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# Modelling Soil Heat and Water Flow as a Coupled Process in Land Surface Models

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To improve model estimates of soil water and heat flow by land surface models (LSMs), in particular in the first few centimetres of the near-surface soil profile, we have to consider in detail all the relevant physical processes involved (see e.g. Milly, 1982). Often, thermal and iso-thermal vapour fluxes in LSMs are neglected and the simplified Richard's equation is used as a result. Vapour transfer may affect the water fluxes and heat transfer in LSMs used for hydrometeorological and climate simulations. Processes occurring in the top 50 cm soil may be relevant for water and heat flux dynamics in the deeper layers, as well as for estimates of evapotranspiration and heterotrophic respiration, or even for climate and weather predictions.

Water vapour transfer, which was not incorporated in previous versions of the MOSES/JULES model (Joint UK Land Environment Simulator; Cox et al., 1999), has now been implemented. Furthermore, we also assessed the effect of the soil vertical resolution on the simulated soil moisture and temperature profiles and the effect of the processes occurring at the upper boundary, mainly in terms of infiltration rates and evapotranspiration. SiSPAT (Simple Soil Plant Atmosphere Transfer Model; Braud et al., 1995) was initially used to quantify the changes that we expect to find when we introduce vapour transfer in JULES, involving parameters such as thermal vapour conductivity and diffusivity. Also, this approach allows us to compare JULES to a more complete and complex numerical model.

Water vapour flux varied with soil texture, depth and soil moisture content, but overall our results suggested that water vapour fluxes change temperature gradients in the entire soil profile and introduce an overall surface cooling effect. Increasing the resolution smoothed and reduced temperature differences between liquid (L) and liquid/vapour (LV) simulations at all depths, and introduced a temperature increase over the entire soil profile. Thermal gradients rather than soil water potential gradients seem to cause temporal and spatial (vertical) soil temperature variability. We conclude that a multi-soil layer configuration may improve soil water dynamics, heat transfer and coupling of these processes, as well as evapotranspiration estimates and land surface-atmosphere coupling. However, a compromise should be reached between numerical and process-simulation aspects.

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