National Aeronautics and Space Administration

M21C Land Budgets

Rolf Reichle & Randy Koster

11 Jun 2024

[edited slides 2, 3, & 13 on 13 June 2024]

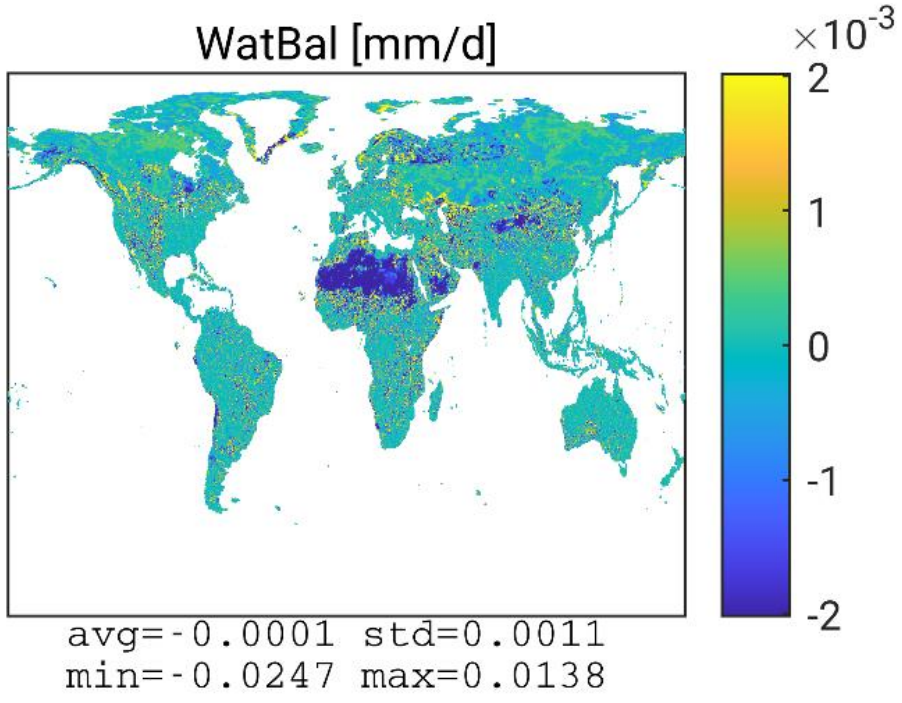
Land Water Balance

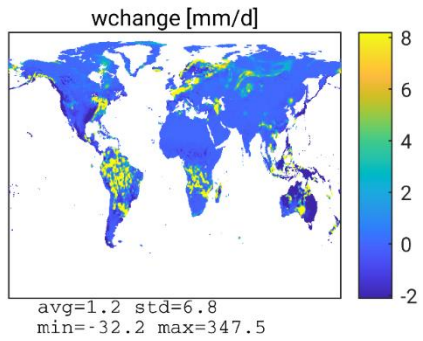
MERRA-2 File Specs (p. 71): **WCHANGE = PRECTOTLAND – EVLAND – RUNOFF – BASEFLOW + SPWATR**

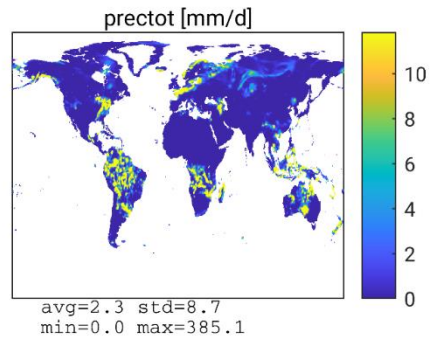
```
m21c_prod.lnd_tavg_2hr_glo_L1152x721_slv.1997-02-05T0000Z.nc4

WatBal = prectot -evland -runsurf -baseflow
         -spwatr
         -wchange;

Colorbar is from 5th to 95th percentile
(except for budget: +/-max(abs([5th 95th]))
Stats are not area-weighted.
```

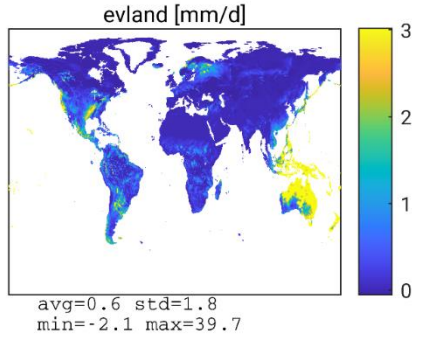
Ok for M21C lat/lon "lnd" output.

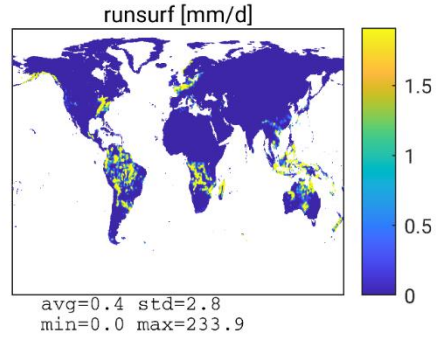
After fixing:
SPWATR
→ –SPWATR

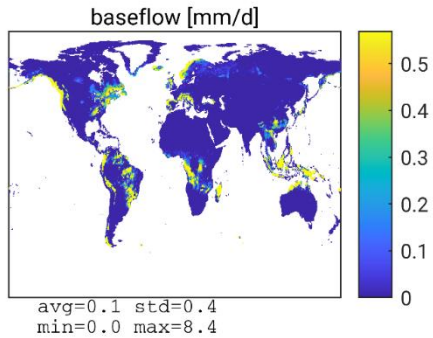


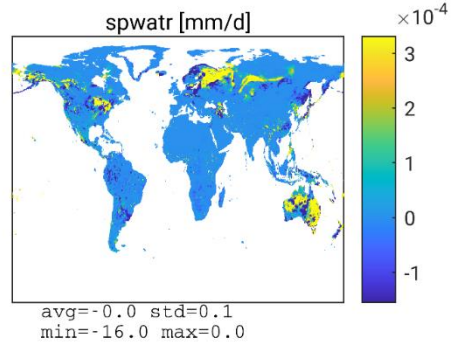












Land Water Balance

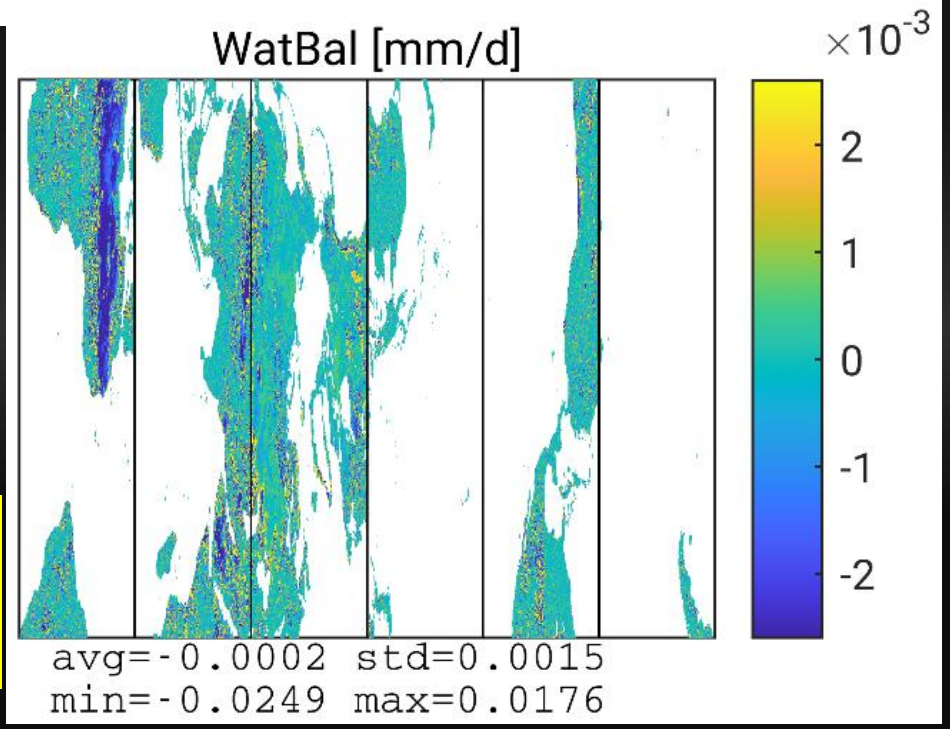
National Aeronautics and Space Administration

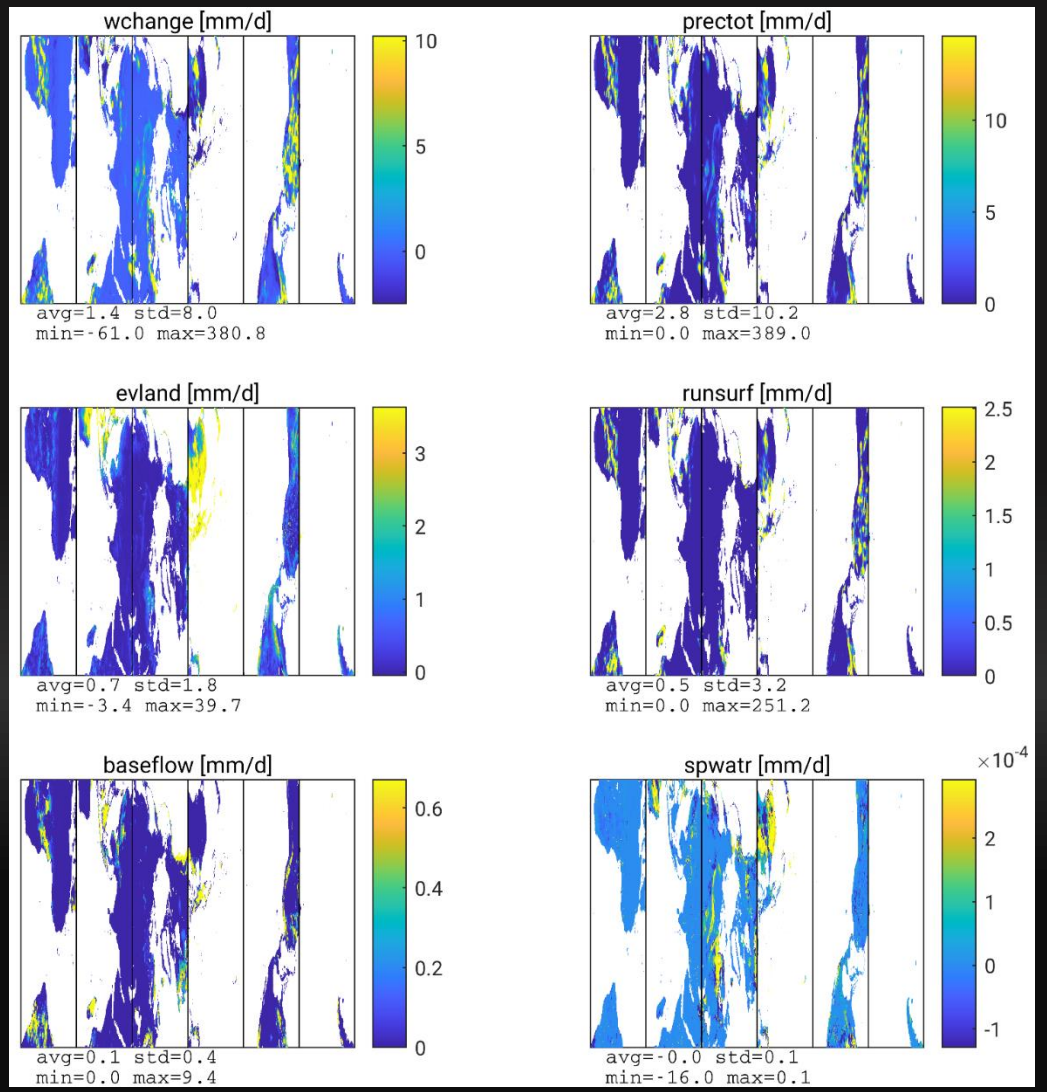
MERRA-2 File Specs (p. 71): **WCHANGE = PRECTOTLAND – EVLAND – RUNOFF – BASEFLOW + SPWATR**

```
m21c_prod.lnd_tavg_2hr_glo_C360x360x6_slv.1997-02-05T0000Z.nc4

WatBal = prectot -evland -runsurf -baseflow
         -spwatr
         -wchange;

Colorbar is from 5th to 95th percentile
(except for budget: +/-max(abs([5th 95th]))
Stats are not area-weighted.
```

Ok for M21C cs "lnd" output.

After fixing:
SPWATR
→ –SPWATR





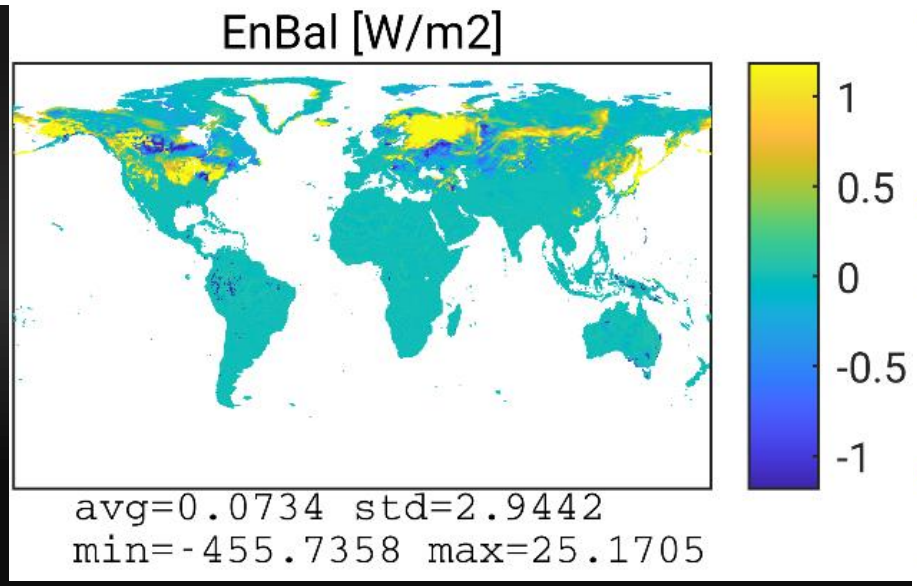
Land Energy Balance

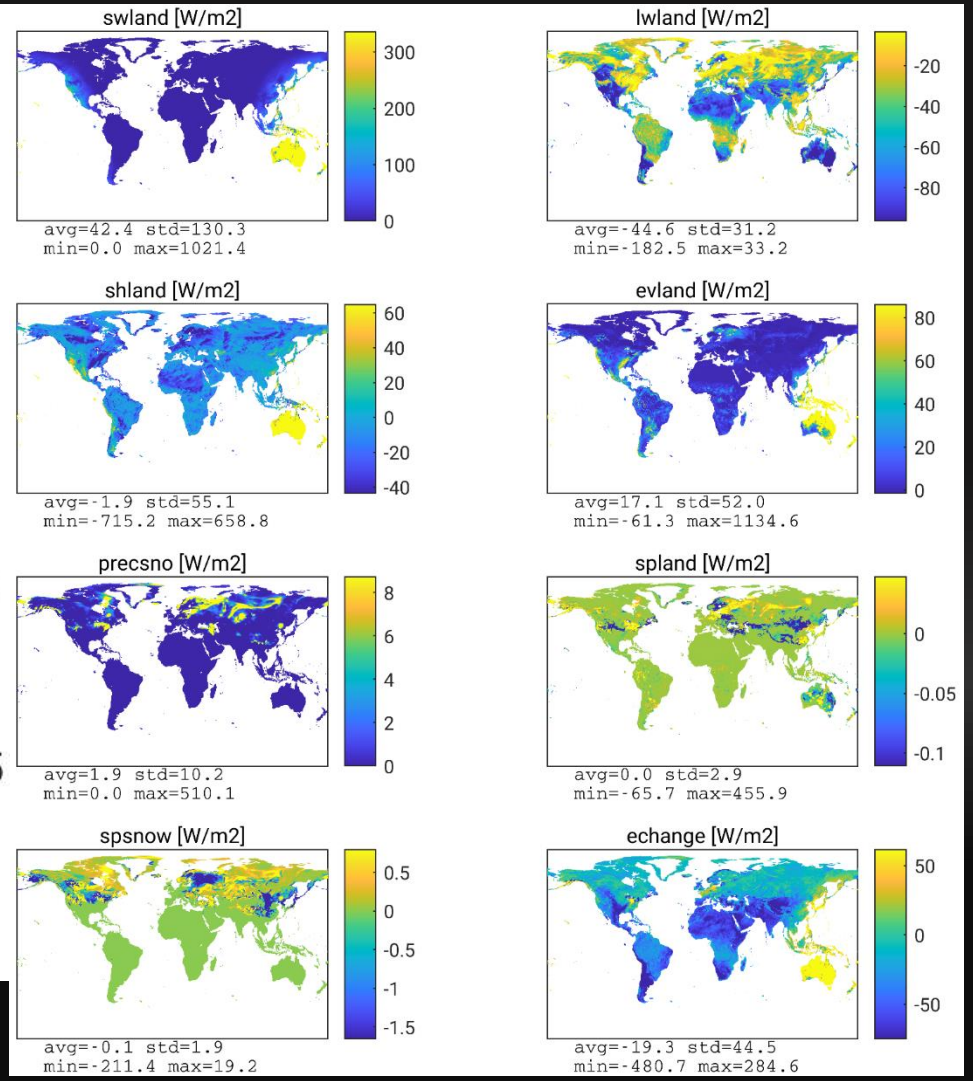
MERRA-2 File Specs (p. 72):

$$\text{ECHANGE} = \text{SWLAND} + \text{LWLAND} - \text{SHLAND} - L_v\,\text{EVLAND} - L_f\,\text{PRECSNOLAND} - \text{SPLAND} - \text{SPSNOW}.$$

```
m21c_prod.lnd_tavg_2hr_glo_L1152x721_slv.1997-02-05T0000Z.nc4

EnBal = swland +lwland -shland
        -Lv*evland
        -Lf*precsno -spland -spsnow
        -echange;

Colorbar is from 5th to 95th percentile
(except for budget: +/-max(abs([5th 95th]))
Stats are not area-weighted.
```

Wrong!!!





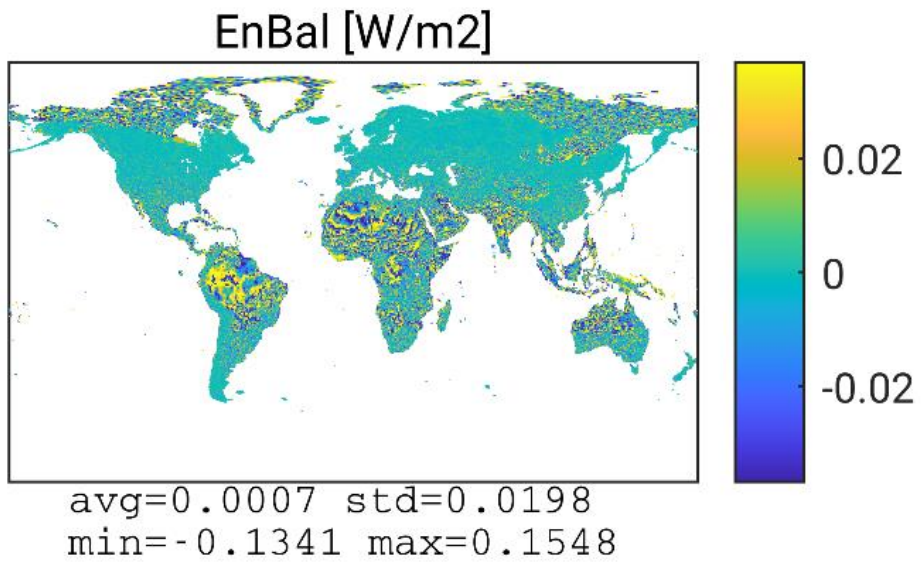
Land Energy Balance

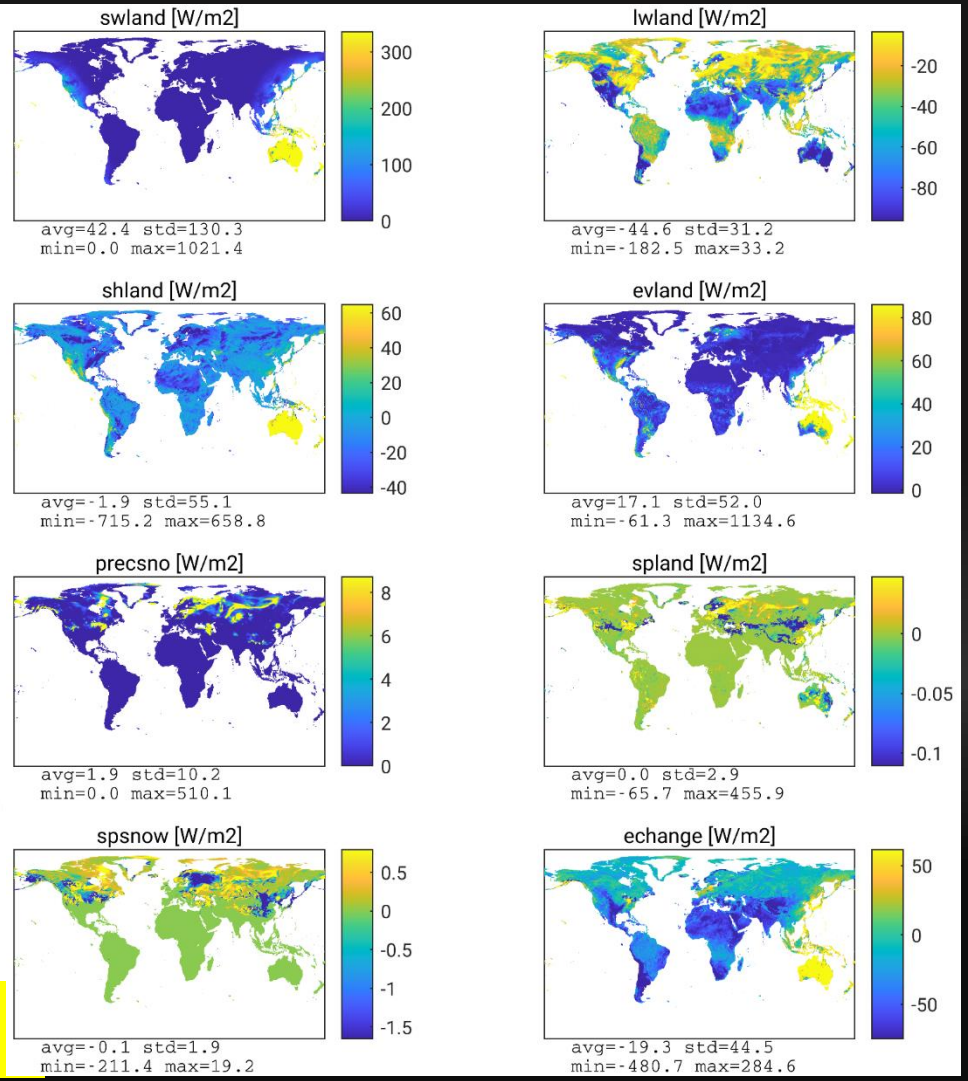
National Aeronautics and Space Administration

MERRA-2 File Specs (p. 72):

ECHANGE = SWLAND + LWLAND – SHLAND – L_v EVLAND – L_f PRECSNOLAND – SPLAND – SPSNOW.

```
m21c_prod.lnd_tavg_2hr_glo_L1152x721_slv.1997-02-05T0000Z.nc4

EnBal = swland +lwland -shland
        -evpintr -evpsbln -evpsoil -evptrns
        -Lf*precsno -spland -spsnow
        -echange;

Colorbar is from 5th to 95th percentile
(except for budget: +/-max(abs([5th 95th]))
Stats are not area-weighted.
```





Revise M2 File Specs!

Replace:

L_v*EVLAND

→ EVPINTR + EVPSBLN + EVPSOIL + EVPTRNS

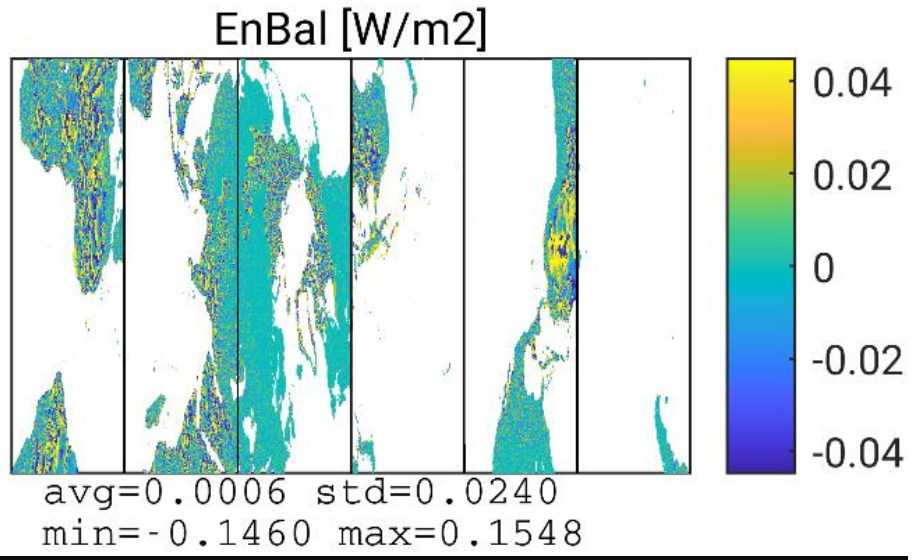
Land Energy Balance

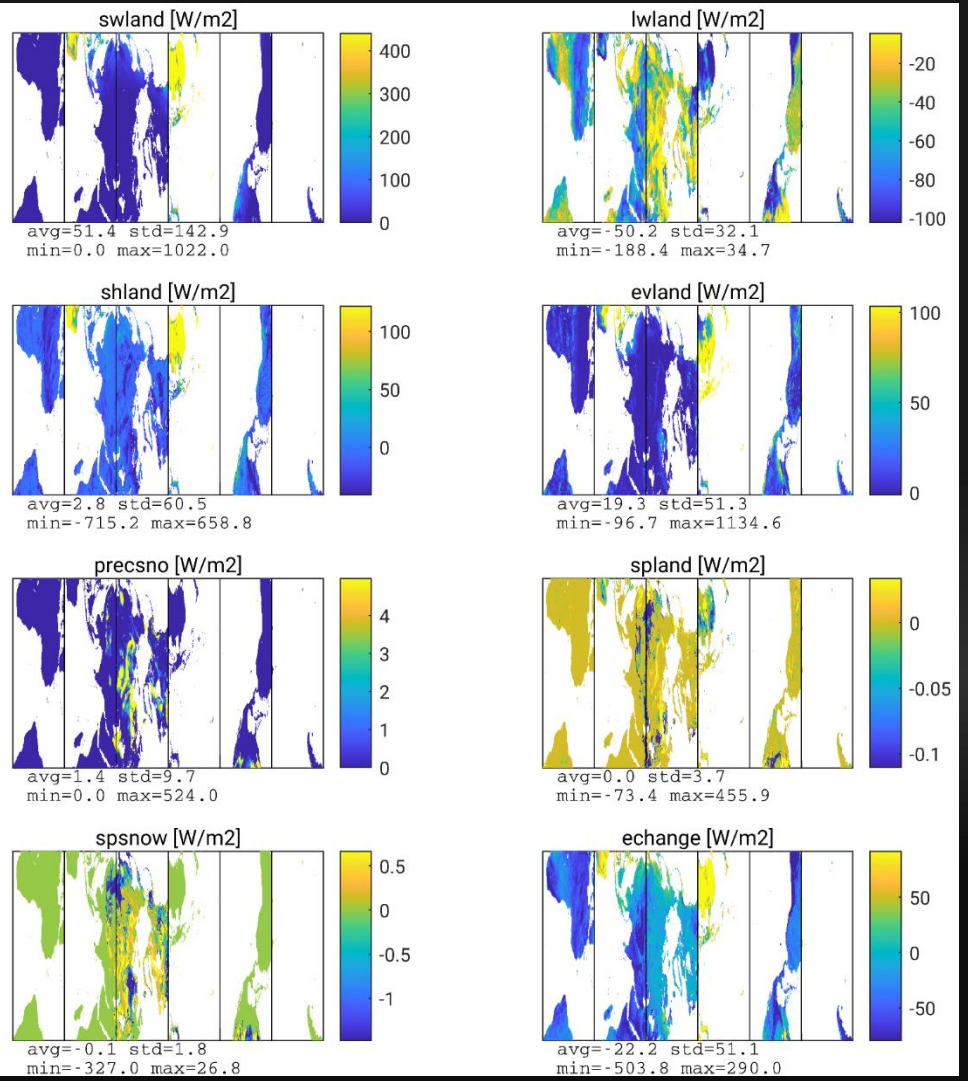
MERRA-2 File Specs (p. 72):

$$\text{ECHANGE} = \text{SWLAND} + \text{LWLAND} - \text{SHLAND} - L_v\,\text{EVLAND} - L_f\,\text{PRECSNOLAND} - \text{SPLAND} - \text{SPSNOW}.$$

```
m21c_prod.lnd_tavg_2hr_glo_C360x360x6_slv.1997-02-05T0000Z.nc4

EnBal = swland +lwland -shland
        -evpintr -evpsbln -evpsoil -evptrns
        -Lf*precsno -spland -spsnow
        -echange;

Colorbar is from 5th to 95th percentile
(except for budget: +/-max(abs([5th 95th]))
Stats are not area-weighted.
```

Revised equation also ok for cs output.



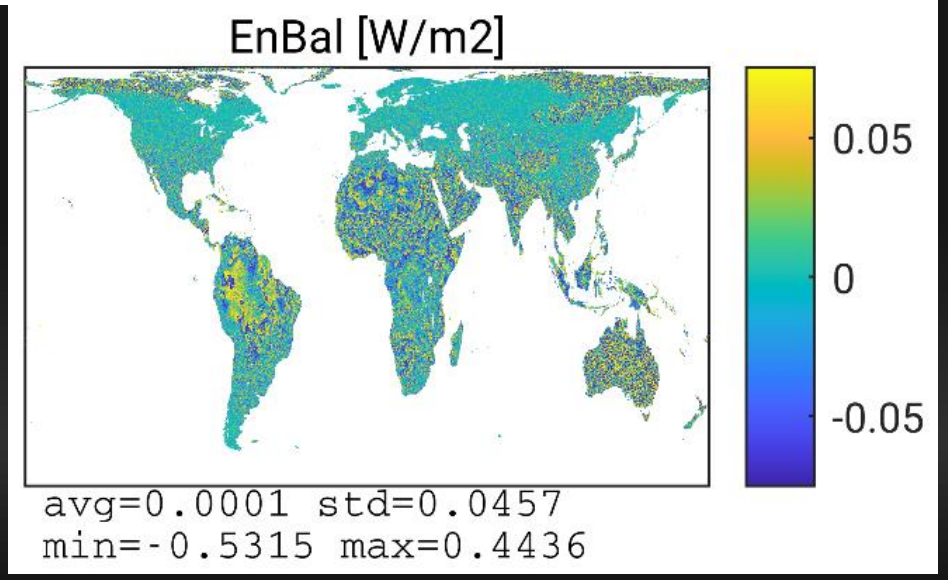


Land Energy Budget

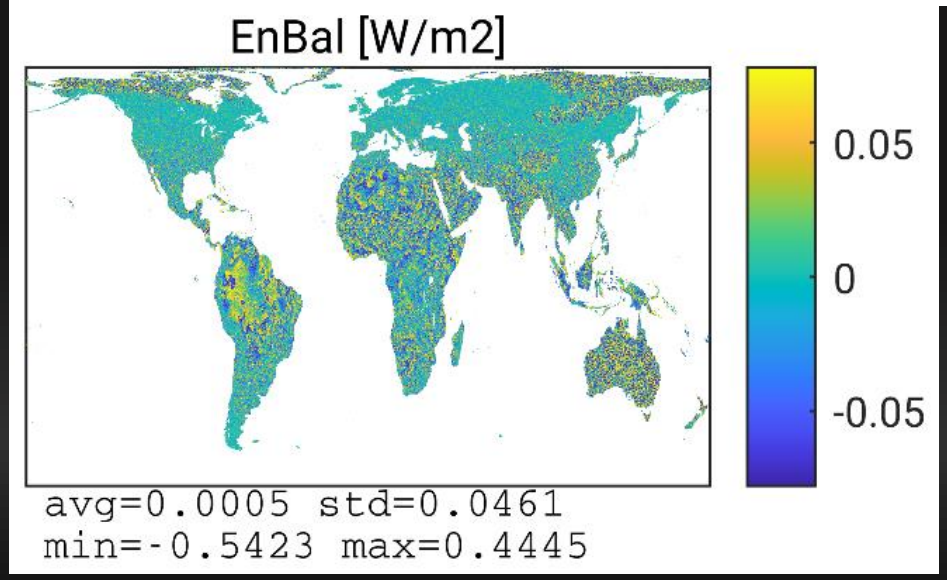
What about:

EVPINTR + EVPSBLN + EVPSOIL + EVPTRNS = LHLAND ???

```
SMAP_Nature_v11.3_budget.tavg1_1d_lnd_Nt.19970205_0030z.nc4

EnBal = swland +lwland -shland
        -evpintr -evpsbln -evpsoil -evptrns
        -Lf*precsno -spland -spsnow
        -echange;
```




```
SMAP_Nature_v11.3_budget.tavg1_1d_lnd_Nt.19970205_0030z.nc4

EnBal = swland +lwland -shland
        -lhland
        -Lf*precsno -spland -spsnow
        -echange;
```



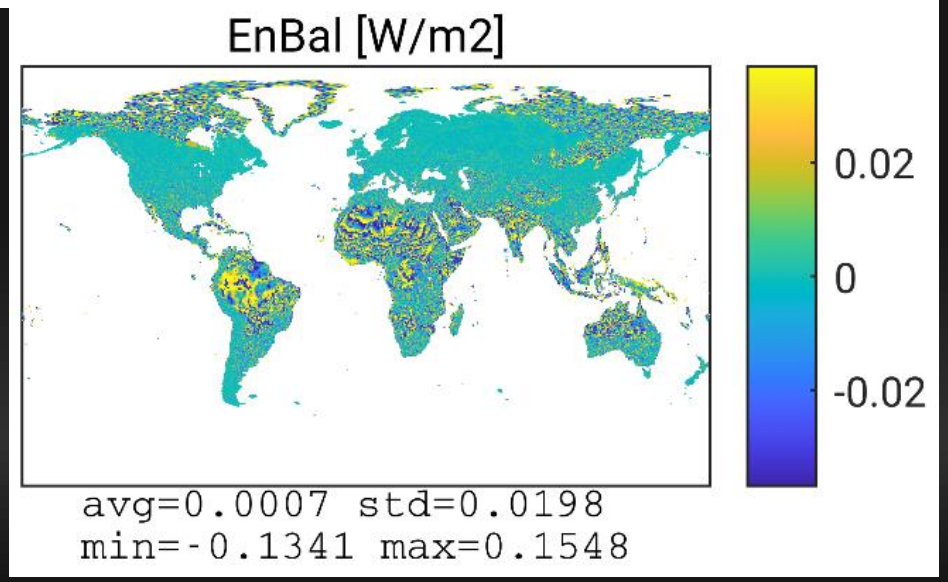
Works in offline (land-only) simulations.

Land Energy Budget

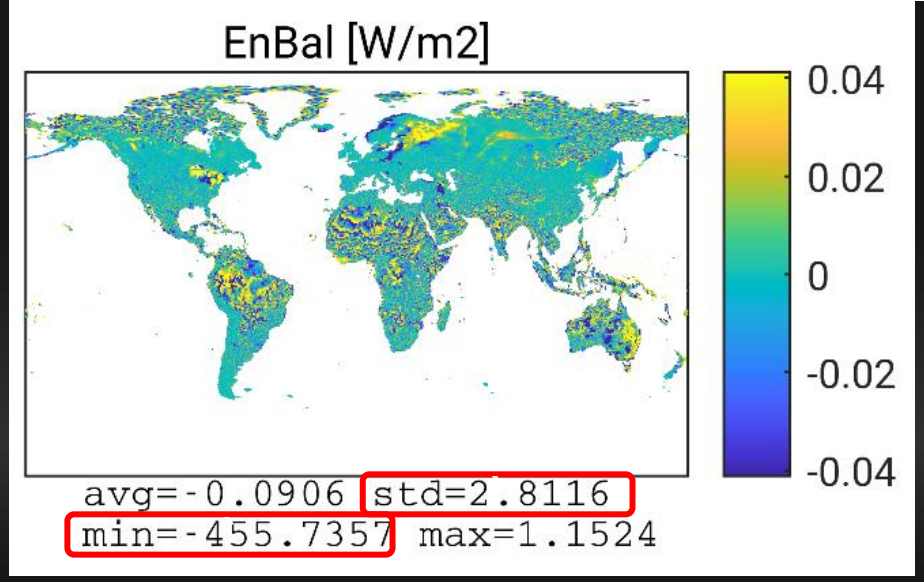
What about:

EVPINTR + EVPSBLN + EVPSOIL + EVPTRNS = LHLAND ???

```
m21c_prod.lnd_tavg_2hr_glo_L1152x721_slv.1997-02-05T0000Z.nc4

EnBal = swland +lwland -shland
        -evpintr -evpsbln -evpsoil -evptrns
        -Lf*precsno -spland -spsnow
        -echange;
```




```
m21c_prod.lnd_tavg_2hr_glo_L1152x721_slv.1997-02-05T0000Z.nc4

EnBal = swland +lwland -shland
        -lhland
        -Lf*precsno -spland -spsnow
        -echange;
```



Similar result for M21C cube-sphere and M2 lat/lon output.

Does **NOT** work in GCM!!!

Land Energy Budget

- In GCM only, after call to catchment(), “accounting” terms are applied to LH and evap components.
- LHACC and EVACC are not export specs.
- Note asymmetric application of “accounting” terms: `where(SUMEV>0.)`

```
if (CATCH_INTERNAL_STATE%CATCH_OFFLINE == 0) then

  !amm add correction term to latent heat diagnostics (HLATN is always allocated)
  !    this will impact the export LHLAND

  HLATN = HLATN - LHACC

  ! also add some portion of the correction term to evap from soil, int, veg and snow

  SUMEV = EVPICE+EVPSOI+EVPVEG+EVPINT

  where(SUMEV>0.)
    EVPICE = EVPICE - EVACC*EVPICE/SUMEV
    EVPSOI = EVPSOI - EVACC*EVPSOI/SUMEV
    EVPINT = EVPINT - EVACC*EVPINT/SUMEV
    EVPVEG = EVPVEG - EVACC*EVPVEG/SUMEV
  endwhere
endif
```

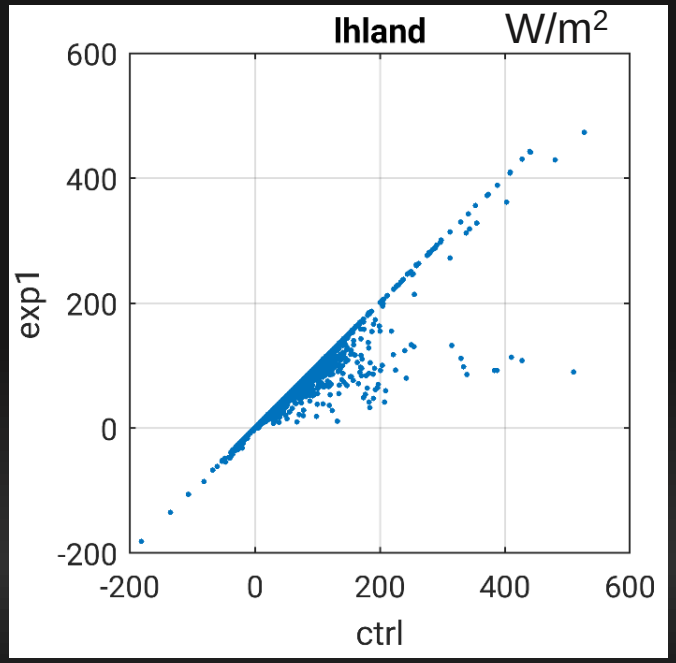
Land Energy Budget

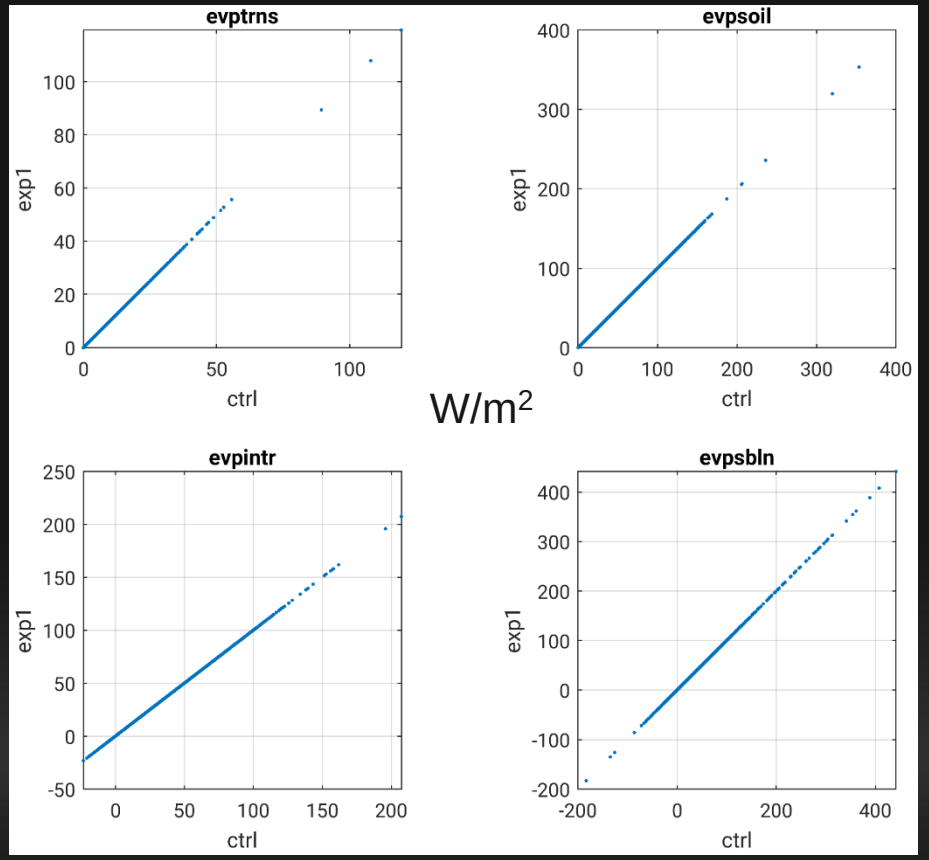
One-day AMIP simulations:

- "ctrl" : LH and evap output as in M21C.
- "exp1" : Without application of "accounting" terms.

Accounting terms:

- **`LHACC /= 0`**
- **`EVACC  = 0 for SUMEV>0 ??`**





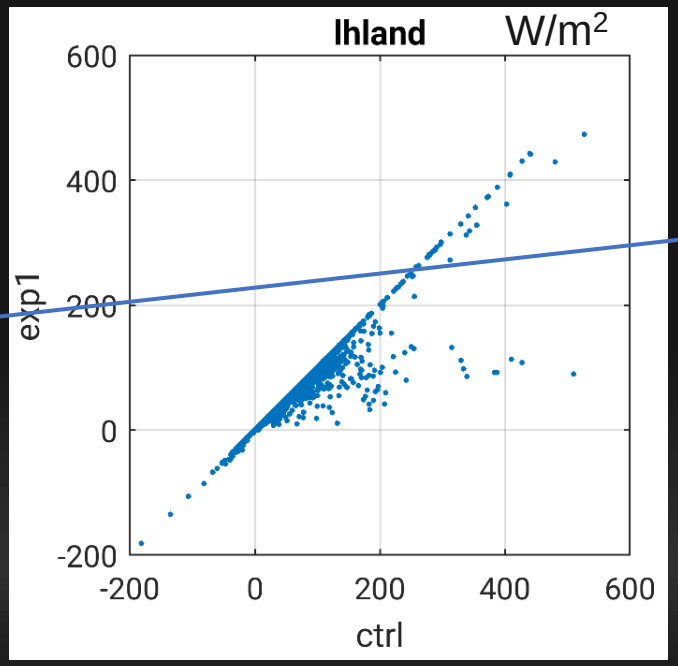
Land Energy Budget

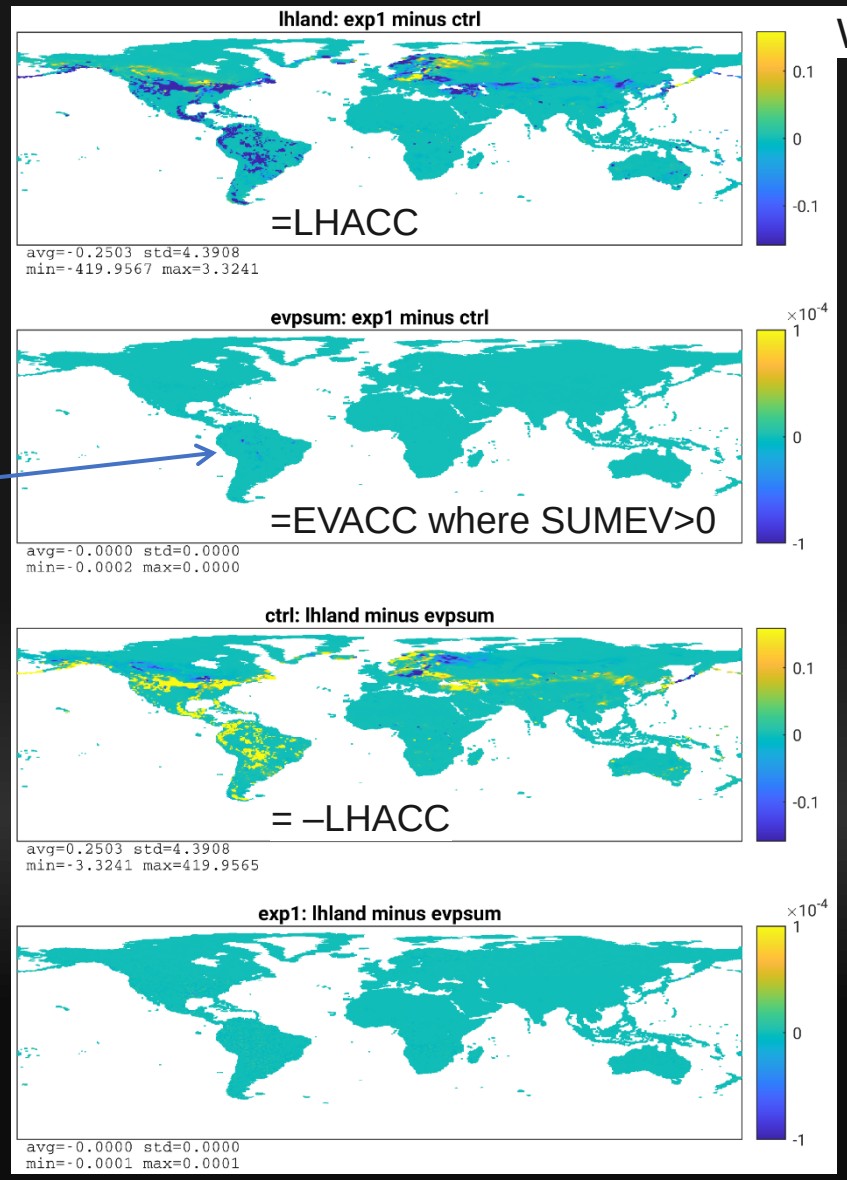
One-day AMIP simulations:

- "ctrl" : LH and evap output as in M21C.
- "exp1" : Without application of "accounting" terms.

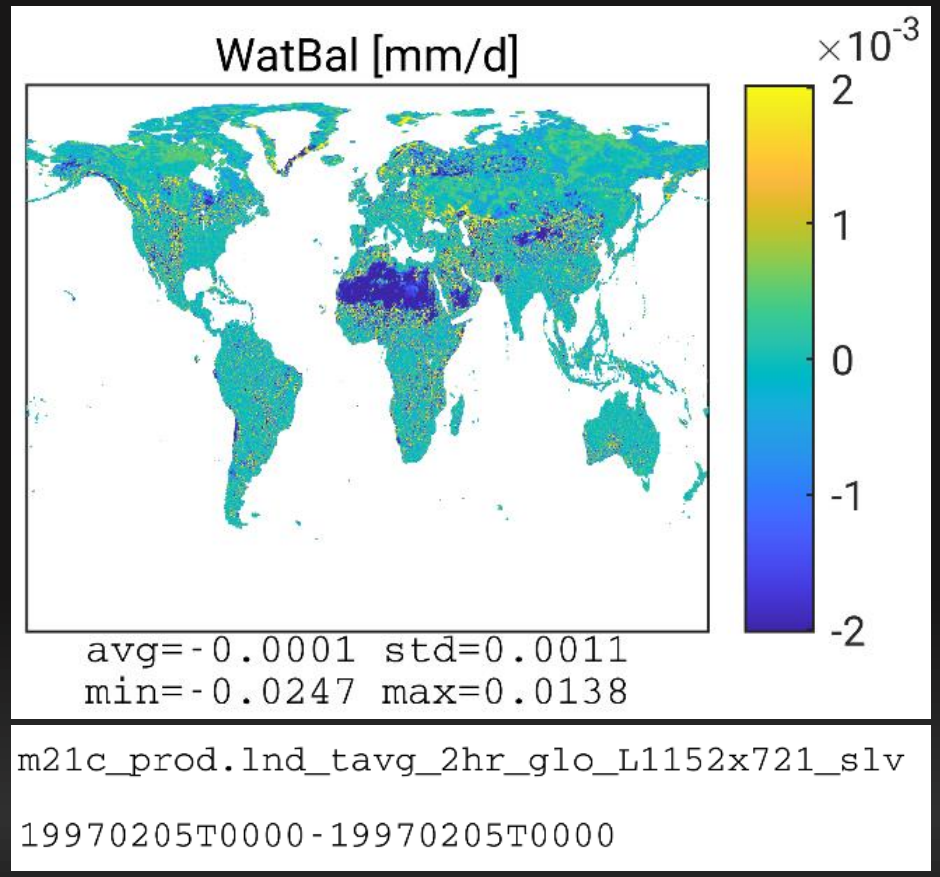
Accounting terms:

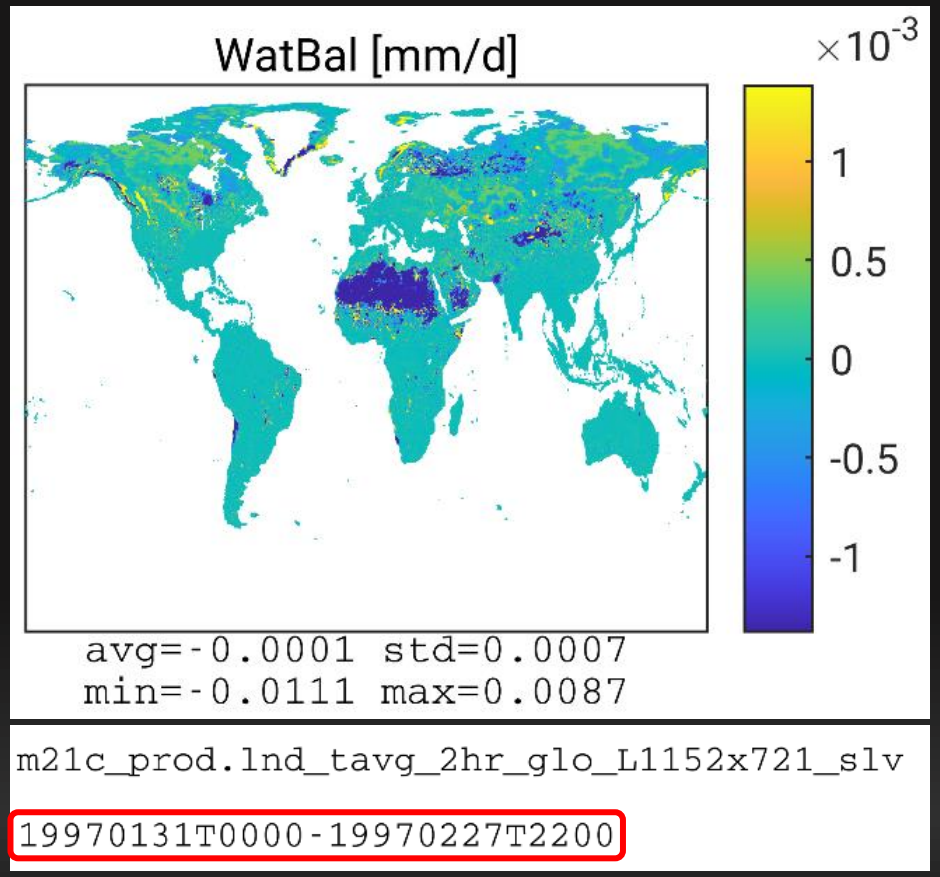
- **`LHACC /= 0`**
- **`EVACC ~ 0 for SUMEV>0`**





Single-Granule vs. Multi-Week Balance





- Spatial pattern of small residuals is persistent. Acceptable?
- Similar results for water balance of cs "lnd" output and for energy balance (not shown).

Summary

- For brevity, variable names in this presentation were shortened from M21C names.
- No bit shaving in “lnd” collection.
- Water and energy balance equations in M2 File Specs are wrong and need to be corrected!
- Corrected balance equations apply equally to M2 and M21C.
- In the GCM, LHLAND is **not** equal to the sum of the EVP* component fluxes!
  Why are “accounting” terms applied? Source code modifications may be needed.
- Spatial pattern of balance residuals is persistent. Acceptable?
- A very minor residual energy balance error may exist in M2 and M21C (“snow mass-limited sublimation from top snow layer”). This error may never happen. If it does, it is expected to be tiny. This will be further examined in GEOSgcm_GridComp PR#956.