REFAG 2022 THESSALONIKI - GREECE

IAG

Comparison of ITRF2020 residual displacements with environmental loading models

J-P. Boy [1], P. Rebischung [2] & Z. Altamimi [2]

(1) EOST/ITES, Strasbourg, France.

(2) IGN/IPGP, Paris, France.

Institut Terre & Environnement de Strasbourg | ITES | UMR 7063 de l'Université de Strasbourg & cnrs & ENGEES

EOST Ecole et Observatoire des Sciences de la Terre

IGN

IPGP

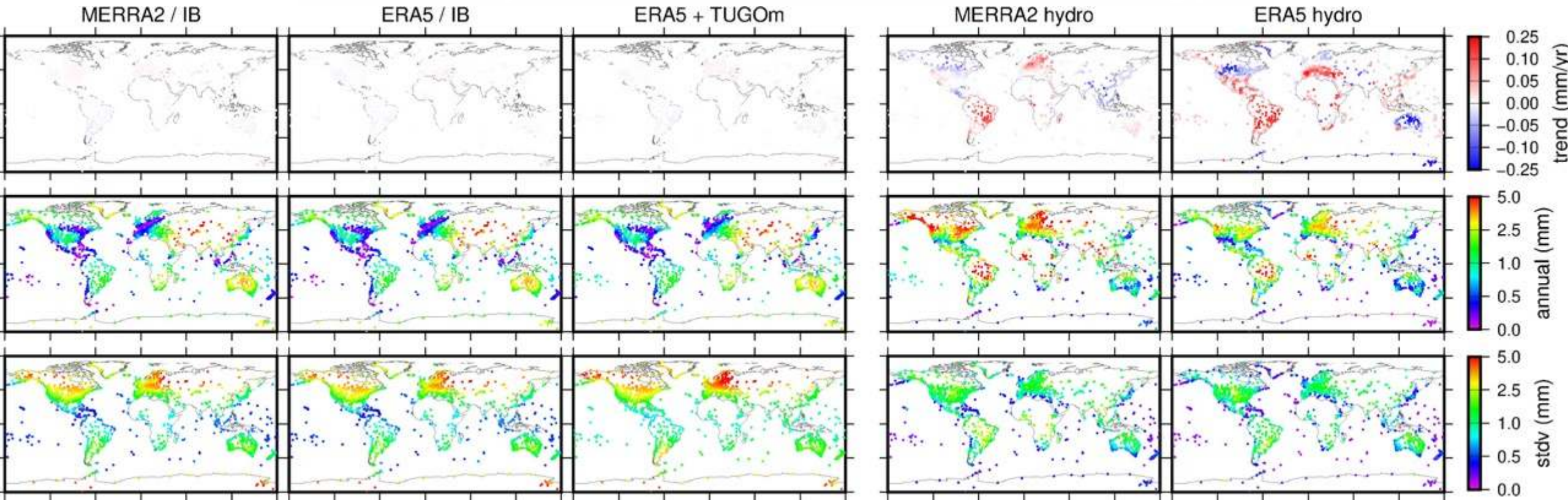
GRGS GROUPE DE RECHERCHE DE GEODESIE SPATIALE

Comparison of ITRF2020 residual displacements with environmental loading models

- Daily GPS residuals from IGS repro3 daily combined solutions, after removing linear trends, offsets, post-seismic relaxation. No scale adjusted for the alignment (1483 series, 949 with duration exceeding 3000 days).
- Loading models (atmosphere + induced ocean & hydrology) based on:
  - ERA5 with IB or TUGOm (update of Carrère & Lyard, 2003), computed for ITRF2020 (GGFC product)
  - MERRA2 (only IB)
- Investigation of the reduction of variance & annual contribution when correcting for loading effects (horizontal & vertical components).

- All loading products are available at EOST Loading Service (displacements, geocenter and Stokes coeff.) at http://loading.u-strasbg.fr

General characteristics of loading models (atmosphere & continental hydrology)

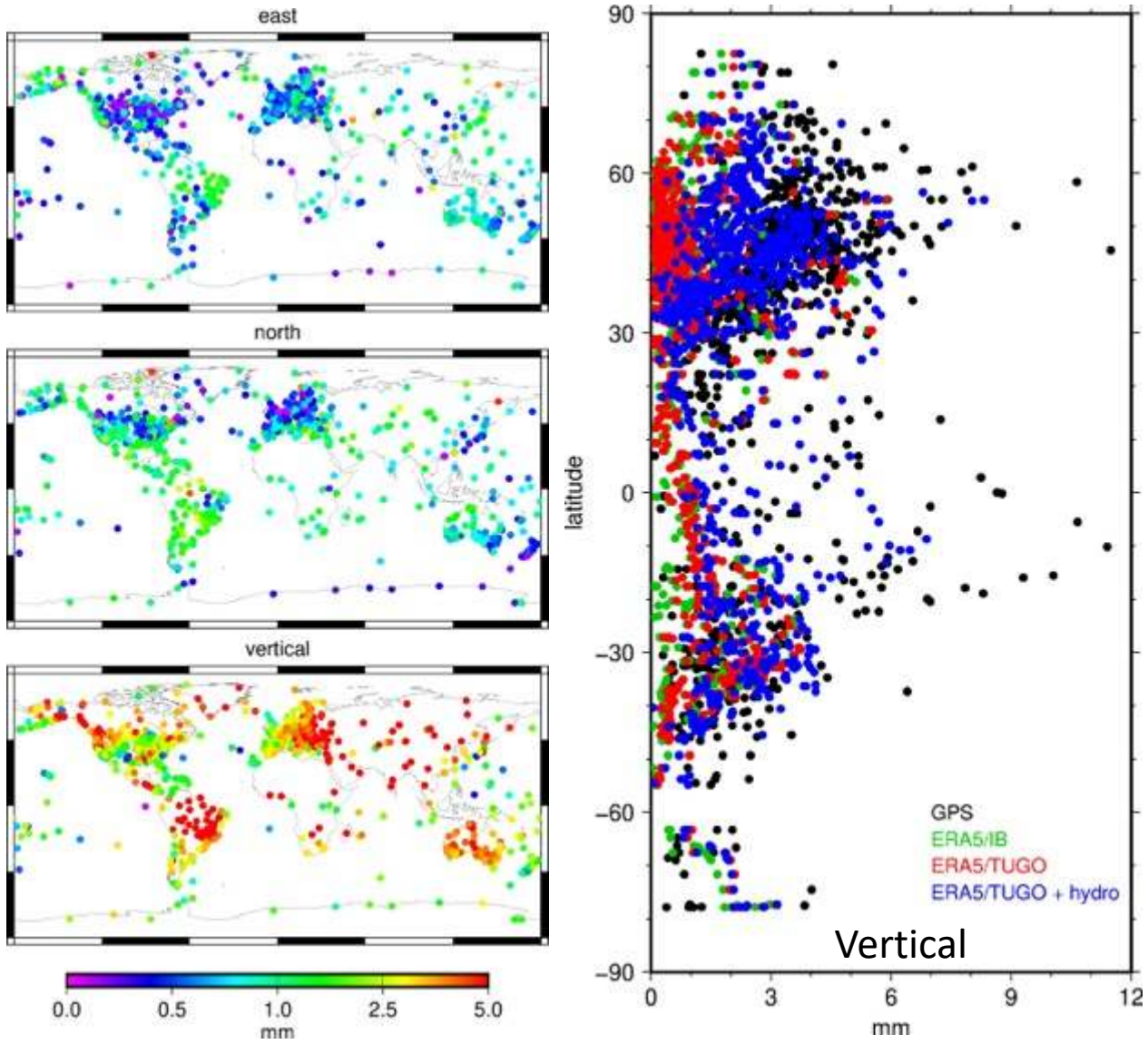


MERRA2: Modern-Era Retrospective analysis for Research and Applications, Version 2, NASA/GSFC GMAO.
ERA5: Fifth generation ECMWF atmospheric reanalysis.
TUGOm: finite element barotropic ocean model forced by ERA5 winds & pressure (update from Carrère & Lyard, 2003).

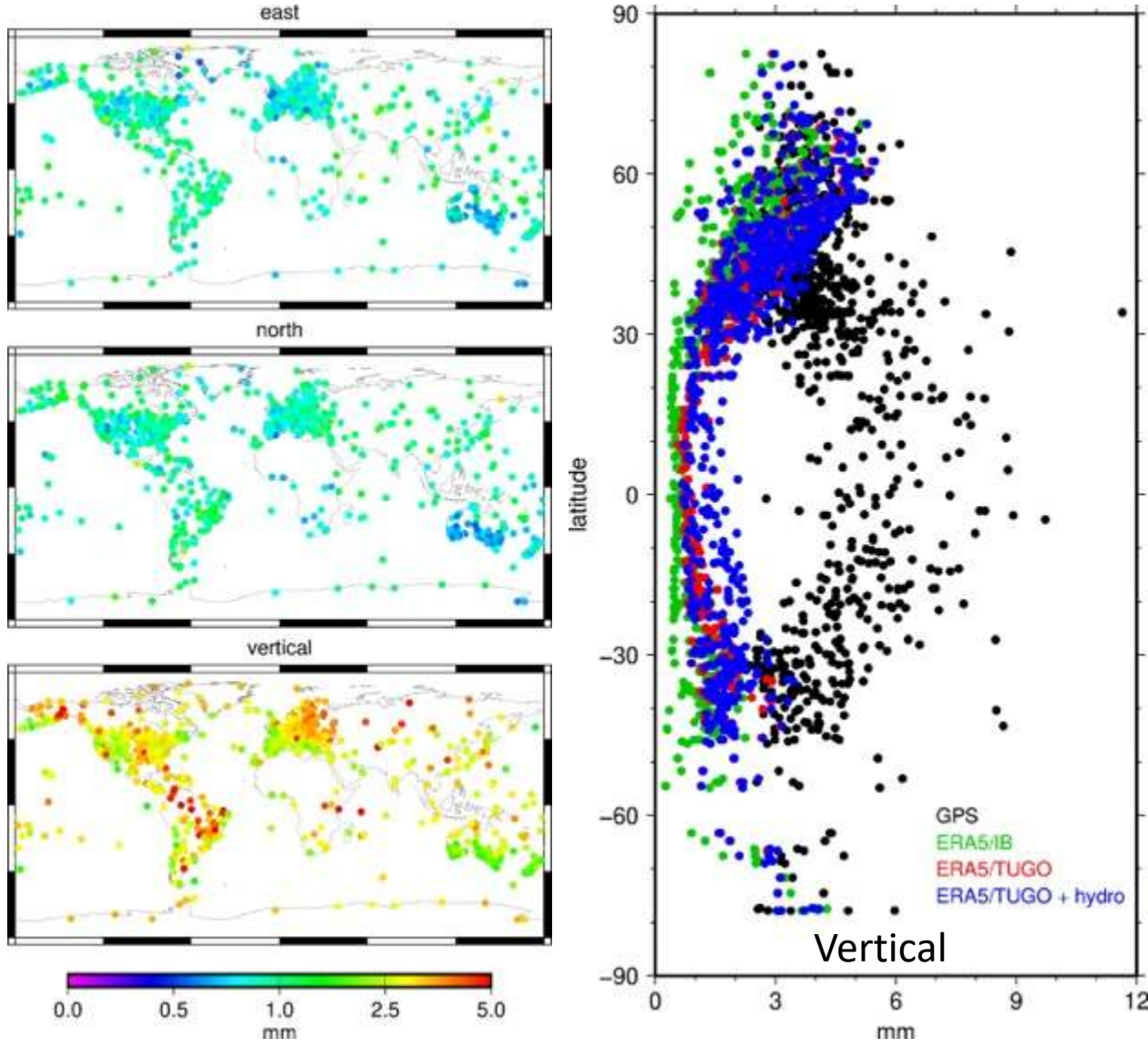
Variability : stdv after removing seasonal + trends

GPS daily series: annual & variability

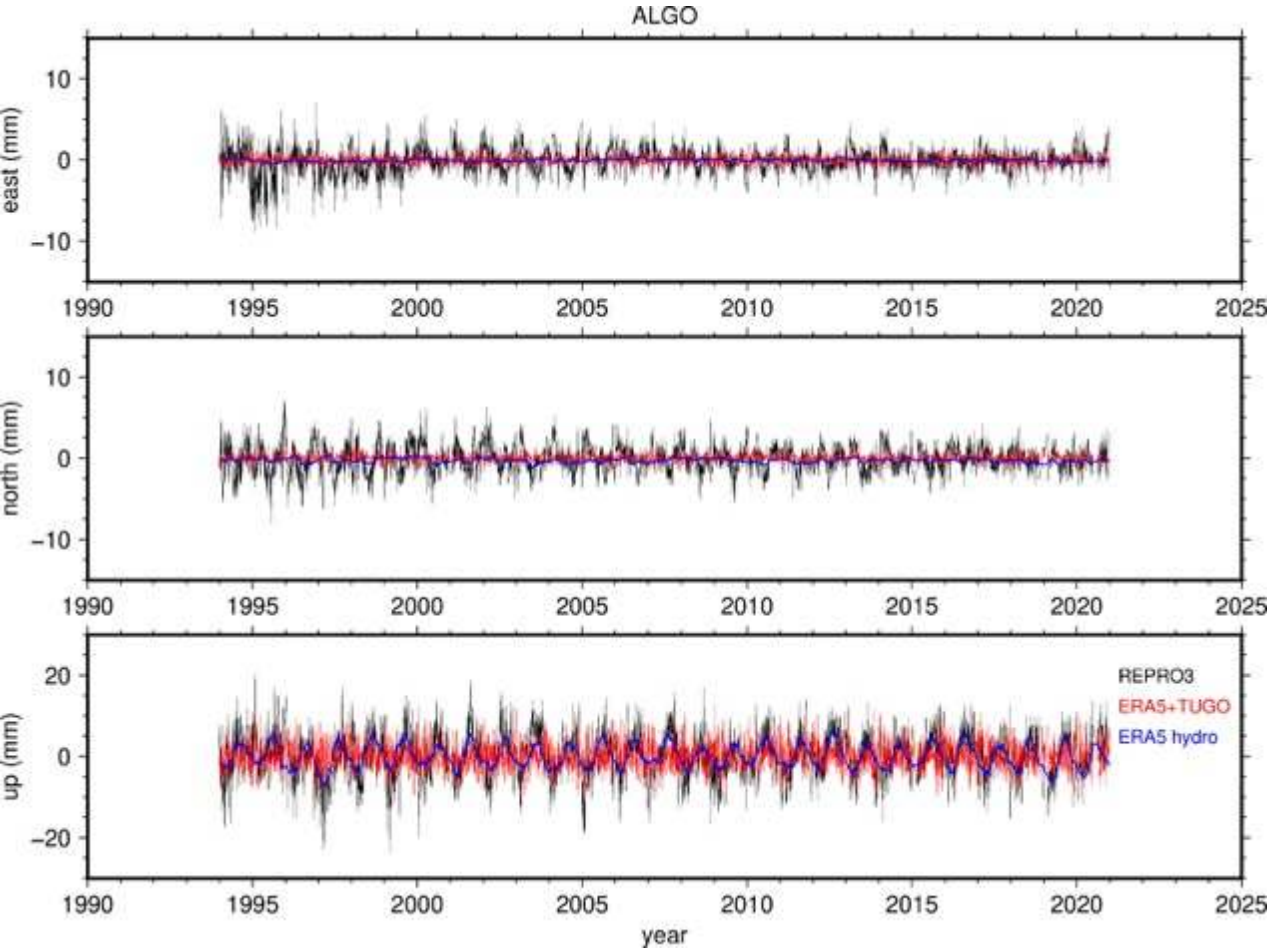
Annual amplitude



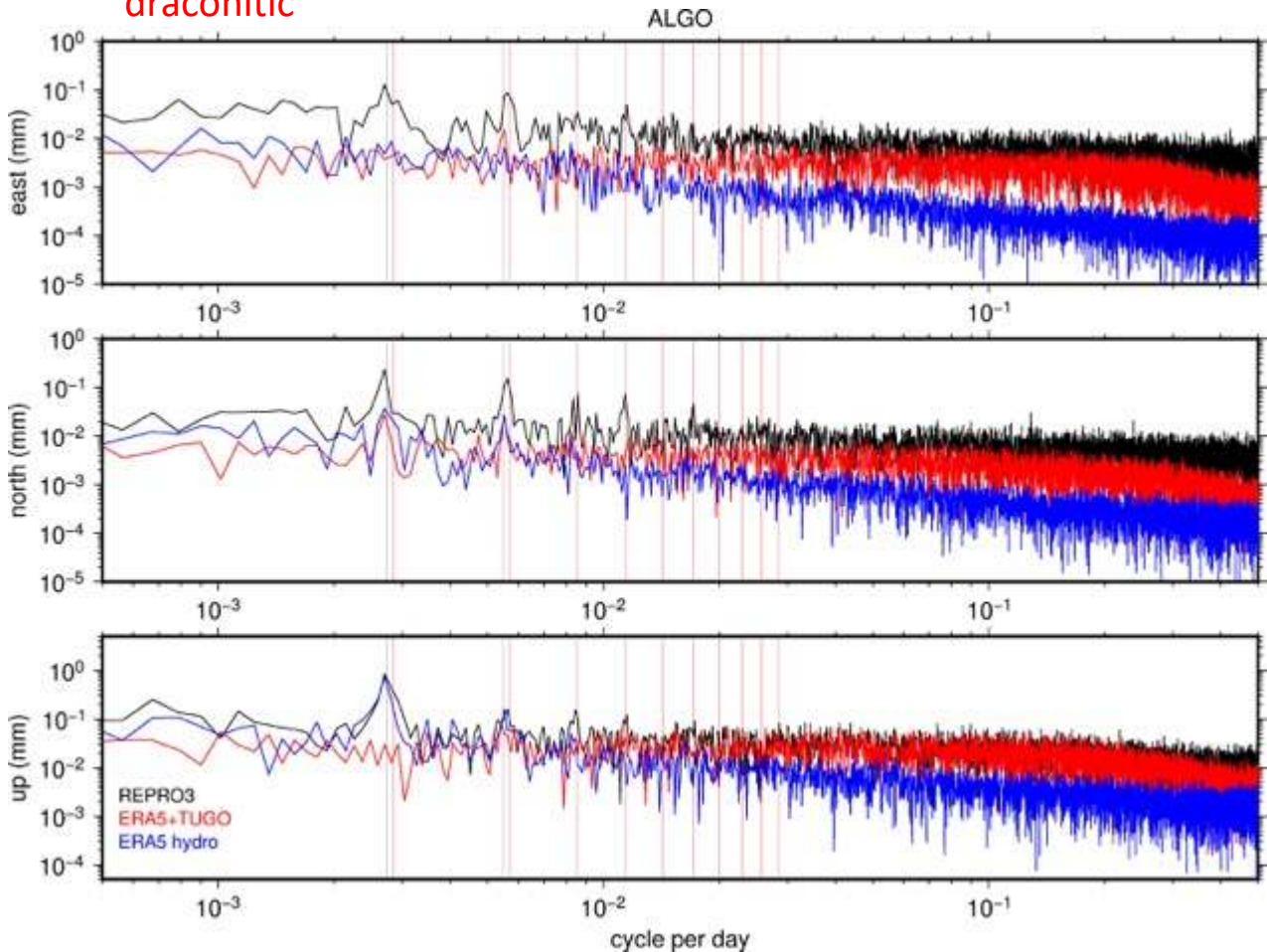
Variability



ALGO, Algonquin, Canada

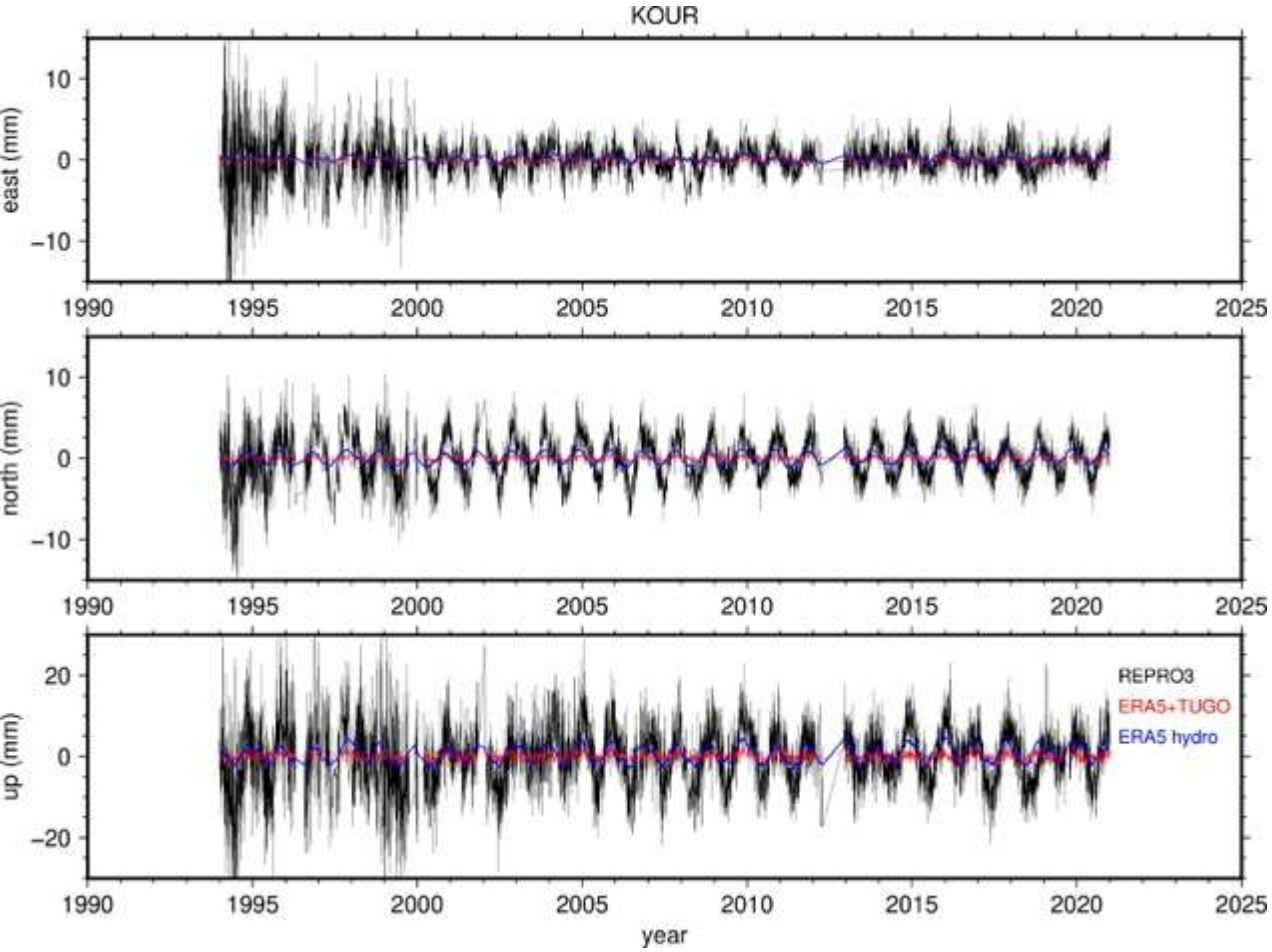


annual, semi-annual
draconitic

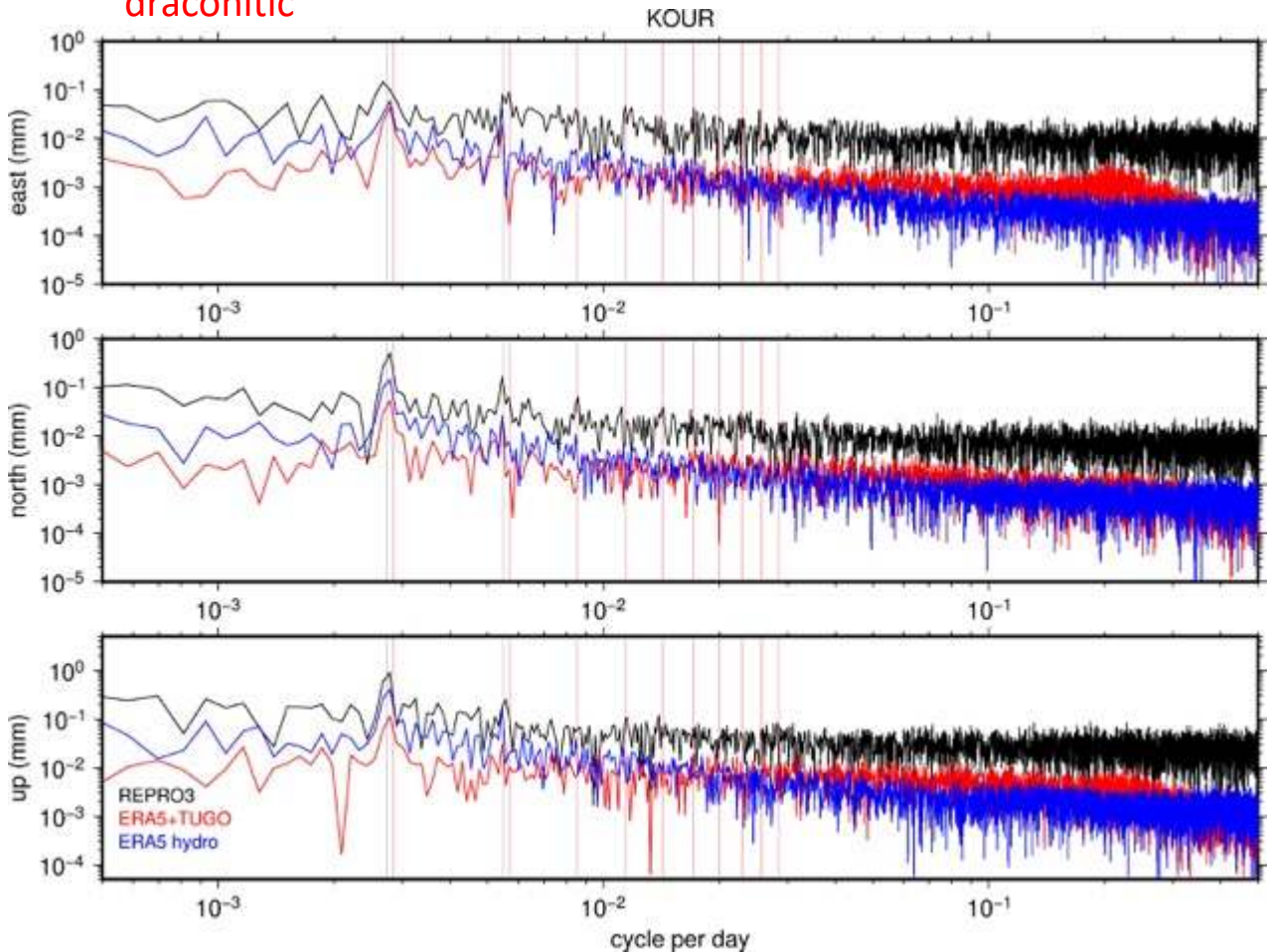


Lon: -78.04° Lat: 45.58°

KOUR, Kourou, French Guiana

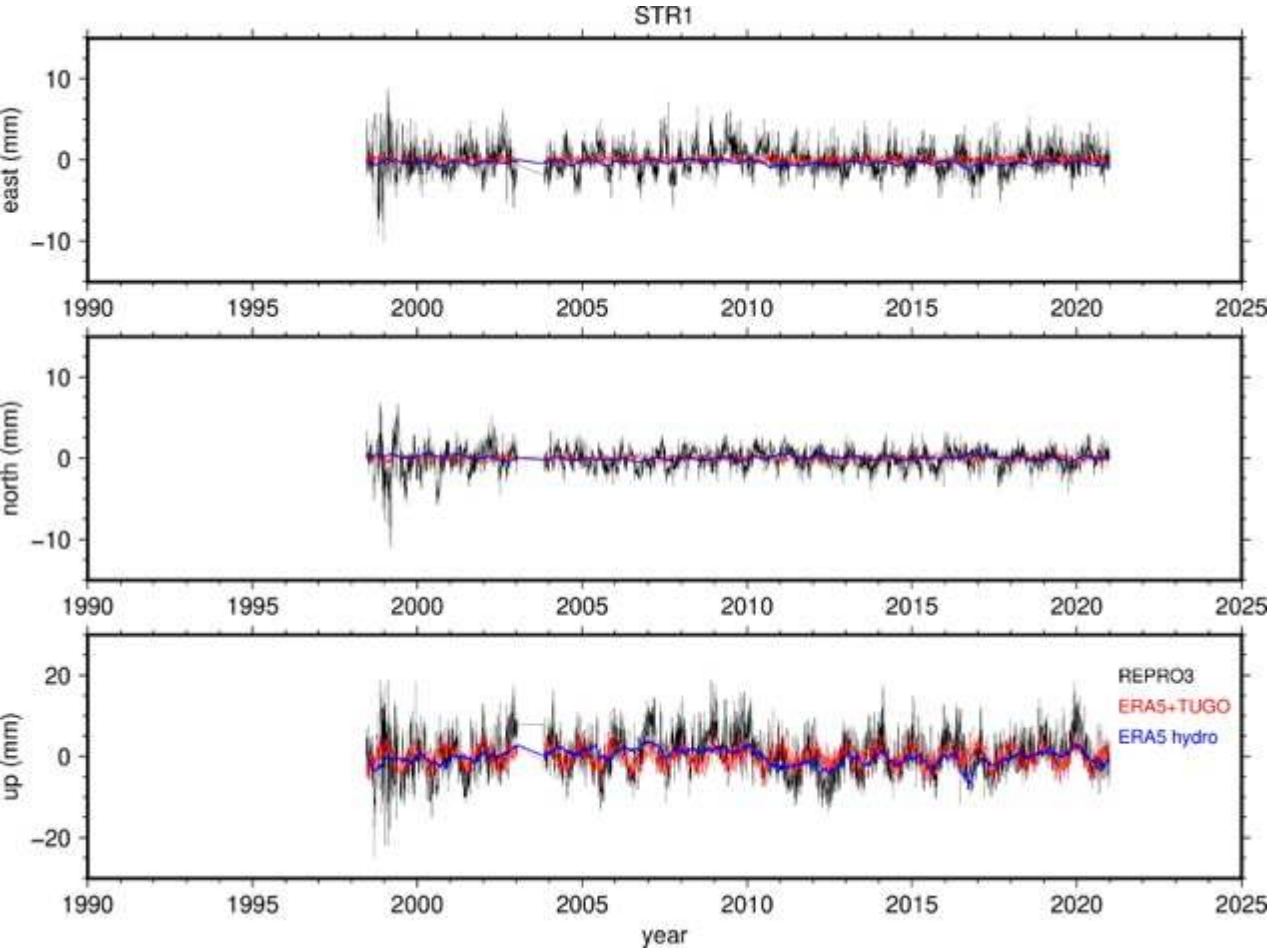


annual, semi-annual
draconitic

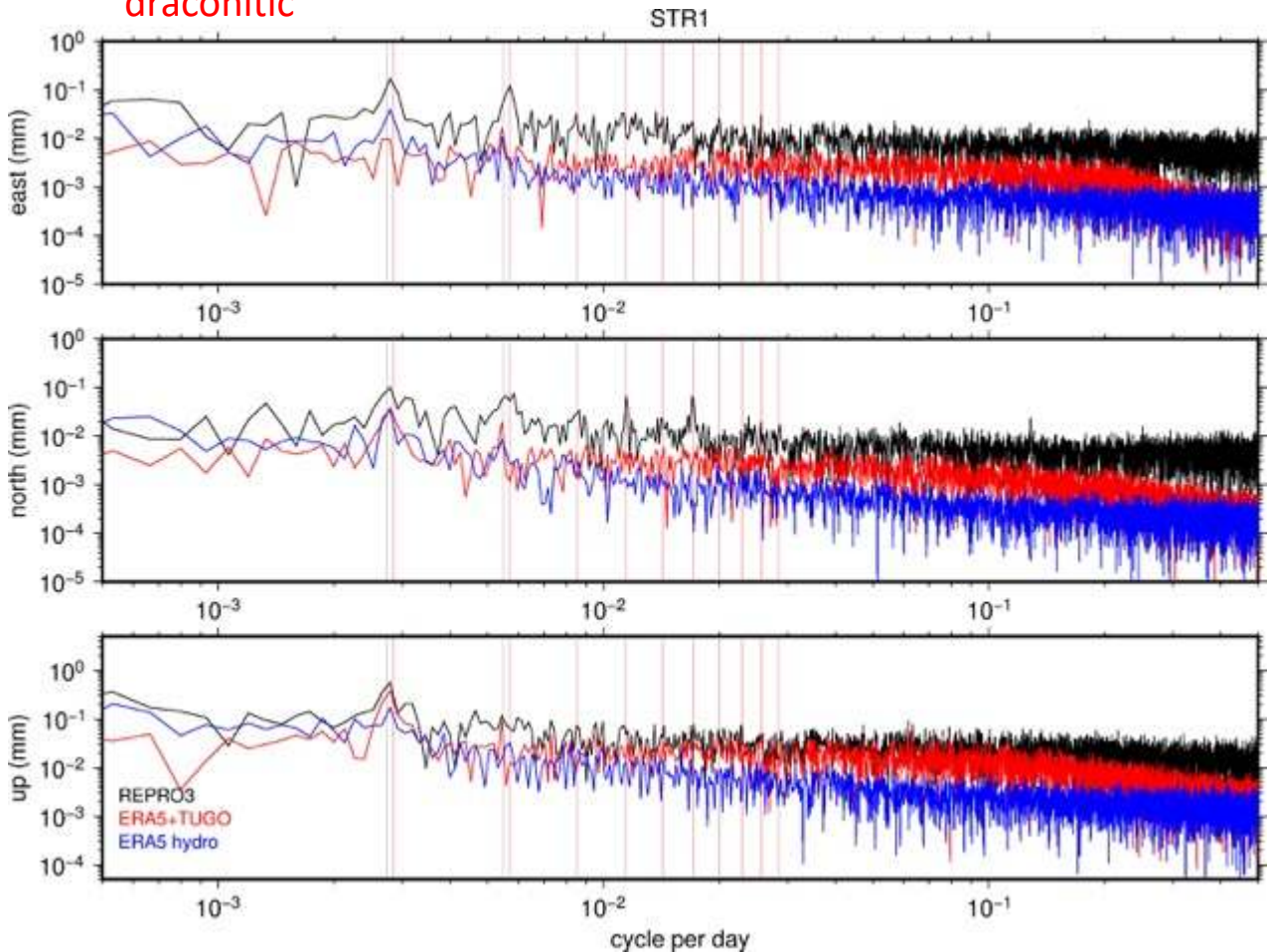


Lon: -52.48° Lat: 5.15°

STR1, Mount Stromlo, Australia



annual, semi-annual
draconitic



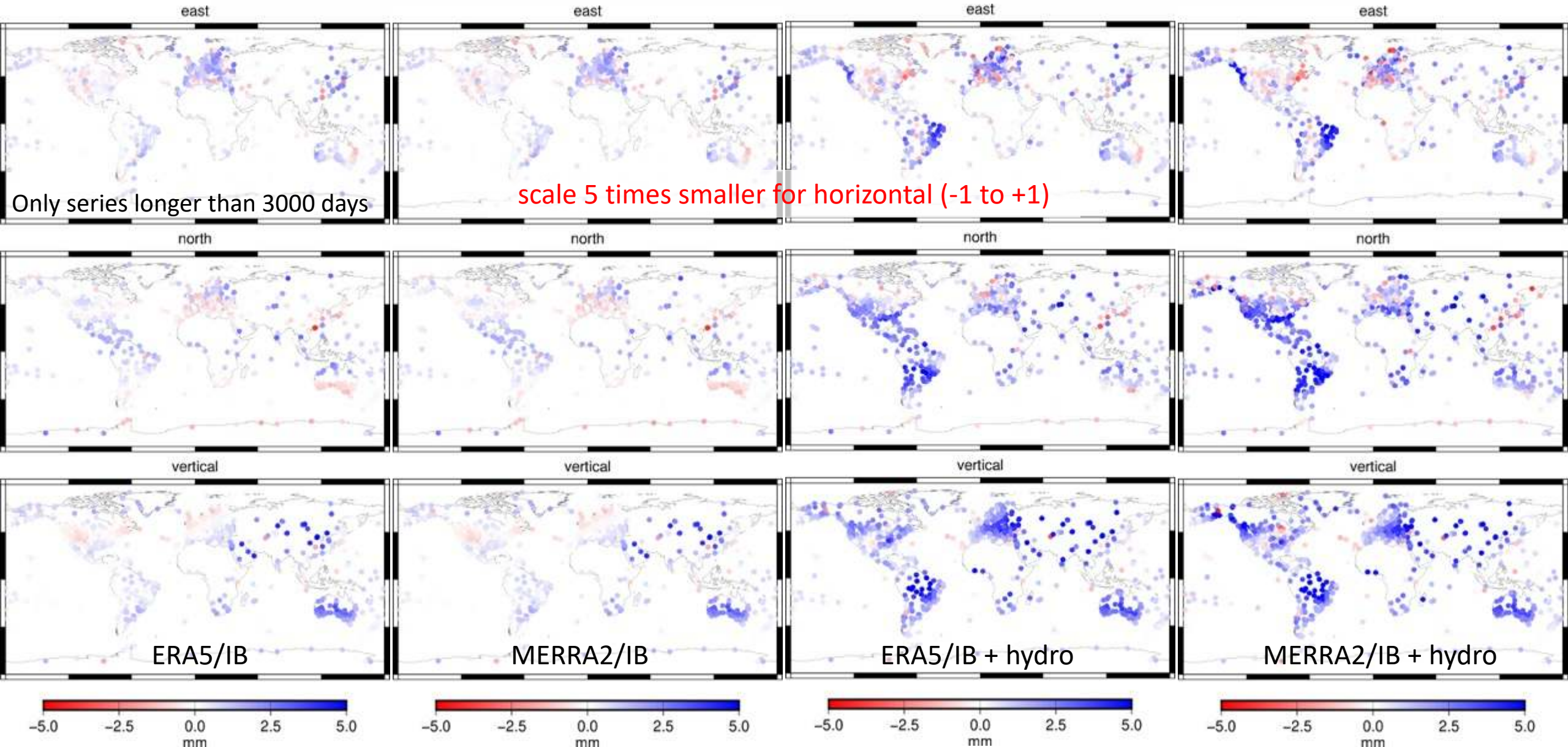
Lon: 149.01° Lat: -35.19°

Comparison of ITRF2020 residual displacements with environmental loading models

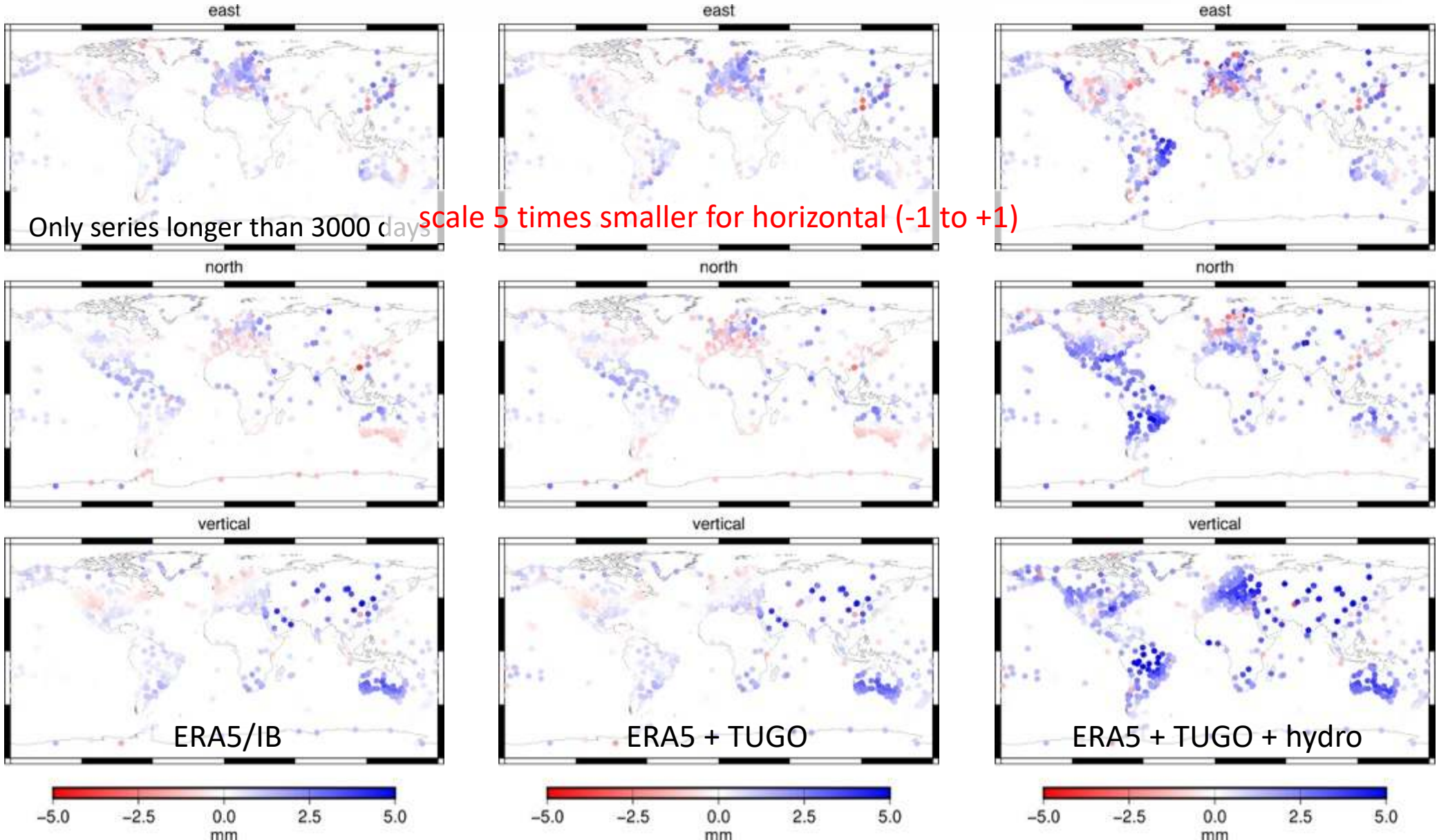
- In mid- and high-latitude regions, GNSS solutions and modeled loading effects (atmosphere + ocean + hydrology) have similar spectrum content and amplitude up to about 10 days, for both horizontal and vertical components.
- In general, differences are larger for island or coastal stations, compared to inland stations.
- In low-latitude regions, loading effects are small (except seasonal and atmospheric tides) and GPS solutions are about 10-times “noisier”.

- Ice sheets are not included in ERA5 and MERRA2 (neither surface water).

Reduction of annual signal (ERA5 vs MERRA2)



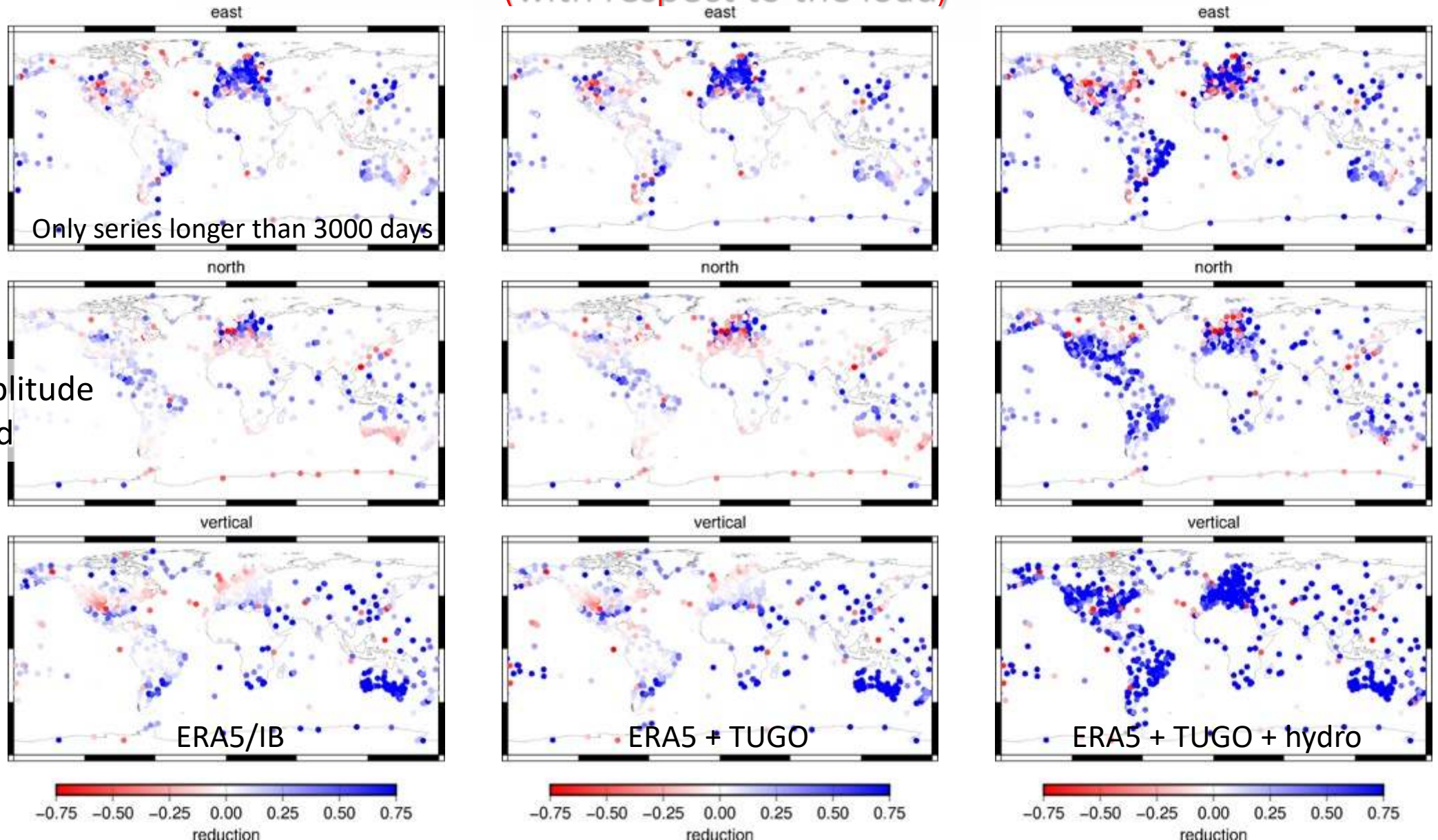
Reduction of annual signal (ERA5, IB vs TUGOm)



$$R = \frac{A_{GPS\_orig} - A_{GPS\_load}}{A_{load}}$$

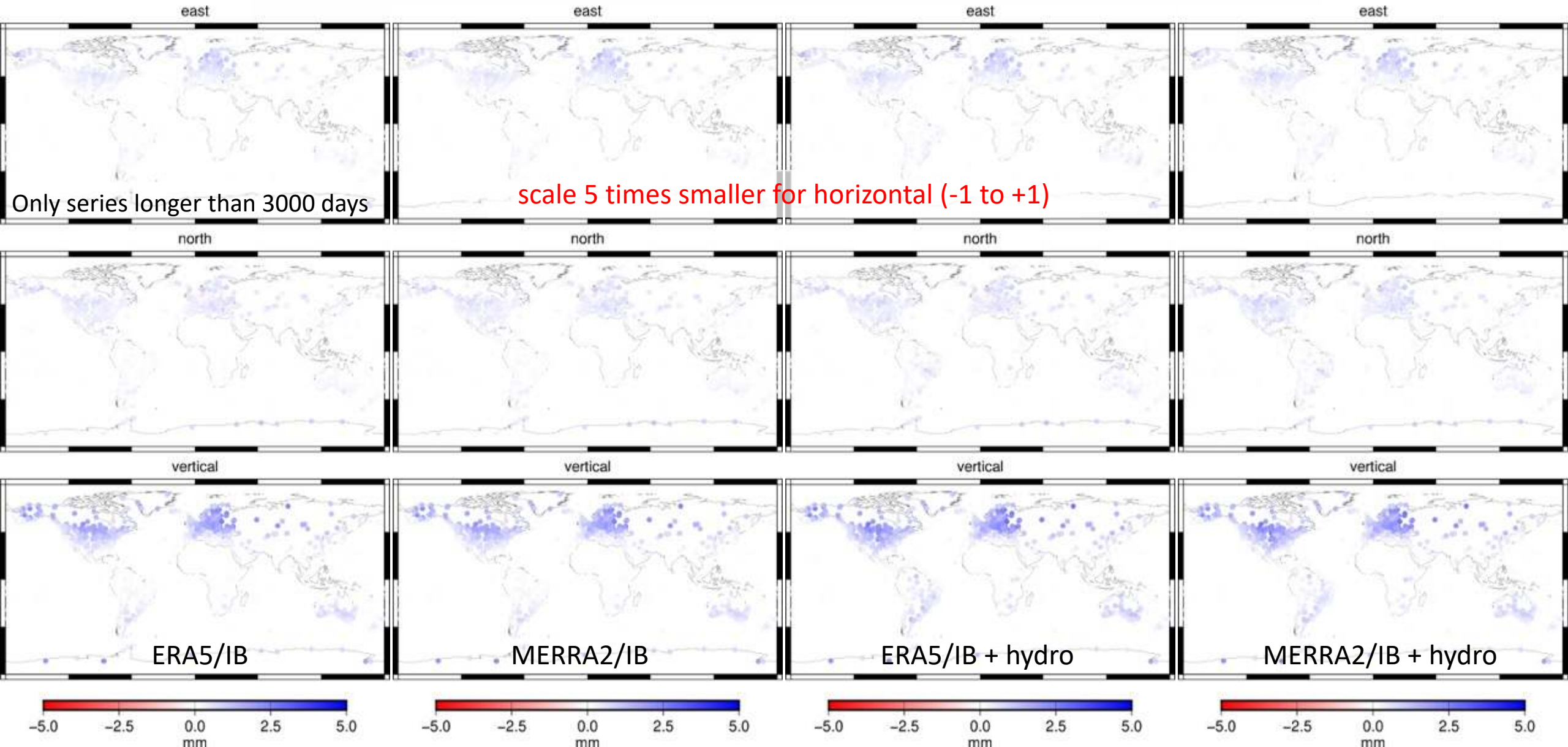
Normalized reduction of annual signal

(with respect to the load)

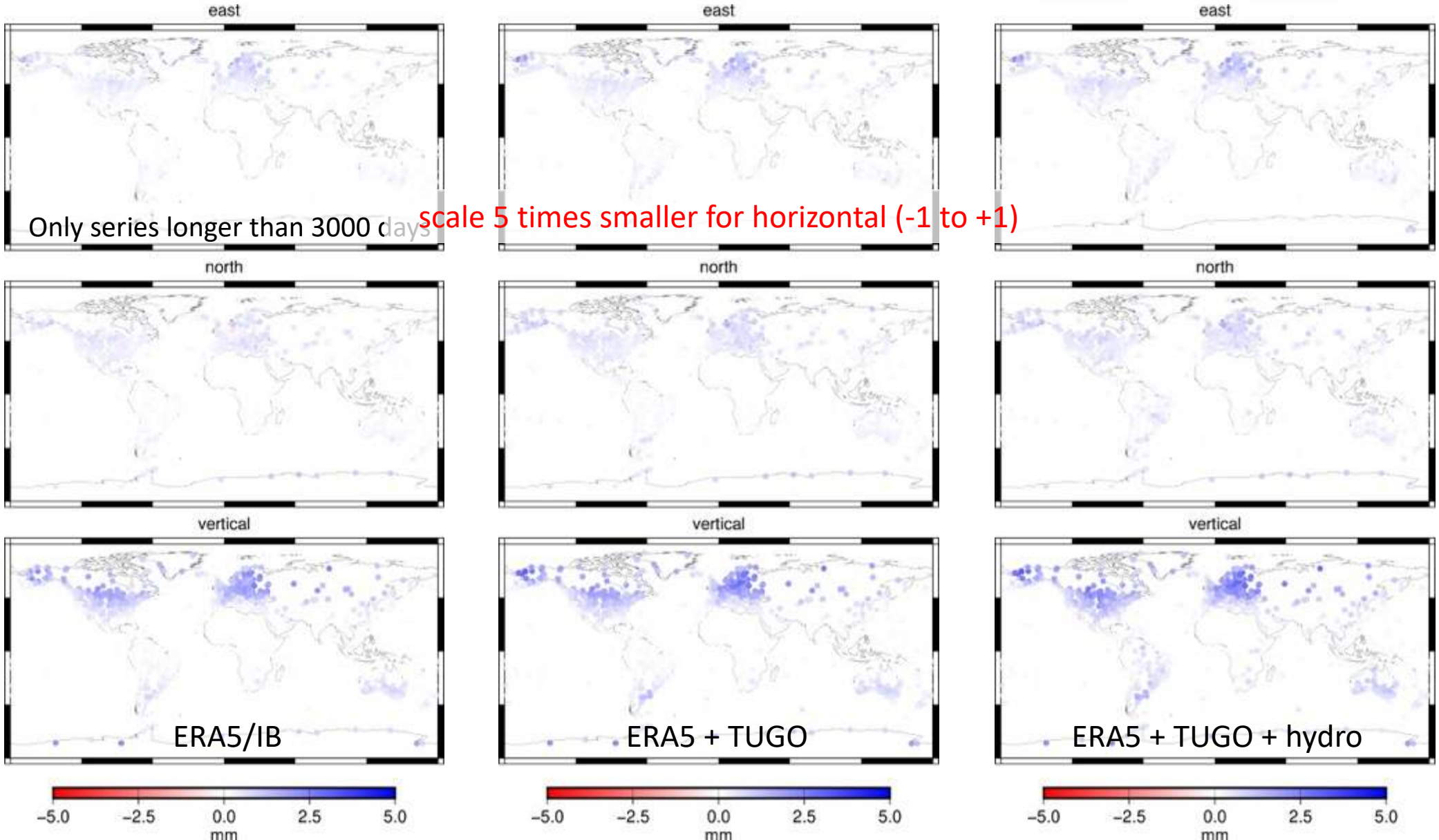


Small amplitude of the load

Reduction of variability (ERA5 vs MERRA2)



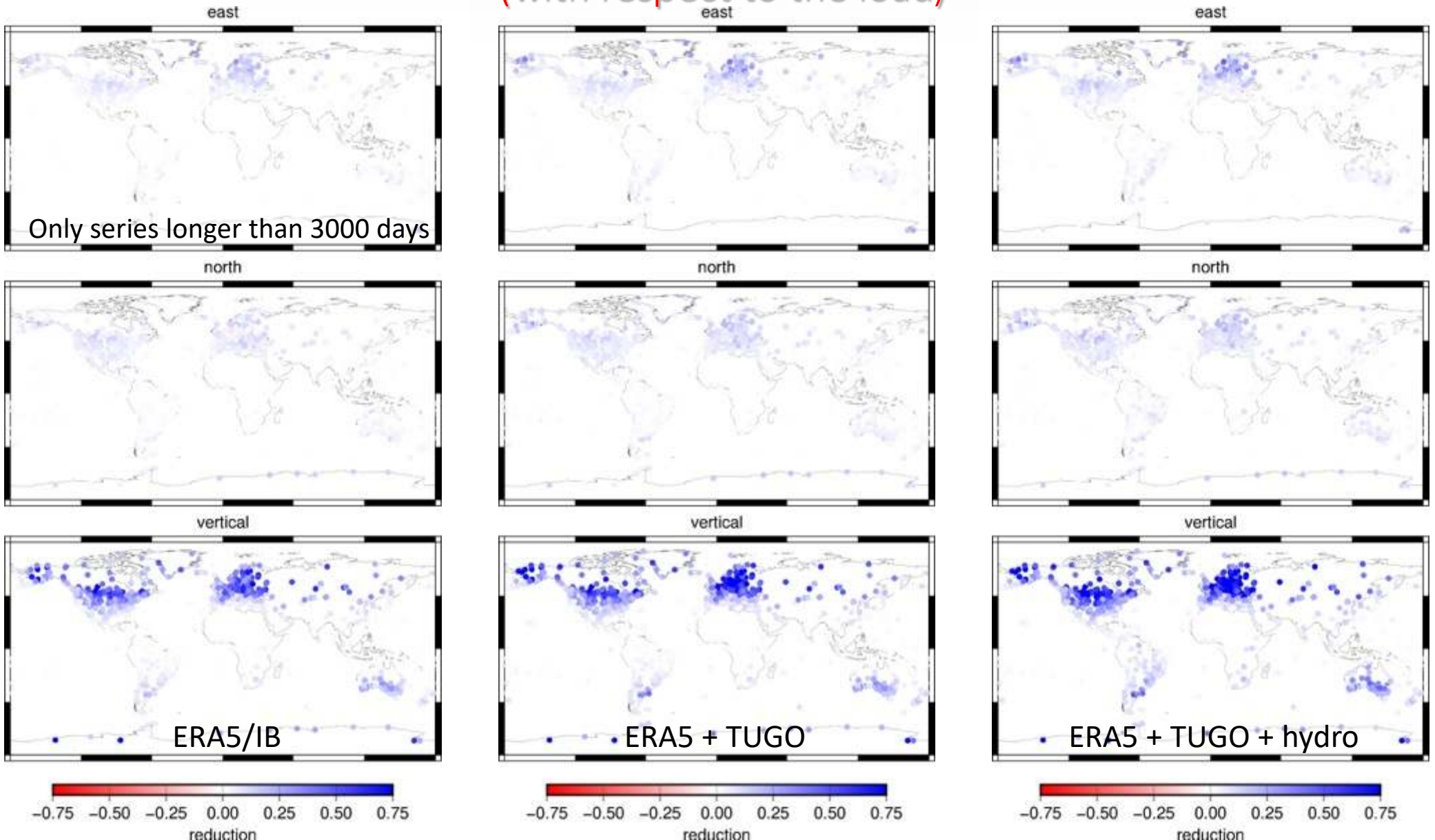
Reduction of variability (ERA5, IB vs TUGOm)



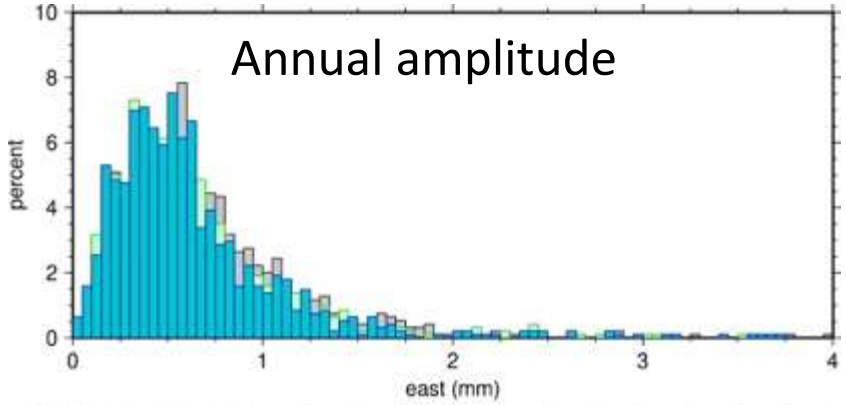
$$R = \frac{\sigma_{GPS\_noload} - \sigma_{GPS\_load}}{\sigma_{load}}$$

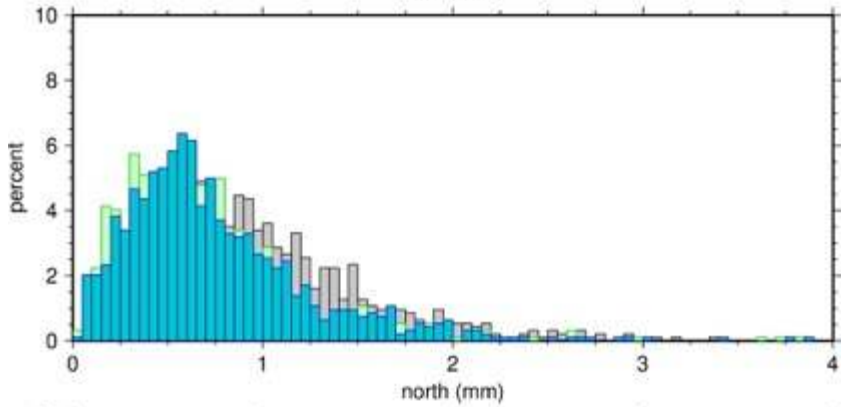
Normalized reduction of variability

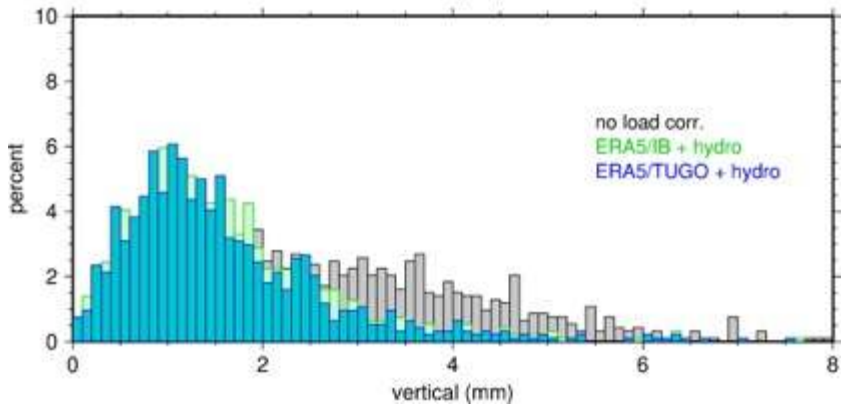
(with respect to the load)

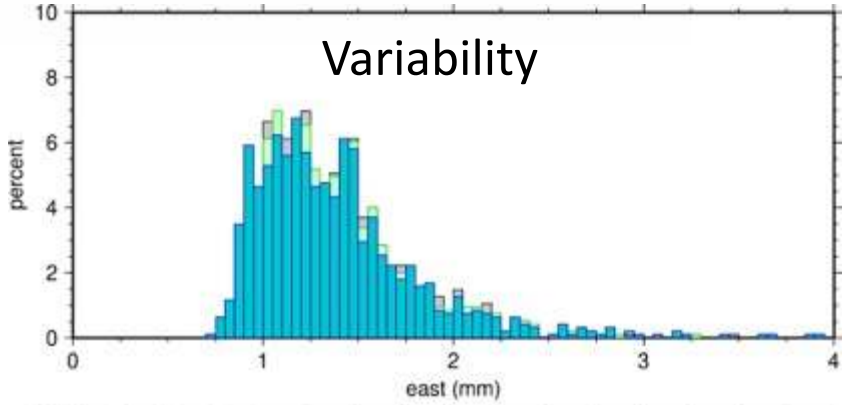


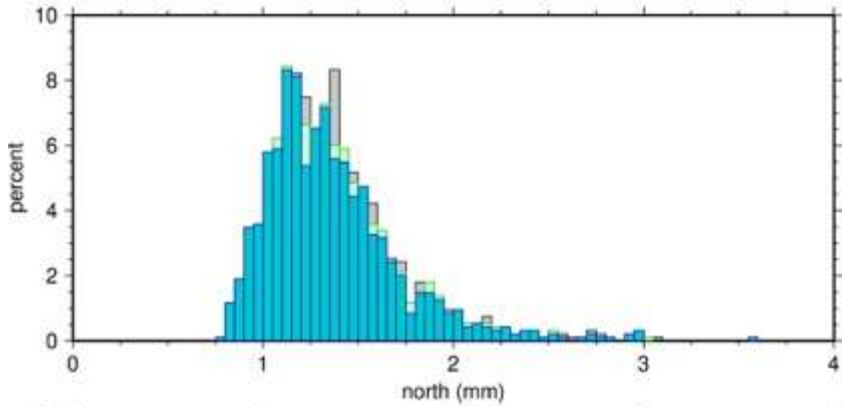
General statistics (ERA5/TUGO or IB + hydro)

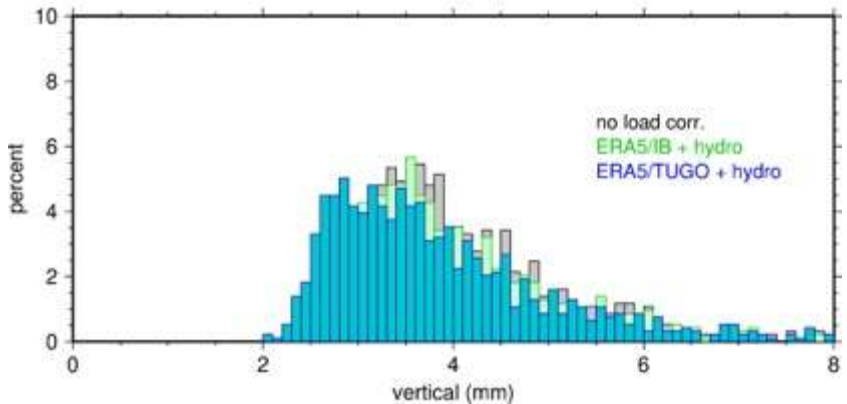




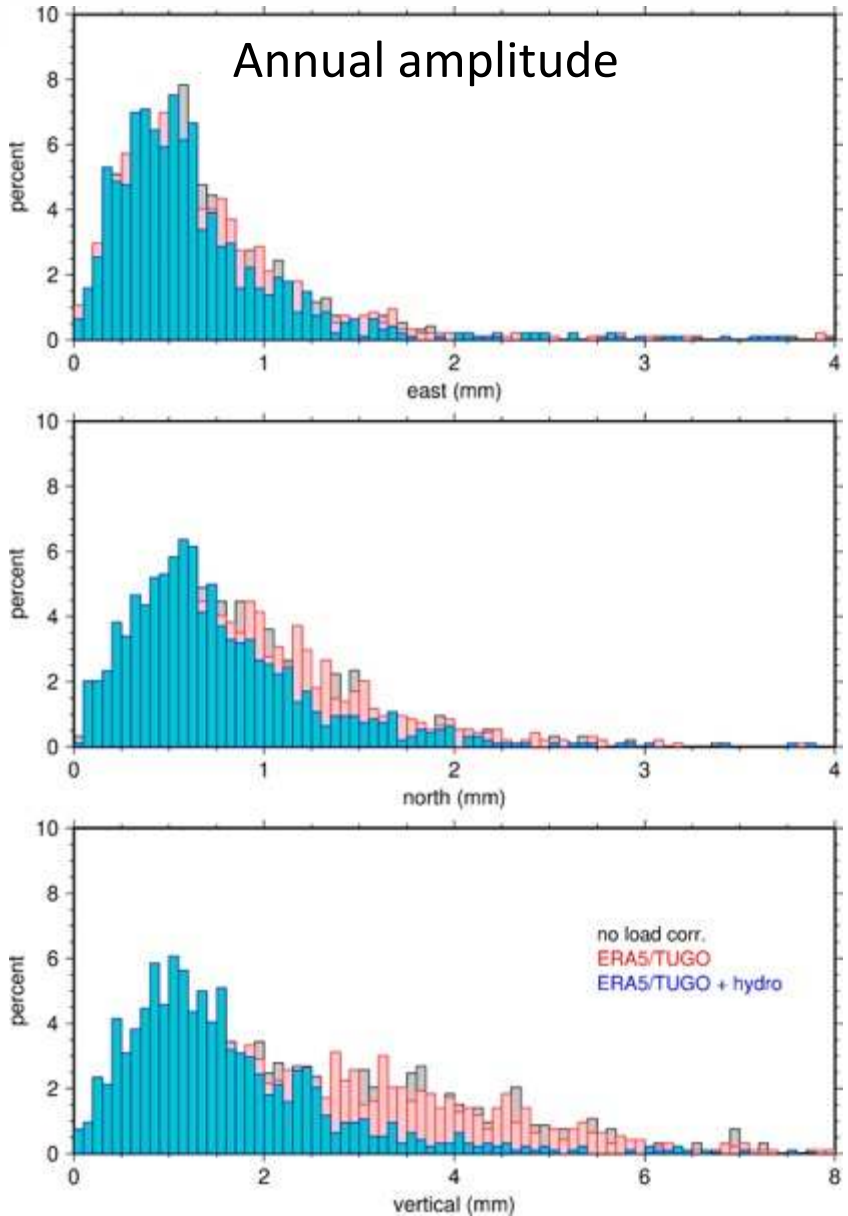


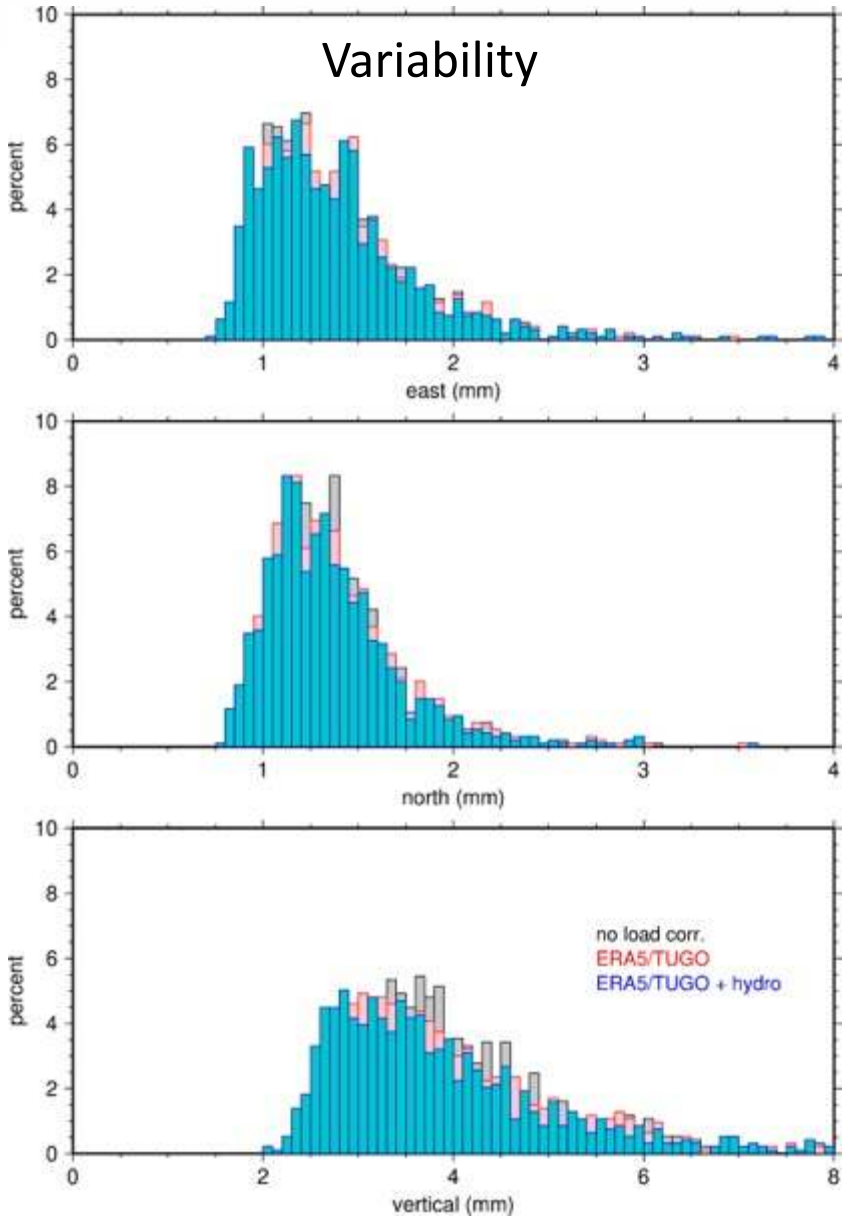






General statistics (ERA5/TUGO with/without hydro)





Conclusions & perspectives

- There is a clear & systematic reduction of the seasonal signal (except for some island and coastal stations) and the variability when removing loading effects, for both vertical and horizontal components. This is a clear improvement, compared to earlier reanalyses (see, for example, Mémin et al., 2020).
- TUGOm (barotropic ocean model forced by ERA5 pressure & winds) seems better than the classical IB assumption (mid- & high-latitude stations).
- MERRA2 hydrology is slightly better than ERA5 (Northern America and Western Europe) => an offline “hydrology-only” reprocessing (ERA5-land) is now available.
- Loading effects cannot explain GNSS variability (H: ~1.25 & V: ~3 mm) between 2 & 10 days.
- Next step is to use loading models at the observation level.