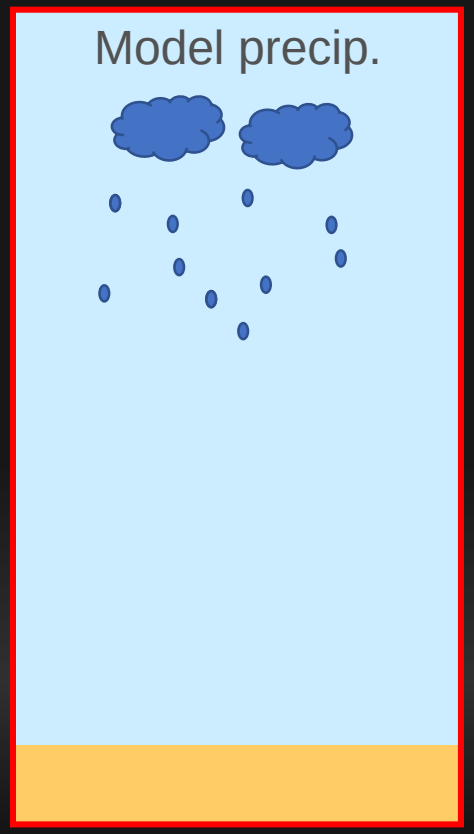
Land surface precipitation and hydrology in MERRA-2

R. Reichle, R. Koster, C. Draper, Q. Liu, M. Girotto,
S. Mahanama, G. De Lannoy, G. Partyka,
and many others…

Land Surface in MERRA Products

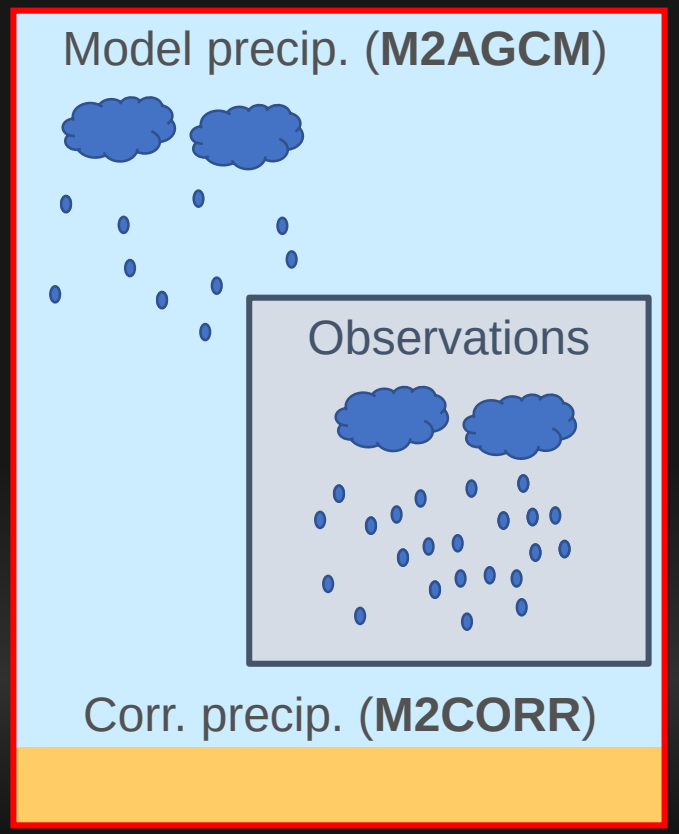
MERRA



MERRA-Land

+ updated land model

MERRA-2

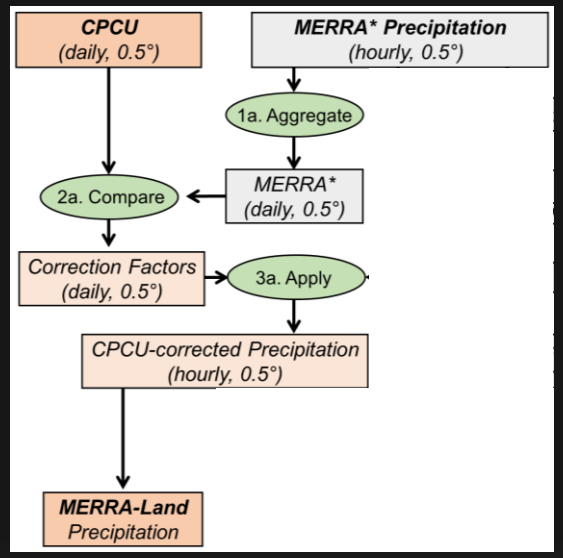


+ updated AGCM and atmospheric analysis

Outline

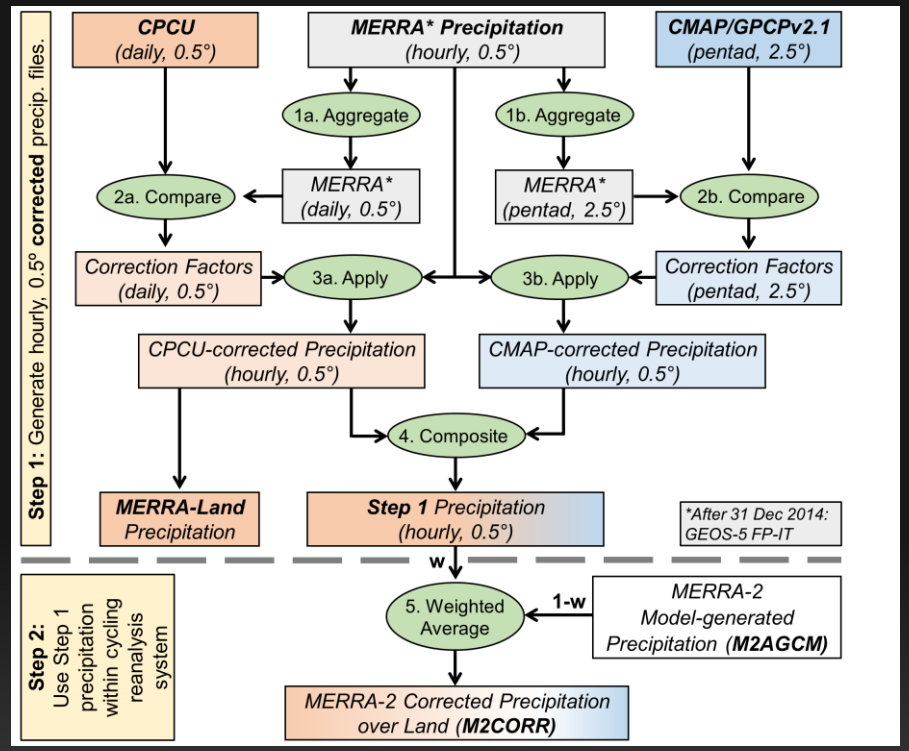
1. Precipitation Corrections and Evaluation
2. Evaluation of Land Surface Hydrology

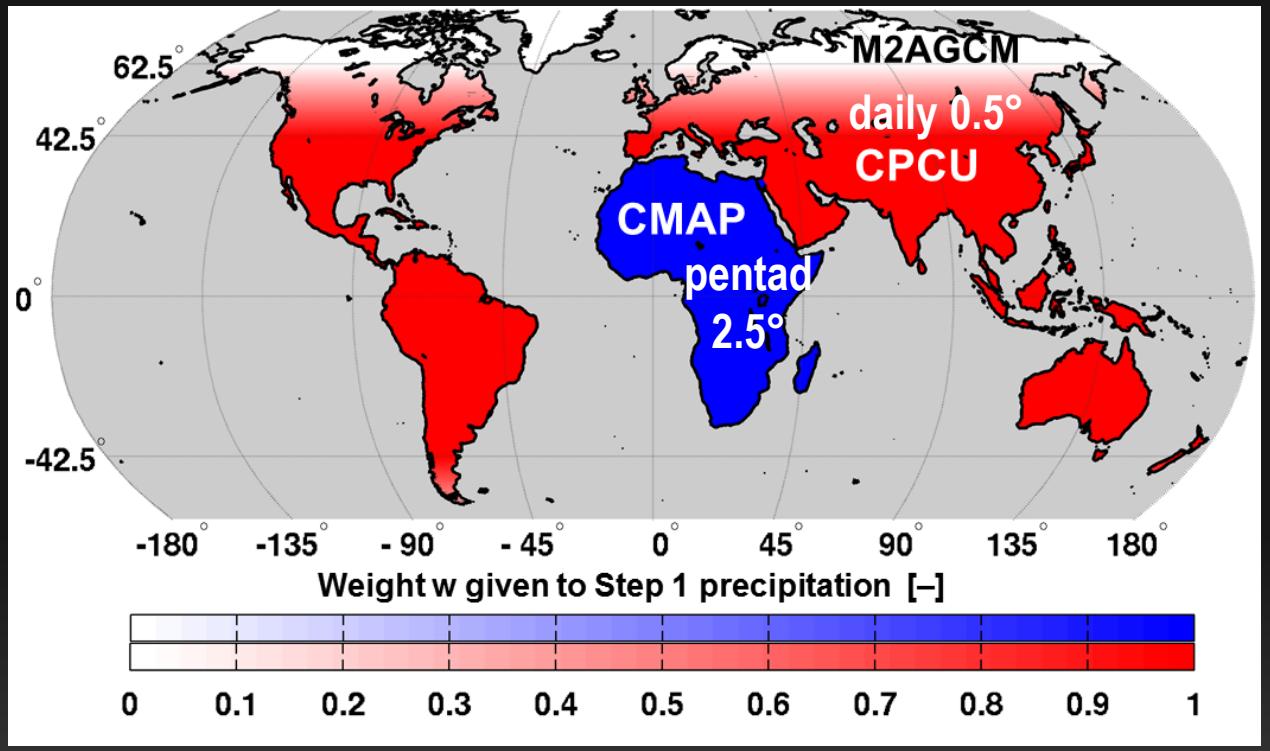
MERRA-Land Precipitation Corrections



- Land surface precipitation corrected to CPCU gauge product everywhere.
- Separately for each day / 0.5° grid cell.
- Sub-daily variations from MERRA.

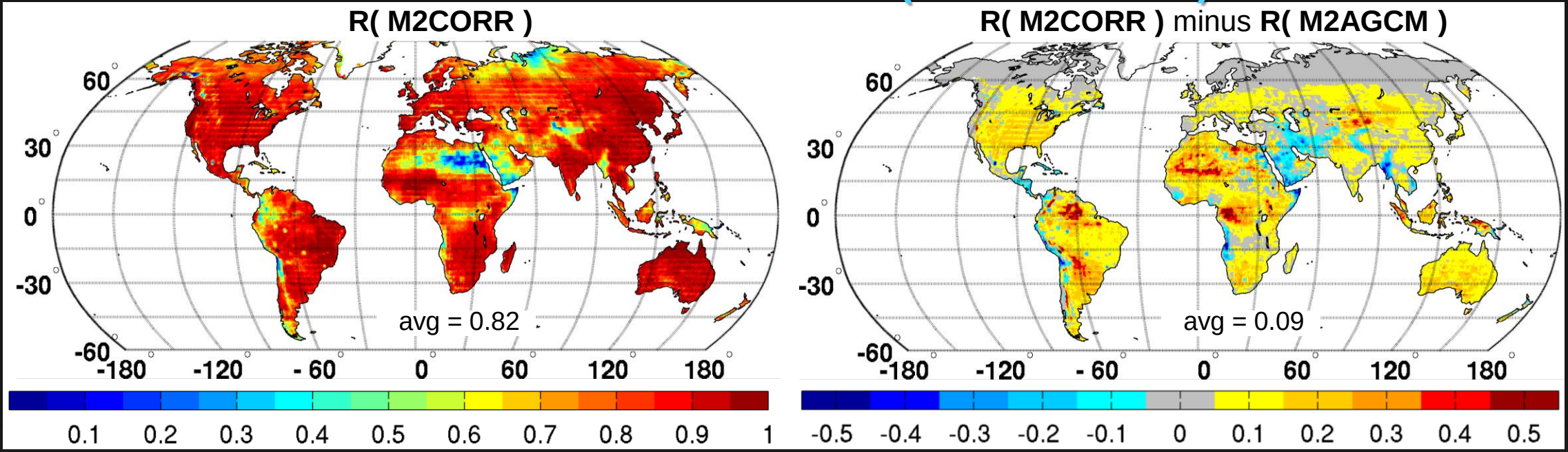
MERRA-2 Precipitation Corrections





- Land surface precipitation corrected to observations-based products except at high latitudes.
- Separately for each day / 0.5° grid cell (CPCU) or pentad / 2.5° grid cell (CMAP).
- Sub-daily/pentad variations from MERRA (through Feb 2016) and GEOS FP-IT thereafter.

Time Series Correlation (vs. GPCPv2.2)



MERRA-2 corrected precipitation:

- agrees with GPCPv2.2 in well-observed regions &
- is better than model precipitation.

Similar results for RMSE and anomaly correlation.

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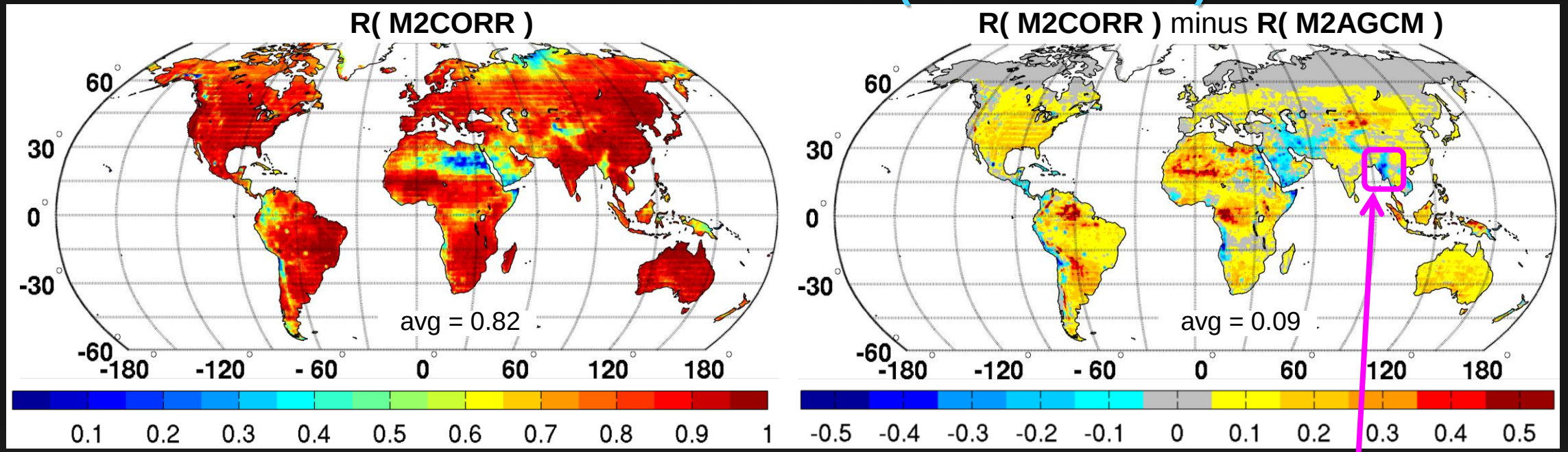

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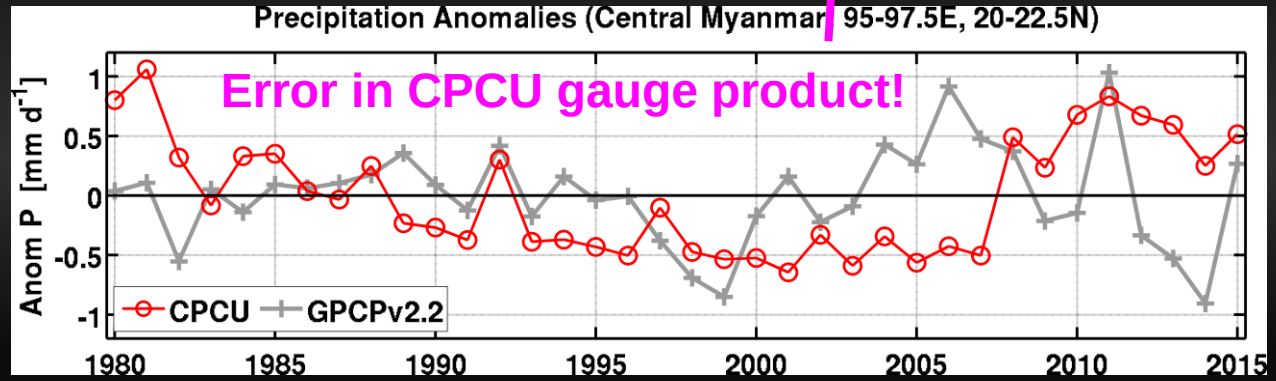
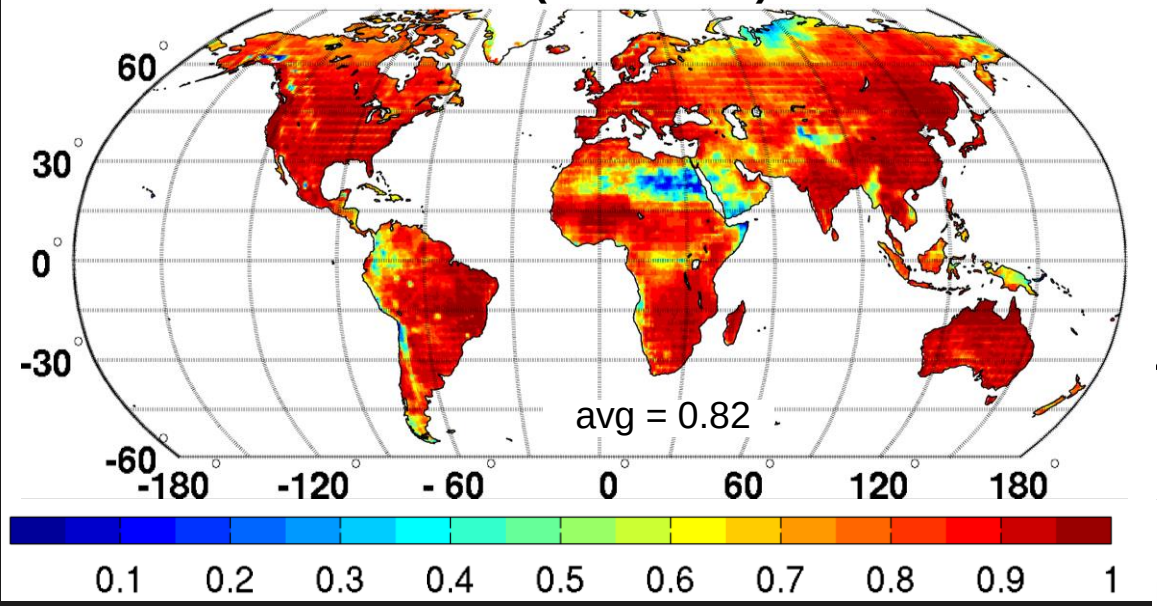
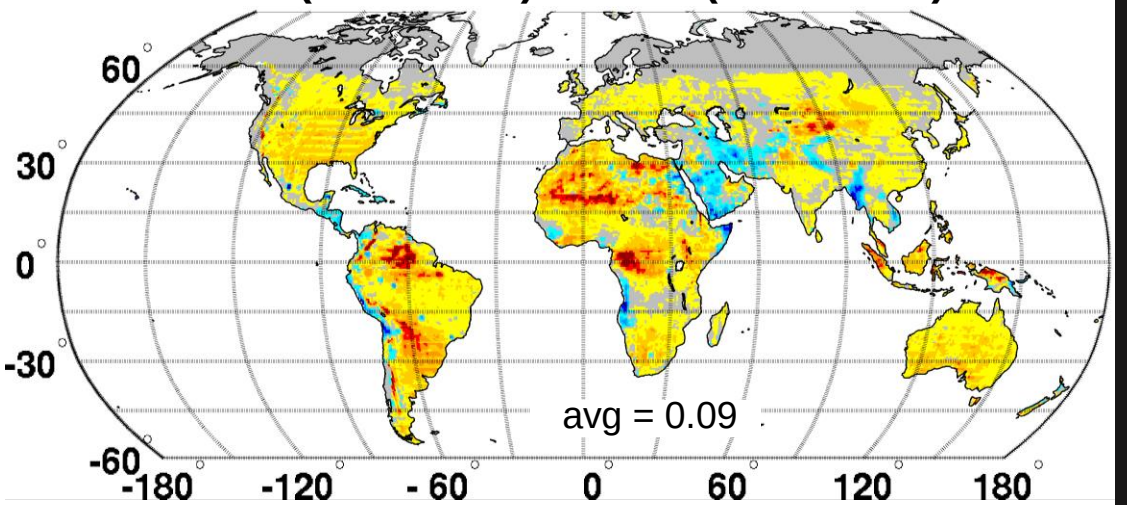


Time Series Correlation (vs. GPCPv2.2)

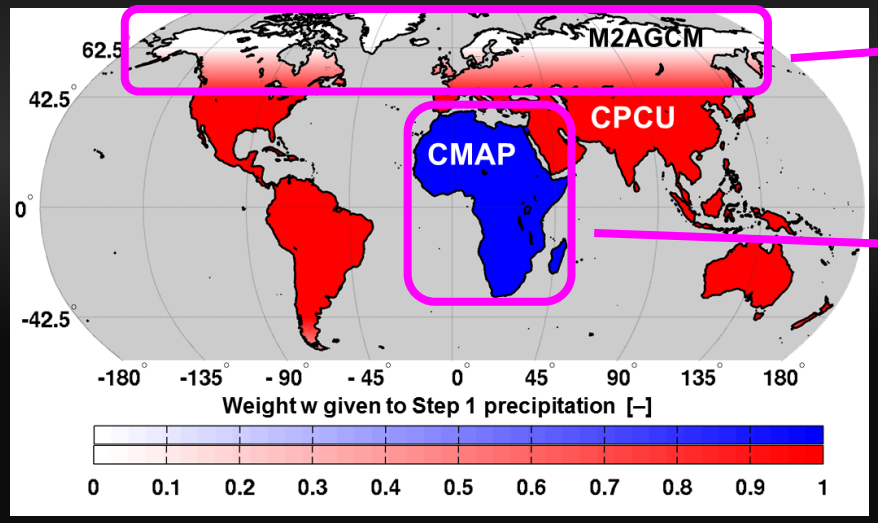
R(M2CORR)



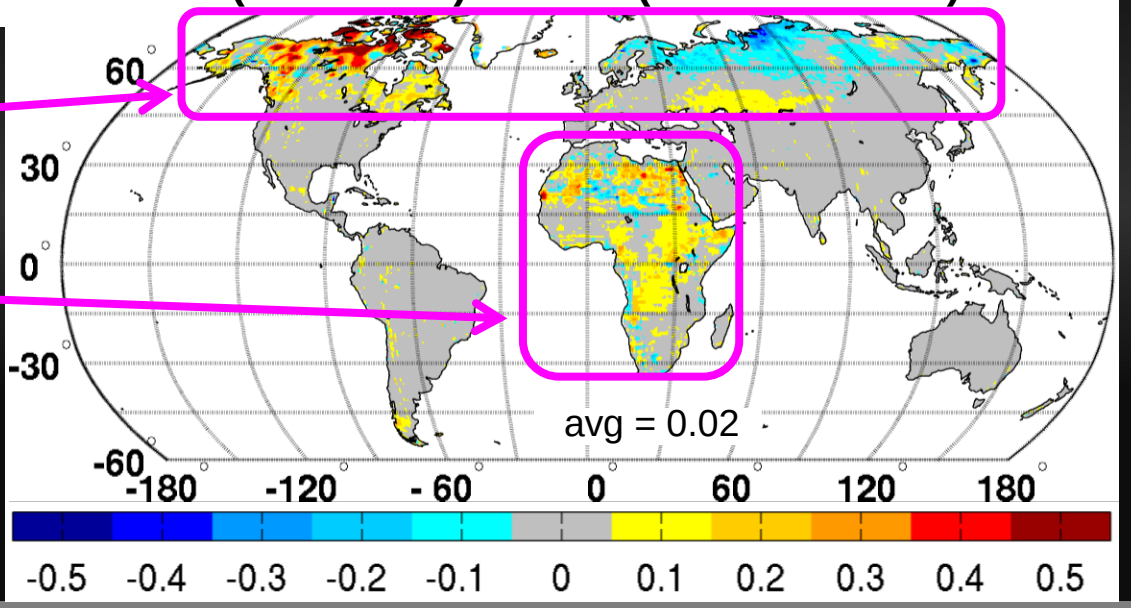
R(M2CORR) minus **R(M2AGCM)**



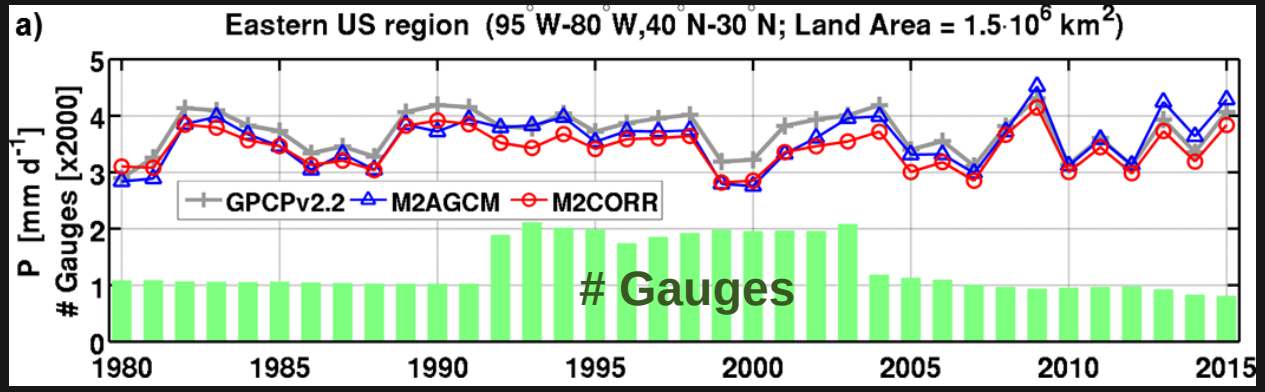
MERRA-2 corrected precipitation also better than MERRA-Land.



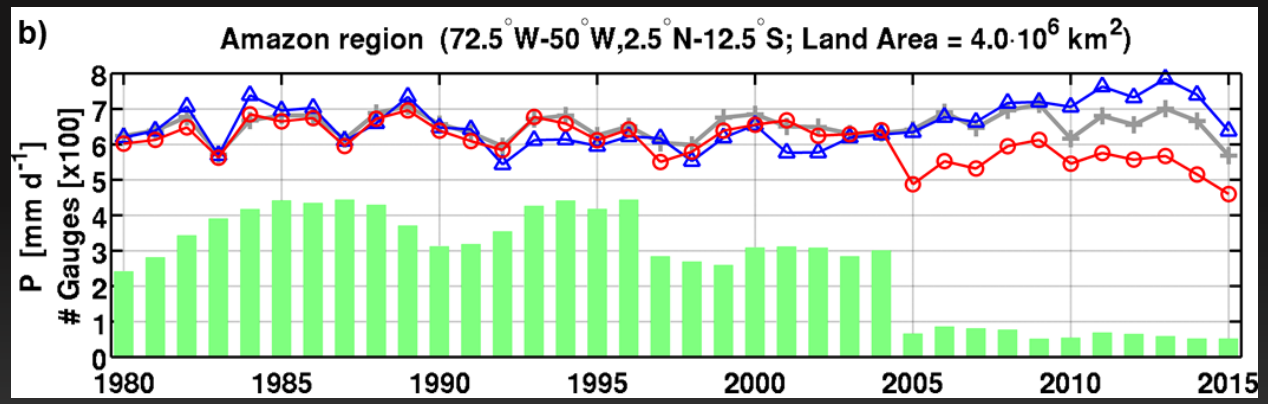
R(M2CORR) minus **R(MERRA-Land)**



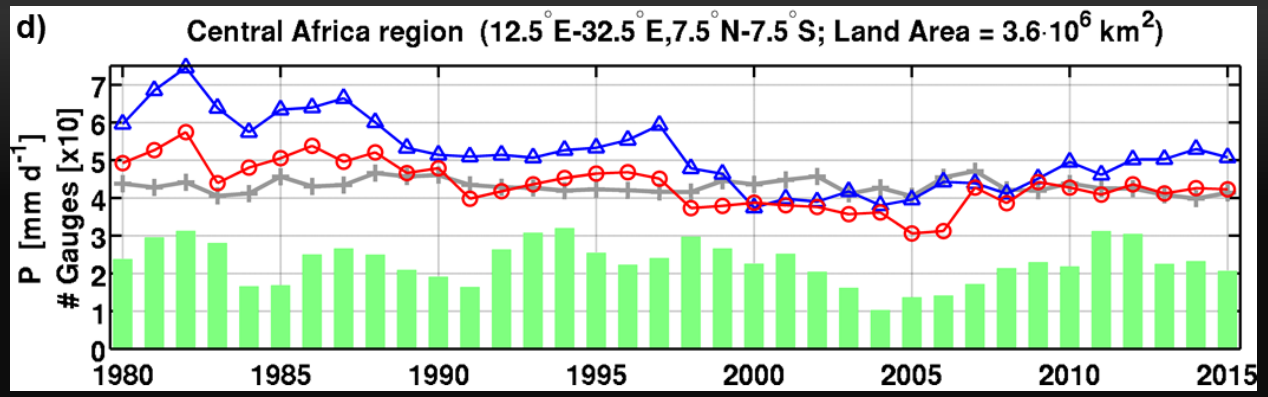
Observing System Impacts



No obvious impact from observing system.

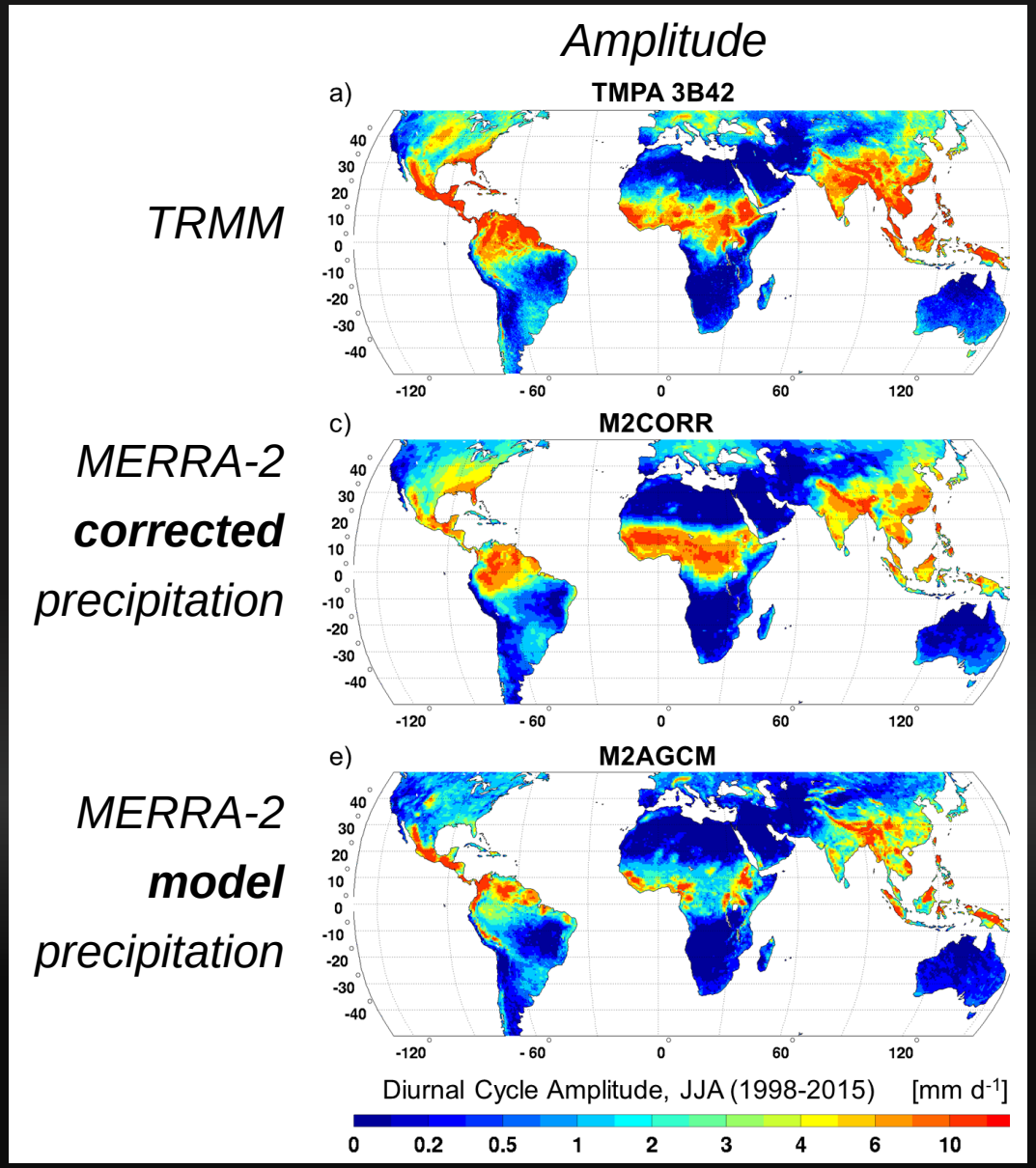


Corrected precipitation impacted by change in gauges.



Model precipitation impacted by change in atmospheric analysis (+AMSU).

Diurnal Cycle



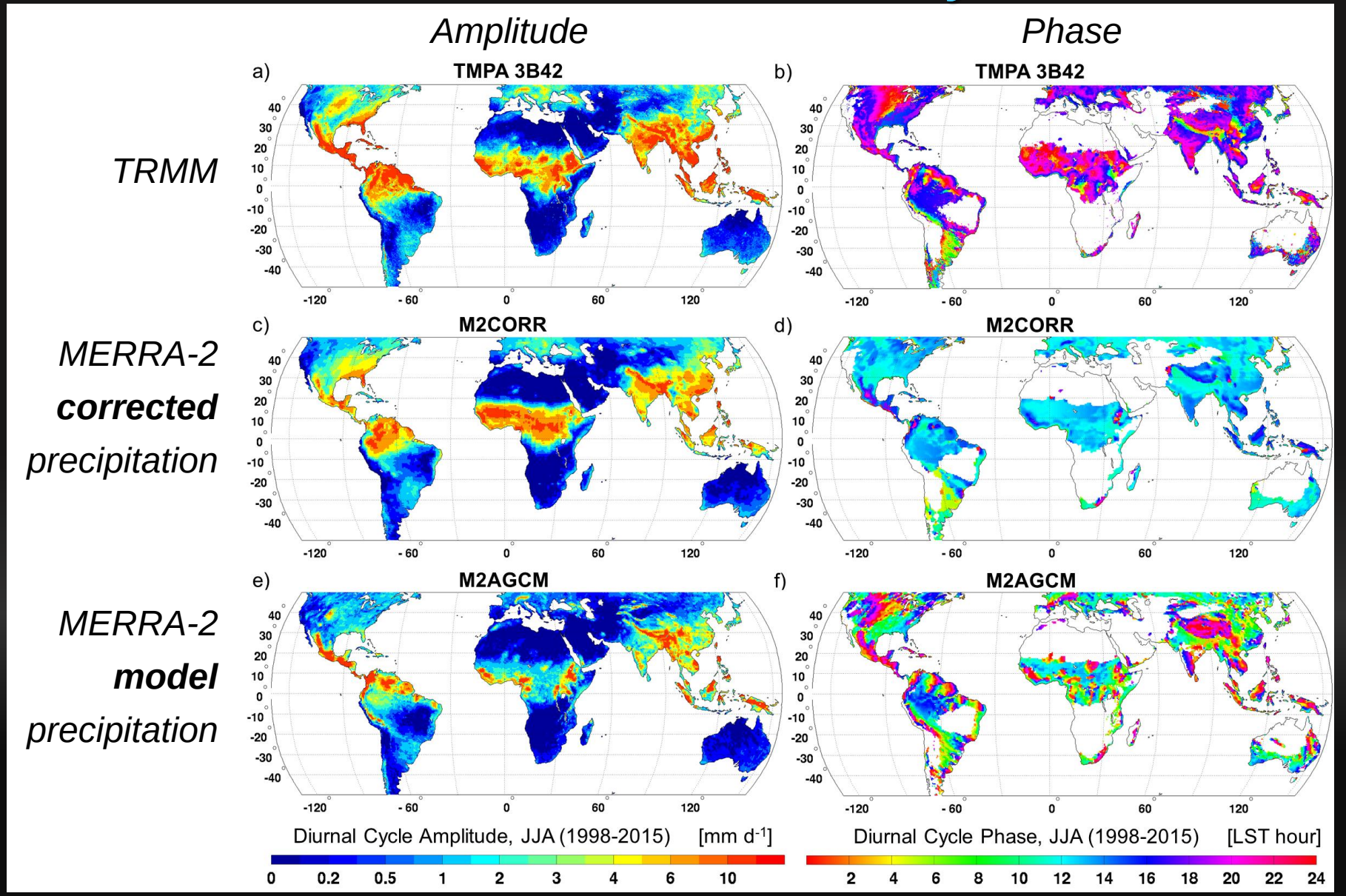
MERRA-2 corrected precipitation inherits diurnal cycle from MERRA.

The diurnal cycle of the MERRA-2 corrected precipitation has

<u>better amplitude</u>

than MERRA-2 model precipitation.

Diurnal Cycle



MERRA-2 corrected precipitation inherits diurnal cycle from MERRA.

The diurnal cycle of the MERRA-2 corrected precipitation has

<u>better amplitude</u> and

<u>worse phase</u>

than MERRA-2 model precipitation.

Outline

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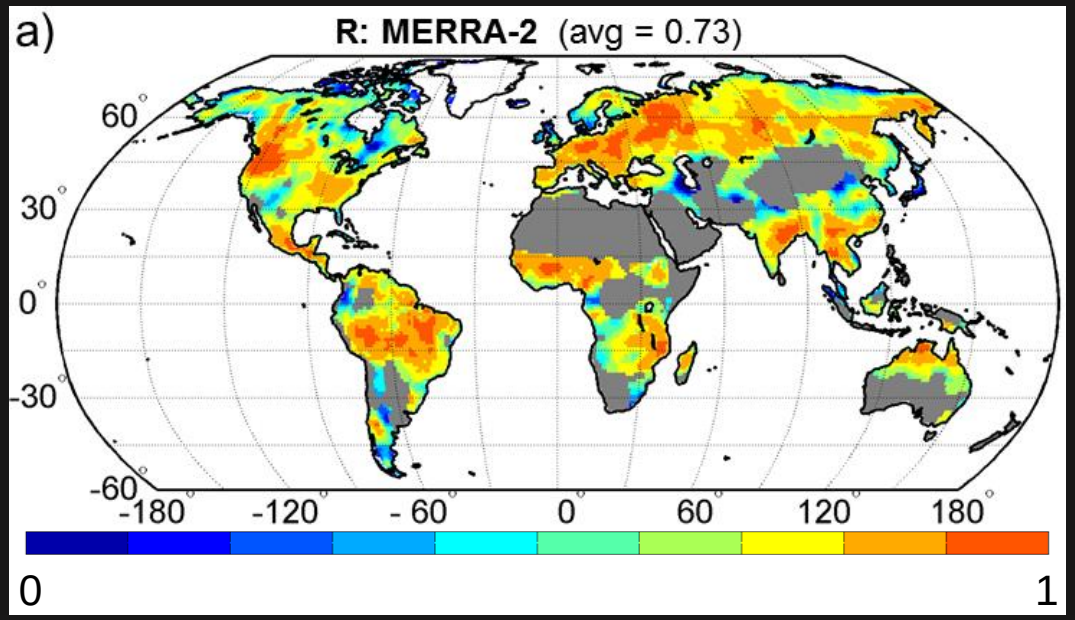
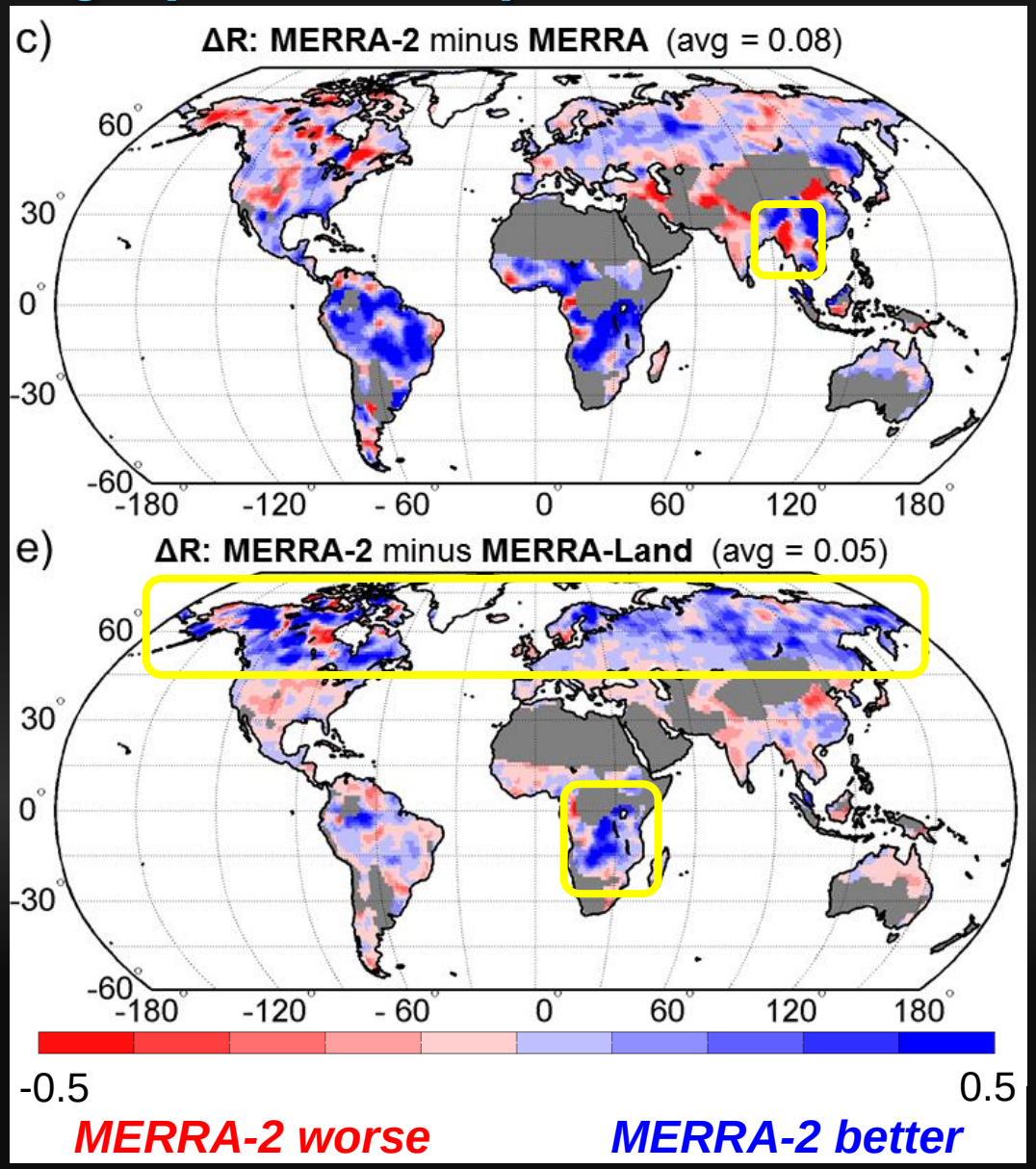
Terrestrial Water Storage (vs. GRACE)

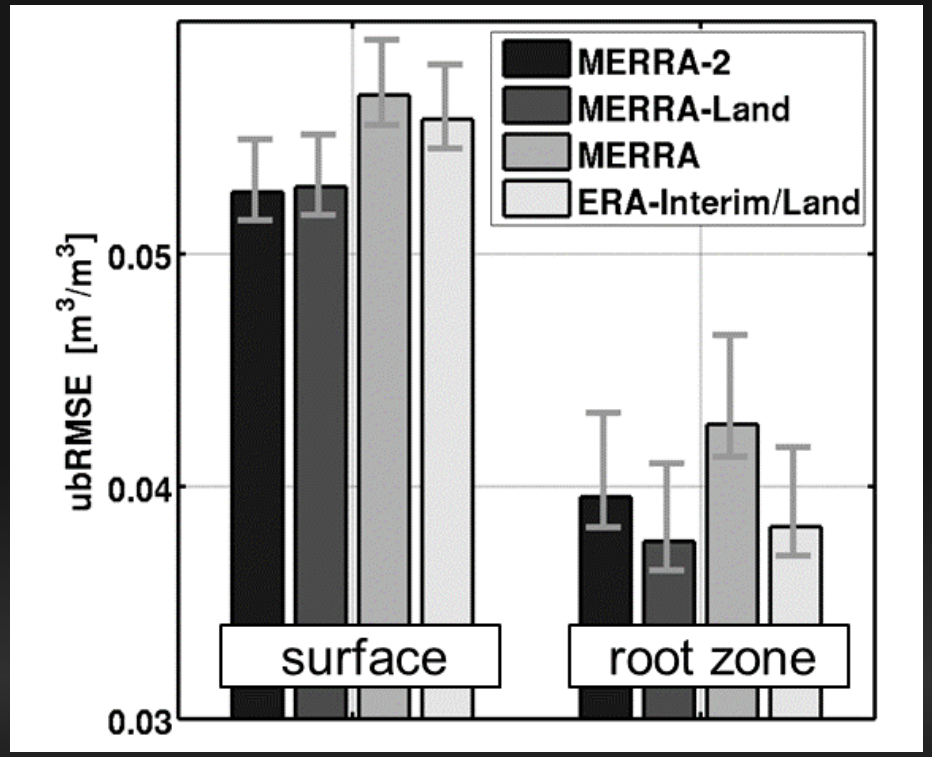


MERRA-2 monthly TWS correlates better with GRACE than TWS from MERRA and MERRA-Land.

Similar for time series anomalies (not shown).



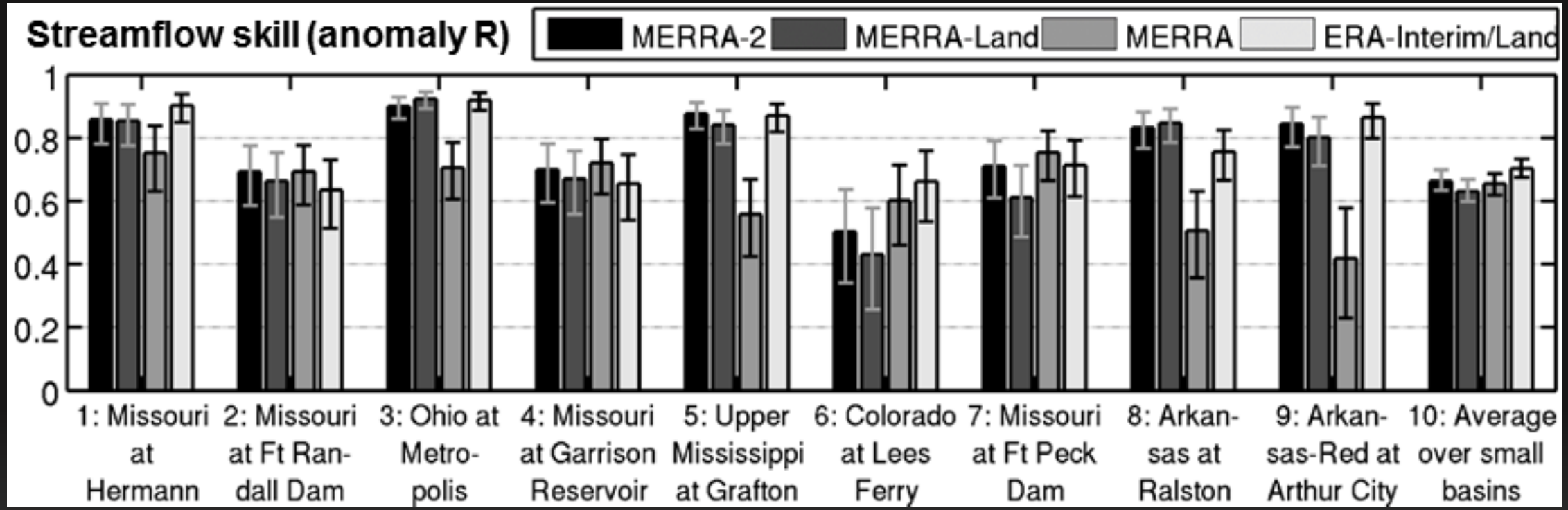
Soil Moisture (vs. In Situ)



MERRA-2 soil moisture skill is

- similar to that of MERRA-Land,
- slightly better than that of ERA-Interim/Land, and
- significantly better than that of MERRA.

Streamflow (vs. Naturalized Gauge Obs.)

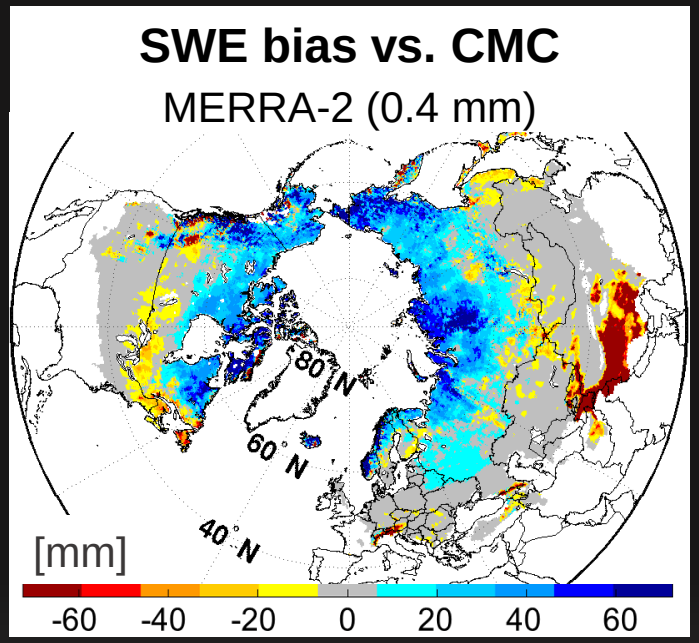


MERRA-2 streamflow anomaly R is

- better than that of MERRA and
- similar to that of land-only products.

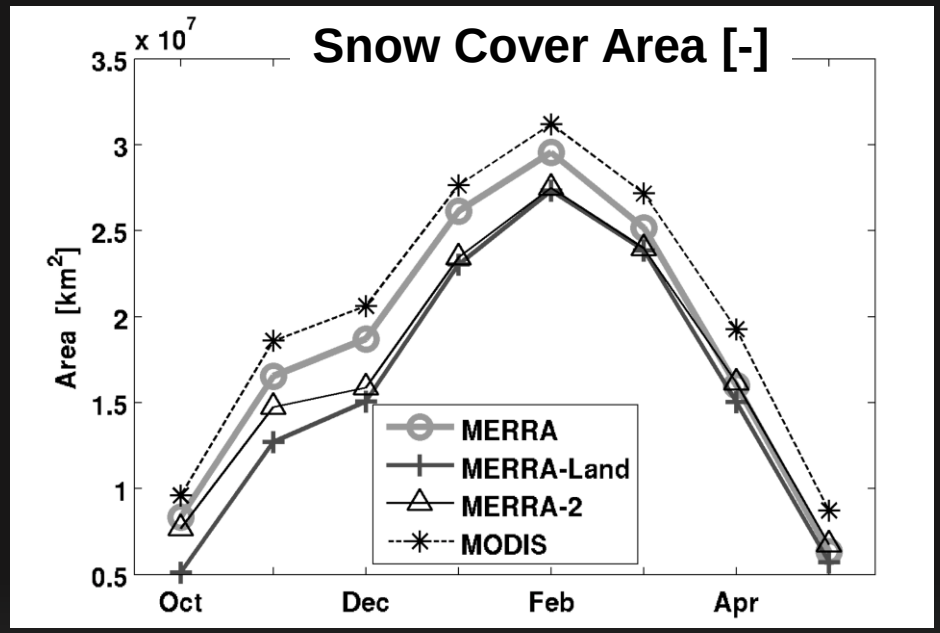
MERRA-2 runoff still biased low (not shown).

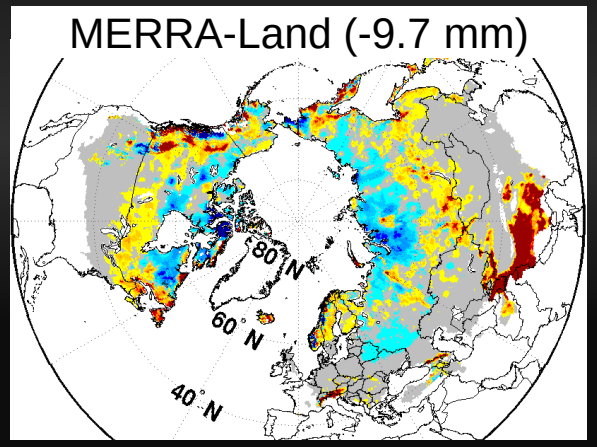
Snow (SWE vs. CMC, SCA vs. MODIS)

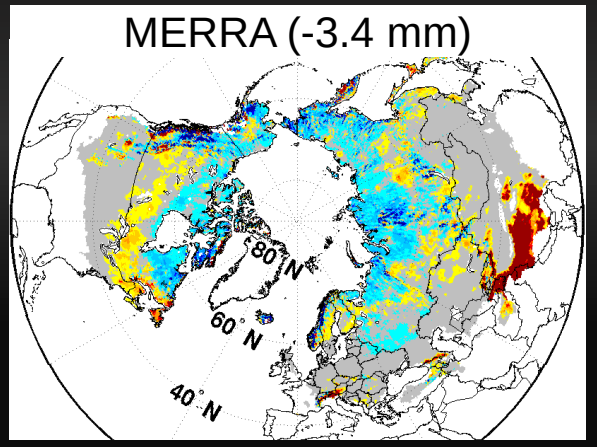


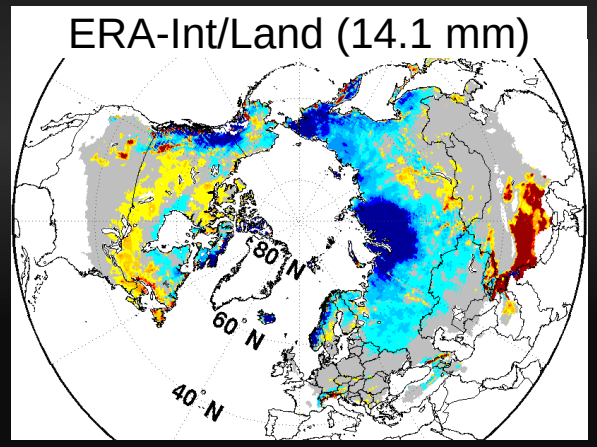
MERRA-2 slightly over-estimates SWE…

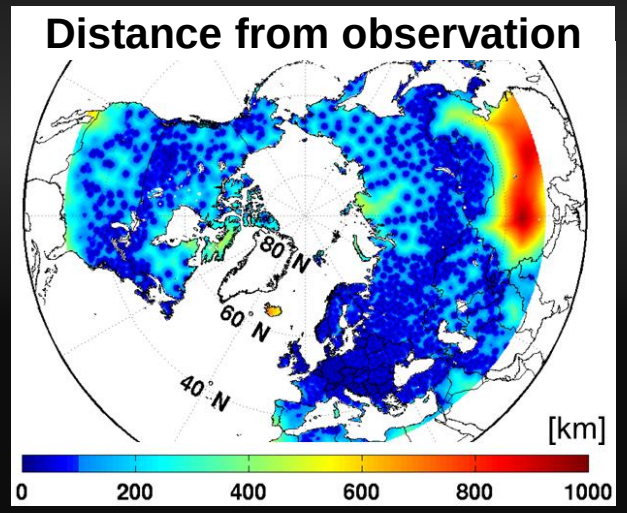
but under-estimates SCA (because of a snow model parameter change).



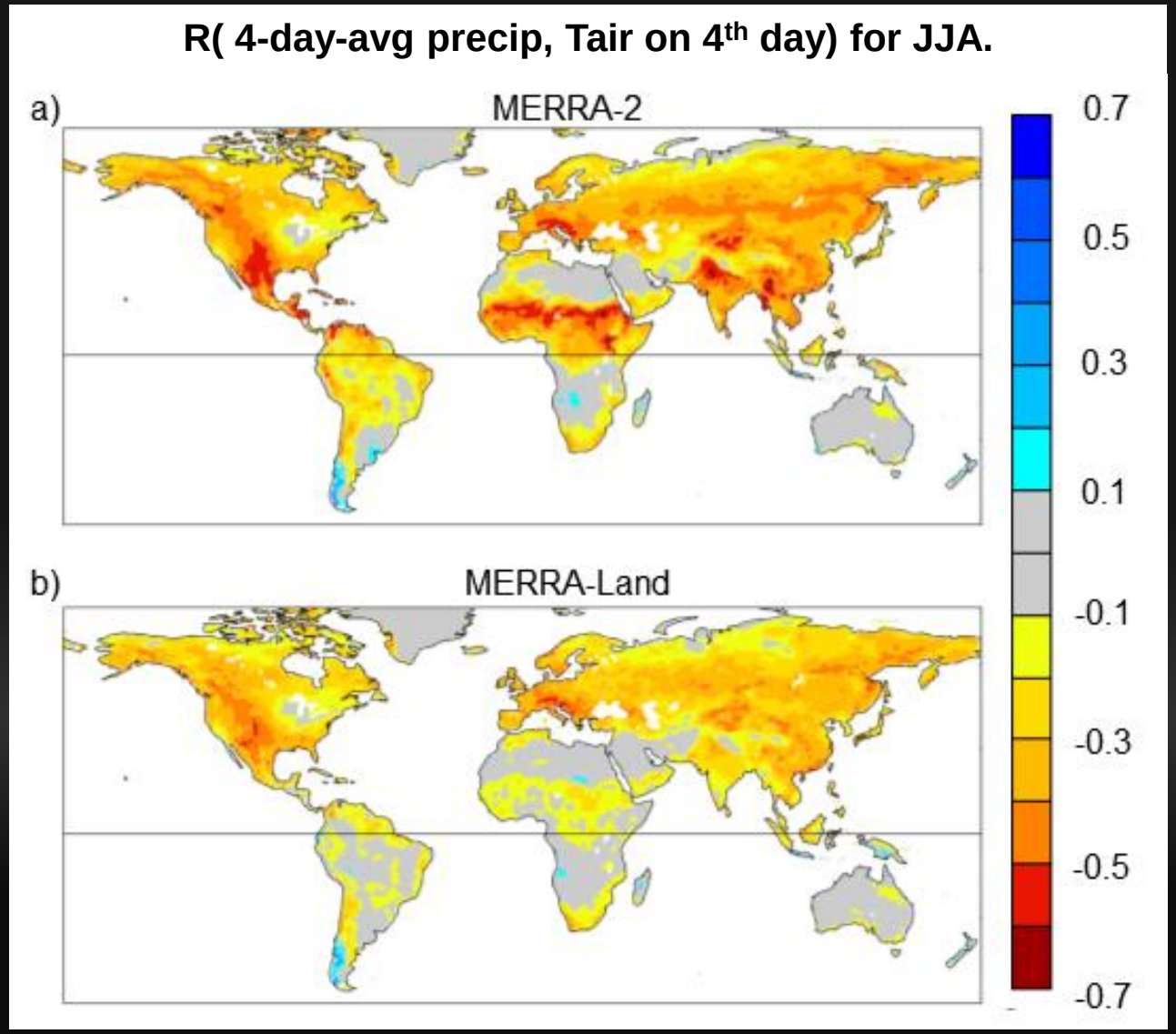






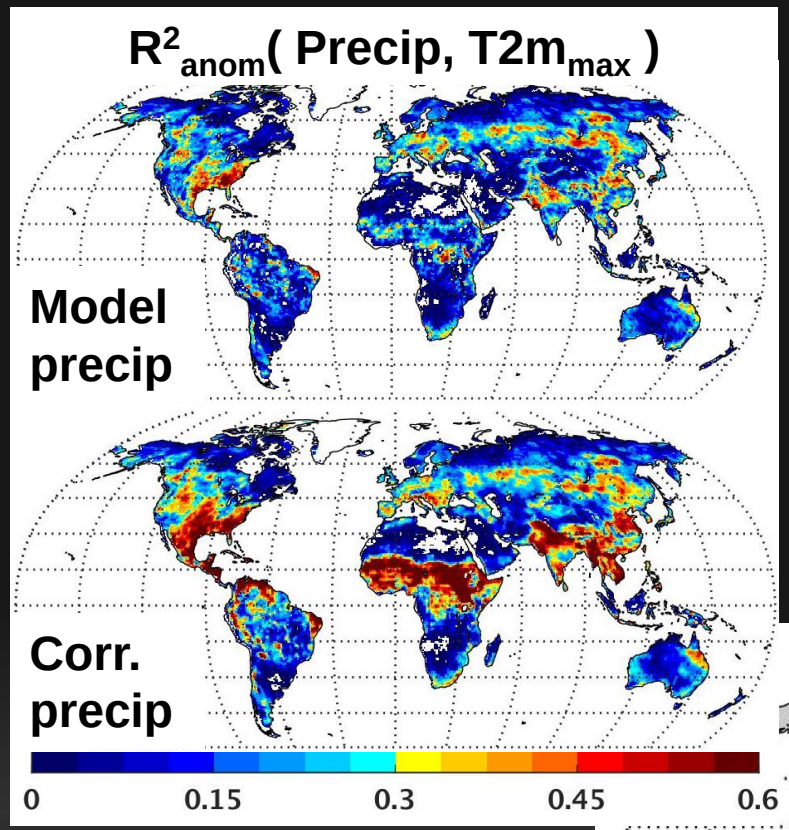


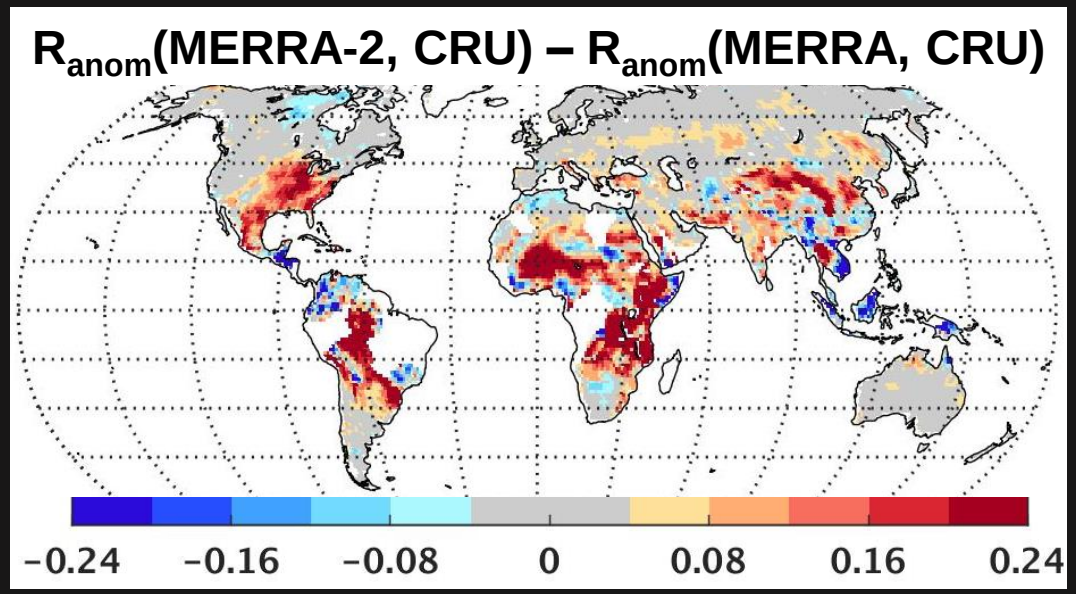
Consistency of Land Surface Forcing

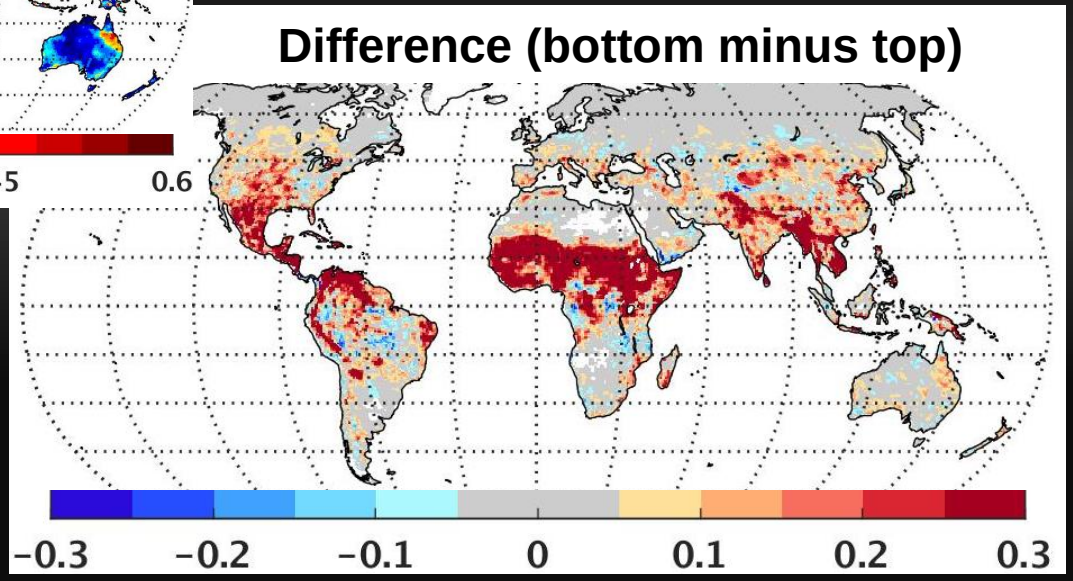


Correcting precipitation within the coupled land-atmosphere system results in higher consistency of land forcing.

Impact of Precipitation Corrections on $T2m_{max}$







MERRA-2 improvement in $T2m_{max}$ vs. CRU.

$T2m_{max}$ variance explained by precip (for JJA).

Sensitivity of MERRA-2 $T2m_{max}$ to precipitation corrections.

Summary

- Land surface precipitation in MERRA-2 is corrected with observations.
- Precipitation corrections algorithm is an extension of that from MERRA-Land with
  - a different observational product in Africa and
  - no corrections at high latitudes.
- MERRA-2 precipitation, terrestrial water storage, soil moisture, and runoff agree better with measurements or reference data than same from MERRA.
- Snow model parameter change yields mixed results for MERRA-2 snow estimates.
- Precipitation corrections within the coupled land-atmosphere system
  - facilitate more consistent land surface forcing compared to MERRA-Land, and
  - improve simulated T2m compared to MERRA.

- Success critically depends on having high-quality global precipitation products with suitable latency. (Thanks to P. Xie et al. at NOAA CPC!)

Thank you for your attention!

For details, see MERRA-2 Special Collection in ***J. Climate***:

Reichle et al. (2017a), **Land surface precipitation in MERRA-2**

doi:10.1175/JCLI-D-16-0570.1

Reichle et al. (2017b), **Assessment of MERRA-2 land surface hydrology estimates**

doi:10.1175/JCLI-D-16-0720.1

Draper et al. (2017), **Assessment of MERRA-2 Land Surface Energy Flux Estimates**

doi:10.1175/JCLI-D-17-0121.1