The impact of the sea-ice thickness assimilation on the short-range forecasts of the Met Office's coupled NWP system

We assess the impacts on short-range forecasts due to the additional data assimilation (DA) of derived Arctic sea-ice thickness (SIT) from CryoSat-2 and SMOS satellites into the UK Met Office's ocean-sea ice-land-atmosphere coupled system. First, we perform SIT DA sensitivity experiments in an ocean-sea ice system, by using different CryoSat-2 along-track freeboard products and by deriving SIT uncertainties from freeboard uncertainties through Gaussian error propagation techniques. These sensitivity experiments, particularly the ones improving the SIT uncertainties used in the DA, led to a Root Mean Squared Deviation (RMSD) decrease of ~35% in ice growing months with respect to independent SIT observations when compared to a control run not assimilating SITs. Based on the optimal configuration for the SIT DA in the ocean-sea ice system, a set of sea-ice DA runs in the coupled NWP system were performed from December 2019 to February 2020: (i) a control run (CTL) derived from the coupled NWP operational configuration, which assimilates sea surface temperatures (SSTs), sea level anomaly, T/S profiles, sea ice concentration (SIC), as well as atmospheric variables, such as air temperatures, wind, humidity, pressure and direct radiances; (ii) a run with the additional SIT assimilation (SIT-DA) with respect to CTL; and (iii) a run with no SIC assimilation (NOICE-DA) relative to CTL. The SIT-DA (NOICE-DA) experiment makes the sea ice thinner (thicker) near the ice edge, which results in an overall warming (cooling) of the Arctic, leading to a bias reduction (increase) in the 6-day forecasts of near-surface air temperatures in the Arctic and, to a lesser extent, in the North Atlantic. Small but positive 6-day forecast RMSD improvements in the North Atlantic SSTs are also seen in the SIT-DA relative to CTL when compared to drifters. The fully coupled system is already heavily constrained by the assimilation of many observation sources on every 6-h cycle so the SIT DA impact on the atmospheric short-range forecasts is confined to the Arctic and its surroundings and mainly for near-surface air temperatures. The SIC and SIT assimilation impacts lead to only minor improvements in the ocean and atmospheric short-range forecasts, but these improvements are consistent across the different components of the coupled NWP system, and they are particularly significant for the sea ice itself.

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