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Interactive comment on "Monitoring soil moisture from middle to high elevation in Switzerland: Set-up and first results from the SOMOMOUNT network" *by* Cécile Pellet and Christian Hauck

Anonymous Referee #1

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This MS describes the new soil moisture monitoring network SOMOMOUNT launched in 2013 consisting of 6 soil moisture stations distributed along an altitudinal gradient between the Jura Mountains and the Swiss Alps.

Soil moisture monitoring in areas with low sensor density like Alpine regions is important e.g. for validation of global models and remote sensing products. Thus, it fits well to the scope of this journal. The MS is mostly written in an understandable way. However part of the text is not well comprehensible and too speculative. Also, there are major issues regarding the methods and interpretations of the results (see comments below).

General comments:

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1) Soil water content measurements This study uses electromagnetic (EM) sensors to measure soil water content. It is very important to understand that this is an indirect measuring method and that EM sensors are only sensible to changes of the dielectric properties of the soil (i.e. the permittivity). To determine soil water content, EM sensors make use of the strong dependence of EM signal properties on volumetric water content that stems from the high permittivity of liquid water ($\sim$80) compared to mineral solids (2–9), and air (1), see e.g. Bogena et al., 2007. However, it is well known that the permittivity of pure ice is extremely lower compared to liquid water ($\sim$2-3) (e.g. Aragones et al., 2010). Therefore, during frozen soil conditions, the EM signal will decrease considerably, while the total soil water content stays the same. In addition, typically not all liquid water freezes at soil temperatures below 0°C, depending on the temperature, salinity, initial moisture, and soil texture (e.g. Zhang et al., 2003). Thus, the EM sensor determines the apparent permittivity of a mixture of liquid water, ice, mineral solids and air, with their respective permittivities. Consequently, the senor calibration determined for unfrozen soil is not valid any more (see e.g. Watanabe and Wake, 2009). From these theoretical considerations it becomes clear that the EM derived volumetric soil water content data shown in the EM during frozen soil conditions is not correct. This also means that the interpretations of the data are, at least partly, incorrect.

These problems are also very important with respect to publishing the data for validation purposes of global models. Clearly, a comparison of the erroneous volumetric soil water contents presented in this MS with model results will lead to deceptive deviations for frozen soil conditions.

Consequently, the authors either need to calculate the total soil water content, e.g. using the expanded dielectric mixing model presented by Watanabe and Wake (2009) or otherwise they would need to restrict their analysis to periods without soil freezing.

2) EM sensor calibration The authors used TDR sensors as reference for the SMT100 sensors. However, they only used the empirical, soil unspecific function of Topp et al.

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(1980) to relate the permittivity measurements to soil water content. However, many studies showed that depending on the soil properties this can lead to uncertainties in the soil water content estimates (e.g. Robinson, 2004). Thus, the reference quality of the TDR data is questionable. The more advanced calibration approach presented by Rosenbaum et al. (2010) using the CRIM model would be more preferable to determine reference soil water content data.

3) Interpretation of the data The authors used so-called moisture orbits to analyse the soil water content data and to determine the dominate soil hydraulic processes. This is a quite appealing way to present the soil water content data and interesting pattern were shown. However, the interpretation of these patterns is at times very speculative and partly unrealistic if not completely wrong (see specific comments for examples).

Specific comments

P3 L20: This paper is not accessible. You should refer to the paper of Qu et al. (2013), which thoroughly described and tested the SPADE sensor, which is the successor of the SISOMOP sensor and precursor of the SMT100. All three sensor types are using exactly the same technique (ring oscillator) and only differ in their specific design (e.g. plastic material, sensor output etc.).

P4 L4-7: I do not think that the technical description is fully correct. See Evett et al. (2006) for a detailed description of the Delta-T PR1/6 Profiler (precursor of the PR2/6).

P8 L14: Arithmetic mean?

P9 L24-25: Different relationships might be due to specific soil properties. Since this is a purely empirical approach, I don't see the need for using the linear model for reasons of consistency. Instead the best model should be used to provide the best relationship between sensor output and soil water content.

P10 L6-7: This is not plausible. Deviations are more likely due to small scale heterogeneities of the soil. Please remember that the SMT100 is only sensible to EM

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properties of the soil directly surrounding the sensor blade (just some mm to cm).

P10 L10-14: Again not plausible. The deviations are due to the different soil properties, which directly influence the measurements.

P10 L14 (K instead of °C)

P10 L14-17: Unclear which physical processes you are referring to.

P10 L28-29: Unclear why freezing should freezing and thawing explain the differences. The wet bias could be explained by the unreliable TDR calibration using the Topp equation.

P11 L12: Unreliable soil water content measurement due to frozen water.

P13 L20: What do you mean with “transfer”

P13 L25-27: Which sensors were used? How did you derive the soil water contents for the profiles (simple arithmetic mean, weighted mean etc.)?

P14 L1-4: This is an indication for preferential flow processes. Dry top soils tend to bypass precipitation water (see e.g. Wiekenkamp et al., 2016).

P14 L5-6: Difference in precipitation sums is too small to explain this difference. P14 L7-9: Not plausible. Evapotranspiration rates in this climate are mainly depending on meteorological forcing and vegetation characteristics.

P14 L13: This is counterintuitive. Why should melting start underground?

P14 L28-29: Not plausible (see above).

P14 L30-31: Not plausible. There seems rather to be a constant groundwater influence at 50 cm depth.

P15 L1-2: This statement is too general (in structured soil Ks is not always lower in greater depths due to preferential flow).

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P15 L18: You need to mention that you are now showing the differentials.

P15 L25-26: Not plausible. In that case, the sensor in 50 cm would show an increase.

P15 L30: What is typical for this soil?

P16 L1-3: Not plausible. From basic soil physics is well known that the soil hydraulic conductivity decreases with decreasing soil water content. However, in structured soils preferential flow can be activated (see e.g. Wiekenkamp et al., 2016).

P16 L7-9: Not plausible why these orbit patterns should indicate lateral processes.

P17 L28-34: Not plausible why these processes can produce lower soil temperatures, although the air temperature is relative high. Are you measuring air temperature farther away from the soil station?

P18 L5-7: Not plausible (see above)

P18 L7-8: The soil seems not have been frozen during these phases (values are still relatively high)

Literature

Aragones J. L., L. G. MacDowell, and C. Vega (2010): Dielectric Constant of Ices and Water: A Lesson about Water Interactions. J. Phys. Chem. A 2011, 115, 5745–5758.

Bogena, H.R., J.A. Huisman, C. Oberdörster and H. Vereecken (2007): Evaluation of a low-cost soil water content sensor for wireless network applications. Journal of Hydrology, 344 (1-2): 32-42.

Evett S.R., J.A. Tolk, and T.A. Howell (2006): Soil Profile Water Content Determination: Sensor Accuracy, Axial Response, Calibration, Temperature Dependence, and Precision. Vadose Zone Journal 5:894–907.

Qu, W., H.R. Bogena, J.A. Huisman and Vereecken (2013): Calibration of a novel low-cost soil water content sensor based on a ring oscillator. Vadose Zone J. 12(2), doi:

10.2136/vzj2012.0139.

Robinson, D. A. (2004): Measurement of the solid dielectric permittivity of clay minerals and granular samples using a time domain reflectometry immersion method, Vadose Zone J., 3(2), 705–713, doi:10.2136/vzj2004.0705.

Watanabe, K. and Wake, T. (2009): Measurement of unfrozen water content and relative permittivity of frozen unsaturated soil using NMR and TDR. Cold Regions Science and Technology 59: 34–41

Wiekenkamp, I., J.A. Huisman, H. Bogena, H. Lin and H. Vereecken (2016): Spatial and Temporal Occurrence of Preferential Flow in a Forested Headwater Catchment. J. Hydrol. 534: 139-149, doi:10.1016/j.jhydrol.2015.12.050.

Zhang, L., J. Shi, Z. Zhang and K. Zhao (2003): The estimation of dielectric constant of frozen soil-water mixture at microwave bands. Geoscience and Remote, doi:10.1109/IGARSS.2003.1294626

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