

SHORT-TERM SCIENTIFIC MISSION

SCIENTIFIC REPORT

COST Action Number: 734

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Period: from 16/08/2008 to 16/09/2008

Place: Lincoln (US)

Reference code: COST-STSM-734-03831

Introduction and objectives of the STMS: The ongoing climate change is not only altering the weather conditions for the crop growth but inevitably also long-term regimes of soil water content and soil temperature i.e. key elements of the soil climate. These changes do and will have pronounced impact on the key soil process (organic matter accumulation, nitrogen cycle or soil microorganisms) but also on the seasonal productivity of the soil as soil moisture (and partly also temperature) are key determinants of the potential productivity of the given site together with other meteorological elements. The Mendel University of Agriculture and Forestry in Brno in close collaboration with the several other institution (including e.g. Czech Hydrometeorological Institute and University of Applied Life Sciences in Vienna) have been developing a tool able to model climate driven changes of hydric and thermic regimes of any soil. The SoilClim model could be efficiently tested only at the areas where high quality measurements of soil parameters (i.e. temperature and water content) and weather elements (air temperature, global radiation, precipitation, air humidity and wind speed) are available. Such sites are relatively scarce in Central Europe and in most cases they provide us only with several years of observations. National Drought Mitigation Centre in cooperation with the High Plain Climate Centre (both are parts of School of Natural Resources at the University of Nebraska) oversee large network of automatic and climatic weather stations that provide up to 25 years of daily data of all necessary parameters together with great deal of expertise in the area of water balance and agricultural drought impacts. The objective of this mission was therefore to test the model performance under the climate conditions that might be occurring in Central Europe within next decades (i.e. significantly warmer and drier conditions), to use the knowledge to estimate impact of these soil climate changes on agriculture and also carry out analysis of climate change impacts on the soil climate in High Plains region of US.

Methods.

Soils are an important control on water fluxes in the landscape and in many parts of the world act as the most important water reservoir mitigating the effects of rainfall variability. Soil

moisture and temperature parameters as well as so called hydric and thermic soil regimes are inherently more stable and quantifiable than their atmospheric counterparts and are essential in determining the environmental conditions of any region. SoilClim is based on an enhanced daily water balance model that incorporates interactions between the soil and atmosphere through a dynamic module of vegetation cover. In addition, a snow cover effect on the water balance (through freezing and thawing), as well as on the soil temperatures, is taken into account as well as the effect of CO₂ concentration on the evapotranspiration.

To validate the SoilClim performance data from the High Plains Climate Centre weather station network (covering Nebraska, Colorado, Iowa, Kansas, North Dakota, South Dakota and Wyoming) were analyzed and those sites with more than 5 years of high quality data were used for further evaluation. The performance of SoilClim model (i.e. ability to estimate soil water content in the rooting zone and soil temperature) was compared with the observations. In total 10 sites with soil temperature measurements and 19 stations with soil moisture measurements were used for the final test. In addition the performance of snow cover model was tested at 5 sites. Brief overview of the results is included in the attached file Figures.pdf (slide 6). The results of the model performance in the region were compared with available results from Czech Republic (8 sites) and Austria (4 sites). In the next step the SoilClim was run at 60 sites in the High Plain region for the present and expected climate conditions (driven by selected SRES scenarios and GCM model runs). The position of the weather stations and scenarios selected are presented at slides 7-11. The impact of climate change on the soil moisture regime and soil temperature and overall soil climate were analyzed and are partly presented in the Figures.pdf both in the forms of charts and digital maps (slides 12-42). The impact of climate change was studied using comparison of SoilClim outputs based on the present climate calculations and set of downscaled global circulation models (based on 4th Assessment Report) under various emission scenarios (e.g. SRES A2 and B1) and time horizons (2025, 2050 and 2100). The results are presented for selected sites representing U.S. High Plains region and for 5x5 km grids.

Results:

The overall results indicated that SoilClim is able to represent soil moisture variability on annual and monthly scales across range of sites through the High Plains regions (as well as in Central Europe) and is able to explain up to 70% of inter-monthly soil moisture variability. It is also able to depict seasonal characteristics of snow cover presence/absence as well as correctly simulate forming and melting of the snow cover. The soil temperature at 50 cm was also well reproduced by the model especially in terms of longer term variability (months – season).

The spatial assessment of soil climate parameters indicates that the U.S. High Plains are presently sandwiched between presently semi-arid and arid regions adjacent to the Rocky Mountains and relatively wet regions to the east, which is reflected in east/west gradient of soil climate parameters. According to the projections based on the NCAR-PCM global circulation

model a considerable improvement of water availability in the U.S. High Plains, translating into a longer biological window across the Nebraska and most of U.S. High Plains is to be expected. It should be accompanied by only moderate increase of soil temperature and shift of soil hydric regimes toward more wet categories. Meanwhile, the HadCM-based projections show a very different pattern indicating significant drying of the region in the west, with eastern part of U.S. High Plains remaining relatively wet. As the result the east-west soil climate gradient becomes much more pronounced over Nebraska with the western part sliding toward aridic soil climate and eastern maintaining its udic character. In the case of the HadCM (and also partly in the ECHAM-based projections), the rate of the change of the soil climate characteristics is alarming, taking place within decades rather than centuries and is much more pronounced compared to NCAR. The results illustrate that identification of feasible adaptation options (especially those requiring structural changes and large investments) over the U.S. High Plains would be met with difficulty due the overall uncertainty in the magnitude and even tendency of the changes. The results will also highlight the potential shortcomings of using only one GCM as the adaptation strategy based on one particular scenario might prove to be disastrous.

Conclusions

- 1) SoilClim model that was previously evaluated under the conditions of Central Europe (from lowlands to Alpine grasslands) has been now tested in the High Plain region (from relatively wet areas Iowa to arid conditions of eastern Colorado);
- 2) SoilClim model was run for the present and expected climate conditions (2020, 2050 and 2100) for the Central US as well as the Central Europe (Czech Republic and Austria);
- 3) The findings of the study were submitted to the AGU 2008 Fall meeting (December, San Francisco) and to Climate Change congress (Copenhagen, March, 2009).
- 4) Manuscript that is under preparation is going to be submitted to one of the leading international journal dealing with Climate Change by spring 2009;
- 5) Calibrated and evaluated model for assessment of the soil climate and its change made available to COST 734 members – by February 2009 including trial data.

Planned cooperation:

Helped by the STSM the cooperation on the field of SoilClim application is going to continue between both Mendel University and NDMC. The preparation of a EU funded fellowship proposal under the Marie Currie program is being presently discussed between the NDMC director and Dr. Trnka. NDMC is going to support COST 734 action with its expertise on drought through joint research papers and participation at the workshops.