

Reconstructed and simulated temperature asymmetry between continents in both hemispheres over the last centuries

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Available proxy-based temperature reconstructions covering the past millennium display contrasted evolutions between the continents. The difference is particularly large between the two hemispheres. When driven by realistic natural and anthropogenic forcings, climate models tend to simulate a more spatially homogenous temperature response. This is associated with a relatively good agreement between model results and reconstructions in the Northern Hemisphere but a low consistency in the Southern Hemisphere. Here, simulations with data assimilations are performed to analyse the causes of this apparent disagreement. It shows that, when the uncertainties are taken into account, states of the climate system compatible with the forcing estimates, the reconstructions and the model physics can be obtained over the past millennium, except for the twentieth century in Antarctica where the simulated warming is always much larger than in the reconstructions. Such states consistent with all sources of information can be achieved even if the uncertainties of the reconstructions are underestimated. Although, well within the range of the proxy-based reconstructions, the temperatures obtained after data assimilation display more similar developments between the hemispheres than in those reconstructions. Ensuring the compatibility does not require to systematically reduce the model response to the forcing or to strongly enhance the model internal variability. From those results, there is thus no reason to suspect that the model is strongly biased in one aspect or another. The constraint imposed by the data assimilation is too low to unambiguously identify the origin of each feature displayed in the reconstructions but, as expected, changes in atmospheric circulation likely played a role in many of them. Furthermore, ocean heat uptake and release as well as oceanic heat transport are key elements to understand the delayed response of the Southern Hemisphere compared to the northern one during some transitions from warmer to colder states or from colder to warmer ones. The last millennium is thus an interesting test period to better understand and quantify the associated mechanisms.