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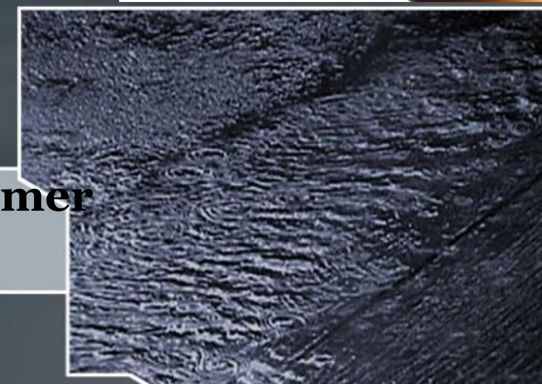

Assessing the changes in drought conditions during summer in the Republic of Moldova based on RegCM simulation

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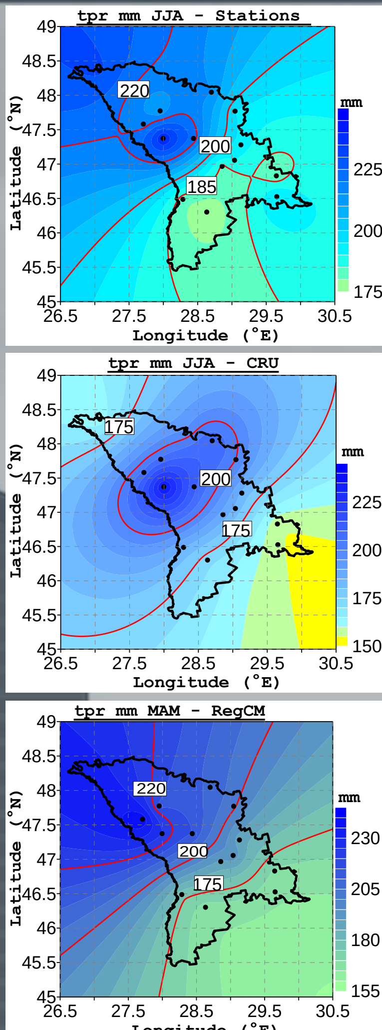
INTRODUCTION

- In the last two decades, drought was one of the greatest threats for farmers cultivating field crops in the Southern and Eastern Europe. In extreme cases, the effects of drought can lead to serious damages to agricultural sector.
- Drier conditions and increasing temperatures already observed in many regions of Eastern Europe could lead to lower agricultural production and crop variability may increase. The RM is among the eastern European countries affected by extreme drought.
- According to the results of six GCM based on A2 and B2 SRES scenarios, Moldova will face warmer and wetter winters and hotter and drier summers and autumns. The projected annual decrease of precipitation in association with increase of temperature would likely stimulate strong humidity deficit inducing droughts.
- In previous studies we have extensively analyzed the spatial and temporal evolution of drought events in RM by comparing results from the most advanced drought indices. In the present study, the SPI was adopted to assess and project drought characteristics in the RM based on RegCM simulations.
- It is well recognized that GCMs can reproduce reasonably well climate features on large scales (global and continental), but their accuracy decreases when proceeding from continental to regional and local scales because of the lack of resolution.
- This is especially true for surface fields, such as precipitation and surface air temperature, which are critically affected by topography and land use.

Objectives

- This article presents the results of the first study on drought characteristics over Moldova based on SPI calculated for RegCM simulated data at high resolution (10 km) for the current (1961–1990) and two future climates (2021–2050 and 2071–2100).
- Firstly, we compare the annual cycle of precipitation based on RegCM simulations with the corresponding values calculated from CRU TS2.1 land observation data set and from observations at 15 representative stations from Republic of Moldova.
- Secondly, the maps of mean seasonal precipitation and air temperature for simulation and CRU data are compared. Both the simulated and CRU data are downscaled at station locations and compared with station data in terms of means and standard deviation of seasonal precipitation totals.
- Thirdly, the changes in seasonal precipitation and temperature sumulateed by the RCM under SRES A1B emossions scenario for the periods 2021-2050 and 2071-2100 were compared with contral run (1961-1990).
- Finally, the SPI index for 3, 6 and 12 months for each grid point of Moldova domain both for the RegCM simulation and CRU data were calculated, spatially averaged and compared.
- The results will present the RegCM performance in simulating precipitation and their influence on the SPI values which are exclusively based on precipitation.

2.1 Data description



- We used monthly temperature means and precipitation totals simulated with the Beta version of the regional climatic model ICTP_RegCM3 at a horizontal resolution of 10 km.

- The RegCM simulations conducted in CECILIA-FP6 Project covered a domain centered over Romania (46ºN, 25ºE) including Republic of Moldova (45.01ºN-49.01ºN; 26.52ºE-30.48ºE).

- The simulations were driven by ERA40 double nested from 25 km RegCM run for the period 1960-1997 and by the ECHAM driven RegCM run at 25 km for the time slices 1961-1990 (control run) and 2021 -2050 and 2071-2100 (A1B scenario runs).

- The CRU TS2.10 land observation data set has been used to validate both the RegCM temperature and precipitation simulations. The horizontal resolution of CRU TS2.10 data set is 0.5ºlat x 0.5ºlon.

- The monthly temperature and precipitation simulations have been also validated against observations recorded at 15 meteorological stations of Moldova's State Hydrometeorological Service (SHS).

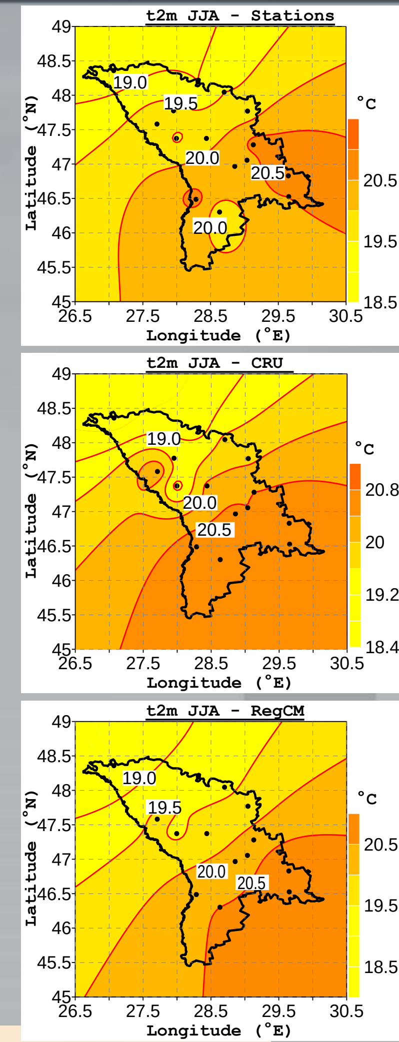


Fig. 1. Location of the 15 meteorological stations and their summer means of precipitation totals and mean air temperature for (3 datasets: Stations, CRU and RegCM) the RegCM-Moldova domain (26.5°-30.5° E; 45°- 49°N) :

2.2 Methods

- We validate the model ability to simulate seasonal temperature and precipitation over the Republic of Moldova domain.
- The annual cycles of temperature and precipitation were calculated in each grid point of data sets downscaled at station coordinates and then spatially averaged. The same rule was applied for the station series.
- The RegCM simulations (control and scenario runs) forced with the ECHAM GCM have been corrected against the systematic errors induced by the GCM.
- The bias correction has been calculated as a difference (ratio) between the temperature (precipitation) mean of the control run and the ERA40 run for the reference period 1961-1990 and then applied to each value of grid point time series.
- We used the distribution version of the SPI program available on ftp://ulysses.atmos.colostate.edu which was adapted for looping over each grid point of the domain.
- To ascertain variability of different type of droughts in the country, the SPI was calculated for short-term (1 to 2 months), medium-term (3 to 12 months) and long-term timescales (13 to 24 months).
- In this study, a summer drought episode (JJA) was defined as a continuous period of SPI values less than -1.0 at least once during the episode.
- The results will present the RegCM performance in simulating precipitation and their influence on the SPI values which are exclusively based on precipitation.

3.1 Validation model – Precipitation and Temperature annual cycle

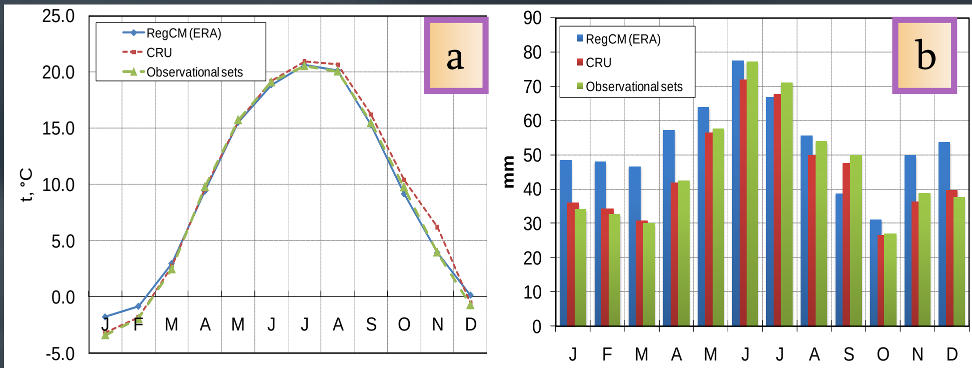


Fig. 2 Annual air temperature (a) and precipitation (b) cycle for RegCM (ERA), CRU and observational datasets for reference period 1961-1990.

- ➢ The gridded data of temperature and precipitation totals of RegCM simulations, CRU observations and station observations were spatially averaged and compared. The results are presented in Figure 2.
- ➢ The model does well representing the annual cycle of temperature but slightly overestimates the winter (DJF) temperatures and slightly underestimates autumn (SON) temperatures (Fig. 2a).
- ➢ Precipitation totals are systematically overestimated by the model compared to stations and CRU data (Fig. 2b).

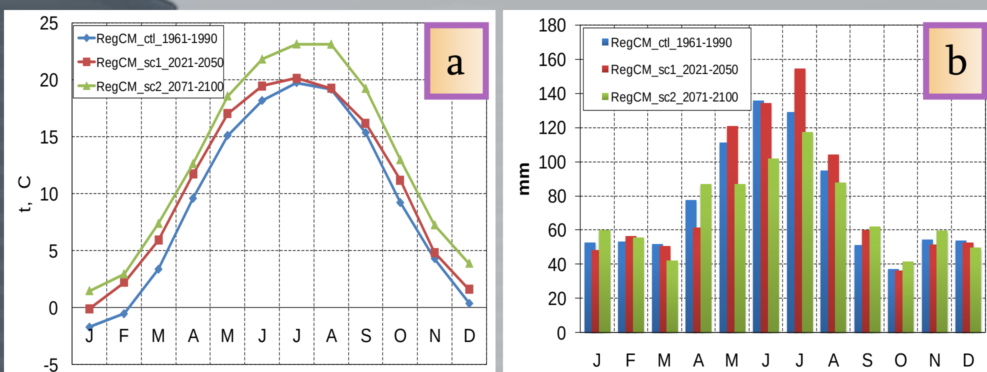


Fig. 3 Annual air temperature (a) and precipitation (b) cycle after bias correction of the RegCM simulations for the time slices 1961-1990 (control run) and 2021 -2050 and 2071-2100 for Moldova domains.

- ➢ The bias correction was applied to each value of the time series in each grid point of Moldova domain for RegCM control run and scenario runs forced with the ECHAM GCM.
- ➢ Then, the annual cycle of temperature and precipitation were calculated for each grid point of the domain and then spatially averaged and compared. The results are presented in Figure 3.
- ➢ The results show that the projected temperatures for A1B scenario runs will increase in all months compared to the control run (Fig.3).

3.2 Projected changes in summer mean air temperatures

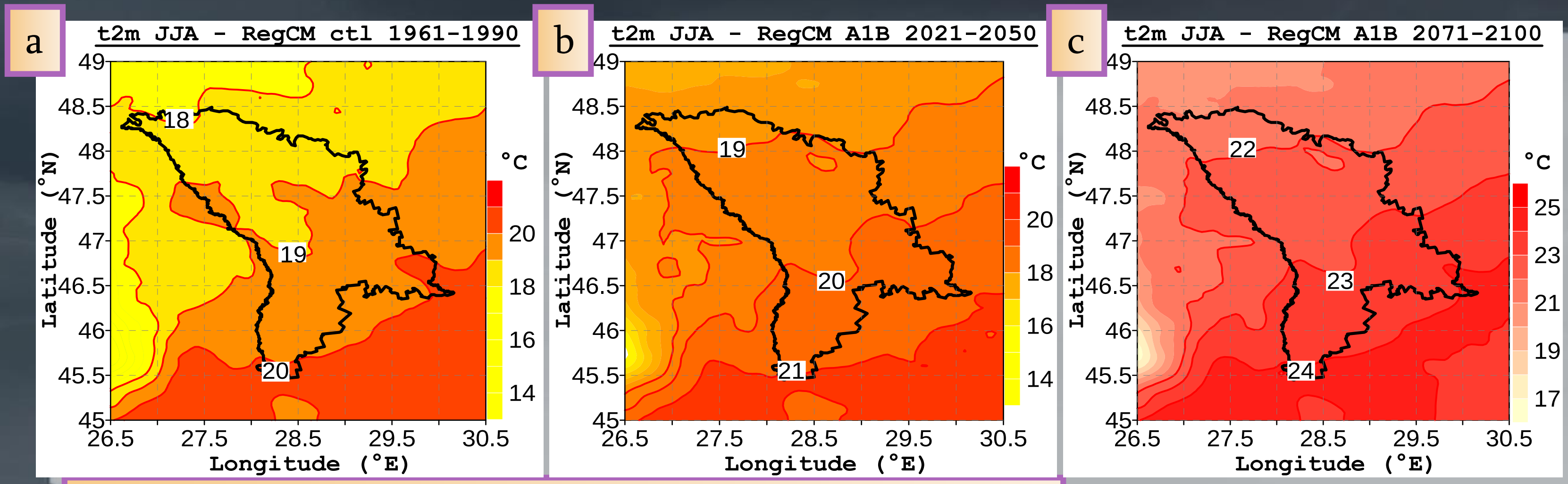


Fig. 4 Projected changes in summer mean air temperatures (a) for the control run (b) for the period 2021-2050 and (c) for the period 2071-2100

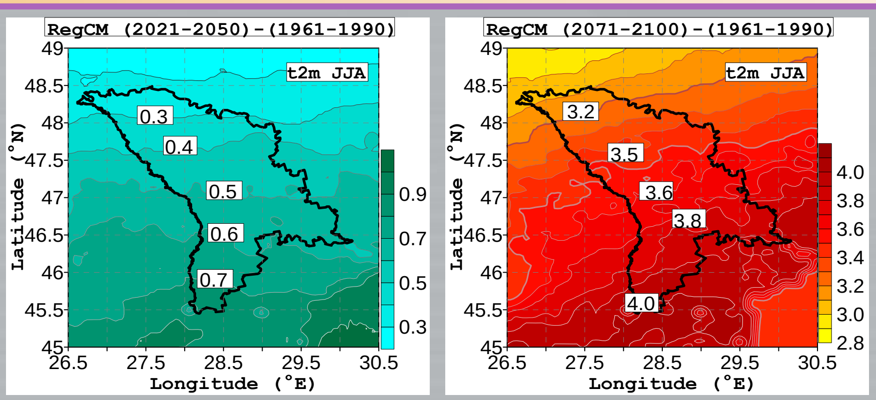


Fig. 5 The bias correction in each grid point of Moldova domain in summer

- The temperatures are projected to a higher increase by the end of the 21st century compared to the mid 21st century and reference period 1961-1990.
- The highest increase is expected during summer months.

3.Results

3.3 Projected changes in summer precipitation amonts

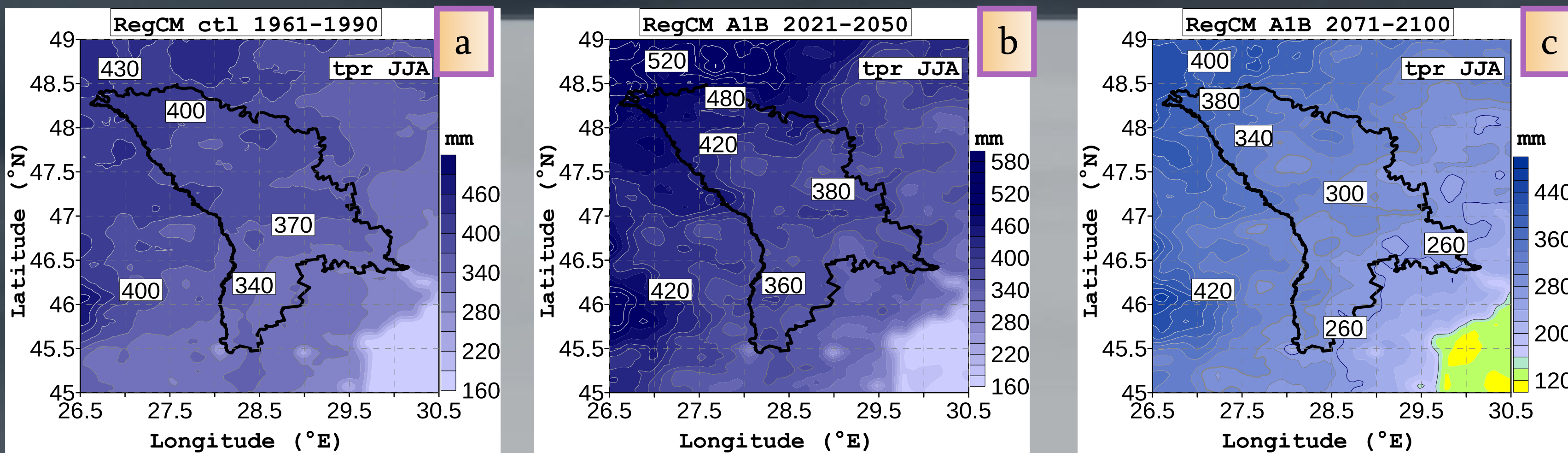


Fig. 6 Projected changes in summer precipitation (a) for the control run (b) for the period 2021-2050 and (c) for the period 2071-2100

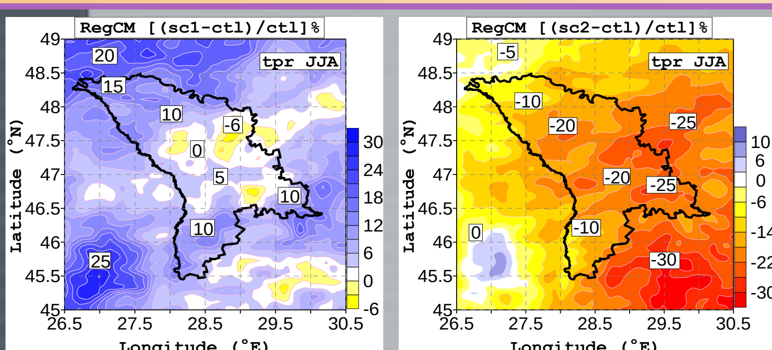
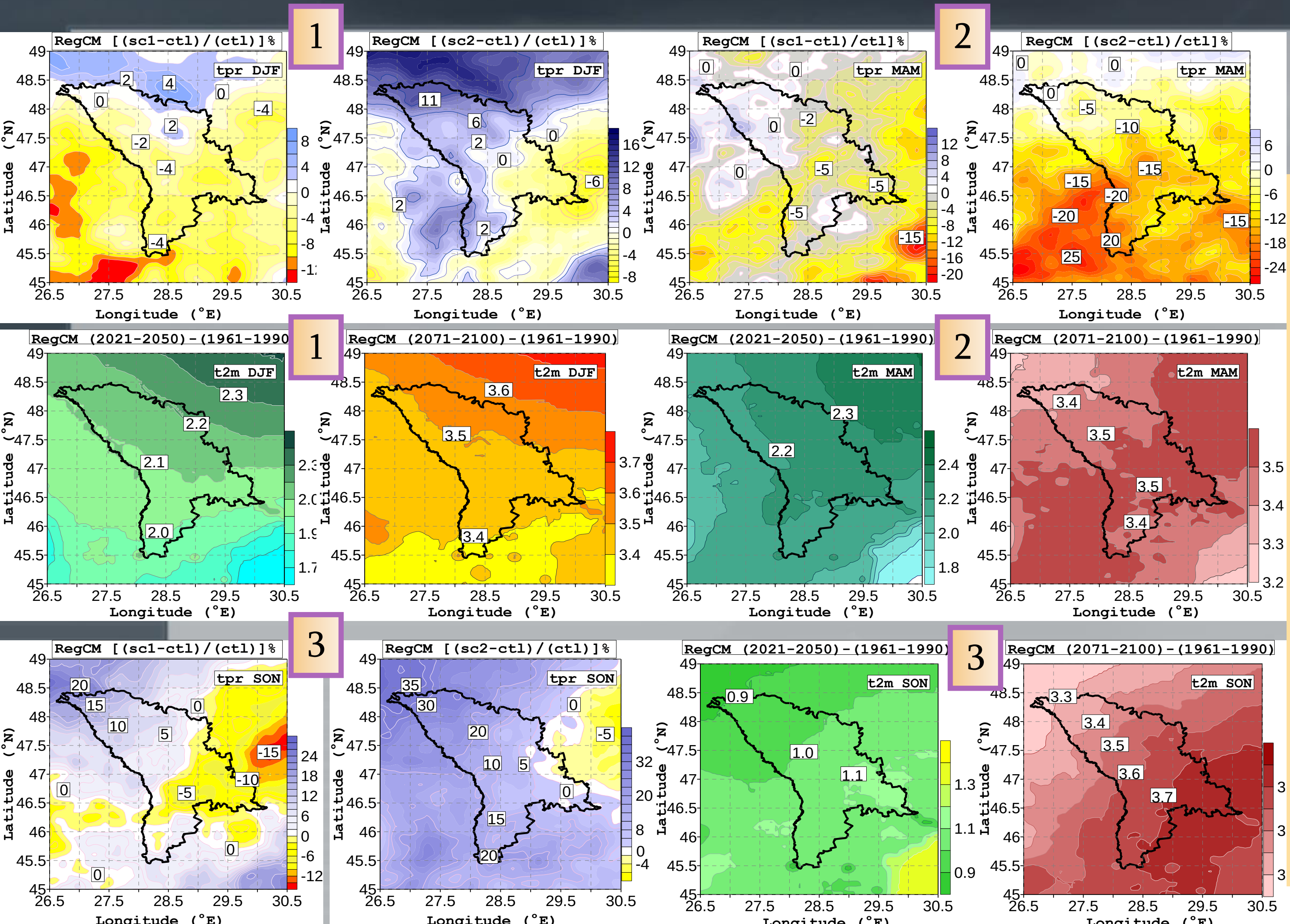


Fig. 7 The bias correction in each grid point of Moldova domain in summer

- ➢The largest magnitude of model precipitation errors are observed in late spring and summer months when the model precipitation means are almost doubled the observed (station and CRU) precipitation means.
- ➢This feature is transferred to SPI which is based only on precipitation.
- ➢The precipitation totals are projected to slightly decrease in late autumn, winter and spring and increase in summer during the period 2021-2050. Significant decrease is projected for summer during the period 2071-2100.

3.4 Biases corection in seasonal mean precipitation amonts and temperatures



- Examinimg the model errors on the regional scale of Moldova domain, it is important to note that the biases are not uniformly distributed throughout the year, indicating seasonal variability of the model to represent physical processes responsable for precipitatuion.

Fig. 8 The bias correction in each grid point of Moldova domain for temperature and precipitation series for the periods 2021-2050 and 2071-2100 in winter (1), spring (2) and autumn (3) seasons.

3.5 Observed spatio-temporal distribution of SPI values for current climate (1960-1997)

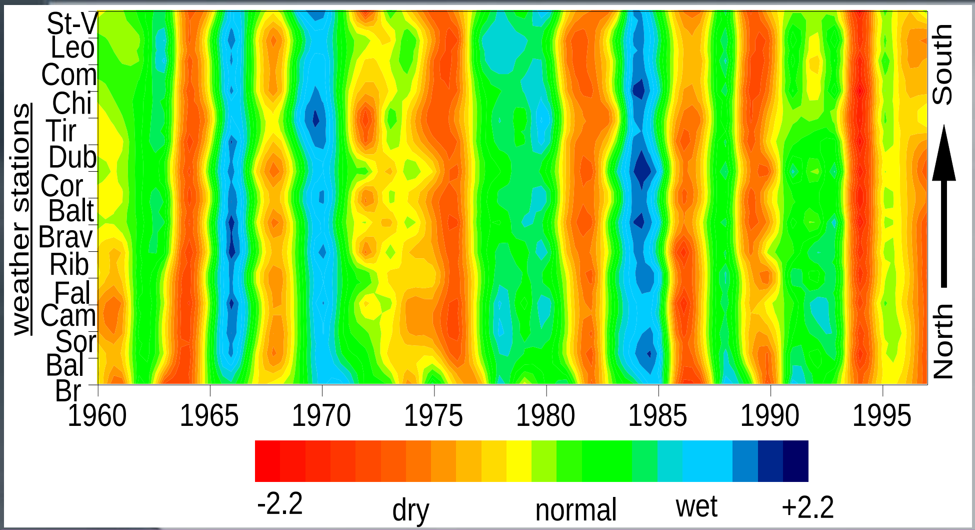
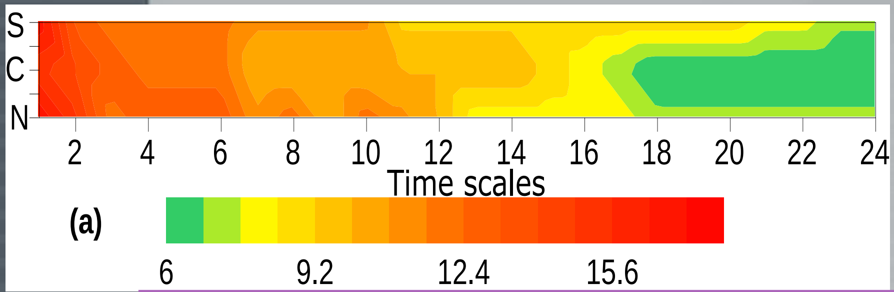


Fig. 9 Spatio-temporal distribution of SPI values at medium-term time scales (3 to 12 months) based on observations at 15 stations (1960-1997).

- Fig. 9 shows that wet summers have shortened their persistence and almost vanished after 1985.
- We computed the consecutive number of months in each drought episode at time scales from 1 month to 24 months.
- Drought appears first in the short time scales and if dry conditions persist, the drought develops at longer time scales.
- With increasing timescales, drought episodes appear with a lower temporal frequency and a longer duration.
- The frequency of summer drought episodes decreases with the increasing length of time scales (Fig. 10a-b).



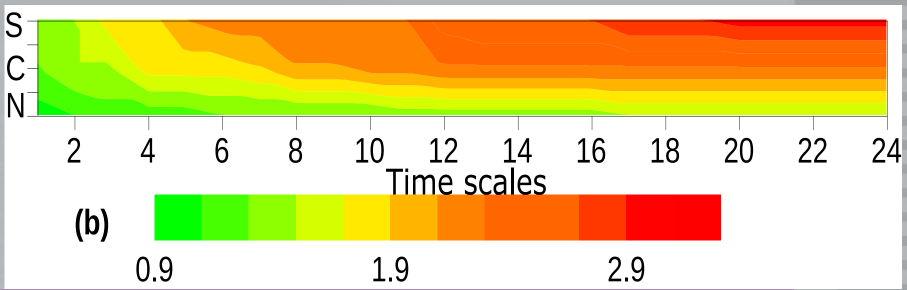


Fig. 10a-b provides a summary for the average number and duration of summer drought episodes determined based on the SPI at short-, mid-, and long-term time spells for 3 agroclimatic regions: Nord (N), Central (C) and South (S) (1960-1997).

3.Results

3.6 Observed spatio-temporal distribution of SPI values for current climate (1960-1997)

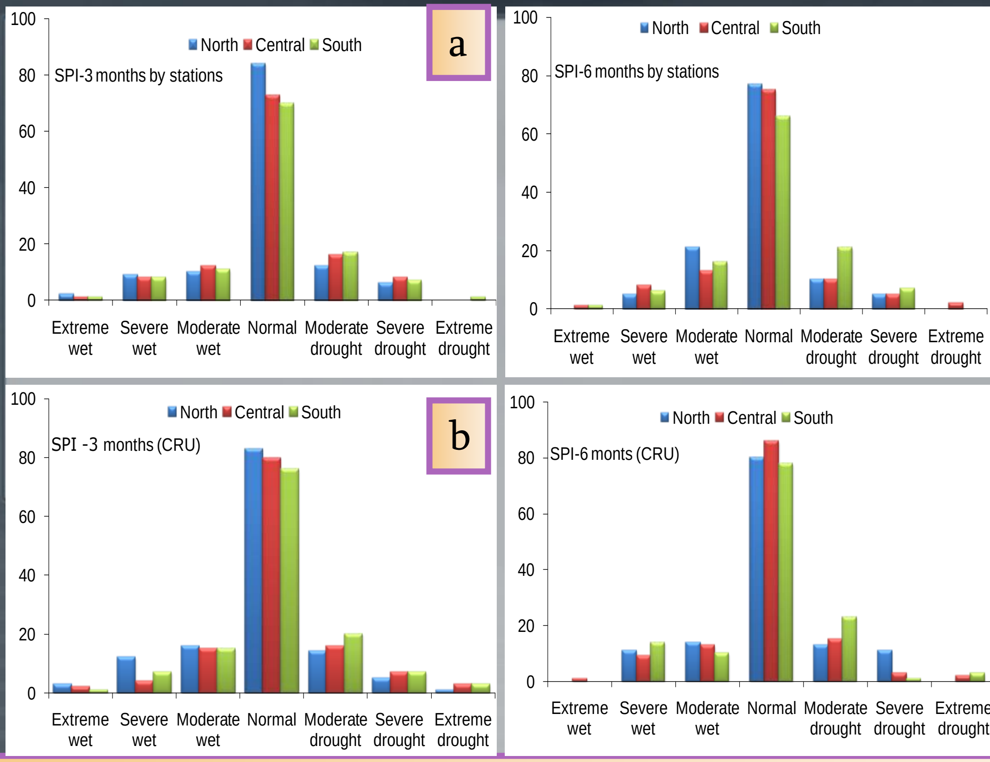


Fig. 10a-b Frequency distribution of the SPI values in 7 classes of drought category (number of cases) based on station observations a) and CRU data b) averaged per agro-climatic regions for the period 1960-1997.

SPI - Frequency distribution

- Fig. 10 shows that in general, the southern region is more affected by droughts from moderate to extreme than the northern region.
- The middle-term drought observed in the South agro-climatic region might be associated with less of precipitation. This result points out that this region is likely more vulnerable to drought.

3.7 Projected changes in drought characteristics

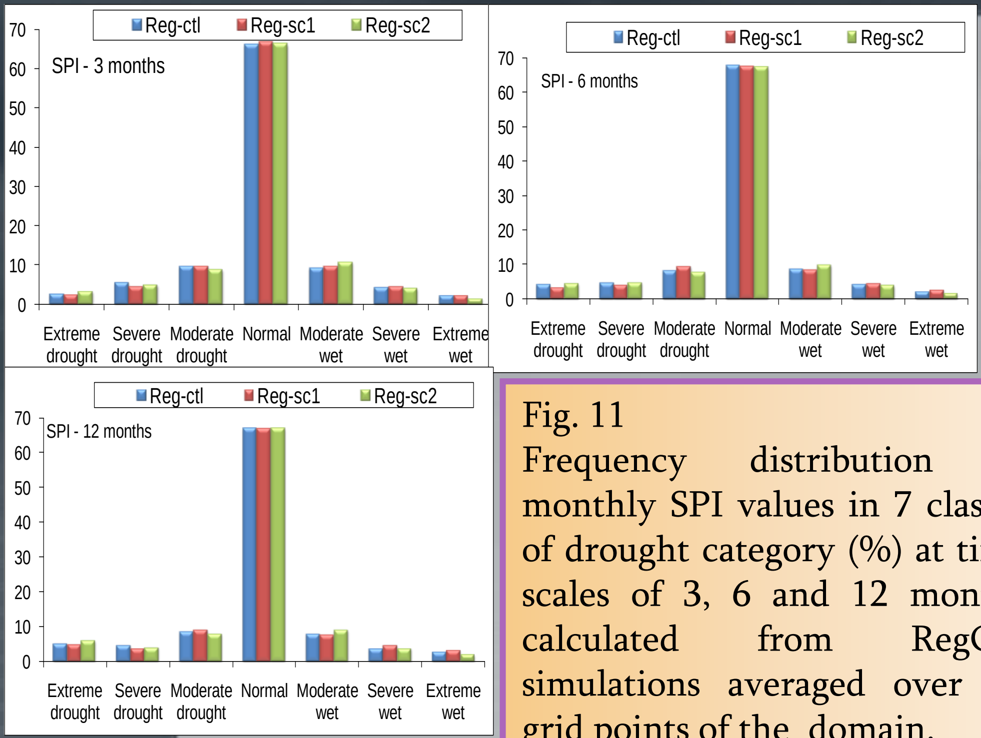


Fig. 11
Frequency distribution of monthly SPI values in 7 classes of drought category (%) at time scales of 3, 6 and 12 months calculated from RegCM simulations averaged over all grid points of the domain.

SPI - Frequency distribution

- Fig. 11 shows that there are not significant differences between frequency distribution of SPI values calculated for 3, 6 and 12 months in the control run and the two A1B scenario runs.
- The normal conditions represent 67% out of the total values of SPI in all grid point of the domain.
- Moderate drought and moderate wet are almost equally distributed around 9% while severe drought and severe wet are equally distribute around 5%.
- Only slightly increase in extremely dry conditions 5% compared to extremely wet conditions 3% is observed both for the control and scenario runs.

3.Results

3.8 Projected changes in drought characteristics

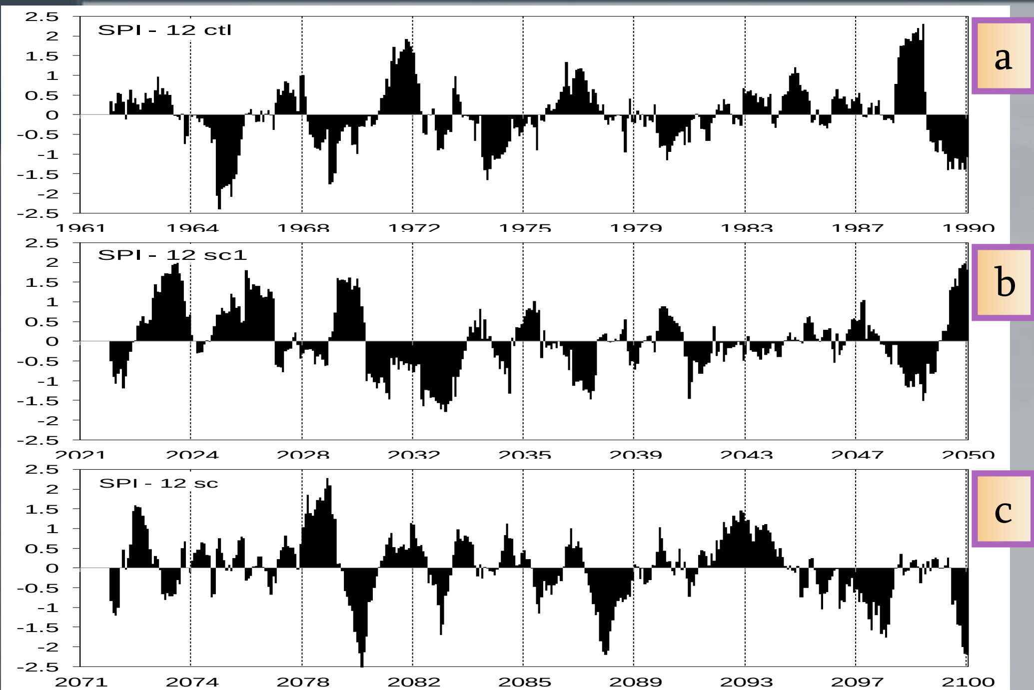


Fig. 10a-b SPI series at time scales of 12 months based on monthly precipitation totals simulated by the RegCM control run a) (1961-1990) and A1B scenario runs b) (2021-2050) and c) (2071-2100), averaged for all grid points of the domain.

SPI – Temporal evolution

- The results show the intensification of summer drought severity due to reduced precipitation in the context of general warming in Moldova.
- 2021-2050 - in terms of intensity and persistence of dry and wet spells, shows that the first part of the this period is charcterized by intense and persistent wet spells which are projected to be followed by some years with severe drought.
- 2071-2100 - the time series are characterized by a higher variability and longer persistence of both wet and dry periods as compared with the control run and scenario run for the period 2021-2050.
- During the mid-century period is projected to be less frequently dry events for almost all timescales of SPI series.
- By the end of the 21st century the projections suggest that long-duration droughts could thus become more important than it is observed during the present climate.
- Increases in drought severity are also projected for the end of century.

The results can be summarized as follows:

- RegCM simulations forced by ERA40 data were compared with station observations and CRU data downscaled at station coordinates.
- The results show that the model does quite well in representing the annual cycle of temperature but precipitation totals are systematically overestimated compared both to stations and CRU data. This feature is transferred to SPI which is based only on precipitation. Consequently, the model underestimates the severity of droughts.
- The temperatures projected by the A1B scenario runs will increase compared to the control run. The temperatures are projected to increase by the end of the 21st century compared to the mid 21st century and to the reference period 1961-1990.
- The precipitation totals are projected to slightly decrease in autumn, winter and spring and increase in summer during the period 2021-2050. Significant decrease of precipitation is projected for summer during the period 2071-2100.
- The evolution of the SPI series calculated for 3 months presents a high variability of the index around normal conditions. As the time scale for calculation the SPI increases (6 and 12 months) the wet and dry conditions can be better identified as well as their persistence.
- Not significant differences between the frequency distribution of SPI values calculated for 3, 6 and 12 months in the control run and the two A1B scenario runs have been identified. The normal conditions represent 67% out of the total values of SPI in all grid point of the domain.
- This study represent the first steps in investigating the country vulnerability to drought in the context of climate change.

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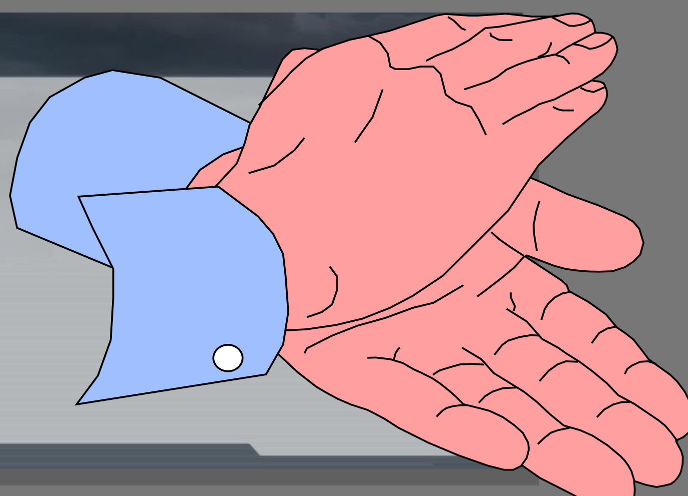

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Thank you.

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