Assessing Version 4 of the SMAP L4_SM Data Product

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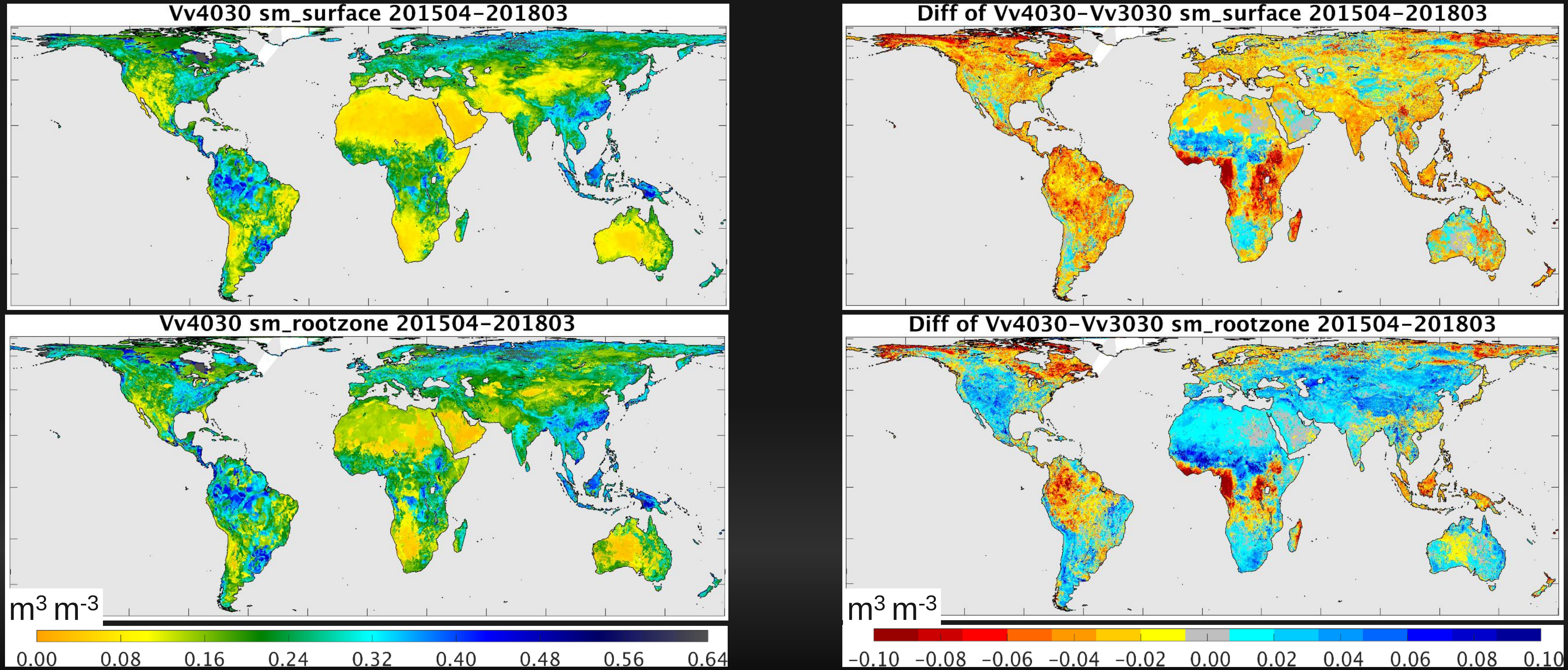
Outline

1. Overview and Status
2. Soil Moisture Validation
3. Water Balance and Runoff Validation
4. Summary

Soil Moisture Climatology



Climatological surface & root zone s.m. are different in V4 (unlike in V3).

Do not mix V3 and V4!

In V4, surface s.m. is generally drier and root zone s.m. wetter than in V3.

In Africa & high lats, V3 and V4 soil moisture different because of precipitation differences.

What's New in Version 4?

Key <u>model changes</u> in L4_SM Version 4 ("NRv7.2") w.r.t. Version 3 ("NRv4.1"):

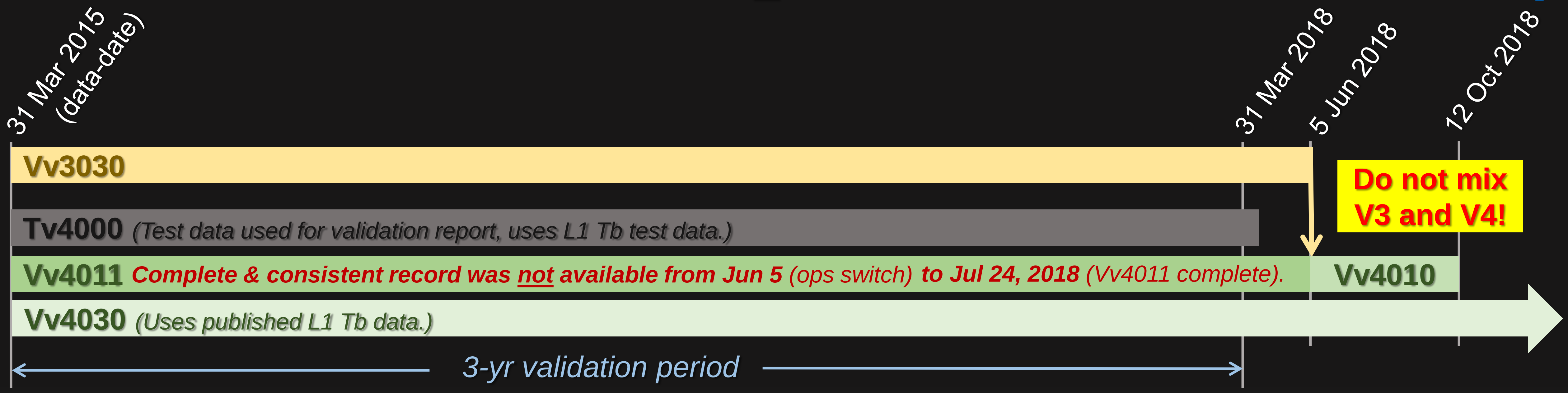
1. New parameters for topography (SRTM), land cover (Globcover), and tree height (Lidar).
2. Revised upward soil moisture recharge from root zone to surface excess reservoir.
3. Climatological rescaling of *background* precipitation to GPCPv2.2 (impacts L4_SM forcing where precipitation is not corrected with CPCU observations).
4. Retrospective forcing (for algorithm calibration and climatology) based on MERRA-2.
5. Minor revisions to surface energy balance and snow depletion curve.

Key <u>Tb analysis changes</u> in L4_SM Version 4 w.r.t. Version 3:

- Assimilated SMAP Tbs generally warmer by a few K owing to new L1 calibration.
- Removed "catdef" model prognostic variable from EnKF state vector.
- Tb scaling parameters based on longer data records (8 yrs of SMOS, filled with 3 yrs of SMAP).

New metadata ("projection coordinates") facilitate easier use with some applications (e.g., ArcGIS).

Recent L4_SM Streams



L4_SM Stream	Description	L1C_TB Inputs	Data Period	Production Status (Completion Date)
Vv3030	Version 3	R14/15 ops	31 Mar 2015 – 5 Jun 2018	complete (Jun 5)
Vv4010	Version 4 (initial ops)	R16 ops; OASIS test data for Tb scaling	5 Jun 2018 – 12 Oct 2018	complete (Oct 12)
Vv4011	Prelim. Version 4 repr.	R16 OASIS test data	31 Mar 2015 – 5 Jun 2018	complete (Jul 24)
Vv4030	Version 4	R16 reprocessing + ops	31 Mar 2015 – …	ongoing

Note: Tv4000, Vv401x and Vv4030 are identical in terms of science quality.

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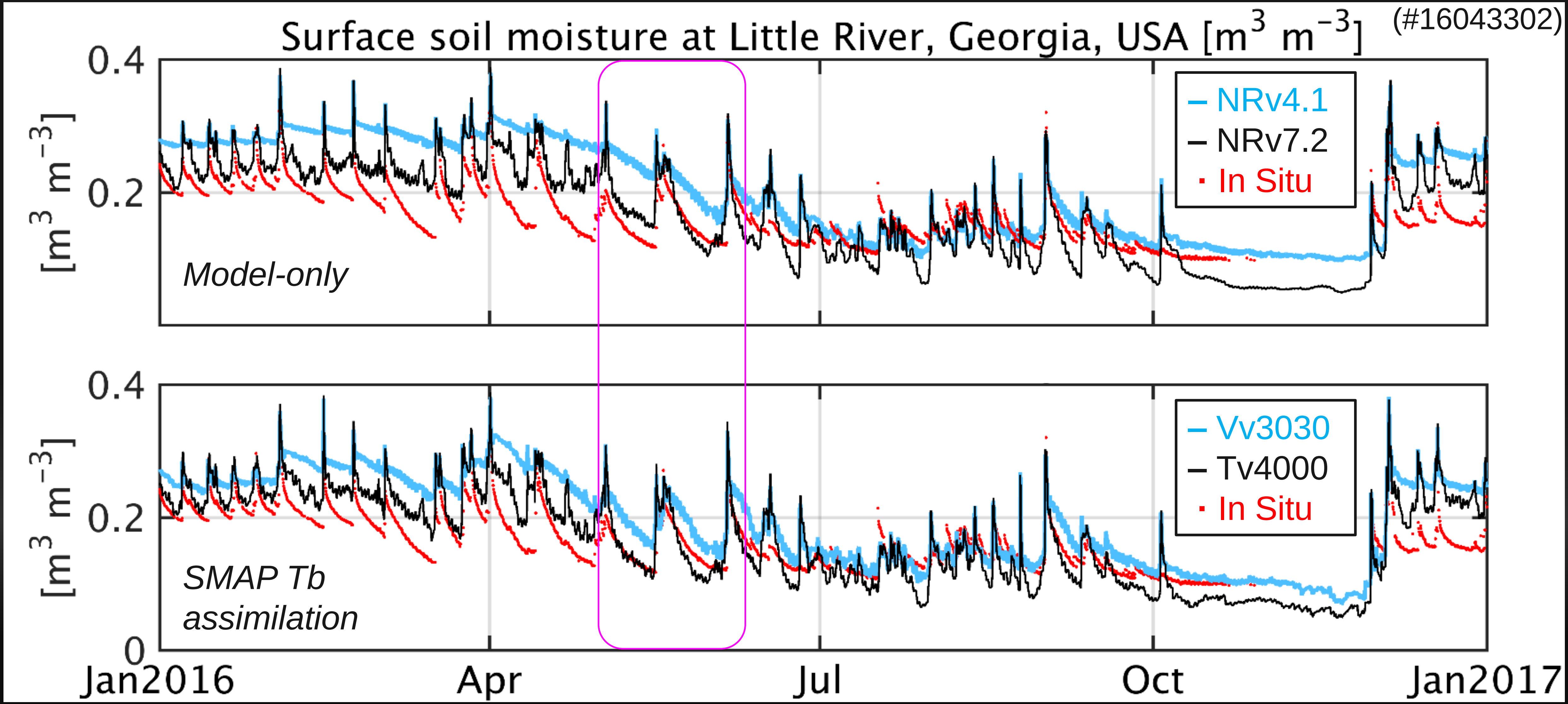
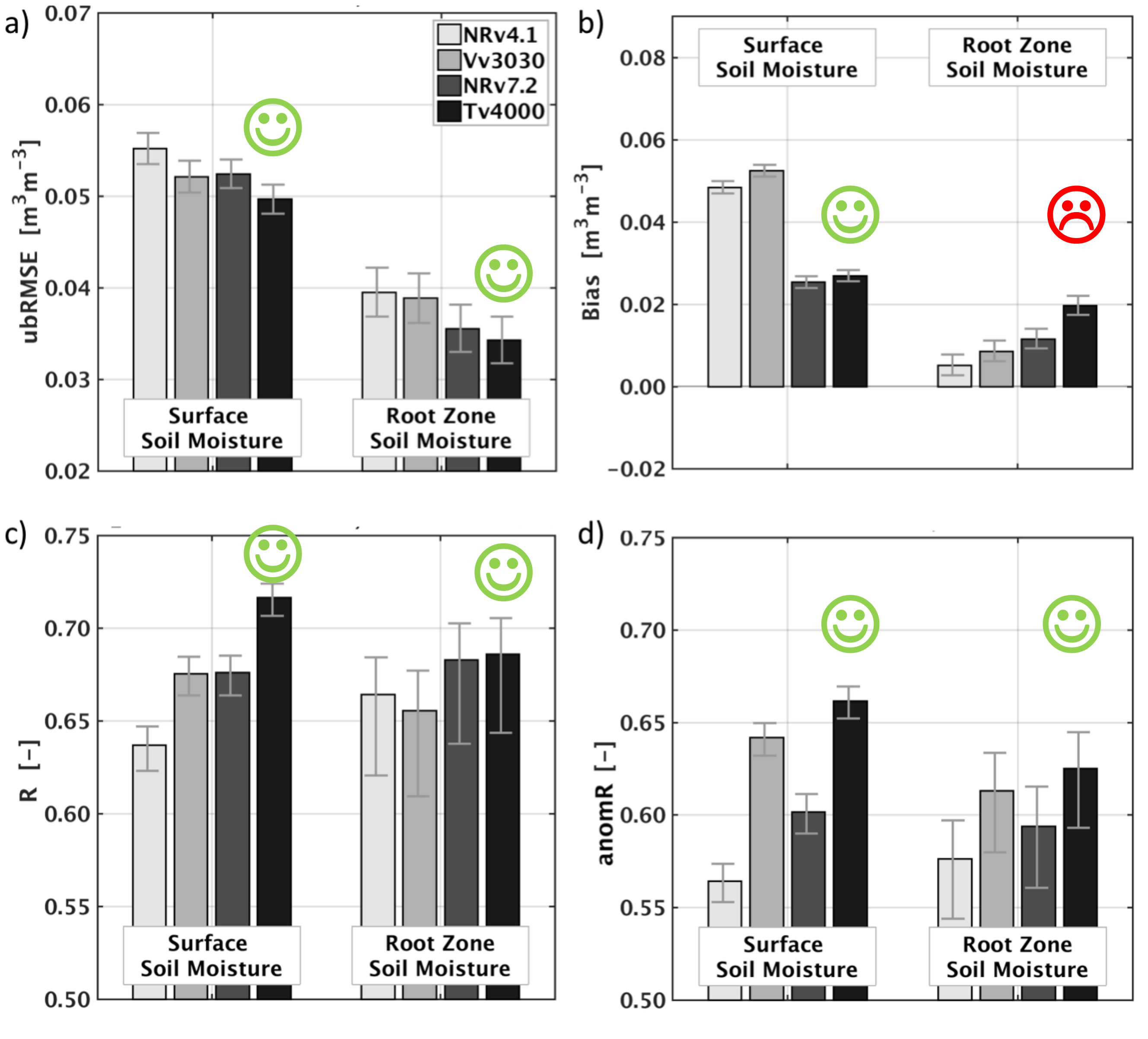
Calibration of Upward Soil Moisture Recharge



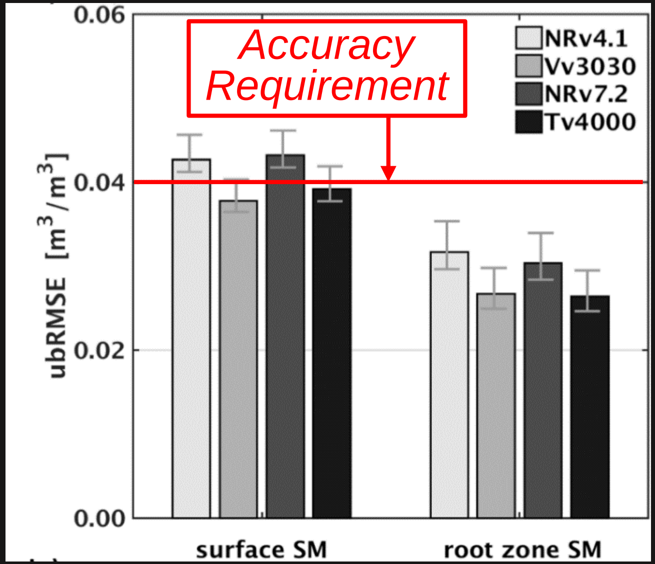
Sparse Network "Validation"

Improved skill vs. sparse network data…

… which were used to calibrate the model.



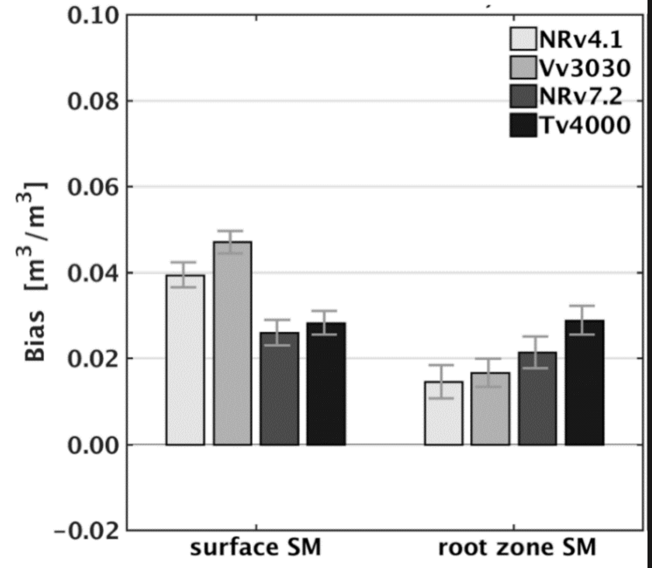
Core Site Validation (9-km reference pixels)

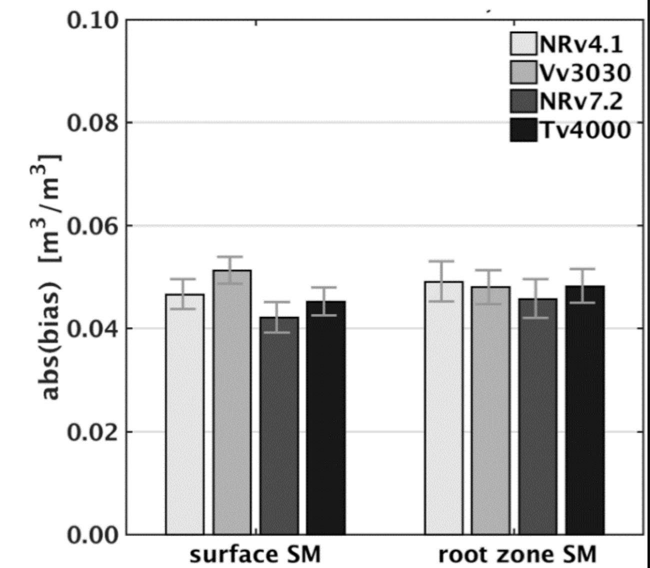


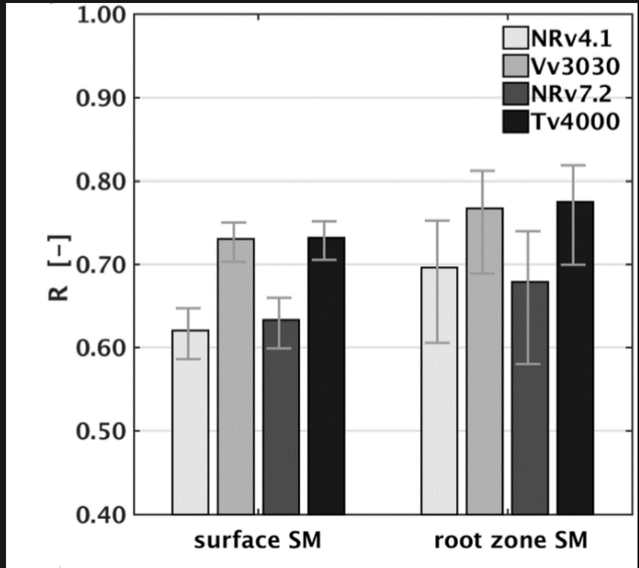
Version 4 meets accuracy requirement.

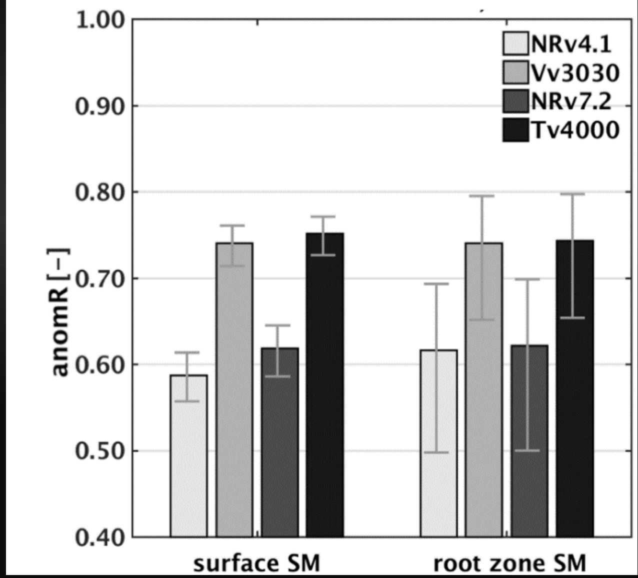
On balance, V4 skill and improvements over model-only simulation are similar to those of V3.

Similar results for 33-km reference pixels.

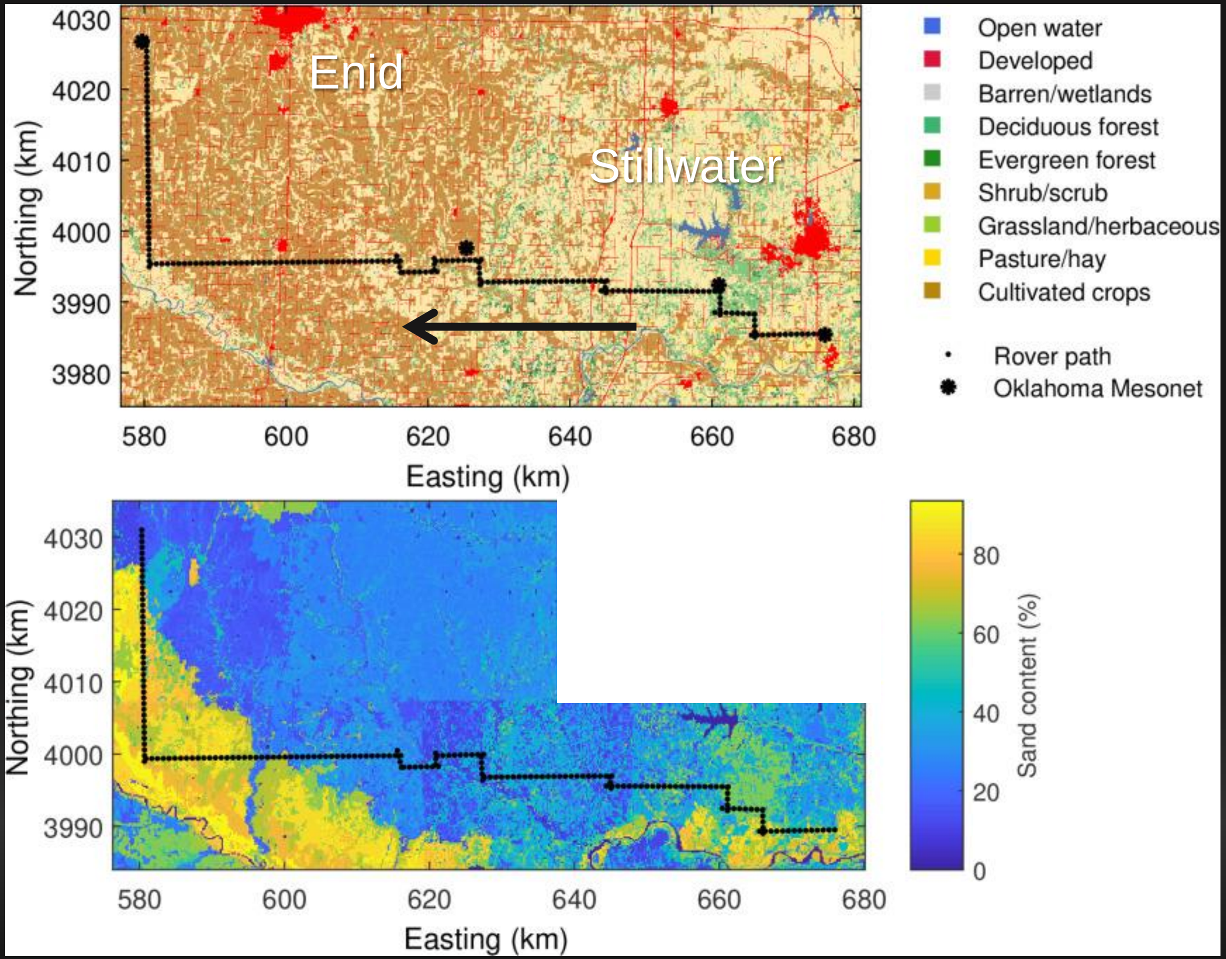








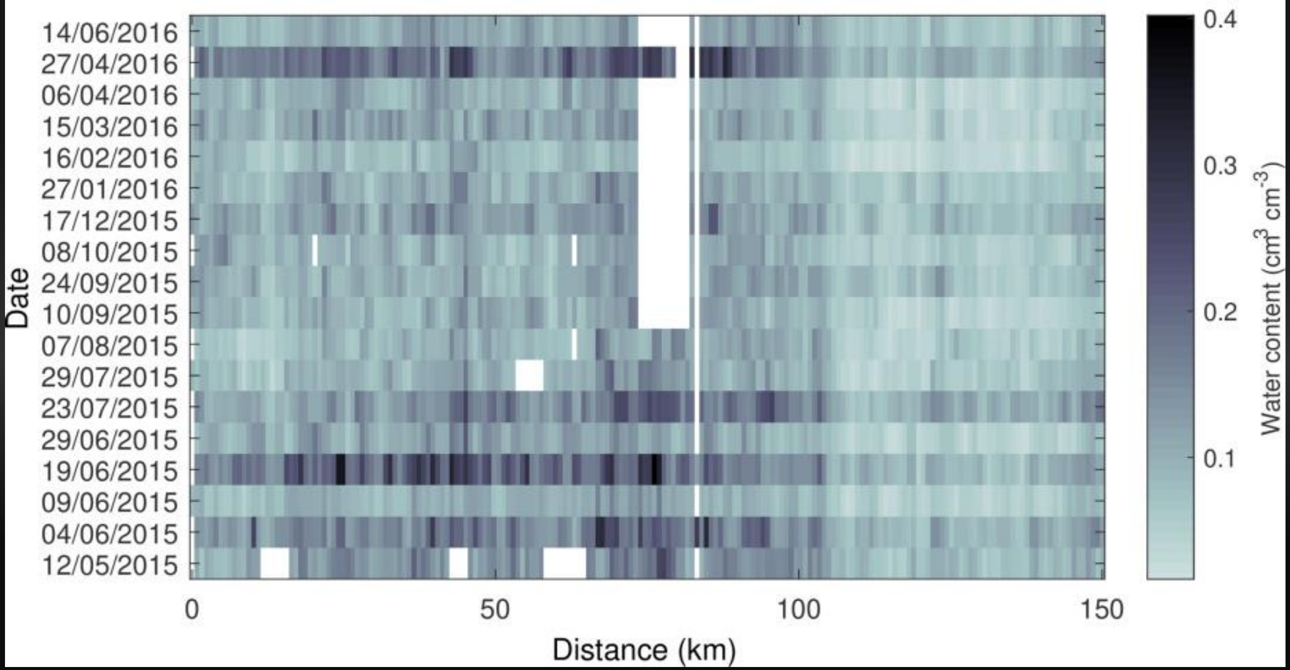
COSMOS Rover Transects



Dong & Ochsner, WRR, 2018

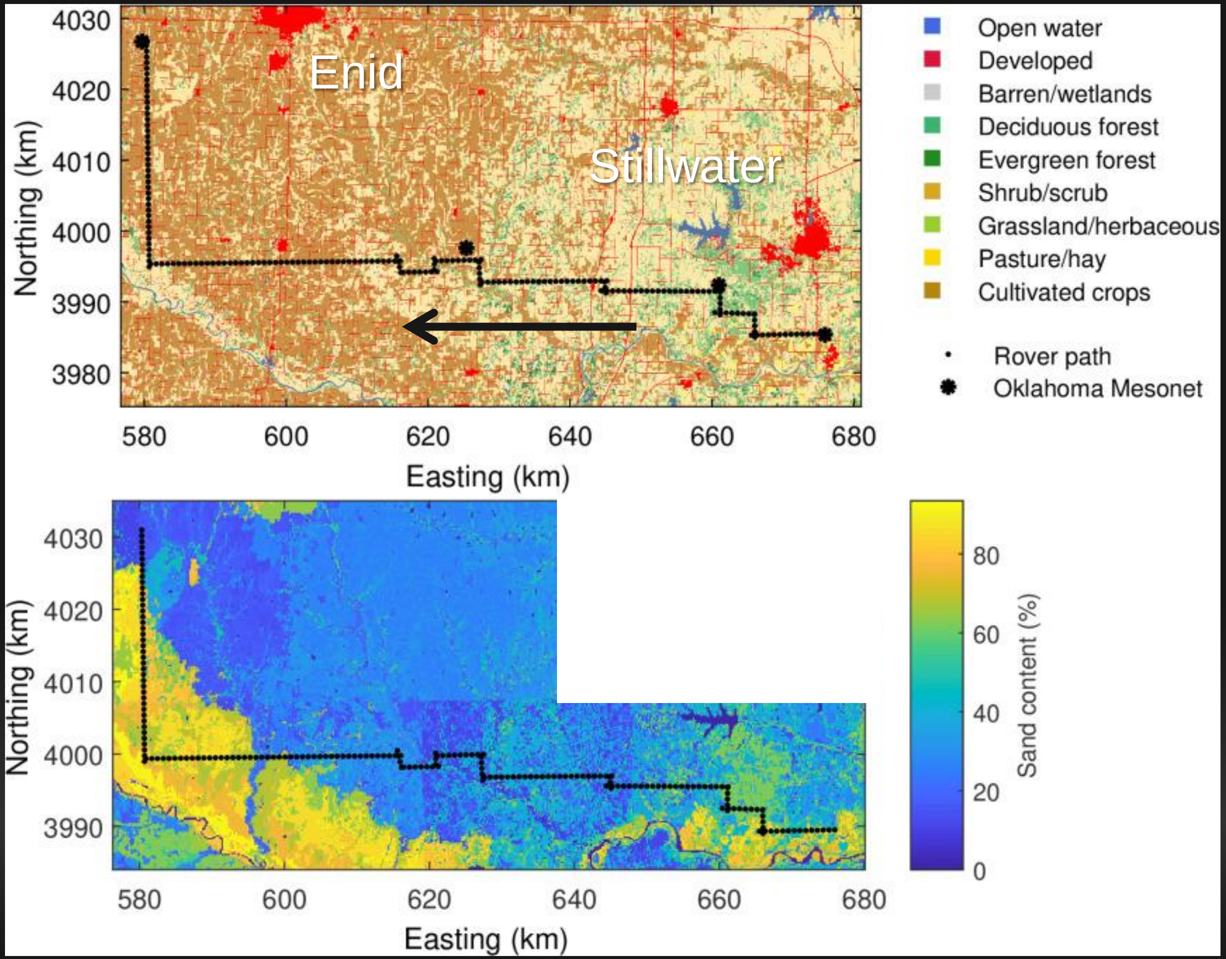
doi:10.1002/2017WR021692

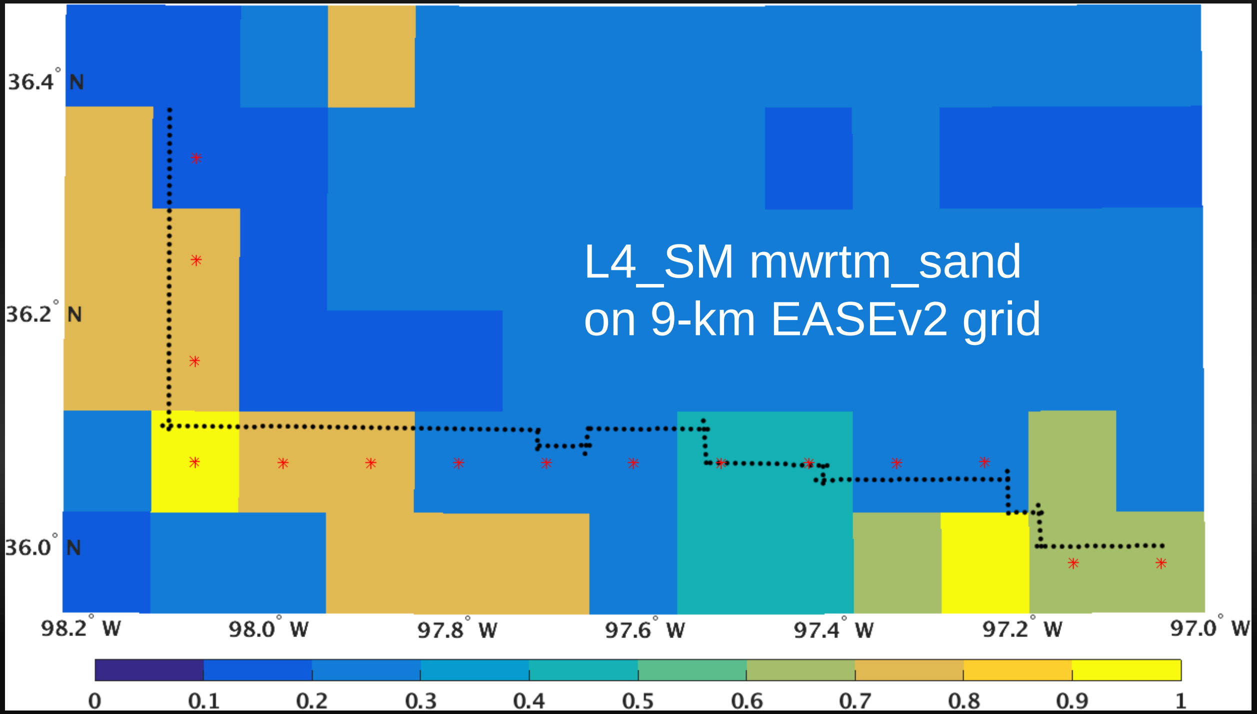
[L]and surface characteristics […] often exert a stronger influence than do precipitation patterns on mesoscale spatial patterns of soil moisture.



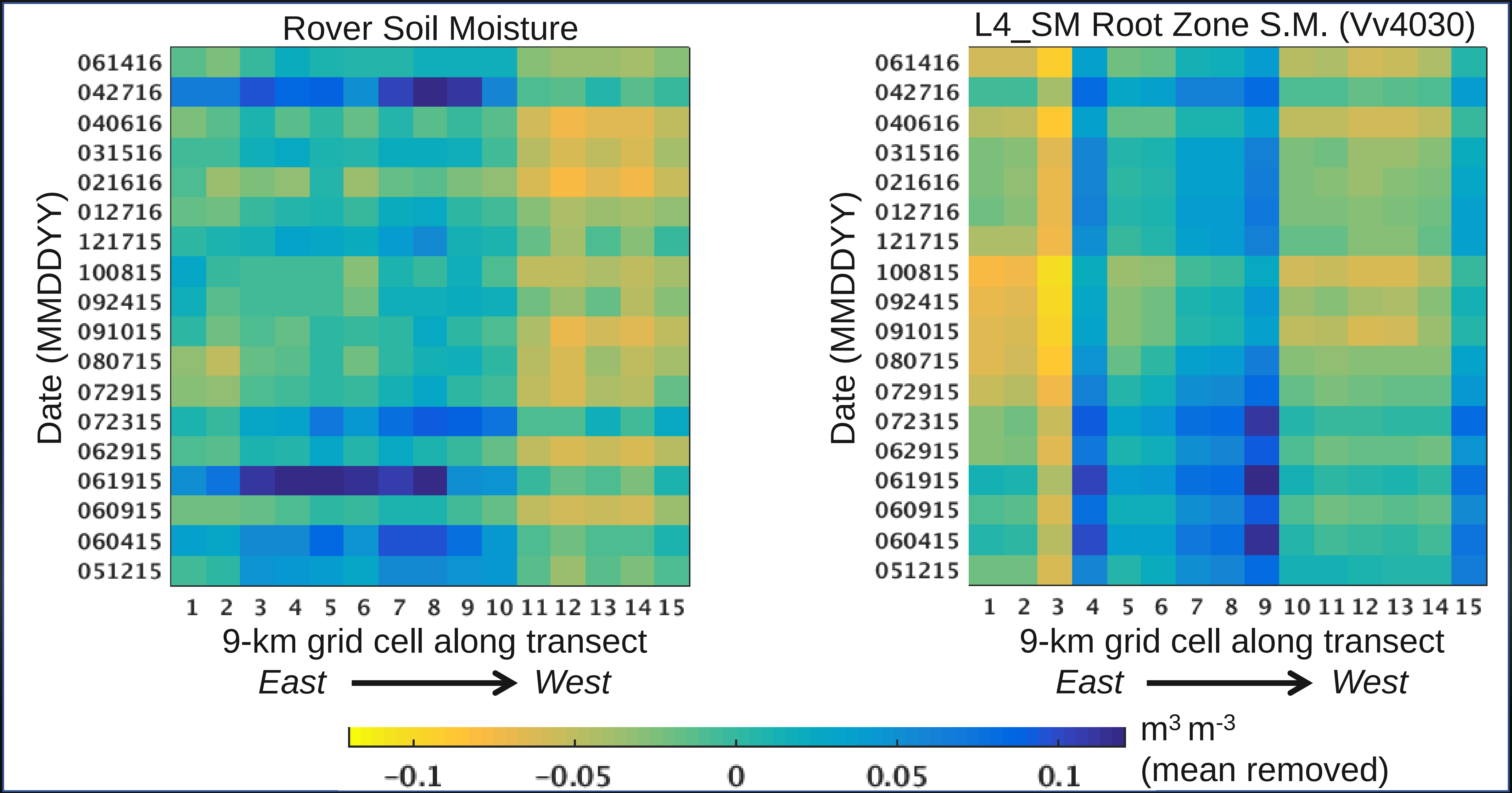
Soil moisture obs from truck-mounted neutron probe, 18 transects (~150 km) in northern Oklahoma between May 2015 and Jun 2016

COSMOS Rover Transect





COSMOS Rover Transect



L4_SM captures main rainfall events and larger-scale texture-driven pattern.

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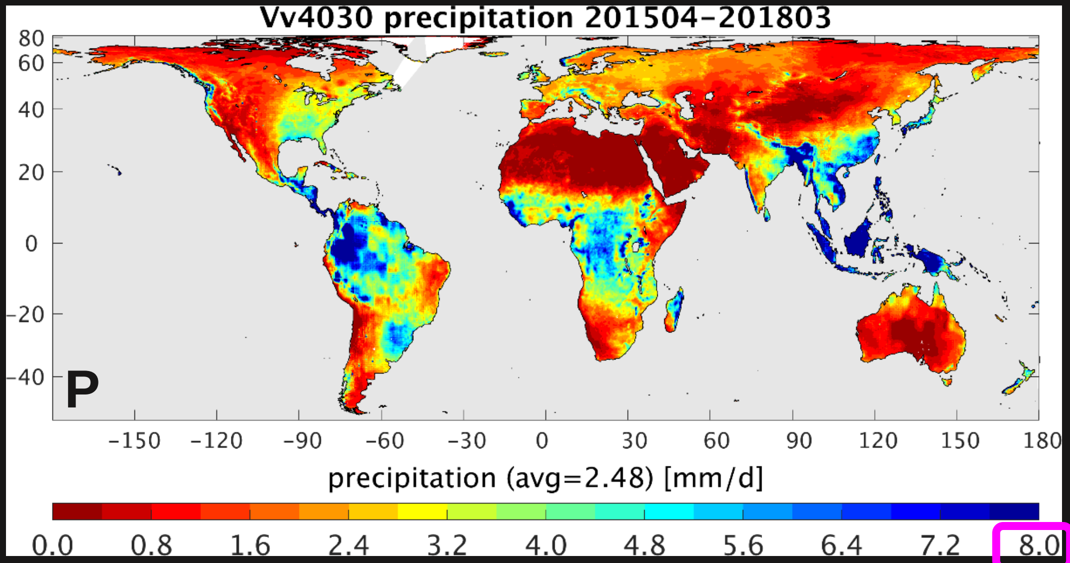
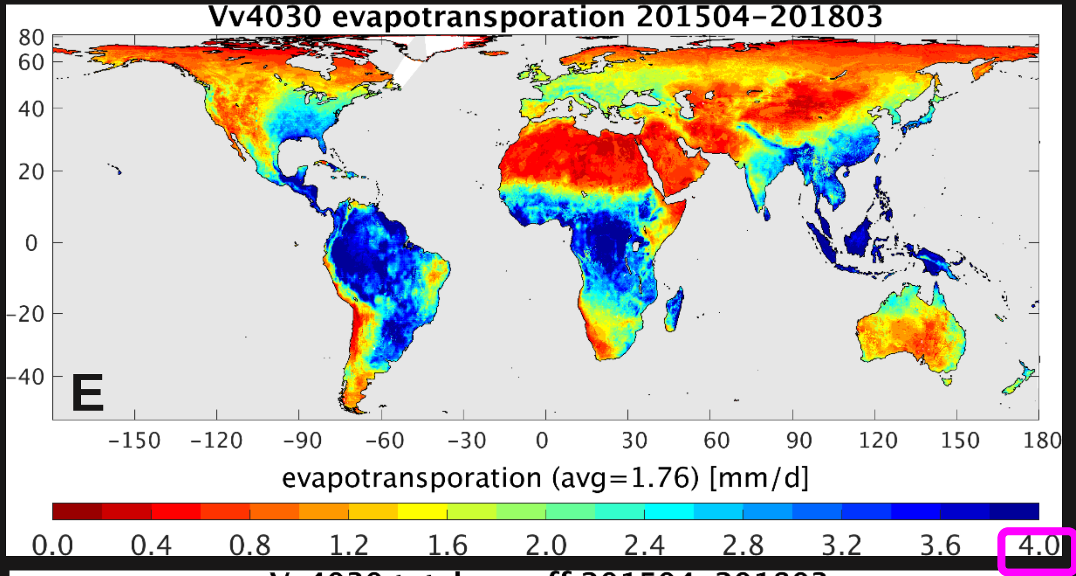
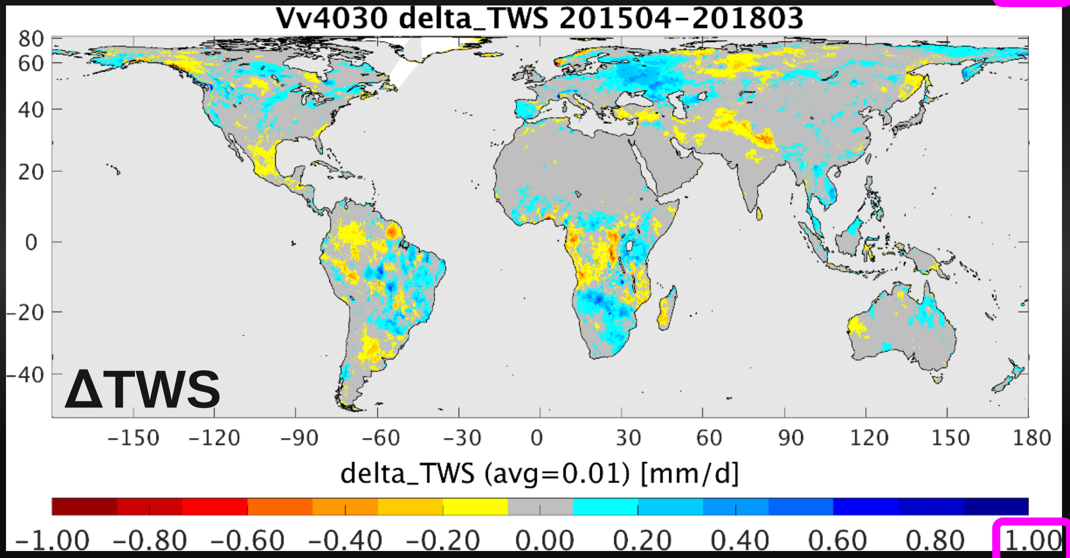
Water Balance (Vv4030)



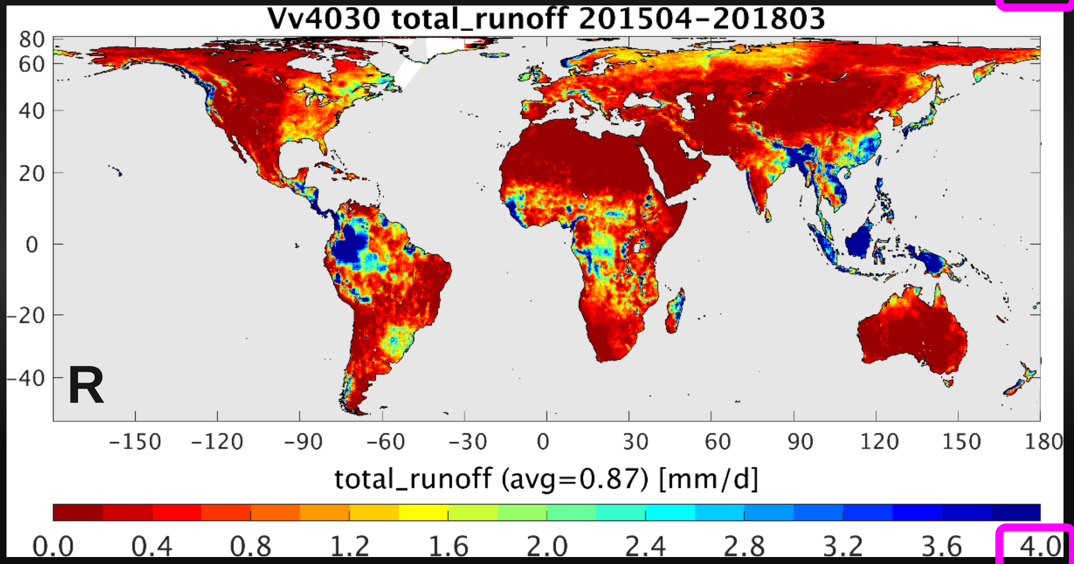
P =
2.48 mm/d



E/P = 0.71

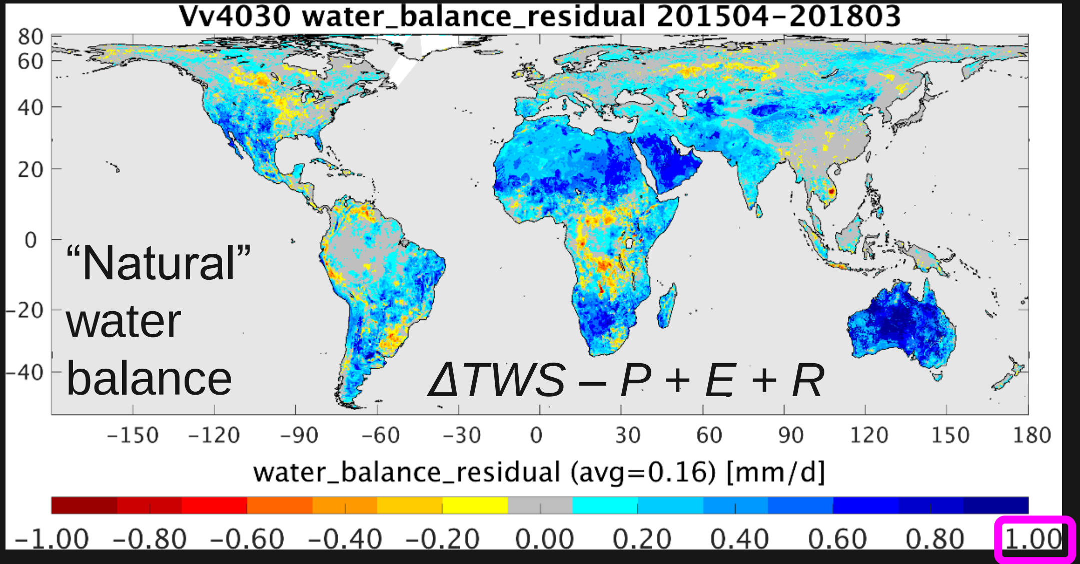


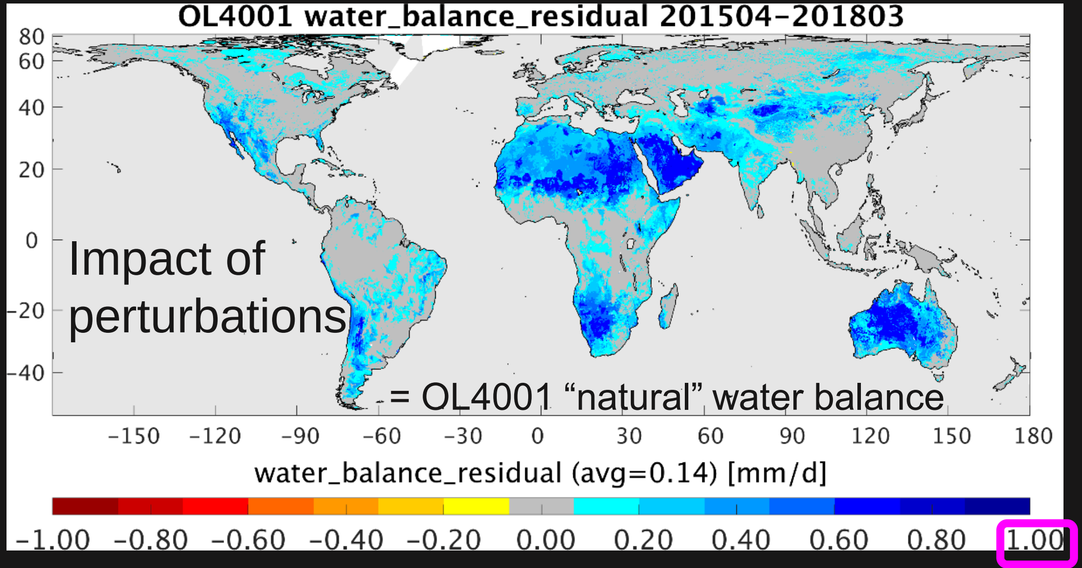
R/P = 0.35

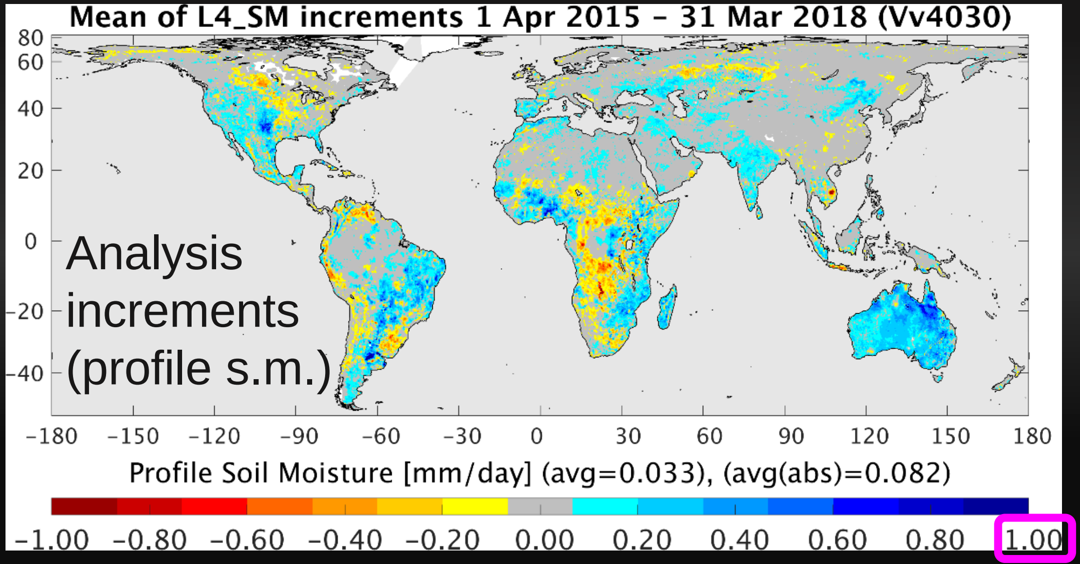


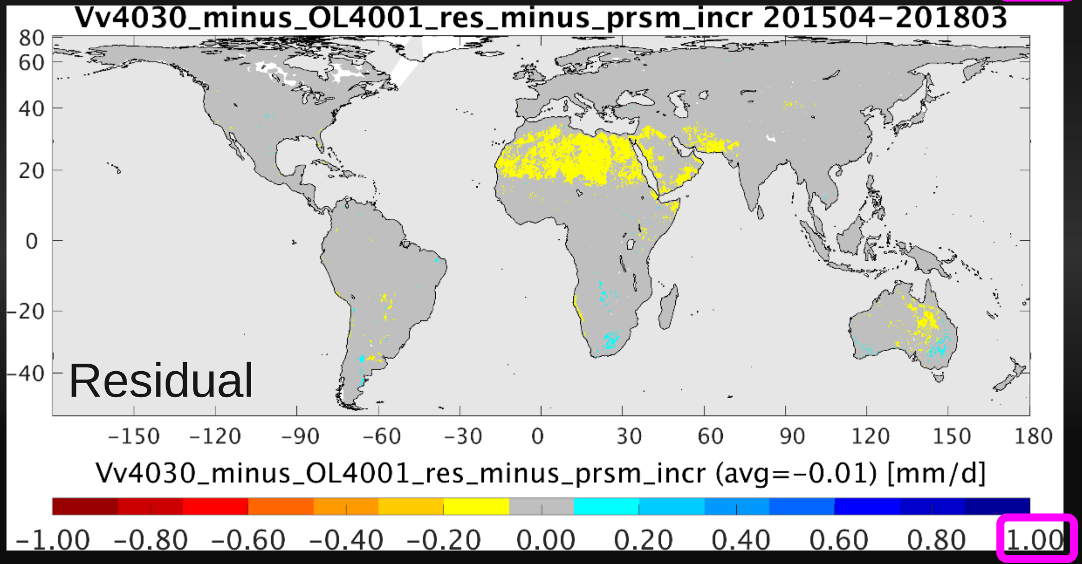
"Natural" water balance does NOT close: $\Delta TWS - P + E + R \sim 0.16$ mm/d

Water Balance (Vv4030)



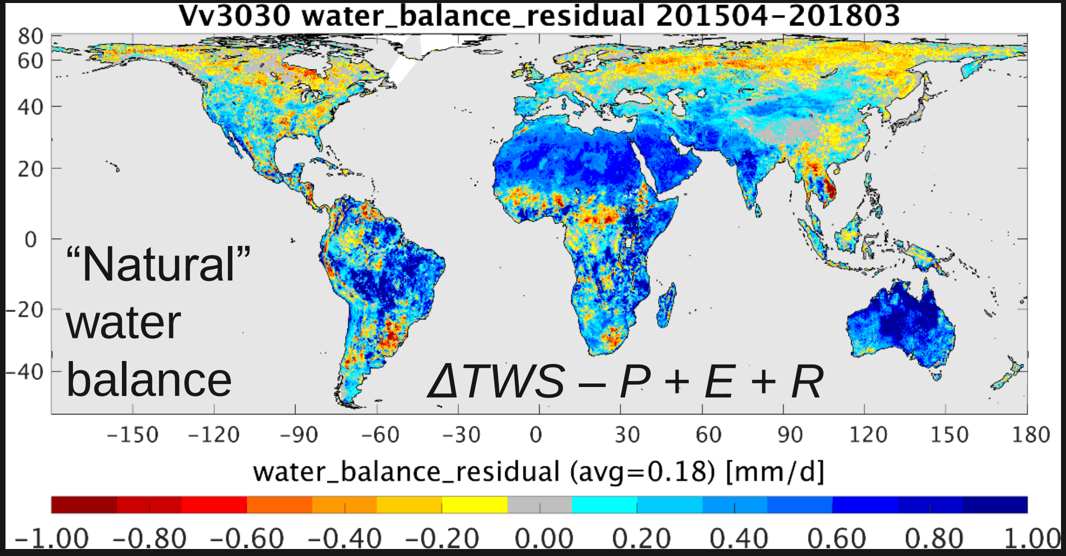


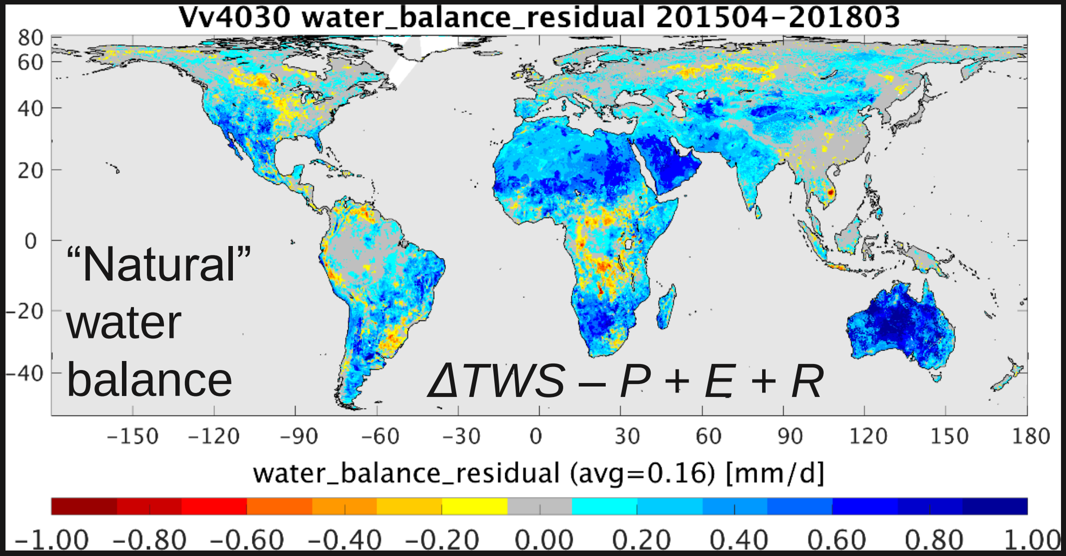


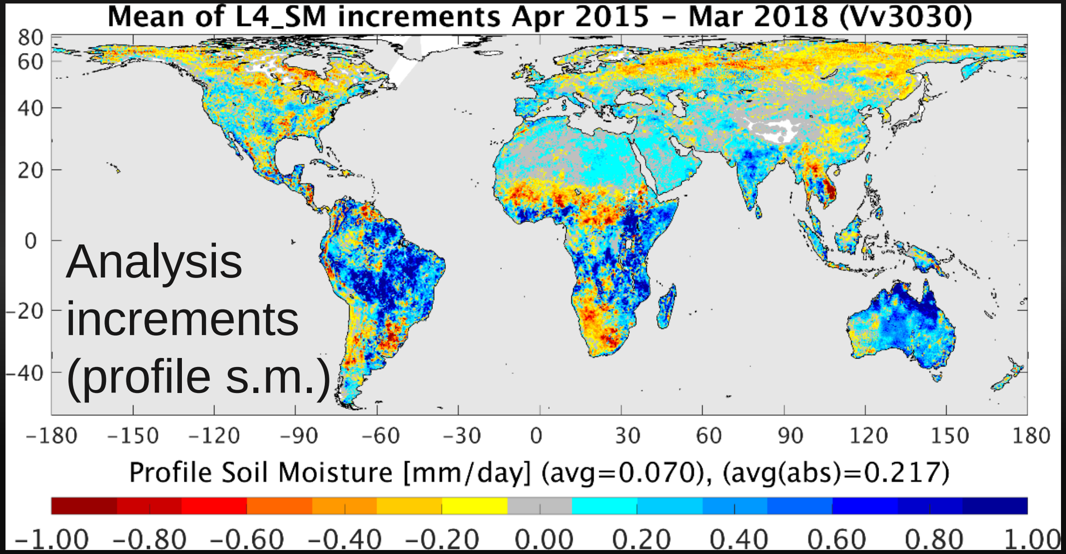


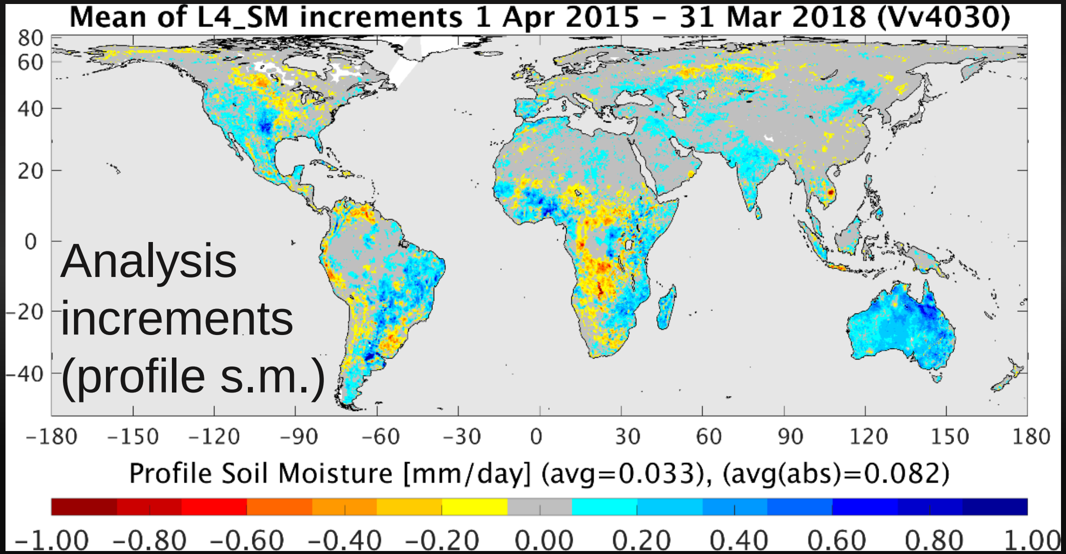
Water balance (nearly) closes after considering analysis increments <u>and</u> impact of perturbations.

Water Balance (Vv3030 vs. Vv4030)





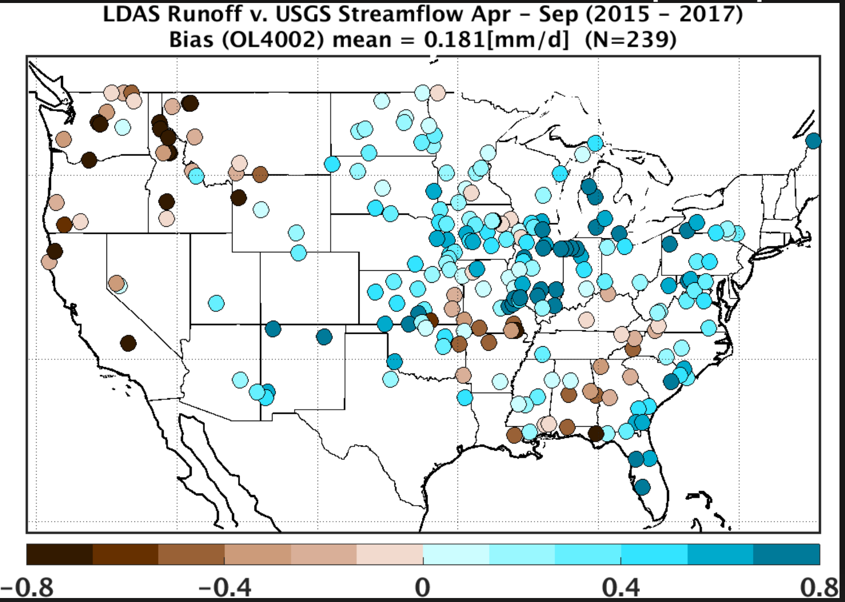




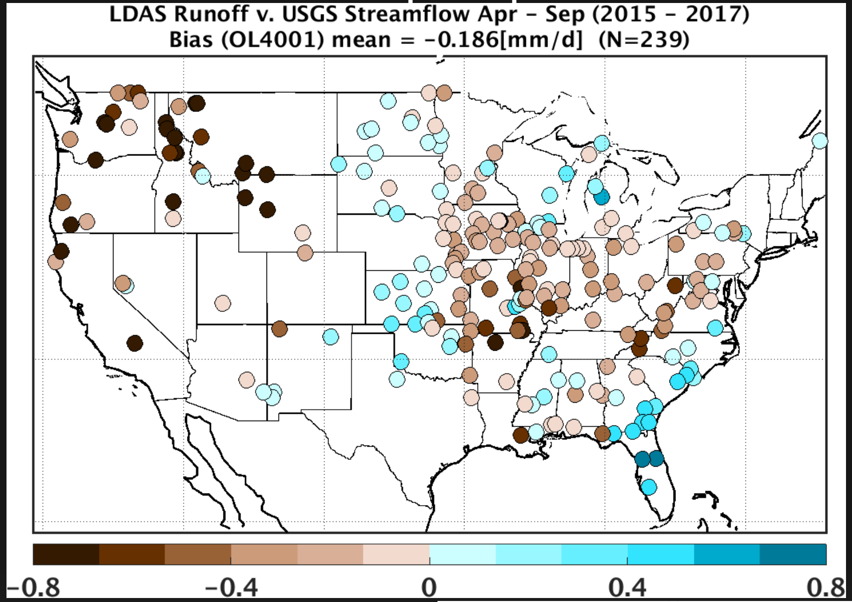
Version 4 has smaller “natural” and increments imbalances than Version 3.

Runoff Validation (Bias)

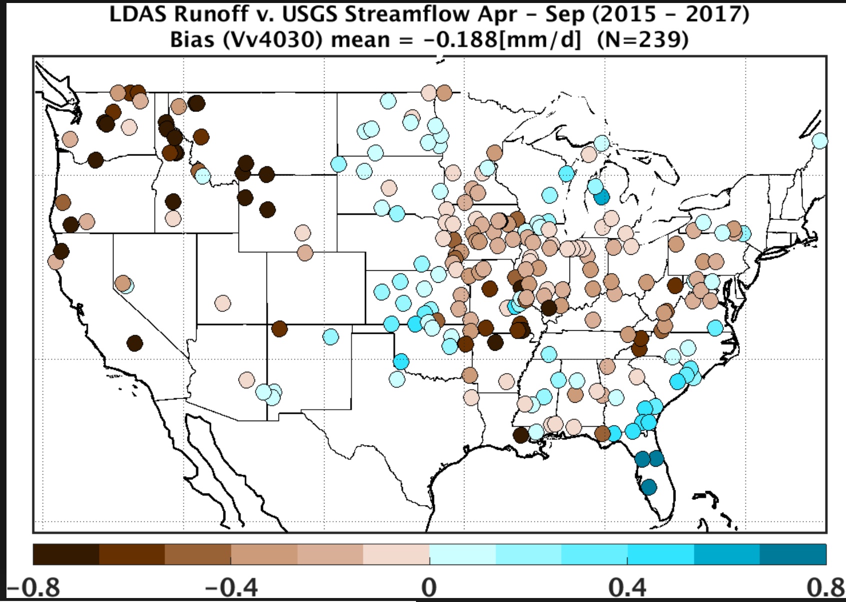
Catchment model w/ GEOS precip.



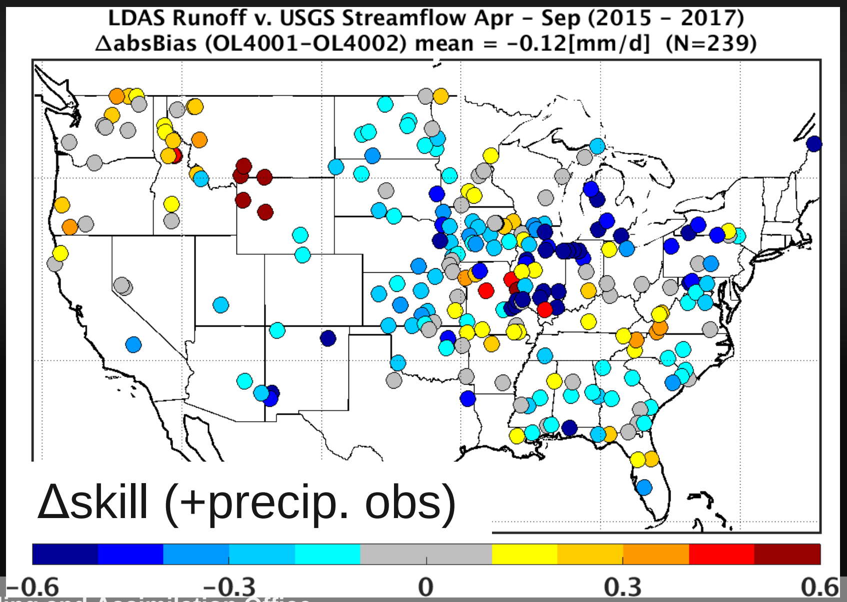
+ CPCU precip. obs

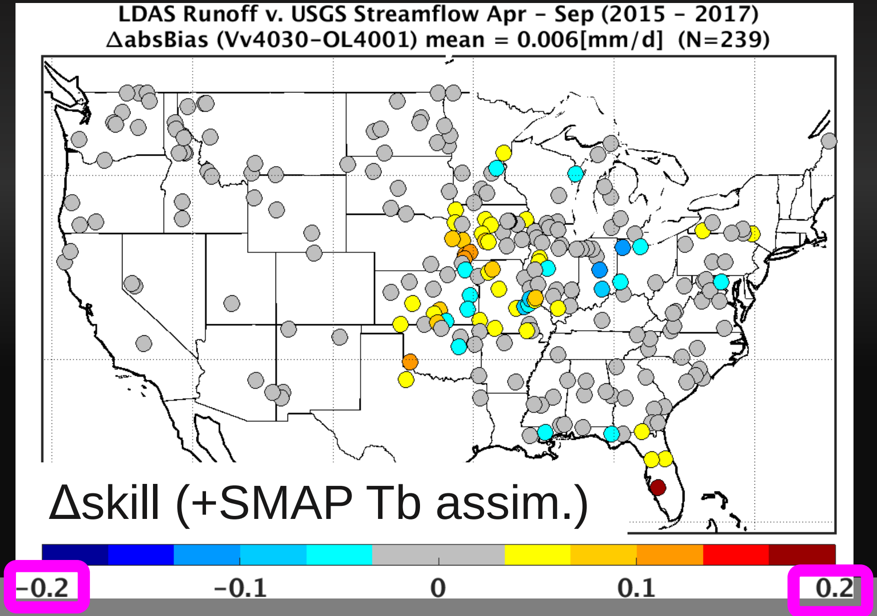


+ SMAP Tb assim.



Observed precip reduces average absolute bias.

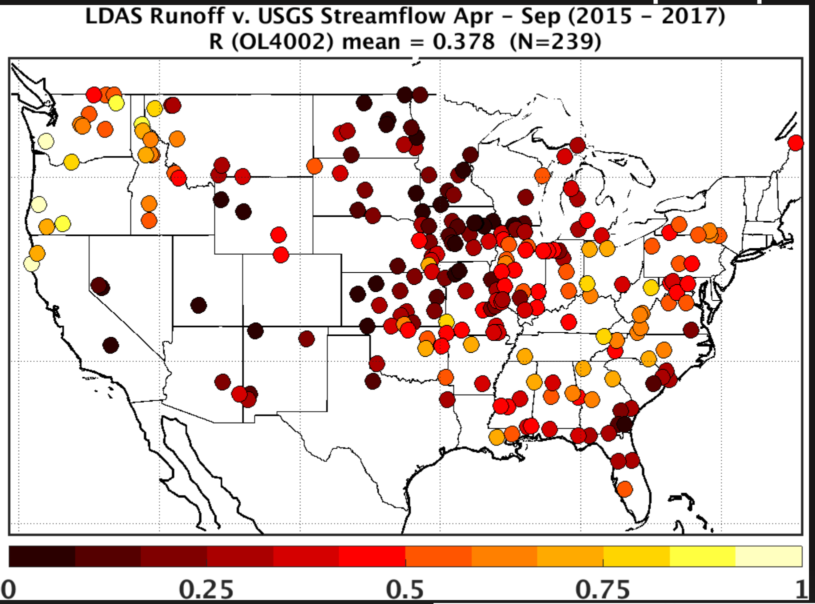




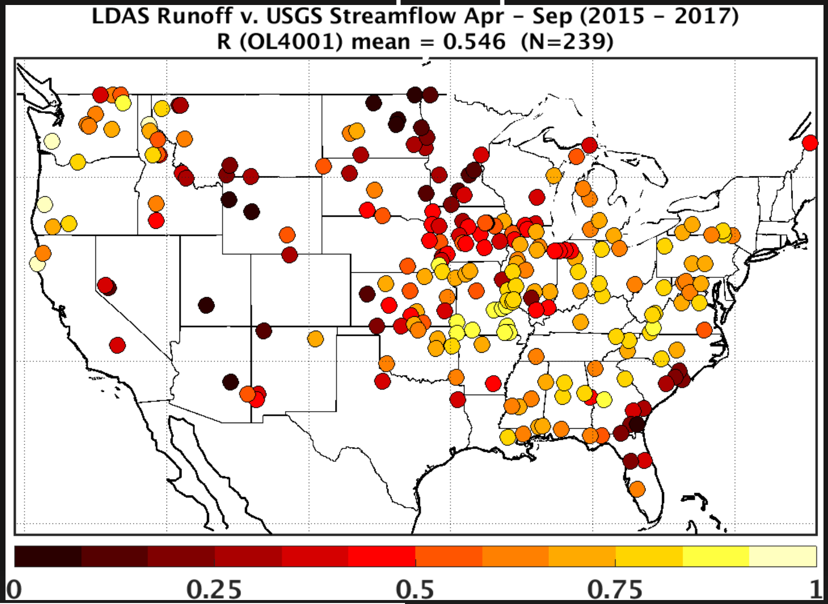
Tb assim. does not (and is not expected to) reduce bias.

Runoff Validation (Correlation)

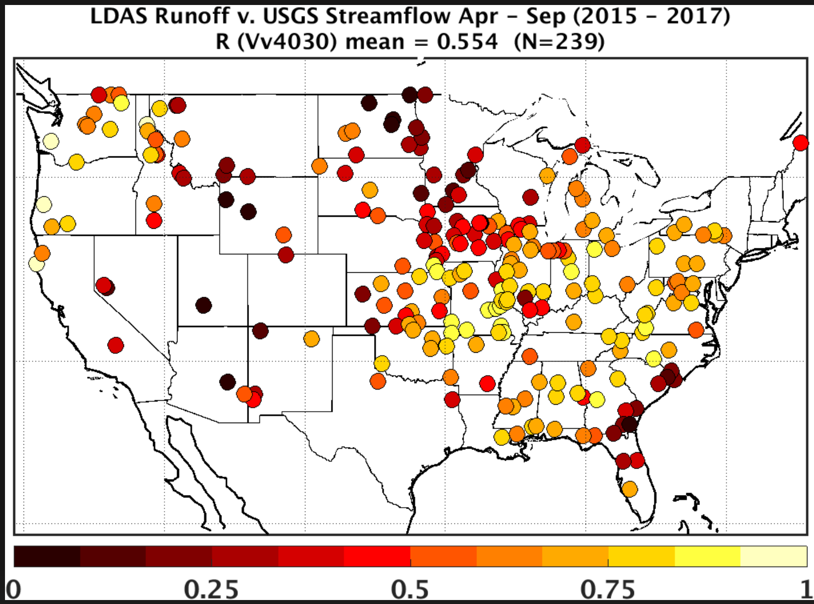
Catchment model w/ GEOS precip.



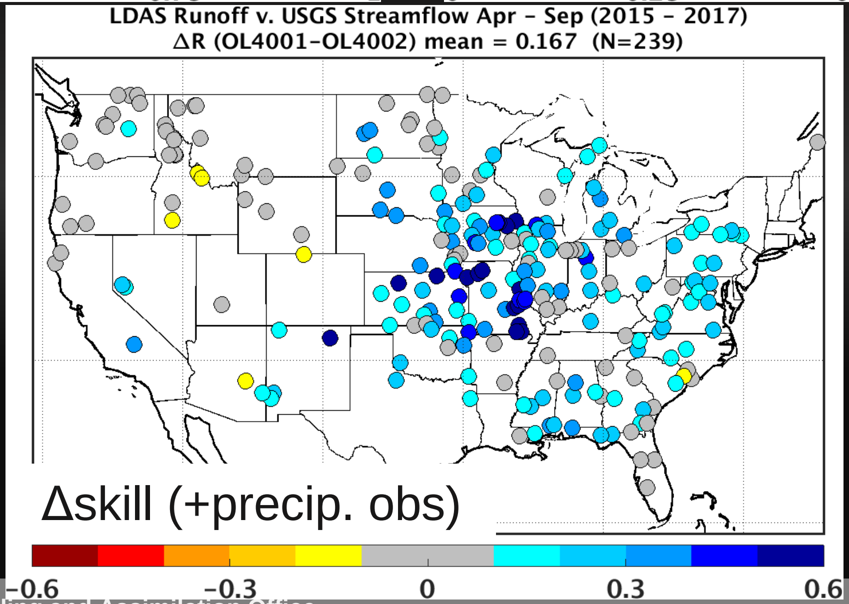
+ CPCU precip. obs

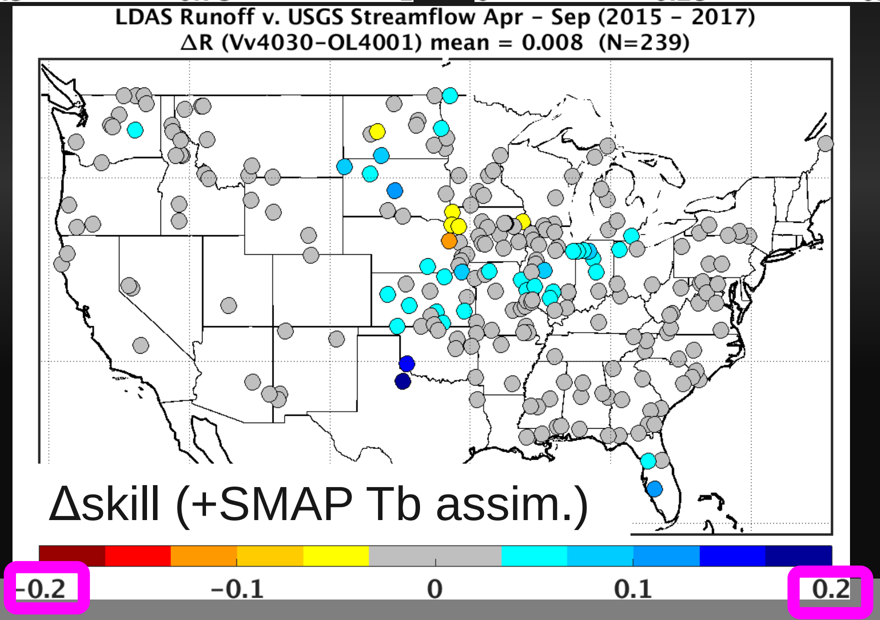


+ SMAP Tb assim.



Observed precip considerably increases correlation.





Tb assim. slightly improves correlation. Much of the skill gain is already realized by precip obs.

Summary

Version 4 meets requirements for new version:

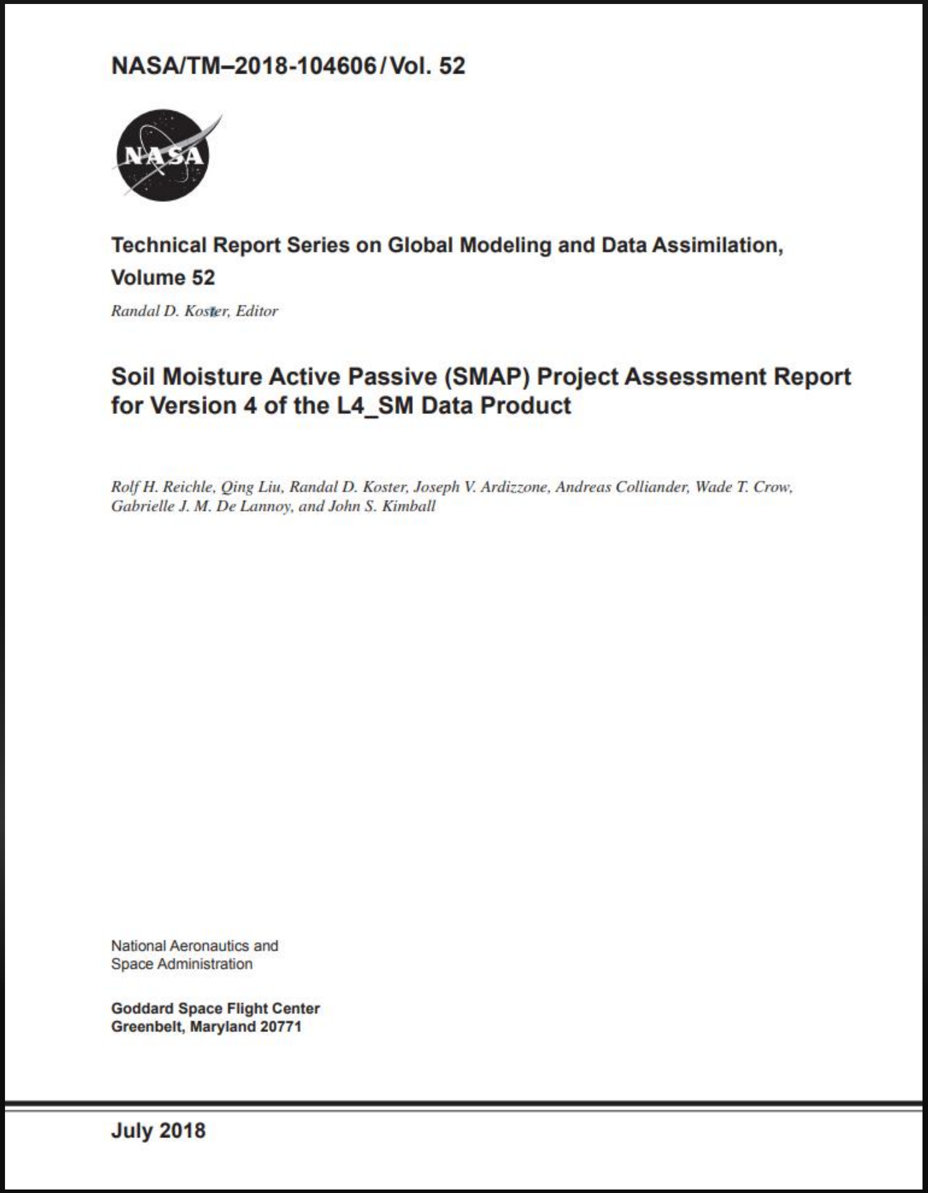
- Soil moisture ubRMSE < 0.04 $m^3 m^{-3}$ (vs. in situ measurements from 9-km core site reference pixels).
- Skill ~same as Vv3030 (on balance across all in situ metrics and assimilation diagnostics).

Compared to Version 3, Version 4 has slightly drier surface and wetter root zone soil moisture, with larger differences in Africa and high-latitudes. Do not mix Version 3 and Version 4!

The water balance closes after considering analysis increments and the impact of ensemble perturbations. Imbalances are smaller in Version 4 than in Version 3.

The use of precipitation observations contributes to runoff skill (minor improvement in bias and large improvement in correlation).
Assimilation of SMAP Tb observations contributes minor improvement in runoff correlation.
Larger improvements expected where precipitation observations are poorer or unavailable.

Version 4 Validation Document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Randal D. Koster, Editor

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https://gmao.gsfc.nasa.gov/pubs