

Water sources for apple trees in Alpine orchards: where does irrigation water go?

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Pressing need to better assess **water uptake strategies by apple orchards** in dry Alpine valleys where apple cultivation is of paramount importance for the local economy.

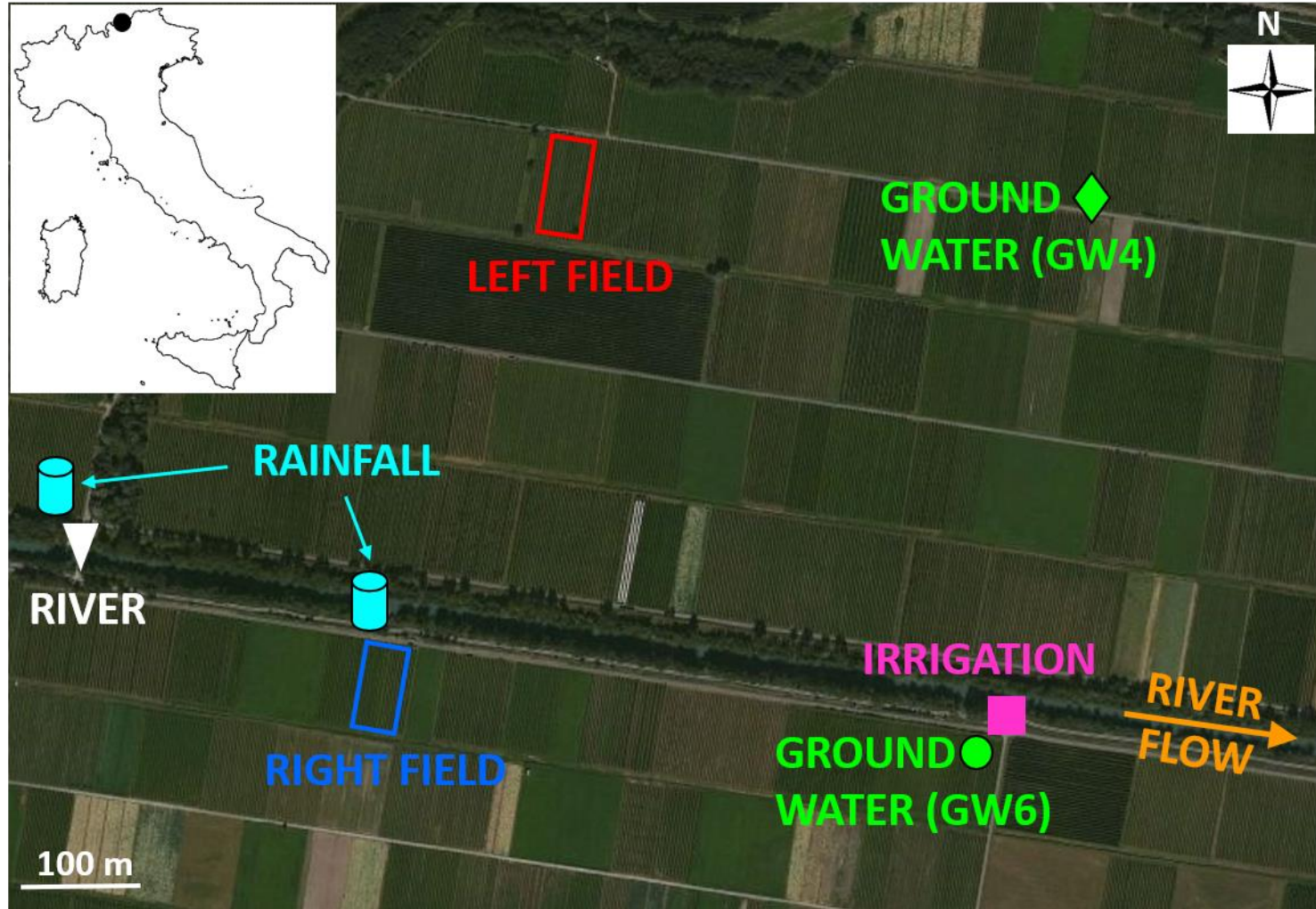
General hypothesis

Apple trees mainly use a mix of irrigation and rainwater in the soil but could also access groundwater according to the different topographical positions of the fields.

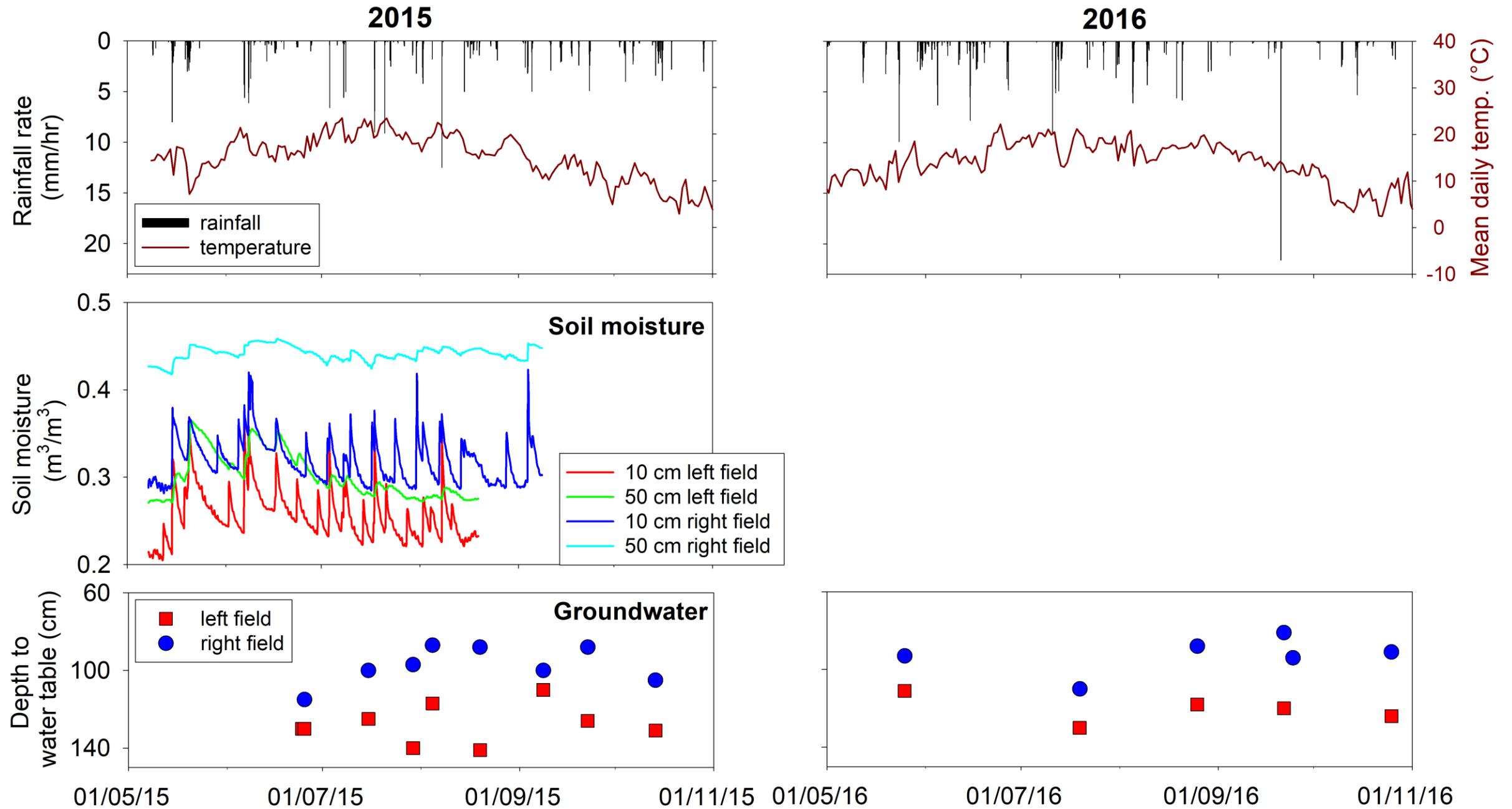
Specific questions

- 1) Which water sources do apple trees predominantly use in dry Alpine valleys?
- 2) Do trees growing at different locations in a valley bottom have access to different water sources?
- 3) Can isotopes support a conceptual model of water uptake strategies in Alpine apple orchards?

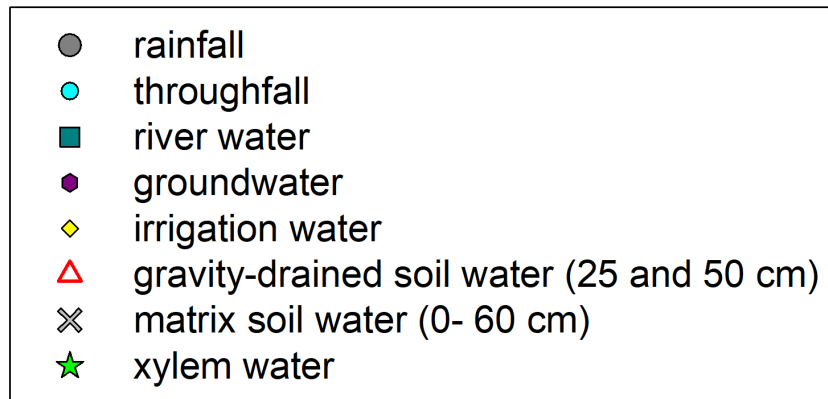
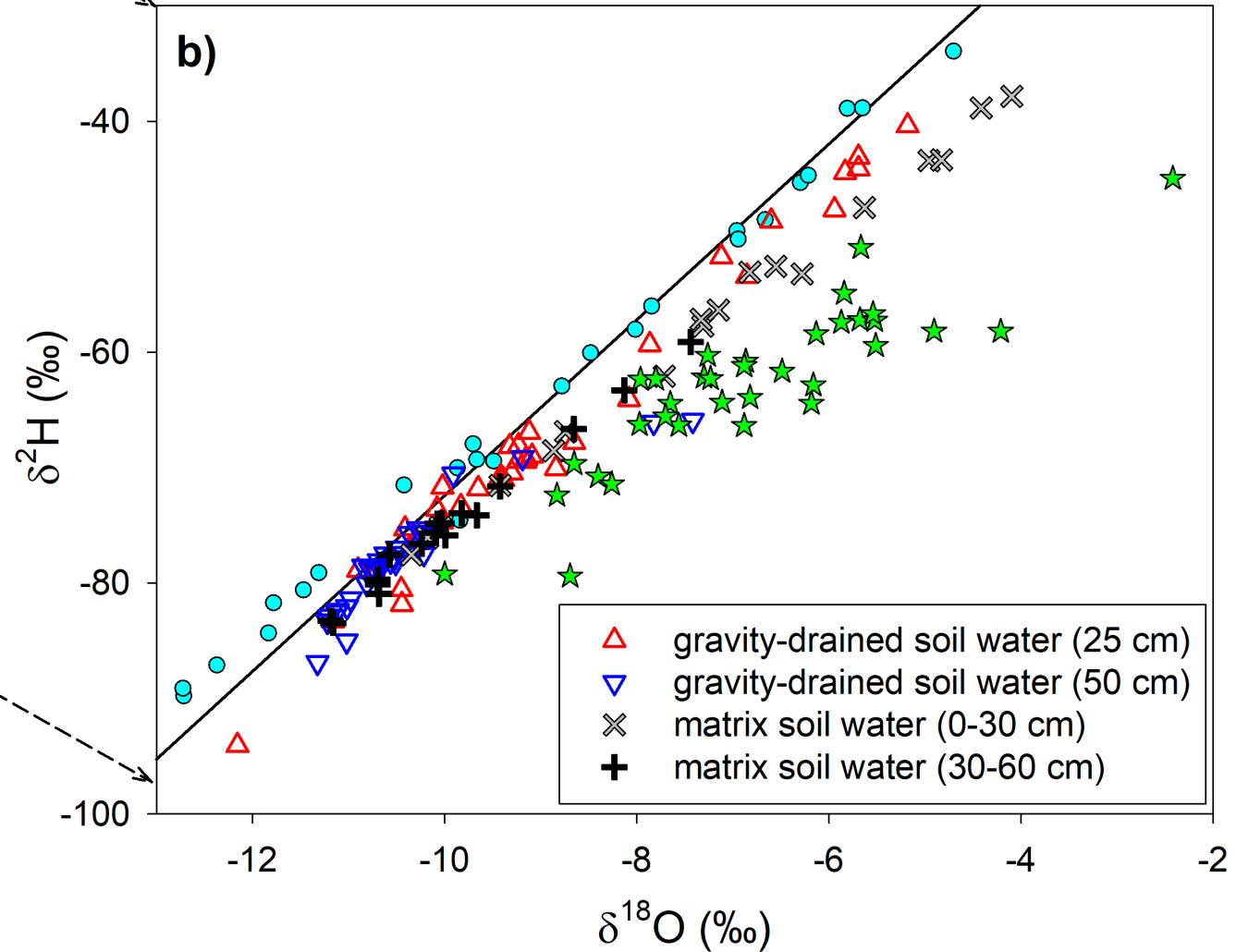
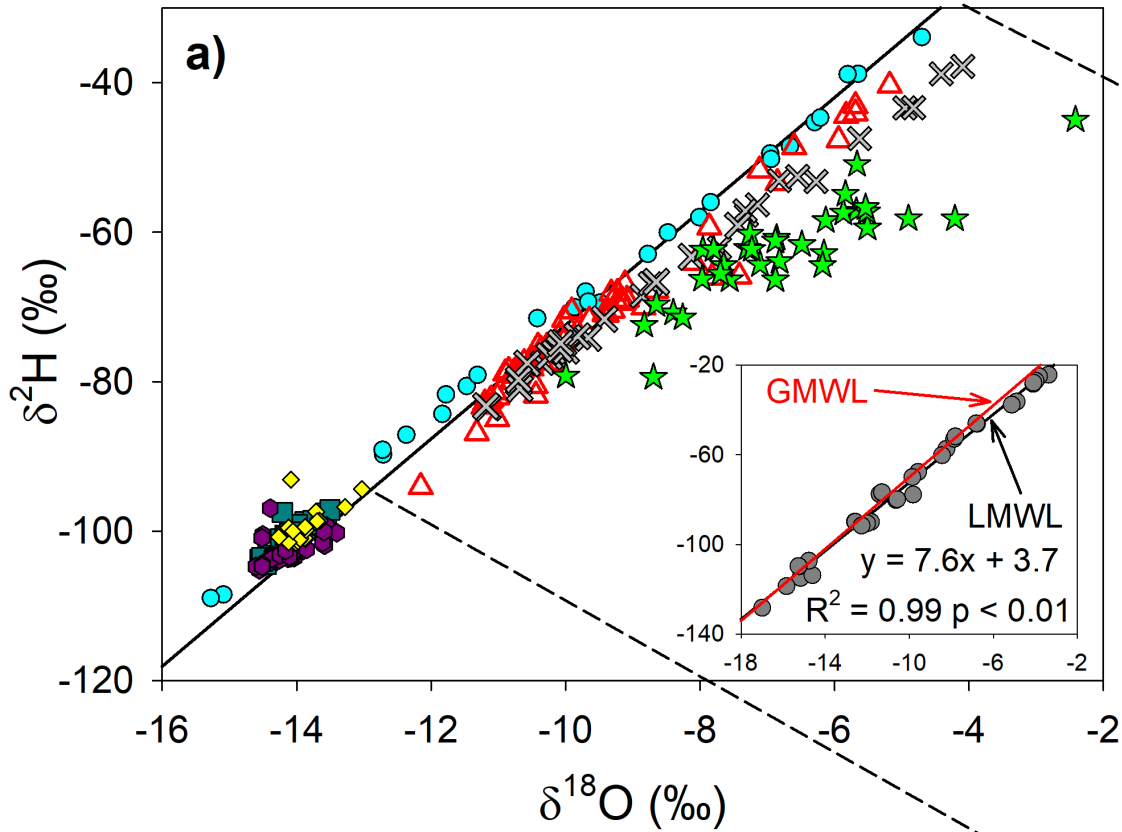
Set up and materials and methods



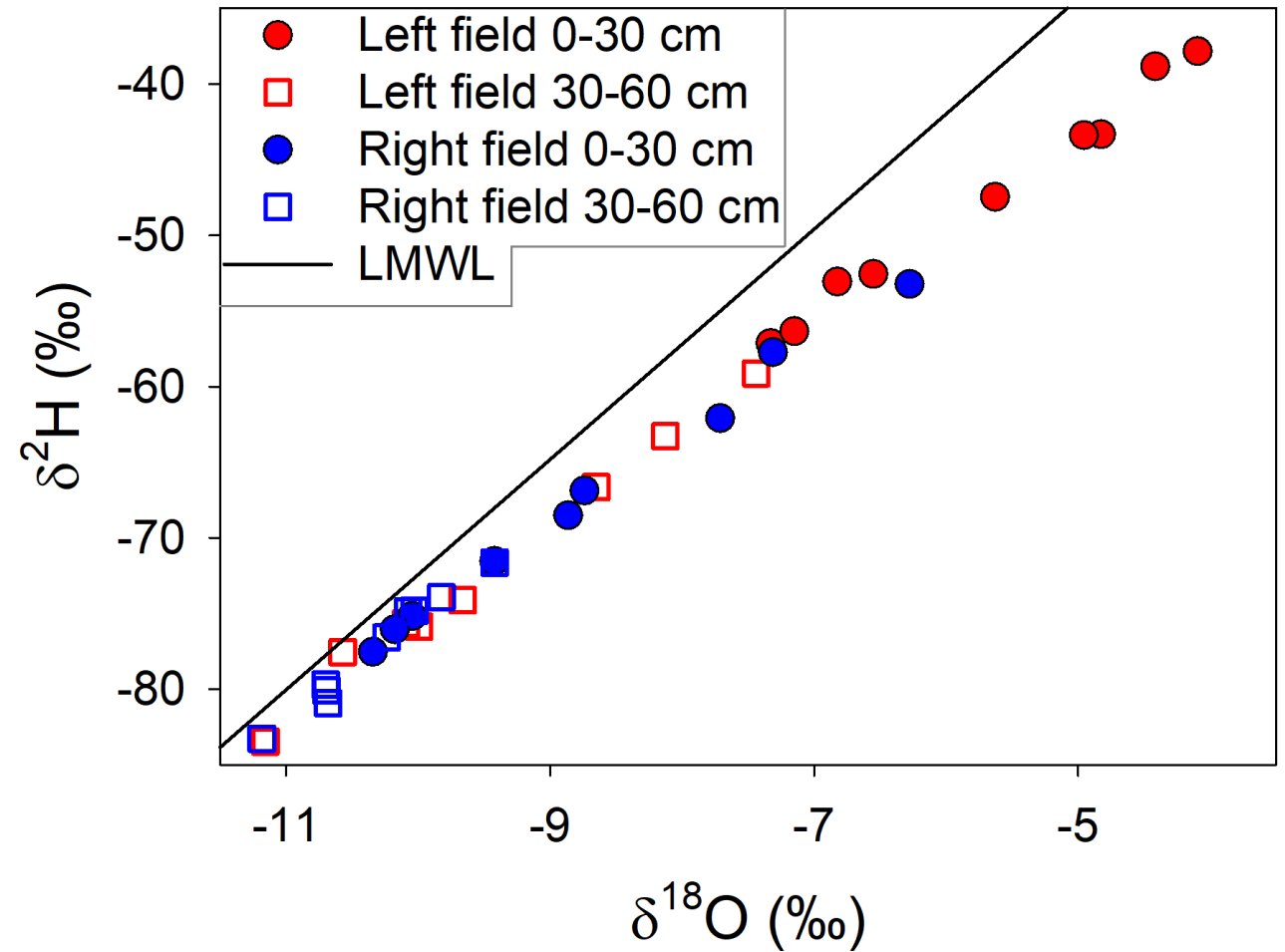
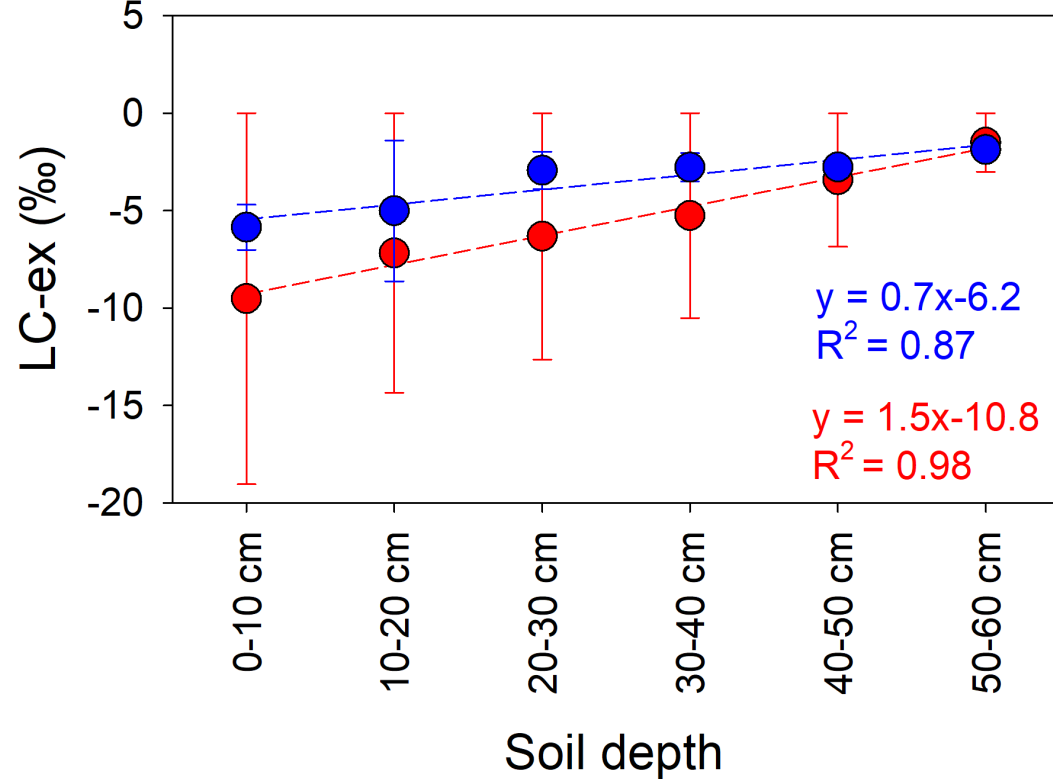
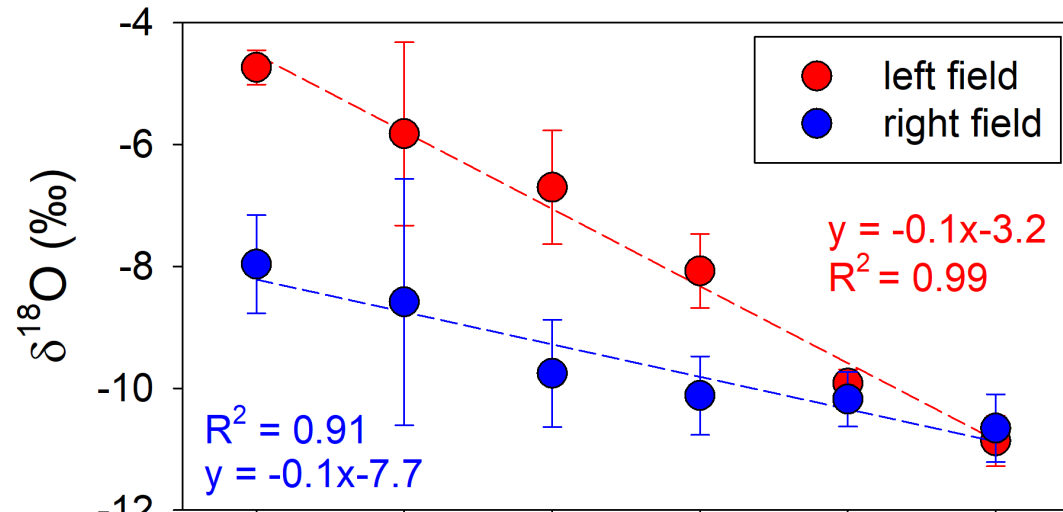
Soil moisture and groundwater level dynamics



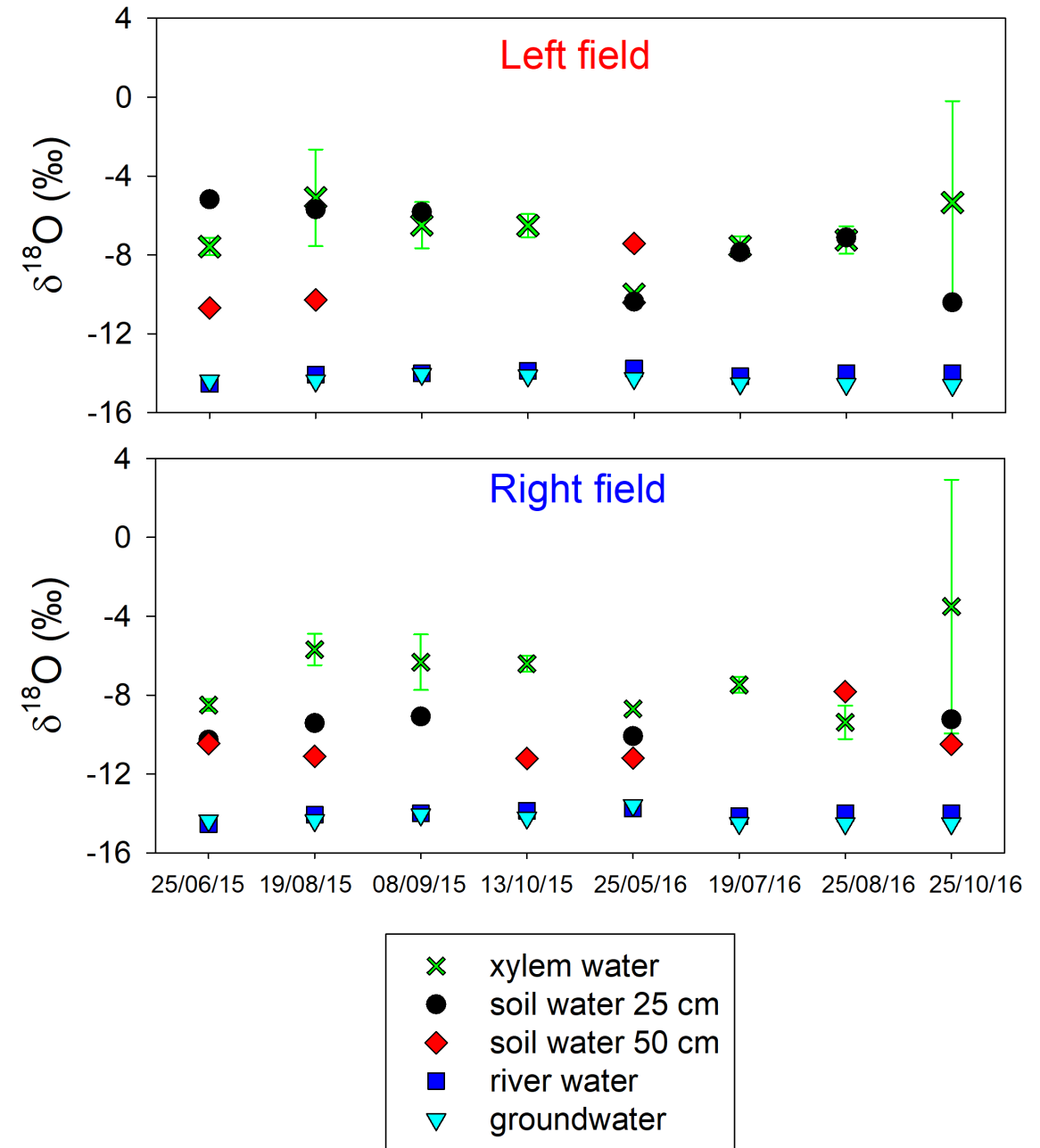
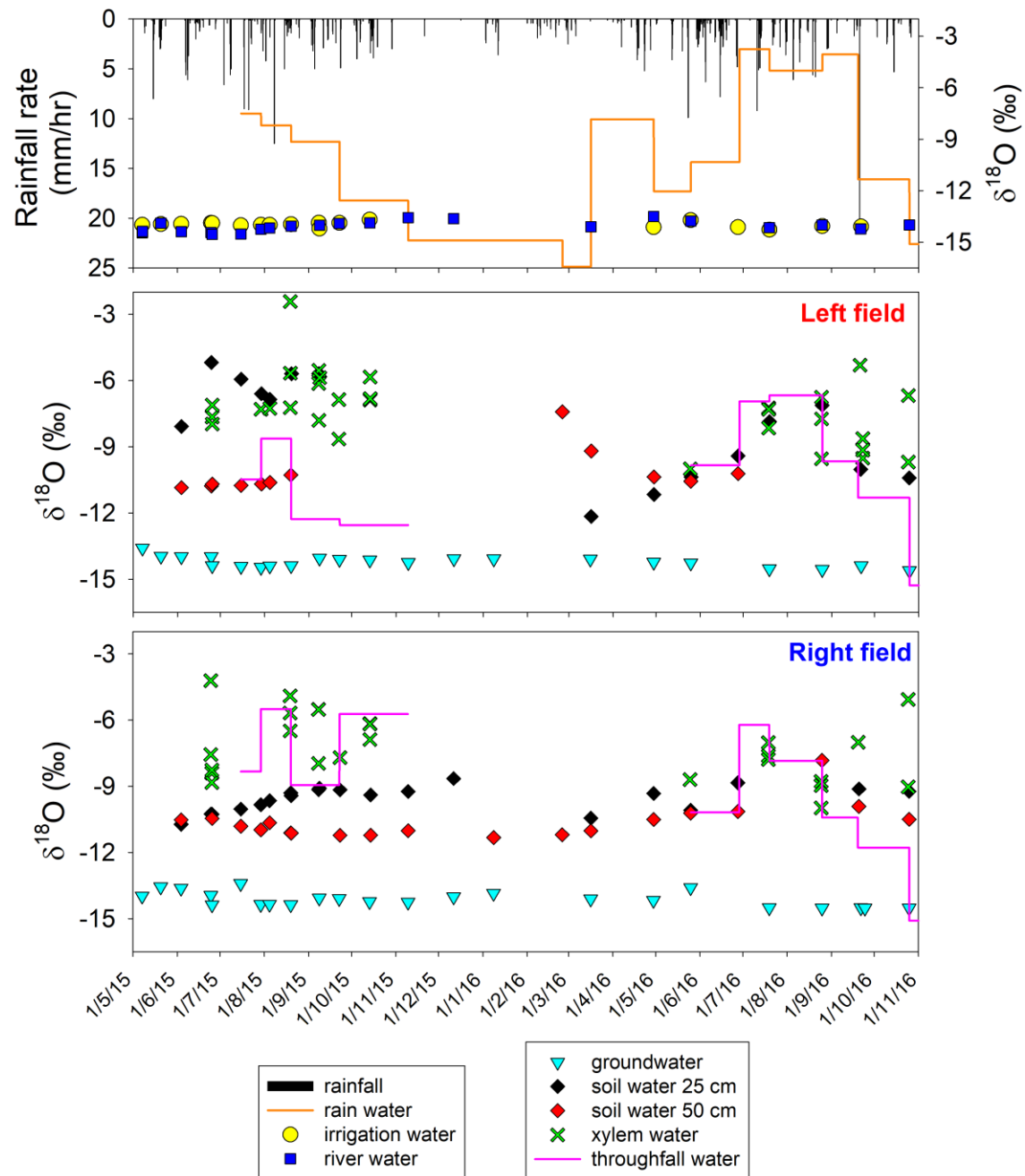
Isotopic composition of different waters



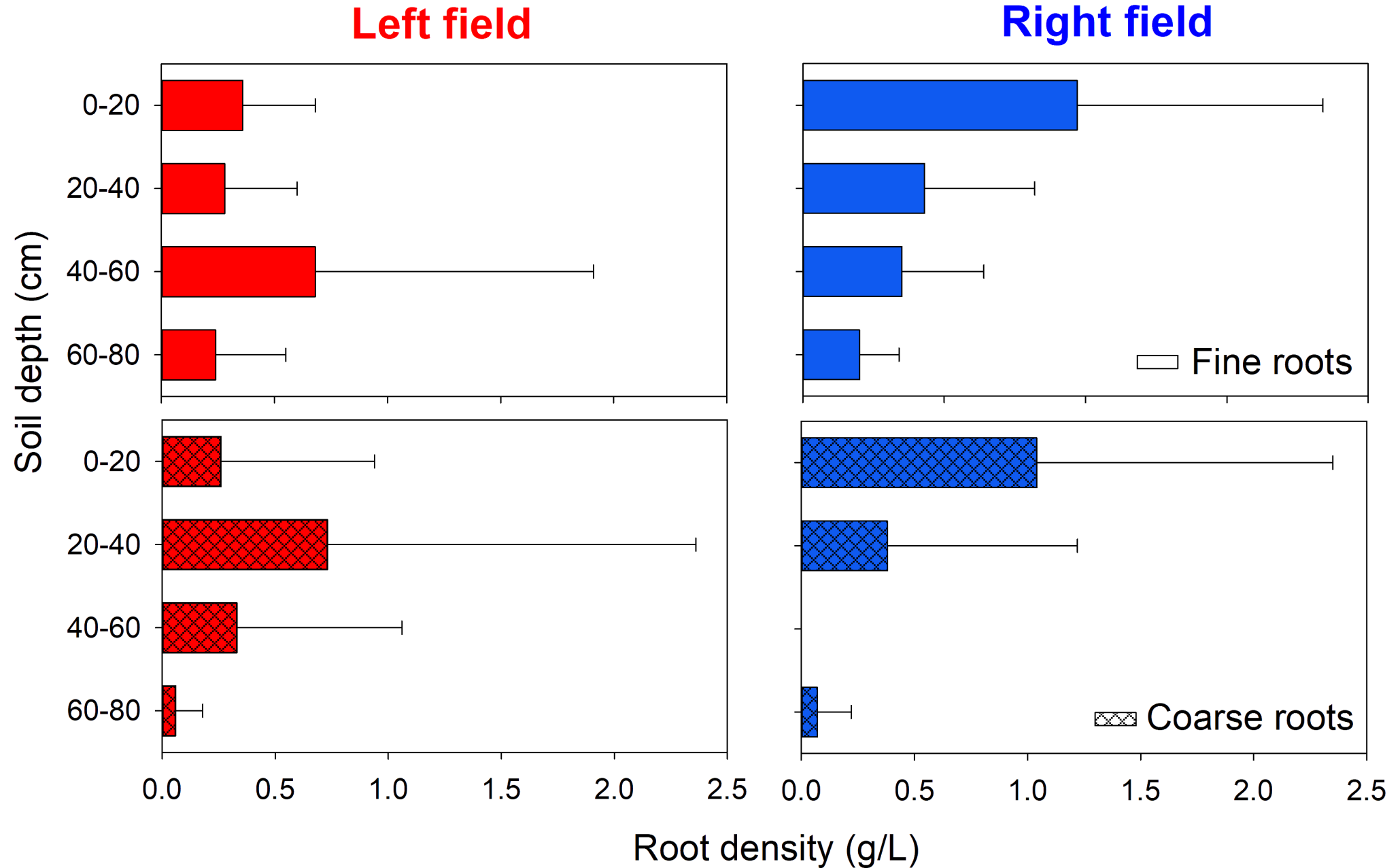
Evaporation-related fractionation of shallow soil water



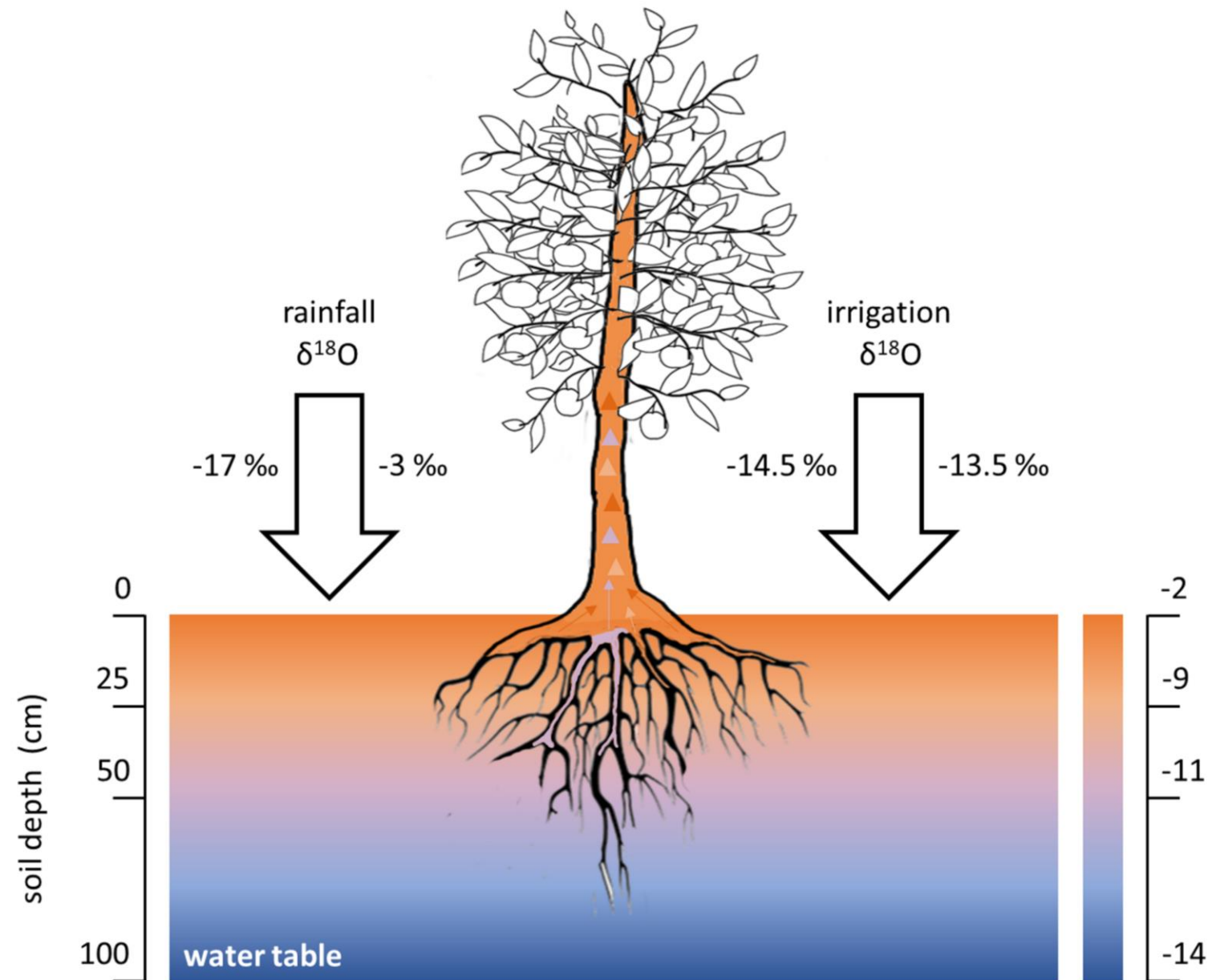
Temporal dynamics of the isotope signature of different waters



Root density of apple trees in the two fields



Conceptual model of water exchange in Alpine apple orchards



- Marked difference between the variable isotopic composition of rainfall and the depleted signature of irrigation water.
- No fractionation in rain and irrigation.
- Soil has isotopic gradient from depleted groundwater to enriched shallow soil.
- Rain and irrigation water mix in the soil, and apple trees preferentially take up water approximately from the upper 20-40 cm in the soil, coherently with their root depth and root density.
- The xylem water isotopic composition reflects this mixed signature.

Main conclusions

- Apple trees rely mostly on **soil water from the shallow layers (0-40 cm)**, where more roots are concentrated.
- The contribution of **groundwater is apparently negligible**, despite capillary rise in the right field might likely affect the soil moisture in the deepest soil layers.
- Xylem water is isotopically very different from irrigation water, apparently suggesting that trees under the tested field conditions did not directly access this source.
- This **“hidden” tracer signature of irrigation water is due to the effects of soil evaporation** that strongly modify its original isotopic composition.
- Irrigation and rainwater infiltrate into the soil and mixed with isotopically fractionated soil water, and **trees took up a mixture of waters** with different isotopic composition compared to that of the original irrigation source.