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Multi-scale gravity field modeling in space and time

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The Earth constantly deforms as it undergoes dynamic phenomena, such as earthquakes, post-glacial rebound and water displacement in its fluid envelopes. These processes have different spatial and temporal scales and are accompanied by mass displacements, which create temporal variations of the gravity field. Since 2002, the GRACE satellite missions provide an unprecedented view of the gravity field spatial and temporal variations. Gravity models built from these satellite data are essential to study the Earth's dynamic processes (Tapley et al., 2004).

Up to present, time variations of the gravity field are often modelled using spatial spherical harmonics functions averaged over a fixed period, as 10 days or 1 month. This approach is well suited for modeling global phenomena. To better estimate gravity related to local and/or transient processes, such as earthquakes or floods, and adapt the temporal resolution of the model to its spatial resolution, we propose to model the gravity field using localized functions in space and time.

For that, we build a model of the gravity field in space and time with a four-dimensional wavelet basis, well localized in space and time. First we design the 4D basis, then, we study the inverse problem to model the gravity field from the potential differences between the twin GRACE satellites, and its regularization using prior knowledge on the water cycle. Our demonstration of surface water mass signals decomposition in time and space is based on the use of synthetic along-track gravitational potential data. We test the developed approach on one year of 4D gravity modeling and compare the reconstructed water heights to those of the input hydrological model.

Perspectives of this work is to apply the approach on real GRACE data, addressing the challenge of a realistic noise, to better describe and understand physical processus with high temporal resolution/low spatial resolution or the contrary.