H51W-1661: Water Balance in the SMAP Level-4 Soil Moisture Algorithm

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1. Motivation

The NASA Soil Moisture Active Passive (SMAP) Level-4 Soil Moisture (L4_SM) product provides global, 3-hourly, 9-km resolution estimates of surface and root-zone soil moisture and related land surface variables with a mean latency of ~2.5 days (Fig 1).

The L4_SM algorithm assimilates SMAP brightness temperature (Tb) observations into the NASA Catchment land surface model using an ensemble Kalman filter.

This presentation investigates the non-physical net addition of water caused by the ensemble perturbations and residual analysis bias in the L4_SM algorithm (Version 4).

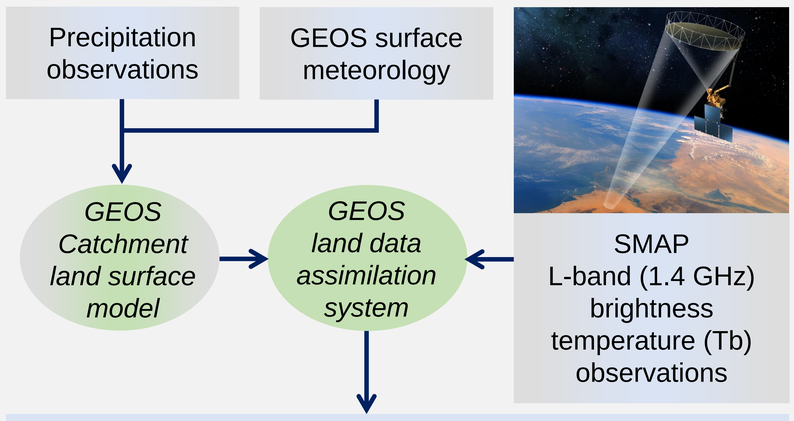

***Fig 1**. The L4_SM product combines SMAP observations with information from the Goddard Earth Observing System (GEOS) model through data assimilation (Reichle et al. 2017a,b).*

2. L4_SM Water Balance

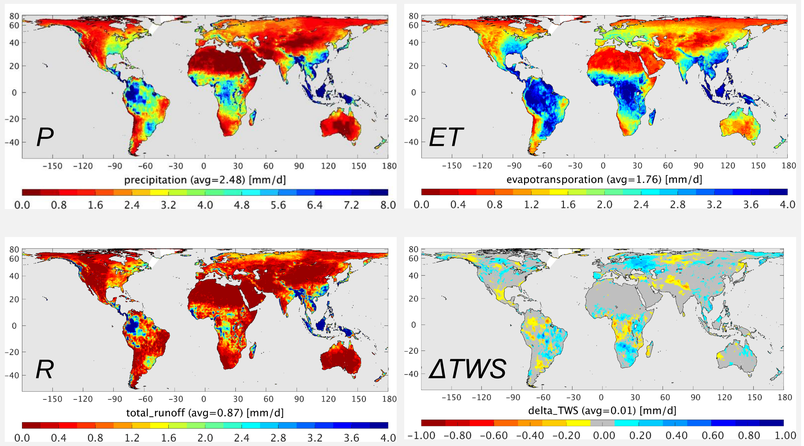

***Fig 2**. L4_SM estimates of natural water balance components: precipitation (P), evapotranspiration (ET), total runoff (R), and change in terrestrial water storage (ΔTWS) for 1 April 2015 to 31 March 2018.*

In nature, the change in terrestrial water storage (ΔTWS) over a period of time is balanced by the average precipitation (P) and evapotranspiration (ET), and total runoff (R):

$$\Delta TWS = P - ET - R$$

The global average L4_SM estimates for precipitation, evapotranspiration and runoff are 2.48, 1.76, and 0.87 mm/d, respectively (Fig 2).

4. Conclusion

A modest water flux imbalance of 0.16 mm/d in the L4_SM system is caused mostly by the ensemble perturbations and is concentrated in dry regions.

The L4_SM Tb analysis is nearly unbiased and contributes only 0.03 mm/d to the imbalance.

3. Impact of Perturbations and Bias

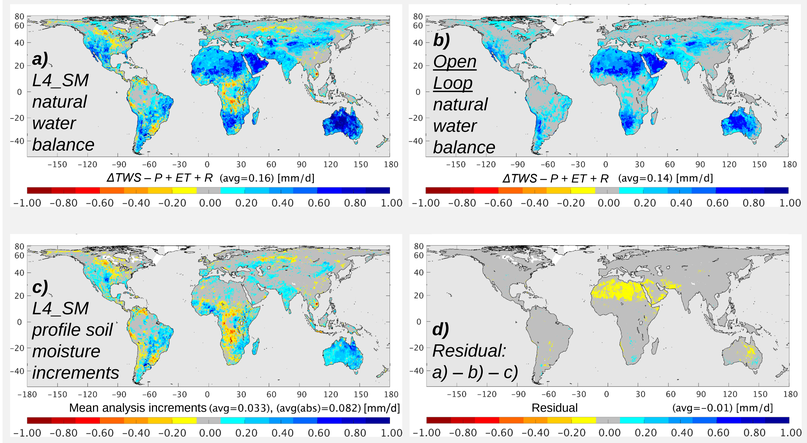

***Fig 3**. Natural water balance for (a) L4_SM and (b) an Open Loop ensemble simulation without assimilation of SMAP observations, along with (c) L4_SM mean profile soil moisture increments and (d) the residual of (a), (b), and (c). All panels are for 1 April 2015 to 31 March 2018.*

The L4_SM product's natural water balance does not close, with a global average net flux of 0.16 mm/d (Fig 3a).

An ensemble "Open Loop" simulation without the assimilation of SMAP observations has a global average net flux imbalance of 0.14 mm/d, dominated by the addition of water through perturbations in dry regions (Fig 3b).

By comparison, the net L4_SM analysis increments amount to only 0.03 mm/d in the global average, albeit with regional (absolute) values up to ~0.5 mm/d (Fig 3c).

The global average of the L4_SM total water balance closes to within 0.01 mm/d when considering the impact of the L4_SM perturbations and bias in the analysis (Fig 3d).

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References

- Reichle et al. (2017a), Global Assessment of the SMAP Level-4 Surface and Root-Zone Soil Moisture Product Using Assimilation Diagnostics, *J. Hydrometeo.*, 18, 3217-3237, doi:10.1175/JHM-D-17-0130.1.
- Reichle et al. (2017b), Assessment of the SMAP Level-4 Surface and Root-Zone Soil Moisture Product Using In Situ Measurements, *J. Hydrometeo.*, 18, 2621-2645, doi:10.1175/JHM-D-17-0063.1.
- Project URL: http://gmao.gsfc.nasa.gov/GMAO_products/SMAP_L4
- Data Access: http://nsidc.org/data/smap

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