CHANGES IN THE SOIL MOISTURE REGIME IN LOWLAND BASIN EVALUATED FROM DATA REPRESENTING CURRENT AND FUTURE CLIMATIC CONDITIONS

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The specific objective of this study was to investigate the differential response of soil moisture to climate change in a typical lowland basin located on the Mazovian Lowland in central Poland. The focus was on (1) the soil water storage evolution that has occurred in the past decades as well as on (2) the shifts in the soil water regime induced by shifts in climatic conditions. Seasonal characteristics of soil water storage and long term trends have been analyzed both for current and future conditions. The study was facilitated by different data sets. The high-quality data set of extensive in-situ soil moisture records in the Lasica basin covering the ten-year period (1995-2004) was used as a benchmark for the following data acquired from other sources:

– the soil moisture reanalysis data expressed as volumetric water content, available from the National Centers for Environmental Prediction/National Center for Atmospheric Research (NCEP/NCAR) that are part of the US-NOAA (Kistler *et al.,* 2001);
– the soil water storage data expressed in mm, simulated with the Global Land Data Assimilation System (GLDAS) in years 1979-2006 (Rodell *et al.*, 2004);
– the soil moisture data expressed as volumetric water content, available from the World Climate Research Programme's (WCRP's) Coupled Model Intercomparison Project phase 3 (CMIP3) multi-model data set; collection of recent model outputs for present-day control experiment as well as for SRES experiments. Outputs from ECHAM5 model were analyzed, as this model is one of those recently identified as effectively representing atmospheric circulation in Europe (Seneviratne *et al.*, 2006). Besides, it has the capability to capture relatively well the observed soil moisture patterns (Li *et al.*, 007). This data has a coarse resolution and regional effects are poorly taken into account, so it has served only as a background for the analysis.

Thus additionally ensemble simulations over Europe with the Regional Climate Model CLM were used in this study. They have been available on the geographical grid (0.2°) since December 2007 from Model and Data group, Max Planck Institute for Meteorology, Hamburg, Germany.

Among different hydrological variables, soil moisture is of special importance as it controls exchange processes between soil, vegetation and atmosphere. Temperature increases and changes in precipitation can have significant impact on terrestrial ecosystems through changes in soil moisture. Decreased soil moisture under higher temperature may limit terrestrial ecosystems productivity and it may drive vegetation evolution. Changes in soil moisture regime can also significantly influence the generation of stream flow. For these reasons, the investigations of possible effects of climatic change on soil moisture are recently often subject to ongoing research (e.g. Yang *et. al.* 2003, Jasper *et. al.* 2006).

The Fourth Assessment Report of the Intergovernmental Panel on Climate Change states that "…continued greenhouse gas emissions at or above current rates would cause further warming and induce many changes in the global climate system during the 21st century that would very likely be larger than those observed during the 20th century" (IPCC Climate Change, 2007). By the end of 21st century, further increase of the global average surface temperature is expected by about 1.8–4.0°C, if emissions are within the range of the SRES scenarios. Along with the increase of temperature, most General Circulation Models predict a precipitation change. In northern Europe (48N, 10W-75N, 40E) the annual change from 1980-1999 related to 2080-2099 in the A1B projections varies from 0 to 16% (IPCC, 2007, Table 11.1). In central Poland the changes are expected to be within the range 0-10% annually, 5-10% in winter months (December, January, February) and from 0 to -5% for summer months (June, July, August), (IPCC, 2007, Figure 11.5).

However, the question if the hydrological cycle is accelerating and what consequences of this acceleration could arise for soil water regime, still remains not fully answered. Accurate estimates of soil moisture are difficult to obtain even for present conditions. This is due to high variability of soil moisture in time and space. In recent discussion on the operational readiness of microwave remote sensing of soil moisture for hydrologic application it was concluded that research methods are still urgently needed to improve both the accuracy of the remotely sensed data and their assimilation into hydrological applications (Wagner *et al.*, 2007). Operational products at 25-50 km scale can be expected within the next few years, while technological breakthroughs are still needed for products at finer scale (< 1 km).

In this study the possible changes in soil moisture regime were investigated. Soil water storage is characterized by the soil water depth or alternatively by the effective relative soil moisture (dimensionless parameter). The effective relative soil moisture is defined in this study as $X=(s-s_w)/(s_{fc}-s_w)$, where s – relative soil moisture (-/-), s_{fc} – relative soil moisture at field capacity (-/-), s_w – relative soil moisture at wilting point (-/-). Relative soil moisture s can be expressed as $s=\theta_v/n$, where: θ_v – fractional volumetric soil moisture, n – porosity. Thus, the effective relative soil moisture, which is dimensionless, can be alternatively expressed as $X=(\theta_v-\theta_{min})/(\theta_{max}-\theta_{min})$, where θ_{min} – minimum volumetric soil moisture, corresponding to wilting point and θ_{max} – maximum volumetric soil moisture, corresponding to field capacity. Effective relative soil moisture represents soil moisture averaged over the depth giving an insight into average wetness conditions present in the soil. Using this dimensionless parameter long-term monthly mean values have been evaluated for selected periods of 20th and 21st century. Monthly mean values of X for the years 1961-1990 were compared with values projected for the years 2070-2099. Values representing current and future conditions are denoted respectively by X_{CTL} and X_{SCEN}.

The major findings are: (1) long term variability of X_{CTL} in the second half of the 20th century shows slight upward tendency, however in last two decades decreasing values of the soil water storage correspond to increasing values of evaporation, as evaluated from GLDAS data, (2) long term variability of X_{SCEN} in the second half of the 21st century shows downward tendency, (3) the simulated future changes for SRES A2 scenario suggest an enhancement of the seasonal cycle of X parameter, with considerably drier conditions in summer months. The amount of available water is projected to decrease, as evaluated by the difference (X_{CTL} - X_{SCEN}) on a monthly base.

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