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Hydrology and Earth System Sciences Discussions

Interactive comment on "COSMOS: The COsmic-ray Soil Moisture Observing System" *by* M. Zreda et al.

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General comments:

1. The monitoring of cosmic-ray neutrons is a promising way to close the gap between point measurements and remote sensing. This paper describes the cosmic-ray soil moisture measurement method, the instrument and its calibration, the design, data processing and dissemination used in COSMOS, and give example time series of soil moisture obtained from COSMOS probes.

2. Although some general papers on the methodology of the cosmic-ray soil moisture measurement technique already exists, the paper gives some valuable further informa-

tion on the processes leading to the neutron generation due to cosmic radiation which helps to better understand the technique and to interpret the neutron count data.

3. However, the paper is at times written like an advertising text, like for example the first sentence "Area-average soil moisture at the sub-kilometer scale is needed but until the advent of the cosmic-ray method it was difficult to measure". As being a user of such an instrument I have experience with the interpretation of the CRP data which is not easy in certain environments (especially humid climates) because the sensitivity of the cosmic ray sensor decreases with increasing soil moisture content.

4. The authors introduce the new name "neutronavka" for the sensor. Since the name "cosmic ray probe" or short CRP is already well established I would suggest to keep this name in order to avoid misunderstandings. Also other names like, e.g. COSMOS probe, should be changed in to "cosmic ray probe" or short CRP.

5. I have observed several redundancies due to the structure of the manuscript (see specific comments).

6. A more detailed analysis of more than two sites of the COSMOS network should be included to better confirm the statements made in the manuscript.

Specific comments:

P2 L29 Recently wireless sensor networks have been developed that allow for real-time measurement of soil moisture pattern dynamics from the field to the catchment scale P3 L4-7 Intermediate scale soil moisture can also be measured using wireless sensor networks (e.g. Vereecken et al., 2009, Bogena et al., 2010). P3 L23-32 This section is very general and should be shortened. P5 L13 Fast neutrons are only produced via the evaporation process? P6 L12 The production of neutron has already been described in the previous chapter. This chapter should exclusively deal with the moderation of fast neutrons. P6 L13 Neutrons can also be produced by other compartments like e.g. biomass, surface water. P6 L14-15 It should be noted that the moderation of fast neutrons is caused by elastic nuclear collision. P7 L7 Manganese is not included in table 1. P7 L22 Fig. 6 should be reduced to 3 cases since 0 kg/kg water content is not possible due to the presence of lattice water. P8 L1 There is a large overlap of this chapter with the two previous chapters leading to redundancy. Therefore this chapter should concentrate on the measurement aspects, which are described in sections 2.4 and 2.5. P8 L11 In reality the production rate for a specific site is not known since there are several unknown influencing factors. P8 L25-26 How much is the production rate influenced by the soil water content? P9 L9 This is only the case where other influences (e.g. biomass) can be neglected. P10 L8 The lattice water issue is not very clear to me. How much lattice water can be typically found in soils? Is this a material constant or does its amount change in time? How can the lattice water content be determined? Some more information on how the effect of lattice water should be considered in the calibration should be presented. P10 L20 An important aspect is the decrease in sensitivity of the CRP with increasing distance. This means that the likelihood that the inferred soil moisture by the CRP corresponds correctly with that of the surrounding soils will sharply decrease with distance. For instance, at our test site we translocated our CRP about 100 m from a hillslope location to a groundwater influenced valley location. Although the wetter zone in the valley was relatively small compared to the footprint size (∼10%), the neutron count rate changed and the original calibration estimated at the hillslope location could not predict accurately values of soil moisture at the valley location (Rivera Villarreyes et al., 2011). P11 L11 Similarly the sensitivity of the CRP will also decrease with depth. This effect should be discussed here in more detail. P12 L15 include surface water P13 L19-20 From our experience with CRP I would strongly advice not to use a universal function without calibration based on in-situ determined soil moisture in the footprint of the CRP, especially one want to use the data for validation purposes (e.g. remote sensing or model results). The measurement error can easily exceed 100%. P14 L8-9 the accuracy will largely depend on the spatiotemporal variability of the soil moisture and the other hydrogen pools within the CRP footprint. P14 L9-11 Bogena et al. showed that the vertical

weights had a large impact on the footprint averaged soil moisture content. During wet periods, the weight for the top soil in-situ measurements increase to >90%. Since the soil water content also depends on the soil porosity, which normally decreases with depth, a weighting for depth is of great importance. For sites with heterogeneous soil pattern (as described above) also the weighing for distance should be applied. P15 L13-15 You are only presenting one example, which not sufficient to make such an argument. In our experience, this stability does not exist (see also above). You should undertake a thorough analysis of several other COSMOS sites confirm this statement. P18-21This sections could be shortened in order to reduce redundancy and parts which are too technically (e.g. P19 L25-28).

References Paper in preparation and presentations should not be cited.

Figures Fig. 5 does not add significant information and thus could be omitted. Fig. 6 could be reduced to 3 graphs (see above) Fig. 10 could be omitted since it is already presented at the web site Fig. 11 does not add significant information and thus could be omitted.

Related references Bogena, H.R., M. Herbst, J.A. Huisman, U. Rosenbaum, A. Weuthen, and H. Vereecken (2010): Potential of wireless sensor networks for measuring soil water content variability. Vadose Zone J., doi:10.2136/vzj2009.0173. Vereecken, H., J.A. Huisman, H.R. Bogena, J. Vanderborght, J.A. Vrugt, and J.W. Hopmans. 2008. On the value of soil moisture measurements in vadose zone hydrology. A review. Water Resour. Res. 44. W00D06. doi:10.1029/2008WR006829. Rivera Villarreyes, C.A., H. Bogena, G. Baroni, D. Metzen, and S.E.Oswald. 2011. Cosmic-Ray Neutrons for Estimation of Areal Mean Soil Moisture in Agricultural and Forest Sites. Geophysical Research Abstracts 13, EGU2011-8632

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