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Testing the Craig and Gordon model with field measurements of oxygen isotope ratios of evaporative fluxes in a Mediterranean oak savannah to partition evapotranspiration

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Stable oxygen isotopes of water provide a valuable tracer for water movements within ecosystems and are used to estimate the contribution of transpiration to total ecosystem evapotranspiration (ft). We tested the Craig and Gordon equation against continuous field measurements of isotopic composition of evaporation and assessed the impact for partitioning evapotranspiration. Therefore, evaporation (E) and its isotopic signature (δ18OE) on bare soil plots, as well as evapotranspiration (ET) and its corresponding isotopic composition of (δ18OET) of an herbaceous understory layer was measured with a cavity ring-down spectrometer connected to a soil chamber on a field site in central Portugal. We quantified the variation in δ18OE arising from uncertainties in the determination of environmental input variables to the Craig and Gordon equation: the isotope signature at the evaporating site (δ18Oe), the temperature at the evaporating site (Te), and the kinetic fractionation factor (αk). We could hence quantify ft based on measured δ18OET, modeled δ18OE from observed soil water isotopic composition at the evaporating site (δ18Oe), and modeled δ18O of transpiration (δ18OT) from observed total soil water isotopic composition.

Our results demonstrate that predicting δ18OE using the Craig and Gordon equation leads to good agreement with measured δ18OE given that the temperature and isotope profiles of the soil are thoroughly characterized. However, modeled δ18OE is highly sensitive to changes in Te and δ18Oe as well as αk. This markedly affected the partition results of transpiration and evaporation from the total ET flux: The fraction of transpiration (ft) varied strongly using different formulations for αk and assuming steady or non-steady state transpiration. These findings provide a first comparison of laser-based and modeled isotopic compositions of evaporation based on the Craig and Gordon equation under field conditions. This is of special interest for studies using stable isotopes to separate soil evaporation and plant transpiration fluxes and highlights the need for a thorough characterization of the micrometeorological and isotopic constitution of the upper soil layer to locate the evaporating front with a resolution of a few cm soil depths. We also call on a better characterization of the kinetic fractionation factor of soil evaporation.