



## **Investigating the consistency between proxy-based reconstructions and climate models using data assimilation: a mid-Holocene case study**

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The mid-Holocene (6 kyr BP; thousand years before present) is a key period to study the consistency between model results and proxy-based reconstruction data as it corresponds to a standard test for models and a reasonable number of proxy-based records is available. Taking advantage of this relatively large amount of information, we have compared a compilation of 50 air and sea surface temperature reconstructions with the results of three simulations performed with general circulation models and one carried out with LOVECLIM, a model of intermediate complexity. The conclusions derived from this analysis confirm that models and data agree on the large-scale spatial pattern but the models underestimate the magnitude of some observed changes and that large discrepancies are observed at the local scale. To further investigate the origin of those inconsistencies, we have constrained LOVECLIM to follow the signal recorded by the proxies selected in the compilation using a data-assimilation method based on a particle filter. In one simulation, all the 50 proxy-based records are used while in the other two only the continental or oceanic proxy-based records constrain the model results. As expected, data assimilation leads to improving the consistency between model results and the reconstructions. In particular, this is achieved in a robust way in all the experiments through a strengthening of the westerlies at midlatitude that warms up northern Europe. Furthermore, the comparison of the LOVECLIM simulations with and without data assimilation has also objectively identified 16 proxy-based paleoclimate records whose reconstructed signal is either incompatible with the signal recorded by some other proxy-based records or with model physics.