THE INFLUENCE OF ATMOSPHERIC CIRCULATION ON THE MID-HOLOCENE (6000 yrs. BP) CLIMATE OF EUROPE

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Introduction

Climate models are essential tools to predict future climate, but their predictions remain uncertain. We can reduce these uncertainties by testing models against known past climates that differed substantially from the present day, such us the warmer climate of the mid-Holocene (6000 yrs. BP).

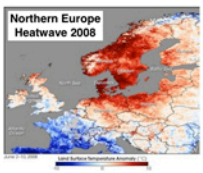
This mid-Holocene warming is thought to have been caused by increased summer insolation as a result of periodic changes in the Earths orbit. However, climate reconstructions do not support this simple explanation, showing warmer winters and cooler summers than expected.

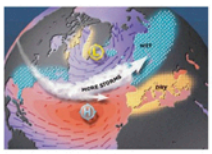
To find a possible explanation for this mismatch we compared a climate model simulation ('**Model**') against pollen-based reconstructed climate ('**Data**') and indices of **atmospheric circulation**.

Atmospheric circulation

North Atlantic Oscillation (NAO)

During **winters** with positive phases of NAO (NAO+) storm tracks are shifted northwards causing warmer Central and Northern Europe and cooler Southern Europe





Scandinavian Pattern (SCAND)

During **summers** with positive phases of SCAND (SCAND+) a high-pressure system is present over Eurasia, causing stable warmer conditions over Scandinavia, similarly to what occurred during the summer heat wave of 2008.

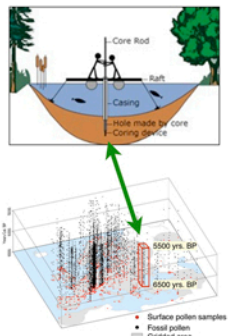
Methods

Reconstructed climate

The pollen preserved in lakes and bogs provides information concerning past vegetation and climate.

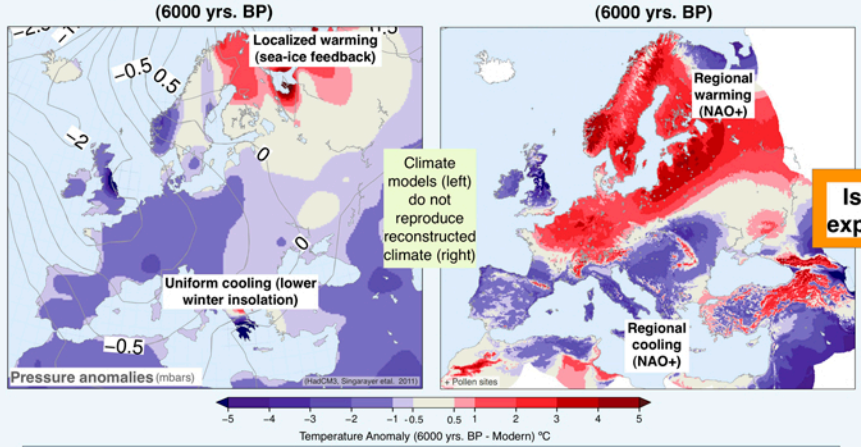
By compiling pollen data throughout the entire Europe, we developed a pollen database with a high data density that allows us to reliably interpolate climate on a large scale.

In doing so, we used a 4D interpolation method that takes into account latitude, longitude, elevation as well as time.



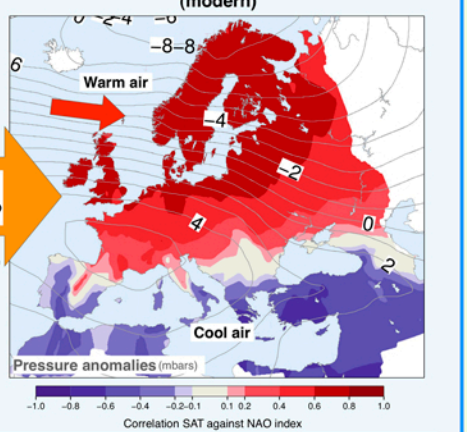
Model - Data comparison

Winter



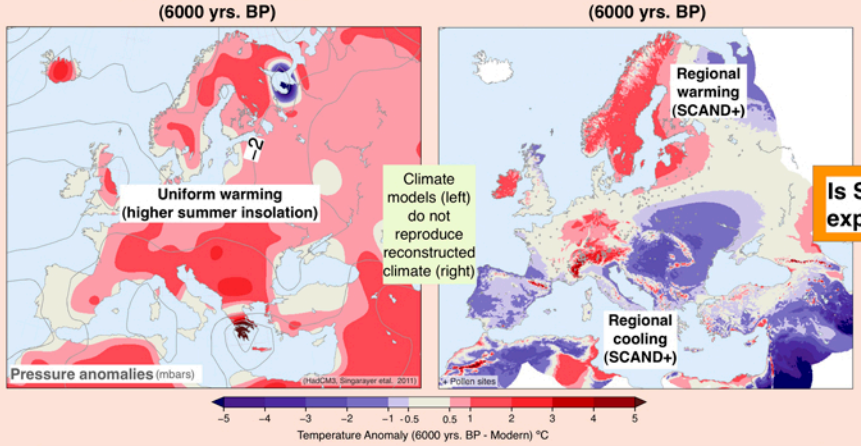
Models show a uniform cooling all over Europe as a response to lower winter insolation forcing. Exception is made for high latitudes where a localized warming is shown due to sea-ice feedback. Contrastingly **data** show a situation typical of NAO+ with a strong warming over Central and Northern Europe and cooling in Southern Europe.

Is NAO an explanation?



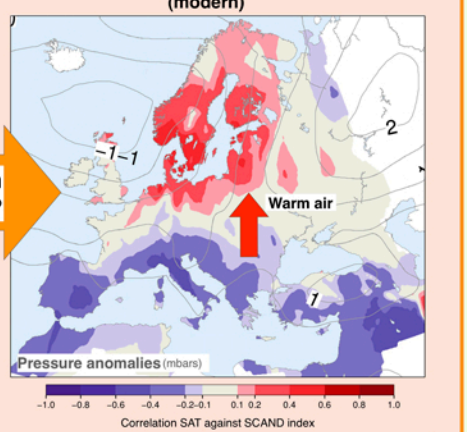
Correlation between winter temperature and NAO+ shows warm air over Central and Northern Europe while Southern Europe is cooler.

Summer



Models show a uniform warming all over Europe as a response to higher summer insolation forcing, while **data** show warmer Scandinavia and cooler Southern Europe similarly to positive phases of SCAND.

Is SCAND an explanation?



Correlation between summer temperature and SCAND+ shows warming over Scandinavia due to advected air from Southern Europe.

Conclusions

In contrast with climate models, reconstructed climate show a complex temperature pattern for both summer and winter. This is best explained by changes in atmospheric circulation similar to the ones occurring during positive phases of NAO and SCAND, rather than insolation forcing alone.

This suggests that changes in atmospheric circulation are underrepresented by climate models during the mid-Holocene (6000 yrs. BP) and therefore maybe underestimated in projections of future climate change. This could have significant implications for understanding regional climate change.

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Acknowledgments
The ARVE group is supported by grants from the Swiss National Science Foundation (PP0022_119049) and the Italian Ministry for Research and Education (FIRB RBIDO8LNFJ) for the research project CASTANEA