MUNI
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10 Historical climatology

Lukáš Dolák, MSc, PhD

Content

1. Historical climatology
2. Current and long-term issues
3. Examples of currently solved issues

Question of the day

Do the results of historical climatology have any relevance in light of the rapidly recent climate change?

If so, for what purpose?

Historical climatology

Historical climatology

- A scientific discipline at the boundary between **climatology** and **(environmental) history**
- Working mainly with **documentary** and **image sources**
- Filling the space between **palaeoclimatology** and **climatology** in time with the period of instrumental measurements, or overlaping them
- Foundations of historical climatology since the **late 19th century**
- **Development** since **1960** (H. Lamb, E. L. R. Ladurie)
- **Major development** after 1990 (Ch. Pfister, R. Brázdil)

Historical climatology

Four generations of historical climatologists:

- Rudolf Brázdil (*1951)
- Christian Pfister (*1944)
- Emmanuel Le Roy Ladurie (*1929)
- Franz Mauelshagen (*1967)

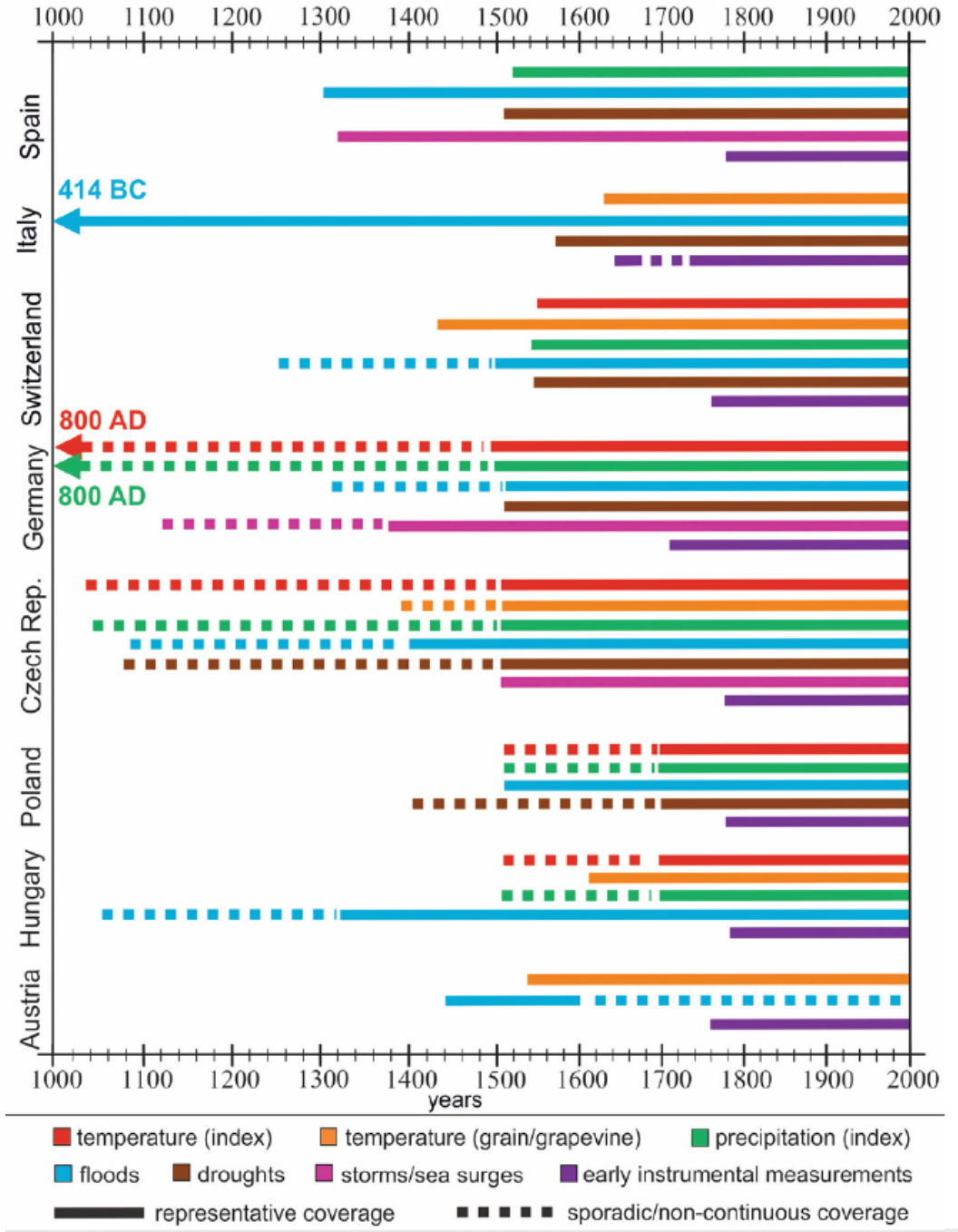
Eveline Zbinden, Bern, 2013

Current and long-term issues

Current issues (world)

- How to analyse **large amounts of different data** on climate, weather and society
- The challenge of **combining qualitative and quantitative** data
- **Reconstructing** past temperature, precipitation and extreme events and linking them to climate models of future trends
- The **impact of climate variability** on past **societies**

Current issues (world)



Kiss et al., 2020

Long-term issues (MU)

- Study of **climate fluctuations** in the Czech Republic based on documentary and dendroclimatic data, early instrumental measurements and systematic meteorological observations during the last millennium
- **Reconstruction** and **study** of **selected hydrometeorological extremes** in terms of their frequency of occurrence, seasonality, intensity and impacts on environment and society

Czech historical climatology in the European context

- Central Europe and the Czech Republic as one of the **fastest growing regions** in the field of historical climatology
- Relatively **long tradition** in research since the early 1990s
- **Developed cooperation** between geographers, climatologists, historians, archivists...
- Rich base of documentary sources
- **Reconstructed series** of temperature, precipitation and drought episodes since 1501
- Study of various issues with regard to their topicality (Tambora eruption, bark beetle calamity, impacts of recent climate change, etc.)

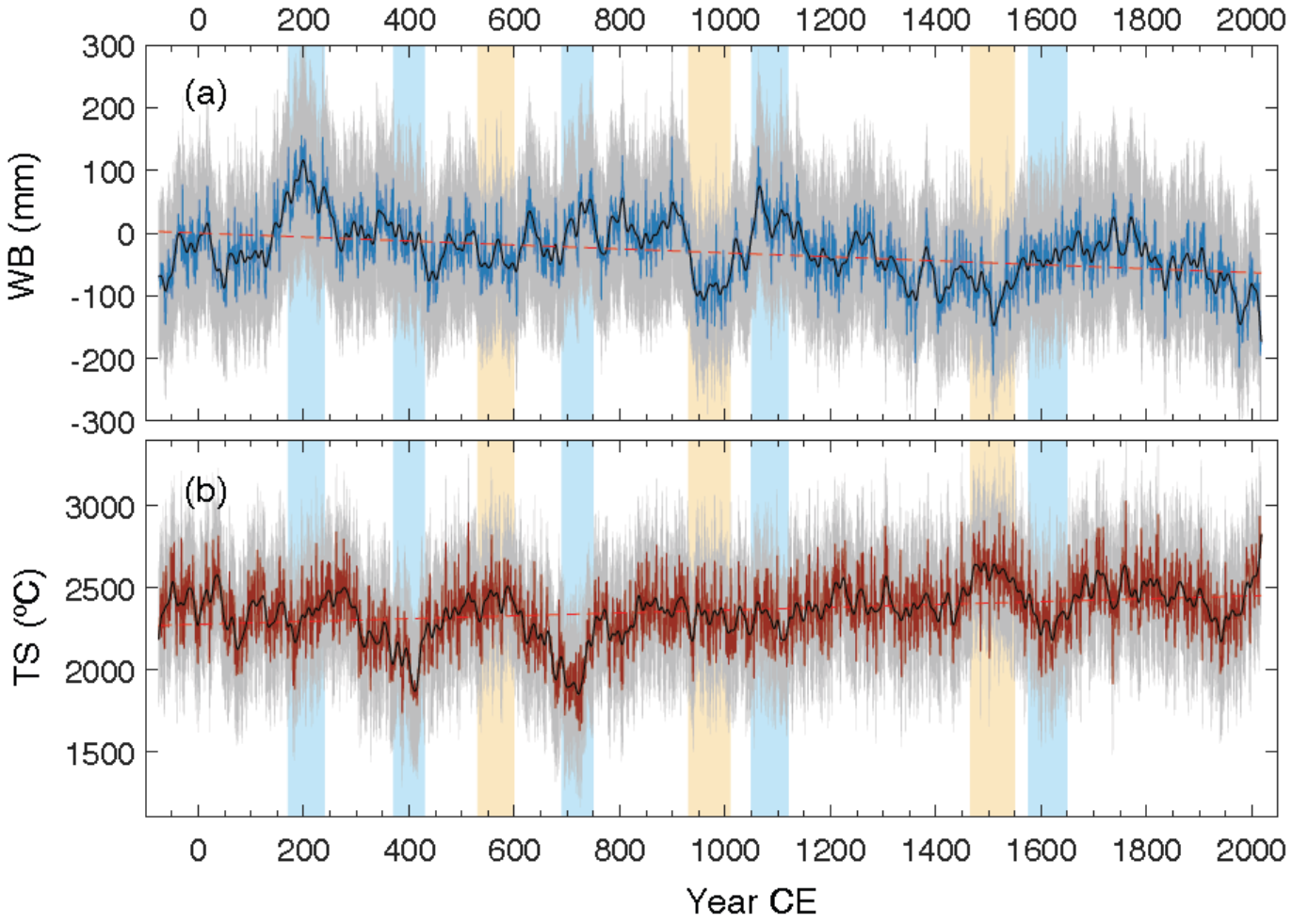
Current and recently solved issues (MU)

- Reconstruction of **(agro)climatic conditions**
- The impact of weather and climate on human society
- **Drought episodes** and their variability
- Variability of **tornadoes** in the Czech lands
- Analysis **of climatic variability since 1961**
- **Landslide movements** in the Czech lands (childa.cz)
- Analysis of HME **victims** and unfavorable weather conditions

Examples of currently solved issues

Agroclimatic conditions in Central Europe over the last 2 000 years

- Analysis of stable O and C isotopes from tree rings to reconstruct **summer temperature** and **water balance** over the last 2 000 years

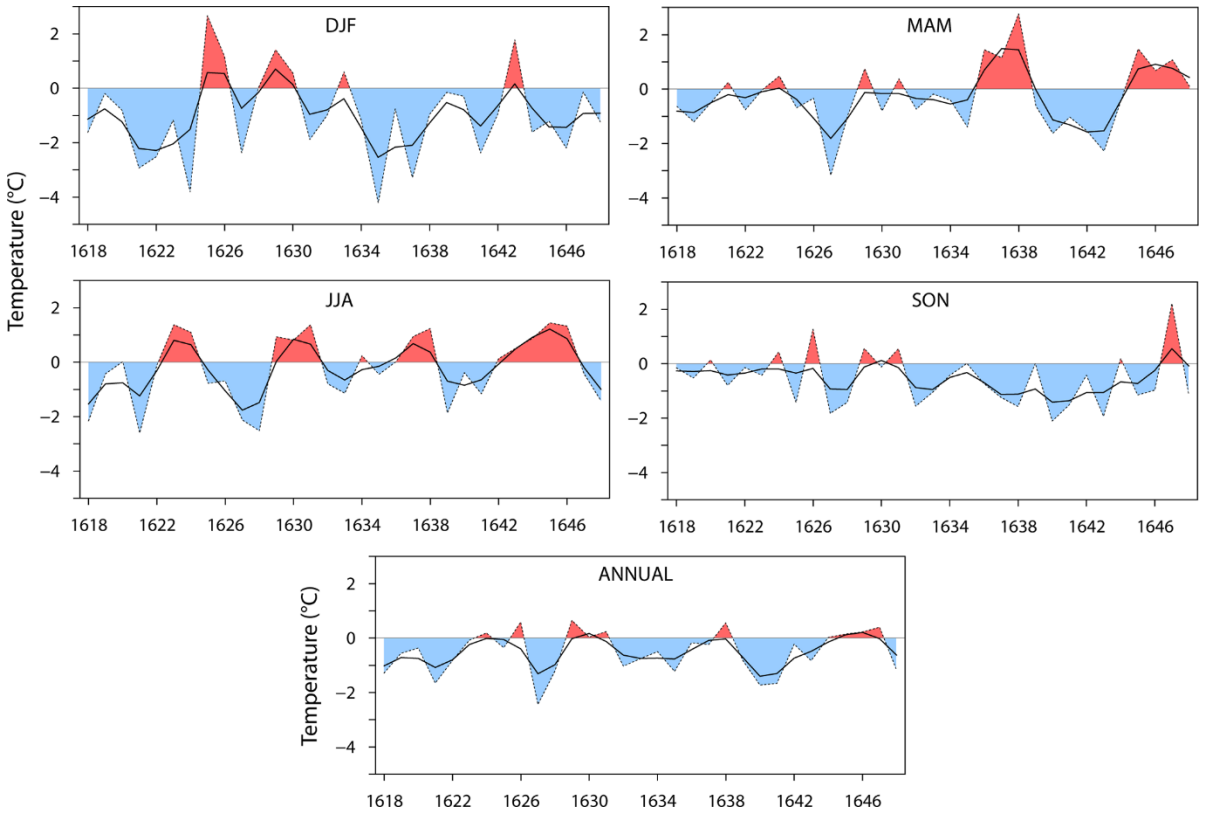


Reconstructions of (a) water balance and (b) temperature sum from 75 BCE to 2018 CE based on oak TRSI from central Europe.

Torbenson et al. 2023

The impact of weather and climate on human society during the 30 Years War

- The gradual **deterioration** of the climate in the Czech lands **in the first half of the 17th century**
  - beginning of the **Maunder Minimum** (1645–1715): decline in solar and increase in volcanic activity (Iceland)
- Significantly **colder winter** and **autumn** season and year (1618–1648) compared to the reference period 1961–1990

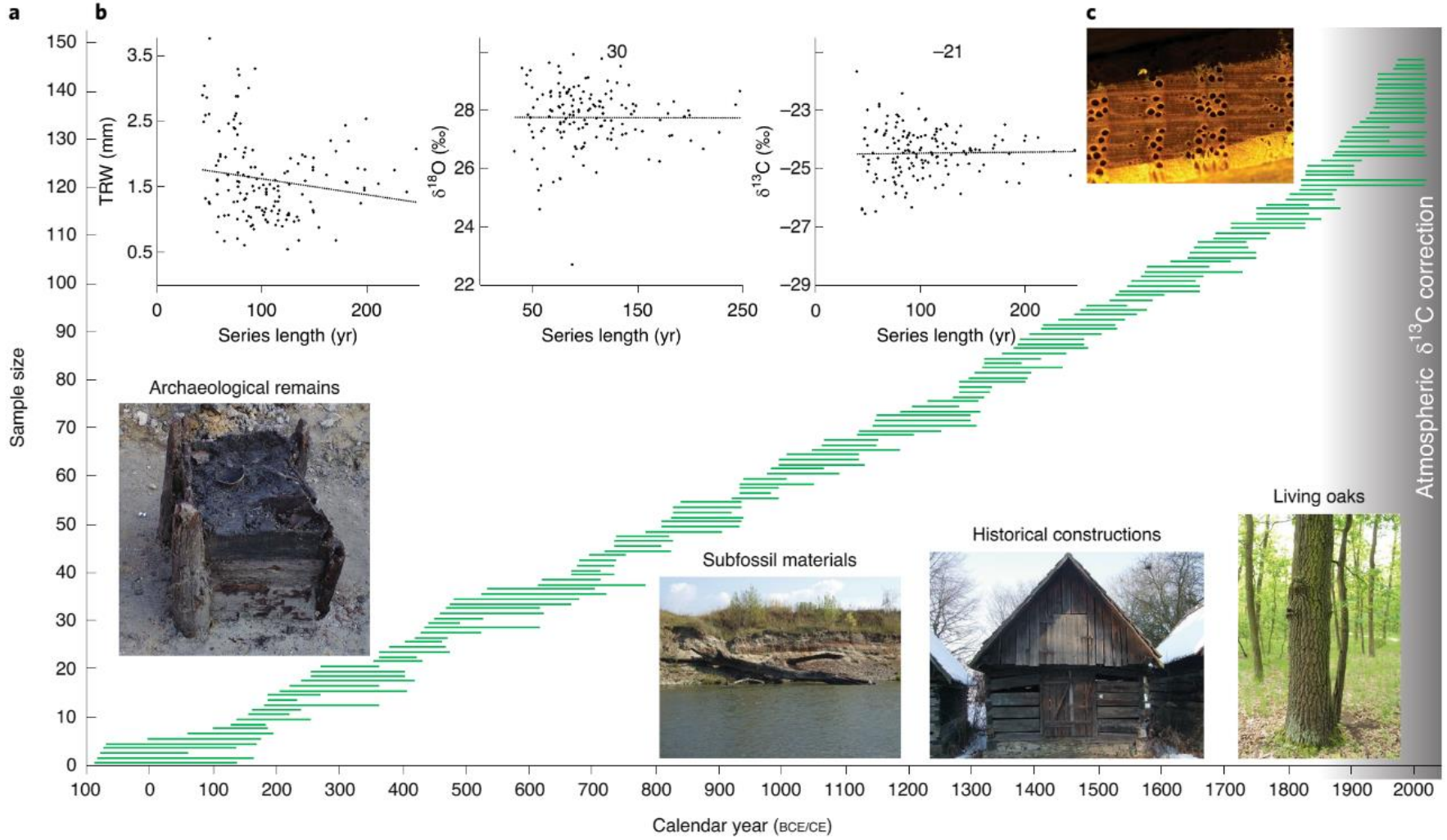


Brázdil et al. 2023

European extreme drought episodes and their variability (91 BC–2018 CE)

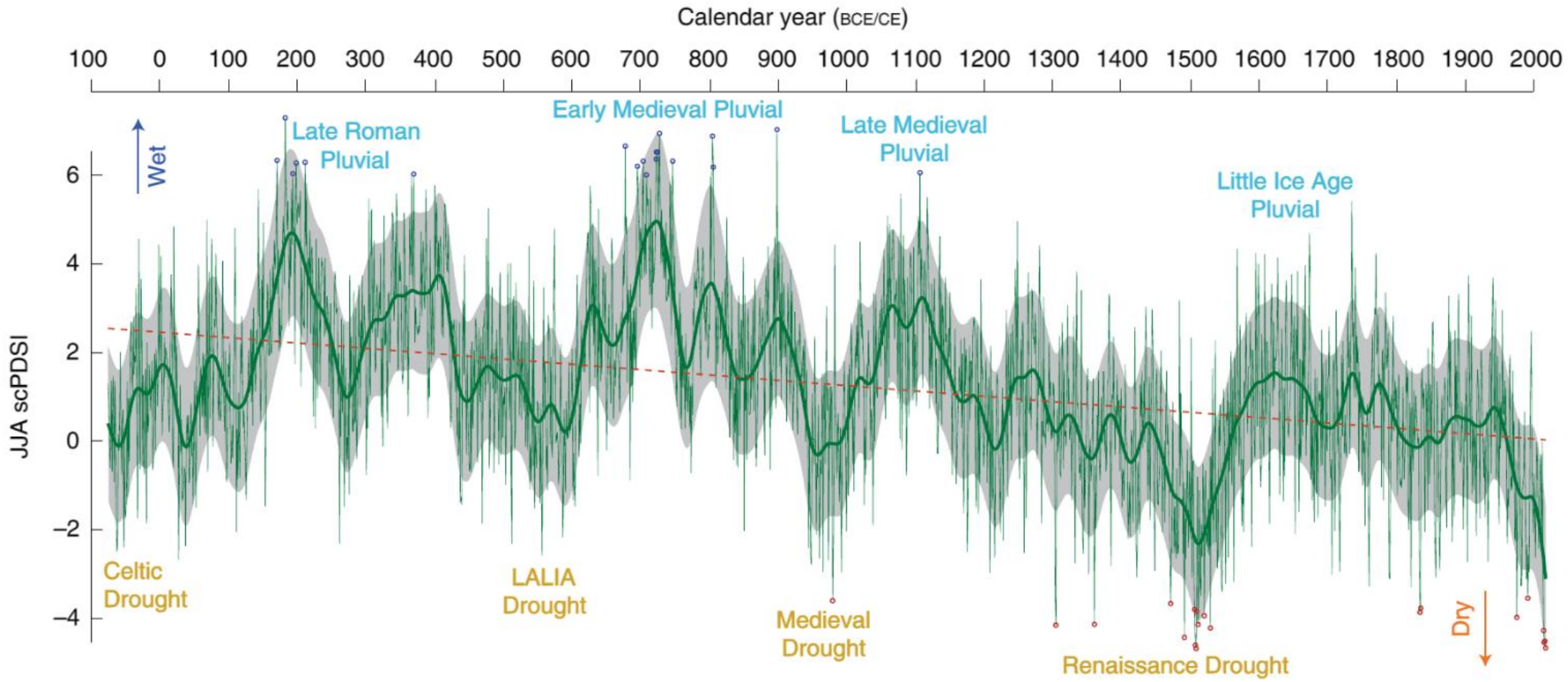
- Radiometric dating based on the analysis of **stable isotopes ^{12}C, ^{13}C, ^{16}O and ^{18}O in tree rings**
- **Lower response** of tree ring width in the Czech Republic to **moisture conditions**
- **Stress periods**: uptake of even heavier isotopes through photosynthesis (^{13}C) and water by the root system (^{18}O), integration into tree cellulose
- Possibility of creating a time series of hydroclimatic conditions

European extreme drought episodes and their variability (91 BC–2018 CE)



Büntgen et al. 2021

European extreme drought episodes and their variability (91 BC–2018 CE)



Büntgen et al. 2021

Drought episodes in the Czech Republic and their causes

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Year	SPI	SPEI	Z-index	Year	SPI	SPEI	Z-index	Year	SPI	SPEI	Z-index	Year	SPI	SPEI	Z-index
1532	50	20	20	**1503**	10	20	20	**1536**	10	20	50	**1504**	10	20	20
1540	50	200	100	**1504**	10	20	20	**1540**	20	100	200	**1534**	10	20	20
1571	20	50	50	**1534**	10	20	20	**1548**	100	50	20	**1536**	20	50	50
1583	20	20	20	**1536**	20	50	50	**1580**	100	20	20	**1540**	200	200	200
1603	50	50	50	**1540**	200	200	200	**1590**	20	50	100	**1590**	200	100	100
1638	200	200	200	**1556**	20	20	20	**1605**	100	100	50	**1616**	100	100	200
1683	200	50	20	**1590**	100	200	200	**1631**	10	20	20	**1631**	20	20	50
1686	20	50	20	**1616**	50	100	200	**1634**	200	50	50	**1684**	10	20	20
1727	50	50	20	**1630**	50	20	20	**1680**	100	200	200	**1706**	10	20	20
1732	20	20	20	**1631**	10	20	20	**1686**	20	20	50	**1718**	10	20	20
1753	20	20	20	**1666**	20	20	20	**1710**	20	20	20	**1726**	10	20	20
1779	200	200	200	**1684**	20	50	50	**1726**	20	20	50	**1727**	20	50	50
1781	50	20	20	**1718**	20	20	20	**1727**	20	50	100	**1728**	10	20	100
1790	200	20	20	**1719**	20	20	20	**1731**	10	20	20	**1800**	20	20	20
1794	50	200	200	**1728**	20	20	100	**1754**	10	20	20				
1800	50	50	50	**1746**	100	50	50	**1772**	20	20	20				

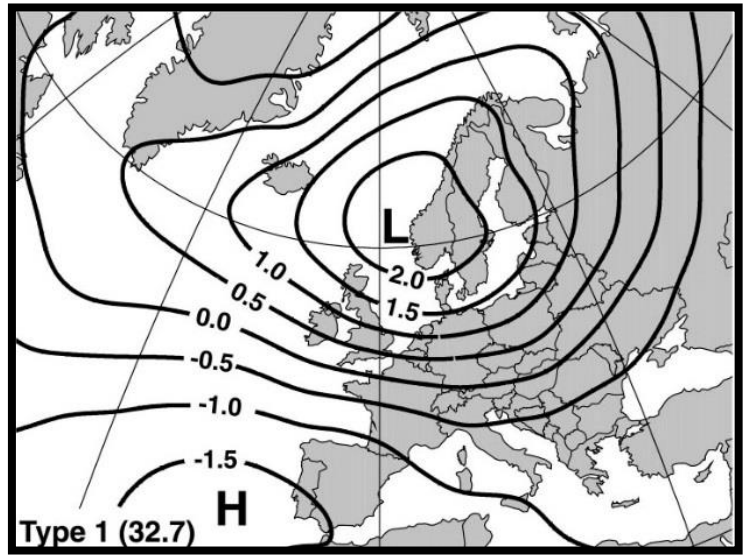
Brázdil et al. 2019

Drought episodes in the Czech Republic and their causes

- **Drought 1540**
  - almost all of Europe affected
  - up to **80% reduction in rainfall** compared to the 20th century average
  - no rainfall recorded in N Italy from 11/1539-4/1540
  - mean annual temperature **up to 9 °C higher in S Europe**
  - **drying up of wells** and smaller streams, rapid drop in river and lake levels
  - **largest forest fires in 500 years** (reduced sunshine)
  - missing tree rings, extreme cracks, bathing in winter…

Windstorms in the Czech lands in the last 500 years

- **Windstorms** in the Czech Republic cause the most damage after floods and drought
- **Two types of storms: „winter“**
  - determined by the existence of a **large horizontal pressure gradient**
  - common occurrence in **October-March**
  - typically **longer duration** (days)
  - affecting **larger areas** (regions-states)

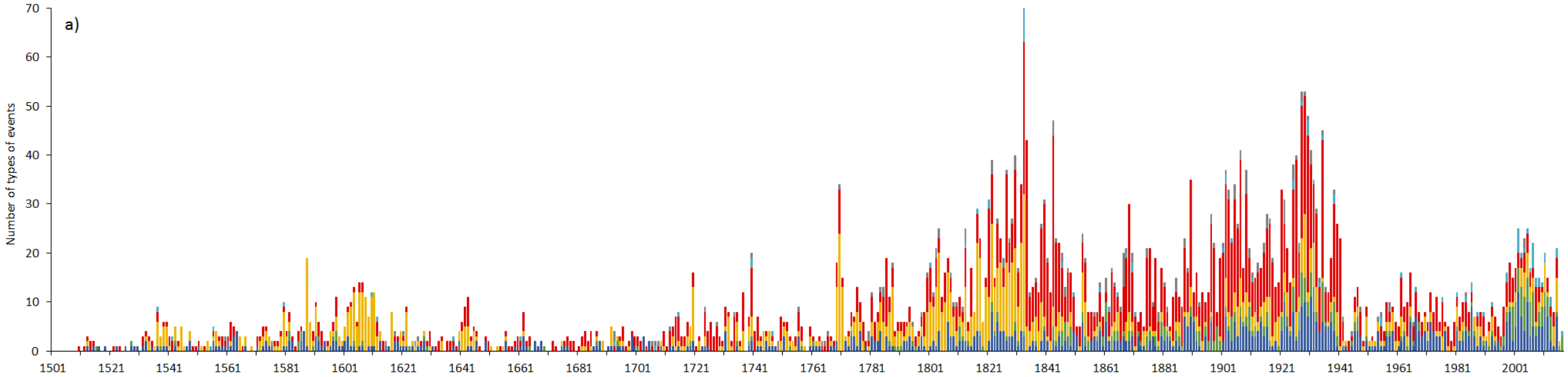


Windstorms in the Czech lands in the last 500 years

- **Two types of storms: „summer“**
  - associated with the occurrence of **convective events**
  - typical occurrence in the **summer half-year** (April-September)
  - usually **shorter duration** (minutes-10s of minutes)
  - affecting **smaller areas**, local damage, area of damage sharply delineated
  - **specific form** (tornadoes, downbursts, etc.)
  - very **limited forecasting capability**

Windstorms in the Czech lands in the last 500 years

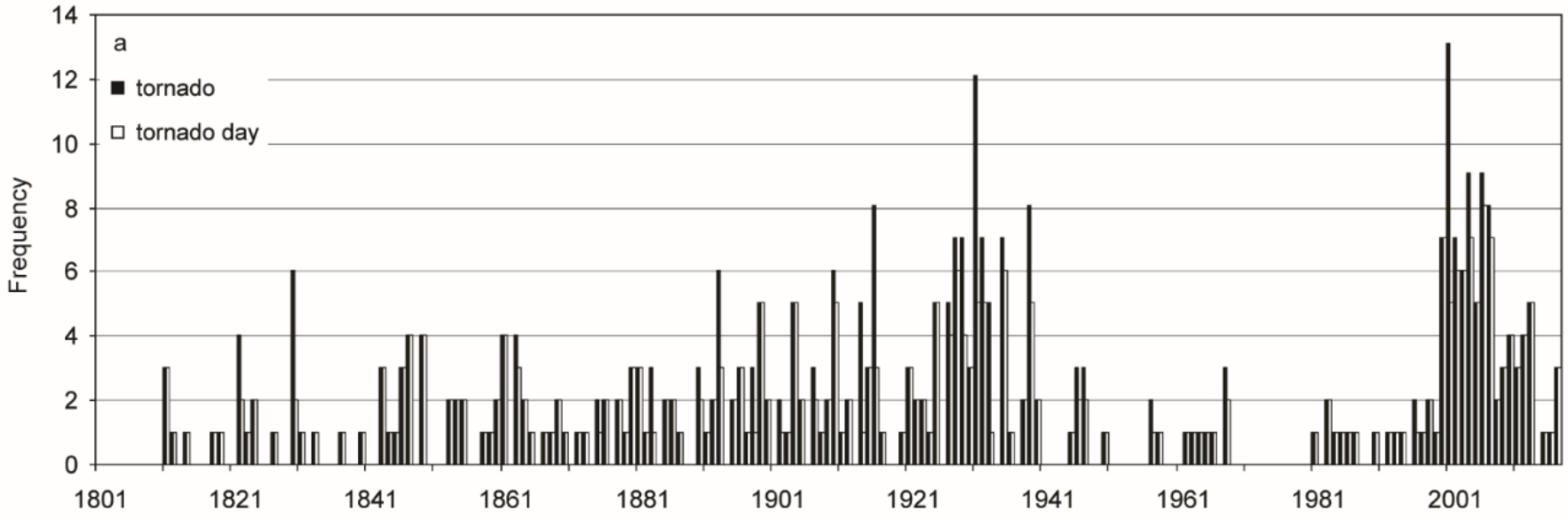
- **4 864 cases of gales and strong winds (1510–2017)**
  - windstorms (43.8%), blizzards (25.7%), gust winds during thunderstorms (17.9%), tornadoes (7.2%), strong winds of uncertain origin (3.5%), wind squalls (1.9%)

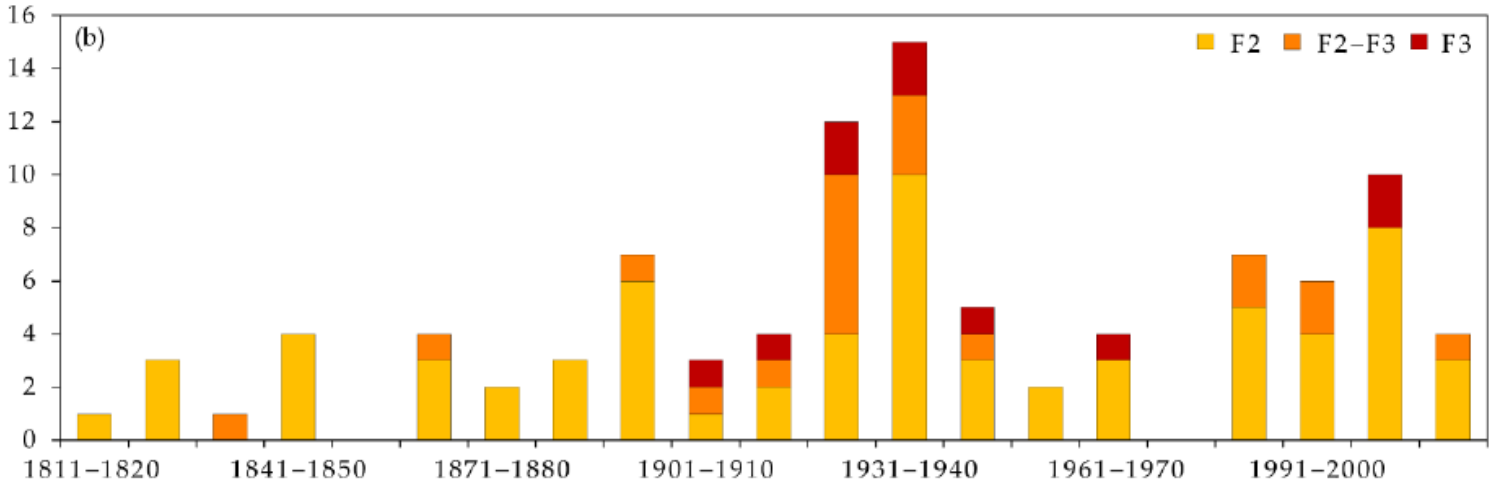


Tornadoes in the Czech lands in the last 200 years

- The **oldest documented tornado** in the Czech Republic: 30 July 1119
- **367 tornadoes** and 299 tornado days recorded (1801–2017)
- Chronology of tornadoes **influenced** by **availability of documentary sources**
- Highest occurrence in **lower** and **middle elevations**
- Average number of tornadoes in the country: **2/year**

Tornadoes in the Czech lands in the last 200 years





Brázdil et al. 2018, 2019

Tornadoes in the Czech lands in the last 200 years

Hněvčeves 1. 6. 2014

Vienna 10. 7. 2017

Severe Weather Europe

Tornadoes in the Czech lands in the last 200 years

- Tornado 24 June 2021 in South Moravia (F4)

Herka, 2021

Impacts of volcanic eruptions on climate, nature and society

- **Lakagígar** (Iceland) 8 June 1783-February 1784:
  - largest lava eruption in 1,000 years
  - resulting in increased mortality in W Europe and a series of climatic anomalies

- **Tambora** (Indonesia) 10 April 1815:
  - one of the largest volcanic eruptions on record
  - more than 35 000 victims
  - year 1816 is known as the 'year without summer'

Impacts of volcanic eruptions on climate, nature and society

Lakagígar 1783	Tambora 1815
Temperature: Extreme winter 1783/1784, spring 1785, summer and autumn 1786	Temperature: Extreme summer 1816
Precipitation: No extreme season	Precipitation: Extreme summer 1815
Weather: Dry fog, heavy thunderstorms (no rain), sun and moon red	Weather: No directly observed post-volcanic weather effects
Large floods: February 1784, April 1785, August 1786	Large floods: August 1815, March 1817
Landslides: No indications of landslides	Landslides: five events in north-western Bohemia (1817)
No effects on agriculture and grain prices	Bad grain harvest, rise in grain prices
No crisis indications	Lack of bread, hunger, high vagrancy
Fatalities among those ringing city bells to ward off thunderstorms – prohibition of ringing	Important natural and societal impacts

Brázdil et al. 2017

CHILDA - Czech Historical Landslide DAtabase

- **Database of landslides and rockfalls** in the Czech Republic (1132–1989/2022)
- 2021: **699 records**
- Analysis of causes, extent, impact of landslides, landslide prevention, source and image (if available)

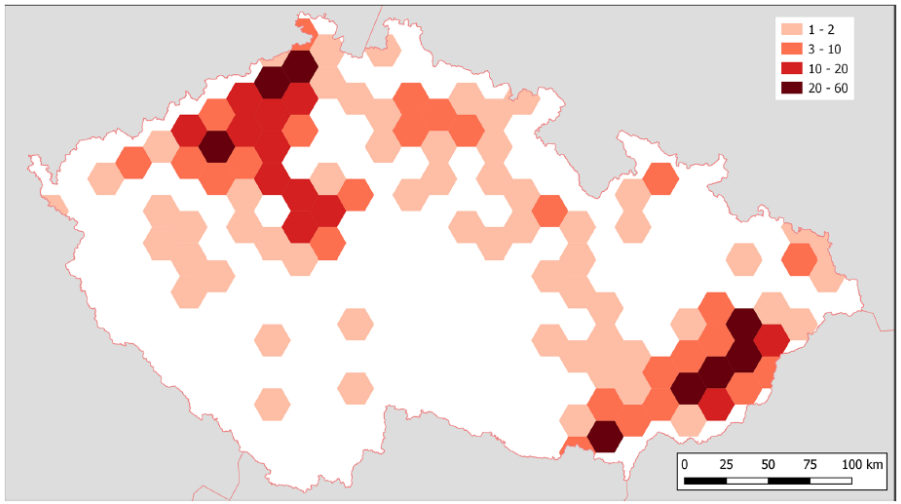
https://childa.cz/?lang=cz

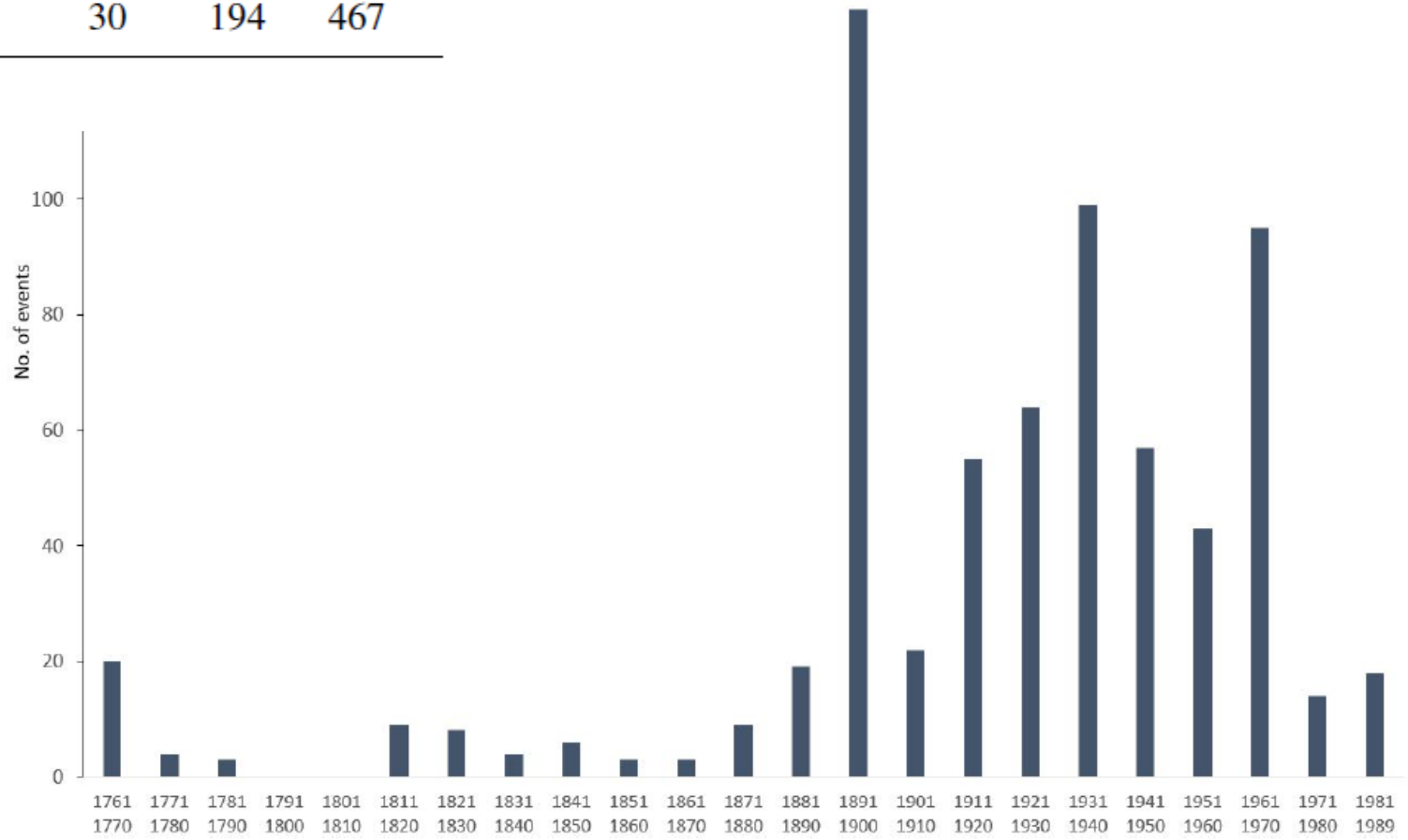
childa.cz, 2022

CHILDA - Czech Historical Landslide DAtabase

Century	12th	13th	14th	15th	16th	17th	18th	19th	20th*
n	1	0	0	0	5	2	30	194	467

* up to and including 1989.



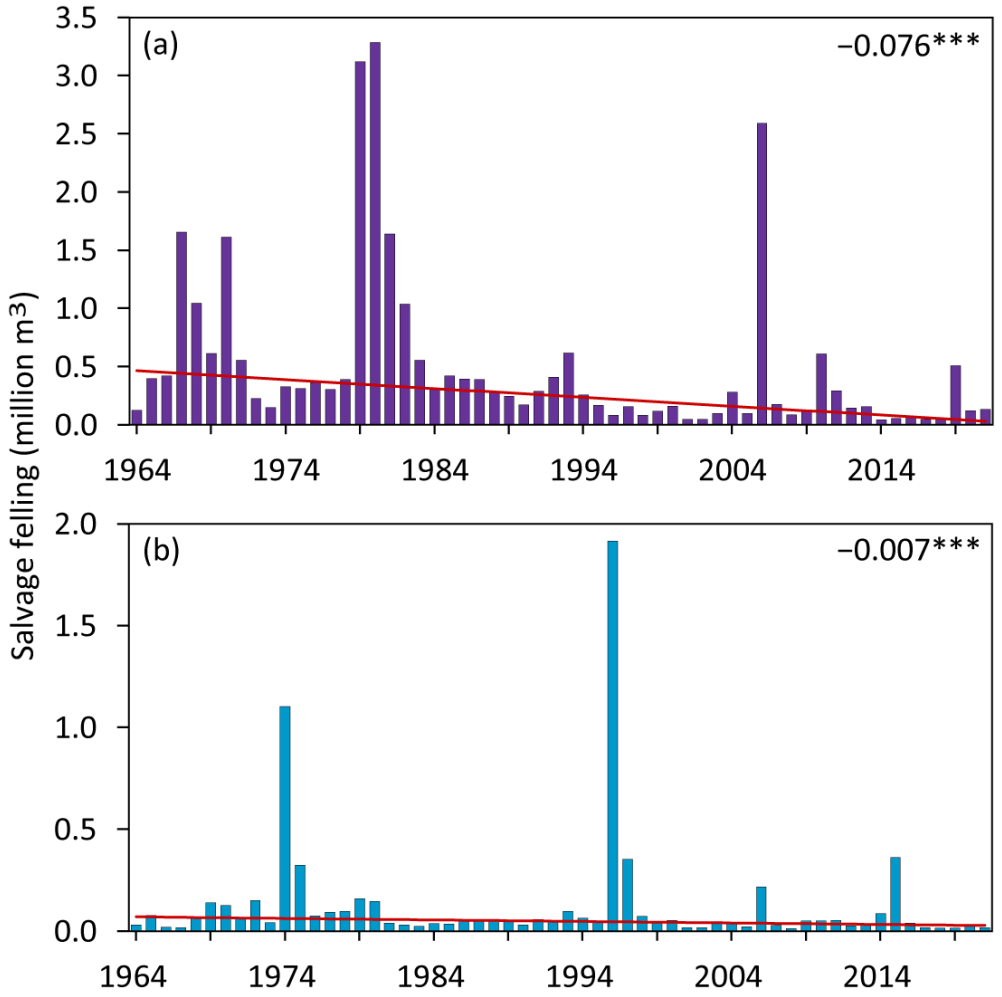


Landslide density (top) and 10-year frequency of landslides in the Czech Republic between 1761 and 1989 (right)

childa.cz, 2022

Analysis of severe winters in the Czech Republic and their environmental impacts (1961–2021)

- Significant **increasing trends** in mean, min, max, absolute min and max air **temperatures**
- Significant **decreases** in the **number** of **frost days, ice days, arctic days, snow days, and cold wave lengths**



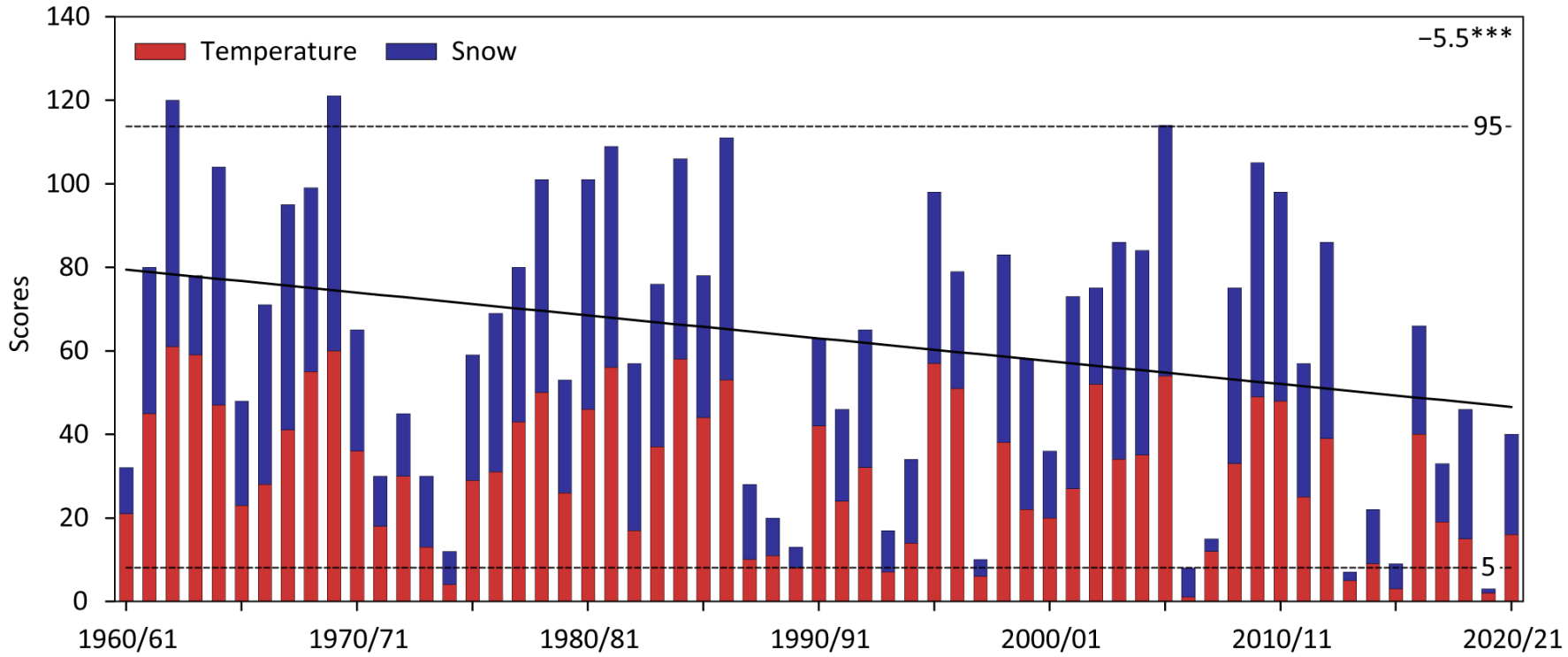
Annual timber logging (million m3) due to snow (a) and ice (b) windfalls in the Czech Republic (1964–2021)

Brázdil et al. 2022

Analysis of severe winters in the Czech Republic and their environmental impacts (1961–2021)

- **Declining severity of winters** in the Czech Republic

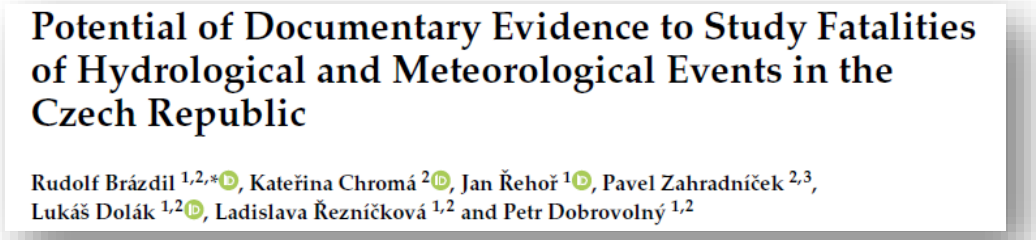
Fluctuations and linear trend in the severity of winters in the Czech Republic (1961–2021) expressed as a score of the sum of air temperature and snow conditions



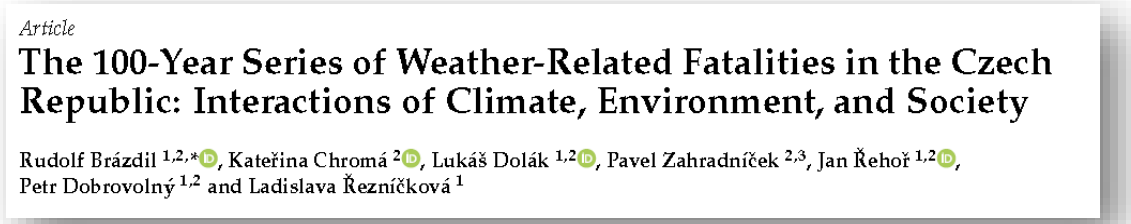
Brázdil et al. 2022

Analysis of HME casualties and unfavourable weather conditions (1921–2020)

- Compilation of **chronologies of victims** on the territory of the Czech Republic based on documentary sources (newspapers, websites, chronicles, police statistics)
- Detection of victims of **natural disasters** (floods, storms, lightning strikes...) and **unfavourable conditions** (ice, fog, heat waves...)


Potential of Documentary Evidence to Study Fatalities of Hydrological and Meteorological Events in the Czech Republic

Rudolf Brázdil [1,2,*], Kateřina Chromá [2], Jan Řehoř [1], Pavel Zahradníček [2,3], Lukáš Dolák [1,2], Ladislava Řezníčková [1,2] and Petr Dobrovolný [1,2]


Article

The 100-Year Series of Weather-Related Fatalities in the Czech Republic: Interactions of Climate, Environment, and Society

Rudolf Brázdil [1,2,*], Kateřina Chromá [2], Lukáš Dolák [1,2], Pavel Zahradníček [2,3], Jan Řehoř [1,2], Petr Dobrovolný [1,2] and Ladislava Řezníčková [1]


Fatalities associated with the severe weather conditions in the Czech Republic, 2000–2019

Rudolf Brázdil[1,2], Kateřina Chromá[2], Lukáš Dolák[1,2], Jan Řehoř[1,2], Ladislava Řezníčková[1,2], Pavel Zahradníček[2,3], and Petr Dobrovolný[1,2]


Weather and traffic accidents in the Czech Republic, 1979–2020

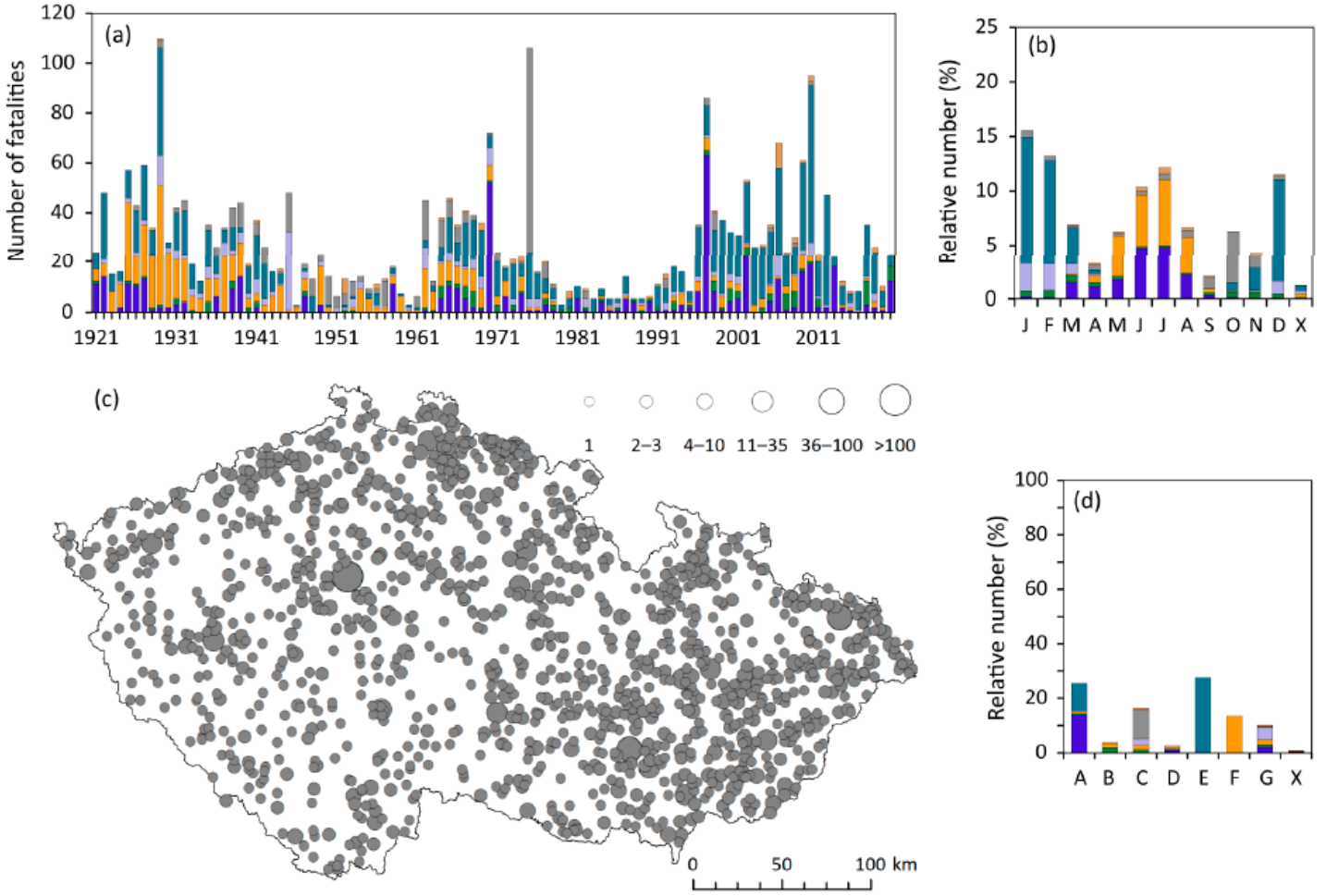
Rudolf Brázdil[1,2] · Kateřina Chromá[2] · Pavel Zahradníček[2,3] · Petr Dobrovolný[1,2] · Lukáš Dolák[1,2]

Analysis of HME casualties and unfavourable weather conditions (1921–2020)

- Total of 2 729 victims
- **Main causes of death**: frost (38%), convective storms (19%), floods (17%)
- **Death peaks**: January, July
- **Most common time of death**: afternoon, night
- **Most common places of death**: open countryside, river banks
- Prevalence of **hazardous behaviour** of victims

Analysis of HME casualties and unfavourable weather conditions (1921–2020)

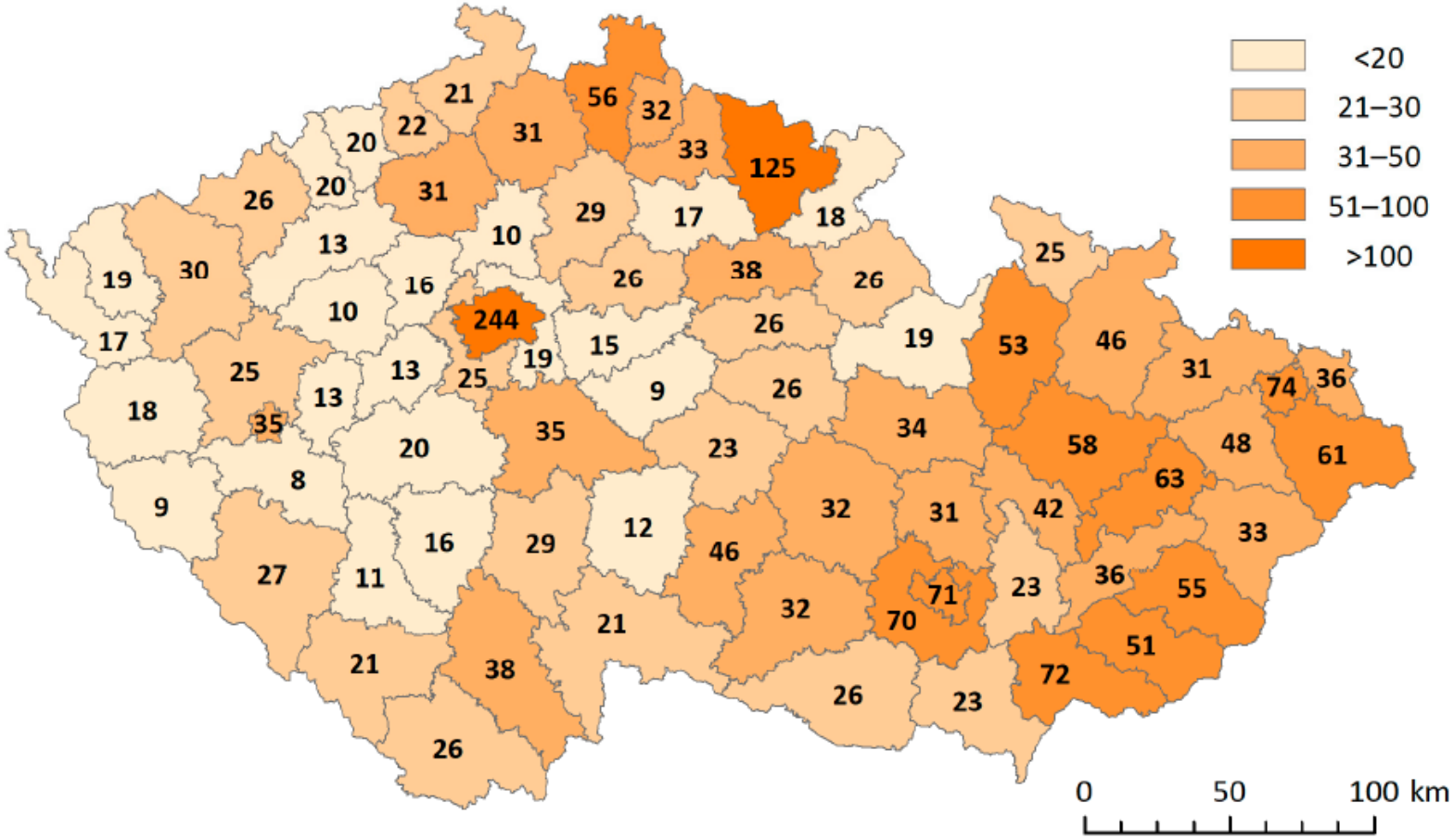
Characteristics of weather-related fatalities (in the Czech Republic during the 1921–2020 period: (a) long-term fluctuation; (b) annual variation; (c) spatial distribution; (d) cause of death



Brázdil et al. 2023

Analysis of HME casualties and unfavourable weather conditions (1921–2020)

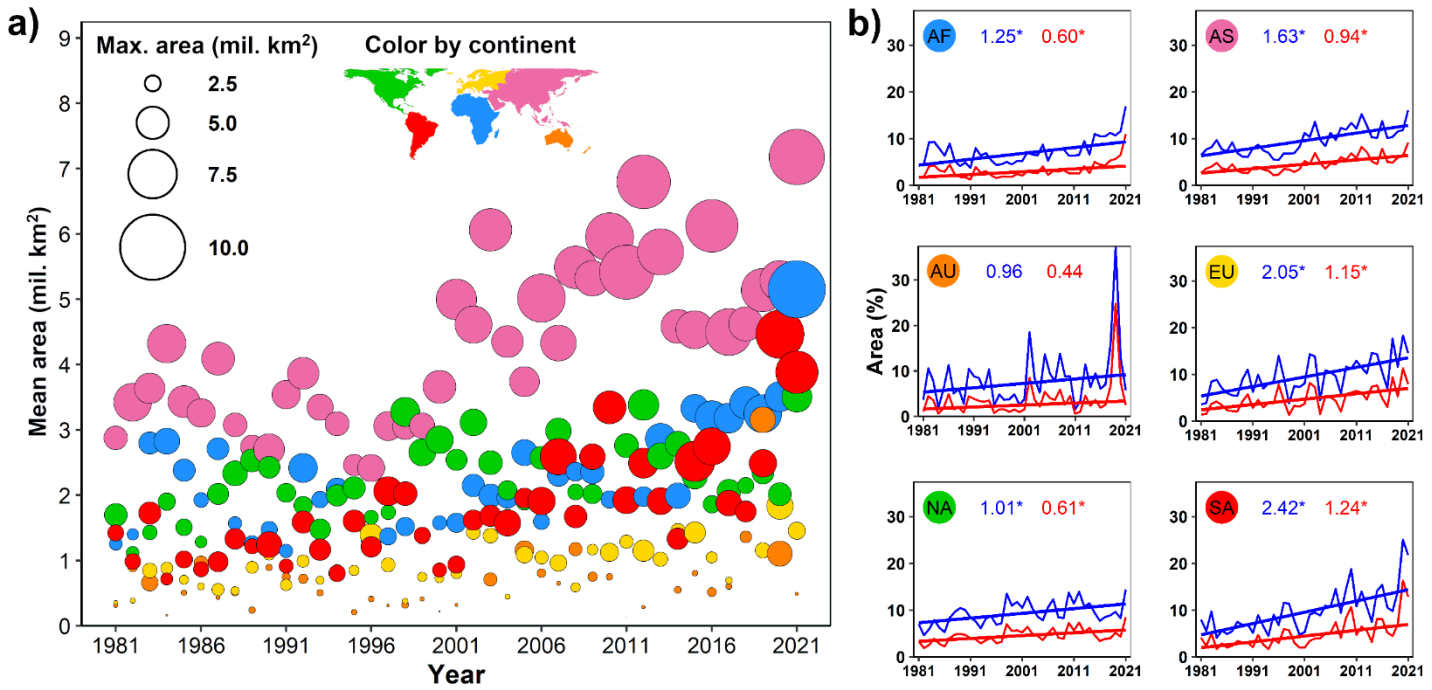
Distribution of weather-related fatalities for the individual districts of the Czech Republic during the period of 1921–2020, expressed in colored intervals and numbers of fatalities.



Brázdil et al. 2023

Soil drought variability in the world (1981–2021)

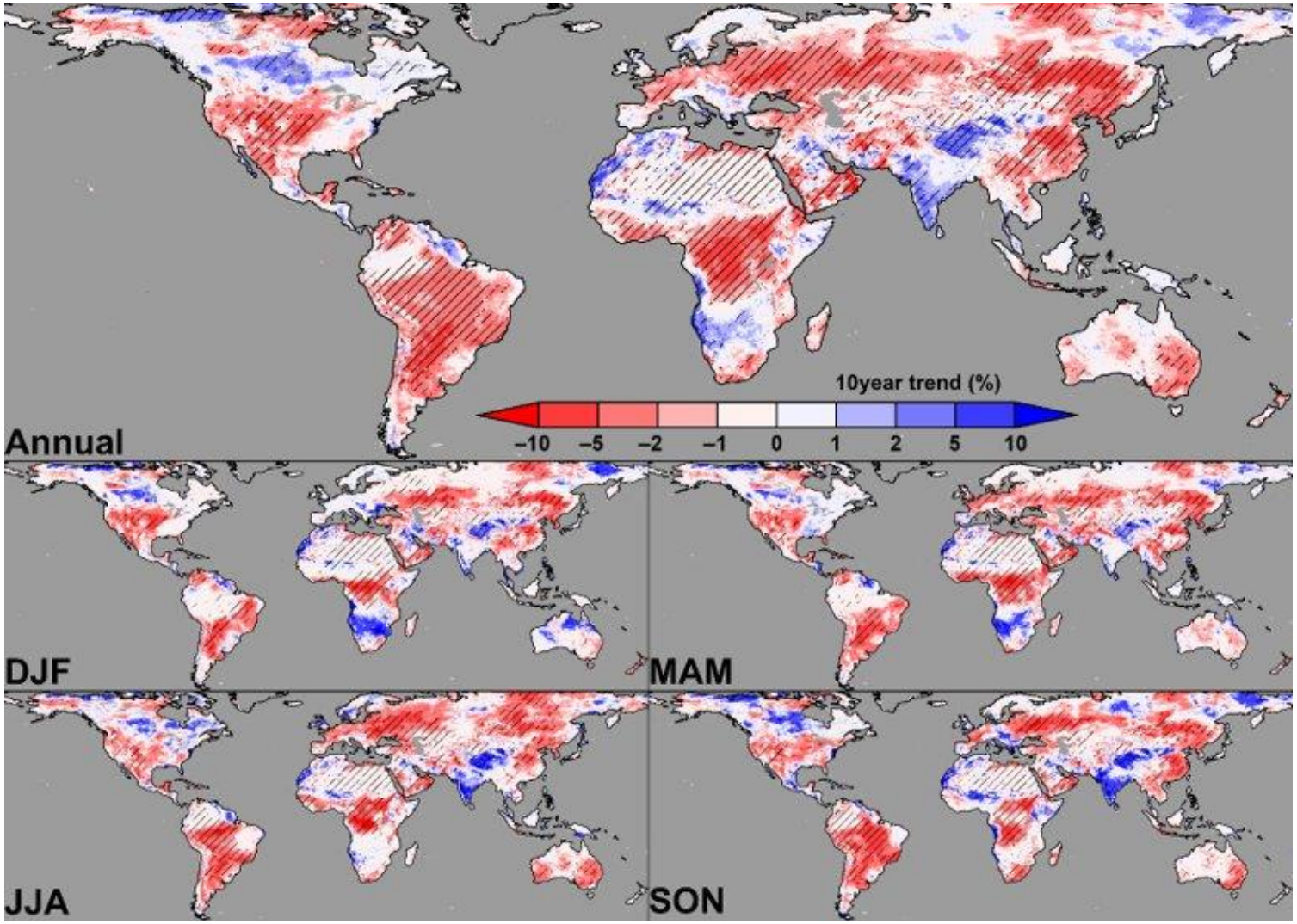
- Analysis of the **relative saturation** of the 0–100 cm **soil profile** (1981–2021)
- Statistically significant **increasing trends in 10/5th percentile drought severity for all continents except Australia**
- Greatest impacts of drought in **temperate** and **humid tropics biomes**



Řehoř et al., 2023

Soil drought variability in the world (1981–2021)

- **Most affected regions:** south America, central Africa, eastern Europe, eastern Asia
- **Soil moisture increase**: India, Tibet, parts of Canada and the dry tropics Africa



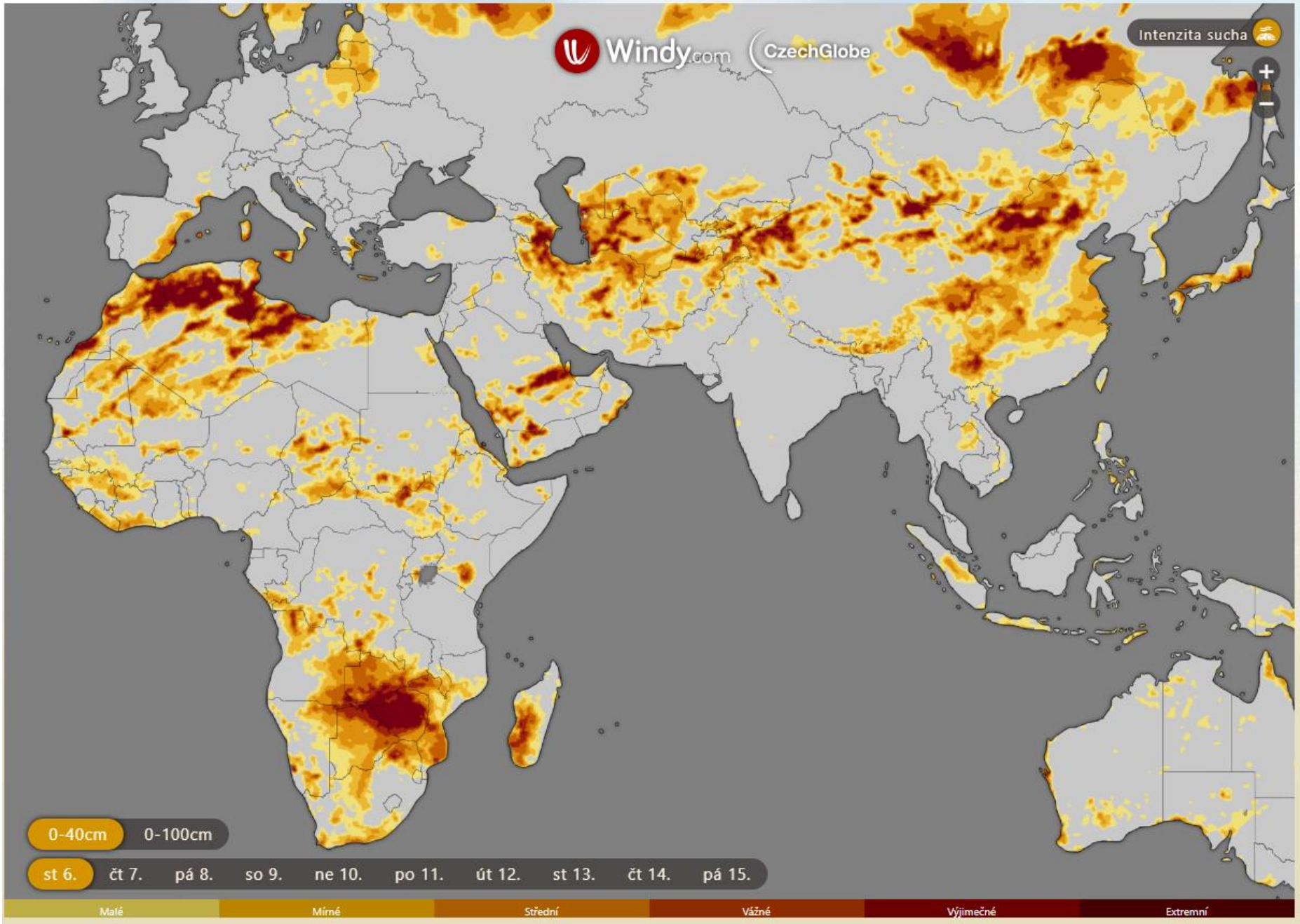
10-year trends in the relative saturation of the 0-100 cm soil profile, 1981-2021

Řehoř et al., 2023

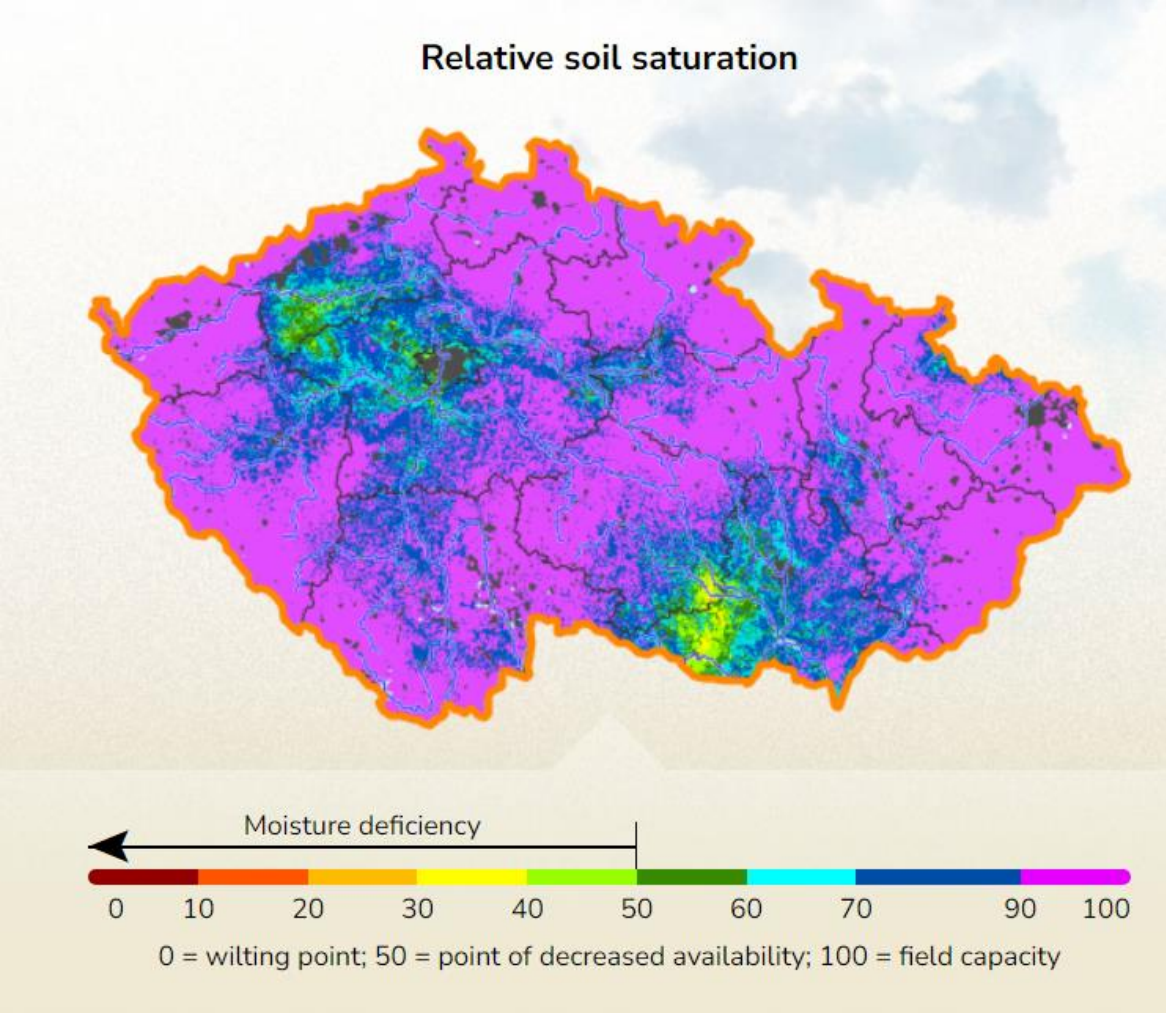
InterDrought project

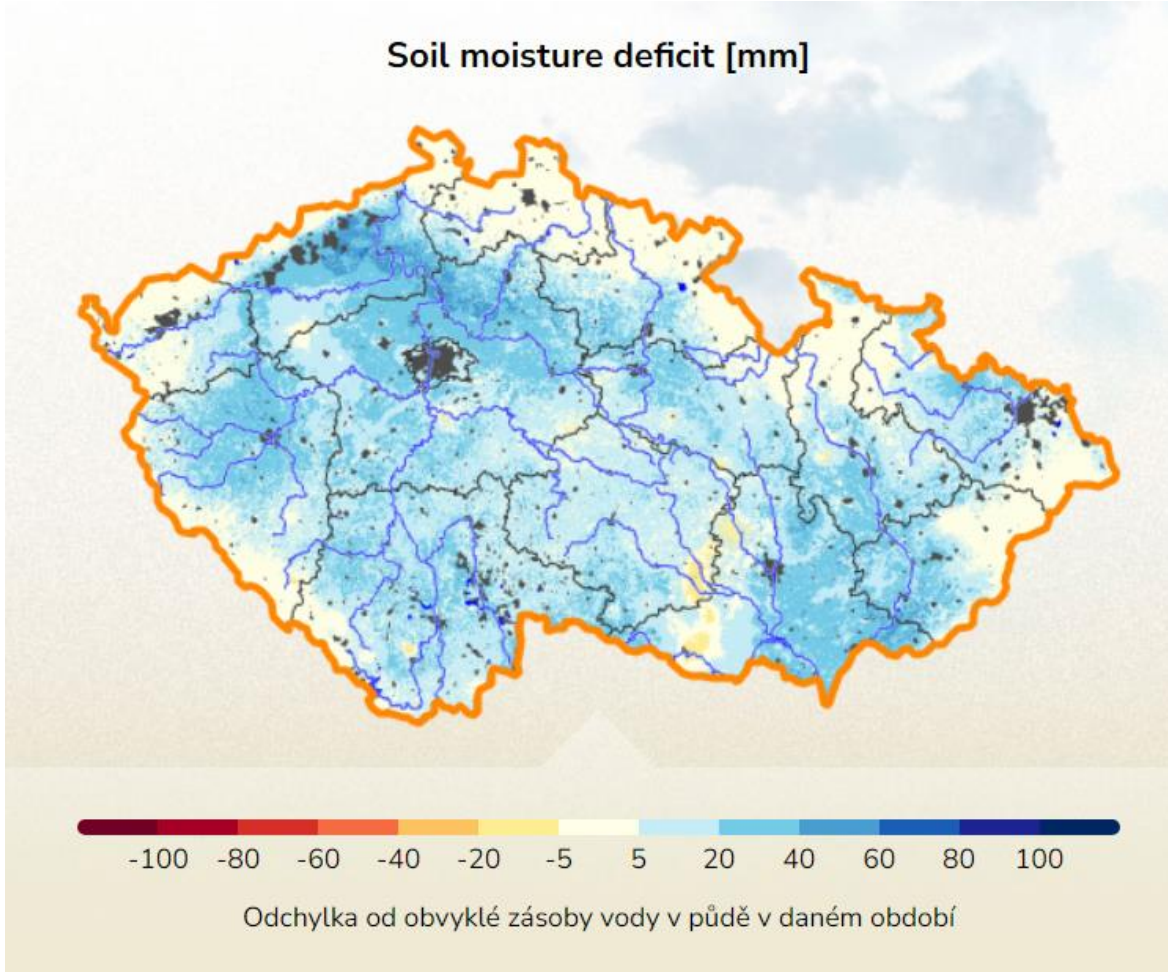
https://www.intersucho.cz/cz/?from=2023-11-09&to=2023-12-07&current=2023-12-03

InterDrought project

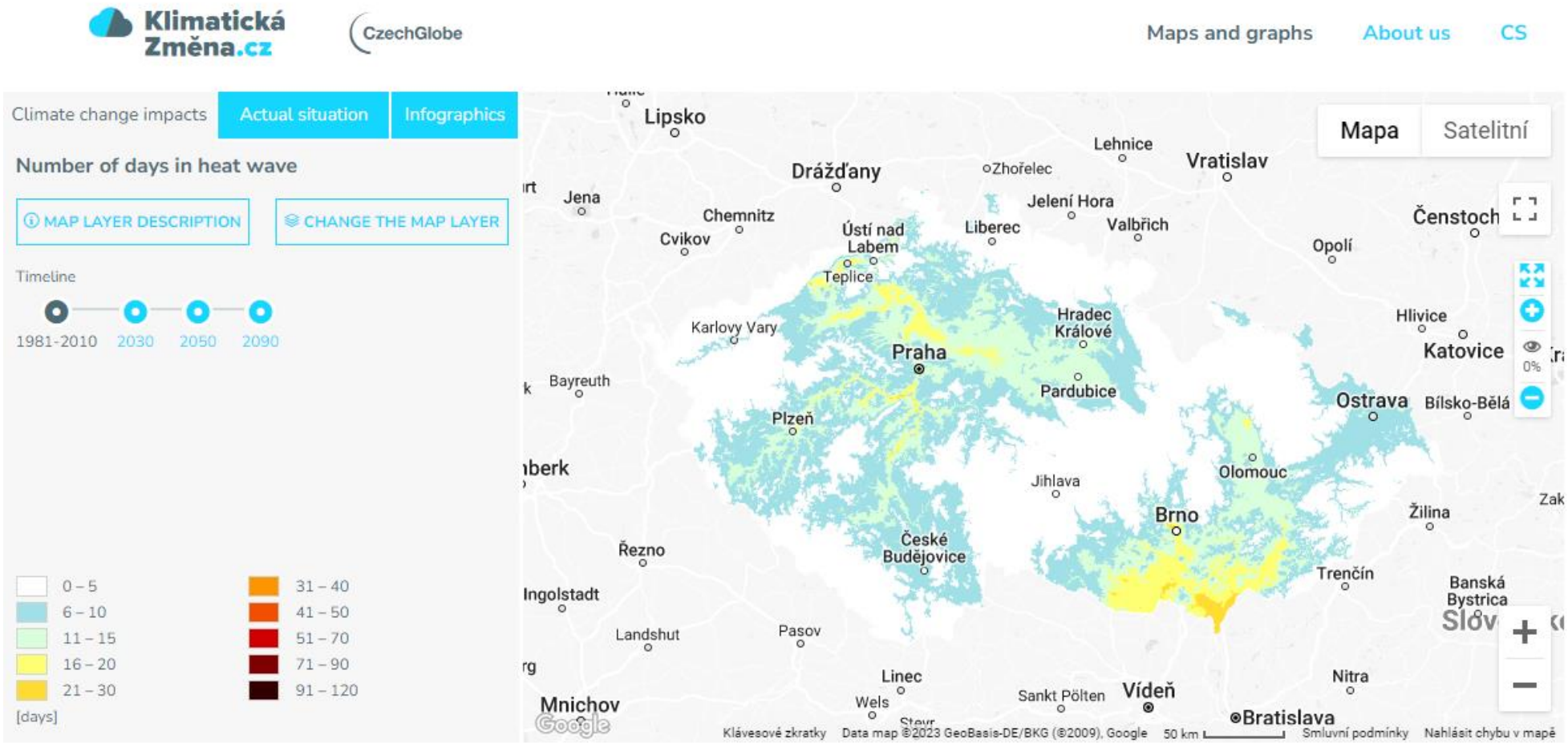


InterDrought project





Climate change project



https://www.klimatickazmena.cz/en/?l=51

Climate change project

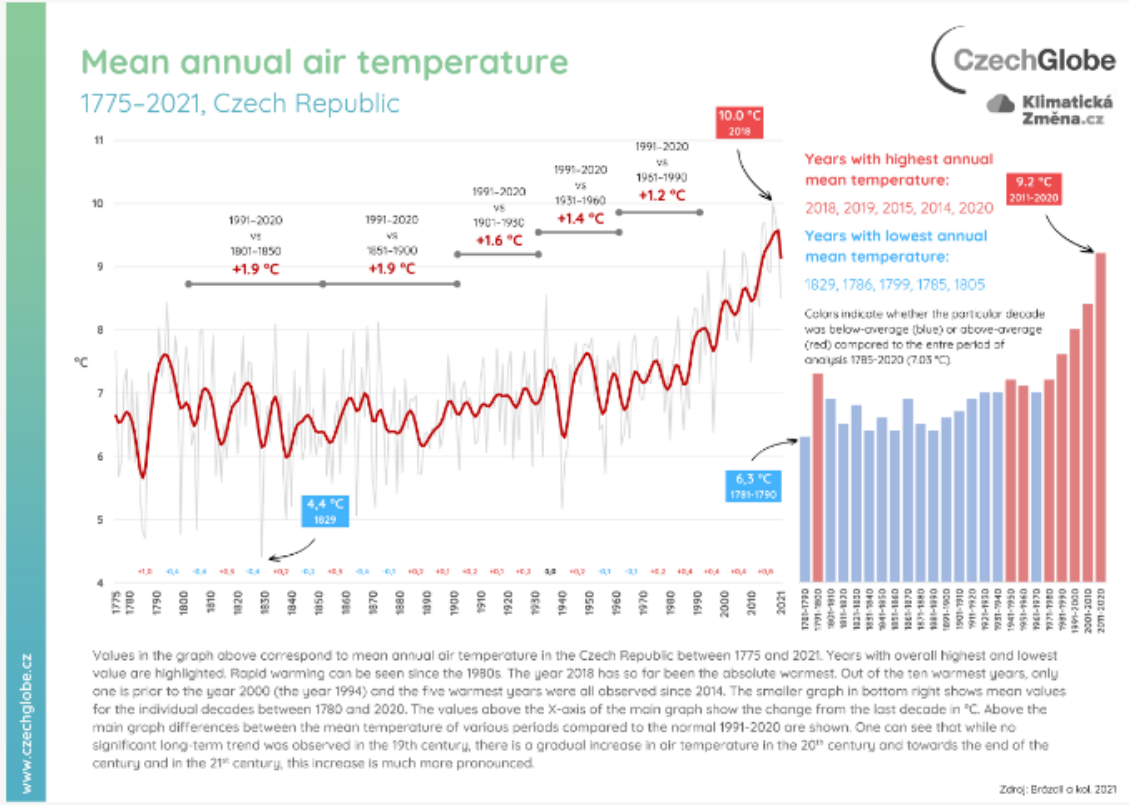
Klimatická Změna.cz | CzechGlobe | Maps and graphs | About us | CS

Climate change impacts | Actual situation | Infographics

Mean annual air temperature

INFOGRAPHICS DESC. | CHANGE THE GRAPH

Download infographics



https://www.klimatickazmena.cz/en/?l=51

Future solved issues (2024)

- **Climate and conflicts** in Europe
- **Rebellions of 1775 and 1821**: possible influence of HME and climatic variability
- Analysis of **compound events** (drought and heat wave episodes) in the Czech Republic since 1961
- Spatio-temporal variability of **drought episodes, heat waves and forest fires** and their impacts in Central Europe in the 21st century
- **Perception** of **climate change** by secondary school students
- **Significant climatological anomalies** in the Czech lands in the past and their impacts on society

Question of the day

Do the results of historical climatology have any relevance in light of the rapidly recent climate change?

If so, for what purpose?

References

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Thank you for your attention