Land surface precipitation and hydrology in MERRA-2

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S. Mahanama, G. De Lannoy, G. Partyka,
and many others…
Land Surface in MERRA Products

**MERRA**
- Model precip.

**MERRA-Land**
- Observations
- + updated land model

**MERRA-2**
- Model precip. (M2AGCM)
- Observations
- Corr. precip. (M2CORR)
- + updated AGCM and atmospheric analysis
Outline

1. Precipitation Corrections and Evaluation
2. Evaluation of Land Surface Hydrology
• Land surface precipitation corrected to CPCU gauge product everywhere.
• Separately for each day / 0.5° grid cell.
• Sub-daily variations from MERRA.
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.
MERRA-2 corrected precipitation:

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

Similar results for RMSE and anomaly correlation.
MERRA-2 corrected precipitation:

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

Similar results for RMSE and anomaly correlation.
MERRA-2 corrected precipitation also better than MERRA-Land.

Time Series Correlation (vs. GPCPv2.2)
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).
MERRA-2 corrected precipitation inherits diurnal cycle from MERRA.

The diurnal cycle of the MERRA-2 corrected precipitation has better amplitude than MERRA-2 model precipitation.
The diurnal cycle of the MERRA-2 corrected precipitation has better amplitude and worse phase than MERRA-2 model precipitation.

MERRA-2 corrected precipitation inherits diurnal cycle from MERRA.
Outline

1. Precipitation Corrections and Evaluation
2. Evaluation of Land Surface Hydrology
MERRA-2 monthly TWS correlates better with GRACE than TWS from MERRA and MERRA-Land. Similar for time series anomalies (not shown).
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.
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).
MERRA-2 slightly over-estimates SWE…

but under-estimates SCA

(because of a snow model parameter change).

Snow Cover Area [\cdot]

[SWE bias vs. CMC
MERRA-2 (0.4 mm)]

[Snow Cover Area [\cdot]
MERRA vs. CMC, SCA vs. MODIS]
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 $T_{2m,\text{max}}$

$R^2_{\text{anom}}(\text{Precip}, T_{2m,\text{max}})$

Model precip

Corr. precip

$R_{\text{anom}}(\text{MERRA-2, CRU}) - R_{\text{anom}}(\text{MERRA, CRU})$

MERRA-2 improvement in $T_{2m,\text{max}}$ vs. CRU.

Difference (bottom minus top)

$T_{2m,\text{max}}$ variance explained by precip (for JJA).

Sensitivity of MERRA-2 $T_{2m,\text{max}}$ to precipitation corrections.
• Land surface precipitation in MERRA-2 is corrected with observations.

• Precipitation corrections algorithm is an extension of that from MERRA-Land with
  o a different observational product in Africa and
  o 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
  o facilitate more consistent land surface forcing compared to MERRA-Land, and
  o 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