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Combining static and portable Cosmic Ray Neutron Sensor (CRNS) data to assess catchment scale heterogeneity in soil water content and implications for runoff generation

Katya Dimitrova Petrova[1,2], Rafael Rosolem[3,4], Chris Soulsby[1], Mark Wilkinson[2], Allan Lilly[2], and Josie Geris[1]

[1]University of Aberdeen, Northern Rivers Institute, School of Geosciences, Geography, Aberdeen, United Kingdom (k.dimitrovap@abdn.ac.uk)

[2]The James Hutton Institute, Craigiebuckler, Aberdeen, United Kingdom

[3]Department of Civil Engineering, University of Bristol, Bristol, United Kingdom

[4]Cabot Institute, University of Bristol, Bristol, United Kingdom

Soil water content (SWC) dynamics can strongly influence catchment runoff generation processes. Knowledge about the amount and spatiotemporal distribution of SWC at the catchment scale can be useful for constraining and evaluating rainfall-runoff models. While it is still challenging to obtain catchment scale-representative measurements of SWC, recent advances in cosmic ray neutron sensor (CRNS) technology have provided opportunities to obtain hectare scale data on SWC. Here we present a new method for obtaining spatially variable near-surface SWC by combining a high temporal resolution static CRNS sensor with 'snapshot' surveys using a portable CRNS. We also explored the role of these soil water storage data for catchment in rainfall-runoff generation models. We used ~4-years of near-surface SWC data from a static CRNS located in a humid mixed-agricultural catchment (~10km^2) in Scotland. These data were complemented with at least three 'snapshot' portable CRNS surveys in each of the four main soil-land use (SLU) units in the catchment to produce SWC timeseries for each of these units. Two SLU units involved rotational crops under poorly or imperfectly draining mineral soils; one SLU unit typically supports livestock farming on freely draining mineral soils and the fourth, moorland on organic-rich soils. While the moorland SLU unit on organic soils had the greatest difference in SWC dynamics under the static CRNS and other SLUs, we also found subtle SWC differences between mineral soil SLU units under different agricultural management. We then evaluated the additional information generated by the combined CRNS method in a rainfall-runoff model (HBV-light) calibration of dynamic catchment storage. For the purpose, we used areal weighted SLU SWC timeseries and compared the model calibration to that using the static CRNS alone. In this case, differences were marginal and model efficiencies similar, suggesting that static CRNS data from a landscape-representative location may be sufficient to inform rainfall-runoff model calibration at the catchment scale. However, this may depend on model structure and the degree to which SWC dynamics vary within the landscape. This study demonstrated the potential of expanding the information value of permanently installed CRNS sensors using portable CRNS surveys in the context of humid mixed-agricultural environment, although testing in different environments

would be required to evaluate wider applicability.