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Projected changes in the evolution of drought assessed with the SPEI over the Czech Republic

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Introduction:

In previous studies (*Potop et al.*, 2011, 2012) drought was extensively analyzed by comparing results from the most advanced drought indices (e.g. the SPI and SPEI), which take into account the role of antecedent conditions in quantifying drought severity in the lowland regions of the Czech Republic. Decadal trend in drought extent detected by the SPEI are apparent, however, with higher values of drought incidences in the 1940s, early 1950s and the 1990s and fewer drought episodes in the 1910s, 1930s and 1980s.

The SPEI and SPI showed a large differences in the evolution drought severity during decades with the lowest summer negative temperature anomalies combined with the lowest precipitation (cold and dry; the first two decades of the 20th century), the highest summer positive temperature anomalies (the end of the 20th century), both high spring positive temperature and precipitation anomalies (warm and wet; at the beginning of the 20th century) and the lowest deficit of water balance (1947, 2003, 1994, 1983 and 1933) (*Potop et al.*, 2012). Conversely, similarity between two indices were recorded in decades with high fluctuations of positive spring temperature deviations and lower precipitation (warm and dry; 1950s, 1990s and 2000s); extremely long sunshine durations (155% of the normal amount in extremely dry June of 2006 and August 2003, up to twice the norm for April of 2007 and 2009) and consecutive dry days. Therefore, the role of temperature was evident in summer drought episodes that depend on temperature anomalies, contributing to a higher water demand by potential evapotranspiration at the end of the century (Box 2).

New detailed results about the temporal evolution of the SPEI at different timescales and its impact on vegetable crops are discussed and presented in broader climatological and European contexts. However, more in-depth analysis is required to explore the vulnerability to drought in the context of climate change and then, to calculate the SPEI for denser station network to better represent different climate conditions which manifest across the Czech Republic.

Data and methods:

- In the present study, the Standardized Precipitation Evapotranspiration Index (SPEI) was adopted to assess and project drought characteristics in the Czech Republic based on the regional climate model ALADIN-Climate/CZ simulated data.
- The simulations were conducted at high resolution for the current (1961-1990) and two future climates (2021-2050 and 2071-2100).
- First, the observed data of air temperature and precipitation totals was transferred into a regular grid of ALADIN-Climate/CZ model.
- The bias correction was applied on the scenario runs. The bias correction method is based on variable correction using individual percentiles whose relationship is derived from observations and control RCM simulation. After the correction, the model outputs are fully compatible with measured data.
- The SPEI was calculated based on observed monthly data of mean temperature and precipitation totals for the period 1961-1990, as reference period, and for the periods 2021-2050 and 2071-2100, as future climates under A1B SRES scenario.
- Monthly series of temperature and precipitation were taken from the Czech Hydrometeorological Institute CLIDATA database.
- The SPEI calculated for each grid point (789) was analysed in terms of temporal evolution and frequency distribution for the scenario runs in comparison with observational run.
- The gridding and all data processing including the presented analysis were done by ProClimDB database software (free download from http://wwww.climahom.eu) for processing of climatological datasets (Štěpánek, 2010).
- For calculation the SPEI, the algorithm developed by Vicente-Serrano et al. (2010) was used. The documentation and executable files are freely available at http://digital.csic.es/handle/10261/10002.
- The SPEI were calculated with various lags, 1, 3, 6, 12 and 24 months because the drought at these time scales is relevant for agricultural, hydrological and socio-economic impact, respectively. The study refers at the warm season of the year (April to September).
- As in the case of observational study, we have identified three climatically homogeneous regions, corresponding to the altitudes below 400 m, between 401 and 700 m and, above 700 m.
- For these three regions the frequency distribution of the SPEI values in 7 classes of drought category (%) were calculated based on grid point data falling in each region, both for the observed data and scenario runs.
- The paper presents the projected changes in frequency distribution of SPEI at various time scales, in intensity, duration and spatial distribution of drought over the territory of the Czech Republic under A1B scenario for the middle and the end of 21st century.

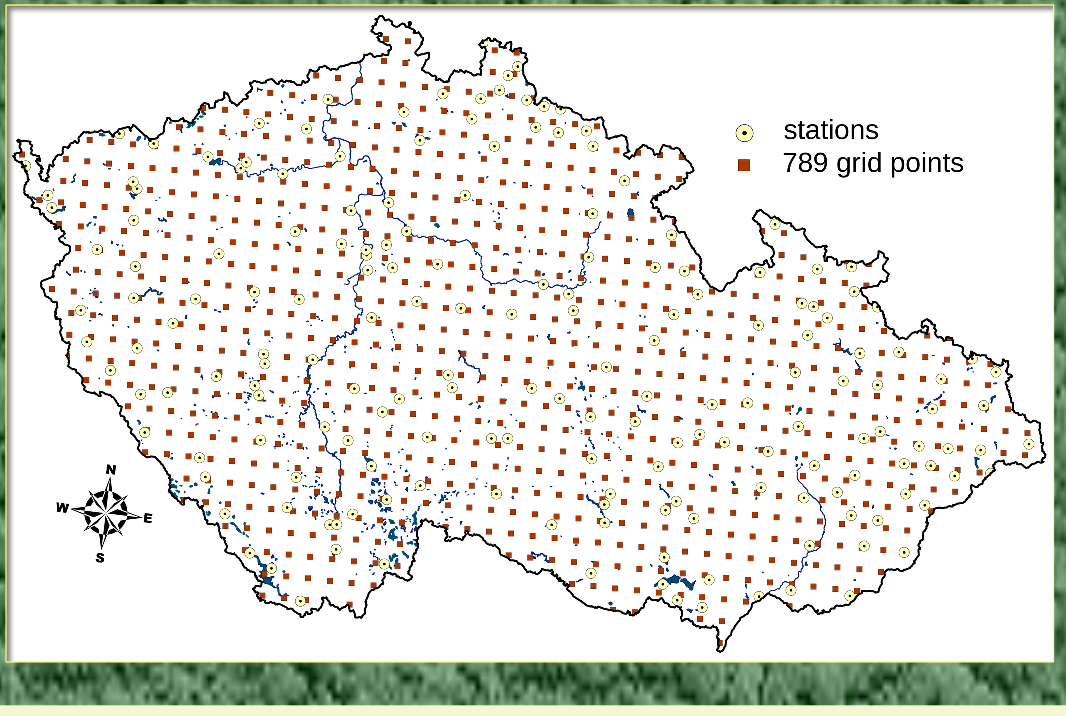
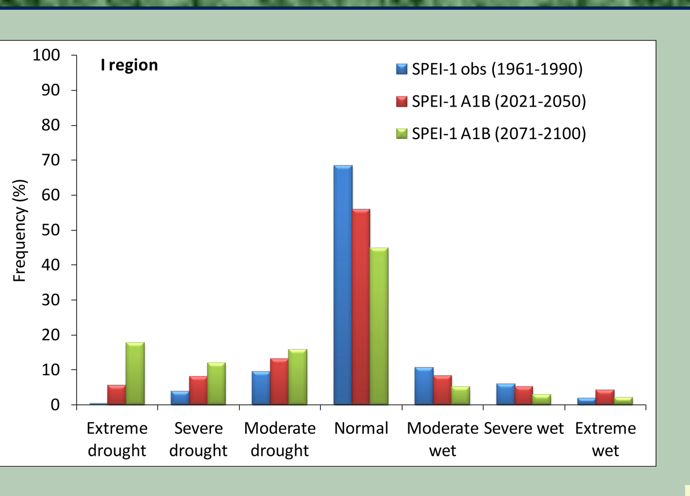


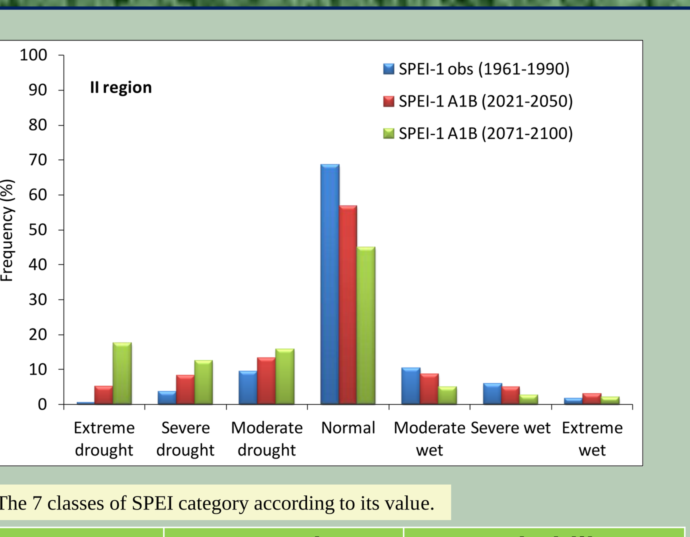
Fig. 1
Map of location of the climatological stations and 789 grid points used for the calculation of SPEI drought index in Czechia.

Summary: „ Projected changes in the evolution of drought assessed with the SPEI over the Czech Republic"

In the present study, the Standardized Precipitation Evapotranspiration Index (SPEI) was adopted to assess and project drought characteristics in the Czech Republic based on the regional climate model ALADIN-Climate/CZ simulated data. The simulations were conducted at high resolution (10km) for the current (1961-2000) and two future climates (2021-2050 and 2071-2100). First, the observed data of air temperature and precipitation totals was transferred into a regular grid of ALADIN-Climate/CZ model. The bias correction was applied on the scenario runs. The bias correction method is based on variable correction using individual percentiles whose relationship is derived from observations and control RCM simulation. The SPEI was calculated based on observed monthly data of mean temperature and precipitation totals for the period 1961-1990, as reference period, and for the periods 2021-2050 and 2071-2100, as future climates under A1B SRES scenario. The SPEI were calculated with various lags, 1, 3, 6, 12 and 24 months because the drought at these time scales is relevant for agricultural, hydrological and socio-economic impact, respectively. The study refers at the warm season of the year (April to September). As in the case of observational study, we have identified three climatically homogeneous regions, corresponding to the altitudes below 400 m, between 401 and 700 m and, above 700 m. For these three regions the frequency distribution of the SPEI values in 7 classes of drought category (%) were calculated based on grid point data falling in each region, both for the observed data and scenario runs. The paper presents the projected changes in frequency distribution of SPEI at various time scales, in intensity, duration and spatial distribution of drought over the territory of the Czech Republic under A1B scenario for the middle and the end of 21st century.

Key words: Standardized precipitation evapotranspiration index, frequency distribution, climate change scenario, Czech Republic.





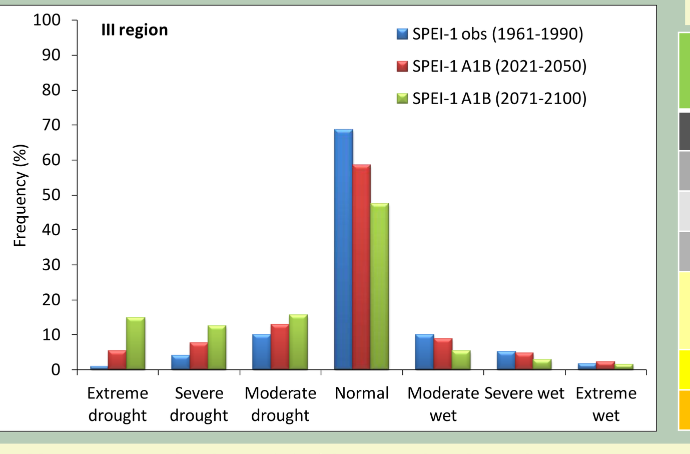


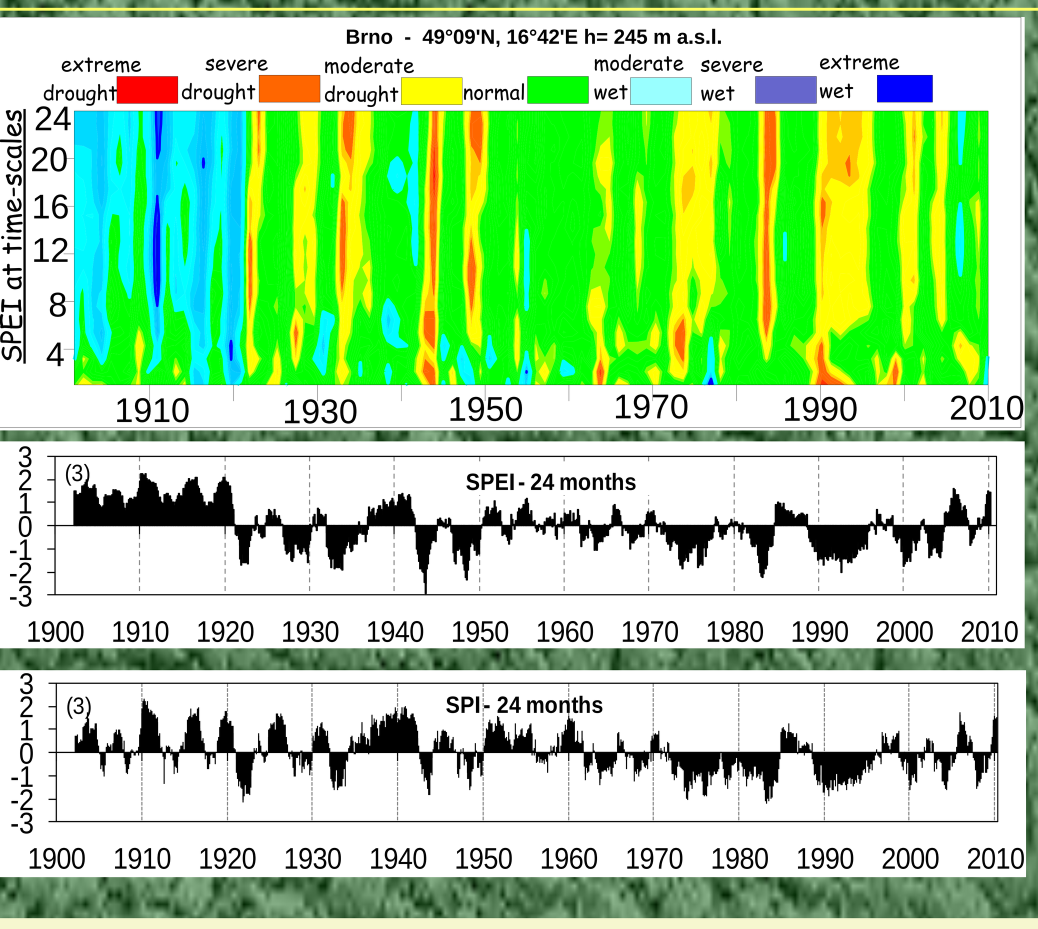
Table 1. The 7 classes of SPEI category according to its value.

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

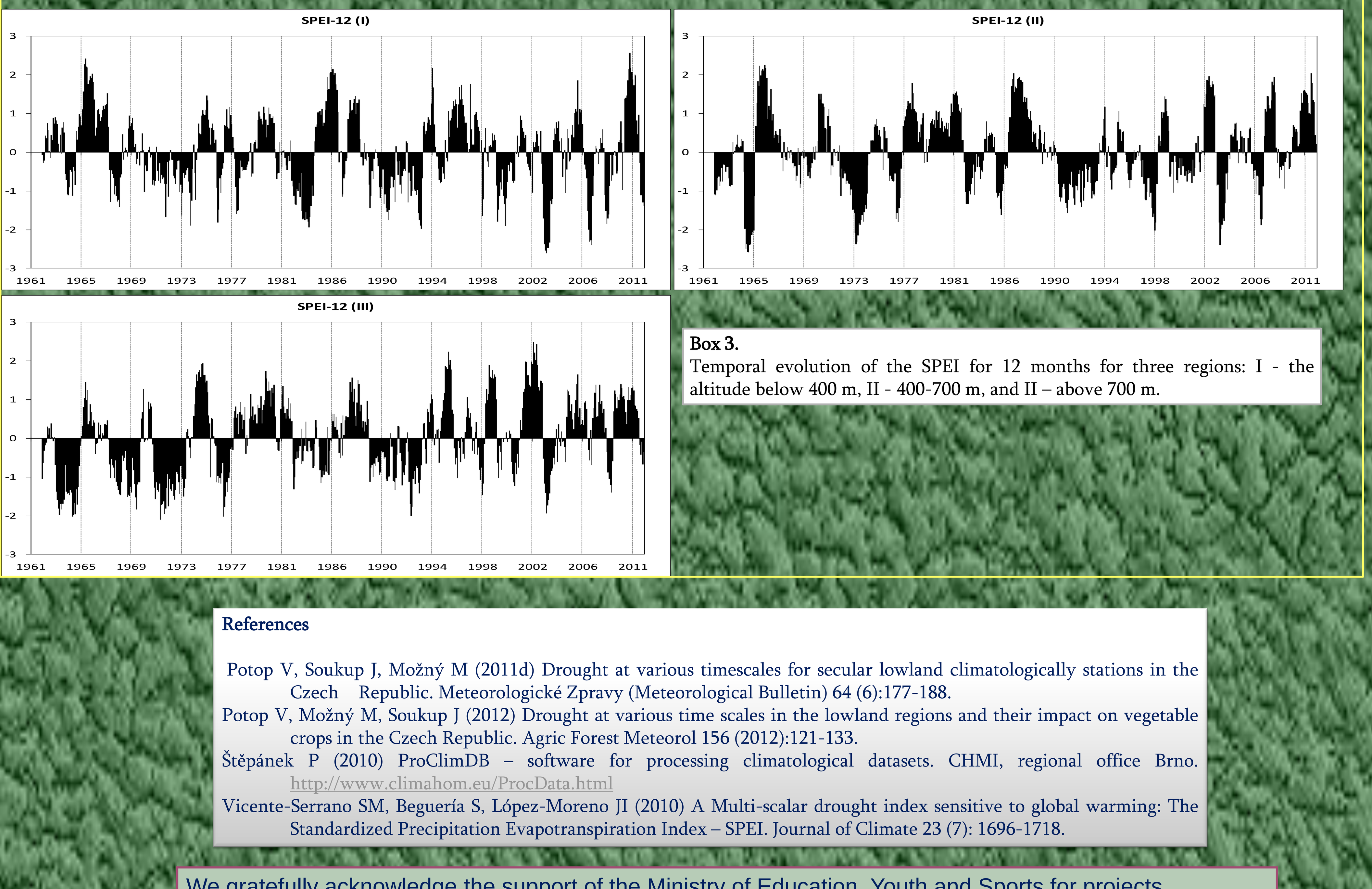
Table 2. Frequency distribution (%) of the SPEI values during the growing season in 7 classes of moisture category at time scales of 1 month per regions.
Region I: the altitudes below 400 m, region II: between 401 and 700 m and region III: above 700 m.

regions	Extreme drought	Severe drought	Moderate drought	Normal	Moderate wet	Severe wet	Extreme wet
			SPEI-1 obs	1961-1990			
I	0.26	3.81	9.31	68.45	10.46	5.90	1.81
II	0.47	3.64	9.39	68.60	10.32	5.87	1.71
III	0.80	3.98	10.05	68.65	9.86	5.07	1.60
			SPEI-1 A1B	2021-2050			
I	5.49	8.07	13.12	55.92	8.13	5.19	4.09
II	5.10	8.26	13.27	56.80	8.69	4.84	3.04
III	5.27	7.66	12.79	58.59	8.83	4.66	2.20
			SPEI-1 A1B	2071-2100			
I	17.70	11.86	15.72	44.81	5.08	2.84	1.98
II	17.48	12.45	15.78	44.93	4.85	2.57	1.95
III	14.83	12.53	15.51	47.48	5.36	2.79	1.50

Box 1.
Frequency distribution of the the SPEI for 1 month during growing seazon (April-September) based on measured monthly temperature and precipitation and simulated by the A1B scenario runs.



Box 2.
Secular temporal evolution (1901-2010) for data series of :
***upper panel)** SPEI at time scales from 1 to 24 months; **bottom panel)** SPEI and SPI at 24-months associated with hydrological drought;*



Box 3.
Temporal evolution of the SPEI for 12 months for three regions: I - the altitude below 400 m, II - 400-700 m, and II – above 700 m.

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