National Aeronautics and Space Administration

Using rainfall and ASCAT observations to verify the SMAP Level-4 soil moisture analysis in Australia

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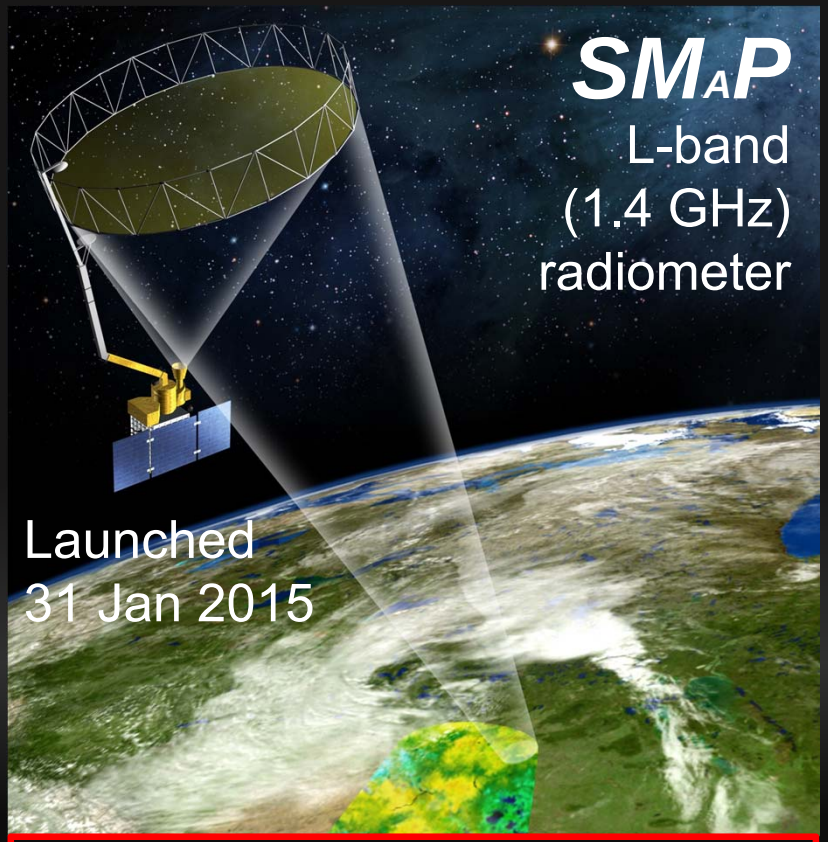
Motivation



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

Status of SMAP…

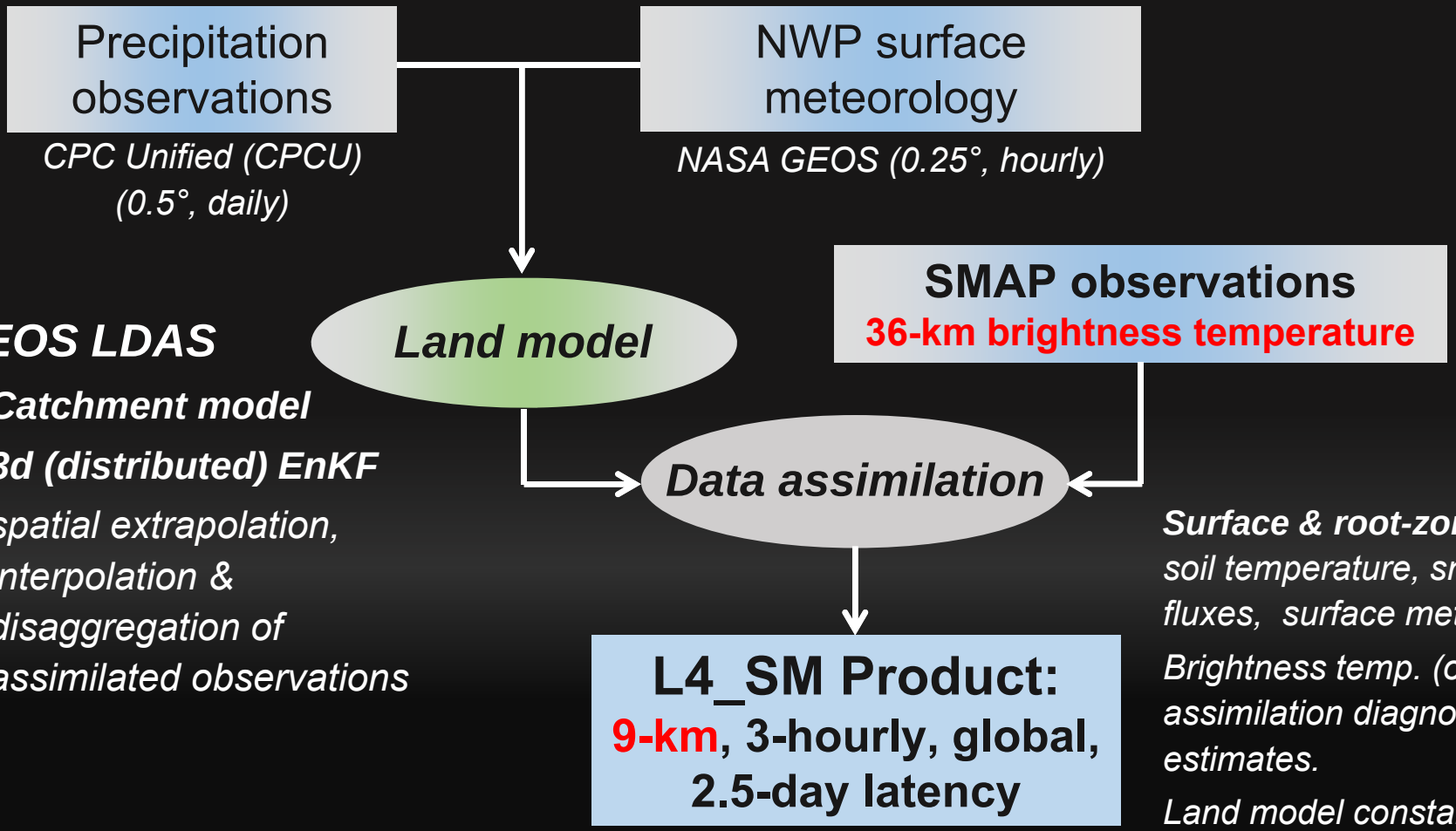
Key Objectives of the

Level 4 Surface & Root-Zone Soil Moisture

(L4_SM) product:

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

L4_SM Algorithm Overview



GEOS LDAS

- ***Catchment model***
- ***3d (distributed) EnKF***

  spatial extrapolation, interpolation & disaggregation of assimilated observations

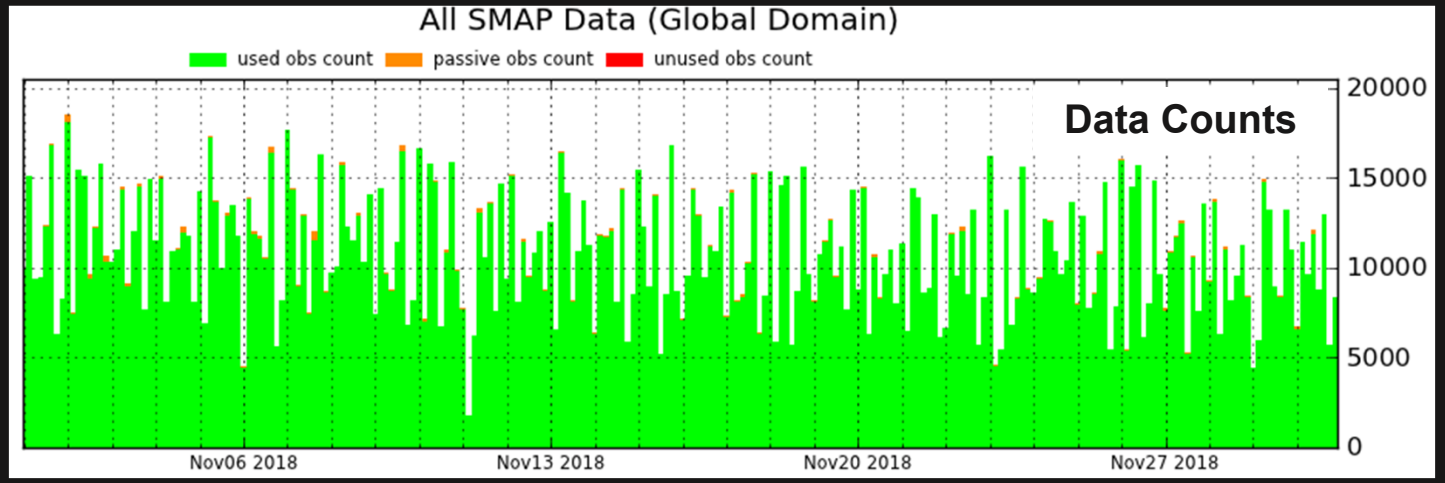
Surface & root-zone soil moisture, *soil temperature, snow, surface fluxes, surface met. forcing.*

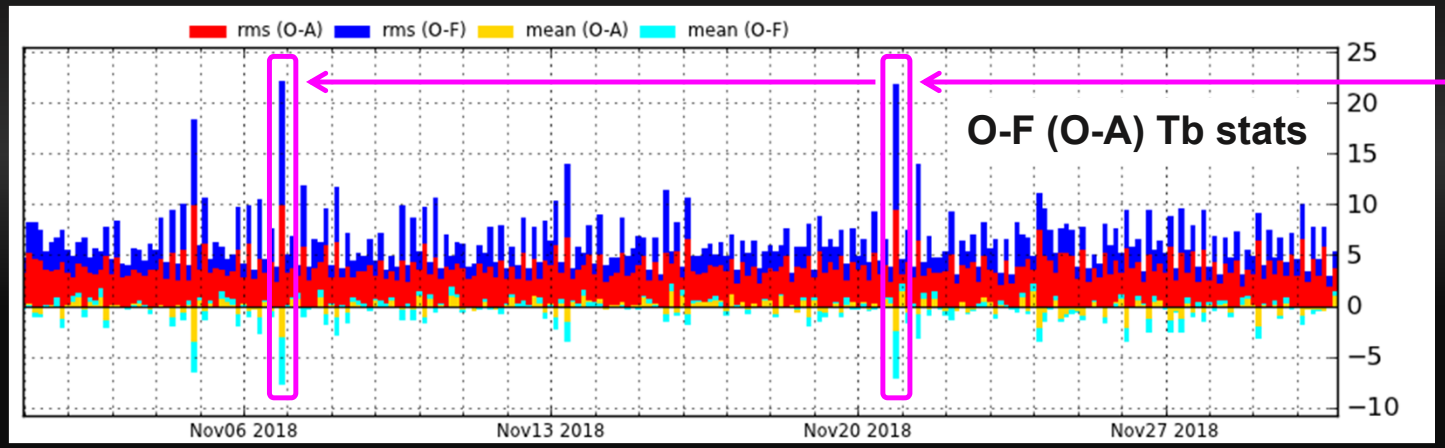
Brightness temp. (obs & modeled), assimilation diagnostics, uncertainty estimates.

Land model constants.

Reichle et al. 2017a, JHM, doi:10.1175/JHM-D-17-0063.1
Reichle et al. 2017b, JHM, doi:10.1175/JHM-D-17-0130.1

L4_SM Monitoring (Nov 2018, Vv4030)

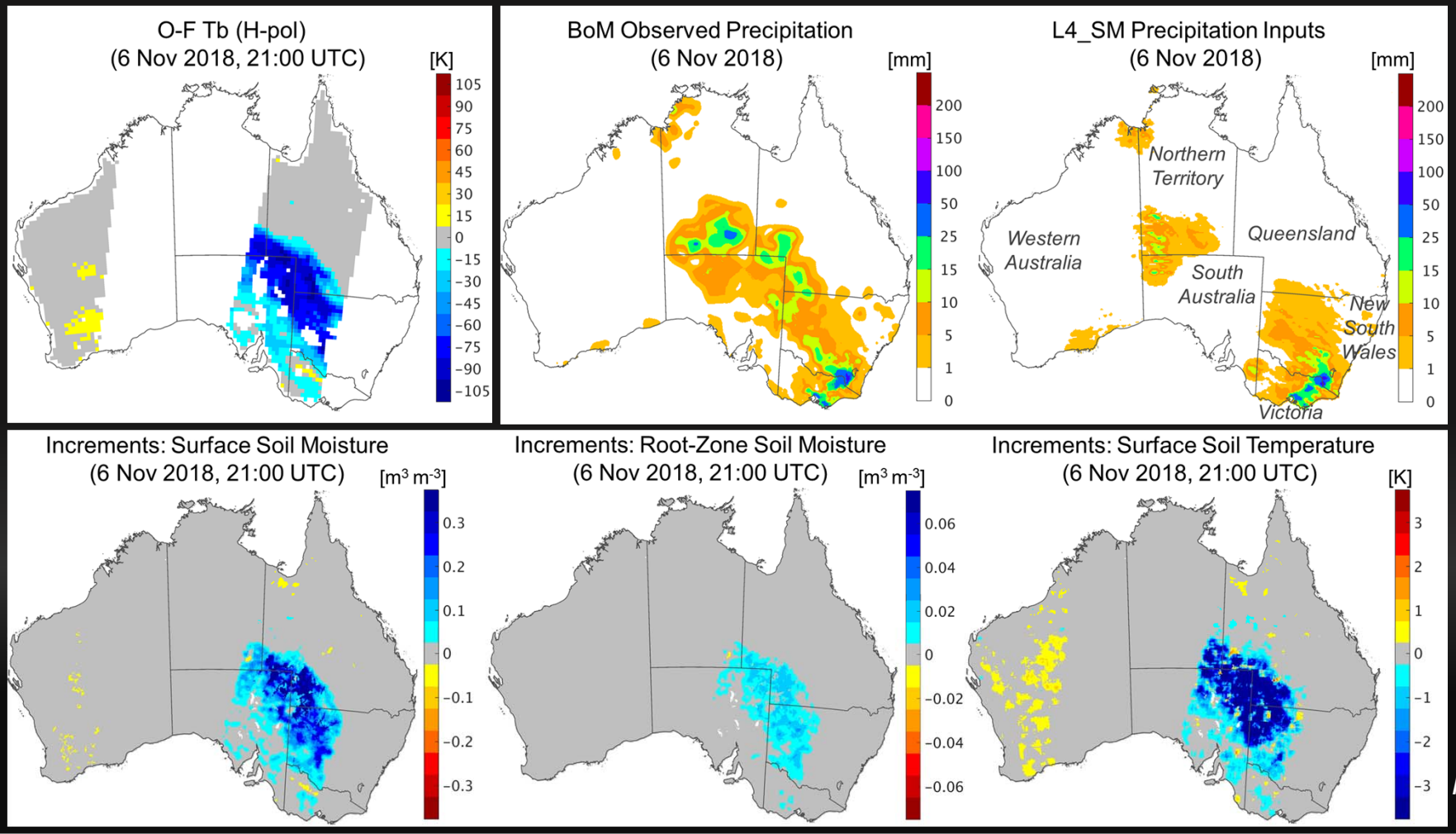




RMS(O-F) > 20 K:
21z on 6 Nov 2018
21z on 20 Nov 2018

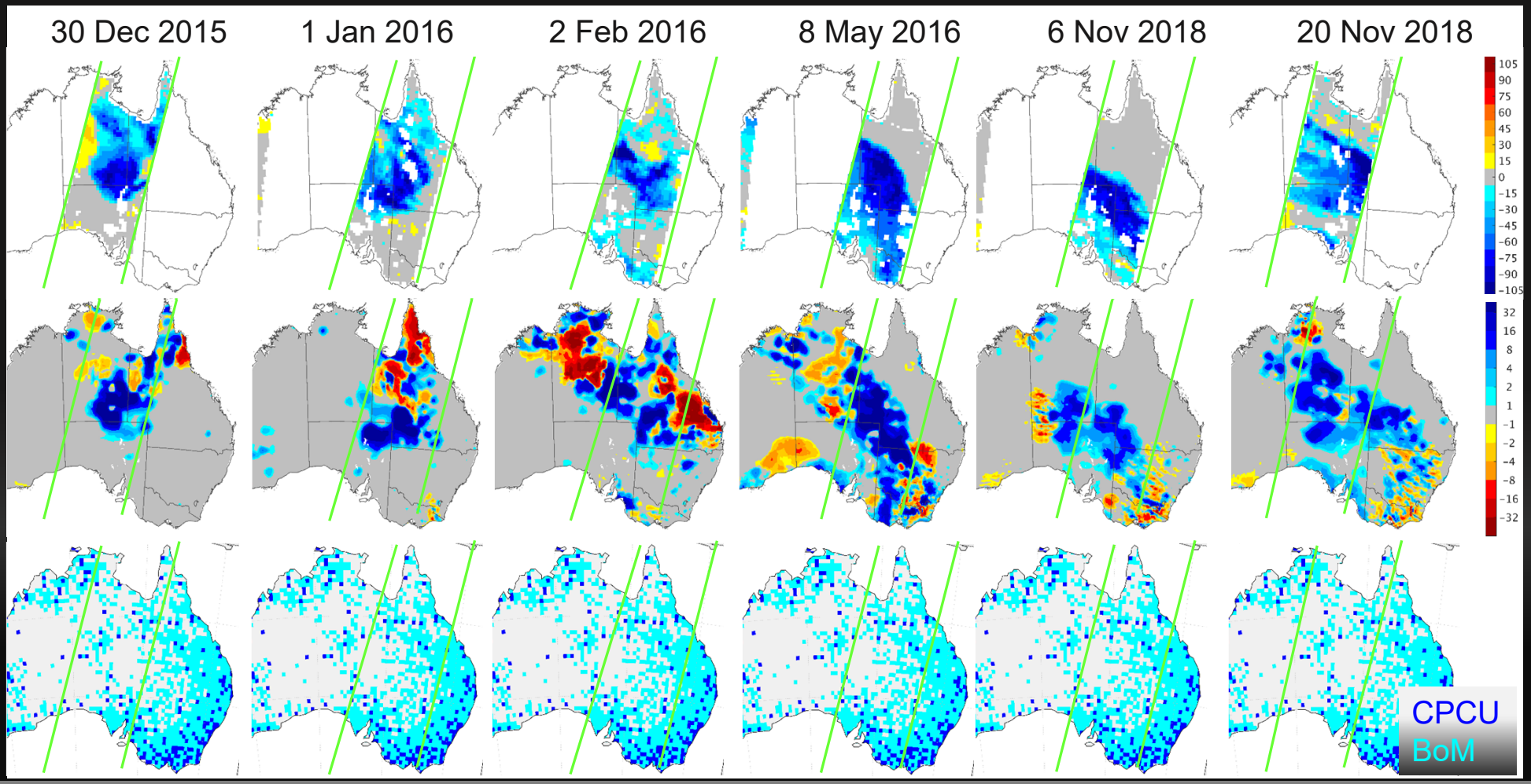
System prevents operators from exporting L4_SM data until approved by system engineer or scientist.

Precipitation Errors in Australia (6 Nov 2018, 21z)

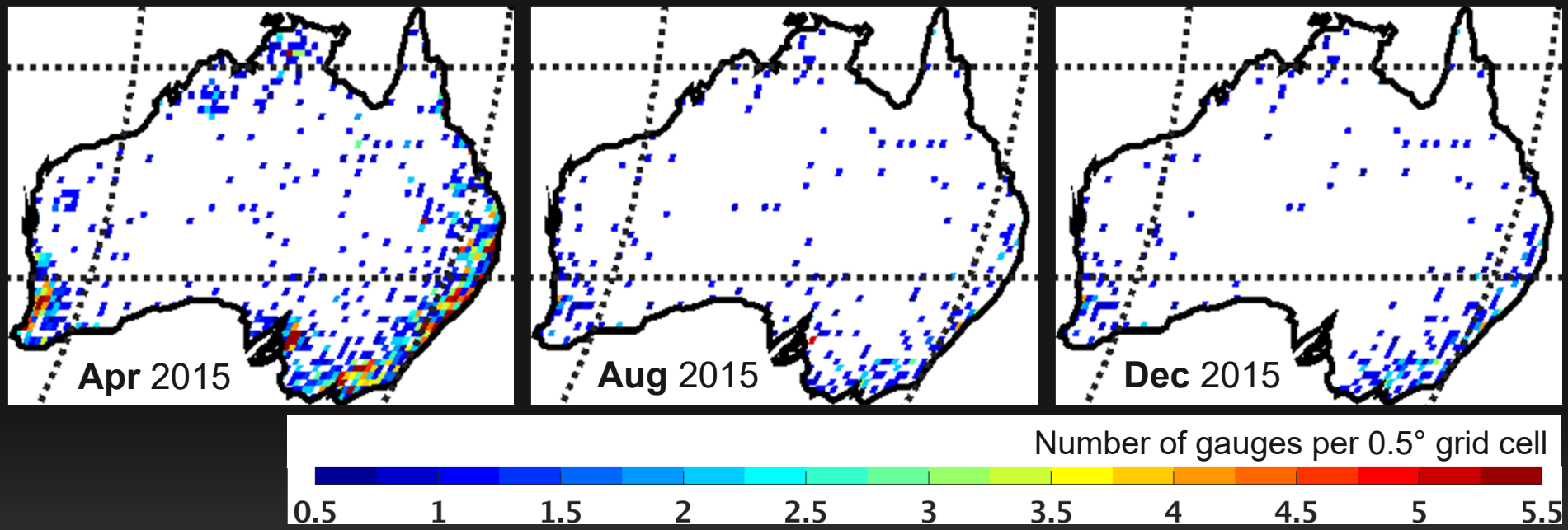


A similar case for May 8, 2016 is discussed in *Reichle et al.* 2017
doi:10.1175/JHM-D-17-0130.1

Events with std-dev(O-F)>20 K (through Dec 2018)



Disappearing CPCU Gauges



During the first few months of SMAP, there was a considerable drop in the number of gauges that contribute to the CPCU product.

Subsequent analysis is for Aug 2015 to Jul 2018.

From Case Study to Systematic Investigation

Objective:

Quantitatively relate soil moisture analysis increments to precip errors.

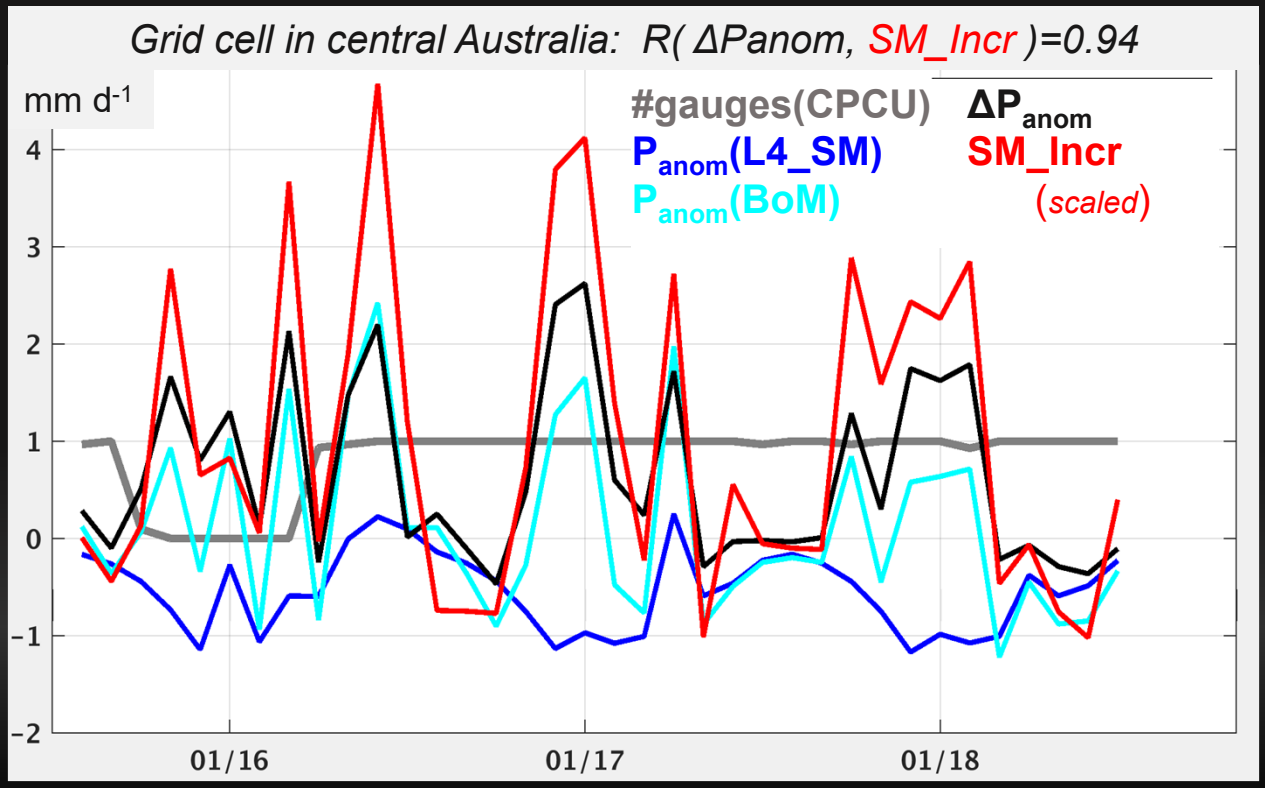
Assuming that

1) BoM precip is correct and L4_SM precip is wrong,

2) soil moisture errors result *only* from precip errors, and

3) seasonally varying *climatological* bias in L4_SM precip does *not* result in soil water increments (b/c of L4_SM calibration):

→ L4_SM soil moisture increments should be correlated with errors in L4_SM precip *anomalies* (w.r.t. BoM).



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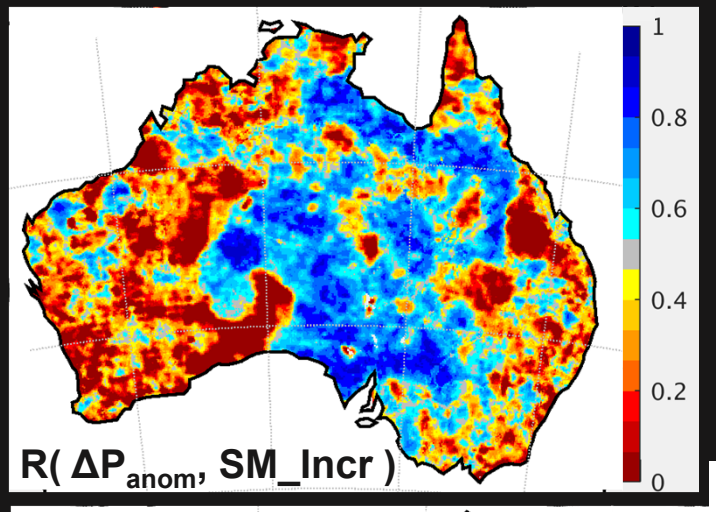
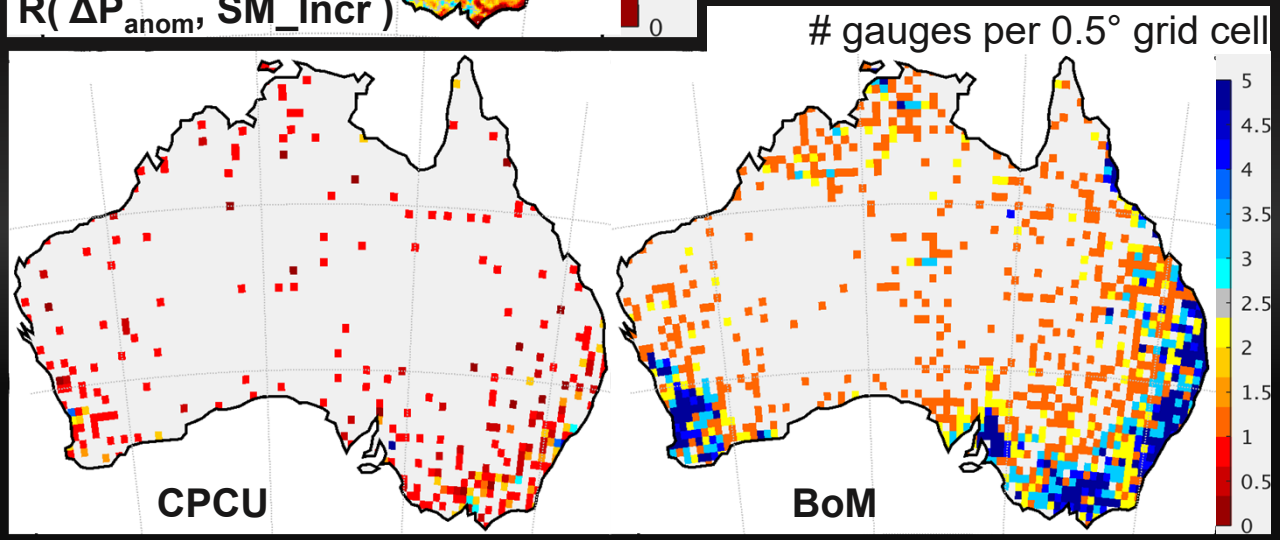


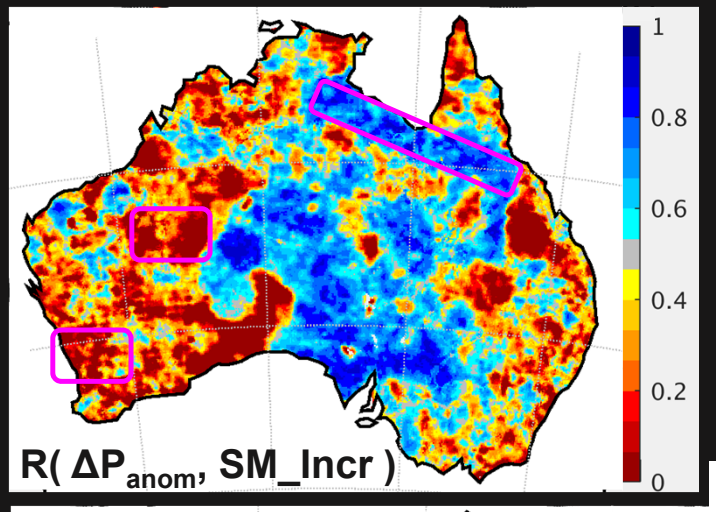


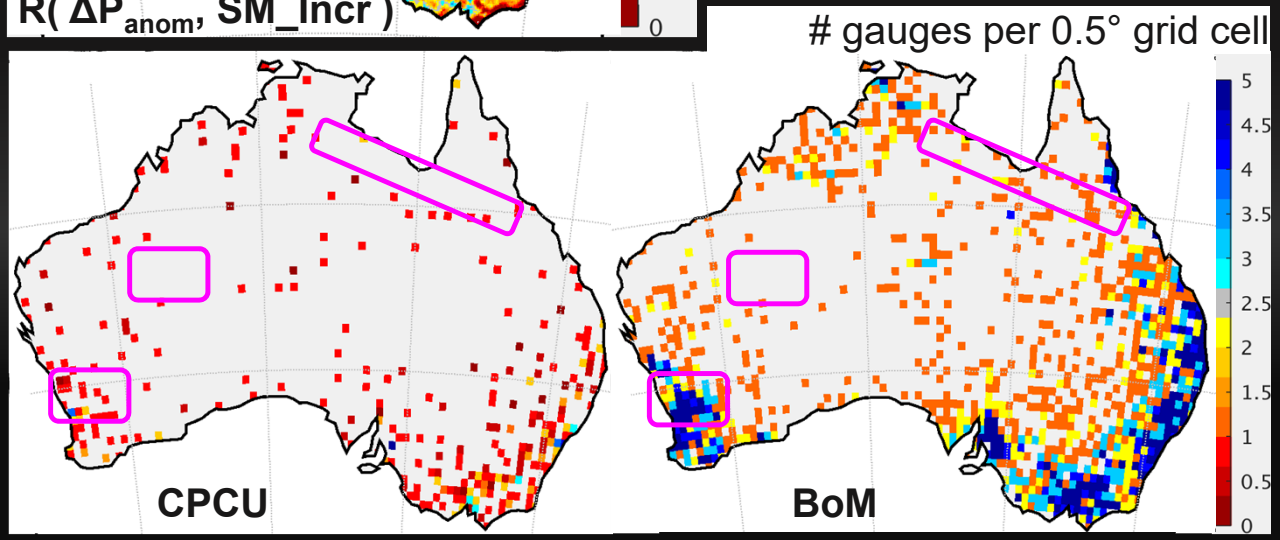
From Case Study to Systematic Investigation

Expect **high** correlation where BoM has good gauge coverage and CPCU has little or none.

Expect **low** correlation where <u>both</u> CPCU and BoM have sufficient gauges or

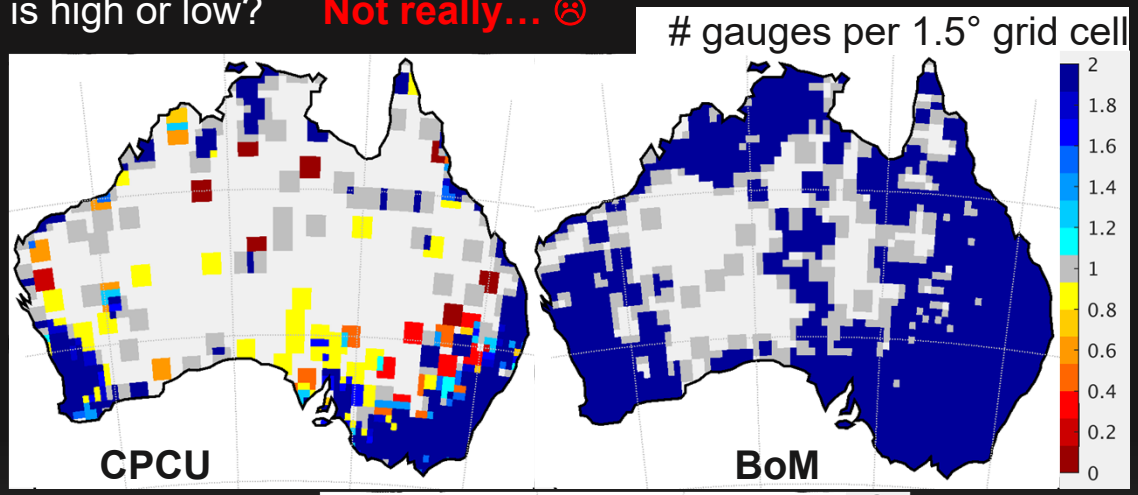
<u>both</u> do <u>not</u> have gauges.

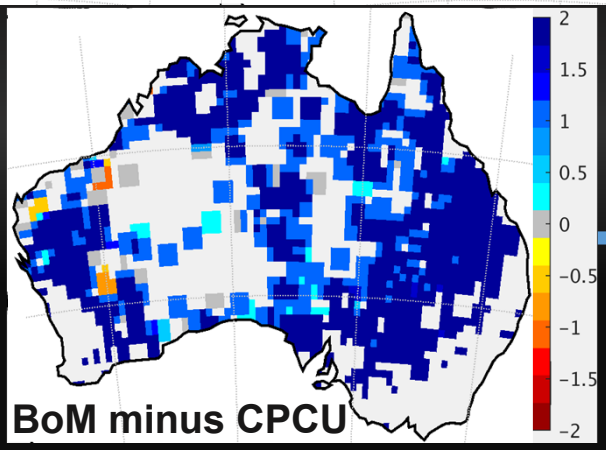




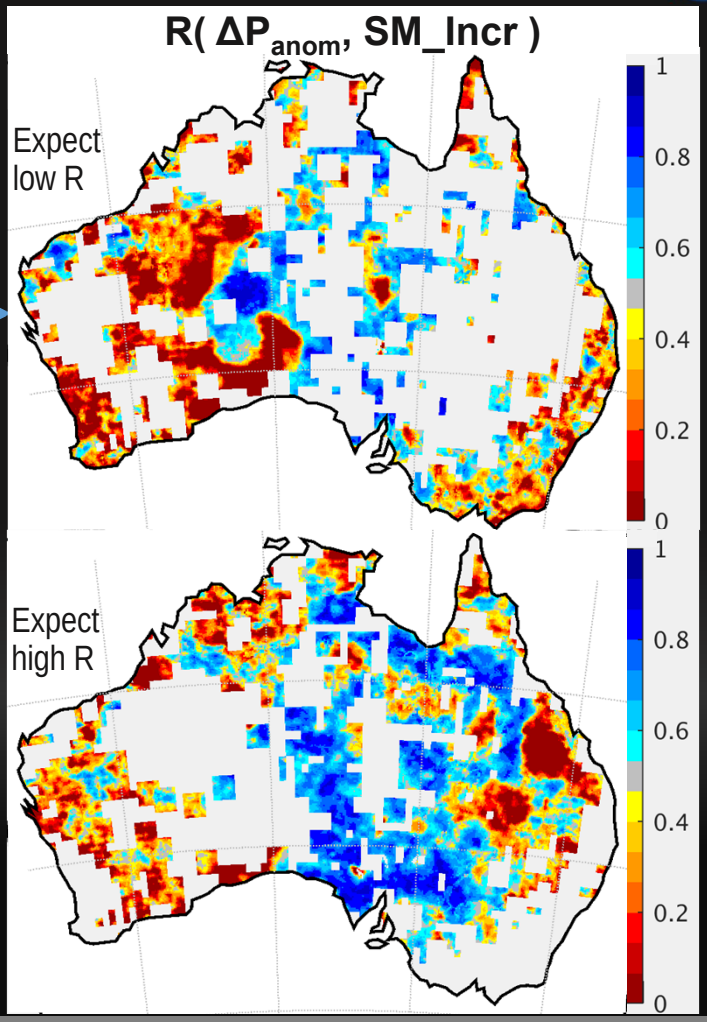
How Can We Explain the Correlation Pattern?

Can we use gauge density to determine whether correlation is high or low? **Not really… ☹**





Gauge density difference



How Can We Explain the Correlation Pattern?

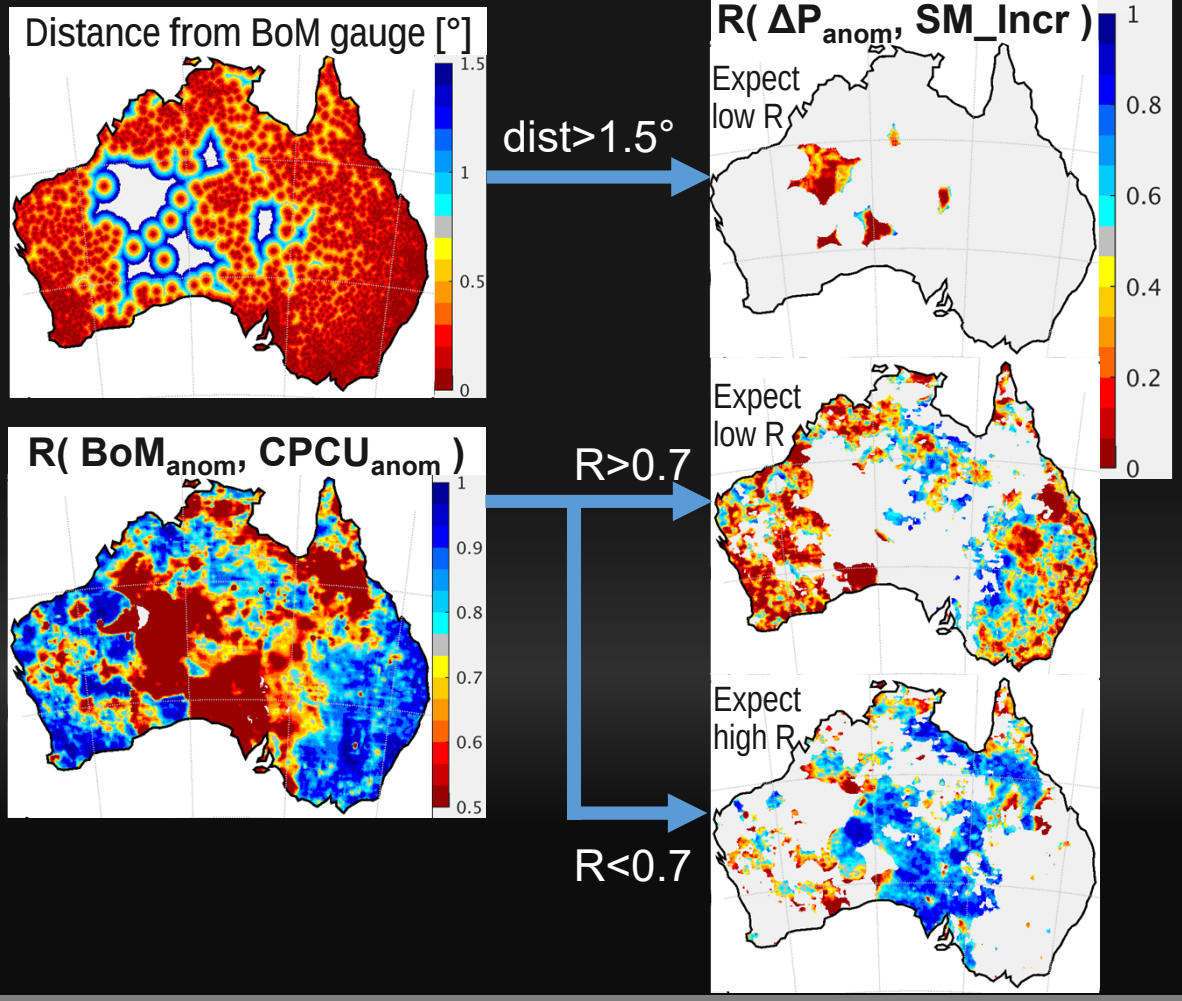
New approach:

- BoM precipitation is bad if distance from nearest gauge > 1.5°

- L4_SM precipitation is ok where there is agreement with BoM:

  R (BoM_{anom},$CPCU_{anom}$)>0.7

➔ SMAP soil moisture analysis increments are consistent with known errors in L4_SM precipitation forcing.



Evaluating L4_SM Using ASCAT Soil Moisture Retrievals

- Triple collocation (TC) can estimate the (anomaly) skill of a soil moisture product (w.r.t. unkown truth), provided two independent products are available.

  Typical triplet: Model / Passive / Active

- However, L4_SM merges modeling and passive microwave observations.

- Dong et al. (2019), GRL, introduced a method to compute skill improvement using only one independent product (e.g., ASCAT):

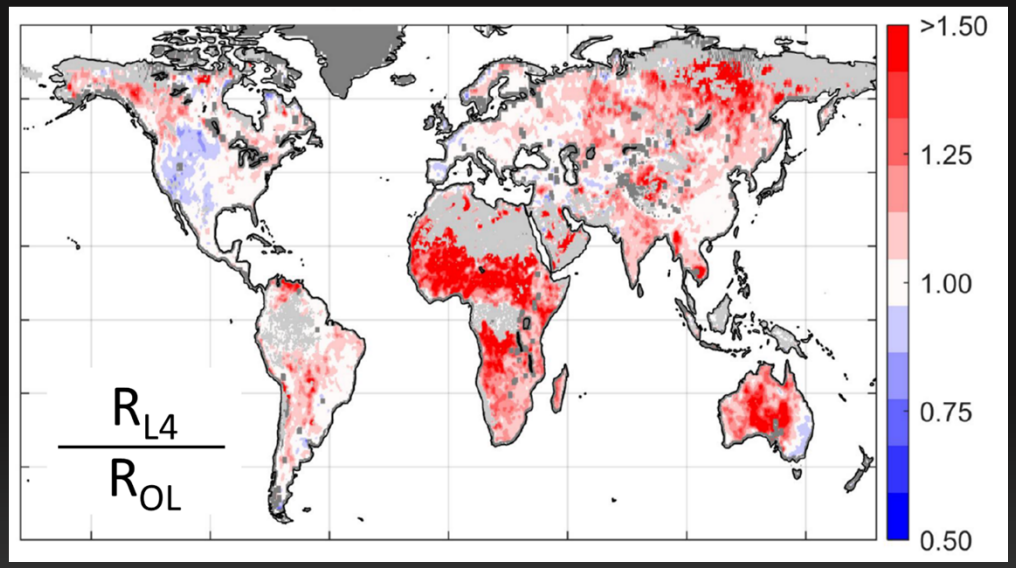
  $R\_ratio \equiv R_{L4,\theta} / R_{OL,\theta}$ (ratio of L4 and OL skill vs. truth θ)

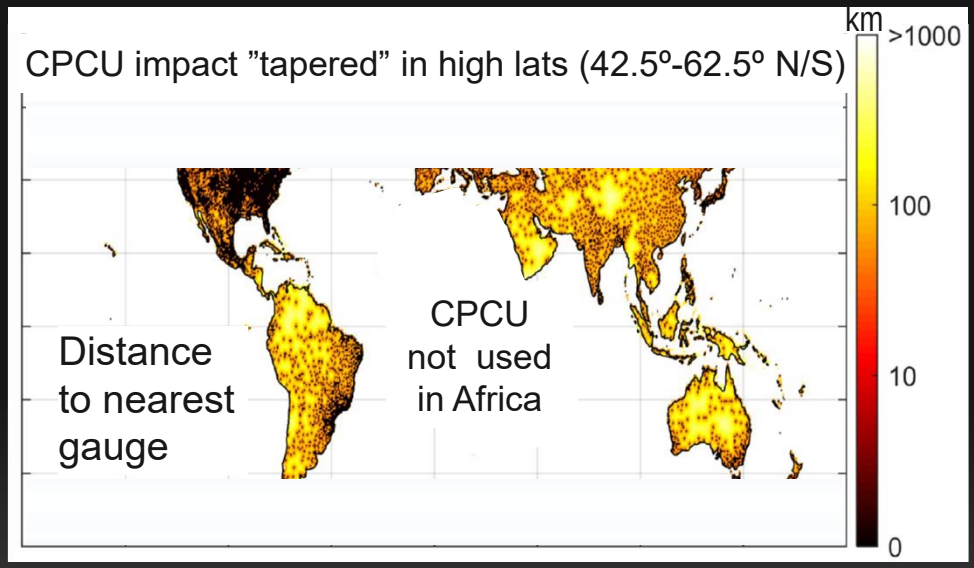
  (after some math) $= R_{L4,ASC} / R_{OL,ASC}$ (ratio of L4 and OL skill vs. ASCAT)

  where R is the anomaly correlation coefficient and OL is a model-only simulation.

Dong et al. 2019, GRL, doi:10.1029/2019GL083398

Skill Improvement from SMAP Data Assimilation





Greatest skill improvement from SMAP assimilation in otherwise data-sparse regions.

Verification with in situ measurements suggests that ASCAT-based metric underestimates true skill improvement (not shown).

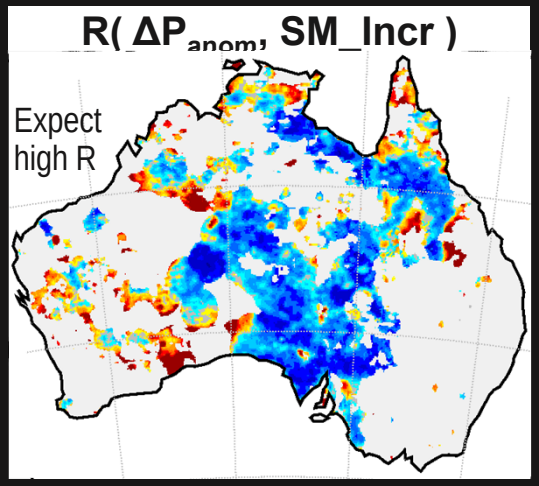
Dong et al. 2019, GRL, doi:10.1029/2019GL083398

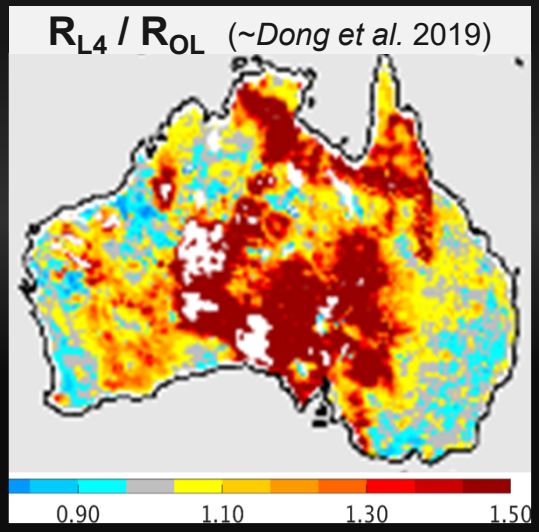
Summary

Using independent BoM precipitation data, we find that SMAP assimilation corrects known errors in L4_SM precipitation forcing in Australia.

Using independent ASCAT soil moisture retrievals, we find that soil moisture skill improvement from SMAP assimilation is greatest in otherwise data-sparse regions.

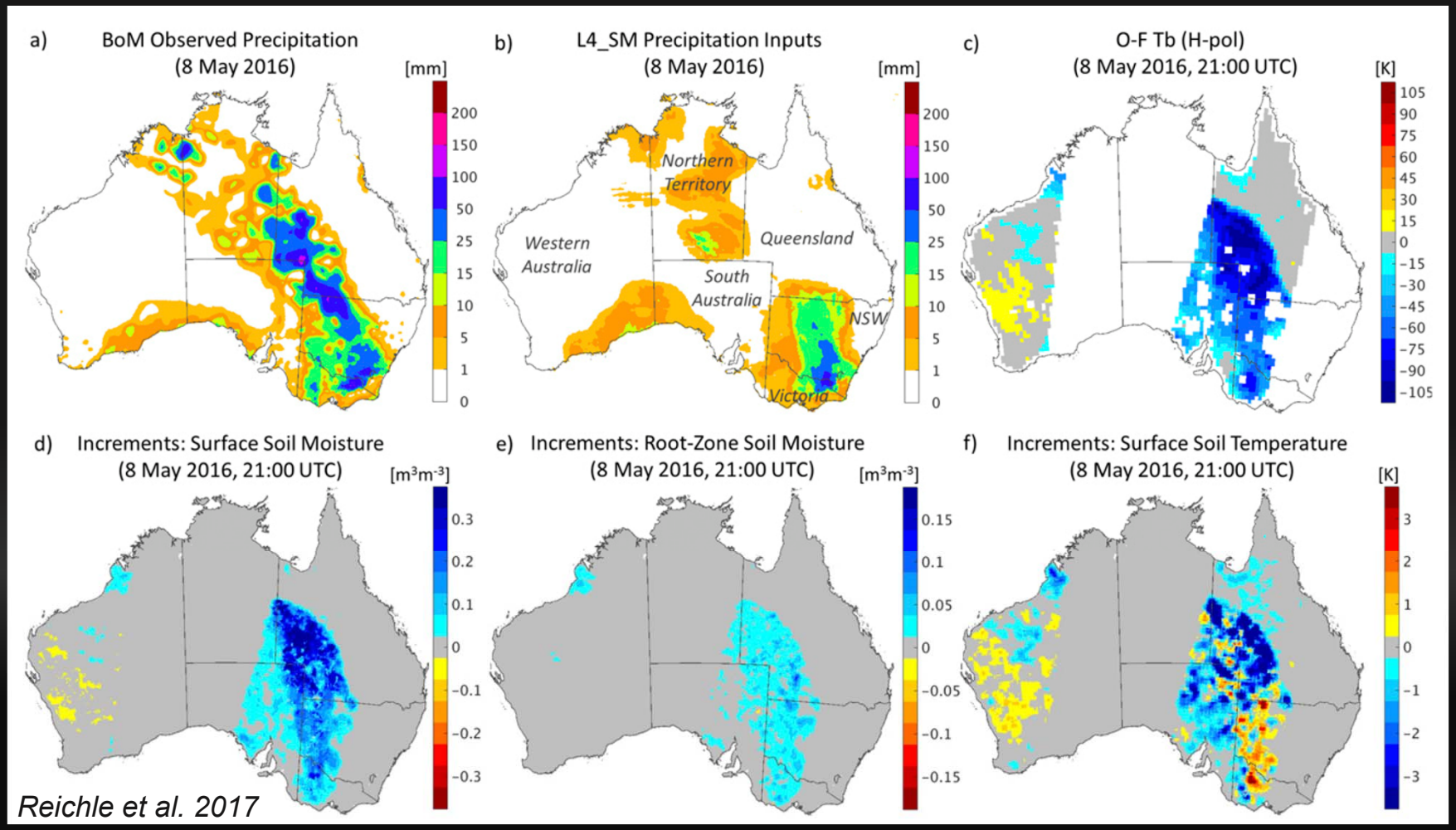
The patterns of corrections/improvements are highly consistent.





EXTRA SLIDES

Precipitation Errors in Australia (8 May 2016, 21z)



Reichle et al. 2017

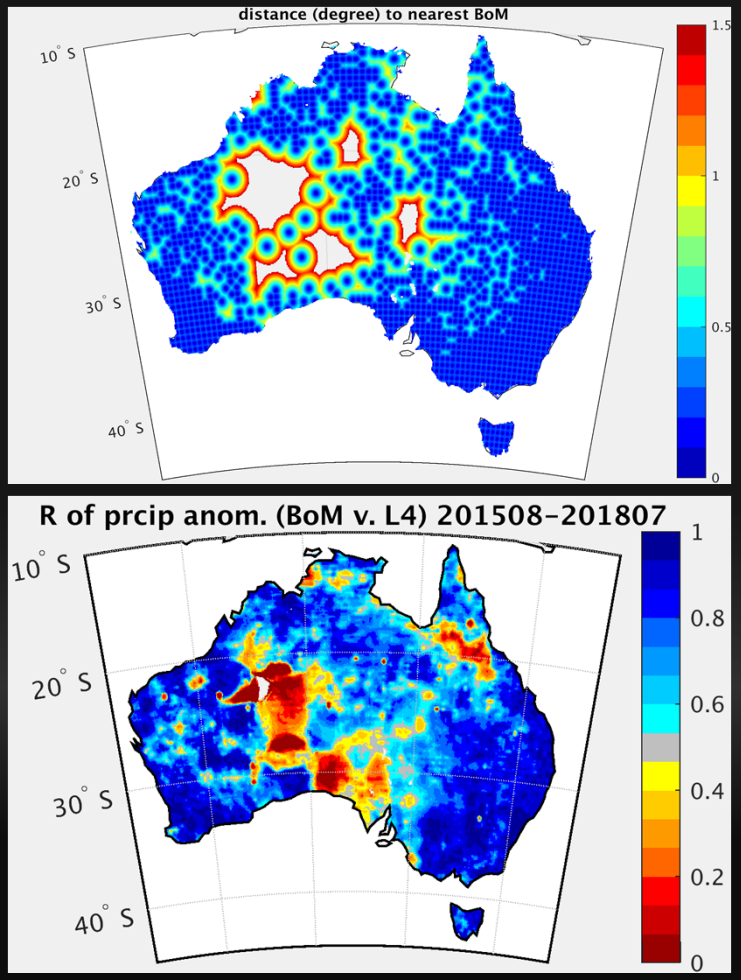
From Case Study to Systematic Investigation

So far limited success.

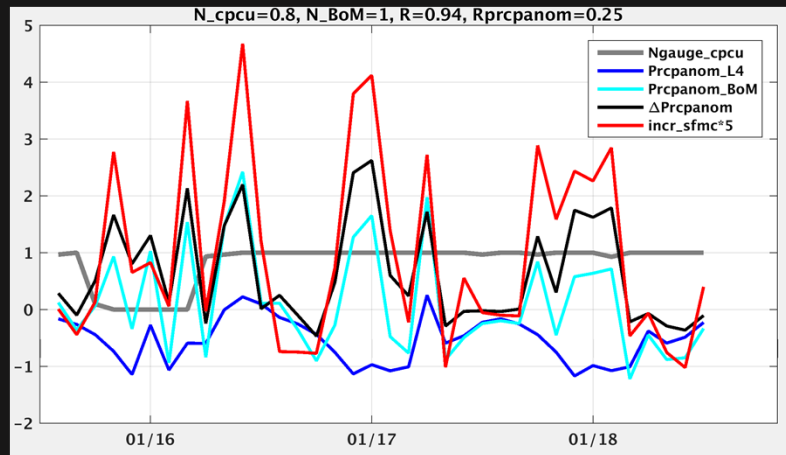
Other factors to consider:

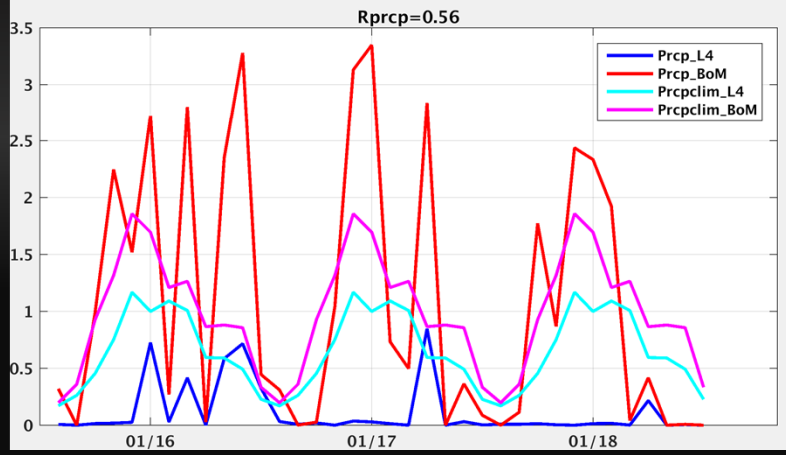
1) Distance from nearest BoM gauge → weed out areas where BoM is not backed by gauges.

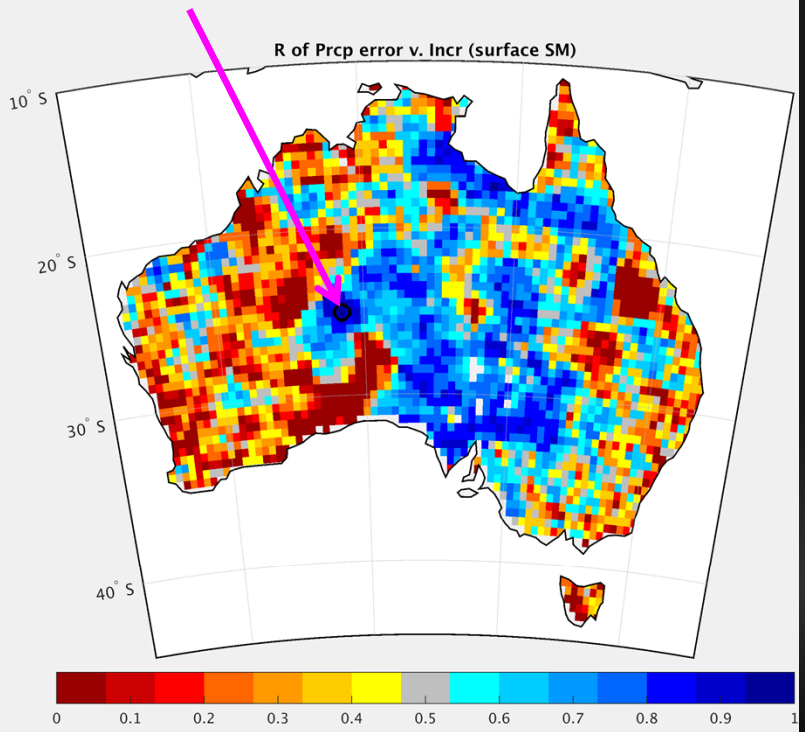
2) Agreement of BoM and CPCU precip → weed out areas where CPCU product is in agreement with BoM (i.e., reliable).



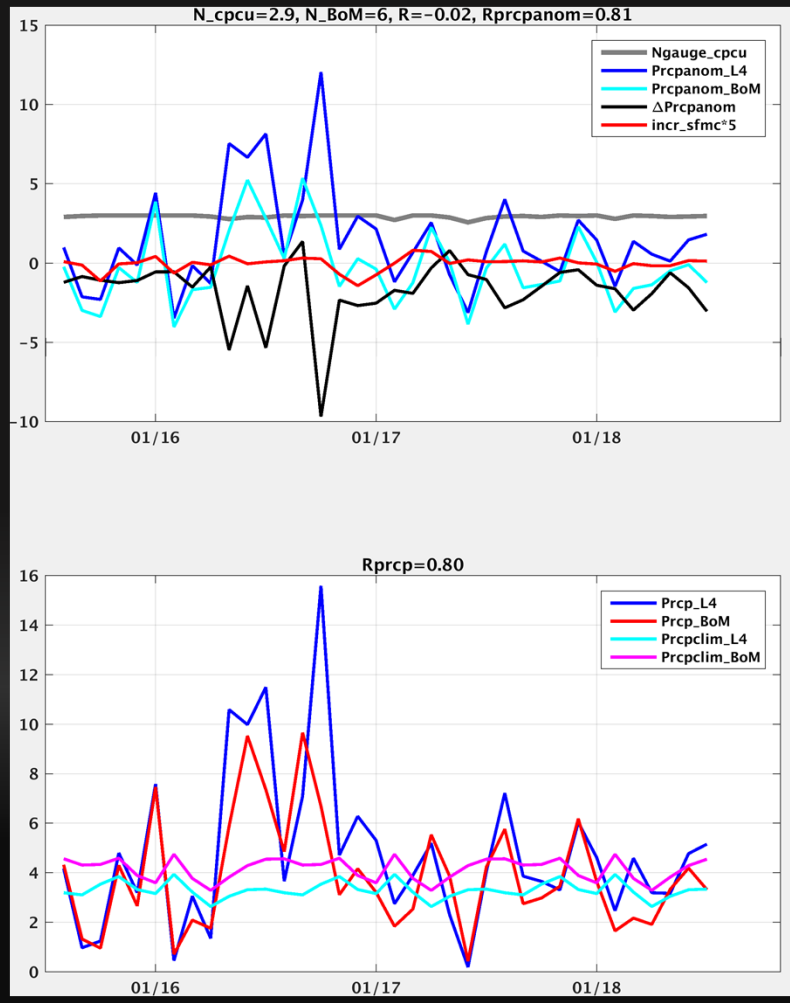
Good BoM and Bad L4 Precipitation

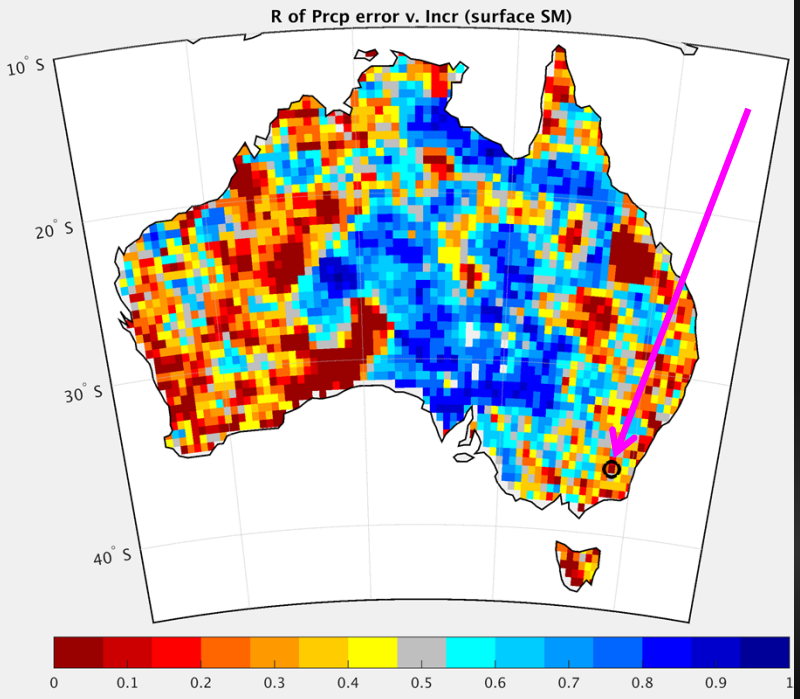






Good BoM and good L4 precip





Bad BoM and bad L4 precip