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Squeezing more information out of Time Variable Gravity data

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Space gravity missions (GRACE, GOCE) give us the unique opportunity to measure mass redistribution within the Earth and at its surface due to a variety of geophysical phenomena involving all the facets of our planet, the solid Earth, the atmosphere, the hydrosphere and the cryosphere. GRACE, flying since 2002, was expressly designed to detect the time-dependent gravity field, and revealed the hydrological cycle of the Earth, but has also evidenced secular trends due to the slow but continuous upwarping of the crust in North America and Scandinavia due to Post Glacial Rebound (PGR). After more than 6 years of GRACE data, the time-series are long enough to allow more elaborate analysis.

The exploitation of the level 2 data for geophysics, however, is not straightforward. Indeed, the quality of the signal is not uniform worldwide and gravity is always the superposition of contributions from solid Earth as well as climate-related phenomena, that cannot be easily distinguished, at a first glance, both in time and space.

In the present study we show that mass changes cannot be classified simply as trends or periodic signals. We follow an alternative way to separate complementary components, periodic and non-periodic signals, without loosing information. We show that the a priori periodic and linear trend fitting function is not everywhere appropriate and in some cases it is even so poor to result in misinterpreting the data.
Variations in long term behavior and periodicities higher than the usual annual (and semi-annual) indeed occur, related to geophysical phenomena, climate and even to human activities. The time analysis approach proposed in this work can be used to discriminate signals from different possible geographical sources mostly in the low latitude regions, where hydrology is strongest, as for example Africa.

By applying our approach to hydrological models we can show similarities and differences with GRACE data. The similarities lie almost all in the geographical signatures of the periodic component even if there are differences in amplitudes and phase. While differences in the non-periodic component can be explained with the presence of other phenomena, the differences in the periodic component can be explained with missing groundwater or other defects in the hydrological models. In this way we tested the adequacy of some hydrological models commonly combined with gravity data to retrieve solid Earth geophysical signatures.