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Long-term changes and spatio-temporal variability of the growing season temperature in Europe during the last Millennium

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A gridded reconstruction of April to September temperature was produced for Europe based on tree-rings, documentaries, pollen and ice cores. The majority of the proxy series have an annual resolution. For a better inference of long-term climate variations, they were completed by number of low resolution data (decadal or more), mostly on pollen and ice-core data. An original spectral analogue method was devised to deal with this heterogeneous dataset, and especially to preserve the long-term variations and the variability of the temperature series. It is the condition is to make pertinent the comparison of the recent climate changes to a broader context of 1400 years. The reconstruction of the April-September temperature was validated with a Jack-knife technique, and it was also compared with other spatially gridded temperature reconstructions, literature data, and glacier advance and retreat curves. We also attempted to relate the spatial distribution of European temperature anomalies to known solar and volcanic forcings.

We found that (1) our results are sound back to A.D. 750; (2) conditions during the last decade have exceeded all those known during the last millennium; (3) before the 20th century, cold periods can partly be explained by low solar activity and/or high volcanic activity and that Medieval Warm Period (MWP) is consistent with a high solar activity; (4) during the 20th century, however only anthropogenic forcing can explain the exceptionally high temperature rise; (5) based on an analysis of the distribution of extreme temperatures, the maximum event of the Medieval Period (1.1°C higher than the 1960-1990 reference period) had a return period of more than 1000 years, but this recently fell to less than 26 years; (6) all decades before AD 1350 were warm on average but relatively heterogeneous, while the last decade was homogeneously warmer.

These results support the fact that we are facing an unprecedented changing climate in Europe unlike any known in the last 1000 years, as pointed out previously. The new result is that this anthropogenic change is characterised by spatial homogeneity and changes as well in average temperatures than in distribution of extreme events, while natural climate forcings induce warm periods with heterogeneous spatial patterns and less frequent extreme events. This study demonstrates that recent changes in temperature differ substantially from temperature changes reconstructed in the past and are well in excess of normal variations experienced in previous centuries and caused by natural forcings.