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Characterizing and detecting climate signals in observations and models using statistical learning

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Internal atmospheric variability fundamentally limits short- and medium-term climate predictability and obscures evidence of climatic changes on regional scales. We discuss the suitability of incorporating statistical learning techniques to detect global climate signals from spatial patterns.

Our detection approach uses climate model simulations and a statistical learning algorithm to encapsulate the relationship between spatial patterns of daily temperature and humidity, and key climate change metrics such as annual global mean temperature or Earth's energy imbalance. Observations are then projected onto this relationship to detect climatic changes. We show that fingerprints of changes in climate can be assessed and detected in the observed global climate record at time steps such as months or days by comparison against a historical baseline from CMIP5 simulations or reanalyses. Detection can be achieved also when ignoring the long-term global mean warming trend.

We further discuss how these approaches could be extended by using statistical techniques that would work well under variations of specific external forcings, e.g. solar or volcanic forcing, to predict only variations in a specific external forcing. Overall, we conclude that statistical learning techniques that characterize multivariate signals from high-dimensional climate data are a useful tool for the detection of climate signals at regional and global scales.