POD/Geoid splinter summary
GDR-C standards summary

- Complete reprocessing of Jason-1 cycles 1 → now
  - Reference Frame: ITRF2005
  - Time Varying Gravity: annual and atmospheric gravity (NCEP, IB)
  - Reduced weight of GPS wrt to SLR and Doris (more robust when GPS tracking was reduced)
  - Use of SAA model extended after the Doris instrument change
Comparison between GDR-C and GDR-B orbits

- Reference frame: from ITRF2000 hybrid configuration to a fully consistent ITRF2005 configuration
  - SLRF2005 station coordinates and biases (bias per pass is solved for a few stations)
  - DPOD2005 Doris coordinates
  - GPS constellation:
    - JPL solution (sp3, clk) @IGS (consistent with IGS05)
    - Ephemeris aligned by JPL to ITRF05 before GPS week 1400, clocks unchanged
  - Polar motion consistent with ITRF05

Mean radial difference GDR-C-GDRB, cycles 001-232

Radial difference rate GDR-C-GDRB, cycles 001-232

L. Cerri – OSTST Meeting, Nov. 10-15, 2008 - Nice
Comparison between GDR-C and GDR-B orbits

- Static gravity field: EIGEN-CG03C → EIGEN-GL04S
- Time varying components:
  - Annual + Semiannual (no drifts) from EIGEN-GL04S-ANNUAL model
  - Atmospheric gravity from AGRA files produced at GSFC
- These effects induce a time varying radial difference with an annual component that can reach 6 mm amplitude

![Annual signal in radial difference GDRC-GDRB (1-232)](image-url)
SLR residuals on GDR-B and GDR-C orbits

- Improved orbit accuracy cross- and along-track (new GPS-phase maps)
- Stronger relative weight of SLR measurements accentuates the improvement

Histogram of SLR residuals

7090YARR, 7105WASH, 7110MONU, 7839GRAZ, 7080FORT
RMS per cycle; all elevations

7090YARR, 7105WASH, 7110MONU, 7839GRAZ, 7080FORT
RMS per cycle; elevation > 60°
The GDR-C orbit “problem”

- Jason-1 orbit is sensitive to order 1 terms in the gravity field
- EIGEN4-GL04S-ANNUAL drifts were estimated using GRACE data from 02/03 to 07/05
- over that period S3,1 drifted significantly, it has since leveled off
- extrapolation of drifts leads to unacceptable results: all drifts have now been removed from the GDR-C standards (except for those included in the IERS standards)
Trend from GRACE over 5 years (mid-2002 to mid-2007) in Equivalent Water Height.
unit: m/y; spherical harmonic degrees 2 to 50
GRACE solutions error for Trend: 0.9 cm/y RMS
(rms: 0.0149 / moy: 0.0000 / min: -0.1794 / max: 0.0717)

1- Post-glacial rebound
2- Glacier melting
3- Hydrological trends
4- Sumatra earthquake
3- Should we use « secular trends » or « broken line » ?

- In some cases, a “broken line” seems more appropriate (e.g. Greenland) or C2,0

BUT...

- More parameters → more noise ;
- More difficult to implement for users ;
- Problem of predictability (extrapolation) ;
- If great accuracy is needed, then the time series solution can be used !
Evidence of SLR station bias / position error, the LPOD2005 solution, and effect on the Jason-1 orbit.
External comparisons 1/3

- CNES orbit compares to the cm level with JPL and GSFC
- Few exceptions mainly on GSFC dynamic orbit (attitude events?)
- Excellent agreement with GSFC reduced dynamic orbits (mean radial RMS=0.83 cm)
Jason-2 Radial Orbit Accuracy: External Measure Yields <1 cm Agreement

JPL RD (GPS) – GSFC TUNED RD(SLR + DORIS) RMS = 9 mm (also Lemoine et al.)

RMS ASC = 7 mm
RMS DES = 6 mm

High Elevation SLR Range Biases: RMS = 15 mm, with 7 mm repeatability at both Yaragadee (N = 66) and Graz (N = 35)
Post-fit SLR Residuals

Better fit for Jason-2: possible causes
- Radial accuracy probably increased by higher number of empirical forces (12 hr 1/rev thanks to GPS)
- SAA effect degrades Jason-1 orbit

RMS of SLR residuals per cycle

7090YARR, 7105WASH, 7110MONU, 7839GRAZ, 7080FORT
All elevations

Jason-1 mean = 0.23 cm, StDev = 1.18 cm
Jason-2 mean = 0.32 cm, Srdev = 0.87 cm
Conclusions (1)

• **GDR-C standards are close to the state of the art**
  – transition from SLRF2005 (with adjusted biases) to LPOD2005 would further improve long term performance; this transition will be implemented without impact on users (no reprocessing)
  – modeling of long term changes in the gravity field due to hydrology and ice melting is not mature enough to enter the standard; impact of long term drifts will be monitored using GRACE monthly solutions, and mitigation techniques involving empirical parametrizations will be investigated

• **Jason-2 POE orbits already have a precision comparable with those of Jason-1**
  – minor modeling issues need to be analyzed (surface force models, instrument phase center corrections, etc.)
  – these orbits already meet GDR precision requirements
Conclusions (2)

- Parametrizations for Jason-1 and Jason-2 are slightly different to optimize orbit precision given the available tracking data
  - these differences in parametrization induce small differences in orbit error signatures that might affect tandem mission intercalibration
  - GSFC has produced a set of orbits for Jason-1 and Jason-2 which are designed to be as consistent as possible
  - current Jason-1 IGDR orbits (MOE) are not suitable for intercalibration work (they do not use the DORIS SAA model)

- POD is not sensitive to the Jason-1 / Jason-2 relative geometry
  - no recommendation is issued by the POD group regarding where and when to move Jason-1
  - SAA model adjustment to the new ground track will require time; during that time orbit precision will likely be degraded
Geoid Summary
GRACE Mission Status: Still Good

NASA 2007 Senior Review and DLR approved mission extension and funding through 2009

- Extension to 2011 approved by NASA “in-principle”; discussions underway at DLR
- Predicted mission lifetime at least 2013

Flight Segment

- Almost 100% of scientific measurements for nearly seven years have been collected and analyzed
- Instrument performance continues to meet mission requirements

New mean gravity models

- GGM03S, EIGEN-GL05S&C, ITG-GRACE03S, EGM2008
Improved Next-Generation Geoid Models  
(EIGEN-GL05C, EGM2008)

EGM2008

EGM2008 vs. EIGEN-5C

GGM03S vs. EIGEN-5C

ITG-GRACE03S vs. EIGEN-5C

Overweighting of the terrestrial data?

EIGEN-5C vs. GGM03S

EIGEN-5C: Degree variances (in terms of geoid heights) in comparison to other current models including EGM2008
Short Wavelength Geoid Residuals
EIGEN-GL04C

The residuals are the difference between a ‘high-frequency DOT’ defined as (GSFCMSS00 – geoid) and the same DOT smoothed to ~900 km

Scale is +/- 25 cm.
The residuals are the difference between a ‘high-frequency DOT’ defined as (GSFCMSS00 – geoid) and the same DOT smoothed to ~900 km.

Scale is +/- 25 cm.
Short Wavelength Geoid Residuals
EGM2008

The residuals are the difference between a ‘high-frequency DOT’ defined as
(GSFCMSS00 − geoid) and the same DOT smoothed to ~900 km

Scale is +/- 25 cm.
Short Wavelength Geoid Comparison

Calculate global RMS of the residual geoid after removing a model for the mean dynamic ocean topography (i.e. MSS - WOA01 DOT - geoid) at different wavelength filtering (shorter and longer than 300 km $\lambda/2$).

<table>
<thead>
<tr>
<th>Model</th>
<th>&gt; 300 km</th>
<th>&lt; 300 km</th>
</tr>
</thead>
<tbody>
<tr>
<td>EGM96</td>
<td>9.3</td>
<td>12.7</td>
</tr>
<tr>
<td>GGM02C (+EGM96)</td>
<td>8.2</td>
<td>12.7</td>
</tr>
<tr>
<td>EIGEN-GL04C</td>
<td>8.7</td>
<td>13.1</td>
</tr>
<tr>
<td>EIGEN-GL05C</td>
<td>7.8</td>
<td>12.6</td>
</tr>
<tr>
<td>EGM08</td>
<td>7.6</td>
<td>11.7</td>
</tr>
</tbody>
</table>

Units are cm

Computed along new T/P groundtrack to provide independent assessment. Mean removed along each altimeter pass before computing the RMS.

(GGM02C extended above 200x200 by EGM96)
Use of oceanographic in-situ measurements and altimetry to assess the accuracy of the latest geoid models

Computation of the ocean Mean Dynamic Topography from filtered altimetric MSS - Geoid (direct MDT)

Use of in-situ oceanographic measurements and altimetry to compute synthetic estimates of the MDT (and mean velocities)

+ geostrophic mean surface currents
Results

MDTsynth versus MDT 133 km (MSS-EIGEN5S) versus MDT 1000 km (MSS-EIGEN5S)

Graph showing RMS (cm) over km range for different models:
- EIGEN6C3V
- EIGEN3C
- GGMO2S
- EGM96
- EIGEN6C5
- EGM08

Colors represent different data sets with variations in magnitude and distribution across the globe.
EGM2008 Complete to 2190x2159

(from Pavlis et al., 2008)
New generation models improve accuracy of marine geoid

- EIGEN-GL05C improvement over EIGEN-GL04C
  - Smoother marine geoid; ‘striations’ nearly eliminated
  - Best orbit determination performance
- EGM08 performs best in the short-wavelength geoid tests
  - Expansion to 2190x2159 provides considerably greater detail
- Looking forward to the contribution of GOCE to geoid accuracy