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SST-hl: Time variable gravity from multiple non-dedicated satellites

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Introduction

For many applications based on time variable gravity field information it is of crucial importance to have a continuous time series of observations. A possible gap between GRACE and its successor GRACE-FO threatens this unique observational record. Recent studies proved that high-low satellite-to-satellite tracking works for long-wavelength signals, like large river basins (Weigelt et al., 2014). However, these studies were all based on data from dedicated gravity field missions (CHAMP, GRACE, GOCE). Non-dedicated satellites were just added as a supplement. We now investigate the possibility of retrieving gravity variations solely based on data from non-dedicated satellites carrying a geodetic GNSS receiver.

Gravity Field Processing

Gravity field determination from SST-hl observations is a two-step process.

1. GNSS observations made by the on-board receiver are used to derive **kinematic orbit positions**
2. **Gravity field estimation** with kinematic positions as observations

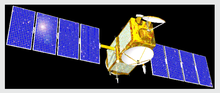
For precise orbit determination we apply a **precise point positioning** method based on **raw GNSS measurements** (Zehentner and Mayer-Gürr, 2014).

- Raw observations, no linear combination or differencing
- Antenna center variations for receivers and transmitters (azimuth and elevation dependent)
- Azimuth and elevation dependent weighting scheme
- Outlier detection by variance component estimation
- Higher order ionospheric terms considered
- Ionospheric signal bending considered
- ...

For gravity field estimation we applied the **short-arc integral approach** (Mayer-Gürr, 2006). Individual solutions are then combined on the level of normal equations with variance component estimation. Important properties of our monthly solutions:

- **No regularization**
- **No Kalman filtering**

Satellite Missions



Jason 1
- Altimetry satellite
- Altitude 1330 km
- BlackJack Receiver

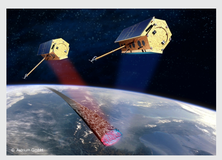
Jason 2
- Altimetry satellite
- Altitude 1330 km
- BlackJack Receiver

MetOp-A
- Weather satellite
- Altitude 820 km
- GRAS Receiver

MetOp-B
- Weather satellite
- Altitude 820 km
- GRAS Receiver

SAC-C
- Earth observation
- Altitude 705 km
- BlackJack Receiver

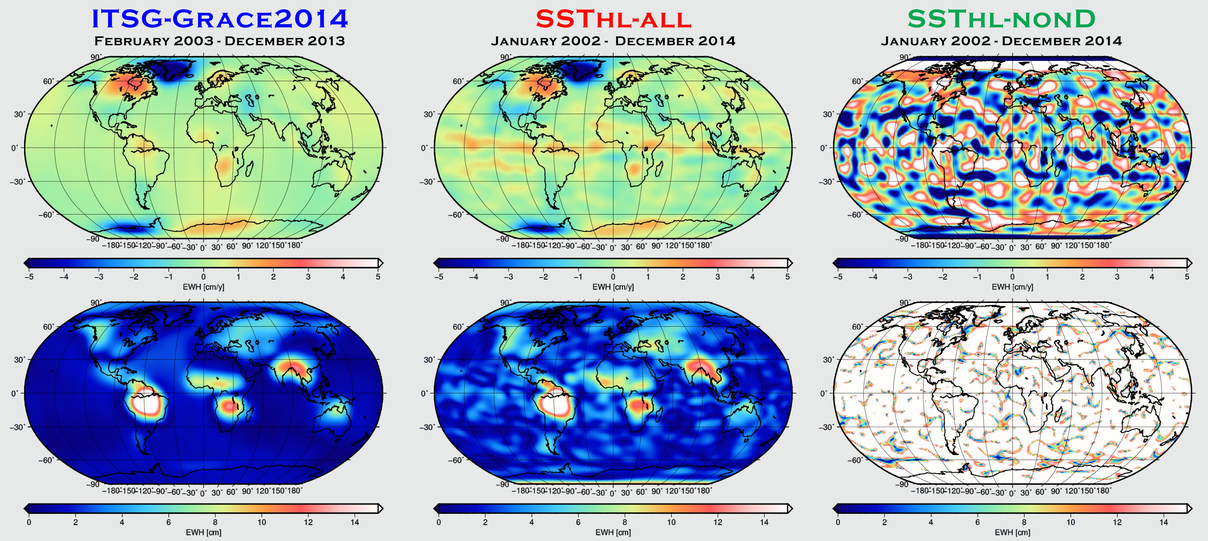
TerraSAR-X & TanDEM-X
- SAR satellites
- Altitude 515 km
- IGOR Receiver



Swarm A, B & C
- Magnetic field
- Altitude 450/530 km
- GPSR Receiver

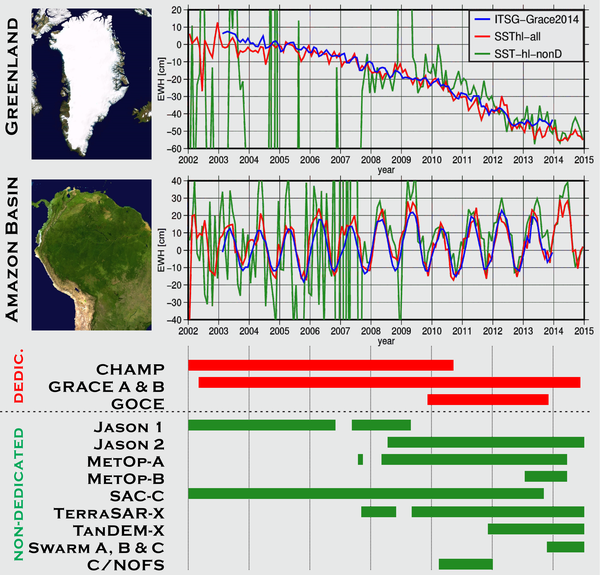
C/NOFS
- Atmospheric research
- Altitude 400-800 km
- CORISS Receiver

Trend and Seasonality



The upper row shows trend estimates derived from three different gravity field time series. The lower row displays the amplitude of the seasonal variations. All plots are expressed in equivalent water height and filtered with a Gaussian filter of radius 750 km.
Blue: ITSG-Grace2014 time series Red: SST-hl solution including CHAMP, GRACE, GOCE and all non-dedicated satellites
Green: SST-hl solution including only non-dedicated satellites

Area Mean Values



Conclusion

We have computed kinematic orbits for several non-dedicated satellite missions and used them to produce monthly gravity field solutions. The results show that in principle it is possible to derive large scale mass variation from non-dedicated satellites.
However, there are some prerequisites to achieve the needed accuracy for the single monthly solutions:

- **Good quality of GNSS observations**
- **Low orbit altitude (<600 km)**
- **High inclination (avoid polar gap)**

After removing missions that are no longer operational or which do not fulfill the accuracy requirements the remaining candidates to bridge a possible gap are:

- **TerraSAR-X**
- **TanDEM-X**
- **Swarm** (limited due to ionosphere induced errors)

All kinematic orbits where computed at the IfG and are publicly available under:

www.itsg.tugraz.at

References

Mayer-Gürr T., 2006, *"Gravitationsfeldbestimmung aus der Analyse kurzer Bahnbögen am Beispiel der Satellitenmissionen CHAMP und GRACE"*

Zehentner N., Mayer-Gürr T., 2014, *"New Approach to Estimate Time Variable Gravity Fields from High-Low Satellite Tracking Data", Gravity, Geoid and Height Systems, International Association of Geodesy Symposia 141*

Weigelt M., van Dam T., Baur O., Tourian M. J., Steffen H., Sosnica K., Jäggi A., Zehentner N., Mayer-Gürr T., Sneeuw N., 2014, *"How well can the combination hISST and SLR replace GRACE? A discussion from the point of view of applications", Grace Science Team Meeting 2014*

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