Synergistic use of satellite soil moisture and precipitation products for hydrological modelling

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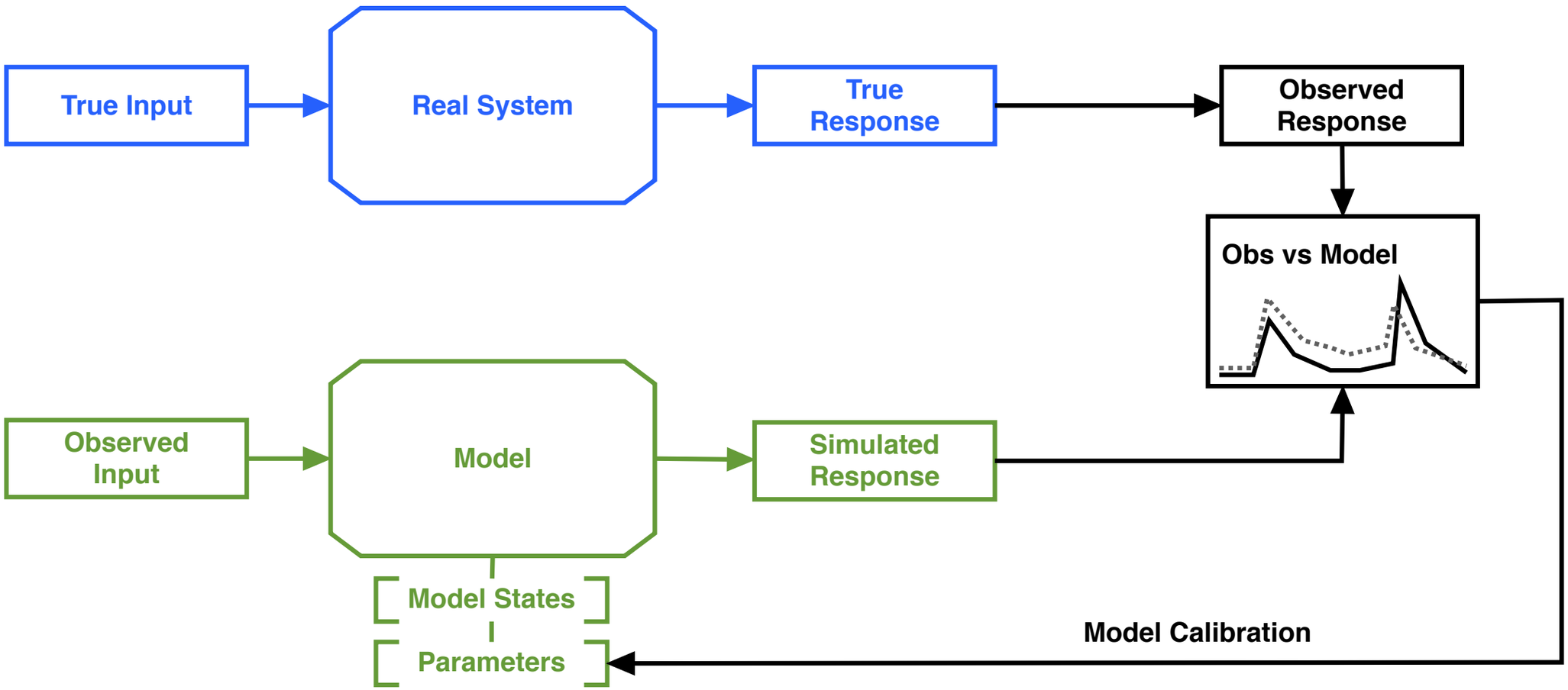
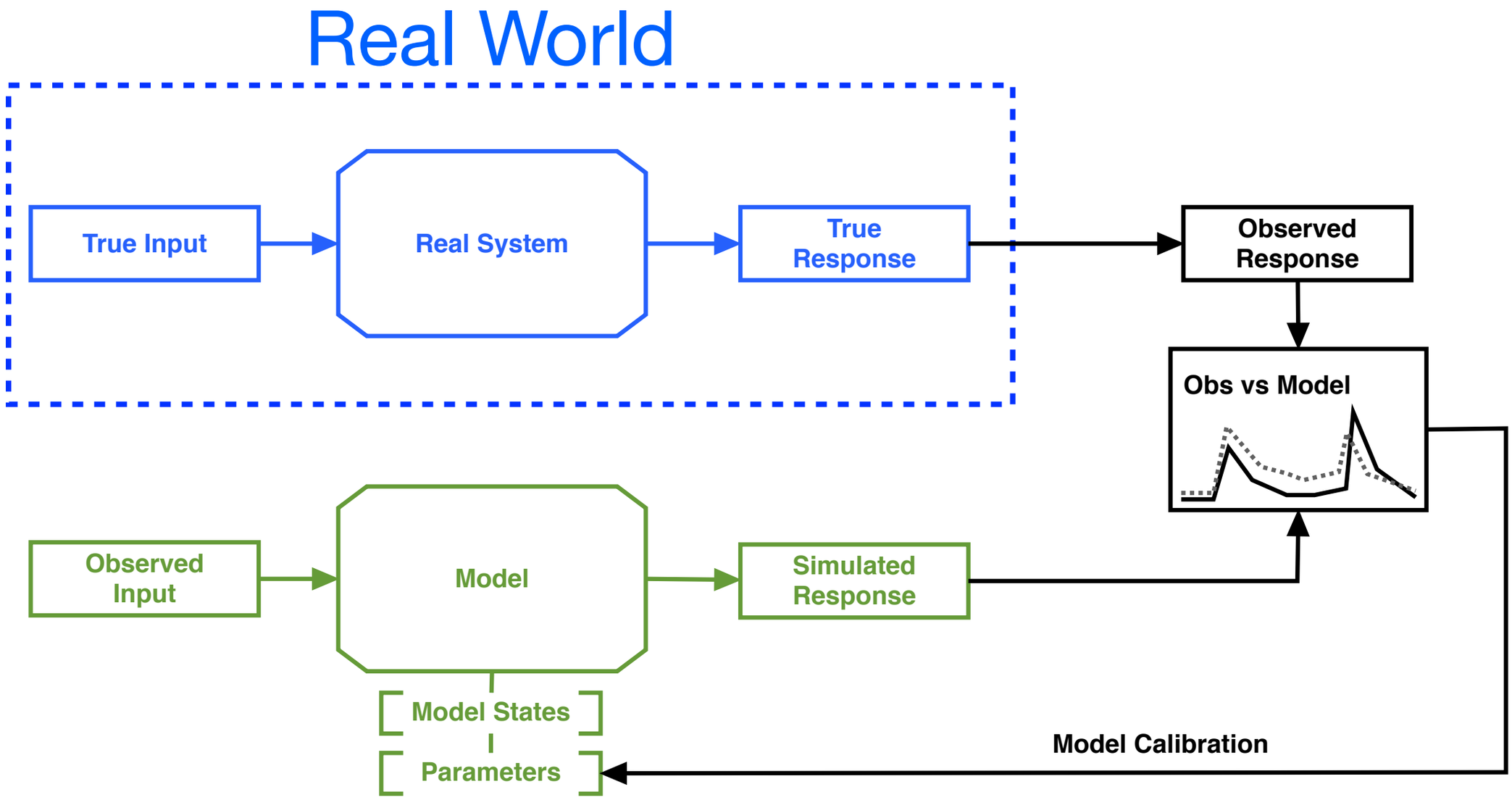
Satellite Observations for Hydrological Modelling

- Advances in satellite instruments and algorithms have led to their innovative applications to hydrological modelling
- Satellite retrievals of soil moisture, precipitation, snow water equivalent (SWE), evapotranspiration, vegetation indices, total water store, river height, etc., are now used as input to hydrological predictions (forcing, direct parameterisation, calibration, data assimilation)
- Here, we present a synergistic use of satellite soil moisture and precipitation products to improve catchment runoff prediction

Mechanics of Flood Prediction



Mechanics of Flood Prediction



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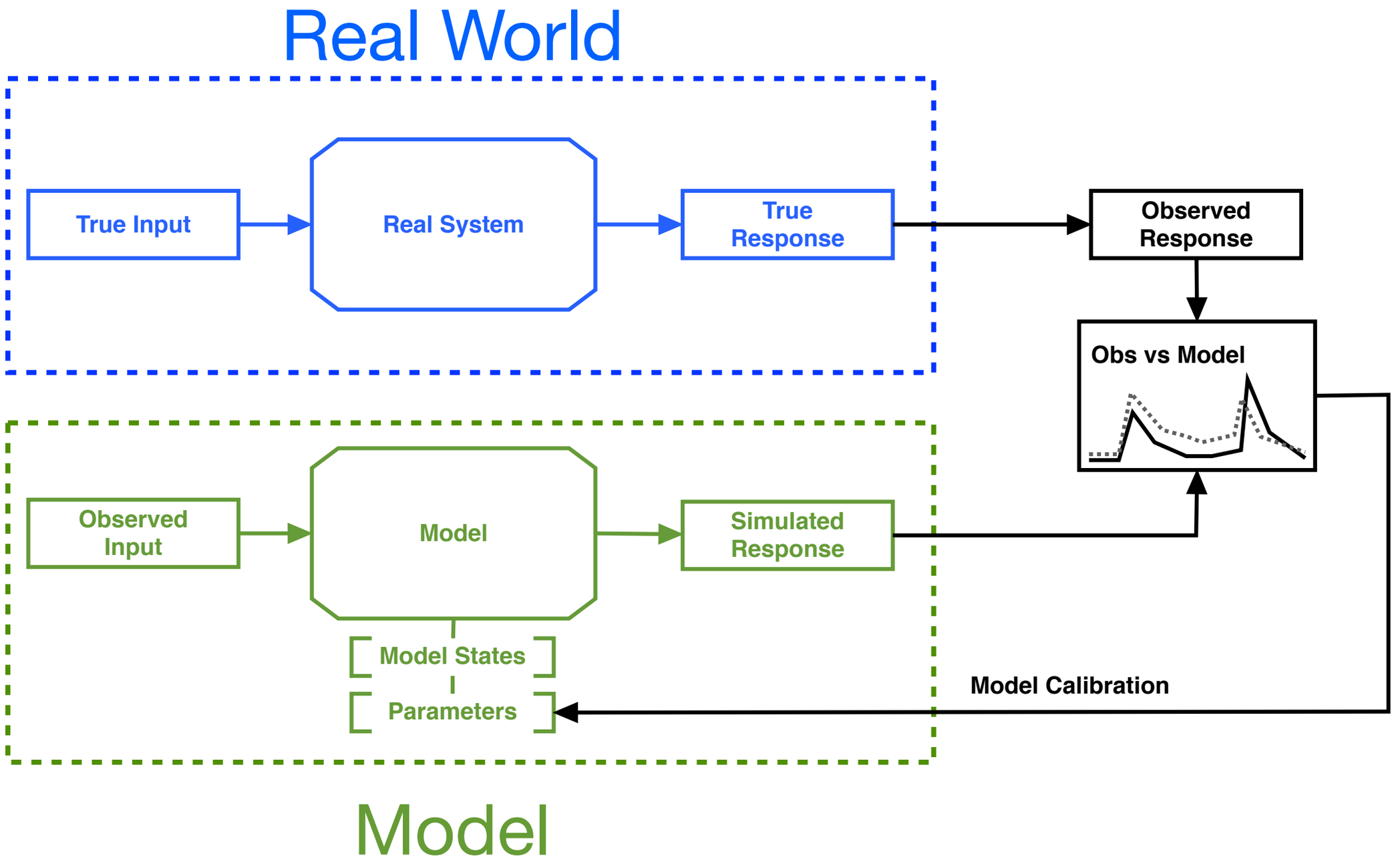
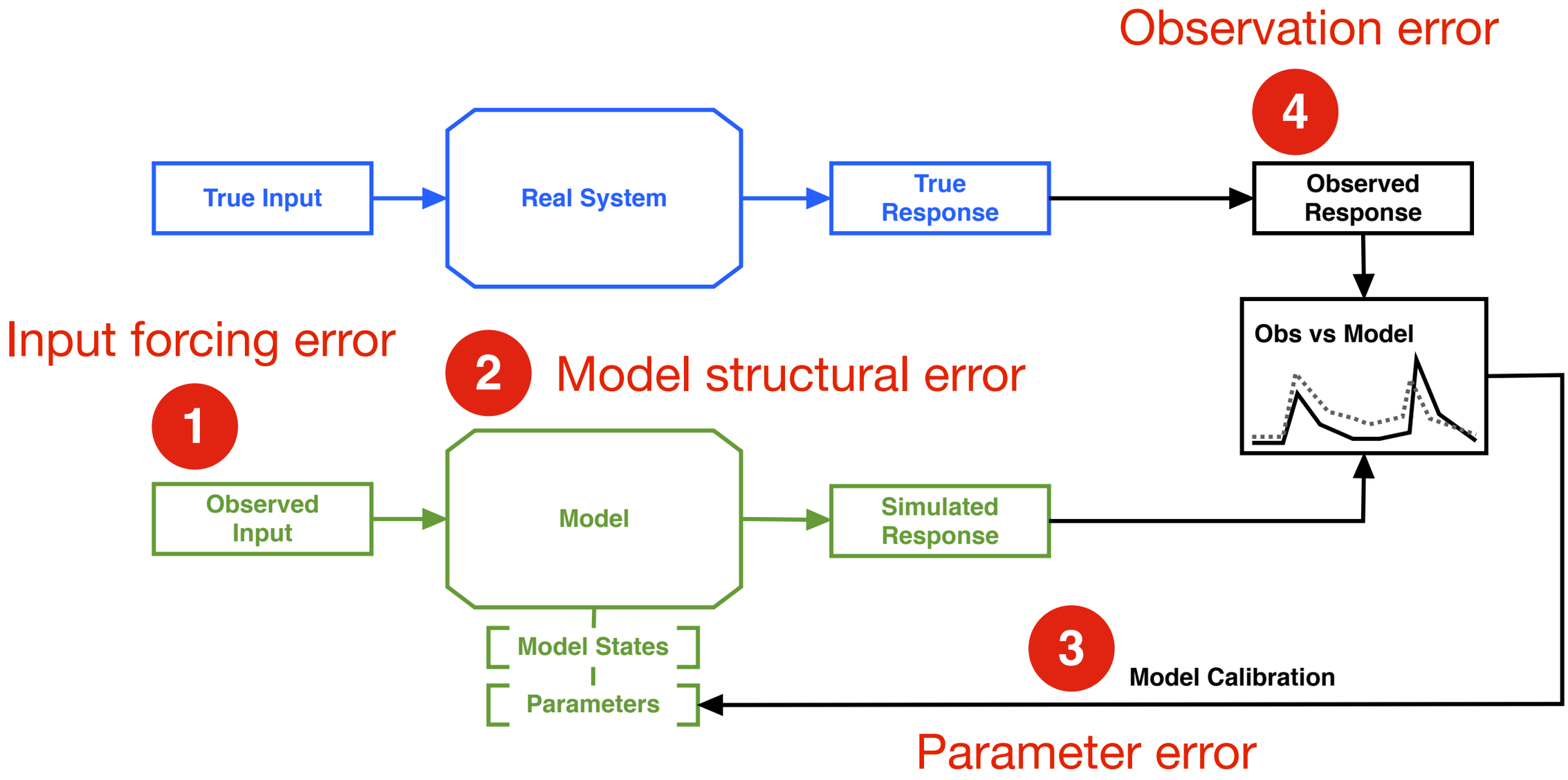


Source of Errors



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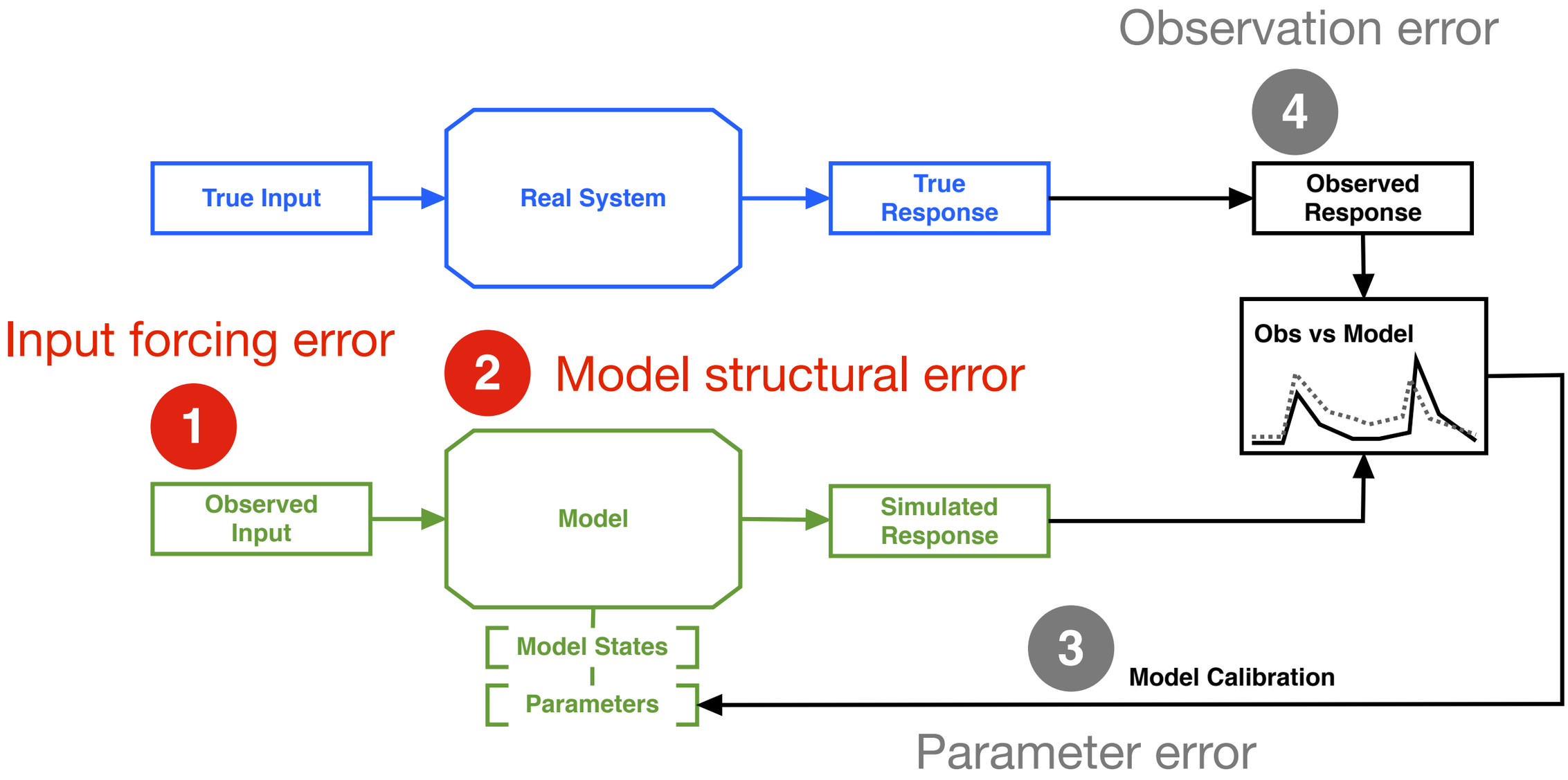
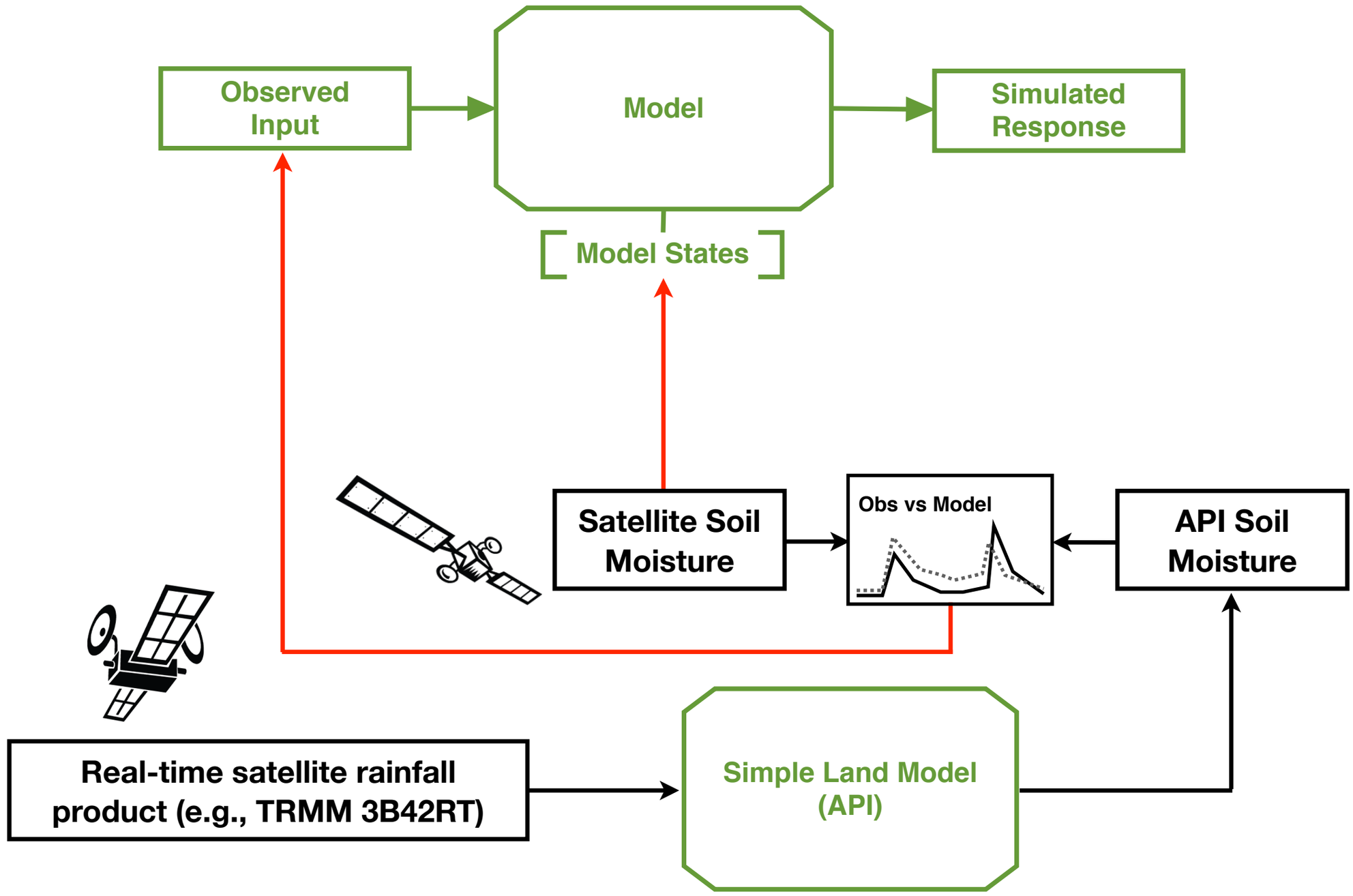


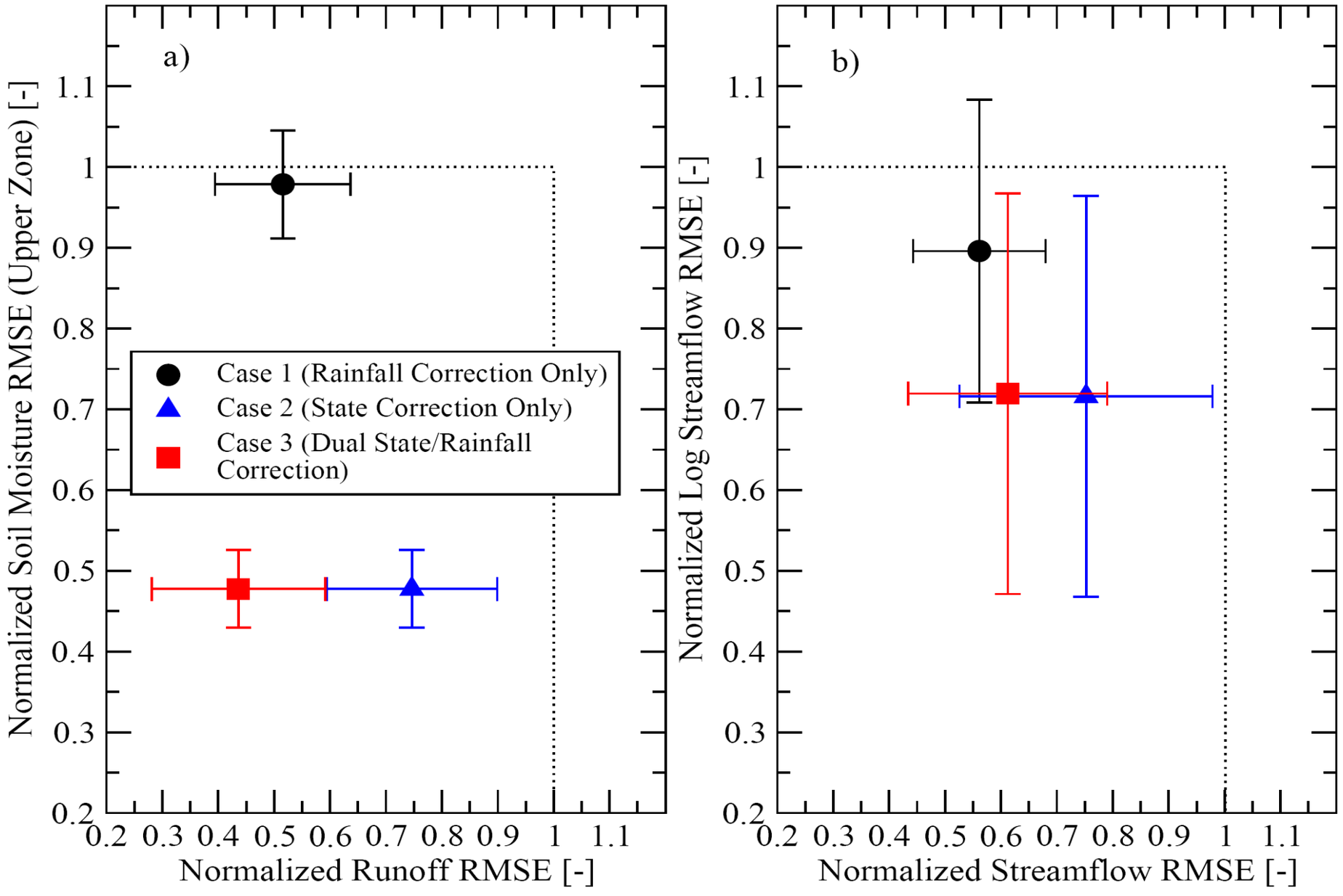
Improvement Strategies

- Satellite soil moisture can be used to correct errors in model soil water store and input forcing (rainfall)



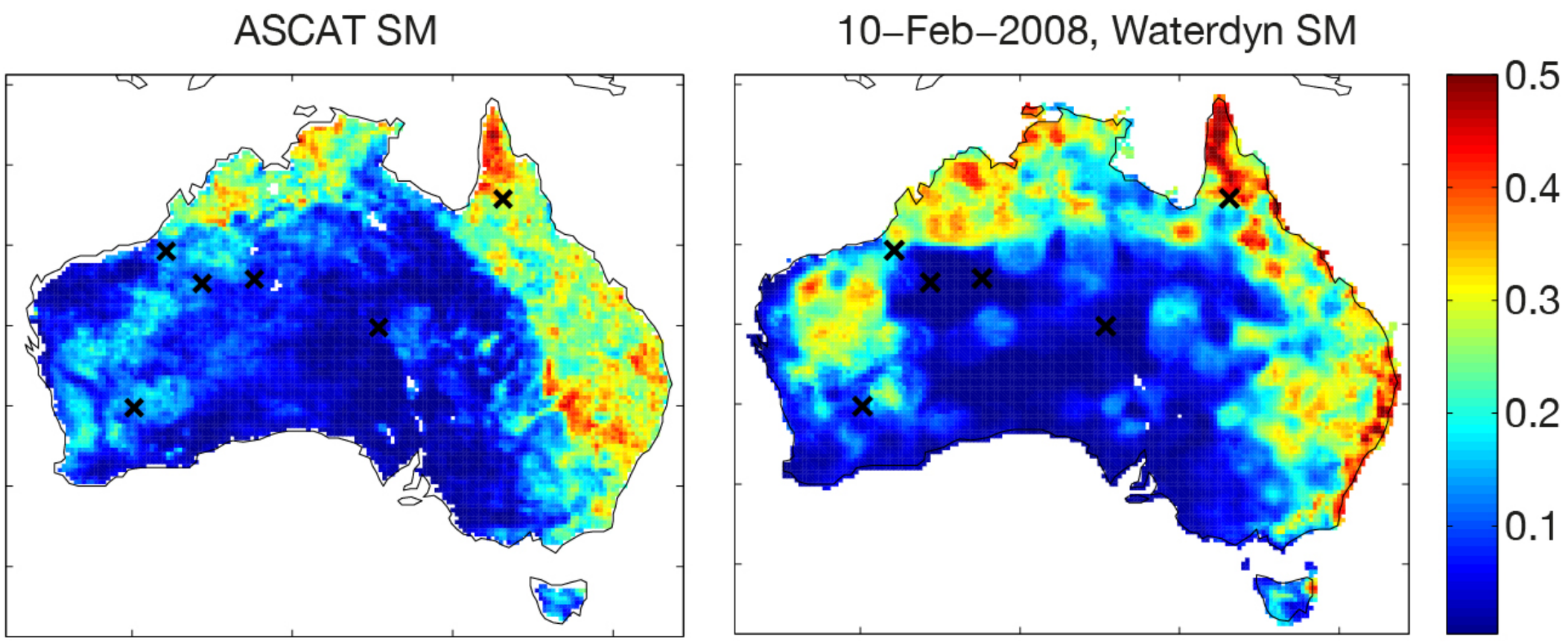
Proof of Concept

- Numerical experiment over 97 basins in the US showed extra skill in streamflow prediction by correcting errors in both rainfall and soil water store (Crow and Ryu, 2008).

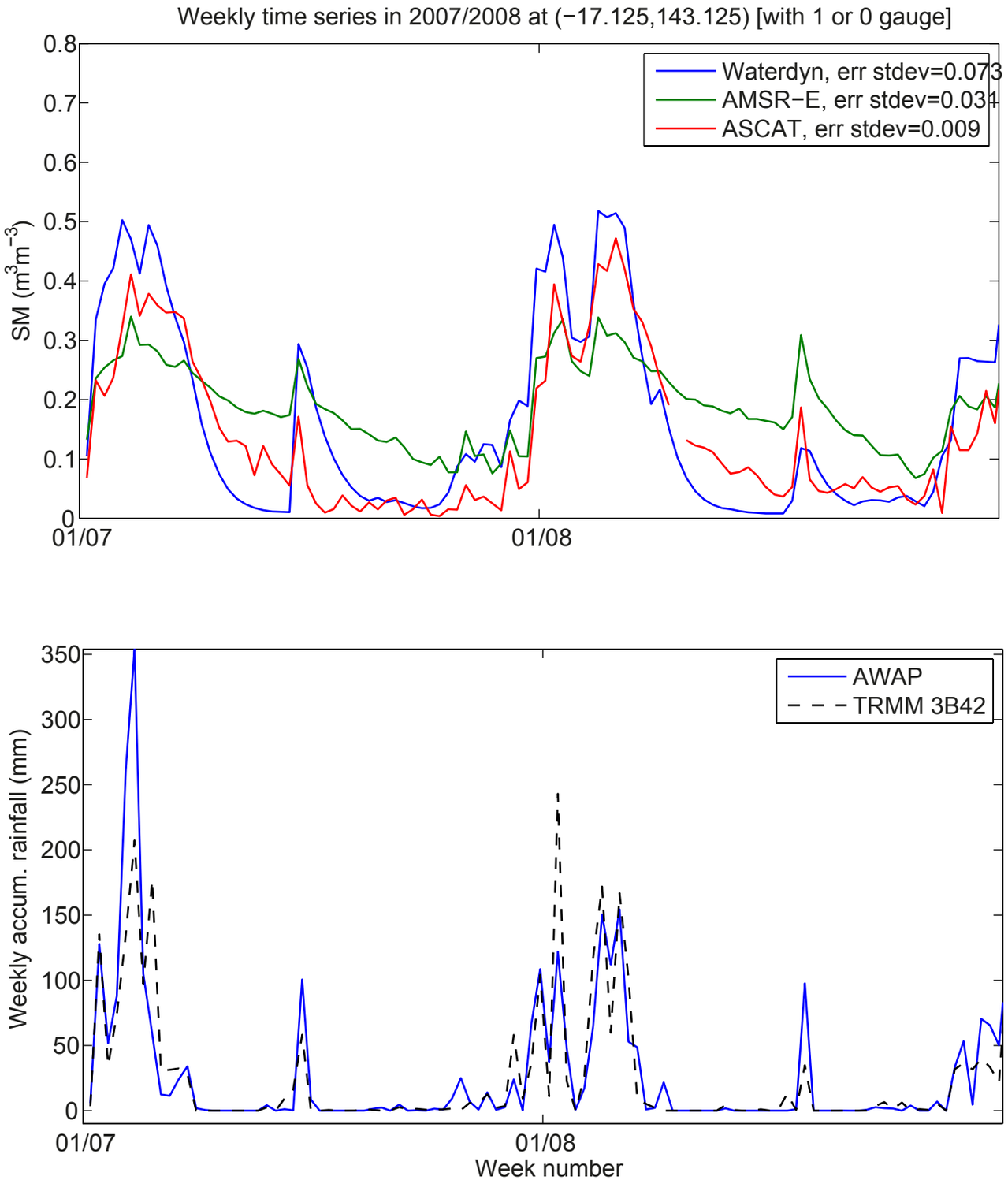


Soil Moisture Analysis Rainfall Tool (SMART): Rationale

- Remotely sensed soil moisture can be used to indirectly evaluate and error-correct rainfall products
- Example: ASCAT/AMSR-E soil moisture versus WaterDyn forced by AWAP



Evaluation of Satellite Rainfall Products



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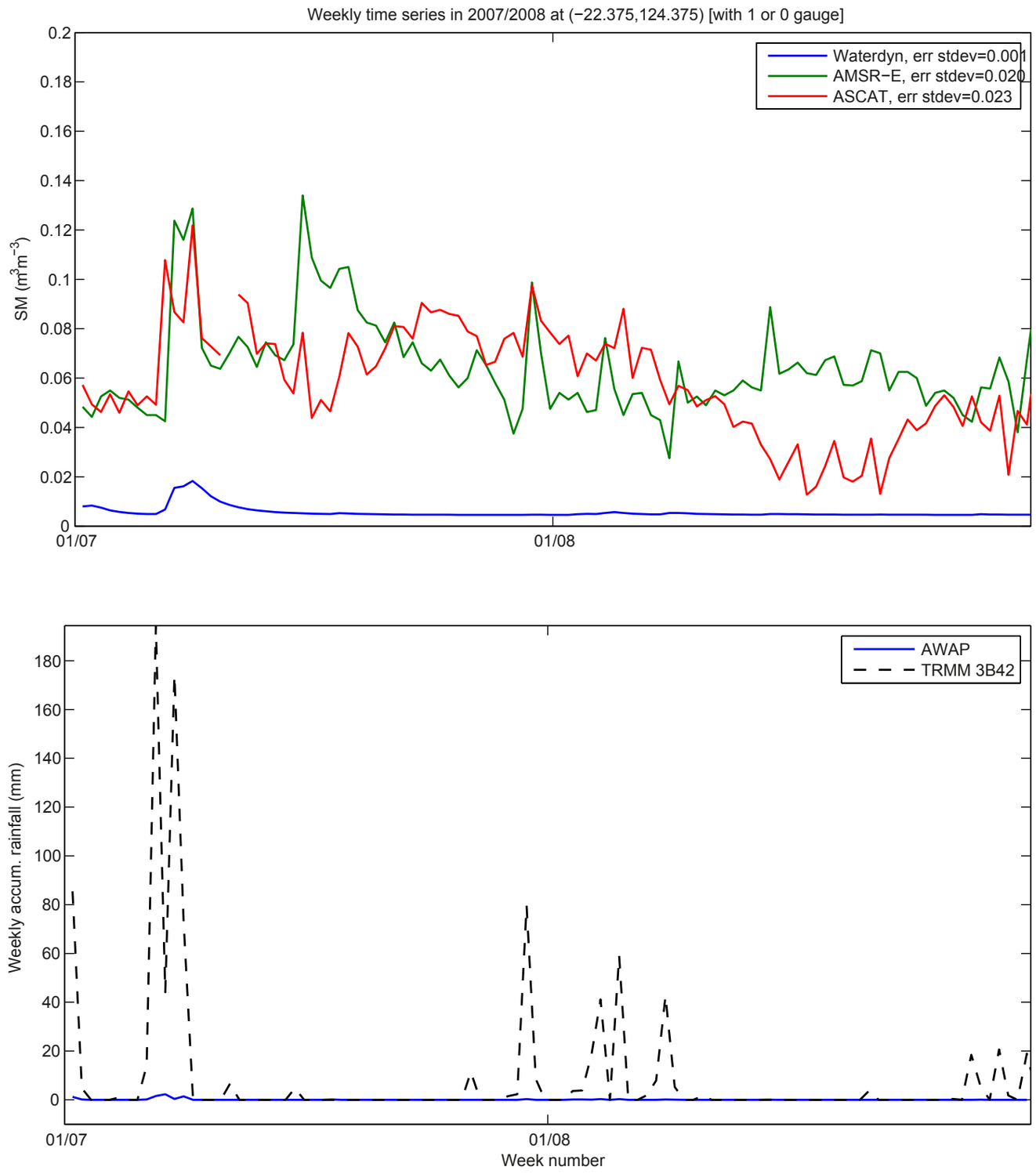
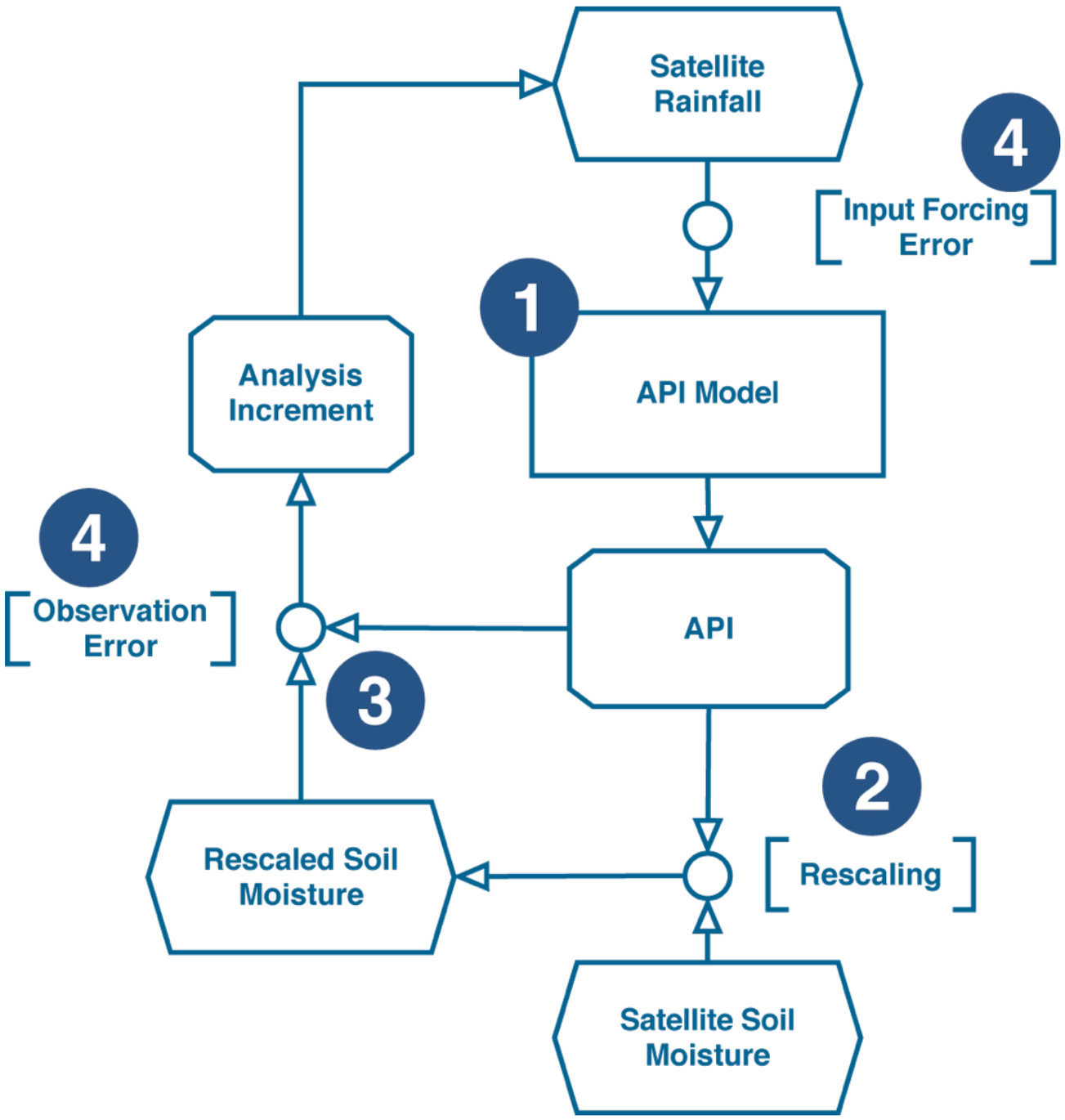


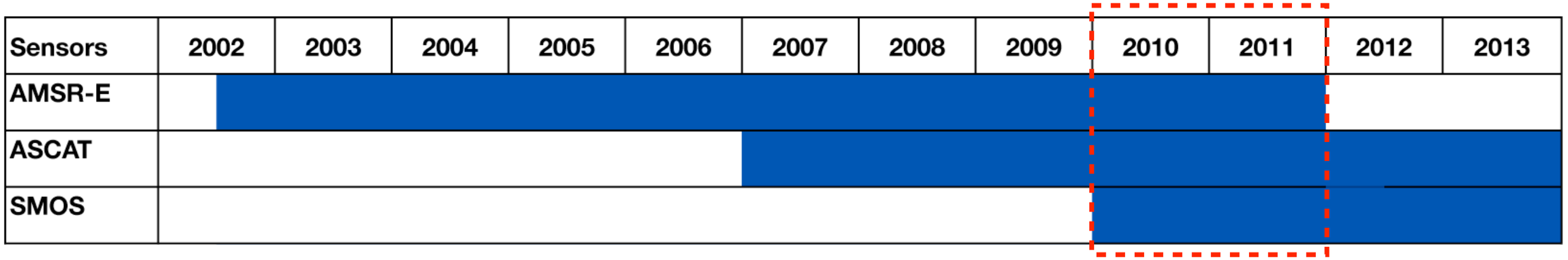
SMART for TRMM 3B42RT Error Correction



- A simple API model forced by TRMM 3B42RT produces surface soil moisture content (Step 1).
- Satellite soil moisture is rescaled to remove the bias and to match the dynamic range against the API outputs (Step 2).
- CDF matching with a moving window to correct for seasonality is adopted here.
- Rescaled satellite soil moisture is assimilated into API using the Kalman Filter and the analysis increment is used to diagnose rainfall error (Step 3).
- API variance and soil moisture observation error are calibrated until the filter innovations become serially “white” (Step 4).

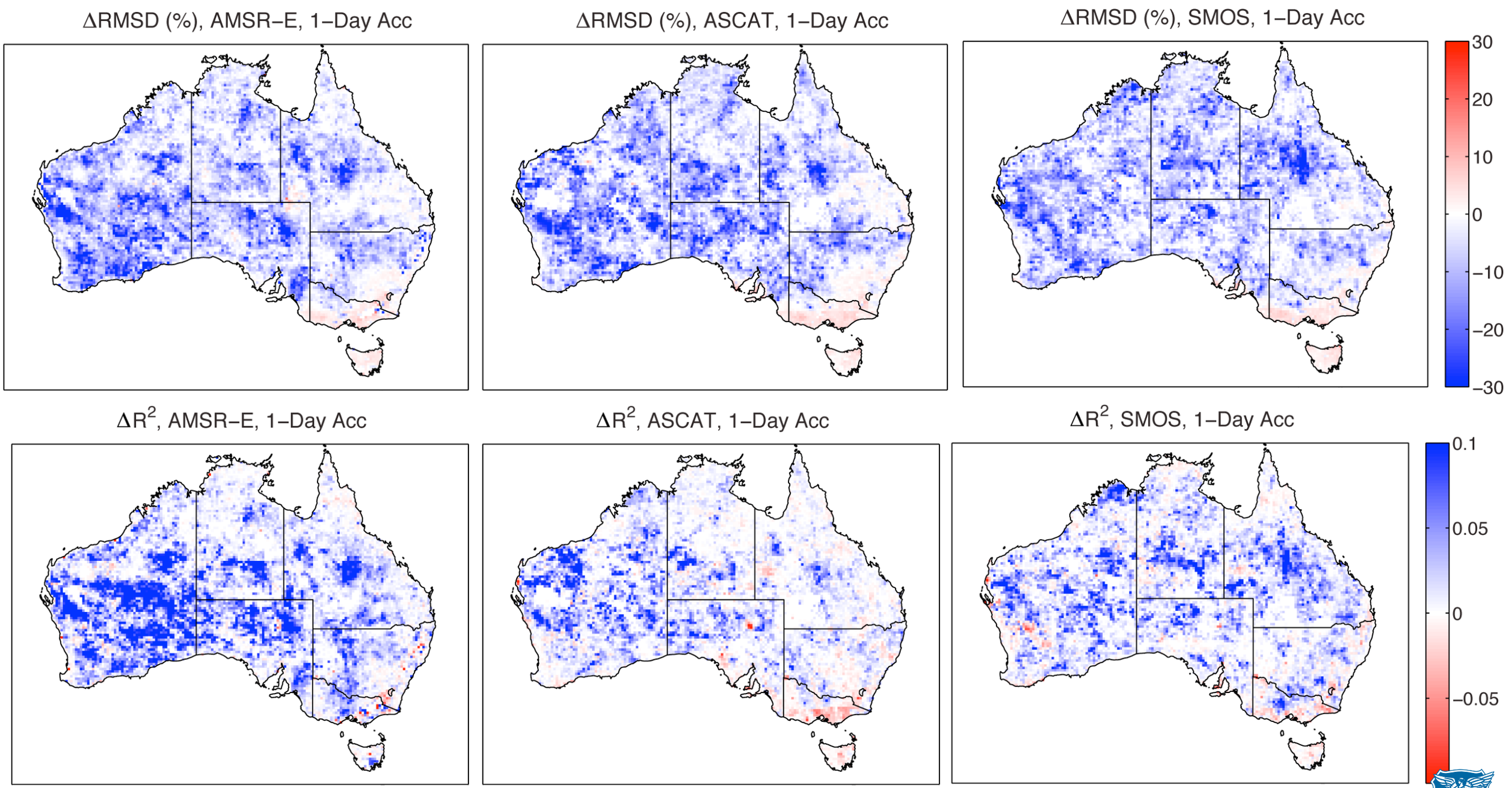
Comparison of Soil Moisture Products over Australia

- Three microwave soil moisture products are used in this study to correct errors in TRMM 3B42RT
- AMSR-E (VUA-NASA, C-/X-band, Passive)
- ASCAT (Vienna Univ. Tech., C-band Active)
- SMOS (L3 CATDS, L-band, Passive)



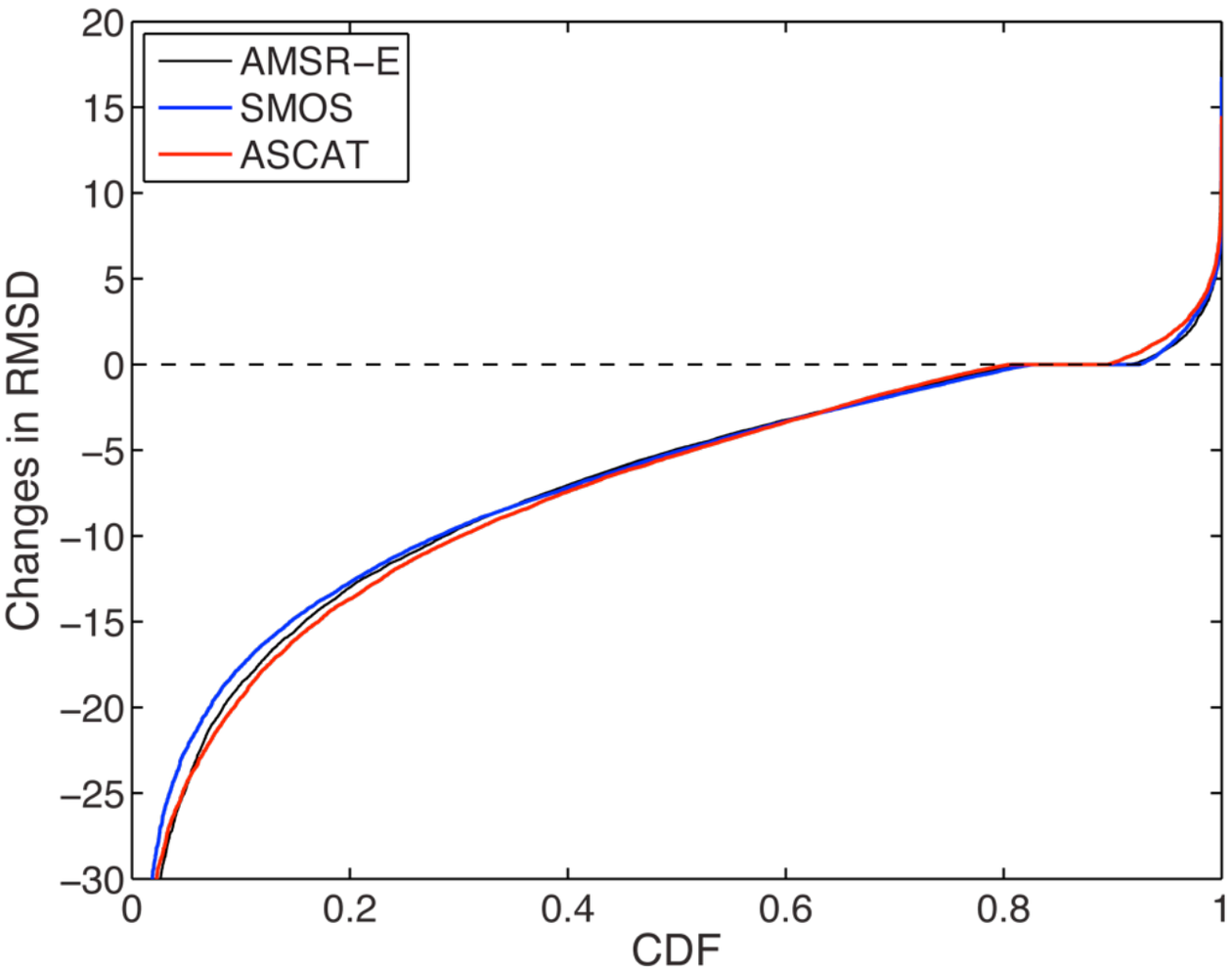
SMART for TRMM 3B42RT Error Correction

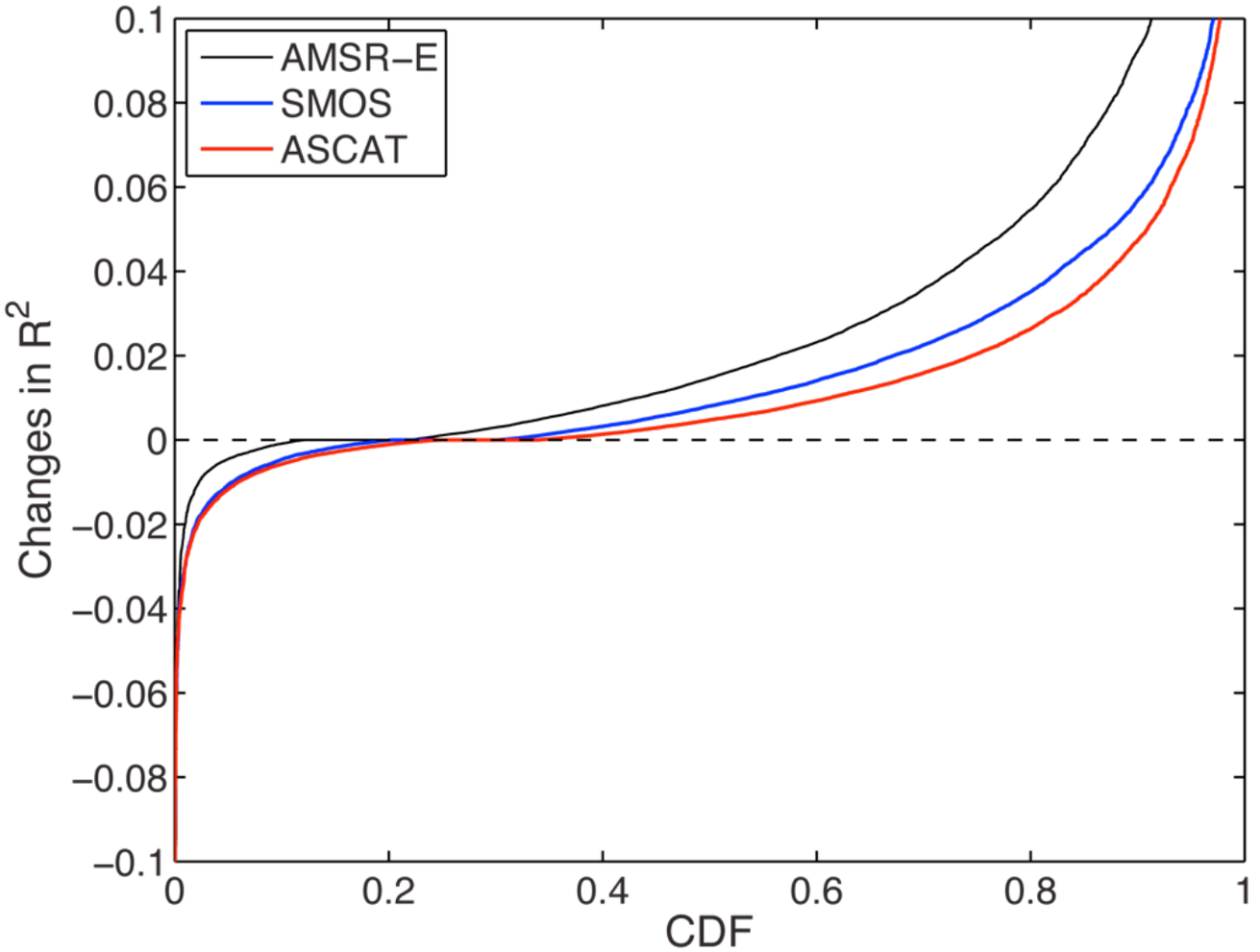
- Changes in RMSD and R^2 with respect to 3B42 after rainfall error correction



SMART for TRMM 3B42RT Error Correction

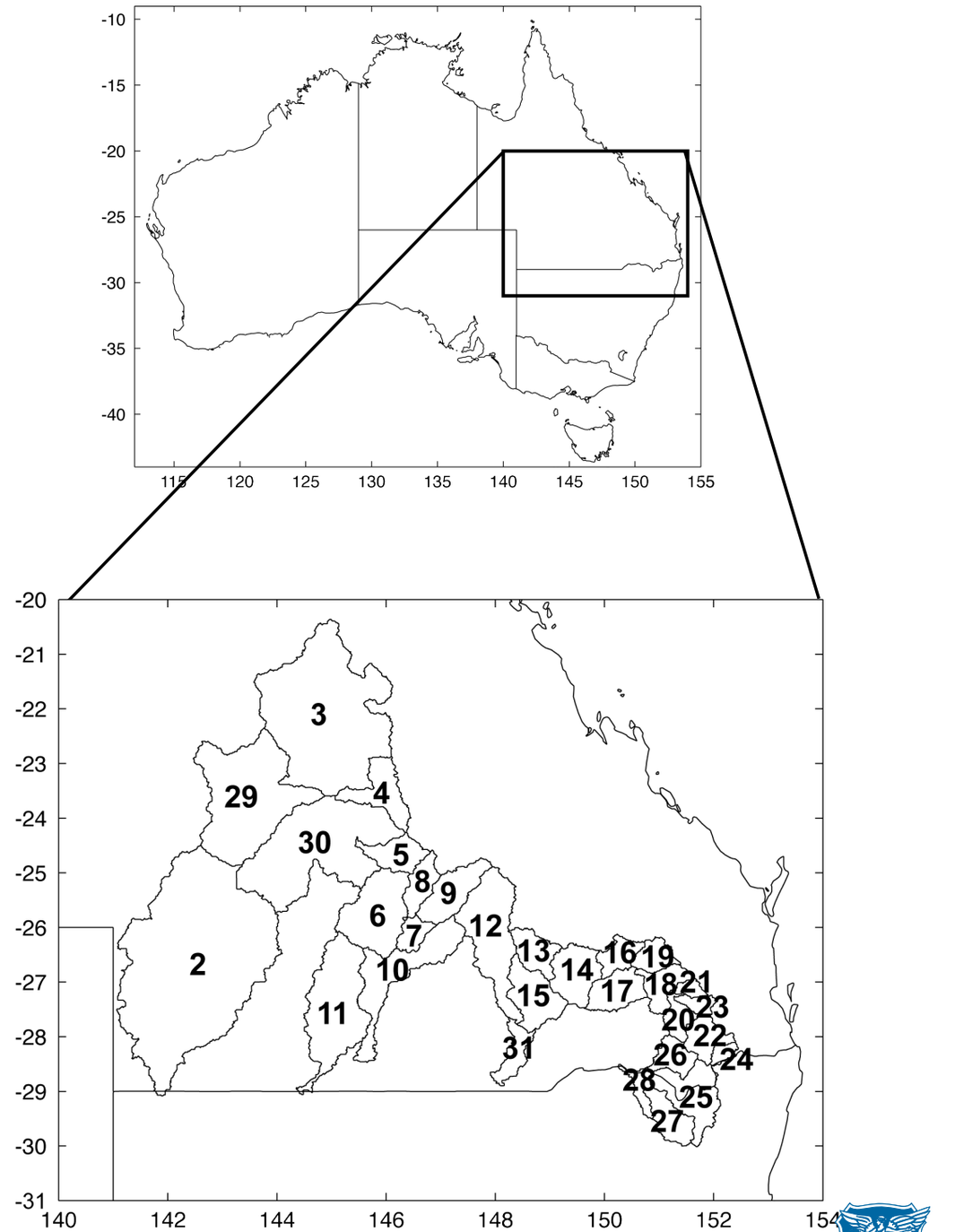
- Over 80% of Australia, RMSD and R2 between 3B42RT and 3B42 are improve by SMART





Application to Semi-Arid Catchments in Queensland

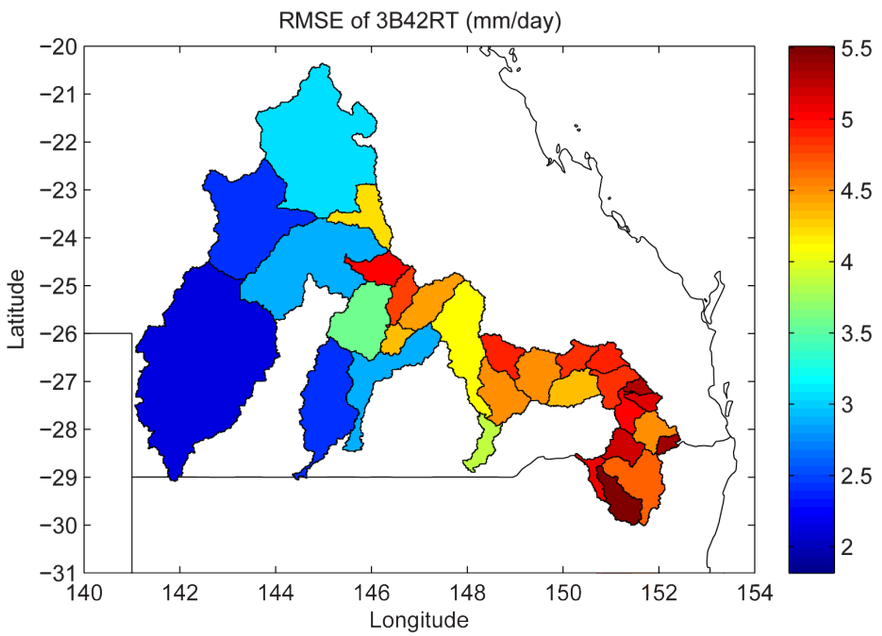
- 31 sub-catchments of Condamine-Culgoa in Queensland
- SMART is used to correct errors in 3B42RT with catchment-averaged AWAP as a reference
- EnKF analysis from 1 July 2002 to 30 June 2008



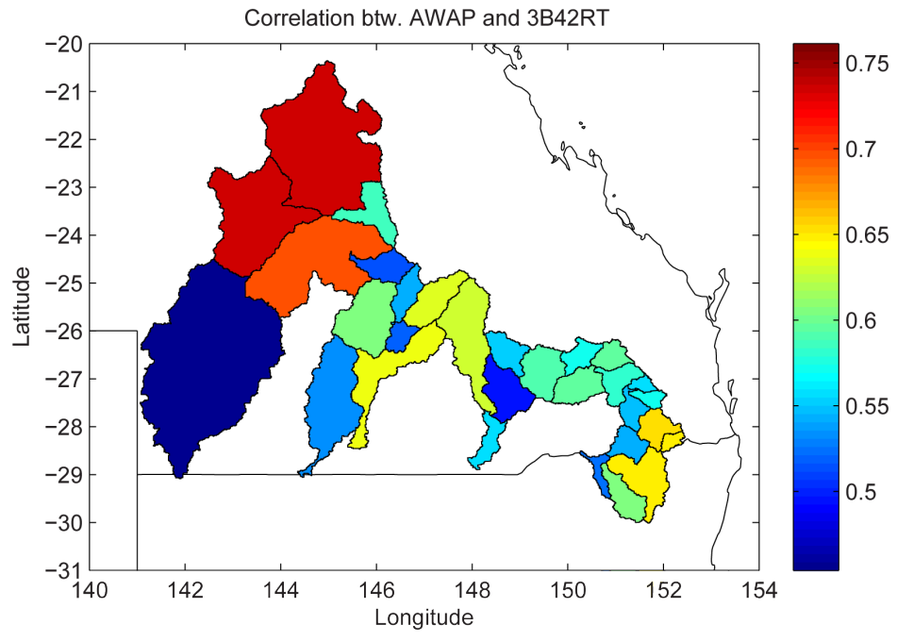
Application to Semi-Arid Catchments in Queensland

- TRMM 3B42RT versus AWAP prior to the soil moisture analysis

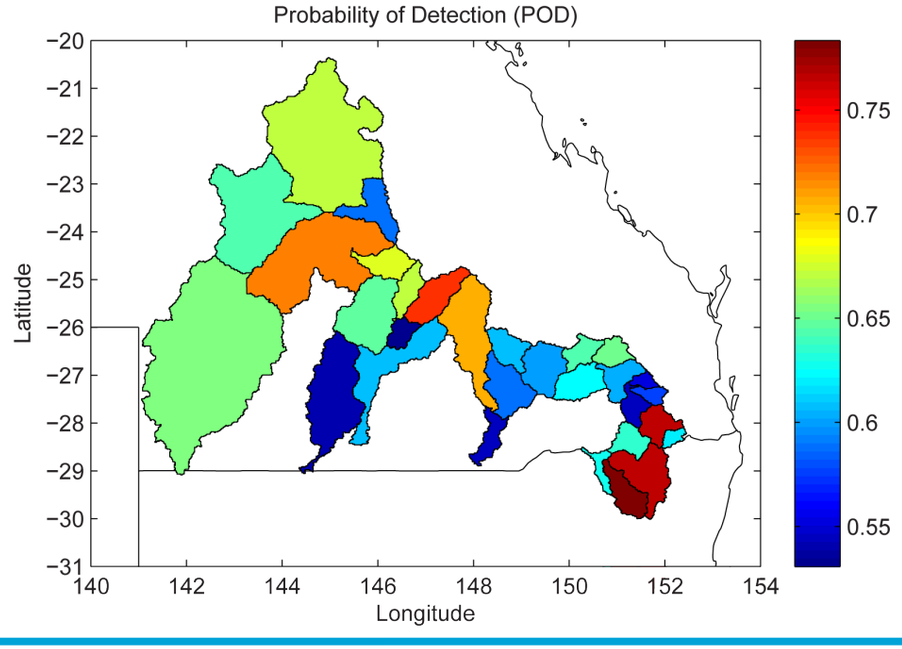
RMSE (mm/day)



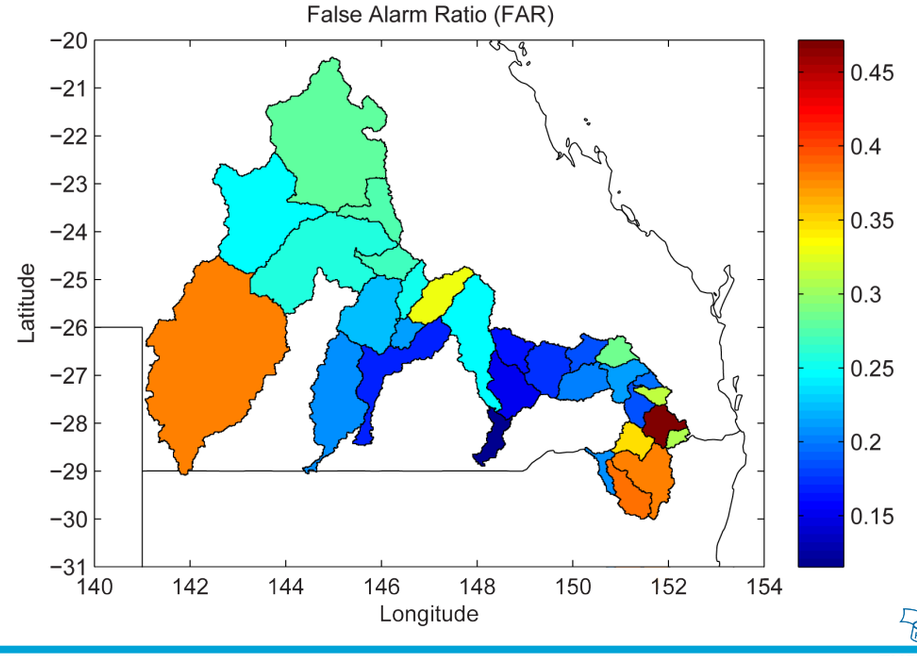
Correlation



POD



FAR



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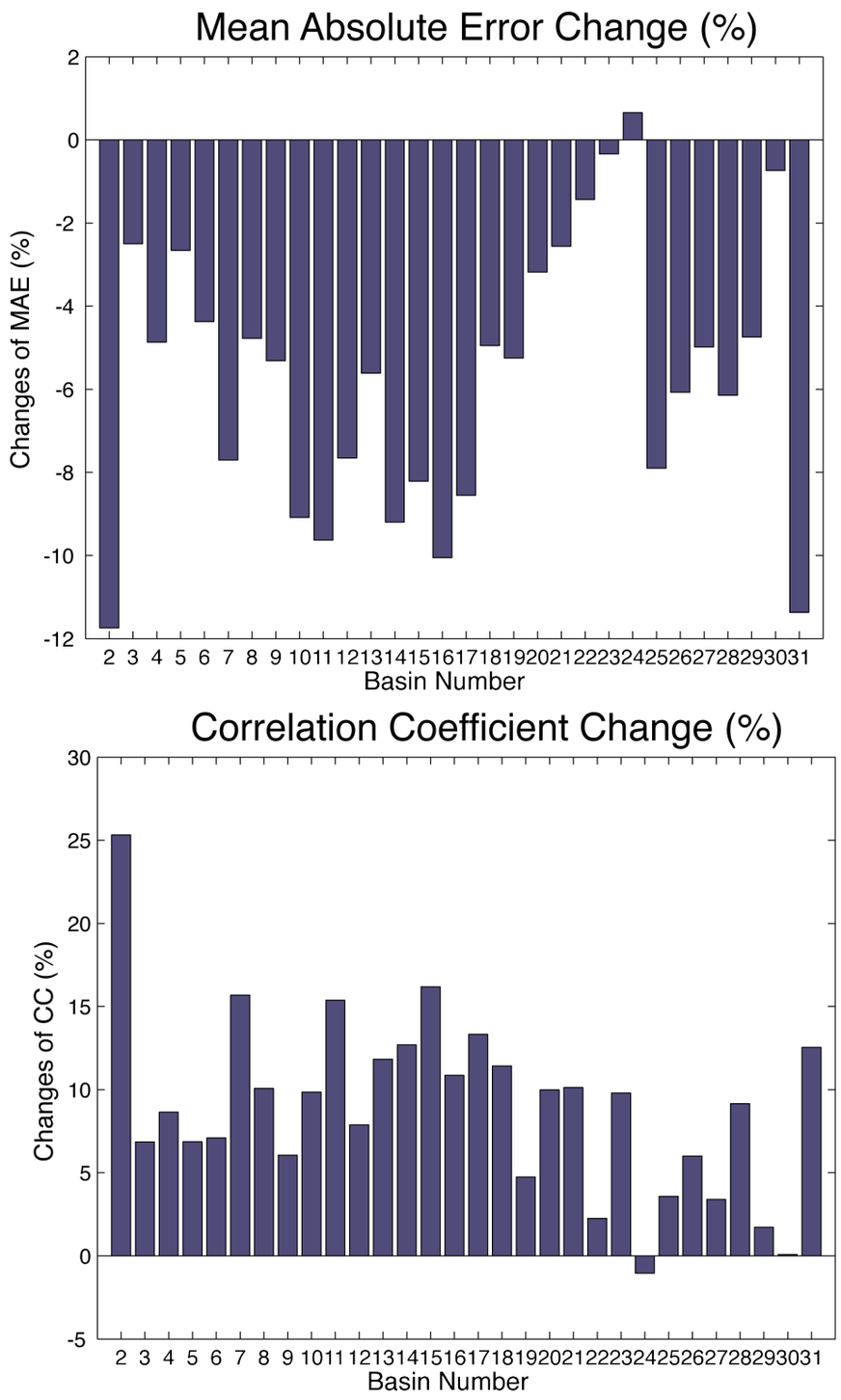
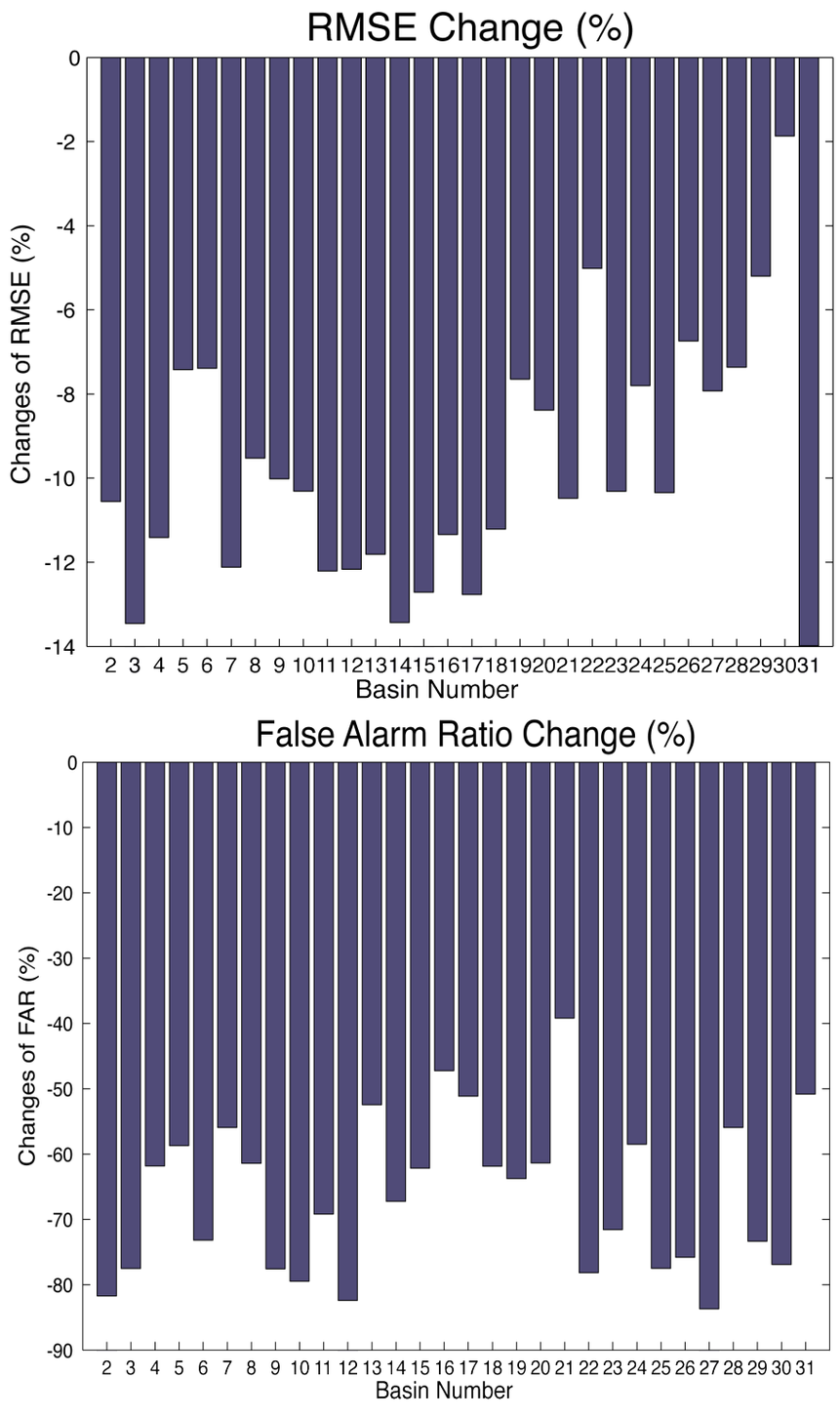
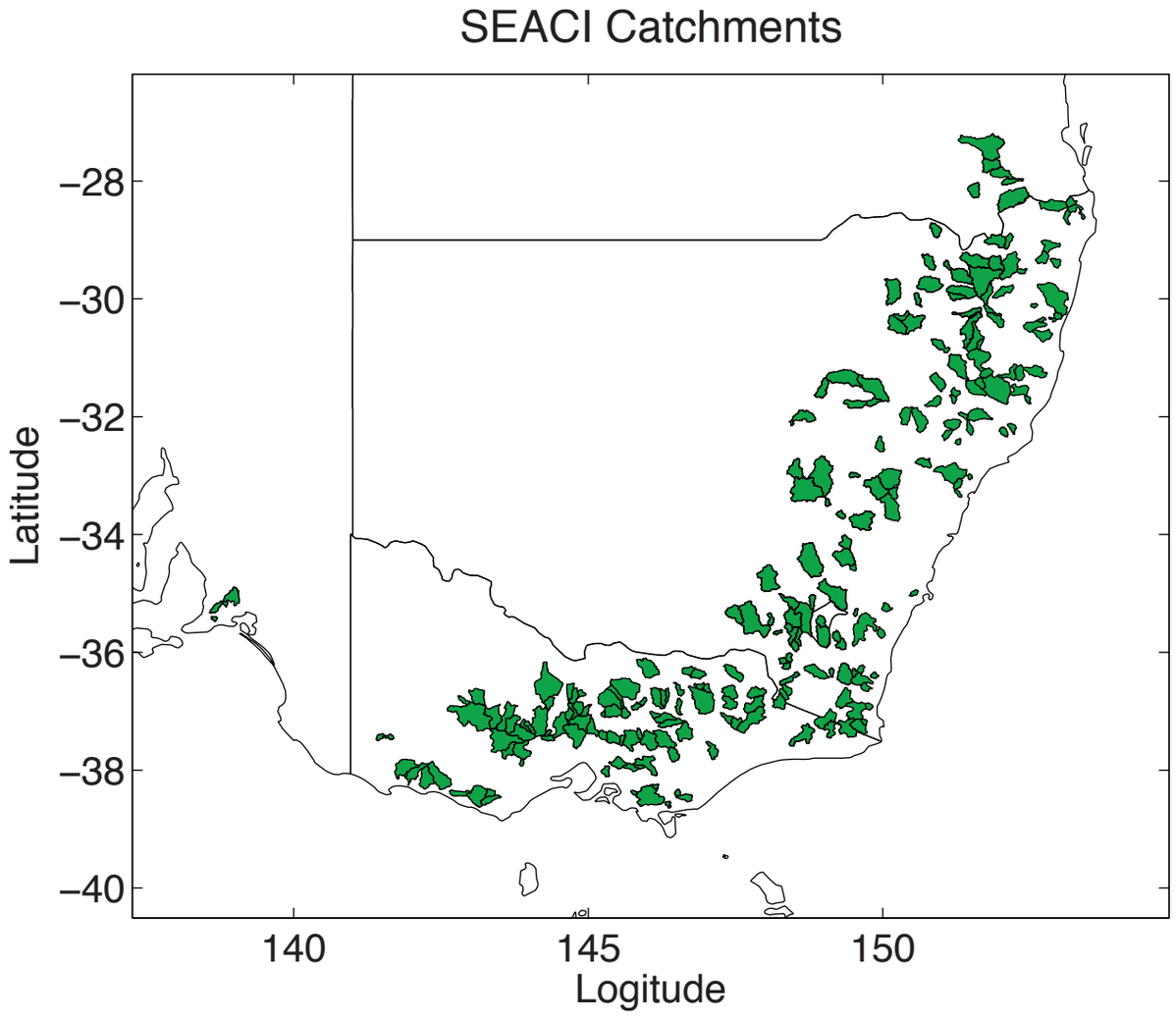




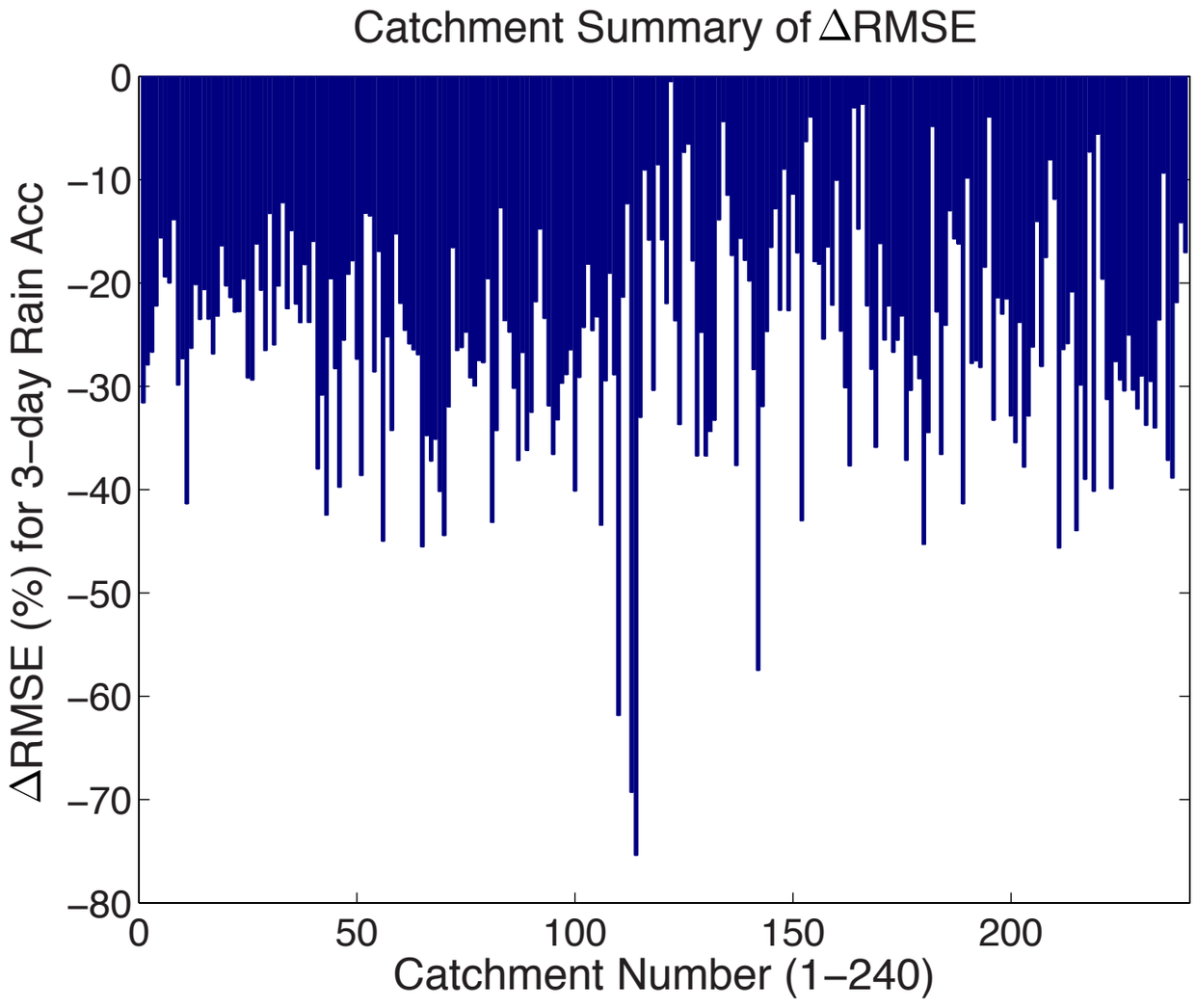
Application to Small Catchments

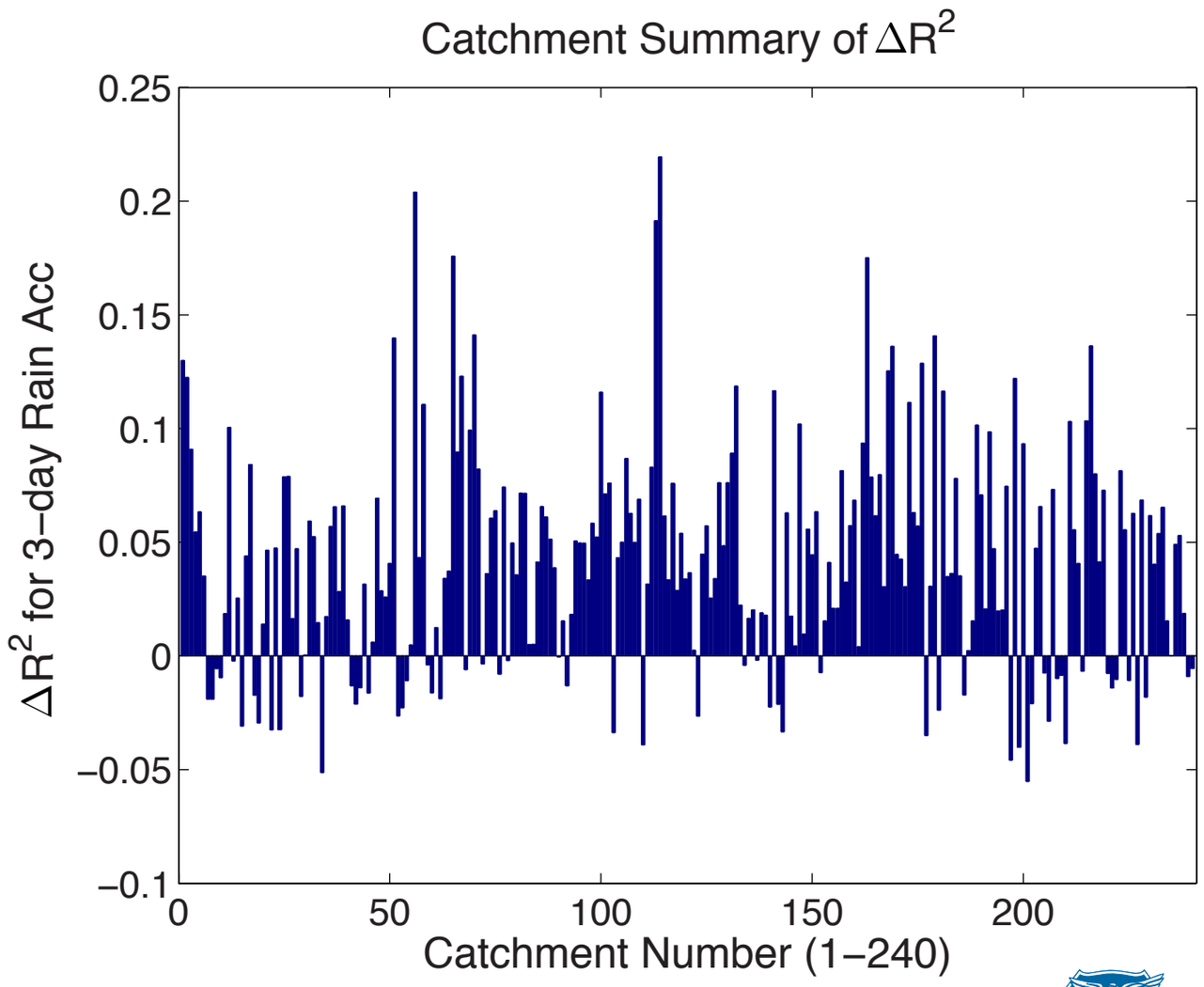
- SMART is also applied to 240 SEACI catchments and evaluated against AWAP rainfall



SMART for Small Catchments

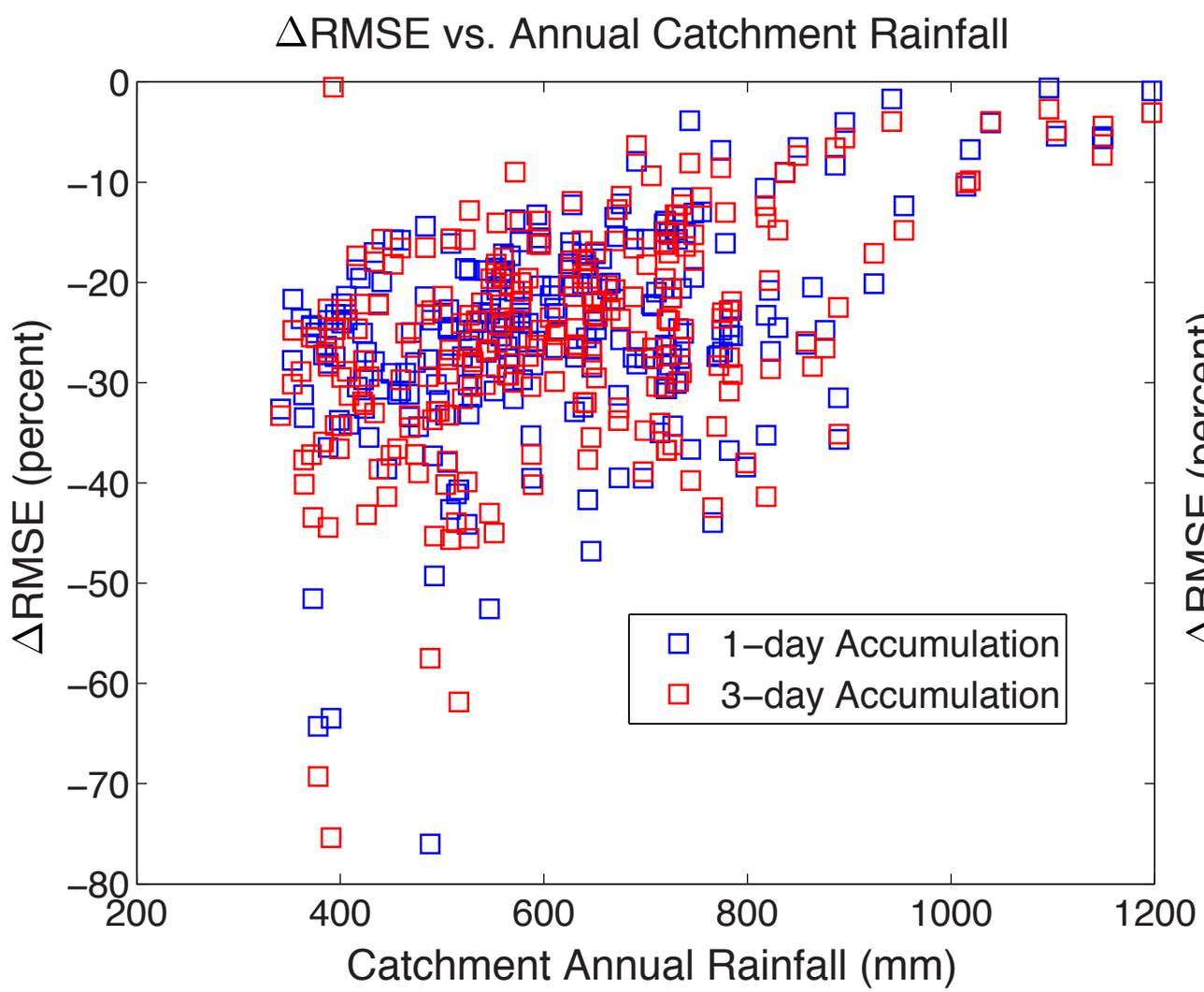
- RMSE and R^2 of 3B42RT are improved in most of SEACI catchments

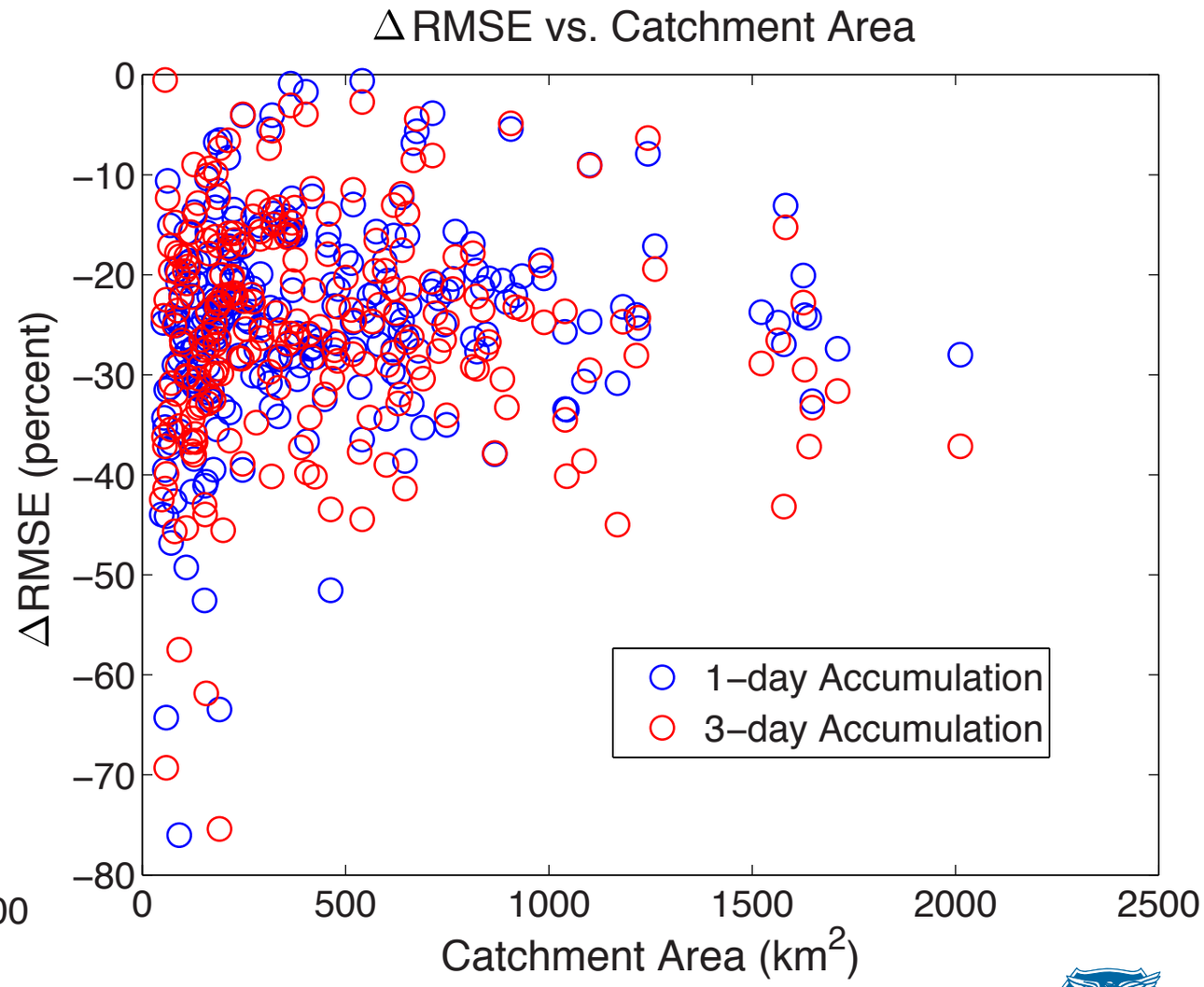




SMART for Small Catchments

- Improvement in RMSE is in general larger for catchments of low~medium annual rainfall





Challenges Remain

- SMART has a limited capability to correct errors for large rainfall events.
- Noisy soil moisture products create numerous small false rainfall events.
- Stochastic filtering based error correction scheme requires obs bias corrected and accurate error models for both soil moisture and input rainfall
- Please come to our posters to see ongoing efforts to address these issues:

  ✓**“Maximizing the value of satellite soil moisture products” by Su *et al.***

  ✓**“Examining the value of satellite precipitation data over Australia” by Pipunic *et al.***

Summary

- The Soil Moisture Analysis Rainfall Tool corrects errors in satellite precipitation products using microwave soil moisture retrievals.
- For 80% of Australia, SMART improved the RMSE and R^2 of TRMM 3B42RT.
- Performance of AMSR-E, SMOS, and ASCAT soil moisture retrievals for SMART did not show significant difference.
- Performance of SMART reduces over high LAI regions.
- Rainfall error can be corrected more effectively for small-to-medium rainfall events at longer accumulation time.