Improving Met Office predictions of Arctic sea ice through assimilation of CryoSat-2 and SMOS thickness data

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Assimilated observations

- Along-track CryoSat-2 (CS2) freeboard data is converted into sea-ice thickness (SIT) assuming the ice is floating in hydrostatic equilibrium and using the model snow depth.
- CS2 and SMOS observations show smaller uncertainties for thick ice (>1 m) and thin ice (< 1 m), respectively.
- However, large differences can be spotted between both satellites in the transition between thick and thin ice regions.

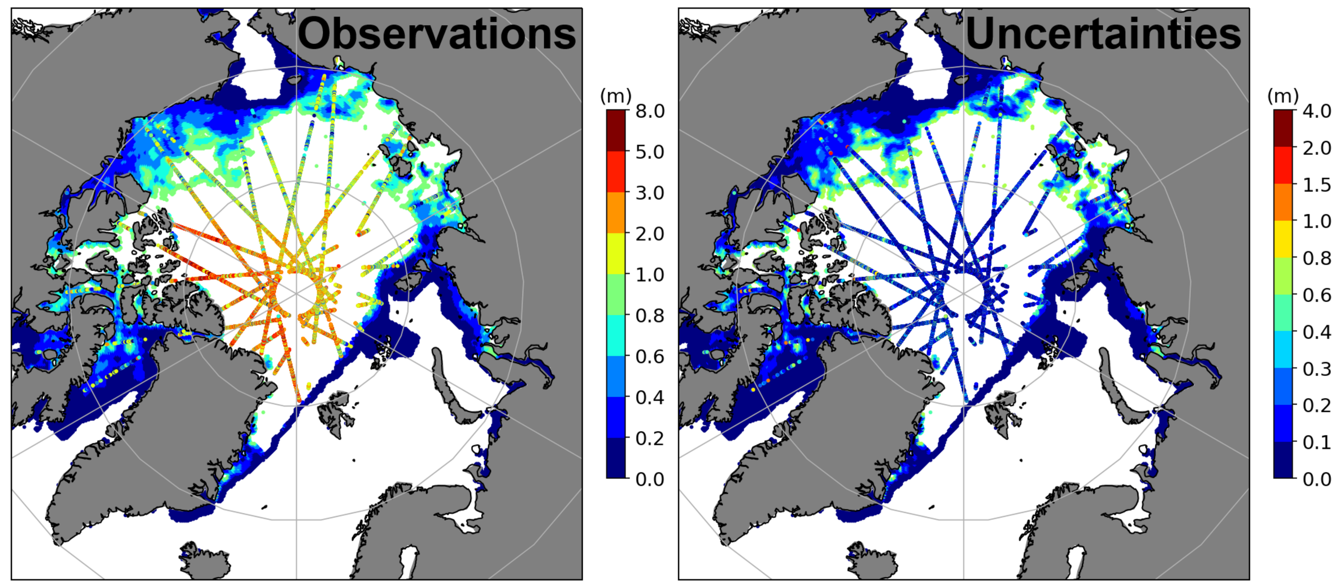

Figure 1: (left) Assimilated SIT observations derived from CS2 (tracks) and SMOS, and (right) their uncertainties within a one-day time window.

Experiment setup

- Based on the Met Office Forecast Assimilation Model (FOAM).
- **Run period:** 25 Nov 2016 - 15 April 2017.

	Model	Grid	Assimilation system	Assimilated observations	Initial condition
CTL				SST, SLA, T&S, SIC	-
A-CS2	NEMO/ CICE	ORCA025 (1/4°)	3D-VAR FGAT (NEMOVAR)	CTL + CS2 SIT	From CTL in 15 Oct 2015
A-CS2SMOS				CTL + CS2 & SMOS SIT	From A-CS2 in 25 Nov 2016

Table 1: Configurations of the model runs.

Analysis assessment

- Ice pack is too thin in CTL. A-CS2 improves the ice pack, but also increases too much the SITs in marginal ice zones (MIZ).

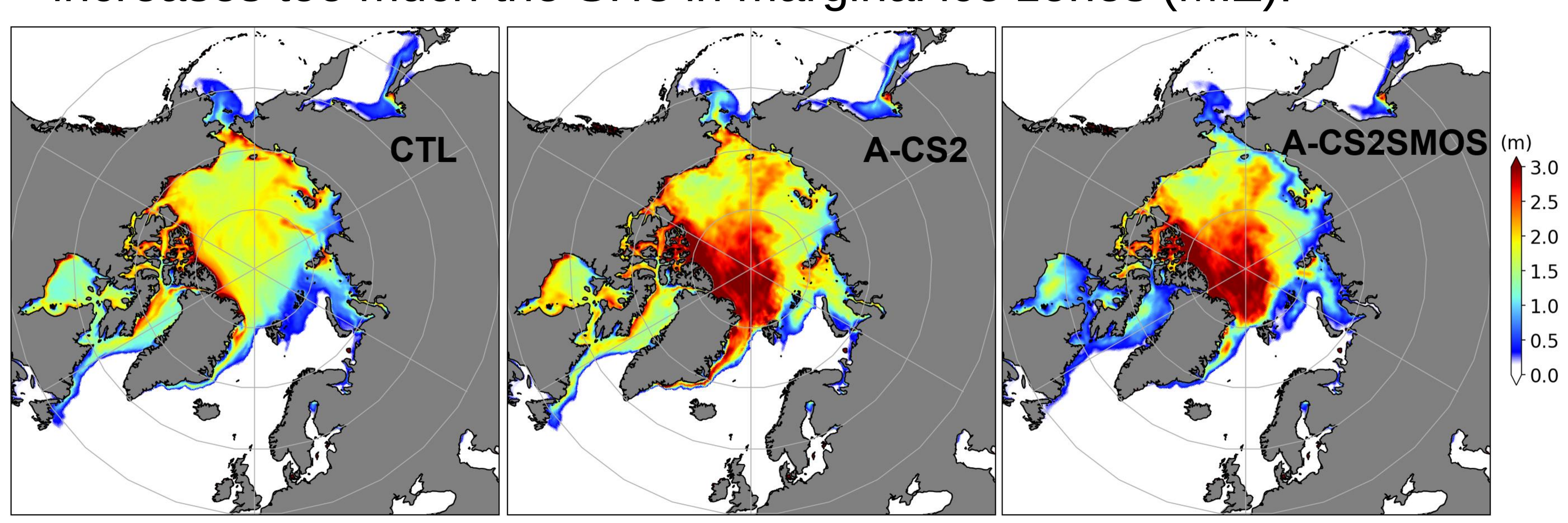

Figure 2: Mean SITs (m) for each model run in March 2017.

- The impact of SMOS assimilation is clear on reducing the MIZ biases introduced by A-CS2 and those already in CTL.

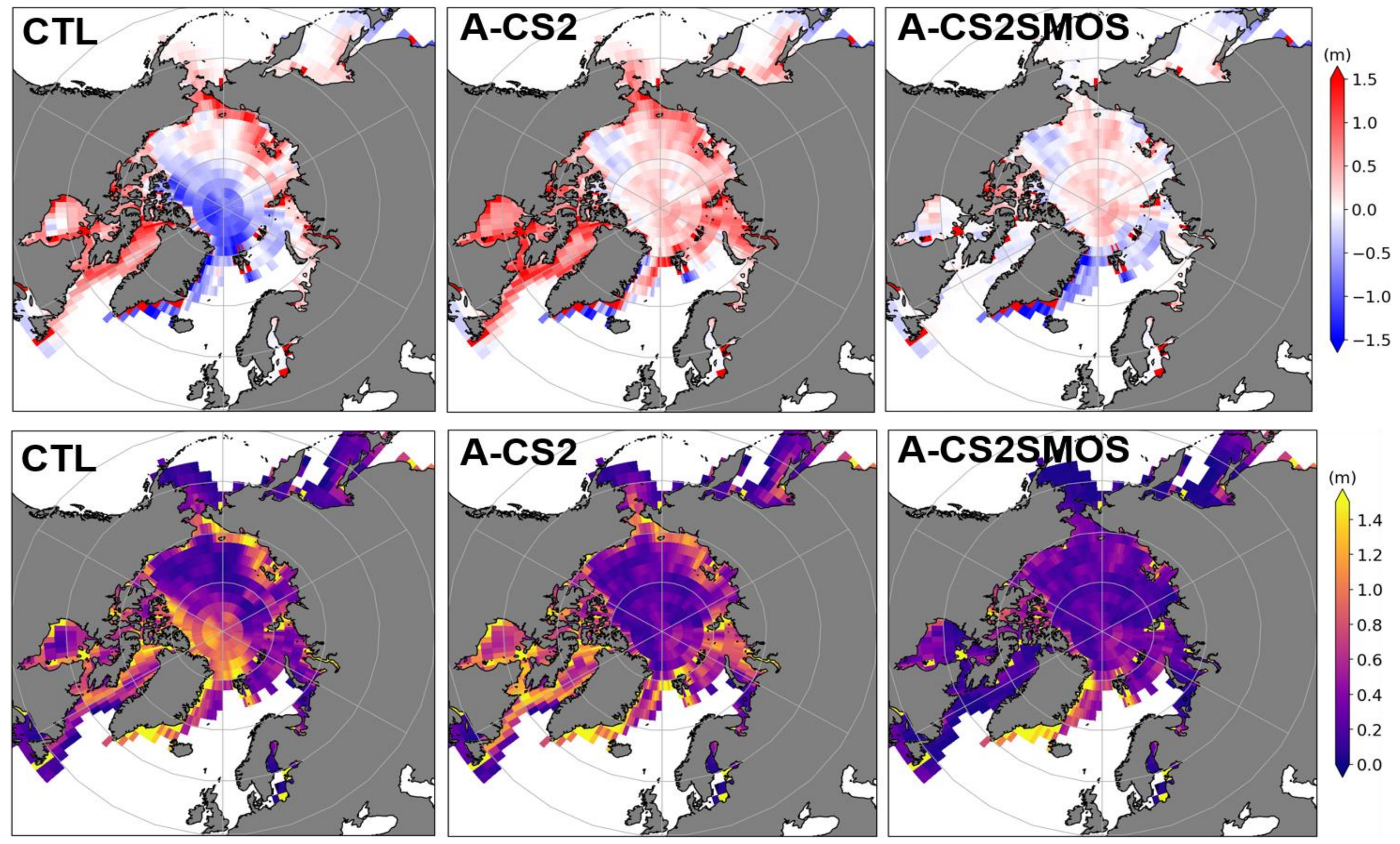

Figure 3: March 2017 (top) mean SIT differences and (bottom) RMSD with respect to the SIT objective analysis from Ricker et al. (2017). Units are in m.

- Similar results from Fig. 2 and Fig.3 are obtained when the model runs are compared to independent SIT measurements from moorings (Fig. 4) and airborne measurements (Fig. 5).

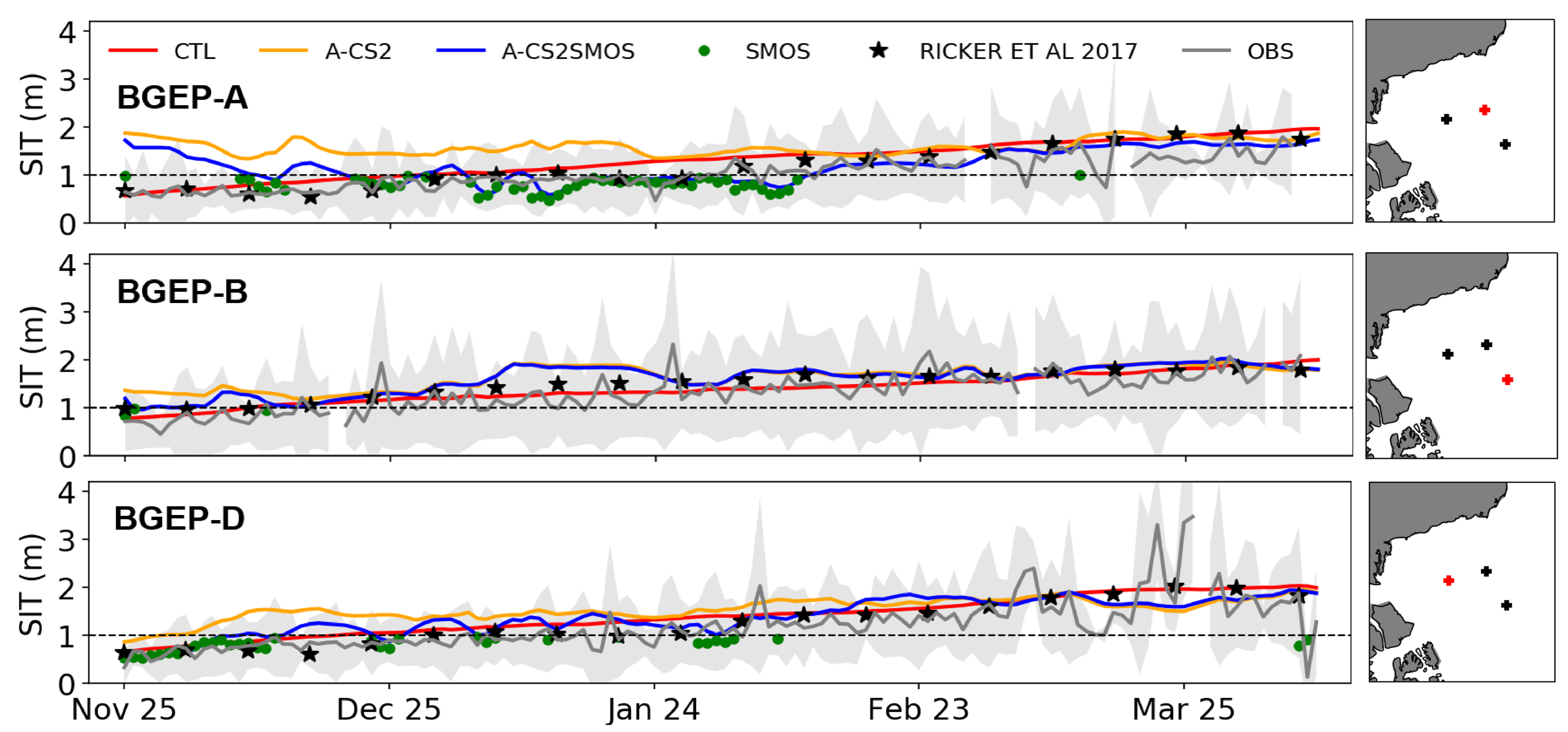

Figure 4: SIT (m) comparison between the model runs and the moorings from the Beaufort Gyre Exploration Project (BGEP).

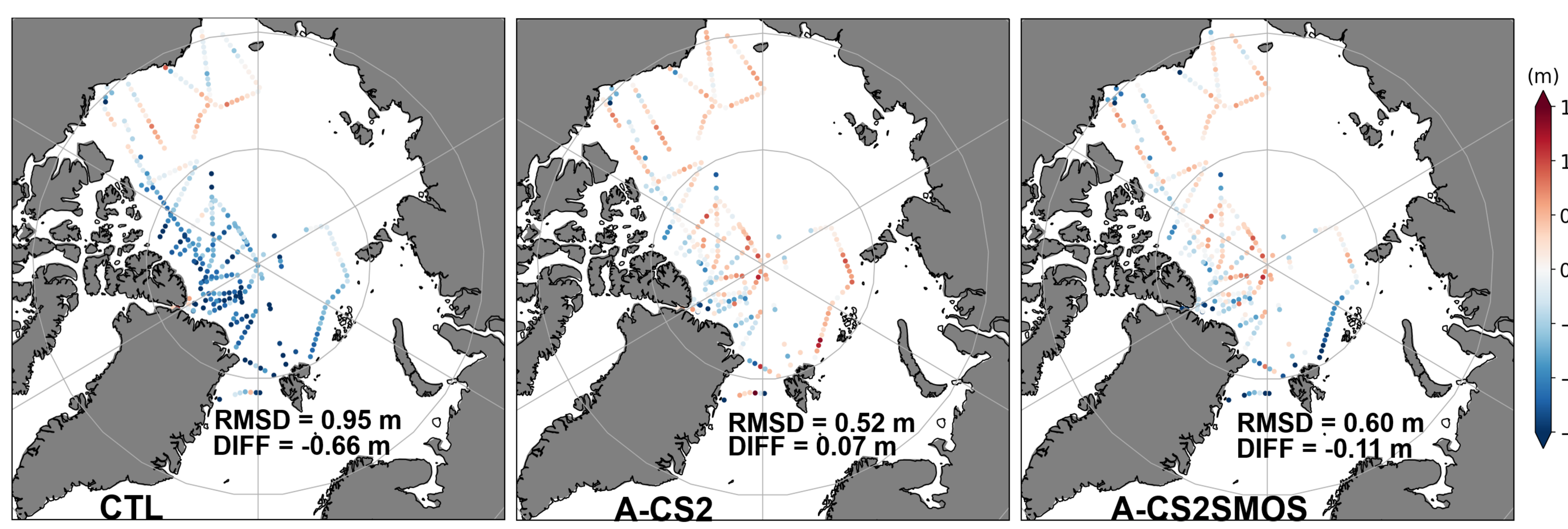

Figure 5: SIT (m) from the model runs minus those measured by the Operation Ice Bridge in March-April 2017.

Forecast assessment

- A-CS2SMOS forecast errors are not only reduced for SIT, but also for the sea-ice concentration (SIC) in the MIZ.

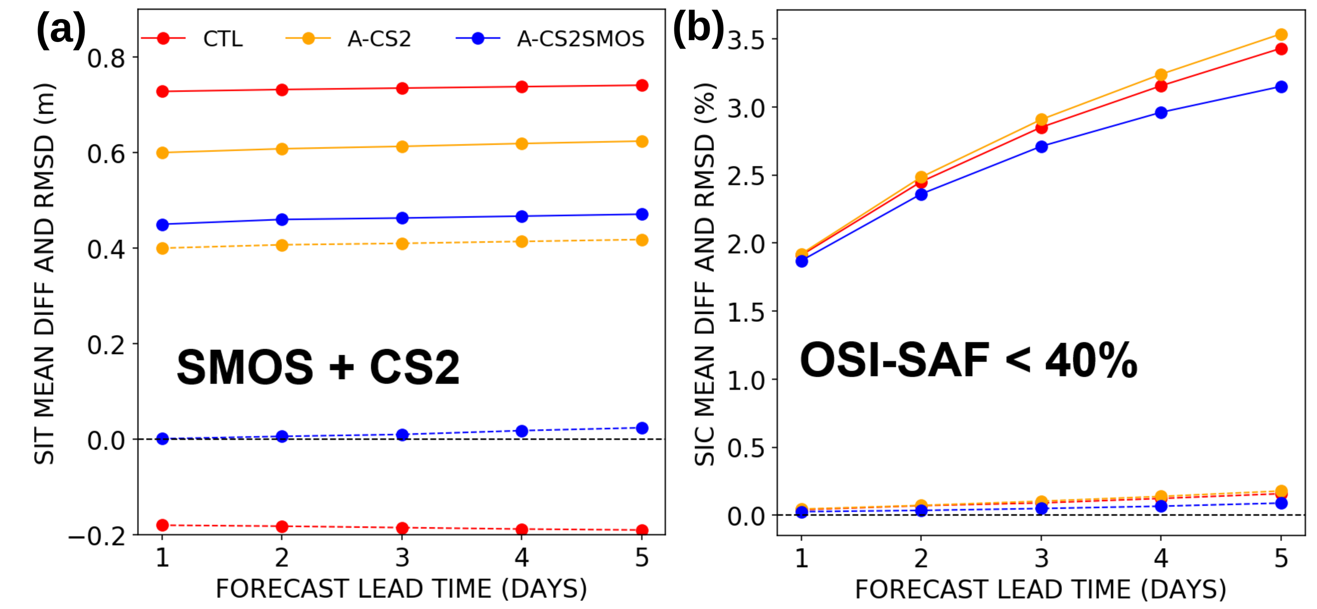

Figure 6: RMSD (solid) and mean difference (dashed) of (a) SIT forecasts with respect to assimilated observations; and (b) the same metrics for SIC forecasts compared to OSI-SAF observations which are less than 40%.

- Clear impacts of SMOS assimilation in improving 5-day forecasts of sea-ice edge near the Fram Strait.

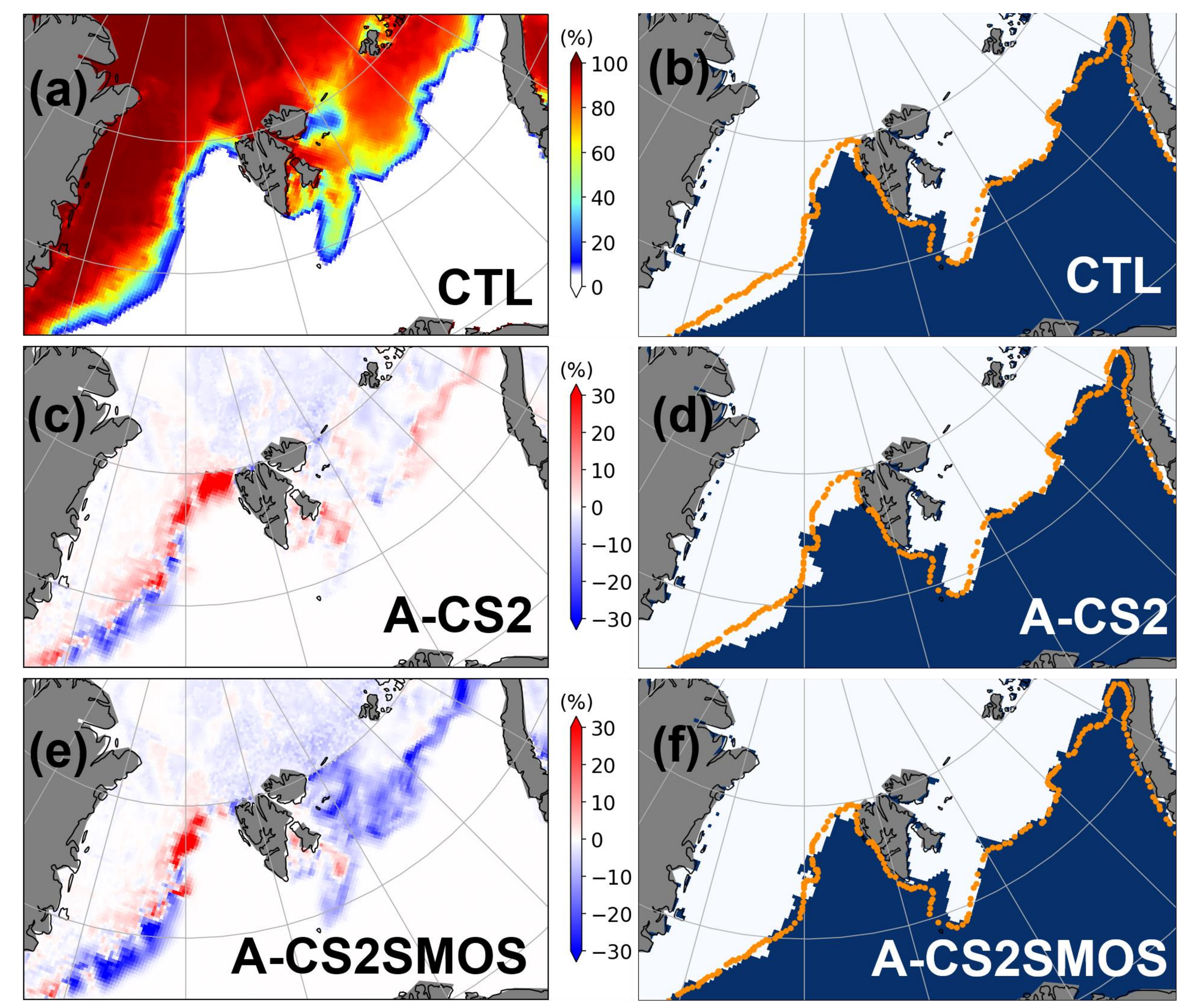

Figure 7: 5-day forecast averaged between 26 March and 31 March 2017 for (a) CTL SIC (%); (c, e) SIC differences (%) between the SIT assimilation experiments and CTL; and (b, d, f) the position of the ice edge. The orange dots correspond to the NIC ice-edge product.

Conclusions

- The assimilations of SMOS and CS2 are complementary, and they improve distinct sea-ice regions in the Arctic.
- The SMOS assimilation enhances the predictive skill of the sea-ice edge locations and the SIC in the MIZ.
- More work is needed to improve the estimation of CS2 observation errors near the MIZ.

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