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Hydrology and Earth System Sciences
Discussions

Interactive comment on "In-situ unsaturated zone stable water isotope (^{2}H and ^{18}O) measurements in semi-arid environments using tunable off-axis integrated cavity output spectroscopy" *by* M. Gaj et al.

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Comment of Markus Weiler: In the paper by Gaj et al. and modified in-situ system is presented to measure stable water isotopes in the unsaturated zone in an arid environment. In my opinion the paper misses to clarify the limitation of the proposed system, as it focuses too much on the potential. The system is a modification of the Volkmann and Weiler (2013), which included a mixing chamber and a dilution line to reduce the saturated vapor concentration in the sampling line after passing through the gas per-

meable PE (or PP) material. Gaj et al. decided to remove this part of the system to simplify their system, which was successful for application in the extreme environment, since the soils are very dry and the temperature is usually hot outside. Hence, there is a low probability of condensation of the vapor in their sampling line. However, it would anyhow be helpful for the user if they would provide any information about the measured vapor concentration at its variability during the measurement in the sampling line. If they would use this system in a more humid environment, they would probably run into the problem of condensation in the sampling line, which may produce insufficient data and produce a long time until the sampling line is liquid water free again. I think it would be helpful, if the authors would not only mention the potential of their system, but also clearly highlight the potential limitations in order to have potential users running into problems when using this set-up within their environment.

ANSWER: We appreciate your comment on potential short comings regarding the discussion on limitation of the in-situ system and will discuss that in more detail in the final version of this manuscript as follows: Condensation within the sample system can lead to unreliable data. This can be either prevented by heating the sample lines, flushing the sample lines with dry air or sufficient dilution of the sample. Hence, under conditions where the ambient temperature is significant warmer then the soil temperature a simple valve controlled membrane inlet will be sufficient for an indirect determination of isotopes in unsaturated zone or saturated zone water. During day time this is the case at the presented study sight, but changes drastically over night as described. Dilution of the vapor concentration can be done by providing dry gas at the other end of the available probes. In case of pure diffusion sampling the maximum dilution rate, if relative humidity is high ($\sim$90%), is controlled by the length of the probe, their diffusion properties, the flow velocity and the temperature at depth. The flow velocity can be different depending on the laser spectrometer that is used. Adding a mixing chamber at the head of the probe has the distinct advantage of additional mixing directly before the vapor enters the sample line (Volkman and Weiler, 2014). This leads to independence on flow velocity, probe length and membrane diffusion properties in terms of

water content. However, under very dry conditions it might be useful to increase probe length for an increase of resolution, since the soil volume around the probe affected by the measurement will be reduced. Another critical point is the long term application of membrane based methods. The pore space of the probes can be altered over time which might increase the memory effect of the system. Further, the calibration of the in-situ methods of Volkman and Weiler (2013) and Gaj et al., (2015), use prior oven dried substrate for the calibration. Though it is assumed that all water is evaporated from the oven dried substrate and only the added standard water will be measured afterwards. The same assumption is made using the equilibration bag method if the standards are treated in the same way as described. A direct comparison of the cryogenic vacuum extraction with a membrane based in-situ measurement showed that this calibration procedure is applicable for fine sand. However, it will probably lead to insufficient data applying this calibration procedure to soil samples with finer texture, especially if clay and/or salt contents are high.

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