

Supporting Information for "Assimilating summer sea-ice thickness observations improves Arctic sea-ice forecast"

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Uncertainty of CryoSat-2 summer SIT observation used in the assimilation and forecast system

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The observation uncertainty used in the assimilation and forecast system includes measurement errors and representation errors (Janjić et al., 2018). Considering the underestimation of the CryoSat-2 (CS2) summer SIT observations, in our study, the total uncertainty (σ) is determined by taking into account both the observational errors (σ_{CS2}) provided in the CS2 SIT dataset and the corrected errors (σ_{corr}) estimated based on the spatial distribution of the CMST SIT, as $\sigma = \max(\sigma_{CS2}, \sigma_{corr})$. We take a piecewise form for σ_{corr} , which is a function of the SIT of a reference product. It is set to 0.5 m when CMST SIT values are between 2.5 and 3.0 m, and 1.0 m when CMST SIT is greater than 4.0 m. A linear interpolation between 0.5 and 1.0 m is utilized for the CMST SIT between 3.0-4.0 m. Note that this correction is most important when the CS2 SIT uncertainty peaks annually, specifically in the range of 0.4-0.8 m in multi-year ice regions from July to August.

References

- Janjić, T., Bormann, N., Bocquet, M., Carton, J. A., Cohn, S. E., Dance, S. L., ... Weston, P. (2018). On the representation error in data assimilation. *Quarterly Journal of the Royal Meteorological Society*, 144(713), 1257-1278. doi: 10.1002/qj.3130
- Schlitzer, R. (2023). *Ocean data view* [software]. Retrieved from <https://odv.awi.de>

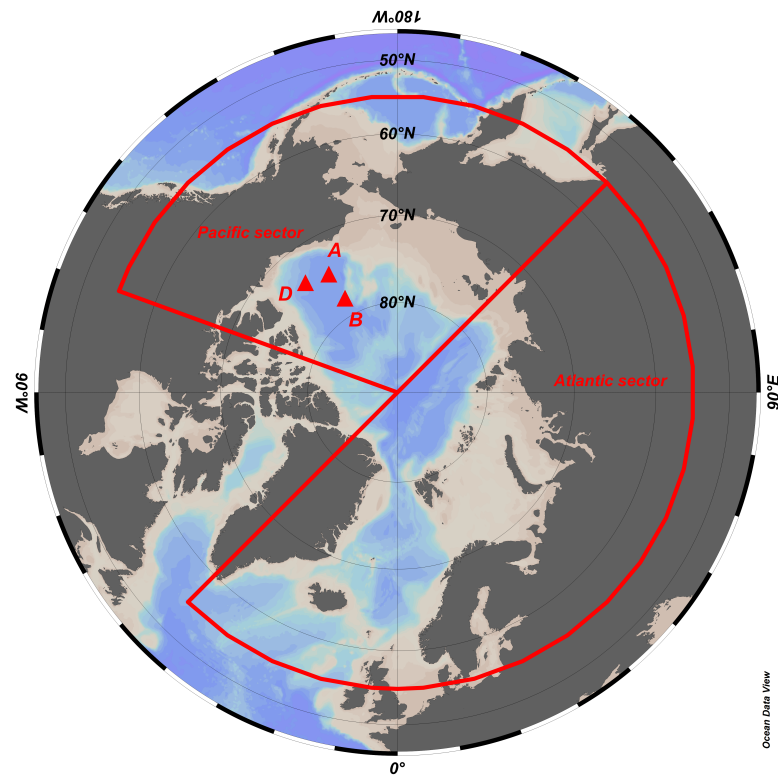


Figure S1. Study area of ice-edge forecasts and the location of BGEP moorings. This figure is plotted with Ocean Data View (Schlitzer, 2023).

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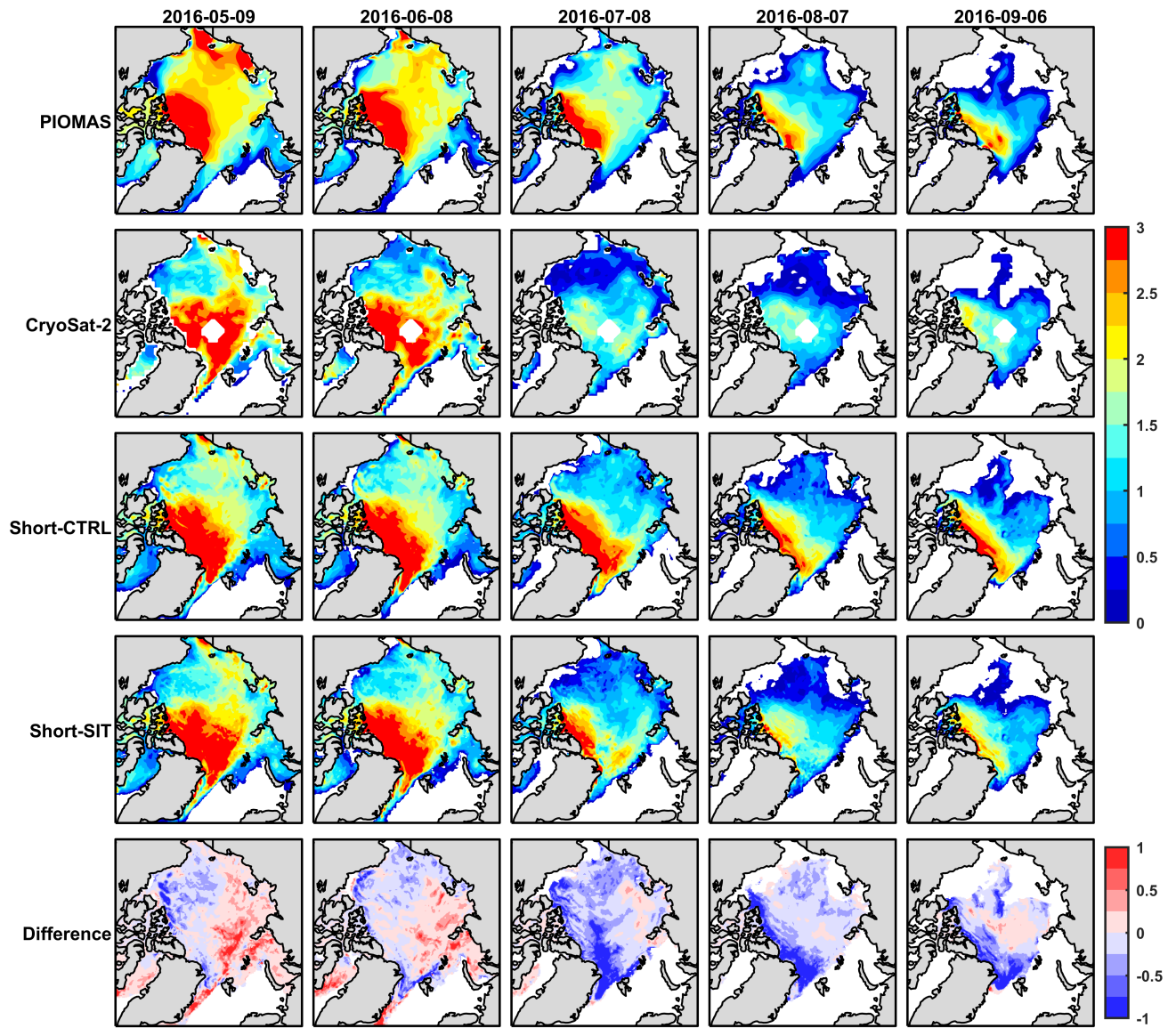


Figure S2. Same as Figure 1, but in 2016

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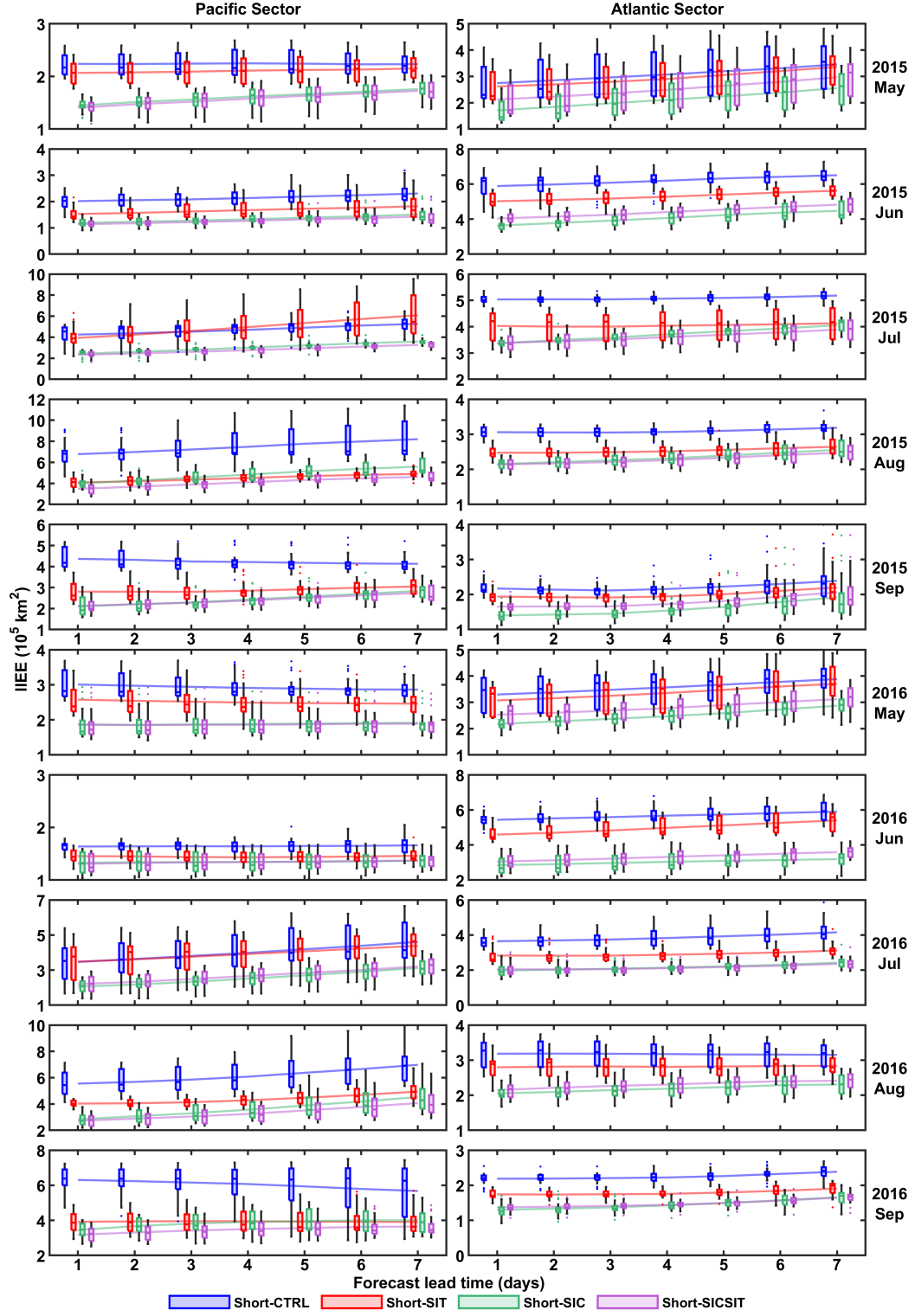


Figure S3. Box plot of IIEE. The forecasted IIEE is calculated after 7 days of assimilation, when the summer CryoSat-2 SIT takes full effect. Blue, red, green, and purple boxes refer to IIEE in Short-CTRL, Short-SIT, Short-SIC, and Short-SICSIT, respectively. Colored boxes indicate IIEE between the lower and upper quartiles. Colored outliers denote values more than 1.5 interquartile range away from the top or bottom of the box. The outer edges of the black lines denote the minimum and maximum of the values that are not outliers. Solid lines show the mean IIEE in each month and region.

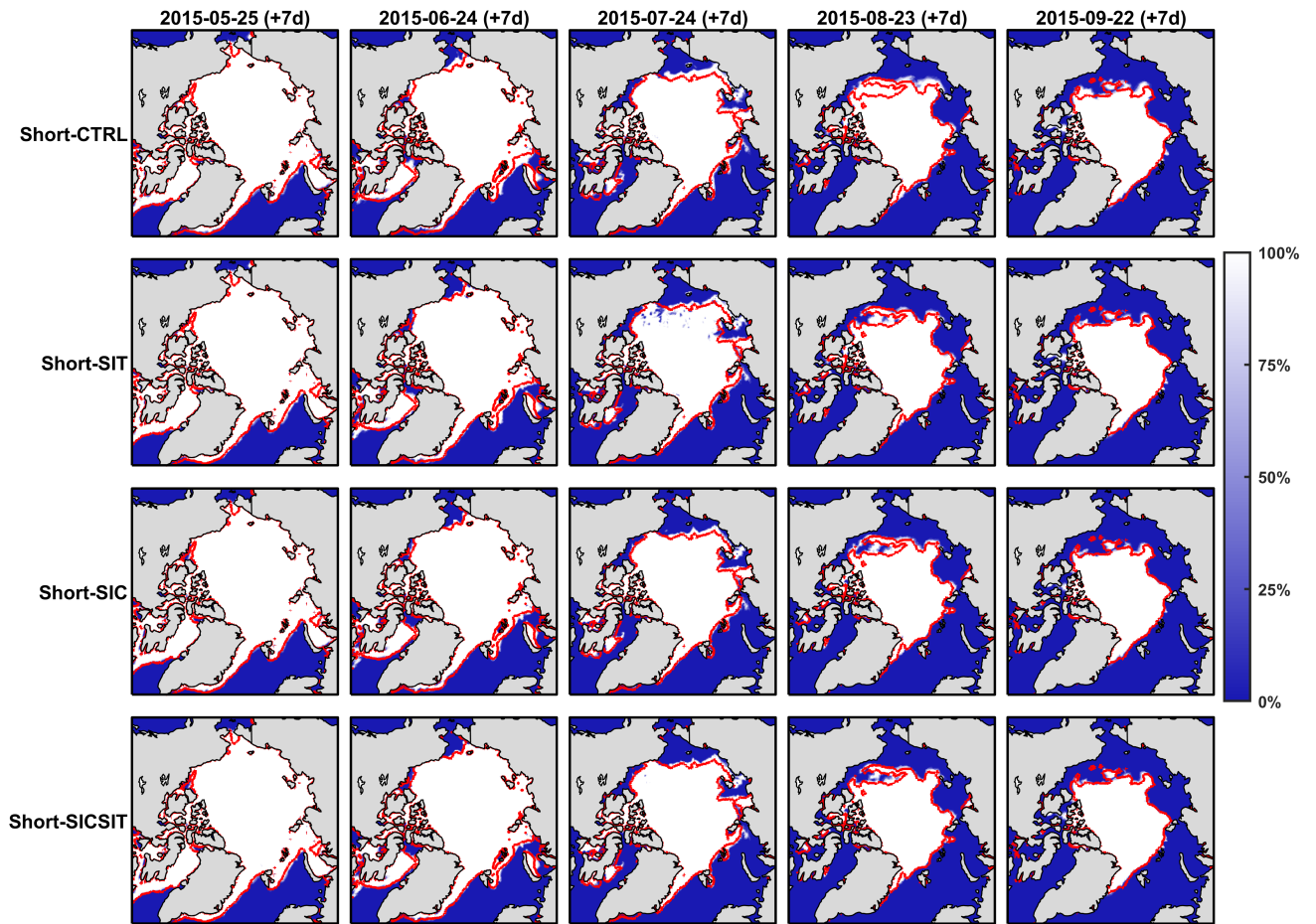


Figure S4. The 7-day lead time ice-edge forecasts from the 18th day after the initialization in May to September in 2015. Red lines indicate the NSIDC observed ice edge. The color scale shows the sea-ice probability computed from the 11 ensemble members.

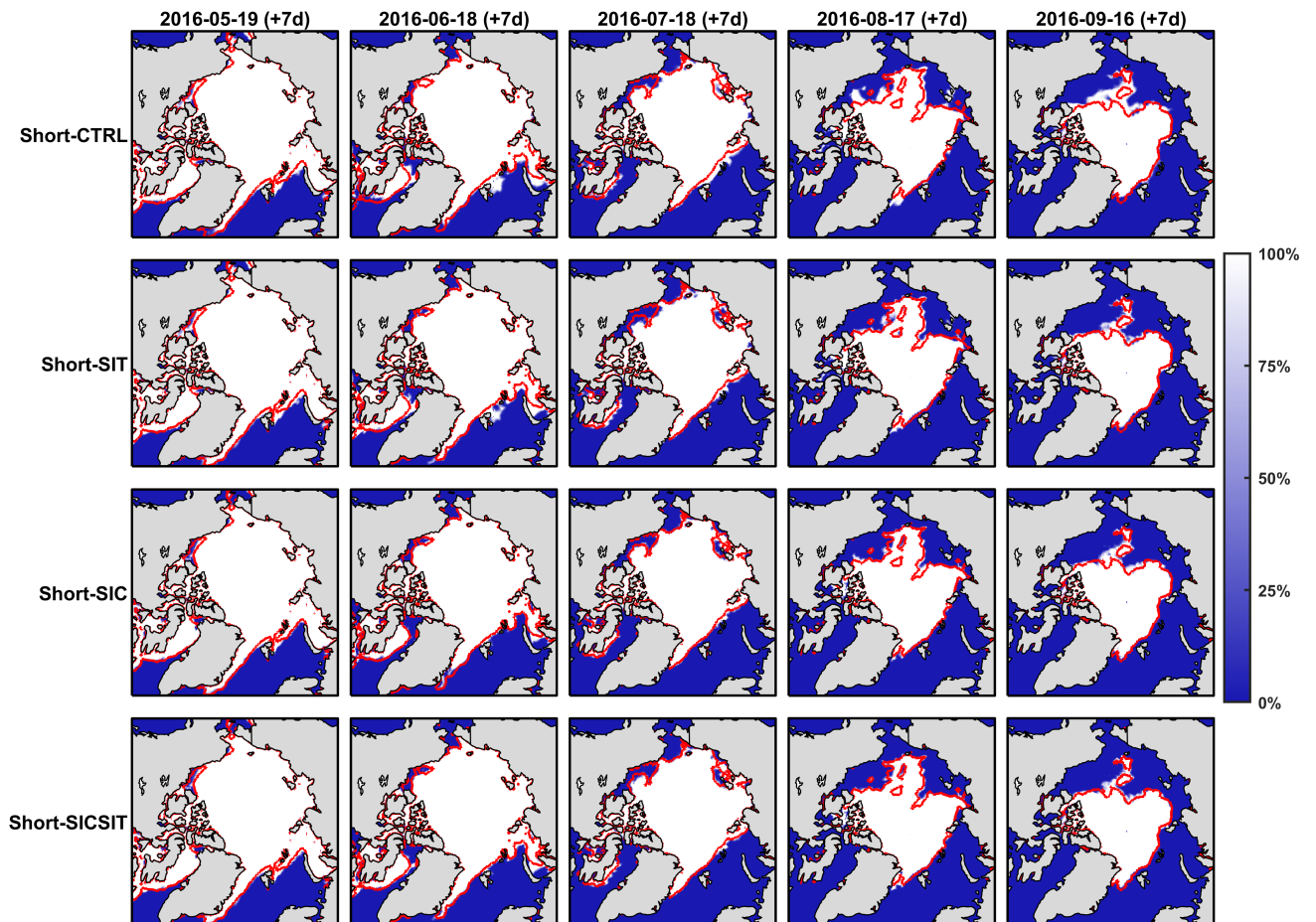


Figure S5. Same as Figure S4, but in 2016

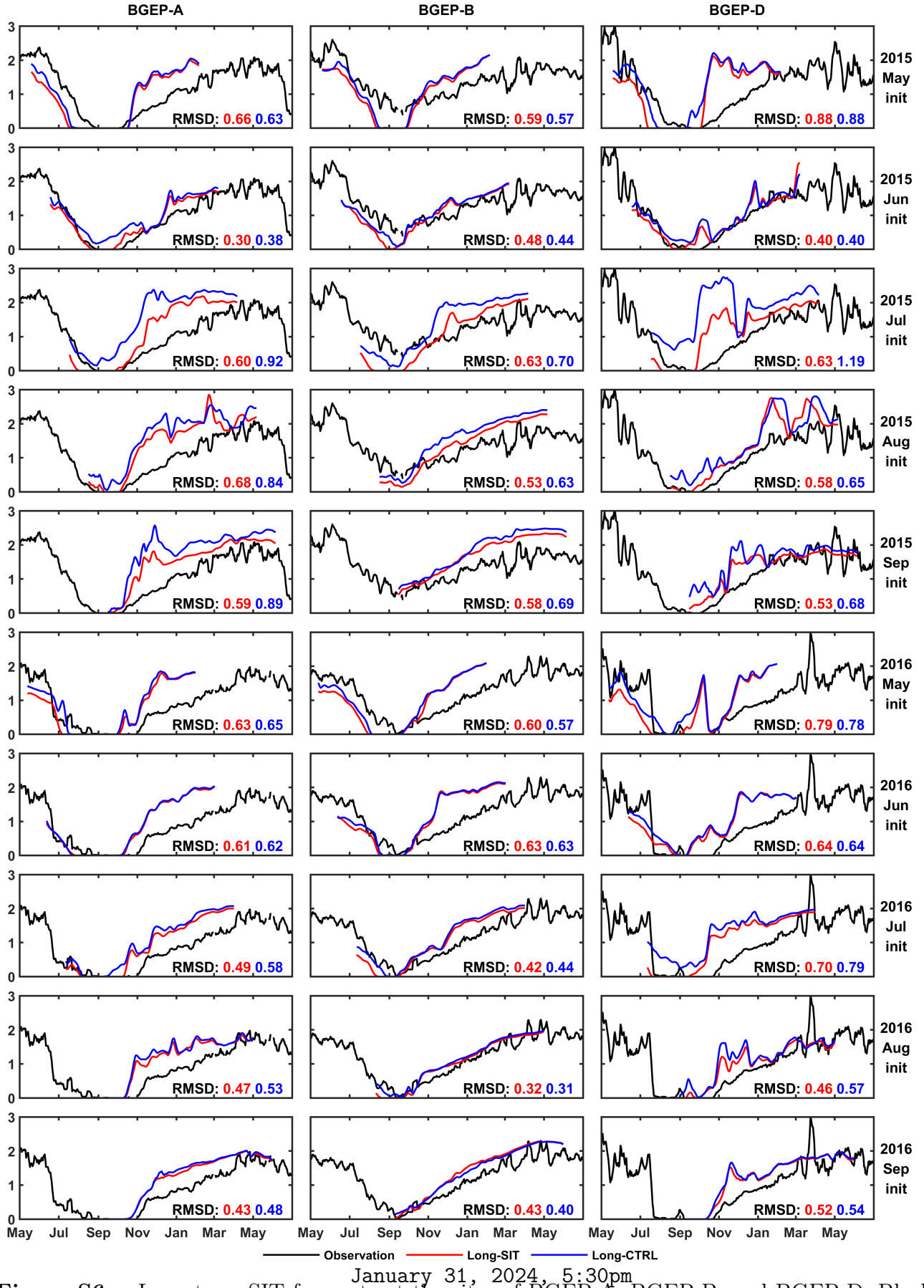


Figure S6. Long-term SIT forecasts at the sites of BGEP-A, BGEP-B, and BGEP-D. Black lines show the 7-day average SIT from the BGEP ULS, red lines indicate the SIT from Long-SIT, while blue lines show the SIT from Long-CTRL.