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Impacts of long-term land use land cover changes on borehole temperature reconstructions

Camilo Melo Aguilar (1), Fidel González Rouco (1,2), Elena Gracía Bustamante (1,3), Jorge Navarro Montesinos (3), and Norman Steinert (1)

(1) Universidad Complutense de Madrid, Dpto Física de la Tierra, Astronomía y Astrofísica, Madrid, Spain (camelo@ucm.es), (2) Instituto de Geociencias (IGEO; UCM-CSIC), Universidad Complutense de Madrid, (3) Centro de Investigaciones Energéticas Medioambientales Tecnológicas -CIEMAT-, Madrid, Spain

The analysis of subsurface temperature measurements from boreholes is a well established approach for reconstructing last millennium (LM) surface air temperature (SAT). It is based on the assumption that SAT variations are strongly coupled to ground surface temperature (GST) variations and transferred to the subsurface by thermal conduction. However, several surface processes can distort the long-term SAT-GST coupling with implications for the interpretation of past SAT variations from borehole temperature measurements.

This work assesses the potential effects of land use land cover forcing changes (LULC) on SAT reconstructions based on borehole temperature measurements at different spatial scales. We follow a pseudo-proxy approach that makes use of the Community Earth System Model-Last Millennium Ensemble (CESM-LME), the largest ensemble of LM simulations with a single model to date. First, a heat-conduction forward model has been used to estimate subsurface temperature perturbation profiles using simulated GST as boundary conditions. Subsequently, an inversion approach has been applied to reconstruct LM GST variations from the simulated profiles. Finally, we test the reliability of the reconstructed GST for recovering the simulated LM SAT. To evaluate the implications for the existing distribution of borehole data, a configuration mimicking real world conditions has been considered, including the actual sites of the global borehole network as well as the date and depth of the measurements.

Results show relatively small changes at the global scales. Nevertheless, for areas where LULC has experienced important changes, the long-term SAT-GST coupling is impacted and subsurface temperature profiles are not representing well past SAT variations. This analysis may be relevant to infer the order of magnitude induced by the LULC biases and the areas that are not recommendable for experimental use.