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Consistent Ocean Mass Time Series from LEO Potential Field Missions (CONTIM)

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Ocean mass variability on timescales of months to decades is still insufficiently understood. On these timescales, large-scale ocean bottom pressure (OBP) anomalies are associated both with wind induced variability as well as baroclinic processes, i.e. related to vertical shear of ocean density. The GRACE mission has been instrumental in quantifying such mass fluctuations, yet its lifetime is limited. The broader importance of non-tidal ocean mass variability for oceanography but also geodesy (i.e. for understanding the time-varying geoid, shape of the Earth's crust, centre of figure, Earth rotation) is obvious. Deep ocean processes can only be understood properly when not only sea surface height and upper ocean steric expansion are measured but deep ocean pressure anomalies are accounted for in addition. Apart from GRACE, the SWARM constellation may provide information on the lowest degrees of the time-variable gravity field of the Earth and therefore of large-scale oceanic processes.

Here we introduce the project CONTIM, which is run in the framework of the German Special Priority Programme "Dynamic Earth" (SPP1788). In CONTIM we propose to combine expertise on precise satellite orbit determination, gravity field and mass modelling, and physical oceanography to retrieve, analyse and verify consistent time series of ocean mass variations from a set of low-flying Earth orbiters including GRACE, but extending the GRACE time series. This information is used to advance our understanding of oceanic movement, ocean warming and sea level rise. CONTIM will thus synergistically address three areas: (1) the methodology of precisely determining LEO orbits, applied here to the SWARM constellation. (2) a new method of retrieving large-scale time-varying gravity (TVG) and mass change associated with oceanic (and cryospheric and hydrological) processes from
results of (1), based on forward modelling. (3) physical modelling of ocean mass variations, both for improved forward modelling in (2) and for integration with satellite-geodetic retrieved ocean mass, and aiding in the determination of a final consistent modelling of sea level rise, ocean warming and oceanic mass budget.

In this contribution, we will give an overview of the objectives of the project and provide some first results. We will highlight the technical challenges associated with the computation of kinematic SWARM orbits. Furthermore, different scenarios for time-variable gravity field retrieval are tested and evaluated, and the CHAMP data are used to test the methods over a longer period. To better understand and parameterize the ocean mass signals, we will discuss output from a high resolution version of the ocean model FESOM forced with tides, surface winds and atmospheric pressure.