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SUMMER DROUGHT ANALYSIS ACROSS ROMANIA BASED ON REGCM SIMULATIONS

Boroneanț, C.[1], M., Caian[2], L. Vasile[3], S. Cheval[4], C. Ilie[4], J. R. Coll[1]

[1]Centre for Climate Change (C3), Geography Department, University Rovira I Virgili, Campus Terres de l'Ebre, 43500 Tortosa, Spain, e-mail: constanta.boroneant@urv.cat; joanramon.coll@urv.cat
[2]Rossby Centre, SMHI, Folkborgsvägen 1, S-601 76 Norrköping, Sweden, email: mihaela.caian@gmail.com
[3]Institute of Mathematical Statistics and Applied Mathematics of Romanian Academy, Calea 13 Septembrie 13, 050711 Bucharest, Romania, e-mail: vsl@fmi.unibuc.ro
[4]National R&D Institute for Environmental Protection, 294 Splaiul Independentei, 060031 Bucharest, Romania, e-mail: sorin.cheval@incdpm.ro; codrinamariailie@gmail.com

INTRODUCTION

Drought is typically defined in terms of its links to meteorology, hydrology, agriculture and society. Efforts to assess possible changes in drought characteristics under global warming scenarios are still limited by uncertainties in how the various components of the atmospheric hydrological cycle respond to a warmer climate. However, coupled climate models used in the IPCC AR4 project increased aridity in the 21st century over most of the global land including southern Europe (Meehl et al., 2007, Dai, 2011). Regional climate models, run at high resolution, could be a better solution for prediction of drought on seasonal to decadal scales.

Two most commonly used metrics to identify meteorological dry and wet spells are the **self-calibrating Palmer Drought Severity Index** (scPDSI) (Wells *et al*., 2004), an improvement of the Palmer Drought Severity Index (PDSI) (Palmer, 1965), and the **Standardized Precipitation Index (SPI) (**Edwards and McKee, 1997). The computation of the PDSI involves a classification of relative soil moisture conditions within 9 categories (Palmer,1965) (Table 1). The index is based on the balance between water supply and demand, which is calculated using a rather complex water-budget system based on historical records of precipitation and temperature, with the soil characteristics of the site being taken into account. The SPI calculation for any location is based on the long-term precipitation record (at least 30 years). This long-term record is fitted to a probability distribution, which is then transformed into a normal distribution (Edwards and McKee 1997). The SPI values are classified into 7 classes (Edwards and McKee, 1997) (Table 2).

In this poster we present the results of the analysis of the self-calibrating Palmer Drought Severity Index (scPDSI) and the Standardized Precipitation Index (SPI) over Romania in relation with climate variables such as temperature, precipitation and evapotranspiration. The scPDSI and SPI indices have been calculated from monthly data simulated by the regional climatic model RegCM3 developed by the Earth System Physics section of the ICTP, Italy. The RegCM simulations over Romania have been conducted at a horizontal resolution of 10 km in the framework of EU-FP6 project – CECILIA (Halenka, 2010). To assess the model ability to reproduce the drought characteristics over Romania the same indices have been calculated based on CRU TS2.1 gridded data set of observations at the horizontal resolution of 0.5 lat x 0.5 lon. The scPDSI and SPI indices have been calculated for all months but only the results of the analysis for summer months (June, July, August) is presented here. The results of EOF analysis for scPDSI and SPI indices calculated from simulated and observation data for summer were compared in terms of spatial distribution and temporal evolution of the principal components (PC) of temperature, precipitation and evapotranspiration.
The period of analysis is 1961-1990.

AIMS

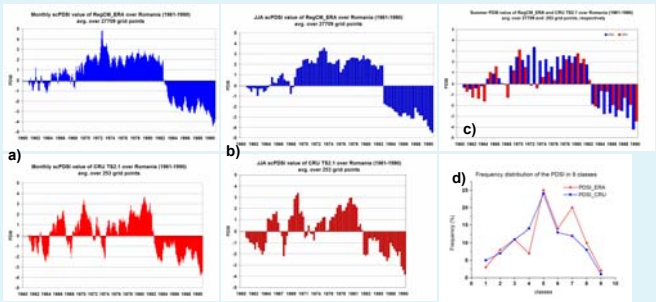
- ❑ to check the capability of the RegCM to simulate the evolution and variability of essential climatic variables of which anomalies are leading to drought
- ❑ to compare the simulated and observed scPDSI and SPI over Romania's domain
- ❑ to evaluate the pros and cons of PDSI and SPI for their abilities to monitor soil moisture on a monthly, seasonal and annual basis to further use the appropriate index for drought projections

DATA AND METHODS

- ❑ Monthly averaged temperature, precipitation and evapotranspiration data simulated with the regional climatic model RegCM3 forced with ERA40 at Lateral Boundary Conditions (LBC). The domain was centered over Romania (46ºN, 25ºE) at the horizontal resolution of 10 km (http://www.cecilia-eu.org).
- ❑ CRU TS2.10 land observation data set at horizontal resolution 0.5lat x 0.5lon http://www.cru.uea.ac.uk/cru/data/hrg/cru_ts_2.10
- ❑ soil parameter, available water content (AWC) from the FAO World-soil-database http://www.iiasa.ac.at/Research/LUC/External-World-soil-database/HTML/
- ❑ The distribution versions of PDSI and SPI programs, available at http://greenleaf.unl.edu have been modified to run for gridded data and run both for simulations and observations. The calibration and calculation period was 1961-1990.
- ❑ Empirical Orthogonal Functions (EOFs) of summer values of the fields of scPDSI, SPI, air temperature at 2 m, precipitation both for simulation and observed data were calculated and for evapotranspiration only for simulation data.
- ❑ The time series of PC coefficients have been normalized with the standard deviation of their series in order to facilitate comparison (variability is larger in the model than in observations) .

RESULTS

scPDSI



Mean Romanian scPDSI: The values are a spatial average of all grid boxes.
a) Monthly scPDSI: the model capture the wet characteristics of the decade 1970's though the precipitation is over estimated compared to observations. The shift to dry period beginning with 1982 is well captured.
b) Summer months (JJA) scPDSI: the same as for a) but the intraseasonal variability is suppressed
c) Summer (averaged JJA) scPDSI: the same as fore b) but intermonthly variability is suppressed
d) The frequency of summer scPDSI values over the major categories of PDSI as in Table 1. The model overestimates the mild drought and moderate wet classes.

Table 1. Classification scale for PDSI values (Palmer, 1965)

Class no	Class	PDSI
1	Extreme drought	≤-4.00
2	Severe drought	-3.00 to -3.99
3	Moderate drought	-2.00 to -2.99
4	Mild drought	-1.00 to -1.99
5	Normal	+0.99 to -0.99
6	Mild wet spell	+1.00 to +2.99
7	Moderate wet spell	+2.00 to +2.99
8	Severe wet spell	+3.00 to +3.99
9	Extremely wet spell	≥+4.0

SPI

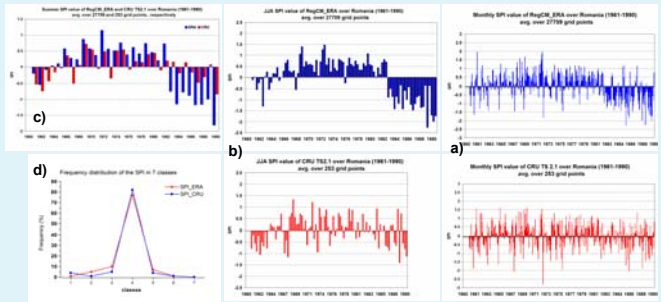


Table 2. Classification scale for SPI values (Edwards and McKee, 1997)

Class no	Class	SPI
1	Extremely dry	≤ -2.00
2	Severely dry	-1.50 to -1.99
3	Moderately dry	-1.00 to -1.49
4	Near Normal	-0.99 to +0.99
5	Moderately wet	+1.00 to +1.49
6	Severely wet	+1.50 to +1.99
7	Extremely wet	≥ +2.00

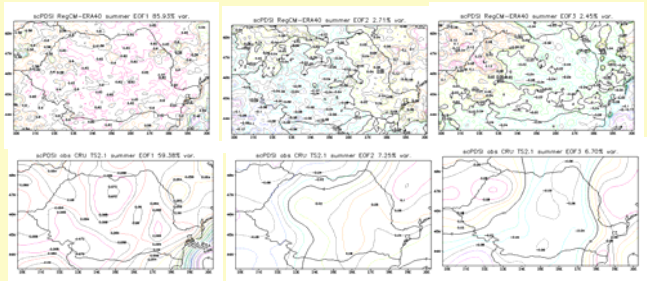
Mean Romanian SPI: The values are a spatial average of all grid boxes.
a) Monthly SPI: the model captures the moisture characteristics, both wet and dry. As the model systematically overestimates precipitation, this feature is transferred to SPI which is based only on precipitation.
b) Summer months (JJA) SPI: the same as for a) but the intraseasonal variability is smoothed
c) Summer (averaged JJA) SPI: the same as fore b) but intermonthly variability is smoothed
d) The frequency of summer SPI values over the major categories of SPI as in Table 2. Both the model and observation SPI fail to capture the extreme moisture conditions (severely and extremely dry and wet classes).

EOF ANALYSIS

a)

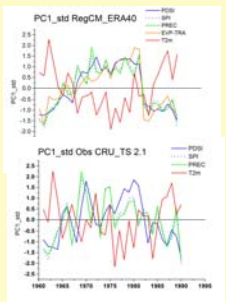
Table 3. Explained variance (%) of the leading EOFs of the analyzed variables in the RegCM simulations forced by ERA40 and in CRU TS 2.1 observed dataset

Variable	Data	EOF1 Var (%)	EOF2 Var.(%)	EOF3 Var (%)
scPDSI	RegCM_ERA40	85.93	2.71	2.45
	CRU_TS 2.1	59.38	7.25	6.70
SPI	RegCM_ERA40	77.51	5.29	3.64
	CRU_TS 2.1	44.86	12.36	11.27
T2m	RegCM_ERA40	82.84	7.22	4.15
	CRU_TS 2.1	81.99	7.14	5.20
Precip	RegCM_ERA40	73.46	5.29	4.68
	CRU_TS 2.1	45.05	12.02	10.89
Evap-tran	RegCM_ERA40	80.76	6.41	3.20



a) The patterns of the spatial coefficients of the leading EOFs for scPDSI. Similarly for SPI, precip, T2m and evap-transp

b)



b) The temporal evolution of PC1 of all variables looks alike in simulation and observation: SPI follows almost identically precipitation, scPDSI follows precipitation but seems to preserve the progression of trend, whether it is a drought or a wet spell. Temperature anomalies are associated with opposite in sign anomalies of evapotranspiration, precipitation, scPDSI and SPI in the sense that positive temperature anomalies are associated with deficit of precipitation and drought.

CONCLUSIONS

- ❑ The RegCM proved its capability to simulate the essential climatic variables of which anomalies are leading to drought over Romania, though systematic overestimation of precipitation was observed.
- ❑ The principal modes of variability of precipitation, air temperature at 2m, evapotranspitarion, scPDSI and SPI shows similar patterns of their leading EOFs. The large percentage of explained variance of the EOF1 for all these fields of climatic variable points out on the large scale processes driving their variability.
- ❑ scPDSI and SPI simulated over Romania's domain captured the evolution of summer moisture characteristics (both dry and wet spells). However, the frequency distribution of SPI values shows the aggregation of the values into the nearly normal class while the extremes are not captured.
- ❑ Analyzing the pros and cons of the RegCM simulations of the summer scPDSI and SPI over Romania it seems that scPDSI could be a better indicator of moisture variability because it is calculated from precipitation, temperature and soil moisture data. That means that a single PDSI value is not representative of just the current conditions, but also of recent conditions to a certain extent.

FURTHER WORK

- ❑ Comparison of the simulated and observed scPDSI and SPI over Romania's domain on seasonal (winter, spring and autumn) and annual time scale
- ❑ Project the seasonal and annual moisture characteristics under SRES A1B scenario for 2021-2050 and 2071-2100 periods.

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