

Water Resources Research



COMMENT

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Key Points:

- Dong and Ochsner (2018) concluded that soil texture exerted a stronger influence on mesoscale soil moisture variability than precipitation
- Dong and Ochsner (2018) made a mistake in their calculation of volumetric soil moisture
- We found that correlations between soil moisture and soil texture and precipitation were significantly different in only 8 of 18 surveys

Correspondence to:

J. Jakobi,
jjakobi@fz-juelich.de

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Comment on Dong and Ochsner (2018): “Soil Texture Often Exerts Stronger Influence Than Precipitation on Mesoscale Soil Moisture Patterns”

J. Jakobi¹, J. A. Huisman¹, and H. R. Bogen¹

¹Agrosphere Institute (IBG-3), Forschungszentrum Jülich, Jülich, Germany

Abstract In their study, Dong and Ochsner (2018, <https://doi.org/10.1002/2017WR021692>) used an extensive data set of 18 cosmic-ray neutron rover surveys along a 150 km long transect on unpaved roads to assess the influence of precipitation and soil texture on mesoscale soil moisture patterns. Based on their analysis, they concluded that soil texture, represented by sand content, exerted a stronger influence on mesoscale soil moisture variability than precipitation, represented by the antecedent precipitation index, on 17 of the 18 survey days. However, we found that Dong and Ochsner (2018) made a mistake in their calculation of volumetric soil moisture. After correction, the validity of the original conclusions of Dong and Ochsner (2018) was considerably weakened, as soil texture exerted a stronger influence on soil moisture than precipitation on 12 of the 18 survey days only.

The Cosmic-Ray Neutron (CRN) rover is a mobile application of the CRN sensing method to measure field-scale soil moisture noninvasively by surveying large regions (Schrön et al., 2018). Dong and Ochsner (2018) used an extensive data set of 18 CRN rover surveys along an approximately 150 km long transect to assess the influence of precipitation and soil texture on mesoscale soil moisture patterns. To this end, they used sand content to represent soil texture and the Antecedent Precipitation Index (API) to represent the influence of precipitation. Based on autocorrelation and Pearson correlation analysis, Dong and Ochsner (2018) concluded that soil texture exerted a stronger influence on mesoscale soil moisture variability than precipitation on 17 out of 18 survey days.

We attempted to reproduce the results of Dong and Ochsner (2018) and found an error in the calculation of volumetric soil moisture from neutron count rates in their analysis (data were retrieved from <https://osf.io/59j6c/>). Dong and Ochsner (2018) wrongly derived volumetric soil moisture content from gravimetric soil moisture content (θ_g [g/g]) by dividing with the soil bulk density (ρ_{bd} [g/cm³]). Obviously, the correct approach to obtain the volumetric soil moisture content (θ_v [m³/m³]) would be the multiplication of θ_g with ρ_{bd} :

$$\theta_v = \frac{\theta_g \cdot \rho_{bd}}{\rho_w} \quad (1)$$

where ρ_w (=1 g/cm³) is the density of liquid water (e.g., Marshall, Holmes, & Rose, 1996). Figure 1 exemplarily shows the wrong volumetric soil moisture content as published by Dong and Ochsner (2018) in comparison to our own calculation of volumetric soil moisture with Equation 1 for one measurement day. We found a considerably higher soil moisture content for all survey days after correction, which is not surprising because bulk density was always higher than 1.36 g/cm³.

After correction of the originally published soil moisture content values of Dong and Ochsner (2018), some differences with the soil moisture content values we obtained from the neutron count rates were still present (Figure 2). These differences are most pronounced between ~35 and ~75 km, where a distinct drop in soil bulk density that was used by Dong and Ochsner (2018, lower panel of Figure 3 in the original publication) is visible. The soil data we extracted from the same database as used by Dong and Ochsner (2018) (SSURGO, <https://websoilsurvey.sc.egov.usda.gov/>, retrieved on 13 April 2020) did not feature this decrease in soil bulk density (not shown), which explains most of the remaining differences in water content estimates shown in Figure 2.

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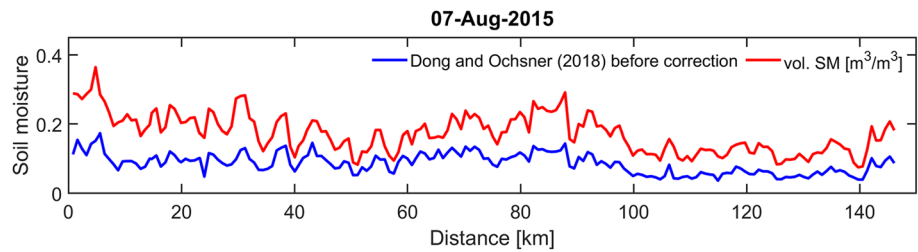


Figure 1. Soil moisture along one of the measurement transects from Dong and Ochsner (2018). Originally published soil moisture (blue) and correctly derived volumetric soil moisture using Equation 1 (red).

In a next step, we evaluated how the corrected soil moisture estimates affected the results and conclusions from Dong and Ochsner (2018). For this, the Pearson correlation coefficients presented in Figure 9 of Dong and Ochsner (2018) were extracted using plot digitizer software (<http://apps.automeris.io/wpd/>). We found that the correlation between sand content and volumetric soil moisture was systematically lower compared to the original findings when using the corrected soil water content estimates (Figure 3). The average absolute Pearson correlation coefficient was reduced from 0.65 to 0.51 for sand content. In the case of API, the average absolute Pearson correlation coefficient slightly increased from 0.42 to 0.44. Because of these changes, the correlation with API was no longer systematically lower than the correlation with sand content. We found a higher correlation between sand content and soil moisture in only 12 of 18 surveys, which is substantially lower than the 17 out of 18 surveys reported in Dong and Ochsner (2018). In addition, the difference between the correlation with API and sand content was lower than 0.03 for 4 out of these 12 survey days (May 12, 2015, June 29, 2015, January 27, 2016, and April 27, 2016, see Figure 3). We also used a Fisher z test to determine whether the Pearson correlation coefficients of soil moisture with API and soil moisture with sand content were significantly different (e.g., Ramseyer, 1979; see Figure 3, black circles). After correction of the falsely derived soil moisture, we found significant differences on 8 out of the 18 survey days, whereas significant differences were found on 12 out of the 18 survey days before correction. In addition, the Pearson correlation coefficients for API were negative on four survey days with significantly higher Pearson correlation coefficients for sand content. As already stated by Dong and Ochsner (2018), such negative correlation coefficients with API are physically implausible. Consequently, the conclusion that soil texture exerted a stronger influence on soil moisture than precipitation is considerably weakened based on our analysis.

We found that the correlation coefficients were also influenced by the extraction of soil properties from the SSURGO database and the rover location assignment to some extent. Both steps involve some degree of subjectivity, as there are many complex processing steps involved. With the help of the authors, we have been able to reproduce the processing steps of Dong and Ochsner (2018) as well as possible. The remaining minor differences are most likely due to a recent update of the database after the original publication.

Dong and Ochsner (2018) used volumetric soil moisture for their analysis, which is perhaps more uncertain than gravimetric water content due to the need for uncertain bulk density values for conversion. Therefore, we also repeated the analysis for gravimetric soil moisture and found higher correlation with sand content

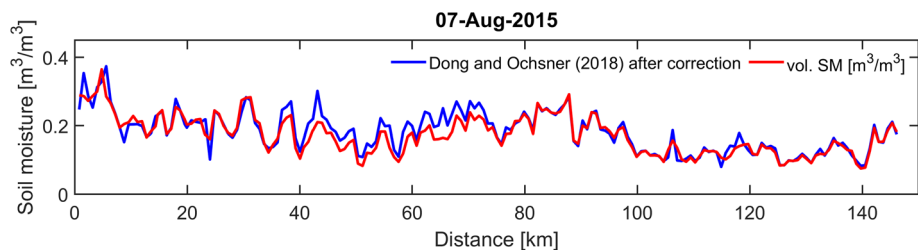


Figure 2. Soil moisture along one of the measurement transects from Dong and Ochsner (2018). Corrected volumetric soil moisture obtained from the published soil moisture (blue), and the volumetric soil moisture obtained in this study (red).

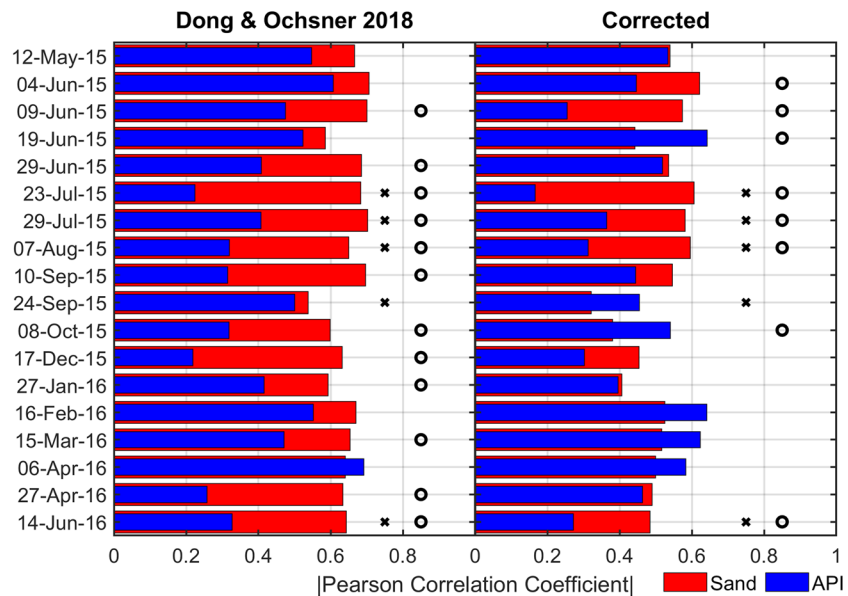


Figure 3. Pearson correlation coefficients between soil moisture and API and soil moisture and sand content with the published, falsely derived volumetric soil moisture (subplot titled “Dong & Ochsner, 2018”) and with the corrected volumetric soil moistures (subplot titled “Corrected”). The correlation coefficients with sand content were all negative. The correlation coefficients with API were mostly positive, but some were negative and those are marked with crosses. The black circles indicate dates with significant difference between the correlation coefficients with API and sand content, respectively, obtained using a Fisher z test (e.g., Ramseyer, 1979). API, Antecedent Precipitation Index.

while correlations with API were relatively similar. In addition to the uncertainties in soil bulk density, lattice water, and organic matter content, the cosmic-ray neutron method is also susceptible to other uncertainties that are not considered here and in the study by Dong and Ochsner (2018), e.g., the uncertainty in raw neutron counts (Jakobi et al., 2020), the influence of vegetation (e.g., Avery et al., 2016; Fersch, Jagdhuber, Schrön, Völksch, & Jäger, 2018; Jakobi, Huisman, Vereecken, Diekkrüger, & Bogena, 2018) and the influence of roads (Schrön et al., 2018). We hope that this exchange will generate further interest in the use of the CRN rover method to improve our understanding of the controls on mesoscale soil moisture patterns.

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