

SWOT-derived geometric marine geoid surface reveals gravimetric geoid modelling deficiencies

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Abstract

Accurate and consistent marine geoid models are essential for improving our understanding of marine environmental processes, enhancing navigational safety, and supporting coastal engineering. However, conventional geoid determination often depends on resource-intensive gravity surveys and complex modelling procedures. To overcome these limitations, this study investigates an alternative method for determining and refining the marine geoid. The approach combines high-resolution, near-global sea-surface observations from the Surface Water and Ocean Topography (SWOT) satellite's Ka-band Radar Interferometer (KaRIn) with dynamic topography estimates provided by a high-quality hydrodynamic model.

Geometrically determined geoid heights are obtained by subtracting the modelled dynamic topography from the SWOT KaRIn sea-surface heights. These estimates are then used to reconstruct a continuous marine geoid surface. The resulting surface is assessed through comparisons with existing gravimetric geoid models and with geoid profiles derived from shipborne GNSS (Global Navigation Satellite System) observations and airborne laser scanning.

The results demonstrate that the SWOT-derived geoid surface can attain an accuracy comparable to that of high-resolution regional gravimetric geoid models, with differences below 5 cm. It also agrees closely with existing gravimetric models, showing an average standard deviation of less than 3 cm, while identifying regional shortcomings in gravity-based solutions. These findings demonstrate the considerable potential of SWOT-derived geometric geoid surfaces for validating and improving geoid models. The method may also provide an independent approximation of the offshore geoid in regions where gravity observations are sparse or unavailable.