ANALYSIS AND SIMULATION OF EXTREME EVENTS AND RARE TRANSITIONS IN THE CLIMATE SYSTEM

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Extremes and rare events like heat waves, floods or wind storms, as well as abrupt transitions associated with tipping elements, can have severe impacts on human societies and ecosystems. Studying these events on a robust statistical basis is challenging, as only few events are available in observational data, and running numerical climate models for long enough to sample a sufficient number of events is often computationally prohibitive. Here we will discuss two approaches that can help to partially overcome these issues. On one side, Extreme Value theory provides limit distributions for block maxima or exceedances of a quantity, that can be used to extrapolate the statistics of observed extreme events to unobserved values. This approach has a long history in hydrology and climate science, and is routinely used for risk assessment and climate change attribution. Another possible approach is given by rare event algorithms, numerical tools designed to reduce the computational effort required to sample rare events in numerical models. These methods typically take the form of genetic algorithms, where a set of suppression and cloning rules are applied to the members of an ensemble simulation, in order to oversample trajectories leading to the events of interest. We will present recent applications of these methods to the simulation of heat waves, extremes of Arctic sea ice reduction, and abrupt transitions associated to the weakening and collapse of the Atlantic Meridional Overturning Circulation. Finally we discuss how these results open the way to further applications to a wide range of problems.