Reconstructing socially relevant Holocene climate using proxy records and a climate model

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Abstract

A reliable representation of the sea surface temperatures (SST) is essential for realistic simulations of past climates, whereas for past societies, the land climate was most important. We reconstruct SST such that a climate model reflects land climate and its variability as apparent in terrestrial proxies. To provide a climate simulation which is relevant for past societies, three steps (i-iii) are carried out.
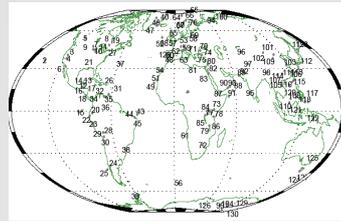
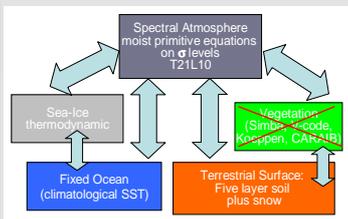## Model and data

Climate Model Planet Simulator

- transient simulation 11-0 kyr BP
- prescribed orbital (Milankovitch) and GHG forcing (from Taylor Dome) on an annual basis

Data

- focus on European land proxies
- based on $\delta^{18}O$

Locations of the proxies in our data base. All time series span at least 4000 yr, most have a resolution of 200 yr or shorter.

(i) Determination of sensitivities of terrestrial PlaSim climate with respect to SST anomalies

- Assigning a proxy region where proxies are available and represent reasonable information about the climate during a certain time period
- Determine an oceanic source region which shows the most relevant impact on the specific proxy region
- Coefficient λ defined as the sensitivity of the model climate ΔT in the proxy region to a change of SST in the source region

$$\Delta SST \xrightarrow{\lambda} \Delta\langle T\rangle$$
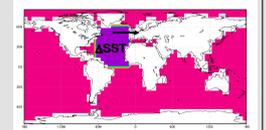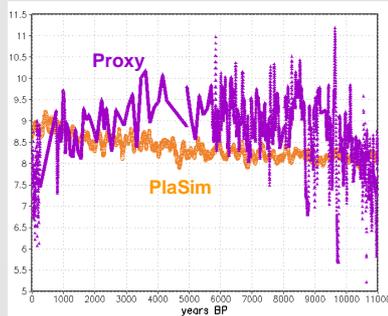

(ii) Definition of the inverse of these sensitivities to find the SST necessary for representing the land proxy climate

$$\Delta T = \lambda\, \Delta SST \iff$$ λ^{-1} **used for readjusting the SST in the source region**

⇨ **Seasonally different thermal reaction of the ocean requires seasonal different sensitivities**

## Annual mean surface temperature, 11–0 kyr BP, transient

- Selected proxy: Ammersee in southern Germany, 11 E, 47 N
- Proxy shows assumed trend with early Holocene cooling and mid-Holocene warming
- Only small differences between proxy and PlaSim
- PlaSim generally colder but…
- …less variability in PlaSim

(iii) Reapplication of PlaSim to reconstructed SST

Proxy
PlaSim original
Reconstructed, NH Atlantic
Reconstructed globally
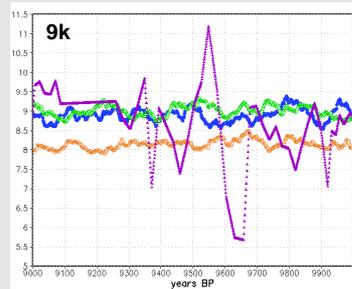
9k:
- PlaSim original colder than proxy
  - Δ T 9k: -0,52 °C
- Simulated warming due to reconstruction
  - Δ T region: -0,05 °C, Δ T glob: 0,35 °C
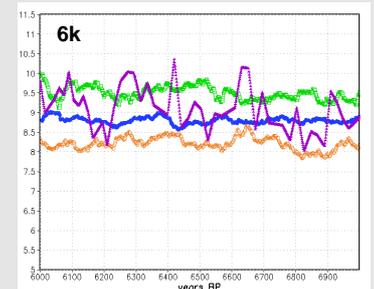
6k:
- PlaSim original colder than proxy
  - Δ T 6k: -0,87 °C
- Simulated warming due to reconstruction
  - Δ T region: -0,28 °C, Δ T glob: 0,42 °C
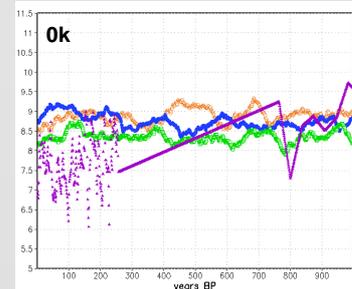
0k:
- PlaSim original warmer than proxy
  - Δ T 0k: 0,62 °C
- Simulated cooling due to reconstruction
 - Δ T region: 0,49 °C, Δ T glob: 0,07 °C

Conclusions, items to discuss and outlook

- Reconstruction method works, as model and proxy time series are converging
- Global reconstruction induces larger changes, but…
- …further analysis of the signal of regional/global reconstruction is necessary to state whether one reconstruction leads to better results than the other; variability analysis
- Aggregation of several proxies (currently one), incorporation of SST-proxies
- Choice of time period for adjusting SST (currently 1000 yr), potential modifications with regard to transient simulation with reconstructed SST
- Due to the existing link between climate and preindustrial cultures, a transient climate will improve the realism of simulated cultural changes.
- ➡ **Overall aim: Transient, full Holocene, socially relevant climate simulation for an advanced discussion of integrated prehistory of people on Earth**

Socio-technological relevance: timing of farming

Earliest farming prediction by GLUES based on Plasim — Calendar year
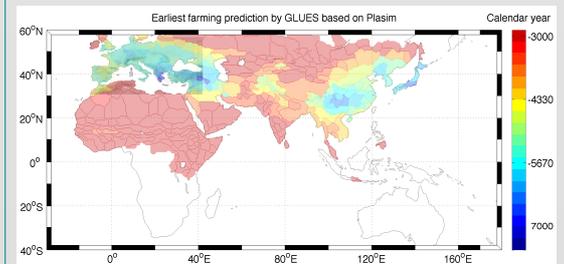
- GLUES: Global Land Use and Technological Evolution Simulator
- Cultural evolution (timing of farming) within climate context
- Climate-derived potential vegetation good predictor for the global pattern of the onset of farming

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