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Towards an "eddy-resolving" climate prediction system

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We have developed, implemented and preliminary evaluated the performance of the first “eddy-resolving” decadal prediction prototype system based on the MPI-ESM-ER model configuration with the aim to investigate potential improvements due to resolving oceanic eddies in interannual to decadal climate variability and in the prediction skill of the North Atlantic circulation and climate of the regions impacted by it (Europe, Nordic Seas, and Arctic). The MPI-ESM-ER setup is employing an eddy-resolving ocean component with a global resolution of 10 km and an atmospheric component with a resolution of 100 km (T127). The eddy-resolving simulations were compared with similar MPI-ESM-HR experiments conducted within the CMIP6 DCPP-A framework employing an eddy-permitting ocean configuration of 0.4° (~40km). Since both the radiative forcing (CMIP6), the assimilation procedure and ensemble generation are exactly identical, has allowed us to isolate the effect of resolving oceanic eddies (and topographic features) in MPI-ESM-ER prediction system. The variability of the sea surface temperature (SST) in the subpolar North Atlantic over the last decades is well reproduced by the initialized predictions, in contrast to the uninitialized historical simulations. Both prediction systems are able to reproduce the mid-1990s abrupt strong warming event, with a more realistic amplitude of the warming in the MPI-ESM-ER hindcasts. Moreover, there is a clear reduction in the systematic model bias by using an eddy-resolving ocean component in MPI-ESM-ER. All MPI-ESM-HR hindcasts are approximately 1°C too warm, but the MPI-ESM-ER hindcast ensemble is very close to the observations. Reducing the SST bias in the North Atlantic will have implications for other quantities than SST, such as storm tracks or blocking events over Europe. We have also investigated the impact of an “eddy-permitting” and an “eddy resolving” ocean configuration on the predictability of the 2015 record Subpolar North Atlantic “Cold Blob”. Predicting such extreme coupled climate phenomena over the North Atlantic-European region has proved to be very challenging for state-of-art prediction systems. However, we could demonstrate that our prediction system is able to reproduce the observed anomalies, but in years where it is absolutely necessary to forecast the atmosphere conditions too, it will require a large ensemble of hindcasts (of the order of 10 or more): two (out of five) ensemble members in MPI-ESM-HR and six (out of ten) ensemble members in MPI-ESM-ER configuration simulate an eastern subpolar North Atlantic “Cold Blob"" in 2015. One of the MPI-ESM-ER ensemble members even reproduces the full observed strength of the ""Cold Blob"", underlining the potential of high-resolution climate predictions. We could also demonstrate that using an eddy-resolving ocean (0.1°) considerably improves the model systematic bias over the North Atlantic subpolar gyre. Based on these promising results, we plan to investigate the predictability of other recent oceanic extreme climate phenomena.