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Detection and attribution of Southern European cold spells via a statistical Mechanics Approach

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Extreme weather and climate events, like cold spells, often have significant impacts on nature and society. A winter cold spell is a marked and unusual cold weather characterized by a sharp and significant drop of air temperatures leading to extremely low values, possibly associated to heavy snowfalls. The DAMA (Detection and Attribution of Southern European cold spells via a Statistical Mechanics Approach) project investigates winter cold spells in the Southern Europe region (10°W to 70°E , 22.5°N to 70°N). Our analysis is based on analogues of atmospheric circulation computed on a reference period over the past decades (1948-2018). We use data from the NCEP reanalysis to identify cold spells.

During the cold spells, the dynamical characteristics of the atmospheric circulation exhibit similar features that can be detected by the analysis of sea level pressure, geopotential high, temperature and snow cover fields. Using documentary sources, we have selected 32 cold wave events over the past decades. We first identify the first day of each event. We then compute the correlation matrix between several atmospheric fields recorded during these events and issued from the NCEP reanalysis dataset. We find that the coefficients of the correlation matrix are significantly nonzero for the first day of the events but also using past lags and therefore it allows us to determine the precursors of cold spells. These precursors are used as initial conditions of our simulations. The simulations are performed with the Planet Simulator (PlaSim) model. We run the model with several slightly perturbed initial conditions for winter season in order to validate the precursors. Under different but fixed emission scenarios, we determine the effect of climate change on the characteristics of cold spells.