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CLIMATE CHANGE RESEARCH

HISTORICAL CLIMATOLOGY

Lecture at Masaryk University Brnó, 27th Ap 2010

Christian Pfister

Oeschger Centre for Climate Change Research/
Institute of History
University of Bern (Switzerland)

Historical Climatology: The Agenda

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1. Definition, objectives, development of the field
2. Data and Sources
    - 2.1. Data
    - 2.2. Individual sources
    - 2.3. Institutional sources
3. Methods of Climate Reconstruction
    - 3.1. Frequencies (Weather Diaries)
    - 3.2. Calibration/Verification
    - 3.3. Spatial Reconstruction
4. Results
5. Perspectives on future research

What is Historical Climatology?

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„Historical Climatology is a research field situated at the interface of climatology and (environmental) history, dealing mainly with documentary evidence and using the methodology of both climatology and history".

(Christian Pfister, Klimawandel in der Geschichte Europas. Zur Entwicklung und zum Potenzial der Historischen Klimatologie in: Österreichische Z. f. Geschichtswissenschaften ÖZG 12/2: 7–43, here)

Historical Climatology in Context

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- **Palaeoclimatology**: analyses climatic parameters derived from evidence stored in natural archives
- **Historical Climatology**: research field at the interface of climatology and (environmental) history, dealing with (non instrumental) documentary evidence and using the methodology of both climatology and history
- **Climatology of the Early instrumental period (EIP):** deals with instrumental observations laid down prior to the establishment of coordinated meteorological networks
- **Climatology of the Modern Instrumental Period (MIP)** deals with meteorological elements systematically measured by standardized instruments in the framework of (inter-) national networks

Pfister et al. 2009

Which are the Objectives of Historical Climatology?

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1. Reconstructing ***past weather and climate*** of the period prior to the creation of national meteorological services networks (***reconstruction of weather and climate***).
2. It investigates the **vulnerability** of past **economies** and **societies** to climate variations, climatic extremes and natural disasters (***historical climate impact analysis***)
3. It explores **debates on** and **social representations of climate (*cultural history of climate*)**

Pfister 2000

Milestones in the Development of Historical Climatology (1)

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- **Geographer Eduard Brückner** (1895) analysis of climate variations and their economic and societal impact.
- **Charles E. P. Brooks (1926) and Cornelis Easton** (1928). First syntheses of European climate based on simple indices:
- **Climatologist Hermann Flohn (1949,1979):** First Scientific analyses of Weather Diaries.
- **Historian Emmanuel Le Roy Ladurie (1967):** Influential monograph on climate of last millennium and its societal impact
- **Climatologist Gordon Manley (1974).** Central England temperature series (from 1659):
- **Climatologist Hubert Lamb (1977):** Further development of index approach. 1st synoptic charts of surface pressure distributions based on documentary data. Discovery of Medieval Warm Period (MWP)

Milestones in the Development of Historical Climatology (2)

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- **Historian Christian Pfister (1984ss)**: Development of present-day standard system of indices. 1st vulnerability studies.
- **Historian Pierre Alexandre (1987):** First critical catalogue of Medieval sources and texts on climate.
- 1990-2010: Networks of scholars around European Science Foundation (ESF) and the EU programmes.
- **Geographer Jürg Luterbacher (2001ss):** Statistical derivation of spatial charts of monthly (from 1659) and seasonal (from 1500) reconstructions of temperature, sea level pressure in Europe
- **Geographer Rudolf Brázdil (2005)** : First review article on Historical Climatology
- **Geographer Petr Dobrovolný (2009)** Calibration and verification of documentary indices

Archives and Data

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Data	Archives of Nature	Archives of Societies
Instrumental	None	Early Instrumental measurements
Direct Narrative	None	Chronicles etc. Weather Diaries etc.
Indirect or Proxy	*Biotic*: Tree-rings Varves etc.	*Biotic* Vegetative development Agricultural producr
	Non biotic: Ice Cores Sediments Glaciers etc.	*Non biotic:* Snow and Ice Seasonality Floods and Low Water

Pfister et al. 1999

Fluctuation of the Great Aletsch Glacier (Swiss Alps) over the last 3200 years

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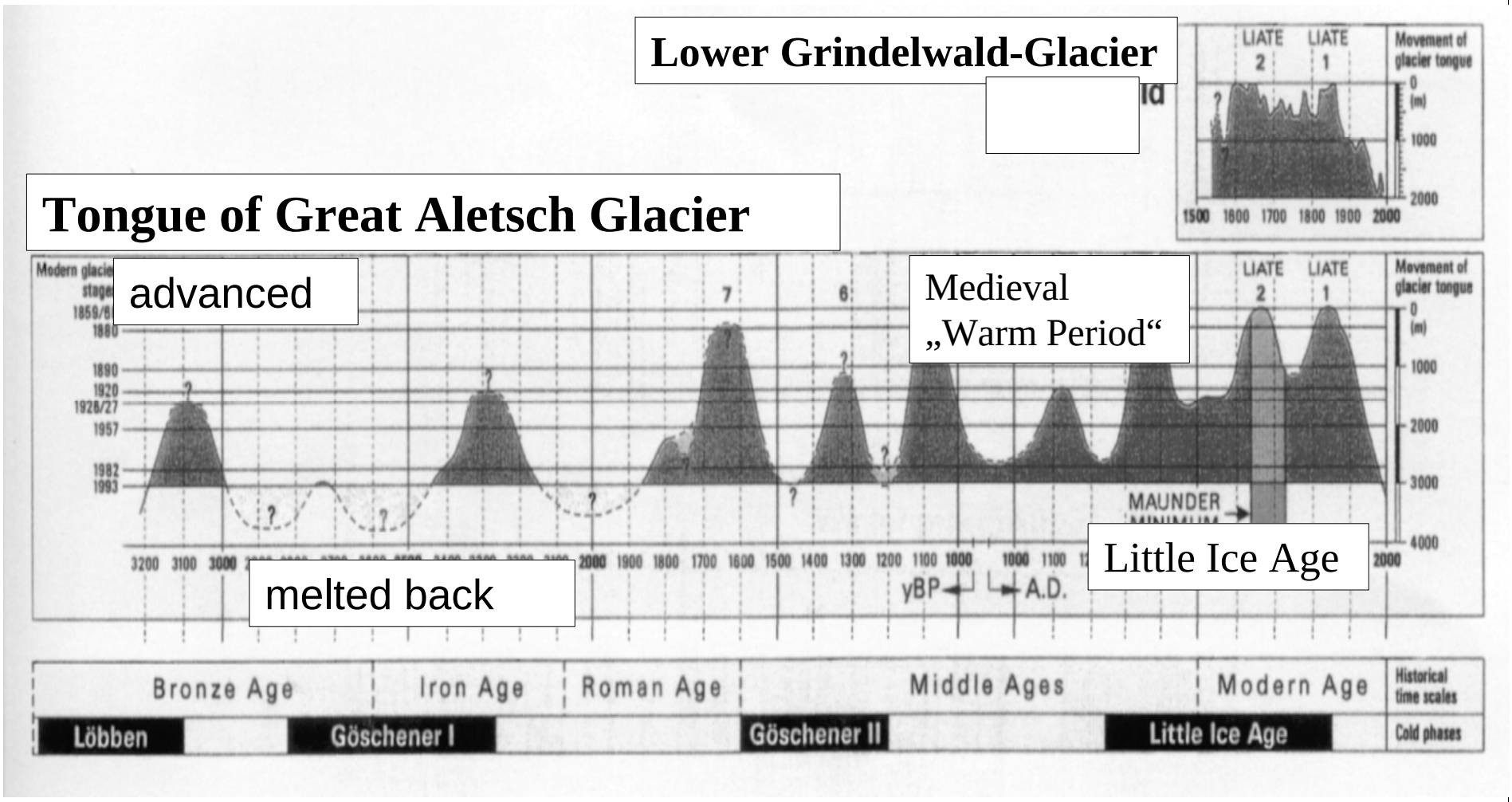

Holzhauser, 1995: 35-58.

Development of climatic record keeping from the High Middle Ages in Europe

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- Prior to AD 1200: Reports of socio-economically significant anomalies and (natural) disasters.
- 1200 to 1500: More or less continuous reports on characteristics of spring, summer and winter including reference to (bio)physical proxies and “normal” conditions. First weather diaries
- 1500 to 1800: Almost complete description of monthly weather, to some extent also of daily weather.
- 1680 to 1860: Instrumental measurements made by isolated individuals. First short-lived international and early national network observations
- From 1860: National (later also international) meteorological networks

Older kinds of climate observations were superposed by more recent ones

From: Pfister 2001

Time-Scales in Historical Climatology

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- **Little Ages:** multidecennial to centennial time scale: Medieval Warm Period (MWP), Little Ice Age (LIA), „Warm 20th century“, „period of greenhouse climate“ (*very long or scientific time scale*)
- **Decadal time scale:** duration 1 to 10 years *(longer human time scale)*
- **Synoptic situations:** duration of several days to several seasons *(shorter human time scale)*
- **Extreme weather***: duration of several hours to several days (very short or „disaster time scale“)*

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Geographical range of Documentary Data

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The geographical range and availability of documentary data depends on:

1. **The sedentary presence of literate individuals. This excludes the high altitudes and high latitudes.**
2. **An appropriate institutional and cultural framework (e.g. the existence of conventions and/or of local elites in towns).**
3. **A tradition of keeping chronicles**
4. **Scholars within well documented regions who engage in Historical Climatology**

Climate evidence from Archives of Society

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Direct Data	***Narrative Data*:** Anomalies, Natural disasters, Weather impacts, Weather spells, Daily to hourly weather ***Instrumental Measurements*:** Air pressure, temperature, Precipitation, Gauges
Indirect or Proxy-Data	***Biotic data*:** Flowering-time of plants, vine and grain harvest dates, yield and sugar content of vine must**.**
	Ice and Snow Seasonality: Ice cover of rivers and lakes, snow-fallls and snow cover
	High and low Water levels:
	***Religious Sources*:** Rogation Ceremonies
	***Epigraphical data*:** Flood-marks, low water marks
	Pictorial data: Paintings,Broadsheets etc.

Descriptive data and proxy data within individual sources

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Quite often individual sources contain both descriptive and proxy information (e.g. June 1616)

- „Most of June **(=temporal information)**
- was extremely hot **(=subjective assessment)**
- there was almost no rain **(= quasi objective observation)**
- so that the rye harvest already began at the end of this month“ **(= phenological proxy information, can be calibrated with thermometrical data)**
- (Abbot Placidus Brunschwiler, Fischingen Monastery, Eastern Switzerland)

What is a climate-historical source?

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- It is a **physical unit of man made information** which refers in some way to weather and climate and its impact on the environment and/or the human world.

  Most climate-historical sources contain **several types of documentary data, e.g.:**

  - narrative and proxy data

  - narrative data and **early instrumental measurements** (instrumental diaries)

  - narrative and pictorial data

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What are institutions?

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- **Institutions: bodies** regulating collective fields of action such as religion or branches of the economy within existing territorial structures (e.g. religious bodies such as chapters or secular institutions such as municipalities).
- **Institutional sources** related to the control of revenues involved standardized book-keeping procedures: Many institutional accounting practices generated quasi-homogenous records over centuries.
- *(Pfister et al. 2009)*

Individual and Institutional Sources

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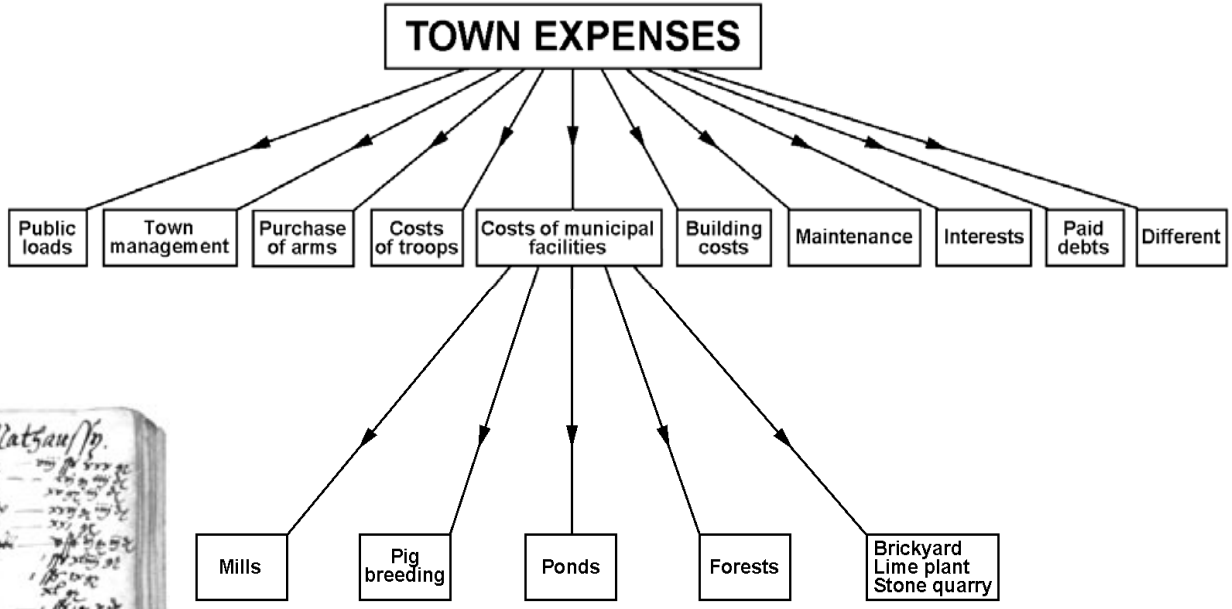
Sources

Data	Institutional	Individual
Instru mental	-Network measurements (standardisation)	- Voluntary Measurement individual observers
Direct narrative	-**Mandatory reporting** -Rogation ceremonies -Damage reports -Ship Logbooks, etc.	-**Voluntary observation** -Chronicles -Weather Diaries etc
Indirect or Proxy	-**Mandatory accounting** -Timing of and reason for receipts and expenditures in kind or money (vine and grain harvest, port records etc.).	**-Documentation of extremes**: -Stages of Plant-Development -Snow and Ice Seasonality -Flood and low water marks -Illustrations, paintings

Pfister et al.2009

Urban account books from Louny (NW Bohemia) 1450-1632

Structure of the town expenses



Books of accounts

Information about **regular Saturday payments of wages** for agricultural and other municipal work related to weather patterns

Bràzdil,Kotyza 2000

Critical evaluation of sources produced by individuals

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The procedure includes:

- **Reconstruction of biography (contemporary vs non contemporary)**
- **Assessing the climatic sensibility of the economy**
- **Social and cultural environment (traditions, focus of reporting)**
- **Assumed reasons for reporting the information (motivation)**

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What are compilations and climate reconstructions?

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Compilation: Chronological arrangement of texts on climatic anomalies and natural disasters originating from different sources which contains neither observations by the author nor assessments of monthly or seasonal climate in the form of indices.

- **Climate reconstruction:** contains results in the form of temperature and precipitation indices and/or estimates of climatic elements .

Critical and uncritical compilations

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Criteria:

- Sources need to be carefully referenced and criticallly evaluated (contemporary vs non contemporary).
- The wording of sources needs to be reproduced
- Places of observation need to be specified.

Critical compilations set up according to rules of historical source evaluation: Examples: Alexandre (1987),Telelis (2004)

Uncritical compilations- e.g. Champion 1876, Britton (1937), Weikinn (1958) should be handled with care

Spurious multiplication of storm floods in the 1370s (Weikinn (1958)

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	Year	*Source*	*Weikinn p.*
•	1374	Chronicum Moguntinum	257
•	1374 Oct	Joh. Adolfs Chronik	257
•	1375 Oct10	Remmer v.Seebeck	258
•	1376	Valois	
•	1376 Oct 10	Tielensee	258
•	1377 Oct 10	Chronik E.F. von Wicht	259-260
•	**1377 Nov 16**	**Chronikum [...] Flandrense**	**260-261**

(this is the only original source!)

(Bell,Ogilvie 1978: 340)

Illustration of the calibration-verification procedure (Example sweet cherry flowering)

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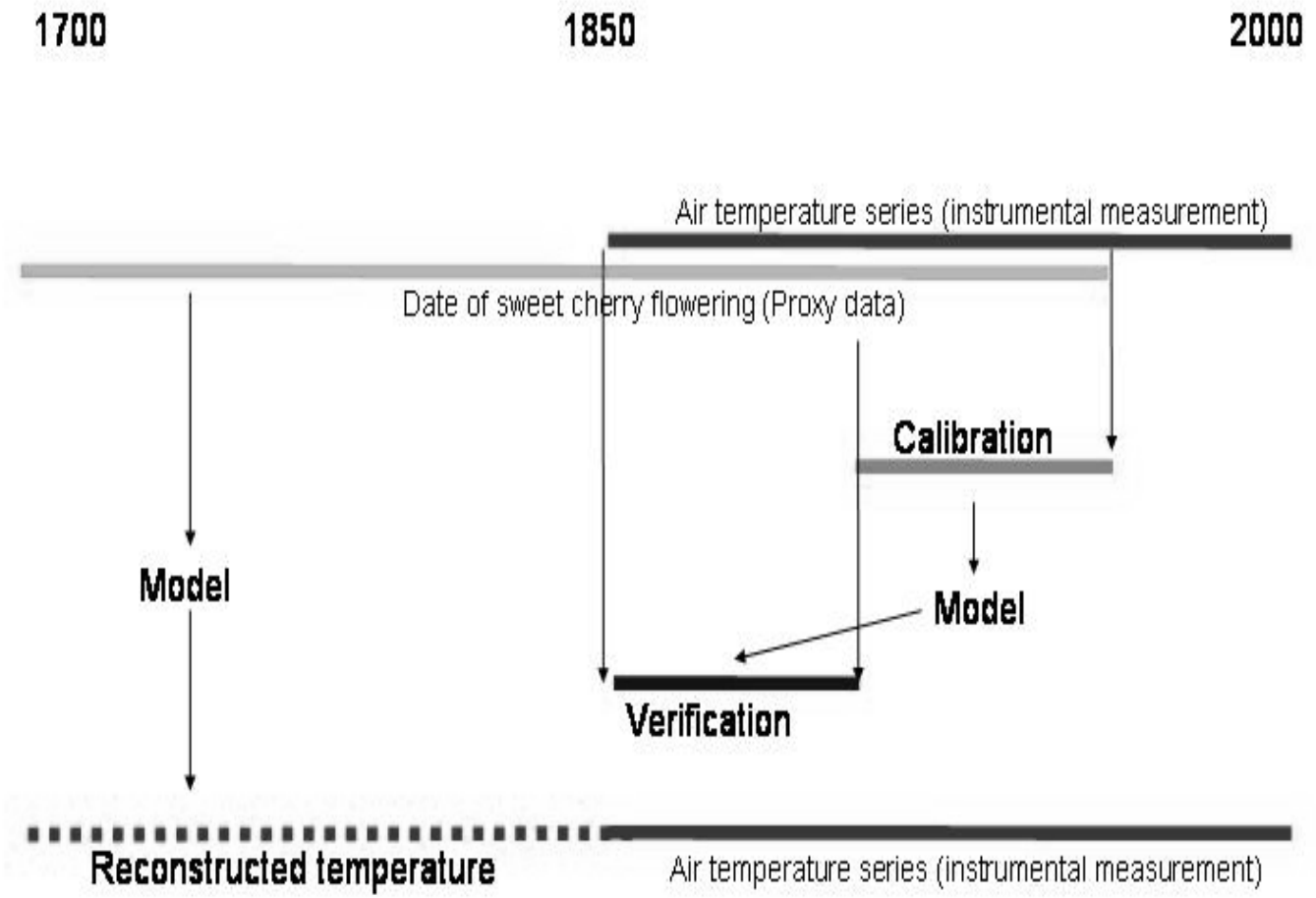

Burri 2008

Documentary Ordinal Temperature and Precipitation Indices (=designed variables)

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Documentary evidence → **Documentary T indices (DTI) designed ordinal variables** → **T = f(DTI)**

Scale	Description	% σ
+3	extremely warm/wet	180%
+2	very warm/wet	130%
+1	warm/wet	65%
0	normal	
-1	cold/dry	65%
-2	very cold/dry	130%
-3	extremely cold/dry	180%

Dobrovolny, improved

Seasonal indices (sum of monthly: -9; +9)
Annual indices =sum of seasonal: -36: +36

Temperature Index building: Preparatory steps

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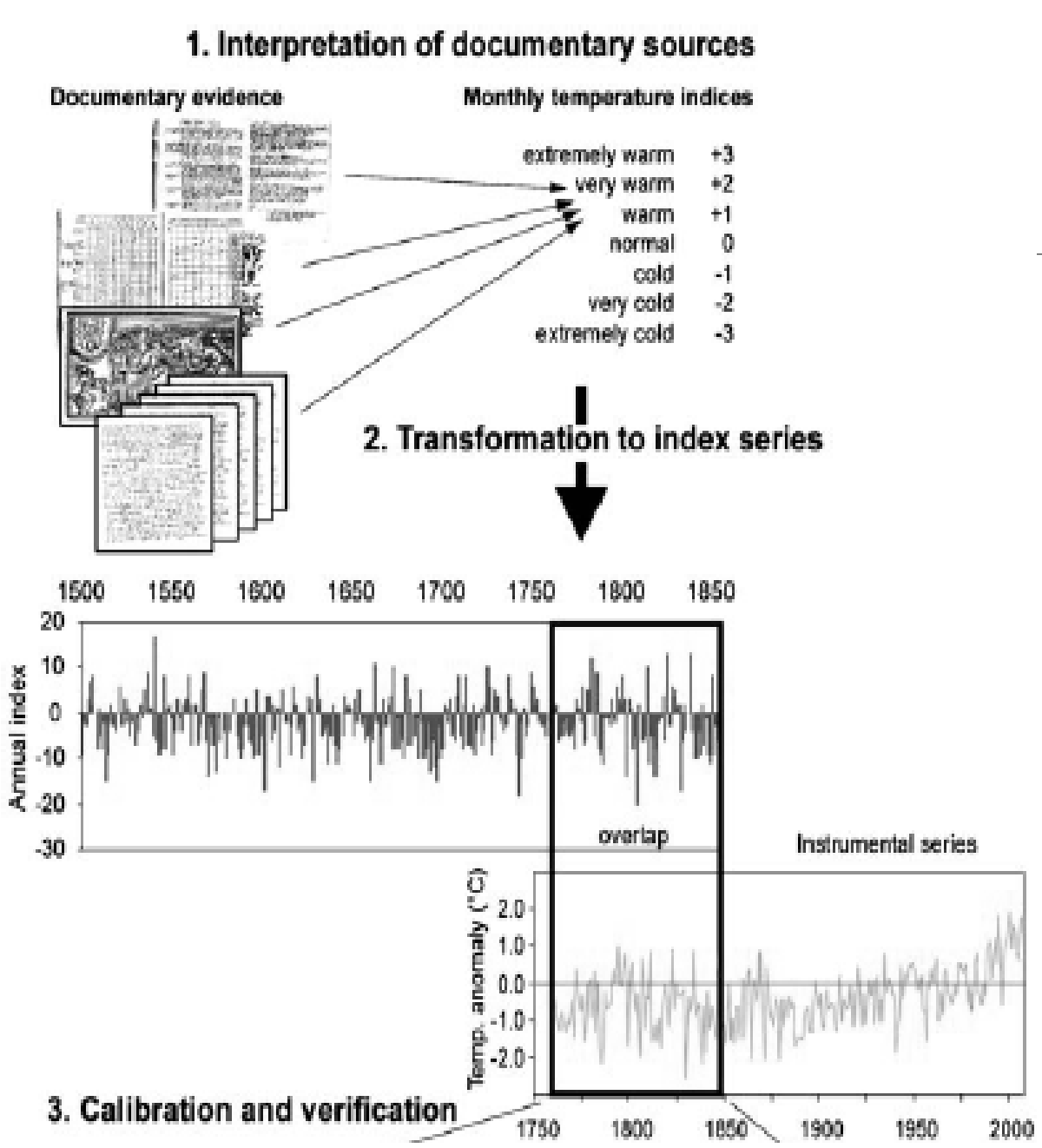
1. Calibrate individual plant, ice and snow-phenologicak data in the record by comparison with data series from the period prior to 1960
2. Analyse daily observations (quality control, calculation of sums für days with precipitation, snowfall, snow-cover etc.). Compare results with those available from a neighboring station in the instrumental period
3. Calibrate institutional data with instrumental series. Usually such results are obtained from the corresponding papers
4. Sort the whole information in chronological order according to data type.

Pfister in prep



Indices Calib.1

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Interpretation and Calibration of Indices (1)

Brazdil et al 2010

Indices 2

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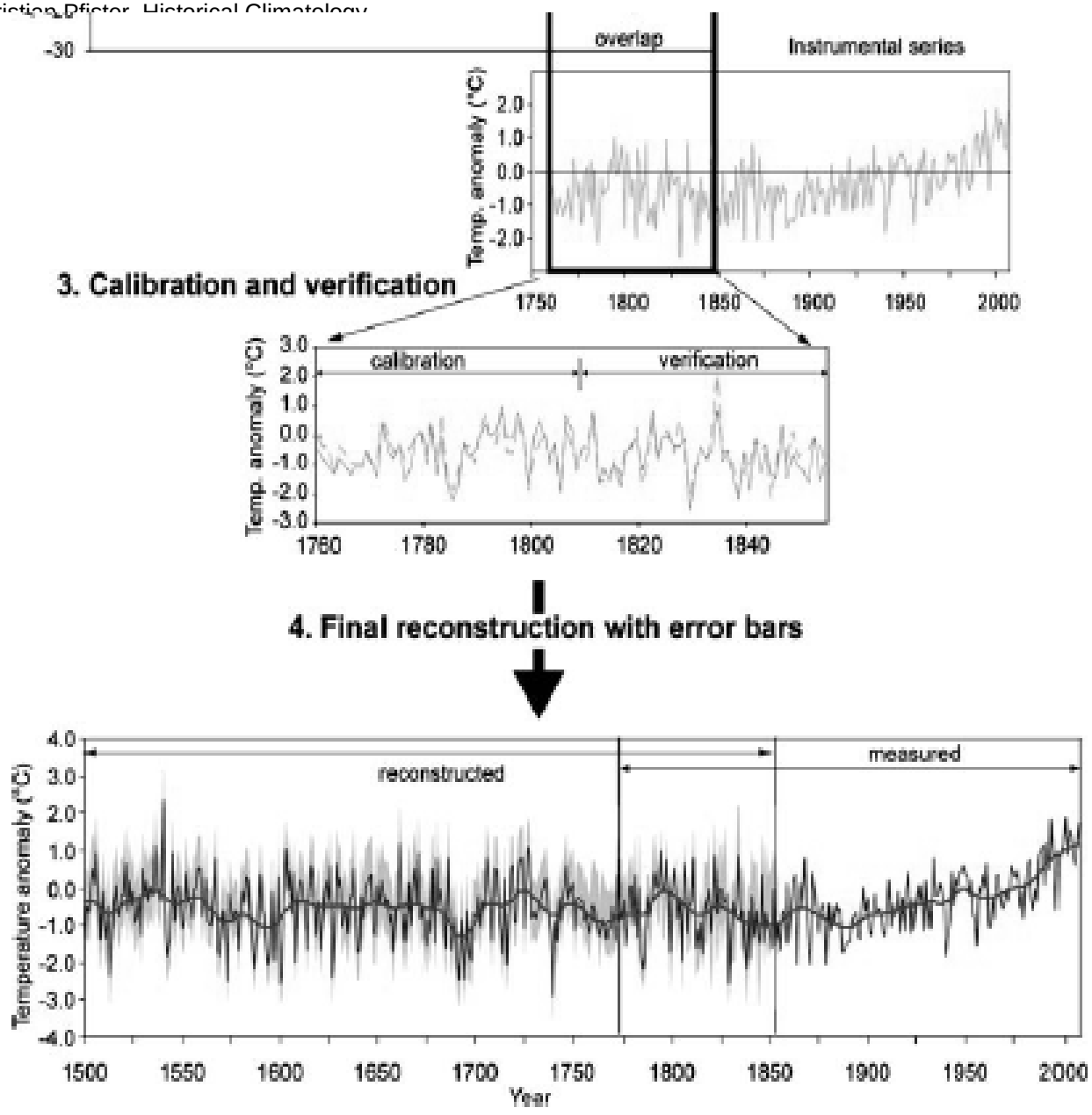

Interpretation and Calibration of Indices (2)

Brazdil et al. 2010

Reconstruction methodology (PCA-multivariate regression)

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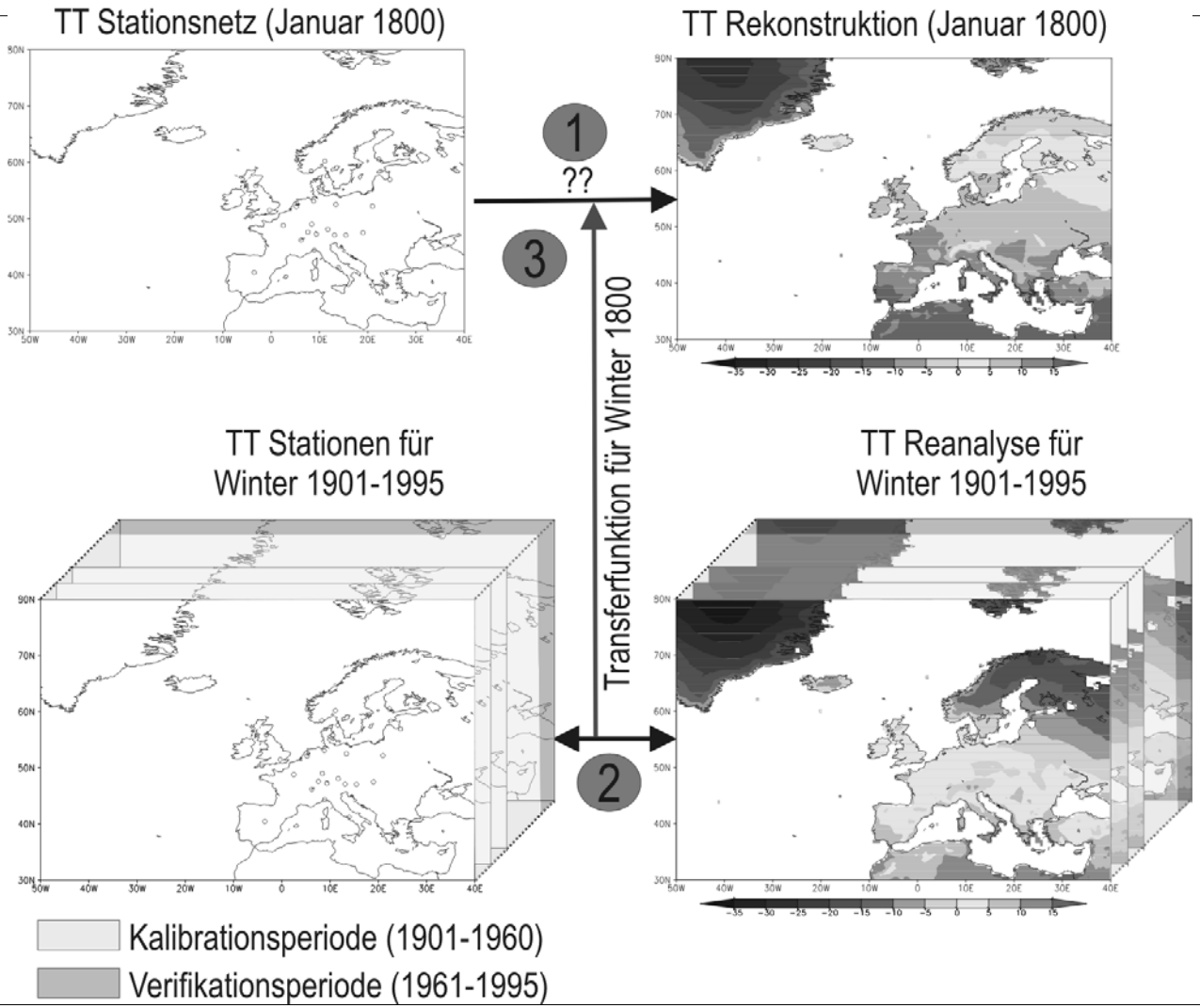

Luterbacher et al 2004
Casty 2004

Graphical representation of the entries in the diary of Kilian Leib (Eichstätt D), July to Dec 1529

JUL	AUG	SEP	OCT	NOV	DEC
◑•	•	•	◑	◑	❄ ✳/
◑	•	●	•	•	❄ ✳•/
◑•	•	◑	•	•	•
•	•	•	•	•W	◑C
◑	•	•	•	•	◑C
◑	•	•	•	◑ /•	◑C
○	○	●	◑	•	◑C
○	○	•	○	/•	❄ ✳
○	•⌈/	○	/D ●	△	◑W
○	•⌈	○	●•	◑	✳
•⌈	•	◑	● ○/	◑	•
•	◑	•	● ○/	◑⊔	•
•	◑	●	○	◑	• W/
•	• ◑/	•▲	● /•	◑C	•
○	•	◑	•	●C𝄢	• /❄
◑	◑•	/⊔ ◑	○C	❄	❄
◑ •/	•	•	◑C	△	◑
/C ○	◑	◑⊔	○C	△	❄
○	◑ /•	●⊔𝄢	•	/•	◑
○	/• ◑	◑	◑	●	◑⊔❄
/○ /𝄢•/	◑	•	•	•	/○C ❄/

/x	night, morning
x/	afternoon, evening
⌈	thunderstorm
𝄢NE	NE wind
𝄢SW	SW wind
𝄢	windy
△	storm
○	clear sky
●	overcast
◑	partly cloudy
⊖	cirrostratus
=	foggy
≡	fog
D	dry
W	warm
C	cold
cm	„calm“
•	rain
•𝄢	storm and rain

Pfister et. al 1999: 132 Schwarz-Zanetti 1992

Average number of rain and snow days in Lucerne (1588-1613) compared to 1901-1960

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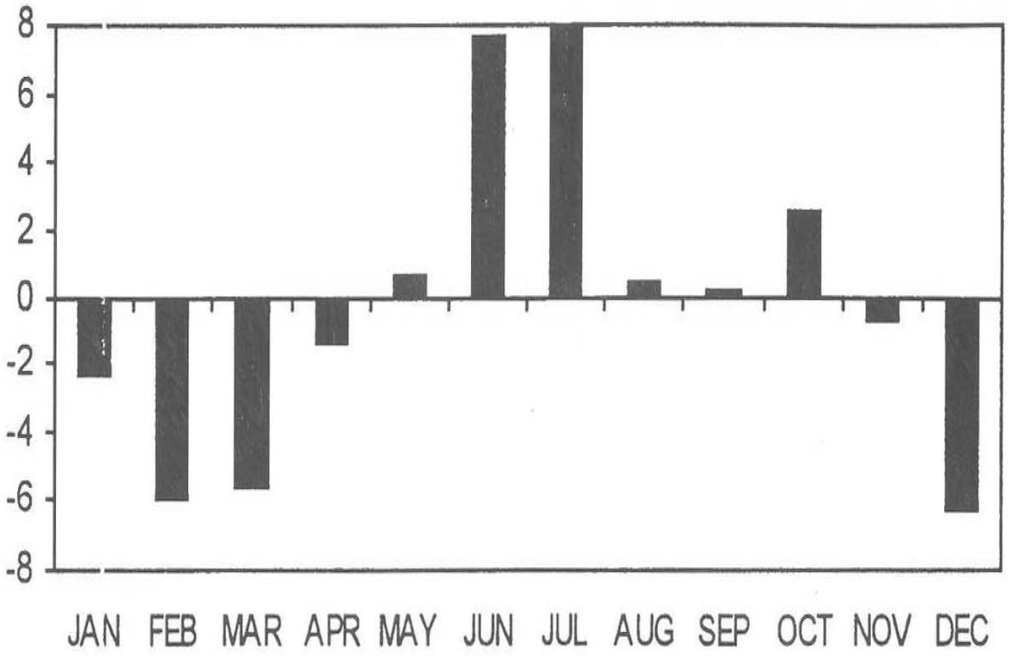

Figure 7. Deviation of average number of days within precipitation in Lucerne 1588-1613 from the mean 1901-1960. Data basis: 1589, 1609, 1610, 1612, 1613: all months of the year. 1588: Jan. through to Aug.; 1596 March through to Dec., 1611: Jan. through to May. Source: Pfister (1988).

Pfister et al. 1999: 142

Stockholm Port Records
Calibration and verification 1756-1892

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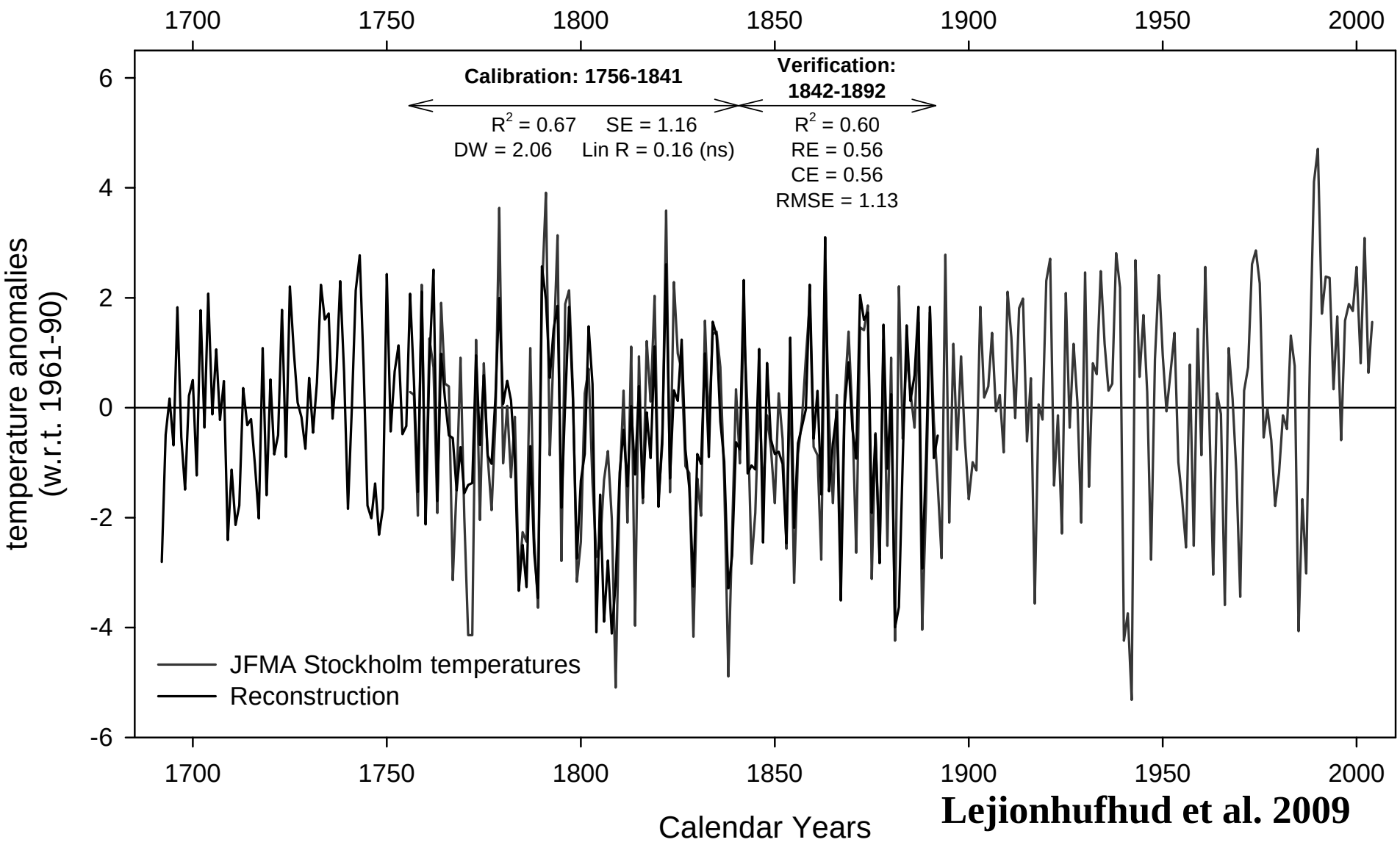
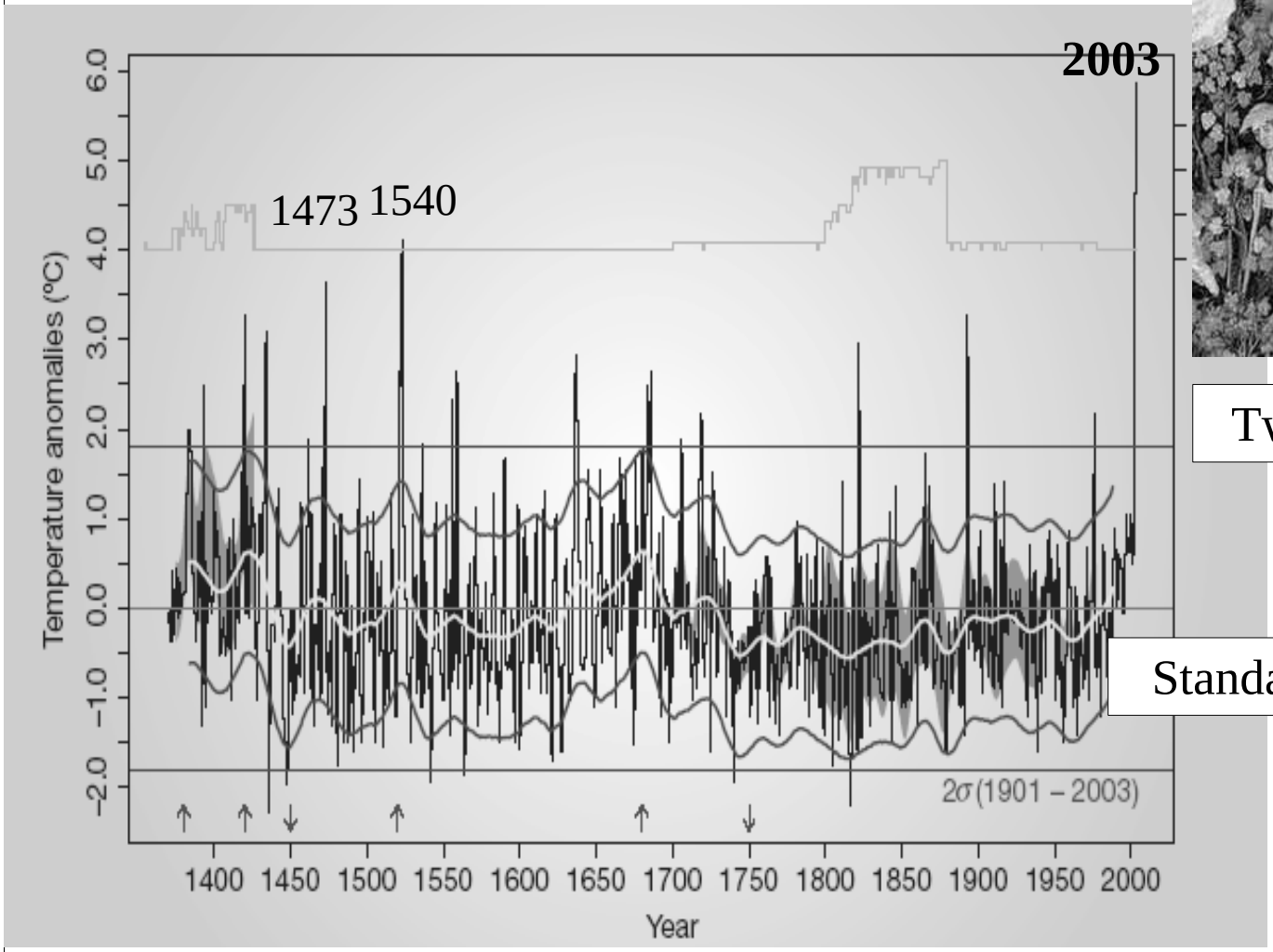


Lejionhufhud et al. 2009

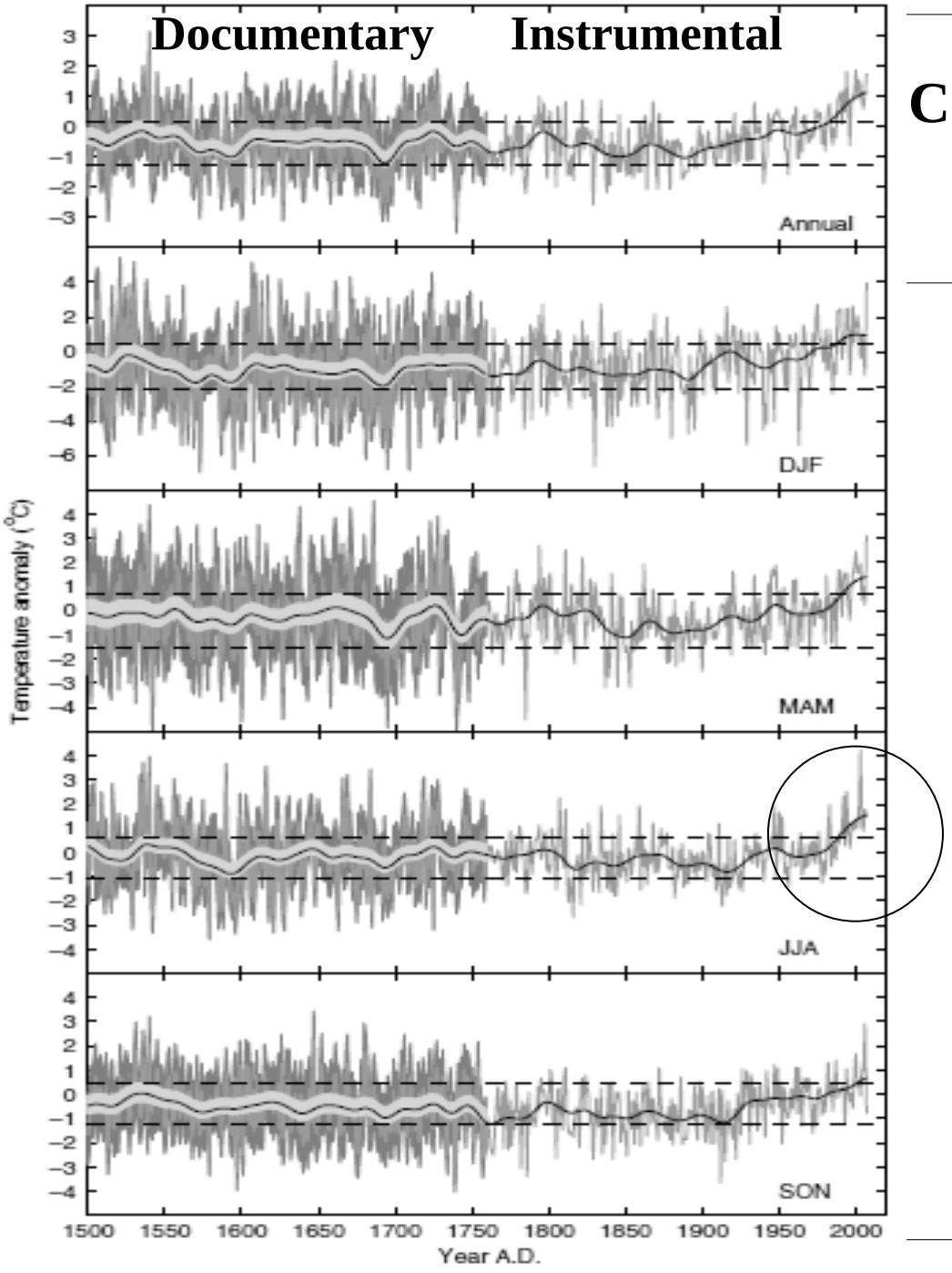
Grape harvest dates in W Europe since 1370 (Proxy for AMJJAS temperatures)



Two sigma boundary

Standard error of estimate

Chuine et al.2004



Central European Temperatures 1500-2000

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Reconstructed from Temperature Indices (+3/-3) from Germany, Czech Republic and Switzterland and the HISTALP Temperature series (Böhm et al., 2007)

Dobrovolny et al. 2009

Number of temperature anomalies per decade 1501-2000

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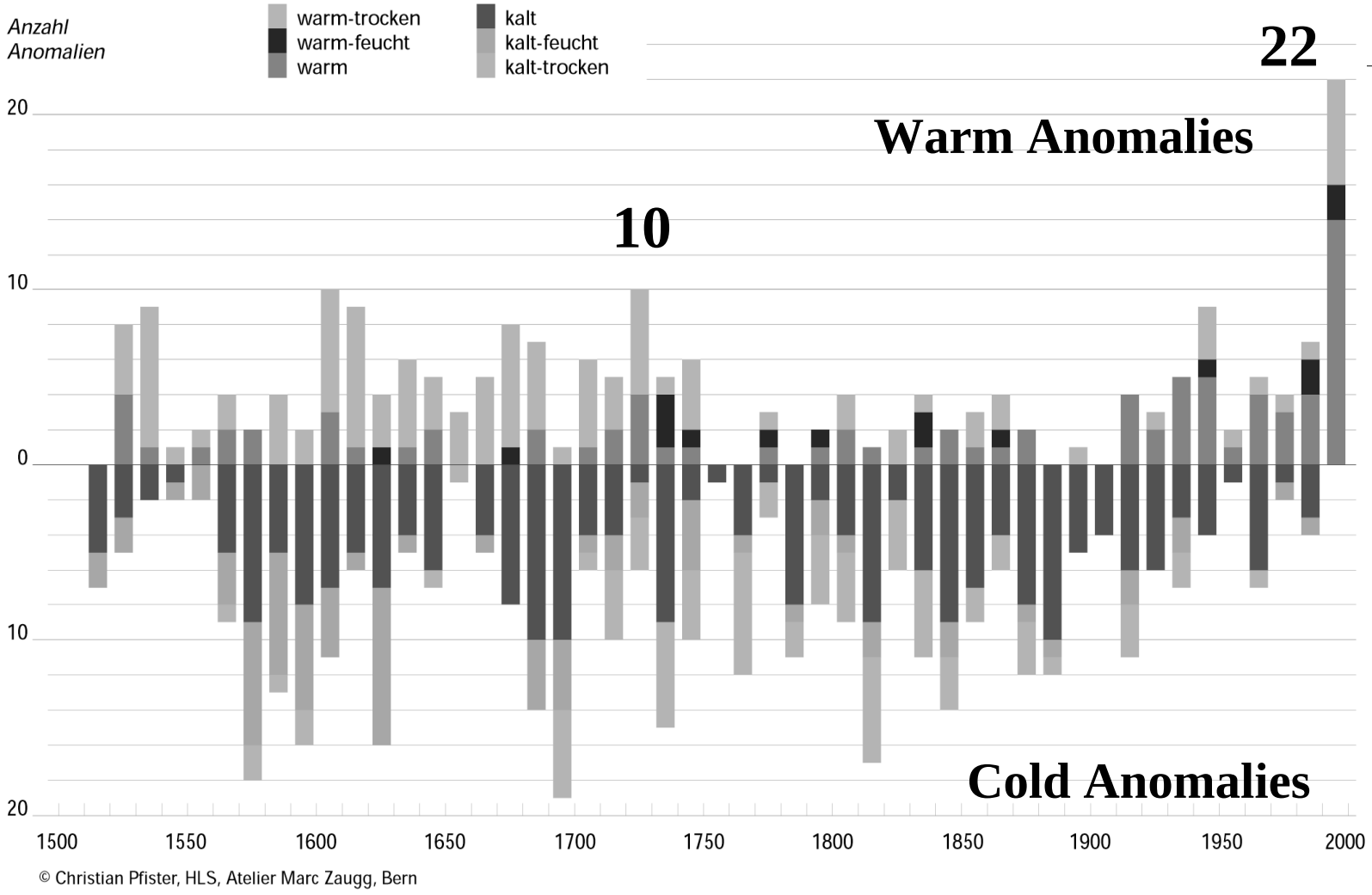

Pfister 2005

1500 1750 2000

1708/1709, likely the coldest European Winter

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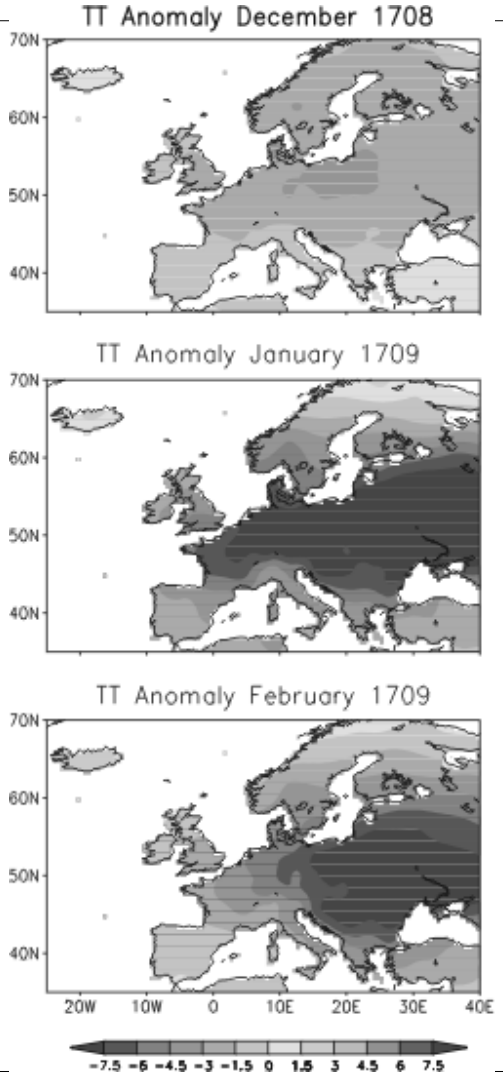

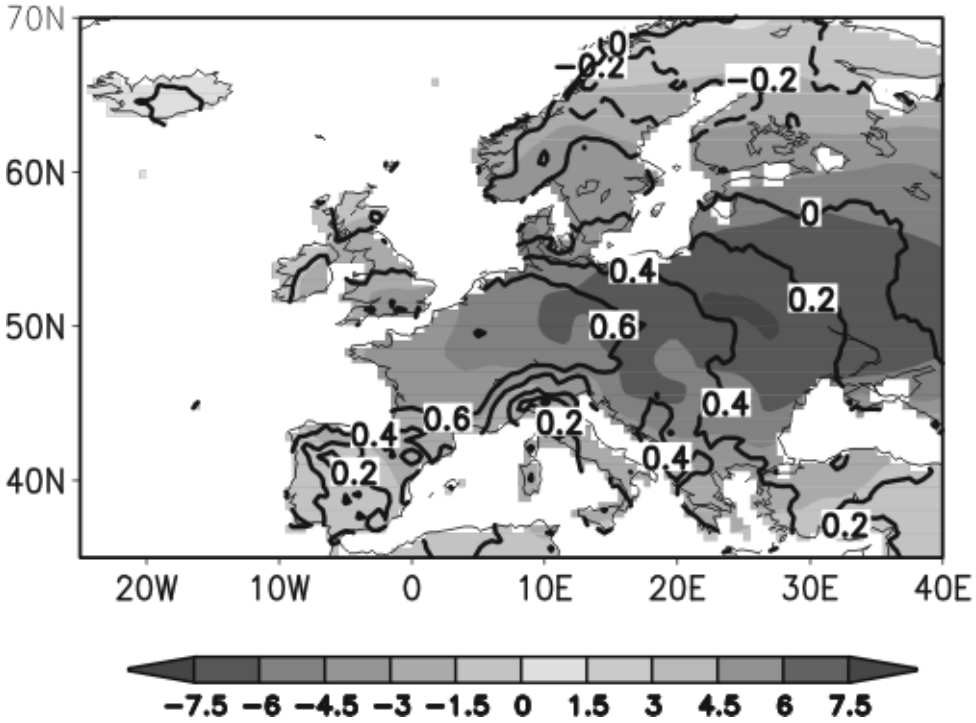

Luterbacher et al. 2004

European Winter temperature 1500-2007 (multiproxy plus instrumental)

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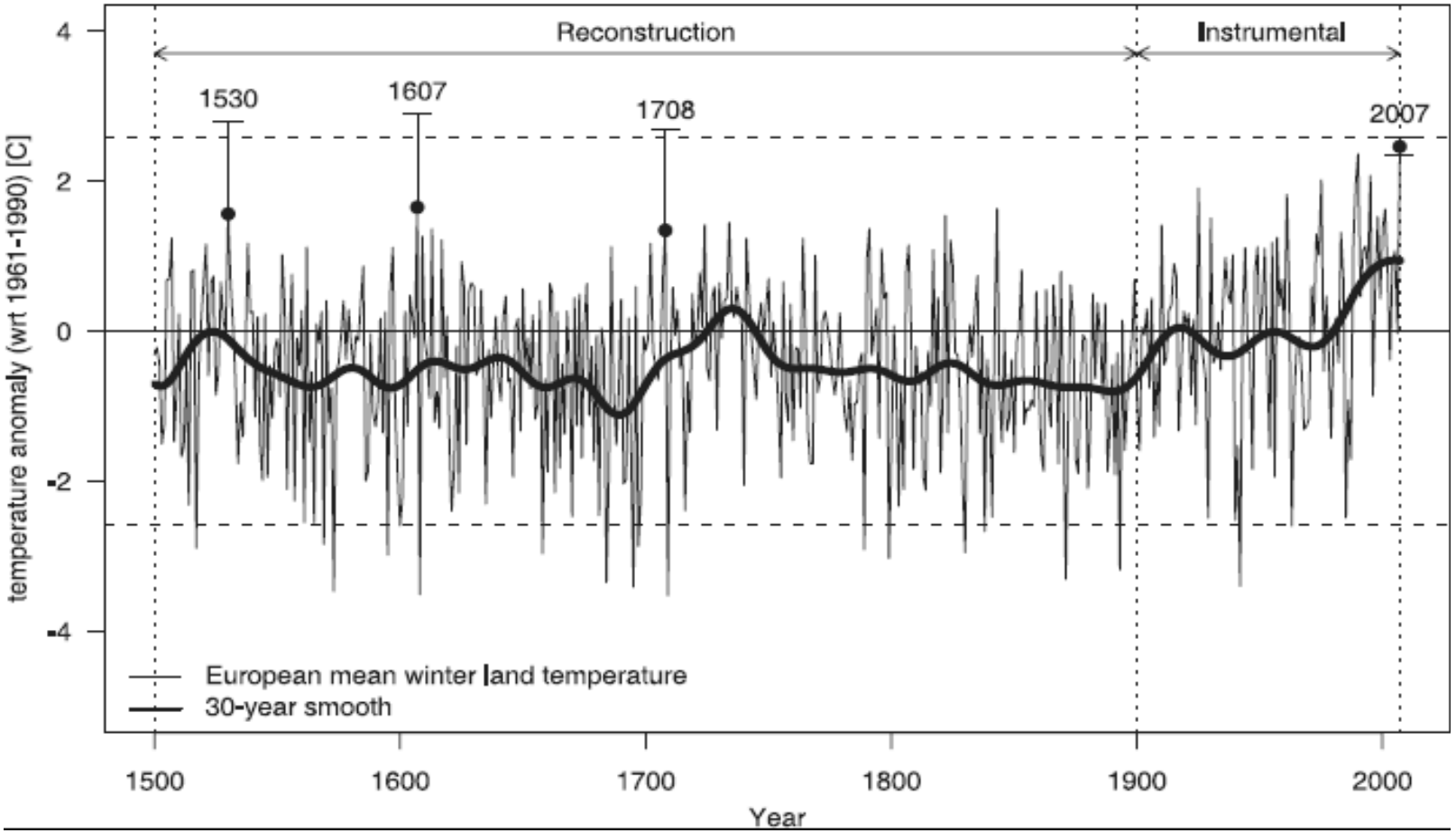

Luterbacher et al 2007

Fluctuations of Lower Grindelwald glacier (Bernese Alps 1500-2000

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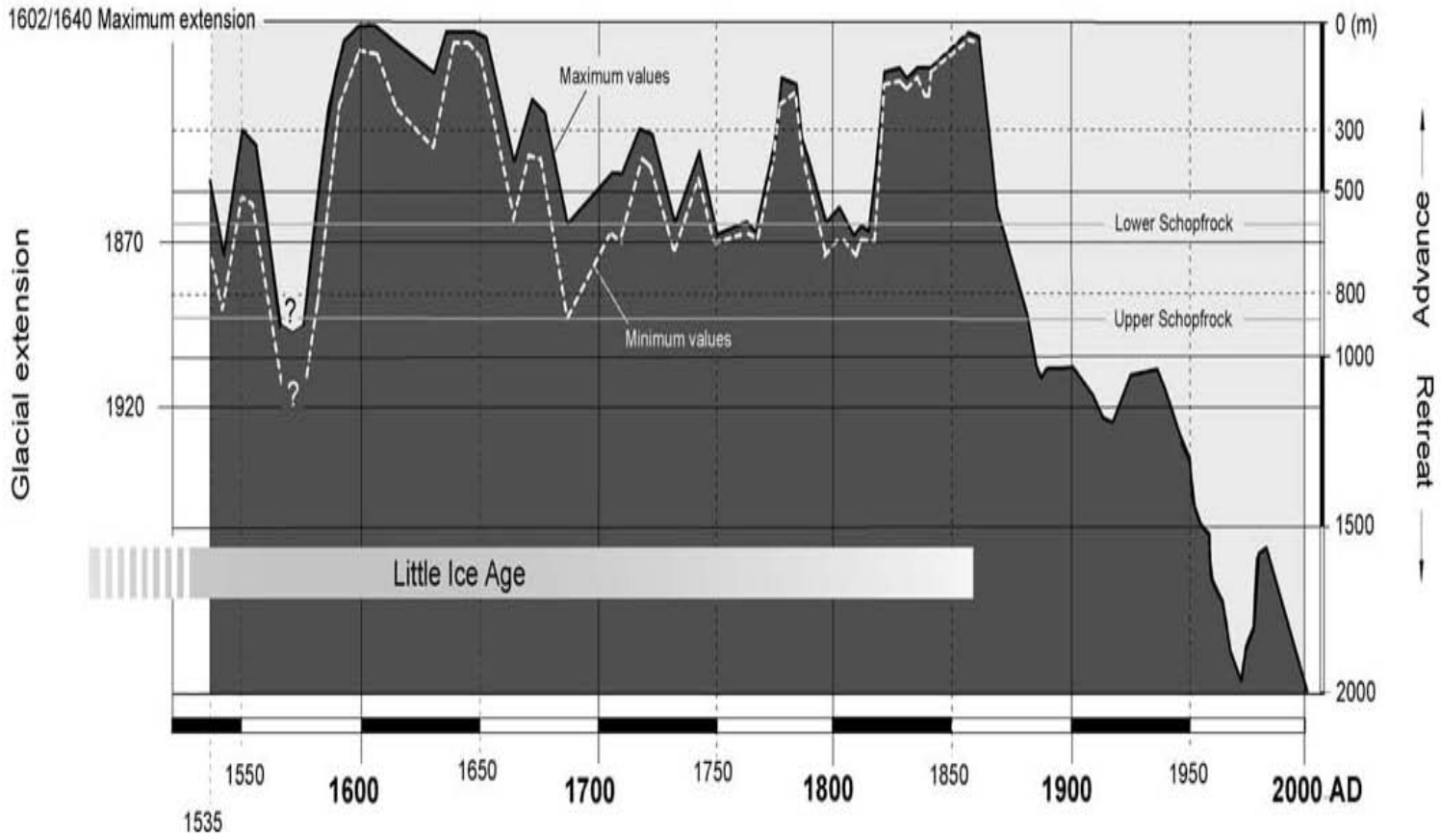

Holzhauser et al. 2005

Annual temperatures in Germany based upon documentary evidence 1000-2000

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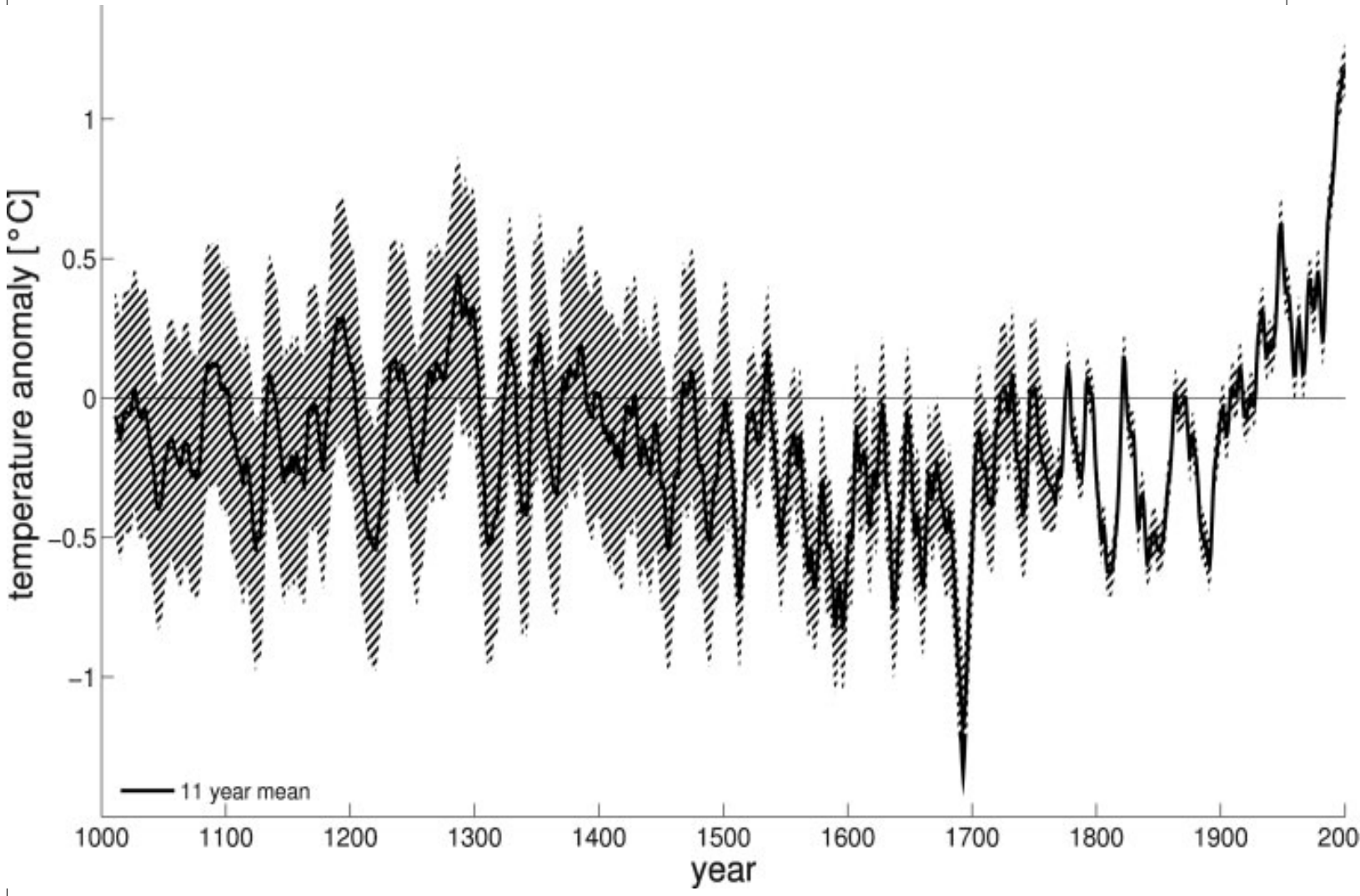

Glaser Riemann 2009

6 future challenges for Historical Climatology

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1. Focus on unexplored parts of world with documentation: South America, Islamic world, India?
2. Central Europe: high resolution reconstruction of Middle-Ages (from about 1170)
3. New N-H reconstructions for last Millennium using documentary reconstructions from China and Europe.
4. Consolidated cooperation between H-C and paleoclimatology
5. Comparisons between GCMs/RCMs and local to regional documentary proxies
6. Studies about social vulnerability in well-researched and well-documented periods

Pfister et al. 2009