Status of GDR orbits for ocean topography missions and prospects for future improvements

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- Improved processing strategies for Jason POD: TEST2013 orbits
- First SARAL POD results
Evaluation of EIGEN6S2

- Improved processing strategies for Jason POD: TEST2013 orbits
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Progressive improvements in geopotential models and reference frame drive 10 year of changes in POD standards

- EIGEN6S2: GRACE data <=2012 and inter-annual TVG

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Next GDR (2014 ?)

EIGEN6-S2 (2013; proposed field for ITRF 2013)
Besides the periodic annual and seasonal components, this new field accounts for non-linear interannual variability with a piecewise linear model: bias and drift per year
Zero-drift extrapolation beyond 2012

EIGEN fields: result from cooperation between GFZ (GeoForschungsZentrum, Potsdam) and CNES/GRGS (Toulouse)
http://grs.obs-mip.fr/grace

EIGEN6S2 – Comparison to GRACE time-series
EIGEN6S2 – Comparison to GRACE time-series

Envisat - RMS of radial orbit difference

Cryosat - RMS of radial orbit difference
EIGEN6S2 – Impact on the rate of radial differences
(GDRD - EIGEN6S2)

- **JASON-2 (2009-2012)**
  Differences below 1 mm/year – impact is small, not sufficient to completely explain differences with respect to other groups

- **ENVISAT (2009-2012)**
  Differences exceed 2 mm/year close to the end of the mission
EIGEN6S2 – POE Post-fit SLR residuals
EIGEN6S2 – POE Post-fit SLR residuals
EIGEN6S2 - Conclusion

- EIGEN6-S2 allows a small improvement over the previous model (GDRD); better SLR fits and makes dynamic orbits closer to reduced dynamic orbits (see backups).

- Usually 2-3 years between successive POD standard definitions (mean model update): next GDR orbit release foreseen in 2014 (ITRF2013).

- If we can’t wait … observed errors induced on Jason are < 2 mm/yr on regional MSL trends and < 0.2 mm/year on global MSL trends, over 3 years (see also Couhert et al.). To mitigate this error:
  - **Dynamic orbits**: need a time series of Grace derived fields compatible with the latency of altimeter GDR products – Recommendation to GFO?
  - **Reduced dynamic orbits**: several options exists. At CNES we tried combining different approaches (Mascon for LEOs, C31/S31 for Jason, GPS based RD orbits). However, for better than 1 mm/year stability over <= 5 years time-span, using only tracking data from Jason, GPS-tracking seems necessary (is it sufficient?)
- Evaluation of EIGEN6S2

- Improved processing strategies for Jason POD: TEST2013 orbits

- First SARAL POD results
CNES TEST 2013 : improved processing strategies

- Need for a more stringent preprocessing of GPS measurements (see previous splinter summaries) → **30 sec processing** → reduced arc-length to avoid cumbersome calculations
  - 36-hour arcs every day (12 hours overlap)

- “Dynamic” step for DORIS, GPS and D+G : 1/rev Al. and Cross track per arc, 1 along-track constant every 6 hours

- Final “TEST2013” orbit: Dynamic D+G step, C31/S31 free to adjust, with 3-axis 1st order Markov process (sigma 1e-9 m/s², time constant : 900 s)

- Improved underlying models: EIGEN6S2, Atmospheric gravity from 3Hr ECMWF + full ocean response from T-UGOm2D, FES2012, Calibrated Semi-Empirical SRP model (Mercier and Cerri, OSTST 2013)
Closer to reference solutions of other groups

4 mm RMS wrt to JPL13A

5 mm

Small residual signatures from SRP modeling differences
Closer to reference solutions of other groups

**jpl13a – GDRD**

Cycles 001-176

**jpl13a – CNESTEST2013**

Cycles 001-176

**GSFC gsfc_ja2_poe_ld_std1204 – GDRD**

Cycles 001-176

**GSFC gsfc_ja2_poe_ld_std1204 – CNESTEST2013**

Cycles 001-176
Improved metrics: crossover variance

Each comparison is performed using common crossover points per cycle, only when nr points > 2800
Sensitivity of TEST2013 orbits to changes in gravity field

- Reduced dynamic approach: when TEST2013 orbits are computed with GDR-C gravity field (no drifts at all) instead of EIGEN6S2, impact on the orbit is negligible (RMS < 2mm, <0.5 mm/year).
TEST2013 orbits: conclusion

- TEST2013 reduced dynamic orbits are very close to JPL13a orbits
  - Both driven by GPS tracking
  - Average radial RMS ~ 4 mm
  - Geographically correlated rate of radial difference < 0.5 mm/year

- Orbit accuracy measured by crossover residuals is better on TEST2013 orbits than GDR-D (variance reduction of more than 20 mm^2)

- The dependency on the gravity field model underlying TEST2013 orbits is negligible

- However, differences between dynamic orbits (either DORIS or GPS-based) are still significant …
- Evaluation of EIGEN6S2
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SARAL POE: SLR RESIDUALS ON DORIS-ONLY ORBITS

- **Radial accuracy** of DORIS-only orbits **better than 2 cm RMS** (SLR residuals > 70°) – Similar to other DGXX-based missions
- Significant error is observed in the horizontal plane (low elevation residuals)

- Cross-track bias of the orbits of about 5 cm; effect is common to Doris-only or SLR-only orbits: either a mismodeled cross-track force or CoM correction
- This effect is likely too large for SRP/TRR mismodeling only, given the satellite surface towards the sun
- No impact on the altimeter mission, but relevant for the IDS analysts
SARAL POE: SENSITIVITY TO GRAVITY FIELD ERRORS

All tracks

Ascending tracks

EIGEN-6S2 - GDRD

Descending tracks

EIGEN-6S2 + MASCON - GDRD

MASCON effect
DORIS allows to solve for local mass anomalies (mascons) to correct a given field.

(Cerri et al. doi: 10.1016/j.asr.2013.03.023)

Mascons wrt to GDRD, drifts removed (Envisat, Cryosat)

Mascons wrt to GDRD, drifts removed (Saral)

Mascons wrt to EIGEN6S2, drifts removed (Saral+Cryosat)
The radial accuracy of SARAL precise orbits is comparable to that of other DORIS-based altimeter missions.

The current estimate of the radial accuracy is better than 2 cm RMS, as measured by the core network SLR residuals at high elevations on DORIS only orbits.

The most significant contributor to the geographically correlated error is to the time varying gravity field; its contribution does not exceed 5 mm on average over the time interval covered by this analysis – TBC when GRACE time series become available.

A significant cross-track error is observed using either DORIS or SLR data. This could be due to an error along Z in a surface force model or in the center of mass Z-coordinate, or both. Given the amplitude of this error, it is unlikely that the cause is a surface force alone. No impact expected on altimeter data analysis – relevant issue for IDS.
Backups
Solar radiation pressure acts mostly as a bias perpendicular to the orbit plane.

In this configuration, atmospheric drag mismodelling errors significantly affect the along-track 1/rev empirical (noticeable signature of the ~25-day sun-rotation cycle).

A different behavior is observed before April 2013. Did anything change in the satellite configuration?
The systematic component in the 1/rev empiricals (constant + f(beta)) could be removed by calibration if a complete beta prime cycle (1 year) is available in stable configuration.

In conclusion, estimated empirical forces are small and comparable in amplitude to those of other missions.