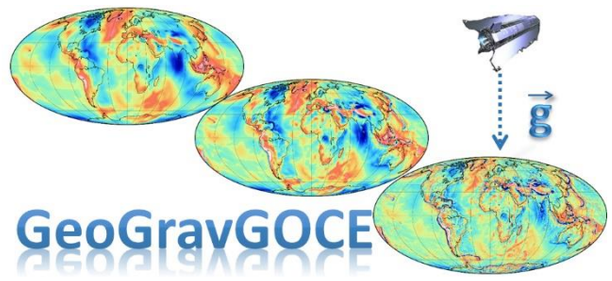
H.F.R.I.
Hellenic Foundation for Research & Innovation

Description of the funded research project

1st Call for H.F.R.I. Research Projects to Support Faculty Members & Researchers and Procure High-Value Research Equipment



Title of the research project: Geoid and Gravity Field Modelling by GOCE Satellite Gradients and Terrestrial Data

Principal Investigator: Prof. Ilias N. Tziavos

Reader-friendly title: GeoGravGOCE

Scientific Area: Engineering Sciences and Technology

Institution and Country: Aristotle University of Thessaloniki, Greece

Host Institution: Aristotle University of Thessaloniki, Greece

Collaborating Institution(s): Department of Geomatics Engineering, University of Calgary, Canada

Project webpage: http://olimpia.topo.auth.gr/GeoGravGOCE/

Budget: 186,895.50 €.

Duration: 24 months

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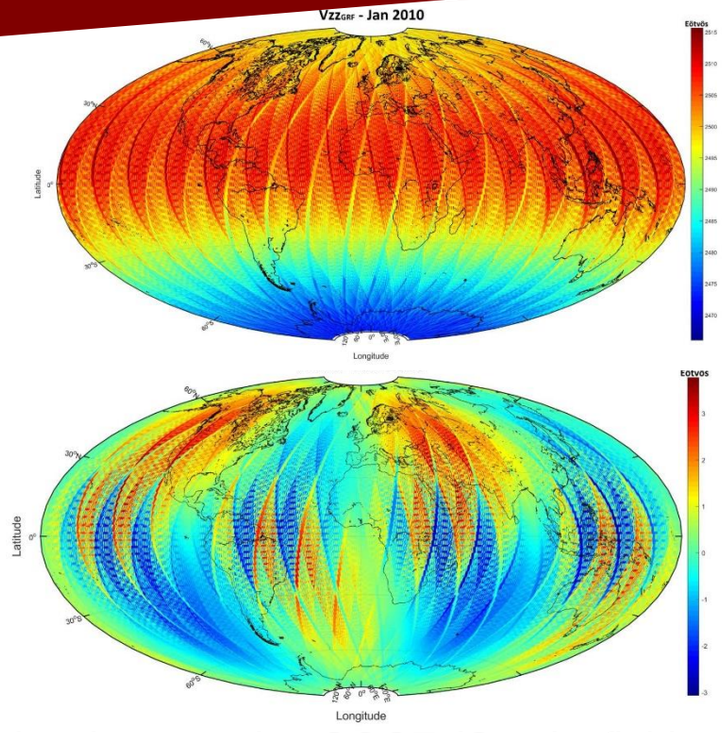
Research Project Synopsis



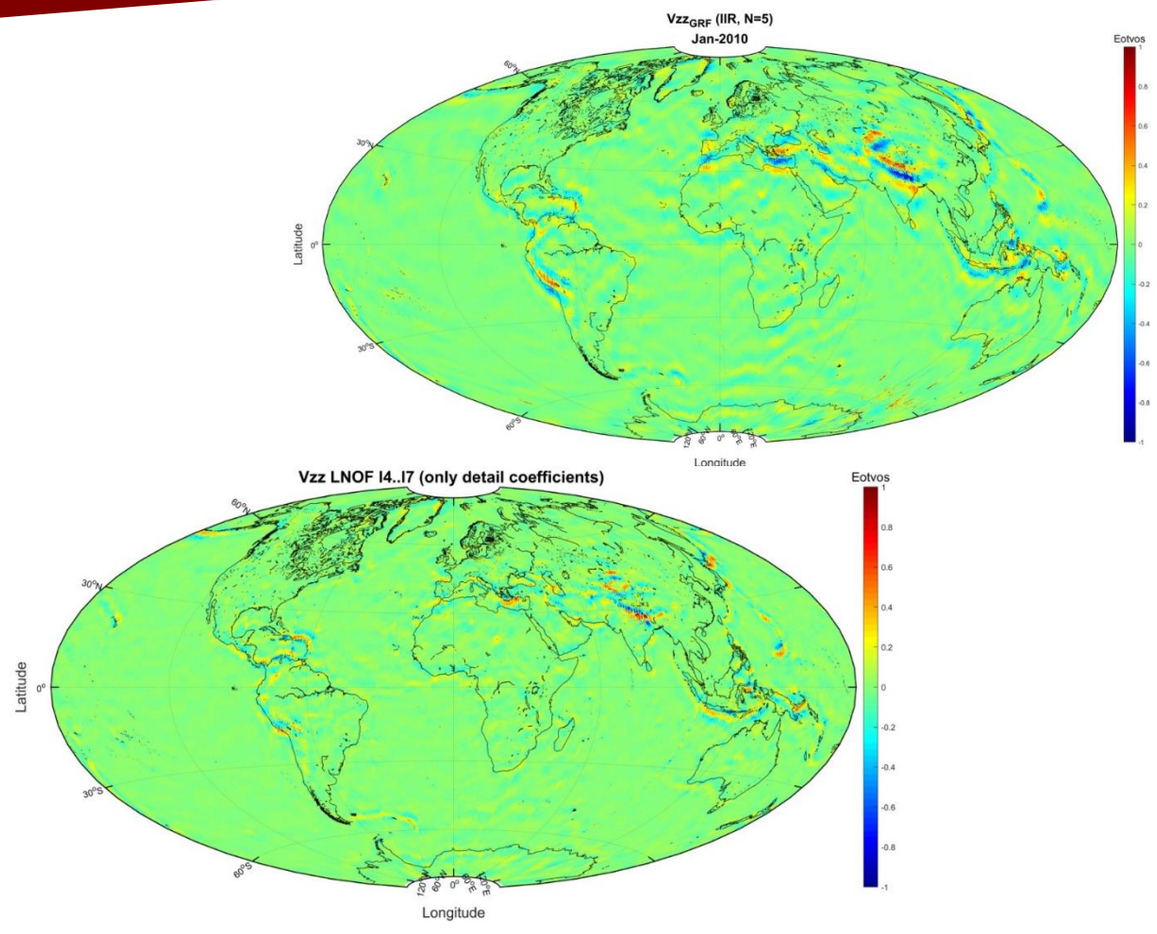
The overall goal of the scientific work that is being carried out within the GeoGravGOCE research project is to employ GOCE (Gravity field and steady-state Ocean Circulation Explorer) data products, mainly the original SGG (Satellite Gravity Gradiometry) data, in order to model the geoid in the Hellenic area and the surrounding regions and investigate the effect of topographic masses on both GOCE gradients and the gravitational potential. More specifically, the objectives of the research are summarized as follows:

a) Validate the spectral behavior of the entire record of GOCE SGG data in terms of their signal and error Power Spectral Density (PSD) functions.
b) Assess the accuracy of GOCE data with upward continued surface free-air gravity anomaly data sets.
c) Develop a Graphical User Interface (GUI) for the automatic transformation of GOCE gradients from the Gradiometer Reference Frame (GRF) to the Local North Oriented Frame (LNOF).
d) Develop novel filtering algorithms for the rigorous filtering of GOCE SGG data.
e) Model the Earth's gravity field in terms of a high-accuracy geoid solution for the wider Hellenic territory by the optimal combination of GOCE and surface data.

Therefore, the overall goal of the GeoGravGOCE project is to utilize the original GOCE SGG data and combine them with local free-air gravity anomaly data towards the estimation of an improved geoid model for the wider Hellenic region bounded between $22° \leq \varphi \leq 53°$ and $12° \leq \lambda \leq 36°$.

In order to perform this combination scheme, we employ a) transformations between the local, inertial and earth fixed reference frames, b) upward-downward continuation of potential-related data from the orbital altitude of the GOCE satellite to Earth's topography, c) novel filtering methods for GOCE gradients to reduced noise and long-wavelength errors, and d) local combination schemes with terrestrial data based on collocation to improve gravity field approximation.

Project originality

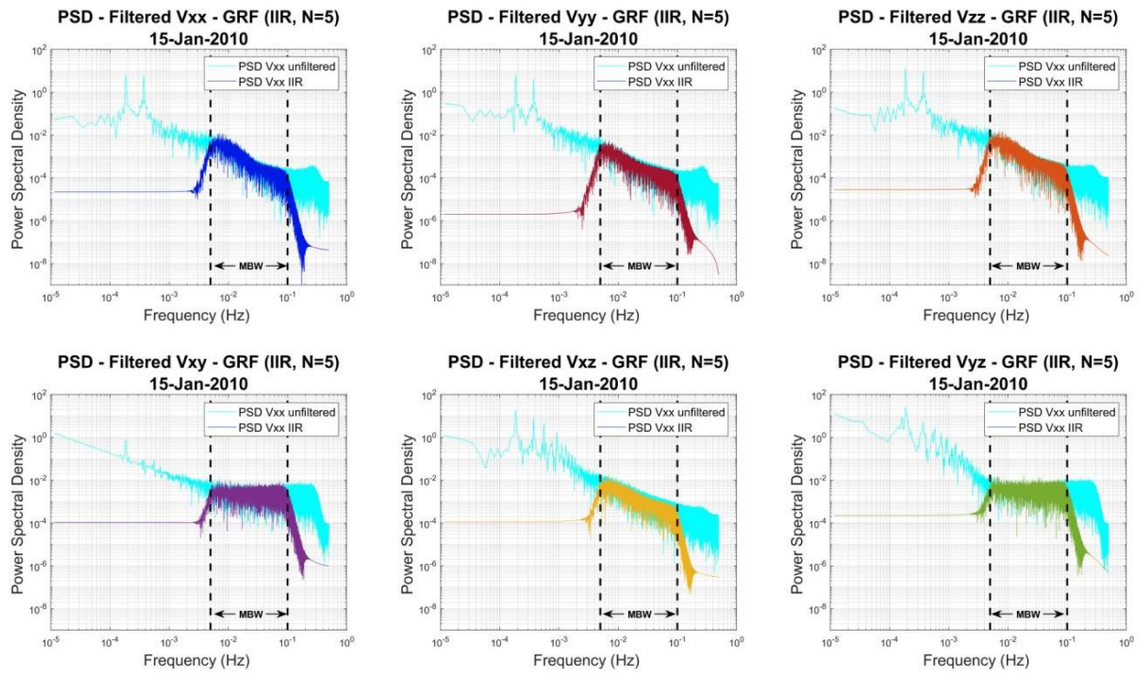


A novel aspect of the GeoGravGOCE project refers to the development of a standalone software which will offer a GUI that will perform gradient pre-processing, transformation from the GRF to the LNOF, and vice versa, as well as filtering of the gradients automatically. The software, also a major deliverable of the project, will be offered freely to interested researchers and will also allow the generation of maps and spectra for the GOCE SGG data in all, intermediate, frames.

Another novel point of the project refers to the filtering of GCE gradients. It is known that gradients of the disturbing potential T_{ij} still contain gradiometric errors, hence they should be filtered. Instead of filtering directly the gradients of the disturbing potential, within GeoGravGOCE, we will determine residual gradients of the disturbing potential, by evaluating the contribution of the latest GOCE-based GGMs. This is another novel point of the proposed GeoGravGOCE project, since a proper evaluation of the contribution of GOCE GGMs will be performed. The models to be tested refer to the latest release GGMs, for each of which an evaluation of their cumulative and band limited contribution to the potential spectrum will be carried out.

Then, the residual disturbing potential gradients will be filtered with an FIR band-pass filter in the GOCE measuring waveband (5-100 mHz) with a Hamming window for spectral leakage. We are developing and testing both spatial (Wiener and Cosine Tapper) as well as digital FIR, IIR and Wavelet -based filters. This is another point of the GeoGravGOCE state of the art, as until now GOCE filtering has been only performed with, mainly, spatial filters, which neglect the individual spectral characteristics of the SGG signal. Within GeoGravGOCE, filtering will be based on digital filters, which will be also applied to the individual gradient levels after WL decomposition.

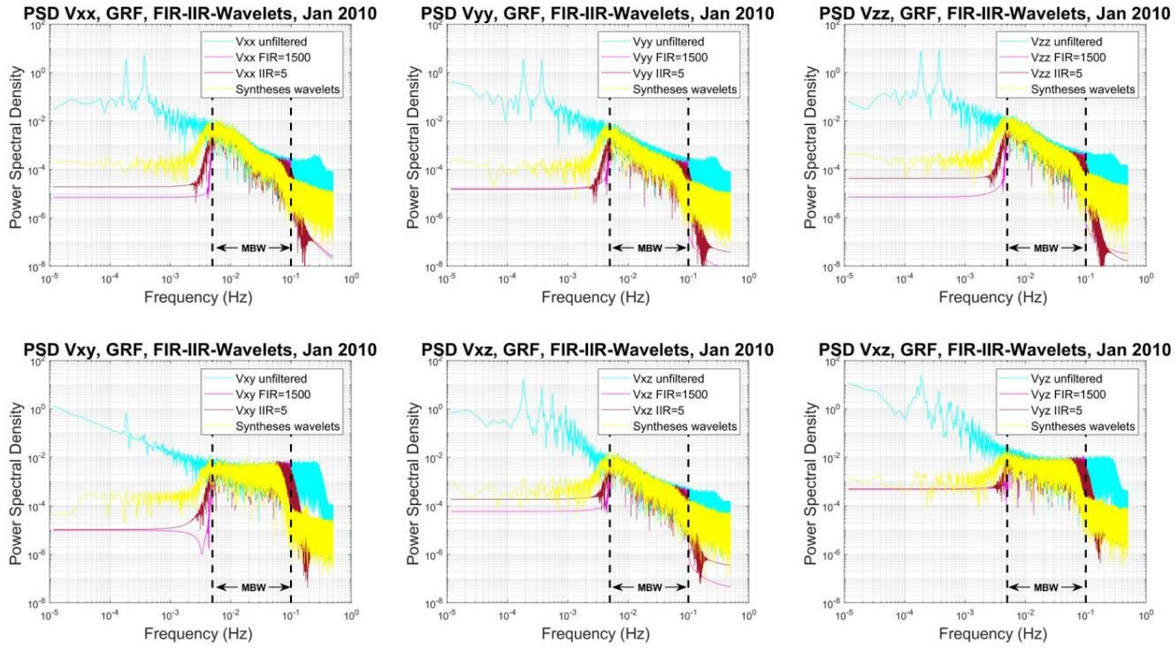
Expected results & Research Project Impact



The results of the GeoGravGOCE project are of importance both to geodesists and the rest of geoscientists, in terms of the development of new methodologies for the efficient treatment of GOCE satellite gradiometry data, their reduction at the Earth's surface and, consequently, their optimal combination with surface gravity data for the optimal determination of a high-accuracy and resolution geoid model. The development of the methods within GeoGravGOCE will allow the evaluation of current practices of physical and satellite geodesy, will provide the basis for further studies and will be easily applied to other scientific areas with significant computational savings. It is expected that the novel aspects of the GeoGravGOCE project will open new frontiers in geodetic research.

The estimated geoid model can considerably contribute to the establishment of an updated vertical reference system for the wider Hellenic area, where a single vertical datum does not exist and large-scale engineering projects, like pipelines, infrastructure, etc., are prone to systematic height differences The realization of a locally enhanced geoid model will allow the adoption of a single reference surface for such applications. The results of the project will benefit as well several branches of the economy and the society. A few examples include the adaptation of Greek policies for climate change to global standards, where a common vertical reference system is needed. Furthermore, realizations of surveying, cadastral and hydrographic studies will no longer need to refer to global and erroneous vertical reference datums, but to a unique and highly accurate one. Finally, the exploitation of not only vertical gradients of the GOCE mission, but of the horizontal ones as well, which are directly correlated with geophysical prospecting and oil and gas exploration, will open new areas of research and contribute to the booming of a Greek exploration industry.

The importance of this funding



The GeoGravGOCE project refers to cutting-edge research in geodesy and the wider field of geosciences. As such, the provided funding is very important, since it allows for the necessary collection of forces in order to focus on the foreseen research activities.

Apart from the provided funding for travel, which is necessary in order to promote the findings of the project results to conferences worldwide, the funding for executing in-situ gravity and GNSS measurements in support of the geoid model development is also vital.

Furthermore, H.F.R.I. funding for research personnel is of outmost importance, since it guarantees that young and experienced researchers will have sufficient funds in order to participate in the project, execute research work at the forefront of their scientific discipline and develop themselves as researchers, both independently and within a research team. H.F.R.I. funding to this respect safeguards that brain-drain is minimized and PI's manage to attract, keep and develop their research team.

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