Geophysical Research Abstracts
Vol. 17, EGU2015-14819, 2015
EGU General Assembly 2015

Soil, the orphan hydrological compartment: evidence from O and H stable isotopes?

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O and H stable isotopes have been successfully used for decades for studying the exchange of waters between the hydrosphere, the pedosphere and the biosphere. They greatly contribute to improve our understanding of soil-water-plant interactions. In particular, the recent hydrological concept of “two water worlds” (separation of meteoric water that infiltrates the soil as (i) mobile water, which can reach the groundwater and can enter the stream, and as (ii) tightly bound water, which is trapped in the soil microporosity and used by plants) calls for a substantial revision of our perceptual models of runoff generation. Nevertheless, there is a need for testing the applicability of this concept over a large range of ecosystemic contexts (i.e.and vegetation types).

To date, many investigations have focused on the relationship between the various processes triggering isotope fractionation within soils. So far, the dominating perception is that the isotope profile of water observed in soils is solely due to evaporative fractionation and its shape is dependent on climate and soil parameters. However, as of today the influence of biogeochemical processes on the spatio-temporal variability of δ18O and δD of the soil solutions has been rarely quantified. O and H exchanges between soil water and other soil compartments (living organisms, minerals, exchange capacity, organic matter) remain poorly known and require deeper investigations. Eventually, we need to better understand the distribution of O and H isotopes throughout the soil matrix.

In order to address these issues, we have designed and carried out two complementary isotope experiments that use one liter soil columns of a 2mm-sieved and air-dried soil. Our objectives were (1) to observe the temporal evolution of the water O and H isotopic composition starting from the field capacity to the complete drying of the soil and (2) to determine the impact of soil biogeochemical properties on the isotopic composition of different water types in soil (weakly-, moderately- and tightly-bound).

Our results show that mobile and tightly bound water may have different hydrogen isotopic signatures and that their respective isotopic signatures may vary between horizons and soil types. However, it is not yet possible to quantify the contribution of different bio-physico-chemical processes to the oxygen and hydrogen isotopic composition of the soil water because the techniques at hand for water separation are not yet reliable enough. Prior to this type of quantifications, we need to focus in a next step at the improvement of water extraction methods.