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Improving the Arctic sea-ice numerical forecasts by assimilation using a local SEIK filter

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Introduction

Appropriate initial conditions are essential for accurate forecasts of sea ice conditions in the Arctic. We present a prototype of an assimilation and forecast system, where a new sea ice thickness data set based on the Soil Moisture and Ocean Salinity (SMOS) satellite data [1,2] and sea ice concentration data (SSMIS) are assimilated with a local Singular Evolutive Interoplated Kalman (SEIK) [3] filter. The system is run for 3 months in the transition between autumn and winter 2011/2012. Forecasts of different length are evaluated and compared to independent in-situ data.

Experimental Setup

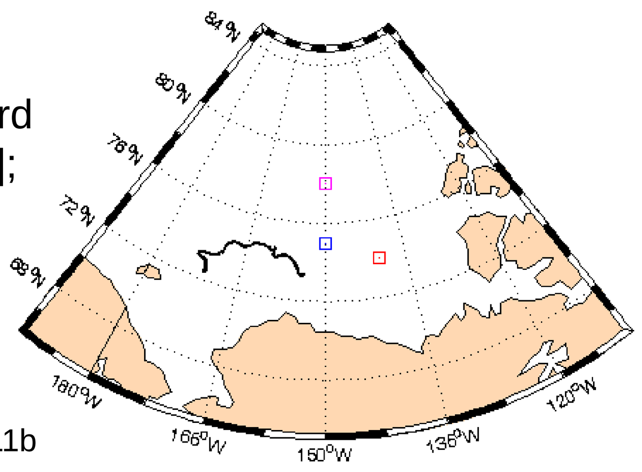
Model: An Arctic configuration [4-5] of Massachusetts Institute of Technology general circulation model (MITgcm; [6]).
Forcing: The analysis (Climate Data Assimilation System) from the Japan Meteorological Agency (JMA) [7].
Assimilated sea ice data: SSMIS sea ice concentration of NSIDC [8]; SMOS sea ice thickness data [9].
Assimilation system: A localized SEIK filter algorithm [10] coded within the Parallel Data Assimilation Framework [11].
Experiments: A freeze-up period: 1 Nov. 2011 to 31 Jan. 2012.
LSEIK-1: SSMIS ice concentration (RMS=0.30);
LSEIK-2: SSMIS concentration (RMS=0.30) + SMOS thickness (0-1 m; space-distributed uncertainty)

Independent sea ice data

Sea ice concentration of European Meteorological Satellite Agency Ocean and Sea Ice Satellite Application Facility (OSISAF) [12];

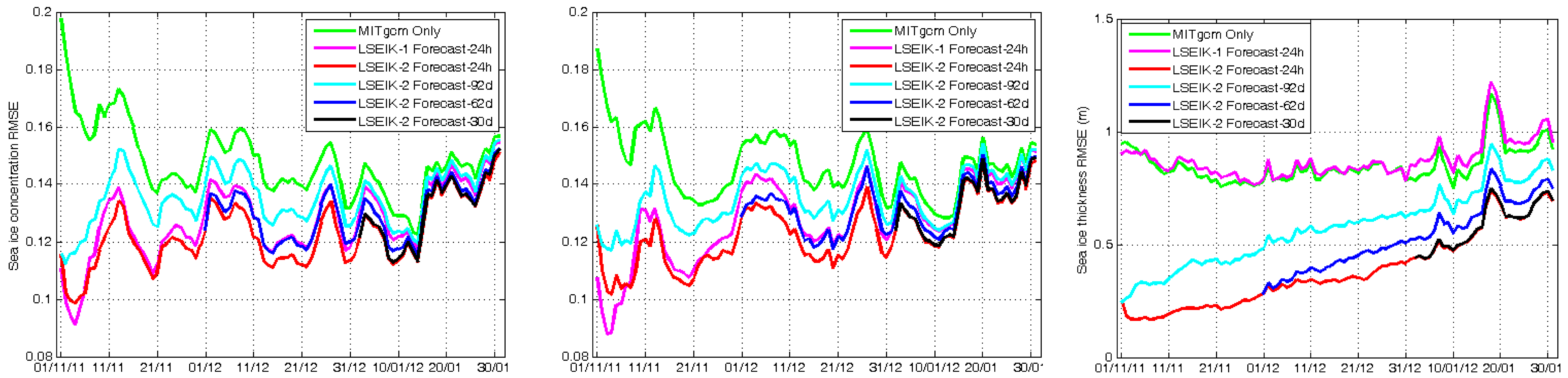
Sea ice draft from Beaufort Gyre Experiment Program (BGEP) Upward Looking Sonar (ULS) moorings [13];

Sea ice thickness data obtained from the autonomous ice mass-balance buoys (IMBs) [14]



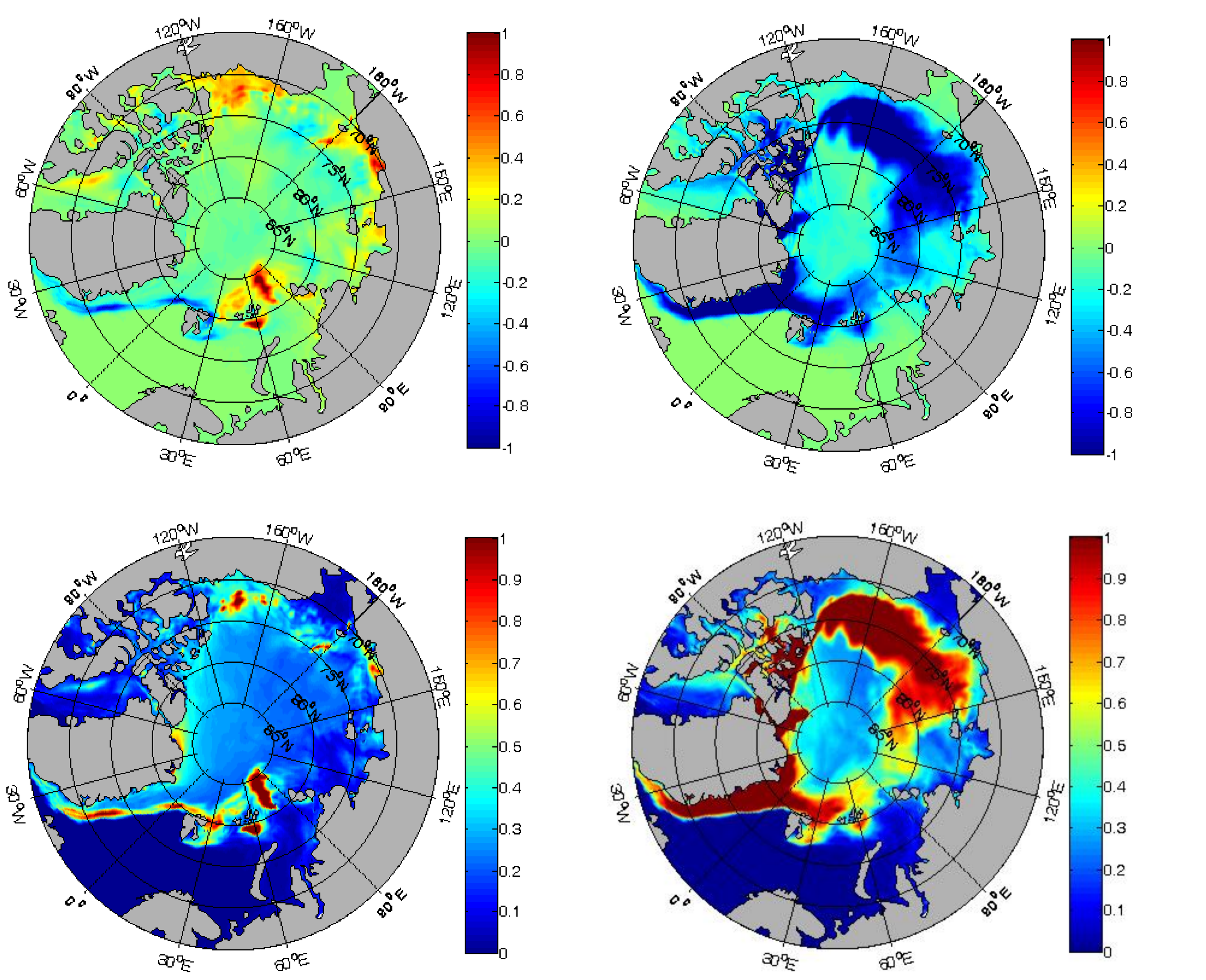
Observations locations, BGEP_2011a (blue), 2011b (magenta), 2011d (red) and IMB_2011K (black)

RMSE evolution of sea ice concentration and thickness



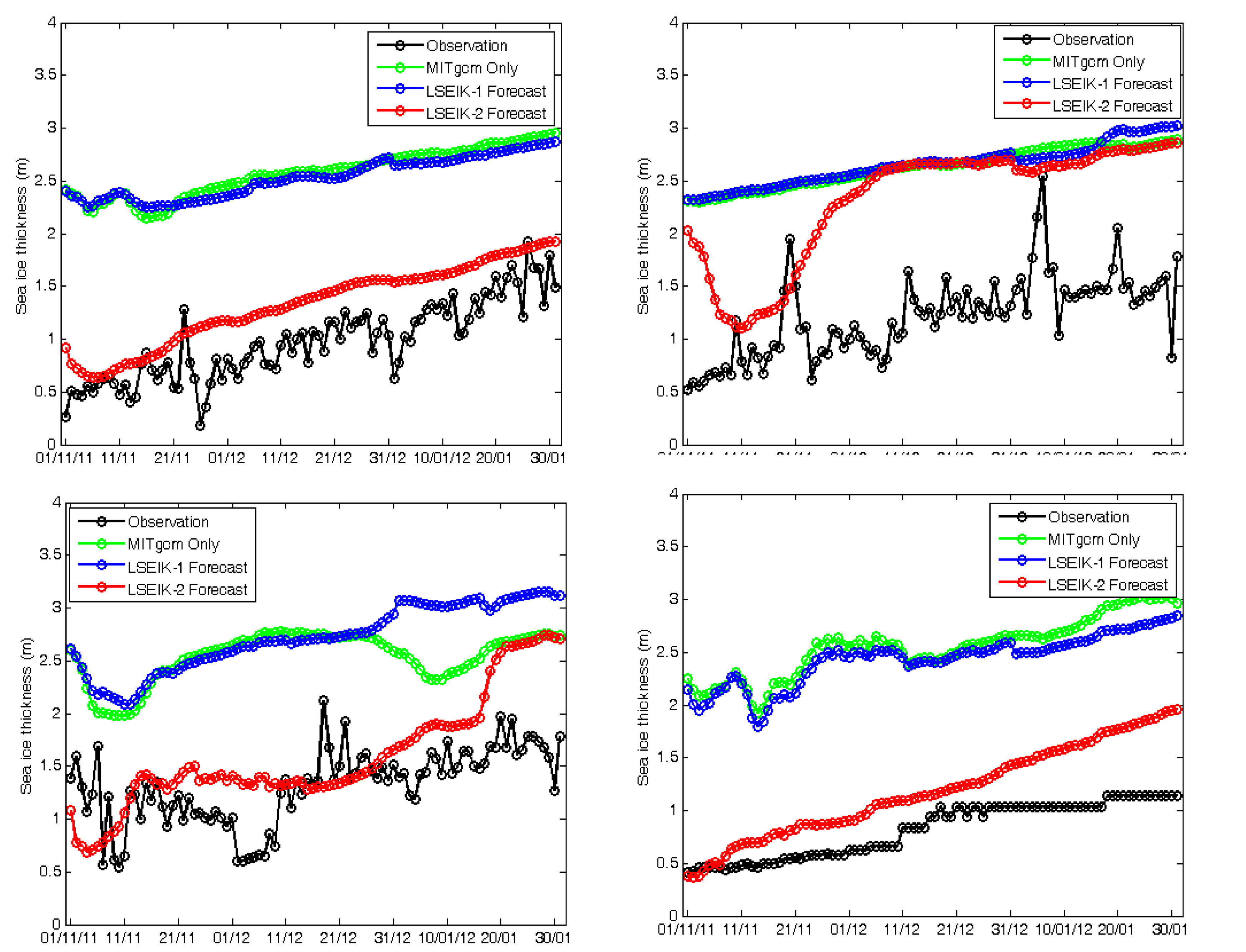
RMSE differences with NSIDC SSMIS (left) /OSIAF ice concentration (middle) , and SMOS ice thickness data (right)

Impact on mean sea ice thickness forecasts



Mean deviation (top) and RMSE deviation (bottom) of the LSEIK-1 (left) and LSEIK-2 (right) sea ice thickness forecast from the MITgcm forecast without assimilation

Comparison with in-situ sea ice thickness



Sea ice thickness evolution at BGEP_2011a (top left), BGEP_2011b (top right), BGEP_2011d (bottom left), IMB_2011K (bottom right)

Summary

- In the cold season, the impact of assimilating only sea ice concentration is much smaller than in summer [15].
- The SMOS ice thickness assimilation leads to much better thickness forecasts.
- With SMOS thickness data, the sea ice concentration forecasts also agree better with observations, although this improvement is smaller.
- The SMOS ice thickness assimilation can also improve long-term (>5 days) sea ice forecasts.

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