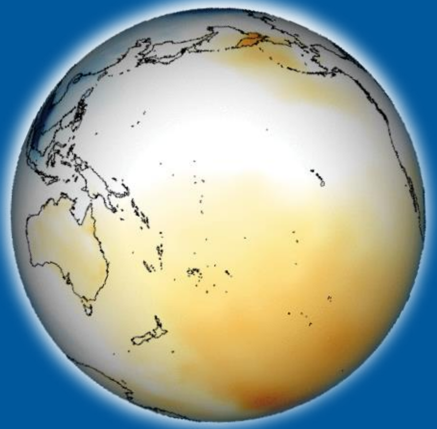
Predicting Non-Tidal Loading Contributions Induced by Environmental Loading



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Reference Frames for Applications in Geosciences, Usage & Challenges of Reference Frames for Earth Science Applications

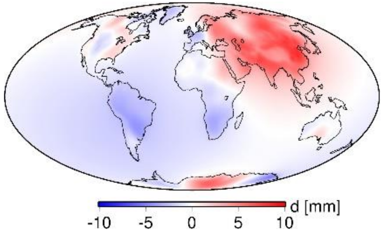
Thessaloniki, October 18th, 2022

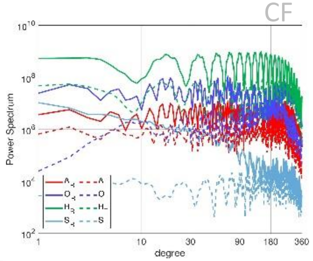
Setting the Stage

- Motivation
  - Mitigate **aliasing** in reference frames
  - **Validate** NWM-derived mass anomalies
- In this presentation
  - Comparison of *modelled* and *observed* station displacements
  - Signal decomposition employing **wavelets**
- Tools and Materials
  - **GFZ's loading models** (ECMWF's IFS, MPIOM, LSDM)
  - Individual GNSS AC contributions to ITRF2020 (**IGS repro 3**)

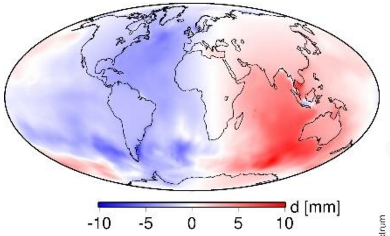
Environmental Loading Displacement Models

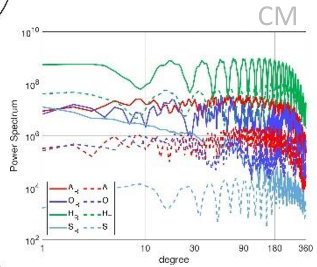
- Atmosphere (3h)
  - De-tided ECMWF's IFS



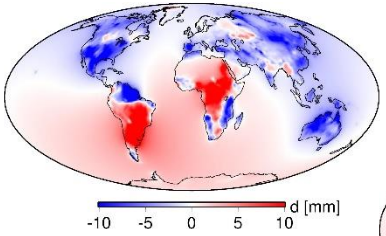


- Oceans (3h)
  - De-tided MPIOM forced from ECMWF's IFS

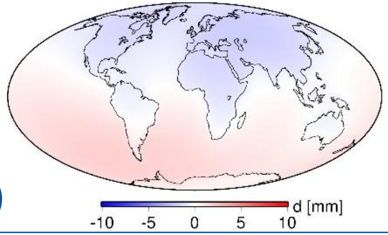




- Hydrosphere (24h)
  - LSDM forced from ECMWF's IFS

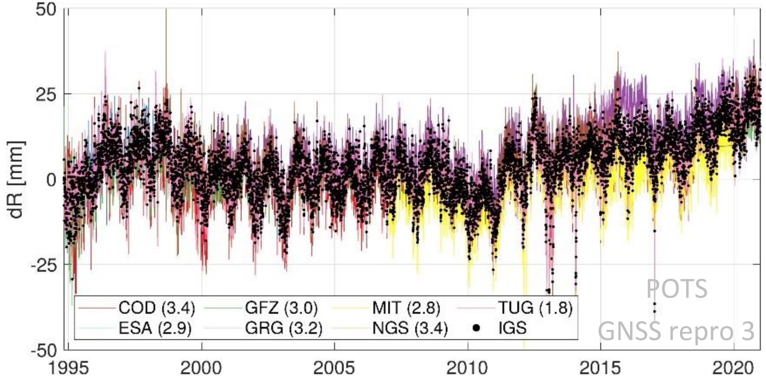


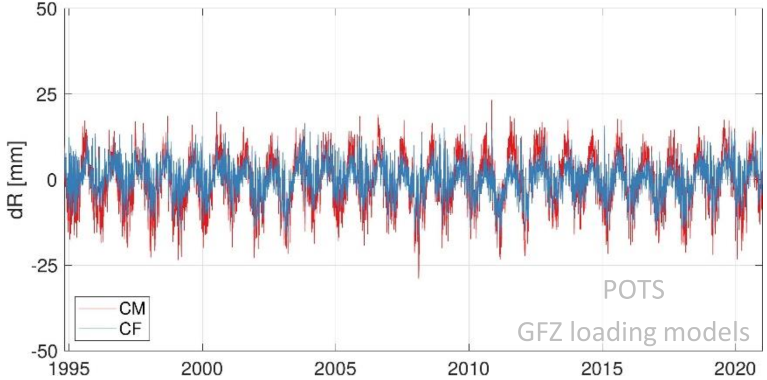
- Barystatic sea-level (24h)
  - Solution to sea-level equation (self-attraction and loading included)



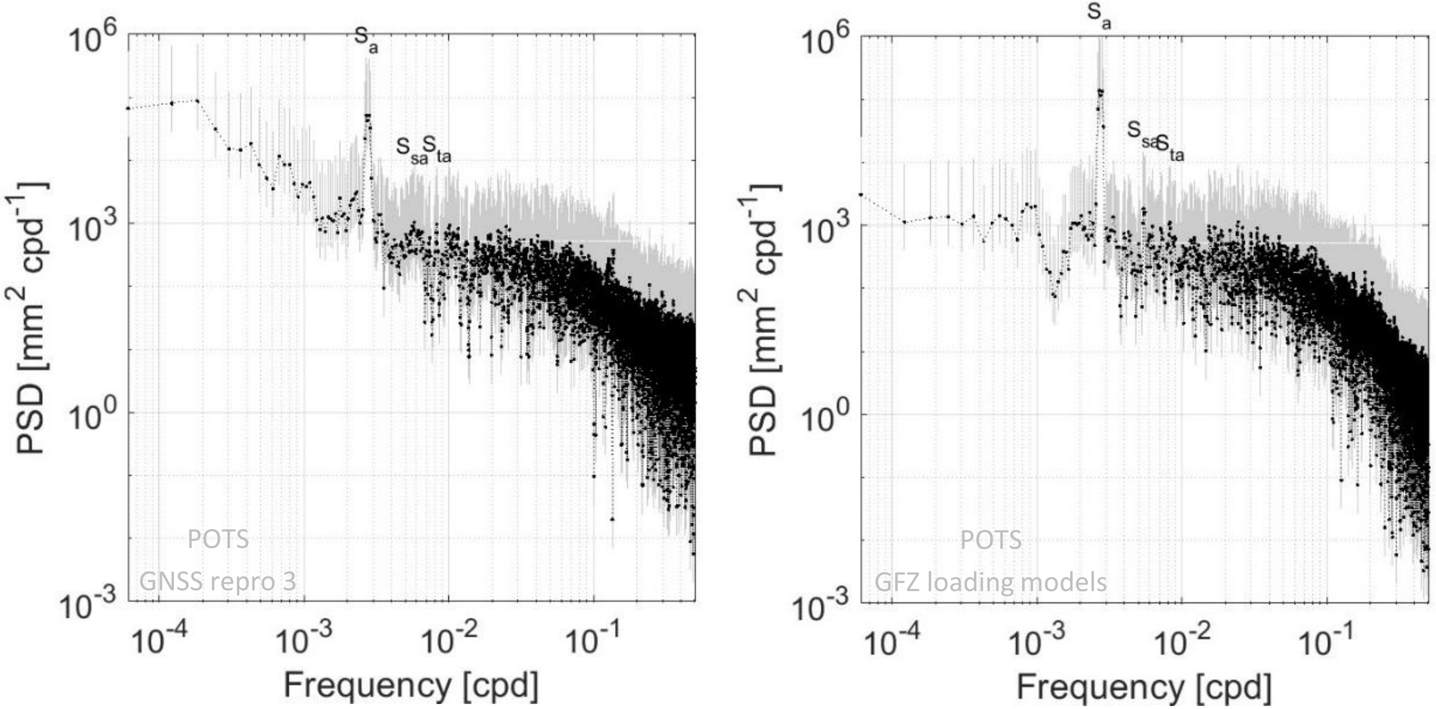
GNSS Displacements from IGS REPRO 3

- Contributions: COD, ESA, GFZ, GRG, JPL, MIT, NGS, TUG, ULR, WHU, and IGS
- Pre-processing
  - Outlier elimination
  - Time series segmentation
  - Mitigation of secular signals (first-order poly + log + exp)

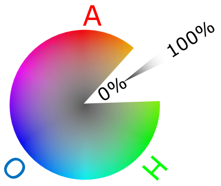




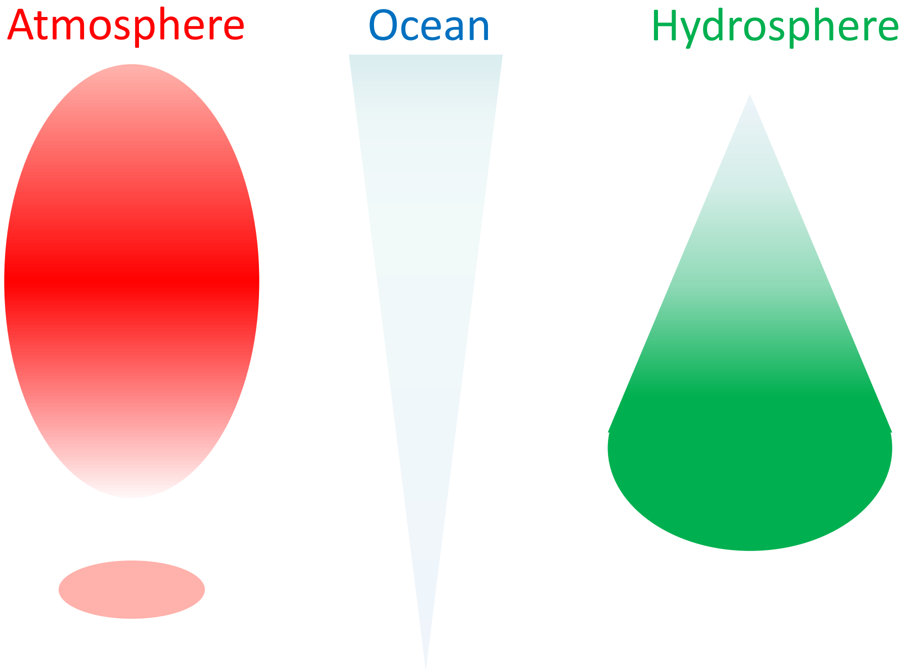
Frequency Domain Displacement Analysis



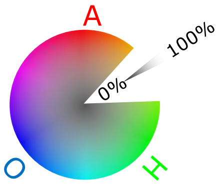
Wavelet Decomposition

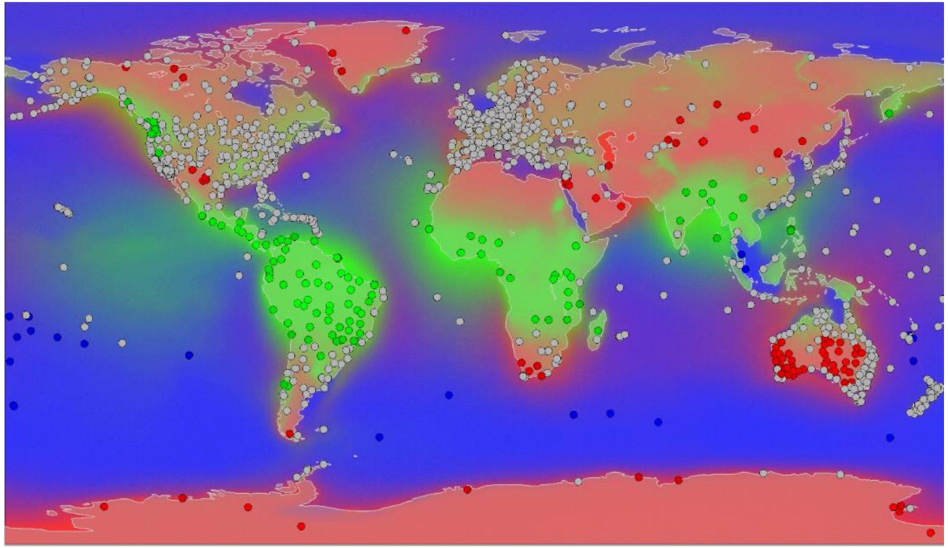


Decomposition Level	Periods
D1	2 days - 5 days
D2	3 days - 10 days
D3	6 days - 18 days
D4	12 days - 37 days
D5	24 days - 3 months
D6	2 months - 5 months
D7	4 months - 9 months
D8	7 months - 1.4 years
A8	1.1 years - ∞

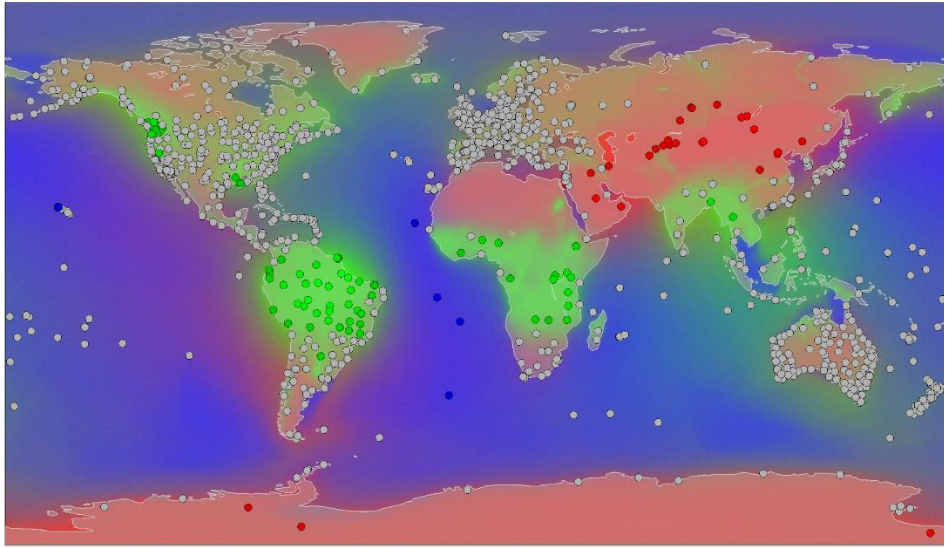


Entire Spectrum



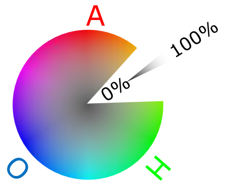


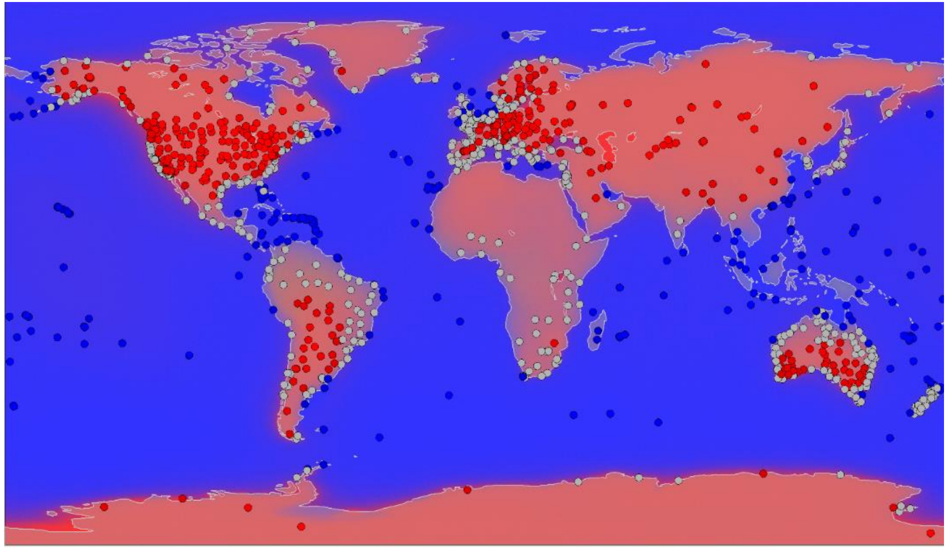
Center of Surface Figure (CF)



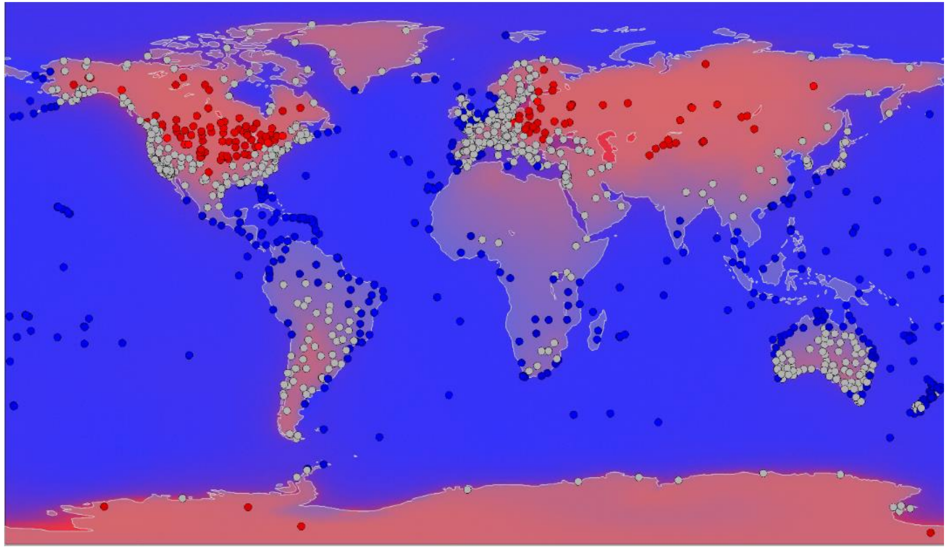
Center of Mass of the Earth System (CM)

D1: 2 days – 5 days





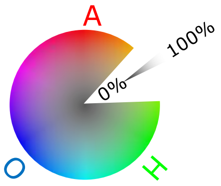
Center of Surface Figure (CF)

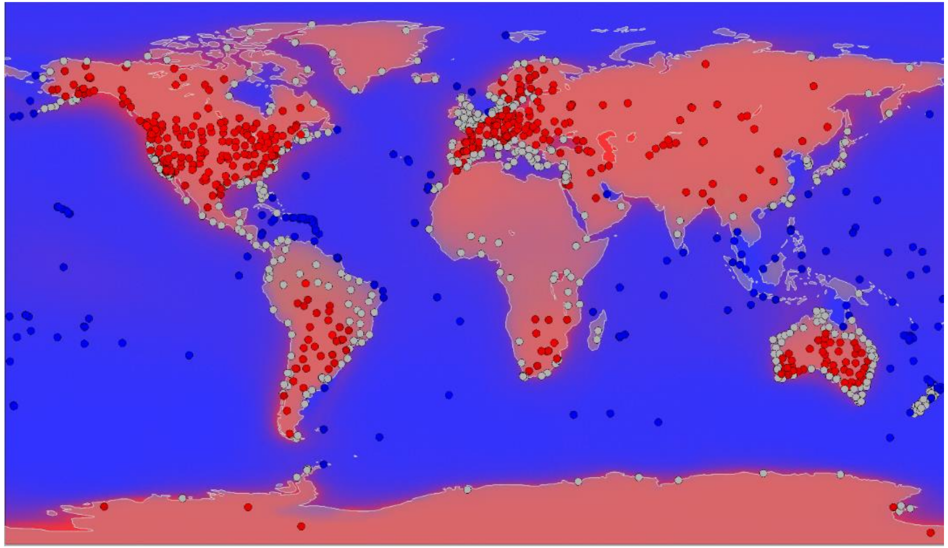


Center of Mass of the Earth System (CM)

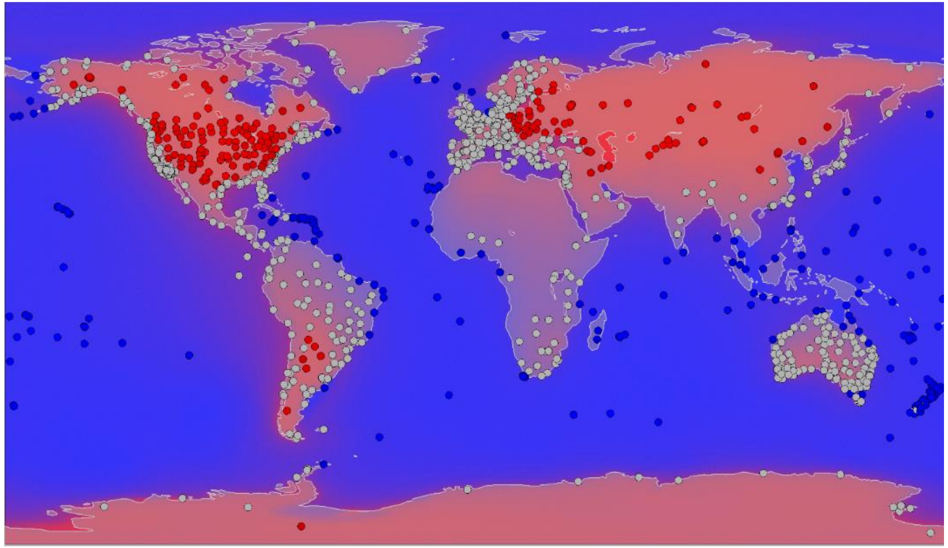
- A: variability far from the coast; O: variability in islands

D2: 3 days – 10 days





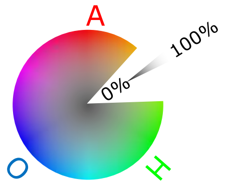
Center of Surface Figure (CF)

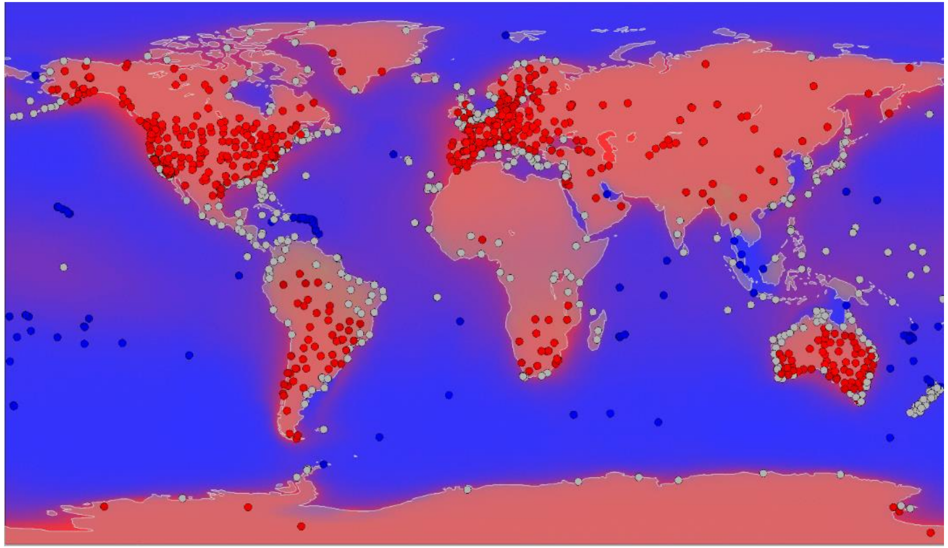


Center of Mass of the Earth System (CM)

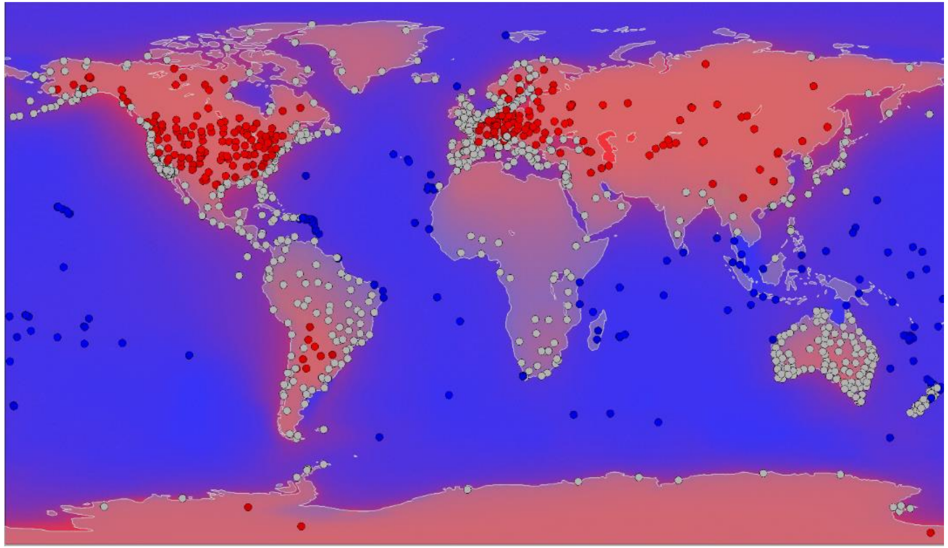
- A: variability far from the coast; O: variability in islands and coastlines

D3: 6 days – 18 days





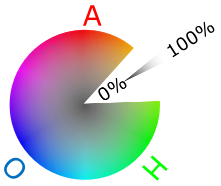
Center of Surface Figure (CF)

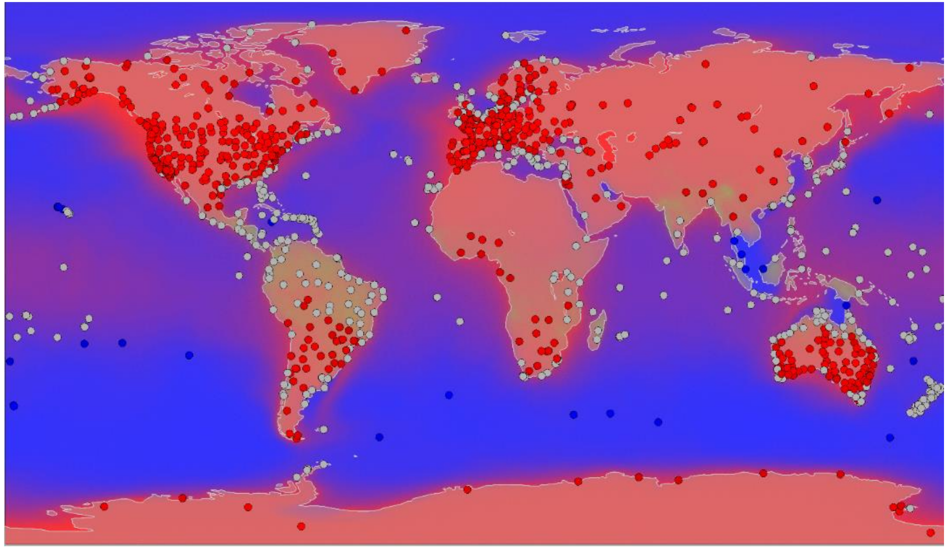


Center of Mass of the Earth System (CM)

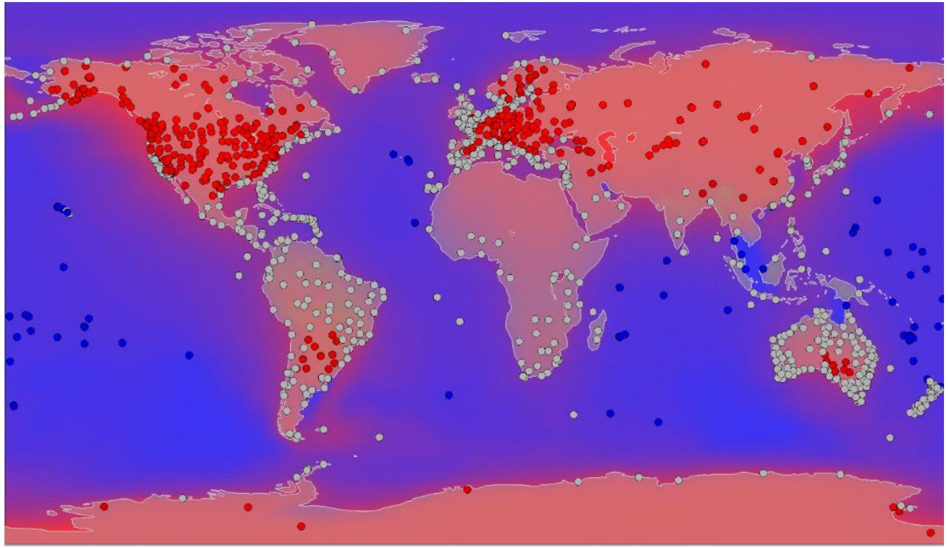
- A: variability explained increases for more sites & larger percentage

D4: 12 days – 37 days





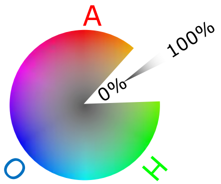
Center of Surface Figure (CF)

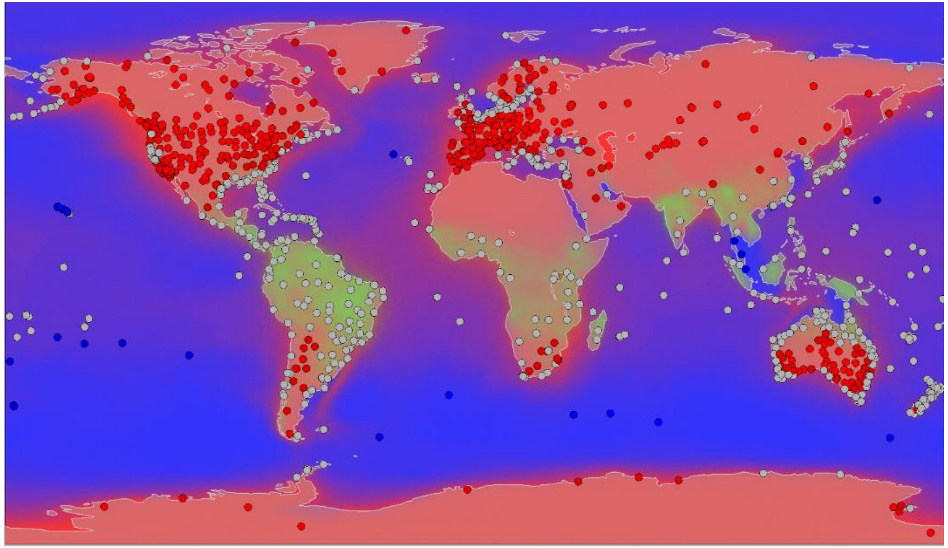


Center of Mass of the Earth System (CM)

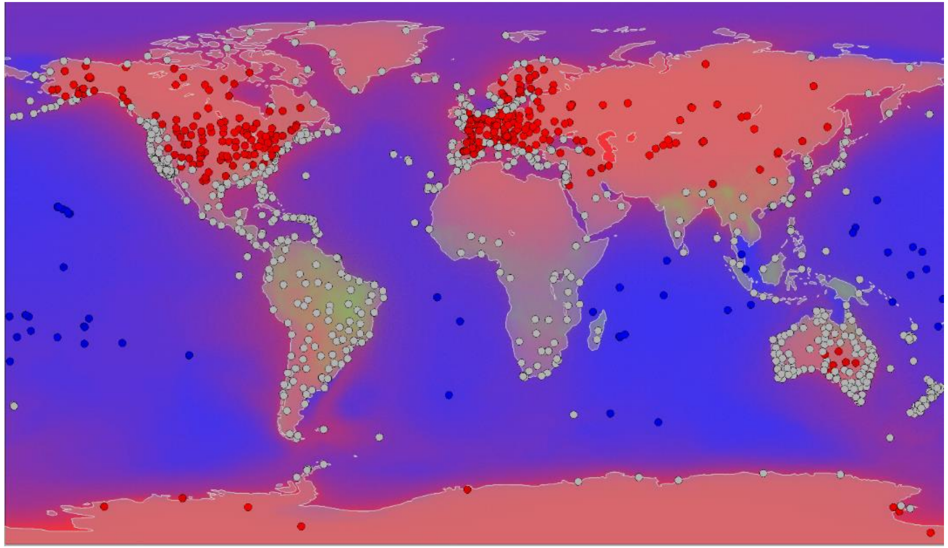
- All continental stations with a 60% RMS reduction → A; island stations → O

D5: 24 days – 3 months





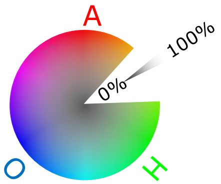
Center of Surface Figure (CF)

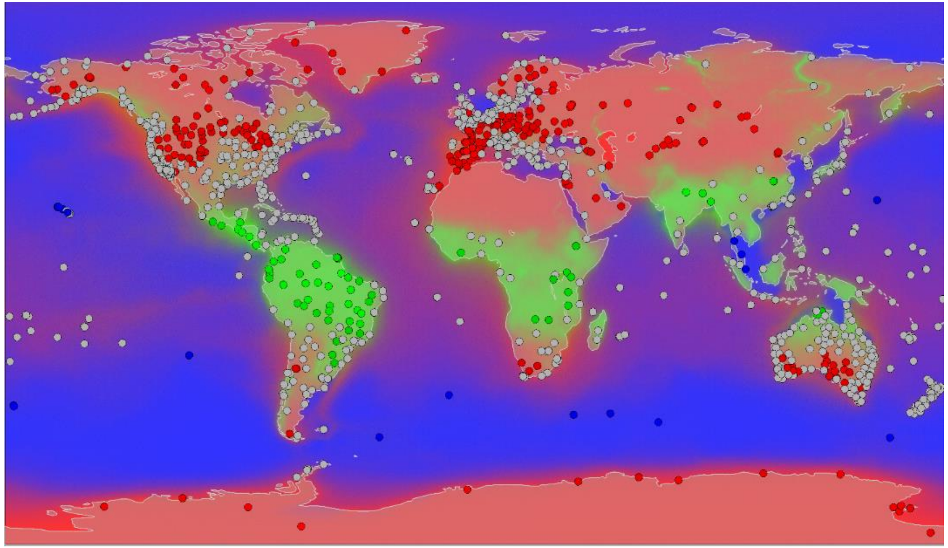


Center of Mass of the Earth System (CM)

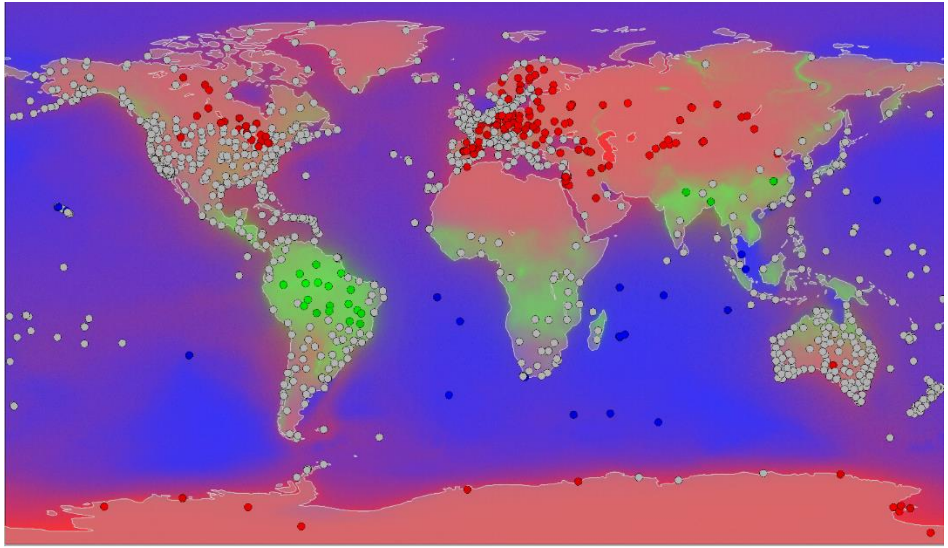
- Relevance of H increases around big catchments; A → continents; O → islands

D6: 2 – 5 months





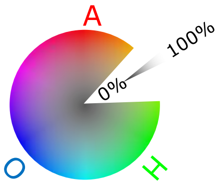
Center of Surface Figure (CF)

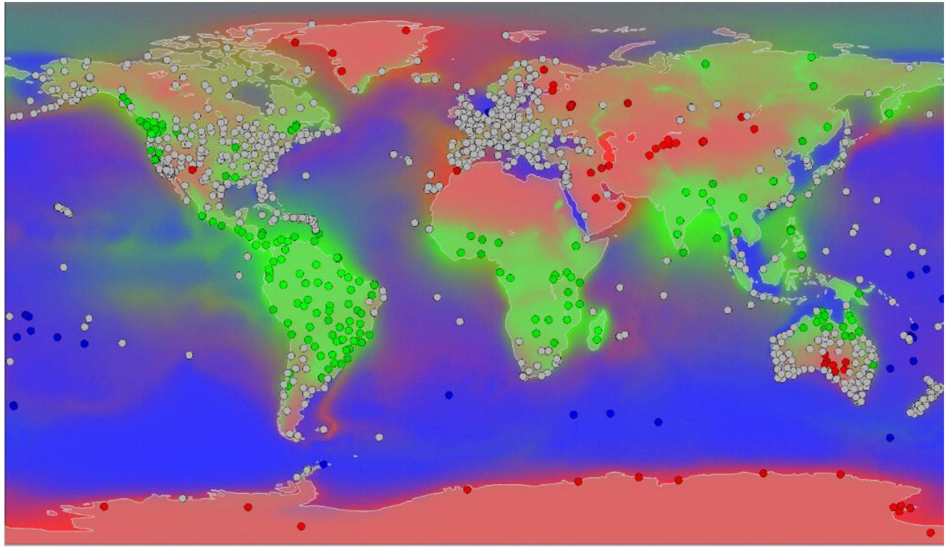


Center of Mass of the Earth System (CM)

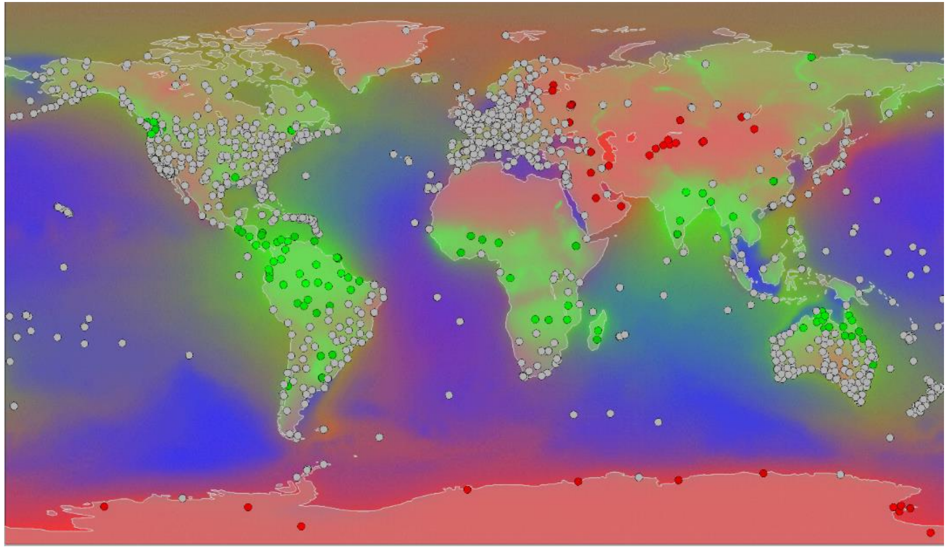
- A and H of comparative importance over continents, depending on site

D7: 4 – 9 months





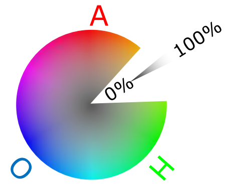
Center of Surface Figure (CF)

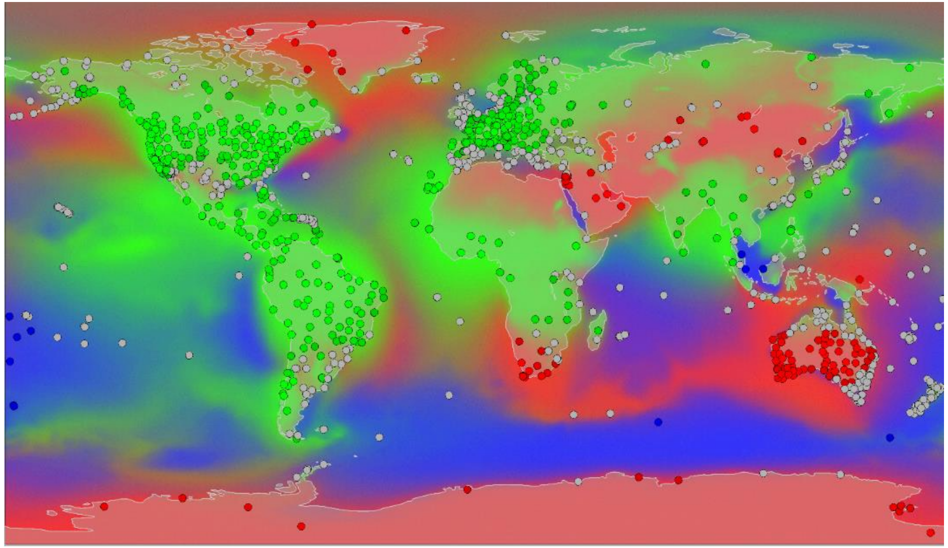


Center of Mass of the Earth System (CM)

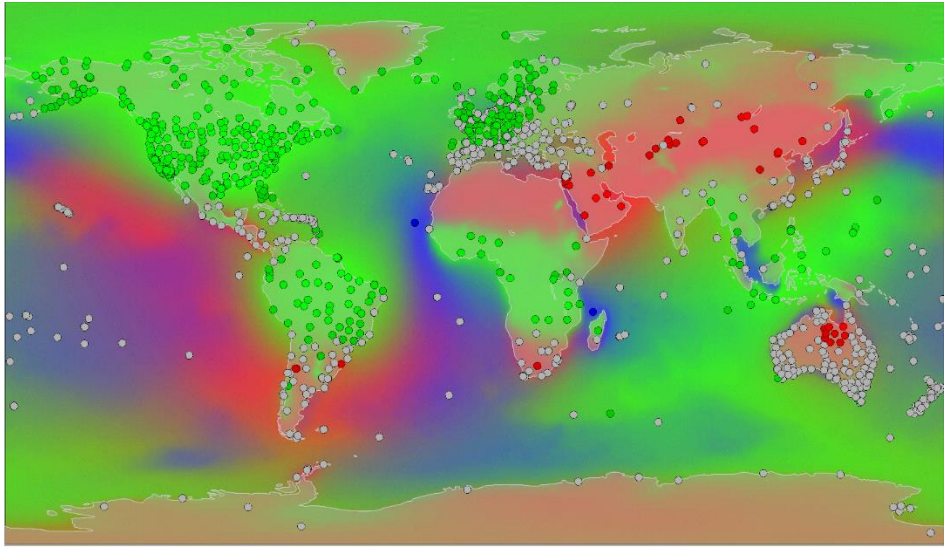
- H more important GNSS variance reductor

D8: 7 months – 1.4 years





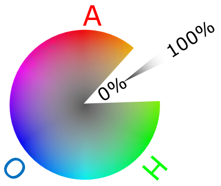
Center of Surface Figure (CF)

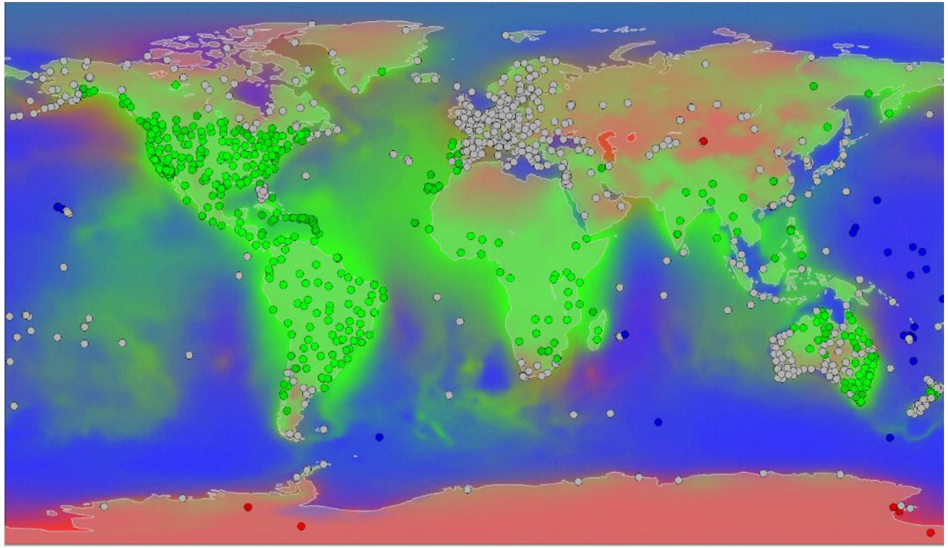


Center of Mass of the Earth System (CM)

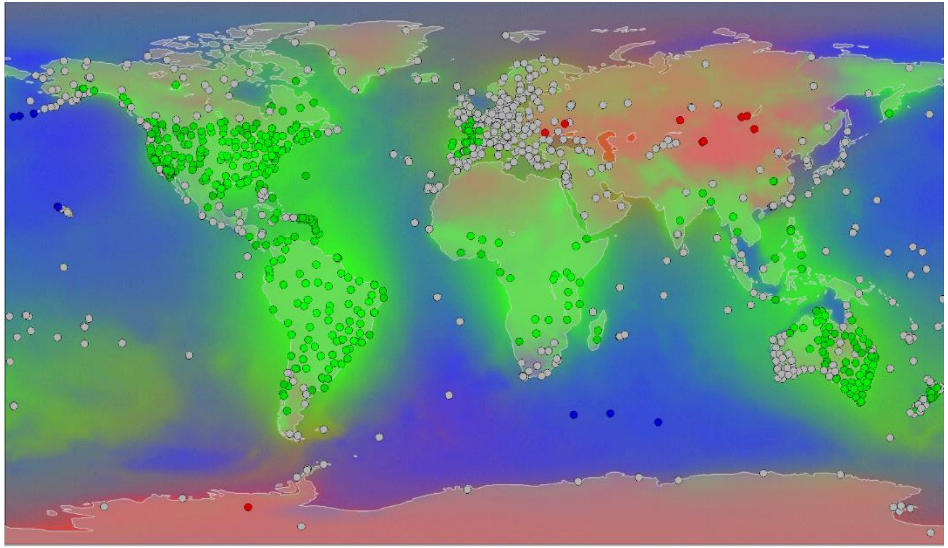
- H even more important GNSS variance reductor

A8: 1.1 years – ∞





Center of Surface Figure (CF)



Center of Mass of the Earth System (CM)

- H most important GNSS variance reductor

Recapitulation

- Compared NWM-derived non-tidal loading displacements (ESMGFZ) to GNSS-derived station displacements (IGS REPRO 3: 10 + 1) in frequency domain employing wavelet decomposition
  - Highest RMS reduction: Sites dominated by atmospheric/sea-level loading
  - Lowest RMS reduction: Sites dominated by ocean loading
  - Largest model/observation discrepancies: Sites dominated by hydrological loading at seasonal timescales
  - Best model/observation agreement: Combined solution

Acknowledgements

Data: ECMWF (IFS), IGS (COD, ESA, GFZ, GRG, JPL, MIT, NGS, TUG, ULR, WHU, and combi)

Funding: DFG (TerraQ)

Computations: DKRZ

Data availability

http://rz-vm115.gfz-potsdam.de:8080