Project: 1394
Project title: Horizon Europe project IMPETUS4CHANGE (I4C)
Principal investigator: Dr. Daniela Matei
Allocation period: 2025-01-01 to 2025-12-31

Achievements in 2024

The main goal of MPI-M within I4C is to assess the predictability of the record-strong marine heat wave in the subpolar North Atlantic in summer 2023 with a new subset of prediction experiments with the MPI-M ocean-eddy resolving climate prediction system. The strategy of the project foresees analysis of existing climate predictions and projections in the first project year (as described below), followed by the performance and analysis of new and improved climate predictions applying novel modelling approaches.

The summer 2023 marine heat wave in the subpolar North Atlantic in the MPI-M Grand Ensemble

A record-strong marine heat wave occurred in the subpolar North Atlantic in summer 2023 with spatially averaged sea surface temperature (SST) anomalies exceeding 1^{o}C (red line in Figure 1). Based on analysis of historical/scenario simulations with different climate models (one realisation each, including the first member of the MPI-M Grand Ensemble), Kuhlbrodt et al. (2024) discuss the 2023 subpolar marine heat wave in the context of the expected mean climate change for various scenarios. Here, we extend the analysis of the MPI-M Grand Ensemble historical/scenario simulations to all 50 members and show that eight ensemble members simulate summer SST anomalies in the subpolar North Atlantic exceeding 1^{o}C within the current decade (Figure 1, one ensemble member even in two adjacent summers). We underline that these eight ensemble members do not include the first member analysed by Kuhlbrodt et al. (2024). Considering the entire simulated period (1850-2100) indicates that the recent decades are a kind of transition phase, in which, due to a warming background state, subpolar marine heat waves as observed in summer 2023 may occur occasionally. Regarding potential drivers of the observed heat wave, our analysis of atmospheric reanalysis data suggests a large heat gain in the western subpolar North Atlantic in the winter of 2022/23, associated with a negative phase of the North Atlantic Oscillation (NAO) in some of the winter months. All ensemble members reproducing the observed subpolar marine heat wave also simulate large subpolar surface heat gain in the respective preceding winter, though partly over different parts of the subpolar North Atlantic, related to the respective atmospheric winter circulation. For most of these ensemble members, an oceanic heat transport convergence across the subpolar gyre also contributes to the simulated subpolar marine heat wave.

Kuhlbrodt, T., R. Swaminathan, P. Ceppi and T. Wilder (2024): A glimpse into the future - The 2023 ocean temperature and sea ice extremes in the context of longer-term climate change. Bulletin of the American Meteorological Society, doi:10.1175/BAMS-D-23-0209.1

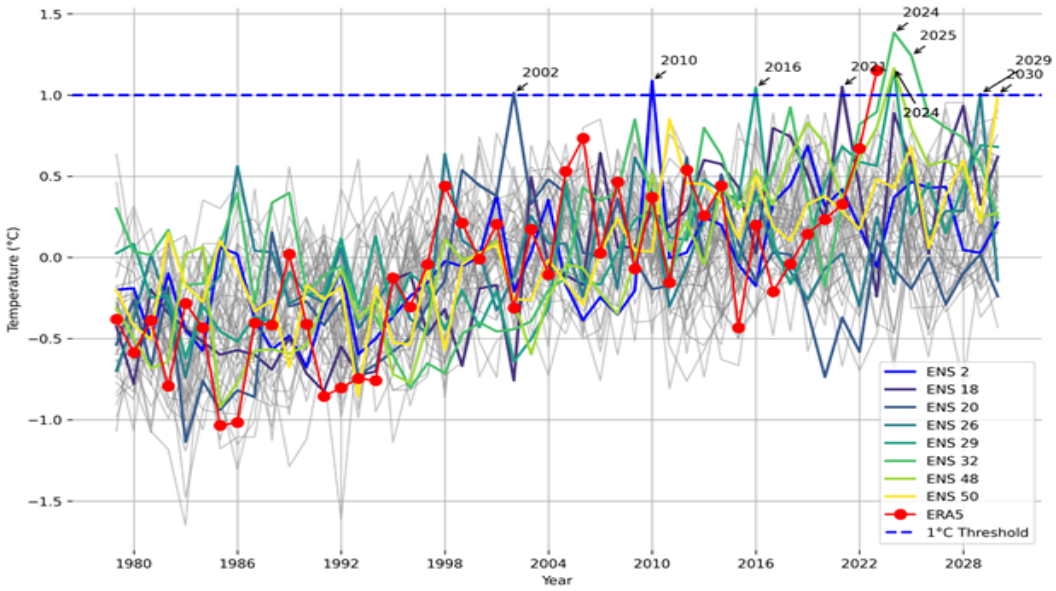

Figure 1: Sea surface temperature anomalies in summer (JJA) in the subpolar North Atlantic in atmospheric reanalysis (red line) and the MPI-M Grand Ensemble historical/scenario simulations.

Skilfully reforecasting the 2015 summer heat waves over central Europe with the MPI-M ocean-eddy-resolving climate prediction system

We have refined the analysis of the 2015 summer heat waves over central Europe in the subset of ocean-eddy resolving prediction experiments performed within JPI Oceans / JPI Climate project ROADMAP by using daily rather than monthly output data to better resolve the limited time periods over which atmospheric heat waves occur. Four hindcasts initialized in November 2014 and two hindcasts initialized in November 2013 reforecast warm SAT anomalies over central Europe in summer 2015, which agree in duration and strength with the observed anomalies (Figure 2). These hindcasts also reproduce the coinciding cold anomalies over Scandinavia. Not only cold SSTs over North Atlantic Subpolar Gyre, but also warm SSTs over western-to-central Mediterranean are required to accurately reforecast the strength and location of 2015 European Heatwaves.

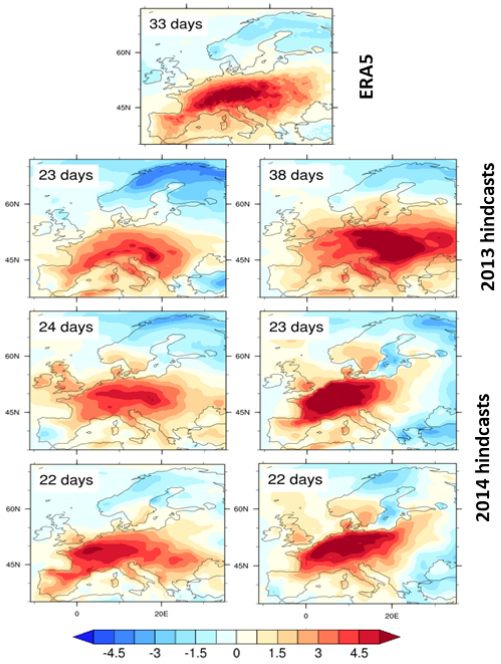

Figure 2: SAT anomalies [K] during heat days in summer 2015 in observations (ERA5) and in selected hindcasts initialized in November 2014 and in November 2013.