Estimation of lake ice thickness using MODIS and AMSR-E for operational data assimilation

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Accurate measurements of ice thickness acquired at high temporal frequency are important for the improvement of operational sea and lake ice forecasting systems. Retrieval of ice thickness is challenging in high latitude regions, at a time when such measurements are increasingly being requested by operational ice centres. The majority of current sea ice forecasting systems assimilate data from passive microwave sensors with coarse spatial resolution (tens of km) and lake ice forecasting has received much less attention. Ice thickness observations are not typically directly assimilated.

This study, currently being conducted as part of the Marine Environmental Observation Prediction and Response Network (MEOPAR) project, aims to improve retrieval algorithms for the estimation of sea ice and lake ice thickness using data from the Moderate Resolution Imaging Spectroradiometer (MODIS) aboard NASA’s Aqua (EOS PM) and Terra (EOS AM) satellites. The accuracy of ice thickness retrievals are investigated based on MODIS Ice Surface Temperature (IST) using a heat balance equation and snow parameterization implemented in a 1-D thermodynamic lake ice model (Canadian Lake Ice Model, CLIMo). Great Slave Lake, a large lake located in the Mackenzie River basin in Canada’s Northwest Territories, is used as a test site due to the availability of in situ snow and ice thickness measurements required for evaluation of satellite retrievals. This allows examination of one of the main sources of uncertainty in retrievals algorithms; the snow depth parameterization. Retrieved ice thicknesses are compared with those obtained from the Advanced Microwave Scanning Radiometer—Earth Observing System (AMSR-E) and in situ measurements from Canadian Ice Database (CID) for the period 2002-2014. The accuracy of ice thickness estimates is improved when using the snow parameterization rather than an empirical relationship between snow depth and ice thickness, with biases of 0.05 m and 0.02 m for ice thickness from MODIS and AMSR-E, respectively.

Further evaluation of the retrieval algorithms are also planned over the Great Lakes of North America and over the Beaufort Sea, where airborne EM thickness measurements have been acquired through the MEOPAR project, with the intent of improving our ability to forecast changing ice conditions.