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Origins of seasonally-variable temperature changes in Europe over the past millennia

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European surface air temperatures have risen sharply during the late twentieth century, with a larger response in winter compared to summer. In order to put the recent strong temperature increase in a longer-term perspective, we analyse here the causes of European seasonal temperature changes during the past millennia in Europe using the three-dimensional climate model ECBILT-CLIO-VECODE. We find that external forcing changes favour temperatures reaching their highest levels during the late twentieth century, in agreement with empirical temperature estimates covering the last five centuries1. However, for the summer, the model indicates that European temperatures roughly a millennium ago may have been similarly high. For this season, the cooling associated with man-made changes in land use over the last 1000 years has the same magnitude as the net anthropogenic warming due to the combined increase in greenhouse gas concentration and in sulphate aerosols during the last 200 years. Those changes over the past millennium lead to a decrease in the difference between summer and winter temperatures at European scale. This is the prolongation of a longer term trend due to orbital forcing that will likely continue at least until the mid twenty-first century, mainly due to anthropogenic forcing.