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Extreme cold years in Europe generated by internal climate variability in Earth System Model simulations over the past millennium

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The year 1740 entered Western European history as the 'Year of the Slaughter' [1]. In that year, about one third of the Irish population died. Extreme cold temperatures, particularly in the winter 1739/40 but also in summer, were the norm in the British Isles, the Netherlands and Northern Europe, as recorded in early instrumental records from these areas. The sudden drop in annual mean temperature was about 3K, which 'virtually' shifted the British Isles into a Scandinavian climate. Other winters, or summers, in isolation had been colder than in 1740, but the persistence of cold temperatures through the year 1740 was unparalleled in the long instrumental records in this region.

The reasons for this extreme year are still unknown. No large volcanic eruptions occurred in the previous years - only a minor one in Japan- and the ^{10}Be record does not show unusually low levels of solar activity. The reasons were likely internal unforced climate variations.

In this contribution we analyze several paleo climate transient and control simulations with Earth System Models participating in the CMIP5 project to evaluate whether climate models are able to produce this type of climatological extreme events and with which probability. These temperature drops in this particular region tend to occur in the simulations once every thousand years. The simulations thus provide a data set to explore what are the internal mechanisms that may be responsible, to investigate if all extremes are caused by the roughly the same mechanisms, and to ascertain whether volcanic eruptions also trigger similar mechanisms.

This preliminary analysis indicates that anomalies in the atmospheric circulation - in winter a very negative NAO with strong meridional temperature advection, and in summer also very marked anomalous circulation patterns that affect surface solar radiation - are likely involved in the generation of this non-volcanic extremes. These anomalies also persist for longer than one year. In the observations, the cold 1739/40 winter recurred in the 1740/1741 winter. In the simulations, the winter in the year following the maximum cold is also extreme cold.

Somewhat intriguingly, there is no clear signal in the simulations of large-scale anomalous sea-surface-temperatures in the North Atlantic in areas not abutting Western Europe, so that the memory for the year-long anomalous atmospheric circulation either lies in other climate subsystem, or these type of extremes are caused by a random, physically unrelated, succession of anomalous atmospheric circulation patterns for several seasons in a row.

Extreme cold years following volcanic eruptions tend to follow a different spatio-seasonal pattern in Europe. For instance, whereas the atmospheric circulation anomalies in summer tend to be weak after volcanic eruptions, they are very marked during '1740' type extreme years.

[1] Jones P.D. and Briffa K.R. (2006) Unusual climate in north western Europe during he period 1730 to 1745 based on instrumental data and documentary data. Climate Change 79, 361-379, doi:10.1007/s10584-006-9078-6