Estimating Basin-Scale Ocean Mass Budgets with Satellite Gravity

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The global mean ocean mass change in the 21st century is relatively well understood. However, there are fewer estimates for ocean mass budgets at the basin and sub-basin scales. In these regional studies, ocean mass estimates derived from Gravity Recovery and Climate Experiment (GRACE) satellite data and steric-corrected altimetry often show differences, particularly in the Atlantic and Indian Oceans. The cause of these discrepancies remains unclear. We use Slepian functions to estimate ocean basin mass trends using GRACE and GRACE Follow-On (GRACE-FO) gravimetry data. We demonstrate that spatial and spectral localisation of GRACE data with Slepian functions yields reliable estimates of ocean mass changes at the basin scale. Through synthetic experiments, we also show that these functions are effective and require a much narrower buffer kernel (1°) than required by most other methods, therefore retaining more ocean signals. With this approach, we obtain the ocean mass change in each basin. We estimate that the global mean ocean mass between 2003 and 2022 is increasing at a rate equivalent to $2.07 \pm 0.05\,\mathrm{mm\,yr^{-1}}$ of sea level rise, consistent with previous studies. Regionally, the South Atlantic Ocean has the largest mass increase rate of $2.95 \pm 0.11\,\mathrm{mm\,yr^{-1}}$, while the North Pacific Ocean has the smallest rate ($1.20 \pm 0.09\,\mathrm{mm\,yr^{-1}}$). Our results suggest that the Slepian functions can be used to provide a more accurate estimate of the ocean mass trend at the basin scale, and the sea level change varies significantly across regions.

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