Project title: PAMIP: Polar Amplification Model Intercomparison Project
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End of 2021 and beginning of 2022 we were able to complete all planned PAMIP experiments ECHAM6.3 with and without SWIFT to investigate the role of interactively coupled stratosphere ozone chemistry for stratospheric circulation and interactions with the troposphere in different climate states. The different climate states are pre-industrial, present-day and future representative of a 2-degree warmer world and different combinations of climate states of sea surface temperature (SST) and sea ice concentration (SIC) ensure that we can investigate the individual role of Arctic and extra-Arctic climate change.

Now we have 300 ensemble members of 1.1 and 1.1T experiments (present-day sea ice concentration (SIC), present-day sea surface temperature (SST) for ECHAM 6.3 only (1.1) and ECHAM 6.3 - SWIFT (1.1T). Furthermore, 100 ensemble members of 1.2 (pre-industrial SIC, pre-industrial SST), 1.3 (present-day SIC, pre-industrial SST), 1.4 (present-day SIC, future SST), 1.5 (pre-industrial SIC, present-day SST), 1.6 (future SIC, present-day SST), 3.1 (future Okhotsk SIC, present-day SST), 3.2 (future Barents Sea, Kara Sea SIC, present-day SST) experiments without SWIFT and 300 ensemble members of 1.2T, 1.3T, 1.4T, 1.5T, 1.6T experiments with SWIFT. The simulations without SWIFT have been published at ESGF.

For the simulations without SWIFT, two papers have been published, one of them describing the results of the PAMIP experiments from all modelling groups that contributed to the CMIP6-endorsed PAMIP project (Smith et al., 2022) and one of them focusing on the Euro-Atlantic circulation regimes and extreme events (Riebold et al., 2022).

Main results are: The response to future Arctic sea ice loss is weak compared to the influence of greenhouse gas induced warming. The North Atlantic circulation response offsets the influence of circulation changes induced by greenhouse gas induced warming and only accounts for 10% of the variability between individual years (Smith et al., 2022). When investigating circulation patterns (Riebold et al., 2022), Scandinavian blocking associated with European cold spells appears to be more frequent under future sea ice conditions (Fig. 1).

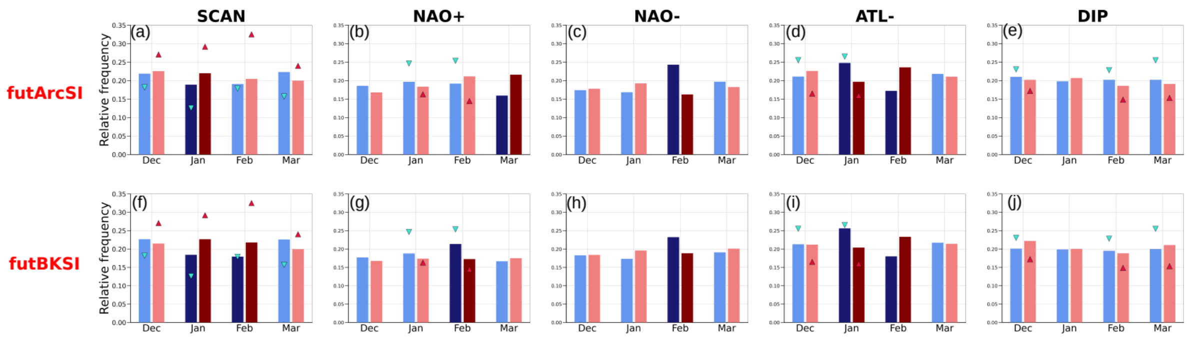

Fig. 1 (from Riebold et al., 2022): Relative regime occurrence frequencies for different winter months compared between the 1.1 reference simulation (blueish bars) and the 1.6 future Arctic sea ice sensitivity simulation (upper row, reddish bars), as well as the 3.2 future Barents Sea / Kara Sea sensitivity simulation (lower row, reddish bars). Transparent reddish and blueish bar indicate non-significant frequency differences between reference and *sensitivity simulations, whereas the paired dark blueish/reddish bars indicate significant differences in occurrence frequencies. Note that by definition the sum over all clusters for a specific month in a given simulation is one. The triangles indicate the respective ERA5 regime occurrence frequencies for low (upright reddish triangles, lower 50% of multiyear mean) and high (inverted bright-blueish triangles, upper 50% of multiyear mean) Arctic sea ice conditions derived from linearly detrended monthly Arctic sea ice area data over the period 1979–2018. Only ERA5 occurrence frequencies for months where significant differences between low and high ice conditions were found are shown here. Significant differences are derived from a moving block bootstrap.*

However, the thermodynamic effect of warmer Arctic conditions counteracts and compensates this cold anomaly. When increasing SSTs, the thermodynamic impact leads to a strong decrease of extreme cold events while changed circulation regimes play a minor role. Compared to SST increases outside the Arctic, the impact of reducing SIC remains small both in terms of dynamical and thermodynamic impacts (Fig. 2).

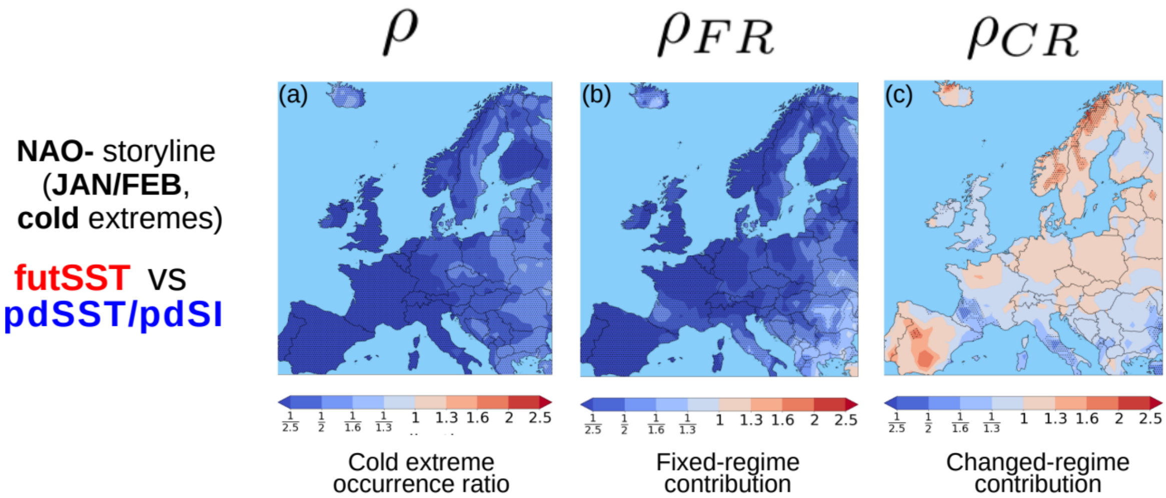

Fig. 2 (from Riebold et al., 2022): Conditional extreme event attribution framework for European cold extremes assuming a NAO minus storyline. Compared are the 1.1 reference simulation (blue indicates favored occurrence) and the 3.2 future Barents Sea / Kara Sea sensitivity simulation (red indicates favored occurrence) for January and February. (a) shows the overall cold extreme occurrence ratio between both simulations, (b) the Fixed-Regime (thermodynamic) contribution, and (c) the Changed-Regime (dynamic) contribution. Stippling indicates regions where the ratios significantly differ from unity based on a moving block bootstrap.

References:

Riebold, J., Richling, A., Ulbrich, U., Rust, H., Semmler, T., & Handorf, D. (2022). On the linkage between future Arctic sea ice retreat, Euro-Atlantic circulation regimes and temperature extremes over Europe. EGUsphere, 1-32.

Smith, D. M., Eade, R., Andrews, M. B., Ayres, H., Clark, A., Chripko, S., ... & Walsh, A. (2022). Robust but weak winter atmospheric circulation response to future Arctic sea ice loss. Nature communications, 13(1), 1-15.