Improved Orbit Standards for Altimeter Satellite POD at GSFC

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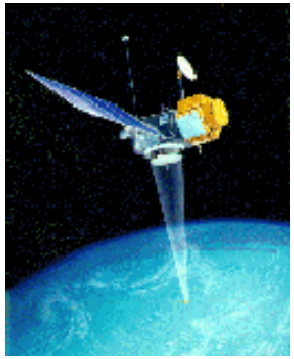
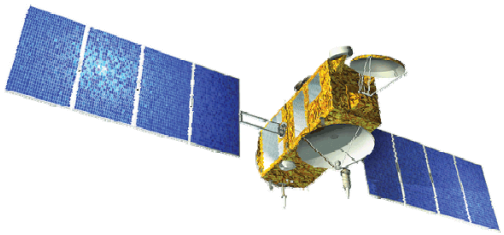


OSTST 2012 POD Splinter
Venice, Italy
September 28, 2012



Sources of Orbit Error and Instability

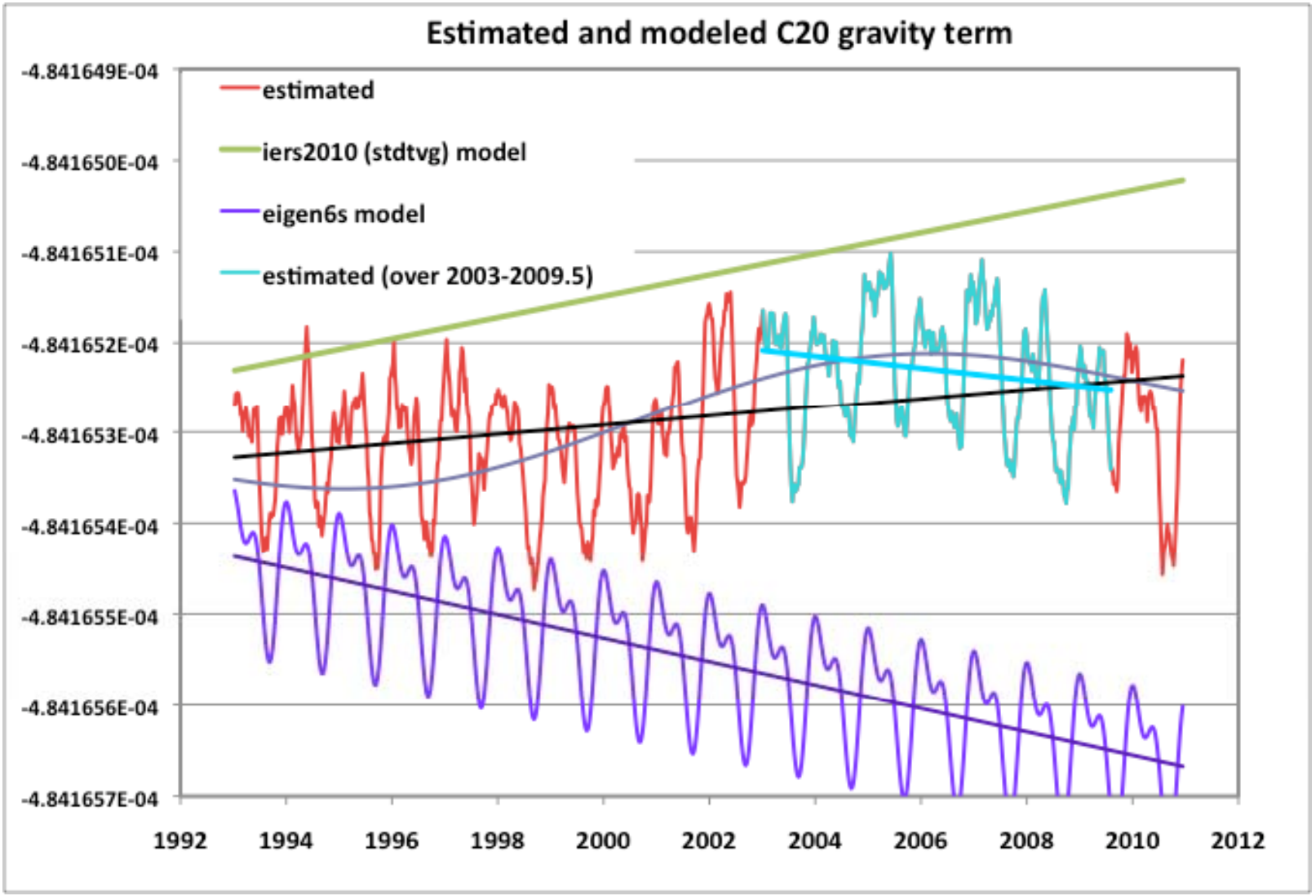
Error	Affect on MSL estimates
Reference Frame	long term or sporadic linear trends North-South regions
Behavior of Tracking Systems (SLR, DORIS, GPS)	long term or sporadic trends, variable
Time Variable Gravity (TVG)	long term linear trends, annual, semi-annual, and possibly other periodic terms
Solar Radiation Pressure (SRP)	118-day term

Changes to GSFC POD Standards

Goal: POD standards which insure consistent and accurate orbits across all missions

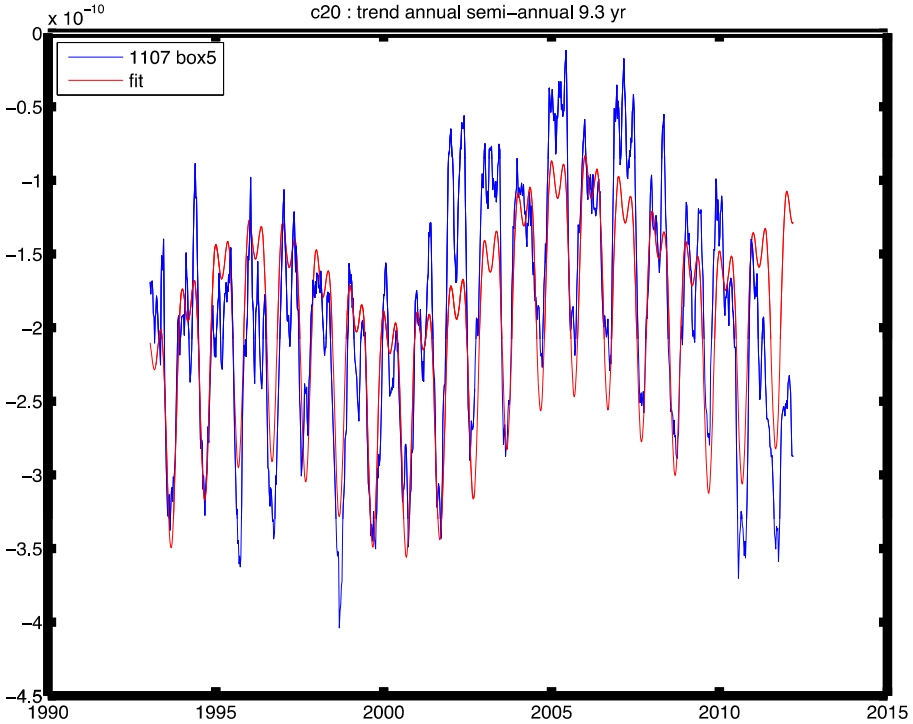
model changed	std1007 (Measures)	std1201 (new)	std1201_tvg4x4 (experimental)
SLR/DORIS stations	ITRF2008	SLRF2008, DPOD2008	same
ocean loading	GOT4.7	GOT4.8	same
static gravity	EIGEN_GL04S	GOCO2S_fit	GGM03S
time varying gravity	standard (stdtvg)	fit to tvg4x4 (goco2s_fit)	tvg4x4
dynamic tides	GOT4.7	GOT4.8	same
J2 radiation scale	tuned 2008	retuned 2011	same
J1/J2 emp. param.	24-hour opr	12-hour opr	same
DORIS troposphere	Niell, estim. wet+dry	GMF, estim. wet	same

Advantage / Disadvantage between TVG model and gravity coefficient time series

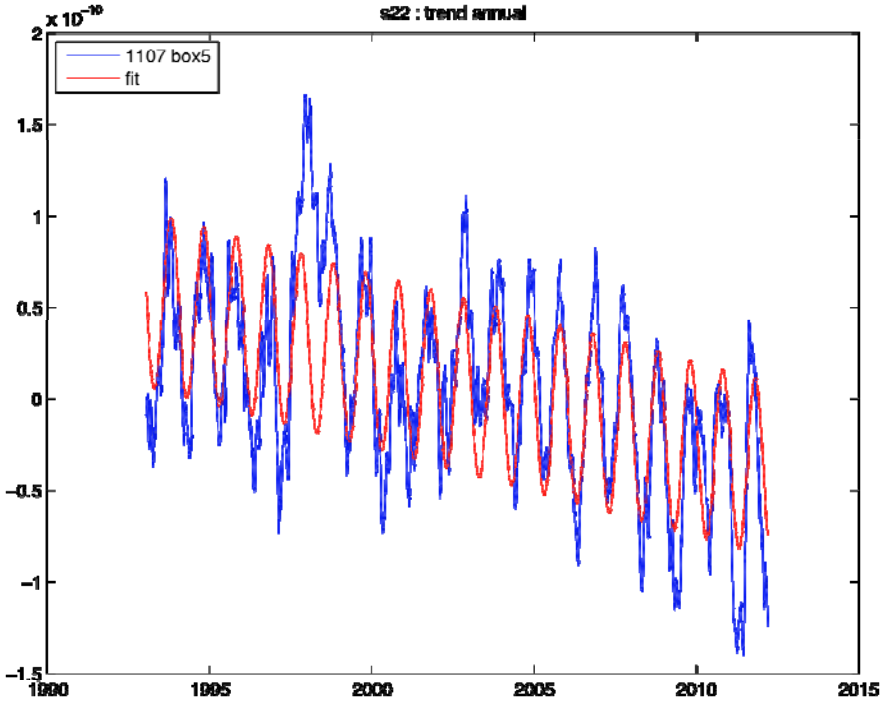


The goco2s_fit TVG model: Examples

C_{20} : estimate trend, annual, semi-annual, 9.3 year



S_{22} : estimate trend, annual



4x4 SLR/DORIS time series (blue curves)
Harmonic Fits to time series (red curves)

Orbits and Time Varying Gravity (TVG) Modeling

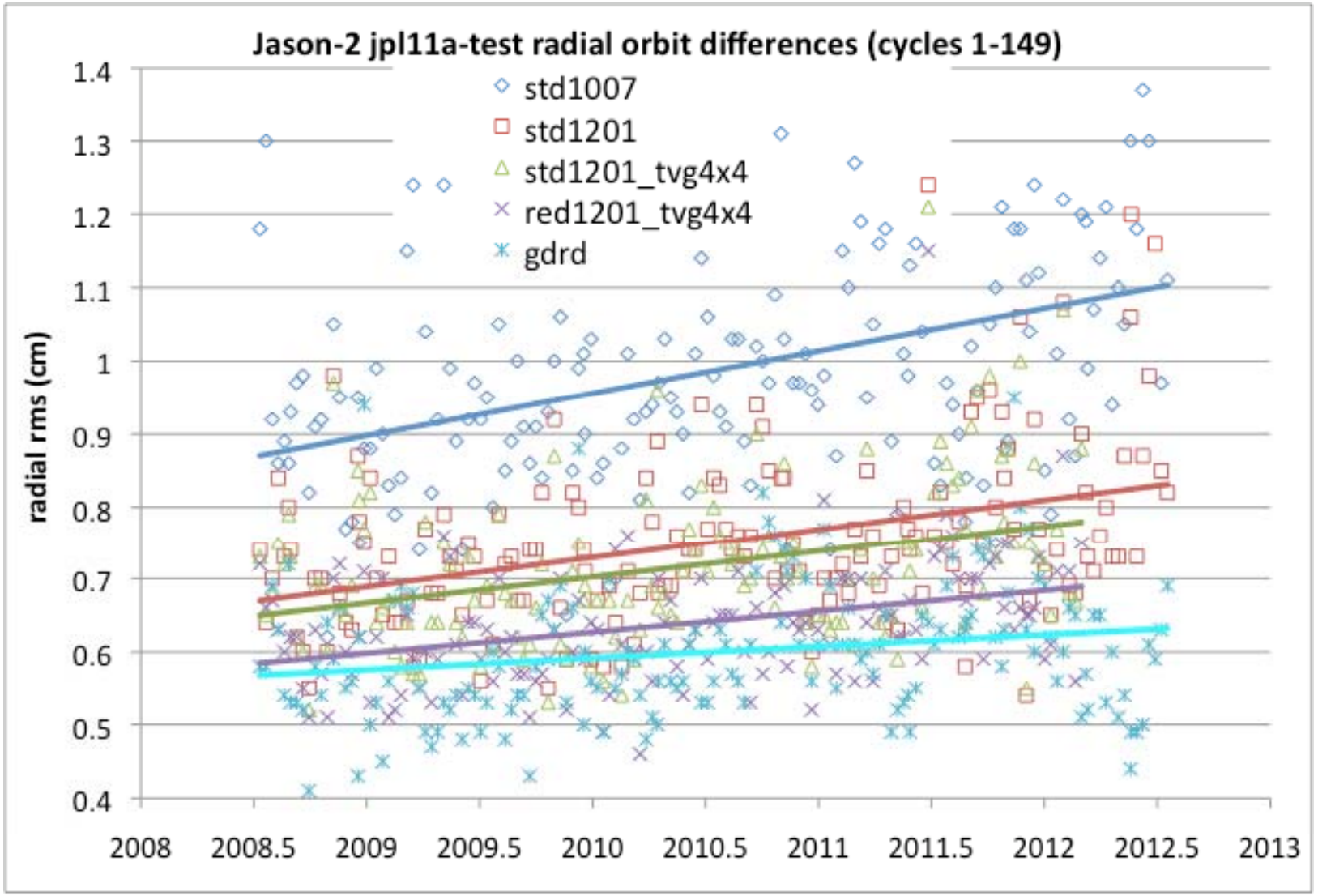
Orbit	TVG Description (atmosphere gravity is forward modeled using ECMWF / NCEP 6-hour pressure data)
std1007 GSFC	**stdtvg:** Linear rates for C_{20}, C_{30}, C_{40}, C_{21}, S_{21}, (IERS 2010, 2003) based on 17 years of SLR data. Plus 20x20 annual field derived from GRACE data. EIGEN_GL04S static field.
std1201 GSFC	**goco2s_fit:** GSFC annual, semi-annual and linear terms estimated from the 19-year **tvg4x4** time series are applied depending on the coefficient. GOCO2S static field.
experimental std1201 red1201 _tvg4x4 _tvg4x4noj2	**tvg4x4:** GSFC 4X4 7-day time series from 1993 re-estimated using SLR/DORIS tracking to 10 satellites; GGM03S static field. **tvg4x4noj2:** as **tvg4x4** without Jason-2 data
gdrd CNES	EIGEN-GRGS_RL02bis_mean, annual, semi-annual and linear terms up to degree/order 50
jpl11a JPL	GPS-based reduced-dynamic rlse11a, no TVG or forward modeling of atmosphere gravity. GGM02C static

For more TVG detail please see:
GSFC “Improved Modeling of Time Variable Gravity for Altimeter Satellite POD”

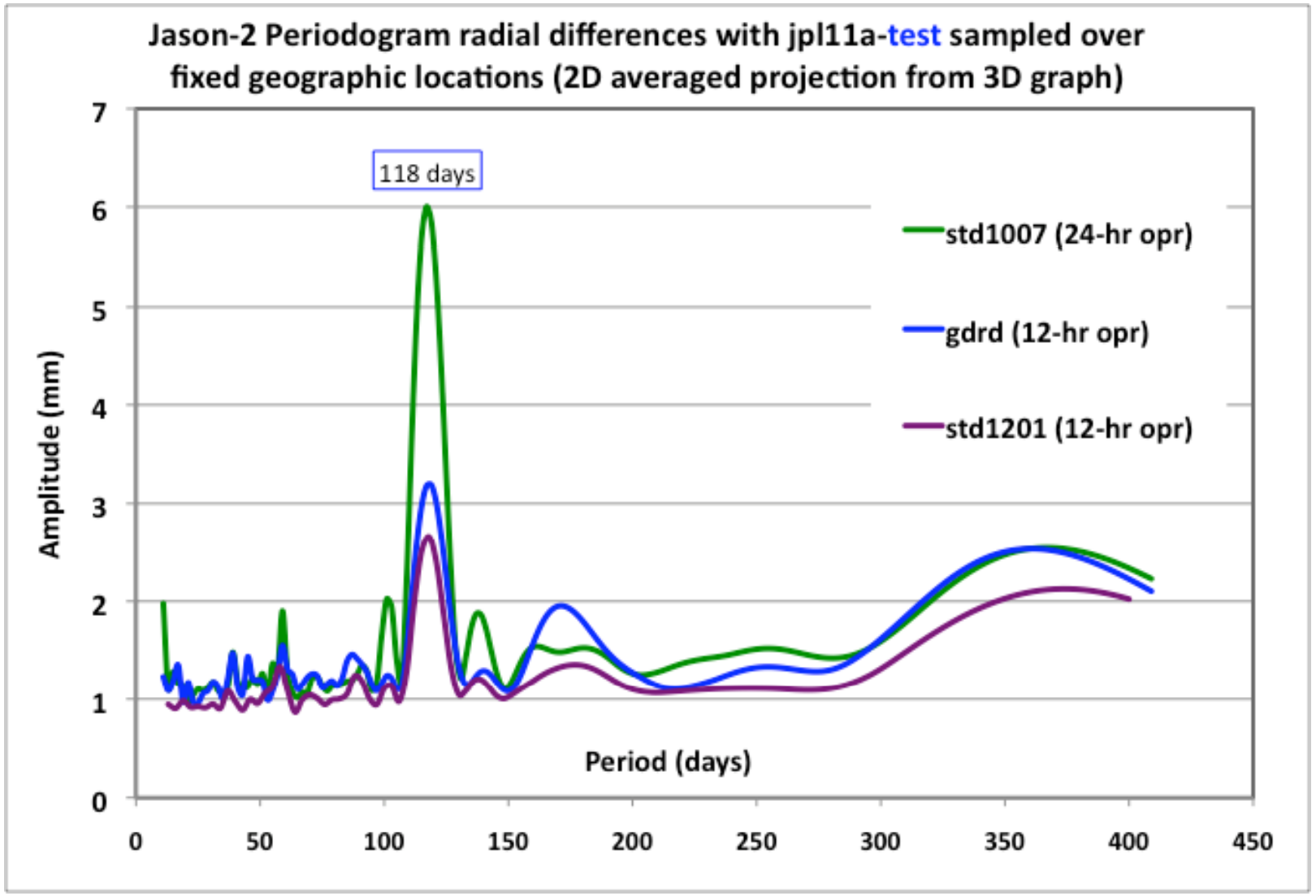
POD Performance Summary

Jason-2 residuals summary cycles 1-135 July 2008 – March 2012 test using external ephemeris having a common span across Analysis Center orbits			
orbit	doris (mm/s)	slr (cm)	xover (cm)
gsfc std1007 (Measures)	0.3812	1.188	5.469
cnes gdrd	0.3804	1.313	5.408
gsfc std1201	0.3808	1.058	5.404
std1201_tvg4x4noj2	0.3808	1.076	5.401
gsfc std1201_tvg4x4	0.3806	1.020	5.395
gsfc red1201_tvg4x4	0.3801	1.086	5.381
jpl11a gps	0.3807	1.199	5.328

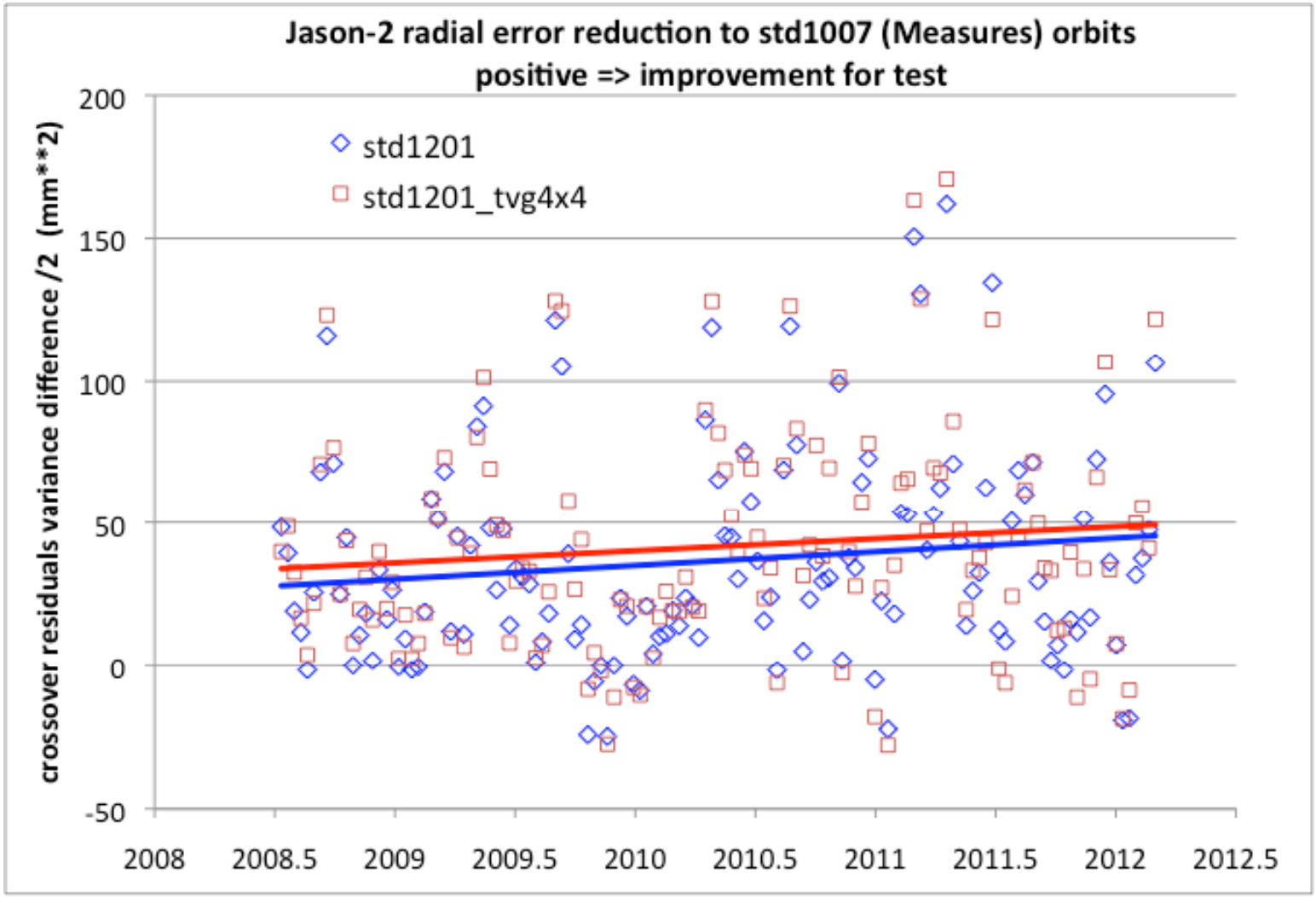
POD Progress since std1007 (2010)



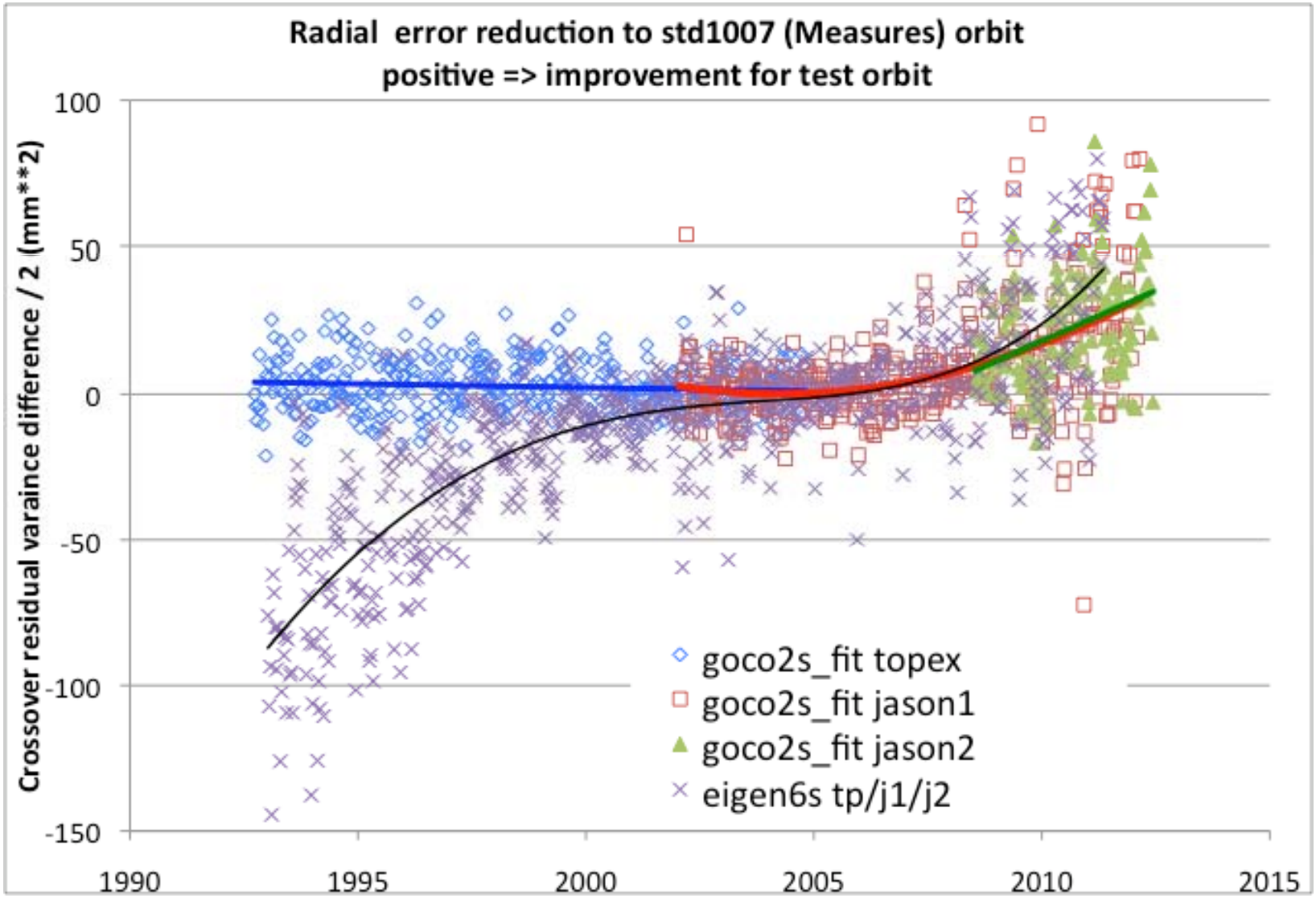
Solar Radiation Pressure error reduced with 12-hr opr estimates



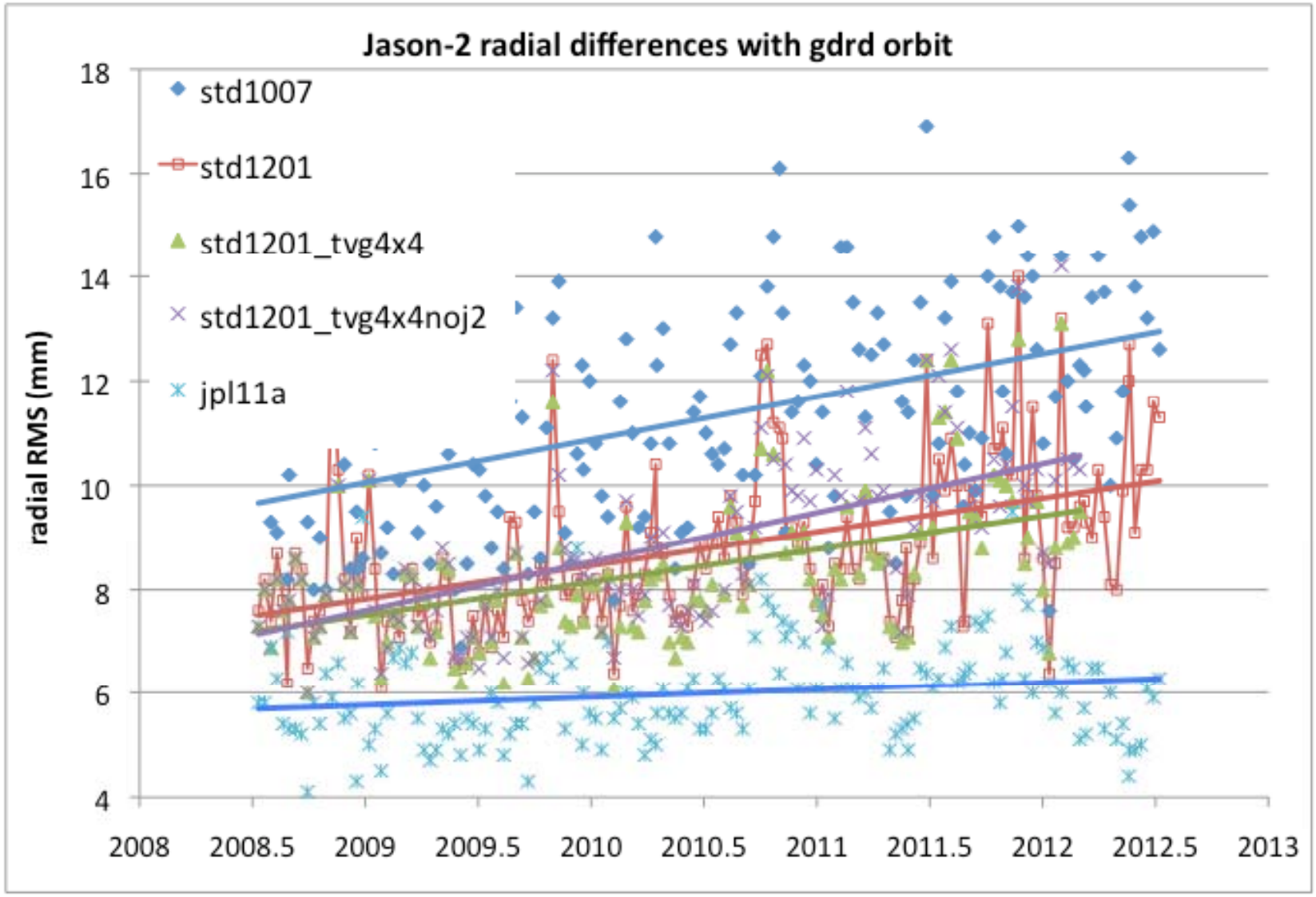
The std1007 stdtvg TVG model appears progressively less adequate for representing time-variable gravity



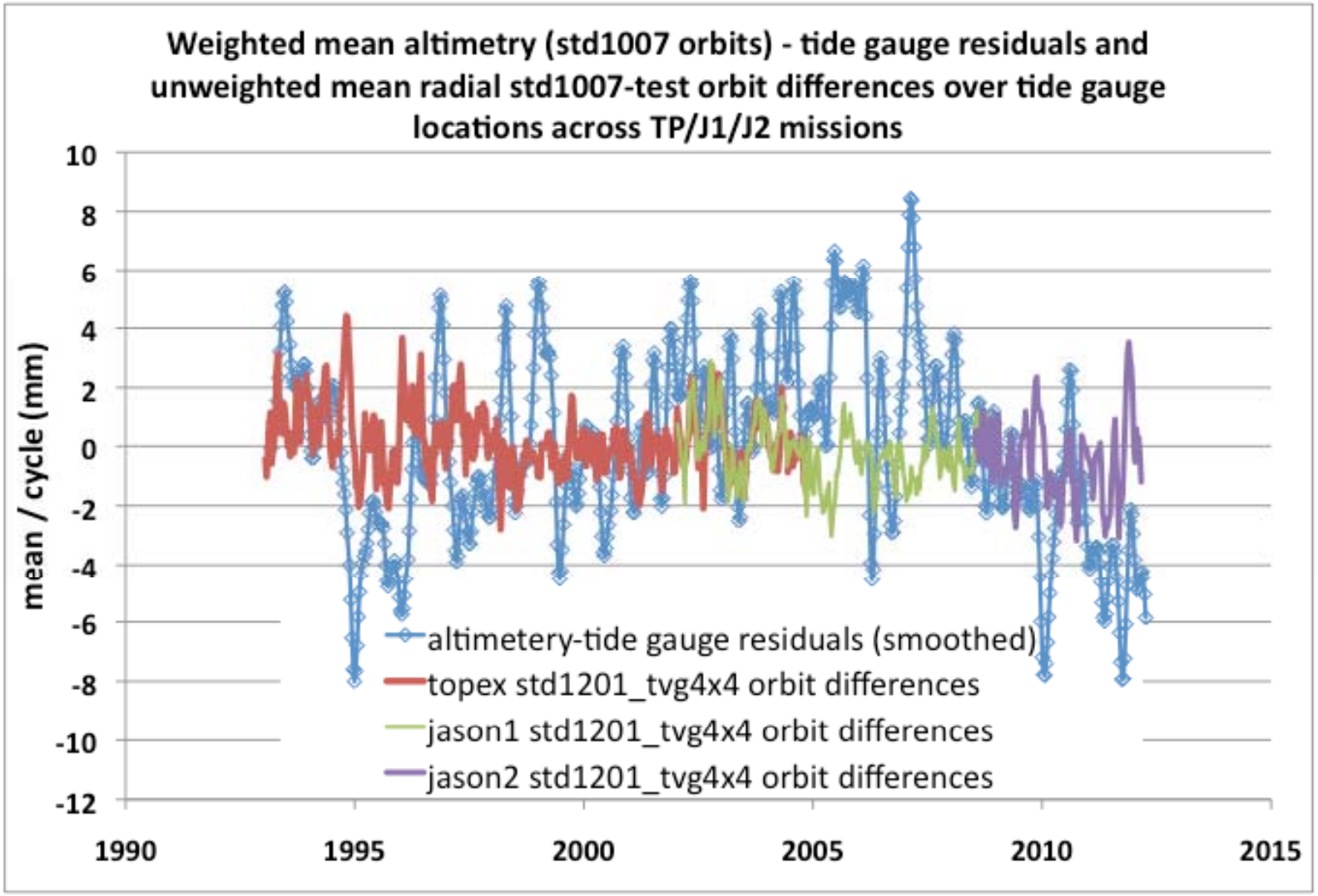
goco2s_fit offers improvement over entire TOPEX/Jason-1/Jason-2 span



Orbit divergence likely due to differences modeling TVG

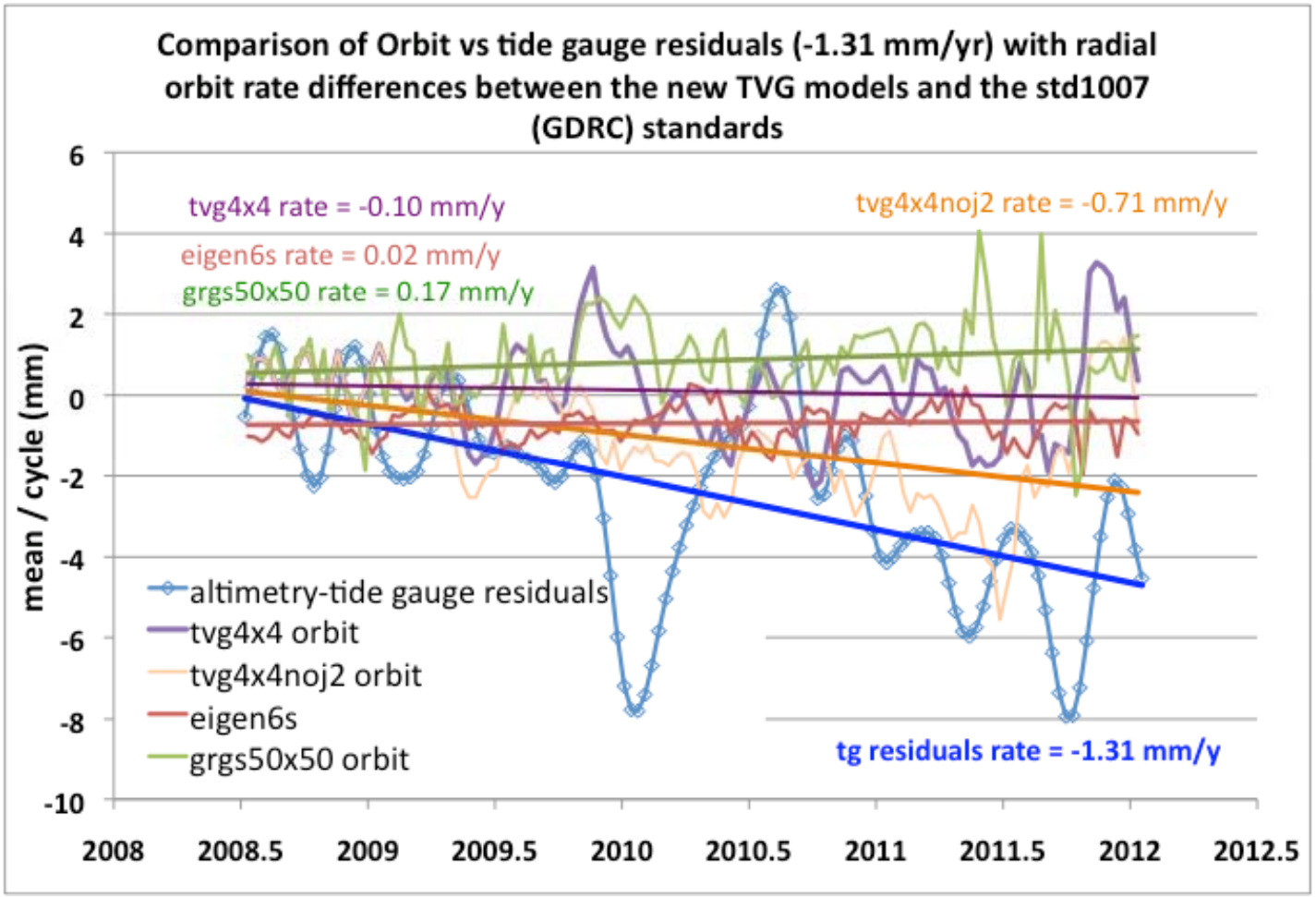


Impact TVG on altimeter tide gauge calibration



Tide gauge calibration results: Gary Mitchum (Univ of South Florida)

Impact TVG on altimeter tide gauge calibration over Jason-2 period

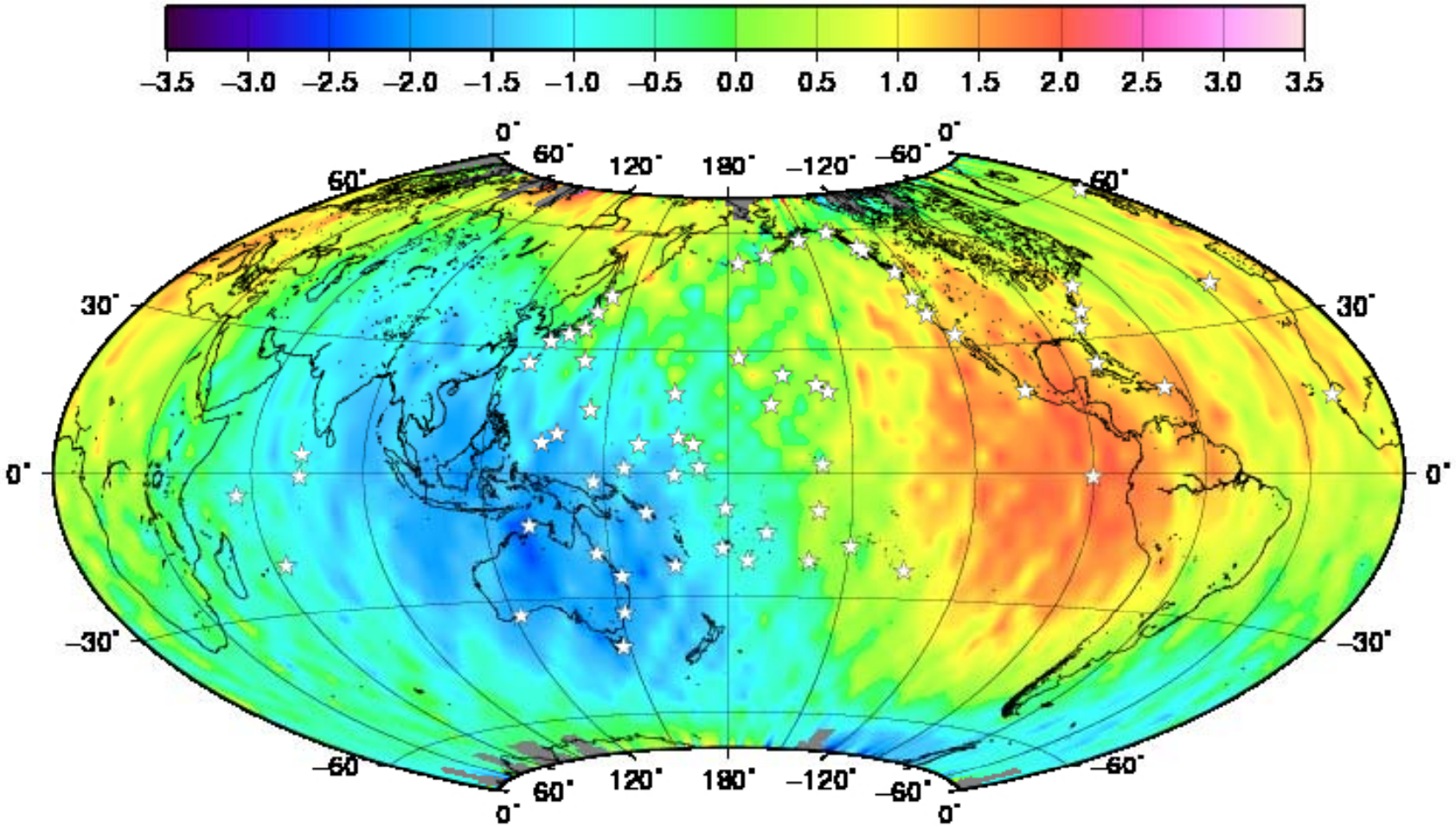


Tide gauge calibration results: Gary Mitchum (Univ of South Florida)

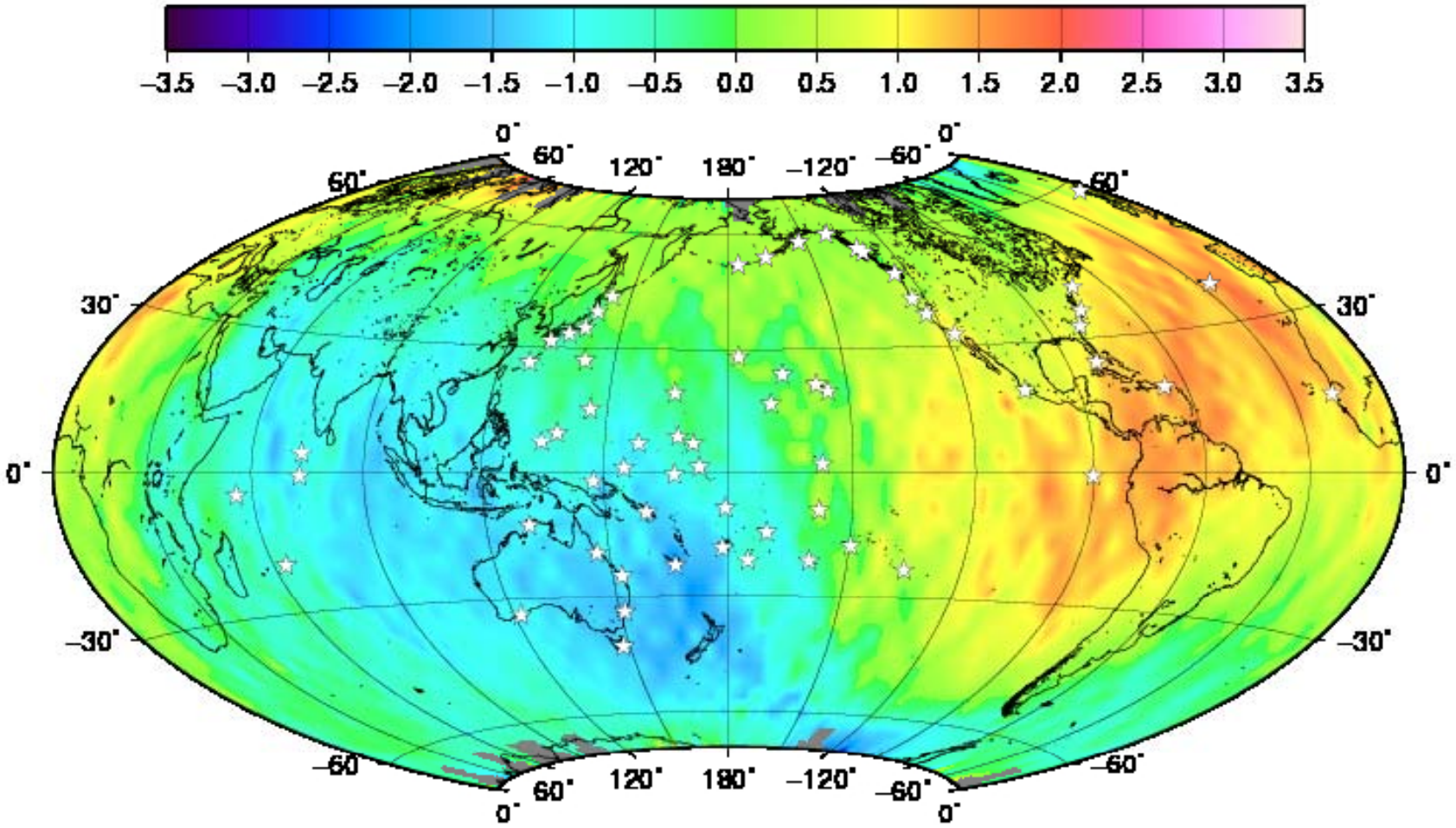
For more detail please see:

GSFC “Improved Modeling of Time Variable Gravity for Altimeter Satellite POD”

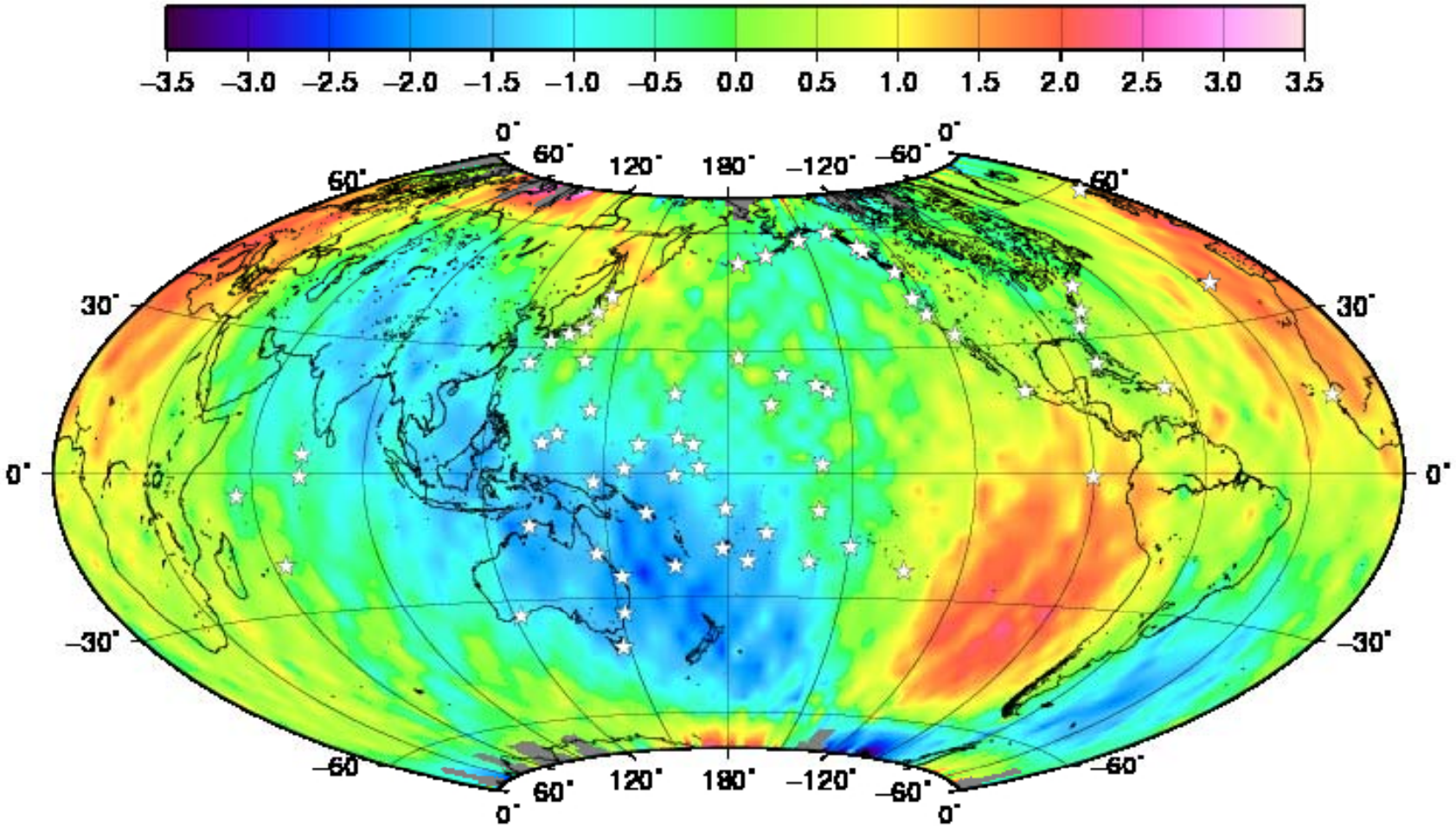
Radial orbit difference linear rate (mm/y) remove annual, semi-annual, 118-day terms gdrd – std1201



Radial orbit difference linear rate (mm/y) remove annual, semi-annual, 118-day terms gdrd – jpl11a



Radial orbit difference linear rate (mm/y) remove annual, semi-annual, 118-day terms gdrd – std1201_tvg4x4



Summary

1) GSFC has developed new POD standards, std1201, which include improved station complements, improved SRP modeling, and improved TVG modeling.

2) The new TVG model, goco2s_fit, has been derived using annual, semi-annual, and linear rate fits to GSFC 19 year time series of 4x4 gravity coefficients determined with SLR/DORIS tracking.

3) goco2s_fit shows improved performance over TP/J1/J2.

4) Considerable POD progress since std1007 release (2010)

5) TVG modeling remains a POD issue for Jason-2

   a) although the GSFC, CNES, and JPL orbits have achieved 1-cm radial accuracy, they show different regional trends due to differences in TVG.

   b) altimeter analysis and tide gauge calibration are sensitive to such regional differences in orbit trends.

BACKUP

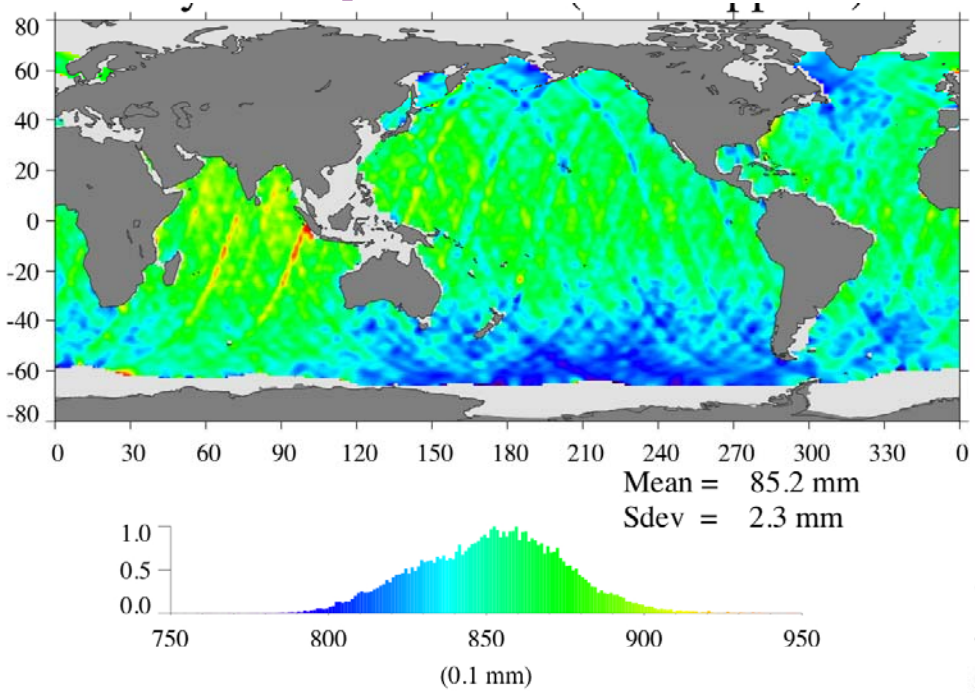
The goco2s_fit TVG model: std1201 standards (gsfc)

• Develop a time series of smoothed weekly 4x4 TVG solutions from SLR and DORIS data to 10 satellites (1993-March 2012).

• Since there is a latency to process the SLR/DORIS satellite data and develop the 4x4 time series, we need a conventional model that we can apply and that can be used for low-latency applications (satellite altimetry, orbits for MEaSURES climate data record products (http://podaac.jpl.nasa.gov/highlights/MEaSUREs_TPJAOSv1.0_SSH)

• Balance the signal content, signal variation over the time span with the degree of the fit per coefficient and seek a compromise.

Orbit Consistency -vs- Accuracy
Jason2 - Jason1 Mean SSH cycles 1-20
(itrf2008, no corrections, SSB applied)

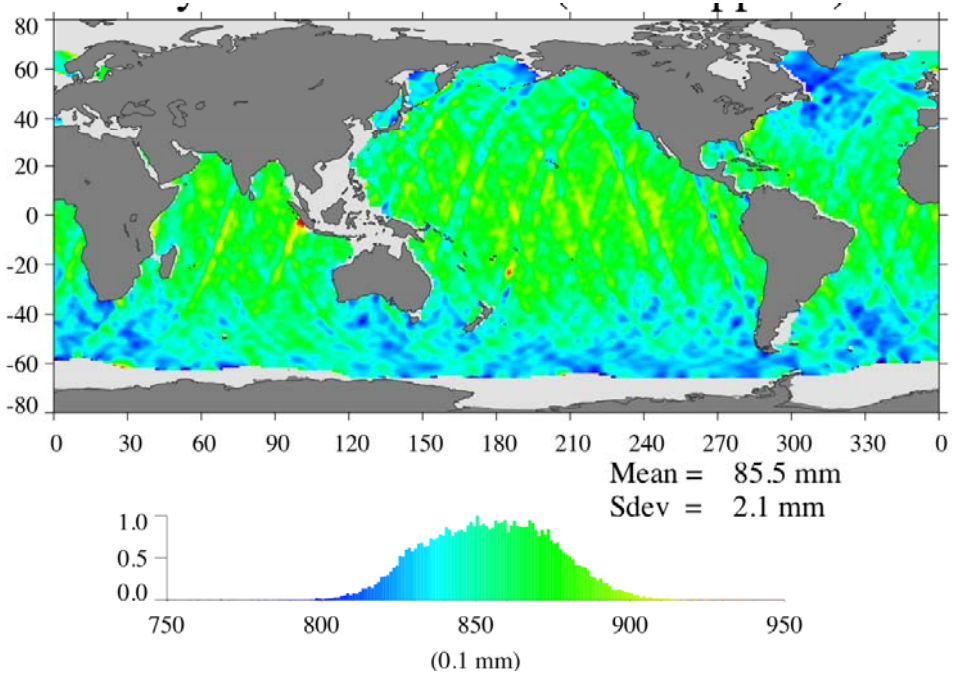


J2 reduced_dynamic -

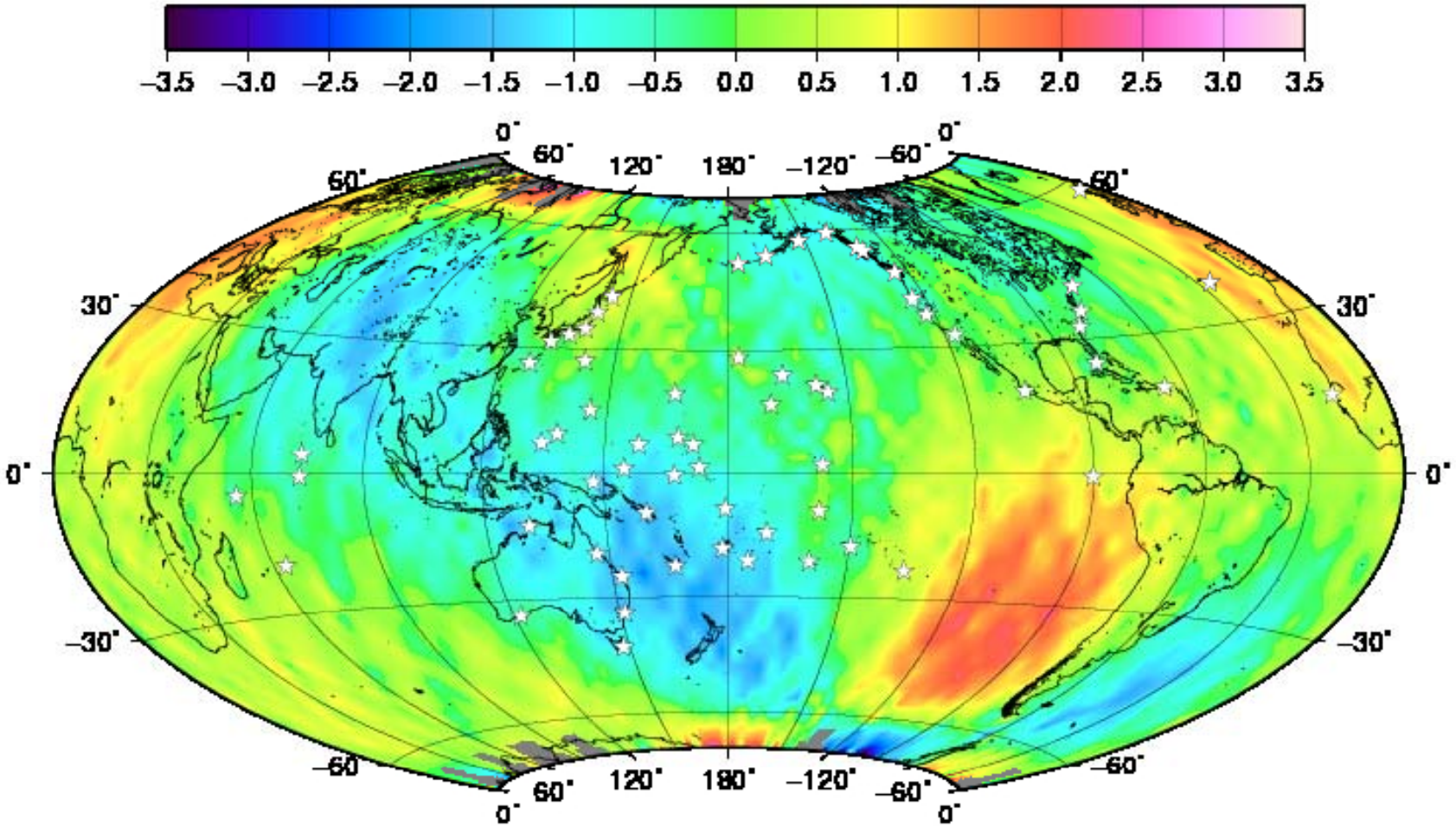
J1 dynamic orbits

J2 dynamic -

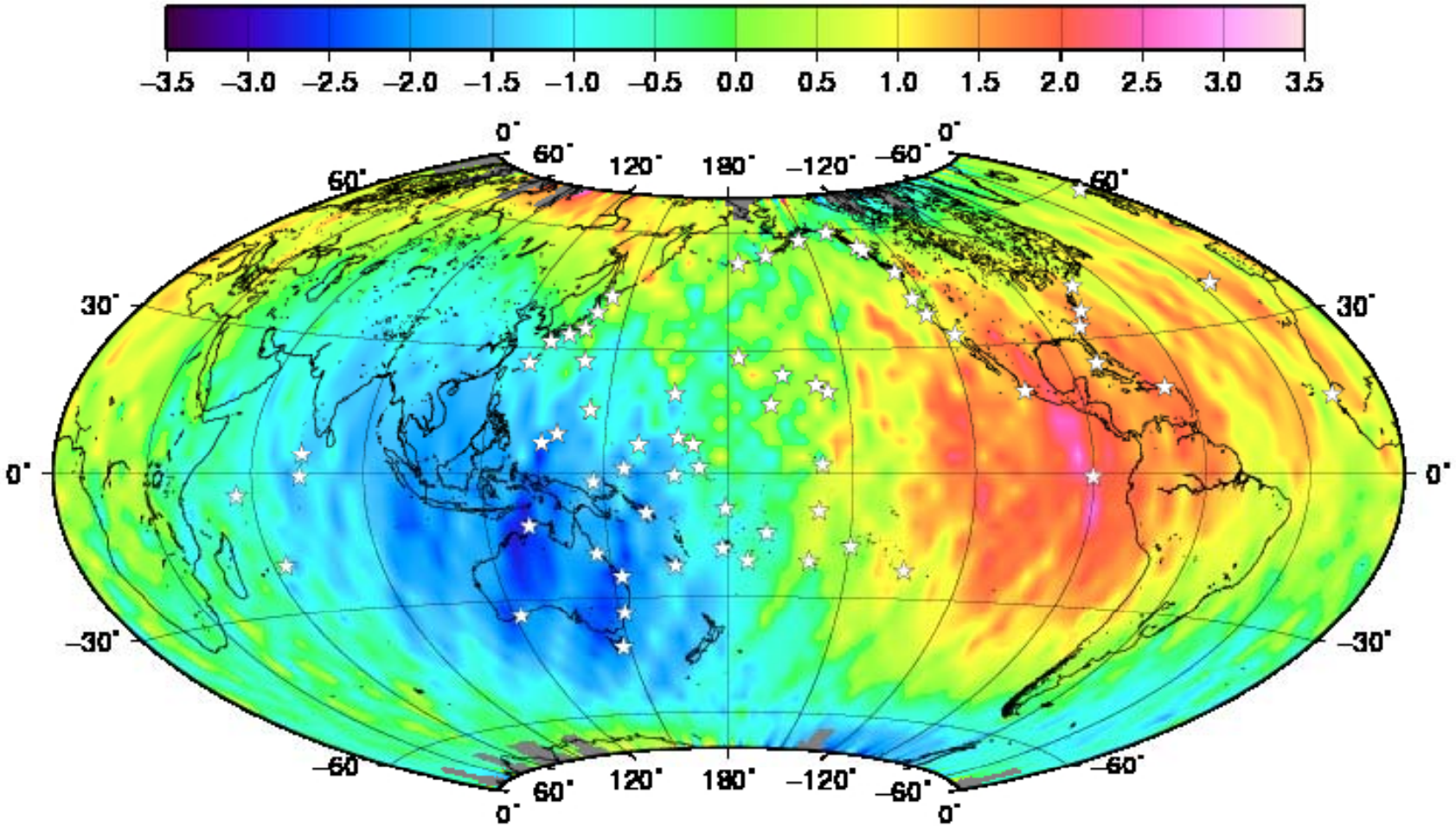
J1 dynamic orbits



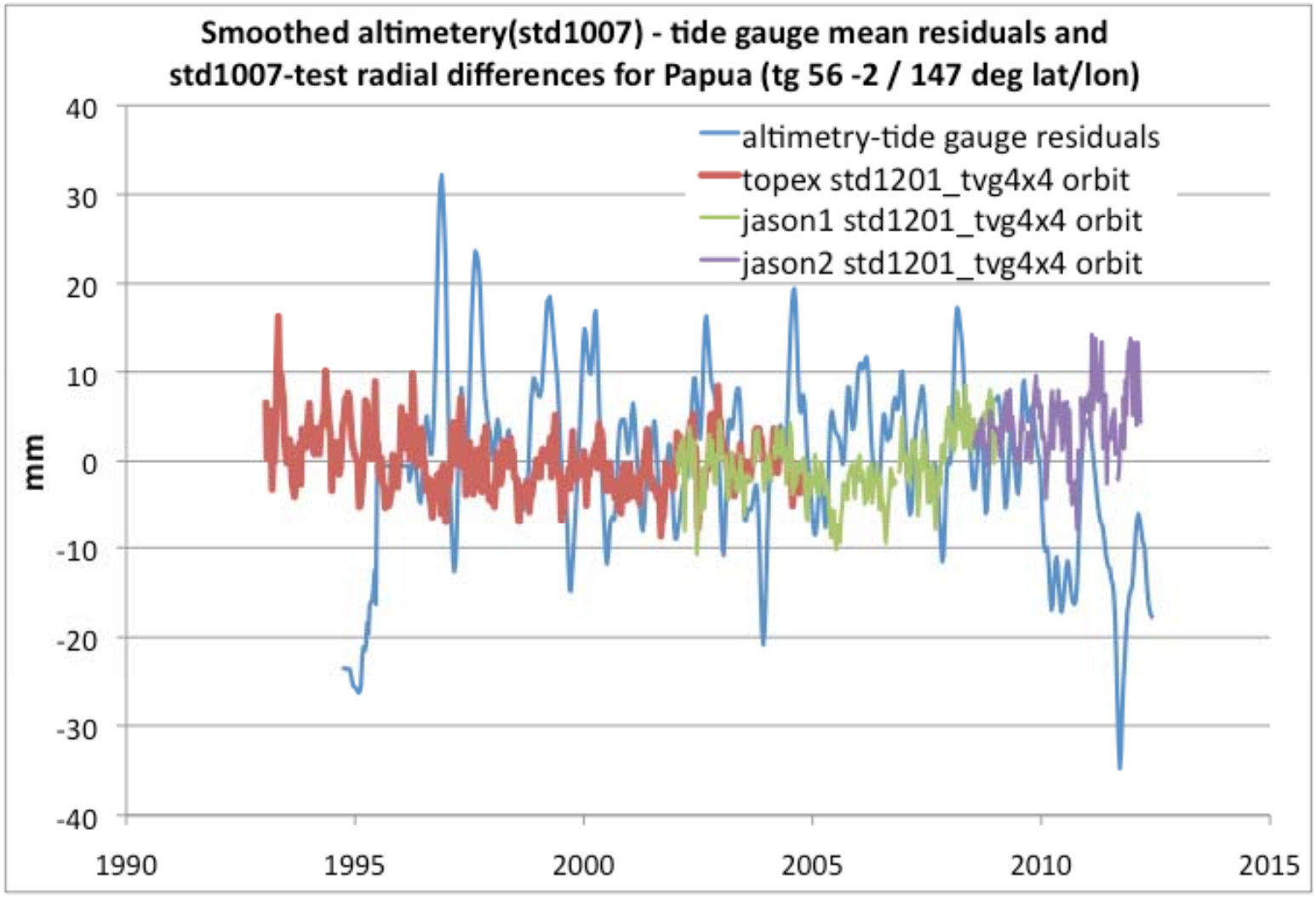
Radial orbit difference linear rate (mm/y) remove annual, semi-annual, 118-day terms gdrd – red1201_tvg4x4



Radial orbit difference linear rate (mm/y) remove annual, semi-annual, 118-day terms gdrd – std1007



Altimeter-tide gauge residuals contain more signal than orbit differences



Recent orbits diverge with std1007 (stdtvg)