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Seasonal cycle of Arctic Ocean circulation inferred from satellite altimetry

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In recent decades, the retreat of the Arctic sea ice has modified vertical momentum fluxes from the atmosphere to the ice and the ocean, in turn affecting the surface circulation. Satellite altimetry has contributed in the past ten years to understand these changes. Most oceanographic datasets are however to date limited either to open ocean and ice-covered regions, given that different techniques are required to track sea surface height over these two surfaces. Hence, efforts to generate unified Arctic-wide datasets are still required to further basin-wide studies of the Arctic Ocean surface circulation.

We present here the assessment of a new Arctic-wide gridded dataset of the Sea Level Anomaly (SLA) and SLA-derived geostrophic velocities. This dataset is based on Cryosat-2 observations over ice-covered and open ocean areas in the Arctic during 2011 to 2018.

We compare the SLA and geostrophic currents derived hereof to in situ observations of ocean bottom pressure, steric height and near-surface ocean velocity, in three regions: the Fram Strait, the shelf break north of the Arctic Cape and the Laptev Sea continental slope. Good agreement in SLA is shown at seasonal time scales, with the dominant component of SLA variability being steric height both in Fram Strait and at the Arctic Cape. On the other hand, ocean bottom pressure dominates SLA changes at the Laptev Sea site. The comparison of velocity at two mooring transects, one in Fram Strait and the other at the Laptev Sea continental slope, reveals that the correlation is highest at the moorings closest to the shelf break, where currents are faster and the seasonal cycle is enhanced.

The seasonal cycle of SLA and geostrophic currents as derived from the altimetric product is in favourable agreement with previous results. A quasi-simultaneous occurrence of the SLA maximum happens between October and January; similar phase has been found in steric height seasonal cycle by studies using hydrographic profiles in several regions of the Arctic Ocean. We thereby find the highest SLA amplitude over the shelves, which other studies point to be possibly related to winter-enhanced shoreward water mass transport. Seasonal variability in the geostrophic currents is most pronounced along the shelf edges, representing a basin wide, coherent seasonal acceleration of the Arctic slope currents in winter and a deceleration in summer. This is consistent with the shelf-amplified SLA seasonal cycle described above. Density driven coastal currents near Alaska and Siberia have variable cycle, consistent with the cycle of river runoff and local wind forcing. Enhanced south-western limb of the Beaufort Gyre in early winter is in agreement with a combination between the Beaufort High buildup and relatively thin sea ice.

In summary, we provide evidence that the altimetric data set has skills to reproduce the seasonal cycle of SLA and geostrophic currents consistently with in situ data and findings from other studies. We suggest that this dataset could be used not only for large scale studies but also to study Arctic boundary currents.