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(In)Consistent estimates of changes in relative precipitation in an European domain over the last 350 years

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How did regional precipitation change in past centuries? We have potentially three sources of information to answer this question: There are, especially for Europe, a number of long records of local station precipitation; documentary records and natural archives of past environmental variability serve as proxy records for empirical reconstructions; in addition, simulations with coupled climate models or Earth System Models provide estimates on the spatial structure of precipitation variability. However, instrumental records rarely extend back to the 18th century, reconstructions include large uncertainties, and simulation skill is often still unsatisfactory for precipitation. Thus, we can only seek to answer to which extent the three sources provide a consistent picture of past regional precipitation changes.

This presentation describes the (lack of) consistency in describing changes of the distributional properties of seasonal precipitation between the different data sources. We concentrate on England and Wales since there are two recent reconstructions and a long observation based record available for this domain. The season of interest is an extended spring (March, April, May, June, July, MAMJJ) over the past 350 years. The main simulated data stem from a regional simulation for the European domain with CCLM driven at its lateral boundaries with conditions provided by a MPI-ESM COSMOS simulation for the last millennium using a high-amplitude solar forcing. A number of simulations for the past 1000 years from the Paleoclimate Modelling Intercomparison Project Phase III provide additional information. We fit a Weibull distribution to the available data sets following the approach for calculating standardized precipitation indices. We do so over 51 year moving windows to assess the consistency of changes in the distributional properties.

Changes in the percentiles for severe (and extreme) dry or wet conditions and in the Weibull standard deviations of precipitation estimates are generally not consistent among the different data sets. Only few common signals are evident. Even the relatively strong exogenous forcing history of the late 18th and early 19th century appears to have only small effects on the precipitation distributions. The reconstructions differ systematically from the long instrumental data in displaying much stronger variability compared to the observations over their common period. Distributional properties for both data sets show to some extent opposite evolutions. The reconstructions do not reliably represent the distributions in specific periods but rather reflect low-frequency changes in the mean plus a certain amount of noise. Moreover, also multi-model simulations do not agree on the changes over this period. The lack of consistent simulated relations under purely naturally forced and internal variability on multi-decadal time-scales therefore questions our ability to conclude on dynamical inferences about regional climate variability in the PMIP3 ensemble and, in turn, in climate simulations in general. The potentially opposite evolution of reconstructions and instrumental data for the chosen domain further hampers reconciling available information about past regional precipitation variability in England and Wales. However, we find some possibly surprising but encouraging agreement between the observed data and the regional simulation.