Geophysical Research Abstracts
Vol. 21, EGU2019-13853-1, 2019
EGU General Assembly 2019

Spatial and temporal dynamics of soil moisture in benchmark soils of the Guinea savannah zone of Ghana - is there an unused potential for food-crop production?

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The demand for increased crop production and food security in arid and semi-arid landscapes of Africa implies the need for adopting sustainable drought-adaptation measures by subsistence smallholder farmers. The efficiency of these adaption measures strongly relies on local soil moisture (SM) conditions. However, spatio-temporal SM information is still missing in large areas of semi-arid Africa. Hence, the challenge to cope with long dry-spells and the implementation of drought-adaptation measures have yet remained unresolved. In this paper, we report spatio-temporal SM variability, measured over one dry season in the Guinea savannah zone of Ghana. Through this work, we aimed at assessing the potential of certain soils to provide enough SM for utilizing also part of the dry season for crop production, in order to satisfy the demand for increased crop production. We measured SM at six soil depths (0-100 cm) of 34 soil profiles, representing seven key benchmark soil types. For each soil profile and depth, we analysed gravimetric SM, bulk density (BD) and particle size distribution. In addition, we measured SM with a calibrated PR2/60 moisture probe at 12-day intervals from February to June 2018. We analysed the influence of internal factors such as BD, clay and silt content, and external factors such as slope, topographic wetness index, antecedent precipitation index (API) and evapotranspiration (ET_o). Multi-factor relationships, as well as direct and indirect interactions between SM and the internal/external factors were also analysed. Using a set of linear mixed-effect models, we built a relationship between the spatial and temporal dimensions in explaining SM variability. SM was low only in the sandy upper parts of the soils ($\leq$ 10 cm). In the lower parts of the soils ($\geq$ 20 cm), clay content increased with soil depth, and SM was kept for longer periods. Internal factors had stronger influence on SM variability than external factors. Clay and silt content accounted for 91% of SM variability, while BD accounted for 11%. ET_o was about three times the daily mean precipitation. Temporally, ET_o influenced SM only in the sandy top soils and showed a strong negative relationship with SM (R^2 = 0.77). API strongly influenced SM at $\geq$ 20 cm soil depth, exhibiting a strong positive relationship with SM (R^2 = 0.83). The lowest SM (found at all soil depths) occurred in the beginning of March, whereas the highest SM occurred in the end of April. The main outcome of this work is that almost all soil types in the study area (except for the Kumayili soil series) below 10 cm depth have soil water storage potentials that match the water requirements of at least some drought-tolerant crops ($>$ 9 mm day^{-1}). We conclude that most benchmark soils of the area hold the potential for implementing a dual farming system that can enhance agricultural productivity and increase the income of local farming communities.