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METHODOLOGY FOR ASSESSMENT OF DROUGHT EPISODES UNDER PRESENT AND EXPECTED CLIMATE CONDITIONS

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Summary:

Drought is a common feature of the climate that has had significant impacts on economy and life of many parts of the world, including Czech Republic in recent decades. Whilst some parts of European Union as e.g. Mediterranean region, are strongly affected by the arid character of the climate itself, Central Europe is often faced with so called "green" droughts episodes. By its nature agriculture in this region is to great extend depended on the moisture from precipitation and thus susceptible to the occurrence of prolonged dry events especially during growing season. With the projected global temperature increase, it is generally agreed that the global hydrological cycle will intensify and the extremes will become or have already become more "common". The seasonal distribution of precipitation is expected to be altered as well. The presented poster will describe an innovative approach for comparing frequencies and statistical characteristics of drought episodes assessed by various methods under present climate derived from 1961-2000 baseline with those under the climatic conditions expected in 2030-2069 and 2060-2099. The effectiveness of the new methodology will be demonstrated on the observed and generated weather data series originating from 45 stations in the Czech Republic.

Abstrakt

Sucho je nedílnou součástí klimatu s výrazným dopadem jak na ekonomiku, tak i živé organismy v mnoha částech naší planety včetně České republiky. Zatímco některé části Evropy jako např. její jižní oblasti jsou samy o sobě silně aridního charakteru, je oblast střední Evropy často konfrontována s tzv."zelenými" epizodami sucha. Povaha zemědělství v tomto regionu je výrazně závislá na srážkové činnosti z pohledu jejího množství a distribuce a tím i mimořádně citlivá k výskytu epizod sucha zejména ve vegetačním období. S předpokládaným nárůstem teploty v rámci změny klimatu jsou všeobecně očekávány změny hydrologického cyklu ve smyslu jeho intensifikace doprovázené výskytem extrémních meteorologických událostí. Součástí těchto změn je zvýšený výskyt suchých period jako doprovodného jevu v distribuci srážek. Příspěvek popisuje novou metodiku srovnání četností a vybraných statistických charakteristik suchých epizod, které jsou posuzovány dvěma metodami pro současné klima (1961-2000) a klima očekávané v standardně vymezených časových hranicích. Metodologie je demonstrována na pozorovaných a generovaných datech z 45 stanic v České republice. Obě metody založené na mezinárodně uznávaných indexech SPI a PDSI jsou schopny posoudit počet měsíců, ve kterých se vyskytlo meteorologické sucho. Pro popis změněného klimatu bylo využito pět Globálních cirkulačních modelů jejichž parametry byly použity pro konstrukci syntetických meteorologických řad pro stanovení počtu suchých měsíců pro současné klima 1961-2000 a pro letní měsíce v časovém horizontu 2060-2099.

Introduction

Drought is a common feature of any climate that has had significant impact on economy and life of many parts of the world, including Eastern and Central Europe, in recent decades (Smith et al., 1996). Whilst some parts of the European Union as e.g. Mediterranean region, are strongly affected by the arid character of the

climate itself, Central Europe is often faced with so called "green" drought episodes. By its nature agriculture in this region is to a great extend depended on the moisture from precipitation and thus susceptible to the occurrence of prolonged dry events especially during growing season. With the projected global temperature increase, it is generally agreed that the global hydrological cycle will intensify and the weather extremes including drought will become or have already become more common. Although the recent occurrence of droughts in Central Europe (e.g. in 2000 or 2003) in these regions cannot be linked directly with human-induced climate change, the impacts of these drought events indicated the vulnerability of this area to the drought.

Material and methods

Out of four types of drought that are generally recognized (Heim 2002) we focused our attention on meteorological drought, which precedes the onset of the remaining three types i.e. agricultural, hydrological and socio-economic. As no drought definition is presently recognized as standard in the Czech Republic we used two drought indices i.e. *Standardized Precipitation Index* (SPI) (McKee *et al.,* 1993) and *Palmer Drought Severity Index* (PDSI) (Palmer, 1965) in order to quantify this extreme weather phenomenon. While the first index is based solely on precipitation data, the second one requires also temperature and characteristics of the soil profile. We have modified the calculation algorithms of both indices so they could be applied for the climate change studies. The core of the modification was in incorporation of a procedure relating the index parameters to the predefined time range (i.e. 1961-2000). This form of indices (called *relative SPI or PDSI*) then allowed comparing drought occurrence under expected climate conditions with the present state. At first step the values of the SPI and PDSI were derived for the present climatic conditions at 45 stations in the Czech Republic. The figures 1a and 1b represents the number of drought episodes at the 45 stations during period 1961-2000 as captured with the help of the *relative SPI or PDSI* methodology.

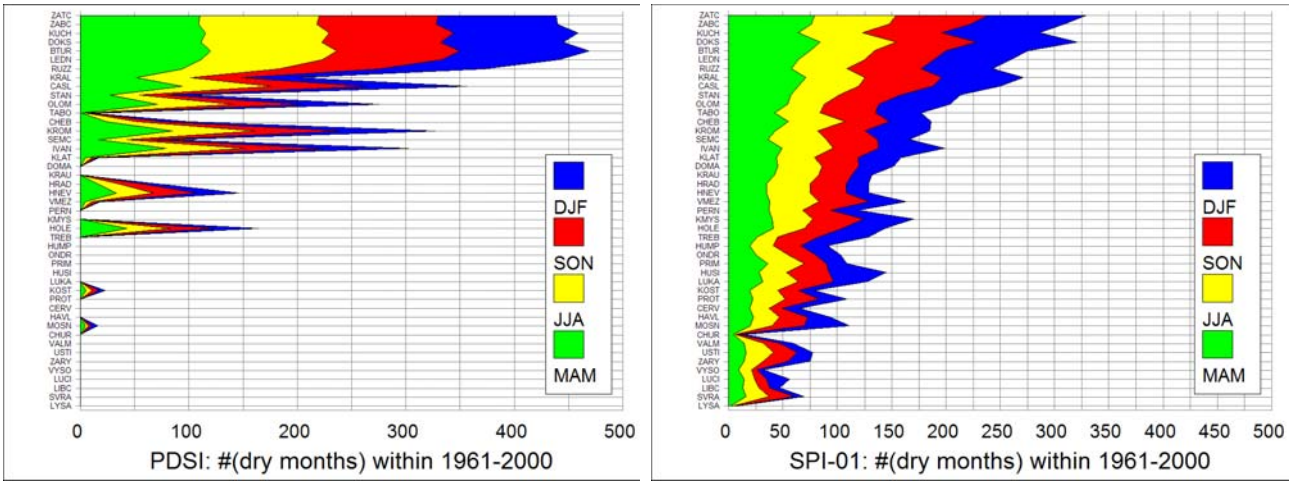

Fig 1: The number of dry months during four meteorological seasons at 45 Czech stations with range of altitude 153-1322 m (vertical-axis) within 1961-2000 period as predicted by relative PDSI (a) and SPI (b) drought indices. *The stations are sorted according to the altitude from top (highest) to the bottom of the charts!*

In the following step five Global Circulation Models (GCMs) were used in order to estimate climate parameters for all weather stations and two SRES emission scenarios (i.e. B1 and A2) for the time slices of 2030-2069 and 2060-2099. Shifts of the drought indices values were calculated for individual sites and compared with the results obtained under the present climatic conditions.

Results and discussion

Overview of the results of PDSI and 1-month SPI calculations for the period 2060-2099 is presented at the Fig. 2a-b. As it is apparent from both charts the number of dry months during summer (June-August) will likely increase at all stations compared to the present state. According to the PDSI almost all lowland stations will experience drought (in the terms of 1961-2000 climate) during all summer months as the direct consequence of increased temperature and decreased precipitation (which are consistently predicted by all GCMs). Marked increase of drought episodes is depicted also in the higher altitudes especially by the PDSI, as the relatively low soil water holding capacity of these sites is taken into account by the index. Results of both indices for winter months are contradictory with SPI showing decrease of drought episodes from December to February and PDSI showing significant increase of the drought events number. The different perception of winter droughts is related to the SPI focus only on precipitation. It is however obvious that marked deterioration in water availability during summer and high probability of drought will be inherent property of vegetation seasons (in the present understanding) during the second half of this century unless necessary actions in curbing carbon dioxide emissions are taken. Such an increase of drought events would negatively influence sustainability of the presently used farming systems and probably will be compensated only partly by positive effect of increased ambient carbon dioxide concentration on the water use efficiency of the crops and other plants in the landscape.

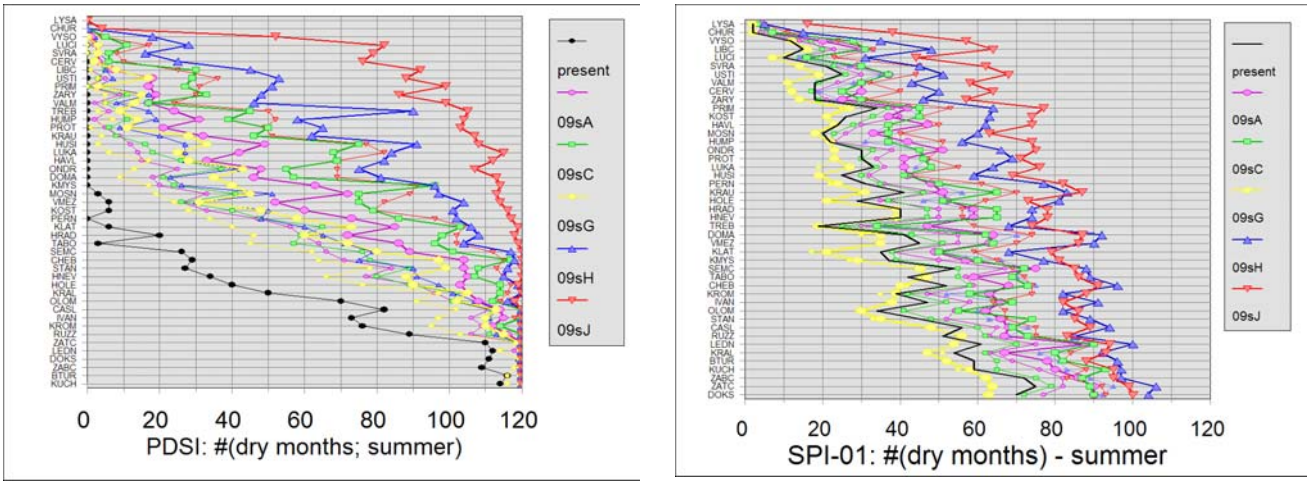

Fig 2: The number of dry months during summer at 45 Czech stations with range of altitude 153-1322 m (vertical-axis) within 2060-2099 period as predicted by relative PDSI (a) and SPI (b) drought indices using 5 GCM scenarios and A2 SRES emission fulfillment. *Legend:* Present: # of dry months in 1961-2000; 09sA-CSIRO; 09sC-CGCM2; 09sG-GFDL30; 09sH-HadCM3; 09sJ-CCSR/NIES; *The stations are sorted according to the altitude from top (highest) to the bottom of the charts!*

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