Sea Level CCI project

Phase II
2nd annual review
SLCCI Phase 2 GFZ Option Study on time variable gravity field models

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WP 2810 A study on the truncation degree of the time variable terms of the EIGEN-6S4 geopotential model for Envisat POD
EIGEN-6S4 time variable geopotential model (maximum n and m is 300).
Gravity field coefficient representation:
\[ C(n,m)(t) = C(n,m)(0) + C(n,m)\text{dot}\, dt + \]
\[ + C(n,m)(\sin{A})\, \sin(2\pi dt) + C(n,m)(\cos{A})\, \cos(2\pi dt) + \]
\[ + C(n,m)(\sin{S})\, \sin(4\pi dt) + C(n,m)(\cos{S})\, \cos(4\pi dt), \]
where \( C(n,m) \), \( C(n,m)(\sin{A}) \), \( C(n,m)(\cos{A}) \), \( C(n,m)(\sin{S}) \), \( C(n,m)(\cos{S}) \) are given as an yearly time series.
Drift terms \( C(n,m)\text{dot} \) and \( S(n,m)\text{dot} \) of degree 1-80 are estimated from GRACE data from 15.08.2002 until 15.06.2014 and set to zero after that date.

Tests for Envisat precise orbit determination from April 2002 till April 2012 (763 seven-day orbital arcs with two-day arc overlaps) were performed. The truncation degree of the static geopotential terms is 90 for all test cases.

Truncation degree of drift geopotential terms \( C(n,m)\text{dot} \) and \( S(n,m)\text{dot} \):
80, 70, 60, 50, 40, 30, 25, 20, 15, 12, 10, 9, 8, 7, 6, 5, 4, 3, 2, 1.
Impact of the truncation degree of the geopotential drift terms on the RMS fits of SLR and DORIS observations for Envisat (2002-2012)

Minimum SLR RMS fits are reached at the truncation degree of geopotential drift terms equal to 12.

Minimum DORIS RMS fits are reached at the truncation degree of geopotential drift terms equal to 12. No additional impact of the drift terms of higher degree on DORIS RMS fits.
Impact of the truncation degree of the geopotential drift terms on the radial and cross-track 2-day orbit arc overlaps for Envisat (2002-2012)

Minimum radial arc overlaps are reached at the truncation degree of geopotential drift terms equal to 20, 60 and 80.

Minimum cross-track arc overlaps are reached at the truncation degree of geopotential drift terms equal to 8 and 10.
Impact of the truncation degree of the geopotential drift terms on the along-track 2-day orbit arc overlaps for Envisat (2002-2012)

Minimum radial arc overlaps are reached at the truncation degree of geopotential drift terms equal to 80.
Conclusions

on the study on the truncation degree of the time variable terms
of the EIGEN-6S4 geopotential model for Envisat POD
(WP 2810)

- The major contribution of the geopotential drift terms to the Envisat orbit quality is given by low degree terms up to degree 12

- However, to reach the best orbit quality in the radial (what is important for altimetry applications) and along-track directions the geopotential drift terms up to degree and order 80 should be used

- Slightly increase of the cross-track orbit error, when using EIGEN-6S4 geopotential drift terms for degree larger than 20
WP 2820 Computation of Envisat, Jason-1 and Jason-2 orbits using GFZ RBF solutions and EIGEN-6S4 geopotential model
Data Input (orbital arcs)
KBRR/ACC/Star camera
GRACE observations
Auto-correl., Emp. Cov Functions
Least Squares Prediction
System update Kalman Gain

Background Modeling

Deterministic constraints

Monthly/Daily Cross/Covariance

Stochastic constraints

AOD1B 6h glo
EIGEN6c static
Ocean Tides
WaterGap Mod +AOD1B

External Data

Processing Scheme Kalman Filter

Daily Output

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Goal is to use gravity measurements as indicator of droughts and flood events. Improved data analysis with increased temporal and spatial resolution -> modeling in spatial domain.

**Daily Kalman state vector consisting of:**
2x2 arc-degree grids of time variable gravity and spherical harmonic coefficients (spherical harmonic degree and order 90)

2x2 arc-degree anomaly to the applied time-variable (secular/seasonal) background modeling

1x1 arc-degree grids (spherical harmonic degree and order 180) of regionalized products for defined areas of interest for early warning and prediction.

Error estimates for the state vector / grid values
Water storage anomalies against time-variable background modeling:

Additional, significant offset to the modeled trend/seasonal variations

Near Real Time (5 days latency)

Results obtained at GFZ within the work of European Gravity Consortium
RMS fits of SLR and DORIS observations of Envisat (2002-2012) obtained using EIGEN-6S4 model and GFZ RBF05 gravity field solutions.

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Radial and cross-track arc overlaps of Envisat (2002-2012) orbits obtained using EIGEN-6S4 model and GFZ RBF05 gravity field solutions.
Along-track arc overlaps of Envisat (2002-2012) orbits obtained using EIGEN-6S4 model and GFZ RBF05 gravity field solutions.

Rather similar behaviour of Envisat SLR and DORIS RMS fits computed using EIGEN-6S4 model and GFZ RBF05 gravity field solutions.

Two-day arc overlaps of Envisat orbits computed using EIGEN-6S4 model are, on average, smaller than those of orbits derived using GFZ RBF05 gravity field solutions. However, the later improve some outliers in arc overlaps.
Conclusions on the computation of Envisat, Jason-1 and Jason-2 orbits using GFZ RBF solutions and EIGEN-6S4 geopotential model (WP 2820)

- Precise orbits of Envisat (2002-2012), Jason-1 (2002-2013) and Jason-2 (2008-2014) have been derived using GFZ RBF05 Earth daily time variable gravity field solutions and EIGEN-6S4 geopotential model.

- The quality of the orbits derived using EIGEN-6S4 geopotential model is presently somewhat higher than the quality of the orbits computed using GFZ RBF05 gravity field solutions. However, the orbit quality is rather comparable.

- Numerous activities are presently undertaken at GFZ within the EGSIEM project in order to improve the quality of RBF Earth daily time variable gravity field solutions. That should also improve the orbit quality.

- The time-variable (drift) information in a gravity field model is not up-to-date. RBF gravity field solutions provide more realistic information due to short latency (5 days) for the period after June 2014.