

# Assessment of MERRA-2 Land Surface Energy Flux Estimates

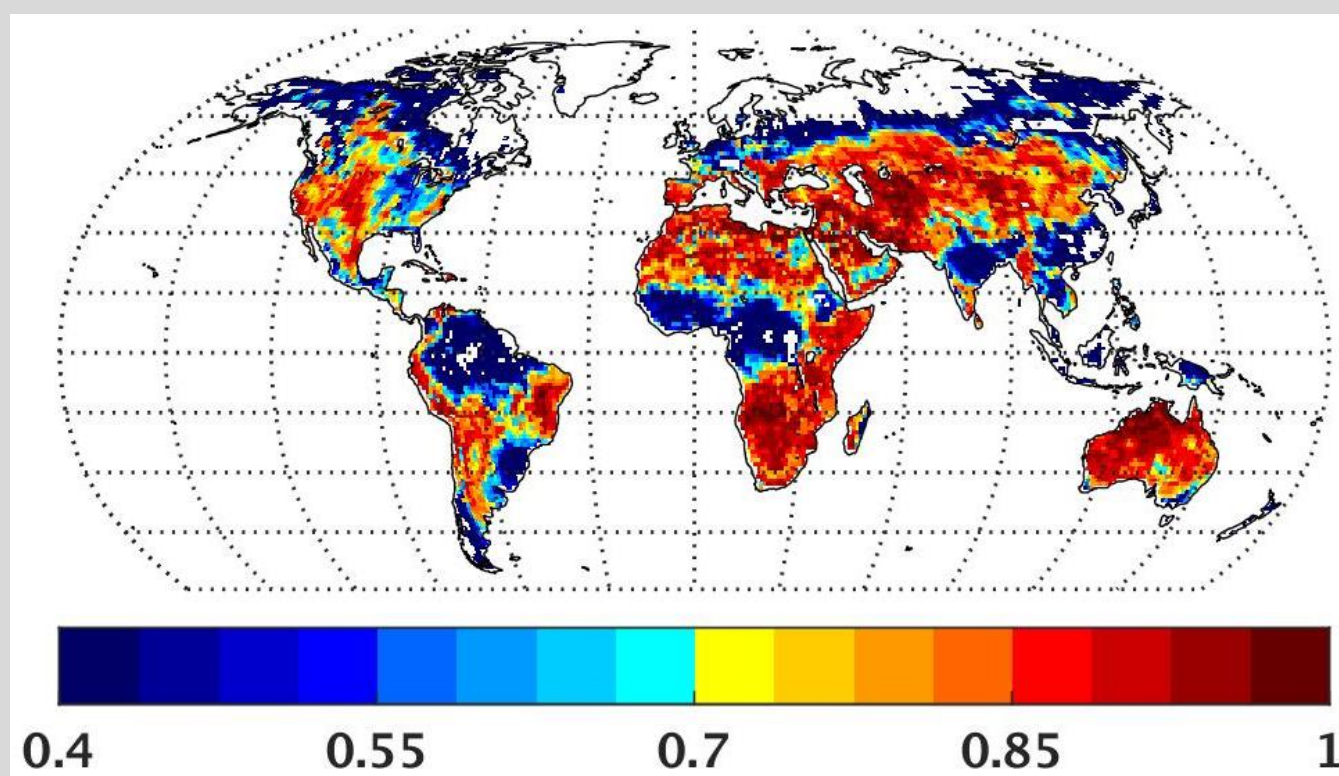
Clara Draper (CIRES/NOAA ESRL PSD: clara.draper@noaa.gov), Rolf Reichle (NASA GMAO), and Randal Koster (NASA GMAO)

## Outline

- In MERRA-2, observed precipitation is inserted in place of model-generated precipitation at the land surface [1,2].
- The use of observed precipitation was originally developed for MERRA-Land (a land-only replay of MERRA with model-generated precipitation replaced with observations)
- Previously shown that the land hydrology in MERRA-2 and MERRA-Land is better than MERRA [3].
- We test whether the improved land surface hydrology in MERRA-2 leads to the expected improvements in the land surface energy fluxes and 2 m air temperatures ( $T^{2m}$ ).

## Sensitivity to observed precip. in MERRA-2

### 1. Sensitivity of Latent Heat (LH) to soil moisture



- High values (red): LH is moisture-limited (sensitive to soil moisture). This is where LH responds most to the improved precipitation.
- Low values: LH is energy-limited.

Fig 1: MERRA-2 JJA  $R^2_{anom}$  (soil moisture, LH).

### 2. Sensitivity of daily max. $T^{2m}$ to precipitation

$R^2_{anom}$  (model-generated precip,  $T^{2m}$ )

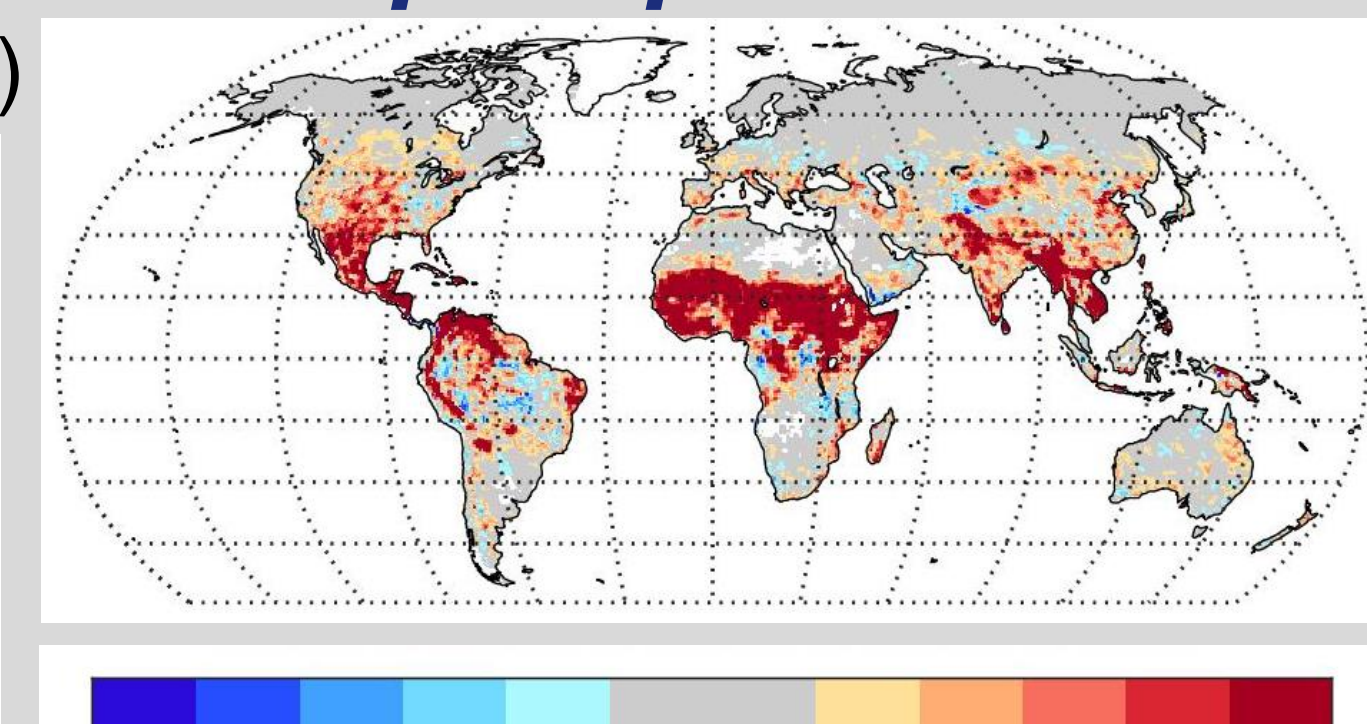
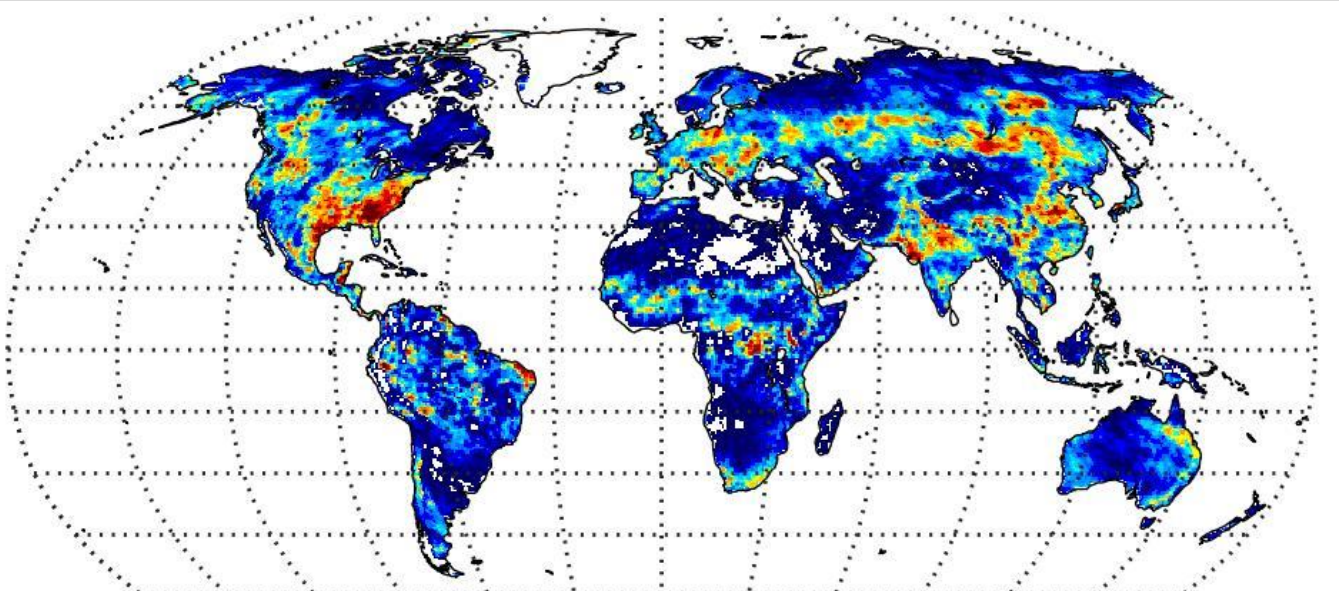


Fig 3: Difference: left lower – left upper plots.

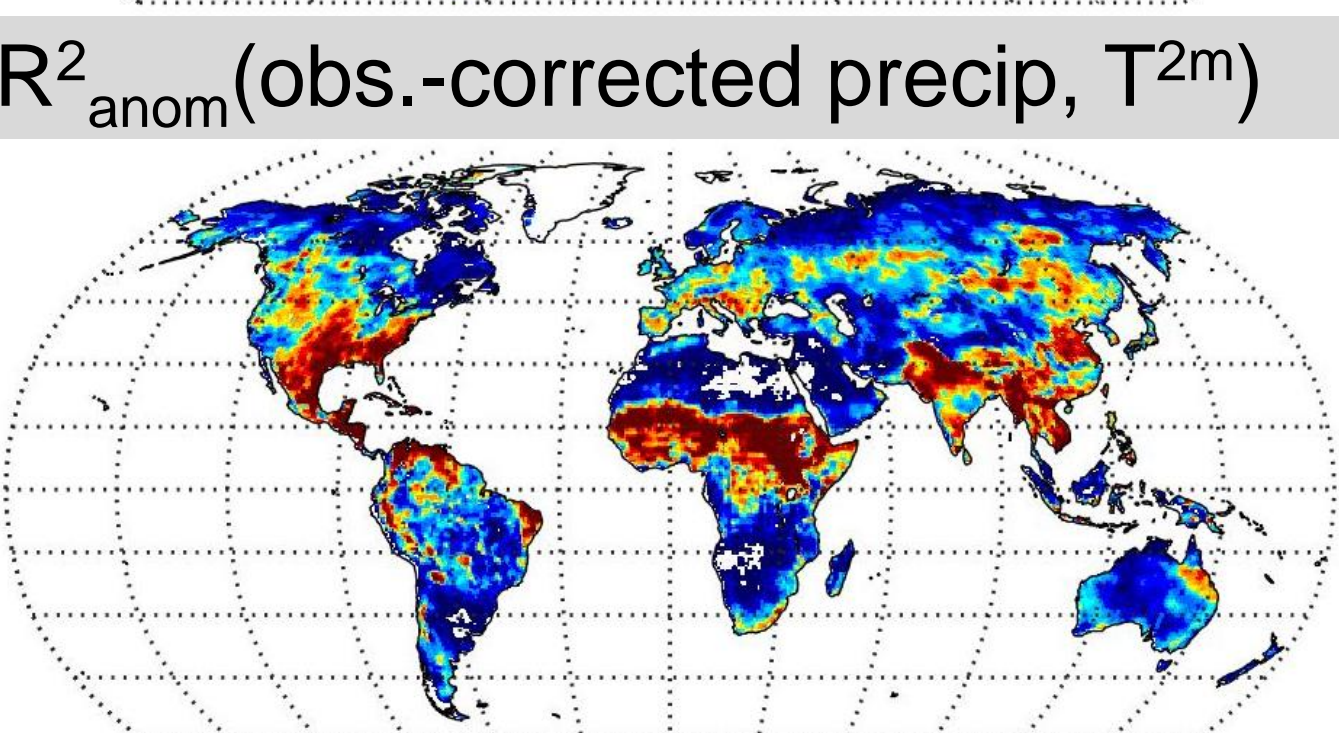


Fig 2: MERRA-2 JJA  $R^2_{anom}$  (antecedent precip.,  $T^{2m}$ ) for model-generated and obs.-corrected precip. See [4] for details.

- Above is the difference in the  $T^{2m}$  variance explained by the obs.-corrected precip (seen by the land) over that explained by the model-generated precip.
- This is the sensitivity of the MERRA-2  $T^{2m}$  to the observed precipitation.

## References:

- [1] Gelaro et al. (2017), MERRA-2, *J. Climate*, doi:10.1175/JCLI-D-16-0758.1.
- [2] Reichle et al. (2017b), Land surface precipitation in MERRA-2, *J. Climate*, doi:10.1175/JCLI-D-16-0570.1.
- [3] Reichle et al. (2017a), Assessment of MERRA-2 land surface hydrology estimates, *J. Climate*, doi:10.1175/JCLI-D-16-0720.1.

## LH anomaly correlations ( $R_{anom}$ )

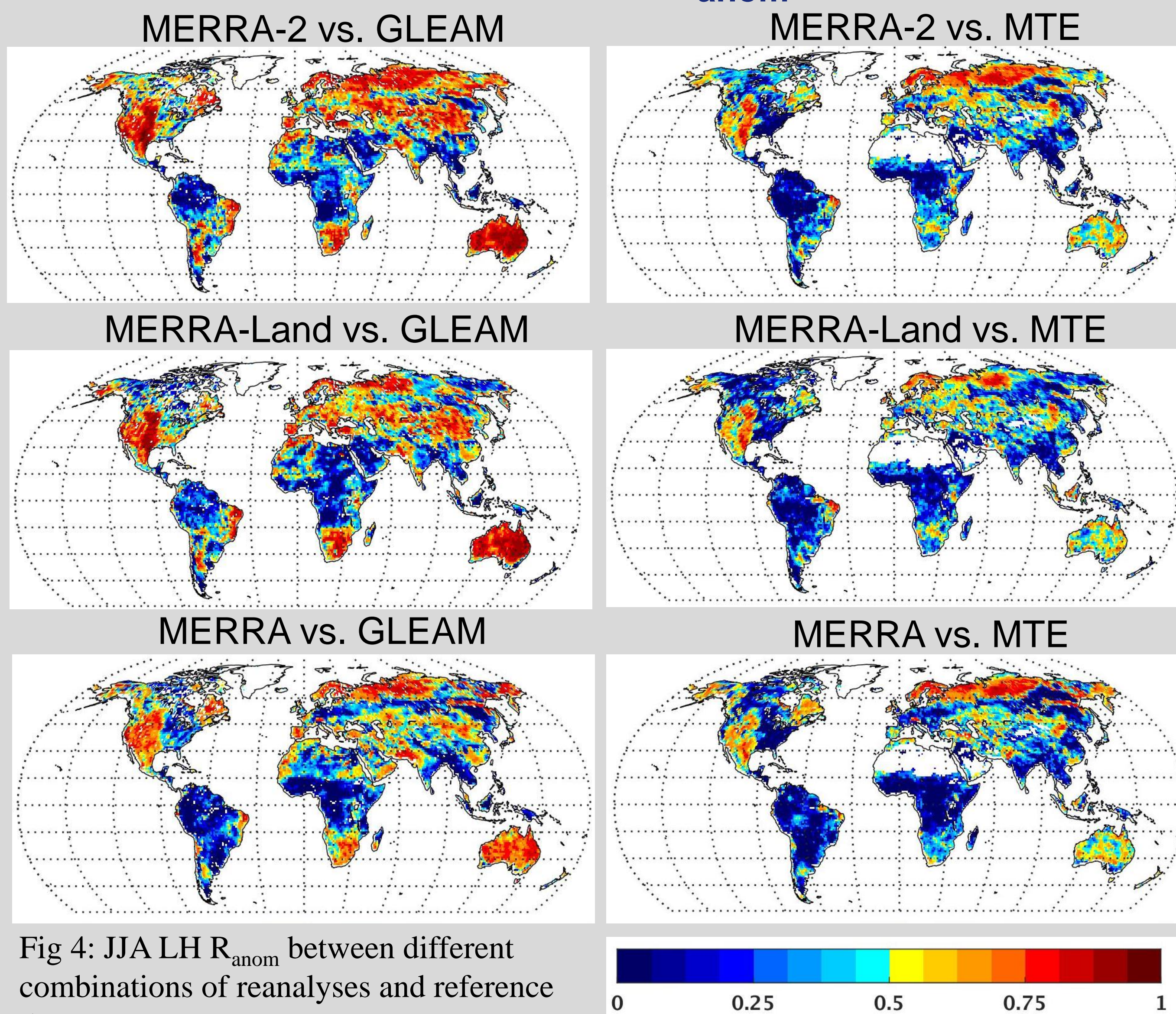


Fig 4: JJA LH  $R_{anom}$  between different combinations of reanalyses and reference data sets.

- Broad similarity of  $R_{anom}$  spatial patterns vs. GLEAM (left) and MTE (right), with GLEAM showing stronger agreement.
- The  $R_{anom}$  are low, likely due to errors in the reanalyses and reference data.
- Agreement is generally better where LH is moisture-limited.

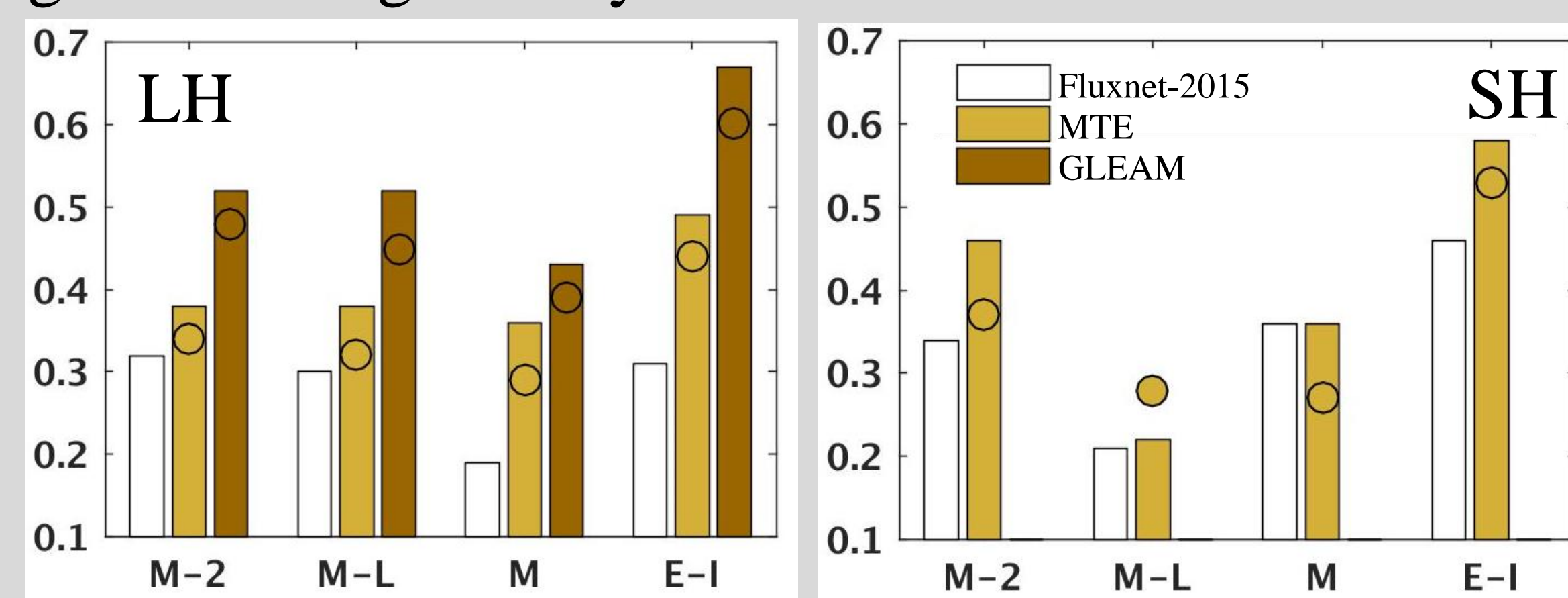


Fig 5: Mean  $R_{anom}$  for LH (left) and SH (right) vs. Fluxnet-2015 tower obs., MTE, and GLEAM, averaged across 20 Fluxnet-2015 sites (bars), and averaged globally (circles).

- Similar results from each reference data set: MERRA-2 and MERRA-Land higher than MERRA, ERA-Interim is highest.
- MERRA-Land SH  $R_{anom}$  is lower than for MERRA.

GLEAM: Global Land Evaporation Amsterdam Model [5]  
 MTE: Fluxnet-Model Tree Ensembles [6]  
 Fluxnet-2015 (<http://fluxnet.fluxdata.org/data/fluxnet2015-dataset/>)  
 CRU: Climatic Research Unit [7]

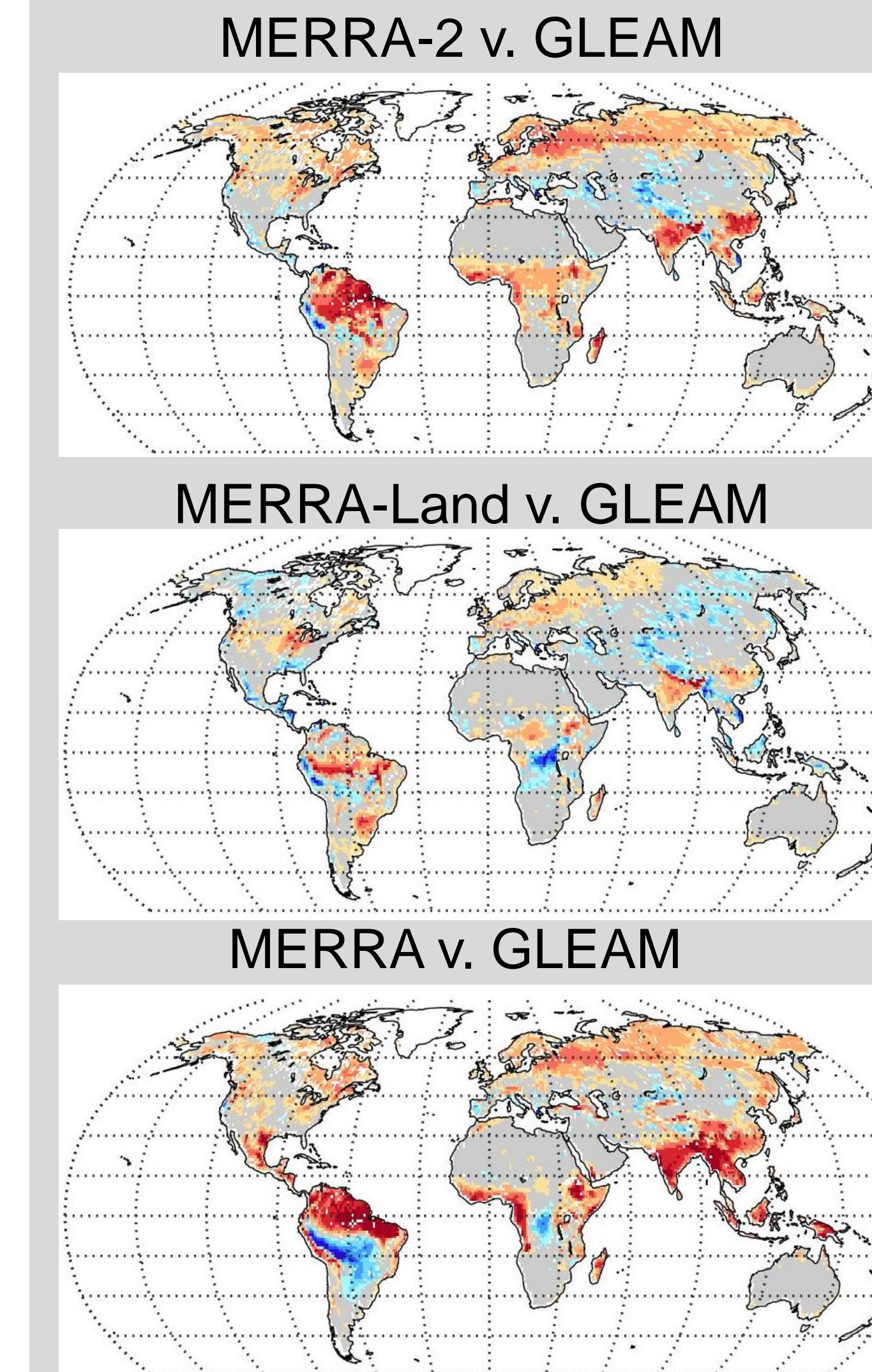
[4] Draper et al. (2017), Assessment of MERRA-2 Land Surface Energy Flux Estimates, *J. Climate*, doi:10.1175/JCLI-D-17-0121.1.

[5] Martens et al. (2017), GLEAMv3, *Geosci. Model Dev.*, doi:10.1175/JCLI-D-14-00556.1

[6] Jung et al. (2009), Towards global empirical upscaling of FLUXNET eddy covariance observations, *Biogeosciences*, doi:10.5194/bg-6-2001-2009.

[7] Harris et al. (2014), Updated high-resolution grids of monthly climatic observations - the CRU TS3.10 Dataset, *Int. J. Climatol.*, doi:10.1002/joc.3711.

## LH biases



- Comparison of LH biases vs. GLEAM (Fig 8.) and vs. MTE (not shown) suggest similar patterns of bias.
- MERRA-2 has large positive biases ( $> 20 \text{ W/m}^2$ ) where LH is energy-limited (hence relatively insensitive to soil moisture/antecedent precip). MERRA shows similar results.
- Biases are reduced in MERRA-Land almost everywhere

Fig 7: Bias between reanalyses and GLEAM LH ( $\text{W/m}^2$ ).

## Daily max. $T^{2m}$ $R_{anom}$

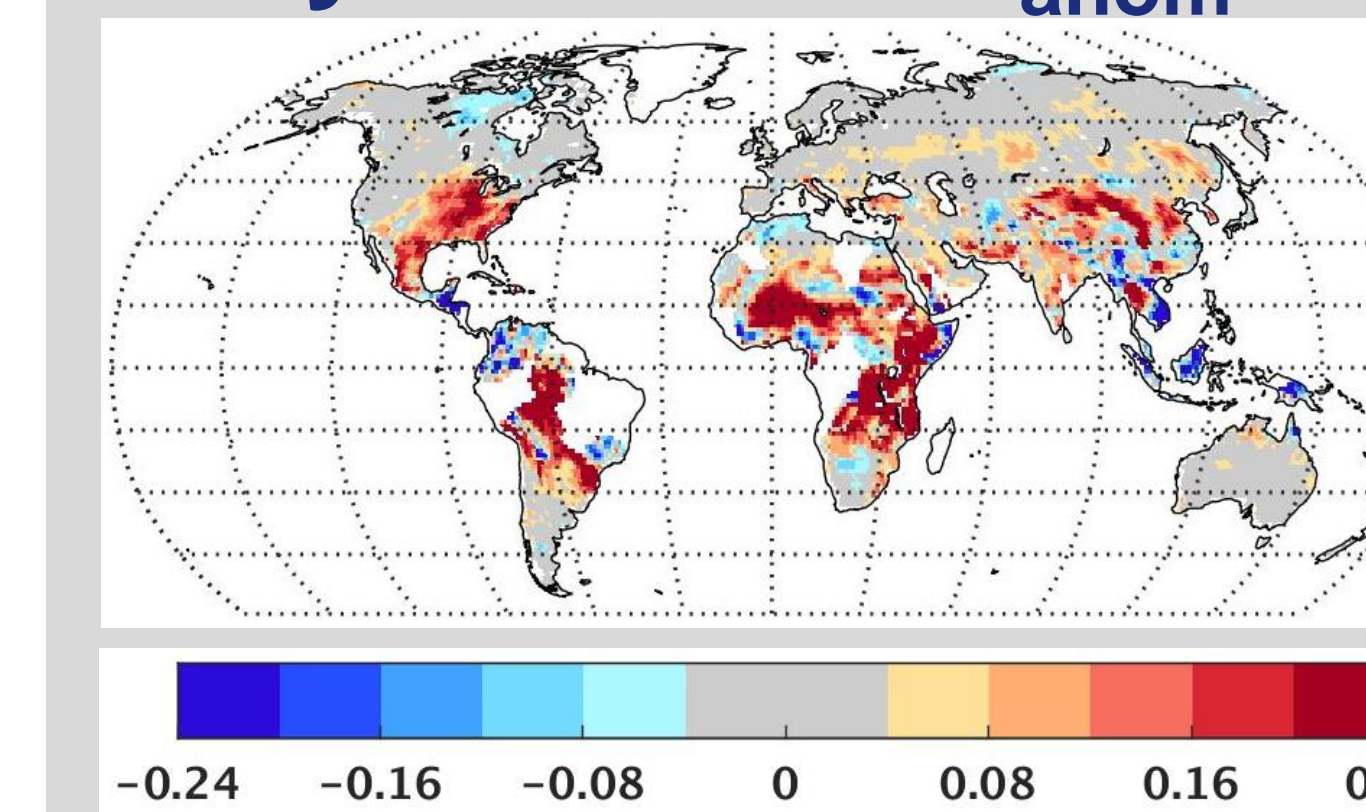


Fig 8: MERRA-2  $R_{anom}$  vs. CRU - MERRA  $R_{anom}$  vs. CRU.

- $T^{2m}$   $R_{anom}$  overall increased.
- Compare to Fig 3: where  $T^{2m}$  is most sensitive to observed precip. the change in  $T^{2m}$   $R_{anom}$  is often large (but not always positive).
- Also large improvements in many insensitive regions: likely due to other system upgrades.

## Conclusions

- It is difficult to evaluate surface energy fluxes, as there is no globally recognized truth
- Comparison to multiple reference data sets (globally: GLEAM, MTE, locally: Fluxnet-2015) suggests the same conclusions: MERRA-2 has improved LH and SH (bias and  $R_{anom}$ ) compared to MERRA, while MERRA-Land has improved LH, but degraded SH (is replacing precipitation in an offline system generating an inconsistency?)
- However, the greatest uncertainties in LH occur in energy-limited regions, where LH is much less sensitive to soil moisture/precipitation.

5th International Conference  
 on Reanalysis  
 Rome, Italy, Nov. 2017.

