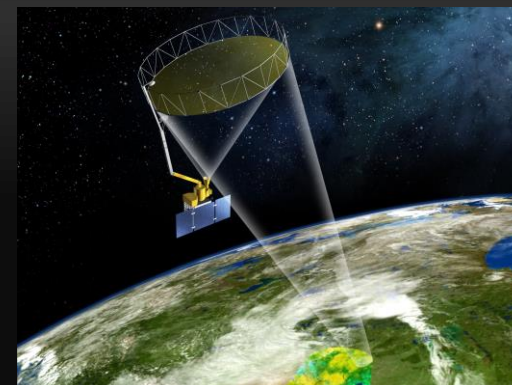


# Global Assimilation of L-band Brightness Temperature Observations From SMAP and SMOS Into the Catchment Land Surface Model, and Contribution to the Skill of Soil Moisture Estimates

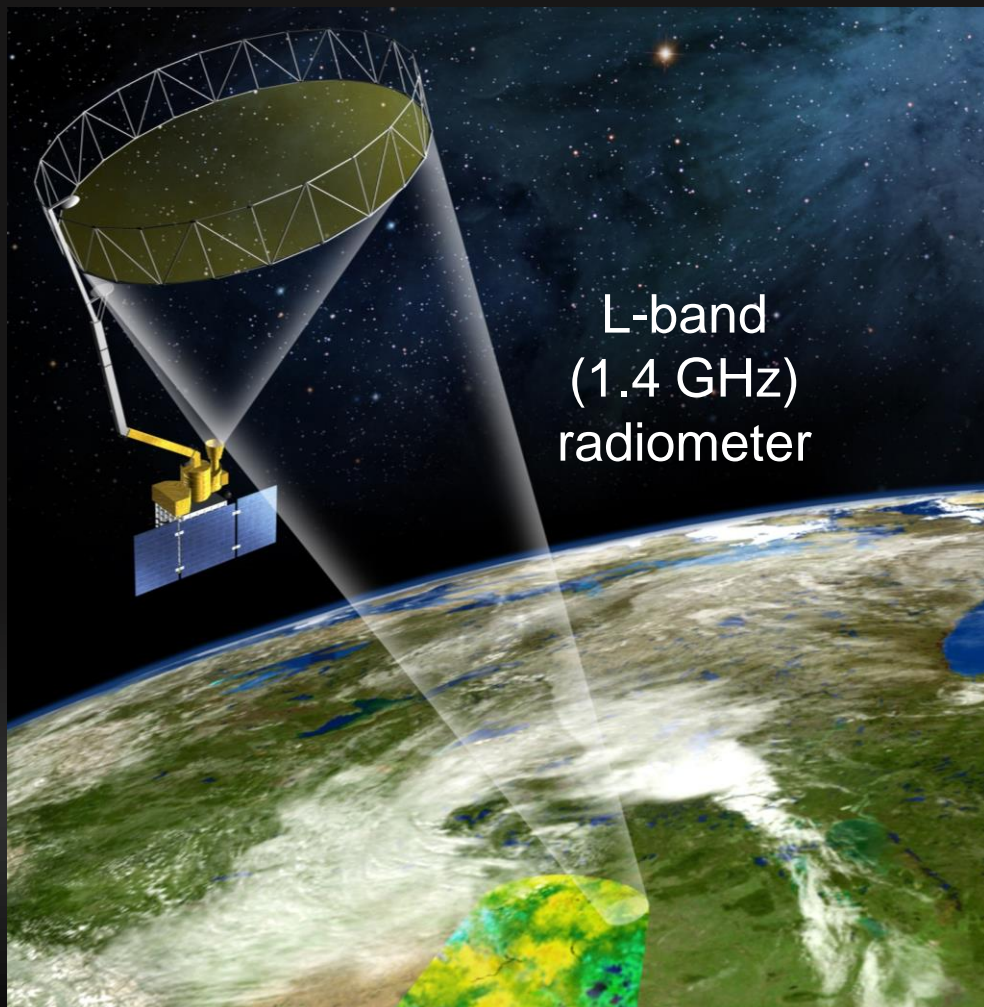
**Rolf Reichle, Q. Liu, J. Ardizzone, W. Crow, G. De Lannoy,  
J. Kimball, J. Kolassa, and R. Koster**



Rolf.Reichle@nasa.gov  
+1-301-614-5693



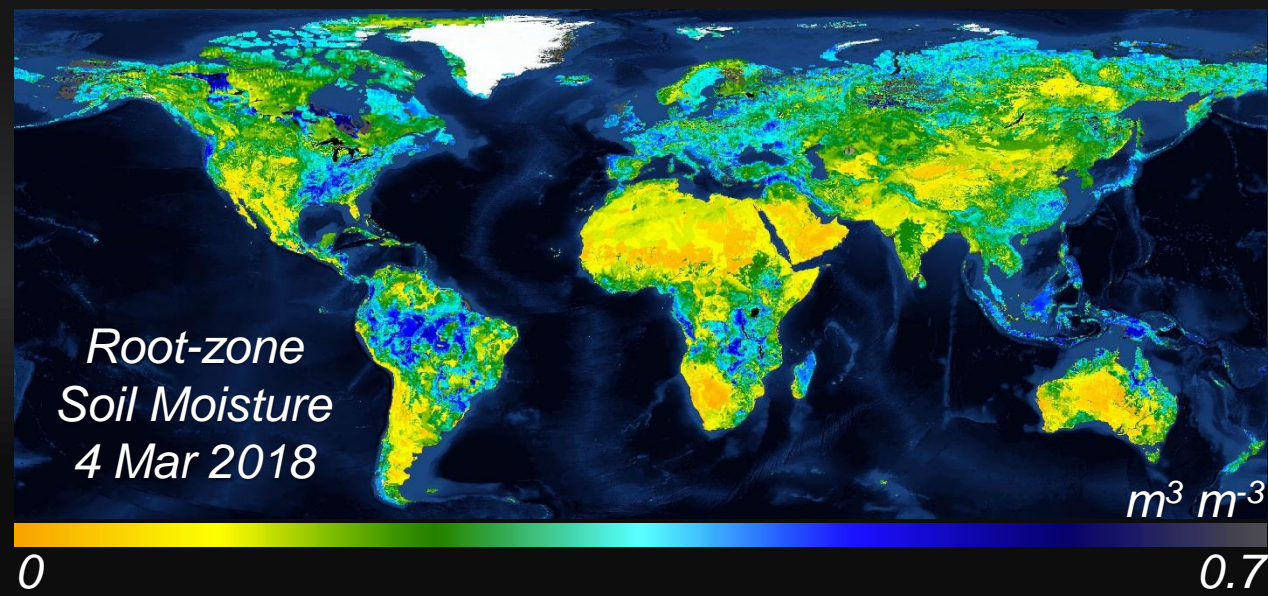
# SMAP Level-4 Soil Moisture (L4\_SM) Product



Sensitive only to surface  
soil moisture (~0-5 cm)

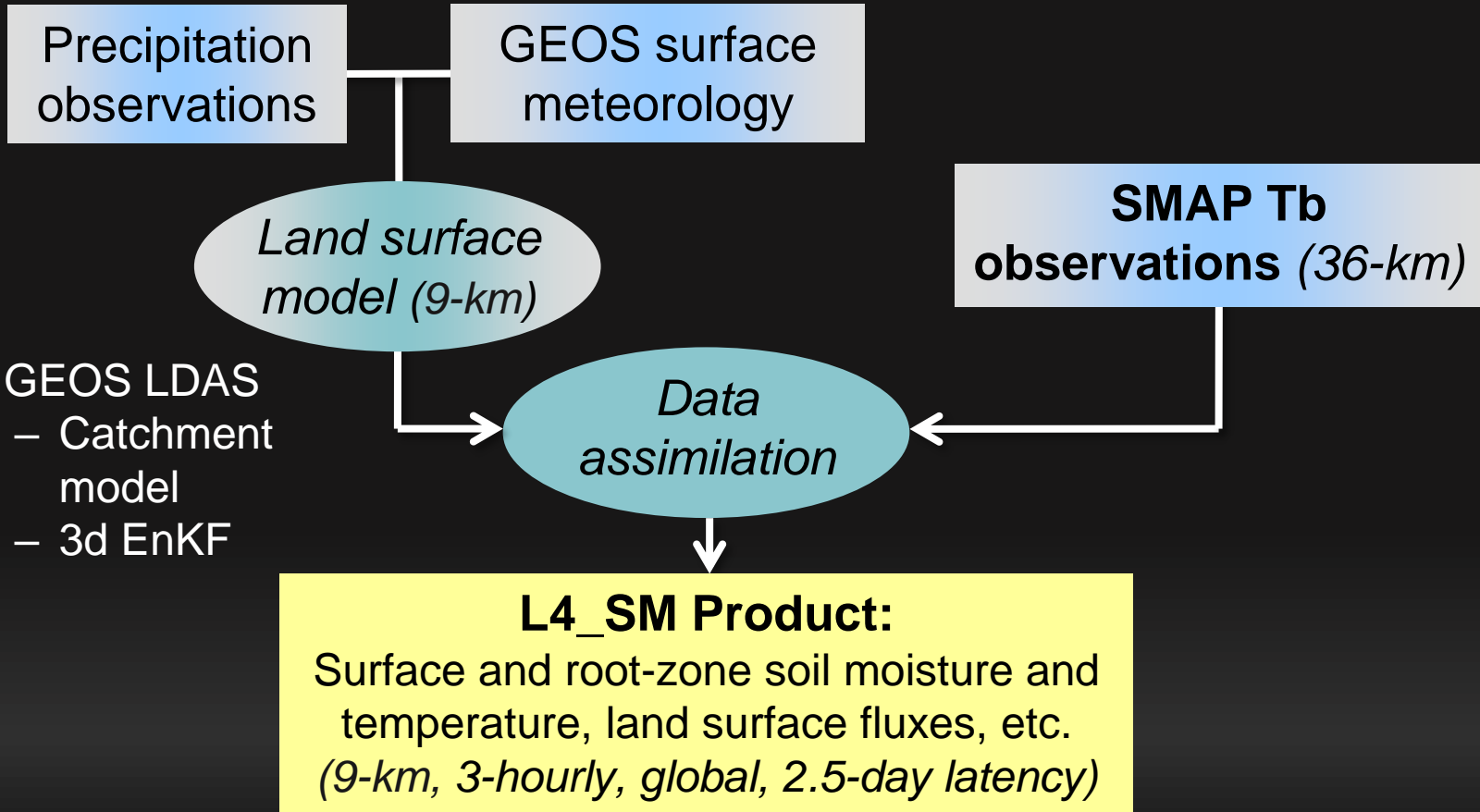
## Key L4\_SM Objectives:

1. “Root-zone” soil moisture (0-100 cm)
2. Spatially & temporally complete





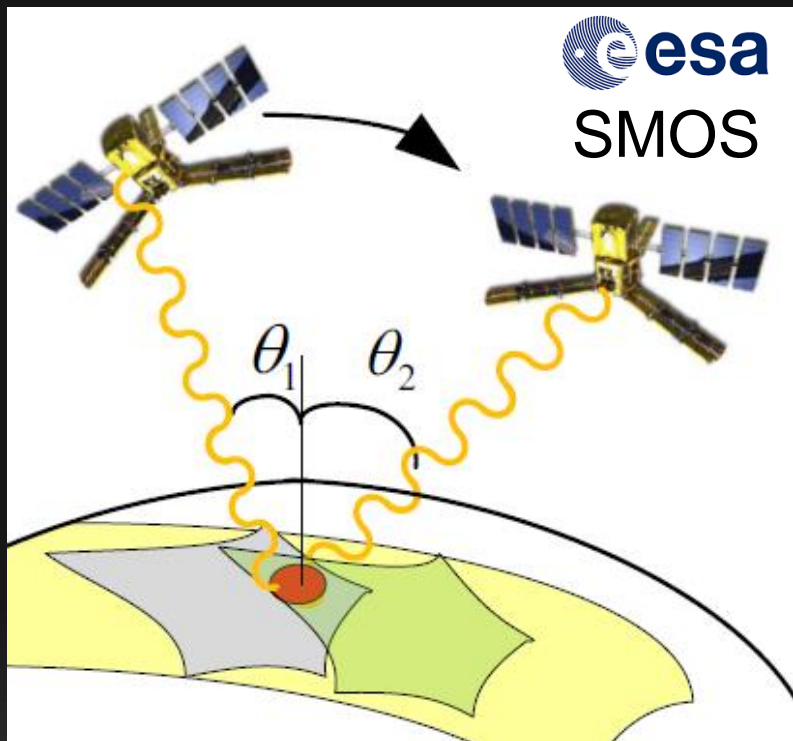
# SMAP Level-4 Algorithm



Reichle et al., JAMES, 2019 (doi:10.1029/2019MS001729).



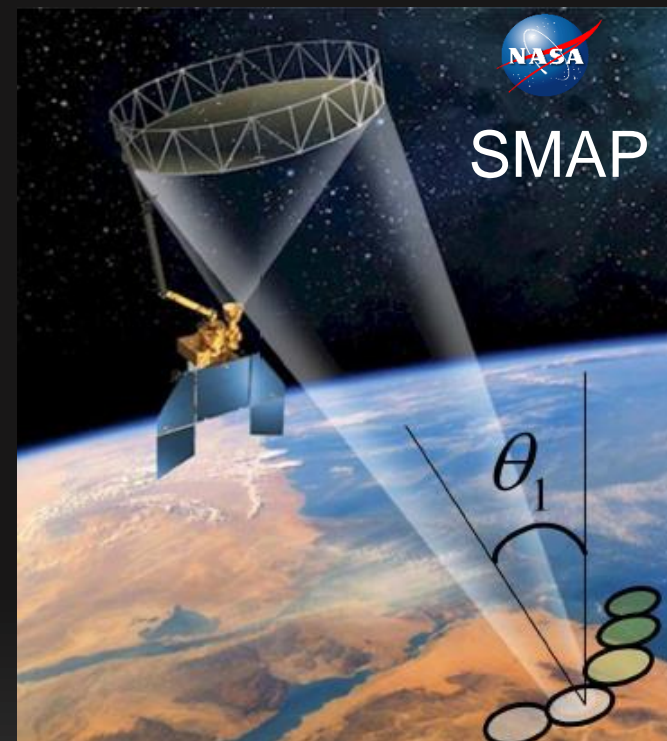
# SMOS and SMAP Observations



2009-present

*Interferometric & multi-angular  
Very vulnerable to RFI*

L-band (1.4 GHz)  
passive microwave  
brightness  
temperature (Tb)  
at ~40-km resolution



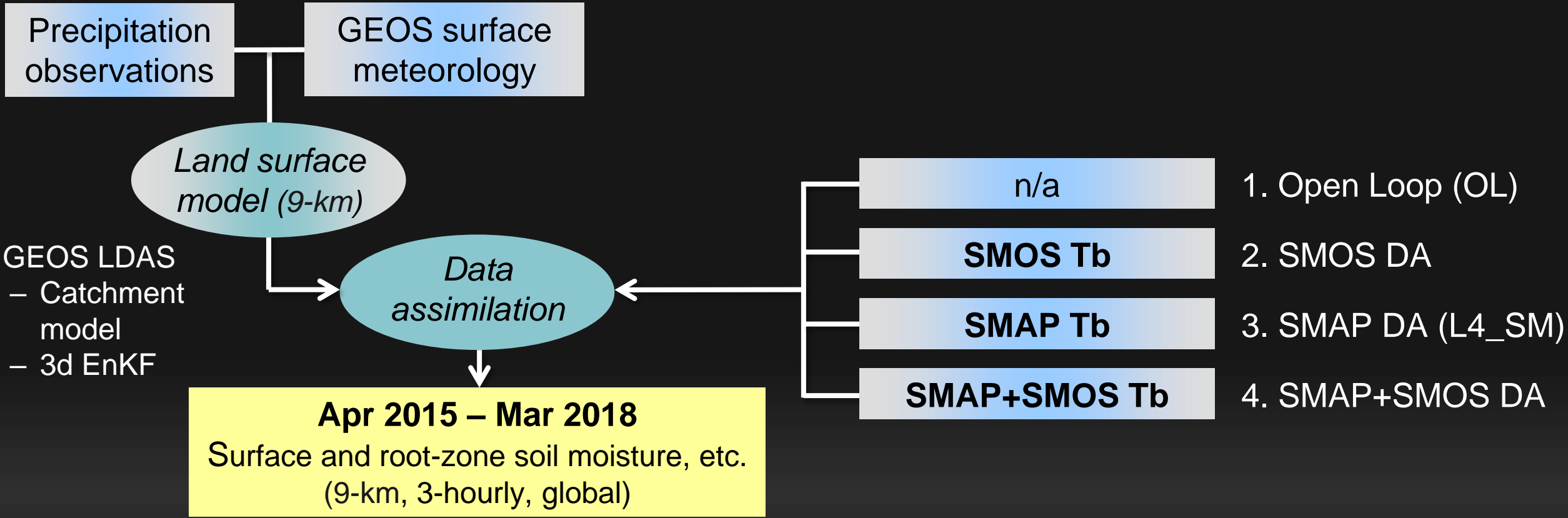
2015-present

*Scanning radiometer  
RFI tools*

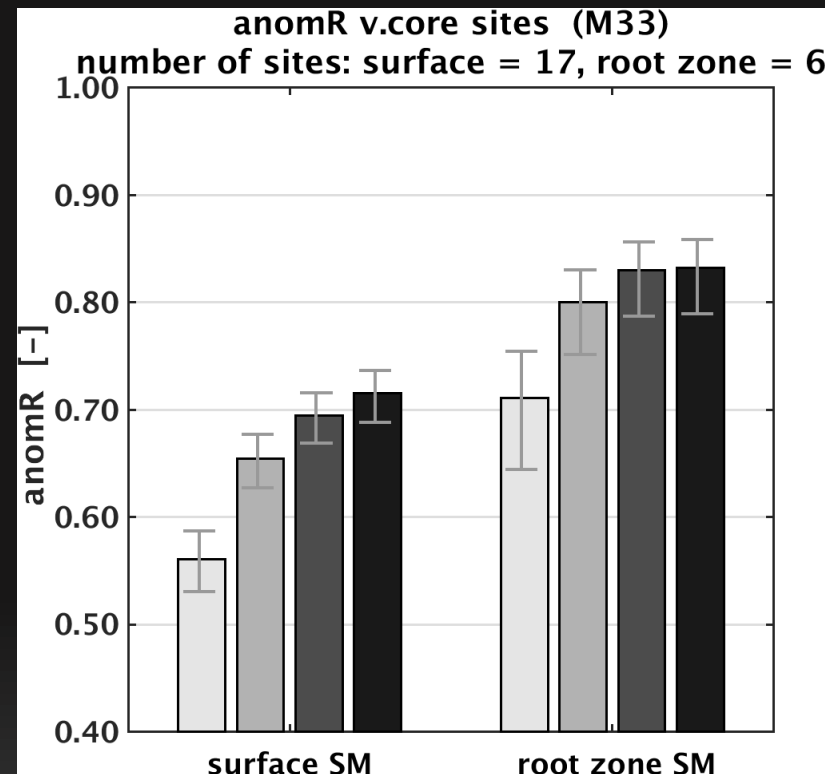
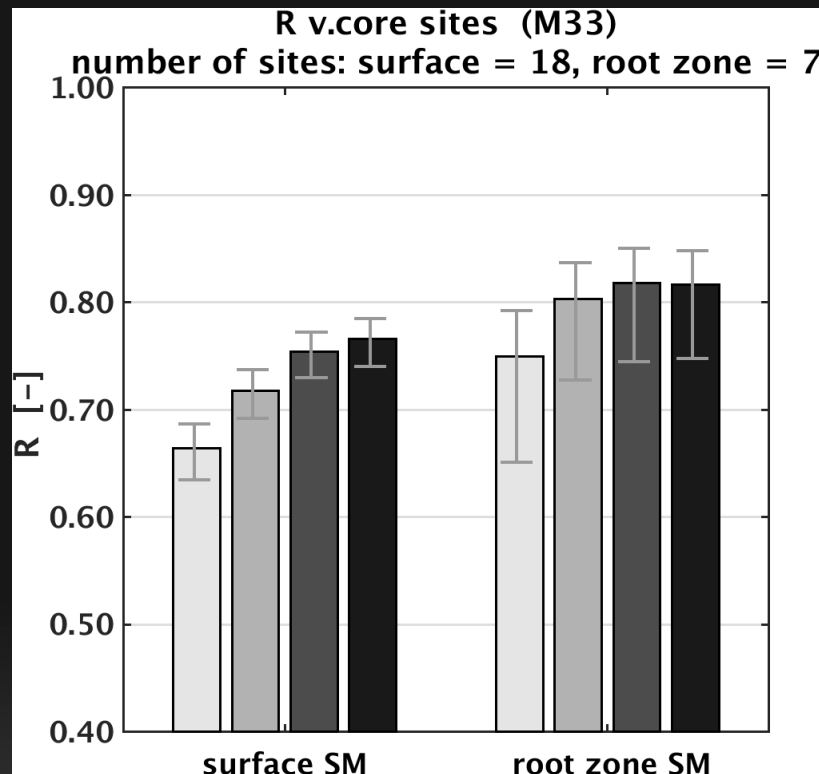
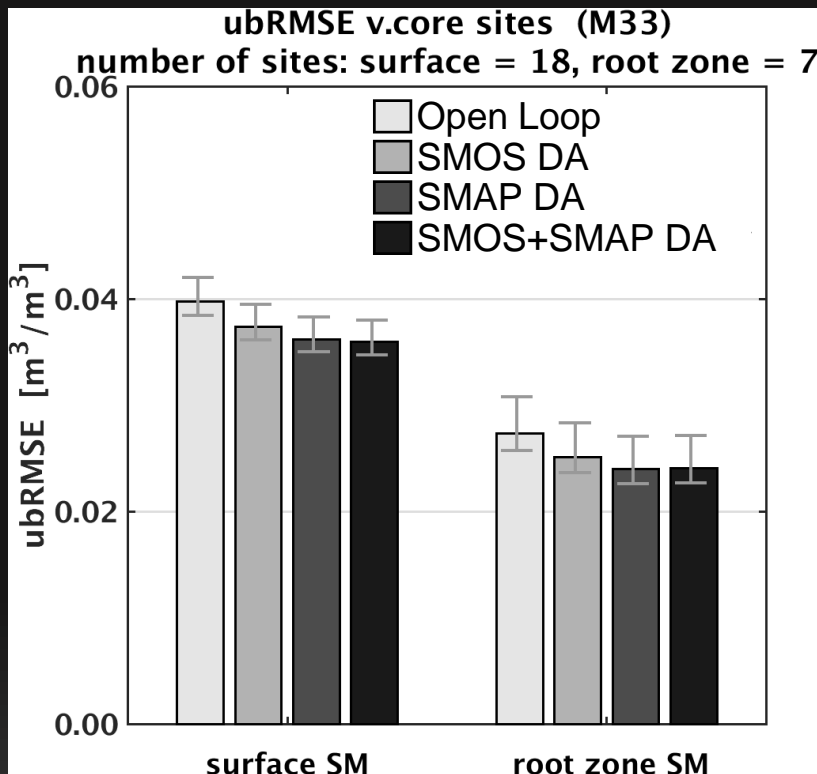
- SMOS Tb pre-processed to fixed (40°) angle (De Lannoy et al. 2015, doi:10.1109/LGRS.2015.2437612).
- SMAP L4\_SM algorithm uses SMOS Tb climatology.



# Assimilation Experiments



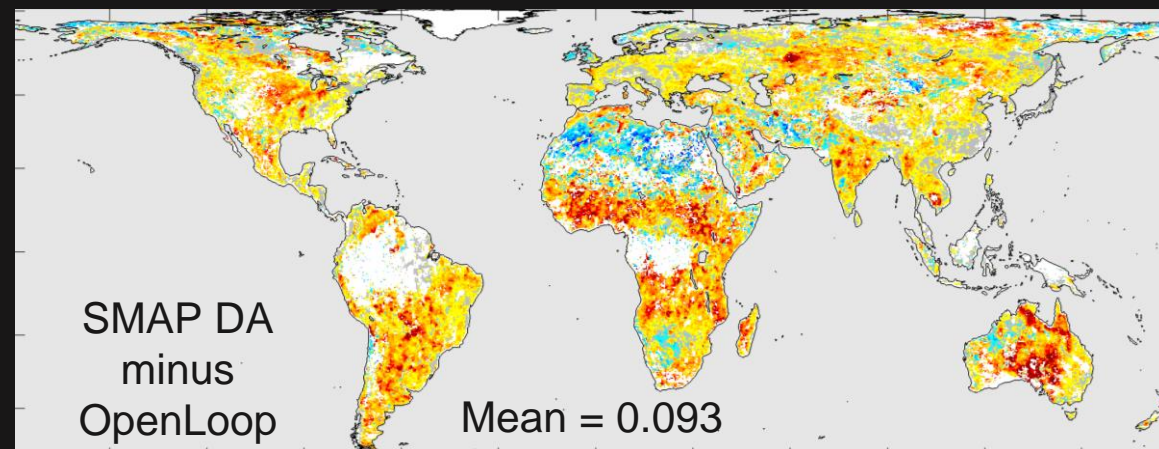
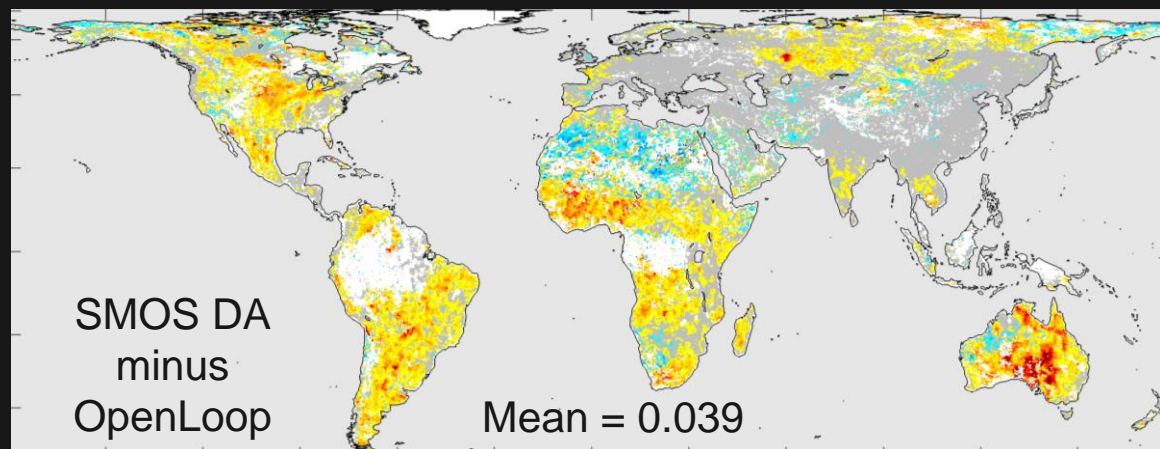
# In Situ Validation (33-km Core Sites)



- SMAP-only assimilation outperforms SMOS-only assimilation.
- Joint SMAP+SMOS assimilation only slightly different from SMAP-only assimilation.
- Performance differences among assimilation experiments are (mostly) not statistically significant at the 5% level.
- Similar results for 9-km core validation sites and sparse network sites (not shown).

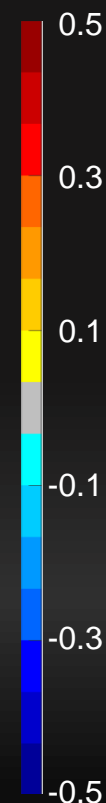
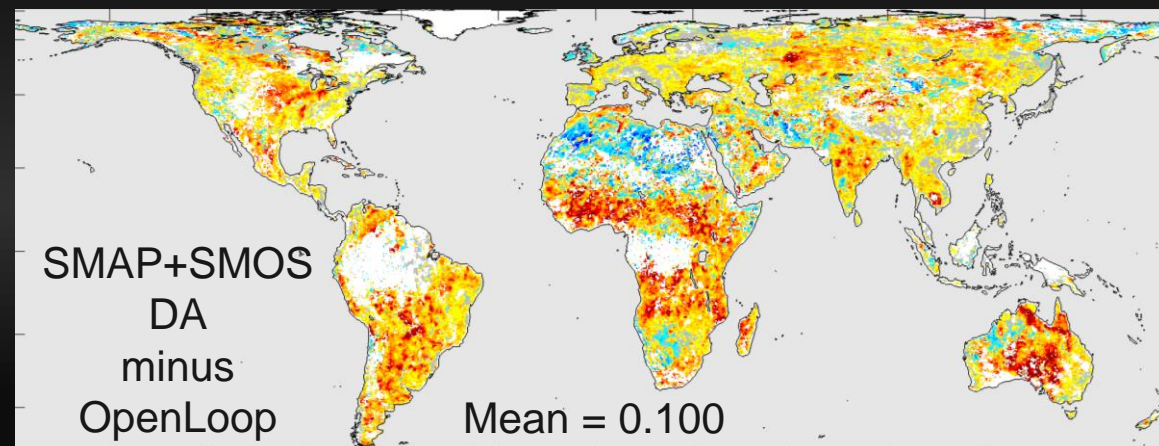
# $\Delta R_{anom}$ Surface Soil Moisture

Global skill assessment using ASCAT soil moisture and “Single Instrumental Variable” approach  
(Su et al. 2014, doi:10.1002/2013JD021043; similar results obtained using R-ratio method of Dong et al. 2019, doi:10.1029/2019GL083398).



- Screening for RFI in Eurasia limits improvements from SMOS.
- Ranking of average skill same as for in situ validation:

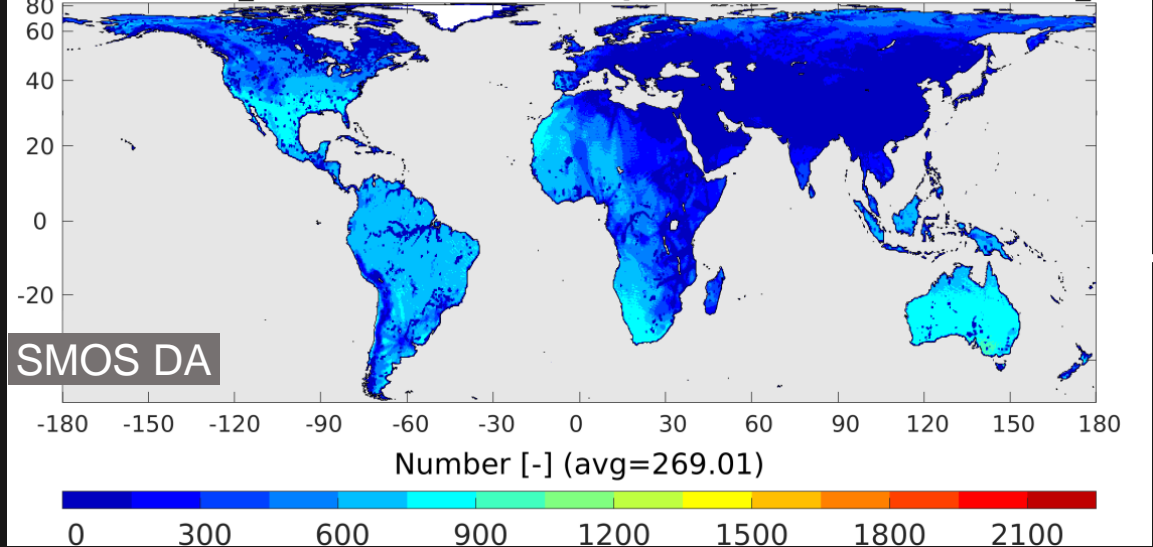
*OpenLoop < SMOS DA < SMAP DA ~ SMAP+SMOS DA*





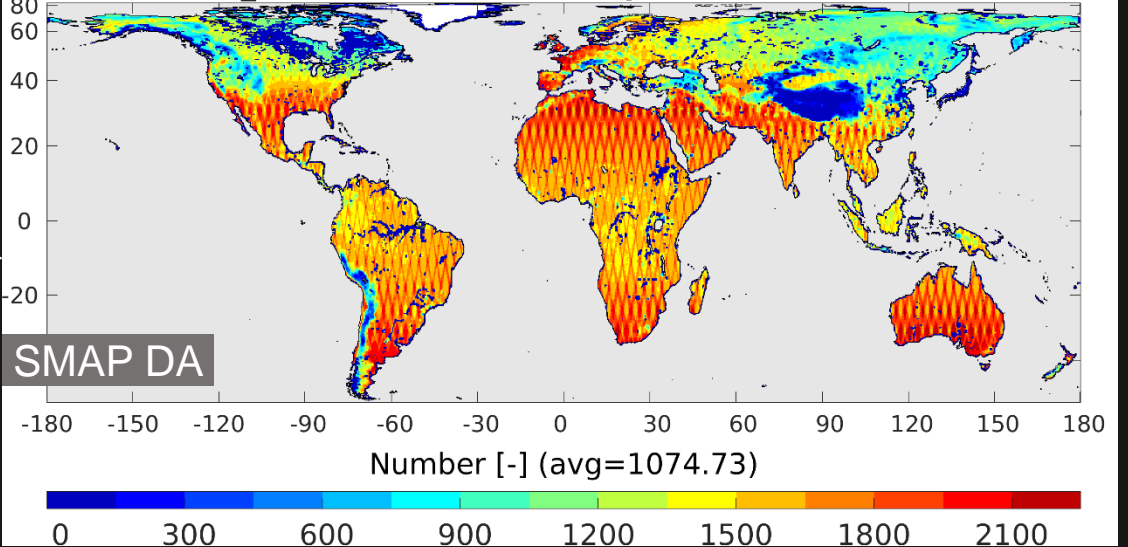
# Number of Assimilated Tb Observations

Number of L4\_SM assimilated obs Apr 2015 - Mar 2018 (SMOS\_DA)

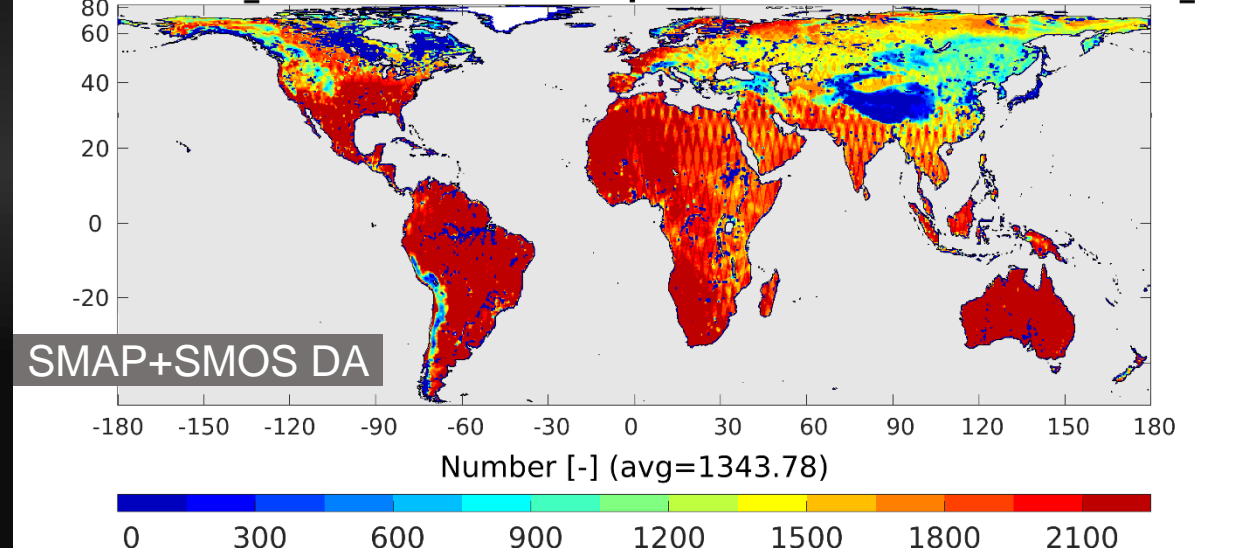


x4

Number of L4\_SM assimilated obs Apr 2015 - Mar 2018 (Vv4030)



Number of L4\_SM assimilated obs Apr 2015 - Mar 2018 (SMAPSMOS\_DA)



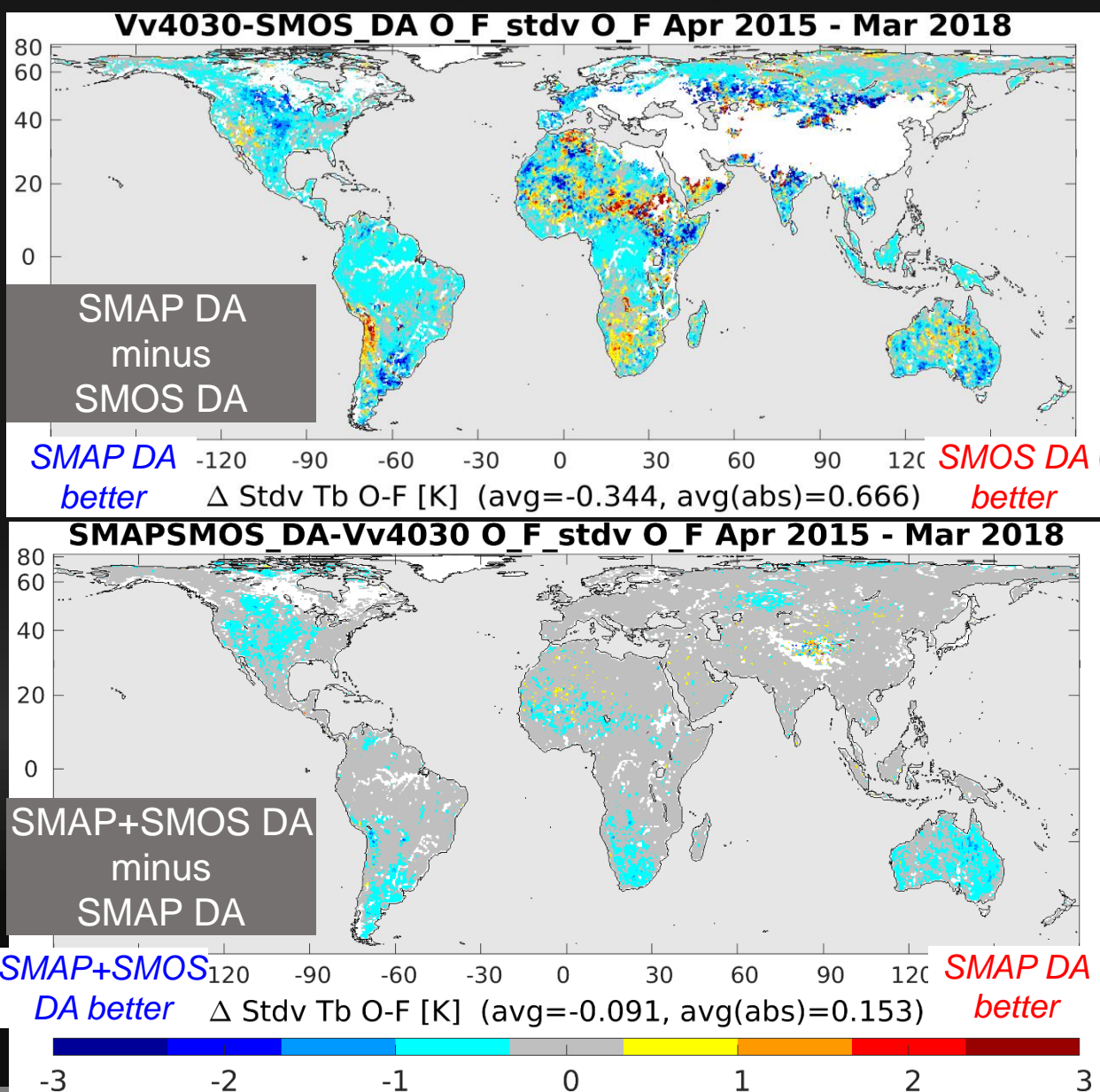
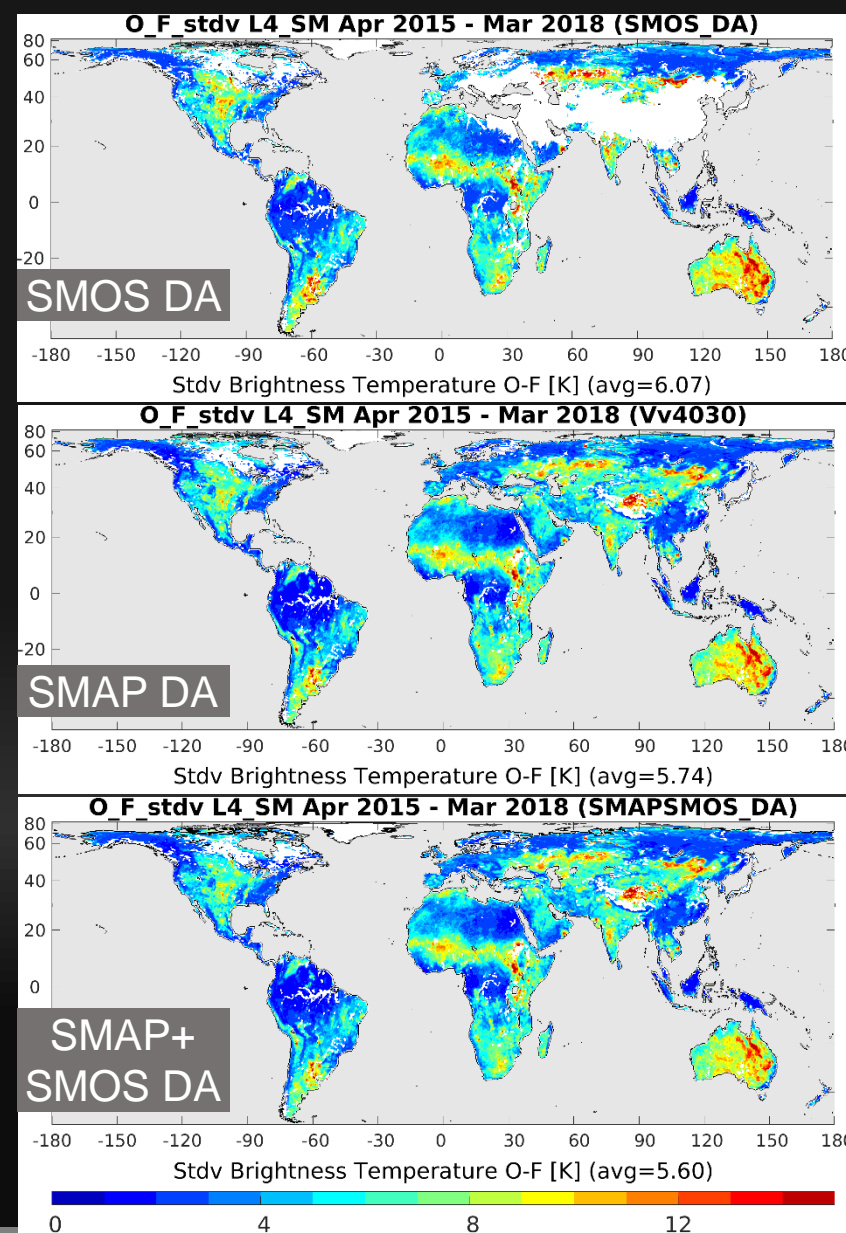
Approximately four times as many Tb obs are assimilated from SMAP than from SMOS.

**Reason:** RFI and conservative approach to SMOS pre-processing (restricted to alias-free zone).





# Tb O-F Residuals (Std-dev)



Typical magnitude of O-F residuals decreases as more observations are assimilated.

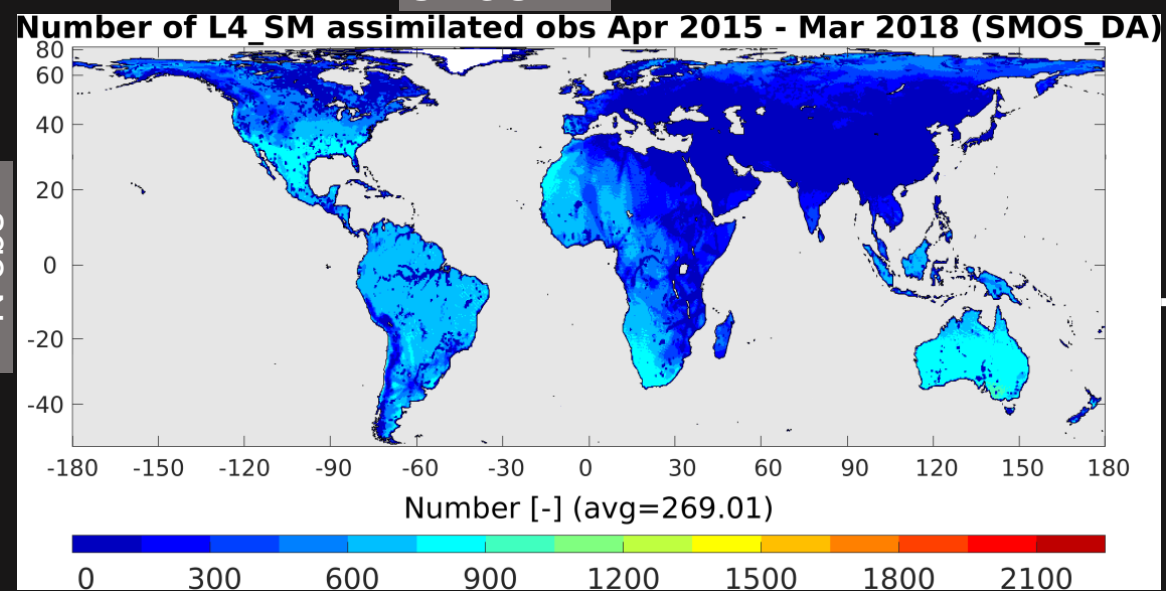


# Number of Obs & Increments

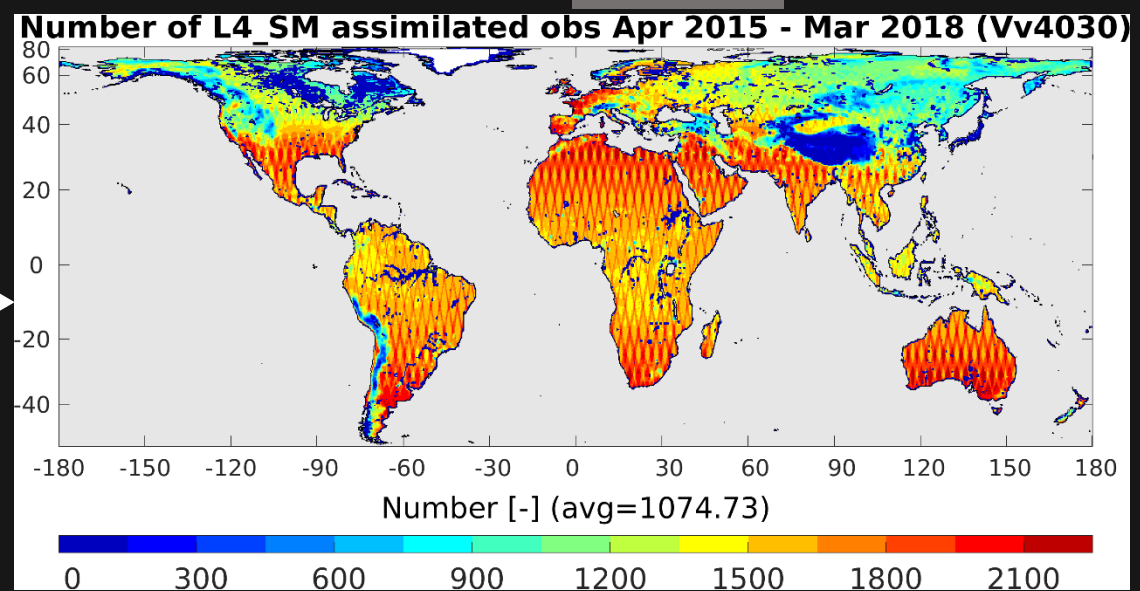
SMOS DA

SMAP DA

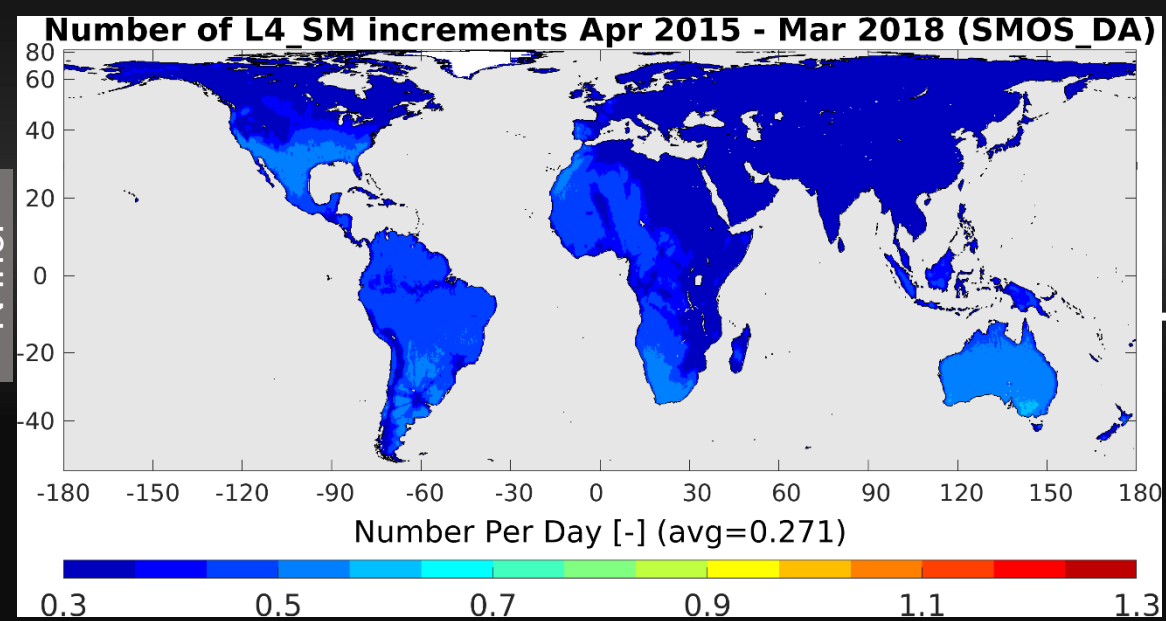
N obs



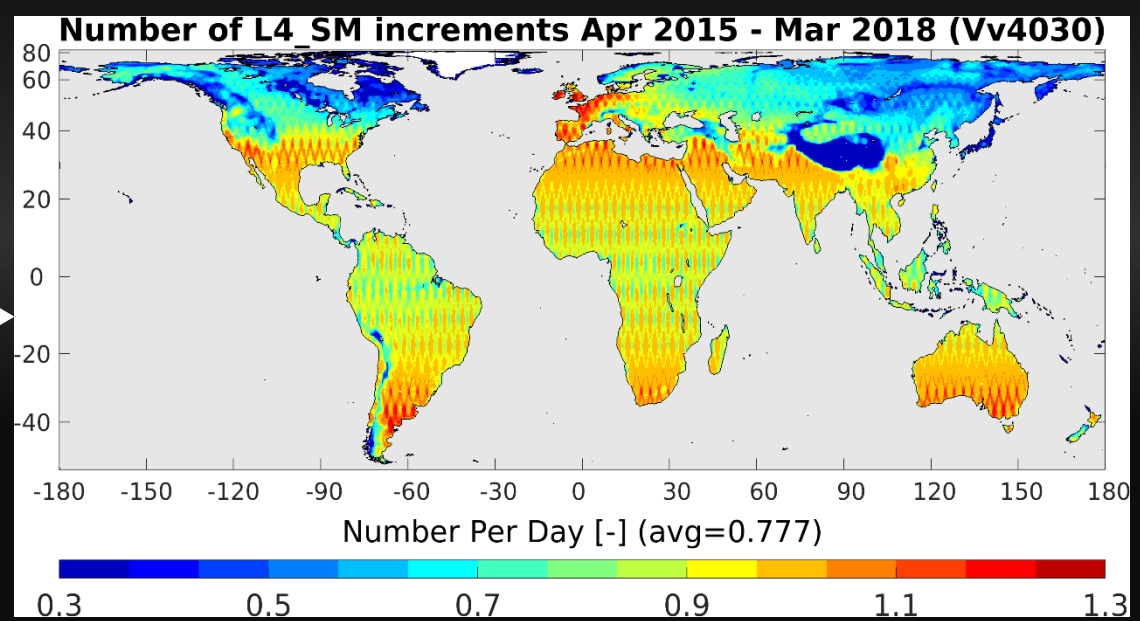
x4



N incr



x3



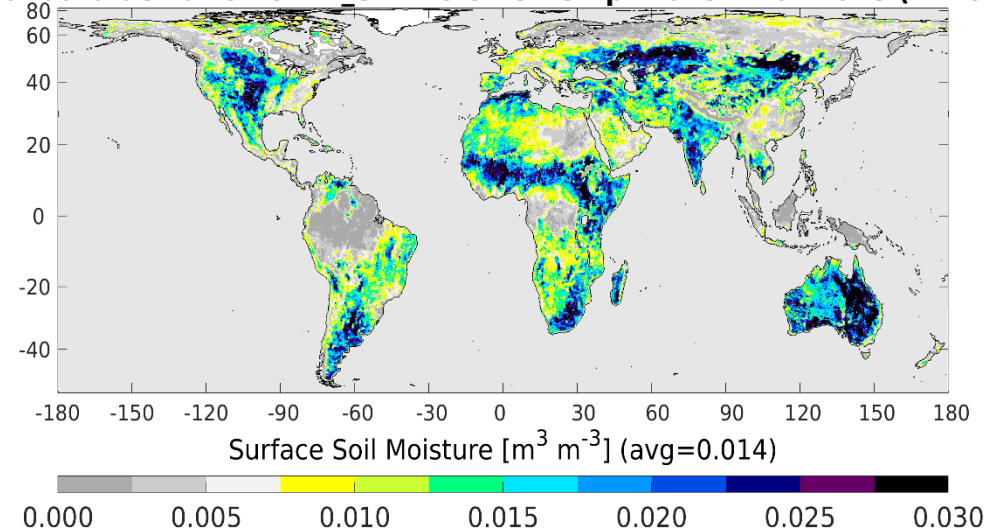




# Soil Moisture Increments (Std-dev)

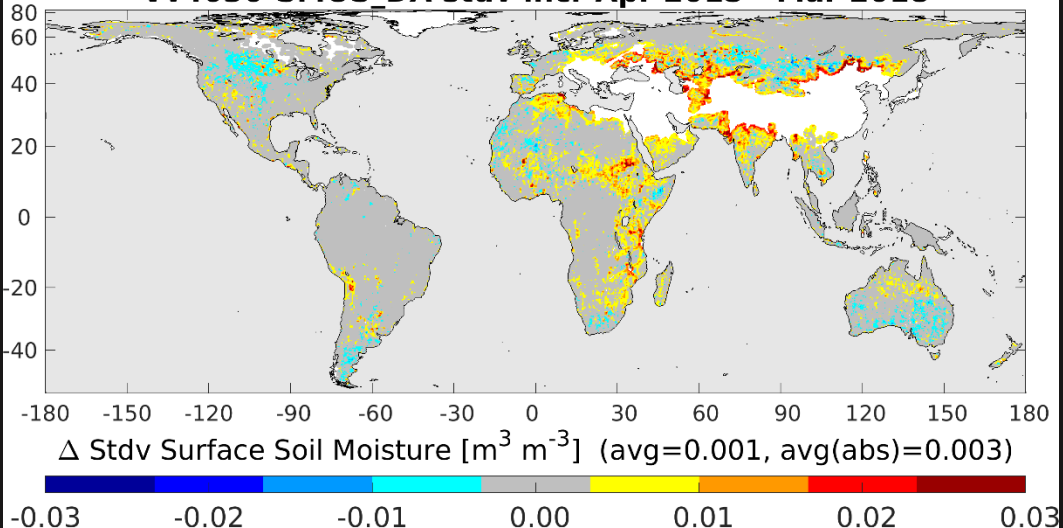
SMAP DA

Standard deviation of L4 SM increments Apr 2015 - Mar 2018 (Vv4030)

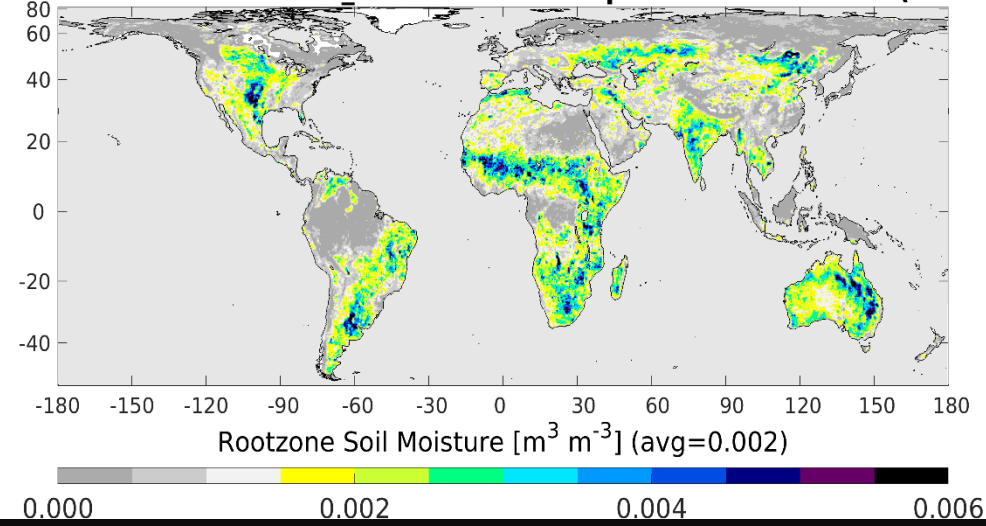


SMAP DA minus SMOS DA

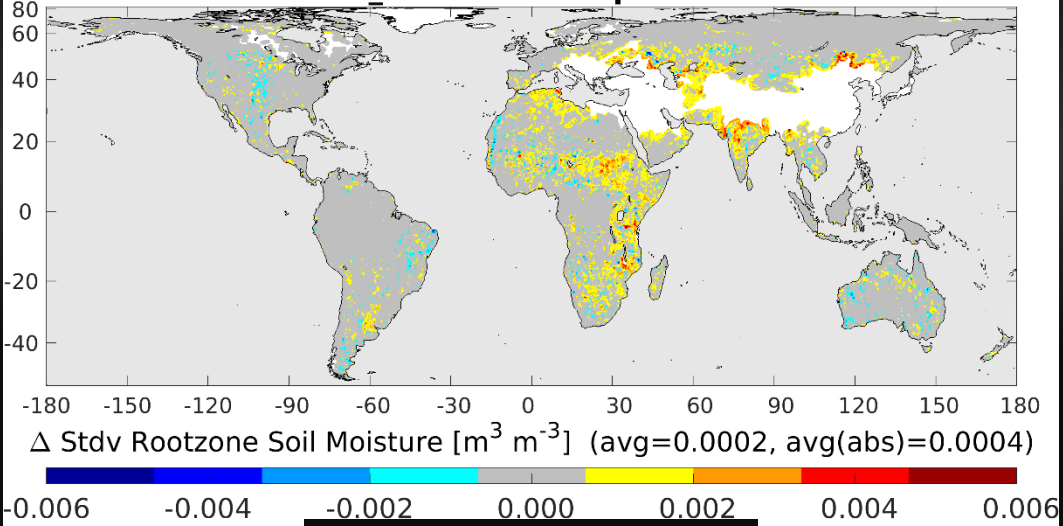
Vv4030-SMOS DA stdv incr Apr 2015 - Mar 2018



Standard deviation of L4 SM increments Apr 2015 - Mar 2018 (Vv4030)



Vv4030-SMOS DA stdv incr Apr 2015 - Mar 2018



Typical SMAP soil moisture increments are larger than those of SMOS!?

Obs and model error settings are the same for SMAP and SMOS assimilation.

Time series used to compute std-dev have different temporal support!

SMAP DA better

SMOS DA better



# Summary and Outlook

Validation vs. in situ measurements and skill improvement derived using ASCAT retrievals show that:

- SMAP-only assimilation outperforms SMOS-only assimilation.
- Joint SMAP+SMOS assimilation is only slightly different from SMAP-only DA.
- Performance differences among assimilation experiments are not statistically significant at the 5% level.

RFI-vulnerability of SMOS and our conservative approach to SMOS pre-processing limit the number of SMOS observations used and, consequently, their impact in the L4\_SM algorithm.

Add SMOS data into L4\_SM operations?

- Con: Latency and pre-processing of SMOS obs.  
Integration of SMOS into existing SMAP file specs.
- Pro: SMOS Tb assimilation ready if SMAP data become unavailable.



# Multi-Week SMAP Outage (Jun/Jul 2019)

