Chapter 2: Past climate variability

Subchapter 2.3

The historical time frame (1000 yr)

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2. Past climate variability
2.3 The historical time frame (1000 yr)

- This chapter discusses past climate variability in the Baltic Sea basin area during the last millennium. The problem of climate change in millennial time-scale was not discussed in the previous BACC report (BACC 2008). When describing climate variability, we paid attention mainly to **thermal conditions** **and** **precipitation**, with respect to their extreme values

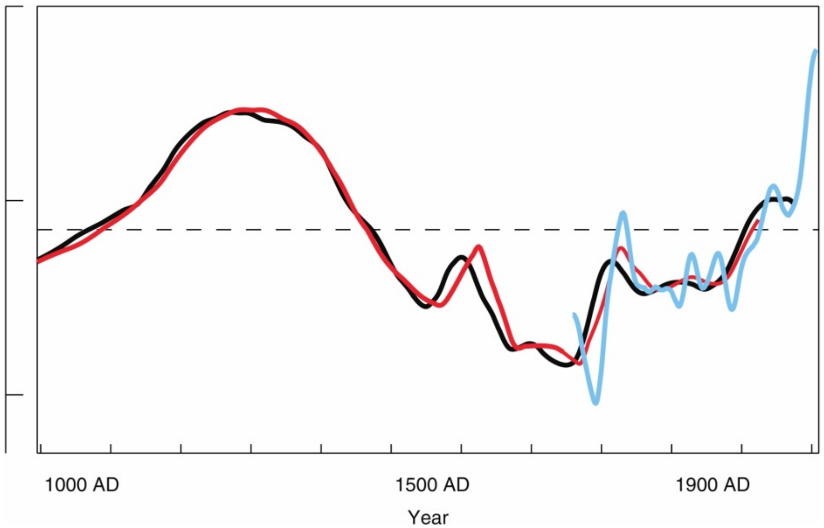
Data sources and methods

The research of millennial climate variability is mainly based on **proxy data**.

- **Historical notes** in the form of chronicles containing information about extreme weather events, and weather disasters are important sources of data about climatic conditions in the last millennium.
- Together with historical documents, **dendroclimatology** has provided a large part of the information on climatic conditions of the last millennium. **Tree-ring width and wood density** are the main sources of dendroclimatological data.
- **Other proxy data** (peat-bogs deposits, laminated lake sediments, bore-hole temperatures ect.)
- are of lesser importance for the reconstruction of the last millennium climate conditions and are rather used to reconstruct the climate of the whole Holocene.
- **Instrumental data**

The general features of Millennial climate

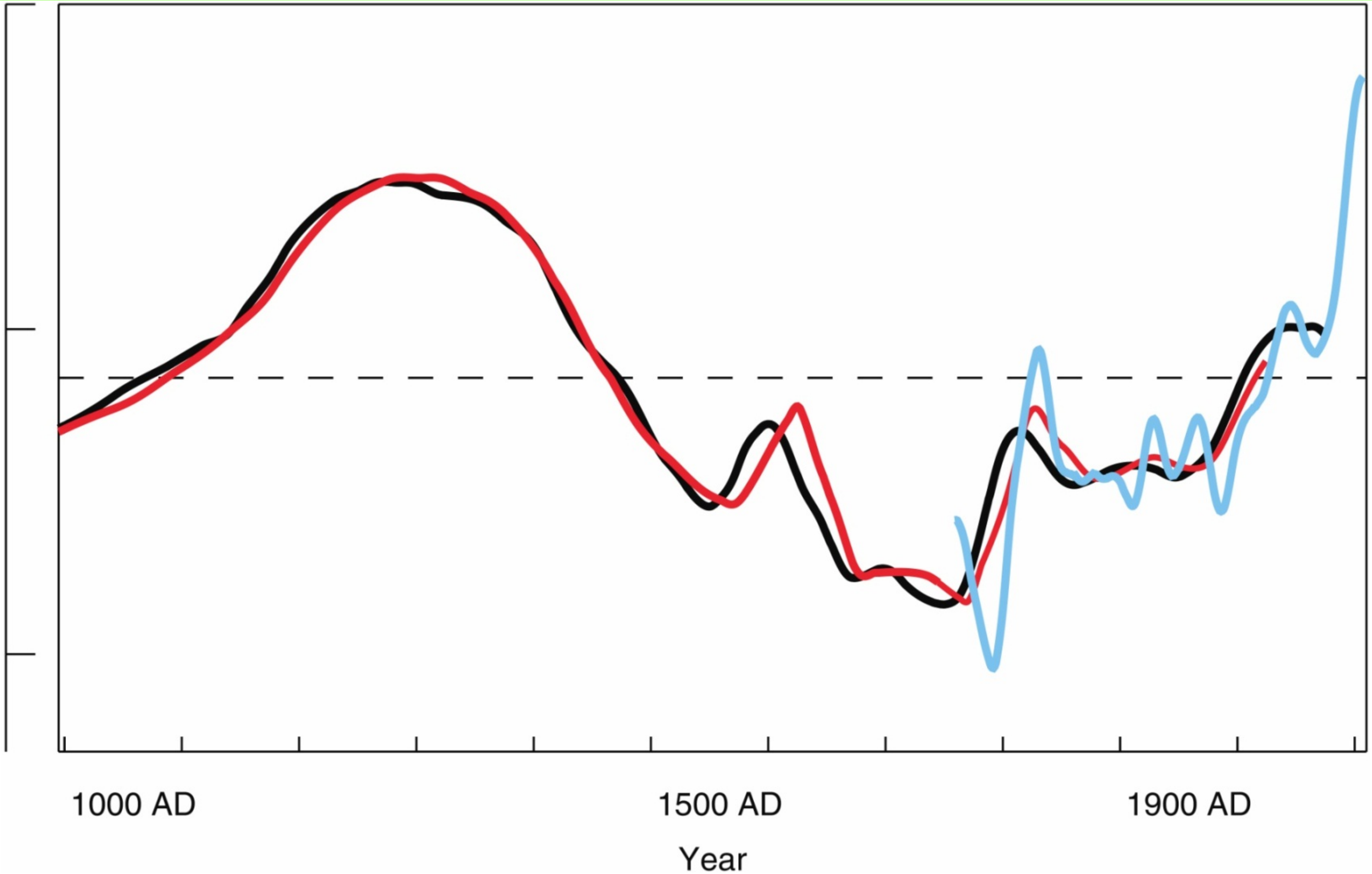
- the **Medieval Warm Period** (MWP 900-1350 AD)
- the **Transitional Period** (TP 1350-1550 AD)
- the **Little Ice Age** (LIA 1550-1850 AD)
- the Contemporary Warm Period (CW after 1850 AD) – see Chapter 3



Past climate variability - the historical time frame (1000 yr)

Schematic change of air temperature in Northern Hemisphere compiled from different sources

scaled to have zero mean and unit standard deviation over the period 1001 to 1980



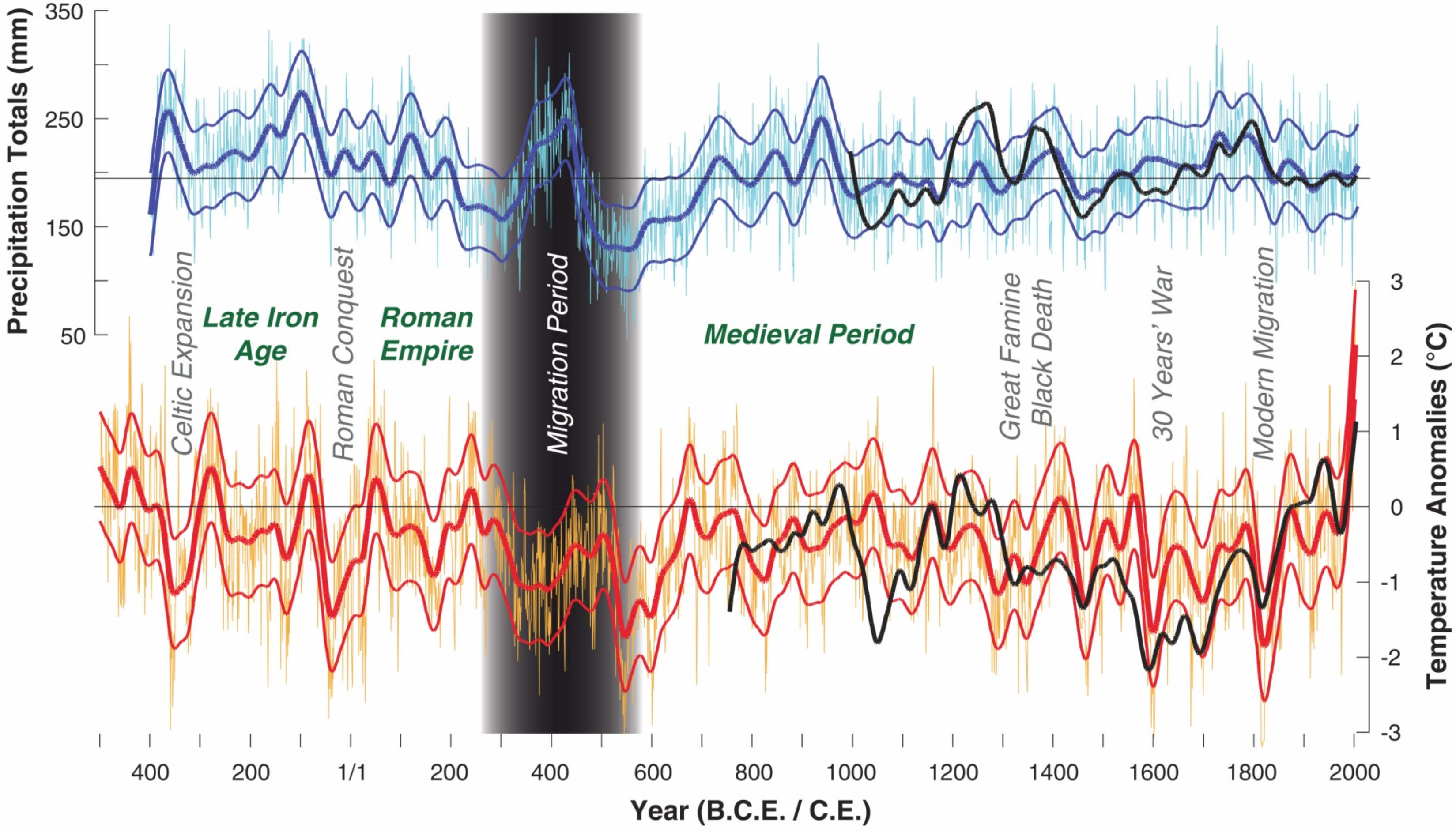
Source: Jones PD, Briffa KR, Osborn TJ, Lough JM, van Ommen TD, Vinther BM, Luterbacher J, Wahl ER, Zwiers FW, Mann ME, Schmidt GA, Ammann CM, Buckley BM, Cobb KM, Esper J, Goosse H, Graham N, Jansen E, Kiefer T, Kull C, Küttel M, Mosley-Thompson E, Overpeck JT, Riedwyl N, Schulz M, Tudhope AW, Villalba R, Wanner H, Wolff E, Xoplaki E (2009) High-resolution palaeoclimatology of the last millennium: a review of current status and future prospects. Holocene 19(1):3-49. Figure 7 p. 34

Medieval Warm Period
(MWP 900-1350 AD)

In the Baltic Sea basin and the surrounding parts of Europe the warmest conditions occurred in between 1200 and 1250 AD. Two periods of strong cooling were detected in the middle of the 11th and at the beginning of the 14th century. In Fennoscandia, warm season (May-September) temperatures during the MWP exceeded the contemporary warming of the end of 20th century by about +0.5 K.

Past climate variability - the historical time frame (1000 yr)

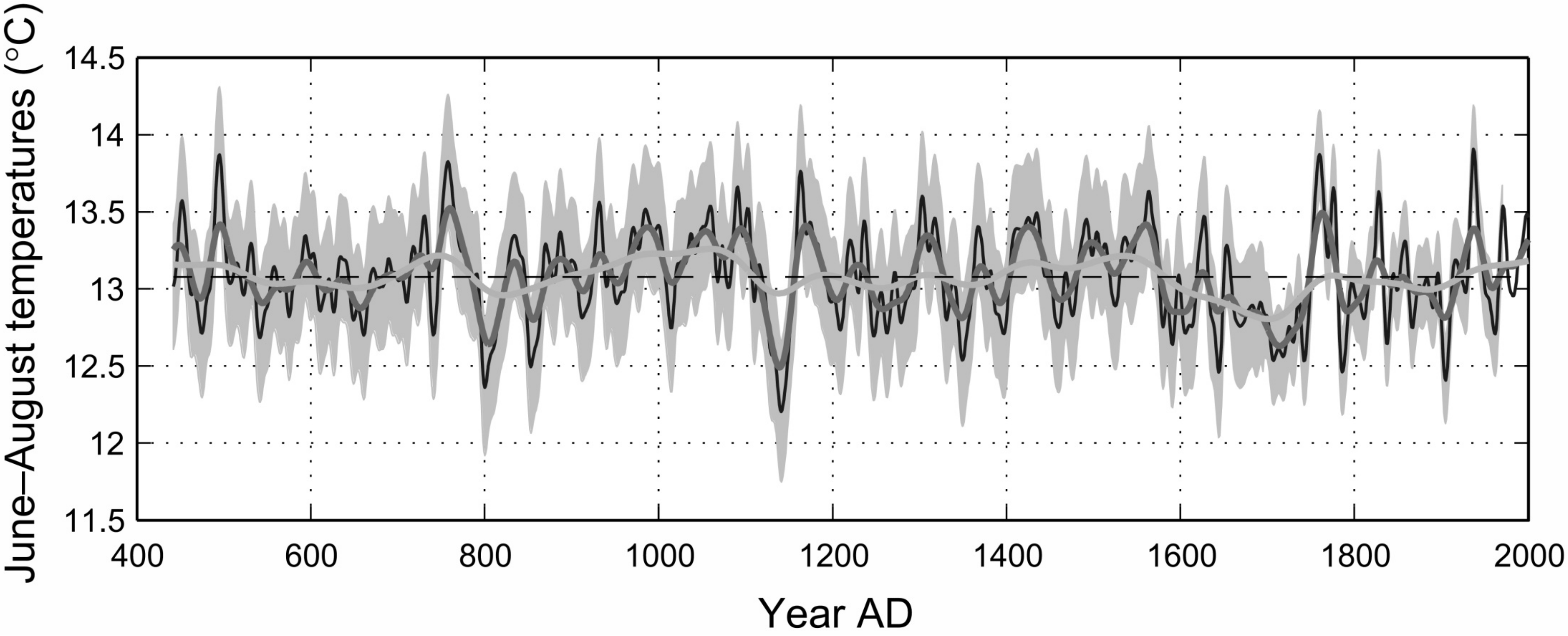
Reconstructed AMJ precipitation totals (top) and JJA temperature anomalies (bottom) with respect to the 1901–2000 period. Error bars are *±1* RMSE of the calibration periods



Source: Büntgen U, Tegel W, Nicolussi K, McCormick M, Frank D, Trouet V, Kaplan JO, Herzig F, Heussner K-U, Wanner H, Luterbacher J, Esper J (2011b) 2500 Years of European Climate Variability and Human Susceptibility. Science 331: 578-582 , Fig4, p. 581

Past climate variability - the historical time frame (1000 yr)

Fennoscandian regional-average summer (June–August) temperatures AD 442–1970 created by merging the seven reconstructions based on the seven networks



Source: Gouirand I, Linderholm HW, Moberg A, Wohlfarth B (2008) On the spatiotemporal characteristics of Fennoscandian tree-ring based summer temperature reconstructions. Theoretical and Applied Climatology 91(1-4):1-25, Fig.10. p. 17

PRECIPITATION DURING MWP

There is less information available on precipitation in the MWP. Nevertheless, a regional precipitation reconstruction from southern Finland showed a uniquely prolonged rainfall deficit coinciding with MWP (Helama et al. 2009).

The drought was particularly severe between 1000 and 1200. Generally in Europe, relatively dry periods occurred in the years 1272-1291 and 1300-1309, while

the wettest conditions were noticed in 1312-1322

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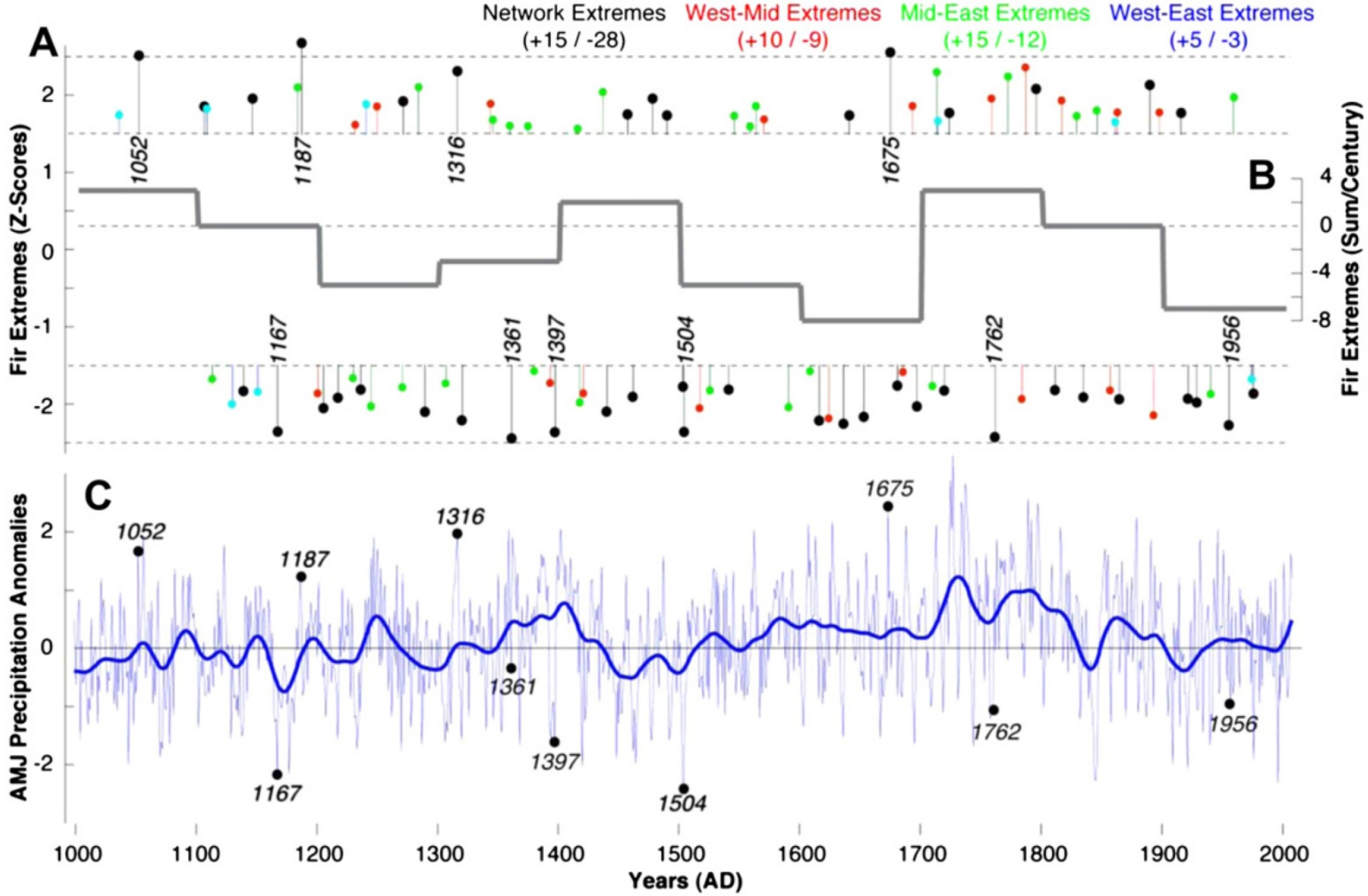
Past climate variability - the historical time frame (1000 yr)

(A) Central European and regional fir TRW extremes, and (B) their centennial changes over the past millennium (network extremes were double weighted), compared to (C) annual-resolve and 40-year low-passed Central European April-June precipitation variability



Source: Büntgen U, Brázdil R, Heussner K-U, Hofmann J, Kontic R, Tyncl T, Pfister C, Chromá K, Tegel W (2011c) Combined dendro-documentary evidence of Central European hydroclimatic springtime extremes over the last millennium. Quaternary Science Reviews 30: 3947-3959, Fig. 5, p. 3951.

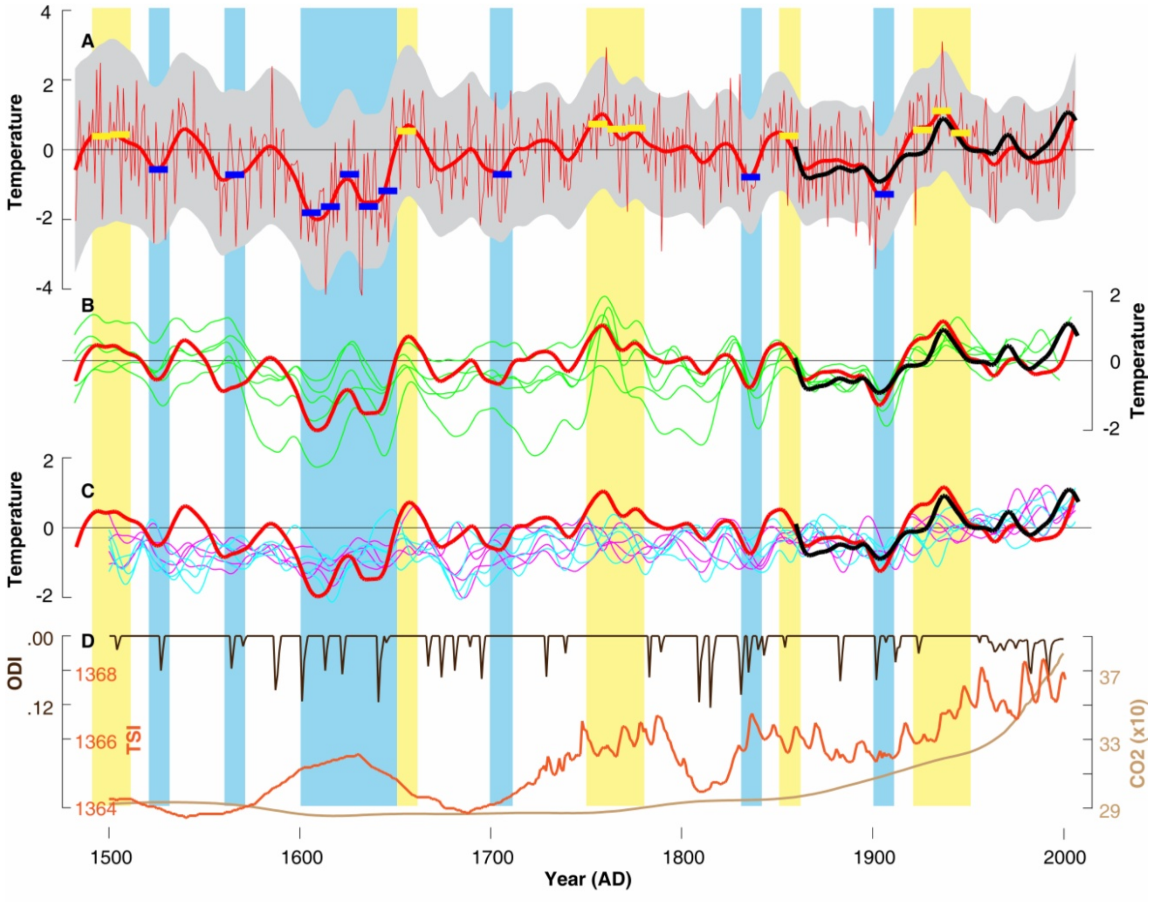
Transitional Period (TP 1350-1550 AD)

The increase in the intra-seasonal variability of climate at the end of the MWP in the period of 1270-1350 is considered to be the beginning of the Little Ice Age (LIA), however Brázdil et al. (2005) suggest that the following 200-year period should be treated as **transitional period between the MWP and LIA**.

This period was characterized by a **great variability of climate** conditions. At that time, temperature decreased by about 1.2 K, but cooling occurred until the second half of the 16th century

Little Ice Age
(LIA 1550-1850 AD)

In the second half of the 16th century, the temperature dropped, initiating the Little Ice Age (LIA). Winter temperatures in connection with atmospheric circulation and ice conditions indicate four cold and three warm periods during the LIA (Figure 3). In the recently modeled and reconstructed North Scandinavian summer temperatures since 1500 AD (Figure 4), the longest cool period prevailed during the first half of the 17th century and at the beginning of the 18th century, as well during the first years of the 19th century. The final phase of the LIA in the first half of the 19th century was the longest period of cooling with exceptionally cold years between 1812 and 1824.



Past climate variability - the historical time frame (1000 yr)

Reconstructed and modelled Northern **Scandinavian summer temperature** variations over the past five centuries. Explanations:

A - Actual (black) and reconstructed (red) JJA temperature anomalies (ºC) with error estimates (grey) and the ten warmest and coldest decades superimposed (colour boxes).

B - Comparison of the actual and reconstructed temperatures with five existing (green) reconstructions.

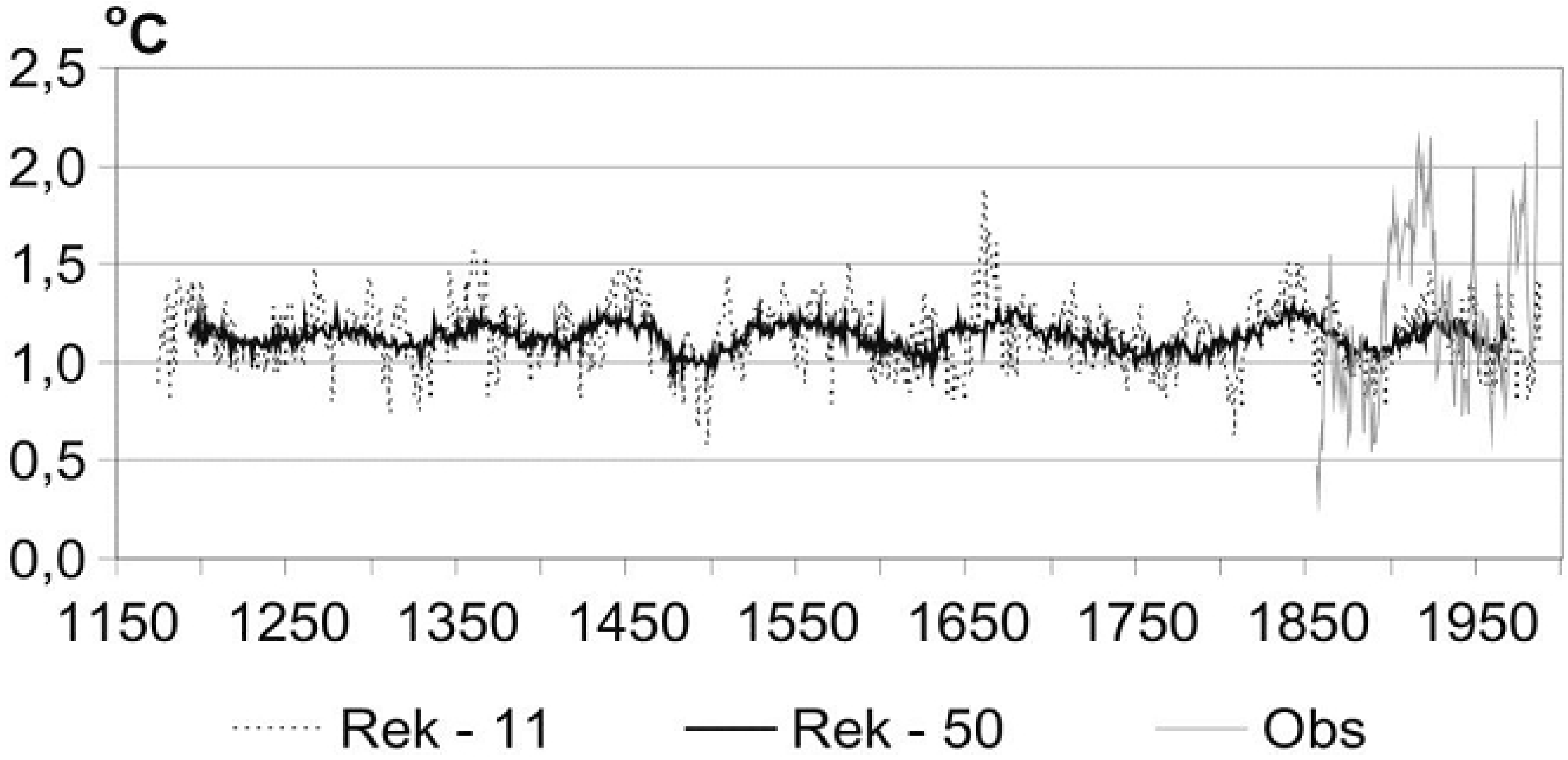
C - Comparison of the actual and reconstructed temperatures with CCSM3 SAT (pink) and SST (blue) model simulations. Mean and variance of the data are scaled against JJA temperature (1860–2006), expressed as anomalies (1961–1990) and 20-year low-pass filtered.

D - Solar (TSI; Total Solar Irradiance), volcanic (ODI; Optical Depth change in the visible band), and CO_2 (ppm) forcing as used in the model simulation.

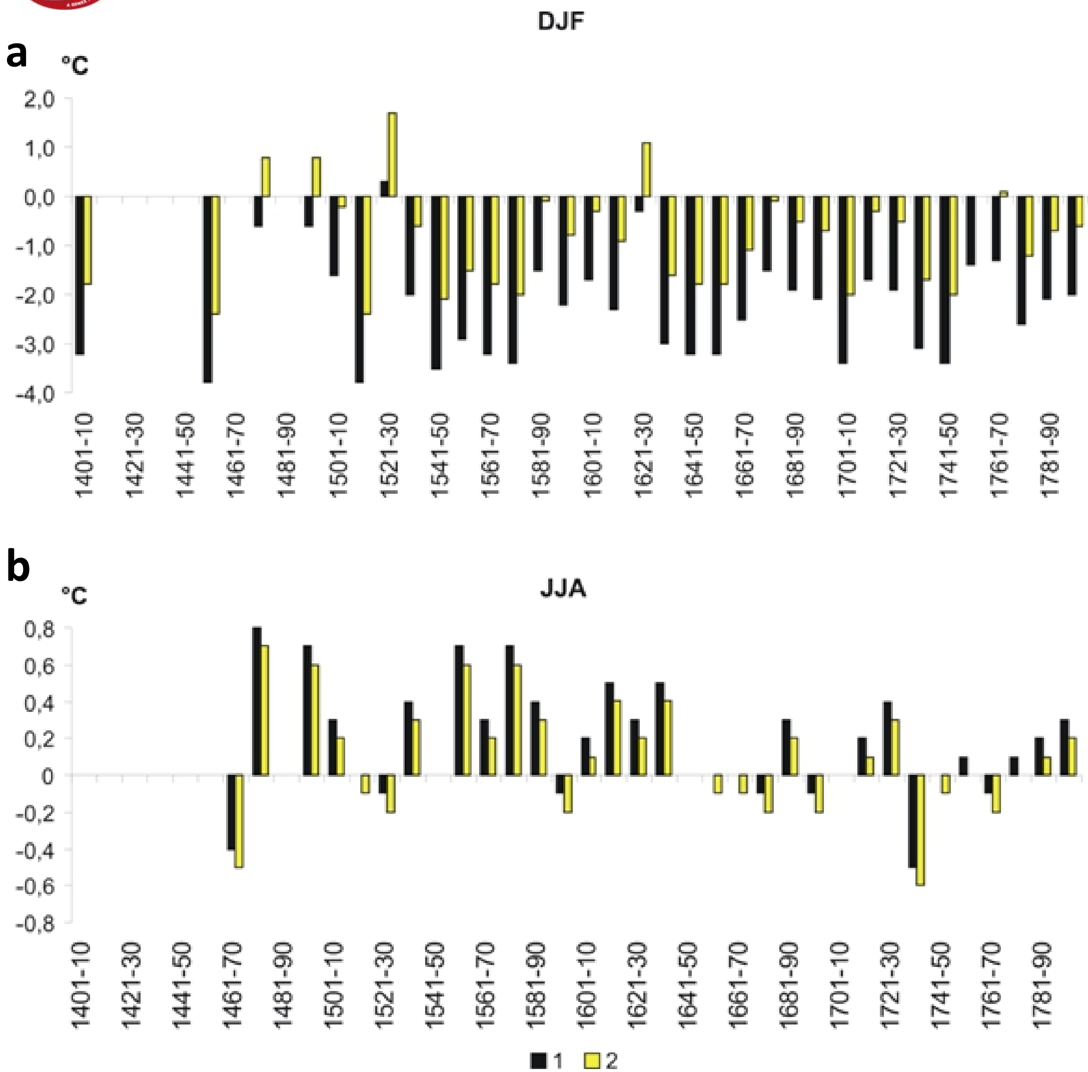
Source: Büntgen U, Raible C, Frank D, Helama S, Cunningham L, Hofer D, Nievergelt D, Verstege A, Stenseth N, Esper J (2011a) Causes and consequences of past and projected Scandinavian summer temperatures, 500-2100 AD. PLoS ONE 6(9), e25133: 1-9. doi:10.1371/journal.pone.0025133.g004. Figure 4, p. 5.

Past climate variability - the historical time frame (1000 yr)

Reconstruction of mean January-April air temperature (°C) in Poland for the period 1170-1994 using a standardized chronology of Scots pine tree-ring widths (Pinus sylvestris L.)



Source: Przybylak R (2011) Changes in Poland's climate over the last millennium. Czasopismo Geograficzne 82(1–2): 23–48. Fig. 1, Page 27

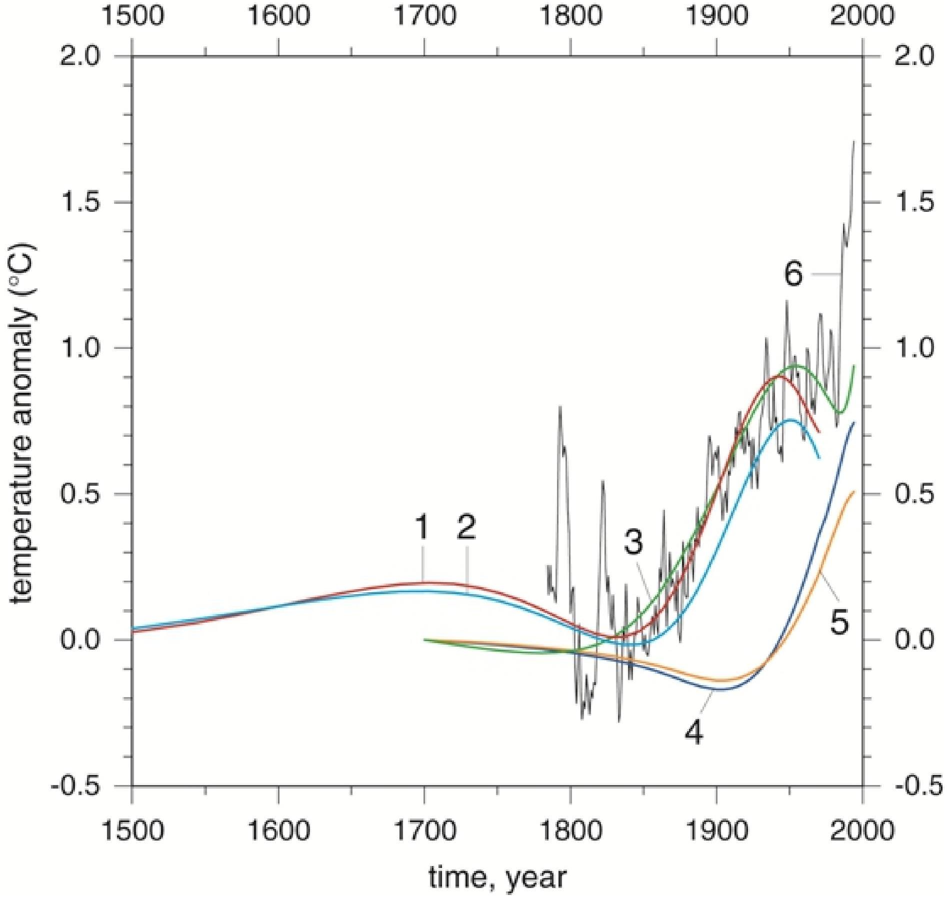


Past climate variability - the historical time frame (1000 yr)

Reconstructions of mean 10-year air temperatures (°C) in Poland from 1401 to 1840:
a) winter (DJF) and
b) summer (JJA).
1 and 2 – anomalies with respect to 1901–1960 and 1789–1850 means, respectively

Source: Przybylak R (2011) Changes in Poland's climate over the last millennium. Czasopismo Geograficzne 82(1–2): 23–48. Fig. 2, Page 28.

Past climate variability - the historical time frame (1000 yr)
Reconstruction of ground surface temperature (°C) history in Poland



Curve 1 - reconstruction from the continuous temperature logs (from wells deeper than 450 m) which indicate large ground surface temperature warming;

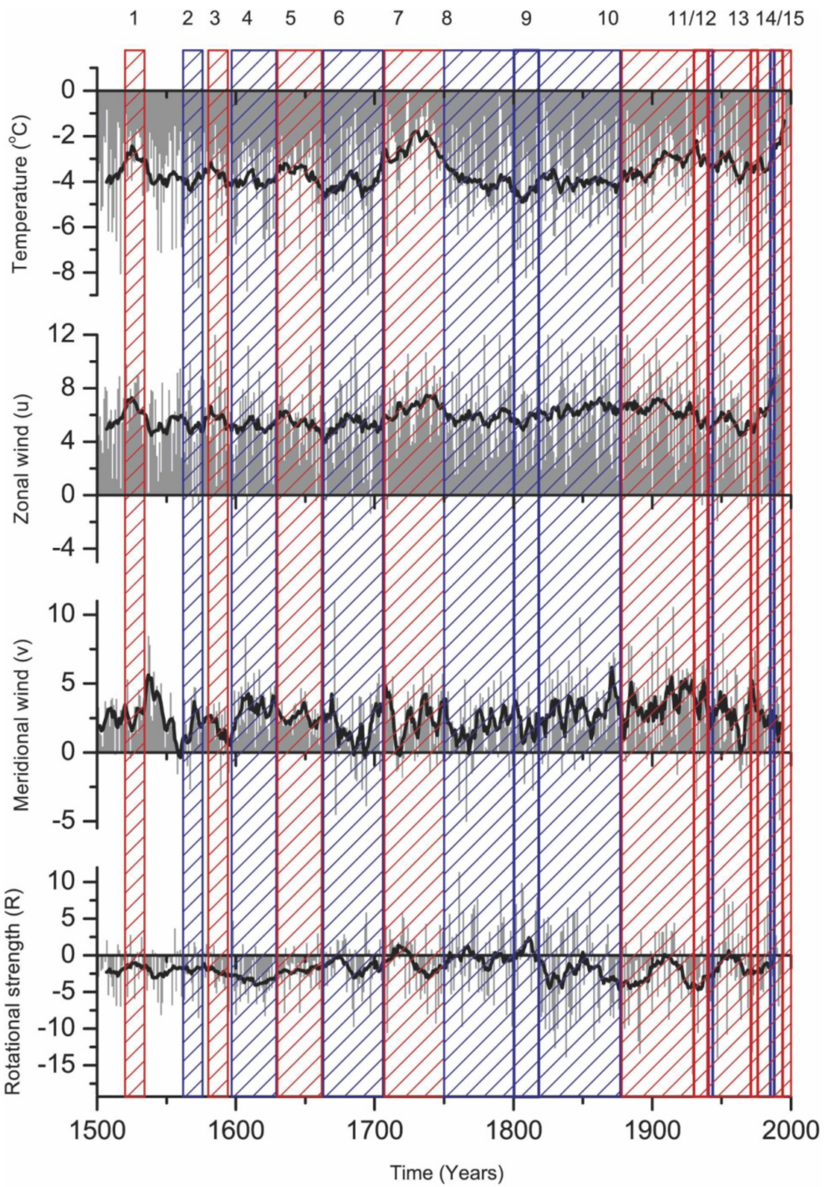
Curve 2 - average based on all deep wells;

Curve 3 - reconstruction based on the entire depth of temperature profile in well Grodziec;

Curves 4 and 5 - reconstructions based on the upper portions of precision temperature profiles above the region of abrupt thermal gradient changes for the high and low assumed error of the a priori conductivity model;

Curve 6 - homogeneous air temperature series from Warsaw (11-year running average) (Lorenc 2000).

Source: Majorowicz J, Šafanda J, Przybylak R, Wójcik G (2004) Ground surface temperature history in Poland in the 16th - 20th centuries derived from the inversion of geothermal profiles. Pure and Applied Geophysics 161(2): 351-363. Fig. 6, page 360

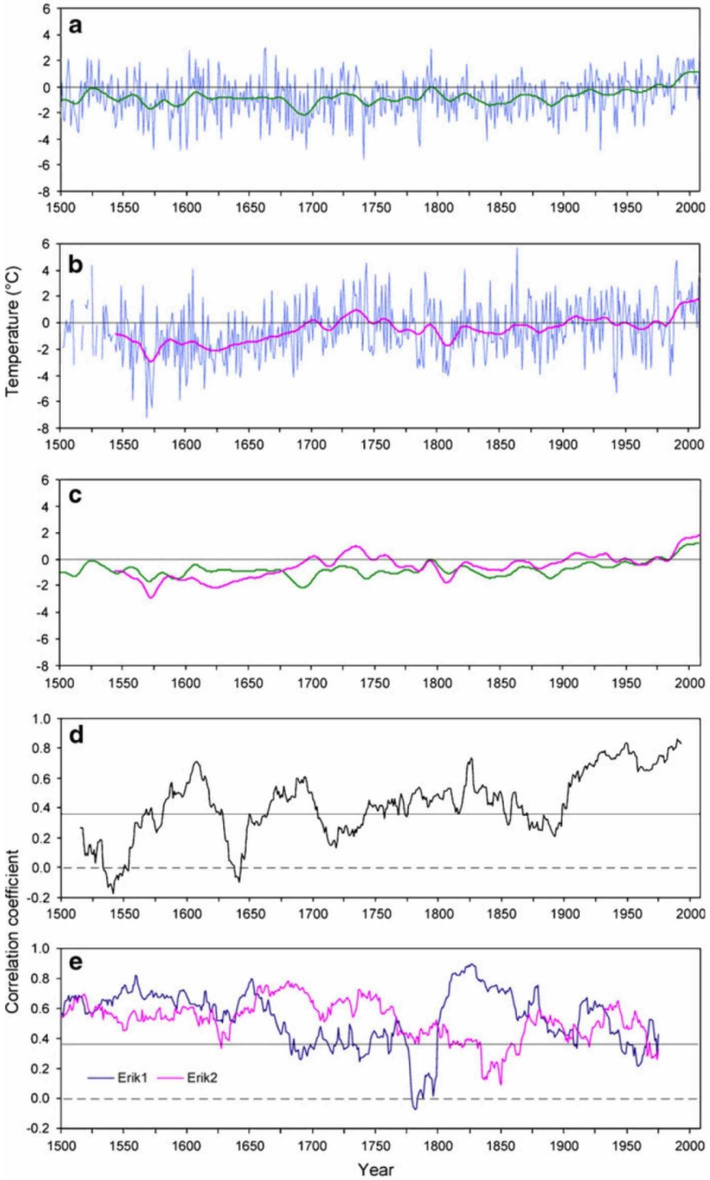


Past climate variability - the historical time frame (1000 yr)

Winter climate conditions in the greater Baltic Sea Region since AD 1500.

The **gray** color shows seasonal winter data from the two gridded datasets: (top to bottom) Baltic Sea mean **winter air temperature**, zonal wind component (westerly winds when positive and easterly winds when negative), meridional wind component (southerly winds when positive and northerly winds when negative), and rotational flows (cyclonic circulation when positive and anticyclonic when negative). **Black line** in all panels is a 15-yr running mean. **Blue** and **red** fields covers time periods classified by MP as mild and cold, respectively

Source: Eriksson Ch, Omsted A, Overland JE, Percival DB, Mofjeld HO (2007) Characterizing of European Sub-Arctic Winter Climate since 1500 Using Ice, Temperature, and Atmospheric Circulation Time Series. Journal of Climate 20: 5316-5334, doi:10.1175/2007JCLI1461.1. Fig. 12 p.5328



Past climate variability - the historical time frame (1000 yr)

Comparison of reconstructed JFMA Stockholm (1502–2008) and CEuT (1500–2007) temperatures (anomalies from the 1961–1990 mean).

Original series of CEuT **(a)**
and Stockholm **(b)**
are smoothed with a 30-year Gaussian filter **(c)**
and compared using 31-year running correlations between unfiltered data (d). Running correlations (31-year window) between ECHO-G modeled JFMA temperatures (Erik1 and Erik2 forced runs) for Stockholm (grid point coordinates: 18.75° E, 61.23°N) and Prague (14.4°E, 50.09°N) in the period 1500–1990.

The horizontal solid lines in **(d)** and **(e)** denote the critical value of correlation coefficients for $\alpha = 0.05$ for one-tailed *t* test

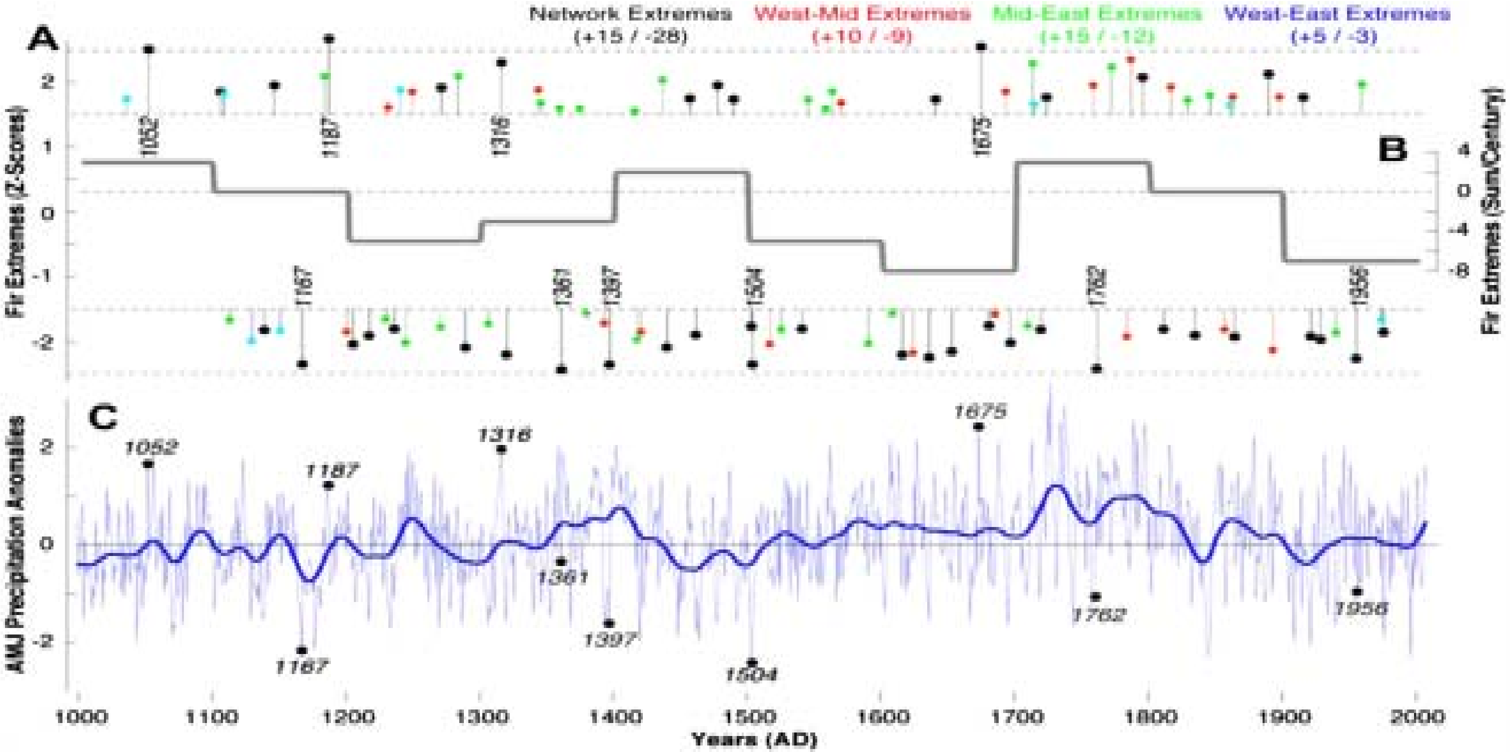
Source: Brázdil R, Dobrovolný P, Luterbacher J, Moberg A, Pfister C, Wheeler D, Zorita E (2010) European climate of the past 500 years: new challenges for historical climatology. Climatic Change 101: 7-40, doi:10.1007/s10584-009-9783-z. Fig. 3, Page 21.

PRECIPITATION DURING LIA

The wettest conditions during the LIA were observed in 1675 and the end of the 17th century,

and the driest were the years 1504 and 1762

(Büntgen et al. 2011c).



2.3 The historical time frame (1000 yr)
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THANK YOU

Past climate variability - the historical time frame (1000 yr)

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