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Effects of biotic and abiotic indices on long term soil moisture data in a grassland biodiversity experiment

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Soil moisture is the dynamic link between climate, soil and vegetation and the dynamics and variation are affected by several often interrelated factors such as soil texture, soil structural parameters (soil organic carbon) and vegetation parameters (belowground- and aboveground biomass). For the characterization and estimation of soil moisture and its variability and the resulting water fluxes and solute transports, the knowledge of the relative importance of these factors is of major challenge for hydrology and bioclimatology. Because of the heterogeneity of these factors, soil moisture varies strongly over time and space. Our objective was to assess the spatio-temporal variability of soil moisture and factors which could explain that variability, like soil properties and vegetation cover, in in a long term biodiversity experiment (Jena Experiment).

The Jena Experiment consist 86 plots on which plant species richness (0, 1, 2, 4, 8, 16, and 60) and functional groups (legumes, grasses, tall herbs, and small herbs) were manipulated in a factorial design Soil moisture measurements were performed weekly April to September 2003-2005 and 2008-2013 using Delta T theta probe. Measurements were integrated to three depth intervals: 0.0 – 0.20, 0.20 – 0.40 and 0.40 – 0.70 m.

We analyze the spatio-temporal patterns of soil water content on (i) the normalized time series and (ii) the first components obtained from a principal component analysis (PCA). Both were correlated with the design variables of the Jena Experiment (plant species richness and plant functional groups) and other influencing factors such as soil texture, soil structural variables and vegetation parameters.

For the time stability of soil water content, the analysis showed that plots containing grasses was consistently drier than average at the soil surface in all observed years while plots containing legumes comparatively moister, but only up to the year 2008. In 0.40 – 0.70 m soil deep plots presence of small herbs led to higher than average soil moisture in some years (2008, 2012, 2013). Interestingly, plant species richness led to moister than average subsoil at the beginning of the experiment (2003 and 2004), which changed to lower than average up to the year 2010 in all depths. There was no effect of species diversity in the years since 2010, although species diversity generally increases leaf area index and aboveground biomass.

The first component from the PCA analysis described the mean behavior in time of all soil moisture time series. The second component reflected the impact of soil depth. The first two components explained 76% of the data set total variance. The third component is linked to plant species richness and explained about 4 % of the total variance of soil moisture data. The fourth component, which explained 2.4 %, showed a high correlation to soil texture.

Within this study we investigate the dominant factors controlling spatio-temporal patterns of soil moisture at several soil depths. Although climate and soil depths were the most important drivers, other factors like plant species richness and soil texture affected the temporal variation while certain plant functional groups were important for the spatial variability.