Subject title: Mass redistributions at the core-mantle interface from satellite gravity

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The Earth's dynamics involves a broad range of time scales, as the crust, the mantle and the core evolve and interact with each other at planetary interfaces still not well constrained by the available observations. In particular, the core-mantle boundary (CMB) appears as a complex area at the interface between the fast-moving core flows and the slowly convecting mantle, which could play a key role in understanding the sudden changes in the secular variation of the geomagnetic field, the 'geomagnetic jerks' [1]. Attributed to rapid changes in the electrically charged currents at the top of the fluid core, their origin remains debated. For example, it has been proposed that they could result from temporal variations of the topography of the CMB, able to modify the flows at the top of the core [2].

Measured by satellites since 2002 (GRACE mission from 2002 to 2017, then GRACE Follow-On since 2018), the space-time variations of the Earth's gravity field can provide us with an original description of the mass redistributions at the CMB, and complement the magnetic field data in order to better understand the origin of these changes in the core flows. In this thesis, we propose to perform a search for signals from the region of the CMB in the GRACE / GRACE Follow-On gravity data, by analyzing the gravity field in a fully independent way from the magnetic field. To enhance the detection of small amplitude, deep signals in the gravity field, and better make the difference with the predominant signals from the water cycle in the Earth's fluid envelops, we will apply dedicated methods of analysis of the gravity field gradients (the second-order spatial derivatives of the gravity potential) at different spatial scales [3,4]. These analyses allow us to finely characterize the geometry of the gravity field signals at different spatial scales, to disentangle on this basis the superimposed contributions in the total field and guide the identification of their sources by pattern recognition. Combined with tools enabling an objective comparison of the shape and amplitude of the observed gravity signals with those predicted from a set of hydrological and oceanic models, these methods will allow us to identify the gravity gradient variations showing significant differences with those of the water cycle sources. These spatial analyses will be coupled with a multi-scale temporal analysis (a wavelet analysis), in order to search for trend changes or pulses at different timescales in the time series of gravity gradients at different spatial scales, in particular in a vicinity of the occurrence time of the geomagnetic jerks during GRACE(FO) lifetime : in 2007, 2011, 2014.

In a second step, we will apply a similar analysis to the magnetic field models based on satellite data (CHAMP mission between 2000 and 2010, then SWARM since 2013). The analysis of the gradients of the magnetic field will improve the geometric description of the signals and their spatial resolution, and may contribute this way to a better identification of the sources of the correlated variations between the gravity and the magnetic field.

→ If deep signals in the gravity field can be correlated with variations of the magnetic field, we will obtain a set of independent observational constraints on the mass redistributions at depth and the magnetic signal at the surface. To understand their origin, these observations will be compared to models, considering two types of core-mantle interactions : (1) the visco-elastic deformations of the mantle induced by the dynamic pressure exerted at its base by the core flows ; (2) the pressure exerted at the top of the core by variations in the CMB topography and their associated visco-elastic mantle response.

→ If deep signals cannot be isolated in the gravity field, we will test if the variations of the magnetic field that correlate with the gravity field are consistent with a source associated with the water cycle.

The results will offer a detailed characterization of the large-scale variabilities of the gravity field and the magnetic field through their gradients, their similarity and their possible link with different types of sources. Such a comparative study is in itself novel.

References :

1. Courtillot V and Le Mouël JL (1984), *Nature*, 311, 709-716.

2. Mandea, M., Narteau, C., Panet, I., Le Mouël, J-L. (2015), *Journal of Geophysical Research*, 120(9), 5983-6000.

3. Panet, I. (2018b), *Journal of Geophysical Research*, 123, 11062 -11090.

4. Panet, I., S. Bonvalot, C. Narteau, D. Remy and J.M. Lemoine (2018a), *Nature Geoscience*, 11(5), p. 367-373.