Symposium 2b: Earth's time-variable gravity field

Organizer:	Adrian Jäggi (Switzerland)	President Commission 2
Co-organizers:	Frank Flechtner (Germany)	Chair Sub-Commission 2.3
	Wei Feng (China)	Chair Sub-Commission 2.6
	Srinivas Bettadpur (USA)	Organiser of GGHS 2020 (resp. GGHS 2022)

Abstract

Earth's time-variable gravity field is related to the mass transport and the physical processes within Earth's system (including the atmosphere, oceans, hydrology and cryosphere), such as melting of ice sheets and glaciers, ocean circulation and sea level variations, hydrological cycle, post-glacial rebound and earthquake-induced gravity change. Nowadays, satellite gravimetry missions, particularly the Gravity Recovery and Climate Experiment (GRACE) and GRACE Follow-On, showed great success to estimate the time-varying gravity field with unprecedented accuracy and resolution, which has been widely used to investigate mass flux within the ocean-land water cycle and Earth's system coupling as well as responses to climate change together with complimentary data from altimetry, GNSS, and InSAR. This interdisciplinary symposium solicits contributions on (1) time-varying gravity field estimation and improvement from satellite gravimetry missions and combination synergies, (2) mass transport in the Earth system and responses to climate change, and (3) status and simulated results of future time-varying gravity field missions.

Symposium 2b: Session 1. Analysis Techniques

Convener: Adrian Jäggi, University of Bern, Switzerland, adrian.jaeggi@aiub.unibe.ch
Co-convener: Andreas Kvas, Graz University of Technology, Austria, kvas@tugraz.at
Yunzhong Shen (China)

Abstract
The recovery of Earth's time variable gravity field from satellite data, especially from the Gravity Recovery and Climate Experiment (GRACE) and from GRACE Follow-On (GRACE-FO), has enabled the study of mass transport on a global scale. Throughout the mission lifetime of GRACE, multiple reprocessing campaigns of both low-level sensor data and derived gravity field solutions have shown that the development of new analysis techniques and the refinement of existing approaches is key for providing high-quality gravity field products. This ongoing research has opened the possibility to investigate new signals and smaller spatial scales.
Additionally, new instrumentation, such as the Laser Ranging Interferometer aboard GRACE-FO, challenge existing processing frameworks with increased accuracy requirements and necessitate the development of new methods and algorithms to be fully exploited.

This session solicits contributions focusing on aspects of:

- New methods and techniques for time-variable gravity field recovery with emphasis on functional and stochastic models
- Impact of new instrumentation, such as the Laser Ranging Interferometer aboard GRACE-FO, on derived gravity field solutions
- Inter-comparison of different gravity field time series and analysis of potential differences
- Accuracy assessment and uncertainty modelling of derived (gridded) gravity field products
- Determination of short-term temporal gravity field variations from satellite data
- Combination strategies for multiple gravity field time series

Keywords: gravity field recovery, analysis techniques, GRACE/GRACE-FO

Symposium 2b: Session 2. Spaceborne and terrestrial gravimetry for hydrology

Convener: Wei Feng, Chinese Academy of Sciences, China, fengwei@whigg.ac.cn
Co-convener: Nico Sneeuw, University of Stuttgart, Germany, sneeuw@gis.uni-stuttgart.de

Abstract

The time-variable gravity field from space gravimetry has provided a unique opportunity to investigate the mass transport in hydrosphere with direct observations of basin-wide and global scale water storage changes. It has contributed to applications such as water resources and disaster management related to floods and droughts. However, the current temporal and spatial resolutions of satellite gravimetry cannot meet the increased demand of hydrology. New methods and algorithms are needed to investigate finer hydrological signals in current satellite gravity measurements and potential more hydrological signals from satellite gravity missions in the near future. In addition, other space geodetic technologies, such as GNSS and InSAR, complement satellite gravimetry by providing high spatial and temporal resolution measurement of crustal deformation, resulting from hydrological mass loading or groundwater depletion. Satellite altimetry provides the measurements of water level/storage variations in rivers, lakes, and reservoirs. The combination of various geodetic observation techniques at different spatiotemporal scales provide an opportunity to further advance our understanding of global and regional water cycling and climate change.

This session solicits contributions focusing on aspects of:

- New methods for inferring hydrological signals from the time-variable gravity field
- Combination of multiple geodetic observation techniques to investigate water cycle fluxes
- Monitoring the dynamics of flood and drought events
- Design of Next Generation Gravity Missions (NGGM) and benefits to hydrology

Keywords: Hydrogeodesy, geodetic observation techniques, satellite gravimetry, water storage changes, climate change, hydrological extremes

Symposium 2b: Session 3. Cryospheric changes from gravity data

Convener: Andreas Groh, Technische Universität Dresden, Germany, andreas.groh@tu-dresden.de
Co-conveners: Isabella Velicogna, University of California, Irvine / Jet Propulsion Laboratory, USA
isabella@uci.edu
Bert Wouters, Utrecht University / Delft University of Technology, The Netherlands
b.wouters@uu.nl
Jiangjun Ran (China)

Abstract
The cryosphere is a key element in the Earth system, which is prone to climate change. Through its interaction with the atmosphere, the oceans and the solid Earth, the cryosphere significantly contributes to global sea-level change. This session is dedicated to the determination of cryospheric changes by using gravity data at all spatial and temporal scales. Studies focusing on glaciers and ice caps are just as welcome as investigations addressing the entire ice sheets in Greenland or Antarctica, or global assessments dealing with the cryosphere as a whole. We invite contributions using time-variable gravity fields from satellite gravimetry, data from air-borne campaigns and terrestrial gravity observations.

Up-to-date ice-mass balance estimates will most likely rely on time-variable gravity fields from the GRACE and GRACE Follow-on (FO) missions. However, we explicitly encourage contributions investigating the potential use of gravity fields of lower spatial resolution as derived from SWARM or other LEO satellites. In particular, studies on their potential to bridge the gap between GRACE and GRACE-FO and to ensure as-seamless-as possible time series of cryospheric mass changes are solicited. This session will also include recent achievements from data combination approaches complementing gravity data with additional data (e.g. altimetry, GNSS, models). A comprehensive uncertainty assessment is crucial for improving our understanding of the cryospheric changes. Assessments based on independent observations (e.g. satellite altimetry) or geophysical modeling are welcome.

This session solicits contributions focusing on aspects of:
- cryospheric changes from gravity observations
- satellite gravimetry, air-borne and terrestrial gravimetry
- bridging the GRACE-GRACE-FO gap
- data combination approaches
- uncertainty assessments including independent observations

Keywords: ice-mass balance, time-variable gravity, terrestrial, air-borne, satellite gravimetry

Symposium 2b: Session 4. Satellite Altimetry and Oceanography
(joint with Symposium 2a of IAG Commission 2)

Convener: Xiaoli Deng, University of Newcastle, Australia, xiaoli.deng@newcastle.edu.au
Co-convener: Carmen Boening, Jet Propulsion Laboratory (JPL), USA, Carmen.Boening@jpl.nasa.gov
Zizhan Zhang (China)

Abstract
Satellite altimetry data have been using to successfully monitor the near global ocean surface topography, greatly improving our knowledge of oceanography, marine geodesy and geophysics, as well as their roles in climate. In this session, we are looking for the scientific and operational results in which satellite altimetry (both radar and laser) measurements, as well as complementary data sources, can be used to address the following issues: regional and global sea level changes, sea level budget, sea ice, river and lake, tides, surface currents, meso-scale circulation and variability, wind speeds and wave heights, sea states, extreme events, marine gravity field, geoid, mean sea surface, mean dynamic topography, seafloor topography, vertical height datum, and land subsidence.

This session solicits contributions focusing on aspects of:

- development for oceanic and emerging applications
- synergy of altimetry with remote sensing and gravity satellite data
- modelling of marine gravity field, mean sea surface, mean dynamic topography, tides and bathymetry
- Monitoring of sea level changes, sea-level extremes, and ocean dynamics
- Studies of multi-satellite altimeters, SAR, SAR-interferometry and SWOT altimetry

Keywords: oceanography, satellite altimetry, marine geodesy

Symposium 2b: Session 5. Gravity Inversion for Solid Earth
(joint with ICCT, Symposium 2a of IAG Commission 2)

Convener: Mirko Reguzzoni, Politecnico di Milano, Italy, mirko.reguzzoni@polimi.it
Co-conveners: Robert Tenzer, Hong Kong Polytechnic University, Hong Kong, China
robert.tenzer@polyu.edu.hk
Srinivas Bettadpur, University of Texas, Austin, USA, srinivas@csr.utexas.edu
Wenke Sun (China)

Abstract
Gravity inversion is an important tool to investigate the Earth's interior. Gravity data have been largely used to investigate the lithospheric structure and its density interfaces such as the structure of sedimentary basins or the Moho surface. The advent of dedicated satellite gravity missions, leading to global gravity models with high accuracy and resolution, gives rise to the possibility of extending these investigations on a global basis, as well as over regions of the world where ground data are sparse or completely absent (such large parts of oceanic areas, Antarctica, Greenland and Africa). The inversion of time-variable gravity signal collected by satellite missions, in particular GRACE and GRACE-FO and in the future NGGM, can be also used to model Solid Earth geophysical phenomena, such as megathrust earthquakes and volcanisms, for instance providing estimates of earthquake source parameters.

Since gravity inversion cannot be used alone to interpret the Earth's inner density distribution due to its non-uniqueness, as well its numerical instability, additional information is required to constrain gravimetric solutions. These constraints primarily comprise seismic surveys as well as additional geophysical, geothermal and geochemical parameters of the Earth, without forgetting mathematical simplifications and numerical regularizations. The development of theoretical and numerical algorithms for a combined processing of gravity, seismic and other types of geophysical data is therefore a crucial issue for a recovery of the Earth's density structures and interfaces.

This session solicits contributions focusing on aspects of:

- developments of theoretical and numerical algorithms of gravity inversion, also combined with seismic information and other geophysical data
- developments of theoretical and numerical algorithms of forward gravity modelling to support gravity inversion or to exploit gravity in constraining geophysical models
- assessment of the gravity inversion solutions, based on errors of input data and uncertainties in the geophysical/geological assumptions
- regional and continental-scale modelling of the lithospheric density structure, focusing on areas with insufficient seismic data coverage (e.g. Africa, South America, Greenland and Antarctica)
- global modelling of the crustal thickness using global gravity models
- global or continental-scale modelling of the mantle density based on combined analysis of gravity and seismic data
- inversion of time-variable gravity data collected from ground or space to detect and model geophysical phenomena, like earthquakes

Keywords: Solid Earth, gravity inversion, forward modelling, data combination, error assessment, lithosphere, density distribution, Moho

Symposium 2b: Session 6. Future Gravity Mission Concepts (joint with QuGe)

Convener: Frank Flechtner, Helmholtz Centre Potsdam GFZ German Research Centre for Geosciences, Germany, frank.flechtner@gfz-potsdam.de
Co-conveners: Wei Feng, Chinese Academy of Sciences, China, fengwei@whigg.ac.cn
Matthias Weigelt (Germany)

Abstract
While the Gravity Recovery and Climate Experiment (GRACE) mission has paved the way for observing the time variable gravity field from space, the Gravity Field and Ocean Circulation Explorer (GOCE) mission has provided a consistent global model of the static gravity field with a resolution of 100 km and 1-2 cm accuracy in terms of geoid heights. The length of the GRACE data record of more than 15 years has made satellite gravimetry indispensable for climate studies, and clearly underlined the strong need for continuing these mass change observations.

The first continuity mission, GRACE-Follow On (GRACE-FO) was successfully launched in 2018 and successfully operates, as a technology demonstration, a Laser Ranging Interferometer providing more precise distance variations between the two spacecraft. International space agencies are currently preparing for future gravity missions which shall guarantee continuity and provide increased spatial and temporal resolution. At the same time quantum gravimetry is developing fast enabling new concepts for static gravity field modeling.

This session solicits contributions focusing on aspects of:

- GRACE-FO mission and instrument status
- Discussion on the status and progress towards the realization, technology, simulation and error analyses of Next Generation (time-variable and static) Gravity Mission concepts.

Keywords: GRACE, GRACE-FO, GOCE, NGGM, MCM, gravity missions, time-variable gravity field, static gravity field