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Predicting sub-grid variability of soil water content from basic soil information

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Knowledge of unresolved soil water content variability within model grid cells (i.e. sub-grid variability) is important for accurate predictions of land-surface energy and hydrologic fluxes. Here, we derived a closed-form expression to describe how soil water content variability depends on mean soil water content using stochastic analysis of 1D unsaturated gravitational flow based on the van Genuchten-Mualem (VGM) model. A sensitivity analysis of this closed-form expression showed that the n parameter strongly influenced both the shape and magnitude of the maximum of this relationship. In a next step, the closed-form expression was used to predict soil water content variability for eight datasets with varying soil texture using VGM parameters obtained from pedotransfer functions that rely on readily available soil information. Generally, there was good agreement between observed and predicted soil water content variability despite the obvious simplifications that were used to derive the closed-form expression (e.g. gravity flow in dry soils). A simplified closed-form expression that neglected the effect of pressure head fluctuations showed that the good performance in the dry soil range is related to the dominant role of the variability in MVG parameters determining water retention as compared to the effect of water flow. Furthermore, the novel closed-form expression was successfully used to inversely estimate the variability of hydraulic properties from observed data on soil water content variability from several test sites in Germany, China and Australia.