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Evolution of the Seasonal Temperature Cycle in a Transient Holocene Simulation: Orbital Forcing and Sea Ice

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Changes in the Earth's orbit lead to changes in the seasonal and meridional distribution of insolation. We quantify the influence of orbitally induced changes on the seasonal temperature cycle in a transient simulation of the last 6,000 years - from the mid-Holocene to today - using a coupled atmosphere-ocean general circulation model (ECHAM5/MPI-OM) including a land surface model (JSBACH).

The seasonal temperature cycle responds directly to the insolation changes almost everywhere. In the Northern Hemisphere, its amplitude decreases according to an increase in winter insolation and a decrease in summer insolation. In the Southern Hemisphere, the opposite is true.

Over the Arctic Ocean, however, decreasing summer insolation leads to an increase of sea-ice cover. The insulating effect of sea ice between the ocean and the atmosphere favors more continental conditions over the Arctic Ocean in winter, resulting in strongly decreasing temperatures. Consequently, there are two competing effects: the direct response to insolation changes and a sea-ice dynamics feedback. The sea-ice feedback is stronger, and thus an increase in the amplitude of the seasonal cycle over the Arctic Ocean occurs. This increase is strongest over the Barents Shelf and influences the temperature response over northern Europe.

We compare our modeled seasonal temperatures over Europe to paleo reconstructions. We find better agreements in winter temperatures than in summer temperatures and better agreements in northern Europe than in southern Europe, since the model does not reproduce the southern European Holocene summer cooling inferred from the paleo data. The temperature reconstructions for northern Europe support the notion of the influence of the sea-ice effect on the evolution of the seasonal temperature cycle.