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Generating extreme weather event sets from very large ensembles of regional climate models

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Extreme events can have large impacts on societies and are therefore being increasingly studied. In particular, climate change is expected to impact the frequency and intensity of these events. However, a major limitation when investigating extreme weather events is that, by definition, only few events are present in observations. A way to overcome this issue it to use large ensembles of model simulations.

Using the volunteer distributed computing (VDC) infrastructure of weather@home [1], we run a very large number (10'000s) of RCM simulations over the European domain at a resolution of 25km, with an improved land-surface scheme, nested within a free-running GCM. Using VDC allows many thousands of climate model runs to be computed. Using observations for the GCM boundary forcings we can run historical "hindcast" simulations over the past 100 to 150 years. This allows us, due to the chaotic variability of the atmosphere, to ascertain how likely an extreme event was, given the boundary forcings, and to derive synthetic event sets. The events in these sets did not actually occur in the observed record but could have occurred given the boundary forcings, with an associated probability. The event sets contain time-series of fields of meteorological variables that allow impact modellers to assess the loss the event would incur.

Projections of events into the future are achieved by modelling projections of the sea-surface temperature (SST) and sea-ice boundary forcings, by combining the variability of the SST in the observed record with a range of warming signals derived from the varying responses of SSTs in the CMIP5 ensemble to elevated greenhouse gas (GHG) emissions in three RCP scenarios. Simulating the future with a range of SST responses, as well as a range of RCP scenarios, allows us to assess the uncertainty in the response to elevated GHG emissions that occurs in the CMIP5 ensemble.

Numerous extreme weather events can be studied. Firstly, we analyse droughts in Europe with a focus on the UK in the context of the project MaRIUS (Managing the Risks, Impacts and Uncertainties of droughts and water Scarcity). We analyse the characteristics of the simulated droughts, the underlying physical mechanisms, and assess droughts observed in the recent past.
Secondly, we analyse windstorms by applying an objective storm-identification and tracking algorithm to the ensemble output, isolating those storms that cause high loss and building a probabilistic storm catalogue, which can be used by impact modellers, insurance loss modellers, etc.
Finally, we combine the model output with a heat-stress index to determine the detrimental effect on health of heat waves in Europe.

[1] Massey, N. et al., 2014, Q. J. R. Meteorol. Soc.