Hydrol. Earth Syst. Sci. Discuss., 12, C3128–C3135, 2015
www.hydrol-earth-syst-sci-discuss.net/12/C3128/2015/

Hydrology and Earth System Sciences Discussions
Open Access

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.

M. Gaj et al.

marcel.gaj@bgr.de

Received and published: 18 August 2015

Anonymous Referee #1 General comments

The study presents soil isotope depth profile data of a semi-arid region in Namibia measured in-situ via soil gas probes attached to an OA-ICOS. The manuscript is well written and structured as well as easy to read. The study is in the scope of the journal and I recommend the presented study for publication in HESS after revising the submitted manuscript based on the suggestions of the review process. The introduction

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper

section is well written and the relevant processes and fundamentals of stable isotope hydrology for this study are addressed. However, I suggest shorten the introduction since a lot of basic information are given in extent. The presented sampling approach and the methods used are well described. However, the data poses more questions than the authors can answer. The amount of samples taken from other water cycle components (e.g. rainfall, groundwater) is rather limited which makes it hard to interpret the measured soil isotope profile data on its own. More frequent rainfall isotope data would be helpful in this regard to answer the following question: What is the driver of the isotopic composition in the presented soil profiles? Given the fact that rainfall and groundwater isotope data are very limited, a more detailed discussion about the vegetation influence on soil water isotopes would be desired. It would further be desirable if the authors could make better use of the spatio-temporal isotope variability rather than just presenting depth profiles, which is nothing new. The authors show soil moisture data for each profile. Did they correlate soil moisture versus isotopic signatures to proof the minor impact on the development of the isotope soil profiles in their study area? When comparing the new in-situ method to the widely used cryogenic vacuum extraction technique, differences especially for isotope data of the upper soil profile were measured which could not be satisfactorily explained. Could these differences in the top soil be attributed to method issues rather than to kinetic processes? Could the new in-situ method after all be limited in terms of low water contents (<5%) as the differences between the cryogenic vacuum extraction and the in-situ approach occurred within the very dry top 15 cm of the profiles (<2% soil moisture) and enriched isotope values were likewise measured in the upper soil profile? For instance, Wassenaar et al. (2008) admitted a limitation of their method, which is likewise based on vapor equilibrium measurements in this regard (not suitable for water contents <5%). The authors addressed this issue in its own section but still, the question remains why almost inverse isotope results were obtained from cryogenic extraction and the in-situ approach (Fig. 4) and further isotope results of which extraction method (in-situ vs. cryogenic extraction) are more reliable in the end. Finally, the authors should include a small paragraph on future research directions in the study area or further applications of the in-situ approach.

ANSWER: The driver of the isotopic composition in the soil can be either the infiltration of rain water, biological processes such as hydraulic redistribution or vapor transport introduced by i.e. strong temperature, humidity and matrix potential gradients. We agree that additional isotope data of rainfall would be helpful. However, work in a remote region limits data availability as well as sampling time and weather can be unpredictable. We did not correlate soil moisture against the isotope data. This is a good point. We will include this data and add a paragraph in the discussion section (see attached Fig. 1). However, the intention to show isotope depth profiles for each transect with their standard deviation for isotopes and soil moisture was to show the difference between the two. The variability within the isotope depth profiles shows a much more heterogeneous pattern than that of the soil moisture data. This might be related to vapor diffusion processes. Another possibility could be that biological processes are relevant to isotope fractionation in the soil, such if bacteria, funghi or roots discriminate between light or heavy isotopologues.

It is unlikely that the soil water content is the issue here. Because for the profile at the vegetated plot soil water contents are below 1% throughout the profile and not such enrichment can be observed. Values of 18O are even more depleted. However, relative humidity of the pore space could be the issue at that point which has to be considered in future studies, because we did not measure it in the soil. The equilibration method of Wassenaar et al., (2008) applied to dry samples has the disadvantage that the headspace is filled with dry air. This causes a small amount of water to evaporate from the sample. This can cause enrichment of the reservoir and causes different isotope equilibrium between vapor and the sample. However, using the in-situ approach the present vapor is sampled directly and the reservoir especially in sandy soils will equilibrate very quickly. In case of diffusive sampling the headspace will be the volume of air transported through the sampling line. When to apply which method depends on

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper

the research question. It can be beneficial to compare methods to account for different water pools or states of the soil water (i.e. vapor, liquid water).

We further added a small paragraph and discussed methodical possibilities, limitation and future research directions in the final manuscript.

Specific comments: Generally, the text should be checked for punctuation. ANSWER: We rechecked the text for punctuation and typos.

P6116 L17-25 and P6118 L1-16: shorten these sections ANSWER: We shortened the section P6116 L17-25. However do not agree to shorten P6118 L1-16

P6120 L15: Volkmann and Weiler (2014) not (2013) ANSWER: We corrected the year.

P6122 L25: Consider deleting Equation (1), not necessarily needed ANSWER: We prefer to keep the equation.

P6124 L7: How was the additional error for sandy soil extractions determined? ANSWER: The additional error for sandy soils is determined from Königer et al., 2011. We added the citation.

P6125 L1-3: Consider addressing this question in more detail in the discussion section: Atmospheric boundary conditions varied drastically between day and night. How does this affect the isotope results? ANSWER: We discussed that in the discussion section P6131 L7-15.

P6126 L1: To which variations are you referring to (these?)? ANSWER: We changed “these” to: “temperature and humidity variations”.

P6126 L8-10: Include this rainfall isotope data in Fig. 4 ANSWER: We included rainfall isotope data.

P6127 L21: With which method was deep soil water extracted and what does “deep” mean in terms of depth? Could you give the standard deviation for the local groundwater and deep soil water values as well? ANSWER: Additionally, mean values of local groundwater (σ18O=0.91, σ2H=4.27) and soil water down to a depth of 4m with 10cm resolution are presented. The analytical error for sand soil water extractions can be considered for the deep soil water profile (Fig. 2).

P6128 L13: Could you explain why the method seemed to be less accurate for _2H (mean accuracy of 5.1‰ ANSWER: In general the analytical error for 2H is higher as for 18O. (see Königer et al., 2011). In addition, considering the adsorption spectrum _2H hast the smallest peak, therefore small changes can lead to high uncertainties during the measurement.

P6131 L20-21: Did the authors consider the fact that destructive soil sampling causes macro pores with effects on the gas exchange and therewith on the isotopic composition. In the soil profile measured in-situ after the destructive sampling? ANSWER: Considering the present soil texture is very unlikely that destructive sampling introduces macro pores. In addition, the probes penetrated 40 cm into the profile, though we expect almost undisturbed conditions.

P6133 L6-10: Present more recent studies as references. ANSWER: We added more recent studies to that paragraph.

Fig. 2: More detailed scheme would be helpful. ANSWER: The general scheme was that simple. However, more valves could be switched using additional wiring. The communication to the analyzer was maintained with a USB-to-RS232 interface. In this particular case, we manipulated the USB-to-RS-232 converter in such a way that we could switch 12V valves by providing high and low signals to the wires of the interface with a python command. We thought that a detailed wiring diagram would be to technical and decided to show a simplified flow diagram. However, the python code and more detailed information can be provided by the author.

Fig. 3: Redundant since texture was uniform throughout depth. The information given in the text is sufficient. ANSWER: We will remove that figure in the final manuscript.

Fig. 4: Enlarge this figure and include rainfall isotope data in the plot (if available) ANSWER: We will enlarge the figure and add rainfall data if available.

Fig. 7: Include rainfall isotope data (if available) ANSWER: The available rainfall isotope data is already included in this figure (grey dots at the top).

Figure 1: Mean soil moisture (Ïť) of each depth plotted against the standard deviation σ[Ïť] between each depth as well as standard deviation of $\sigma[\delta 18O]$ and $\sigma[\delta 2H]$.

Figure 2:$\delta 18O$ vs $\delta 2H$ plot of the profiles E01.1, E01.2, E02.7. Also shown is the LMWL for the northern part of Namibia as well as groundwater and soil water down to a depth of 4 m.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 12, 6115, 2015.

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper

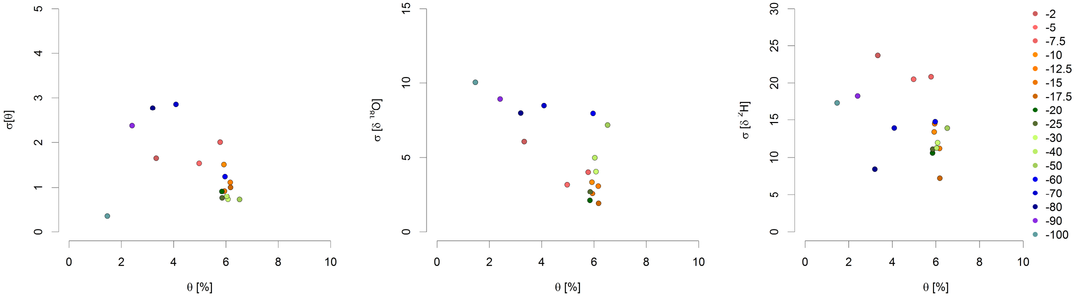

Fig. 1. Mean soil moisture (Ïť) of each depth plotted against the standard deviation σ[Ïť] between each depth as well as standard deviation of $\sigma[\delta 18O]$ and $\sigma[\delta 2H]$.

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper

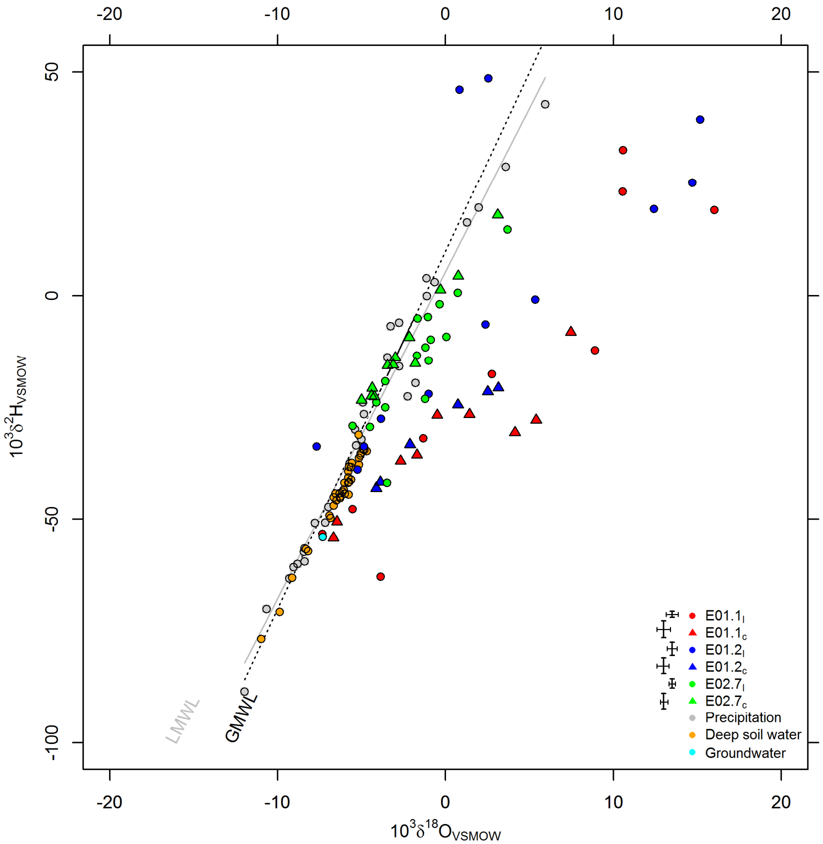

Fig. 2. δ18O vs δ2H plot of the profiles E01.1, E01.2, E02.7. Also shown is the LMWL for the northern part of Namibia as well as groundwater and soil water down to a depth of 4 m.