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Deriving soil thermal properties from continuous soil profile observations in southern France

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Soil moisture is the main driver of temporal changes in values of the soil thermal conductivity. The latter is a key variable in land surface models (LSMs) used in hydrometeorology, for the simulation of the vertical profile of soil temperature, in relation to soil moisture. Shortcomings in soil thermal conductivity models tend to limit the impact of improving the simulation of soil moisture in LSMs. Models of the thermal conductivity of soils are affected by uncertainties, especially in the representation of the impact of soil properties such as the volumetric fraction of quartz (q), soil organic matter (FSOM), and gravel. As soil organic matter and gravel are often neglected in LSMs, the soil thermal conductivity models used in most LSMs represent the mineral fine earth, only. Moreover, there is no map of q and it is often assumed that this quantity is equal to the volumetric fraction of sand (Fsand). In this study, q values are derived by reverse modelling from the continuous soil moisture and soil temperature sub-hourly observations of the SMOSMANIA network at 18 grassland sites in southern France, from 2009 to 2013. The soil temperature observations are used to retrieve the soil thermal diffusivity (Dh) at a depth of 0.10 m by solving the thermal diffusion equation. The soil moisture and Dh values are then used together with the measured soil properties to retrieve effective soil thermal conductivity (L) values. For 15 sites, it is shown that q can be derived from regressed empirical equations using a linear combination of Fsand and FSOM measurements, together with porosity estimates. For three sites, very low values of q and of the L values at saturation (Lsat) are obtained, probably in relation to a high density of grass roots at these sites. The impact of neglecting gravel and organic matter on Lsat, and the impact of uncertainties on the estimation of q are assessed. It is shown that neglecting the soil organic matter has a major impact on Lsat.