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Evidence of inter-hemispheric temperature contrasts over the last millennium from a new Southern Hemisphere multi-proxy reconstruction

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The instrumental temperature record shows distinct inter-hemispheric temperature differences superimposed on the common warming trend over the last 150 years. Asynchronicity between the hemispheres is also suggested by millennial-scale analyses over the last deglaciation and the Holocene, indicating a significant modulation of the response to external forcing by internal climate system variability on multiple temporal scales. However, on multi-decadal to centennial times-scales, quantitative analyses on inter-hemispheric temperature variability are largely missing due to the lack of hemispheric-scale high-resolution reconstructions from the Southern Hemisphere.

We introduce a new annually resolved multi-proxy ensemble reconstruction of Southern Hemisphere mean temperatures over the last 1000 years. The reconstruction is based on an unprecedented network of 325 proxy records yielding 111 temperature sensitive predictors.

In 99.7% of the reconstruction ensemble members, the warmest decade of the last millennium occurs after 1970. Comparing our results with an ensemble of Northern Hemisphere mean reconstructions, we identify periods, where both hemispheres simultaneously exhibit extreme temperatures (defined as exceeding ± 1 standard deviations of 1000-2000 temperatures). The only pre-industrial period where >33% of ensemble members indicate globally synchronous extremes is the cold phase between 1594 and 1677. Simultaneous warm temperatures are only identified in the years after 1974 (1979) where more than 66% (90%) of ensemble members indicate extreme warmth. This suggests existence of a globally coherent peak “Little Ice Age”, but no consistent “Medieval Climate Anomaly” during last 1000 years.

We then compare our ensemble of temperature reconstructions to an ensemble of 24 climate model simulations. While the simulated globally consistent cold periods coincide with major volcanic eruptions, the simulations do not account for key features of reconstructed temperature variations over the last millennium.

Calculation of the reconstructed inter-hemispheric temperature difference (Northern Hemisphere minus Southern Hemisphere; NS) shows that large fluctuations, such as the Northern Hemisphere temperature drop around 1970, occurred repeatedly over the last millennium. In contrast, the model simulations show much smaller inter-hemispheric temperature differences: during 42% of the years within the past millennium, median reconstructed NS differences are outside the 10th-90th percentile range of the climate model simulations.

The over-estimated coherence between the hemispheres in the simulations suggests a strong role of internal climate system variability relative to external forcing. This holds particularly true for the Southern Hemisphere, which shows reduced correlations between reconstructed and simulated temperatures (r=0.35) compared to the NH (r=0.77). Our results imply that climate sensitivity and detection and attribution studies, which are based on data from the Northern Hemisphere alone, may not be representative for the global climate. We conclude that multi-decadal predictability of the climate system on regional to global scales may be more limited than previously estimated.