



SLR Test Products Using ECMWF Atmospheric Loading and Gravity

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Overview

- Atmospheric loading and gravity variations from Jean-Paul Boy's ECMWF-based products
- Original tests done with various ECMWF products with different analysis and resolution
- New analysis of LAGEOS 1 & 2 and ETALON 1 & 2 SLR data over 2004 – 2009 used ERAint
- Background and a priori models from IERS Standards and Conventions and GRACE RL04



MODELING STANDARDS

- IERS Conventions 2010 (except gravity model)
- GRACE RL04-based gravity model
- TVG (12x12) from GRACE RL04 (Secular, 1, 2, 4 cpy)
- Use state-of-the-art force and s/c models
- A priori Reference Frame: ITRF2008 (SLRF2008)
- Use the latest data releases from CDDIS



FORCE & MEASUREMENT MODELING

Gravity from *GRACE* and *GOT4.7* ocean tides

Extended ocean tides' model from hydrodynamics,
atmospheric tides included

Secular rates for $C_{2,0}$, $C_{2,1}$, $S_{2,1}$ and rotational
deformation (IERS)

Solar Pressure and Thermal Drag with LAGEOS' spin
axes modeled by LOSSAM models

Earth Albedo (Knocke-Rubincam)

J2000 Reference frame (DE403)



FORCE & MEASUREMENT MODELING

EOP (*a priori*) from IERS C04 08

Ocean loading from GOT4.7 tides (*R. Ray/GSFC*)

“Geocenter” and EOP tide-induced variations (*IERIS--Ray model*)

Improved Atmospheric Refraction zenith delay and mapping function (*Mendes & Pavlis, 2004*)

Atmospheric loading and gravity from ECMWF 6hr ERAint

Adopted IERS-info on calibrated measurement biases (*a priori*)



DATA ANALYSIS

Analyzed **7^{day}** arcs in **20004 - end of 2009**

State-vector estimated for each arc

Constant and 1 *cpr* along-track accelerations (per **3.5^d**)

Cross-track 1 *cpr* accelerations (per **3.5^d**)

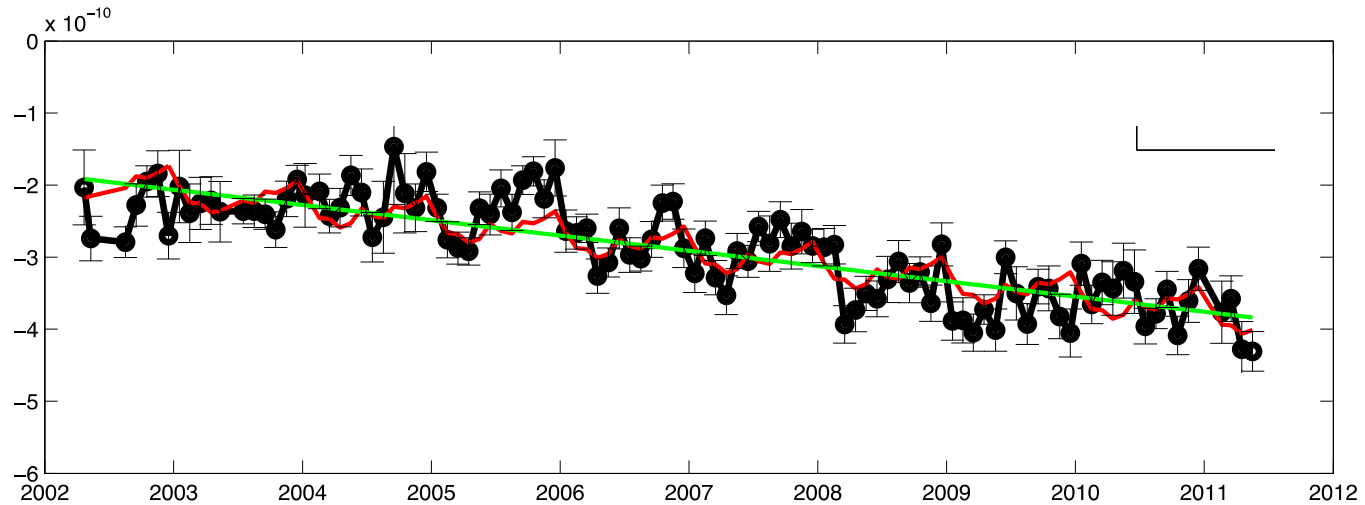
Non-core sites' data biases estimated (*L-1 & 2, no E1&2*)

Polar motion and **LOD** estimated **daily**

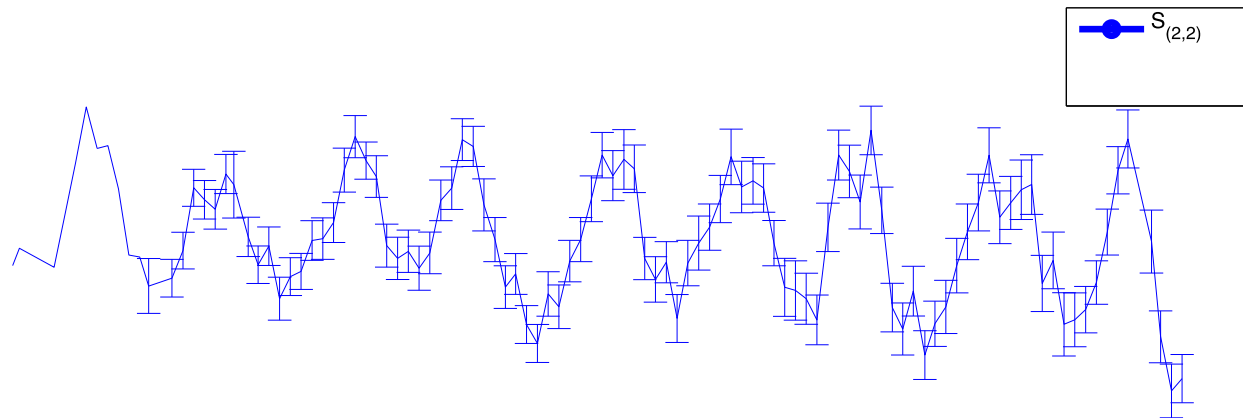
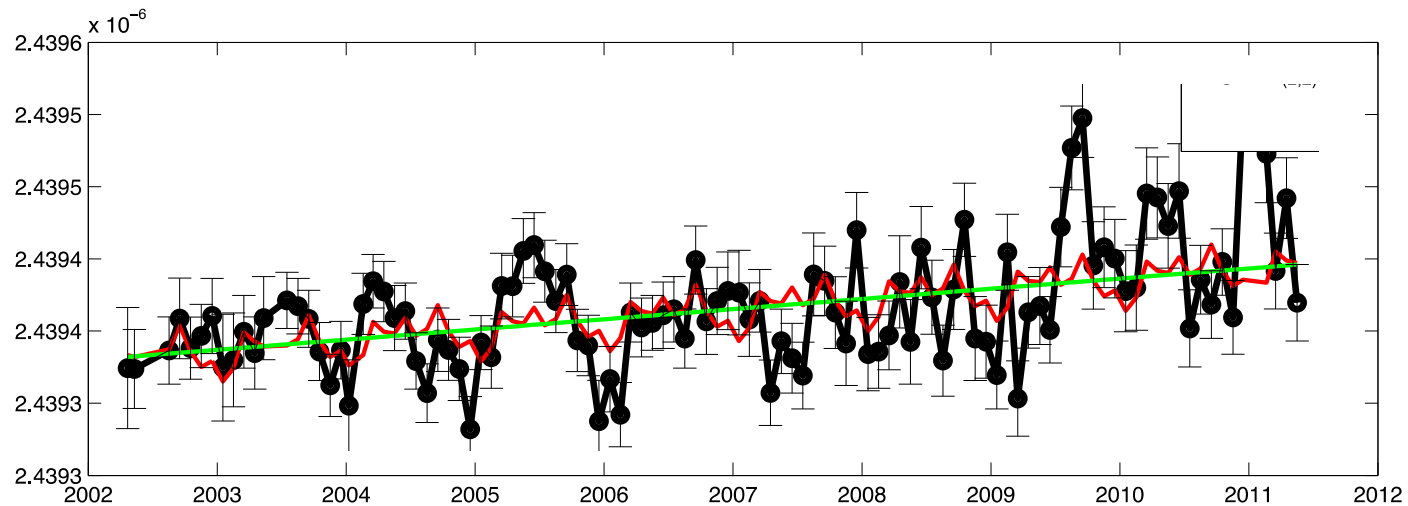
Site positions and velocities estimated from **the entire**
data span



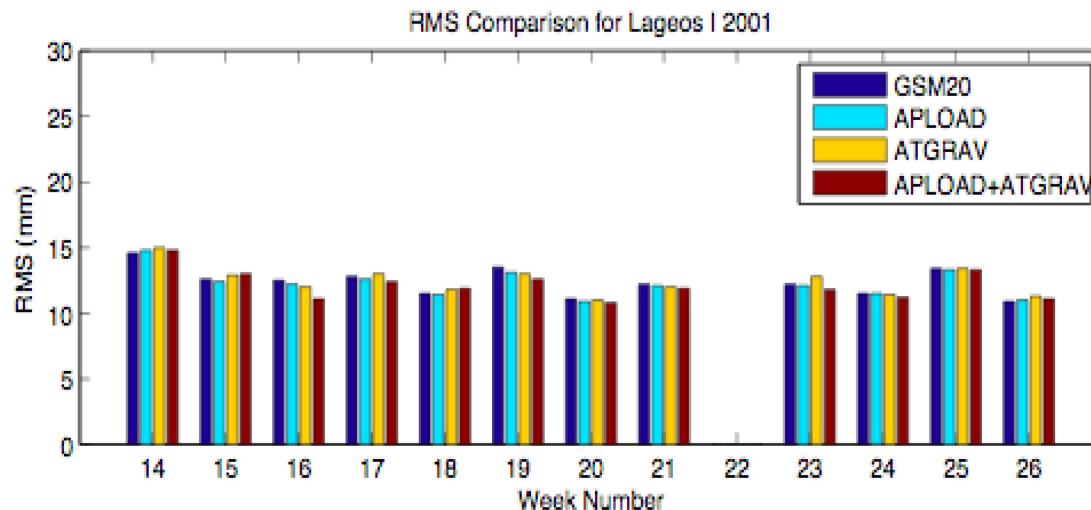
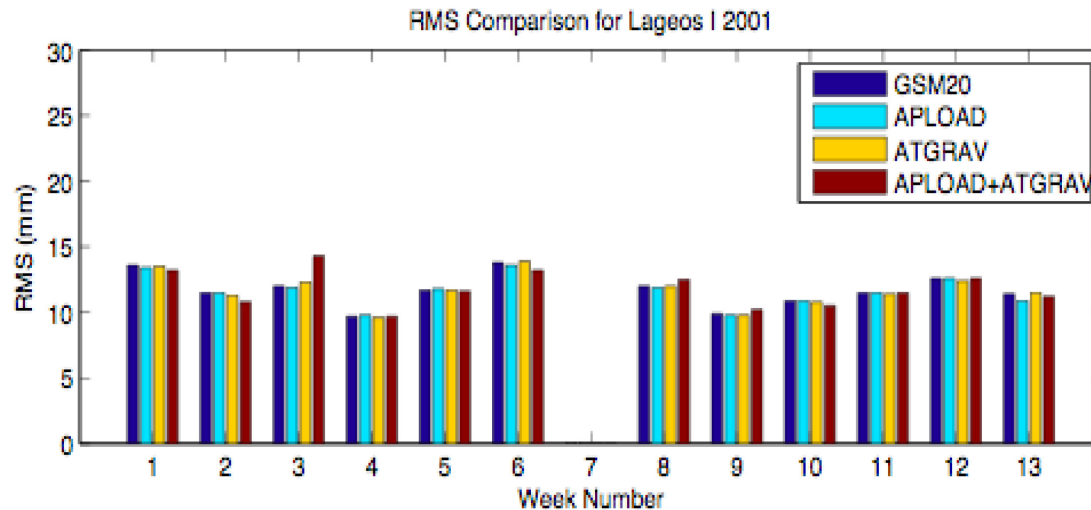
A priori Gravity from GRACE (2,1)



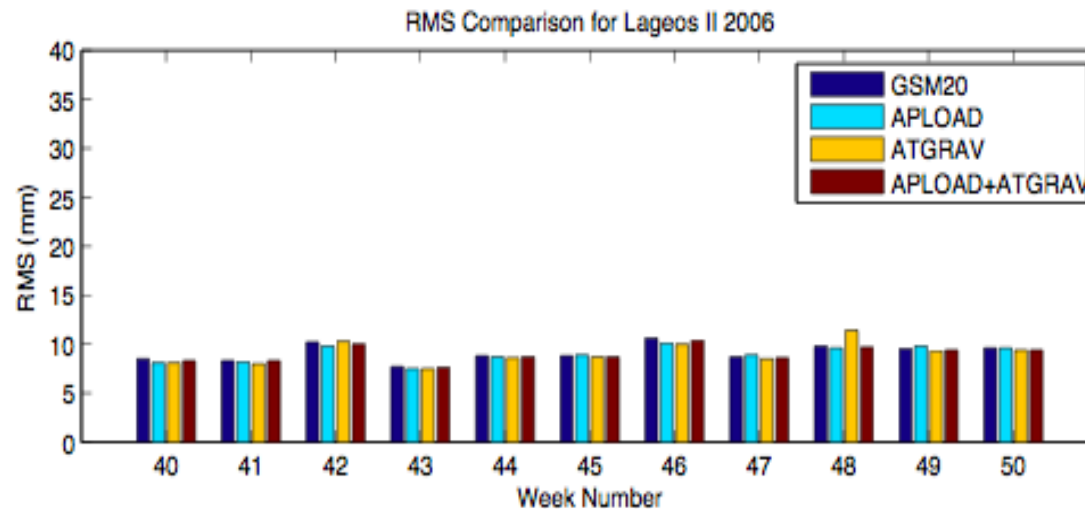
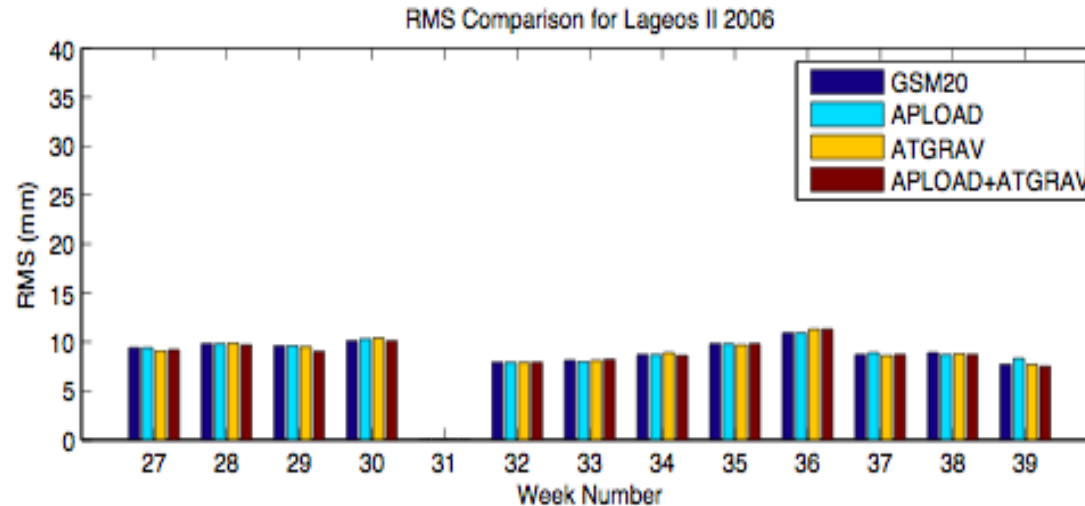
A priori Gravity from GRACE (2,2)



LAGEOS 1 RMS of FIT (2001)



LAGEOS 2 RMS of FIT (2006)



SLR TESTS in 2001 & 2006

**Difference in the RMS of fit of weekly arcs of LAGEOS SLR for 2001 & 2006
and four Atmospheric loading treatments (one being NO loading)**

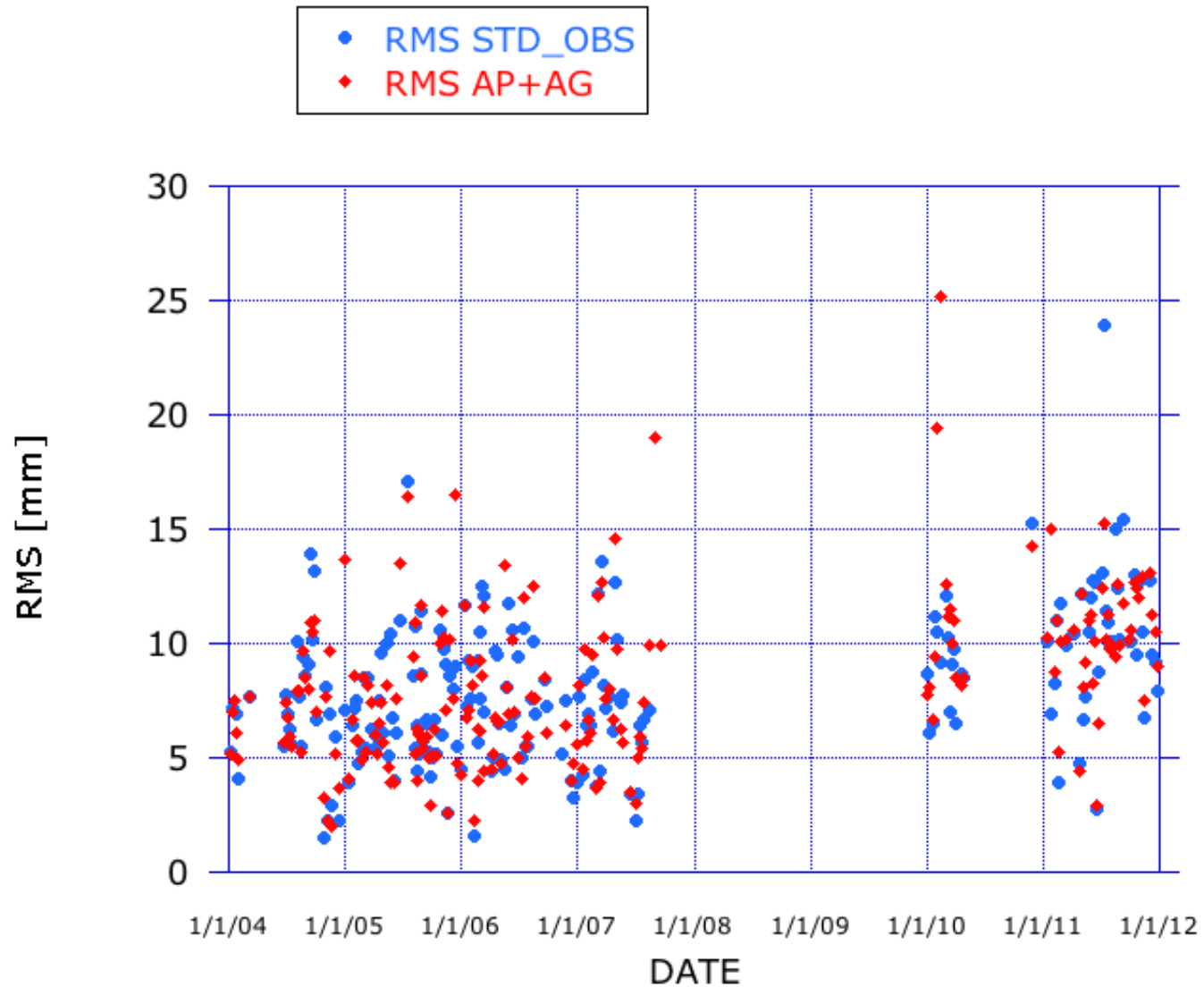
Variable	Points	Mean	Median	RMS	Std Deviation
Δ RMS v0-NO	52	3.4	2.7	4.45	2.87
Δ RMS v1-NO	104	2.9	2.1	4.31	3.16
Δ RMS v2-NO	52	2.7	1.7	4.09	3.08
Δ RMS v1-v0	52	0.4	0.0	0.92	0.82
Δ RMS v2-v1	52	1.7	1.4	2.58	1.96

"v0": 1970/01 - 2002/08: ECMWF Reanalysis (ERA40), with a spatial resolution of 1.125 degrees

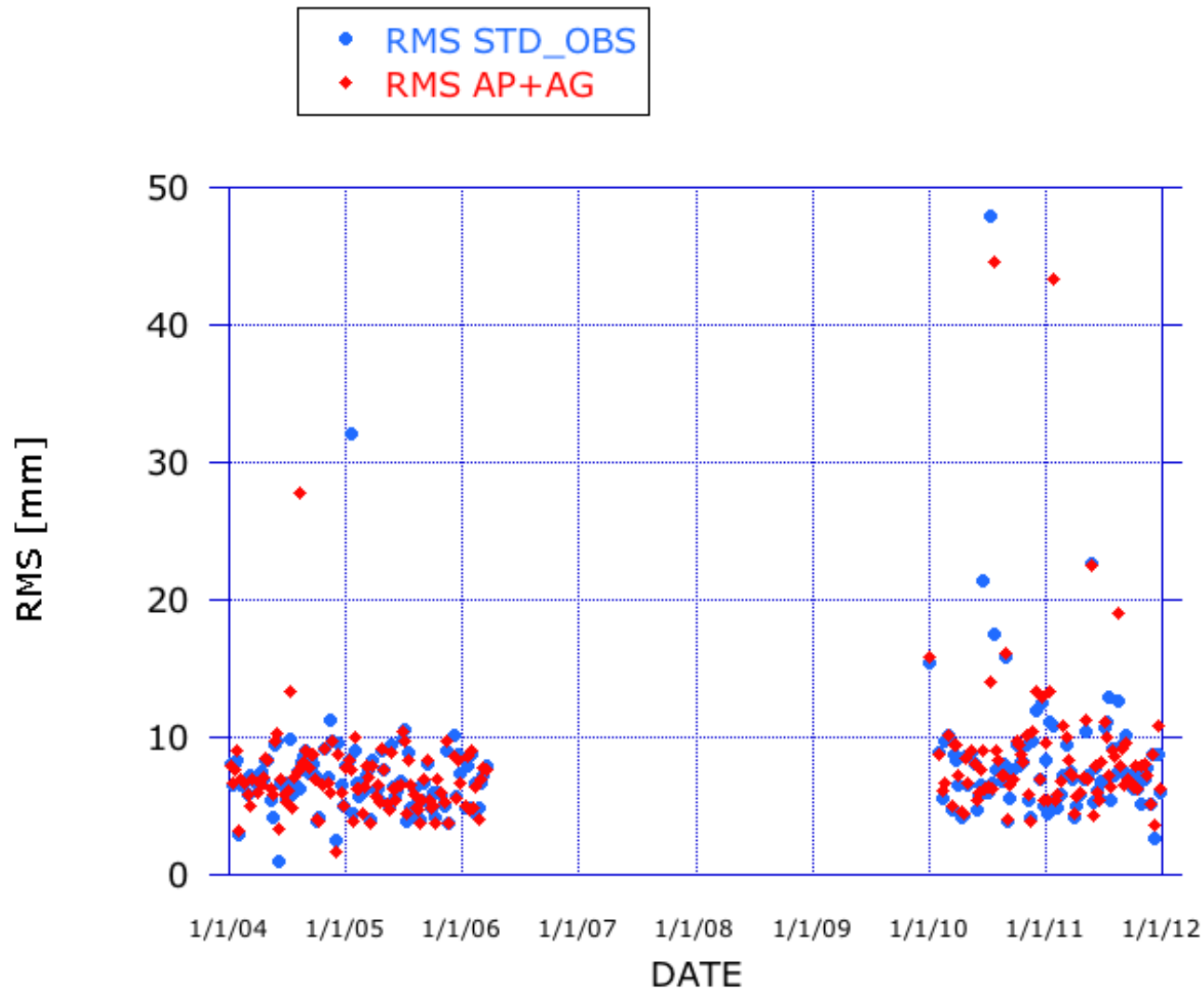
"v1": 2000/12 - 2006/12: ECMWF Operational, with a spatial resolution of about 0.350 degrees

"v2": 2005/10 - now: ECMWF Operational, with a spatial resolution of about 0.250 degrees

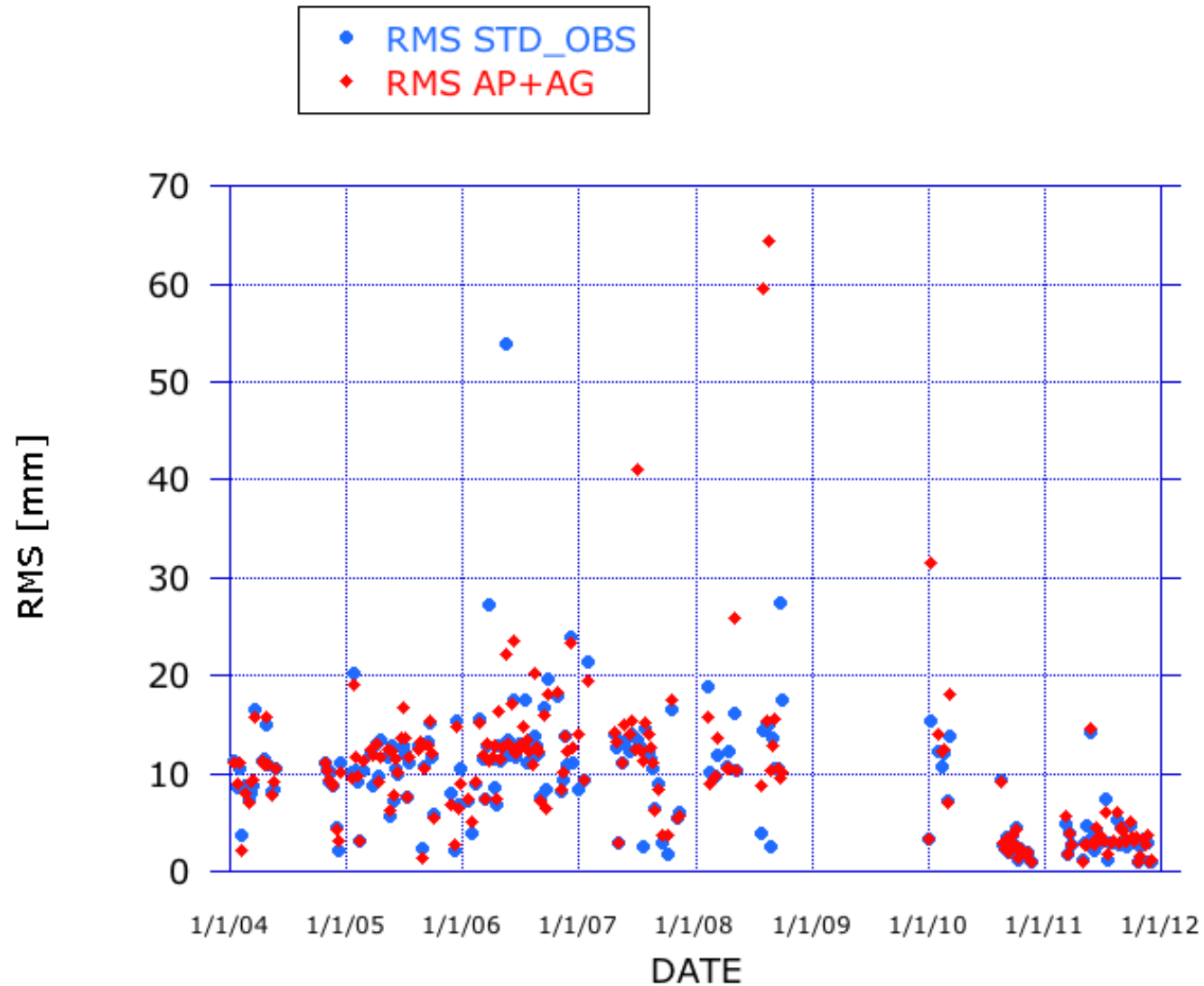
Greenbelt, MD LAGEOS 2



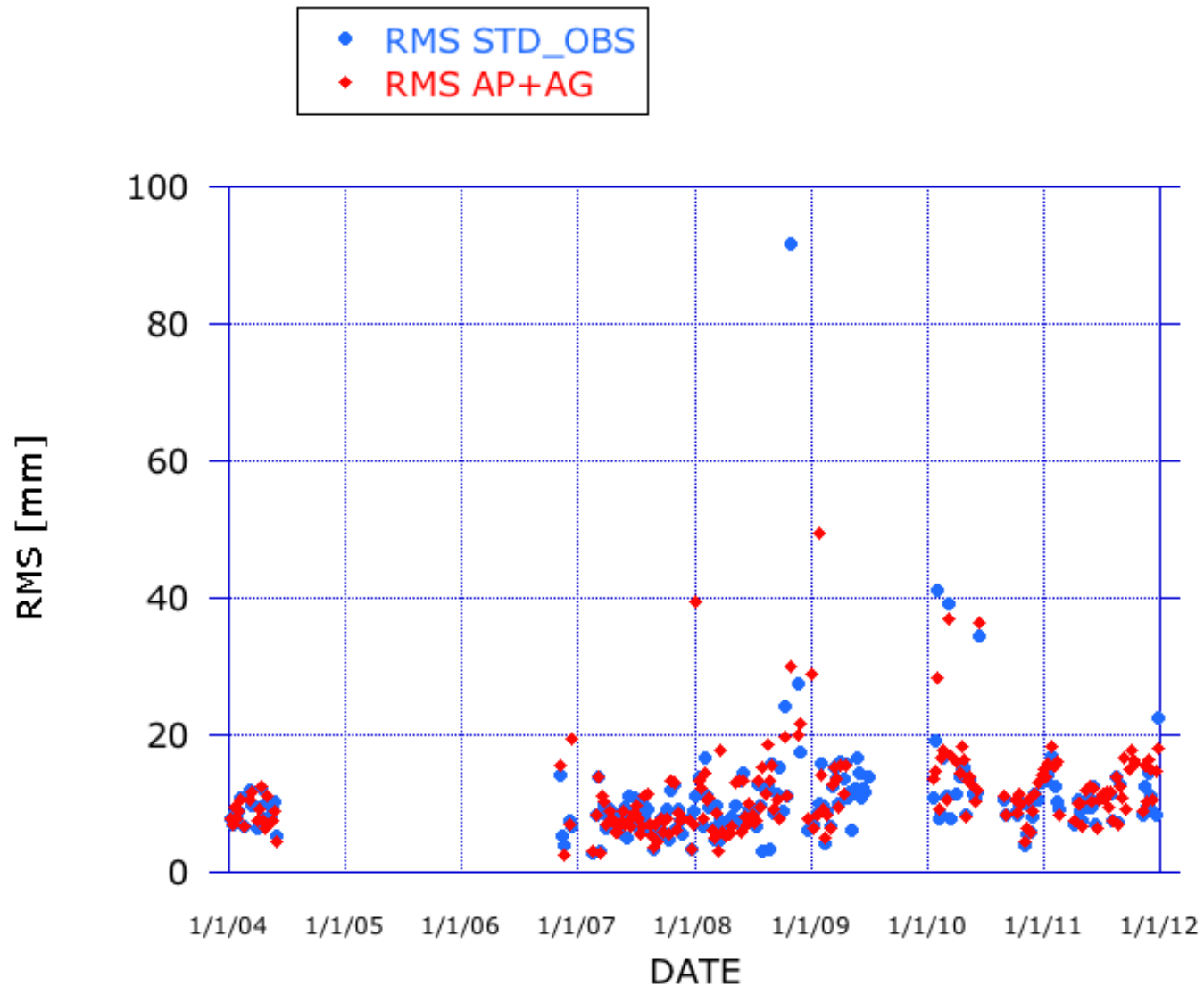
Graz, Austria LAGEOS 1



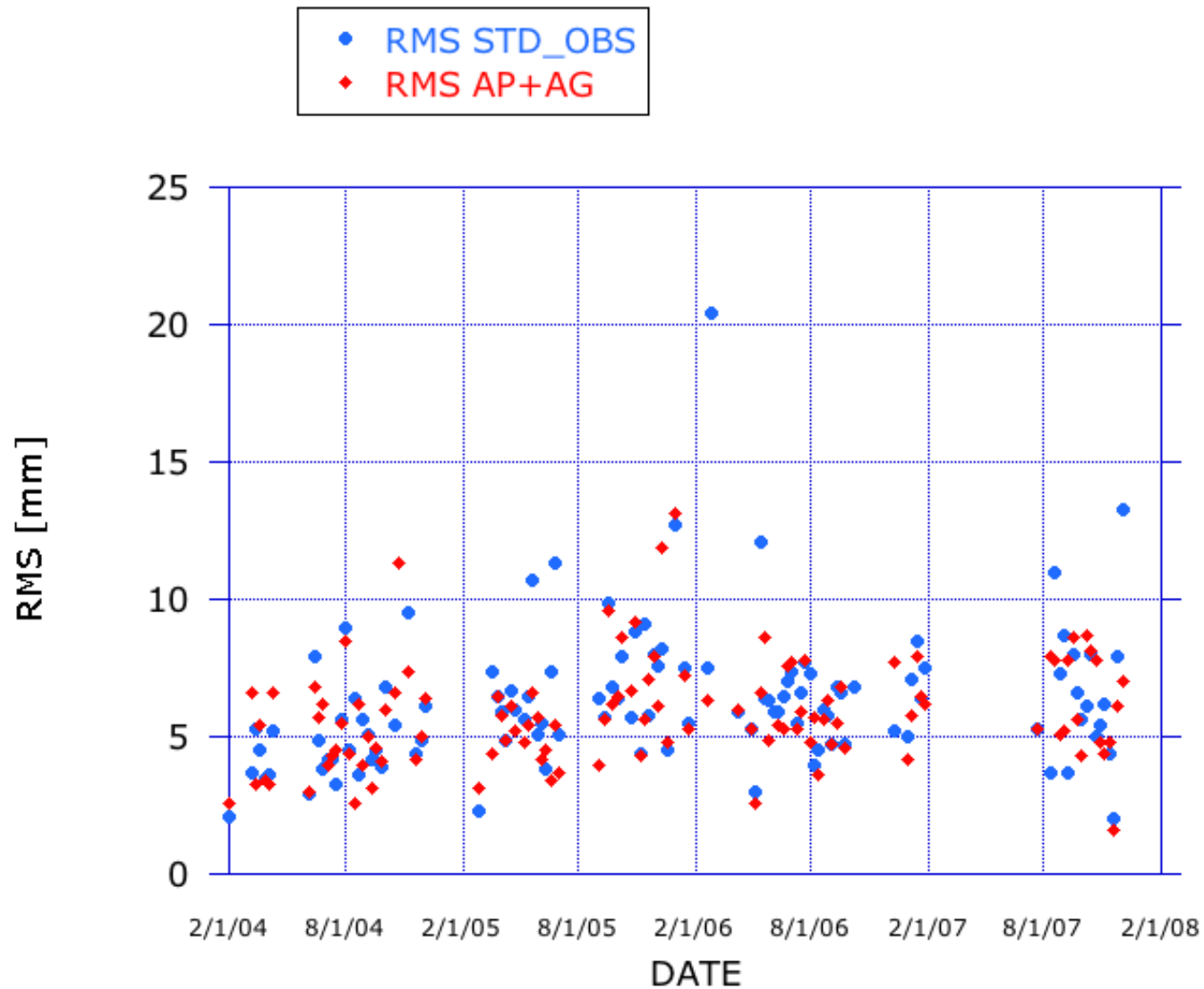
Hartebeesthoek, SA, LAGEOS 1



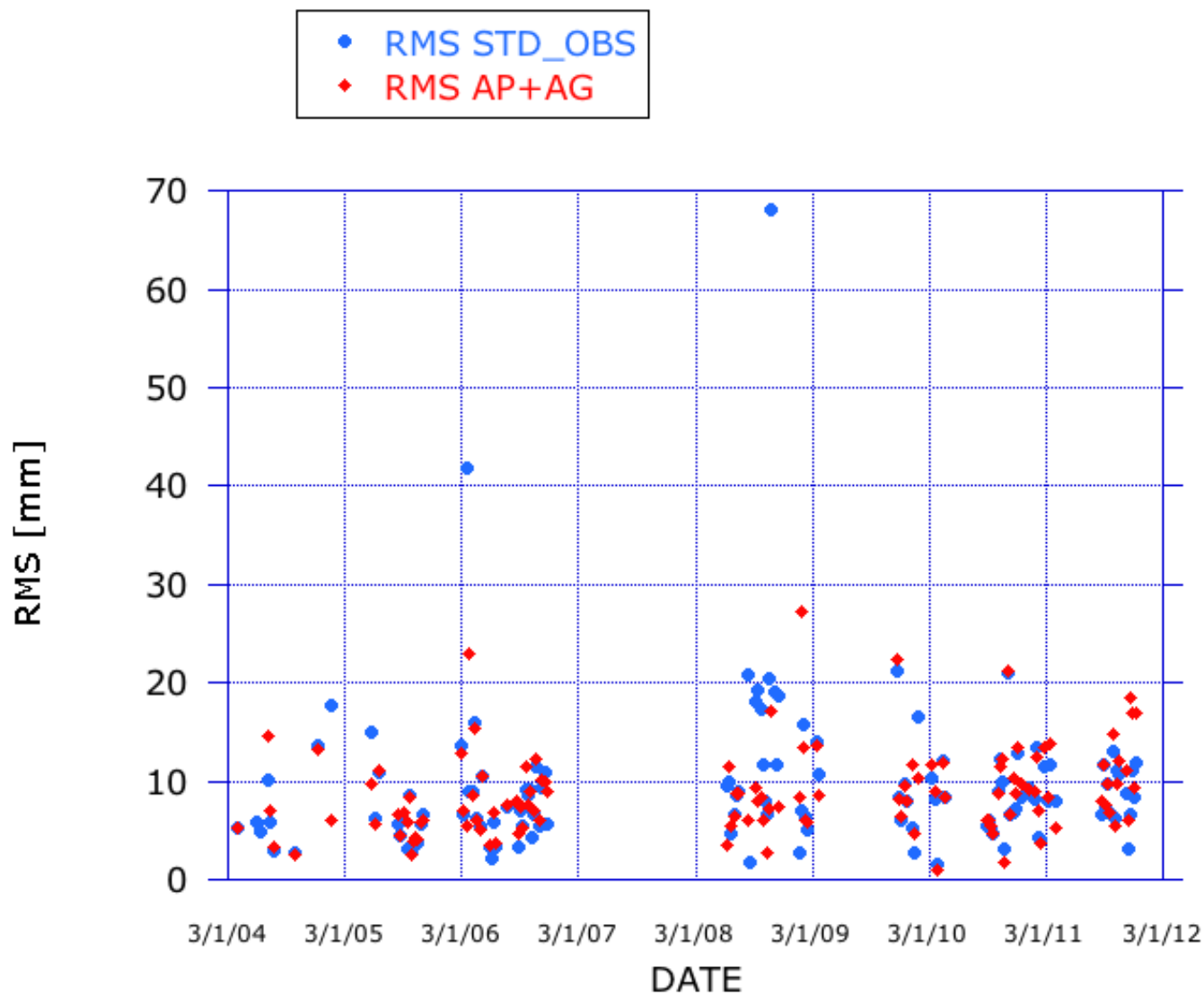
Haleakala, Hawaii, LAGEOS 2



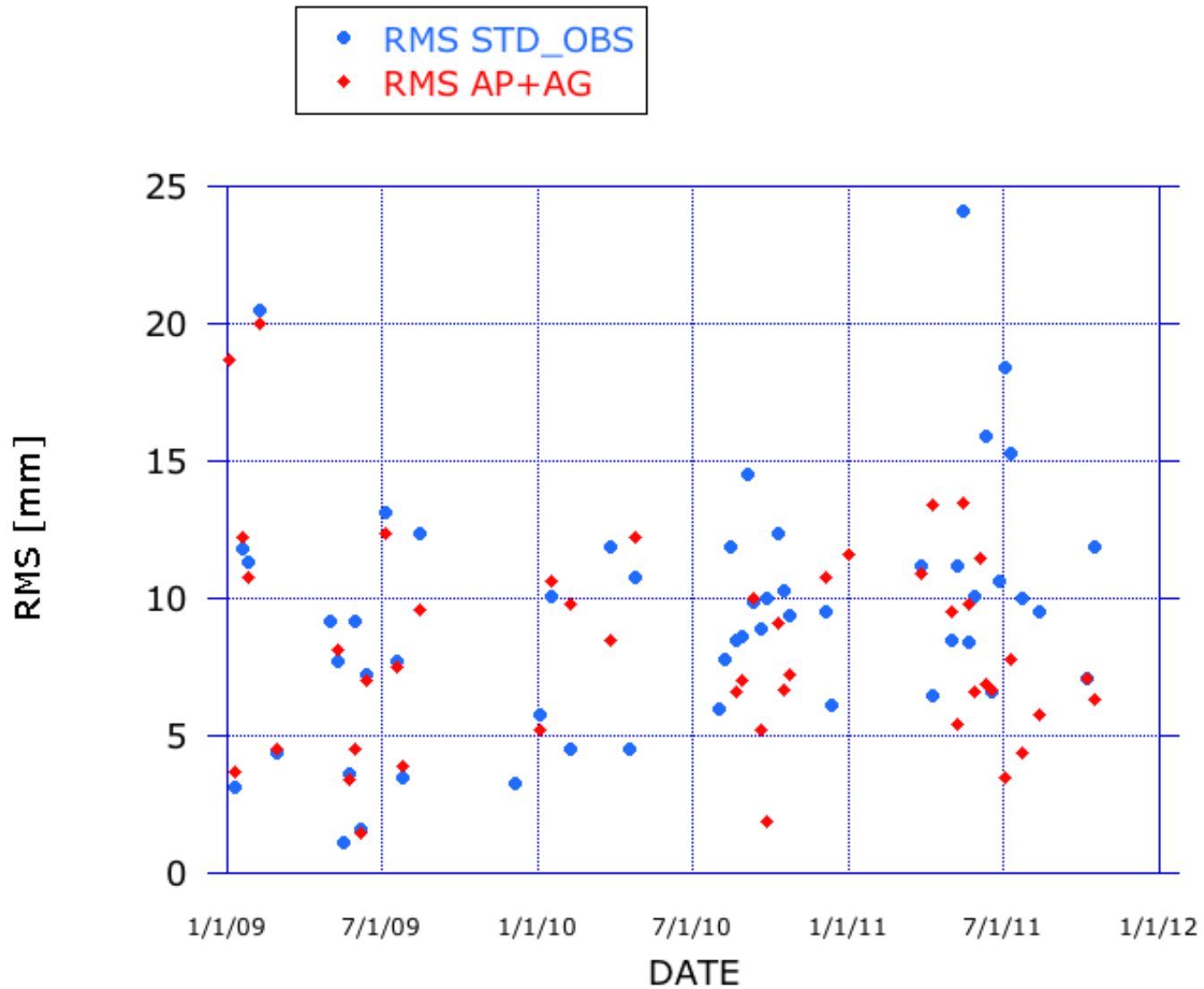
Maidanak, Uzbekistan, LAGEOS 2



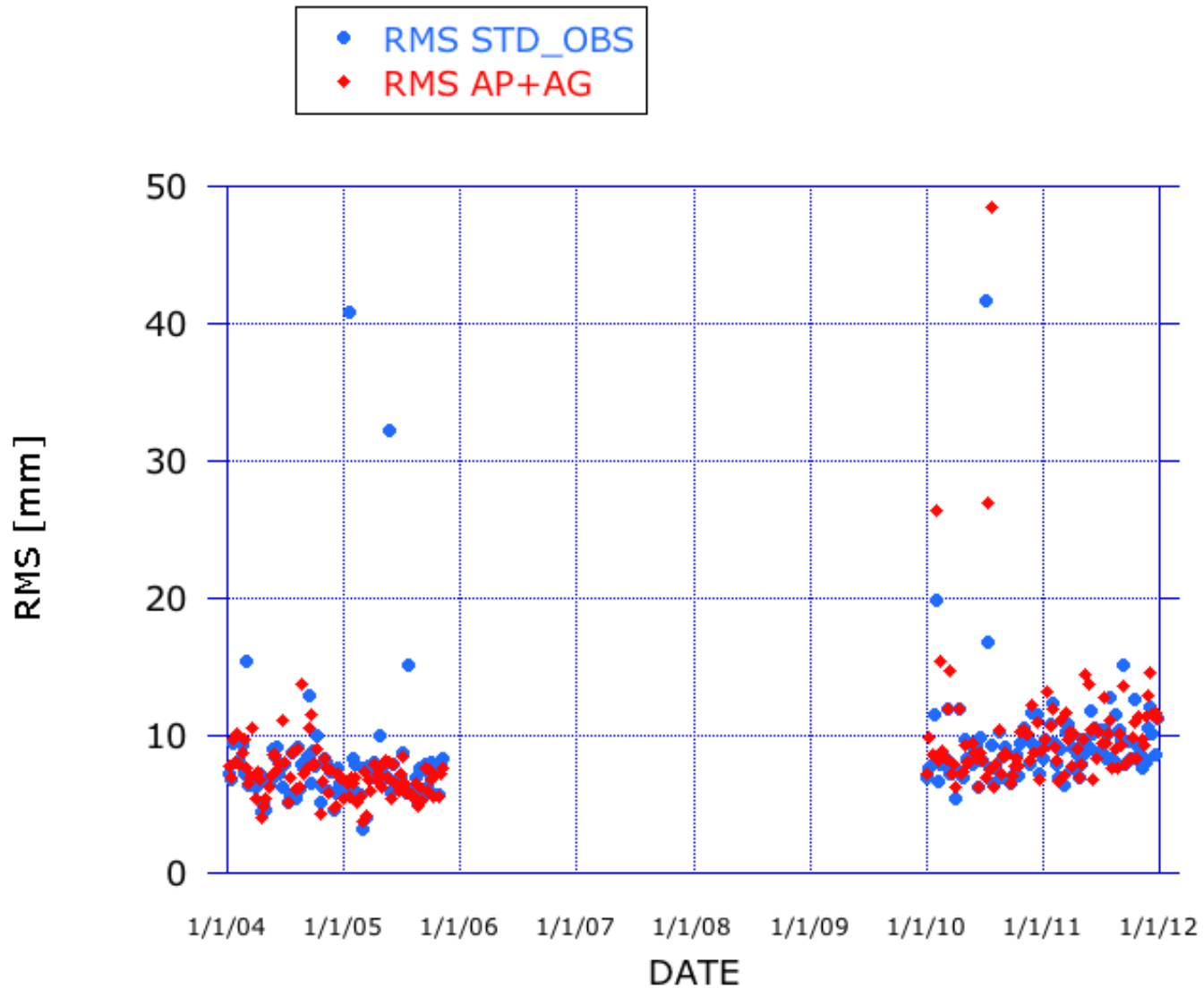
Papeete, Fr. Pol/sia, LAGEOS 2



Altay, Russia, LAGEOS 2



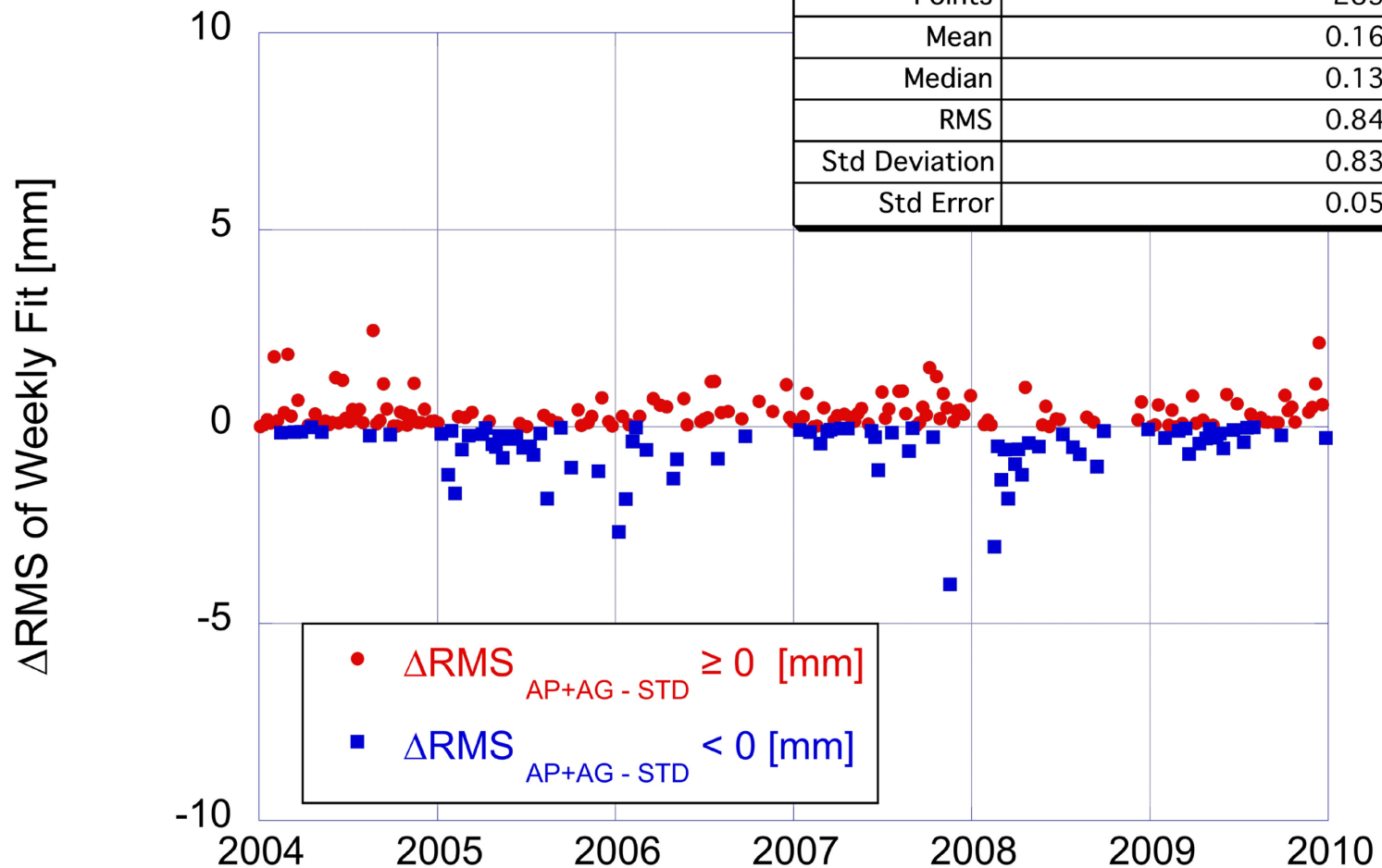
Yarragadee, Australia, LAGEOS 2



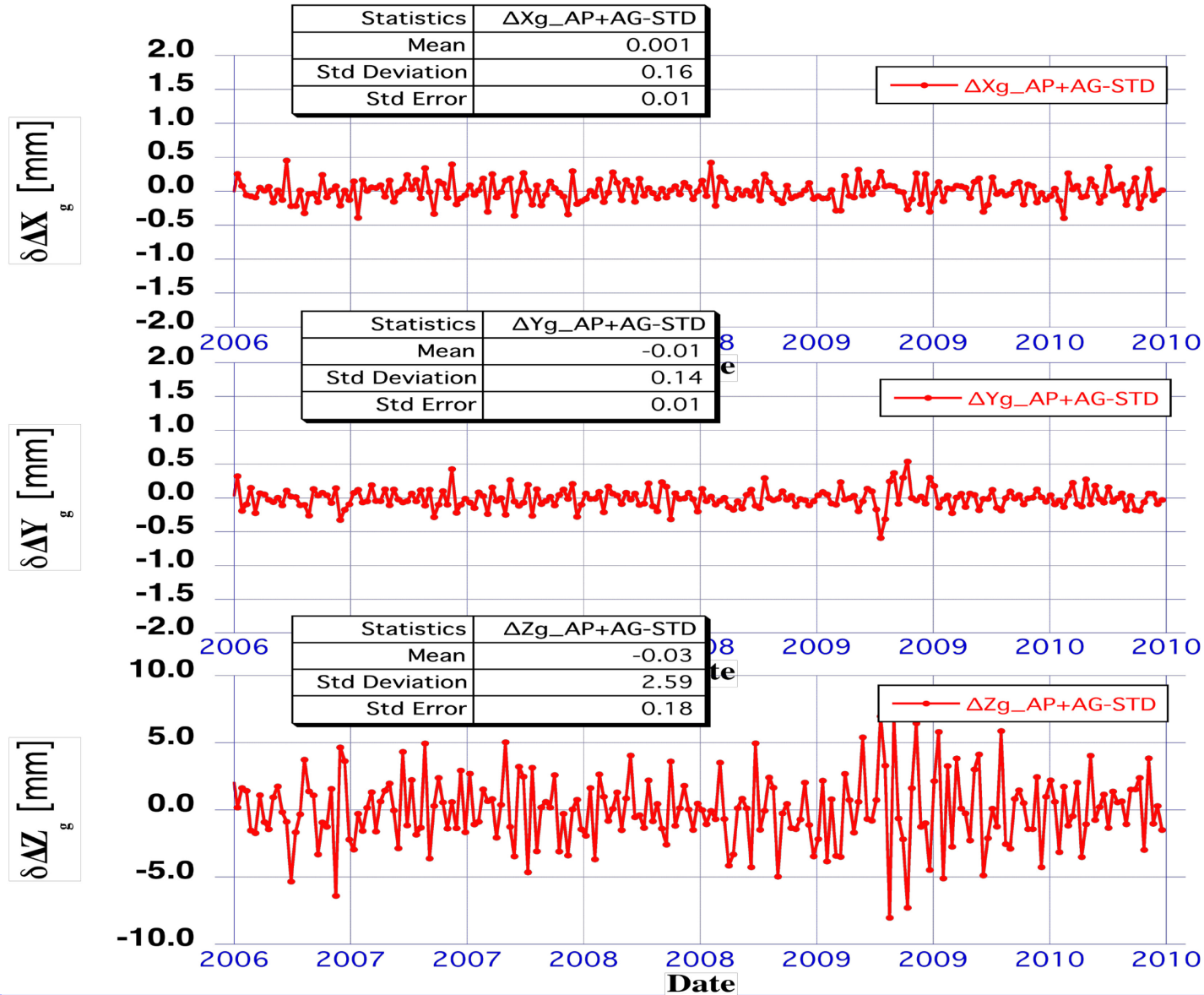
SLR TESTS over 2004 - 2010

Atmospheric Model Corrections
Comparison: ECMWF(J-P.B.)

Statistics	$\Delta\text{RMS} \{\text{AP}+\text{AG} - \text{STD}\} [\text{mm}]$
Minimum	-4.10
Maximum	4.30
Points	283
Mean	0.16
Median	0.13
RMS	0.84
Std Deviation	0.83
Std Error	0.05



Change in "Geocenter" Series





Summary

- Inclusion of atmospheric loading and gravity variations in the reduction of SLR data resulted in a small increase of the overall RMS of the weekly arcs for most of the 2004-2009 cases, although at the individual site level, there are several sites that show improvement
- The resulting “geocenter variations” series show little difference compared to the ones without the atmospheric corrections applied, especially the equatorial components
- Future reanalysis will use improved background TVG from GRACE RL05 and data from IERS GGFC
- Availability of GGFC data needs to be better understood