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Quantification of the partition between bare soil evaporation and plant transpiration using stable water isotopes

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Evapotranspiration from continental surfaces is one of the most important components of the global water cycle, but it is certainly the less known. The lack of knowledge is even larger when referring to the partition of evapotranspiration between its components: bare soil evaporation and plant transpiration. Isotopic biogeochemistry can provide useful information to progress in a better quantification of this partition. Assuming specific hypotheses of stationarity, it is possible to identify and quantify the different sources of the atmospheric water vapour (local and regional, vegetation and soil) Analysis of the heavy stable isotopic ratios of water in both the liquid and vapour phases : 18O and 2H can allow to determine the « history » of the water in the soil since the last rainfall event (infiltration, re-evaporation) or the root extraction depths. .

The presentation will provide a synthesis of the theoretical basis for the interpretation of the isotopic composition of the various reservoir water (soil, plant, atmosphere) and an illustration of recent advances obtained within the framework of the PIETE (Isotopic partition of evapotranspiration between evaporation and transpiration) project. The project combines laboratory and field experiments with a modelling work in order to progress in the understanding of the coupled water, heat and isotopic transfer within the soil vegetation atmosphere continuum. Four types of experiments were conducted : (i) Laboratory Characterization of the water vapour released during plants transpiration, focusing on transient regimes and especially water stress; (ii) laboratory characterization of the isotopic signature of the water vapour released by soil evaporation; (iii) determination of the partition between evaporation and transpiration under controlled conditions using a soil monolith which was sawn with grass.; (iv) determination of the partition of evapotranspiration under field conditions, with an experiment conducted in Lusignan (France) during the whole growing cycle of a maize field in 2004.

The experiments were complemented with a modelling of the experimental conditions using the SiSPAT_Isotope SVAT model (Braud et al., J. Hydrology, 2005) which couples water, heat and isotope transport within the soil – vegetation – atmosphere continuum. The modelling of the bare soil columns allowed some progress in the understanding of evaporation under dry conditions, and especially about the formation and evolution of the evaporation front. Isotope measures were also useful to better quantify the hydrodynamic behaviour of the soil. The modelling of the field and laboratory experiments with vegetation was more complicated and required simplifying hypotheses about isotope transport within the plants. Data and model were used to determine the conditions when these hypotheses can be considered as valid.

All the conducted experiments allowed some progress in the understanding of the partition of evapotranspiration between bare soil evaporation and plant transpiration. They open perspectives for the improvement of root extraction modules and showed that isotopic data were providing additional information for a better understanding of surface processes, but also to evaluate existing SVAT models.