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Soil moisture proxies from MODIS-derived apparent thermal inertia time series

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Topsoil water content – an important parameter for several hydrological and biological processes - can be linked to the amplitude of the diurnal temperature variation of land surfaces through the concept of thermal inertia, i.e. the resistance of the material to external temperature driving forces. Approximations of thermal inertia, called apparent thermal inertia (ATI), can be derived from consecutive night- and daytime land surface temperature (LST) measurements by spaceborne thermal infrared radiometers such as the MODIS instrument onboard the Terra and Aqua satellites. Unfortunately, the establishment of meaningful MODIS-derived ATI time series is hampered by the difference in time of observation between two consecutive days. As a result of the wide swath width of the MODIS instrument this difference can be as large as almost one hour and additional heating or cooling of the surface during this period adds noise to the ATI.
We propose a method that replaces the day-night temperature difference in the formulation of ATI by the amplitude of a simplified surface temperature curve, empirically fitted to the four daily MODIS LST observations. Temporal fluctuations in apparent thermal inertia can then be related to changes in moisture content, thus allowing the creation of a computationally simple soil moisture proxy without the need for ground reference datasets. It is investigated whether MODIS-derived apparent thermal inertia can be used as a soil moisture proxy at different scales at two sites: the first is the region of Calabria in southern Italy, the second site is located in southern Africa covering parts of South Africa, Namibia, Botswana, Zimbabwe and Mozambique. The relation between apparent thermal inertia and surface soil moisture is validated in both space and time, using ground-based volumetric soil moisture measurements and meteorological data for Calabria and the coarse resolution AMSR-E soil moisture product for southern Africa.