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Last Millennium atmosphere and soil temperature coupling in surrogate climates: implications for borehole temperature reconstructions

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The last millennium climate has experienced important variability at different timescales going from a relatively warmer period at the beginning of the last millennium (MCA; Medieval Climate Anomaly) to a colder period after the 15th century (LIA; Little Ice Age) that is interrupted by industrial warming in the 19th century. These past climate variations are known both from reconstruction methods that use proxy data as predictors and from simulations with climate models. Borehole reconstruction is a well established method to reconstruct past surface air temperature (SAT) based on the assumption that SAT changes are coupled to ground surface temperature (GST) changes and transferred to the subsurface by thermal conduction. However, some physical processes can impact this hypothesis since they decouple SAT and GST. Therefore borehole temperature reconstructions might be affected by such type of processes. Herein, the influence of these processes on SAT-GST coupling at long-time scales is specifically assessed in pseudo proxy experiments.

First, we have assessed the most important processes that corrupt the coupling between SAT and GST at local, regional and large to global scales in a set of simulations with the Community Earth System Model Last Millennium Experiment (CESM-LME) considering both full forcing and individual external forcing simulations. Once the most relevant mechanisms that have an impact on the coupling are understood, the influence of different forcings on SAT and GST coupling is analyzed; in particular that of land use land cover (LULC) and aerosols. The relationship between SAT and GST is analyzed on both the influence on the covariance structure within the last millennium and on the trend changes during the industrial period.

The results indicate that although some processes do have an impact on the SAT and GST coupling, they are important mainly at local and regional scales. Consequently, they do not affect significantly the global long-term coupling supporting the reliability of the borehole reconstruction technique in retrieving the low frequency past surface temperature variations.