Enhancing Subseasonal-to-Seasonal Prediction of Arctic Summer Sea Ice through hybrid Machine Learning–dynamical modelling

Lin Yongchen, Wang Yiguo, Counillon François

NERSC

Abstract

Both machine learning and dynamical prediction are commonly used for Arctic sea-ice prediction. The former show promising performance but lack sufficient physical constraints due to their pure data-driven nature; the latter (including Earth system models) are physically grounded with strong consistency and multivariable coherence, yet suffer from high computational costs and imperfect parameterisations. To overcome these limitations, we propose a hybrid framework that integrates the complementary strengths of machine learning and dynamical models. Specifically, we develop an interactive ensemble prediction system, referred to as SUPER, which couples the machine learning model Ice-kNN with the Norwegian Climate Prediction Model (NorCPM) to enable recursive information exchange between the two prediction systems. Within SUPER, Ice-kNN and NorCPM run in parallel and exchange information at regular intervals (e.g., weekly or monthly), allowing mutual adjustment of their predictions. We conduct subseasonal-to-seasonal forecast experiments for the period 2000–2023 and evaluate the daily sea-ice prediction skill of SUPER against that of the standalone models. Results indicate that the hybrid system significantly reduces errors in sea-ice concentration and sea-ice edge predictions compared to both standard NorCPM and Ice-kNN prediction systems.