Klima und Geschichte: Der Ausbruch des Tambora 1815 und das Jahr ohne Sommer 1816

Stephan Matthiesen

www.klima-und-geschichte.de

Naturhistorische Gesellschaft (NHG)
Nürnberg, 15 Oktober 2018

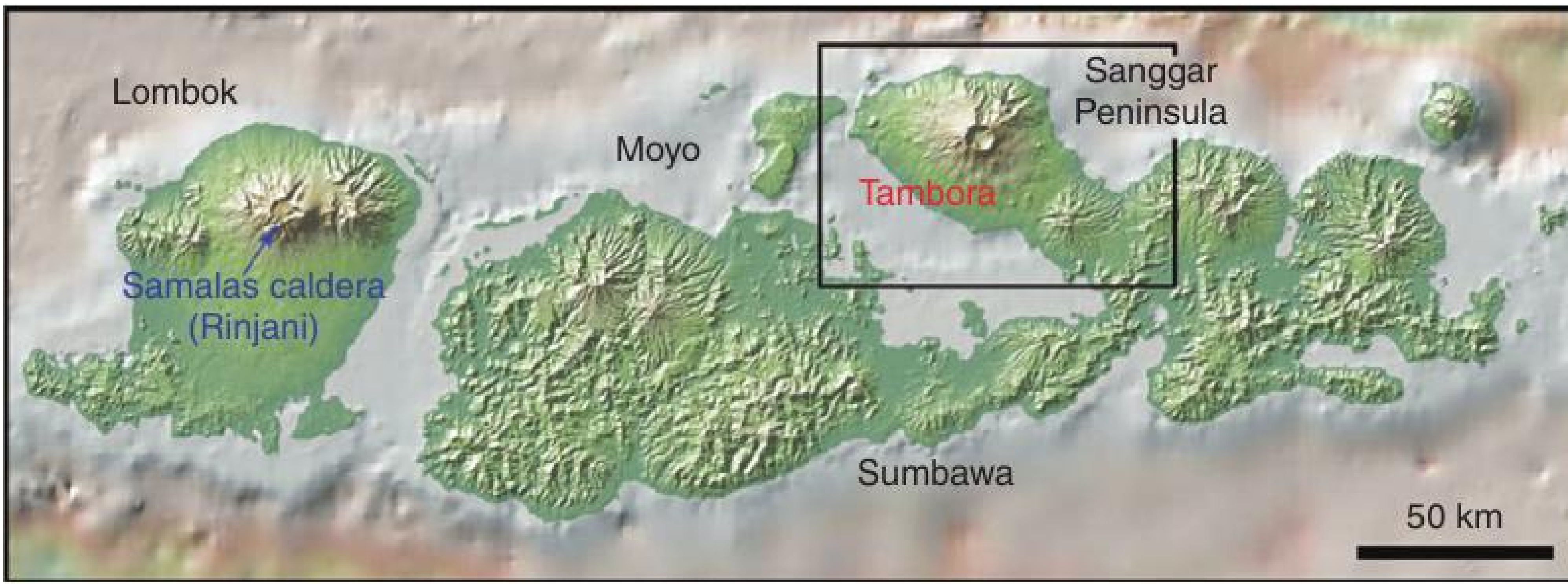
Vulkan Tambora

Haeseler, Der Ausbruch des Vulkans Tambora in Indonesien im Jahr 1815 und seine weltweiten Folgen, insbesondere das ‚Jahr ohne Sommer' 1816". Deutscher Wetterdienst, 27. Juli 2016.

Plinianische Ausbrüche

aus: Dinwidde, Lamb, Reynolds: Naturgewalten, Dorling Kindersley, 2012


Pyroklastischer Strom
Mayon, Philippinen



Raible et al., Tambora 1815 as a Test Case for High Impact Volcanic Eruptions: Earth System Effects. Wiley Interdisciplinary Reviews: Climate Change 7, Nr. 4 (1. Juli 2016): 569–89.

ISS Astronaut photograph ISS020-E-6563; 3. Juni 2009

Heinrich Zollinger
Reise 1847

- Schätzung der Todeszahlen:
  - 10.000 direkt bei der Eruption
  - 38.000 auf Sumbawa durch Hunger
  - 10.000 auf Lombok durch Asche und Hunger
- meist werden heute 71.000 angenommen

Ascheregen

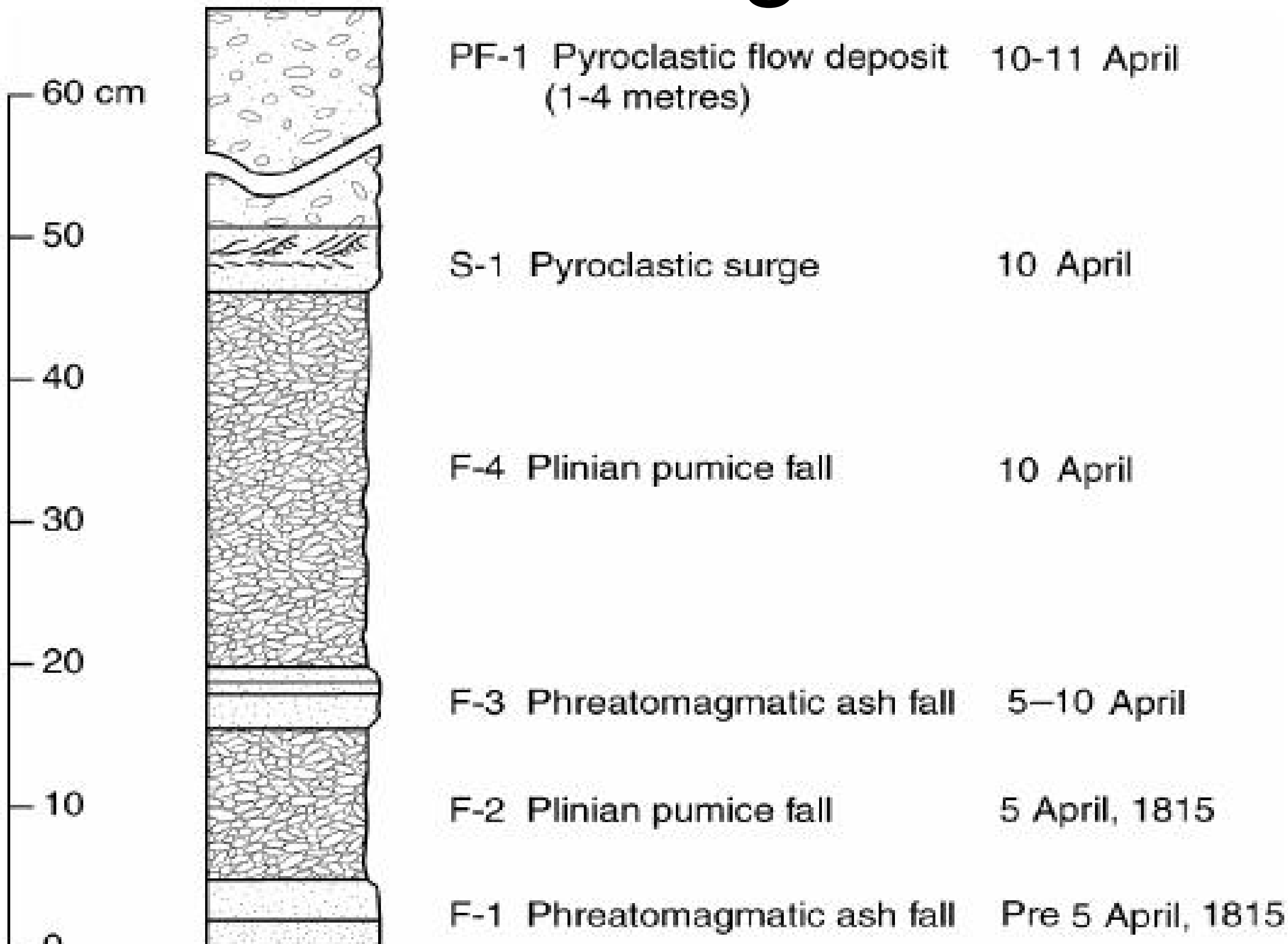
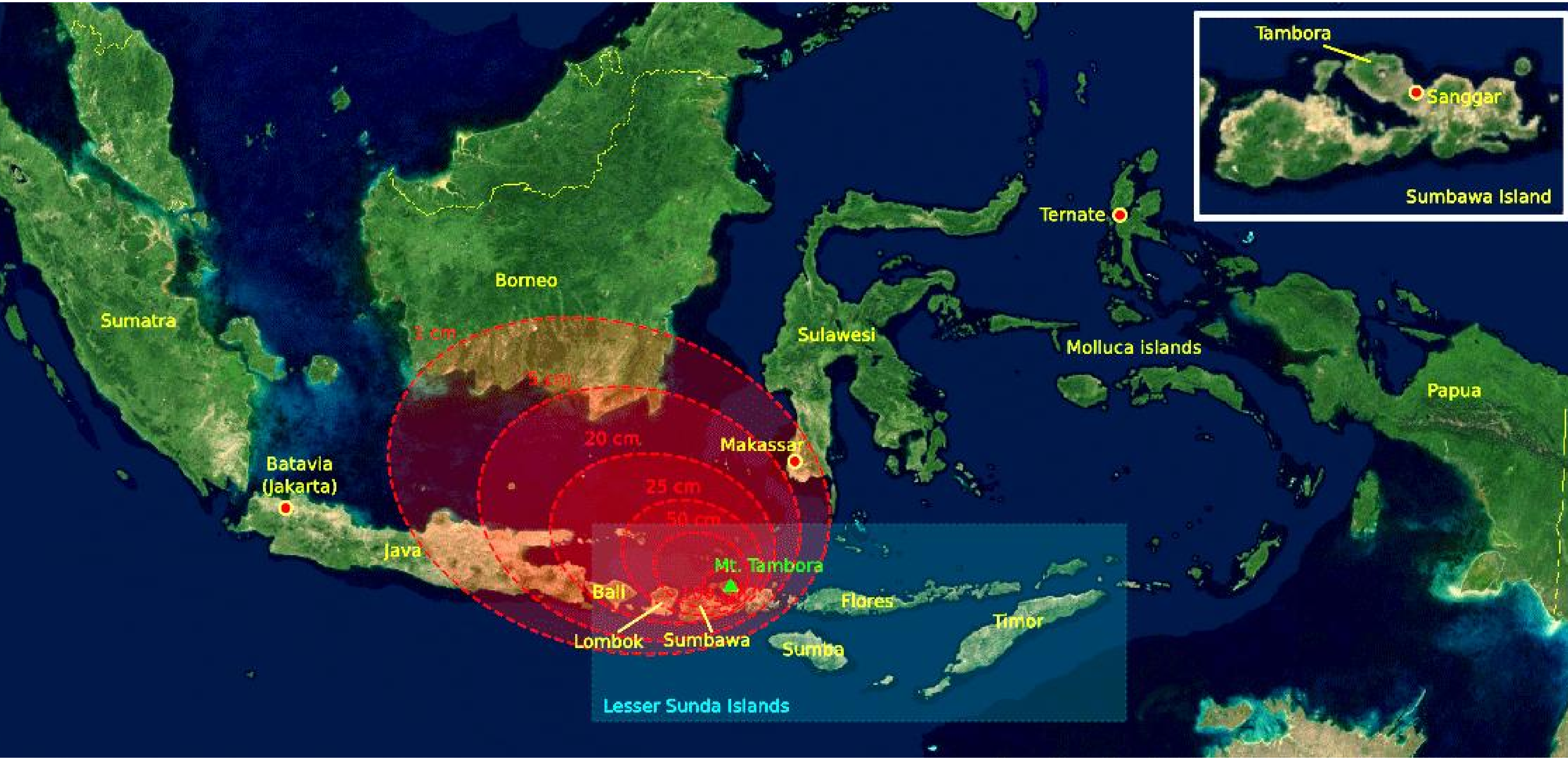


Figure 2 Stratigraphy of tephra deposits from the Tambora eruption logged at Gambah, 25 km from the summit

Oppenheimer, Clive. „Climatic, Environmental and Human Consequences of the Largest Known Historic Eruption: Tambora Volcano (Indonesia) 1815“. Progress in Physical Geography: Earth and Environment 27, Nr. 2 (1. Juni 2003): 230–59.

Ascheregen



Tambora
Sanggar
Sumbawa Island
Ternate
Borneo
Sumatra
Sulawesi
Molluca islands
Papua
1 cm
5 cm
20 cm
Makassar
Batavia
(Jakarta)
25 cm
50 cm
Java
Mt. Tambora
Bali
Flores
Timor
Lombok
Sumbawa
Sumba
Lesser Sunda Islands

Staubschleier

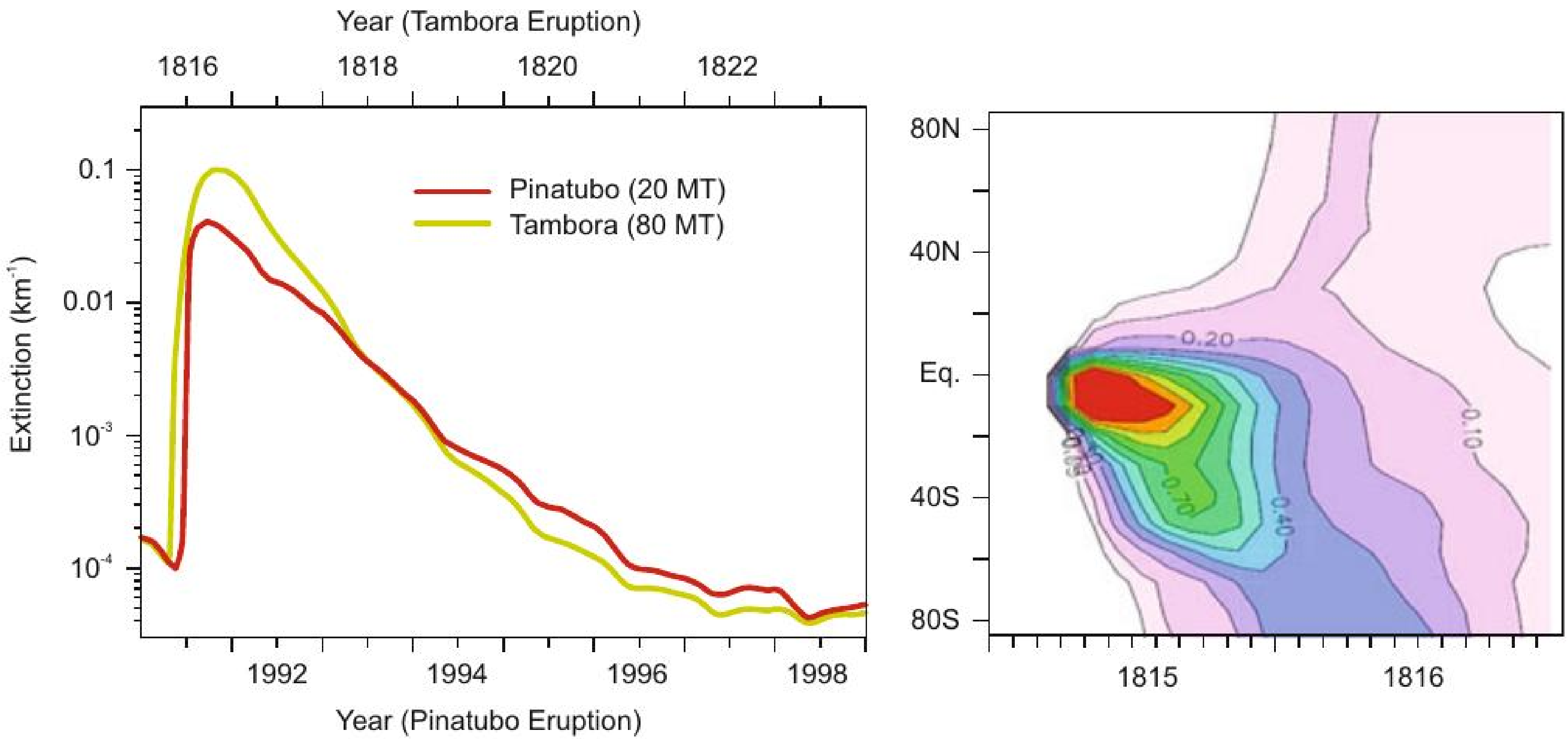


Fig. 4.28 (*left*) Aerosol extinction (1.02 µm) at 20-km altitude above the equator for the Tambora and Pinatubo eruptions. (*right*) Aerosol optical depth (500 nm) modelled for the Tambora eruption. These are obtained from a two-dimensional aerosols microphysics model, assuming a sulphur amount of 80 and 20 Mt for Tambora and Pinatubo, respectively (See Arfeuille et al. (2014) for details)

Brönnimann, Stefan. Climatic changes since 1700. Cham: Springer, 2015.

Abendstimmung in Wales 1838 von William Turner

Kleine Eiszeit

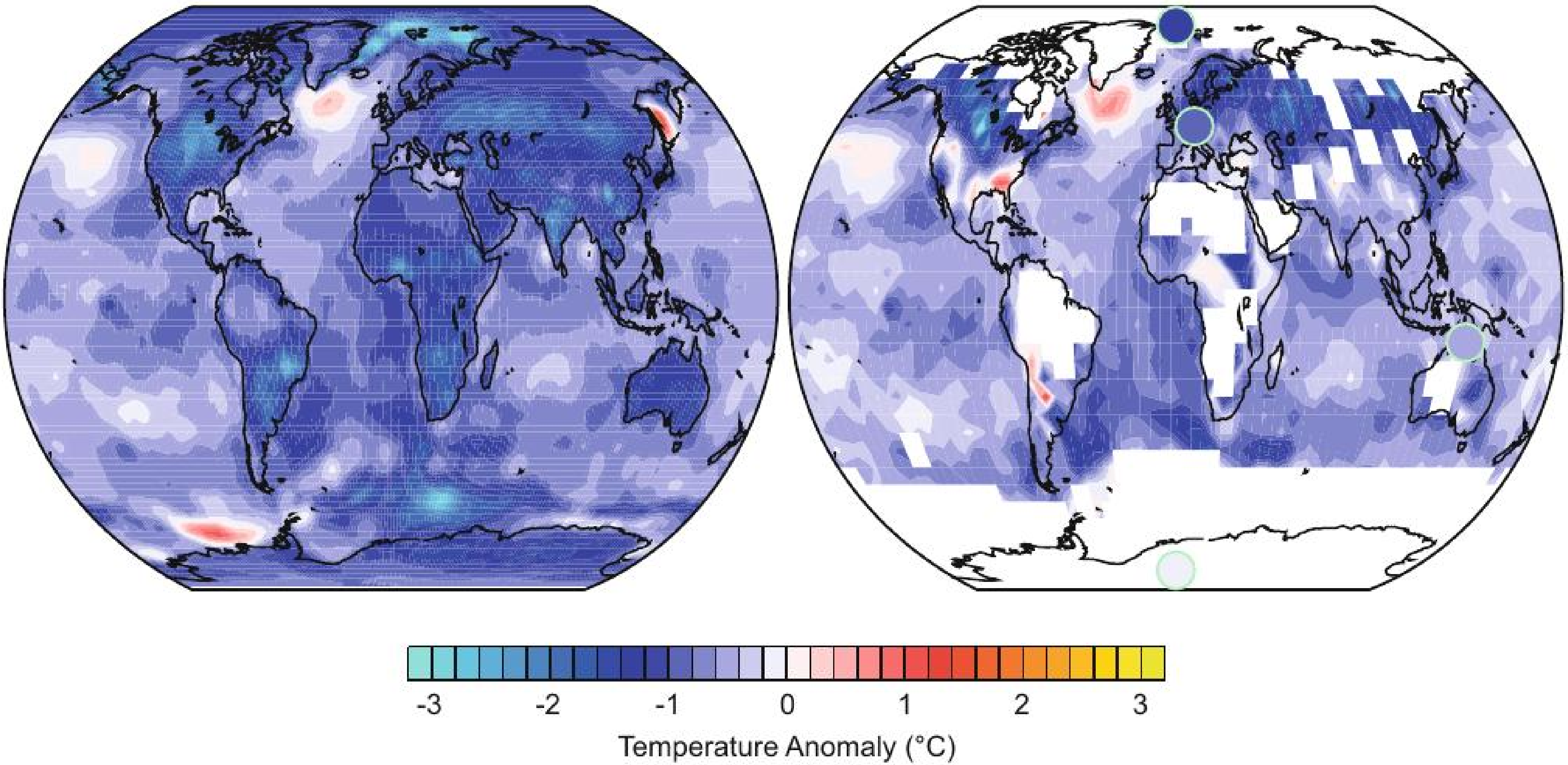


Fig. 4.15 Global map of the annual mean temperature difference in 1700–1890 relative to 1985–2005 in the (*left*) CCC400 simulations and (*right*) reconstructions (Mann et al. 2009b). The *dots* indicate temperature anomalies from the PAGES 2k reconstructions (Fig. 4.5; only shown if they reach at least to 2001)

Brönnimann 2015

Meteorologie in Genf um 1800

Horace-Bénédict de Saussure
1740-1799

Marc-Auguste Pictet
1752-1825

Marc-Auguste Pictet Wettermessungen 1799-1821

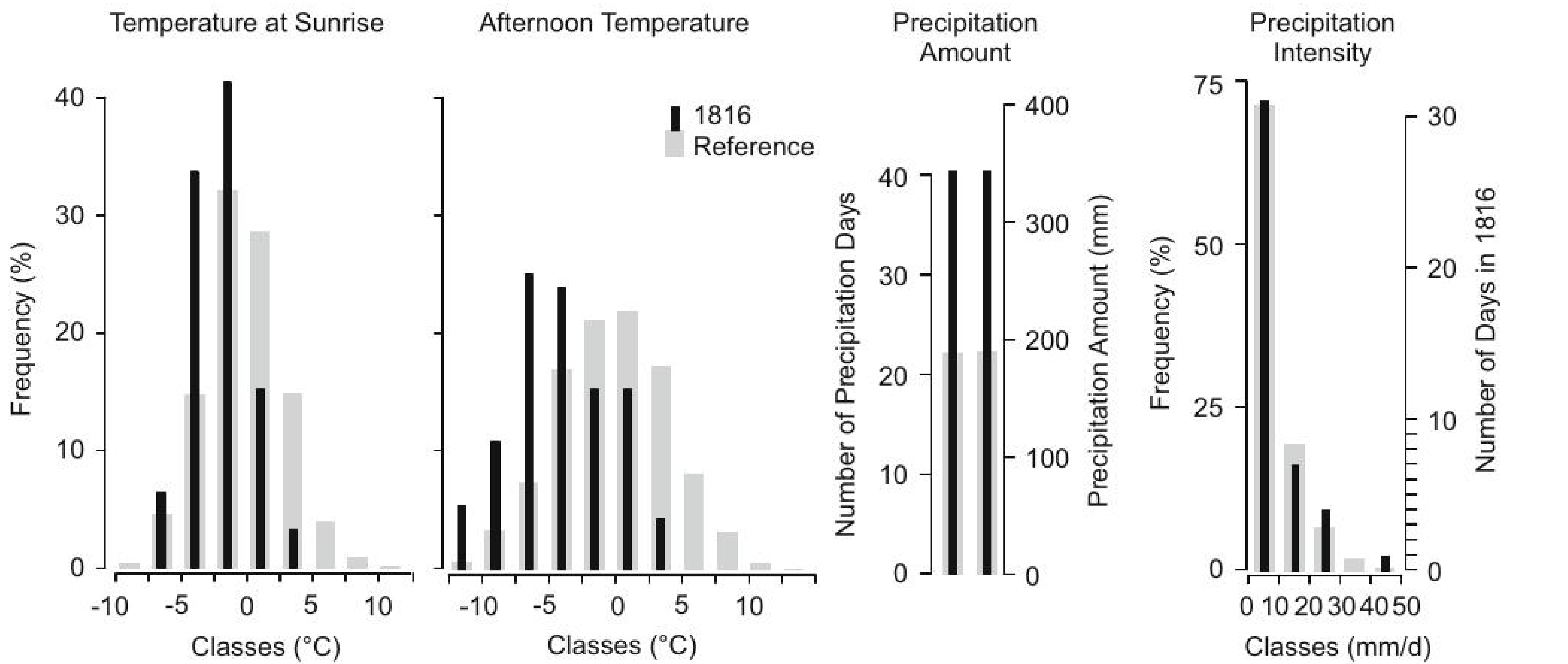


Fig. 4.25 Statistics of daily weather from Geneva from June to August 1816 relative to the reference period 1799–1821. (*left*) and (second from left) Histograms of temperature anomalies (with respect to the 1799–1821 mean seasonal cycle) at sunrise and 2 p.m. local time (second from *right*) Precipitation amount and frequency, and (*right*) intensity (precipitation on days with >0.1 mm of precipitation) (Auchmann et al. 2012)

Brönnimann 2015

Mary Shelley

Temperaturen und Niederschläge Rekonstruktionen

Mitteleuropa Sommer (Jun-Aug)

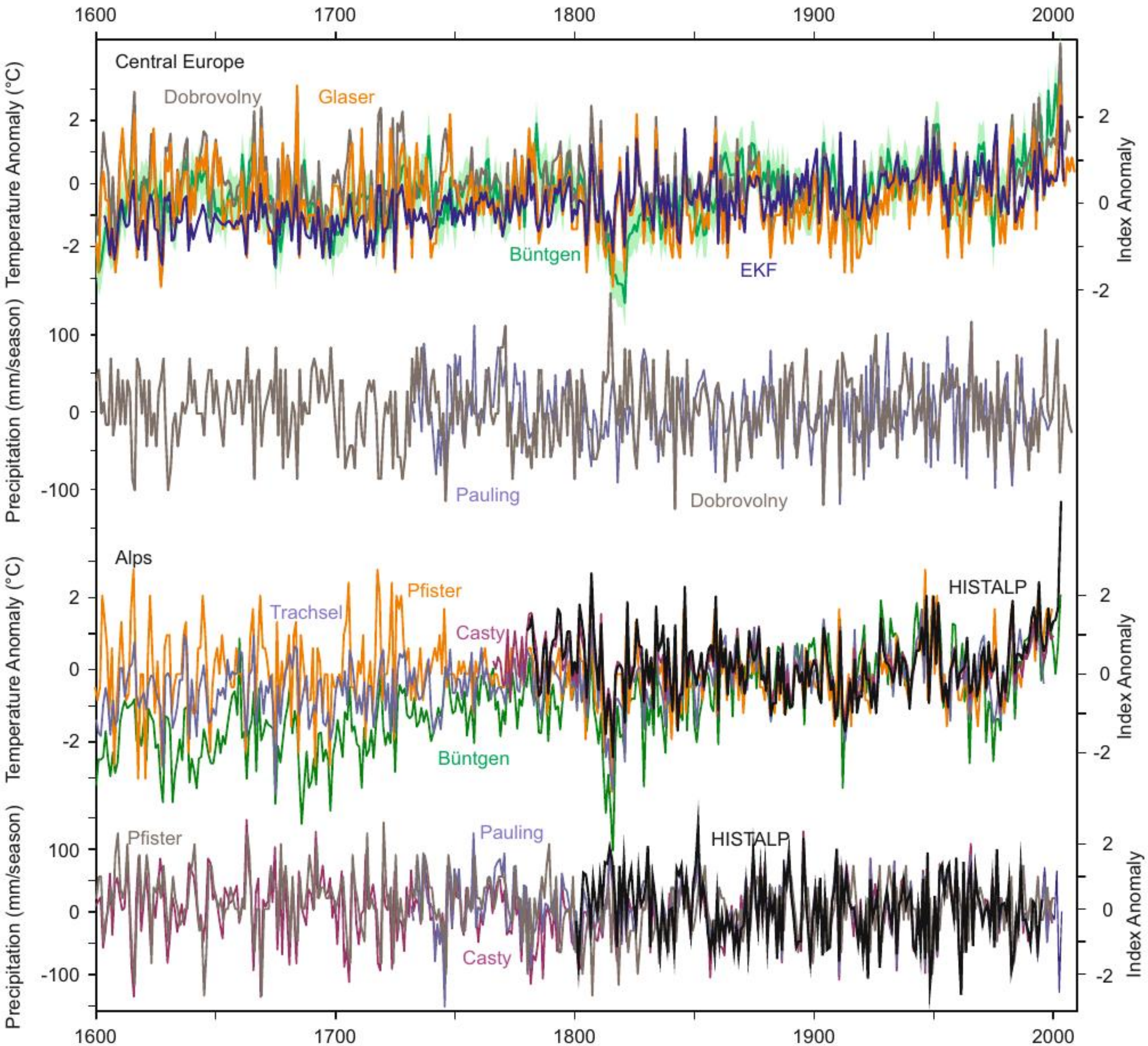
Temp.

Nieder-schläge

Alpen Sommer

Temp.

Nieder-schläge



Brönnimann 2015

Staubschleier

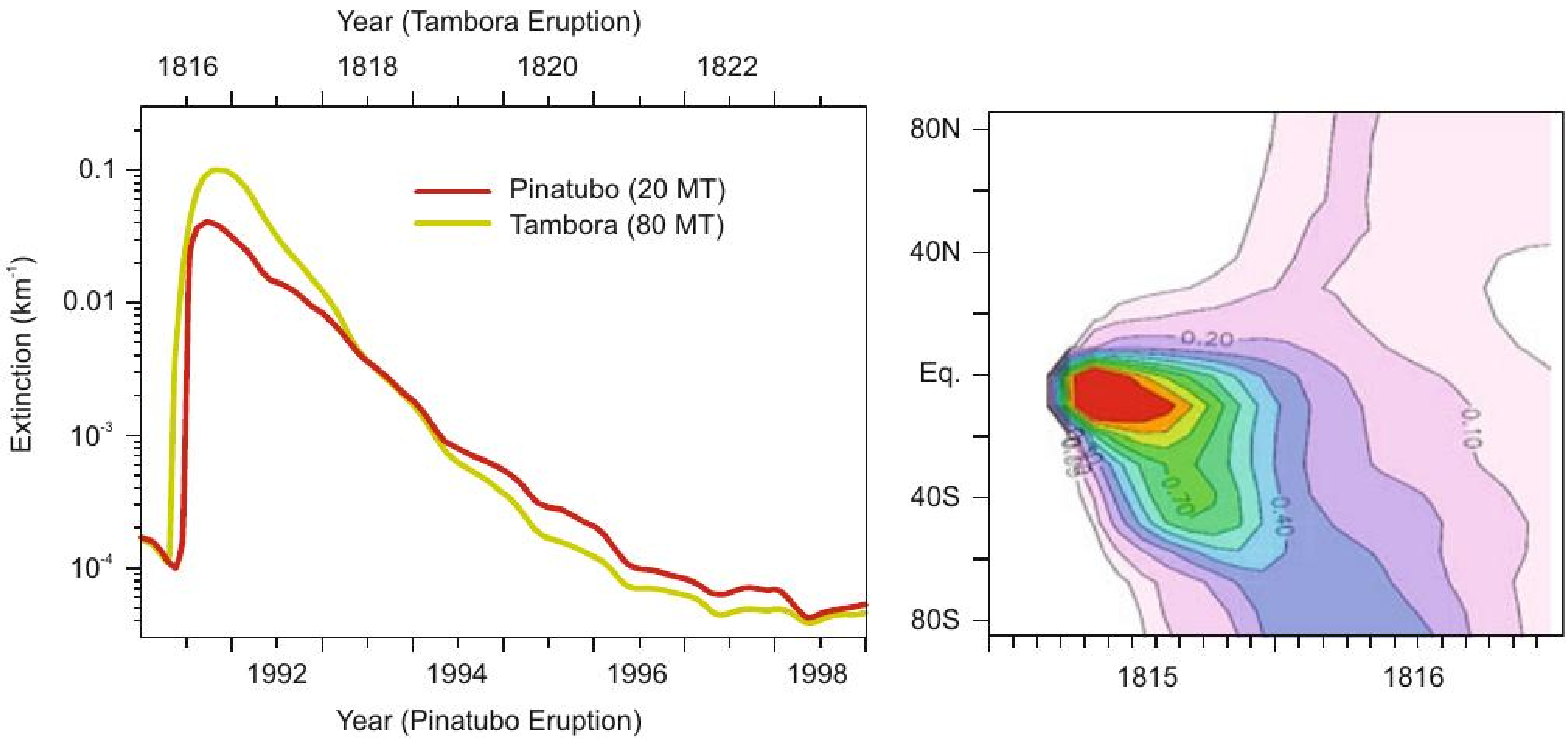
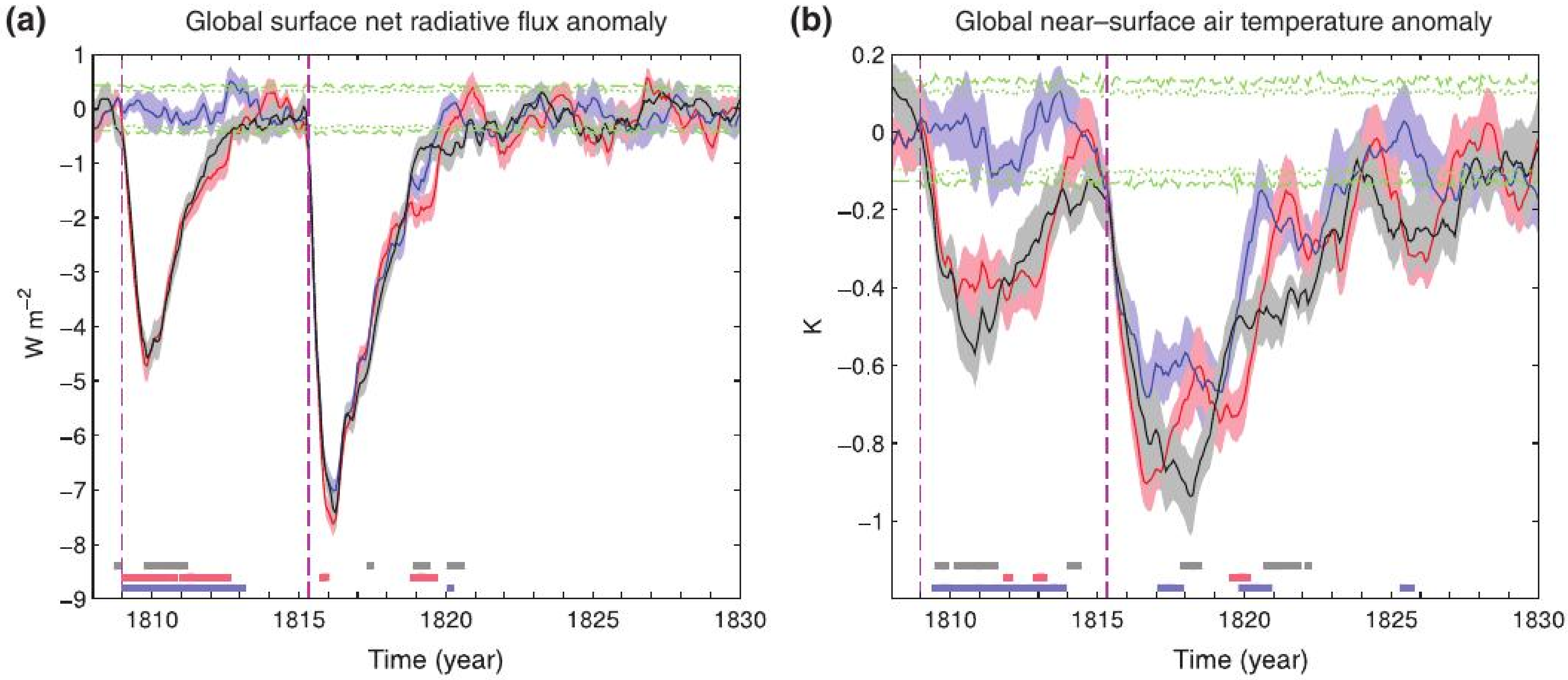


Fig. 4.28 (*left*) Aerosol extinction (1.02 μm) at 20-km altitude above the equator for the Tambora and Pinatubo eruptions. (*right*) Aerosol optical depth (500 nm) modelled for the Tambora eruption. These are obtained from a two-dimensional aerosols microphysics model, assuming a sulphur amount of 80 and 20 Mt for Tambora and Pinatubo, respectively (See Arfeuille et al. (2014) for details)

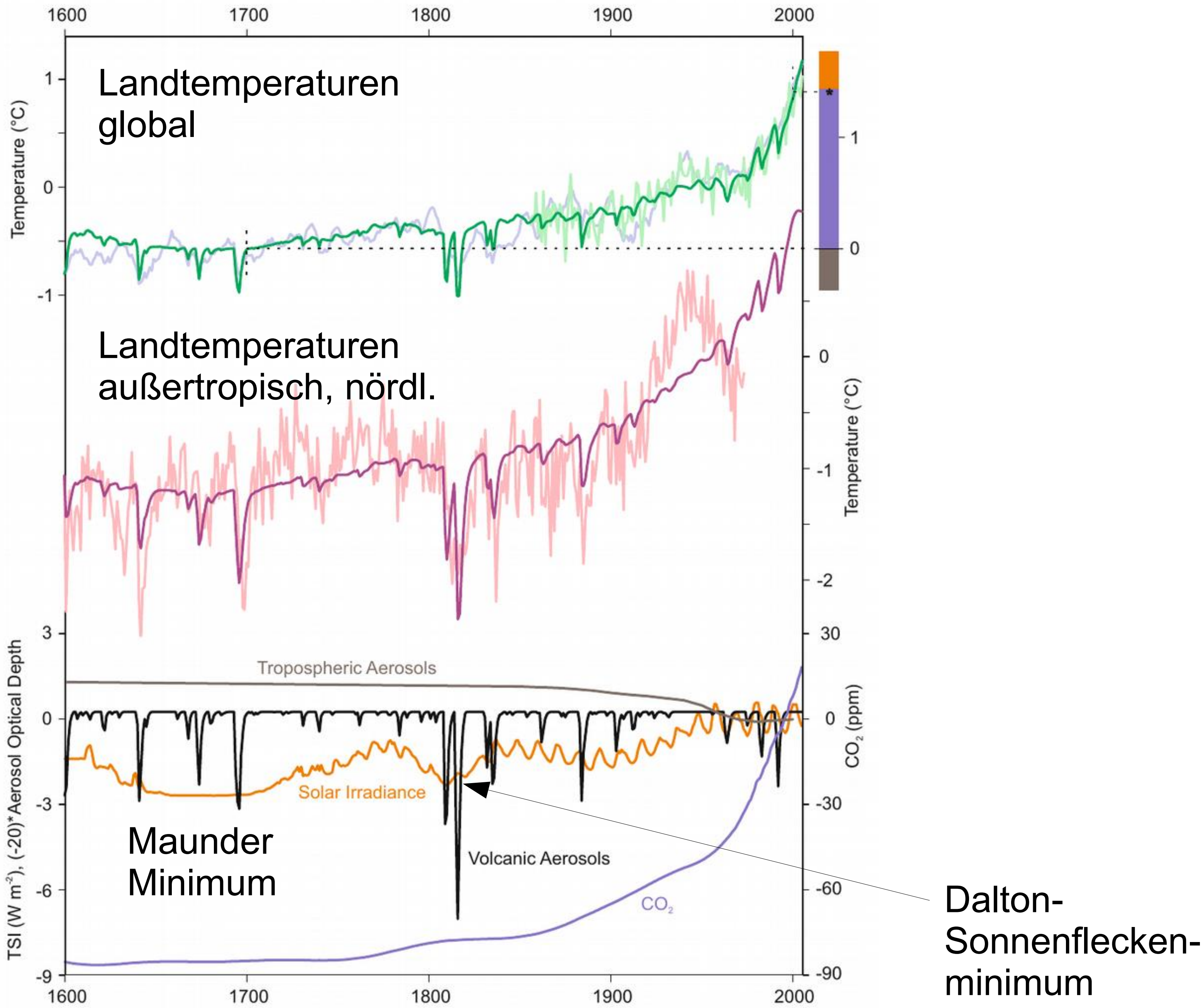
Brönnimann 2015

Abkühlung durch stratosphärische Aerosole



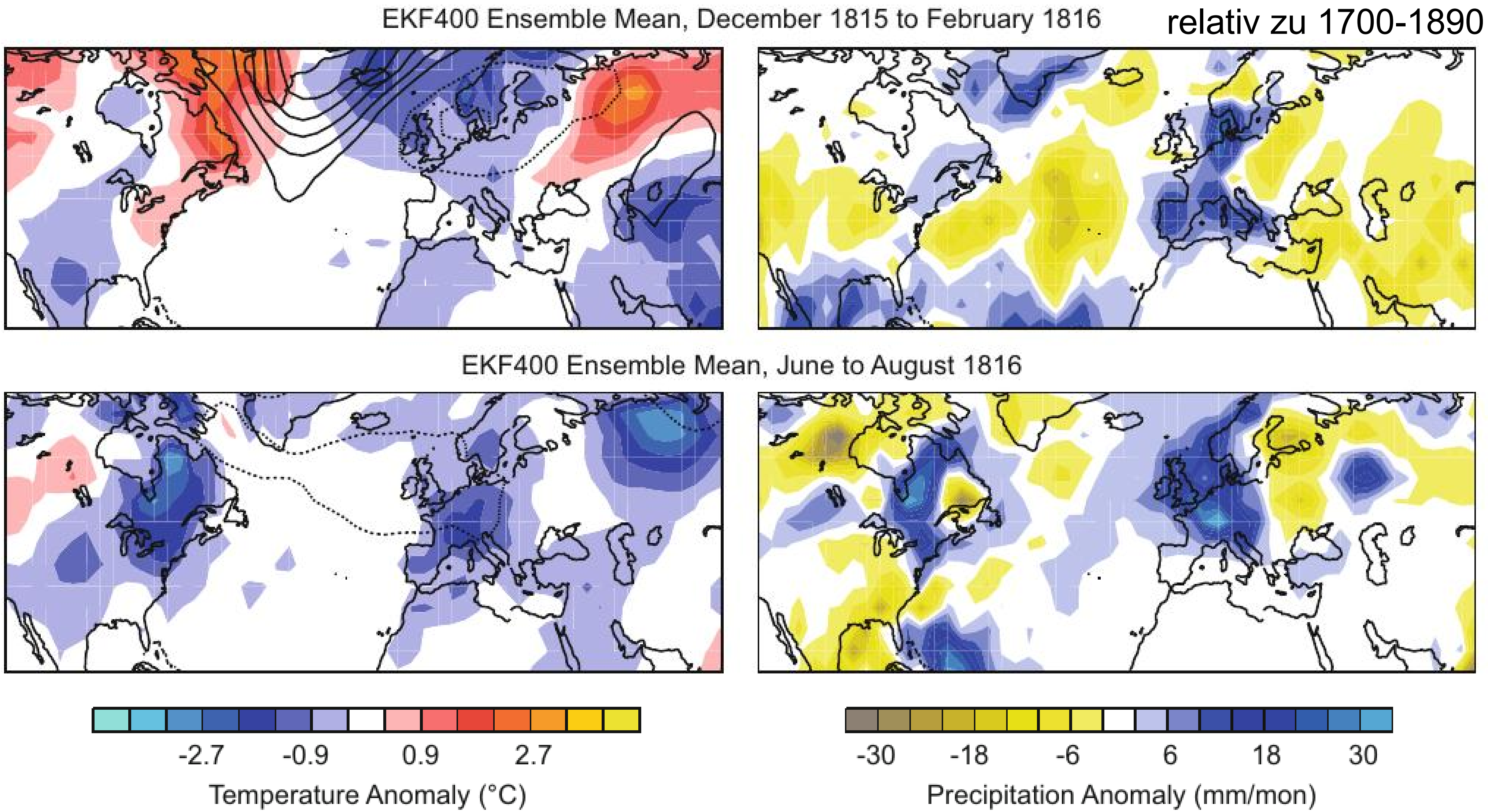
Raible et al., Tambora 1815 as a Test Case for High Impact Volcanic Eruptions: Earth System Effects. Wiley Interdisciplinary Reviews: Climate Change 7, Nr. 4 (1. Juli 2016): 569–89.

Klima und Strahlungsantrieb



Brönnimann 2015

Temperatur/Niederschlag
1816 relativ zu 1700-1899



Brönnimann 2015

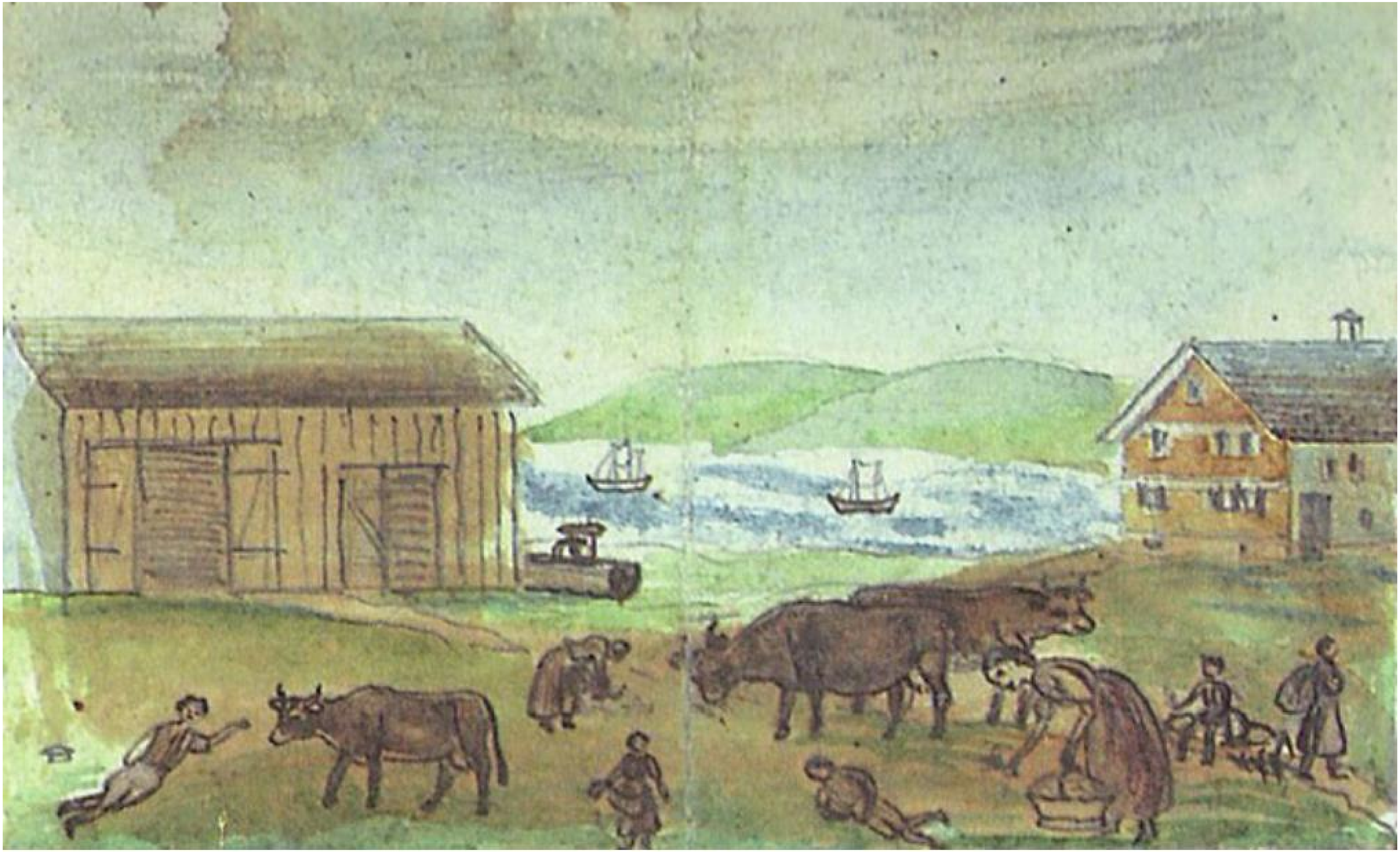
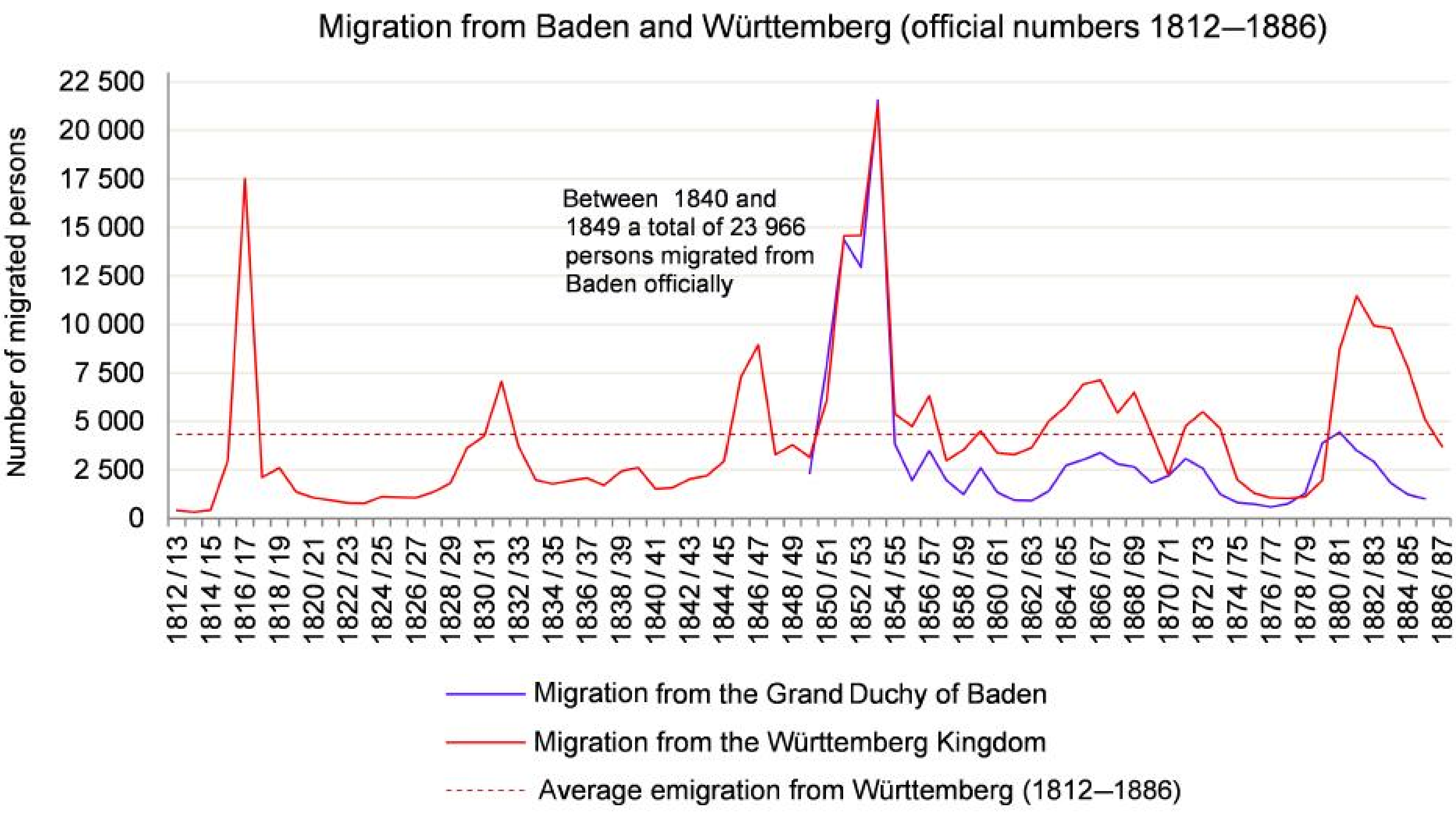


Fig. 4.24 Painting from Anna Barbara Giezendanner (1831–1905), showing people eating grass during famine in Switzerland

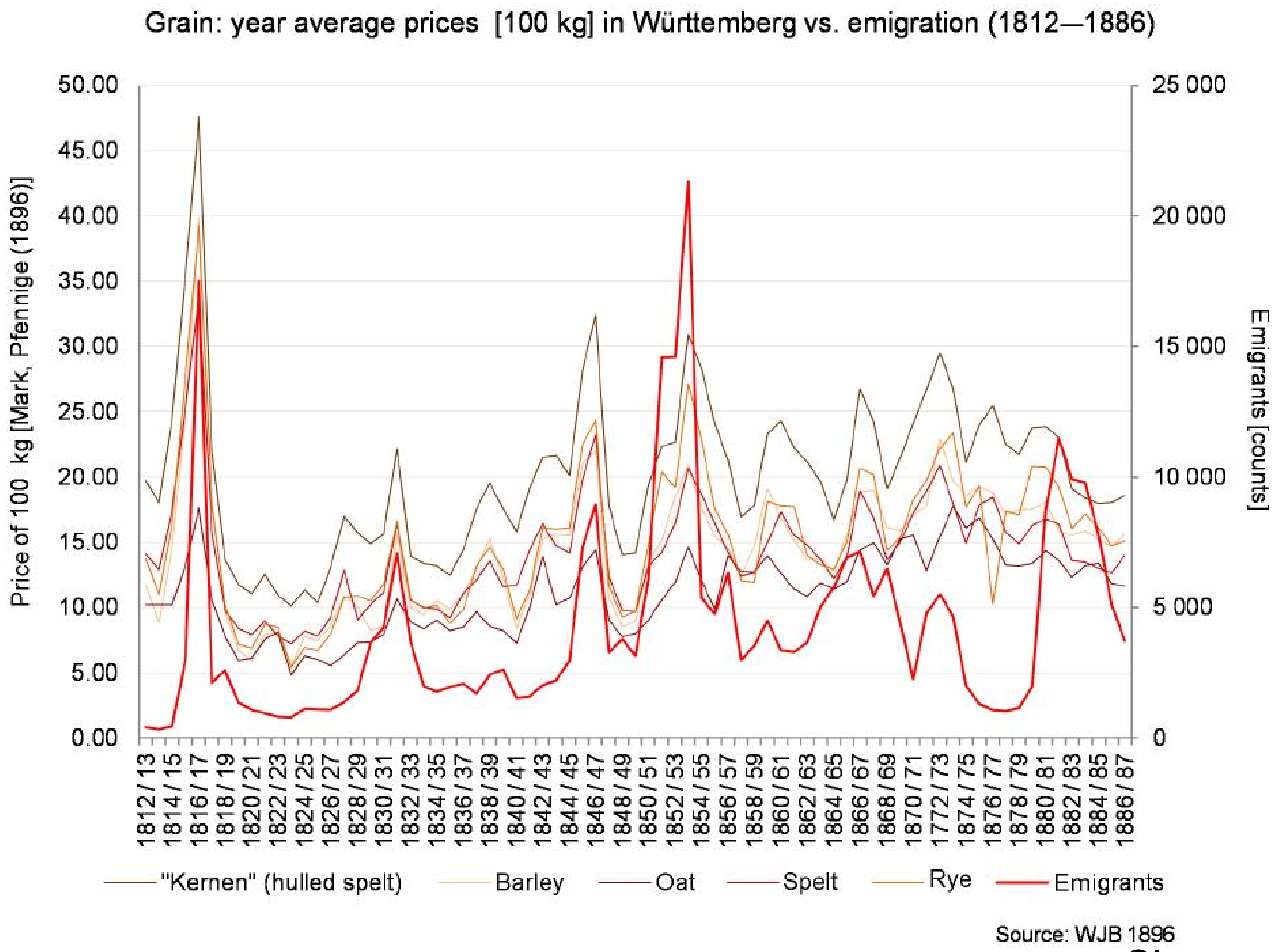
Brönnimann 2015

Auswanderung aus Baden und Württemberg



Glaser et al., Climate of Migration? Clim. Past, 13, 1573–1592, 2017

Getreidepreise und Auswanderung

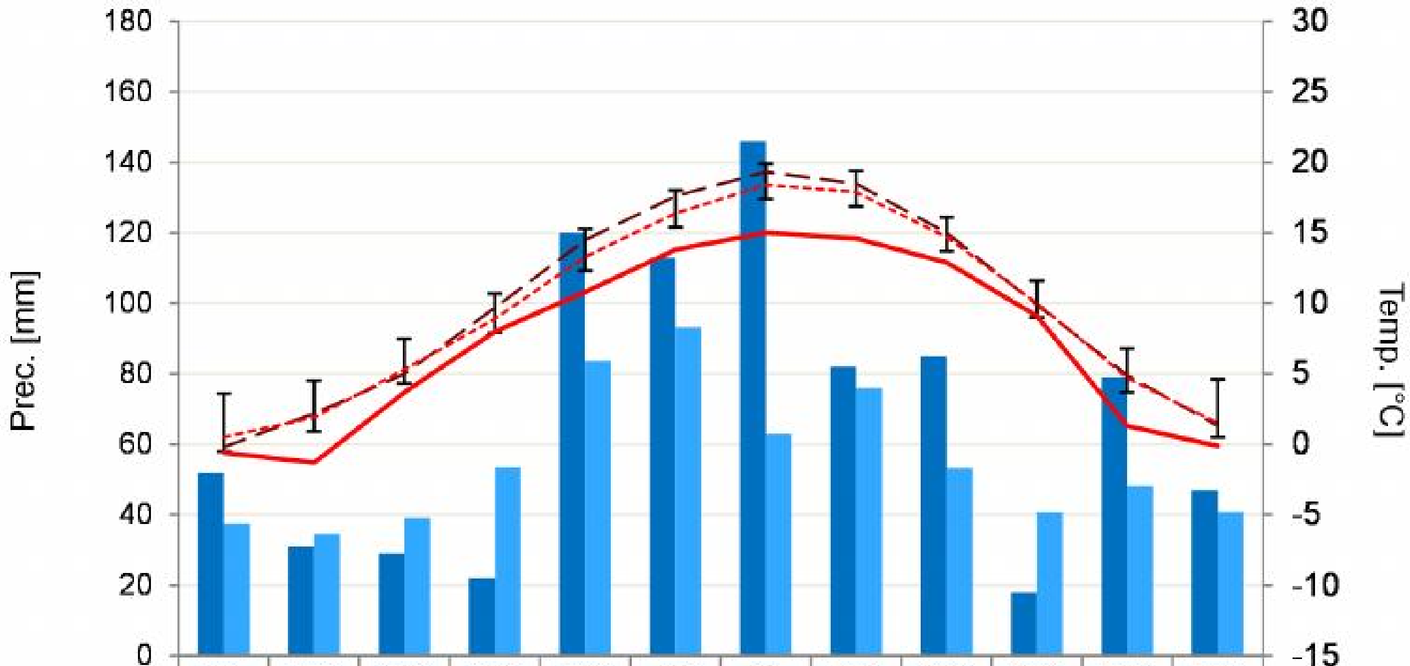


Glaser et al. 2017

Stuttgart, 1816

Kälteste Jahre in Stuttgart im 19. Jh:
1829: 7,83°C
1879: 8,09°C
1816: 8,10°C

Climate Stuttgart 1816 and CLINO period 1961–1990



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1816 prec. [mm]	52.0	31.0	29.0	22.0	120.0	113.0	146.0	82.0	85.0	18.0	79.0	47.0
1961–1990 prec. [mm]	37.5	34.6	39.2	53.6	83.6	93.2	63.0	76.0	53.3	40.6	48.2	40.7
1816 temp. [°C]	-0.6	-1.3	3.7	8.0	10.8	13.8	15.0	14.6	12.9	9.1	1.3	-0.1
Mean temp. [°C] 1804–1886)	-0.2	2.2	5.0	9.7	14.5	17.6	19.3	18.5	15.0	9.9	4.9	1.3
SD temp. [°C] (1804–1886)	3.1	2.6	2.2	1.8	2.0	1.6	1.5	1.5	1.4	1.6	2.1	3.1
1961–1990 temp. [°C]	0.5	1.9	5.3	8.9	13.3	16.4	18.4	17.9	14.7	10.0	4.7	1.5

Data sources: 1815–1817: temp (KNMI), prec. (CRU); 1804–1886: KNMI and WJB; 1961–1990 (DWD)

Glaser et al. 2017

Baden und Württemberg 1816

- Extreme Ernteausfälle durch Witterung
- Napoleonische Kriege: Maraudierende Truppen, fehlende politische Strukturen
- Große Teile der Flächen seit Jahren nicht bewirtschaftet; letzte volle Ernte 1812
- Politik reagiert viel zu spät:
  - Regulierung von Ein- und Ausfuhr ab November
  - Ankauf von Getreide aus dem Ausland ab Oktober
  - Eis auf Flüssen behindert Transport
  - Verschuldung der Gemeinden

Glaser et al. 2017

Hilfsvereine

- z.B. März 2017 Allgemeiner Wohltätigkeitsverein für das Großherzogtum Baden zur Bewältigung der Auswirkungen des Krieges und der Mißernte

Stéphanie de Beauharnais
Großherzogin von Baden

1816-17:
"Jahr ohne Sommer"

1829-33:
Schlechtwetter,
Ernteausfälle,
Spekulationen

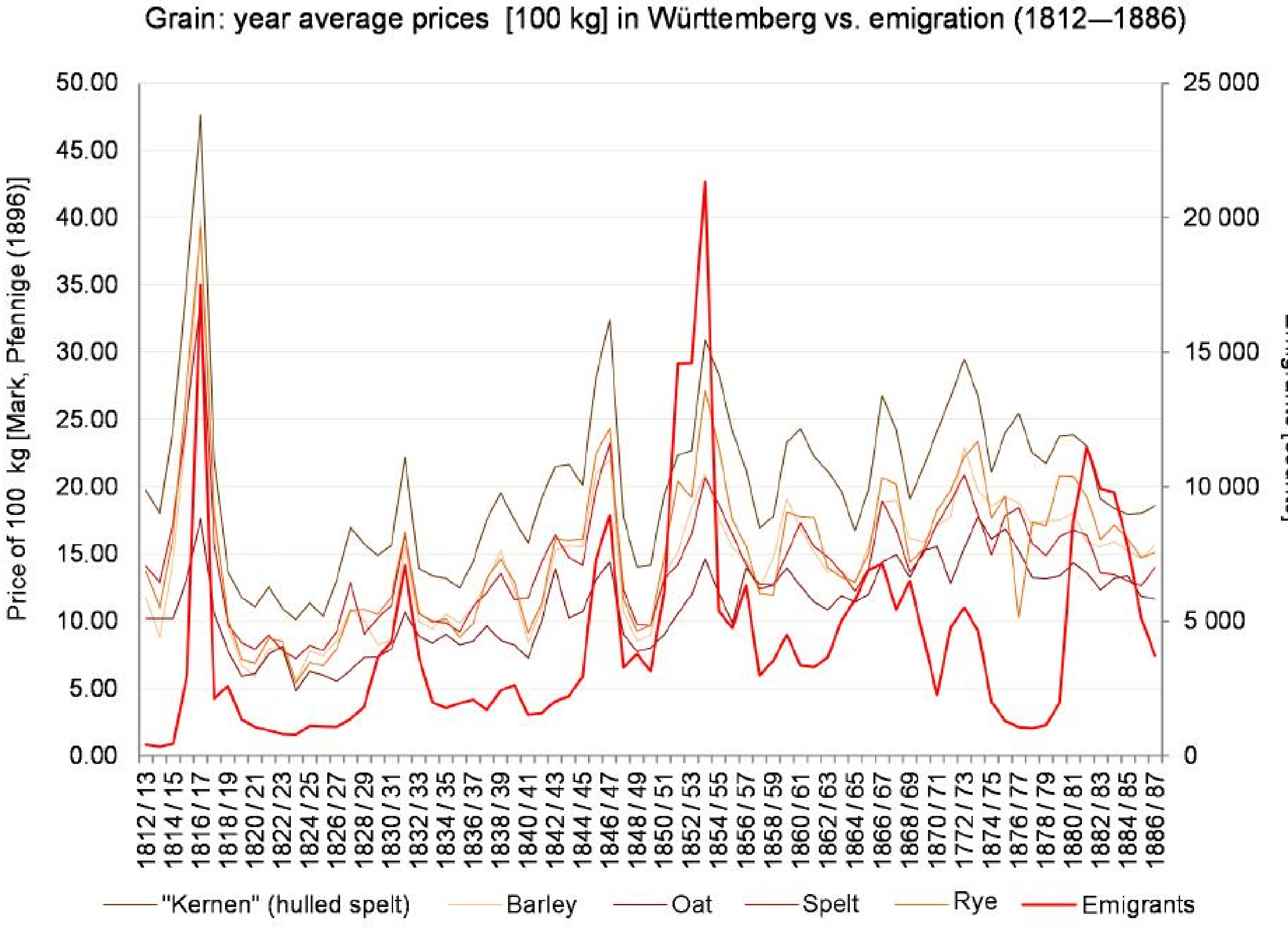
1845-48:
Heiße, trockene
Sommer,
Ernteausfälle,
Kartoffelfäule

1850-55:
Schlechte Ernten,
Krimkrieg (Frankreich
schafft Einfuhrzölle
ab), staatliche
Förderung der
Auswanderung

1863-69:
Warm, trocken

1880-86:
Attraktivität der
"Neuen Welt",
Familiennachzug

Auswanderung



Glaser et al. 2017

Tejedor et al., Rogation Ceremonies: Key to Understand Past Drought Variability in Northeastern Spain since 1650. Climate of the Past, 18. Juni 2018, 1–22.

Andenken auf Elba (Foto: Andrea Kamphuis 2018)

24. August 2018, 12:24 Uhr Napoleon

Entschied ein Vulkanausbruch die Schlacht von Waterloo?

Der Ausbruch des Tambora im Jahr 1815 tötete Zehntausende Menschen - und beeinflusste selbst im fernen Europa das Wetter. (Foto: AFP)

- Atmosphärenforscher vermuten einen Zusammenhang zwischen einem Vulkanausbruch in Indonesien und der Schlacht von Waterloo 1815.

Nachrichten + Themen Rubriken Lexikon Rezensionen Kooperationen

Geschichte+Archäologie

Waterloo-Schlacht: War ein Vulkan beteiligt?

29. August 2018

Düstere Regenwolken bildeten die Kulisse der Schlacht bei Waterloo. (Stich, 1891, benoitb/iStock)

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Electrostatic levitation of volcanic ash into the ionosphere and its abrupt effect on climate

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ABSTRACT

Large volcanic eruptions cause short-term climate change owing to the convective rise of fine ash and aerosols into the stratosphere. Volcanic plumes are, however, also associated with large net electrical charges that can also influence the dynamics of their ash particles. Here I show that electrostatic levitation of ash from plumes with a net charge is capable of injecting volcanic particles <500 nm in diameter into the ionosphere in large eruptions lasting more than a few hours. Measured disturbances in the ionosphere during eruptions, and the first discovery of polar mesospheric clouds after the A.D. 1883 Krakatau (Indonesia) eruption, are both consistent with levitation of ash into the mesosphere. Supervolcano eruptions are likely to inject significant quantities of charged ash into the ionosphere, resulting in disturbance or collapse of the global electrical circuit on time scales of 10^2 s. Because atmospheric electrical potential moderates cloud formation, large eruptions may have abrupt effects on climate through radiative forcing. Average air temperature and precipitation records from the 1883 eruption of Krakatau are consistent with a sudden effect on climate.

INTRODUCTION

Volcanic plumes are formed during explosive eruptions through convective rise of gas and tephra into the atmosphere, and can reach altitudes

that can produce non-thermal forces and affect the rise of charged ash particles.

Measurements of potential gradient anomalies in the ambient electric field associated with

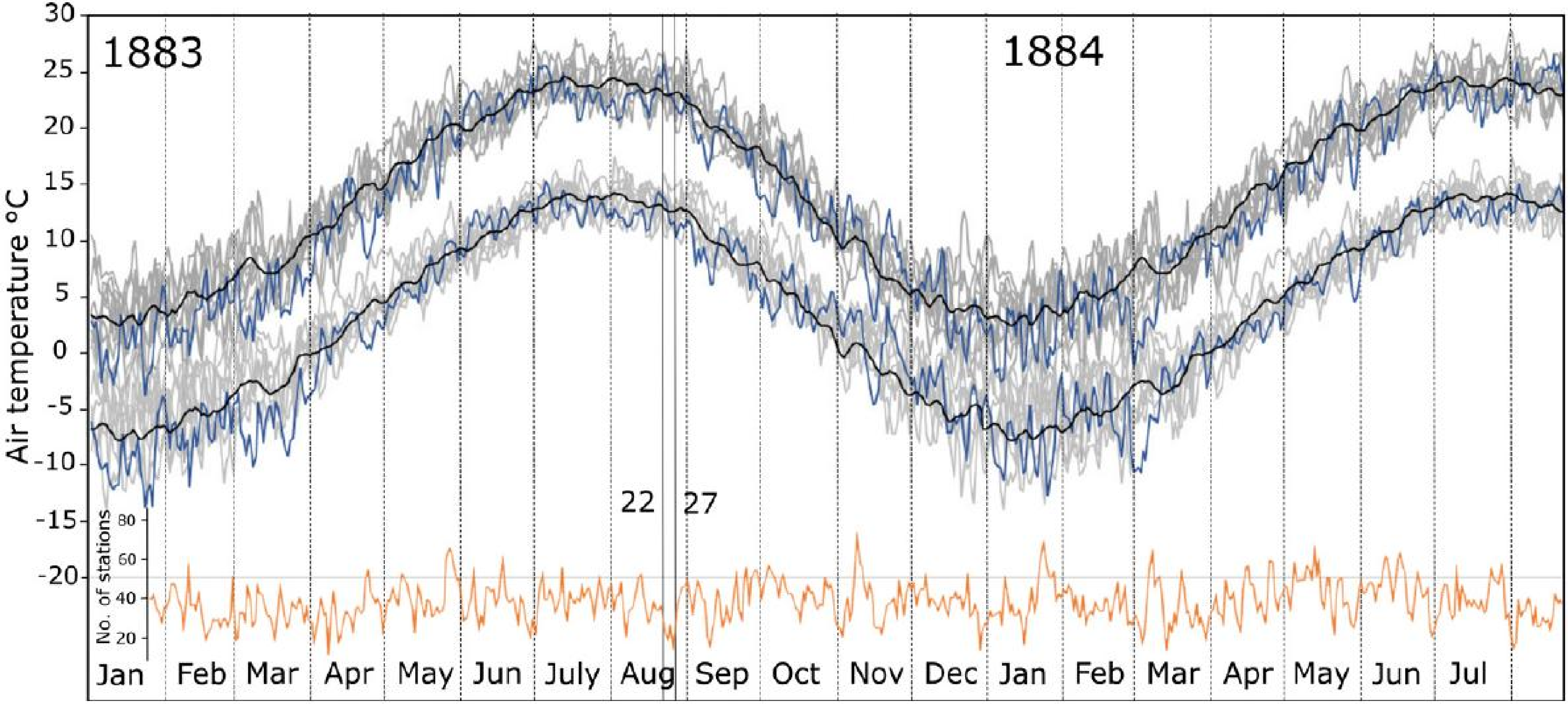
are, therefore, effective generators and separators of electrical charge.

ELECTROSTATIC LEVITATION

Electrostatic levitation is a process that causes lofting of charged particles within an electrical field and is important on atmosphere-less bodies such as the Moon (Colwell et al., 2009) and asteroids (Lee, 1996). Electrostatic interaction between charged volcanic ash particles and plumes having a net charge of the same polarity will unavoidably cause levitation of particles.

The migration of volcanic ash liberated from the upper regions of a large plume was evaluated using a model of particle motion under the influence of electrostatic forces and atmospheric gas drag (see the methods in the GSA Data Repository[1]). The cloud of liberated ash was assumed to be sufficiently tenuous that

Krakatau 1883
Kurzfristige Auswirkungen?



Genge 2018

Napoleon und der Vulkan

Few reliable weather data by which the effects of electrostatic levitation can be evaluated are available for the larger VEI 7 eruption of Tambora (Indonesia; Raible et al., 2016) in 1815. The months of May and June 1815, however, were notably wet in Europe (Wheeler and Demarée, 2006), following the end of the eruption in late April. The unseasonal weather in Europe, however, cannot be related to sulfate aerosols from the Tambora eruption, which did not reach the region until early 1816 (Clausen and Hammer, 1988), but it could be explained by suppression and subsequent recovery of cloud formation owing to levitation of volcanic ash. The wet weather in Europe has, furthermore, been noted by historians as a contributing factor in the defeat of Napoleon Bonaparte at the Battle of Waterloo (Wheeler and Demarée, 2006).

Genge 2018

Napoleon und der Vulkan vorläufige Einschätzung

- Möglicher, aber sehr spekulativer Mechanismus (elektrostatische Levitation von Staub stört Ionosphärenströme und damit das Wetter)
- Daten nur vom Krakatau (1883), nicht vom Tambora (1815)
- Effekt (bei Krakatau) noch nicht sehr überzeugend belegt
- Verbindung zu Waterloo wurde in den populären Artikeln überbetont; militärhistorische Faktoren dabei teils zu wenig gewürdigt.

Zusammenfassung: Tambora & Jahr ohne Sommer

- Ausbruch des Tambora 11 April 1815
  Vulkan-Explosivitäts-Index (VEI) 7
- ca 71.000 Todesopfer in Indonesien
  tödlichster dokumentierter Ausbruch
- Aerosole verbreiten sich weltweit in der Stratosphäre
- Kalter, regenreicher Sommer 1816 in Europa
- Letzte Subsistenzkrise Mitteleuropas
- Gesellschaftliche Folgen mit denen der Napoleonischen Kriege verwoben