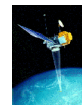


## New GSFC POD Standards for TOPEX/Poseidon, Jason-1, Jason-2 (OSTM)



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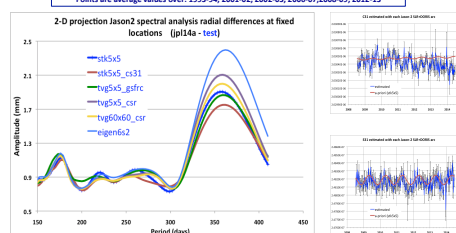
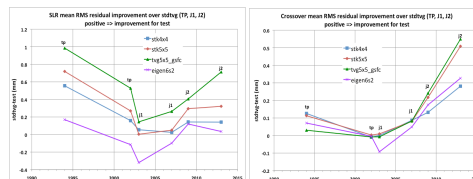
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POD gravity tests across TP, J1, and J2 show *stk5x5* is superior to other models, and second to the most recent *tv95x5* time series  
Estimating C31/S31 per arc greatly reduces annual signal wrt. *jpl14a* (*GPS-red-dyn.-based*) orbit.

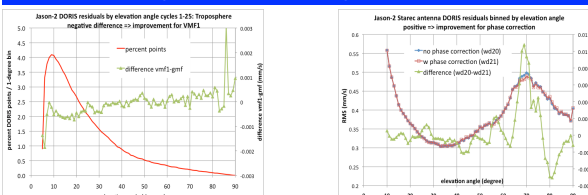
| TVG model        | Description (all forward model atmosphere gravity using ECMWF 6-hour data and apply the IERS2010 C21/S21 model)                                                                                   |
|------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| stdtvg (std1007) | 3 linear coefficient terms (IERS2010), 20x20 annual (GRACE); static EIGEN GL04s                                                                                                                   |
| stk4x4 (std1204) | 4x4 linear+periodic fit to previous tvg4x4 series, 5x20 annual (GRACE); static GOCO02s (from 5x5)                                                                                                 |
| tvgs5x5_gscf     | 7-day SRR/DORIS SXS estimates with relative weights for 21 satellites in solution calibrated using subset analysis (SPOT-2, SPOT-4 down-weighted), 6x20 annual (GRACE); static GOCO02s (from 6x6) |
| stk5x5 (std1404) | stacked tvgs5x5_gscf 5x5 solutions of static, periodic, linear terms in periods: 1) 1993-2002 and 2003-2013, 2) 1993-2002 and 2003-2006 and 2007-2013; ; static GOCO02s (from 6x6)                |
| eigen-6x2        | GRACE, LAGEOS, GCE solutions of static, periodic, linear terms in periods: 1) 2x2 1986-2002, 2) 50x50 2013-2013; static EIGEN6s2                                                                  |
| tvgs5x5_csr      | 5x5 from monthly CSR GRACE RL05 60x60 solutions; 6x20 annual (GRACE); static GGM05s                                                                                                               |
| tvgs60x60_csr    | 60x60 from monthly CSR GRACE RL05 60x60 solutions;                                                                                                                                                |

| Test gravity model                                    | Jason-2 55 arcs span<br>2006-2009 |               |                 | Jason-2 63 arcs span<br>2010-2013 |             |                 |
|-------------------------------------------------------|-----------------------------------|---------------|-----------------|-----------------------------------|-------------|-----------------|
| SLR/DORIS POD<br>(external<br>ephemeris<br>residuals) | DORIS<br>SLR (mm/<br>s)           | Xover<br>(mm) | Xover<br>(mm/s) | DORIS<br>SLR (mm/s)               | SLR<br>(mm) | Xover<br>(mm/s) |
| stdlv (std1007)                                       | 0.3765                            | 0.940         | 4.475           | 0.3803                            | 1.092       | 5.364           |
| std4x4 (std1204)                                      | 0.3764                            | 0.925         | 5.462           | 0.3801                            | 1.078       | 5.336           |
| std5x5 (std1404)                                      | 0.3764                            | 0.910         | 5.453           | 0.3800                            | 1.076       | 5.333           |
| std5x5 est. $C_{22}$ /<br>$S_{11}$                    | 0.3763                            | 0.900         | 5.454           | 0.3799                            | 1.038       | 5.312           |
| eigen-6x2                                             | 0.3763                            | 0.928         | 5.457           | 0.3799                            | 1.036       | 5.309           |
| std5x5_gsfsc                                          | 0.3764                            | 0.899         | 5.451           | 0.3799                            | 1.021       | 5.309           |
| ** tvstd5x5_gsf                                       | 0.3763                            | 0.907         | 5.452           | 0.3799                            | 1.051       | 5.307           |
| ** tvstd6060_csr                                      | 0.3763                            | 0.905         | 5.452           | 0.3797                            | 1.014       | 5.303           |

**\*\* cannot be extended prior to GRACE launch in 2002.**  
**New orbits (OSTST-2014)**



## Jason-2 DORIS test show VMF1 troposphere model and beacon phase correction improve POD



The new preliminary POD standard std1404 orbits offer an improvement over the current Measures std1204 orbits

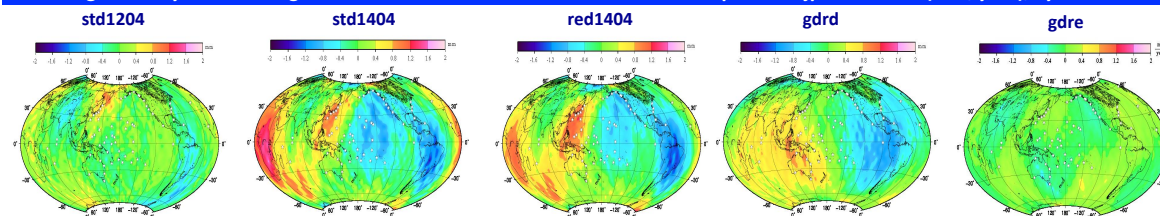
Comparison with the JPL jpl14a and CNES gdrd / gdre orbits show jpl14a / gdre offer the best xover residuals. All current orbits differ radially by less than 1-cm RMS with the jpl14a

| ORBIT<br>(external<br>ephemeris<br>residuals) | Jason2 mean RMS residuals<br>cycles 1-216 (July 2008 – May<br>2014) |             |                 | Jason2<br>jpl14a-test<br>orbit<br>differences<br>cycles 1-224 | Mean RMS TOD<br>(mm) |                 |                 | Mean ECF<br>(mm) |          |     |
|-----------------------------------------------|---------------------------------------------------------------------|-------------|-----------------|---------------------------------------------------------------|----------------------|-----------------|-----------------|------------------|----------|-----|
|                                               | DORIS<br>(mm/s)                                                     | SLR<br>(mm) | Xover<br>(cm) * |                                                               | radl                 | cross-<br>s-trk | along-<br>t-trk | X                | Y        | Z   |
| std1007                                       | 0.3789                                                              | 1.126       | 5.435           | std1007 (old<br>Meas)                                         | 10.<br>7             | 24.1            | 35.6            | 2.4              | -4.<br>8 | 3.0 |
| std1204                                       | 0.3782                                                              | 0.931       | 5.350           | std1204 (cur<br>Meas)                                         | 8.0                  | 23.1            | 30.5            | 1.4              | -2.<br>2 | 3.1 |
| std1404                                       | 0.3781                                                              | 0.949       | 5.336           | std1404 (new<br>Meas)                                         | 7.6                  | 22.2            | 29.3            | 3.1              | 0.3      | 2.9 |
| red1404 (red-<br>dyn)                         | 0.3777                                                              | 0.993       | 5.318           | red1404                                                       | 6.5                  | 18.9            | 24.8            | 2.0              | 0.8      | 2.5 |
| gdrr                                          | 0.3779                                                              | 1.216       | 5.341           | gdrr                                                          | 6.2                  | 13.0            | 17.5            | 1.1              | 2.7      | 1.5 |
| gdre                                          | 0.3782                                                              | 1.450       | 5.270           | gdre                                                          | 4.3                  | 13.0            | 15.4            | 0.5              | 1.4      | 1.4 |
| jpl14a                                        | 0.3785 *                                                            | 1.070 *     | 5.270           |                                                               |                      |                 |                 |                  |          |     |

[illegible]

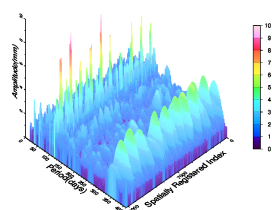
| satellite                                           | test    | mean RMS residuals |          |            |
|-----------------------------------------------------|---------|--------------------|----------|------------|
|                                                     |         | DORIS (mm/s)       | SLR (cm) | Xover (cm) |
| <b>topex</b><br><b>cyc 1-446</b>                    | std1204 | 0.4962             | 1.597    | 5.605      |
|                                                     | std1404 | 0.4960             | 1.579    | 5.610      |
| <b>jason1</b><br><b>cyc 1-374</b>                   | std1204 | 0.3697             | 0.853    | 5.458      |
|                                                     | std1404 | 0.3673             | 0.795    | 5.445      |
| <b>jason2</b><br><b>cyc 1-226</b><br>(xover<br>146) | std1204 | 0.3778             | 0.934    | 5.345      |
|                                                     | std1404 | 0.3779             | 0.907    | 5.332      |

Significantly different regional rates remain in the current orbits as compared to jpl14a – test (mm/year), cycles 1-224

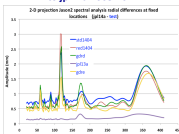


## Orbit comparison shows significant periodic error remains in modeling SRP and TVG

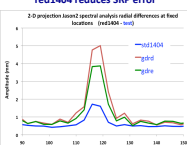
**Spectral analysis of (jpl14a-stk5x5)  
radial differences at fixed geographic  
points shows residual orbit error**



2-D projection of 3-D spectral plots  
show remaining orbit error relative  
to jpl14a 2008-2014



Comparison with the gdr orbits shows  
red1404 reduces SRP error



## SUMMARY

- **std1404 improvements over std1204 include the time-variable gravity modeling; station coordinate updates (*SLR & DORIS*), DORIS measurement modeling (*antenna phase map & VMF1*).**
- **All current orbits compare to within 1-cm with the jpl14a.**
- **Errors due to SRP (6-10mm 120-day amplitudes) and TVG (5 mm annual amplitudes) remain.**
- **Significant differences remain in regional orbit difference rates. Estimating  $C_{31}/S_{31}$  per arc reduces the differences.**
- **Future work will include:**
  - **Inclusion of a forward model for Earth center-of-mass variations.**
  - **Improvement of non-conservative force modeling for Jason-2.**
  - **Continued evaluation of the best methodology to parameterize time-variable gravity.**

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POD  
Konstanz, Germany