João de Teixeira da Encarnação

SUMMARY

I am a researcher in the field of satellite geodesy, with a background in Aerospace Engineering.

As a Scientist Associate at Center for Space Research (CSR) of the University of Texas at Austin (UTexas), I am studying ways of exploiting the maximum resolution and accuracy of the measurements collected by the Gravity Recovery And Climate Experiment (GRACE) satellites. My work focuses on:

- the calibration of the accelerometers, particular relevant after 2011, when the thermal control on the satellites was switched off;
- testing large number of unconventional parametrization schemes;
- developing time-series analysis methods and processing suitable gravimetric data to predict the long-term trends in the GRACE gravity field models over the GRACE/GRACE Follow On (GRACE-FO) gap; and
- developing novel methods of connecting the L1B data directly to parameters describing hydrological, solid Earth and glaciological models.

As a Post-doctoral Fellow at Delft University of Technology (TU Delft), I dedicated my efforts to implement the Level 2 data processing facility of the Swarm satellite mission, concerning the Precise Orbit Determination and Thermospheric Neutral Density processing streams. I have acquired expertise in Digital Signal Processing (DSP) techniques and contributed to the processing of Swarm accelerometer data, by combining non-gravitational accelerations derived from Global Positioning System (GPS) data and the accelerometer measurements. In doing so, I have greatly removed the long-term bias in the accelerometer data. During this time, I also matured my skills in data management and automated processing.

During my PhD, I have worked with different types of satellite gravimetric data, namely High-low Satellite-to-Satellite tracking (Kinematic Orbits), low-low Satellite-to-Satellite Tracking (Inter-Satellite Ranges), and Satellite Gravity Gradient (differential accelerometer measurements). My PhD research focused on:

- modelling the data errors accurately and how its amplitude and spectra influences the quality of the resulting gravity field models;
- quantifying the error budget of future gravimetric satellite missions, to an unprecedented level of detail;
- analysing several mission concepts and modelled their error budget in terms of the observations and gravity field parameters;
- establishing that a constellation of numerous non-dedicated satellites make it possible to measure fast mass transport processes;
- demonstrating that some mission concepts (those with large radial distances, e.g. the cartwheel formation) are very sensitive to particular types of errors (specifically errors connected with GPS observations);
- proved that alternative mission concepts (the cross-track pendulum formation) are much better suited to complement planned future gravimetric missions.

This has allowed me to study future gravimetric missions in detail, even unconventional ones such as augmenting dedicated gravimetric missions with a large constellation of non-dedicated satellites. My expertise on this topic has been noted by peers, who have invited me to participate in numerous research projects involving international teams.

I manage a research project that exploits the GPS data from the Swarm satellites to describe the temporal variations of Earth's gravity, describing the hydrological cycle and climatological trends over river basins and Polar Regions. I took the lead in coordinating with several European and US institutes (Institute of Geodesy of the Graz University of Technology – Austria, Astronomical Institute of the Academy of Sciences of the Czech Republic, Astronomical Institute of the University of Bern – Switzerland, Faculty of Aerospace Engineering of the Delft University of Technology – the Netherlands – and School of Earth Sciences of the Ohio State University – USA) the cooperation initiative for the research and promotion of Swarm's gravity field models, which eventually lead to being funded by the Swarm Data, Innovation and Science Cluster (DISC) consortium and will continue in the coming years. This project has moved from a development phase, where we tested the added value of inter-satellite baselines estimated from GPS data and different options for the modelling or observation of the non-gravitational accelerations, into an operational stage, where the Swarm gravity fields will be distributed quarterly to the scientific community.

High in my research priorities is to find ways of increasing the temporal resolution of gravimetric data, while reducing the cost of maintain the continued monitoring of the Earth System. Data collected by multiple satellites systems would address the problem of temporal aliasing, which cannot be mitigated with a single observing system. Furthermore, the geophysical processes taking place from sub-orbital to sub-weekly periods can be better understood if gravimetric data is able to describe them accurately. These objectives are best achieved with the augmentation of dedicated missions. My research looks into the development of a CubeSat architecture that replicates the gravimetric capabilities of the GRACE satellites while identifying key technology gaps. These activities are the initial steps towards the objective of developing a complete suite of capable miniaturized sensors, in order to mature the technology required for a "CubeSat-GRACE".

My research also aims at exploiting satellite gravimetric data to better constrain regional geophysical models, in particular those related to hydrology and glaciological studies. In this data assimilation approach, the gravimetric data collected by the GRACE and GRACE-FO satellites are linked to parameters that drive spatial and time-variable aspects in the geophysical models, instead of the traditional process of considering monthly gravity field models. This allows for the particular dynamics of a geographical region to be parametrised in the most realistic way, when building the model describing the dominant geophysical process that takes place over that region. For example, a particular hydrological storage catchment might be loaded with rainwater homogeneously over the wet season and gradually drain in such a way that water mass collects towards the outlet along the associated river system. The same idea can be applied to the drainage basin of large glaciers, although the intrinsic temporal scale is much larger. The intrinsically inhomogeneous distribution and evolution of mass in space and time, which is known from (*exempli gratia*, for example (e.g.)) ground measurements, can be constrained with GRACE data because these data observe and represent such evolutions (if large enough). In practice, the spatial and temporal variations are described by model parameters that represent mass changes with assumed and predefined spatial and temporal functions, which are fitted to the gravimetric data. Extreme events such as floods are properly represented by sharp functions super-imposed to the undisturbed seasonal variations, with coefficients that unequivocally describe onset speed, mass flow (and consequently average water height) and drainage delays, to which (e.g.) risk of infrastructure damage can be directly correlated. This approach circumvents the weaknesses of the traditional monthly models, most notably spatial leakage and aliasing of other high-frequency geophysical signals, and takes full advantage of the data's spatial and temporal information to improve our understanding of large geophysical processes.

I have studied and worked in numerous areas, including Structural Mechanics, Aerodynamics, Preliminary Vehicle Design, Single Stage to Orbit and Laser Propulsion, which have given me the opportunity to broaden my understanding of Physics. I am an avid programmer, actively learning new languages and techniques in order to better implement the algorithms and procedures required to develop my research. I openly share the code I develop in GitHub.