

Modeling and Observation of Loading Contribution to Time-Variable GPS Site Positions

Are we able to Detect and Identify
Loading Contribution inside GPS Position ?

Does the Integration of Loading in GPS Processing
improve Vertical Positioning ?

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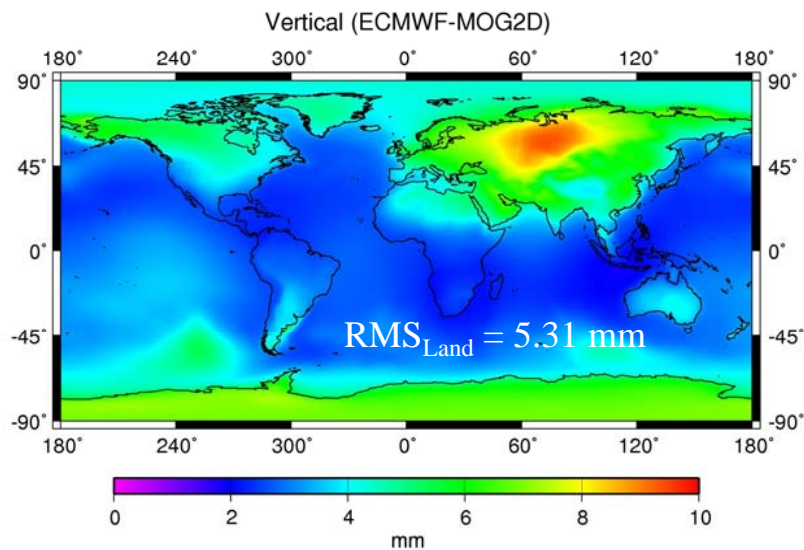
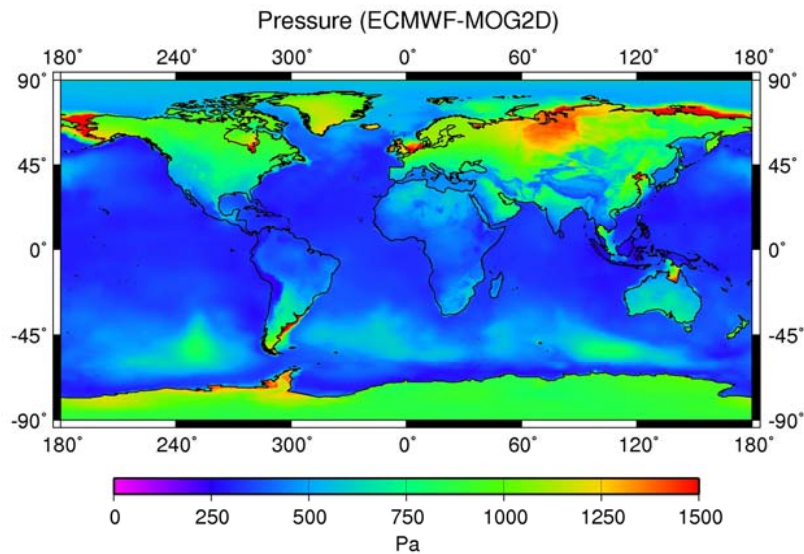
INSA de Strasbourg, 24 blvd de la Victoire, 67084 Strasbourg, France

Modeling the Loading Contribution to Time-Variable GPS Sites Positions

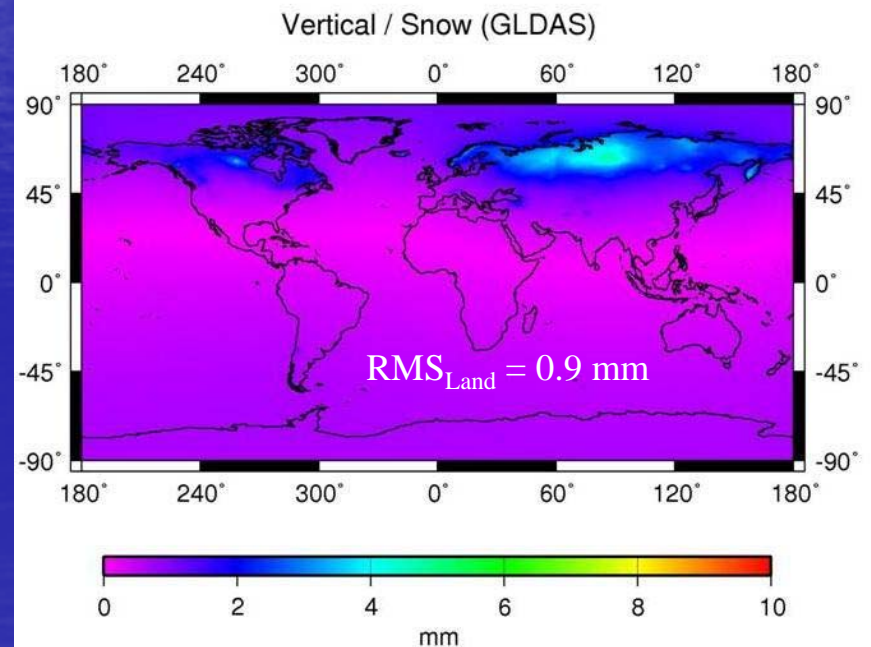
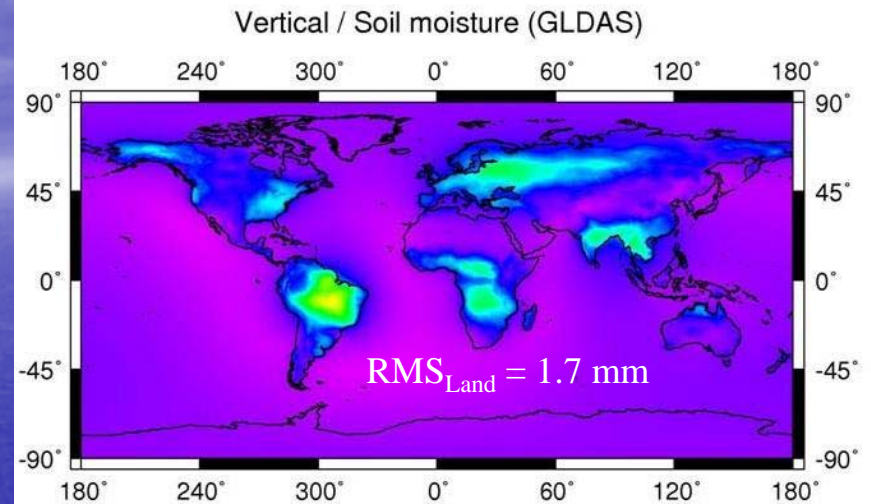
2001–2006 Period, 6-hourly, 3D site displacements:

- Refined Green's functions [J.-P. Boy et al., 2002]
- Spherical Harmonics for Global Maps
- Atmospheric Loading (6-hourly)
 - ECMWF Operational Analysis
 - NCEP Reanalysis
- Oceanic Loading (6-hourly)
 - Static response: IB (Inverted Barometer)
 - Dynamic response: MOG2D [F. Lyard, 2003]
- Hydrological Loading (6-hourly)
 - GLDAS [M. Rodell, 2004]
 - ECMWF [P. Viterbo, 1995]
- Variability of the vertical displacement:
Root Mean Squares estimated in 2002.

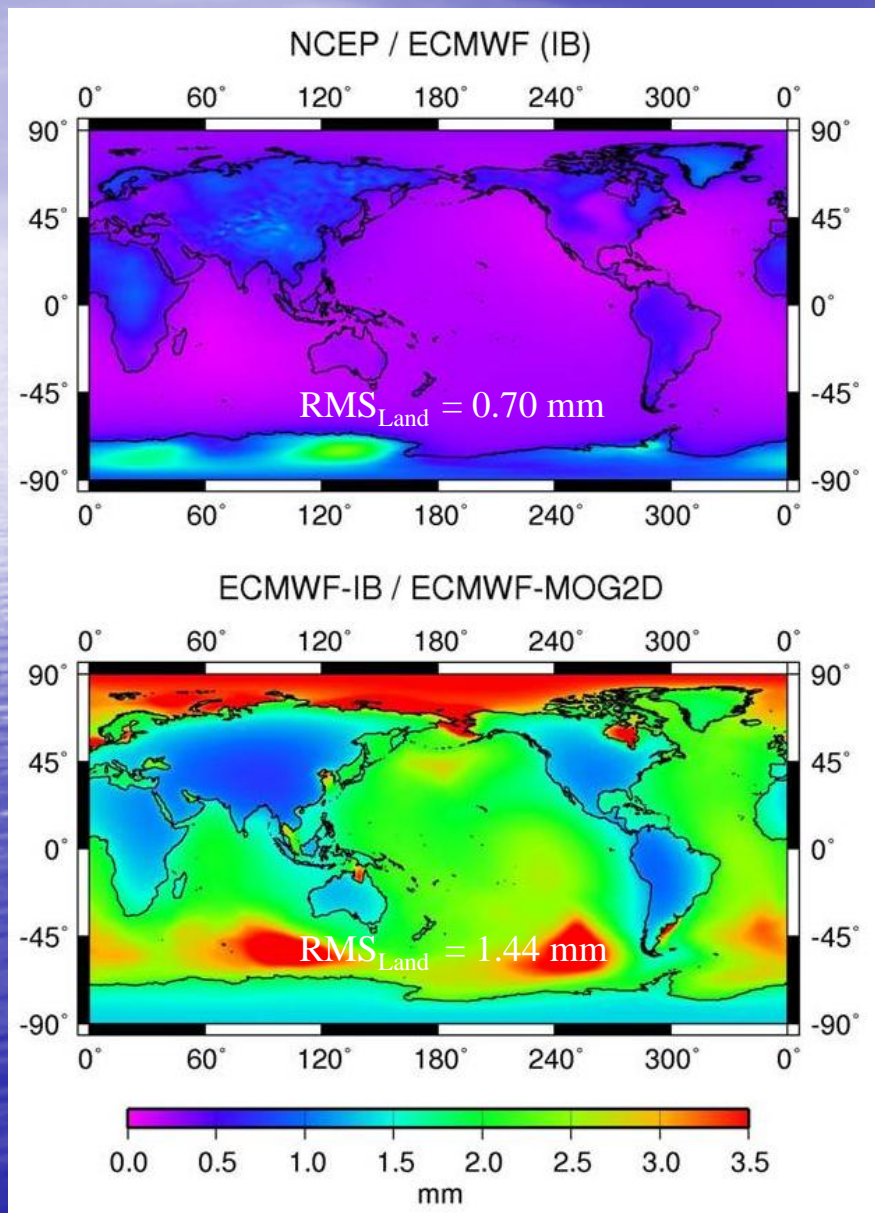
Atmosphere + Ocean Loadings (ECMWF-MOG2D, 6-hourly)



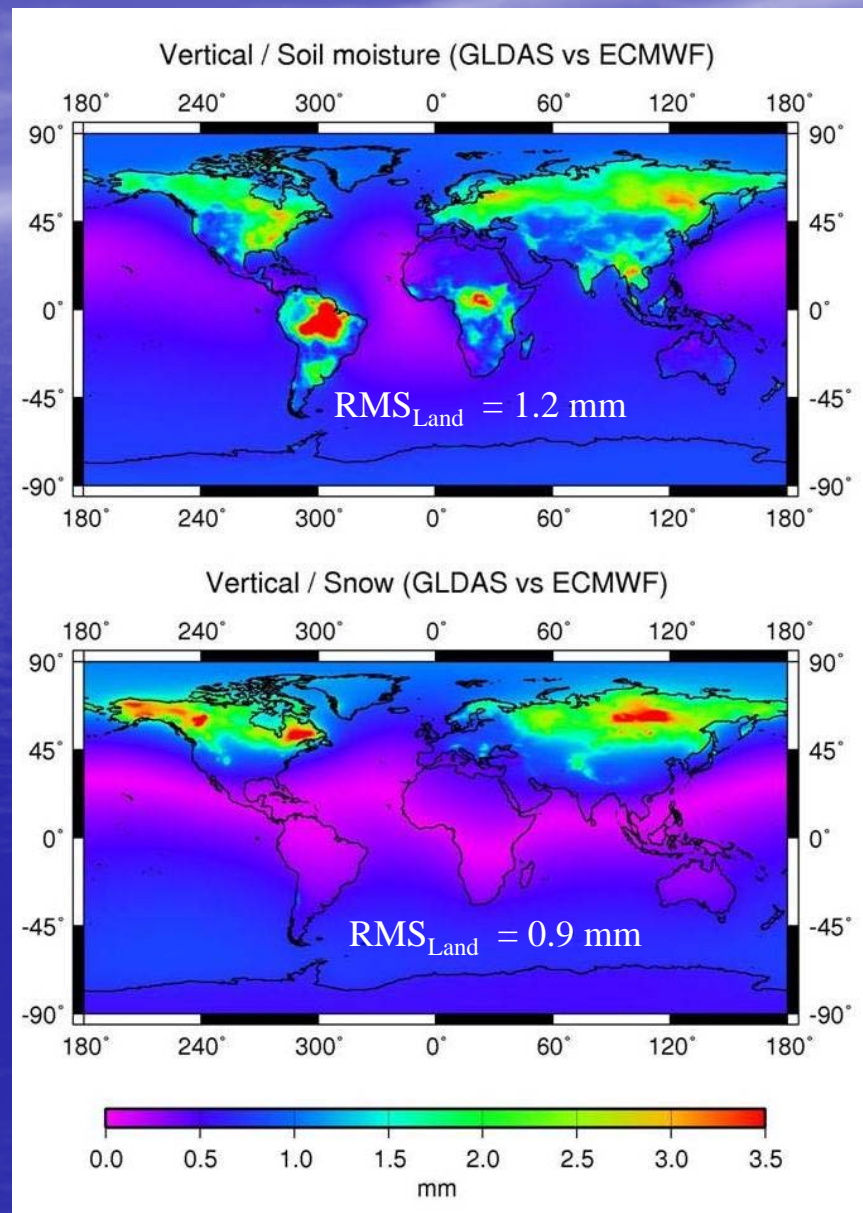
Hydrological Loading (GLDAS/NOAH, 3 hourly)



Atmosphere: ECMWF vs. NCEP Ocean: IB vs. Dynamic MOG2D



GLDAS vs. ECMWF Hydrology Soil Moisture & Snow



Observation of Time-Variable Site Positions

Single GAMIT analysis of 100 sites among IGS best sites equally distributed around the world.

Form as many as possible double differences to:

- Tighten the network
- Enhance ambiguity resolutions
- Enhance realization of the reference frame

Process **twice** the 6-yr series:

- Once without the load (**GPS NO LOAD**)
- Integrating the AOH loading model (**GPS&AOH**)

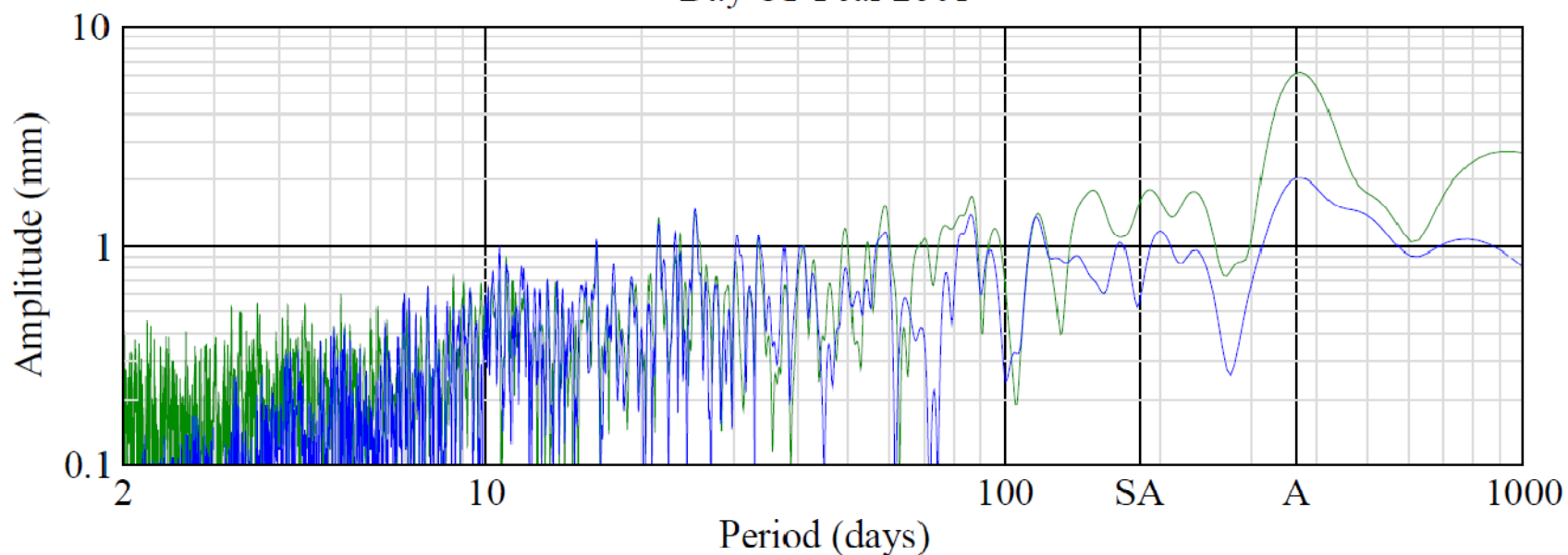
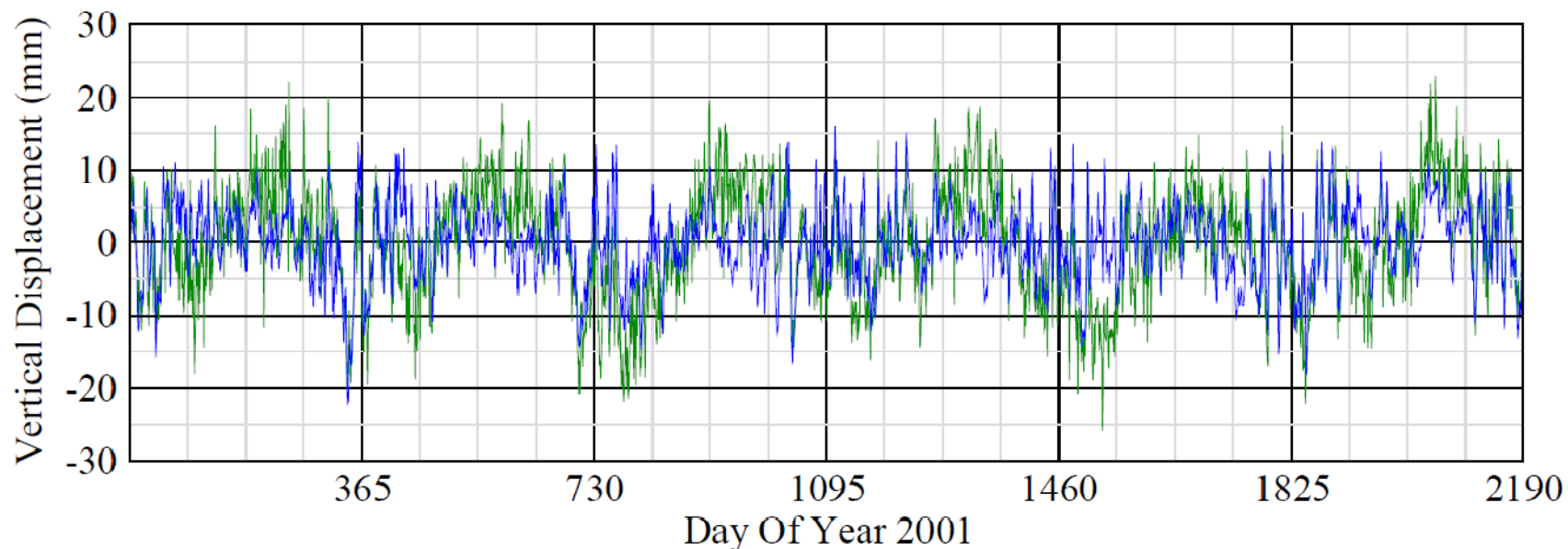
using the “ Apply ATM load ” GAMIT feature implemented by [Tregoning & van Dam, 2005].

- GAMIT/GLOBK 10.33: Enhanced Ambiguity Resolution Scheme
- Cutoff elevation = 10° ; Interval Zenith delay = 2 hours
- Use Tide model with degree 1 deformation ...



GPS (NO LOAD) INV (ECMWF & IB)

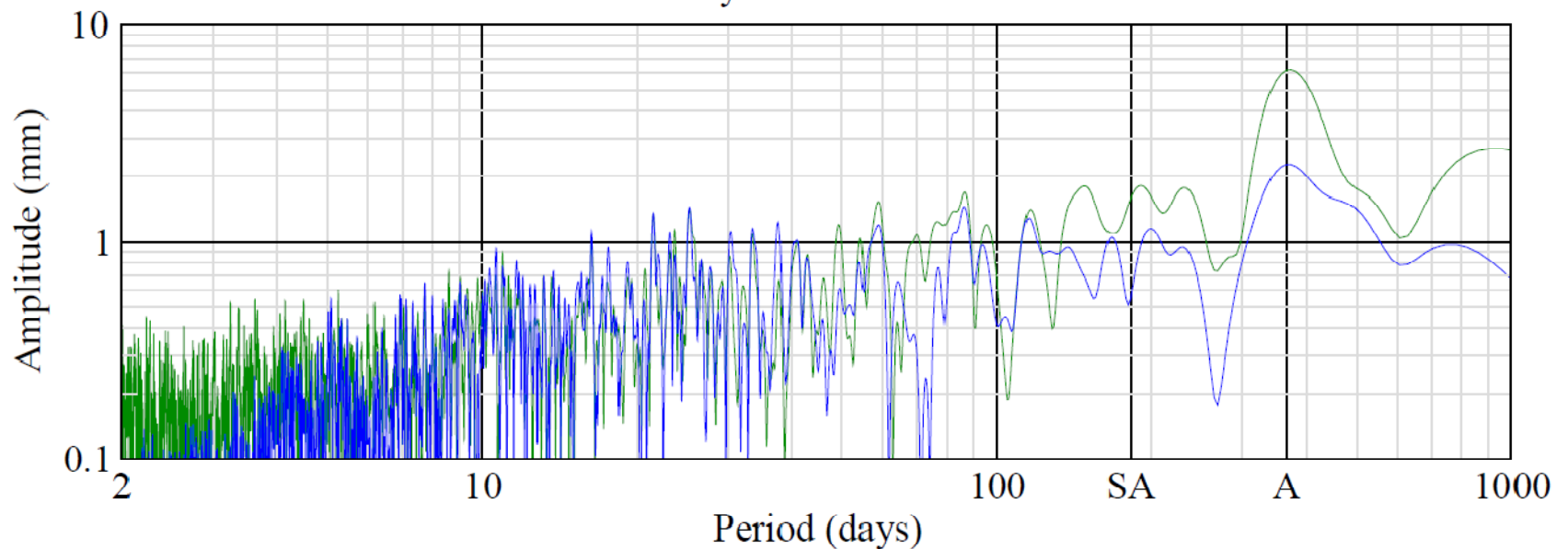
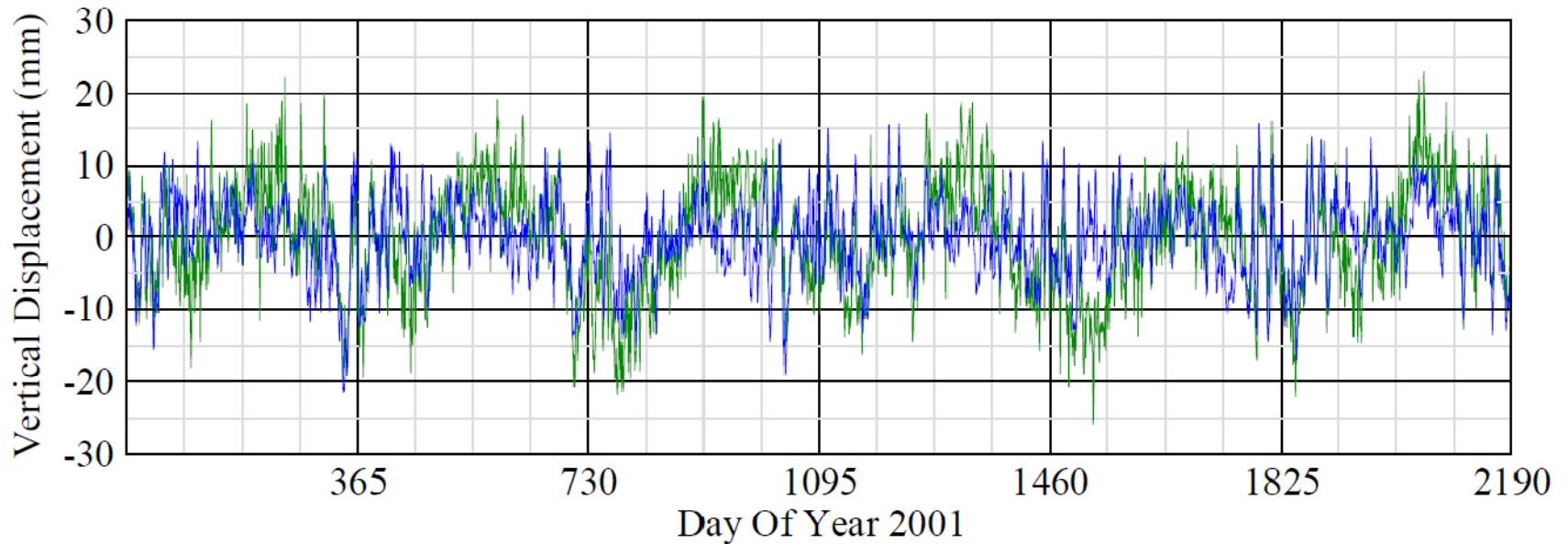
Vertical Displacement at POTS - GPS vs INV





GPS (NO LOAD) MOG (ECMWF & MOG2D)

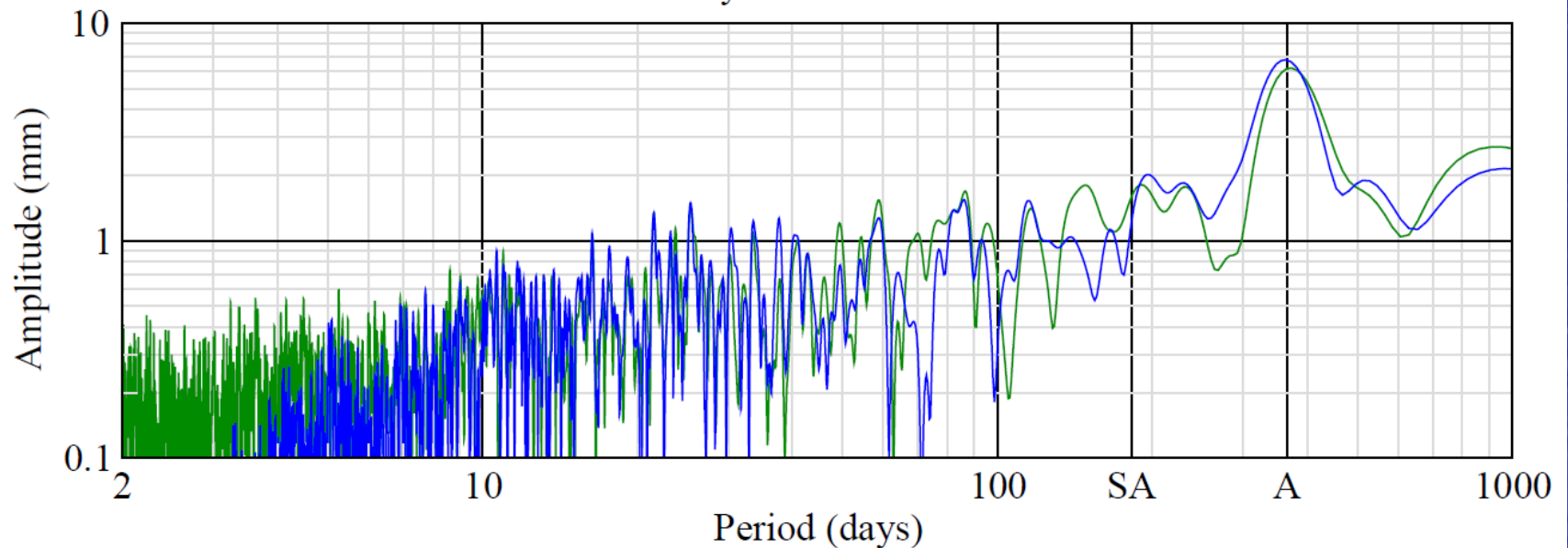
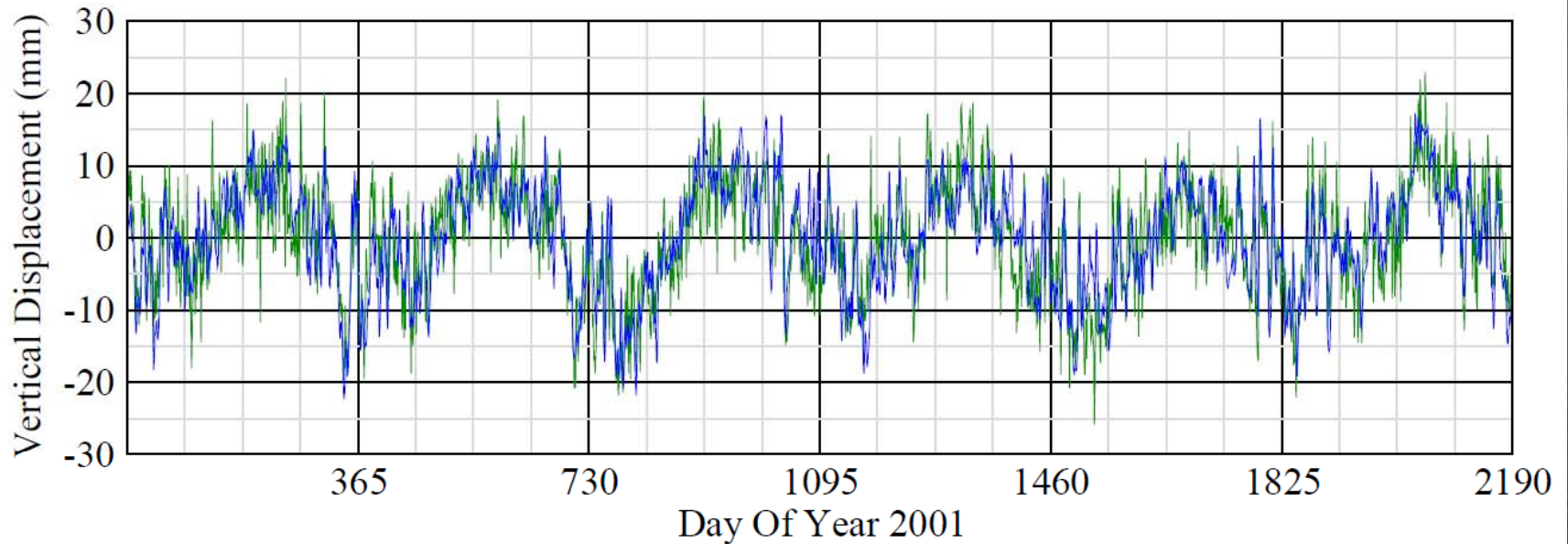
Vertical Displacement at POTS - GPS vs MOG





GPS (NO LOAD) AOH (ECMWF & MOG2D & GLDAS)

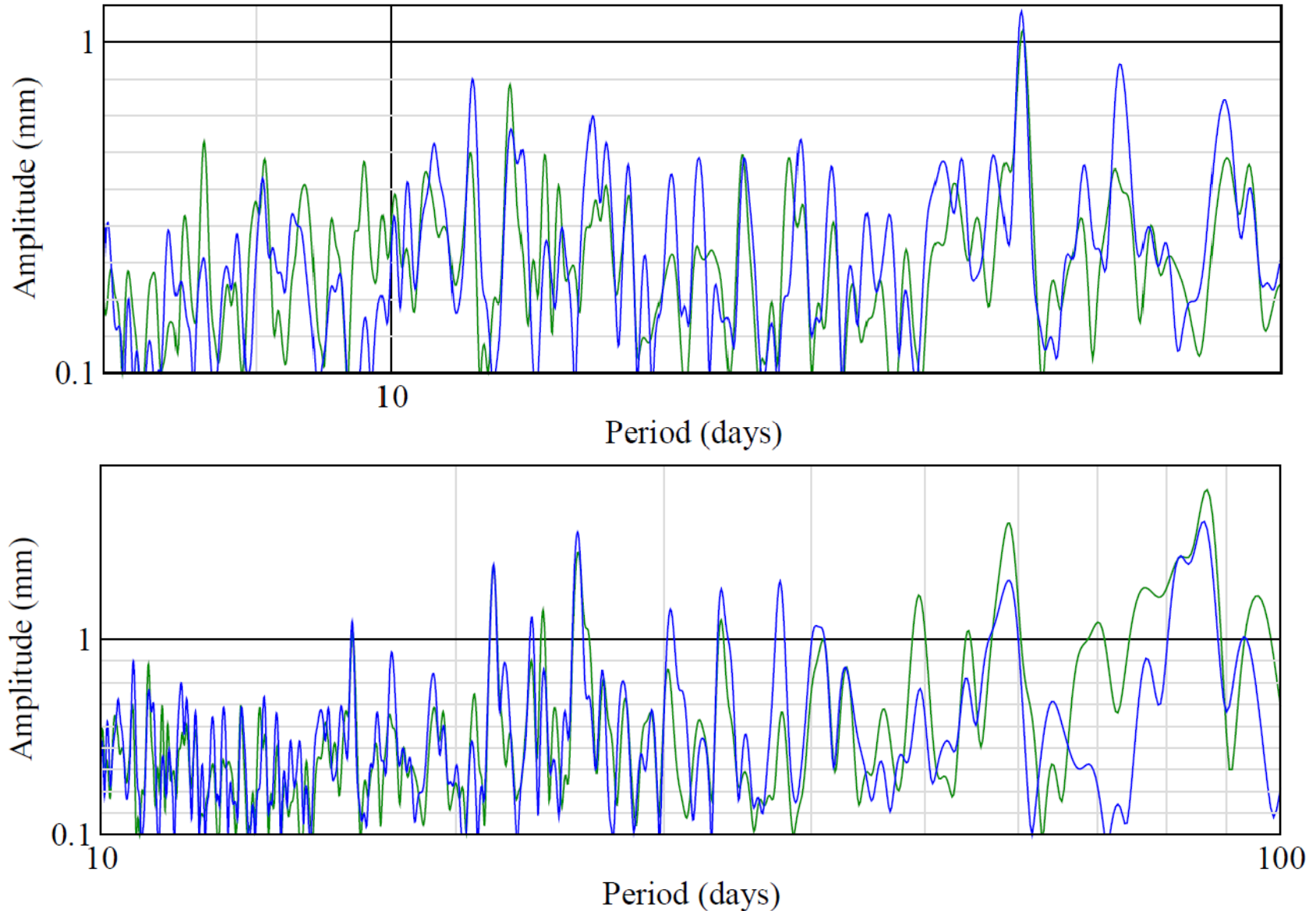
Vertical Displacement at POTS - GPS vs AOH





GPS (NO LOAD) AOH (ECMWF & MOG2D & GLDAS)

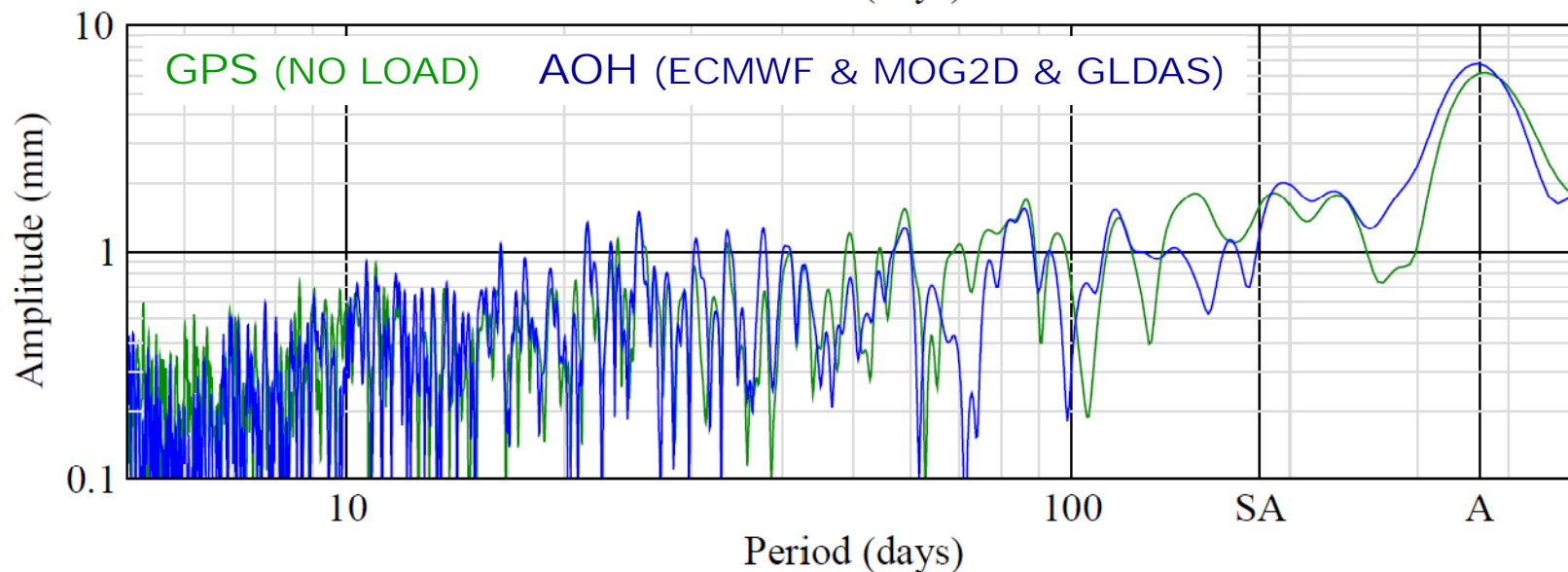
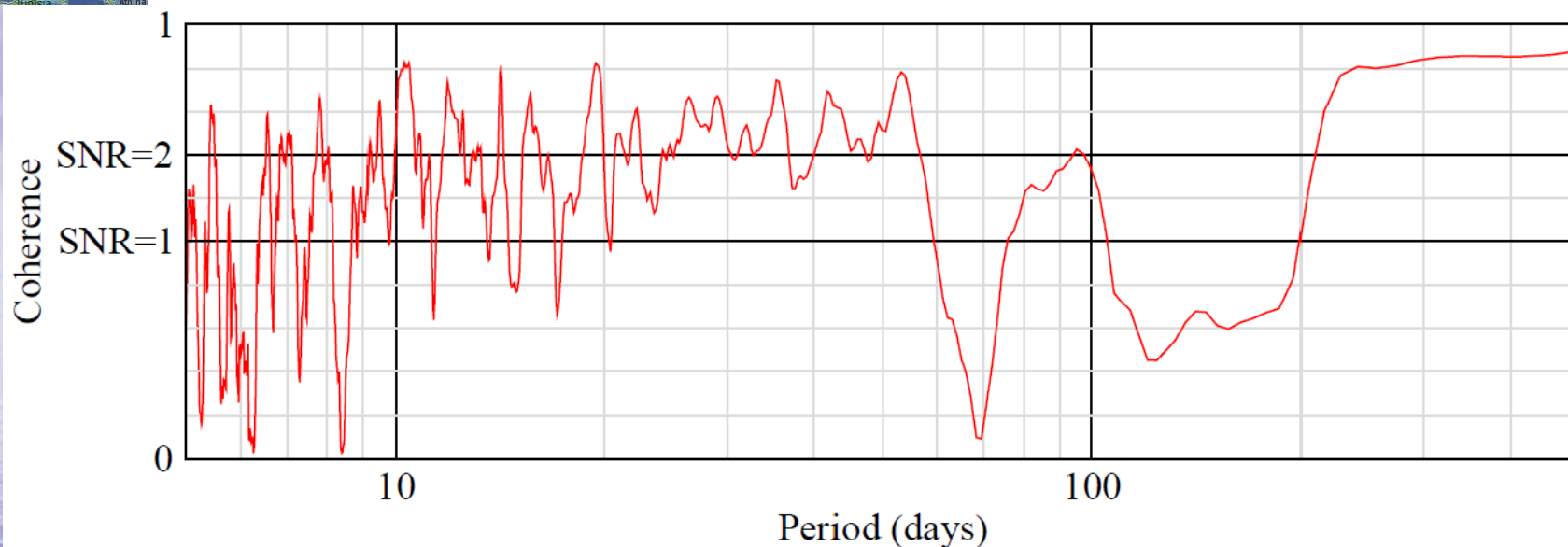
Vertical Displacement at POTS - GPS vs AOH





GPS (NO LOAD) AOH (ECMWF & MOG2D & GLDAS)

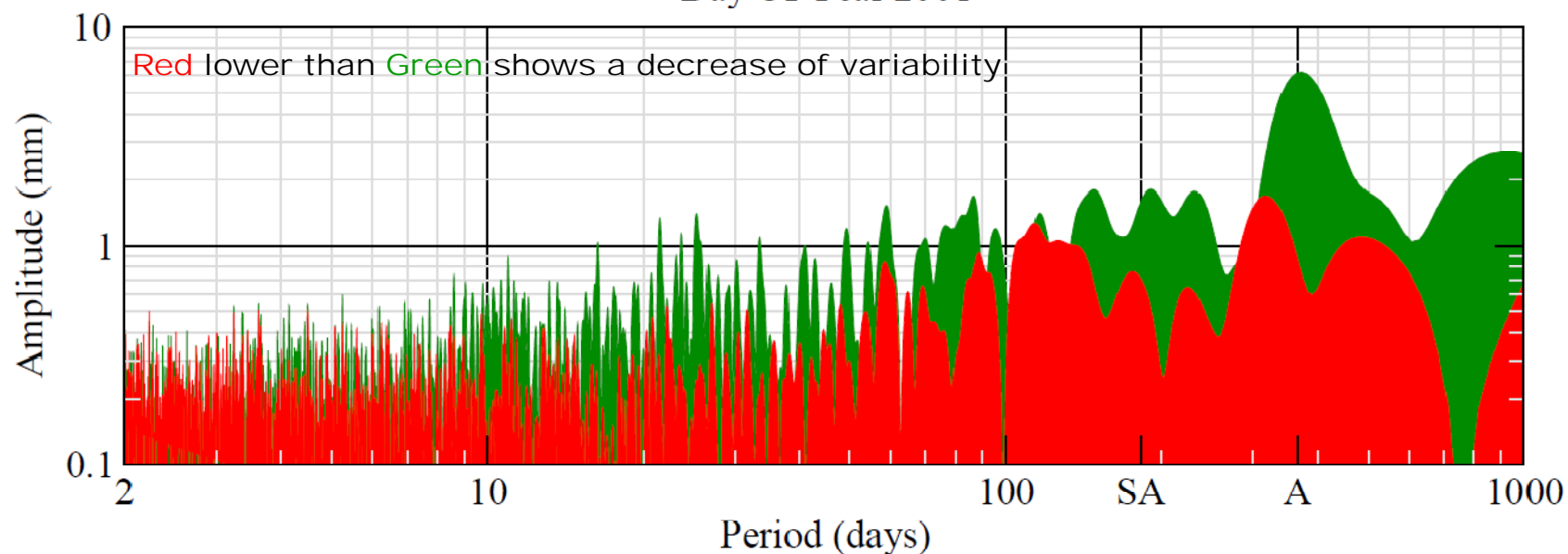
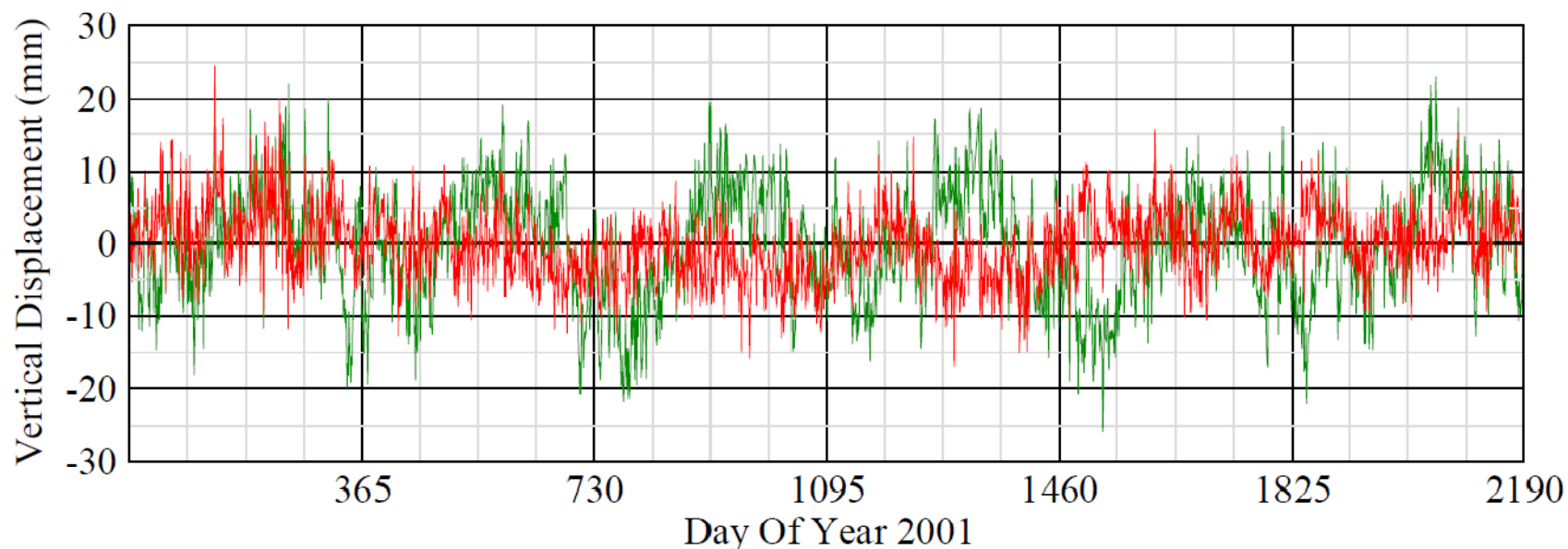
Coherence between modeled (AOH) and observed (GPS no load) vertical displacement





GPS (NO LOAD) GPS&AOH (A PRIORI: ECMWF & MOG2D & GLDAS)

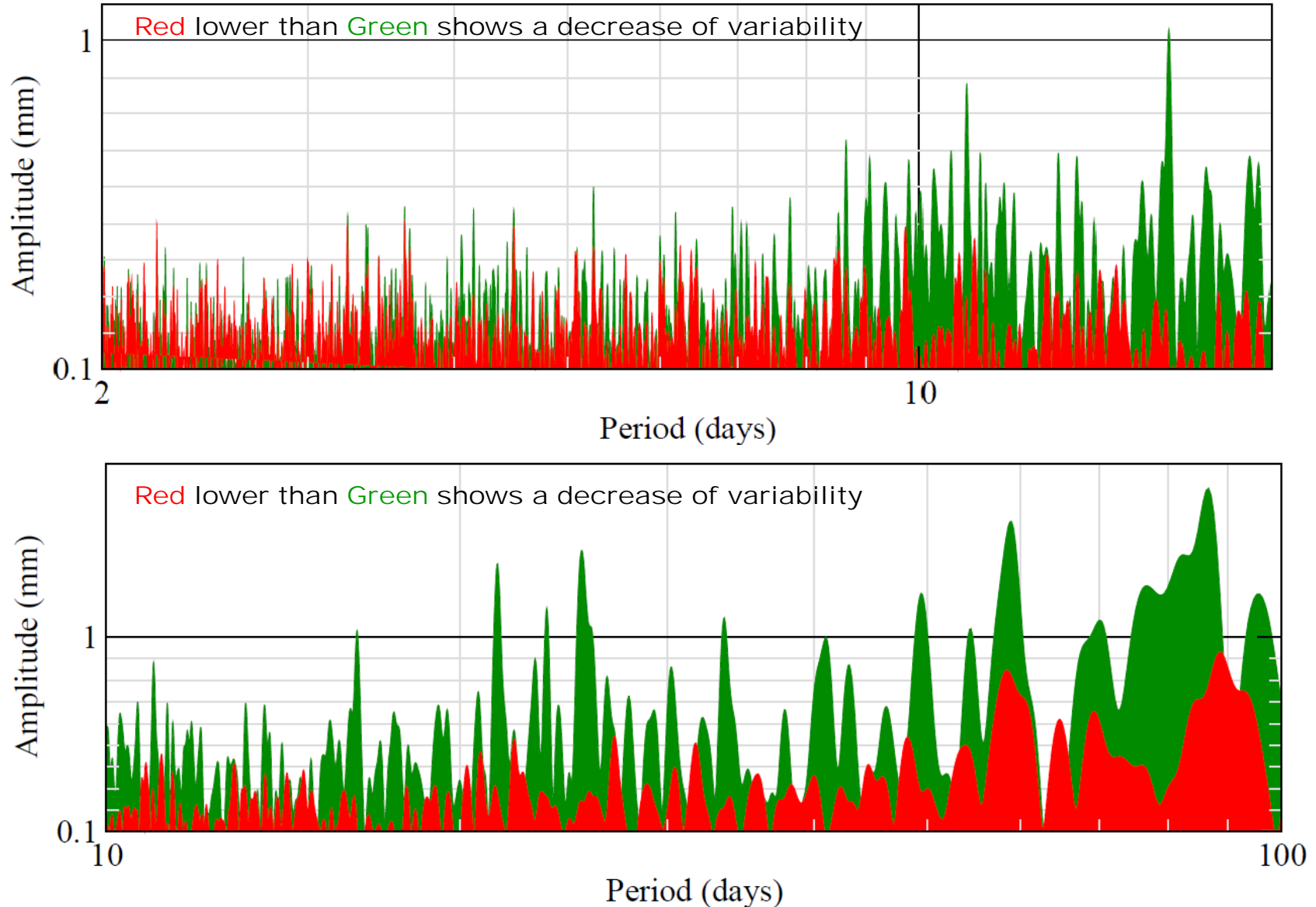
Vertical Displacement at POTS - GPS vs GPS&AOH





GPS (NO LOAD) GPS&AOH (A PRIORI: ECMWF & MOG2D & GLDAS)

Vertical Displacement at POTS - GPS vs GPS&AOH

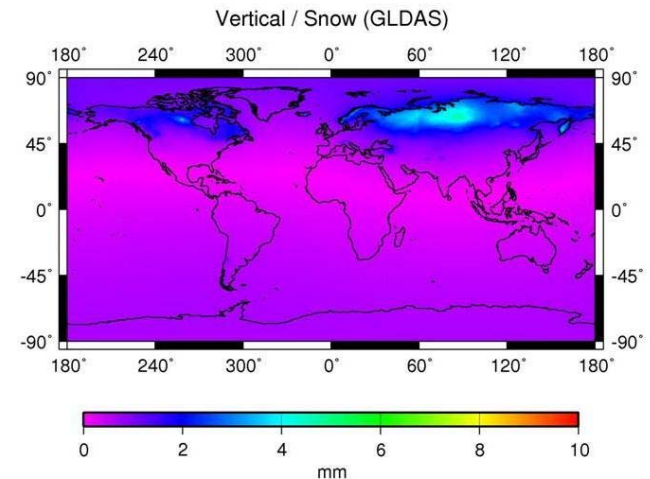
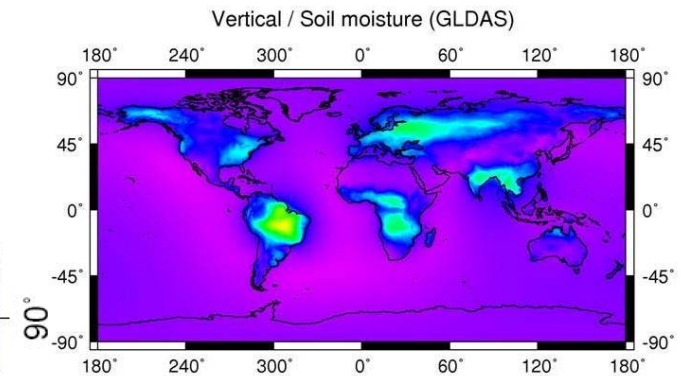
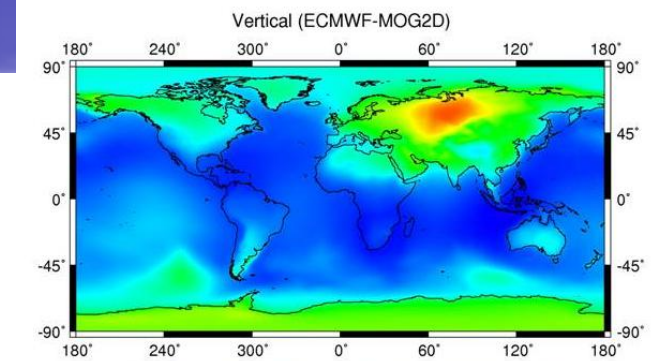
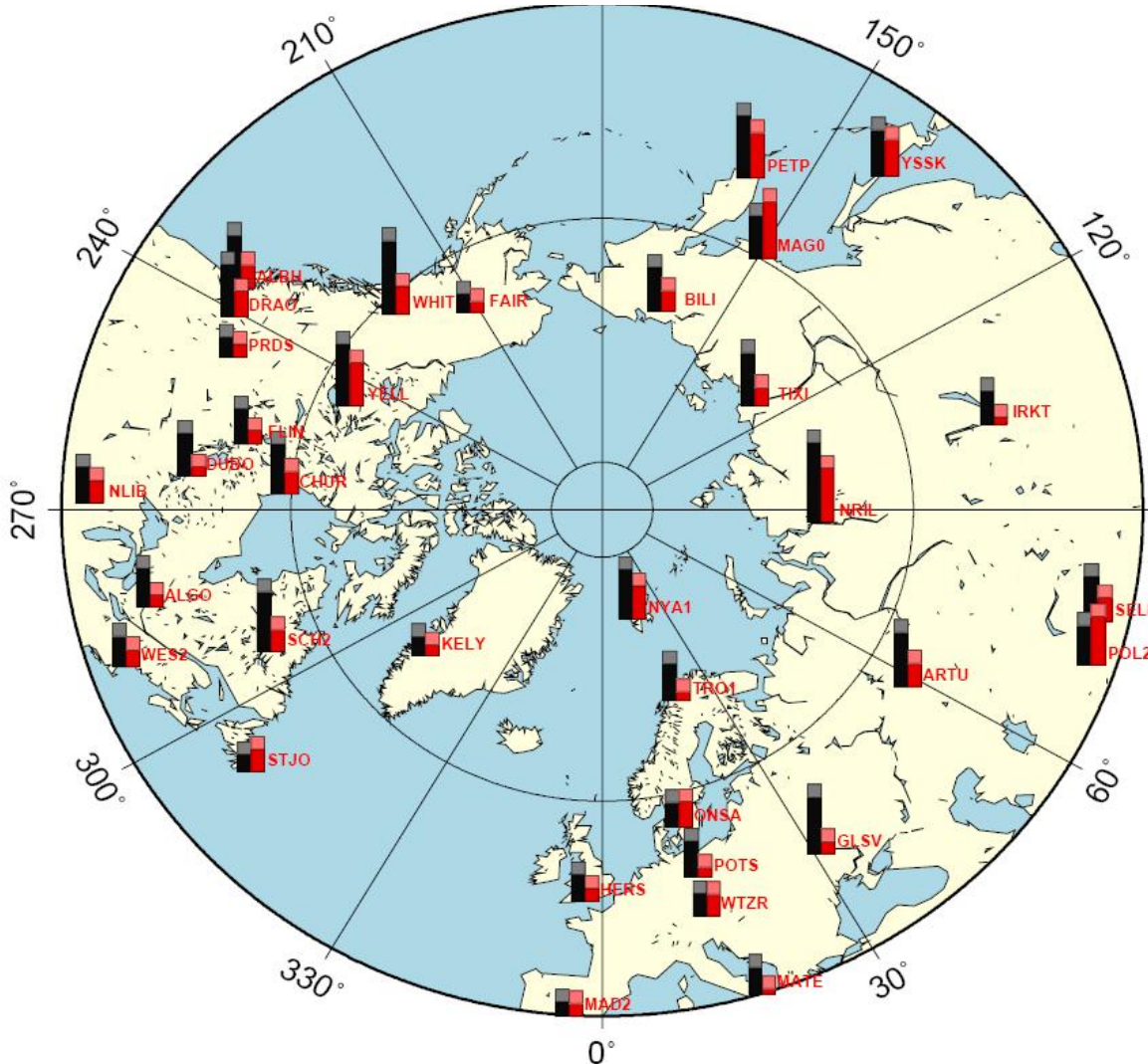


Annual Variability of the Vertical Displacement: Northern Hemisphere

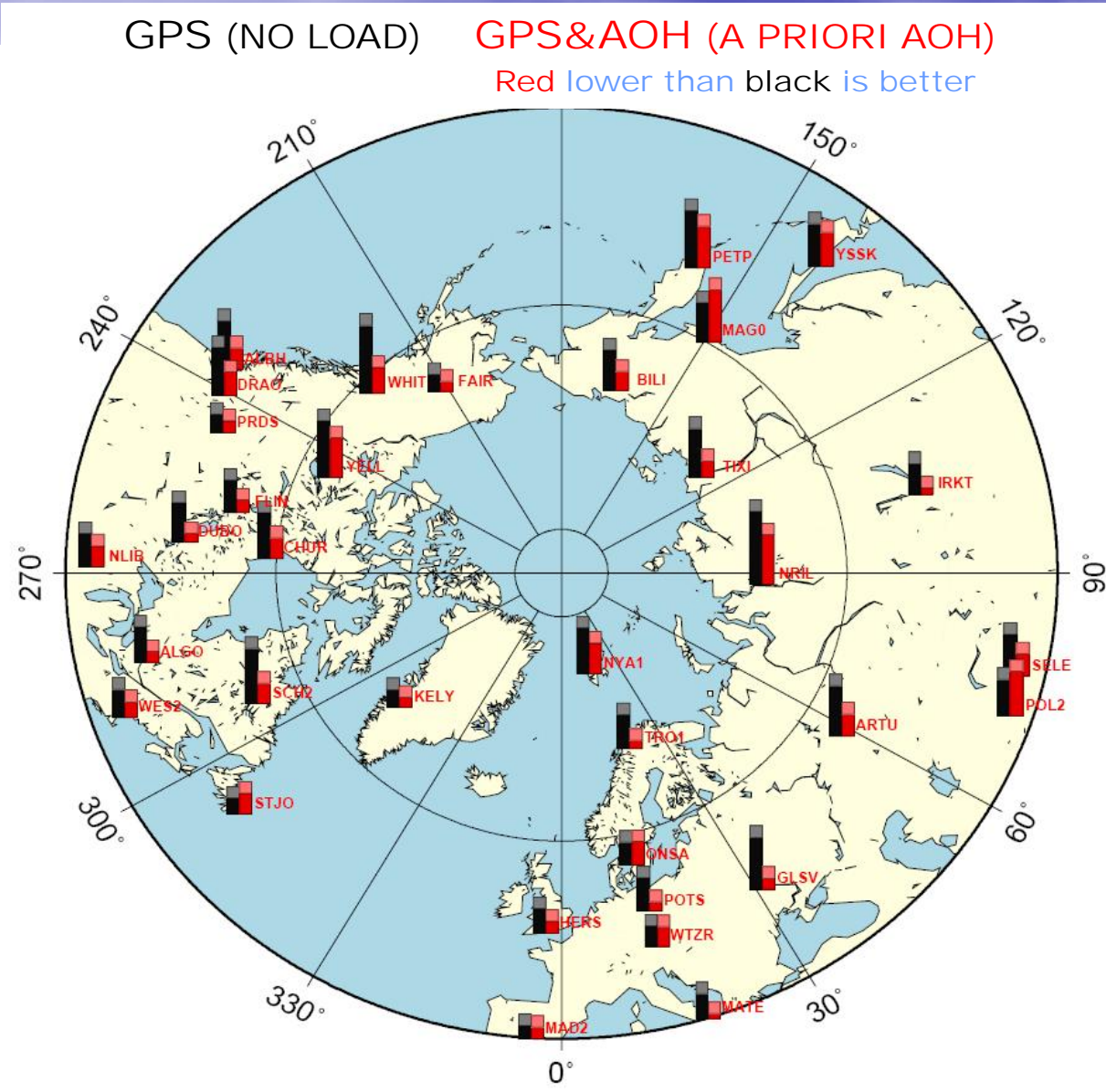
GPS (NO LOAD)

GPS&AOH (A PRIORI AOH)

Red lower than black is better



Annual Variability of the Vertical Displacement: Conclusions for the Northern Hemisphere



Improvements :

Large continental
areas: Eurasia,
North America

Why ?

Large Atmospheric
and Hydrological
Signals. Less
Oceanic Influence.

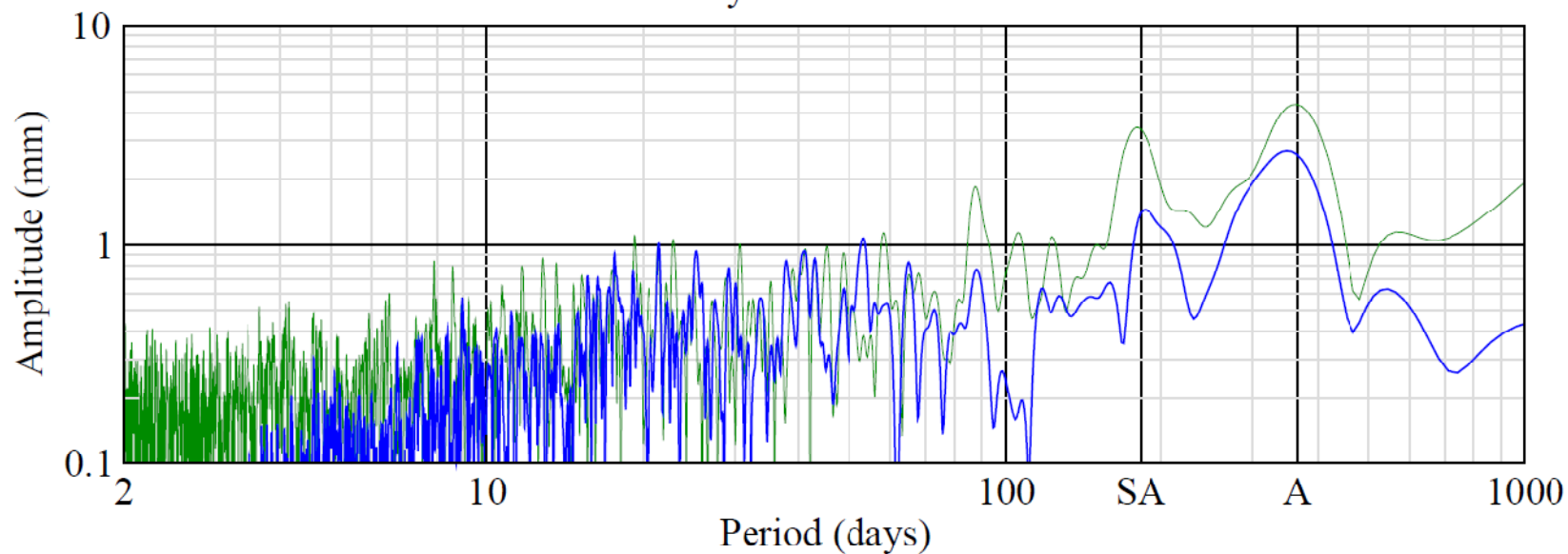
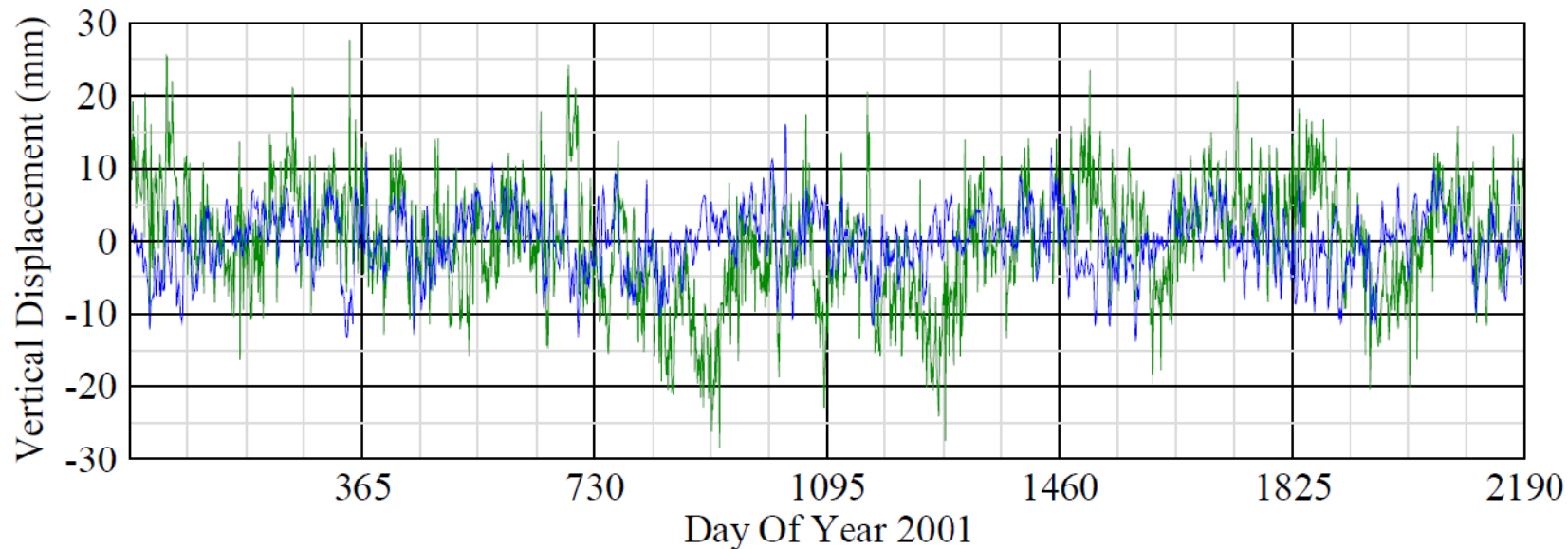
Well known high
and mid-latitudes
weather conditions

GPS Tracking
Network.



GPS (NO LOAD) AOH (ECMWF & MOG2D & GLDAS)

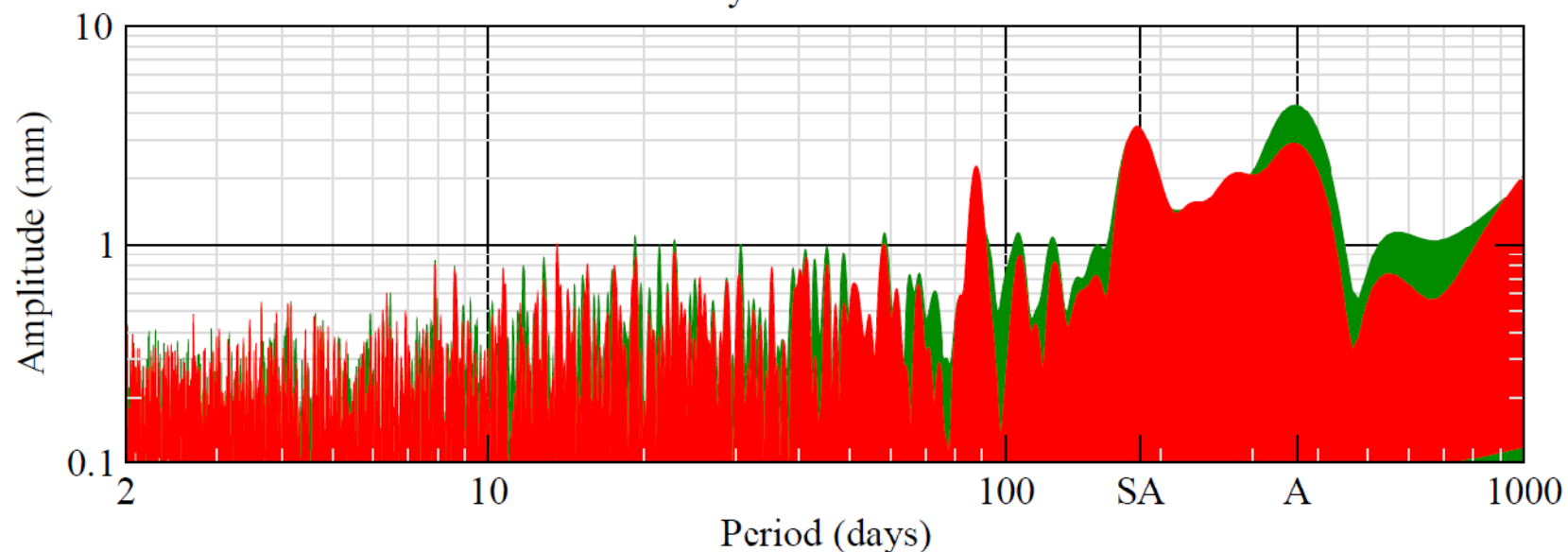
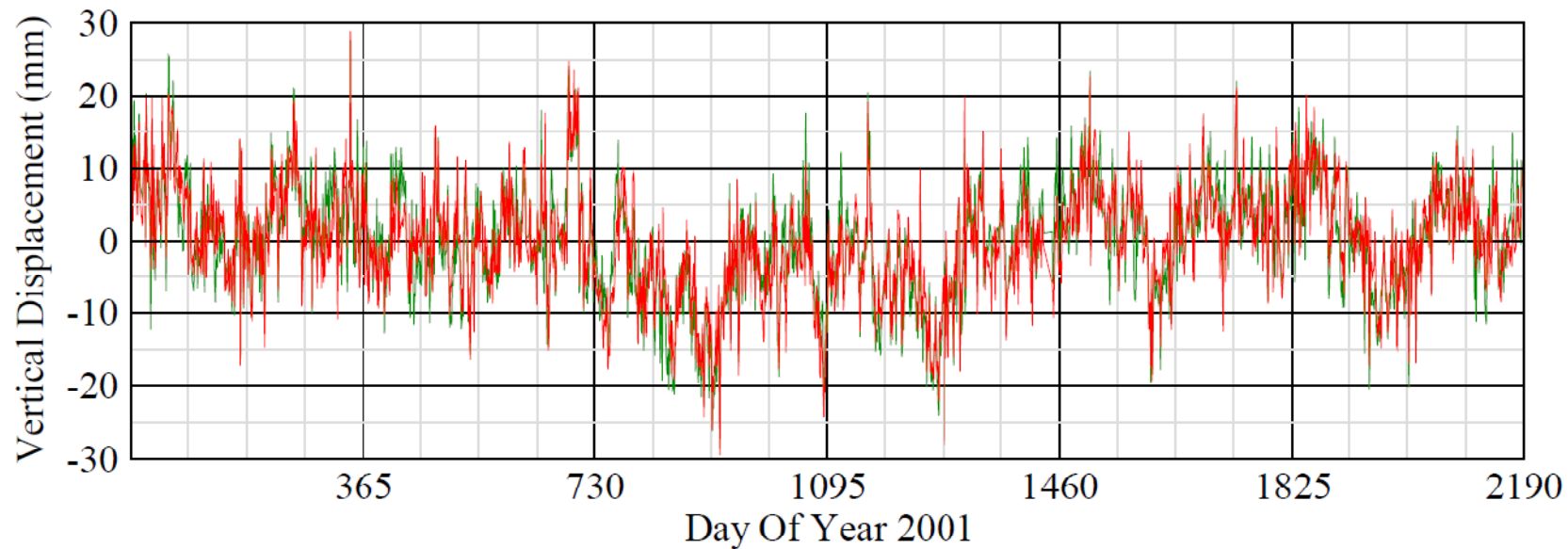
Vertical Displacement at NYA1 - GPS vs AOH



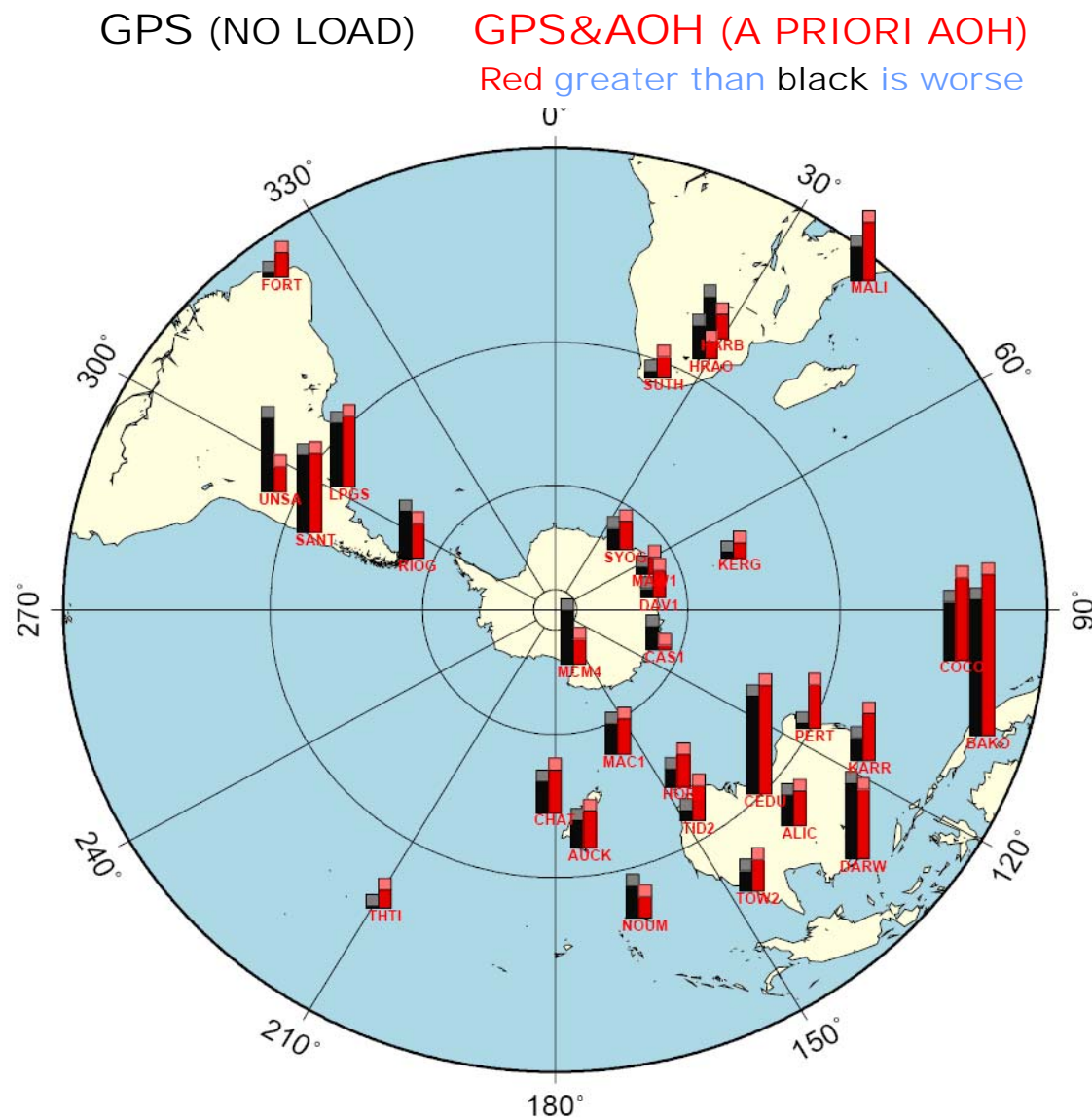


GPS (NO LOAD) GPS&AOH (A PRIORI: ECMWF & MOG2D & GLDAS)

Vertical Displacement at NYA1 - GPS vs GPS&AOH



Annual Variability of the Vertical Displacement: Conclusions for the Southern Hemisphere



No improvements :

Peninsulas,
Islands,
Coastal Sites ...

Why ?

Tracking Network ?

Tiny loading signal ?

Tides ? Unmodeled
Oceanic Loading ?

Tropospheric delays
(use of ZTD & VMF)

Elevation weighting
(too much weight
on low elevation)

Modeling and Observation of Loading Contribution to Time-Variable GPS Site Positions

Are we able to Detect and Identify
Loading Contribution inside GPS Position?

YES!

Does the Integration of Loading in GPS Processing
improve Vertical Positioning at All Sites?

**Tropospheric effects
are not accurately modeled in our current study and
mask loading signal for sites near costal areas.**

Acknowledgements:

- GAMITeers (P. Tregoning, T. Herring, R. King, ...)
- Florent Lyard (MOG2D), Matthew Rodell (GLDAS)
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- GPS Rinex Archive Centers (IGS, SOPAC, UNAVCO)

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