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Closing the global and regional sea level budgets by combining multi-mission altimetry and GRACE(-FO) data

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Understanding present day sea level changes and their drivers requires the separation of the total sea level change into individual mass and steric related contributions. Total sea level rise has been observed continuously since 1993 providing a more than 25 year long time series of global and regional sea level variations. However, direct monitoring of ocean mass change has only been done since the start of the Gravity Recovery And Climate Experiment (GRACE) mission in 2002. It ended in 2017 and was succeeded by the follow-on mission (GRACE-FO) in 2018 leaving a gap of about 1 year. In the same time period of GRACE, since the early 2000s, a global array of freely drifting Argo floats samples temperature and salinity profiles of up to 2000m depth which can be converted to steric sea level change.

By combining altimetry, GRACE(-FO) and Argo data sets it is possible to derive global and regional sea level budgets. The conventional approach is to analyze at least two of the data sets and derive the residual, or compare with the third one. A more recent approach is the global joint inversion method (Rietbroek et al., 2016) which fits forward-modeled spatial fingerprints to a combination of GRACE gravity data and Jason-1/-2 satellite altimetry data. This enables us, additionally, to separate altimetric sea level change into mass contributions from terrestrial hydrology, the melting of land glaciers and the ice-sheets in Greenland and Antarctica as well as contributions from steric sea level changes due to variations in ocean temperature and salinity. It also allows to include a data weighting scheme in the analysis.

Here, we present global and regional sea level budget results from an updated inversion based on multi-mission altimetry (Jason-1/-2/-3, Envisat, Cryosat-2, Sentinel-3, ...) providing better spatial coverage as well as new RL06 GRACE and GRACE-FO data which enables us to extend the time series of individual components of the sea level budget beyond the GRACE era from 2002-04 till 2019-06. The presented sea level budget is closed on global scale with a residual (unexplained) contribution of about 0.1 mm/yr, globally, originating in eddy-active regions. We provide consistent validation of our results against conventionally analyzed altimetry and GRACE data sets where we find agreement on global scales to be better than 0.1 mm/yr but a larger disagreement at regional scales as well as the implications of our results for deriving ocean heat content. We will also provide first results for filling the gap in the sea level budget estimates due to the gap between the GRACE and GRACE-FO missions by additionally incorporating time-variable gravity information from the Swarm mission as well as from Satellite Laser Ranging (SLR) to 5 satellites

(Lageos-1/-2, Stella, Starlette, Ajisai).