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Assessment of decadal prediction skills and sensitivity to sea-ice thickness initialization in the Arctic when seasonal ice becomes dominant in the Arctic

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The Arctic has lost more than 50% multiyear sea ice (MYI) area during 1999-2017. Observation analysis suggests that if the decline of the MYI coverage continues, changes in the Arctic ice cover (i.e. area and volume) will be more controlled by seasonal ice than the effect of global warming. To investigate how large and where the source of Arctic prediction skill is given a large losses of thick MYI during the last two decades, we explore the decadal prediction skills and sensitivity to sea ice thickness (SIT) initialization from the EC-Earth3 Climate Prediction System with Anomaly Initialization (EC-Earth3-CPSAI). Three sets of ensemble hind-cast experiments following the protocol for the CMIP6 Decadal Climate Prediction Project (DCPP) are carried out in which the predictions start from: 1) a baseline system with ocean only initialization; 2) with ocean and sea ice concentration (SIC) initialization; 3) with ocean, SIC and SIT initialization. The hind-cast experiments are initialized and validated based on the ERA-Interim-reanalysis for the atmosphere and ORAS5 for ocean and sea-ice, with a focus period 1997-2016. All initialized experiments show better agreement with ORAS5 than the CMIP6 historical run (i.e. the Free run) for the first winter sea ice forecast. The SIT initialized experiments show the best skill in predicting SIT (or volume) and the added value by greatly reducing errors of near surface air temperature over the Greenland and its surrounding waters. In the Central Arctic, the Beaufort and East Siberian Seas, there are only minor differences in prediction skills on seasonal to decadal time scales between the ocean-only initialized and the SIT initialized experiments, indicating that the source of predictability in these regions are mainly from the ocean; while the ocean-only initialization degrades skill with larger RMSE than the Free run, e.g. during the ice-freezing season in the GIN and Barents Seas, or at the summer minimum in the Kara Sea, the added value from the SIT initialized experiment is present, and it may have long-term effect (>4 years) probably associated with sea-ice recirculation. In all cases, the improvement from the ocean-only initialization to also including SIC initialization is found negligible, even somehow degrading the skills. This highlights the important use of SIT in predicting changes in the Arctic sea ice cover at various time scales during the study period. Therefore, the sea-ice initialization with constraint on SIT is recommended as the most effective

initialization strategy in our EC-Earth3-CPSAI for present climate prediction from seasonal to decadal time scales.

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