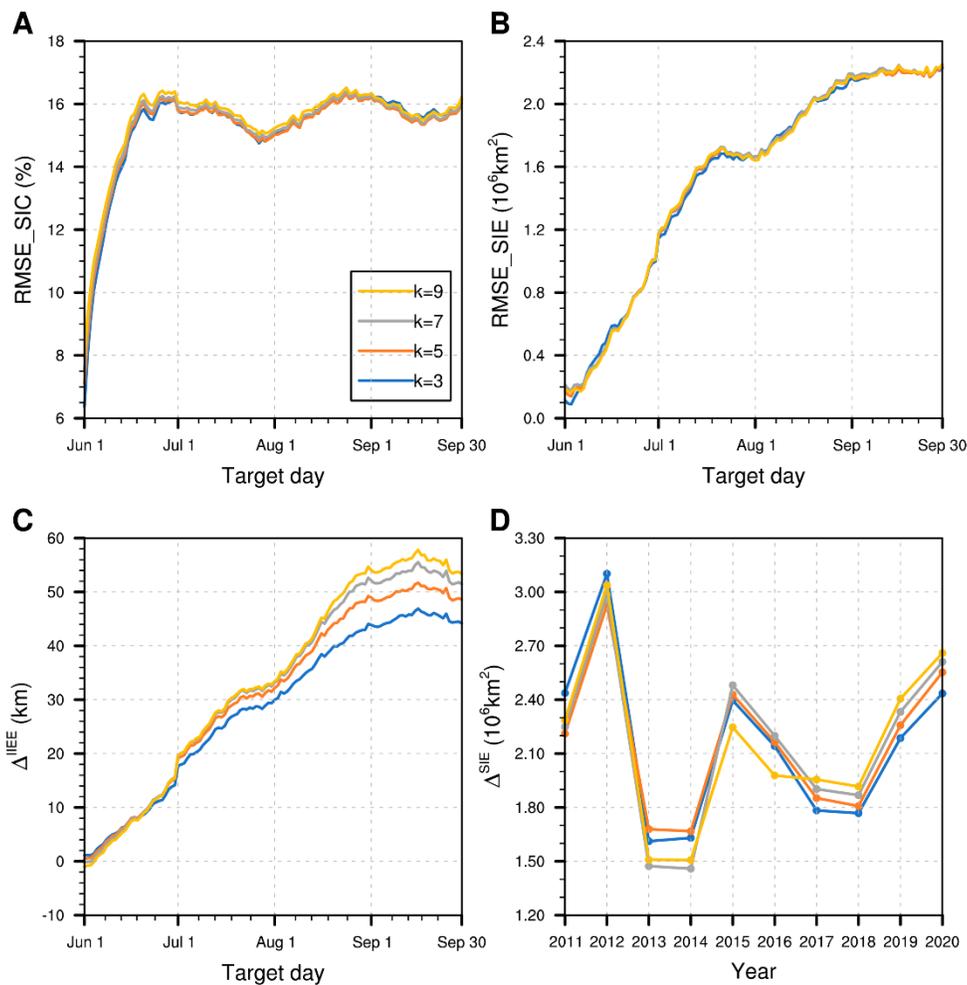


## Supplementary Material

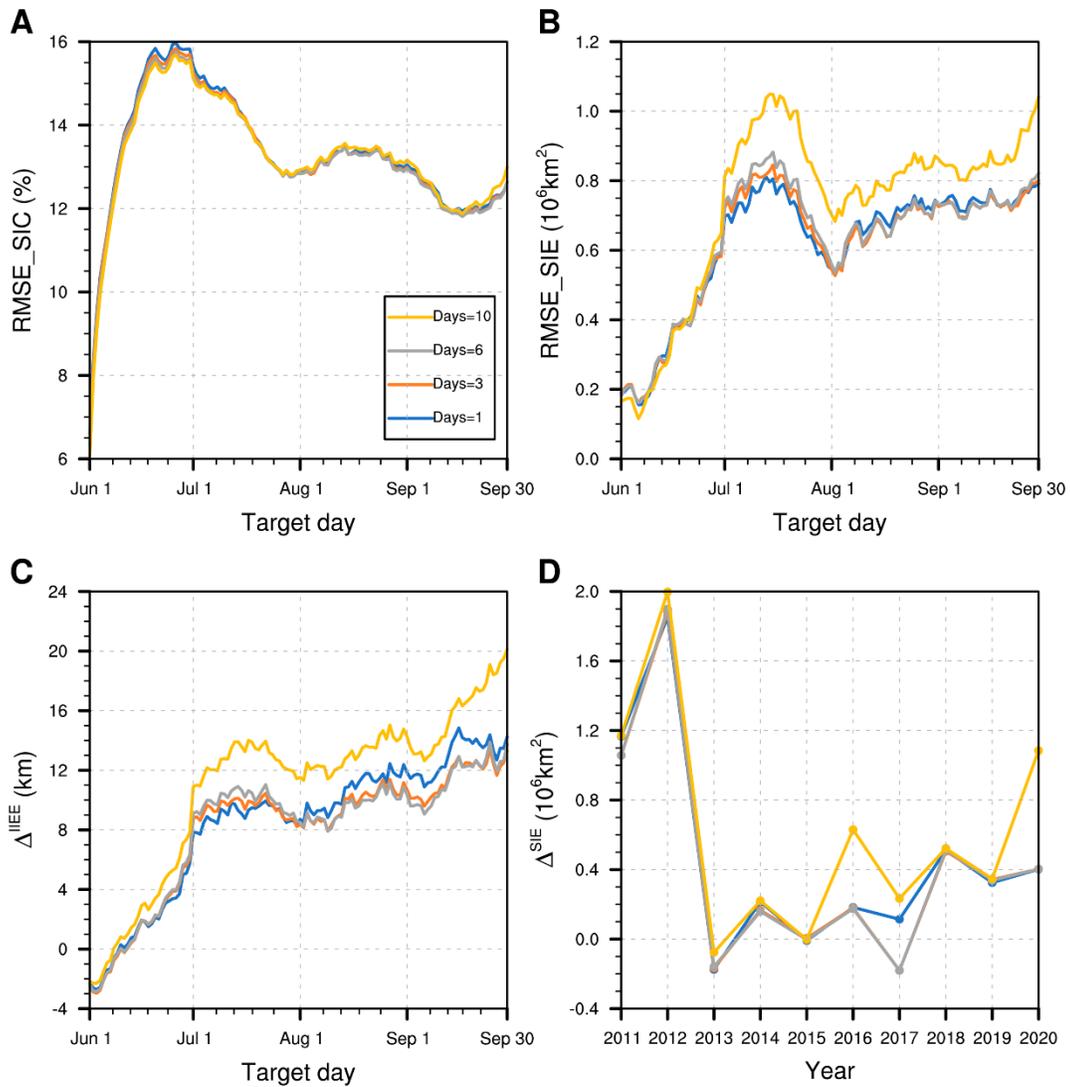
# Optimization of the k-nearest-neighbors model for summer Arctic sea ice prediction

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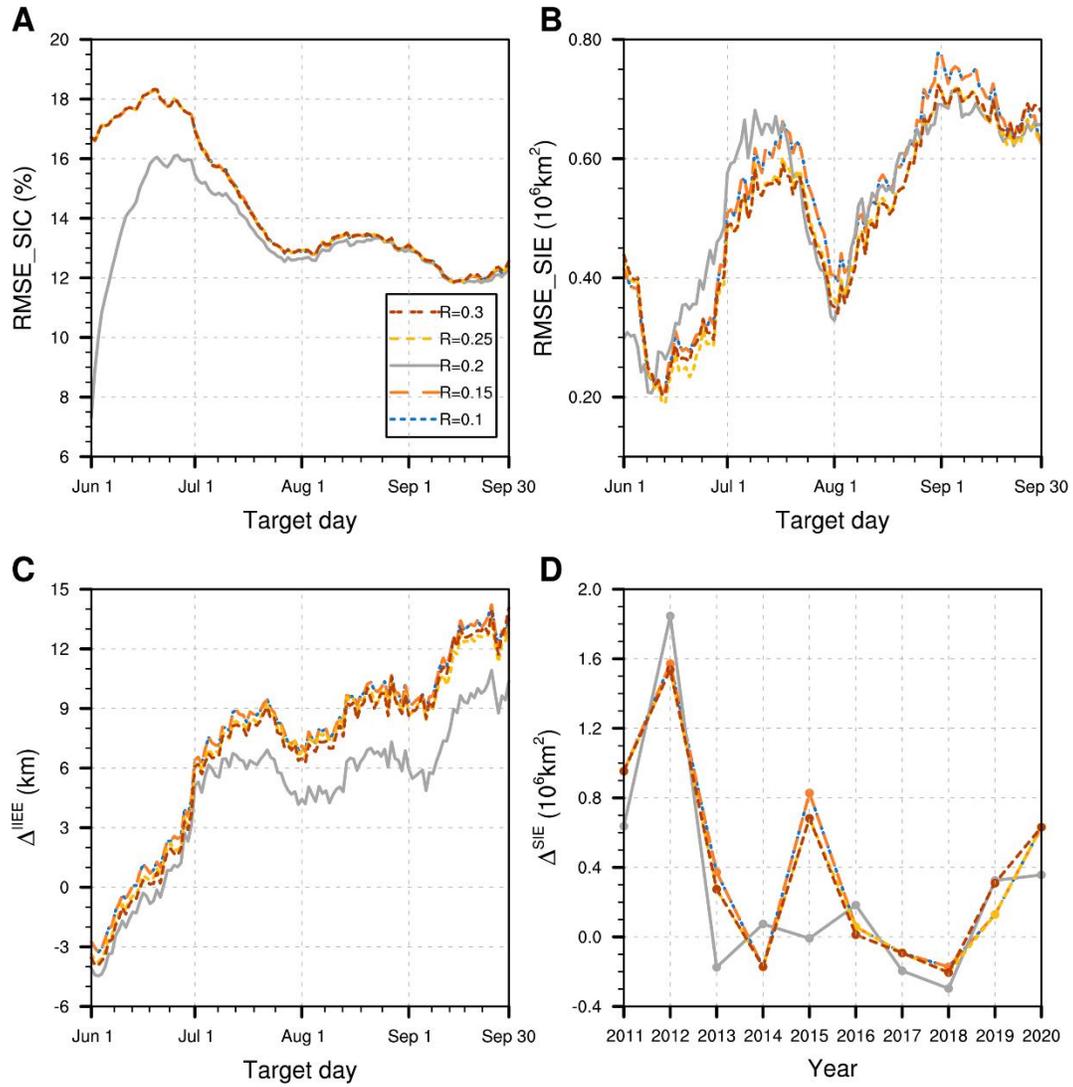
\* Correspondence: Xuewei Li: [lixw39@mail.sysu.edu.cn](mailto:lixw39@mail.sysu.edu.cn)



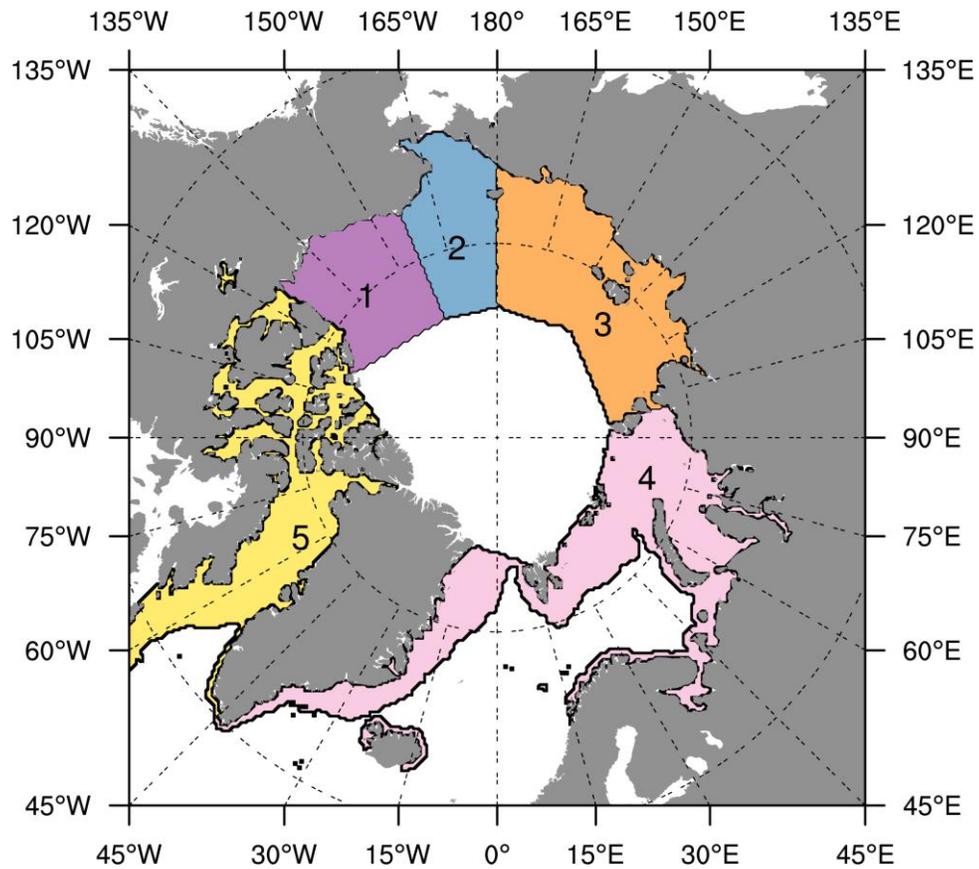
**Supplementary Figure 1.** Hindcast skill comparison between different k values based on the Ice-kNN-Ctrl measure by (A) spatial averaged RMSE\_SIC, (B) RMSE\_SIE, (C)  $\Delta^{\text{IEE}}$ , and (D)  $\Delta^{\text{SIE}}$ .



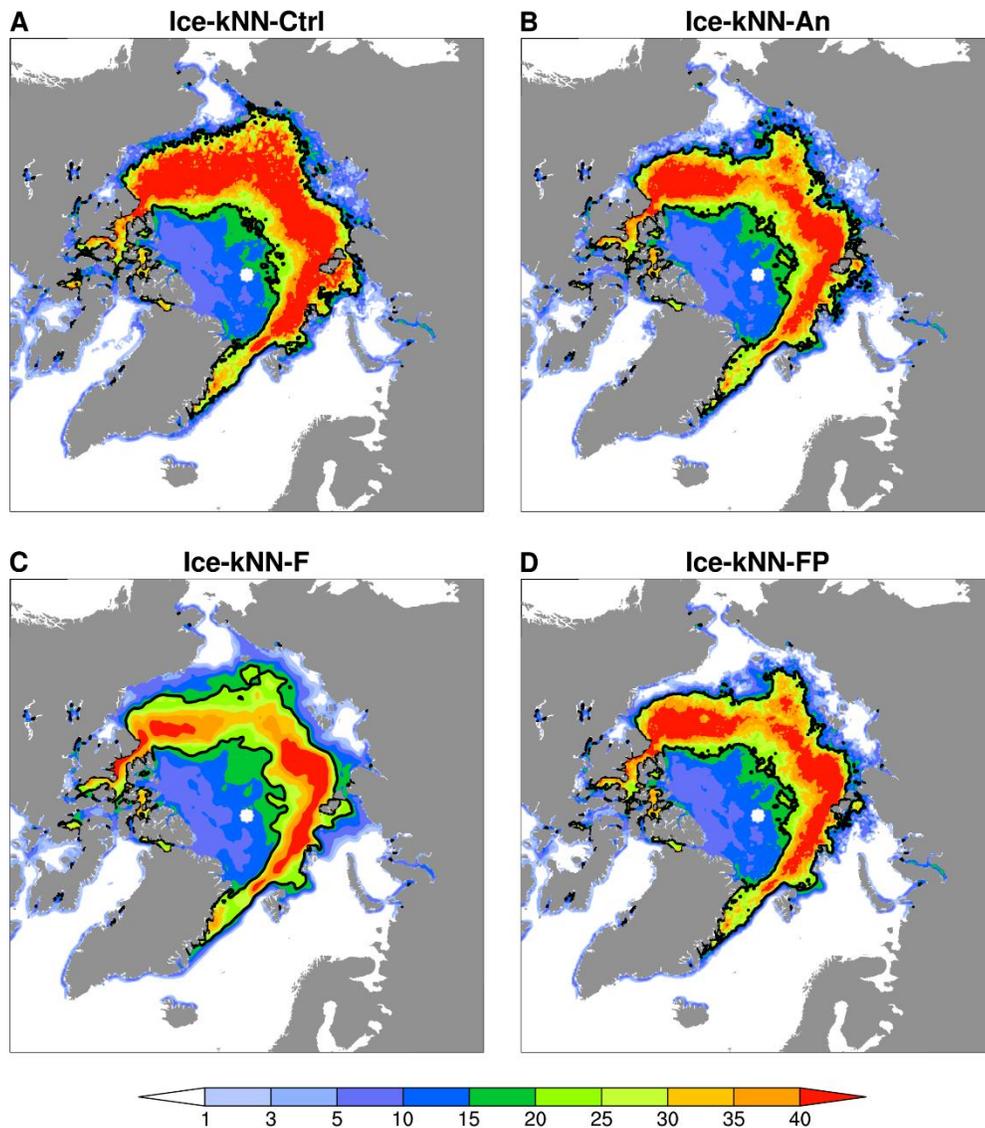
**Supplementary Figure 2.** Hindcast skill comparison between different adjacent days based on the Ice-kNN-FP measure by (A) spatial averaged RMSE\_SIC, (B) RMSE\_SIE, (C)  $\Delta^{\text{IEE}}$ , and (D)  $\Delta^{\text{SIE}}$ .



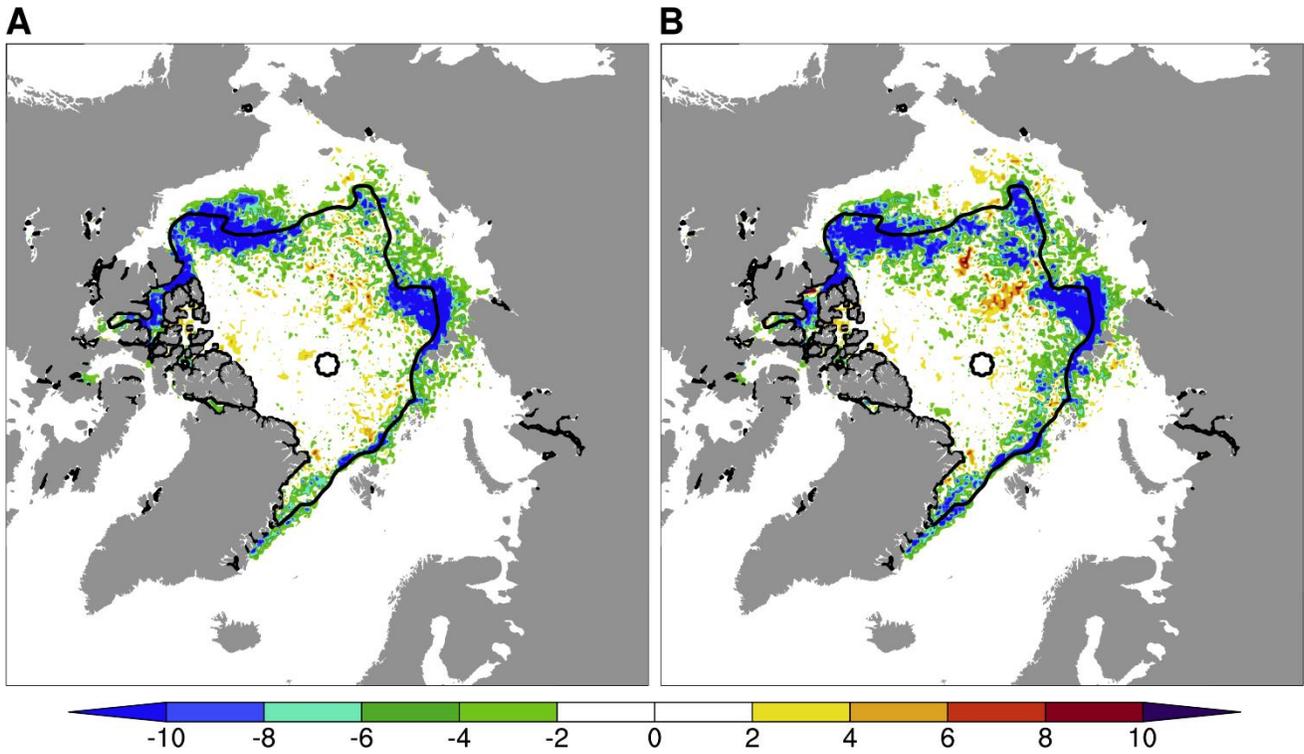
**Supplementary Figure 3.** Hindcast skill comparison between different threshold R based on the Ice-kNN-PC measure by (A) spatial averaged RMSE\_SIC, (B) RMSE\_SIE, (C)  $\Delta^{\text{IEE}}$ , and (D)  $\Delta^{\text{SIE}}$ .



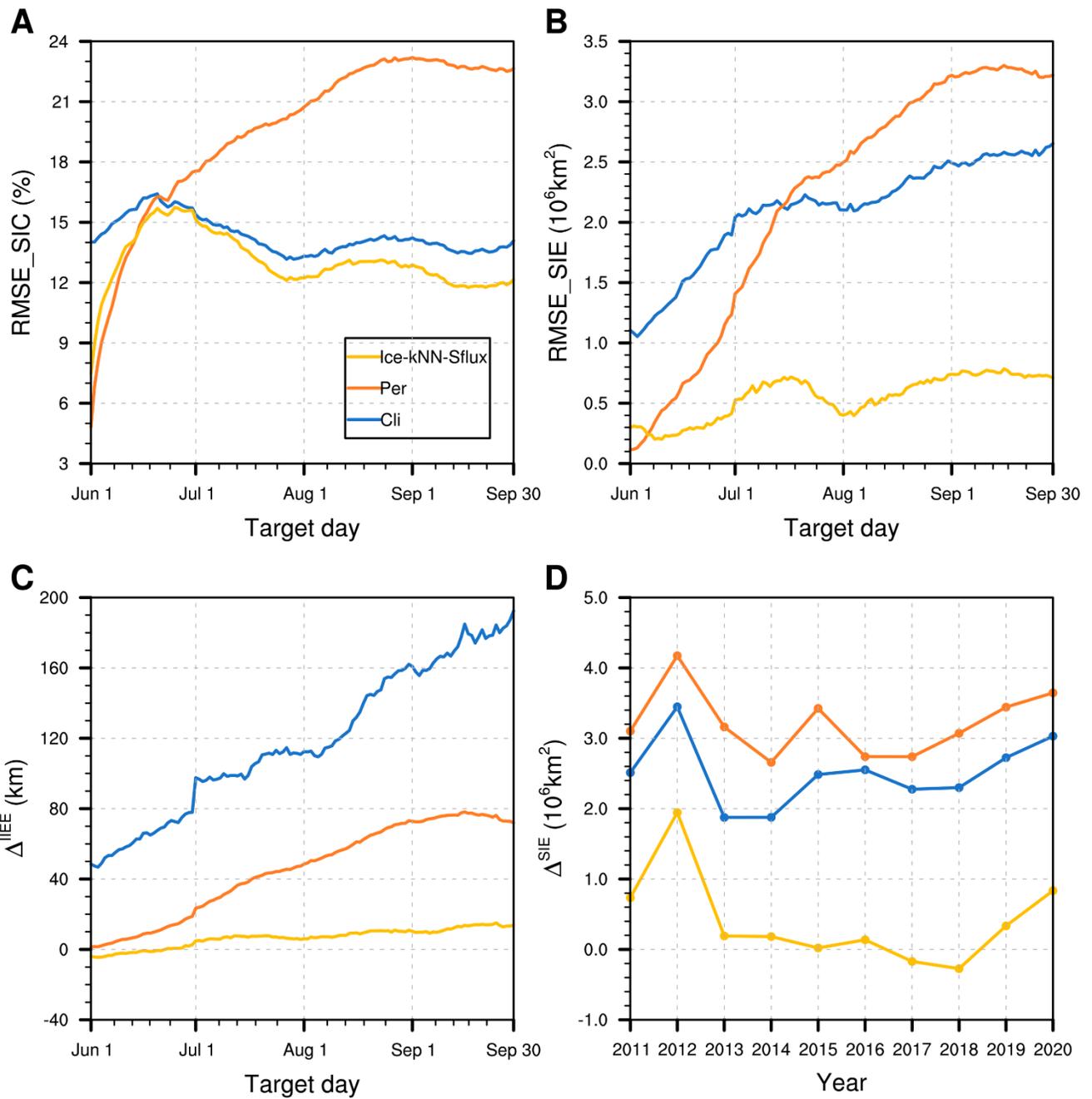
**Supplementary Figure 4.** The Arctic is subdivided into maritime boundaries provided by NSIDC via MAISIE, including 1) Beaufort Sea, 2) Chukchi Sea, 3) East Siberian-Laptev seas, 4) Kara-Barents-Greenland seas and 5) Baffin Bay-Canadian Archipelago.



**Supplementary Figure 5.** The monthly-mean RMSE\_SIC in September averaged from 2011 to 2020 in (A) Ice-kNN-Ctrl, (B) Ice-kNN-An, (C) Ice-kNN-F and (D) Ice-kNN-FP. The black lines represent the contour line where RMSE\_SIC is 20%.



**Supplementary Figure 6.** The prediction bias between (A) the Ice-kNN-PA and Ice-kNN-FP, (B) the Ice-kNN-PFA and Ice-kNN-FP in September averaged from 2011 to 2020. The black line represents sea ice extent with an outline of the 10-year (2011-2020) mean extent for the September.



**Supplementary Figure 7.** Hindcast skill comparison between climatology prediction (red), anomaly persistence prediction (blue), Ice-kNN-Sflux (yellow) measure by (A) spatial averaged RMSE\_SIC, (B) RMSE\_SIE, (C)  $\Delta^{\text{IEE}}$ , and (D)  $\Delta^{\text{SIE}}$ .

**Supplementary Table 1.** June, July, August, and September estimates of September Arctic SIE comparison between the Ice-kNN-Sflux and SIPN contributors in **(A)** 2021 and **(B)** 2022. Unit: million square kilometers.

<b>A</b>					
<b>2021</b>					
	<b>Prediction</b>				<b>Observation</b>
Initial	June	July	August	September	
Ice-kNN-Sflux	5.34	4.94	4.66	4.49	4.92
The median of all models	4.37	4.36	4.39	4.39	
<b>B</b>					
<b>2022</b>					
	<b>Prediction</b>				<b>Observation</b>
Initial	June	July	August	September	
Ice-kNN-Sflux	5.05	4.47	5.65	4.62	4.87
The median of all models	4.57	4.64	4.83	4.91	