Geophysical Research Abstracts
Vol. 18, EGU2016-2652, 2016
EGU General Assembly 2016

Coupled Soil Water and Heat Transport Near the Land Surface in Arid and Semiarid Regions – Multi-Domain Modeling

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Understanding and simulating coupled water and heat transfer appropriately in the shallow subsurface is of vital significance for accurate prediction of soil evaporation that would improve the coupling between land surface and atmosphere, which consequently could enhance the reliability of weather as well as climate forecast. The theory of Philip and de Vries (1957), accounting for water vapor diffusion only, was considered physically incomplete and consequently extended and improved by several researchers by explicitly taking water vapor convection, dispersion or air flow into account. It is generally believed that the soil moisture is usually low in the near surface layer under highly transient field conditions, particularly in arid and semiarid regions, and that accurate characterization of water vapor transport is critical when modeling simultaneous water and heat transport in the shallow field soils. The first objective of this study is thus mainly to test existing coupled water and heat transport theories and to develop reasonable and simplified numerical models using field experimental data collected under semi-arid and arid hydro-climatic conditions. In addition, more complex multi-domain models are developed for ubiquitous heterogeneous terrestrial surfaces such as horizontal textural contrasts or structured heterogeneity including macropores (fractures, cracks, root channels, etc.). This would make coupled water and heat transfer models applicable in such non-homogeneous soils more meaningful and enhance the skill of land-atmosphere interaction models at a larger context.