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Assessing changes in the intensity and dynamics of extreme cold spells in France from CMIP6

Camille Cadiou and Pascal Yiou
IPSL - LSCE (CEA, CNRS, UVSQ), LSCE, Gif-sur-Yvette, France (camille.cadiou@lsce.ipsl.fr)

Extreme cold winters have been projected to decrease in the future, although their impacts on society are still significant. The goal of this study is to assess whether climate change affects the atmospheric mechanisms leading to cold winters.

We first explore the dynamics of 15-day winter cold spells in France, as observed since 1950. We find that the most extreme events tend to have the same atmospheric circulation pattern, consisting of an eastward-shifted NAO- dipole. We calculate an atmospheric index that characterizes this dipole. Then, using a stochastic weather generator with importance sampling, we show that this is a sufficient condition to trigger extremely cold temperatures in France, and that it performs better than a classical North Atlantic Oscillation index. This suggests that a dipole of atmospheric circulation is a necessary and sufficient condition leading to extreme cold spells in France.

We use this atmospheric index to select the CMIP6 models that best reproduce the identified dynamics leading to extreme cold spells of 15 days. Using a stochastic weather generator with importance sampling, we run simulations of worst-case winter cold spells from 2015 to 2100, following different emission trajectories for the selected models. 15-day winter cold spells in France will reach less extreme temperatures at the end of the century, especially in the case of a high-emission scenario (SSP5-8.5). However, the simulated ensembles of extreme cold spells do not show the same warming trend as the mean temperature, and very extreme cold spells are still possible in the near future. The atmospheric circulation prevailing during these events is analyzed and compared with the circulation observed during previous events.