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A space-time multiscale modelling of Earth's gravity field variations

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The mass distribution within the Earth varies over a wide range of spatial and temporal scales, generating variations in the Earth's gravity field in space and time. These variations are monitored by satellites as the GRACE mission, with a 400 km spatial resolution and 10 days to 1 month temporal resolution. They are expressed in the form of gravity field models, often with a fixed spatial or temporal resolution. The analysis of these models allows us to study the mass transfers within the Earth system.

Here, we have developed space-time multi-scale models of the gravity field, in order to optimize the estimation of gravity signals resulting from local processes at different spatial and temporal scales, and to adapt the time resolution of the model to its spatial resolution according to the satellites sampling. For that, we first build a 4D wavelet family combining spatial Poisson wavelets with temporal Haar wavelets. Then, we set-up a regularized inversion of inter-satellites gravity potential differences in a bayesian framework, to estimate the model parameters. To build the prior, we develop a spectral analysis, localized in time and space, of geophysical models of mass transport and associated gravity variations. Finally, we test our approach to the reconstruction of space-time variations of the gravity field due to hydrology. We first consider a global distribution of observations along the orbit, from a simplified synthetic hydrology signal comprising only annual variations at large spatial scales. Then, we consider a regional distribution of observations in Africa, and a larger number of spatial and temporal scales. We test the influence of an imperfect prior and discuss our results.