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Empirical storylines of climate change using clustering analysis

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Storylines are intended to provide concrete realizations of the climate response to global warming, to help anticipate the possible impacts of climate change on society and nature. Recent studies on climate change storylines have used a multivariate linear regression (MLR) framework to determine those climate realizations, for specific variables, regions and seasons (called target variables); this is achieved by leveraging known climatic interactions across a large number of model projections, which are represented by the covariability of the target variable with pre-determined climate indices (called predictor indices). Yet, a systematic methodology for selecting the best set of predictor indices for a specific target variable is lacking, with the set of predictors usually being chosen according to our current understanding of the most important climatic interactions. Furthermore, the storylines that emerge from it are tailored to explain changes in one specific variable, region and season (the target variable), and thus are unable to be generally applicable to a range of target variables.

Even if the MLR framework succeeds in generating an array of representative climate outcomes for specific cases, we hypothesize that alternative methodologies can be used to generate likely climate outcomes from model simulations while alleviating some of the limitations of the MLR framework. Here, we propose to use clustering analysis to provide possible climate realizations from model projections. Clustering ensures a comprehensive and efficient decomposition of the spread in climate projections found across model simulations, without the need of predefining predictors (both an advantage and inconvenience), but also can be applied to more than one target variable at a time.

We present findings from various empirical clustering methods, using the three main categories of algorithm (e.g. distribution-, density-, and centroid-based) to produce our so-called empirical storylines. We focus on the Arctic region during the boreal summer season, comparing storylines obtained from each clustering method with findings from a set of “classic” storylines obtained using the MLR framework. We discuss the implications of our results for improving our understanding of the spread in climate projections, and conclude on the existence of a most likely cluster (storyline) by relating our climate change clusters with clusters for the present-day climate.