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Assimilation of CryoSat-2 radar Freeboard data in a global ocean-sea ice modelling system.

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Sea ice is a key element in our climate system, and it is very sensitive to the current observed climate change. Sea ice volume is a sensitive indicator of the health of Arctic although very challenging to estimate precisely since it is a combination of sea ice area and sea ice thickness. Arctic sea ice volume has decreased by as much as 75% at the end of the summer season if compared with the conditions 40 years ago. The ongoing decline of Arctic sea ice exposes the ocean to anomalous surface heat and freshwater fluxes that can have potential implication for the Arctic region and beyond, for the general oceanic circulation itself.

For more than a decade, Mercator Ocean International develops and produces Global Ocean Reanalysis with a 1/4° resolution system. Based on the NEMO modelling platform, observations are assimilated by a reduced-order Kalman filter. In-situ CORA database, altimetric data, sea surface temperature, and sea ice concentration are jointly assimilated to constrain the ocean and sea ice model.

In previous reanalysis, long-term sea ice volume drift has been observed in the Arctic. To obtain a better constraint on the sea ice thickness, Cryosat-2 radar Freeboard data are assimilated jointly with the sea ice concentration in a multidata/multivariate sea ice analysis. The coupled ocean and ice assimilation system runs on a 7-day cycle, using IAU (Incremental Analysis Update) and a 4D increment. The “white ocean” is modelled with the multi-categories LIM3.6 sea ice numerical model. The aim of this study is to initiate the development of the future operational multi-variate and multi-data sea ice analysis system with freeboard radar assimilation.

After describing this global sea ice reanalysis system, we present results on the abilities of this configuration to reproduce sea ice extent and volume interannual variability in both hemispheres. Comparisons between experiments with and without assimilation show that the joint assimilation of CryoSat-2 radar freeboard and sea ice concentration reduces most of model biases of sea ice thickness, e.g., in the north of the Canadian Arctic Archipelago and in the Beaufort Sea in the Arctic. Moreover, radar freeboard assimilation does not hinder the good results in simulating sea ice extent previously obtained with the assimilation of only sea ice concentration. Validation with

non-assimilated satellite data and in-situ data supports these findings. Lastly, snow depth significantly influences the Freeboard measurement: this study also reveals the importance of including snow information on freeboard retrieval and on the ice volume assimilation methodology.

These experiments take place in a context of increasing interest in polar regions and prepare the launch of Copernicus Sentinel expansion satellite missions.