



Accuracy of soil water content estimates from gamma radiation monitoring data

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Terrestrial gamma radiation is known to be sensitive to soil water content, and could be promising for soil water content determination because of the availability of continental-scale gamma radiation monitoring networks. However, the accuracy of soil water content estimates that can be obtained from this type of data is currently unknown. Therefore, the aim of this study is to assess the accuracy of soil water content estimates from measured time series of gamma radiation. For this, four gamma radiation monitoring stations were each equipped with four soil water content sensors at 5 and 15 cm depth to provide reference soil water content measurements. The contributions of terrestrial radiation and secondary cosmic radiation were separated from the total amount of measured gamma radiation by assuming that the long-term contribution of secondary cosmic radiation was constant, and that variations were related to changes in air pressure and incoming neutrons. In addition, precipitation effects related to atmospheric washout of radon progenies to the ground that cause an increase of gamma radiation were considered by excluding time periods with precipitation and time periods less than three hours after precipitation. The estimated terrestrial gamma radiation was related to soil water content using an exponential function with two fit parameters. For daily soil water content estimates, the goodness of fit ranged from $R^2 = 0.21$ to 0.48 and the RMSE ranged from 0.048 to $0.117 \text{ m}^3\text{m}^{-3}$. The accuracy of the soil water content estimates improved considerably when a weekly resolution was used (RMSE ranged from 0.029 to $0.084 \text{ m}^3\text{m}^{-3}$). Overall, these results indicate that gamma radiation monitoring data can be used to obtain useful soil water content information. The remaining differences between measured and estimated soil water content can at least partly be explained by the fact that the terrestrial gamma radiation is strongly determined by the upper few centimeters of the soil, which may not be well represented by the reference soil water content measurements at 5 and 15 cm depth due to near-surface gradients in water content associated with precipitation events, textural variation, and the presence of litter layers.