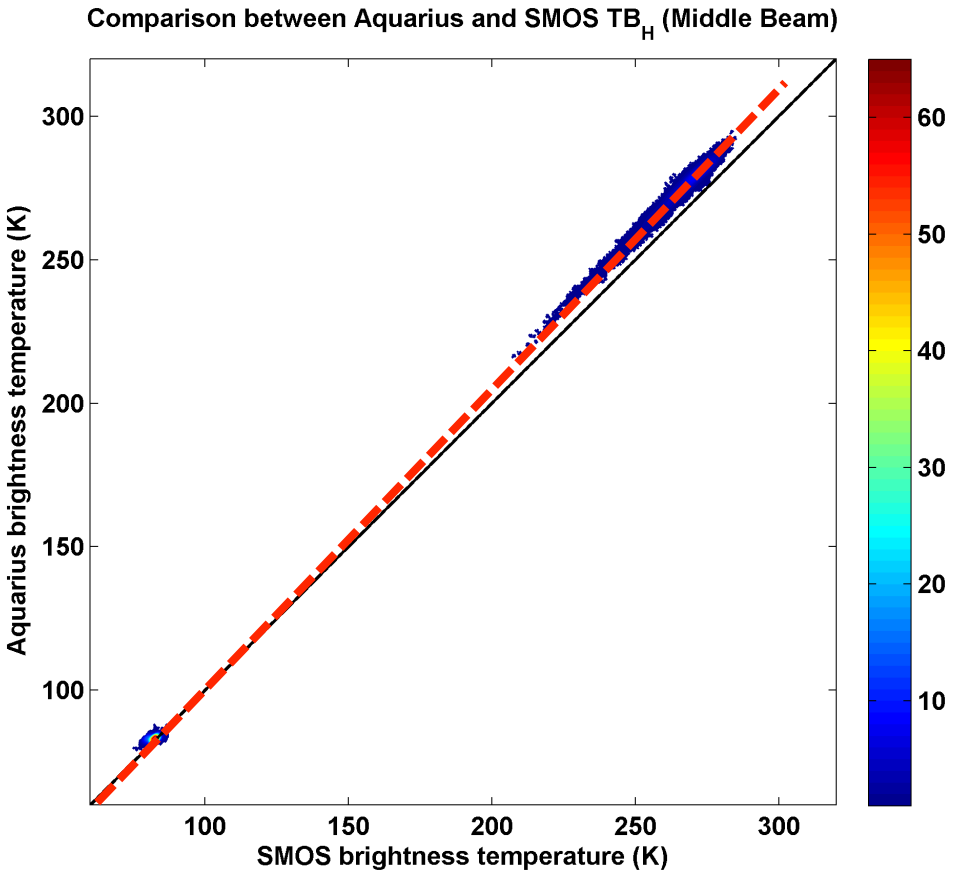
Comparison Between Aquarius and SMOS over Land (h-pol)



- Recognizing all caveats of the data sources, we are concerned by the bias.
  - Scatter increases with angle
  - ~RMSE 8K
  - ~Bias 8K (Aquarius>SMOS) – results in soil moisture difference of 0.04-0.08 m^3/m^3

Interim Recalibration of Aquarius Brightness Temperature over Land

- In order to move forward on the SM algorithm, we need to fix the bias.
- An interim approach, only used in the algorithm is being implemented pending further studies by the Aquarius Cal/Val Team.
  - Use Ocean as a pivot point
  - Compute gain and offset using concurrent SMOS for each channel
  - Aquarius TB are recomputed using these gain and offset before they are used in the soil moisture retrieval



Aquarius Soil Moisture Algorithm and Incidence Angle

- The baseline soil moisture algorithm uses the radiative transfer equation (τ−ω model). Same as the baseline SMAP L2 Soil Moisture algorithm, referred to as the Single Channel Algorithm (SCA).
  - τ-ω model

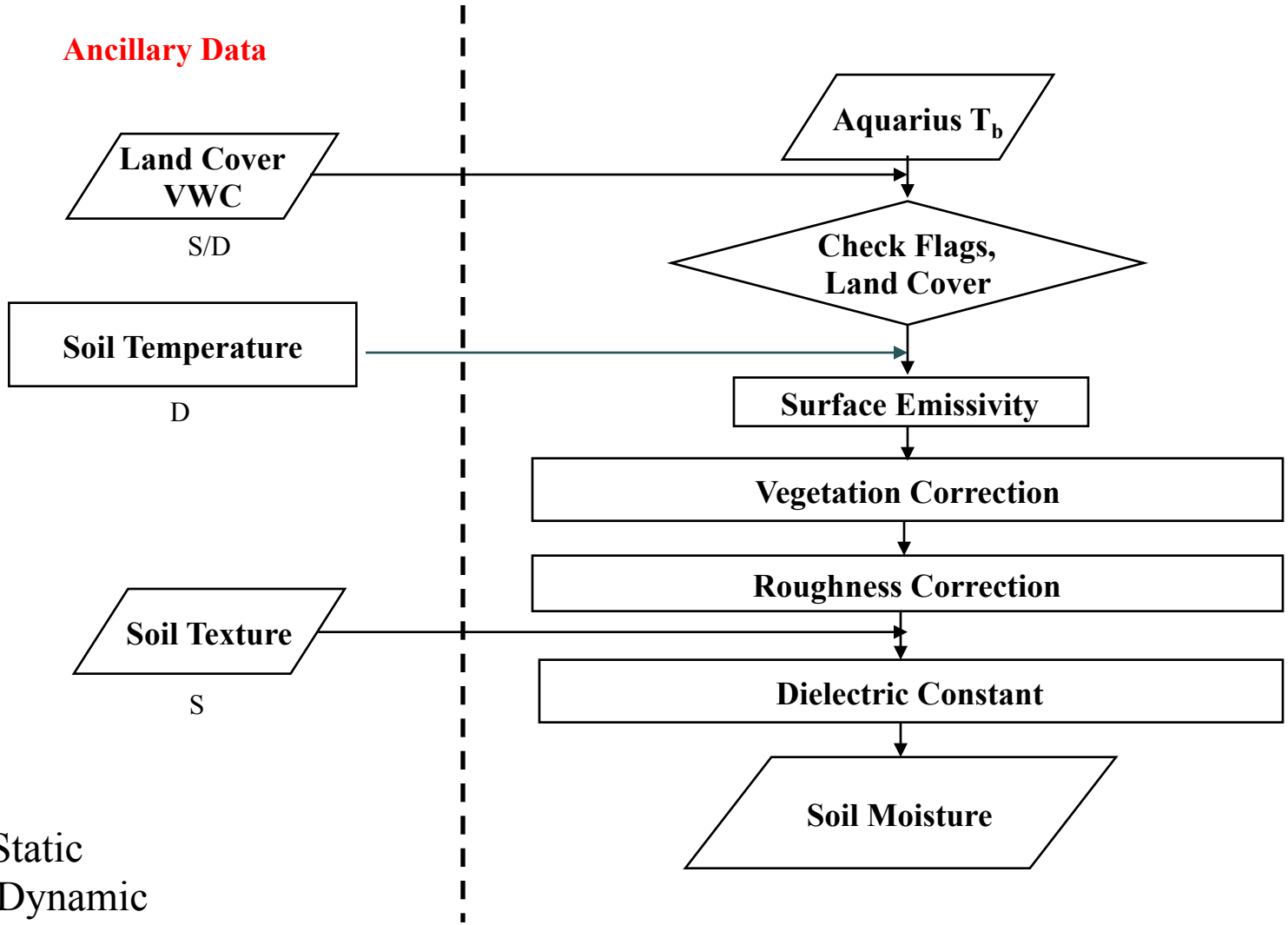
$$TB = T_{soil}(1 - R_{soil})\exp^{-\tau\cos\theta} + T_{veg}(1-\omega)(1-\exp^{-\tau\cos\theta})(1 + R_{soil}\exp^{-\tau\cos\theta})$$

  - Fresnel equation (Horizontal Polarization)

$$R_{Soil}(\theta) = \left| \frac{\cos\theta - \sqrt{\varepsilon_r - \sin^2\theta}}{\cos\theta + \sqrt{\varepsilon_r - \sin^2\theta}} \right|^2$$

- Earlier soil moisture efforts have focused on retrievals using constant incidence angle (conical scanners)
- Do we need to develop an incidence angle correction?
  - Note: Incidence angle is already incorporated into both the τ-ω and Fresnel equations
- Critical issue in using all three Aquarius beams

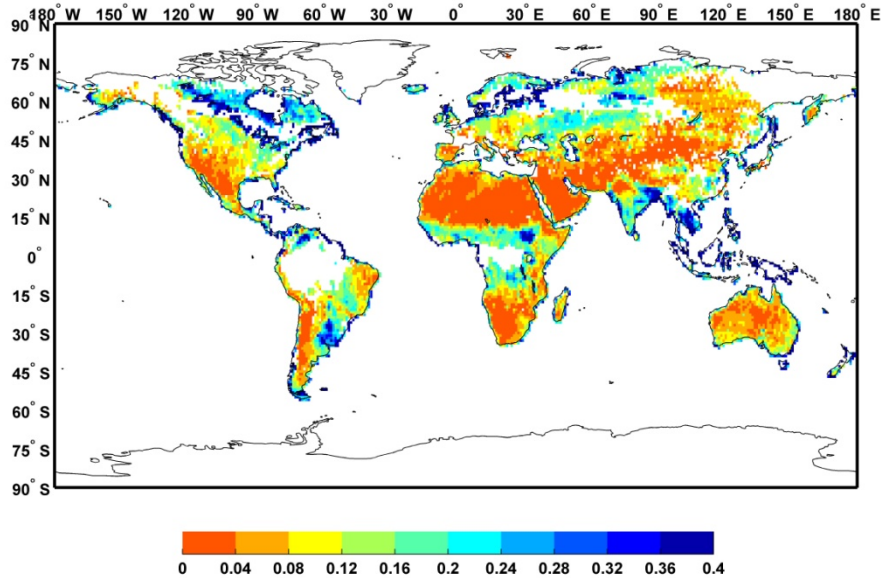
SCA Soil Moisture Retrieval (Ver. 1)



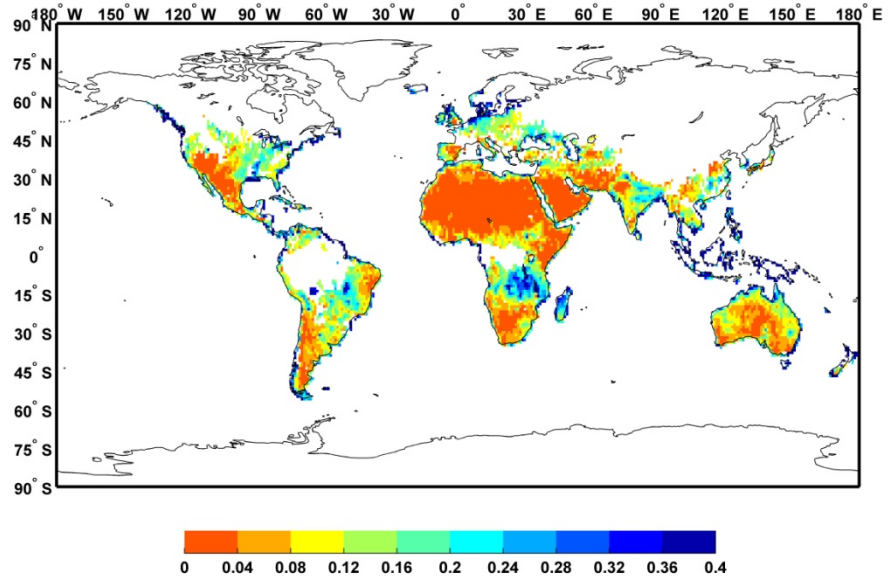
S-Static
D-Dynamic

Monthly Aquarius Soil Moisture

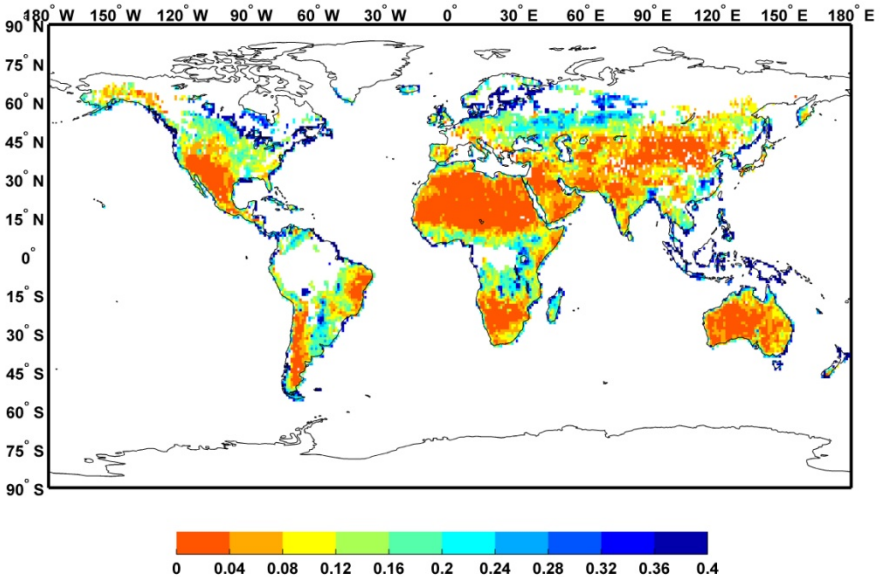
October 2011



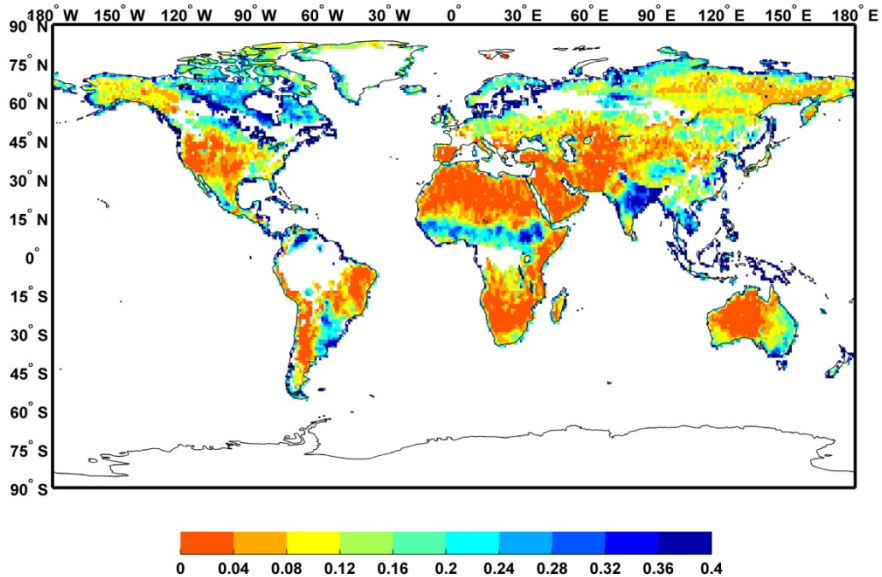
January 2012



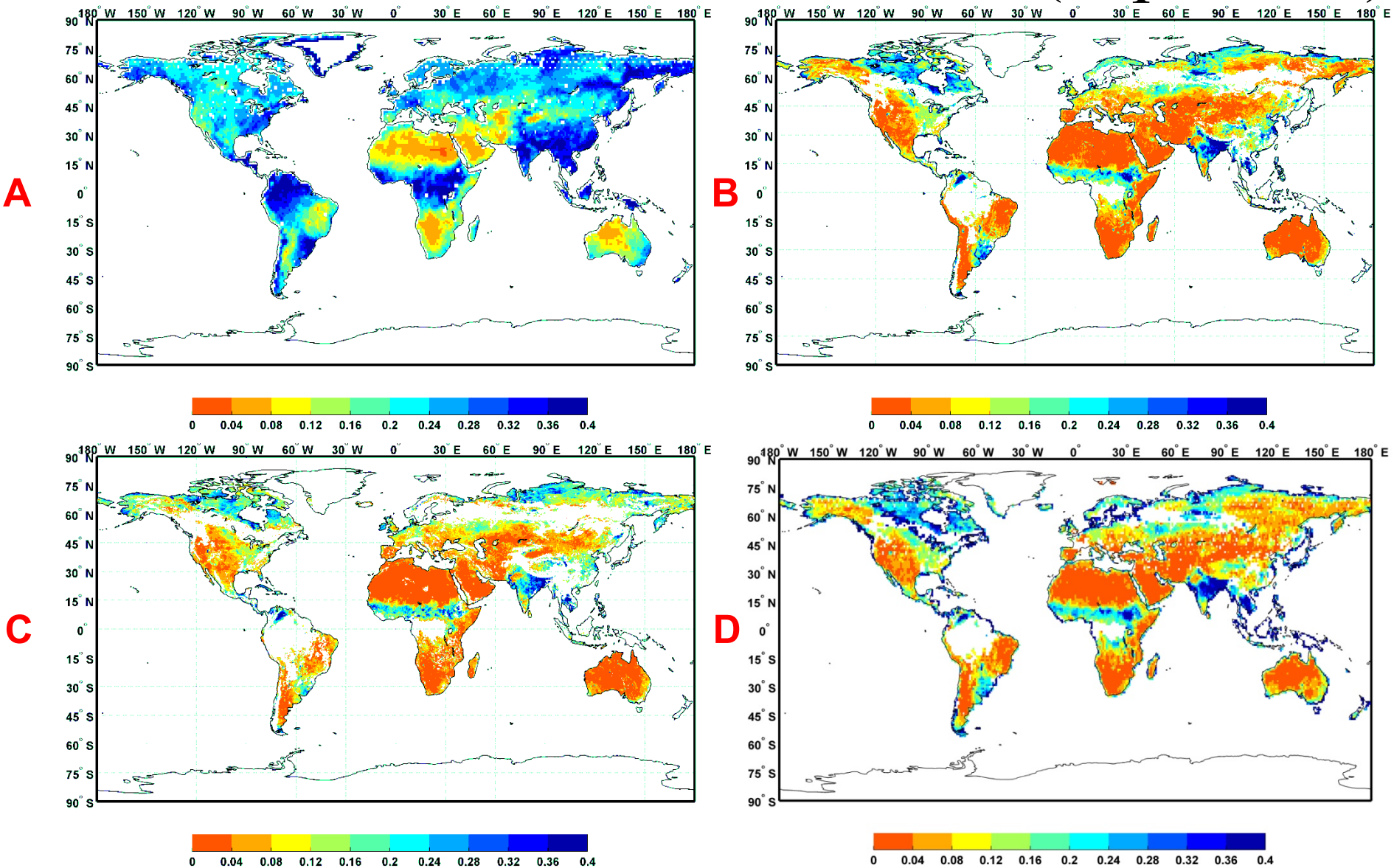
April 2012



July 2012



Four Global Soil Moisture Products (Sept. 2011)



A NCEP Soil Moisture

B SMOS Soil Moisture (L2 data)

C SMOS/SMAP SCA Soil Moisture

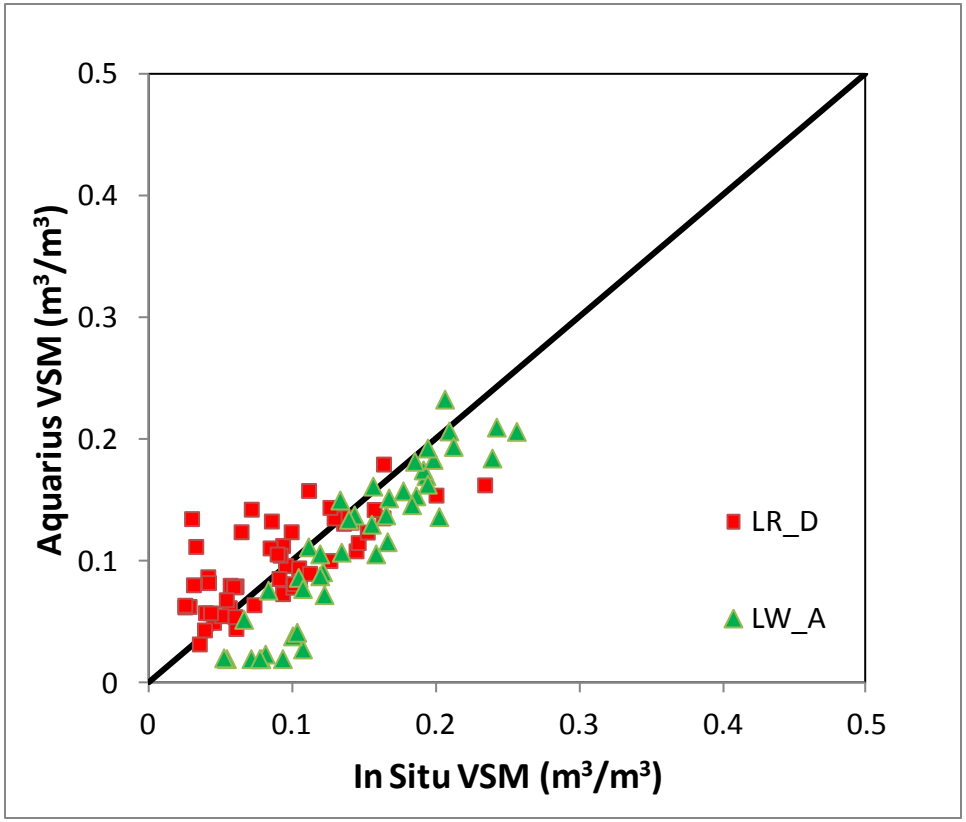
D Aquarius Soil Moisture (SCA)

Aquarius SM Validation Results

- USDA Watershed sites
- Period of record – (Sept 2011-Sept 2012)
- Coverage issues
  - Aquarius footprint ~100 km
  - Only LW and LR used for soil moisture validation because of the size of the Aquarius footprint
- Impact of Aquarius TB modification

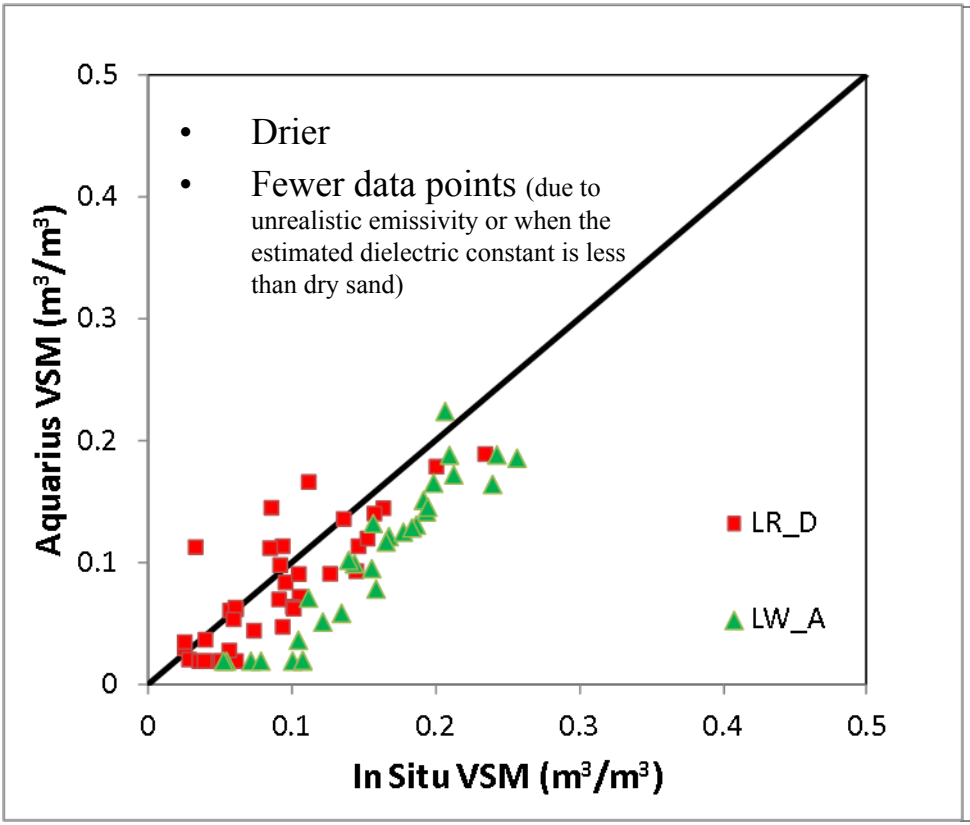
Aquarius SM Validation Results

- NCEP skin temperature is too shallow for L-band microwave penetration depth.
- NCEP skin temperature and 0-10 cm surface temperature used in the retrieval algorithm
- Aquarius soil moisture compare well with in situ observations
- RMSE ~ 0.036 m^3/m^3, Bias ~ 0.008 m^3/m^3
  - Using modified TB

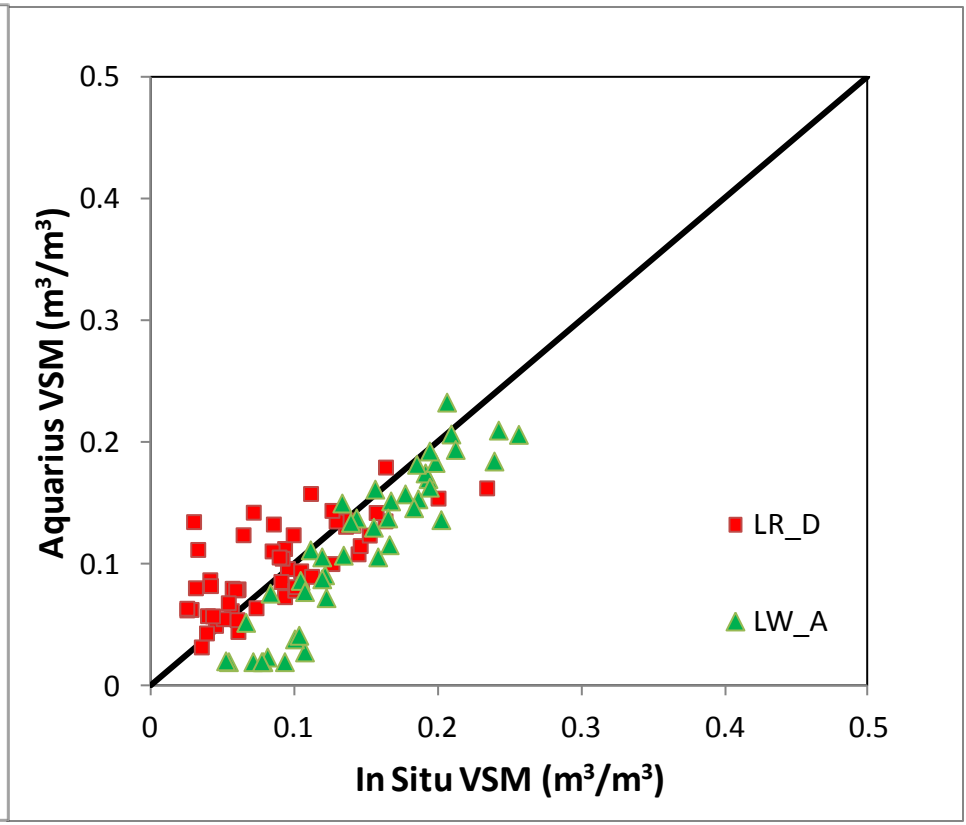


Impact of Modifying TB on Validation Results

Unmodified TB



Modified TB

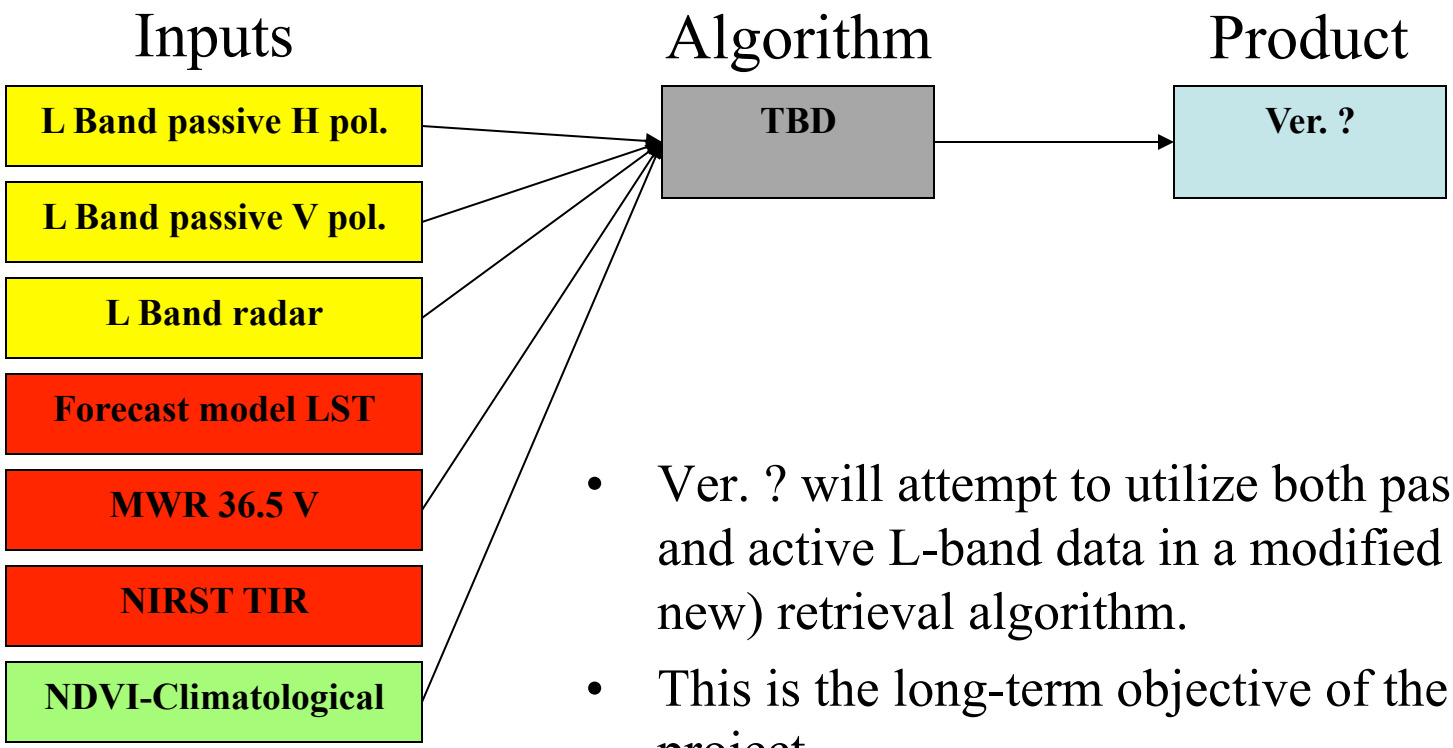


	Bias	RMSE	N
Unmodified TB	-0.042	0.068	78
Modified TB	-0.008	0.036	99

Next Steps

- Vegetation information from Aquarius radar
- LST from SAC-D MWR

Aquarius/SAC-D Soil Moisture Retrieval Ver. ?



- Ver. ? will attempt to utilize both passive and active L-band data in a modified (or new) retrieval algorithm.
- This is the long-term objective of the project.
- New vegetation and LST products from Aquarius/SAC-D will be required.

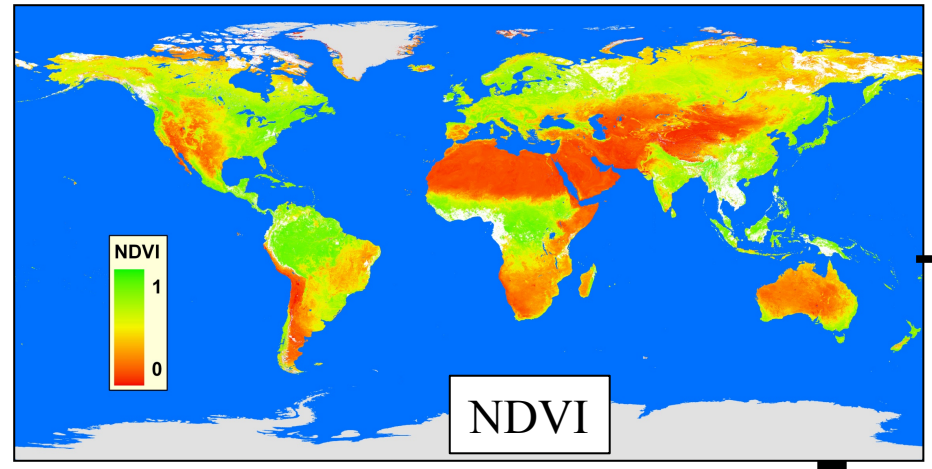
Vegetation Information from Radar Data

- It is well known that radar responds to variations in electrical and structural properties of vegetation.
- Polarimetric measurements and indices such as the Radar Vegetation Index (RVI) may provide information.

$$\mathrm{RVI} = \frac{8\sigma_{HV}}{\sigma_{HH} + \sigma_{VV} + 2\sigma_{HV}}$$

- Must proceed carefully
  - RVI has not been rigorously validated for a range of cover types
  - Since it utilizes multiple polarization backscatter and is highly dependent cross-pol, all channels must be well-calibrated
  - Aquarius provides coarse resolution observations. The validity of this methodology for different land covers and over heterogeneous domains needs to be examined.

Global Aquarius RVI (Sept. 11-17, 2011)



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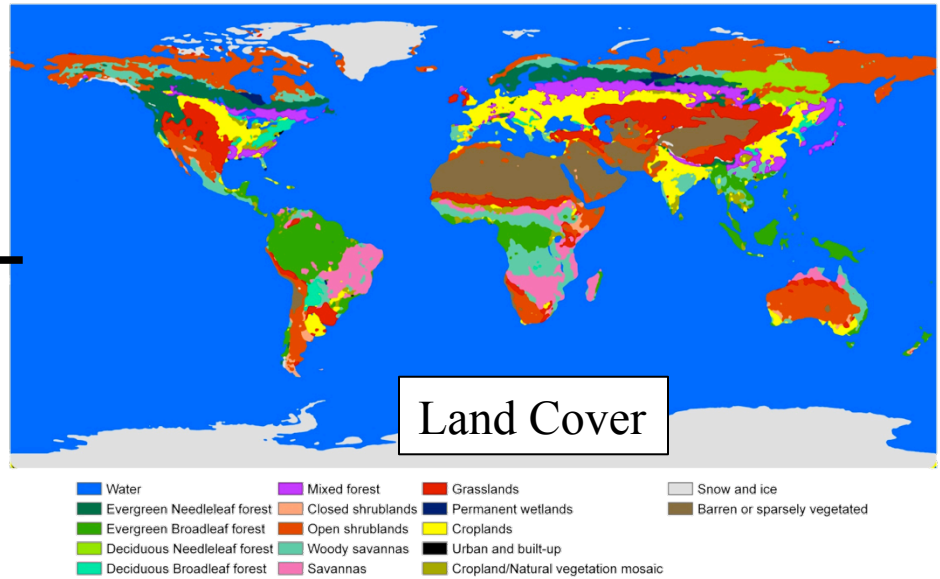

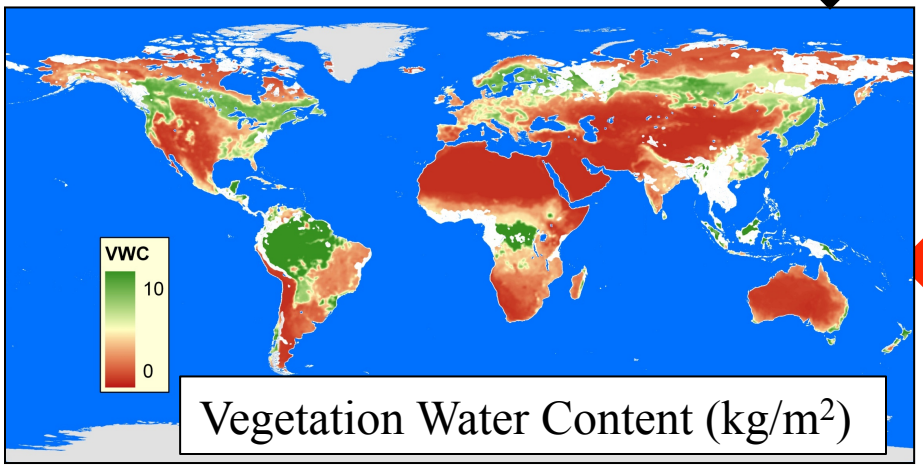

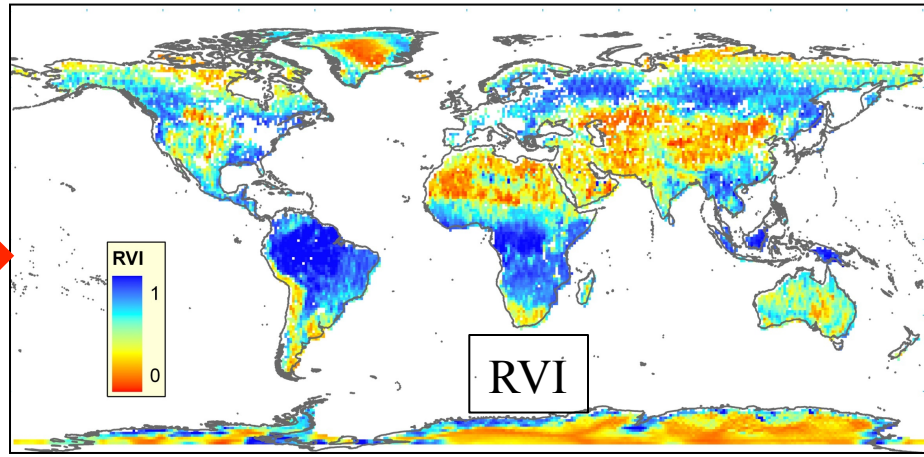

Land Surface Temperature (LST)

- Required for all SM algorithms (T_B to emissivity)
- Options
  - Numerical Weather Forecast Model products
    - SMOS and SMAP approach
    - Several options and resolutions (NCEP, MERRA, ECMWF)
      - Currently NCEP product is integrated in the Aquarius L2 data
  - MWR 36.5 GHz V algorithm
    - It has been rigorously tested and used with AMSR-E observations
    - Heritage from SSM/I, TMI, AMSR-E, and WindSat
    - Potential mission product
    - Data integration issues with Aquarius L2 product
    - Added capability to detect active precipitation, snow

Summary

- Our approach to soil moisture retrieval uses the SCA with NCEP LST and MODIS NDVI climatology
  - Results are consistent with expected spatial patterns, SMOS, and model soil moisture.
  - Results are encouraging.
  - Effects of ongoing Aquarius calibration activities will have an impact on the soil moisture.
  - Next: Validation using in situ and alternative satellite SM products.
- Working with ADPS to implement the Aquarius soil moisture algorithm
- The use of scatterometer to parameterize vegetation will be investigated.
- The use of MWR to compute LST will be investigated.