International Scientific Conference
9 - 11 September 2013 | Skalica, Slovakia

A multi-scalar character of droughts based on the SPEI in the Republic of Moldova

Vera Potop

Czech University of Life Sciences Prague, Faculty of Agrobiology,
Food and Natural Resources, Department of Agroecology and Biometeorology, Prague, Czech Republic **potop@af.czu.cz**

Abstract

- This study presents a detailed assessment on drought characteristics in a multi-scalar way based on the Standardized Precipitation Evapotranspiration (SPEI) in the Republic of Moldova.
- This study combined two SPEI datasets: (1) the global 0.5°gridded the SPEI dataset at time scales between 1 and 48 months from December 1950 to May 2013 over Moldova domain (45.01ºN-49.01ºN; 26.52ºE-30.48ºE) obtained from the SPEIbase, and (2) the Chisinau climatological station as a representative station with relatively long continuous series (1945-2011) in the Republic of Moldova.
- The SPEIbase is based on the FAO-56 Penman-Monteith estimation of potential evapotranspiration from CRU with spatial resolution of 0.5ºlat x 0.5ºlon.
- The SPEI at climatological station is based on Hargreaves estimation of potential evapotranspiration (the minimum and maximum air temperatures and extraterrestrial radiation).
- The 0.5°gridded SPEIbase as new global product can be suitable for the detection, monitoring, and assessment of drought conditions at the regional scale.

Key words: SPEIbase, time-scale, summer and winter drought

Standardized Precipitation Evapotranspiration (SPEI)

- The SPEI is a site-specific drought indicator of deviations from the average water balance (precipitation minus potential evapotranspiration) (Vicente-Serrano *et al.*, 2010).
- The standardization procedure for SPEI follows the same steps as SPI, however the developers of SPEI recommend using the three parameter log-logistic theoretical distribution to account for extreme negative values which are found in the time series (precipitation – PET).
- One of the weaknesses of the SPEI is that it requires more data than the SPI. Like the SPI, the SPEI has trouble dealing with arid climates where precipitation is near zero (Vicente-Serrano *et al.*, 2012).
- However, the SPEI includes the role of temperature on drought severity by means of its influence on the atmospheric evaporation demand.

Table 1
The 7 classes of the SPEI category according to its values

SPEI	Drought category	Probability
≥2.0	Extreme wet	0.02
1.50 – 1.99	Severe wet	0.06
1.49 - 1.00	Moderate wet	0.10
0.99 - -0.99	Normal	0.65
-1.00 – -1.49	Moderate drought	0.10
-1.50 - -1.99	Severe drought	0.05
≤-2.00	Extreme drought	0.02

Data and methods

- This study presents the evolution of two SPEI datasets:
  (1) the global 0.5°gridded the SPEI dataset at time scales between 1 and 48 months from December 1950 to May 2013 over Moldova domain (45.01ºN-49.01ºN; 26.52ºE-30.48ºE) obtained from the SPEIbase (Beguería *et al.*, 2010);
  (2) the Chisinau climatological station as a representative station with relatively long continuous series (1945-2011) in the Republic of Moldova.
- The SPEIbase is based on the FAO-56 Penman-Monteith estimation of potential evapotranspiration from CRU with spatial resolution of 0.5ºlat x 0.5ºlon. A complete description of the data and links to download the files, are provided at http://sac.csic.es/spei.
- In this study, gridded data of SPEIbase have been downloaded to climatological station coordinates (Figure 1). The SPEI series at Chisinau station was calculated as follows:
  - the parameterization of potential evapotranspiration (PET) based on monthly minimum (Tmin) and maximum air temperature (Tmax) and extraterrestrial radiation;
  - a simple monthly water balance (D), calculated as the difference between monthly precipitation (P) and potential evapotranspiration (PET) and
  - normalisation of the water balance into a log-logistic probability distribution to obtain the SPEI series at time scales between 1 and 24 months.
- In this study, we have also analysed the trends of extreme temperatures (Tmin and Tmax) and precipitation anomalies as helpful factors to assess their influence on drought characteristics.

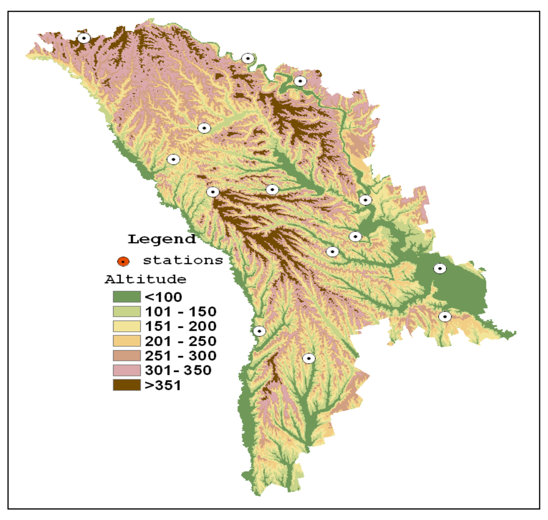
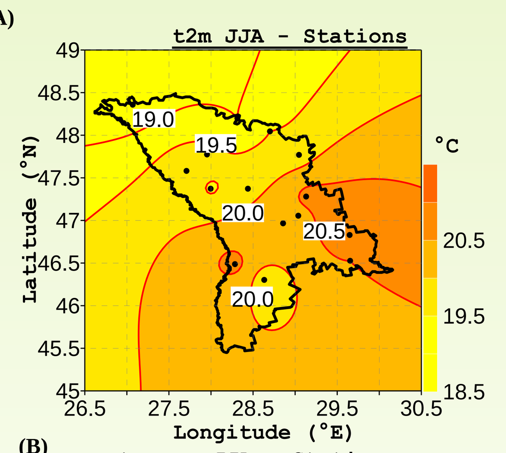
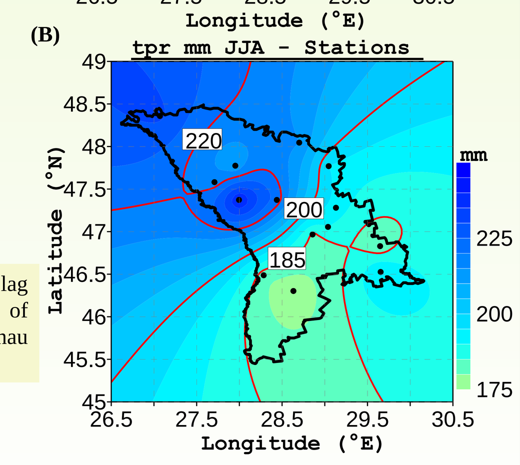


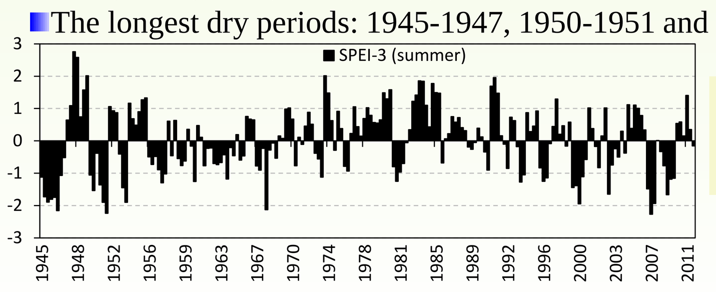
Figure 1.
Location of the 15 meteorological stations and their elevation (m a.s.l.) situated in the Republic of Moldova.

Summer (JJA)

- The summer mean of air temperature in Republic of Moldova was calculated from monthly data from 15 meteorological stations for the period 1961-1997.
- The summer mean air temperature ranges between +18.5ºC and +21.0ºC (map A).
- **The hottest summer:** 2007 with *Tmean* ranging 22.0 to 25.0ºC (exceeding the norm with 3.0-4.0ºC)
  - **Absolut maximum:** +41.5ºC (on 21 July 2007 in Kamenka, *source Moldova's State Hydrometeorological Service source*)
- **Precipitation:** in average 175-235 mm (map B)
- **The lowest**: 37 mm (Cahul, 1924)
- The hierarchy of the driest summers according to the SPEI: 2007, 1946, 1951, 1968, 2000, 1953, 1951, 1945, 2003 and 2009.
- The longest dry periods: 1945-1947, 1950-1951 and 1999-2000.





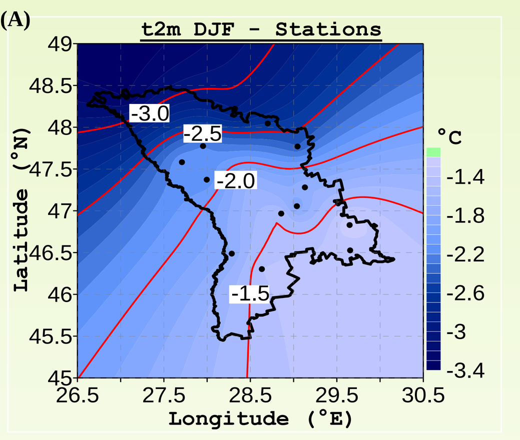


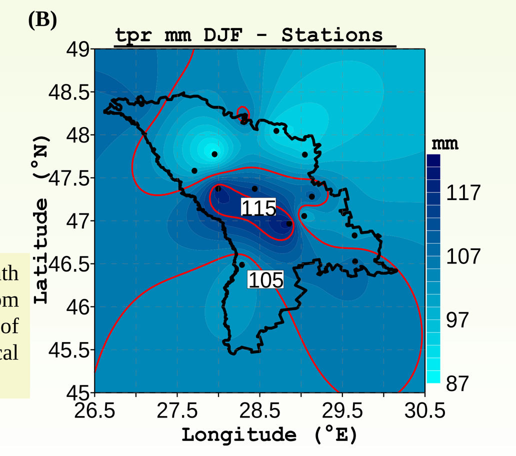
Evolution of the SPEI at 3-month lag during summer (JJA) from June of 1945 to August of 2011 at Chisinau climatological station

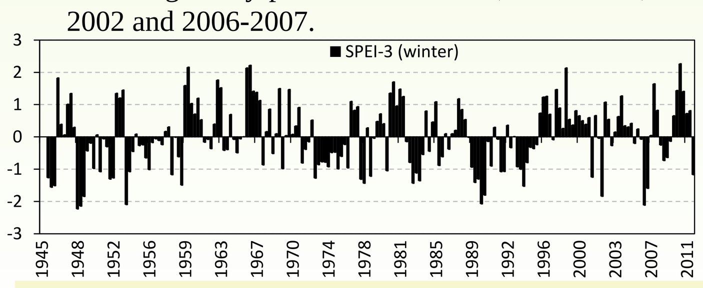
Box 1. Summer temperature mean and precipitation total climatologies (1960-1997) and drought characteristics (1945-2011) in the Republic of Moldova.

Winter (DJF)

- The winter mean of air temperature in the Republic of Moldova was calculated from monthly data from 15 meteorological stations for the period 1960-1997.
- The winter air temperature mean ranges between -1.4 and -3.4ºC (map A).
- **The coldest winter**: 1953/1954, with *Tmean* ranging -8.0 to -9.0ºC (6.0-7.0ºC lower than the norm according to *Moldova's State Hydrometeorological Service*).
- **The warmest winter**: 2006/2007, with *Tmean ranging* +1.0ºC to +3.0ºC (exceeded the norm with 4.0-5.0ºC).
- The high variability of the air temperature during winter season is one of the climatic particularities of Moldova.
- **Precipitation**: on average 87-117 mm or 16-20% of the average annual amount (map B).
- The hierarchy of the driest winters according to the SPEI: 1948, 1949, 2006, 1953, 1990, 1949, 2002, 1990, 2007, 1946, 1994 and 1959.
- The longest dry periods: 1948-1954, 1958-1959, 1977-1978, 1989-1990, 2001-2002 and 2006-2007.





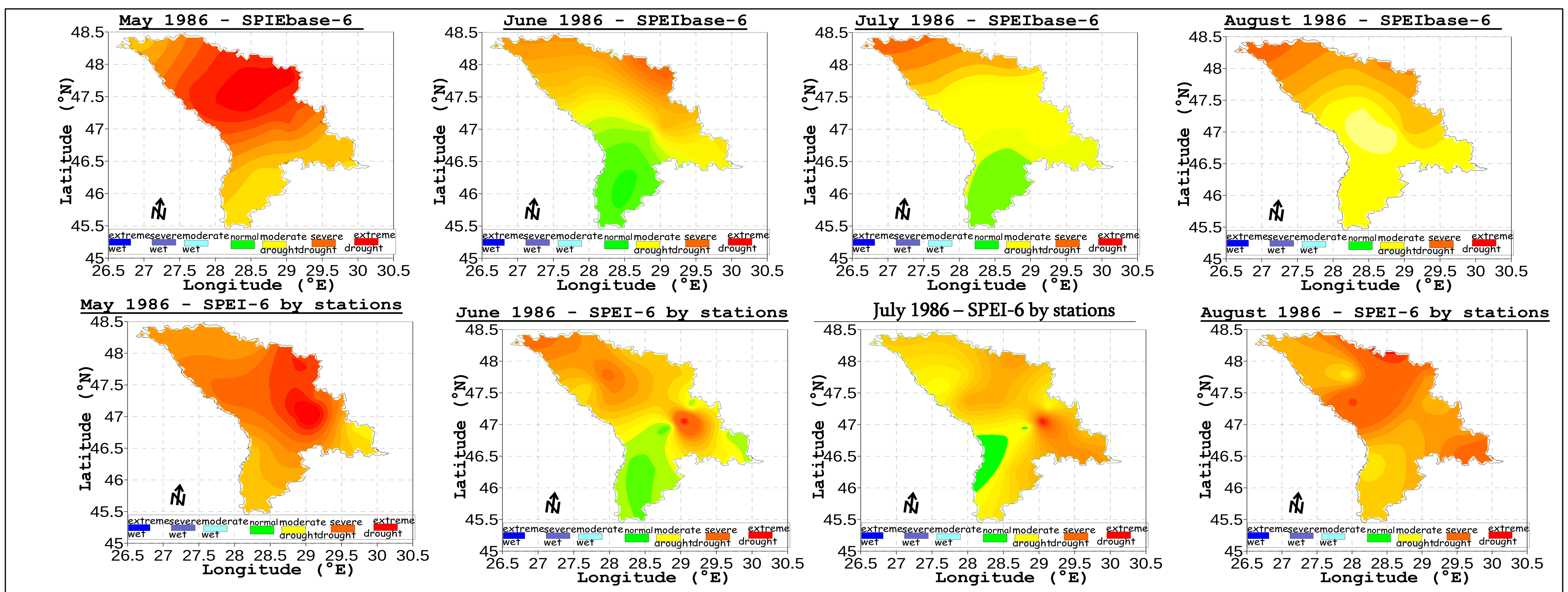


Evolution of the SPEI at 3-month lag during winter (DJF) from December of 1946 to February of 2011 at Chisinau climatological station

Box 2. Winter temperature mean and precipitation total climatologies (1960-1997) and drought characteristics (1945-2011) in the Republic of Moldova.

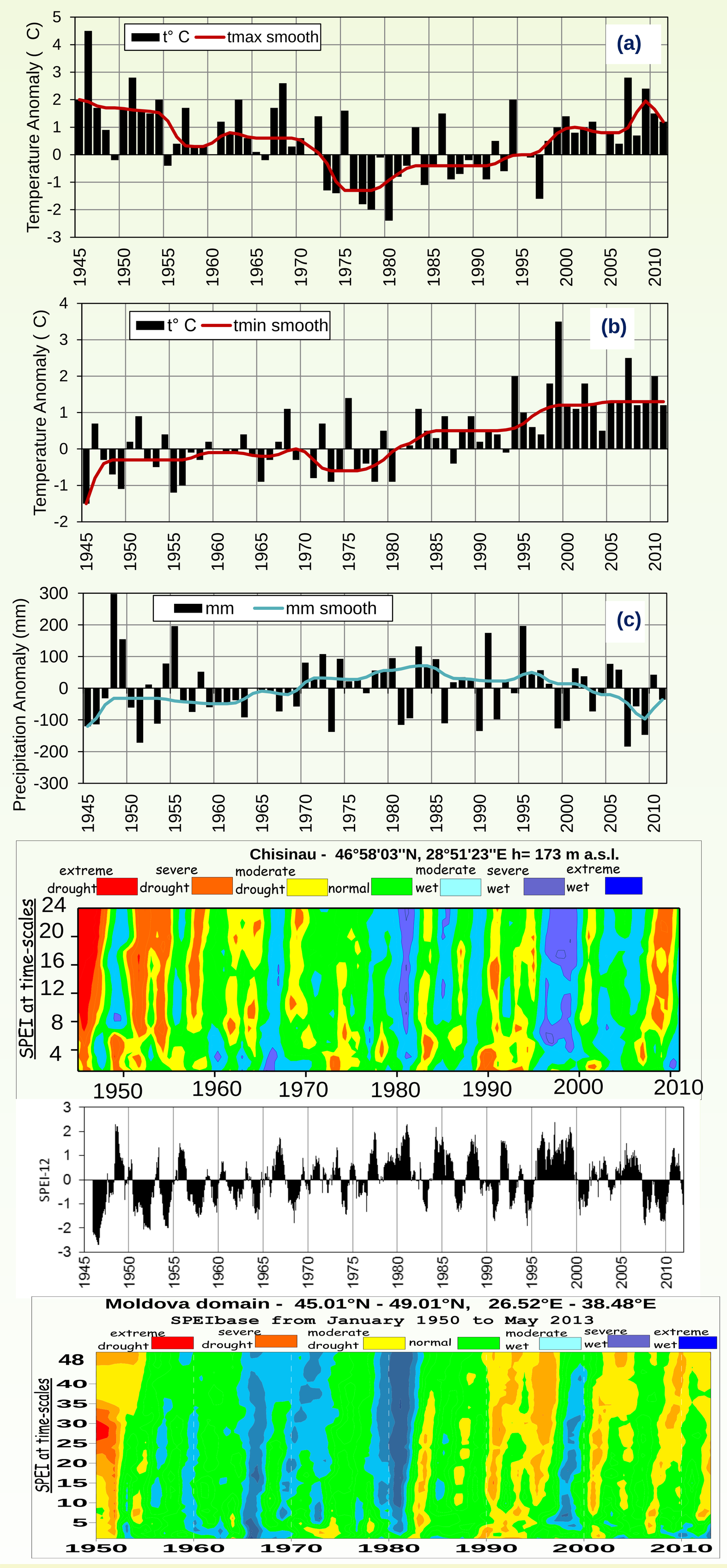
Results and discussion

- The high variability of temperature and precipitation during the 1950s and 2000s is associated with multiple periods of large drought extent. The majority of the hottest and driest summers since 1945 were precedes by winter and spring precipitation deficit over Moldova (e.g. 1946, 1953, 2000 and 2007) (Boxes 1-2) .
- For all the time scales of the SPEI calculation during the warm season of the year (April to September), the longest duration and highest severity was identified during in the mid 1940s-1950s, 1960s and 2000s (Box 3). These periods correspond to the association of the highest temperature and lowest precipitation anomalies (i.e., more than 2.5°C associated with precipitation anomalies up to 60% below normal) (Box 3). The largest impact on water deficit during the last three decades was found to be mainly due to the increase of maximum temperature (+0.7°C decade^{-1}) and minimum temperature (+0.5°C decade^{-1}) associated with decreased precipitation (20 mm decade^{-1}).
- The increasing trend of extreme temperatures in the Republic of Moldova has particularly affected Tmin (the highest positive deviation was ranging between 1.5°C to 3.5°C) during warm season of the year and the increasing water deficit in this season (top panel of Box 3).
- Hovmoller-type diagram provides a visualisation of the spatiotemporal evolution of the 0.5°gridded the SPEIbase series at time scales between 1 and 48 months for the period 1950-2013 over Moldova domain (bottom panel of Box 3).



Box 4. Spatial evolution of SPEI at 6-month accumulation period during the driest growing season of 1986 over Moldova domain at 0.5°gridded SPEIbase (top) and stations dataset (down).

- According to SPEI-6 values and its categories (Table 1) the drought of May 1986 based on station observations was characterized as severe in most of the regions and extreme in the eastern half of country. Based on the global 0.5°gridded SPEIbase , the drought was severe and extreme, but the area with extreme drought is larger than that resulted from 15 station observations.
- Similarly, for August 1986 based on station observation the drought was severe and extreme over the whole country, moderate in the southern half, severe and extreme in the northern half of the country based on the global 0.5°gridded SPEIbase .
- However, the global 0.5°gridded SPEIbase dataset capture the general characteristics of drought in terms of spatial and temporal distribution and it can be used for vulnerability to drought assessments for the Republic of Moldova



Box 3. Temporal evolution of data series from 1945 to 2011: **upper panel**) air anomalies of maximum temperature (a) and minimum temperature (b), and precipitation totals (c) during the warm season of the year (c). **middle panel**) SPEI at time scales from 1 to 24 months and the SPEI at 12-month lag, and **bottom panel**) spatiotemporal evolution of the 0.5°gridded the SPEIbase series at time scales between 1 and 48 months for the period 1950-2013 over Moldova domain (45.01ºN-49.01ºN; 26.52ºE-30.48ºE).

Conclusion

- Two SPEI data sets and two different method of parametrization of potential evapotranspiration were used to compare ability of gridded SPEIbase to reproduce the spatial and temporal evolution of drought at the territory of the Republic of Moldova.
- The approach to drought characterisation based on the global 0.5°gridded SPEIbase calculated for various accumulation periods provides comprehensive results on the complexity of drought phenomena in the Republic of Moldova.

References:
Beguería, S., Vicente-Serrano, S.M. & Angulo, M., 2010: A multi-scalar global drought data set: the SPEIbase: a new gridded product for the analysis of drought variability and impacts. *Bulletin of the American Meteorological Society* 91: 1351-1354
Vicente-Serrano, S.M., Beguería, S., López-Moreno, J.I. (2010): A Multi-scalar drought index sensitive to global warming: The Standardized Precipitation Evapotranspiration Index – SPEI. *Journal of Climate* 23 (7): 1696-1718.
Vicente-Serrano, S.M., Beguería, S., Eklundh, L., Gimeno, G., Weston, D., Kenawy, A.E., López-Moreno, J.I., Nieto, R., Ayenew, T., Konte, D., Ardö, J., Pegram, G.G.S. (2012): Challenges for drought mitigation in Africa: The potential use of geospatial data and drought information systems. Applied Geography 34: 471-486.

Acknowledgements:
This study was supported by project 6046070901.