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SOIL HYDRIC REGIMES UNDER CLIMATE CHANGE SCENARIOS IN CZECH REPUBLIC

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Abstract. The present contribution summarizes potential impacts of climate change on hydric regime in Central Europe (Czech Republic and northern part of Austria). We used model SoilClim, which allows for the daily assessment of soil climate regimes rather than a monthly time step. The model is used to estimate the soil climate regimes under present climate conditions and compares the results with selected soil climate dependent soil characteristics. In the next step the model is used to estimate soil climate regimes under expected climate conditions. The assessment of the future change of hydric soil regimes under climate change scenarios indicates a serious challenge for both regions.

Introduction

Soils form and continually change, at different rates and along different pathways, they continually evolve and are never static for more than short period of time and because of this perpetual evolution we will likely never fully understand the complex patterns of the Earth´s soils (Schaetzel et al., 2005). The moisture regime of a soil was by (Soil Survey Staff, 1999) described as an important property of the given soil as well as a determinant of processes that can occur in it. It is clear that the soil moisture regime is only partially a function of climate. Most deep, permeable soils under high and well distributed rainfall have water that is available to plants most of the time. Soils in areas of an arid climate, however, are not necessarily dry. They may be dry, moist, or saturated, depending on their position on the landscape, because they may receive water from sources other than the rain that falls on them. The extra water may be runoff from rainfall on an adjacent slope or on distant mountains, or it may come from melting snow, seepage, or even natural artesian sources. Soils may also lose part, or most of, the water that falls on them, particularly if they are sloping and the surface horizon has few noncapillary pores. On any given landscape that has a uniform climate, adjacent soils may have different moisture regimes. Each of the moisture regimes in the history of a soil is a factor in the genesis of that soil and is the cause of many accessory characteristics. Most of the accessory characteristics, however, and those most important for interpretations are associated with the present moisture regime, even if the present regime differs widely from some of the earlier regimes. More importantly, the present climate determines use and management of the soil.

Data and methods

The soil hydric (moisture) regime describes the presence or absence of soil water held at a tension of <1500 kPa (or between field capacity and permanent wilting point) in specific horizons during a defined period of the year (Waltman et al., 1997). According to the algorithms defined by Waltman et al. (1997) soil hydric regimes are derived from water content in the moisture control sections (MSC). The soil climate is determined not only by the proportion of time during which soil layers stay moist or dry, but also by the occurrence of prolonged episodes of drought as well as climatological water balance (difference between precipitation and reference evapotranspiration ETr) during the warmest months (June-August) and for the whole year. The Central European case study covers the territory of the Czech Republic along with the upper and lower regions of Austria, which are represented by 129 weather stations (Fig.1) provided by the Czech Hydrometeorological Institute and Austrian Weather Service. As the aim of the study was to explore long-term characteristics of the soil climate, a high number of annual series was required. Therefore, observed data were used to train the stochastic weather generator M&rfi (Dubrovský, 2007), and for each site, a 600-year stochastic weather series of the daily sum of global radiation, maximum and minimum temperatures, gross precipitation, daily mean air humidity and wind speed was prepared for present and expected climate according to used climate change scenarios (MPH5 (Max-Planck-Institut for Meteorology, Germany), HadGEM (UK Met. Office, UK), a CSMk3 (Australia's Commonwealth Scientific and Industrial Research Organization, Australia). Then the SoilClim model was run for a continuous period of 600 years with the first 100 years used for "spinning-up"and initializing the model. The soil conditions were derived based on a 1:1,000,000 FAO map of soil types complemented by a 1:250,000 soil map of the Czech Republic (Tomášek, 2007) 1:25,000 soil map of Austria (Murer, 2007). The terrain was represented by the digital elevation model derived from the Shuttle Radar Topography Mission in 2007. Land-use data were based by on the Corine land cover layer CLC2000-9/2007 (EEA, Copenhagen, 2007). The SoilClim model (Hlavinka et al., 2010) was used to determine soil moisture regimes at all weather stations and for all soil classes represented by retention capacity (Fig. 1-2). The results were interpolated using a co-kriging method (ArcInfo 9.3) and then visualized according to the soil conditions as individual grid cells. The winter C3 crop was considered as the „cover"crop within the Central European domain.

Results and disscussion

Under present climate conditions (Fig. 3) the region is dominated by rather "wet" soil regimes and are defined as Dry Tempudic (42.5%), Subhumid Udic (22.7%) and Perudic (30.3%). Perudic areas are dominated by evergreen forests and permanent grasslands, while in Dry Tempudic and Subhumid Udic areas arable land is primary type of land-use. All three dominant regimes will be greatly reduced or diminished under future climate scenarios (Fig. 3) with Perudic regimes almost gone by 2100 under all scenarios. Instead, much drier Typic Tempustic dominates soil climate in the region.

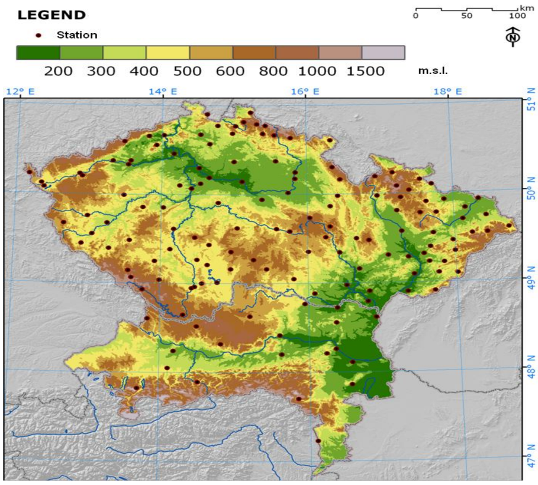

Fig. 1: Location of meteorological stations and altitude of interest area

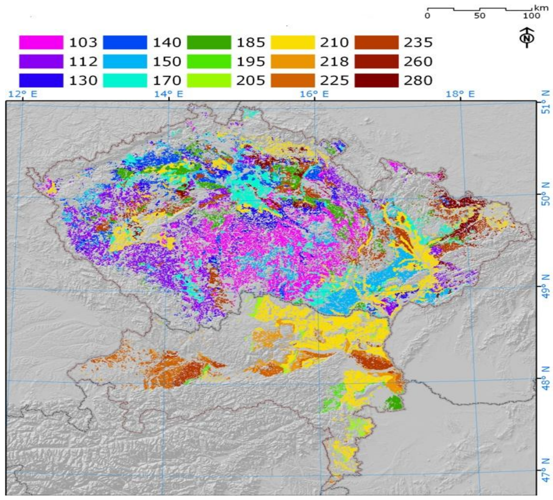

Fig. 2: Soil retention capacity (mm)

If the present land-use patterns are preserved then the majority of arable land would be situated within a Dry Tempustic soil climate regime (that in general requires additional irrigation in order to use the full production potential of the site). Similarly areas covered by evergreen forests (mostly spruce) will experience shifts from Perudic and Dry Tempudic regime to Temustic and even Xeric soil climate regime that will inevitably lead to profound changes in the forest composition.

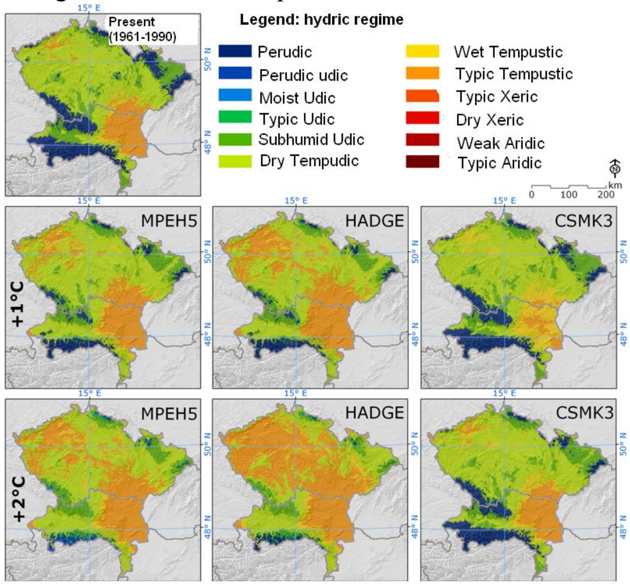

Fig. 3: Estimated hydric regimes (USDA classification) of soils in the period 1961-1990 (present) situation and to increase global temperatures by +1°C and +2°C according to selected climate change scenarios

Conclusions

These results illustrate that identification of feasible adaptation options (especially those requiring structural changes and large investments) over case study region would be met with difficulty due to the overall uncertainty in the magnitude and even the tendency of the changes. The results also highlight the potential shortcomings of using only one GCM as an adaptation strategy based on one particular scenario, which might prove to be ill advised.

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