Detection and attribution of sea-level change in the Arctic between January 2011 and December 2021

F. Mangini[1], A. Bonaduce[1], R. P. Raj[1]
[1]Nansen Environmental and Remote Sensing Center and Bjerknes Centre for Climate Research, Bergen, Norway

Objectives

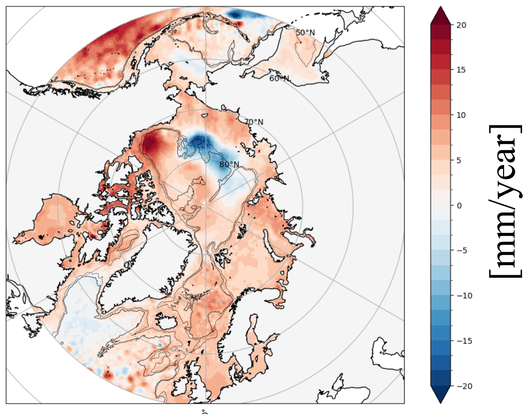
The poster presents preliminary results on the sea-level budget of the Arctic Ocean between January 2011 and December 2021 (11 years). The aim of the work, which is part of the ESA SLBC+ project, is twofold. At first, it aims to assess the ability of different observational and modelling products to monitor ocean variations in the Arctic. Secondly, it aims to evaluate how the synergy of different products can help explain key oceanographic processes in the region.

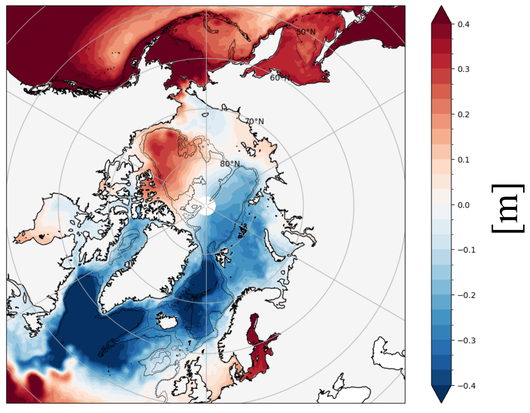
Datasets

1. Experimental Ssalto/Duacs gridded multi-mission altimeter products for the Arctic Ocean (AVISO), to analyse sea-level changes. The dataset, spanning the 2011-2021 period, includes CryoSat-2 measurements, thus allowing coverage up to 88°N, and provides observations in ice-covered regions through leads.
2. MDT-CNES-CLS2022 mean dynamic topography, which estimates the mean of the sea surface height above geoid over the period between 1993 and 2012.
3. EN4 ocean analysis, to estimate the thermosteric and halosteric components of sea level, computed over the upper 2000 m.
4. GRACE Mascon solution provided by the Goddard Space Flight Center (GSFC), to analyse mass-related sea-level changes.

Arctic sea-level trend

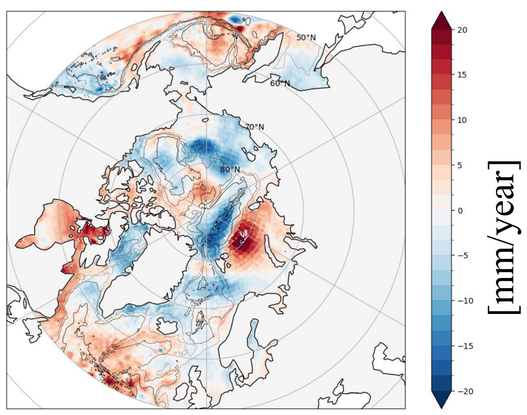
The Arctic sea-level trend (left), while mostly positive, ranges from about −17 mm/yr, off the East Siberian Shelf, to +17 mm/yr, in the Beaufort Gyre. Over the 11-year period under study, these trends amount to circa ±0.19 m, which is not negligible when compared with the magnitude of the mean dynamic topography (right).





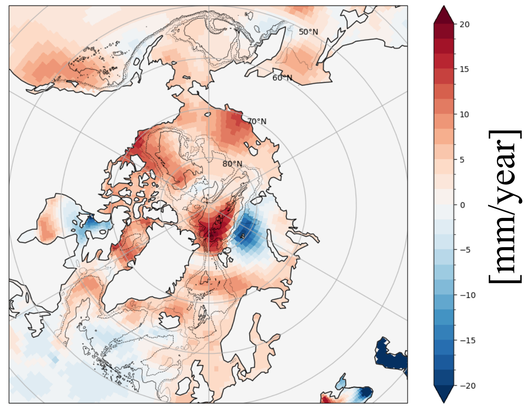
Arctic sea-level trend budget

The Arctic sea-level trend budget (right), computed as the linear trend of the residual between total sea level and the sum of steric and mass components, remains unclosed, with discrepancies exceeding ±10 mm/yr over the East Siberian Shelf, the Eurasian Basin, and the Barents Sea. The following sections discuss possible issues affecting the halosteric and mass components, which might contribute to these residuals.



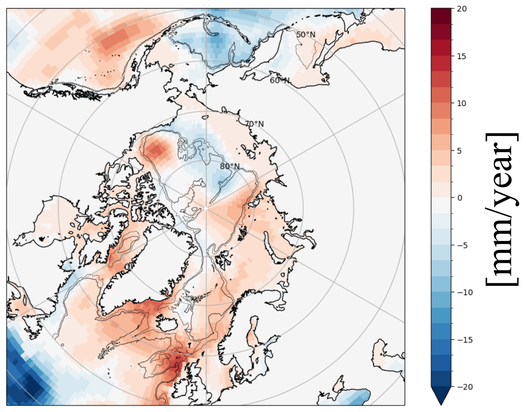
Mass component

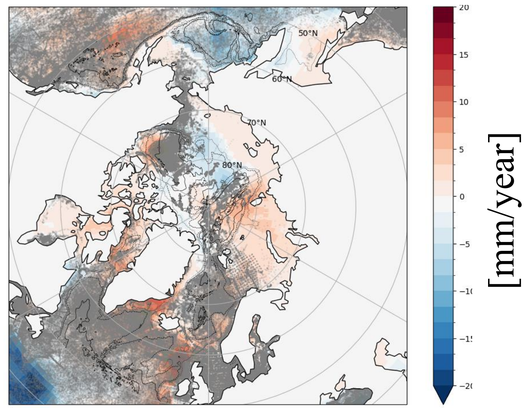
The linear trend of the sea-level mass component shows anomalously high and low values in the Eurasian Basin and the Barents Sea, indicating that the corresponding residuals in the sea-level budget map originate from the GRACE GSFC dataset. We consider these features to be artefacts, as they are difficult to justify from an oceanographic perspective and because the GRACE GSFC product disagrees with the JPL and CSR solutions over the Arctic (not shown).



Halosteric component

The halosteric component of the sea-level trend (left) shows the strongest resemblance to the observed Arctic sea-level trend. Instead, the thermosteric contribution (not shown) is negligible. However, the halosteric sea-level trend from EN4 does not fully capture the observed sea-level trend, particularly off the East Siberian Shelf, possibly due to the scarcity of in-situ observations during the study period (gray shading in the map on the right).





Conclusions & Future work

We presented a preliminary sea-level trend budget for the Arctic Ocean using a dedicated satellite altimetry product, the EN4 ocean reanalysis, and GRACE mascon solutions provided by the GSFC. The results suggest that the budget remains unclosed, particularly in the Eurasian Basin and the Barents Sea, likely due to artefacts in the GRACE mass estimates, and off the East Siberian Shelf, possibly due to a lack of in-situ observations that affects the EN4 halosteric estimates.

We plan to extend this analysis by further characterising the features identified above and by investigating the oceanographic processes driving the observed trends. In particular, we aim to determine the depths at which salinity changes contribute most strongly to the halosteric sea-level signal. We also intend to explore links between oceanographic and sea-ice variables, such as sea-ice drift, thickness, and concentration, given that changes in sea-level gradients affect geostrophic currents and may influence sea-ice redistribution across the Arctic. Finally, we will incorporate TOPAZ4, an Arctic ocean reanalysis, both to evaluate its performance and to complement existing observations.