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GOCE mission follow-on by cold atom technology: the MOCASS study

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MOCASS (Mass Observation with Cold Atom Sensors in Space) is a study project funded by the Italian Space Agency in the framework of preparatory activities for future missions and payloads of Earth Observation. The idea is to propose a GOCE mission follow-on, launching a unique spacecraft with an on-board gradiometer based on advanced cold atom interferometry (CAI) accelerometers and capable of measuring Earth's gravity gradients along one or two orthogonal directions. The MOCASS project aims at investigating whether this mission concept can improve GOCE results in terms of accuracy and resolution of the estimated gravity field model, and the capability of detecting mass distribution and monitoring mass variations. To this purpose, firstly the instrument characteristics are defined in terms of long-term stability, accuracy, and spectral responses. Then simulations on gravity field recovery based on the space-wise approach already used for the GOCE data processing are implemented. Finally, an analysis on the geophysical signals that can be detected given the simulated mission performance is made.
Simulations were assembled by considering real GOCE orbits at different altitudes, but assuming that a CAI gradiometer is on board the spacecraft. This allows a direct comparison between GOCE and MOCASS performances. Instrumental error spectra were defined depending on the orbit and the orientation of the CAI gradiometer arms, considering both a nadir-pointing satellite and an inertial-pointing one. For each configuration, the effect of the satellite angular velocity was computed from the time series of the GOCE orbit coordinates at different altitudes. The resulting instrumental error shows a flat spectrum in the low frequencies, differently from the one of the GOCE electrostatic accelerometers. On the other hand, the interferometer transfer function introduces a strong correlation between close observations. Given the error spectra and the interferometer integration spectral response, observations of gravity gradients were first simulated and then processed by the space-wise approach, which basically consists in a sequential application of a Wiener filter deconvolution, a local collocation gridding and a spherical harmonic analysis. From Monte Carlo sample statistics, the estimation error of the retrieved gravity field model was evaluated for the different mission configurations, showing an improvement in both accuracy and resolution with respect to GOCE. This estimation error was finally compared with the expected gravity signal from selected geophysical phenomena. In particular, the focus was on the India-Tibet region, which involves important and different movements of mass through time and comprises several different crustal structures. The results show that both time-varying gravity signals, like those due to the Tibet-Himalaya glacier melting and crustal uplift, and static gravity signals, like those due to the India seamounts, could be detected by the MOCASS mission.