Geophysical Research Abstracts
Vol. 16, EGU2014-14726, 2014
EGU General Assembly 2014

A simple method for accurate reconstruction of istantaneous soil temperature profiles

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When assessing the energy and water balance of the hydrologically active soil layer, an important role is played by the stored heat and by the heat flux at the bottom boundary of the soil. Both these components are directly related to the istantaneous temperature profiles which are usually described by integrating the Fourier equation. As a boundary condition, the soil surface temperature or the temperature at a certain depth nearby the soil surface can be used. The soil temperature signals show a typical asymmetrical periodic–like pattern with a minimum in the morning and a maximum in the afternoon. These characteristics suggest to solve the Fourier equation in terms of periodic functions, which are often only roughly approximated by a single trigonometric function.

In this framework we developed a simple method, based on the assessment of the contribution of each harmonic to the solution, to estimate the Fourier coefficients of the meaningful ones, knowing at least two temperature series at different depths.

Data of soil temperature at the depth of $5,\ 10,\ 15\,\mathrm{cm}$ and soil heat flux at $7.5\,\mathrm{cm}$, collected in Summer 2012 and Summer 2013 during the CividatEX experiment (Oglio river basin, Central Italian Alps, $274\,\mathrm{m\,a.s.l.}$), were used to calibrate and test the method.

The method allowed to estimate the apparent soil thermal diffusivity and to accurately reproduce the temperature observations by means of the first three harmonics. The heat fluxes and the soil heat storage were reconstructed both on the basis of calibration of thermal conductivity and apparent soil thermal capacity, and on the basis of literature values. A sensitivity analysis of the thermal soil properties to the soil water content is provided and compared with the literature.