Evaluation of Atmospheric Loading and Improved Troposphere Modeling

N.P. Zelensky[1], F.G. Lemoine[2], D.S. Chinn[1], K. Le Bail[3], D.E. Pavlis[1], S.S. Sanders[1]

[1] *SGT Inc., Greenbelt, Maryland, U.S.A.*
[2] *NASA Goddard Space Flight Center, Greenbelt, Maryland, U.S.A.*
[3] *NVI Inc., Greenbelt, Maryland, U.S.A.*

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Atmospheric station loading - Outline

• Evaluate non-tidal atmospheric station loading on SLR/DORIS Jason-2 POD with GEODYN, loading applied at the observation level.
• non-tidal atmospheric station surface displacements from ECMWF 6-hour pressure data (Tonie Van Dam, 2012, and/or Jean-Paul Boy, 2012).
• "nominal" orbit strategy includes SLRF2008 / DPOD2008 stations, and the Eigen_gl04s gravity field (std1007 POD standards).

Atmospheric Loading displacement at Greenbelt, Maryland 2009-2011
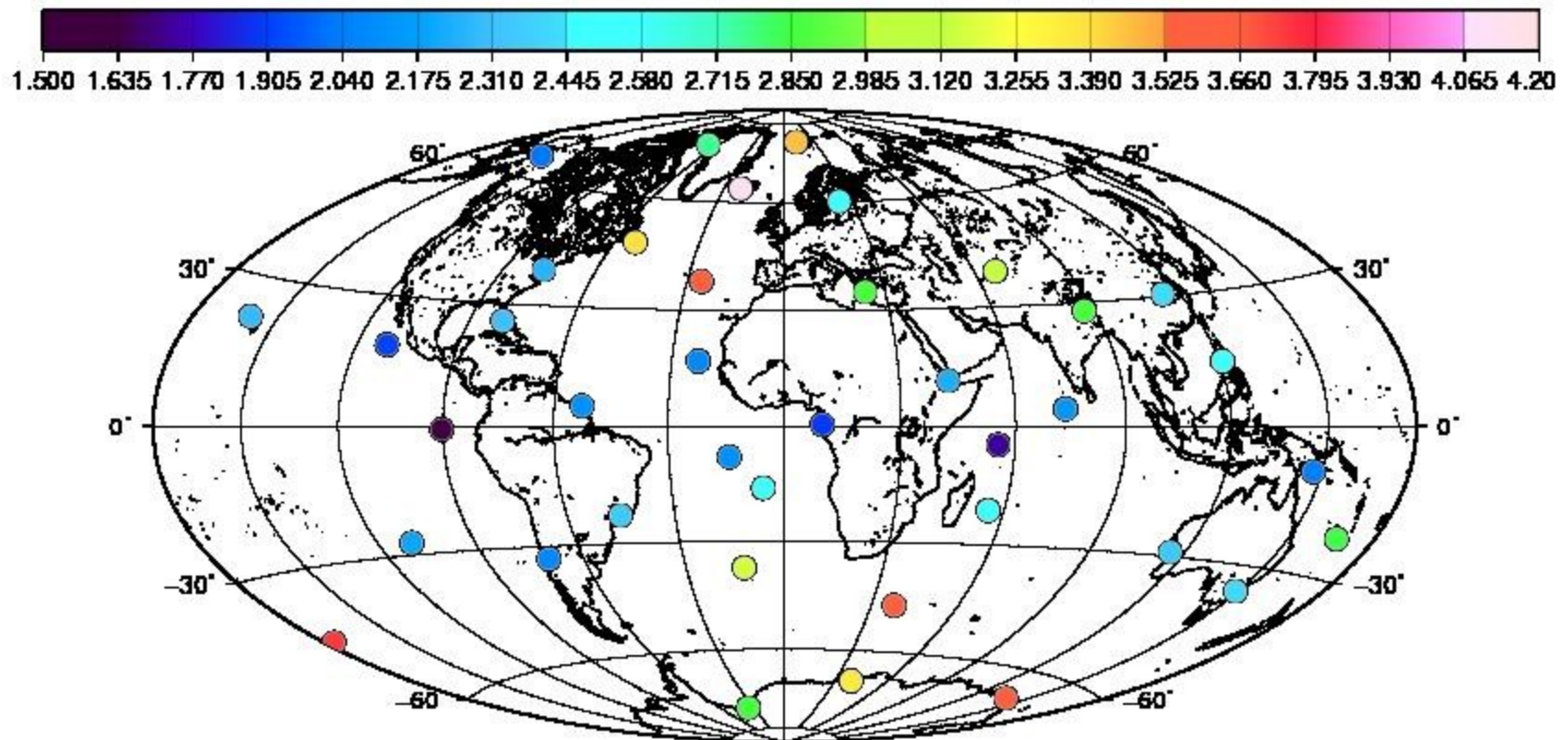

courtesy Jean-Paul Boy
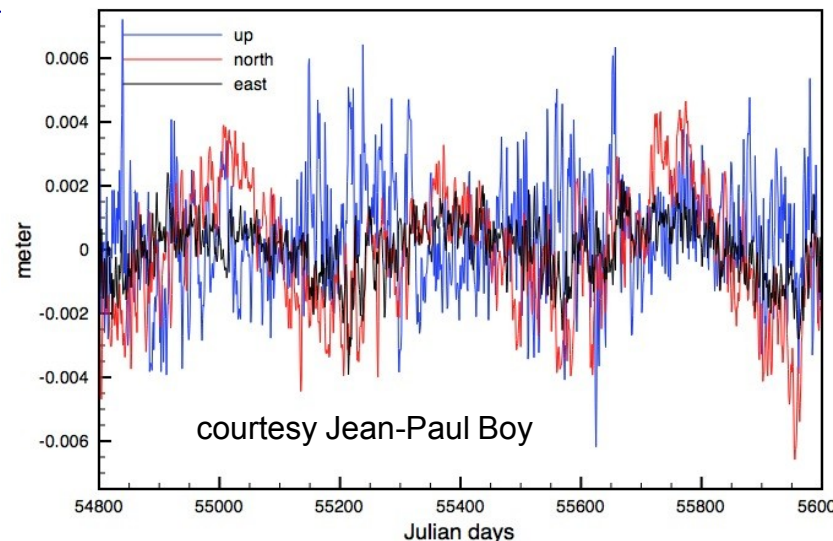
Many thanks to Tonie Van Dam and to Jean-Paul Boy for their help validating the GEODYN implementation!!
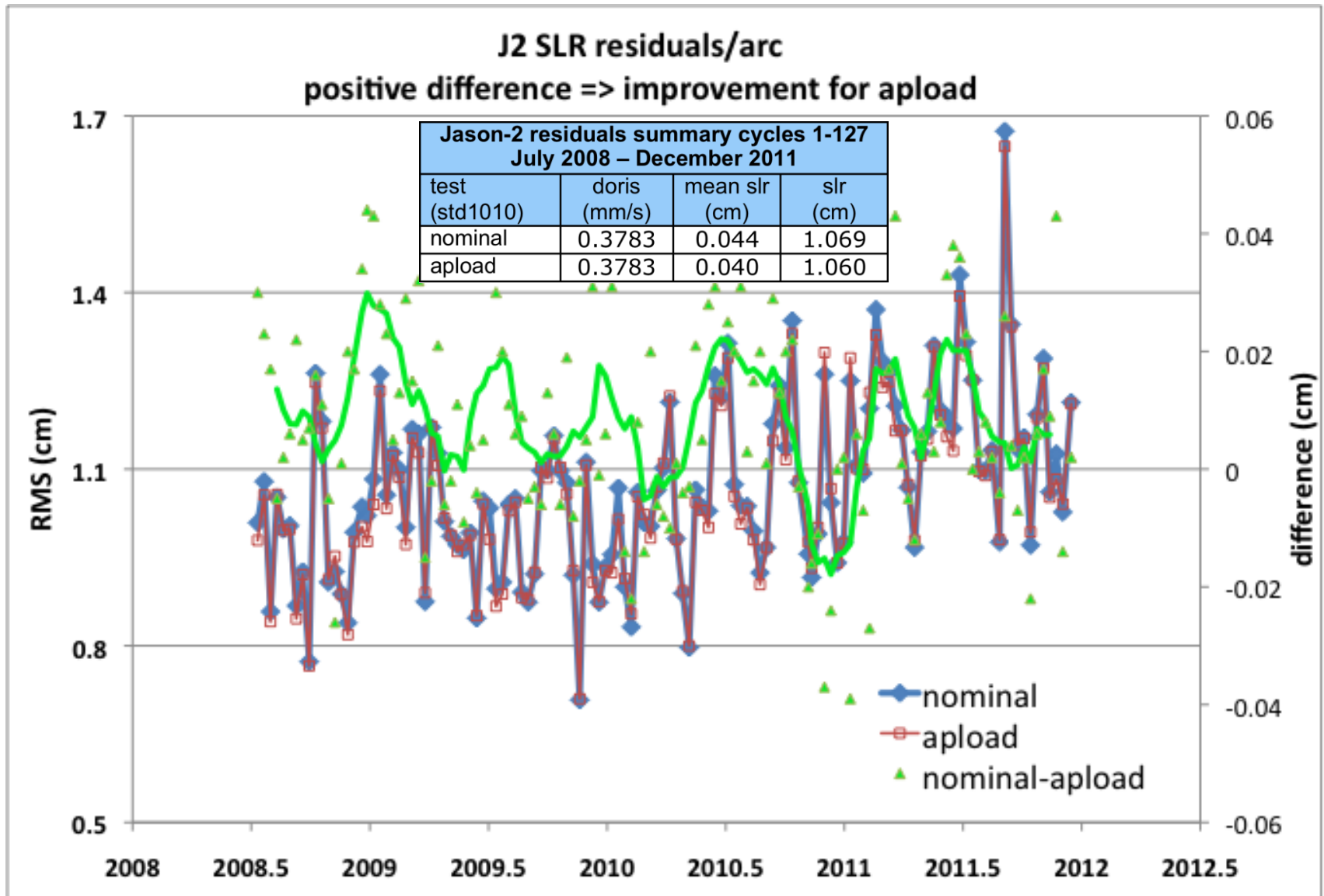
Atmospheric loading (apload) displacement on average varies from about 1-5 mm RMS by station

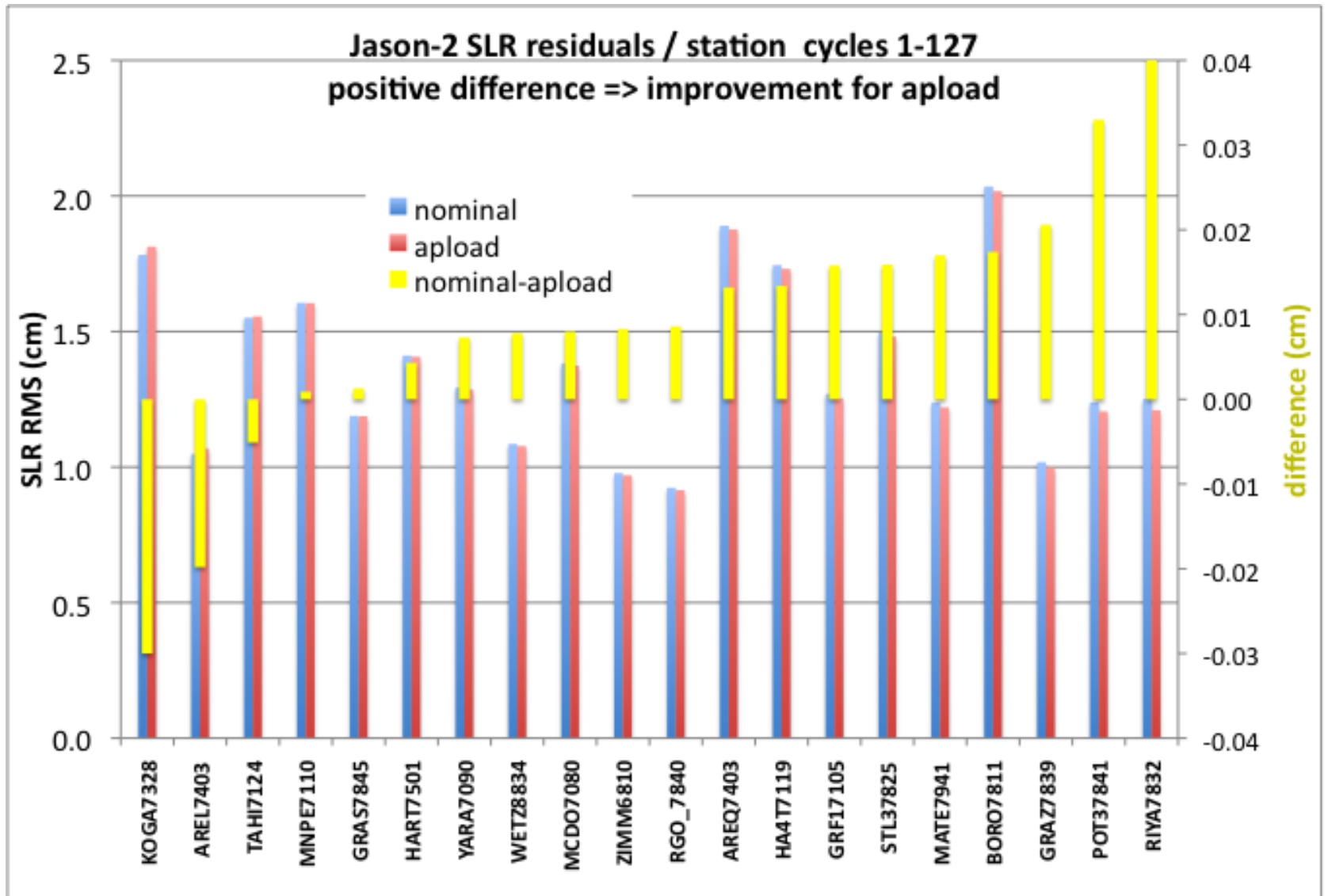**apload RMS (mm) for 39 DORIS stations tracking Jason-2 cycles 1-57**

SLR residuals improve with apload, DORIS residuals not sensitive

J2 SLR residuals/arc
positive difference => improvement for apload

Jason-2 residuals summary cycles 1-127 July 2008 – December 2011			
test (std1010)	doris (mm/s)	mean slr (cm)	slr (cm)
nominal	0.3783	0.044	1.069
apload	0.3783	0.040	1.060

SLR residuals improve for most stations

Jason-2 SLR residuals / station cycles 1-127
positive difference => improvement for apload

apload effect on SLR/DORIS orbits is small, with annual 1-2 mm amplitude in Z

Jason-2 apload-nominal SLR/DORIS orbit differences
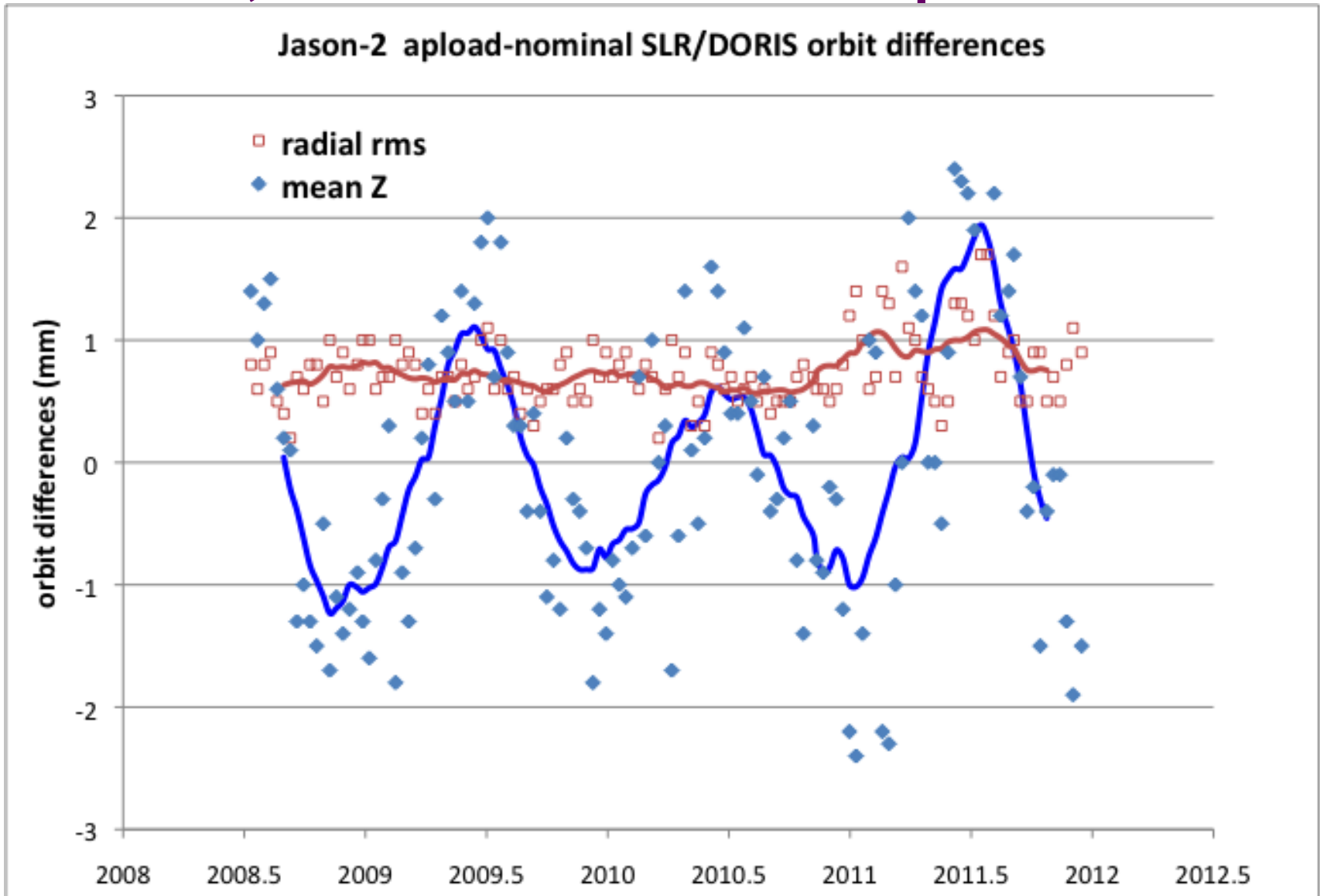
New GSFC GSC DORIS weekly station solutions – gscwd13

• Data to DORIS satellites are updated from the operational gscwd12 processing.

• New GSFC POD standards, std1201, are applied which include GOCO2S_fit (Gravity Model), GOT4.8, ocean pole tide, GOT4.8 ocean loading, GMF/Saastamoinen/GPT instead of EIGEN-GL04S1/GOT4.7, Niell/Hopfield/GPT.

• All available satellites used to form weekly station-only solutions with SOLVE (weakly constrained). Satellites include SPOT2 (through 2009), SPOT4, SPOT5, ENVISAT, Jason2 (after July 2008), Cryosat2 (after June 2010).

• The baseline run is done without atmospheric loading and will be designated gscwd13. It will form basis of new operational series and is prelude to reprocessing & model updates for next ITRF.

• The atmospheric loading is applied on top of the gscwd13 modeling.

• Both SINEX series will be submitted to the IERS in response to the IERS Call (Toni Van Dam, Xavier Collilieux).

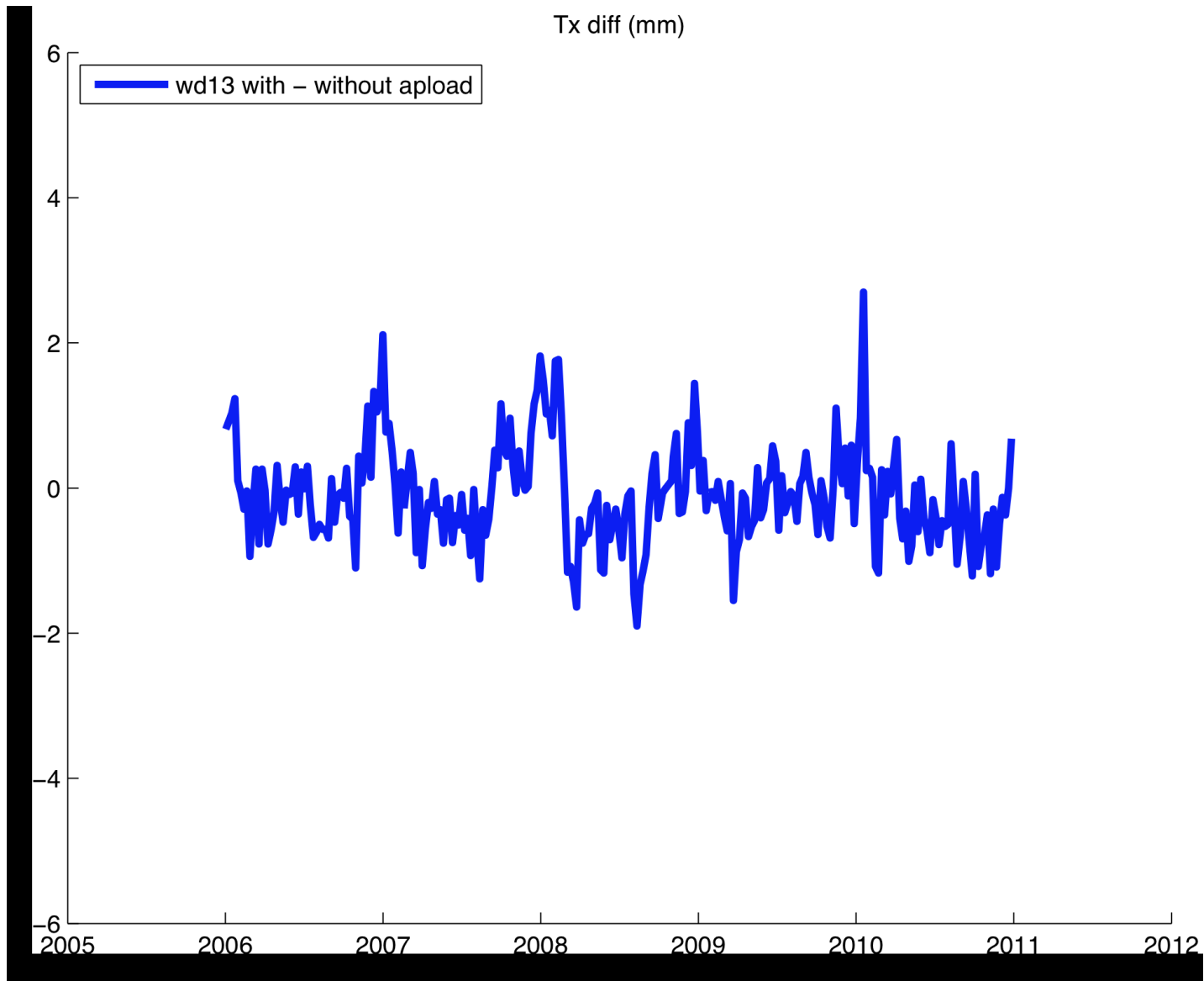# DORIS weekly GSFC station solutions
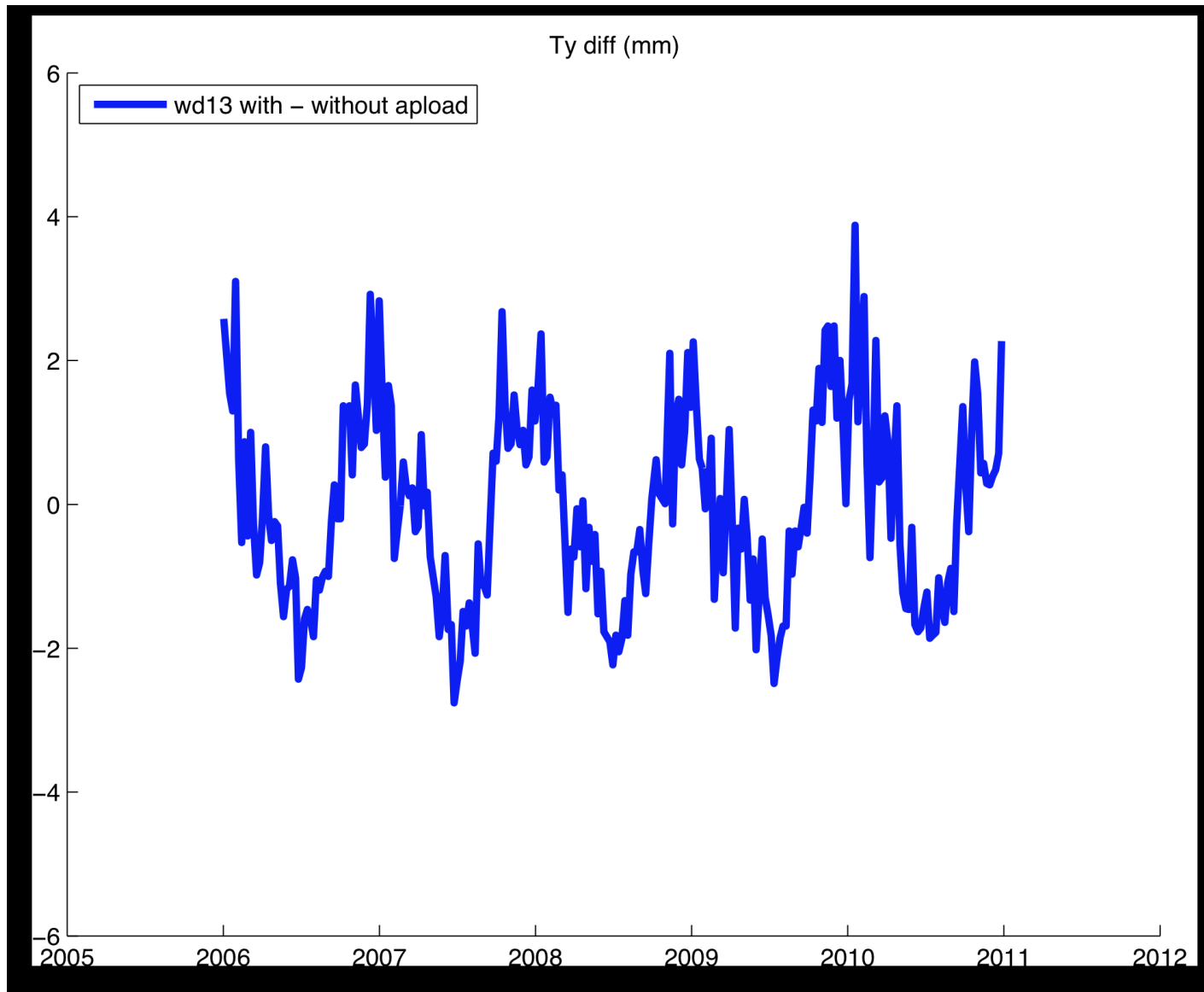# Helmert transfer to DPOD2008_1.9

Helmert translation in X (mm)
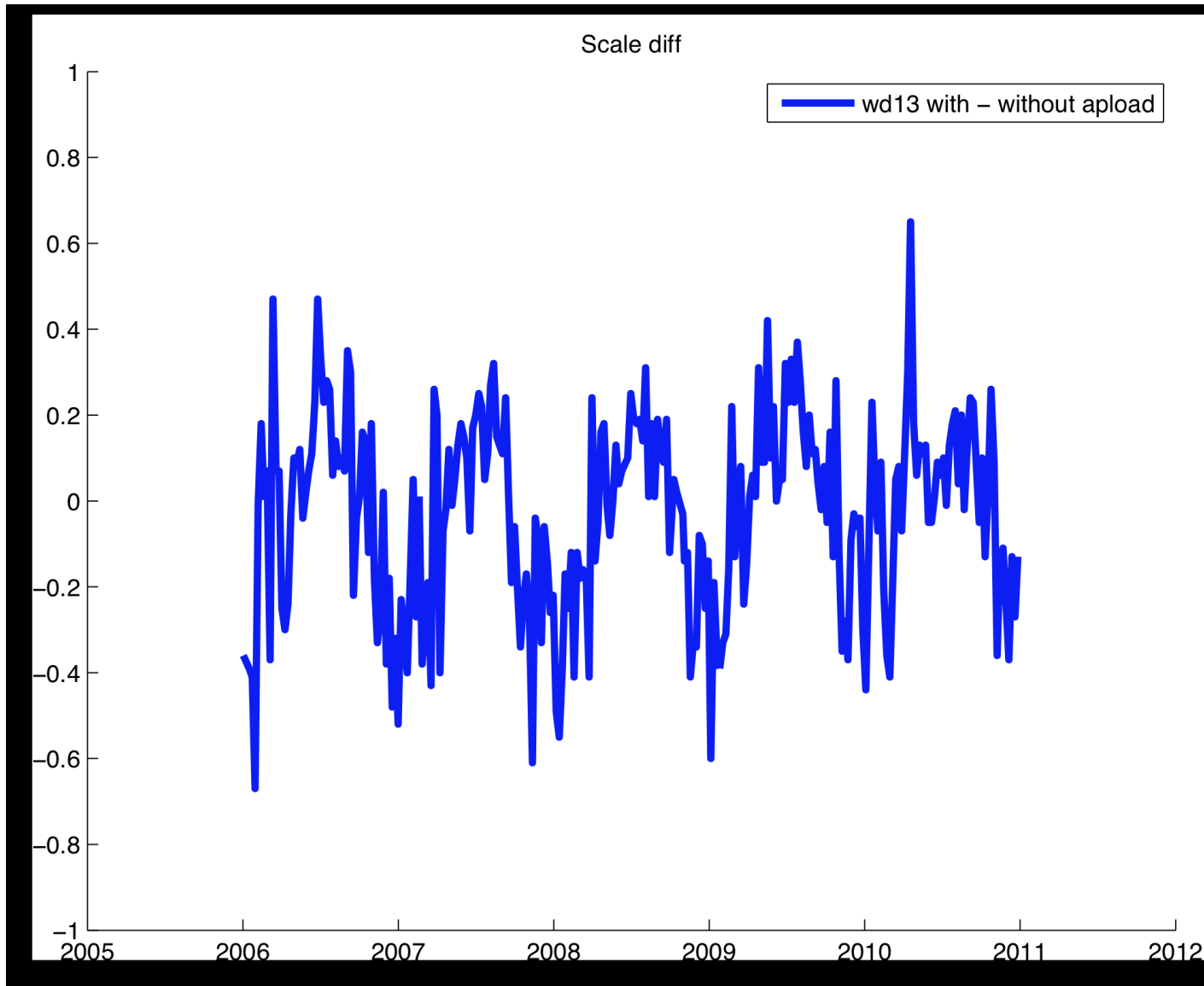
Difference apload-nominal Helmert X (mm)

Tx diff (mm)

Legend: wd13 with – without apload
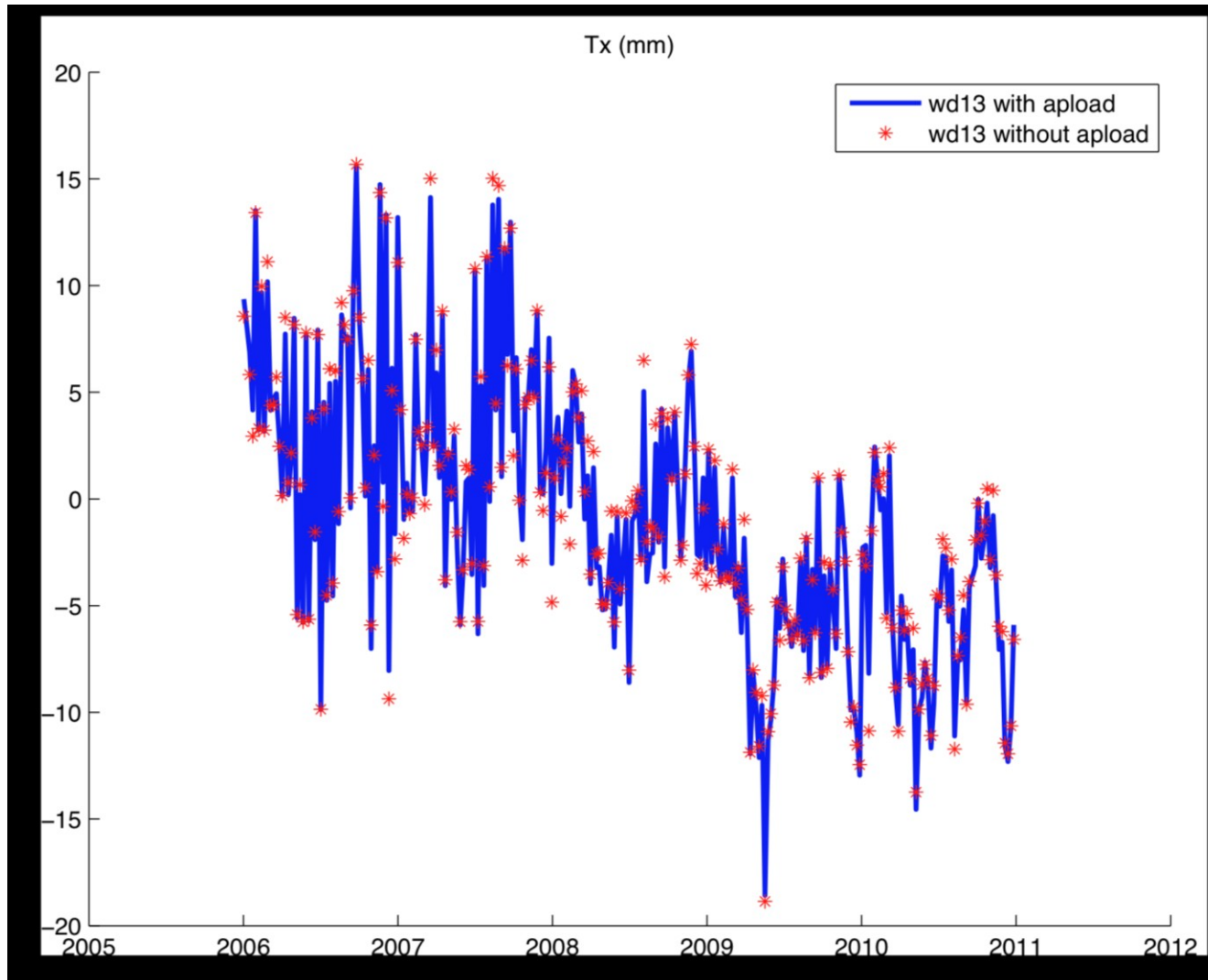
Difference apload-nominal Helmert Y (mm)

Ty diff (mm)

Difference apload-nominal Helmert Scale (mm)

Summary - apload

Atmospheric station loading (apload) based on 6-hour ECMWF pressure data has been implemented in GEODYN and evaluated with SLR and DORIS processing.

a) **Jason-2 SLR residuals show a small, but consistent improvement over most stations.**

b) **Jason-2 SLR/DORIS orbits show a 1-2 mm annual amplitude in Z**

c) **DORIS gscwd13 station solution Helmert parameter differences show strong annual signals in Y of 2 mm amplitude and in scale of 0.4 mm amplitude (0.06 ppb).**

d) **DORIS gscwd13 station solution with and without apload will be submitted to the IERS.**
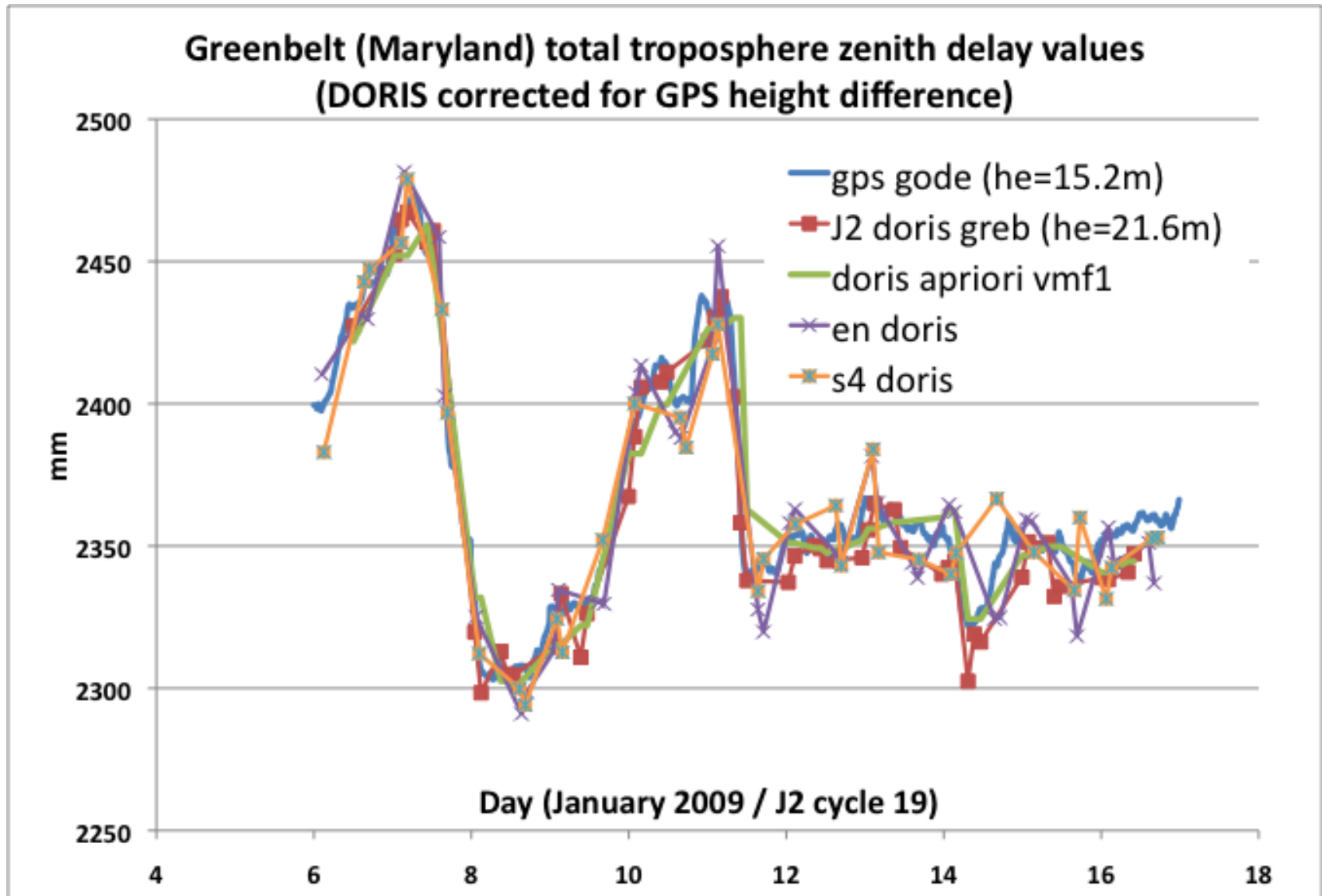
Improved troposphere modeling - Outline

• The gridded Vienna Mapping Function (VMF1) troposphere refraction modeling capability has recently been implemented in GEODYN and is evaluated using DORIS. The gridded dry/wet zenith delay heights are reduced to the station height following Kouba (2007).

• DORIS VMF1 total zenith delay estimates compared to GPS.

• Jason-2 POD used to compare:
  • VMF1
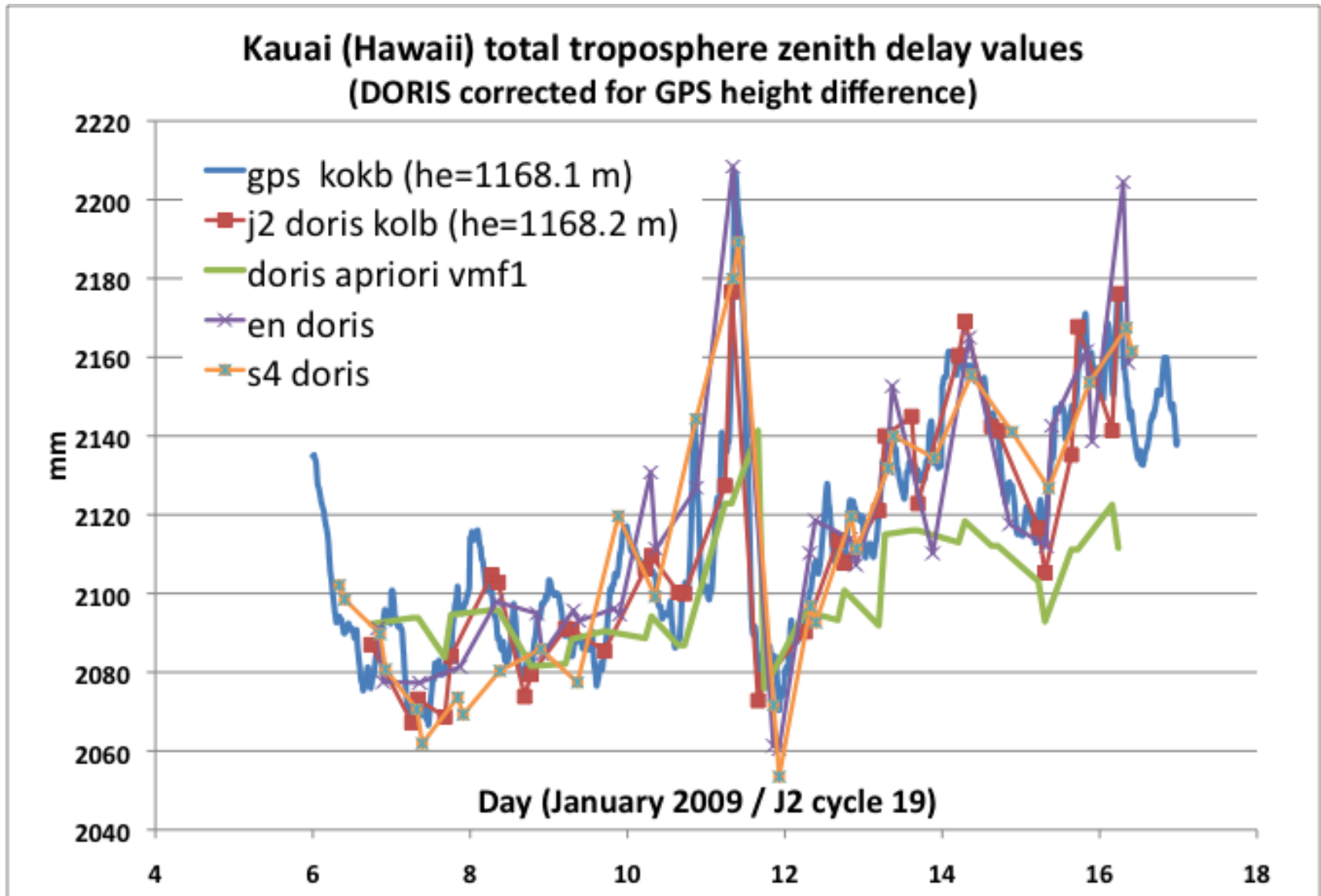 • GMF/GPT/Saastamoinen
  • Niell/GPT/Hopfield

Greenbelt (Maryland) total troposphere zenith delay values (DORIS corrected for GPS height difference)

Legend:
- gps gode (he=15.2m)
- J2 doris greb (he=21.6m)
- doris apriori vmf1
- en doris
- s4 doris

Day (January 2009 / J2 cycle 19)

Total Zenith Delay Estimate – Kauai (total VMF1 = apriori dry + estimated wet)

Kauai (Hawaii) total troposphere zenith delay values
(DORIS corrected for GPS height difference)

Legend:
- gps kokb (he=1168.1 m)
- j2 doris kolb (he=1168.2 m)
- doris apriori vmf1
- en doris
- s4 doris

Day (January 2009 / J2 cycle 19)

Syowa (Antartica) total troposphere zenith delay values
(DORIS corrected for GPS height difference)

Legend:
- gps syog (he=50.7 m)
- J2 doris sypb (he=44.1 m)
- doris apriori (vmf1)
- en doris sypb
- s4 doris sypb

Day (January 2009 / J2 cycle 19)
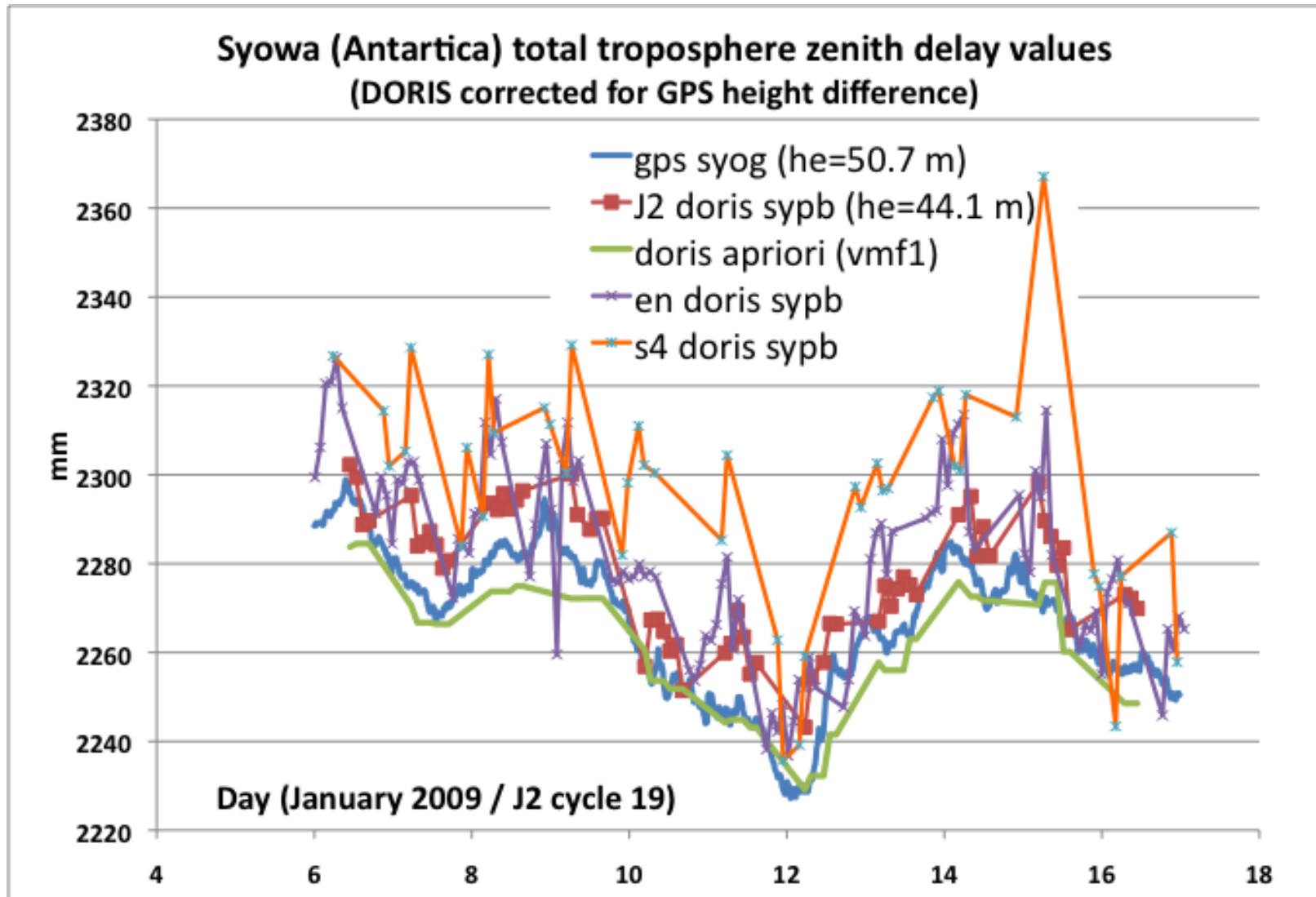
Total Zenith Delay Estimate – Yarragadee (total VMF1 = apriori dry + estimated wet)

Yarragadee (Australia) total troposphere zenith delay values
(DORIS corrected for GPS height difference)

Legend:
- gps yar2 (he=242.0 m)
- j2 doris yasb (he=244.2 m)
- doris apriori vmf1
- en doris
- s4 doris

Day (January 2009 / J2 cycle 19)
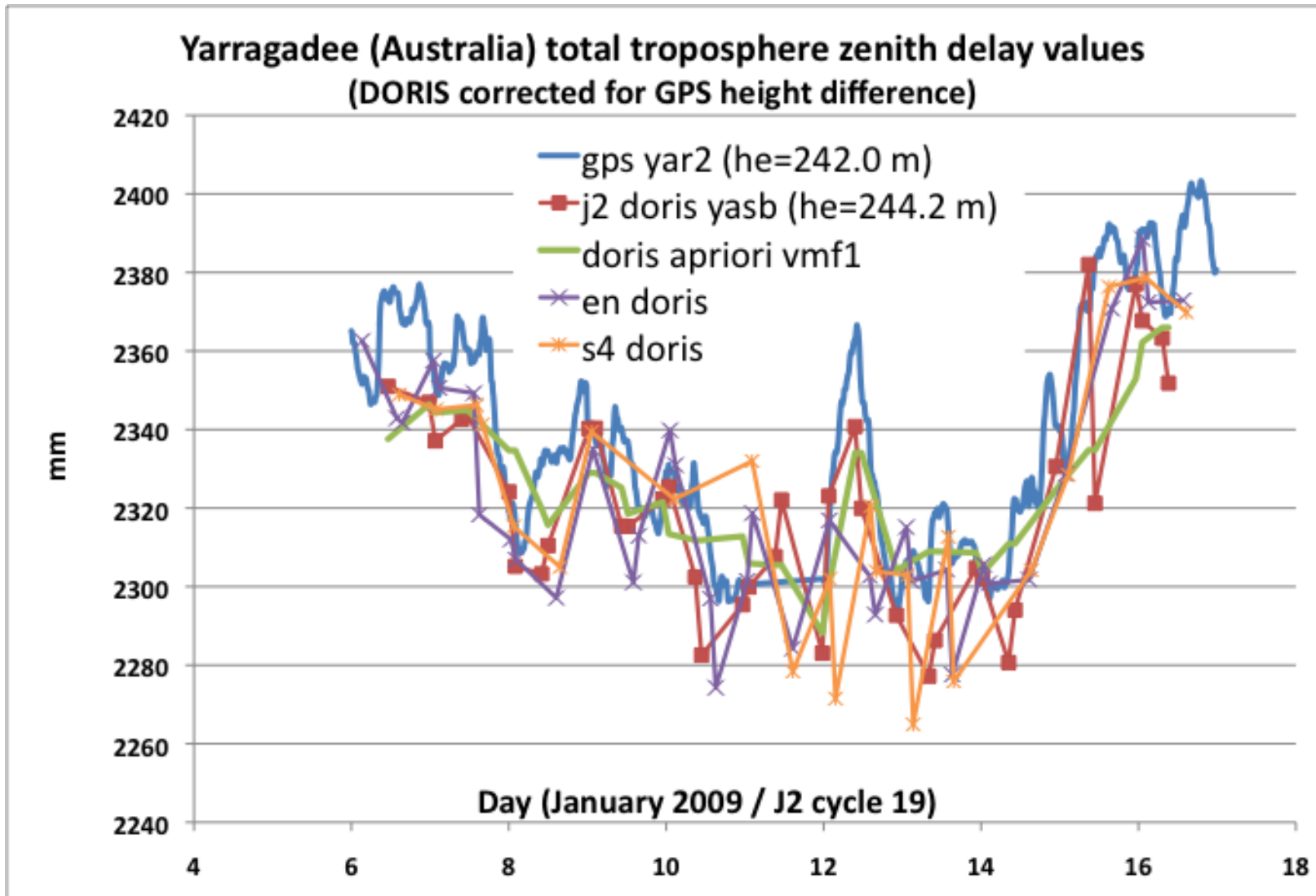
VMF1 impact on Jason-2 Orbit

Jason-2 DORIS orbit difference/cycle due to troposphere modeling: (Saastamoinen, GPT, GMF) - (VMF1)
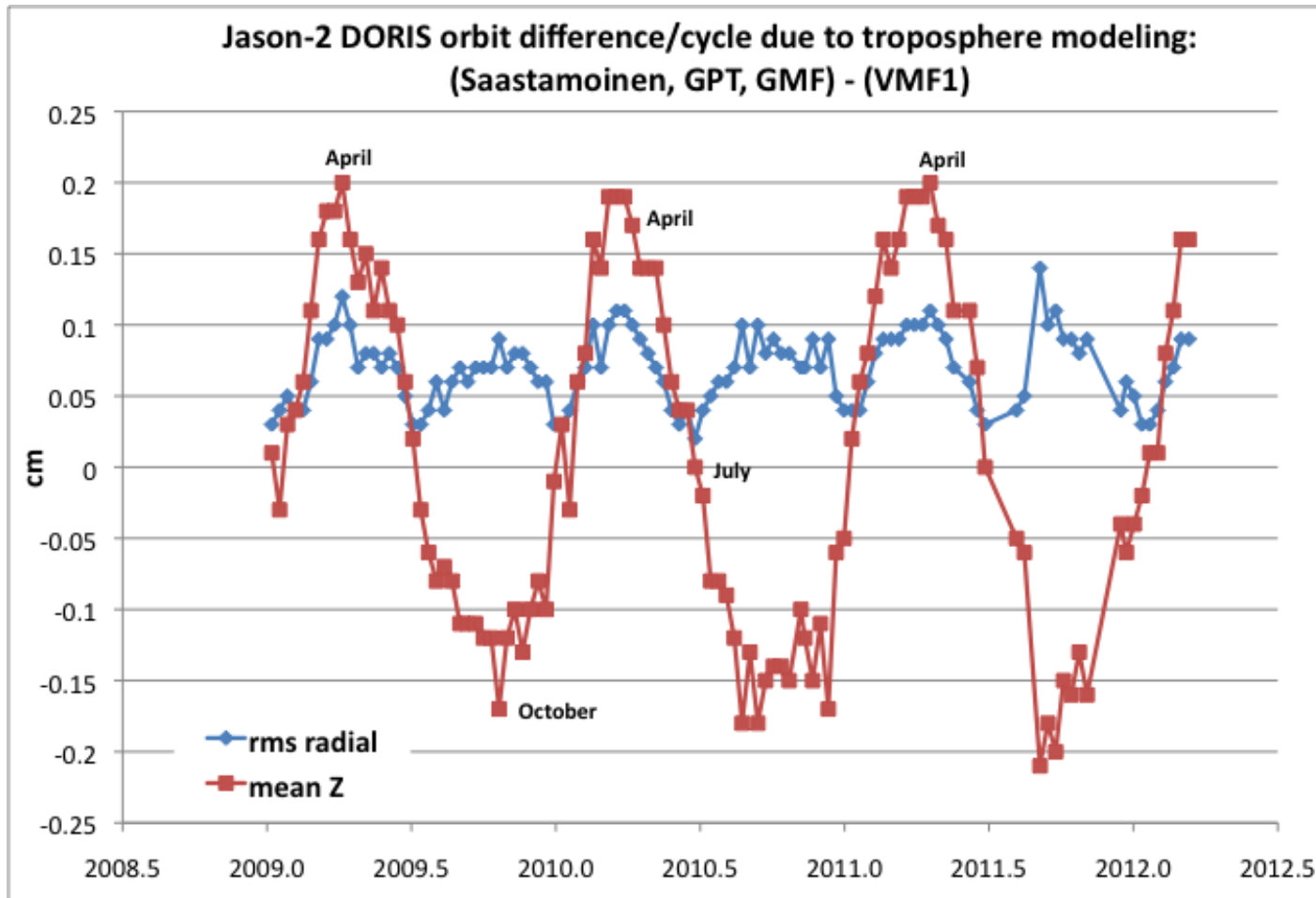
- 1 mm RMS signal in radial orbit differences;
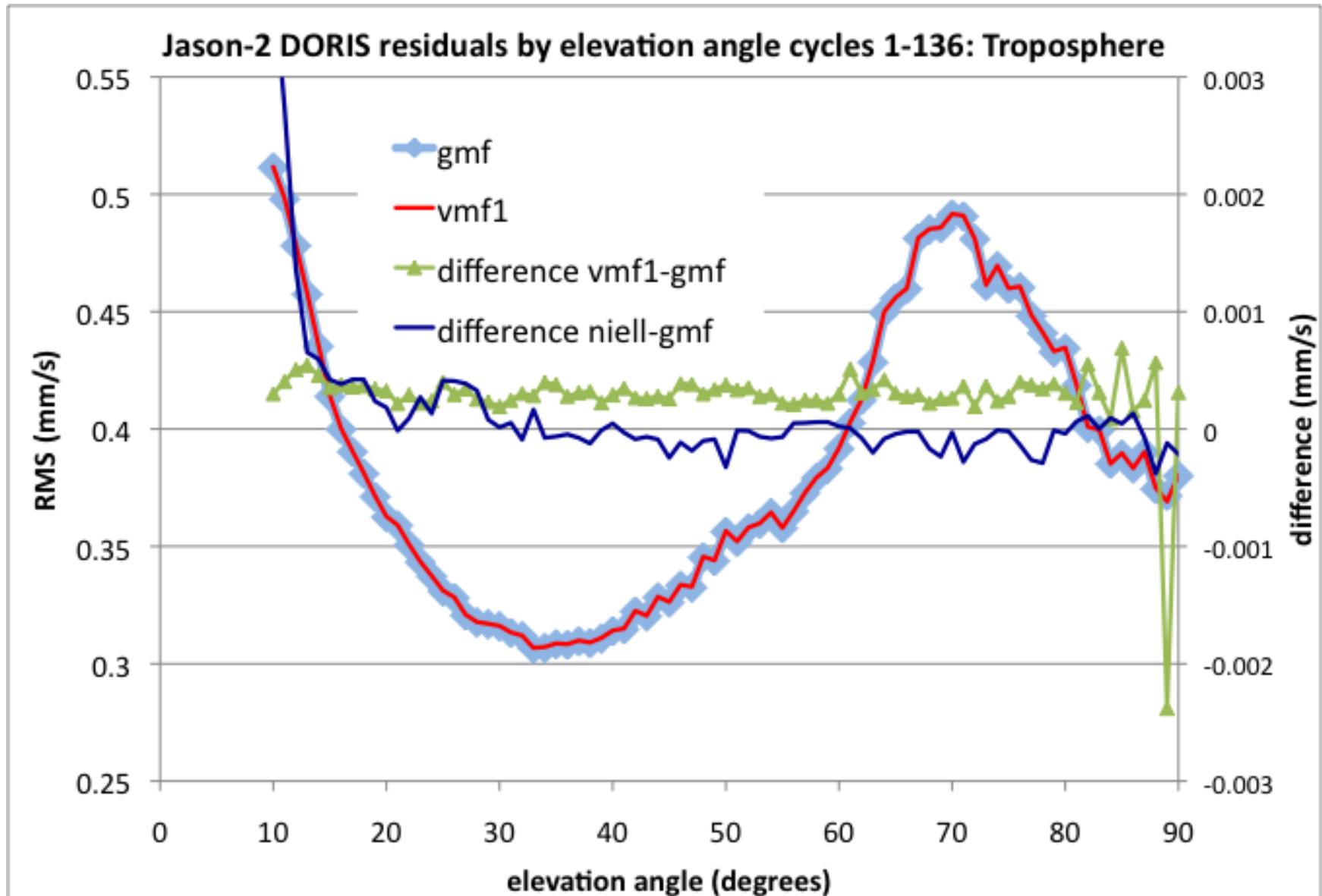- Annual signal in Z orbit differences – peak-to-peak of up to 3-4 mm.

DORIS-only Jason-2 POD performance

Jason-2 residuals summary cycles 1-136: Troposphere July 2008 – April 2012			
test (DORIS-only) mapping/zenith/meteo.	doris (mm/s)	independent data	
		slr (cm)	xover (cm)
Niell/ Hopfield/ GPT	0.3781	1.781	5.505
GMF/ Saastamoinen/ GPT	0.3777	1.849	5.504
VMF1 gridded	0.3781	1.837	5.505

DORIS residuals by elevation angle

Jason-2 DORIS residuals by elevation angle cycles 1-136: Troposphere

DORIS residuals by station

Jason-2 DORIS residuals cycle 1-136: Troposphere difference positive => improvement for gmf
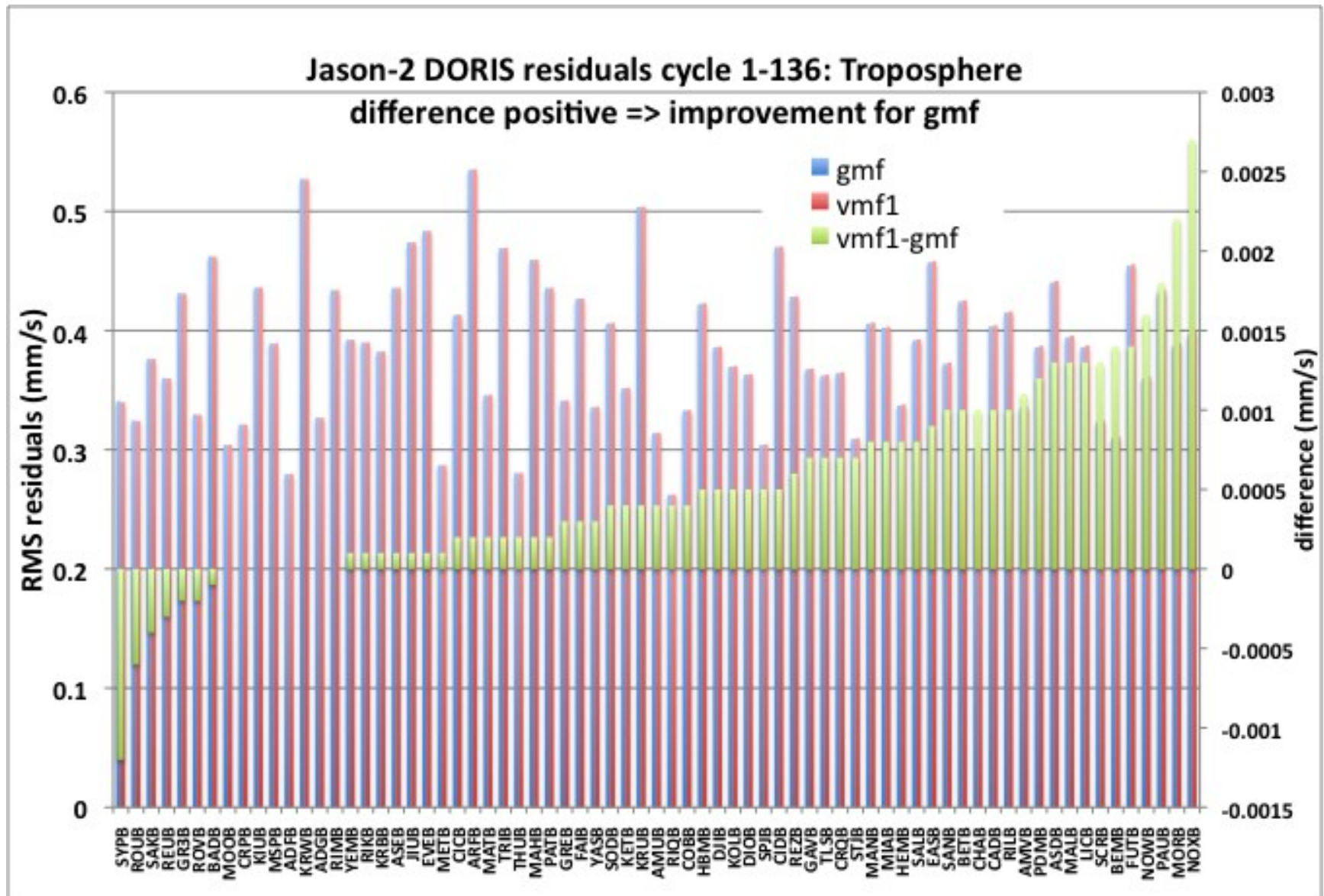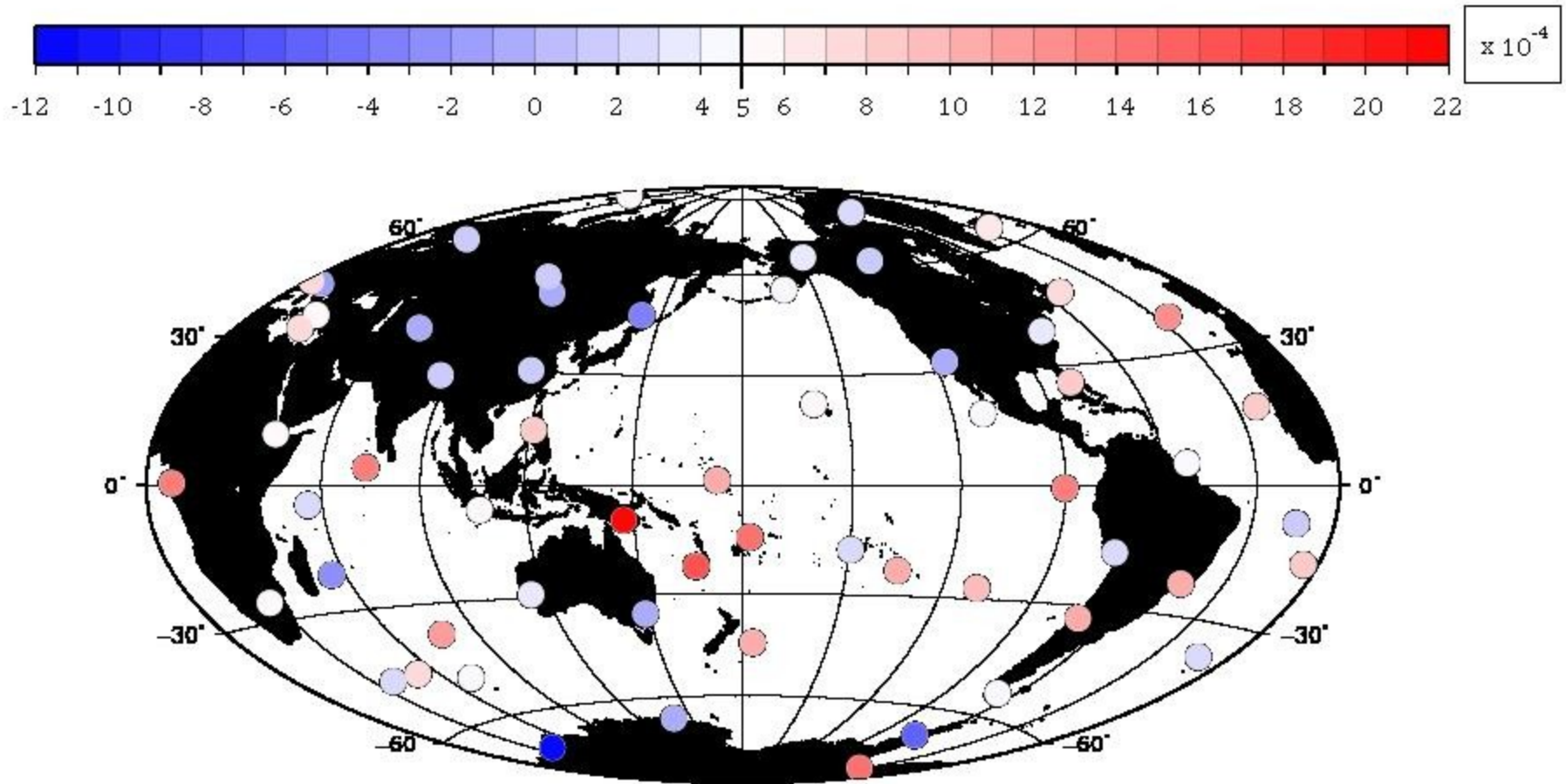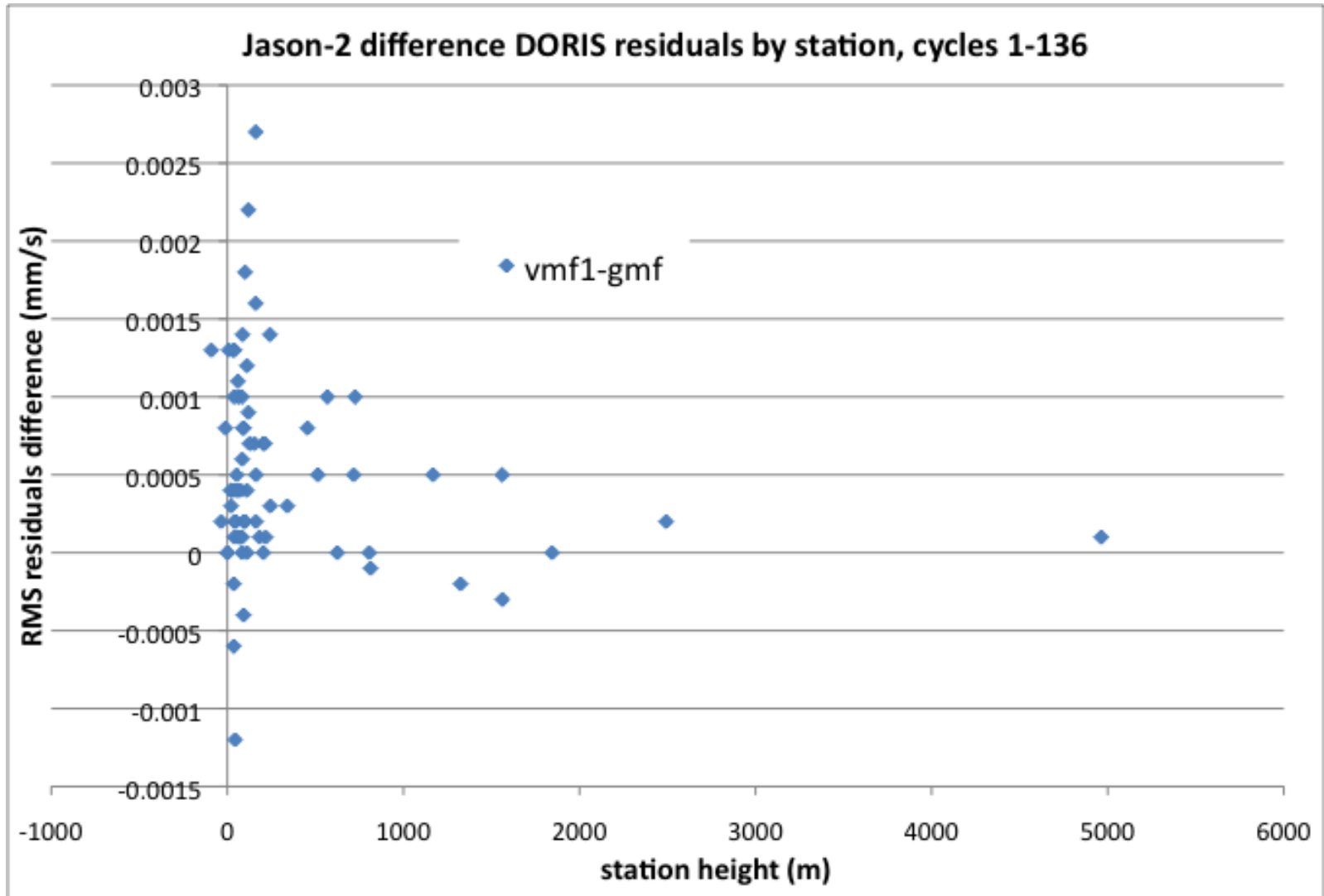
DORIS (vmf1-gmf) difference residuals by station location

DORIS (vmf1-gmf) difference residuals by station height

Jason-2 difference DORIS residuals by station, cycles 1-136

Summary - Troposphere

VMF1 gridded capability has been implemented in GEODYN and evaluated with DORIS processing.

a) VMF1 zenith delay DORIS estimates compare to those from GPS in a sanity check

b) Jason-2 DORIS residuals are very slightly, but consistently degraded using VMF1 compared to GMF/GPT.

c) VMF1 will be further evaluated with station solution comparison which includes atmospheric station loading and also using GPS data.

d) Other gridded VMF1 station height reduction approximations will be tested such as Steigenberger et al. (2009)

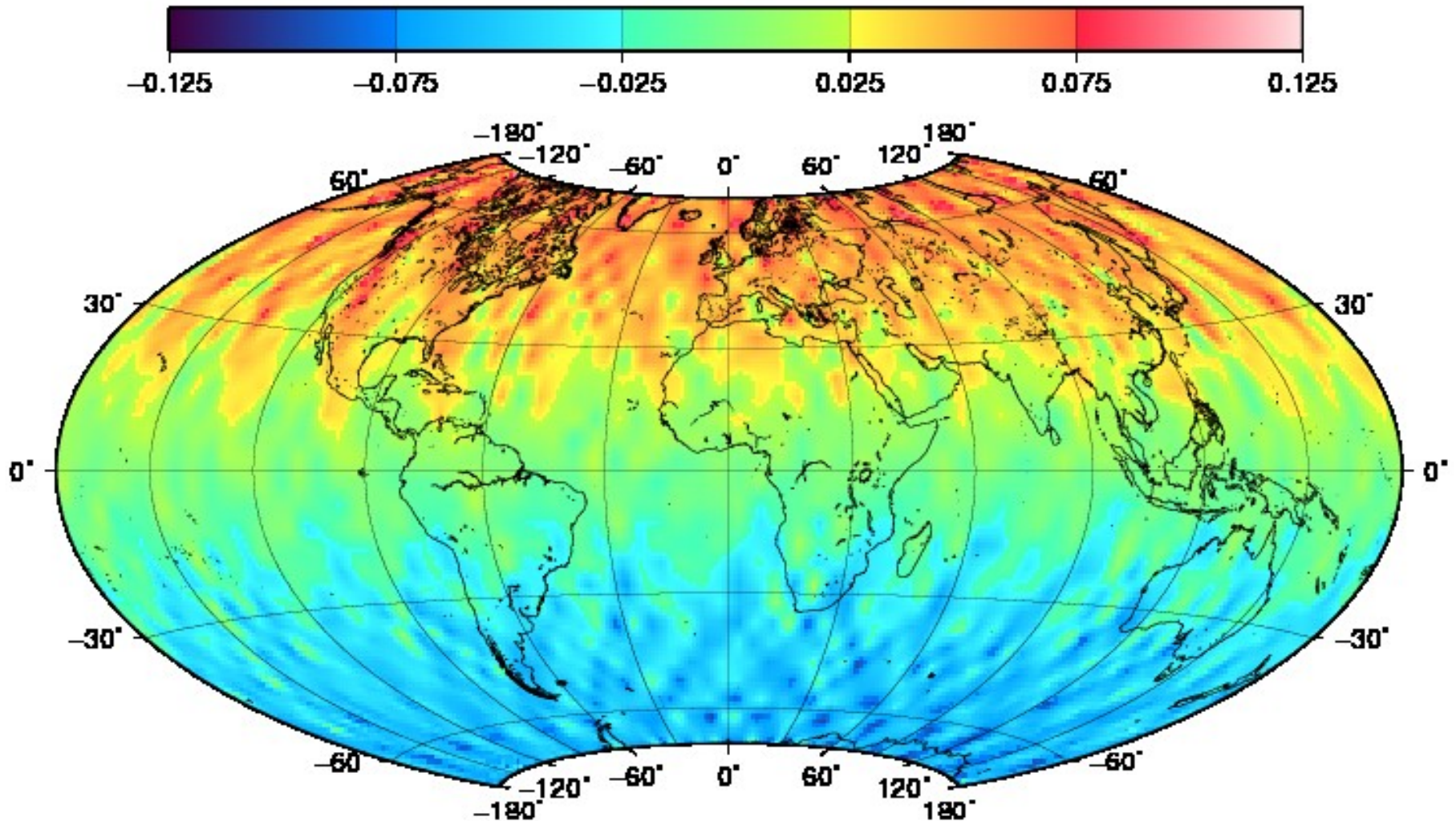# BACKUP

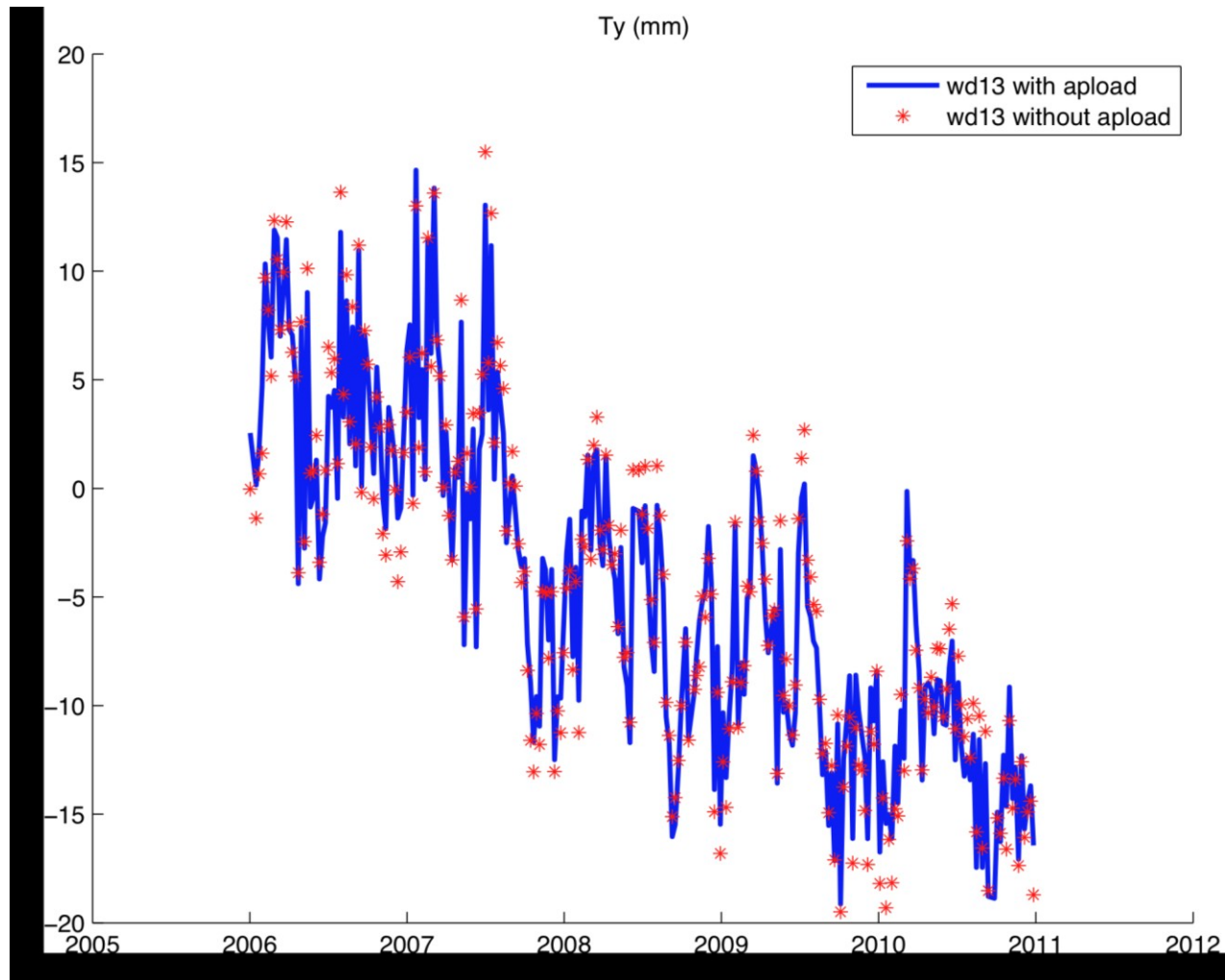# Jason-2 nominal-apload mean radial orbit differences cycles 1-57 (mm)
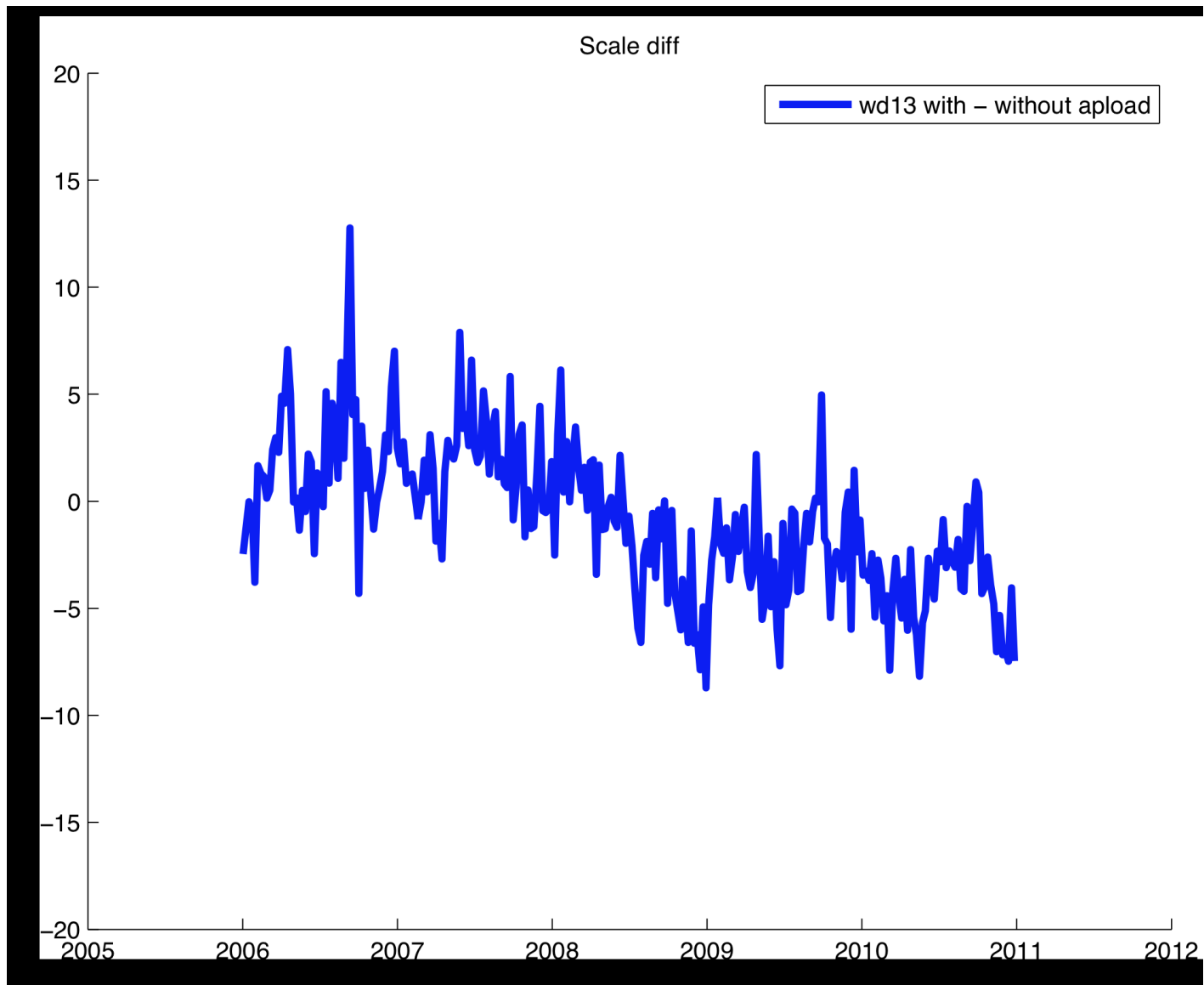
Helmert translation in Y (mm)

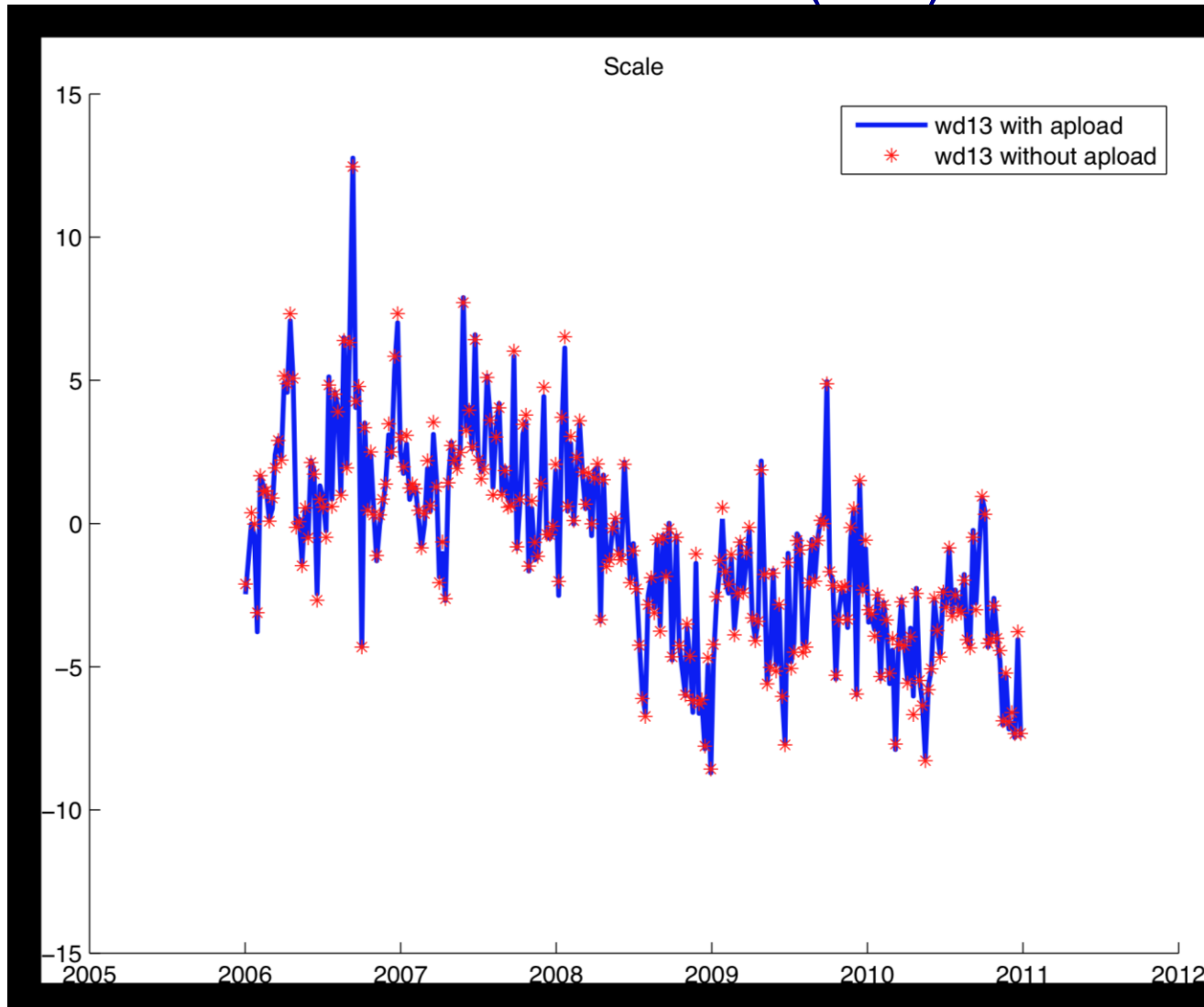# Difference apload-nominal Helmert Z (mm)

DORIS weekly GSFC station solutions
Helmert transfer to DPOD2008_1.9

Helmert Scale (mm)

Total Zenith Delay Estimate – summary (total VMF1 = apriori dry + estimated wet)

Mean troposphere total zenith delay estimated by GPS and DORIS satellites (Jan 6, 2009 - Jan 16, 2009)