Geophysical Research Abstracts
Vol. 15, EGU2013-11026-3, 2013
EGU General Assembly 2013
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Temperature trends during the Present and Last interglacial periods - A multi-model-data comparison

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We present the first multi-model-data comparison of transient millennial-scale temperature changes through the Present and Last interglacial periods (PIG and LIG respectively). Though primarily driven by insolation changes associated with well-known variations in Earth's orbital parameters, the response of the climate system includes a diversity of feedbacks involving the atmosphere, ocean, sea ice, vegetation and land ice. A thorough multi-model-data comparison is essential to assess the ability of climate models to resolve interglacial climate trends and to help in understanding the recorded climatic signal and the underlying climate dynamics.

During the last decade, substantial progress has been made by documenting past climate variability from new archives with improved chronologies for the PIG and LIG periods. In parallel, the increased computing capacities as well as the development of computationally efficient climate models have enabled transient multi-millennial climate simulations. This allows us to compare PIG and LIG multi-millennial temperature trends derived from transient climate experiments (9 different climate models) with alkenone-based temperature reconstructions (117 locations globally distributed; about 45% of them with the LIG interval) and ice-core-based temperature profiles from Greenland and Antarctica (12 sites; 6 include the LIG).

Our analysis shows that in Greenland and Antarctica the multi-model-mean temperature trends for the warmest months compare well with ice-core based temperature reconstructions. Regarding reconstructed annual mean temperatures based on alkenone-data, models and data are in reasonable agreement with some exceptions at high-latitude areas. The next step in the analysis is to assess whether the simulated warmest month temperature trends of the PIG and LIG periods are linearly scaled to the orbital forcing. In the Northern Hemisphere the models consistently show a linear response to the trends in the insolation forcing for both interglacial periods. The exceptions are the Arctic region, where the simulated trend are relatively small compared to that of the insolation signal and the Sahel and Indian regions where a negative relation is observed. For the Southern Hemisphere climate models are consistent in the simulated warmest month temperature trends but the relation with the insolation trends is more complex. We find a positive relation over South America and Africa, and a positive though strongly dampened response over the low and mid-latitude oceans of the Southern Hemisphere. However, despite the positive trend in the warmest month insolation forcing, which is especially large in the LIG period, the simulations lack any substantial temperature changes for the Southern Ocean and the Antarctic region. This suggests that, regardless of the large differences in model-complexity, the climate models consistently show that the increase in summer insolation is balanced out by a considerable growth of the Southern Ocean sea-ice cover resulting from obliquity-related changes in the seasonal distribution of insolation.