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On the capability of Swarm for surface mass variation monitoring: Quantitative assessment based on orbit information from CHAMP, GRACE and GOCE

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In the last decade, temporal variations of the gravity field from GRACE observations have become one of the most ubiquitous and valuable sources of information for geophysical and environmental studies. In the context of global climate change, mass balance of the Arctic and Antarctic ice sheets gained particular attention. Because GRACE has outlived its predicted lifetime by several years already, it is very likely that a gap between GRACE and its successor GRACE follow-on (supposed to be launched in 2017, at the earliest) occurs. The Swarm mission – launched on November 22, 2013 – is the most promising candidate to bridge this potential gap, i.e. to directly acquire large-scale mass variation information on the Earth's surface in case of a gap between the present GRACE and the upcoming GRACE follow-on projects.

Although the magnetometry mission Swarm has not been designed for gravity field purposes, its three satellites have the characteristics for such an endeavor: (i) low, near-circular and near-polar orbits, (ii) precise positioning with high-quality GNSS receivers, (iii) on-board accelerometers to measure the influence of non-gravitational forces. Hence, from an orbit analysis point of view the Swarm satellites are comparable to the CHAMP, GRACE and GOCE spacecraft. Indeed and as data analysis from CHAMP has been shown, the detection of annual signals and trends from orbit analysis is possible for long-wavelength features of the gravity field, although the accuracy associated with the inter-satellite GRACE measurements cannot be reached.

We assess the capability of the (non-dedicated) mission Swarm for mass variation detection in a real-case environment (opposed to simulation studies). For this purpose, we "approximate" the Swarm scenario by the GRACE+CHAMP and GRACE+GOCE constellations. In a first step, kinematic orbits of the individual satellites are derived from GNSS observations. From these orbits, we compute monthly combined GRACE+CHAMP and GRACE+GOCE time-variable gravity fields; sophisticated techniques based on Kalman filtering are applied to reduce noise in the time series. Finally, we infer mass variation in selected areas from to gravity signal. These results are compared to the findings obtained from mass variation detection exploiting CSR-RL05 gravity fields; due to their superior quality (which is due to the fact that they are derived from inter-satellite GRACE measurements), the CSR-RL05 solutions serve as benchmark. Our quantitative assessment shows the potential and limitations of what can be expected from Swarm with regard to surface mass variation monitoring.