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Repeat Temperature Measurements in Boreholes may Quantify Climate Forcing

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Repeat temperature vs. depth measurements acquired during a twenty-seven year period in three boreholes specifically drilled and completed for heat flow measurements provide a record of surface energy flux that may provide a measure of non-solar climate forcing. Because conductive diffusion of the surface temperature into the ground filters short-period temperature changes, using the air temperature record as forcing signal should yield computed temperature vs. depth profiles that agree with the observed profiles. The boreholes are located near the North Dakota- Manitoba border in the center of the North American continent. The terrain is flat and ground cover is grass and seasonal grain crops. The boreholes were drilled in a homogeneous shale (Pierre Shale, Cretaceous) which has a thermal conductivity of 1.2 W $m^{-1}K^{-2}$. We used time-series of surface air temperatures from an array of automated weather stations operated by the MidWest Regional Climate Center as a proxy for ground surface temperature for the twenty-seven year period during which the boreholes were logged. The initial borehole measurements (1984) were subtracted from each subsequent temperature profile (1995, 2002, 2007, 2009, 2011) for both the observations and the models to yield a record of changes. The results show close agreement between observation and models. The energy flux into the ground was determined to be approximately 40 mW m^{-2}. We then used the daily TOA solar irradiance as a forcing signal (0.3 K per W) and found that solar forcing was only a fraction of the observed change. We propose that the difference between the observed temperature flux and that calculated from solar irradiance may yield a measurement of greenhouse gas forcing.