Error Mitigation in DORIS Derived Geocenter Motion

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DORIS has tended to produce the least reliable geocenter motion estimates, especially for the Z-component (Wu, 2012)

While some progress is likely, results comparable to SLR, or even GNSS, seem remote (Wu, 2012)

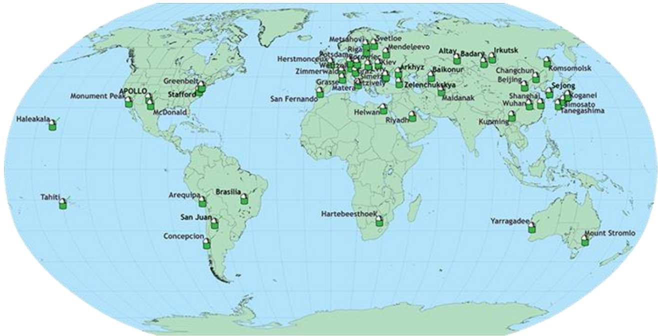
Definitions

- "Geocenter motion"
  - Motion of the center-of-mass (CM) of the total Earth system with respect to the center-of-figure (CF) of the solid Earth surface (Ray 1999)
  - Relative motions between CF and CN contributing to apparent geocenter motion have been termed **"network effect"**

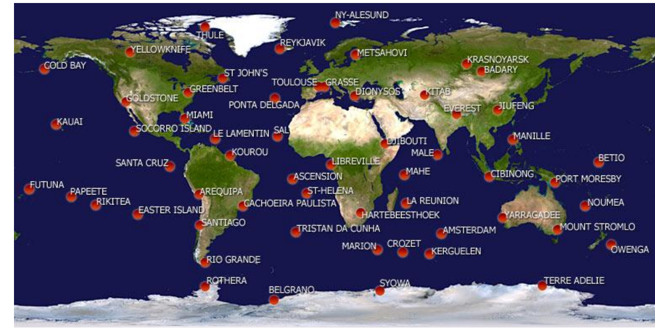
    => C*omplicates a direct comparison of the different tracking techniques*
  - The ITRF origin is approximately located at a point with a fixed offset from CF with no motion between them (Wu et al. 2012)

Goal

SLR network

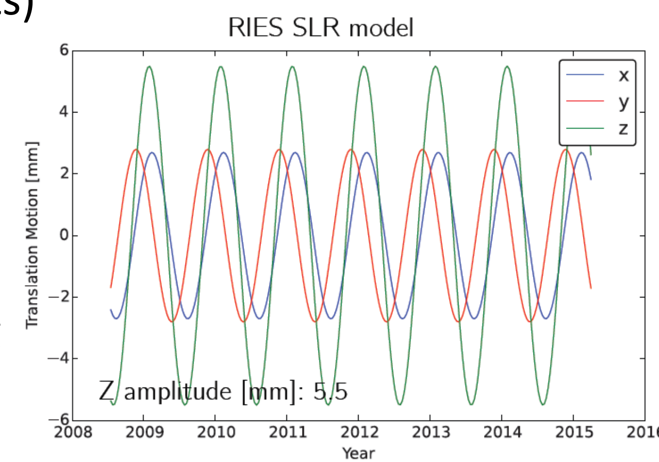


DORIS network



- Focus on the **non-tidal (seasonal) geocenter** motion
  - Less reliable (non-unique, uncertain)
  - Background models (tropospheric refraction, solar radiation pressure, non-tidal loading, …) used to estimate geocenter motion are not sufficiently precise
  - Measuring the small amplitude of the geocenter motion is very challenging (noise, systematic effects in observational data sets)

    => *Performance indicator for the geodetic systems*



- Analysis of **DORIS data**
  - SLR is the most reliable space geodetic technique for determining geocenter motion but…
  - Sparse number of operational SLR ground tracking stations, poorly distributed geographically, limited to night-time/cloudless weather observing
  - More uniform and denser network for the DORIS system

Method

- Three methods have been used to estimate geocenter motions from geodetic observations
  - The dynamic approach (degree-one coefficients of Earth's gravitational potential)
  - **The network shift approach (translation parameters, SLR/DORIS)**
  - The degree-one deformation approach (degree-one mass load coefficients, GPS)

- In this study, the geocenter motion is estimated simultaneously with the orbit, force and measurement parameters from DORIS data
  - Jason-2 GDR-E DORIS-only dynamic solutions (10-day orbit arcs)
  - 2008.5 – 2015.0

Mitigation Strategies

- Estimation of **station heights**
- **Draconitic** error effects
- Impact of errors in the **tropospheric delay** modeling (and network configurations)
- Making the most of **low-elevation DORIS data**
  - Estimation of tropospheric horizontal gradients
  - Use of an elevation-dependent weighting of the observations

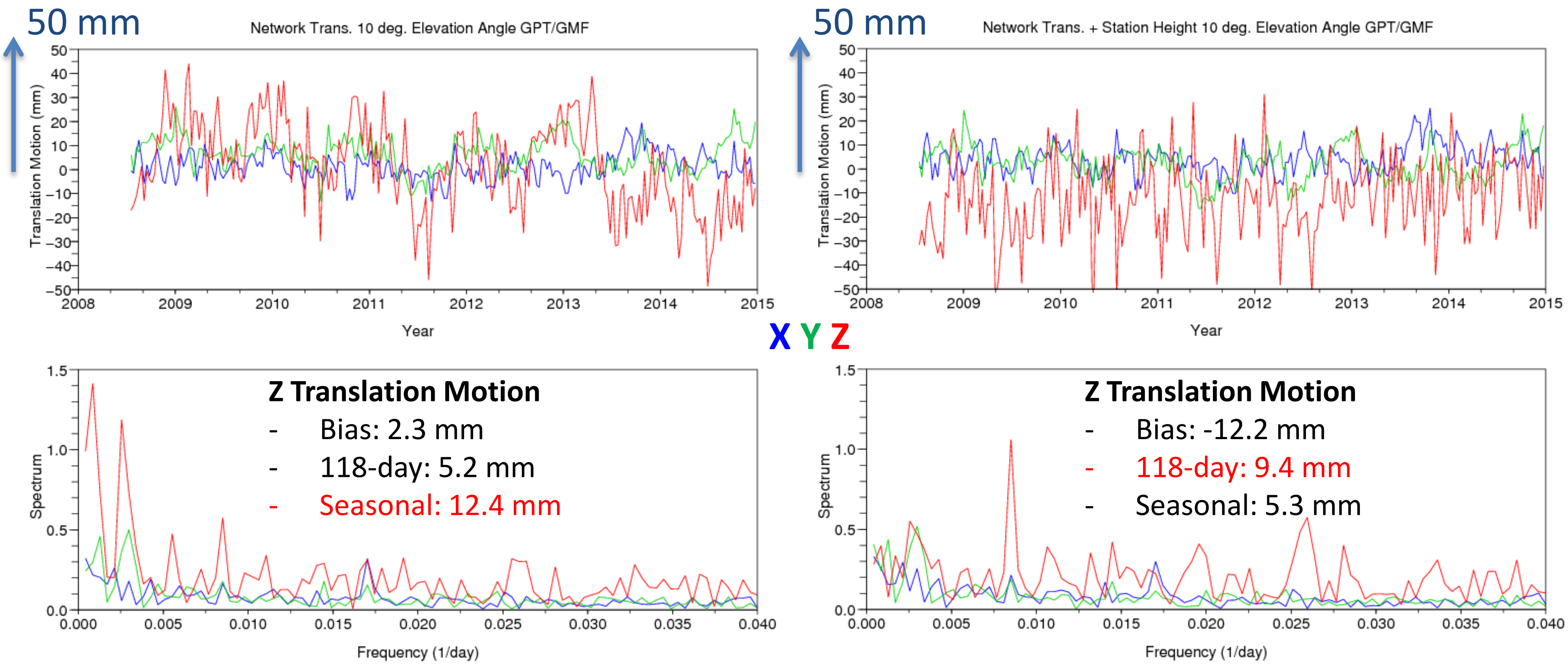
Station Height Inaccuracy

- **Error sources** affecting the station height estimation
  - Non-tidal (atmospheric, hydrological) loading models
  - Troposphere zenith delay parameters
  - Multipath
  - DORIS USO frequency drift
  - Observations limited above the horizon
  - …

- If not taken into account, the troposphere zenith delay estimates will absorb most of these errors

  => *Aliased while estimating geocenter motion*

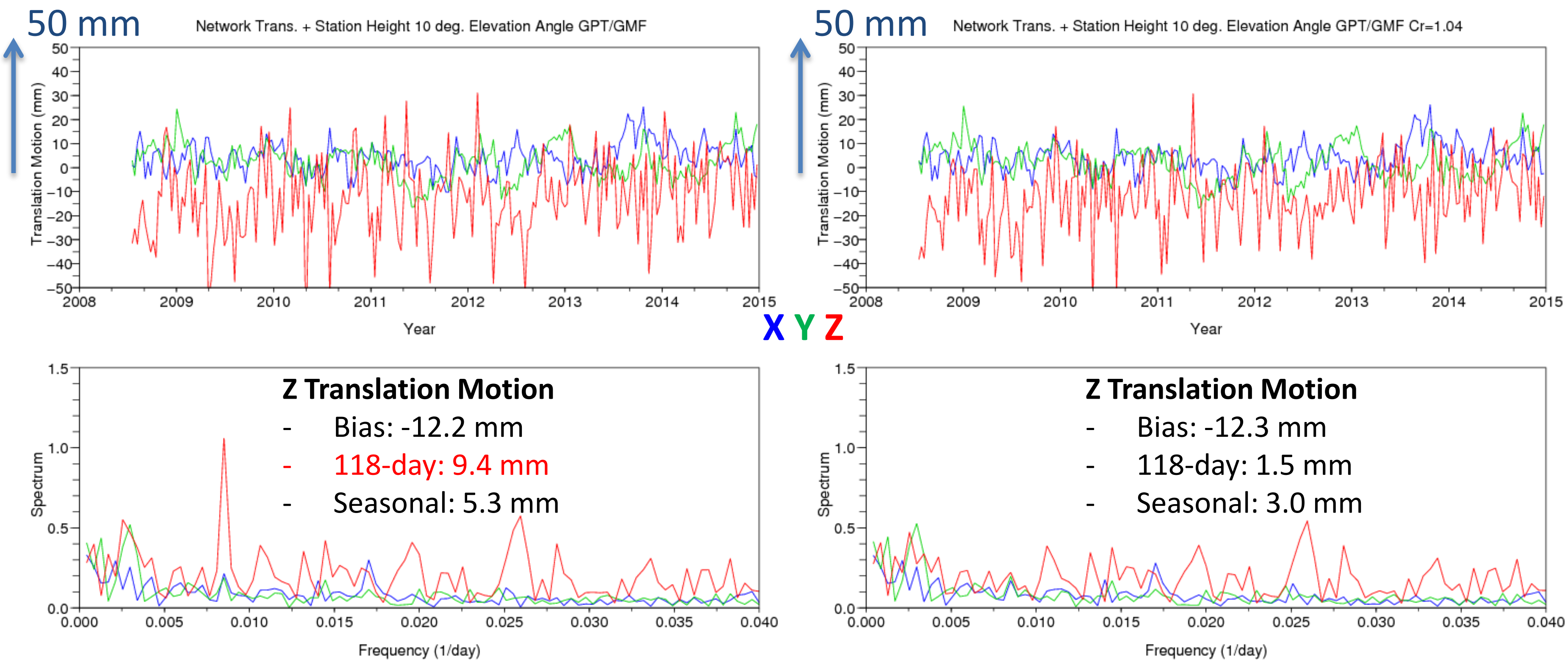
Station Height Correction



Station heights from ITRF2008/DPOD2008

Station heights adjusted

Solar Radiation Pressure Model Tuning

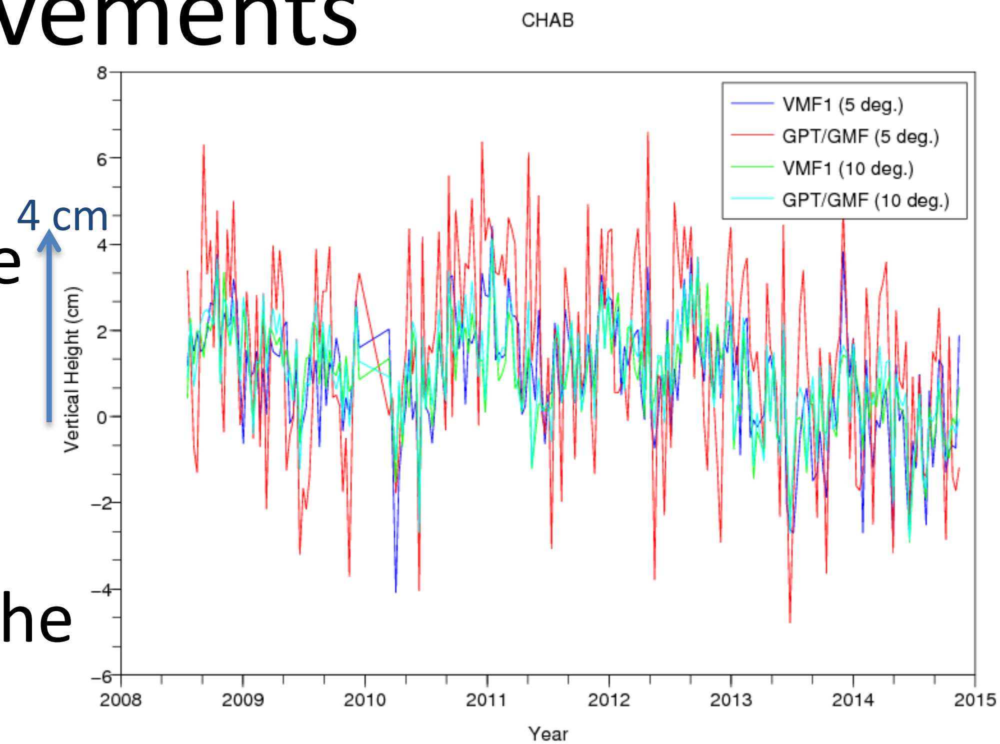


Cr=1.00

Cr=1.04

Tropospheric Delay Modeling Improvements

- GPT/GMF => VMF1
  - Effects become visible below 10-degree elevations
  - **Negligible effect** on the geocenter motion estimate (lower than the "network effect" encountered with the use of VMF1 Site, see next slide)



VMF1 Site – IDS (DORIS)

- Gridded vs site resolution
  - Global grid: 2.5 x 2.0 degrees
  - **Selected sites: 0.25 degrees** (no spatial interpolation is needed)

- Missing sites
  - Terre-Adelie: 2010, 252 -> 2011, 101 and 2015, 084 -> 2015, 113
  - Ajaccio, Betio, Cold-Bay, Dionysos, Grasse, Le-Lamentin, Male, Miami, Monument-Peak, Owenga, Paramashir, Rikitea, Santa-Cruz

- Erroneous sites
  - Reykjavik, Rothera

$\Rightarrow$ *Possible network effects between the reduced and full network*

Feedback to J. Böhm => **New list of stations from May 5, 2016**

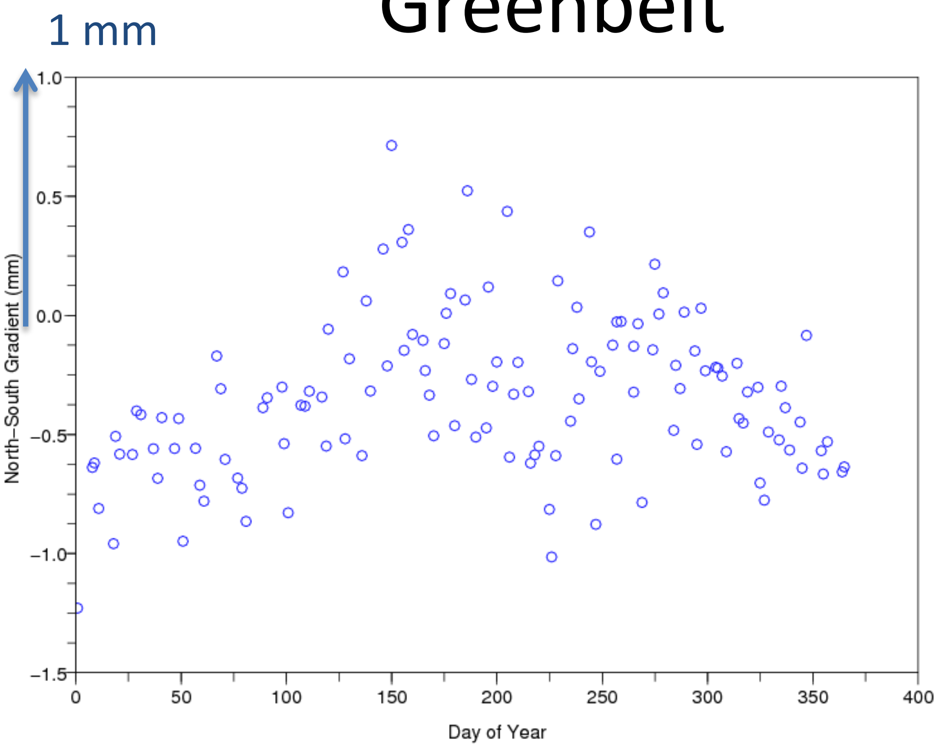
Low-Elevation Data

- Advantage
  - Help to **better discriminate** between the different estimated parameters

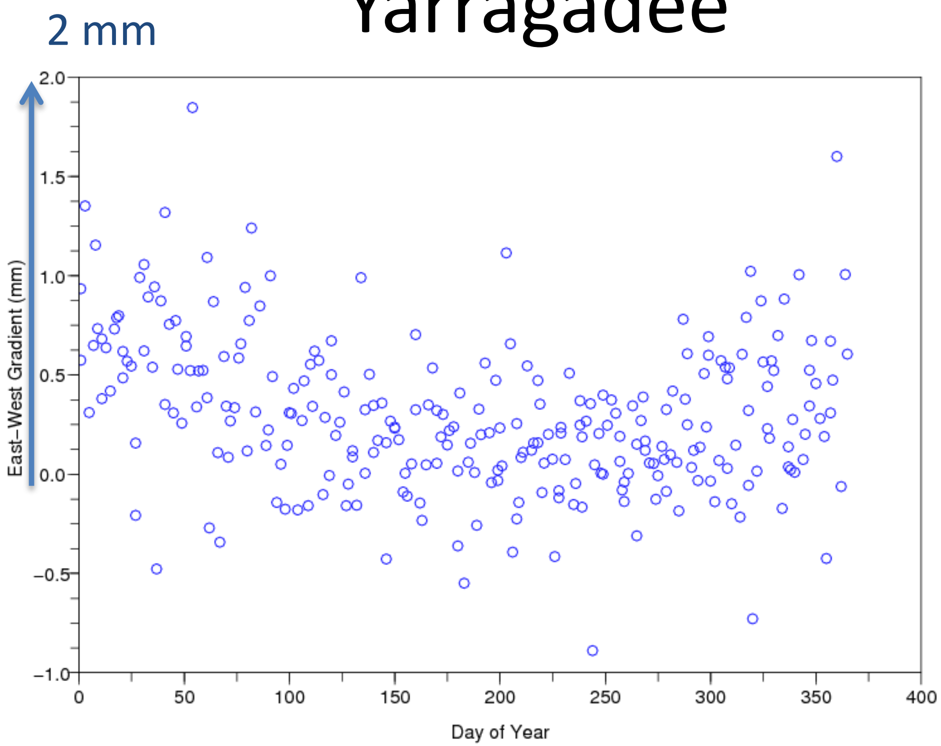
- Drawback
  - **Noise level and systematic effects** (troposphere, multipath and antenna phase center variations) are much larger than for high-elevation data

Estimated Horizontal Tropospheric Gradients

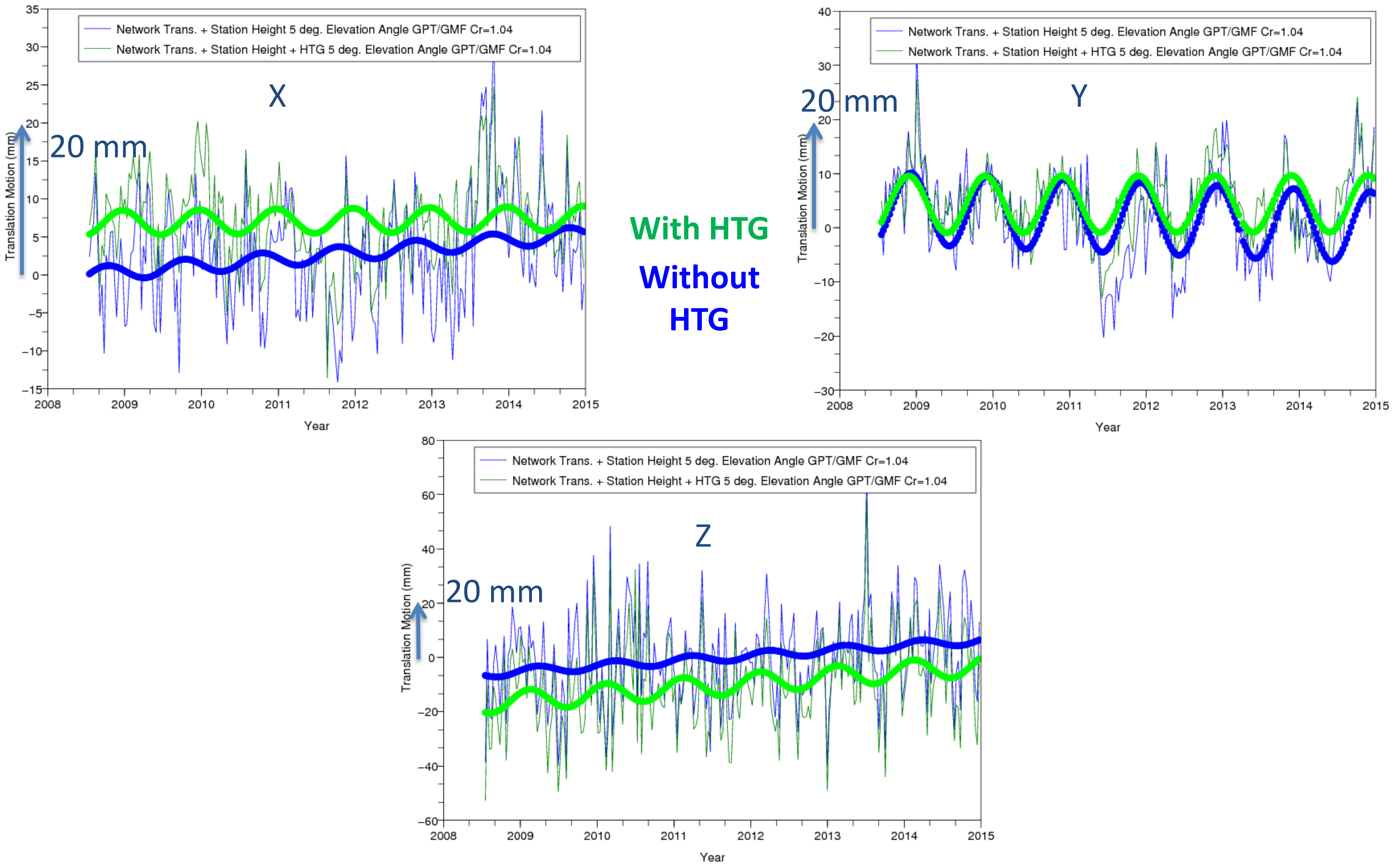
Greenbelt



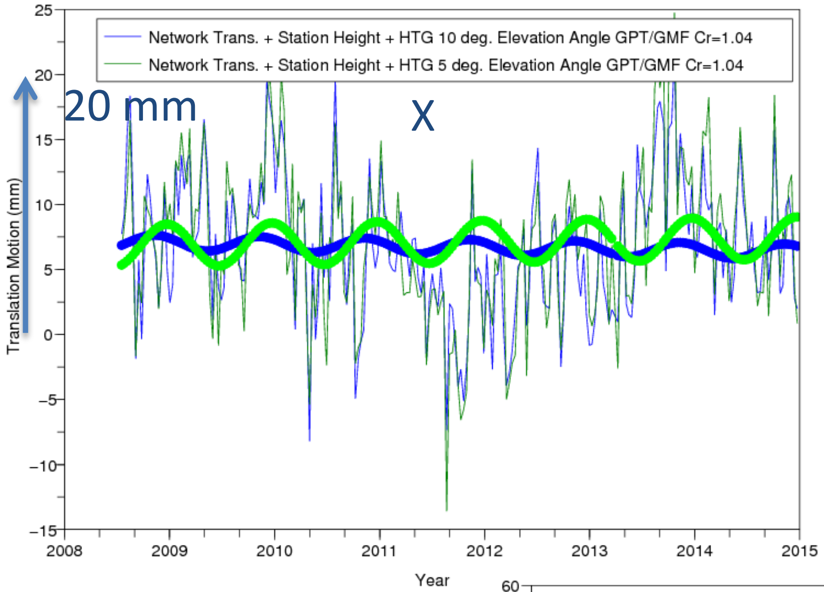
Yarragadee

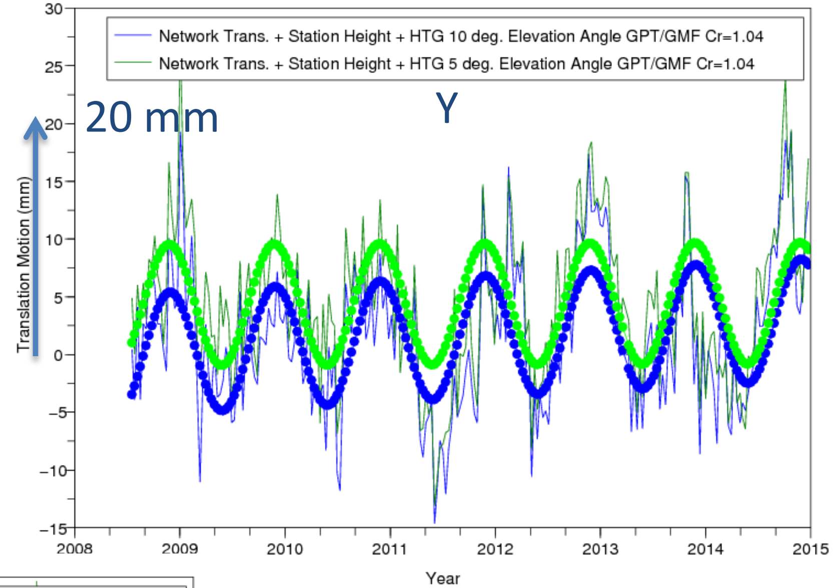


HTG Effect on the Geocenter Motion Estimate



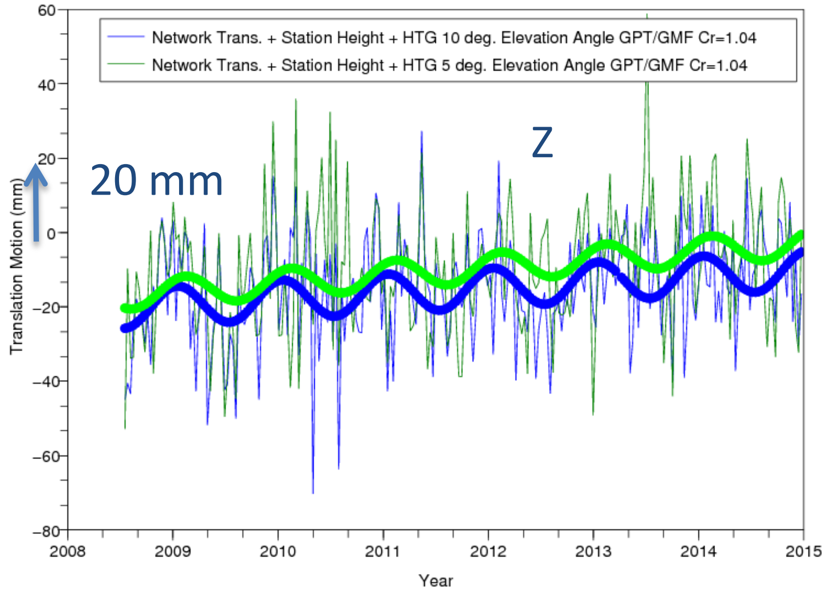
Benefit of Low-Elevation Data





> 10 deg.

> 5 deg.

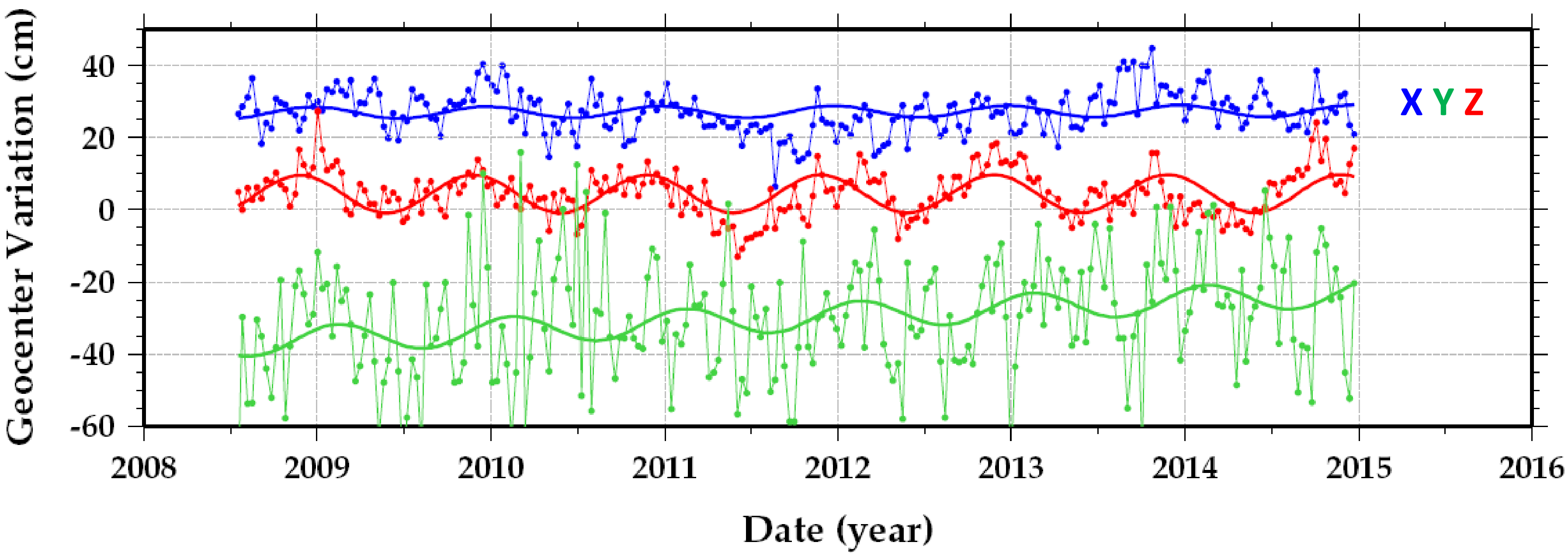


Realistic Elevation-Dependent Weighting

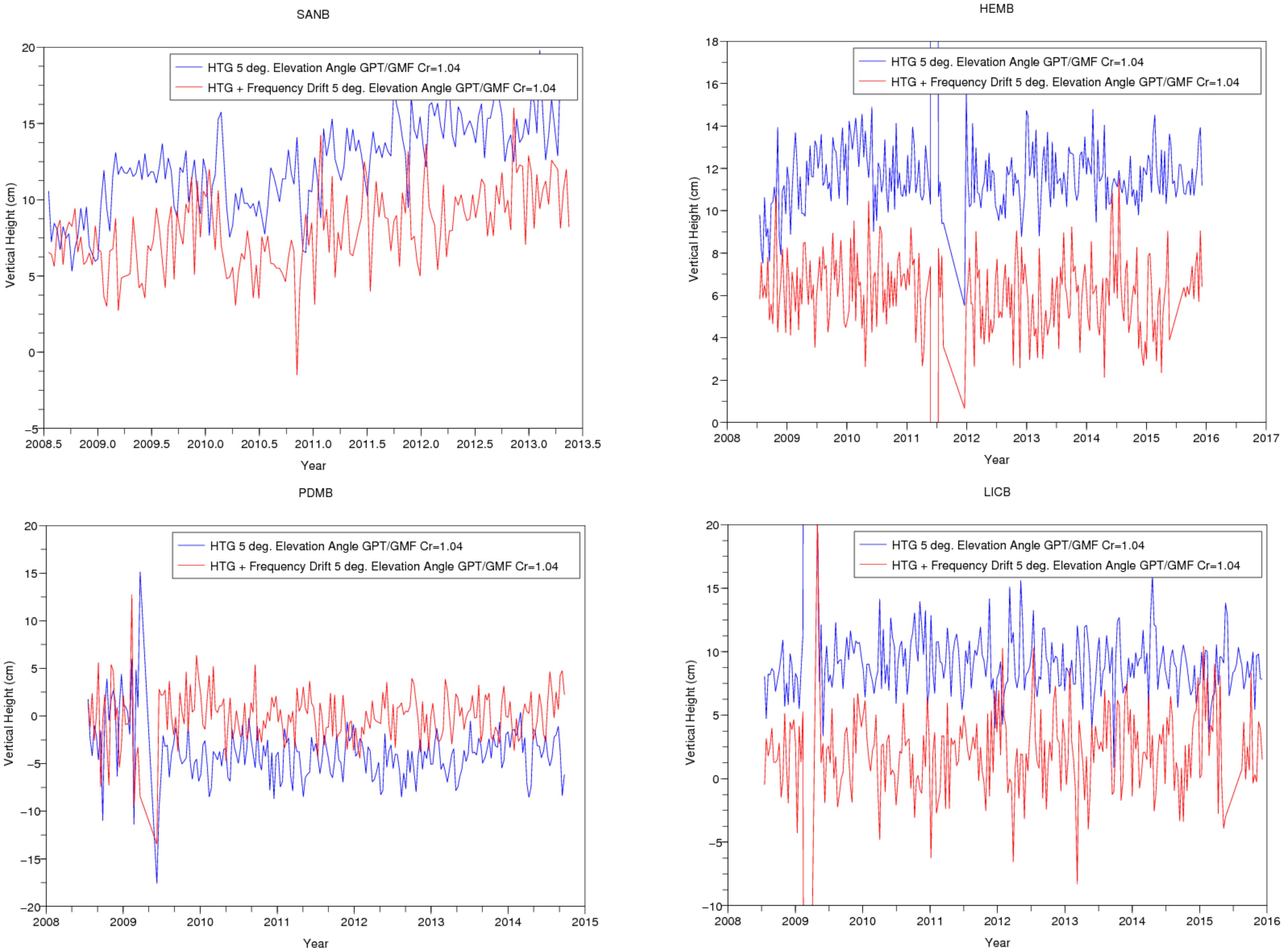
- To be continued…
  - May help to better sense geocenter X component and further reduce the draconitic contribution to its Z component estimate

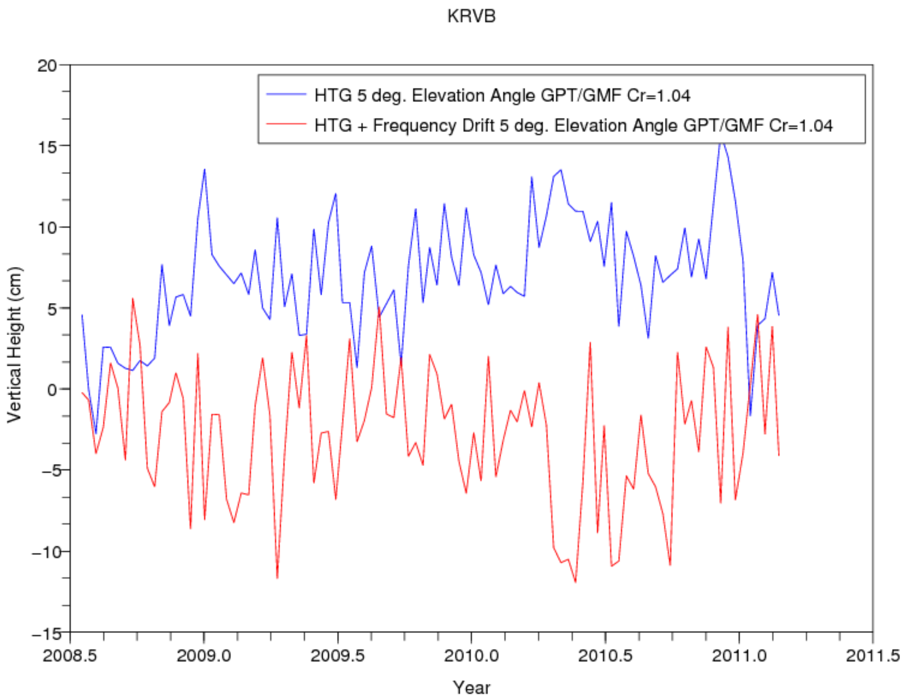
Comparison and discussion

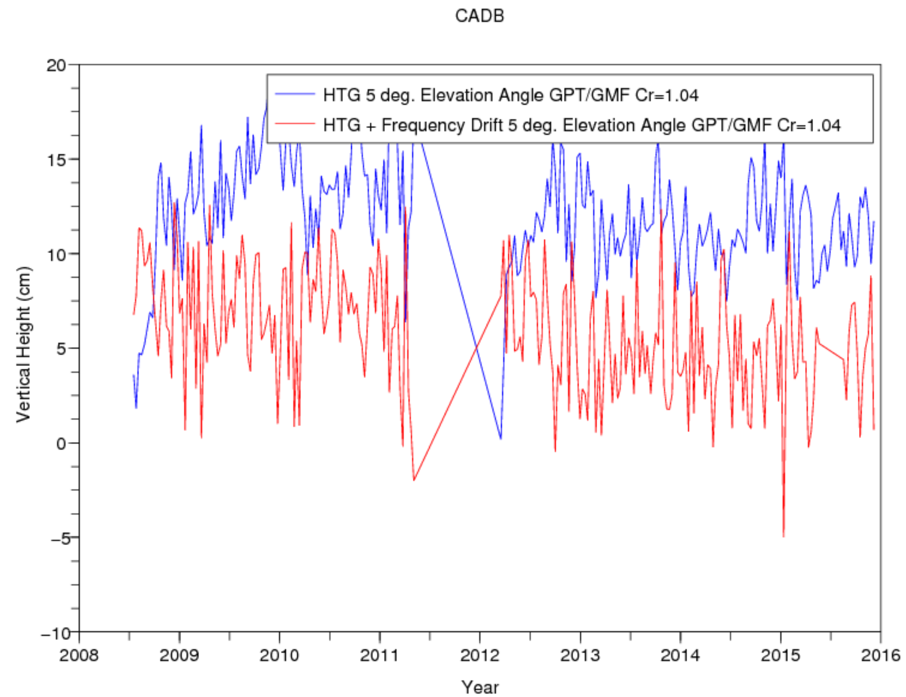
Case	X Amp. (mm)/Phase (day)	Y Amp. (mm)/Phase (day)	Z Amp. (mm)/Phase (day)
SLR (Ries 2013)	2.7/41	2.8/321	5.5/27
GPS (Wu et al. 2010)	1.8/49	2.7/329	4.2/31
DORIS	1.6/5	5.2/332	4.0/44

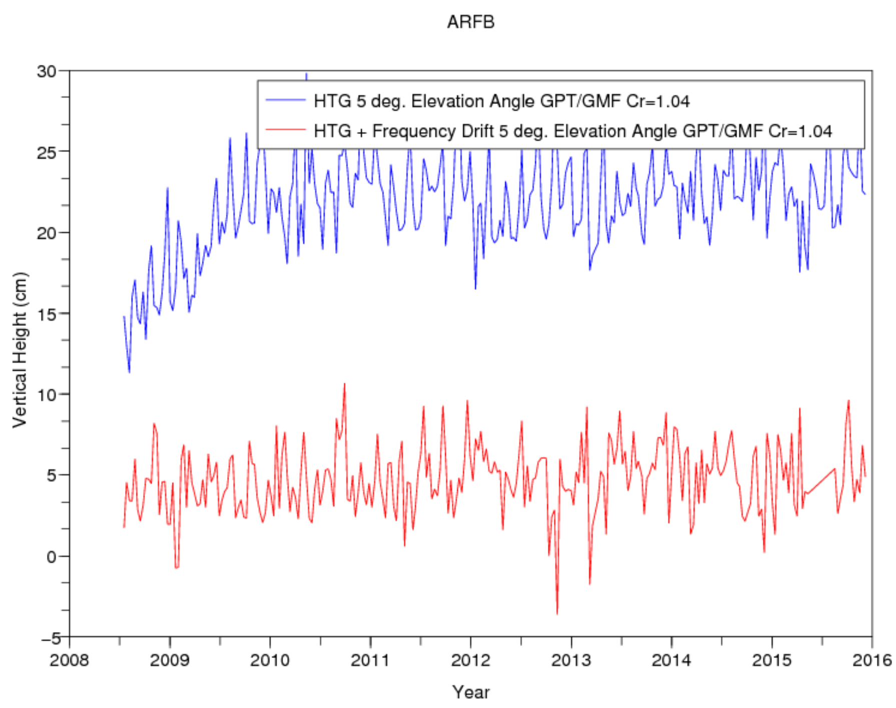


Back-up


SANB
HTG 5 deg. Elevation Angle GPT/GMF Cr=1.04
HTG + Frequency Drift 5 deg. Elevation Angle GPT/GMF Cr=1.04
Vertical Height (cm)
Year
HEMB
HTG 5 deg. Elevation Angle GPT/GMF Cr=1.04
HTG + Frequency Drift 5 deg. Elevation Angle GPT/GMF Cr=1.04
Vertical Height (cm)
Year
PDMB
HTG 5 deg. Elevation Angle GPT/GMF Cr=1.04
HTG + Frequency Drift 5 deg. Elevation Angle GPT/GMF Cr=1.04
Vertical Height (cm)
Year
LICB
HTG 5 deg. Elevation Angle GPT/GMF Cr=1.04
HTG + Frequency Drift 5 deg. Elevation Angle GPT/GMF Cr=1.04
Vertical Height (cm)
Year


KRVB
HTG 5 deg. Elevation Angle GPT/GMF Cr=1.04
HTG + Frequency Drift 5 deg. Elevation Angle GPT/GMF Cr=1.04
Vertical Height (cm)
Year


CADB
HTG 5 deg. Elevation Angle GPT/GMF Cr=1.04
HTG + Frequency Drift 5 deg. Elevation Angle GPT/GMF Cr=1.04
Vertical Height (cm)
Year


ARFB
HTG 5 deg. Elevation Angle GPT/GMF Cr=1.04
HTG + Frequency Drift 5 deg. Elevation Angle GPT/GMF Cr=1.04
Vertical Height (cm)
Year