The GOCE gradiometer - instrument status, data processing and product performance

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Observed gravity gradients

- The following plots show gradiometer Level 1b data products from 30 September to 16 November 2009
- Sinc filtered and Hanning windowed to emphasise measurement band (high-pass)
- Gradients are:
  - given in instrument reference frame
  - internally calibrated (i.e. no confrontation with pre-GOCE gravity field information to determine scales, biases, n cprs, etc.)
Observed gravity gradients: $U_{xx}$
Observed gravity gradients: $U_{yy}$
Observed gravity gradients: $U_{zz}$
Observed gravity gradients: $U_{xx} - U_{zz}$
Observed gravity gradients: $U_{xz}$
Observed gravity gradients: $U_{xy}$ and $U_{yz}$
Differences w.r.t. EIGEN5C: $U_{xx}$
Differences w.r.t. EIGEN5C: $U_{yy}$
Differences w.r.t. EIGEN5C: U_{zz}
Differences w.r.t. EIGEN5C: $U_{xx} - U_{zz}$
Differences w.r.t. EIGEN5C: \( U_{xy} \) and \( U_{yz} \)
GRADIOMETRY
Comparison with EGM2008 up to degree/order 250

Filtered $V_{zz}$ (Pre-whitening filter), epoch 0:53:50.73, 5/11/2009

correlation coeff. is 0.99503
Improvements during commissioning phase

Change of proof mass angular control about less-sensitive axis

- A very significant 30% improvement has been achieved by not using electrode pairs along the directions of individual gradiometer arms in proof mass angular control
- Conclusion: there was a “noise” introduced using in-line electrodes for angular control; remaining error now in transversal axis

Parameter update for determination of centrifugal accelerations

- Affects the mix of star camera and gradiometer observations
- Implemented in dedicated Kalman filter as part of Level 1 processing

- Trace of gradient tensor in upper measurement band now $\sim 20 \text{ mE/}\sqrt{\text{Hz}}$
Differential accelerations

DoY 278-280 - DFM-Fine Mode -

Acceleration SD [m/(s² Hz¹/2)]

Frequency [Hz]
Centrifugal accelerations

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Square of Angular Rate SD [mE/Hz^{1/2}]

Frequency [Hz]
Along-track gradients (GRF)

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\[ U_{xx} \text{ SD} \text{ [mE/Hz}^{1/2}] \]

Frequency [Hz]
Cross-track gradients (GRF)

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Uncalibrated EGG
Calibrated EGG

$U_{yy} \text{ SD [mE/Hz}^{1/2}\text{]}$

Frequency [Hz]

European Space Agency
Satellite-to-Satellite Tracking Instrument

- Top class orbits: **current POD accuracy is at 1-2 cm level** in each of the three orthogonal directions
- In most cases better than 2 cm 3D RMS
- Rapid science orbits (<1 day latency) are at 3-4 cm accuracy
- Validated by Satellite Laser Ranging to within absolute differences of approximately 2.5 cm
Orbit overlaps

Daily RMS of overlaps of consecutive orbits (6h each day)

- red: radial
- green: along-track
- blue: cross-track
Reduced-dynamic vs. kinematic orbits

Daily RMS of differences between reduced-dynamic and kinematic orbit

- **radial**
- **along-track**
- **cross-track**

Days of Year 2009

RMS [mm]
POD validation by Satellite Laser Ranging

SLR Residuals for GOCE

DoY 2009 [days]

Ascending
- Yarragadee
- San Juan
- Mt. Stromlo
- Greenbelt
- Haleakala
- Hartebeestoek
- Zimmerwald
- Herstmonceux
- Monument Peak
- Changchun
- Potsdam
- Graz
- Concepcion
- San Fernando
- Riga
- Matera
- Katziely
- Koganei

Descending
CONCLUSIONS

- Science data are continuously delivered to ground (1 Hz data rate); no gaps in gradiometer data stream
- Gradiometric observing system (satellite + instrument) performs excellently
- Precise orbit product is top-notch
- Analysis of gradiometer data quality indicates that all mission objectives will be met
- Data from non drag-free periods (commissioning phase, April - September) will also be made available (use with care!)