

EGU General Assembly 2019

**Session G4.1: Satellite Gravimetry** 

UNIVERSITÄT BERN

## GPS-based gravity field recovery from reprocessed GOCE precise science orbits

Thomas Grombein<sup>1</sup>, Daniel Arnold<sup>2</sup>, Adrian Jäggi<sup>2</sup>

<sup>1</sup> Geodetic Institute, Karlsruhe Institute of Technology <sup>2</sup> Astronomical Institute, University of Bern





#### Introduction



- GOCE Precise Science Orbits (PSO)
  - GPS-based orbit determination via Satellite-to-Satellite Tracking (SST-hl)
  - Kinematic and reduced-dynamic orbits



- Kinematic orbit position are used to recover the long-wavelengths gravity field
- Input for combined GOCE gravity field models (GPS + gradiometry)
- Degradation of kinematic positons propagates into gravity field solutions





#### **Motivation**



Gravity field recovery based on operational GOCE PSO (Jäggi et. al., 2015)



Ionosphere-induced artifacts along the geomagnetic equator

Differences w.r.t. ITSG-GRACE2016 (300 km Gauss-filtered)

Workaround: Exclusion of affected GPS observations from orbit determination Problem: Degradation of orbit quality (→ not applied for official PSO product) GOCE Reprocessing campaign: Reprocessing of GOCE PSO and gravity field recovery

#### Efforts within the GOCE Reprocessing Campaign (1/2)



- Complete reprocessing of GOCE PSO
  - Bernese GNSS software using reprocessed GPS products (IGb08)
  - Down-weighting strategy to mitigate ionosphere-induced effects
    - Affected GPS observations get higher covariance values
    - Criterion 1: Large changes in geometry-free linear combination (2<sup>nd</sup> derivative)
    - Criterion 2: Large ROTI values (Rate Of TEC Index)
    - Performance is validated by orbit overlaps and SLR residuals

#### Efforts within the GOCE Reprocessing Campaign (2/2)



- Gravity field recovery (Celestial Mechanics Approach)
  - 1-sec reprocessed kinematic GOCE positions (epoch-wise covariance information)
  - Arc-specific orbit and gravity field parameters are estimated simultaneously
    - Six initial Keplerian elements for each 24-hour arc
    - Constant and once-per-revolution empirical accelerations over 24 hours
    - Pseudo-stochastic pulses each 6 minutes (constrained)
    - SH coefficients up to degree and order 120 (without regularization)
  - Use of GOCE accelerometer (ACC) data to improve lowest SH coefficients

#### Gravity field solutions



#### **Gravity field recovery**

6





T. Grombein, D. Arnold, A. Jäggi – GPS-based gravity field recovery from reprocessed GOCE PSO

2019-04-11

#### **Operational PSO**





#### **Reprocessed PSO**





#### **Reprocessed PSO + ACC data**







# Accumulated solutions

#### **Accumulated solutions for 2011**





#### 11 T. Grombein, D. Arnold, A. Jäggi – GPS-based gravity field recovery from reprocessed GOCE PSO

#### Accumulated solutions for 2011





#### 12 T. Grombein, D. Arnold, A. Jäggi – GPS-based gravity field recovery from reprocessed GOCE PSO













Statistics of differences in the region  $|\varphi| \le 50^{\circ}$ 

Version	Min [mm]	Max [mm]	WRMS [mm]
Operational PSO	-32.5	50.1	10.9
Reprocessed PSO + ACC	-11.7	16.7	3.3







#### Current activities: Additional screening of kinematic positions

- Screening based on covariance values of positions in the region  $|\phi| \le 50^{\circ}$
- Threshold of 3 cm  $\rightarrow$  2.97 % reduction of observations







Statistics of differences in the region  $|\varphi| \le 50^{\circ}$ 

Version	Min [mm]	Max [mm]	WRMS [mm]
Reprocessed PSO + ACC	-11.7	16.7	3.3
Reprocessed PSO (screened) + ACC	-11.9	9.4	2.7







Statistics of differences in the region  $|\varphi| \le 50^{\circ}$ 

Version	Min [mm]	Max [mm]	WRMS [mm]
Reprocessed PSO + ACC	-11.7	16.7	3.3
Reprocessed PSO (screened) + ACC	-11.9	9.4	2.7

#### Summary



- GOCE Reprocessing Campaign
  - Complete reprocessing of the GOCE Precise Science Orbits (PSO)
  - Improved GPS-based gravity field recovery based on reprocessed PSO
- Main findings
  - Observation weighting positively impacts lower degrees (esp. 10 < n < 50)
  - Strong reduction of artifacts along the geomagnetic equator
  - Use of GOCE accelerometer data improves lowest degrees (n < 10)
  - Further significant reduction of artifacts by screening based on covariance values

New long-term GOCE GPS-only gravity field solution based on reprocessed
PSO is available for the whole mission period (2009 – 2013)



#### Thank you for your attention



#### Contact: grombein@kit.edu