500-year April-September droughts in the Czech Lands based on documentary data and instrumental records

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Introduction

Temporal and spatial variability of April-September (the vegetation period) droughts in the Czech Lands over the last 500 years is analysed. The study is based on different types of documentary data covering the pre-instrumental period AD 1501-1804 and on the systematic instrumental meteorological measurements afterwards. Consequently the 500-year chronology of drought episodes derived from both data sources is compiled and the temporal and spatial variability of droughts in the Czech Lands from AD 1501 is analysed. The results obtained for the Czech Lands are evaluated with respect to climate variability in Central Europe during the last 500 years.

Data

Documentary data

Information about past droughts can be derived from various kinds of documentary evidence used as the basic data in historical climatology and hydrology.

Following data sources report droughts in the Czech Lands:

- **annals, chronicles, memories**
- **diaries**
- **tax documents**
- **religious data**
- **letters**
- **printed sources**
- **epigraphic data**

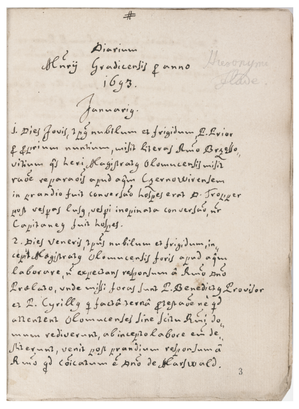


Figure 1 Systematic daily weather reports covering the 1693-1783 period come from diaries kept by the Premonstratensian abbey Hradisko and the priory Svatý Kopeček near Olomouc. Drought is mentioned in totally 17 years.

Figure 2 A hunger stone at the left bank of the River Elbe at Děčín-Podmokly with chiselled years and initials of today already unknown authors.

Instrumental data and drought indices

Analysis of droughts in the Czech Lands in the instrumental period is based on drought indices:

- **one month Standardised Precipitation-Evaporation Index (SPEI-1)**
- **Palmer Z-index**
- **Palmer Drought Severity Index (PDSI)**

Drought indices were calculated from the homogenised monthly series of mean areal Czech temperature and precipitation for the 1805-2012 period.

Methods and Results

Droughts in the Czech Lands based on documentary data

Many documentary sources mention drought directly or by its various impacts to express extremeness of this event: bad yields of crops, shortage of water, low level of water in rivers, drying up of watercourses, possibility to cross river on foot or with conveyance, water mills can not mill, dearth of meal and bred, longer period without rain, hampered autumn sowing, processions and praying for rain etc.

Dry months are described by following indices: -1 dry, -2 very dry, -3 extremely dry.

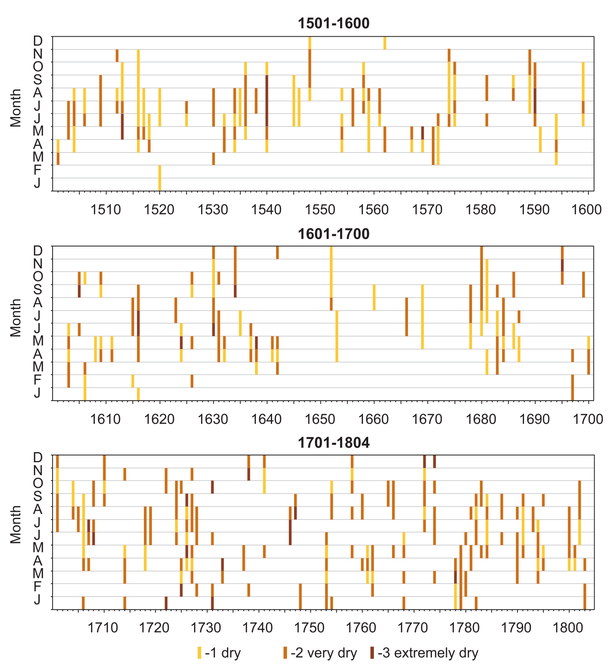


Figure 3 Dry months/droughts in the Czech Lands interpreted from documentary evidence for the 1501-1804 period with expression of their intensity by precipitation indices.

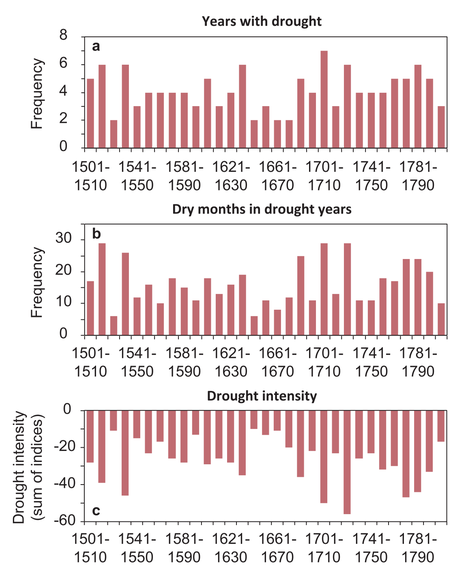


Figure 4 Decadal frequencies of droughts in the Czech Lands in the 1501-1804 period.

Various documentary sources were used for selection of dry months/droughts which were interpreted with the monthly resolution. While the data about droughts before AD 1500 are scarce, analysis concentrated mainly on droughts afterwards. As drought episodes in 1501-1804 were finally taken years in which dry patterns occurred at least at two consequent months.

Table 1 Frequency of drougts in the Czech Lands in the pre-instrumental period.

Century	Frequency
12th	4
13th	5
14th	14
15th	12
16th	41
17th	36
18th	49

Droughts in the Czech Lands in the instrumental period

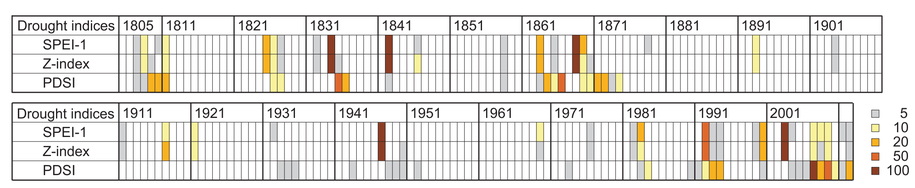


Figure 5 Droughts expressed by SPEI-1, Z-index and PDSI for April-September with their re-occurrence interval N > 5 years in the Czech Lands during the 1805-2012 period.

From drought indices SPEI-1, Z-index and PDSI April-September series, their values with the re-occurrence interval of N years (N = 2, 5, 10, 20, 50, 100) were calculated using GEV statistics.

SPEI-1 and Palmer Z-index represent short-term or medium-term drought, and PDSI characterises long-term drought.

Table 2 Frequency of drougts in the Czech Lands in the instrumental period (1805-2012).

Century	Frequency	Percentage distribution in individual centuries		
		SPEI-1	Z-index	PDSI
19th	47	45.0%	48.7%	44.7%
20th	47	37.5%	38.5%	36.2%
2001-2012	9	17.5%	12.8%	19.1%

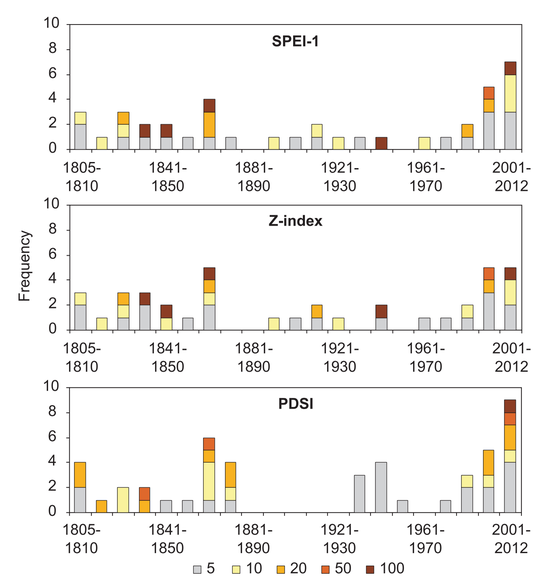
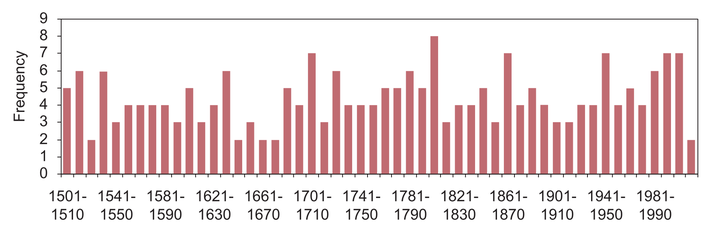


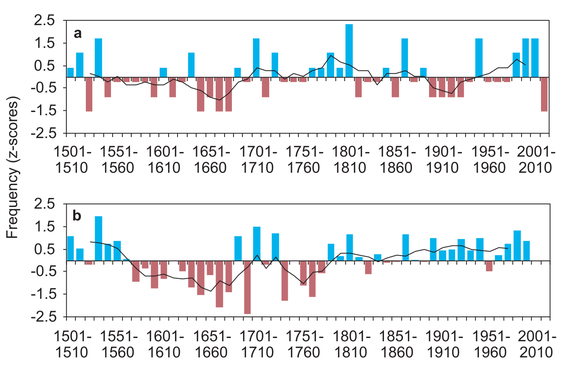
Figure 6 Decadal frequencies of droughts expressed by SPEI-1, Z-index and PDSI for April-September ordered according their N-year re-occurrence interval (N = 5, 10, 20, 50, 100) for the Czech Lands in the 1805-2012 period.

Long-term chronology of droughts in the Czech Lands

Figure 7 Decadal frequencies of droughts in the Czech Lands in the 1501-2012 period compiled from documentary data (1501-1804) and instrumental record (1805-2012).



Droughts in the Czech Lands in Central European context



More frequent droughts covered the first part of the 16th century, end of the 18th century and both series also indicate more droughts during the 20th century.

Correlation coefficient between (a) and (b) (see Figure 8): r = -0.58

Figure 8 Decadal frequencies of dry months in the Czech Lands derived from documentary sources and instrumental data (a) and decadal means of JJA reconstructed precipitation totals (Pauling et al. 2006) (b) in the period 1501-2000. Both series are expressed as standardised values (z-scores) and values of precipitation totals were inverted for better interpretation - that is in both graphs more positive values in the both graphs show more dry periods; black lines are running averages for five terms.

Conclusions

Temporal and spatial variability of April-September droughts in the Czech Lands over the last 500 years was analysed.

The study was based on two types of data:

a) documetary data from pre-instrumental period AD 1501-1804 - totally 129 dry years were distinguished (on average one drought per 2.4 years), 73.7% from April to September,

b) mean monthly precipitation and temperature series (instumental period AD 1805-2012) - totally 100 dry years from April to September were selected (on average one drought per 2.1 years).

Droughts were studied in context with Central European climate: while severe droughts of the 19th century in relatively cooler climate were caused by lack of precipitation, the last onset of droughts can be attributed to significant increasing temperatures than to the significant decrease in precipitation totals.

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