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On the comparison of high-temporal resolution data and model simulation in paleoclimate studies

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It is becoming common practice to take parallel approach of climate reconstruction and modelling in paleoclimate studies. Proxy data reveal the fact that the earth experienced in the past, provide opportunity to evaluate the model performance under a wide range of environmental conditions and are used to estimate the fundamental properties of the climate system (e.g., climate sensitivity). Modelling serves as a tool to quantitatively test the proposed hypothesis or to provide a mechanism of the reconstructed climate change. Models may also be used to suggest a location for additional proxy data to be acquired for a particular climatic event or to provide pseudo-proxy data for which statistical reconstruction techniques for limited number of samples are tested. More recently, the data assimilation techniques are applied to paleoclimate reconstruction. In all these studies, classical issues in the data-model comparison (regardless of forward or inverse modelling) are relevant, and we review and discuss them in preparing for the coming era of high-resolution proxy data.

Proxy data are often compared with model simulations along time axis. While the dating errors in the data may be more easily taken into consideration in this approach, there are many aspects that need to be concerned. It is often unclear what spatial scale that the data represent, and whether that spatial scale is resolved in the model. In addition, it is subjective to the bias in simulated spatial patterns because proxies often locate in the sensitive region to the changes in the climate pattern. More meaningful comparison would be made if spatially integrated reconstruction or the climate index constructed from multiple sites is used. It is often unclear whether the reconstructed climate variation represents internal variability inherent in the climate system or the change forced by the condition external to the climate system (e.g., volcanic eruptions). This is not independent from the spatial-scale issue as the internal variability usually predominates in smaller scales. More meaningful comparison would be made for the externally forced change that is demonstrated by the model ensemble simulation.

We highlight these issues by conceptual examples and Pacific Decadal Oscillation simulated in the last millennial simulations.

Keywords: paleoclimate modelling, last millennium, Pacific Decadal Oscillation