

Typical “environmental” corrections in geodesy processing

- No loading correction (except ocean tides) for **displacements** (except VLBI).
- **Gravity field** (GRACE, GRACE-FO): atmosphere and ocean (currently AOD1B RL7, based on ECMWF and MPIOM).
- **Altimetry**
 - Precise Orbit Determination: atmosphere and ocean (currently AOD1B RL6 + GRACE derived long-term variations).
 - Sea Surface Height high-frequency ocean variability (departure from IB) (DAC, Dynamic Atmospheric Correction, based on TUGO-m).
- **EOP parameters**: a posteriori correction (atmosphere and ocean).

Operational models and Reanalyzes

Operational models are the most up-to-date models, compared to reanalyzes. However, significant updates can occur (here due to improved spatial resolution).

For reanalyzes, the model version is fixed; the number of assimilated data increases through time.

But some spurious issues can still happen (see next slide ...)

Duan et al., GJI, 2012.

Fagiolini et al., GJI, 2015.

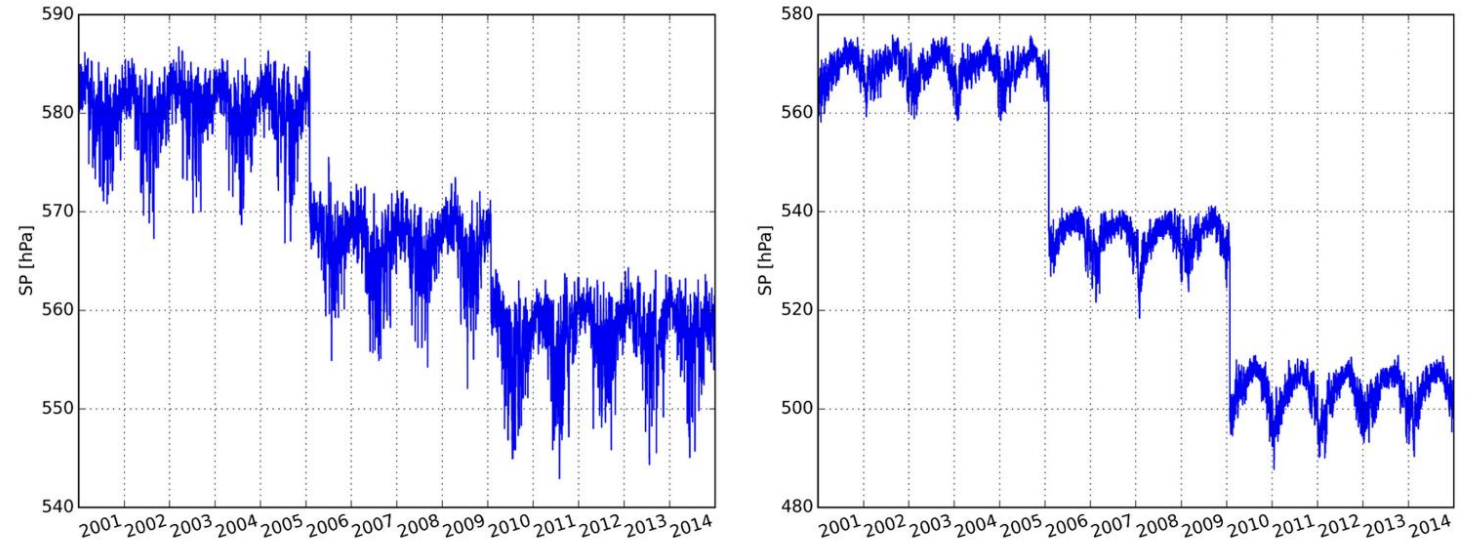


Figure 1. 6-h surface pressure variation between 2001 January and 2014 December at a location over the Andes (latitude -27.24 , longitude -68.04) (left) and over Mount Everest (latitude 27.80 , longitude 87.00) (right). Two discontinuities are visible in 2006 January and 2010 January.

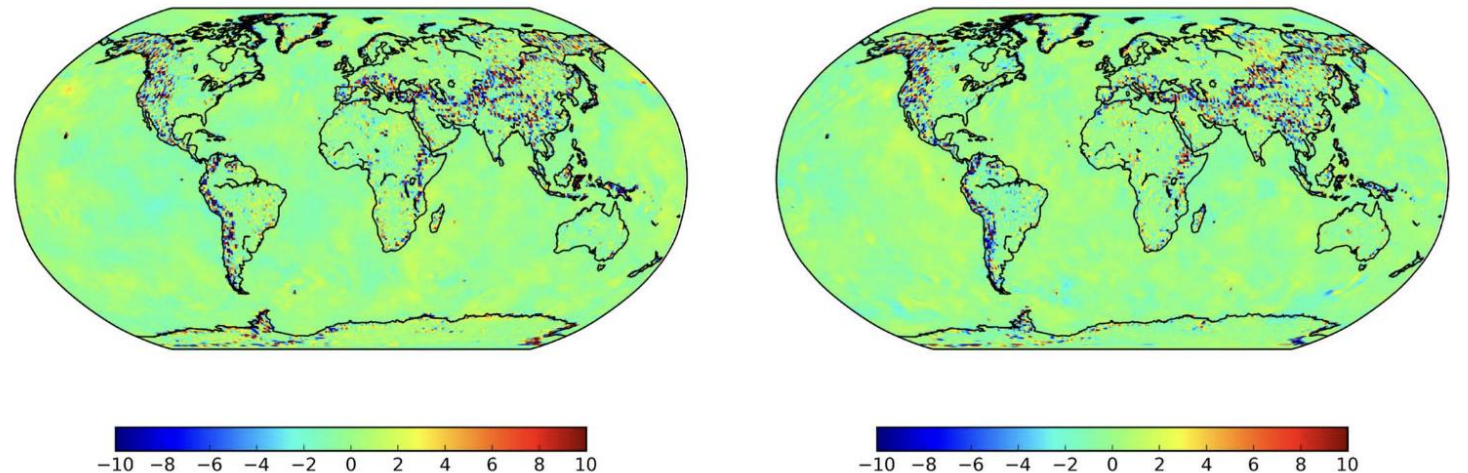
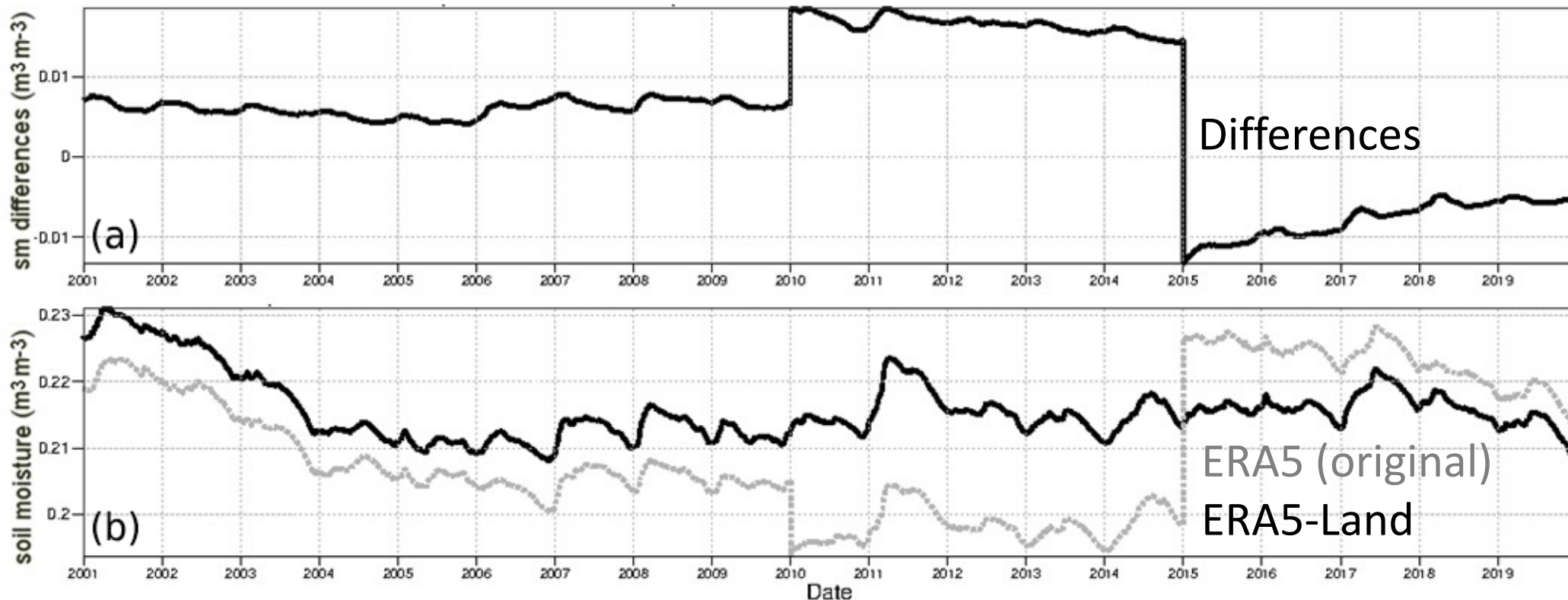


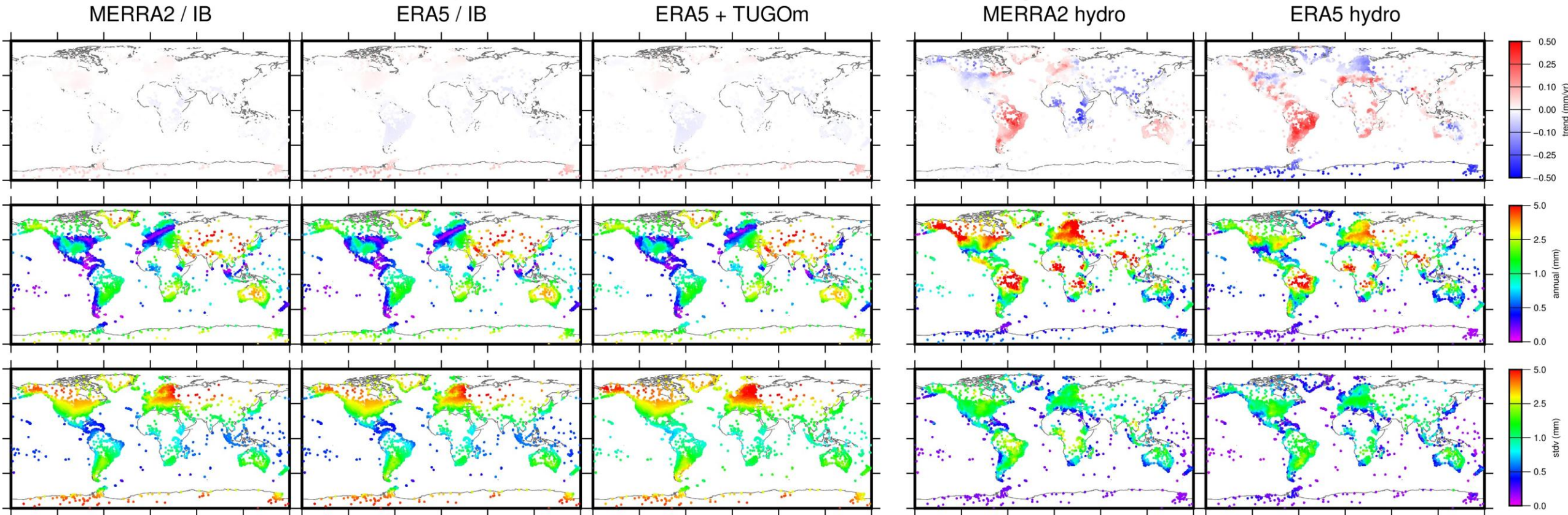
Figure 2. Surface pressure bias [hectopascals] at t_1 (left) and at t_2 (right).

Differences between ERA5 "hydro" and ERA5-Land



Mean differences between ERA5-Land and ERA5 soil moisture time series for the fourth soil layer (CHTESSEL) land surface model (100–289 cm), averaged for the latitudes 60–20° S.

General characteristics of loading models (MERRA2 & ERA5 reanalyzes)



MERRA2: Modern-Era Retrospective analysis for Research and Applications, Version 2, NASA/GSFC GMAO.

ERA5: Fifth generation ECMWF atmospheric reanalysis.

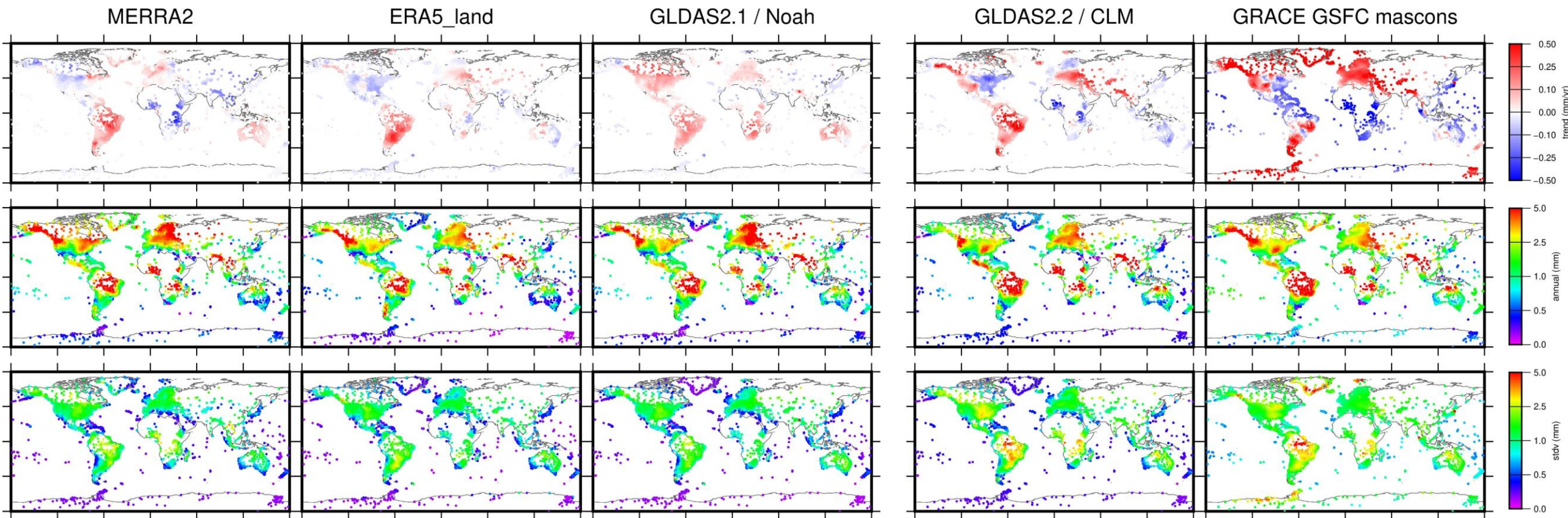
(GGFC official products)

TUGOm: Finite element barotropic ocean model forced by ERA5 winds & pressure (update from Carrère & Lyard, 2003).

Variability: stdv after removing seasonal + trends.

(all series available on <http://loading.eost.unistra.fr>)

Hydrology loading (operational vs reanalyzes)



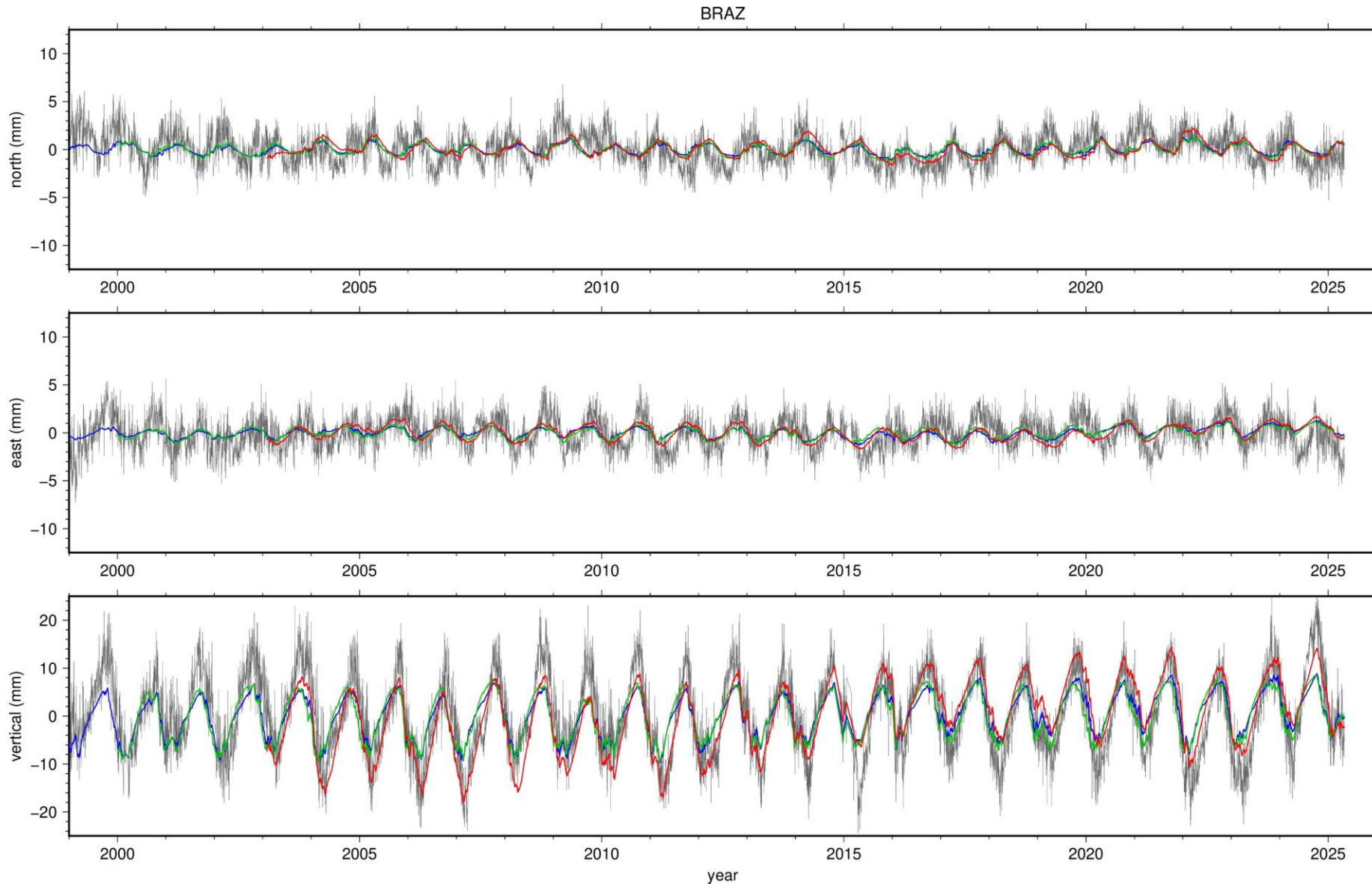
GLDAS2.1/Noah without GRACE assimilation (2000-now)

GLDAS2.2/CLM with assimilation of GRACE and GRACE-FO (2003-now)

Variability: stdv after removing seasonal + trends.

(all series available on <http://loading.eost.unistra.fr>)

Example of time series (BRAZ - 41606M001)



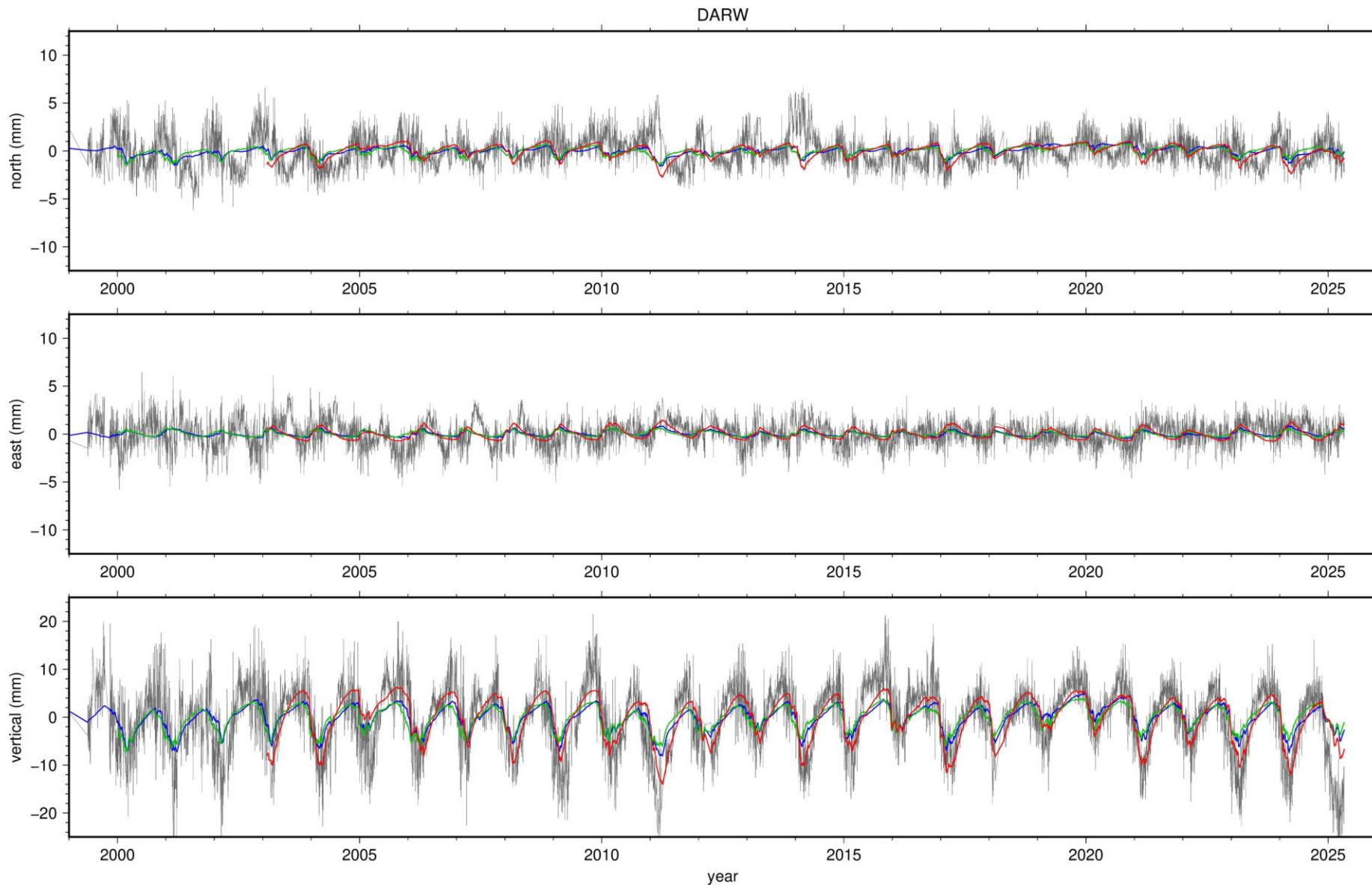
GNSS – ERA5/TUGO

ERA5_land

GLDAS2.1 (Noah)

GLDAS2.2 (CLM + GRACE)

Example of time series (DARW - 50134M001)



GNSS – ERA5/TUGO

ERA5_land

GLDAS2.1 (Noah)

GLDAS2.2 (CLM + GRACE)

Updating geoid model on radial orbits (Jason-1)

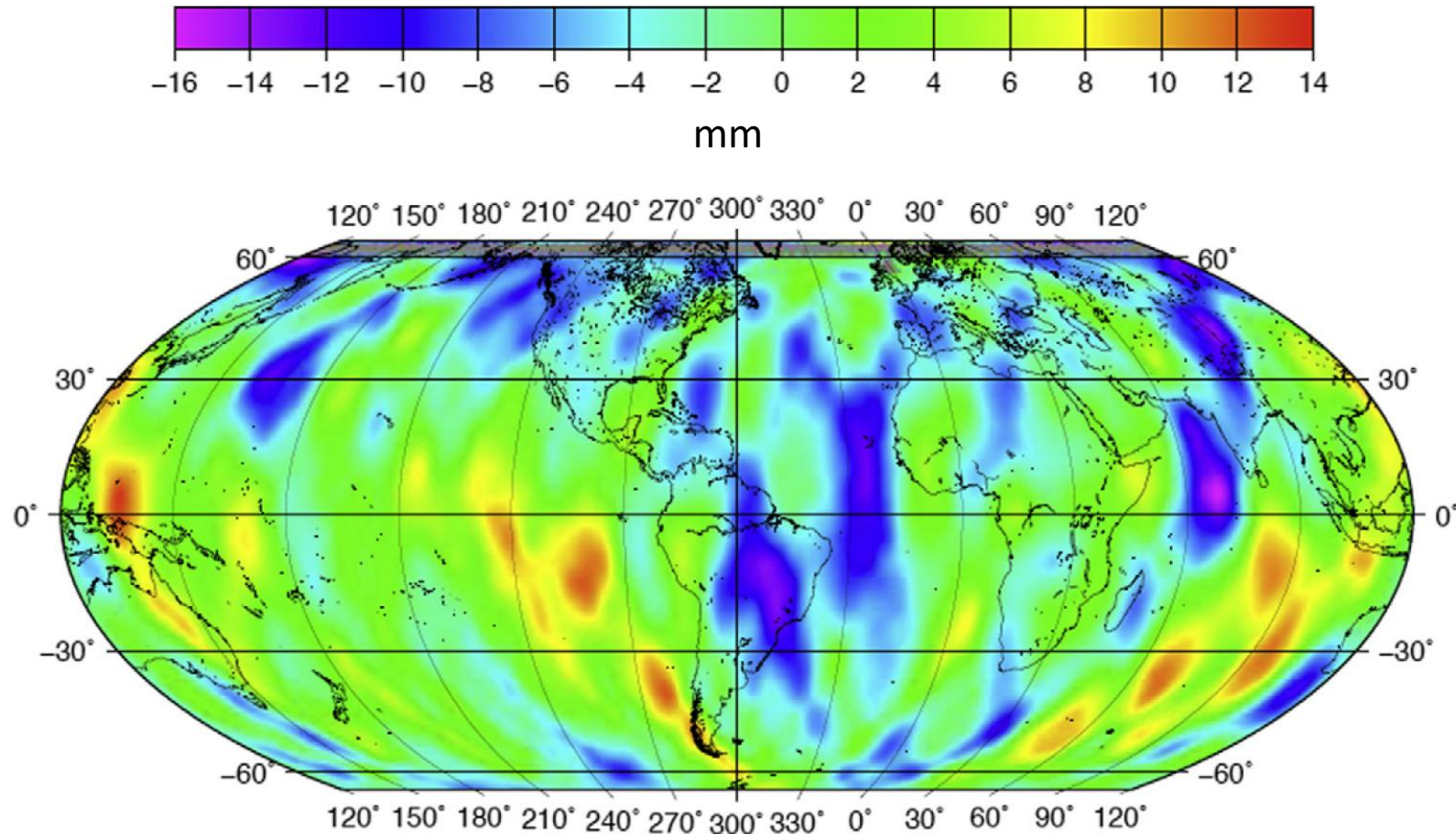


Fig. 5. Jason-1 Mean radial orbit differences between the Jason-1 JGM-3-based orbits (cycles 1–21), and orbits using the new gravity model, EIGEN-GL04S1. The units are mm, and the orbit differences have been averaged over $5^\circ \times 5^\circ$ bins.

Modeling TVG gravity on radial orbits (Jason-1)

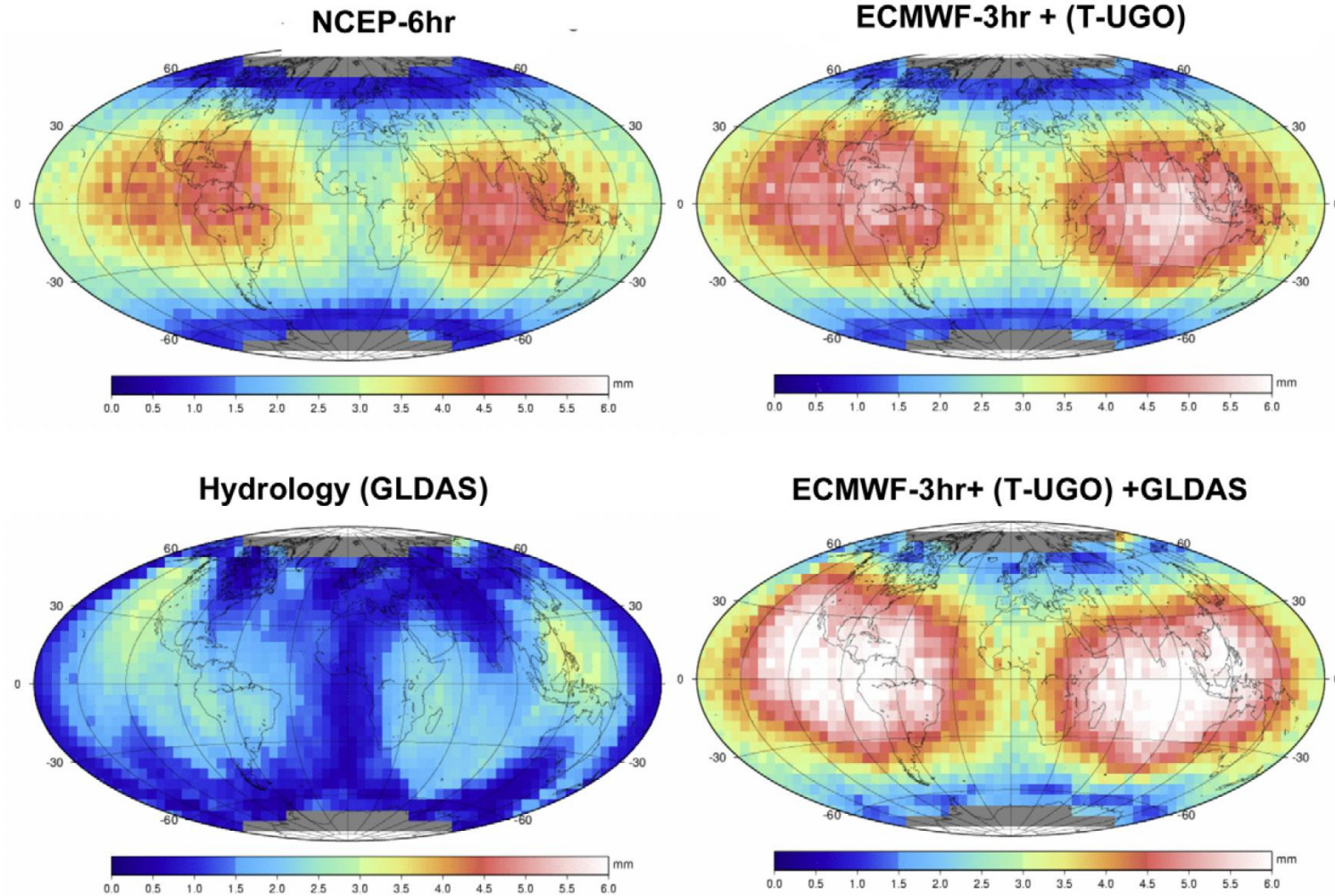
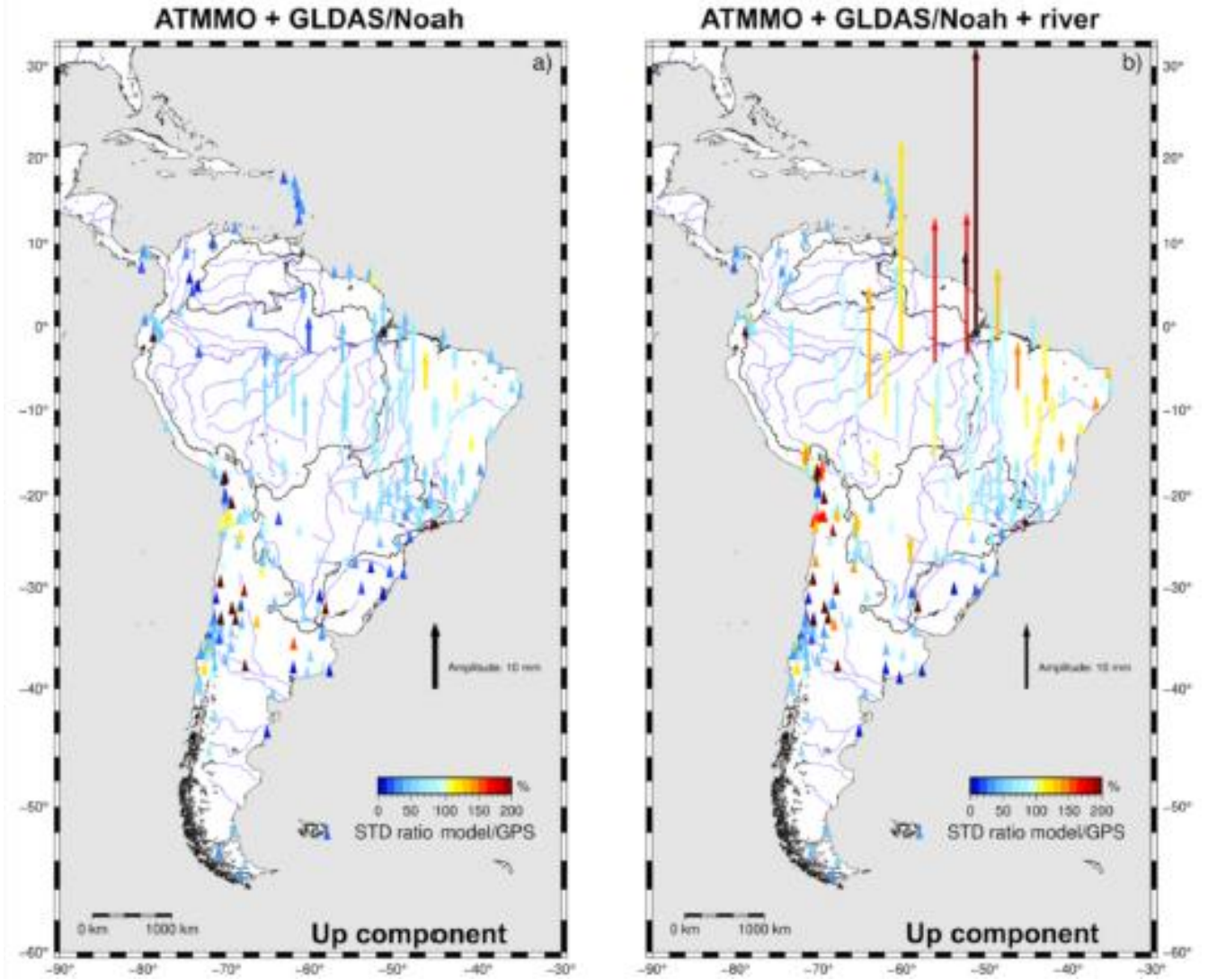
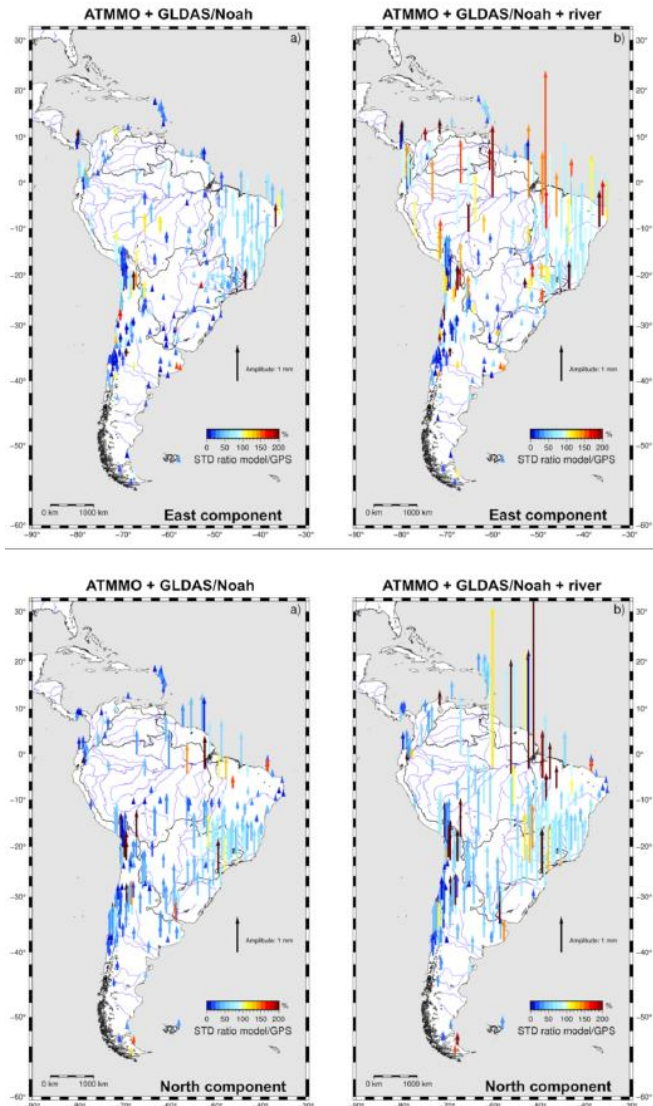


Fig. 6. RMS Radial differences on the Jason-1 orbit (from January 2003 to January 2005) due to each of the geophysical fields tested: (1) NCEP-6hr (atmospheric gravity); (2) ECMWF-3hr (atmospheric gravity) + barotropic ocean (T-UGO); (3) Hydrology (GLDAS); (4) The total signal (ECMWF-3hr + T-UGO + GLDAS).

Contribution of rivers to loading effects



- Arrow: amplitude of the full seasonal signal (atmosphere + ocean + hydrology)
- Color-scale: standard deviation ratio of the model with respect to GPS (in %).

from Nicolas et al., RS, 2021.

Re-routing hydrology model runoffs

- Flow velocity adjusted using radar altimetry water level and water extent from MODIS imagery.
- Mean annual velocity validated using in situ gauges.

$$\frac{\partial h(t)}{\partial t} + \frac{u}{L}h(t) - \sum_i \frac{u_i}{L_i}h_i(t) = q(t)$$

