Investigations of GNSS-derived baselines for gravity field recovery

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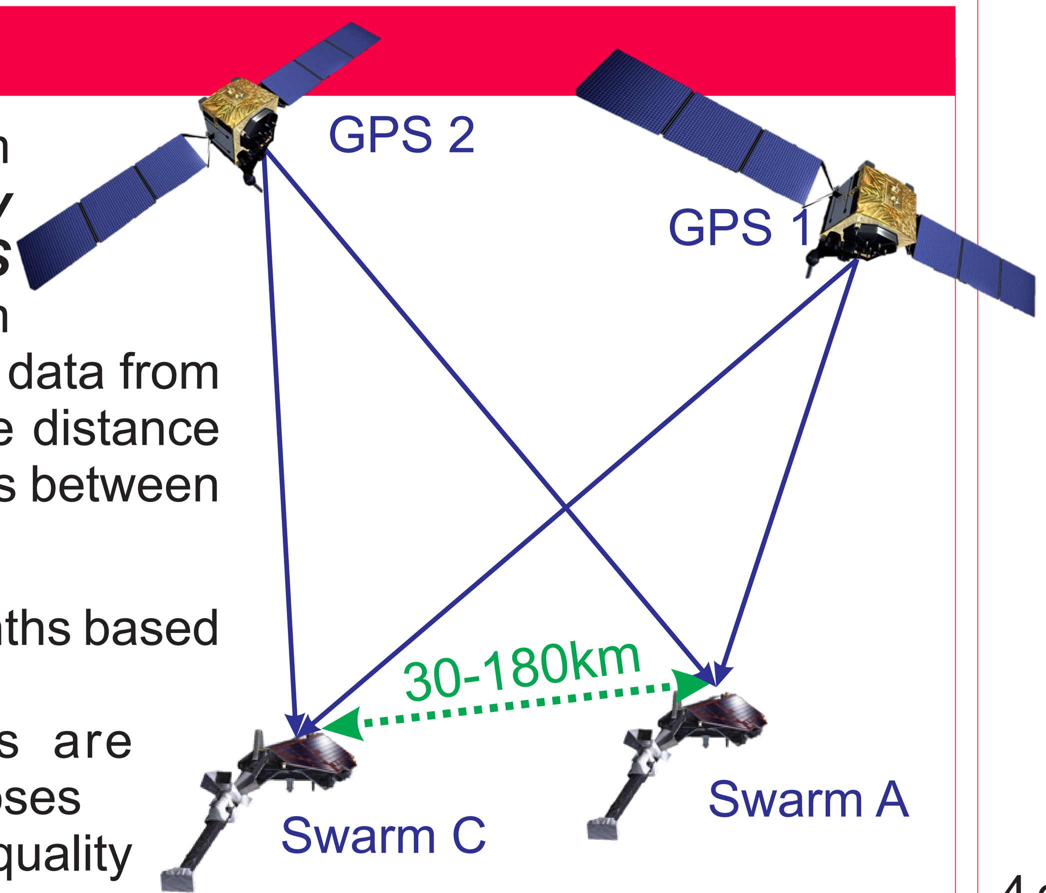
Introduction

Gravity field recovery from GNSS observations of Low-Earth orbiting satellites is a well known approach. Commonly kinematic satellite orbits are use as observations for the gravity field estimation. Some of satellite missions include more than one satellite, orbiting the Earth in a close formation, e.g. Swarm A and C or TerraSAR-X and TanDEM-X. Thus, GNSS observations of two satellites can be used to determine the inter-satellite baseline with high accuracy in the range of millimeters[1]. The question was:

Is the usage of GNSS-derived inter-satellite baselines beneficial for gravity field inversion?

Test set up



The analysis is part of the Swarm project ***Multi-approach gravity field models from Swarm GPS data*** funded by the European Space Agency. We analyzed GPS data from the Swarm satellites A and C. The distance between the two spacecrafts varies between 30 and 180 km.

We have selected several test months based on the following criteria:

- Grace monthly solutions are available for validation purposes
- Months with varying data quality shall be included

"bad" data quality: high ionospheric acitivty, error in the RINEX converter present, and receiver tracking loop settings not optimized yet.

- January and March 2015

"good" data quality: low ionospheric activity, error in the RINEX converter solved (as of 12. April 2016), and receiver tracking loop settings optimized.

- June, July and August 2016

"intermediate" data quality: partly optimized receiver settings and medium ionospheric activity

- February and March 2016

Kinematic baselines from TU Delft

Baseline processing was done at TU Delft using the GPS High Precision Orbit Determination Software Tools (GHOST).

Kinematic baselines from AIUB

At AIUB the estimation of the kinematic baselines was carried out using the GNSS processing software BERNESE.

Results and validation

Gravity field inversion from kinematic baselines and orbits

Gravity field processing was carried out at the IfG. The method is based on the variational equation approach and is identical to the processing routines used for the generation of the ITSG-Grace2016 solutions[2]. The kinematic baselines from TUD and AIUB have been transformed to range observations. These were then processed as if they would originate from a ranging instrument like the Grace K-Band instrument.

Some processing facts:

Observations:	*kinematic orbits Swarm A and C + range observations (kinematic baselines)*
Co-variance infromation:	*3x3 epoch covariance for kinematic orbit*
Co-variance function:	*estimated for orbits and range observations*
Non-gravitational forces:	*simulated accelerometer measurement*
observation sampling:	*10s*
arc length:	*3h*
maximum D/O:	*60*
accelerometer bias:	*arc-wise spline of degree 3*
a priori gravity field:	*GOCO05*

4 different solutions have been computed for each of the selected test months:

- **hl-SST**: based on kinematic orbits from **TUD**
- **ll+hl SST:** based on kinematic orbits and baselines from **TUD**
- **hl-SST:** based on kinematic orbits from **AIUB**
- **ll+hl SST**: based on kinematic orbits and baselines from **AIUB**

	TU Delft		AIUB	
	hl-SST [mm]	ll+hl SST [mm]	hl-SST [mm]	ll+hl SST [mm]
01.2015	9.5	9.6	9.8	10.5
03.2015	10.9	11.1	8.4	9.6
02.2016	7.5	7.4	7.4	7.2
03.2016	8.8	8.6	7.3	7.3
06.2016	5.4	5.5	4.8	4.8
07.2016	6.7	6.5	6.3	6.1
08.2016	5.7	5.8	5.3	5.4

Table 1: RMS of geoid height differences in millimeters on a 1°x1° grid for different solutions with respect to the corresponding ITSG-Grace2016 monthly solution. 500 km gaussian Filter applied.

Difference degree amplitudes

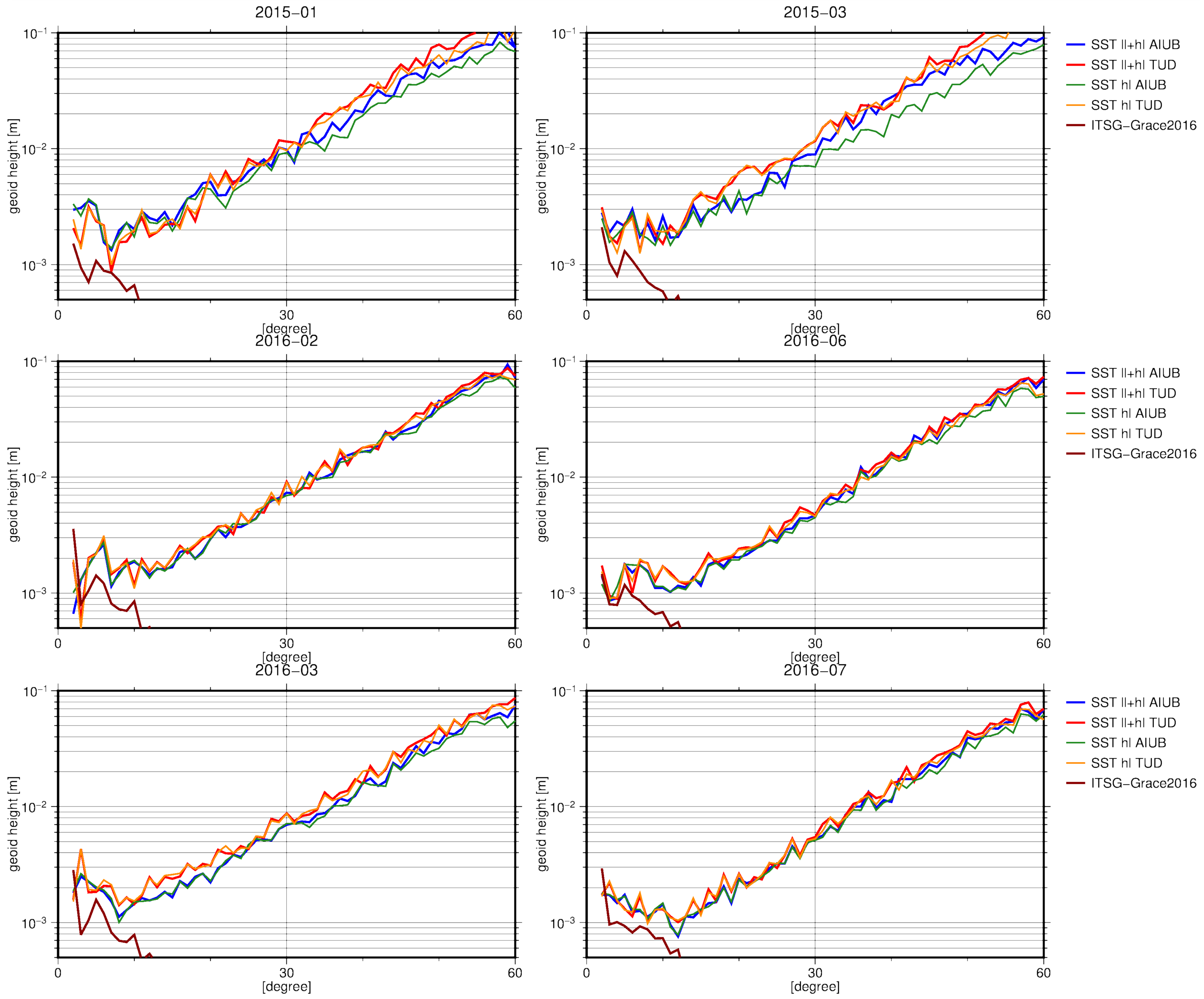


Figure 1: Difference degree amplitudes of all four solutions for "bad" (top row), "intermediate" (center row), and "good" (bottom row) data quality months with respect to GOCO05S. ITSG-Grace2016 solution shown for comparison.

Discussion

The main conclusion that can be drawn from the analysis is:

Including GNSS derived baselines into the gravity field inversion process does not result in an improved estimate compared to only using kinematic orbit information.

Conclusion holds for "bad", "intermediate" and "good" quality months. Only small differences seen between AIUB and TUD solutions.

Possible explanations:

- Common errors are already sufficiently modeled in the kinematic orbits, thus no additional information contained in the baselines.
- Orbits and baselines are based on the same observations => same information content in orbits and baseline.

Institutions

TU Graz · asu Astronomical Institute of the Czech Academy of Sciences · TU Delft · u^b Universität Bern · The Ohio State University · Swarm DISC · swarm

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References

[1] Jäggi A., Montenbruck O, Moon Y, et al. (2012) Inter-agency comparison of TanDEM-X baseline solutions. Adv Sp Res 50:260–271. doi: 10.1016/j.asr.2012.03.027
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