

# CLIMATE, DISEASE, AND THE END OF ROME?

## NEW FINDINGS AND OLD DEBATES IN THE ENVIRONMENTAL HISTORY OF LATE ANTIQUITY

Moore Auditorium

6th of March 2019

from 18.15 to 20.15



**Johannes Preiser-Kapeller, Austrian Academy of Sciences**



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# CLIMATE, DISEASE, AND THE END OF ROME?

NEW FINDINGS AND OLD  
DEBATES IN THE  
ENVIRONMENTAL  
HISTORY OF LATE ANTIQUITY



## How does climate change affect civilisations?

The end of the Roman empire was **peppered** with floods, plagues, and earthquakes. But how crucial were these phenomena in the dissolution of the greatest single state the western world has ever known?

This lecture will explore this thrilling topic, discussing the ominous accounts of those who suffered these episodes and providing an overview of the main multidisciplinary methods and debates in the field.

Book your FREE tickets at Eventbrite <https://bit.ly/2HZDgO9>

Dr Johannes Preiser-Kapeller is Senior Researcher at the Austrian Academy of Sciences and member of the 'Climate Change and History Research Initiative' of Princeton University.

## Moore Auditorium

6th of March 2019  
from 18.15 to 20.15

CONNEC has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 757866

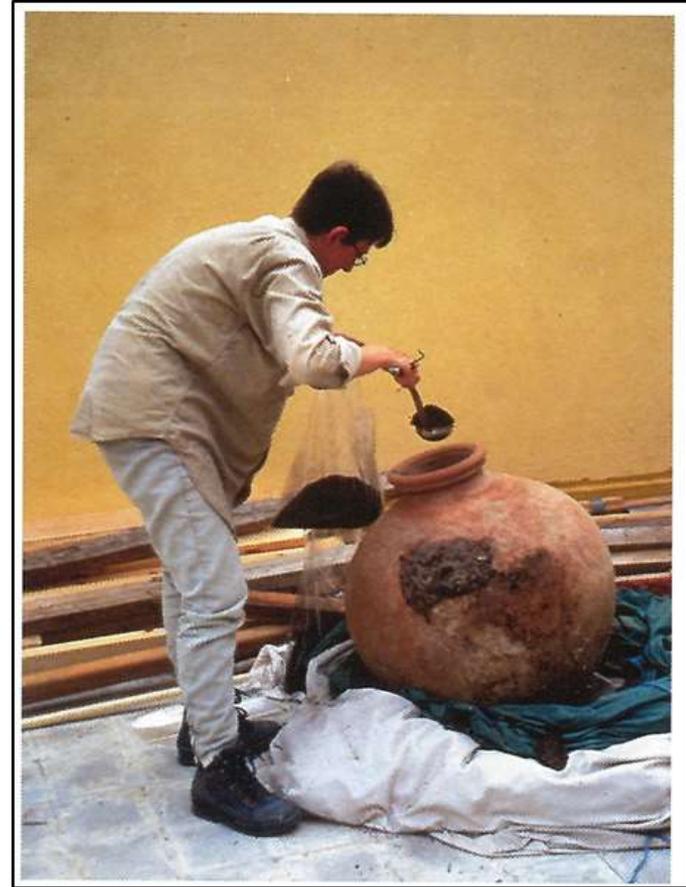


# Pepper –widely used, but rarely found (in archaeological evidence)

Apicius (ca. 400 CE): 478 recipes, 369 with pepper



Pepper pot from the Hoxne Hoard  
(England, 5th cent. CE)

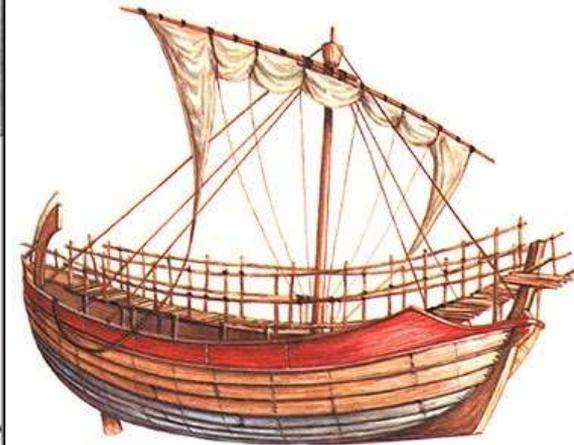
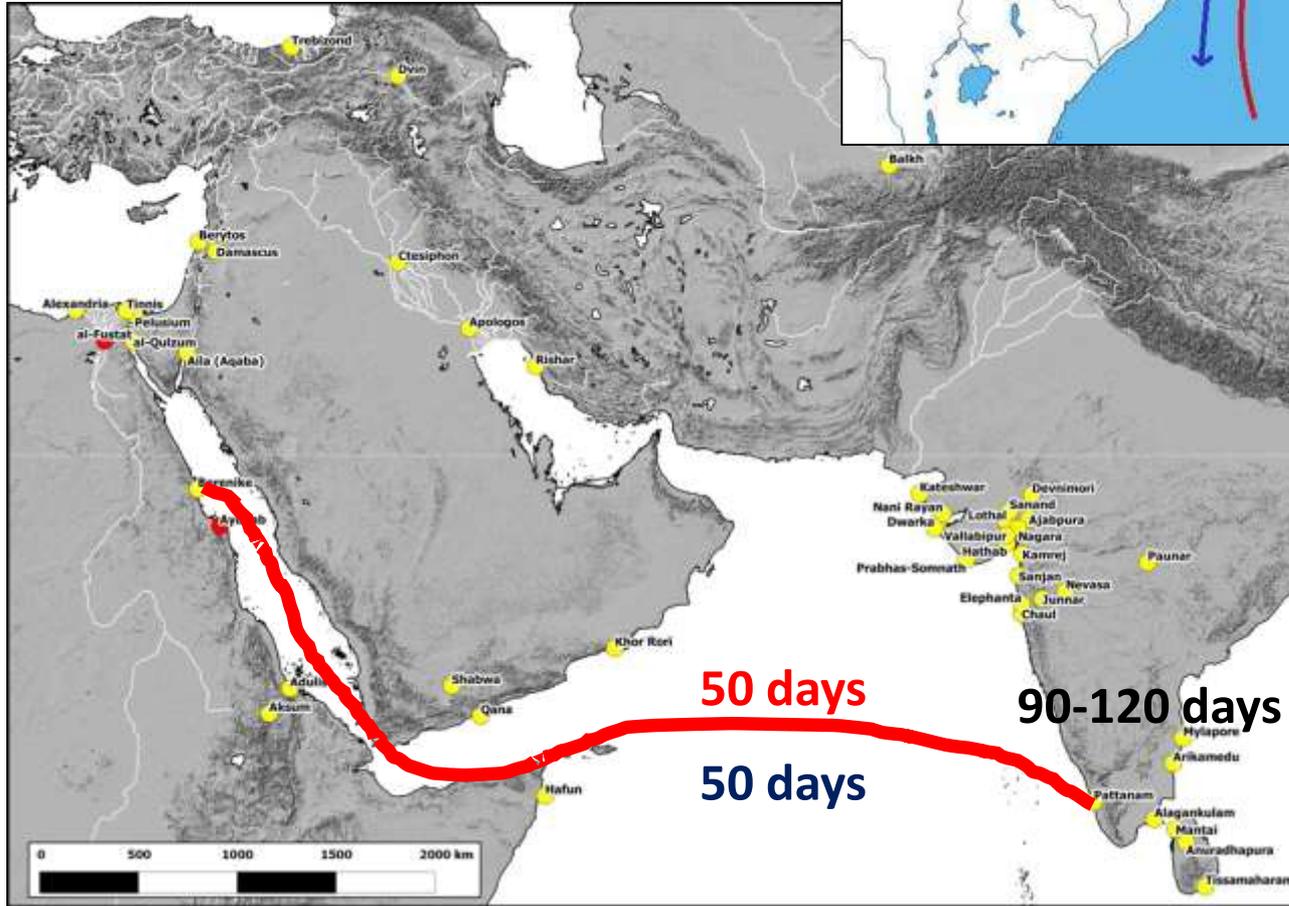
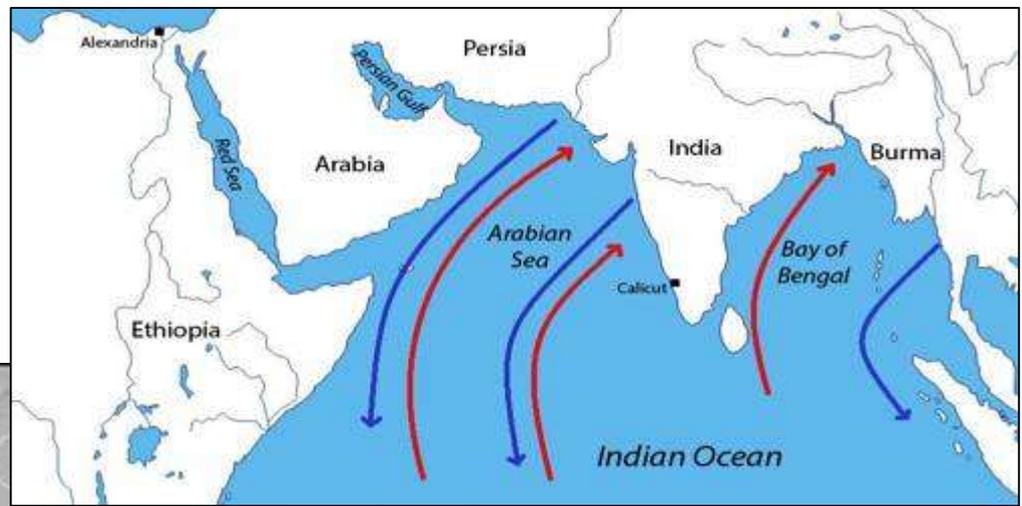


Dolium with 7.5 kg pepper,  
Port of Berenike in Egypt

A ship coming from Muziris with a very valuable cargo (138 t pepper, 60 boxes of nard)  
(ÖNB, P. Vindob. Graec. 40822, SB XVIII 13167)



# Through the Monsoon...



# Archaeological evidence: garnet from India via Byzantium to Merovingian graves, 5th-7th cent. CE

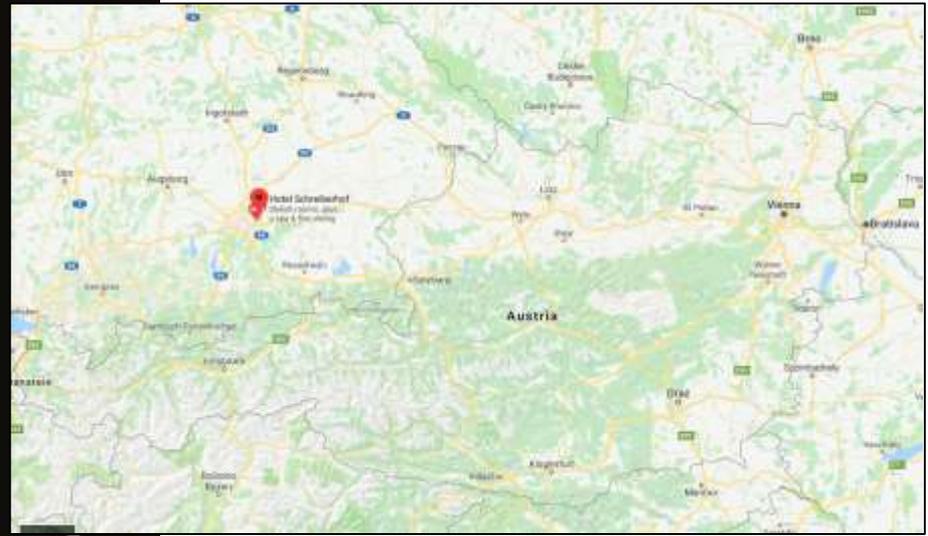


Warrior of Planig (Rheinland-Pfalz), early 6th cent. CE

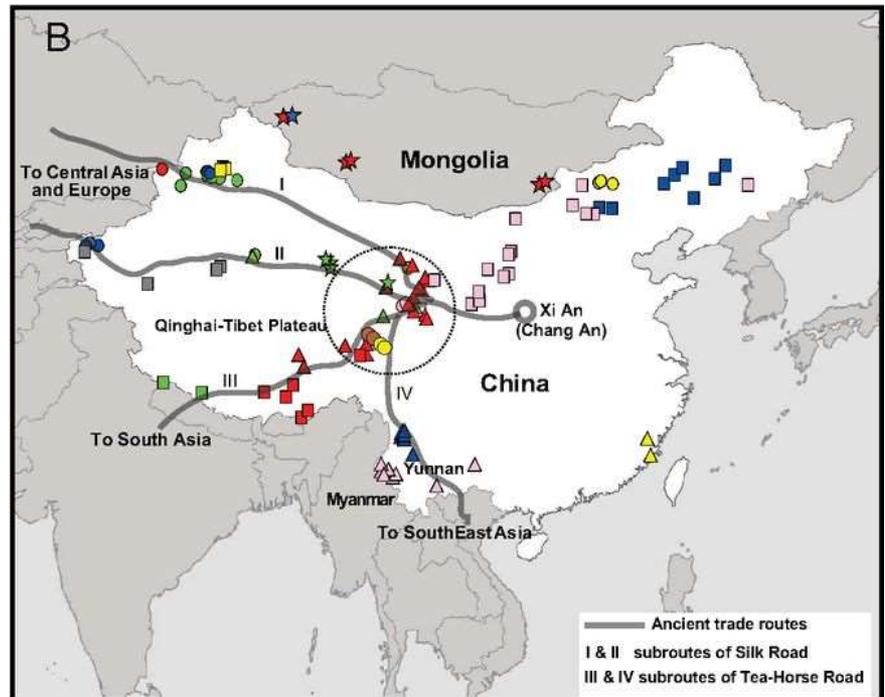
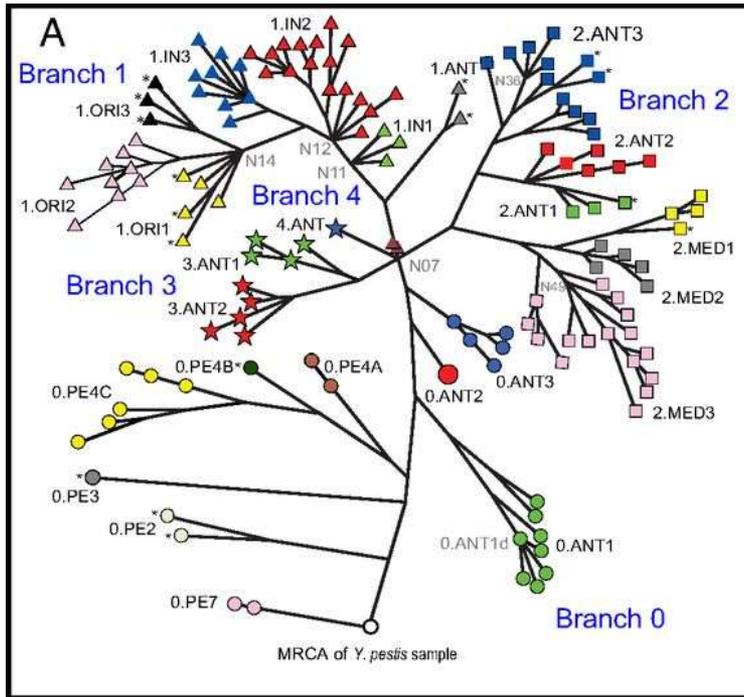


Pieces with garnet from India

# The burial ground of Aschheim in Germany: Coral and cowrie shells from the Red Sea, plague bacteria in the bones and teeth



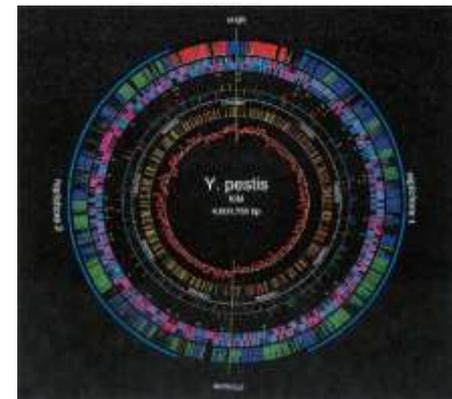
# Palaeogenetic tests shows where the bacterium came from



- Branch 0**
- 0.ANT1 ● 0.ANT2
  - 0.ANT3 ○ 0.PE2
  - 0.PE3 ● 0.PE4A
  - 0.PE4B ● 0.PE4C
  - 0.PE7

- Branch 1**
- ▲ 1.IN1 ▲ 1.IN2
  - ▲ 1.IN3 ▲ 1.ANT
  - ▲ 1.ORI1 ▲ 1.ORI2
  - ▲ 1.ORI3 ▲ Ancient genomes

- Branch 2**
- 2.ANT1 ■ 2.ANT2
  - 2.ANT3 ■ 2.MED1
  - 2.MED2 ■ 2.MED3



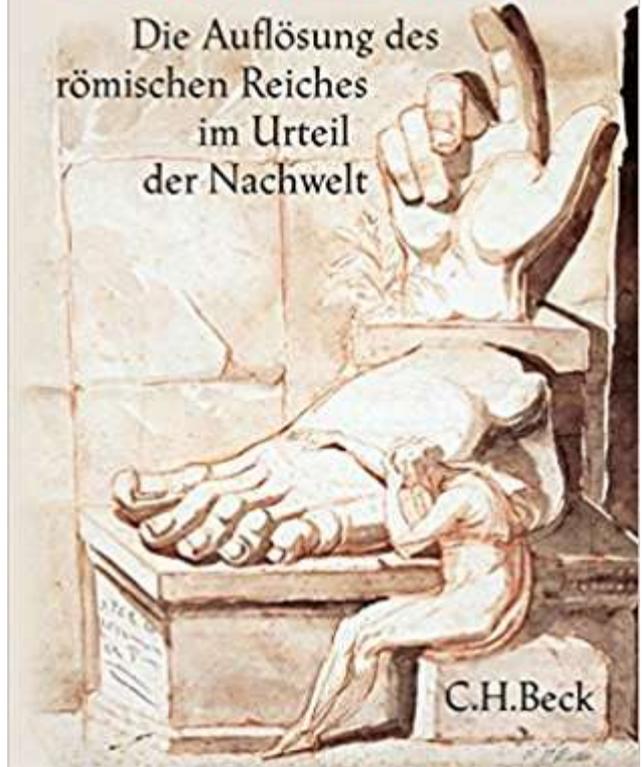
# The Fall of Rome, climate and disease – an old debate

*Für den Niedergang des Römerreiches sind bisher die folgenden 210 im Register nachgewiesenen Faktoren herangezogen worden:*

Aberglaube, Absolutismus, Ackersklaverei, Agrarfrage, Akeidia, Anarchie, Antgermanismus, Apathie, Arbeitskräftemangel, Arbeitsteilung, Aristokratie, Askese, Ausbeutung, negative Auslese, Ausrottung der Besten, Autoritätsverlust, Badewesen, Bankrott, Barbarisierung, Vernichtung des Bauernstandes, Berufsarmee, Berufsbindung, Besitzunterschiede, Bevölkerungsdruck, Bleivergiftung, Blutvergiftung, Blutzersetzung, Bodenerosion, Bodenschöpfung, Versiegen der Bodenschätze, Bodensperre, Bolschewisation, Bürgerkrieg, Bürgerrechtsverleihung, Bürokratie, Byzantinismus, capillarité sociale, Charakterlosigkeit, Christentum, Coovenienzheiraten, Degeneration des Intellekts, Demoralisierung, Despotismus, Dezentralisation, Disziplinlosigkeit des Heeres, Duckmäuserei, soziale Egalisierung, Egoismus, Energieschwund, Entartung, Entgötterung, Entoersung, Entordnung, Entpolitisierung, Entrechtung, Entromanisierung, Entvölkerung, Entvolkung, Entwaldung, Erdbeben, Erstarrung, unzureichendes Erziehungswesen, Etatismus, Expansion, Faulheit, Feinschmeckerei, Feudalisierung, Fiskalismus, Frauenemanzipation, Freiheit im Übermaß, Freilassungen von Sklaven, Friedensromantik, Frühreife, Führungsschwäche, Geldgier, Geldknappheit, Geldwirtschaft, Genußsucht, Germanenangriffe, Gift, Gladiatorenwesen, Glaubenskämpfe, Gleichberechtigung, Goldabfluß, Gräusierung, Großgrundbesitz, Halbbildung, Verlagerung der Handelswege, Hauptstadtwechsel, Hedonismus, Homosexualität, Hünensturm, Hybris, Hyperthermia, moralischer Idealismus, Imperialismus, Impotenz, Individualismus, Indoktrination, Inflation, Instinktverlust, Integrationsschwäche, Intellektualismus, Irrationalismus, Irregularität, Kapitalismus, Ka-

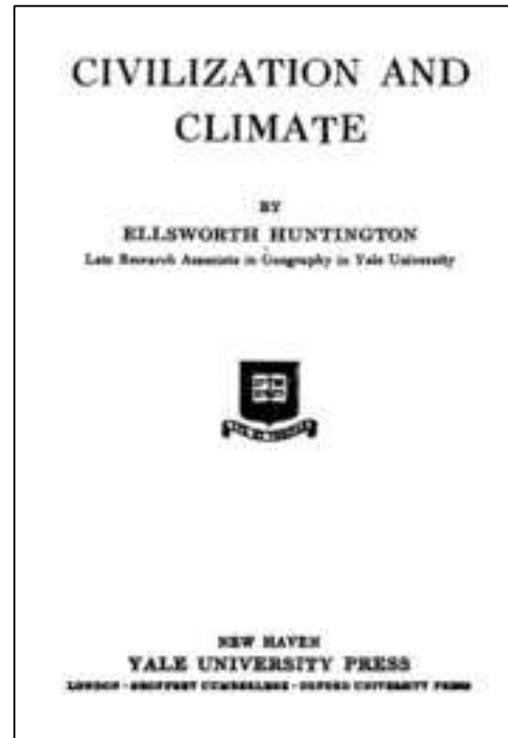
stenwesen, Ketzerei, Kinderlosigkeit, Klimaver-schlechterung, Kommunismus, Konservatismus, Korruption, Kosmopolitismus, Kulturneurose, Lebensangst, Lebensüberdruß, Legitimitätskrise, Lethargie, Luxus, fehlende Männerwürde, Malaria, moralischer Materialismus, Militarismus, Ruin des Mittelstandes, Mysterienreligionen, Nationalismus der Unterworfenen, Nichternst, kulturelle Nivellierung, Orientalisierung, panem et circenses, Parasitismus, Partikularismus, Patrozinienvogelzug, Pauperismus, Pazifismus, Plutokratie, Polytheismus, Proletarisierung, Prostitution, Psychosen, Quecksilberschäden, Rassen-diskriminierung, Rassenentartung, Rassen-selbstmord, Rationalismus, Regenmangel, Reichsteilung, Angriffe der Reiternomaden, Rekrutenmangel, Rentsvergessenheit, Resignation, Rhetorik, naturwissenschaftliche Rückständigkeit, Ruhmsucht, Seelenbarbarei, Selbstgefälligkeit, Semitisierung, Seuchen, Sexualität, Sinnlichkeit, Sittenverfall, Sklaverei, Slawenangriffe, Söldnerwesen, Schamlosigkeit, Schlemmerei, Schollenbindung, Staatsegoismus, Staatssozialismus, Staatsverdrossenheit, Niedergang der Städte, Stagnation, Steuerdruck, Stoizismus, Streß, Strukturschwäche, Terrorismus, fehlende Thronfolgeordnung, Totalitarismus, Traurigkeit, Trosthauskultur, Überalterung, Überfeinerung, Überfremdung, Übergröße, Überkultur, Überzivilisation, Umweltzerstörung, Unglücks-karte, unnütze Esser, Unterentwicklung, Verarmung, Verbastardung, Verkankung, Vermassung, Verödung, Verpöbelung, Verrat, Verstärkung, unkluge Vorfelddpolitik, Wehrdienstverweigerung, Wehrlosmachung, Weltflucht, Welt-herrschaft, Willenslähmung, Wohlstand, Zentralismus, Zölibat, Zweifrontenkrieg,

Alexander Demandt  
**DER FALL ROMS**  
Die Auflösung des  
römischen Reiches  
im Urteil  
der Nachwelt



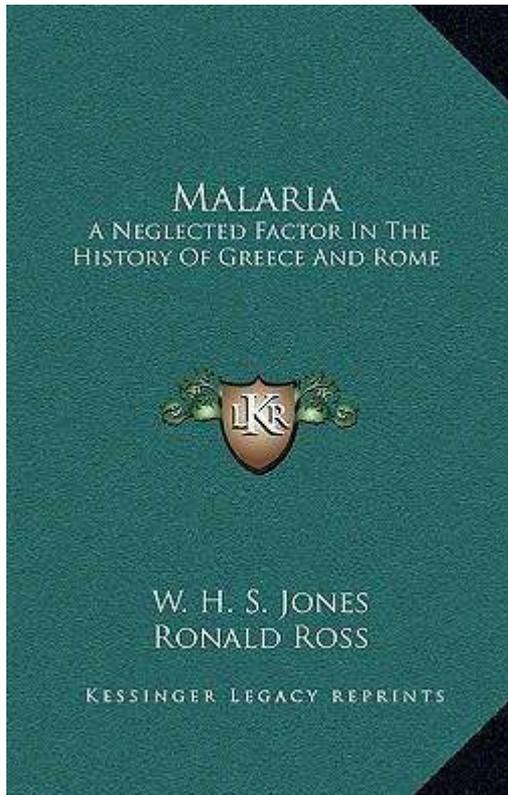
2nd edition, 2014

Ellsworth Huntington, 1915/1917: „many of the great nations of antiquity had risen or fallen in harmony with favorable or unfavorable conditions of climate“

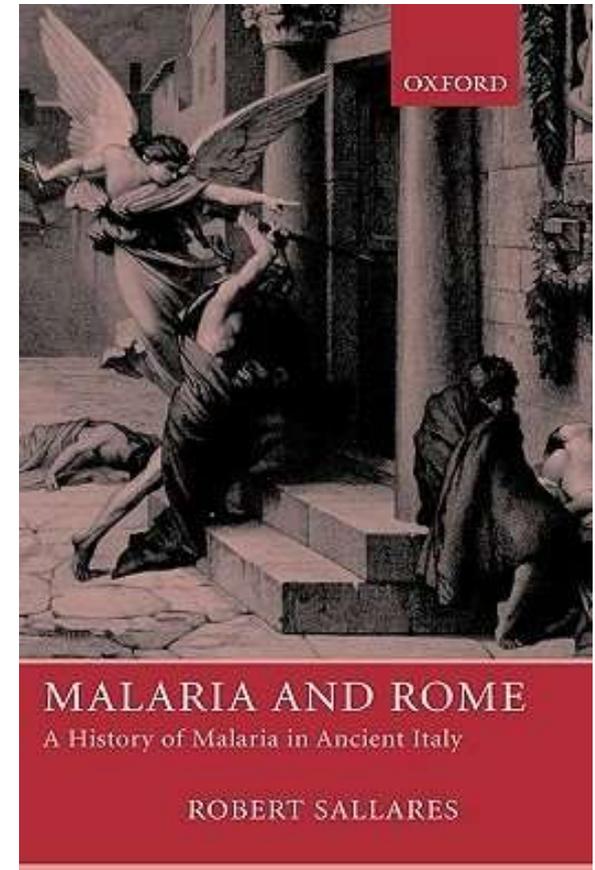


Ellsworth Huntington (1876-1947)

# William Henry Samuel Jones (1876–1963) and Malaria, 1907



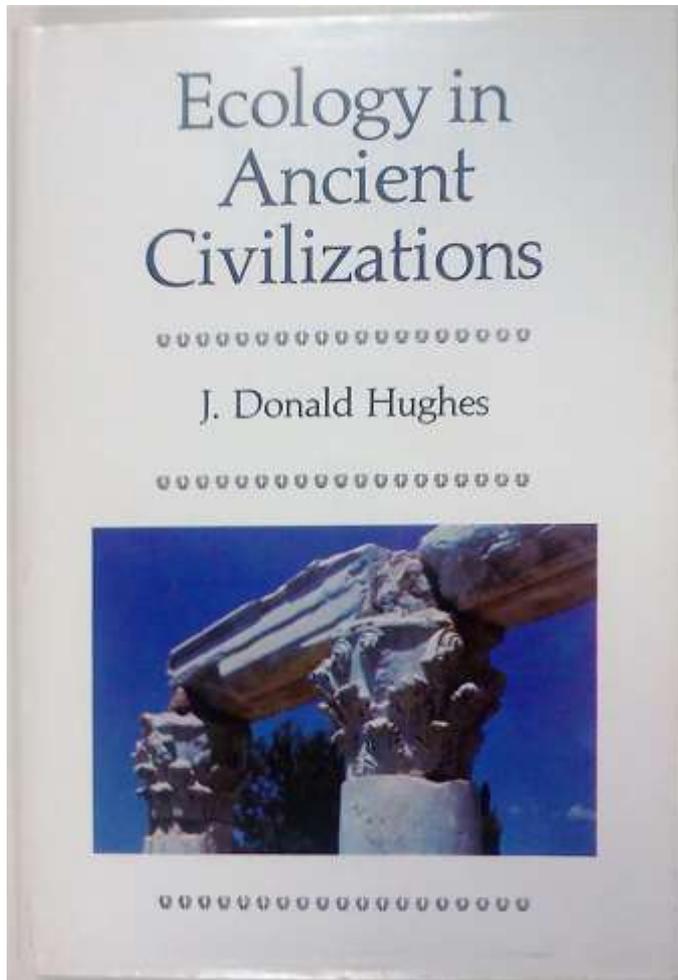
*„It is not pretended, that malaria was the sole cause, but it is certain, that the disease gave full scope to other disintegrating factors. (...) Malaria made the Greek weak and inefficient; it turned the sterner Roman into a bloodthirsty brute.“ (p. 85)*



2002

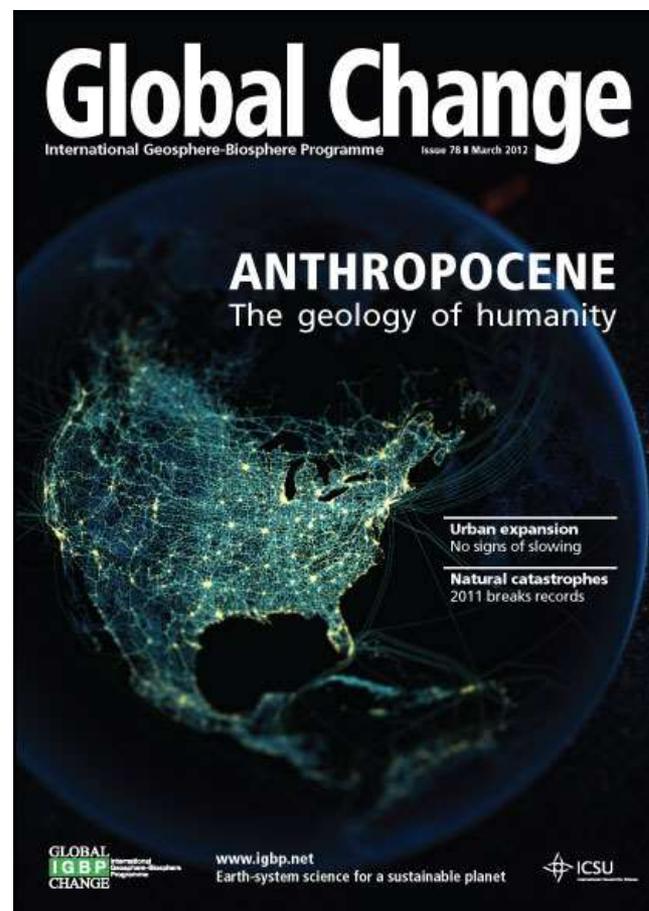
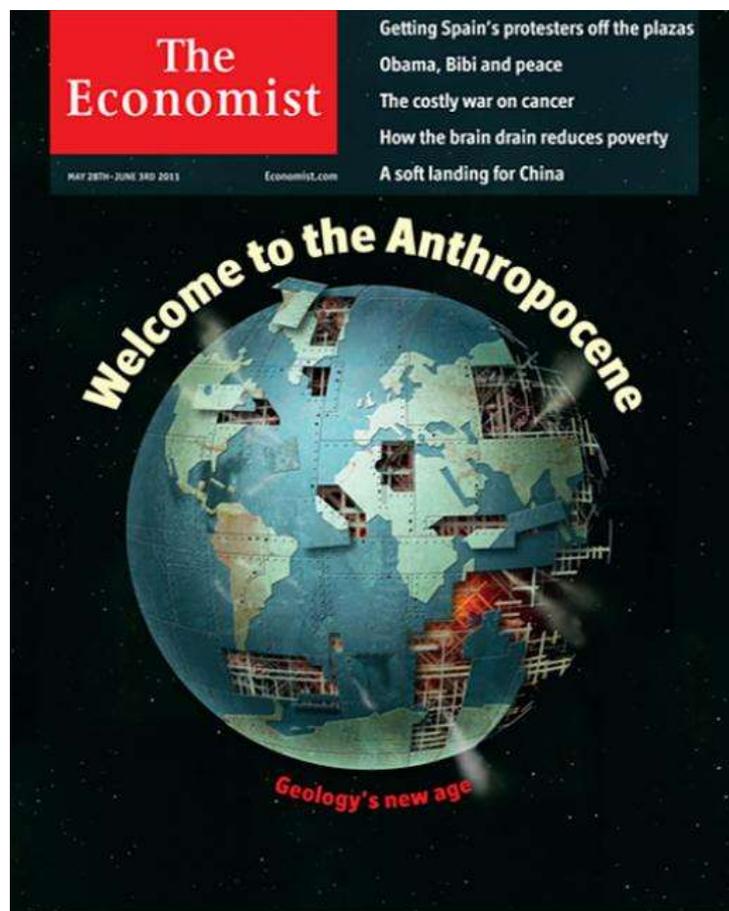
J. Donald Hughes (1933-2019), 1975:

*„An environmentalist movement did not exist in Rome“*

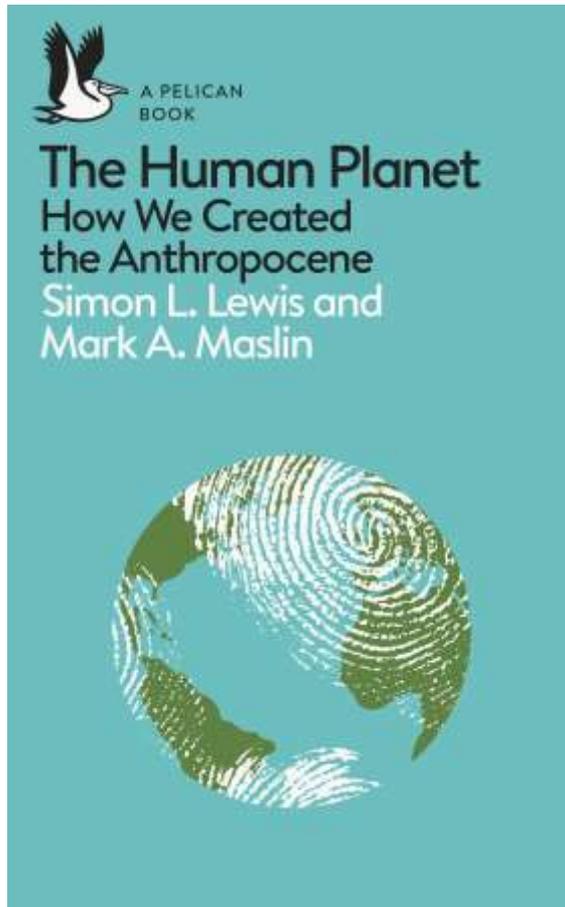


*„The Romans’ failure to adapt their society and economy to the natural environment in harmonious ways is one of the causes of the decline and fall of the Roman Empire, if not in fact the basic and underlying one.“*  
(p. 128)

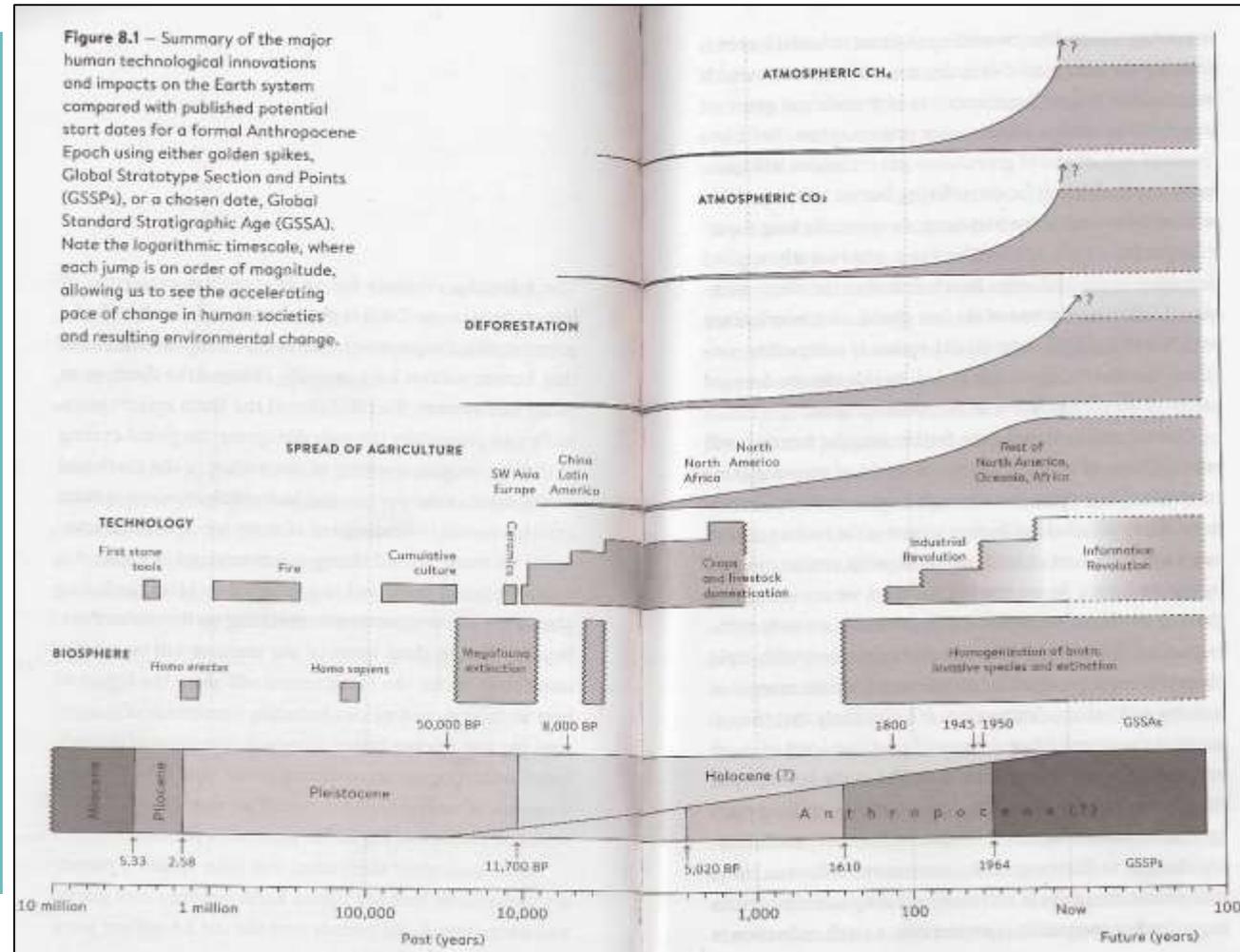
# Welcome to the Anthropocene?



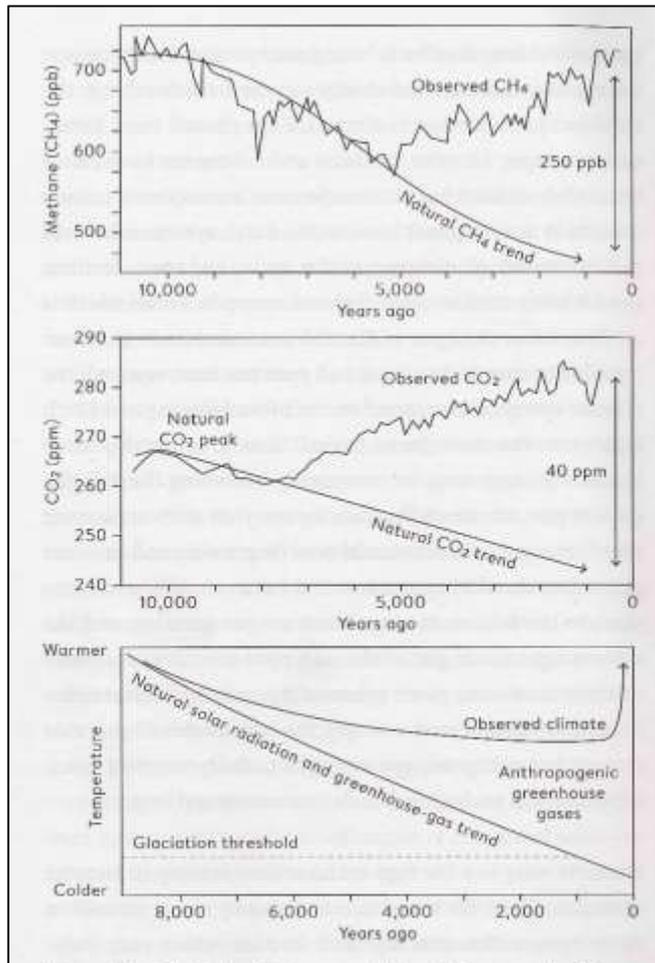
# „When did we become a geological superpower?“



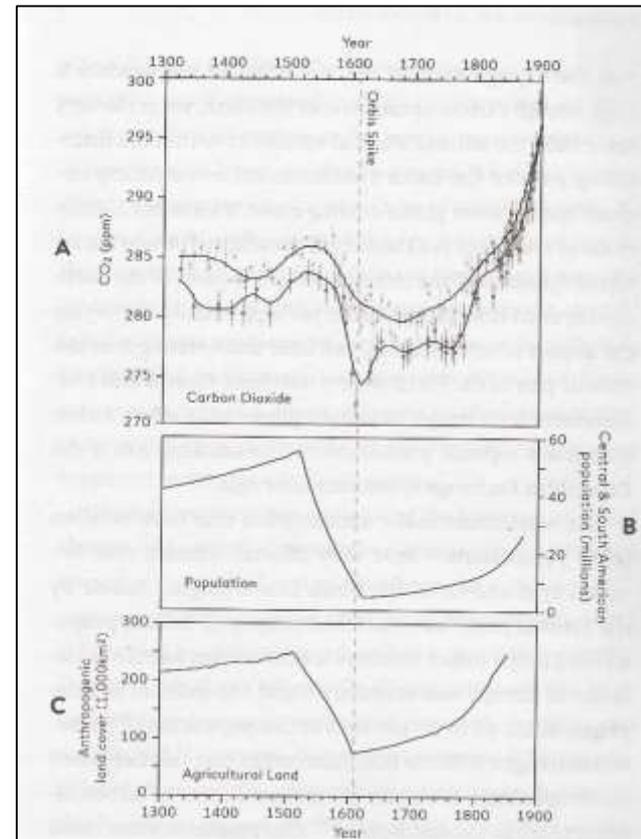
2018



# Early starts of the Anthropocene: 10,000 BCE or 1610 CE ? (Lewis/Maslin 2018)

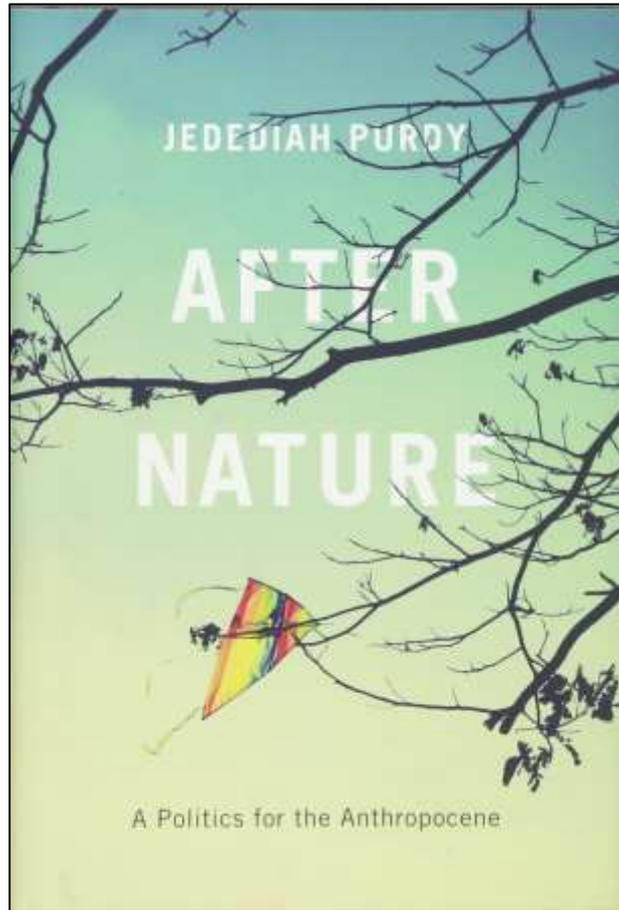


**Figure 4.3** – The Early Anthropogenic Hypothesis suggests that widespread farming began elevating atmospheric carbon dioxide and methane levels away from their expected trajectories thereby stabilizing the Earth's climate and may have been enough to prevent the next ice age.<sup>28</sup>



**Figure 5.3** – The decline in atmospheric carbon dioxide after 1520, seen in two Antarctic ice-cores (A), occurring after the deaths of 50 million people in Central and South America (B). The resultant decline in the area of farmland (C), and the regrowth of trees in its place, has been calculated to have absorbed enough carbon dioxide to account for much of the decline in global atmospheric carbon dioxide levels. The minima of carbon dioxide may provide a golden spike to define the Anthropocene, the Orbis Spike.<sup>47</sup>

# The Anthropocene as framework for research and analysis

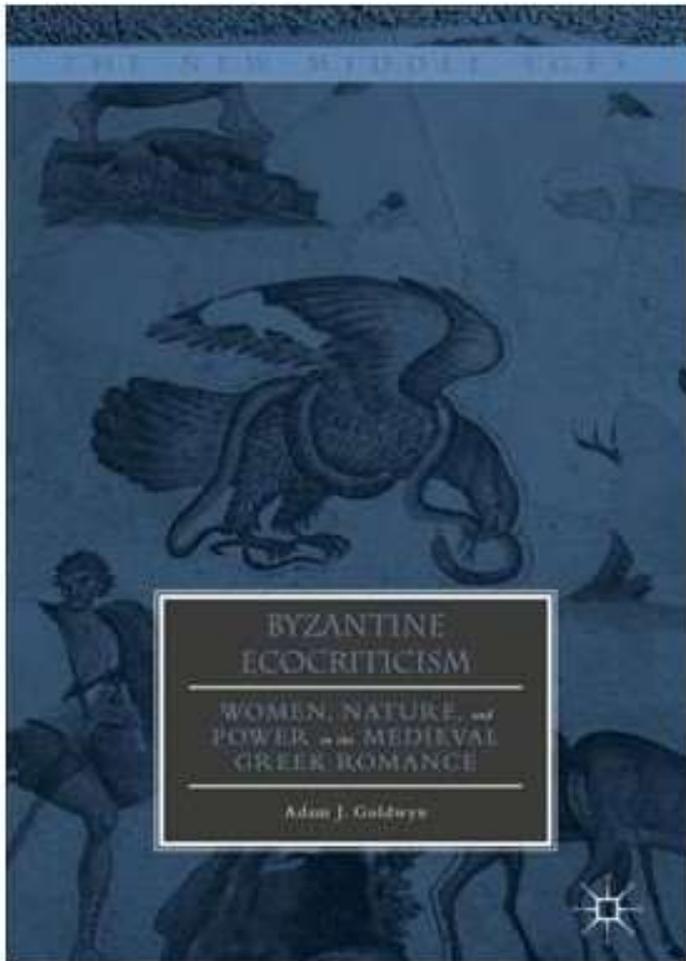


2015

*“The Anthropocene finds its most radical expression in our acknowledgment that the familiar divide between people and the natural world is no longer useful or accurate. Because we shape everything, from the upper atmosphere to the deep seas, there is no more nature that stands apart from human beings.”*

(Purdy 2015, p. 9)

# The Anthropocene in Byzantine Studies (Goldwyn 2017)



2017

*“This new environmental context requires a new language, a new set of concerns, for thinking about scholarship in general (anthropogenic climate change and its various causes, manifestations, and possible solutions have become virtually all-consuming in atmospheric sciences, oceanography, and related hard sciences) and in thinking about literary criticism and humanities scholarship in the Anthropocene.”*

(Goldwyn 2017, p. 9)



# *The Byzantine Anthropocene*: consilience (humanities – sciences), vulnerability and resilience (instead of collapse)



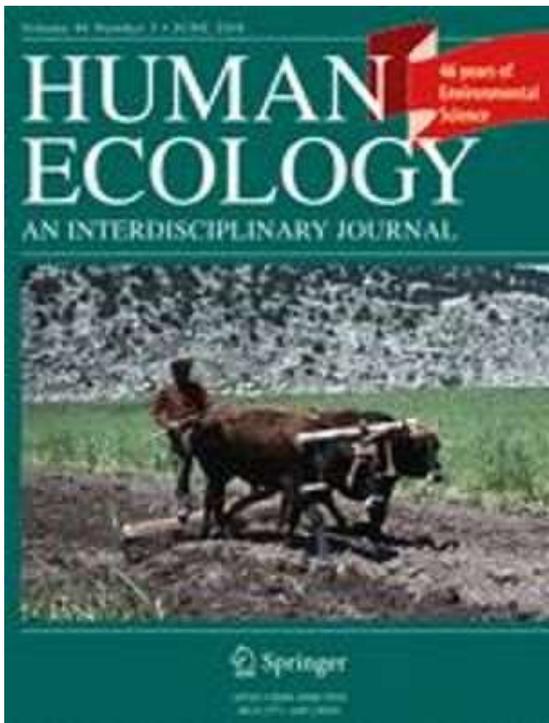
<http://climatechangeandhistory.princeton.edu/>

*Journal of Interdisciplinary History*, XLV:2 (Autumn, 2014), 113–161.

*John Haldon et al.*

## **The Climate and Environment of Byzantine Anatolia: Integrating Science, History and Archaeology**

This article, which is part of a larger project, examines cases in which high-resolution archaeological, textual, and environmental data can be integrated with longer-term, low-resolution data to afford greater precision in identifying some of the causal relationships underlying societal change. The issue of how



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**The Medieval Climate Anomaly and Byzantium: A review of the evidence on climatic fluctuations, economic performance and societal change**

Elena Xoplaki <sup>a,\*</sup>, Dominik Fleitmann <sup>b</sup>, Juerg Luterbacher <sup>a</sup>, Sebastian Wagner <sup>c</sup>, John F. Haldon <sup>d</sup>, Eduardo Zorita <sup>c</sup>, Ioannis Telelis <sup>e</sup>, Andrea Toreti <sup>f</sup>, Adam Izdebski <sup>g</sup>

JAHRBUCH DER ÖSTERREICHISCHEN BYZANTINISTIK, 65. Band 2015, 195–242  
© by Österreichische Akademie der Wissenschaften, Wien

JOHANNES PREISER-KAPPELLER

**A collapse of the Eastern Mediterranean?**

*New results and theories on the interplay between climate and societies in Byzantium and the Near East, ca. 1000–1200 AD\**

*With seven appendices, including three tables and 33 figures*

**Abstract:** This paper discusses a recently proposed scenario of a climate-induced “Collapse of the Eastern Mediterranean” in the 11<sup>th</sup> century AD. It demonstrates that such a scenario cannot be maintained when confronted with proxy data from various regions. On the other hand, data on the interplay between environment and economy in the Komnenian period (1081–1185) and evidence for a change of climatic conditions in the period of the Angeles (1185–1204) is presented, arguing that climatic parameters should be taken into consideration when comparing socio-economic dynamics in the Eastern Mediterranean with those in Western Europe. The necessity of further research on the regional as well as over-regional level for many aspects of the interaction between human society and environment in the medieval Eastern Mediterranean is highlighted.

<https://link.springer.com/journal/10745/46/3/page/1>

# „Archives of nature“ and „archives of society“ (Christian Pfister)

Archiv		Minimal erfassbarer Zeitraum (in Jahren)	Maximal erfassbarer Zeitraum (in Jahren)	Informationen über
Eis		1	10 <sup>6</sup>	T, N, C <sub>L</sub> , B, V, E, S
Marine Sedimente		10	10 <sup>8</sup>	T, C <sub>W</sub> , B, E, M, N
Limnische Sedimente		<1	10 <sup>5</sup>	T, B, E, N, V, C <sub>W</sub>
Terrestrische Sedimente und Bildungen	Löss	10 <sup>2</sup>	10 <sup>6</sup>	N, B, E, V
	Dünen	10 <sup>2</sup>	10 <sup>5</sup>	N, B
	Böden	10 <sup>2</sup>	10 <sup>6</sup>	N, B
	Winter (Tropfsteine)	10 <sup>2</sup>	10 <sup>5</sup>	C <sub>W</sub> , T, N
	Fluviale Ablagerungen	10 <sup>2</sup>	10 <sup>4</sup>	N, B
Biologische Gebilde	Baumringe	<1	10 <sup>4</sup>	T, N, B, V, E, S
	Pollen	1	10 <sup>5</sup>	T, N, B
	Korallen	1	10 <sup>4</sup>	C <sub>W</sub> , M, T, N
	Torf/Moore	10 <sup>2</sup>	10 <sup>5</sup>	B
Historische Archive		<1	10 <sup>4</sup>	T, N, X, B, V, E, M, S, C <sub>LW</sub>

T – Temperatur	E – Veränderungen im Erdmagnetfeld
N – Niederschlag	M – Meeresspiegelschwankungen
X – Extremereignisse (Hagel, Sturm, Gewitter etc.)	V – Vulkanausbrüche
B – Biomasse und Vegetationszusammensetzung	C – Chemische Zusammensetzung von Luft (C <sub>L</sub> ) und Wasser (C <sub>W</sub> )
	S – Schwankungen in der Sonneneinstrahlung

Archive zur Rekonstruktion von Klimawandel (nach Bubenzer u.a. in Endlicher 2007, ergänzt nach Bradley 1999; ergänzt wurde zudem der Faktor „X – Extremereignisse“).

Informationen	Archive der Gesellschaft	
	beobachtet	gemessen
Direkte Beobachtung und/oder instrumentelle Messung meteorologischer Parameter	<ul style="list-style-type: none"> <li>– Anomalien</li> <li>– Naturgefahren</li> <li>– Wetterlagen</li> <li>– tägliches Wetter</li> <li>– Sonnenaktivität</li> </ul>	<ul style="list-style-type: none"> <li>– Luftdruck</li> <li>– Temperatur</li> <li>– Niederschlag</li> <li>– Wasserstand</li> </ul>
	Indirekte Daten (Proxydaten) Spuren klimatisch beeinflusster Prozesse	<b>organisch</b> <ul style="list-style-type: none"> <li>– Pflanzenphänologie: Blüte- und Reifezeit, Erntetermine und Erntevolumen von Kulturpflanzen</li> <li>– Volumen und Zuckergehalt von Weinmosterten</li> </ul>
		<b>Schriftliche Quellen</b> <ul style="list-style-type: none"> <li><i>kulturell</i> <ul style="list-style-type: none"> <li>– Bittprozessionen (klimabedingt, insbes. bei Trockenheit)</li> <li>– Bildquellen</li> <li>– archäologische Reste</li> </ul> </li> </ul>

Typen klimageschichtlicher Informationen, leicht verändert nach Chr. Pfister u.a.: WeterNachhersage, S. 16.

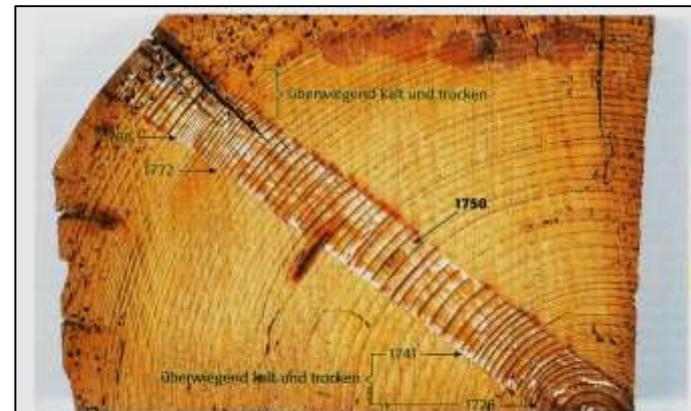


Abb. 11: Ausschnitt aus einer Baumscheibe. Der Jahrgang 1750 ist mit der Jahreszahl versehen. Derartige Baumscheiben sind nicht nur Zeile, sondern auch Umweltarchive. Breite Ringe zeigen wachstumsfördernde, enge Ringe wachstumsminimale Jahre an. Quelle und Bearbeitung: Dendrologie, Hohenheim.

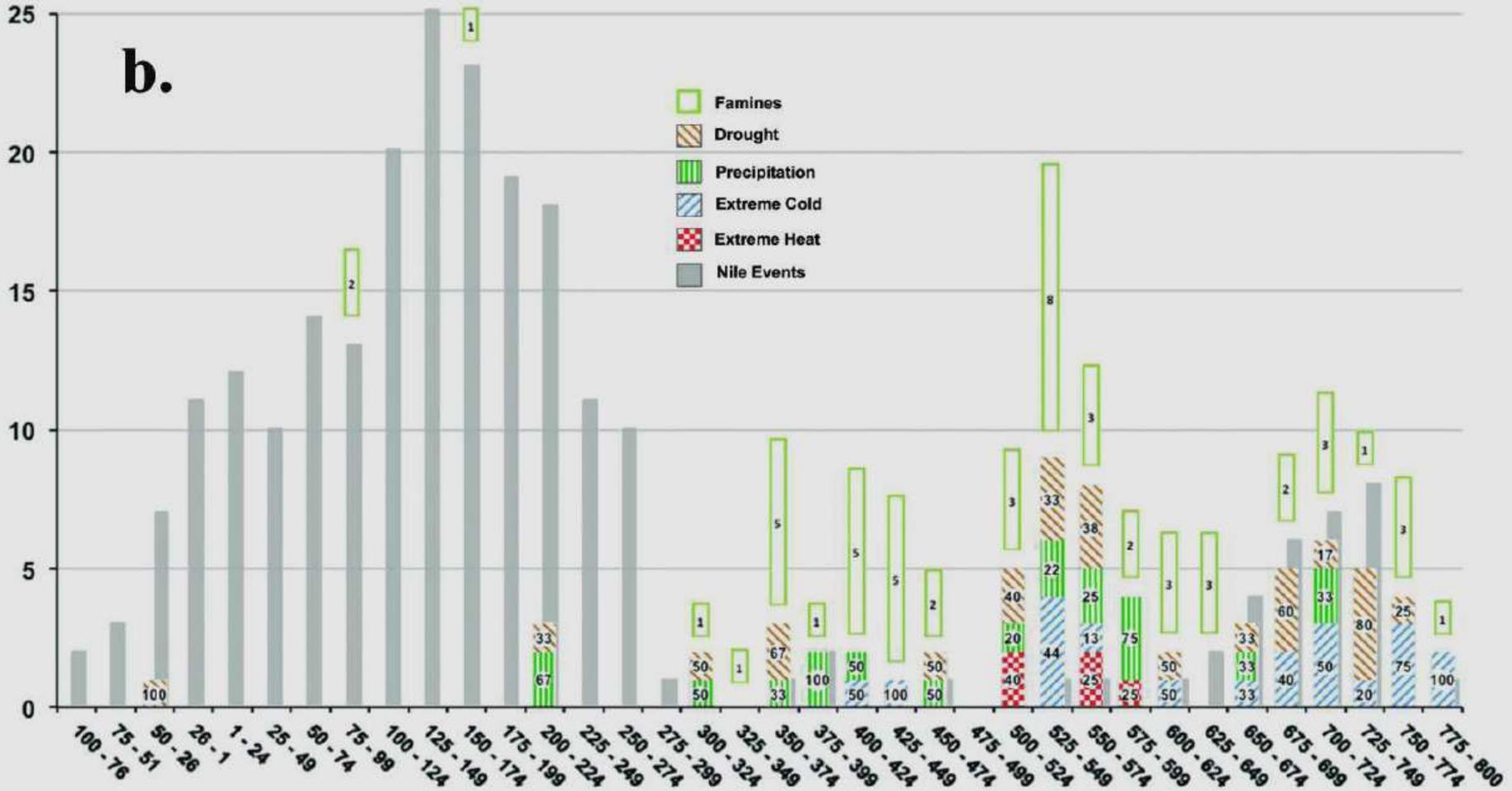
# Geodatabase of Historical Evidence on Roman and Post-Roman Climate (McCORMICK et al. 2012)

Kapitel von McCormick\_et\_al\_2012\_Geodatabase\_Historical\_Evidence\_on\_Roman\_Post-Roman\_Climate.xls [Kompatibilitätsmodus] - Microsoft Excel

Severe winter, sea of Pznowick freezes (apparently refers to Lake Van)

Item	When 1	When 2	EVIDENCE	Item 2 used Within a g	What	What cod	What 2 cod	man	Contemp	Space	Certainty	NO	Where	Phenomena	Comments	Constr date	Site name	Geo Code	Latitude 1	Longitude 1	Latitude 2	Longitude 2			
449	481	518	Stathakopoulos 2004, no. 78, citing Ptolemy	Annals of Procopius	famine?	la		2	1	1		Constantinople	Famine under	Very late source and no contemporary parallel evidence			41.01224	28.97608							
450	449	492	Consularia Italica, a. 492, MGH Auct Ant 3.319	Famine	la			4	3	3		Rome and Italy	Famine cause of	Quite possibly connected with the drought event ca. 492			1.45.9								
451	450	480	Stathakopoulos 2004, no. 77, citing Gelasius	drought cause food	la			4	4	3		Africa and Gaul	general drought	Alpine larch seem to show stress?			1.46.85006	10.32396	45.70694	4.834167					
452	451	493	484 Stathakopoulos 2004, no. 75, citing ?	famine	la		7	3	3	2		Italy	Famine occur	Etiodius seems to date the famine to the invasion, ca. 484			1.45.9								
453	453	497	Annals of Tjemoch, a. 497, Annals of Ulster, a. 497	Edessa	e							southern Mediter	Eclipse of the	4 This eclipse was very likely that of 497, April 18, visible in			1.42.033333	35.15							
454	453	499	Annals of Tjemoch, a. 499, Annals of Ulster, a. 499	Earthquake	q							Portus	Great earthquake	shook Portus			1.42.033333	35.15							
455	454	499	Marcellinus Comes, a. 499 2, MGH Auct Ant 11	Earthquake	n							Portus	Great earthquake	rocked the province			1.42.033333	35.15							
456	455	499	Teles 2004, no. 108, ca 10	sky obscured, food?	n			2	2	2		Euphrates, Mesopotamia	sky darkened,	Euphrates overflowed that same day			1.32								
457	456	500	Procopius of Gaza (ca. 485-ca. 528), ca	drought	d			3	1	3		Euboua island?	Drought and	Presented as a new, disturbing development. No clear dating element poss			31.516667	34.45							
458	457	500	Teles 2004, no. 109, ca 12	frost ice	w			3	1	3		y	Epidemic begu	ary? See Stathakopoulos 2004, p254-5 for not unusual winter			37.15								
459	458	500	Stathakopoulos 2004, no. 03-09	huge locust hatch	lo			2	3	3		03	Edessa	locust hatch	ca (same as Teles 2004, 109-110, Stathakopoulos 2004, p254-8 concludes th			37.15							
460	459	501	Teles 2004, no. 110, ca 07-08	great heat	h			3	1	3		y	Edessa	hot wind	killed grain but excellent grape harvest, dried grapes			37.15							
461	460	501	Teles 2004, no. 111, ca 10-04	excessive rain all w	pr			3	1	4		y	Mesopotamia E	excessive rain	all winter caused sown seeds to sprout early and reach			1.37.15							
462	461	502	Victor Tormenensis, a. 502 1, MGH Auct Ant 11	Hail	na			3	1	3		y	Edessa	Massive earthquake,	thunder, hail - total commotion of land and sky			41.9							
463	462	502	Teles 2004, no. 112, ca 05	hot wind for 3 days	h			3	2	3			Edessa	dried up grain	in whole land except for few places			37.15							
464	463	504	Stathakopoulos 2004, no. 81, citing Pseudo-Jo	famine	la		y	3	1	3			Amida	siege of Persian	defenders causes famine, cannibalism, man-made			37.9619							
465	464	505	Teles 2004, no. 115, ca 01-02	great cold, much sn	w			1	1	3			Amida	Roman troops	unclear whether this is unusual in winter in Dyabkir			37.9619							
466	465	505	Stathakopoulos 2004, no. 82, citing Theophan	famine	la		?	3	1	3			Nisibis	Famine almost	every possibly man-made			37.066667							
467	466	505	Consularia Italica, a. 505, MGH Auct Ant 9.330	Volcano	v								Vesuvius	Vesuvius erupt	481 GRP2, 504-507 7, 58 10 pp ?			40.816667							
468	467	512	Annals of Ulster, a. 512, Chronicon Scodorum,	Edipse	e								Mediterranean	Eclipse of the	4 This record of an eclipse refers actually to one that was			1							
469	468	512	Marcellinus Comes, a. 512 1, MGH Auct Ant 11	sky burning	a								Constantinople	From the south	presumably effect of Vesuvius eruption			41.01224							
470	469	512	Consularia Italica, a. 512, MGH Auct Ant 9.330	Volcano	v			a few					Vesuvius	Vesuvius erupt	0 GRP2			40.816667							
471	470	515	Stathakopoulos 2004, no. 09-09	grain and oil shorta	lo			3	2	3			Alexandria	waters fall	the Augustalis because of lack of bread and oil			31.2							
472	471	515	Stathakopoulos 2004, no. 85, citing Cyril of Bor	5 year drought, locu	lo			4	1	2			Jerusalem	5 years of drou	See C.P. Jones 2007 on waterworks for Jerusalem around this time			31.783333							
473	472	518	Annals of Tjemoch, a. 518, CE 1	Earthquake	q								Dardania	Earthquake	destroyed "xvi castra" in one moment			41.3							
474	473	518	Teles 2004, no. 119, citing Procopius, Belur	great wind storm, g	w			3	1	4			Antioch	wind uproots	cypress trees			36.2							
475	474	518	Teles 2004, no. 129, citing Chronicle of Seer	locust plague of 5 y	lo			3	2	2			Syria	Seem adds to	qCI Teles 2004, no. 130, which would place locusts ca			31.2							
476	475	520	Teles 2004, no. 122, ca 06	local rain during d	r			2	1	2			Jurt Palestine	heavy rainfall	during dry season and in drought around Megiste Lava, K			31.783333							
477	476	521	Teles 2004, no. 123, ca 09	beginning of rains	pr			3	1	2			Sea Jerusalem	A south wind	began to blow at Jerusalem during the exceptionally hot			31.783333							
478	477	522	Teles 2004, no. 124, ca 02	intense rain	pr			2	1	2			Jer Palestine	end great drought			31.783333								
479	478	522	Stathakopoulos 2004, no. 86, citing Boethius D	famine	la			3	2	3			Rome? Italy? CA	but famine	la Stathakopoulos wondered whether this was the same			1.45.9							
480	479	523	Stathakopoulos 2004, no. 89, citing Cassiodoru	food shortage	la			3	3	3			Italy, Africa?	Cassiodorus	q Stathakopoulos follows Ruggini and dates the shortage			1.45.9							
481	480	523	Teles 2004, no. 126 citing Zachary of Mythen	drought? Spring d	r			4	1	3			Palestine Jerusa	the spring of	Sloam, Jerusalem, dried up for 15 years; starts in year 7			31.783333							
482	481	524	Stathakopoulos 2004, no. 87, citing Theodos	Food shortage	la			3	1	3			Constantinople	Shortage of			41.01224								
483	482	525	Teles 2004, no. 128, ca 04	flood	pr			3	3	4		y	Syria Antioch, Ed	to winter	ice destroys much of the city walls and reportedly kills 30 00			1.36.2							
484	483	525	Teles 2004, no. 130, citing Agapiti 7 5297	drought	d			3	2	3			Syria	rain rare,	poor year 8 of Justin I			1.36.2							
485	484	525	Teles 2004, no. 129, citing Agapiti p165, Ch	severe winter	w			3	2	2			Syria	heavy snowfall	year 7 of "Justinian" i.e. Justin? Chron Seaf adds: 5-y			1.36.2							
486	485	528	Marcellinus Comes, a. 528, MGH Auct Ant 11	Earthquake	q								Antioch	Massive earthquake			1.36.2								
487	486	527	Teles 2004, no. 132, citing George 7	drought	d			2	1	2			Arctia area	drought ended	late St. Theodora was 14 years old			1.39.875							
488	487	527	Procopius, De aedificiis, before	multiple dry summers	in Thrace			3	1	3			Thrace Constantin	Procopius rep	cambic suffers sensitive to dry seasons; situation repo			1							
489	488	527	Teles 2004, no. 133, citing Samuel Ant 6391	famine	la			3	3	3			Persia	3-year famine	follows eclipse			1.33.093611							
490	489	527	Teles 2004, nos. 134-135, citing Procopius,	heavy rains, floods	pr			2	3	3			Bithynia Helene	rains, flooding	unspecified date during Justinian's reign, cf. also Tele			1.40.8975							
491	490	527	Teles 2004, nos. 137 and 140, citing George	drought	d			2	3	1			Jerusalem, Pers	drought in	Teles suspects these are the same as his no. 128, th			31.783333							
492	491	528	Teles 2004, no. 141, citing John Malalas, Ch	severe winter	w			3	1	3			Antioch	harsh winter,	3 ellis of snow, causes truce in war between Romans and Persians			36.2							
493	492	530	Teles 2004, no. 142, ca 09	drought follows cold	r			3	1	3			Constantinople	comet visible	for 20 days in west in September and there was drought			41.01224							
494	493	532	Gregory of Tours, Historiae 3.13, MGH SS rer M	drought	d			2	1	3			Voltaire-Montagn	30 days	without Year when the Franks invaded the Burgundian kingdom			45.763333							
495	494	532	Gregory of Tours, Historiae 3.15, MGH SS rer M	drought	d			2	1	3			Voltaire-Montagn	30 days	without Year when the Franks invaded the Burgundian kingdom			45.763333							
496	495	535	Stathakopoulos 2004, no. 06	famine	la			3	3	4			bel Thrace	Justinian takes	no important military activities, except the possible trans			1.42.7							

# Number of climatic events recorded in written sources for the eastern part of the Roman Empire and the successor states, 100 BCE- 800 CE (McCORMICK et al. 2012)



# A catalog of meteorological phenomena in Byzantine sources, 300-1500 (Telelis 2004)

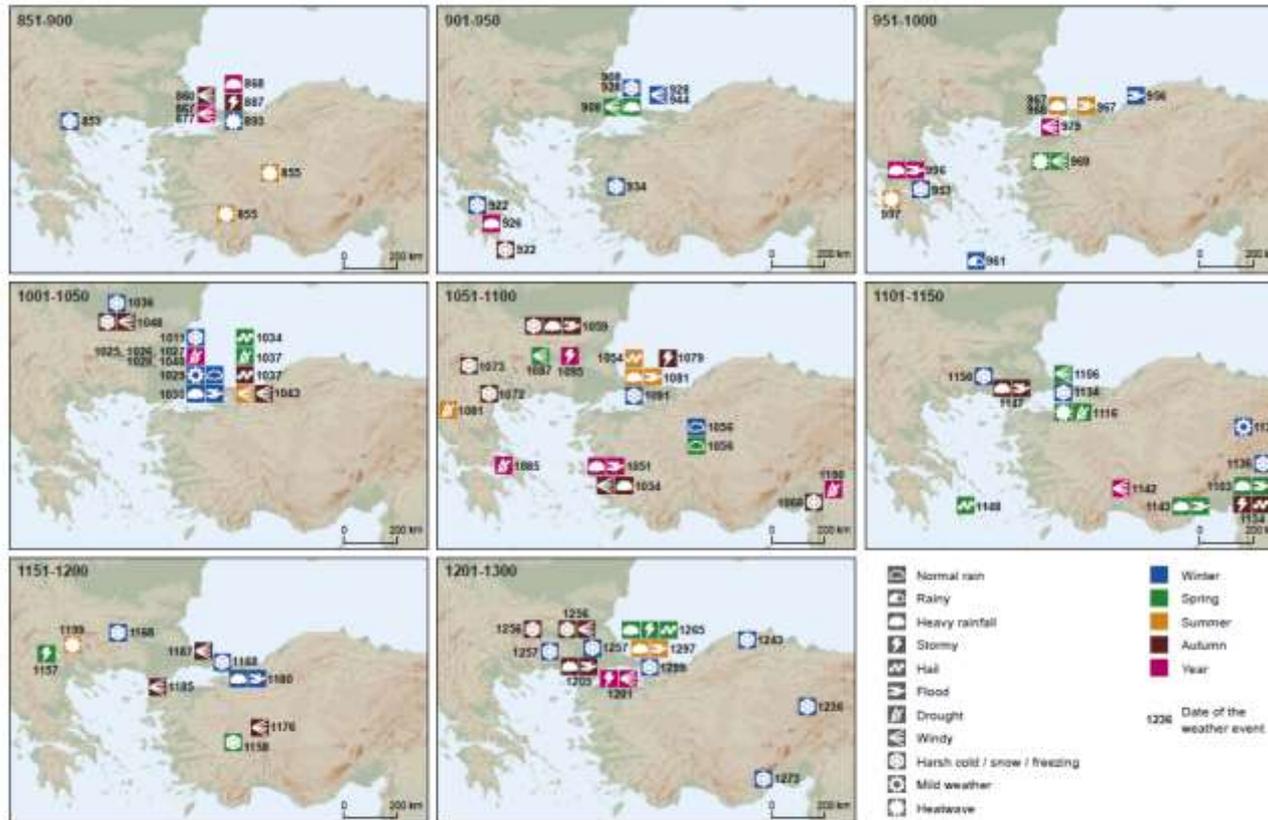
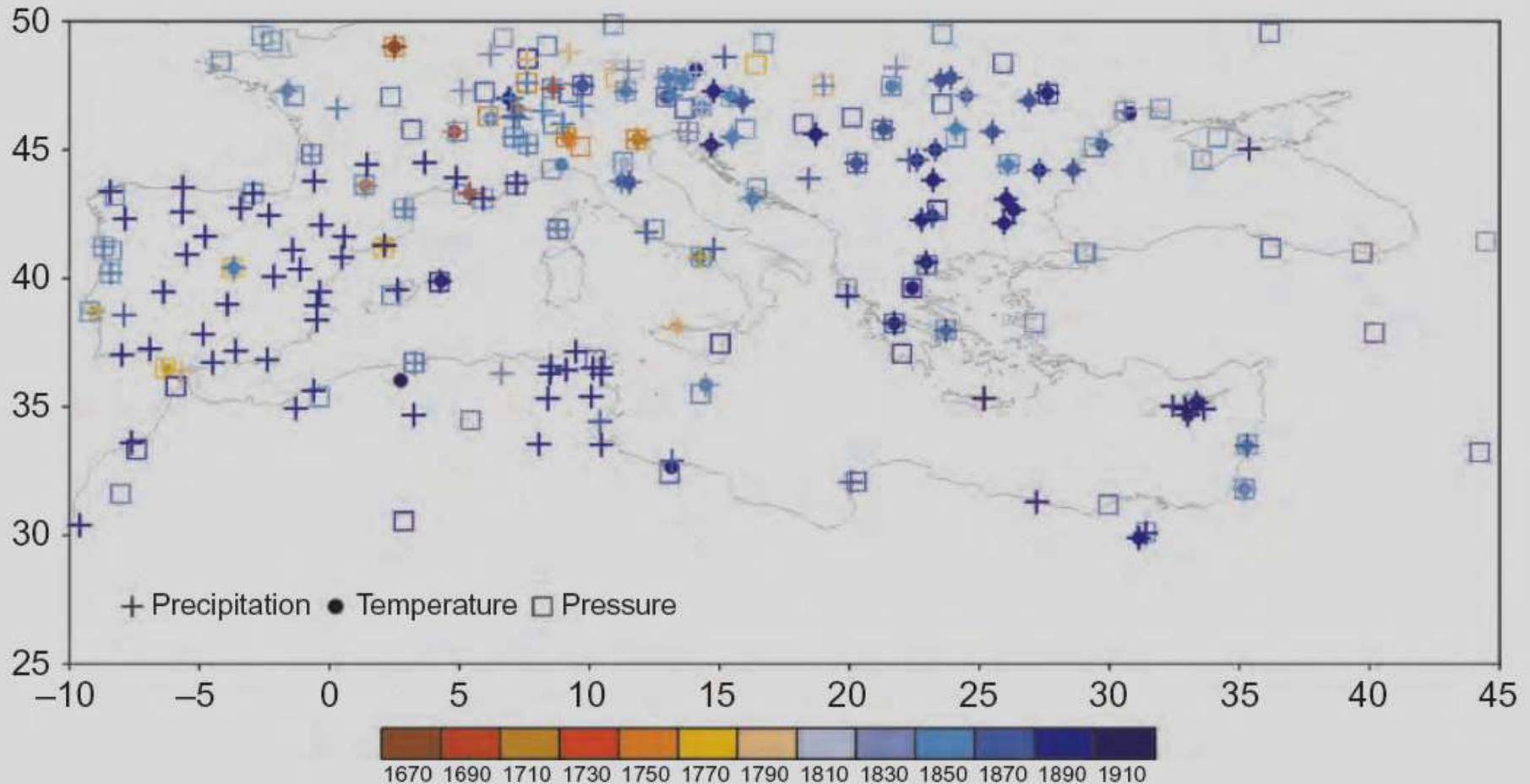


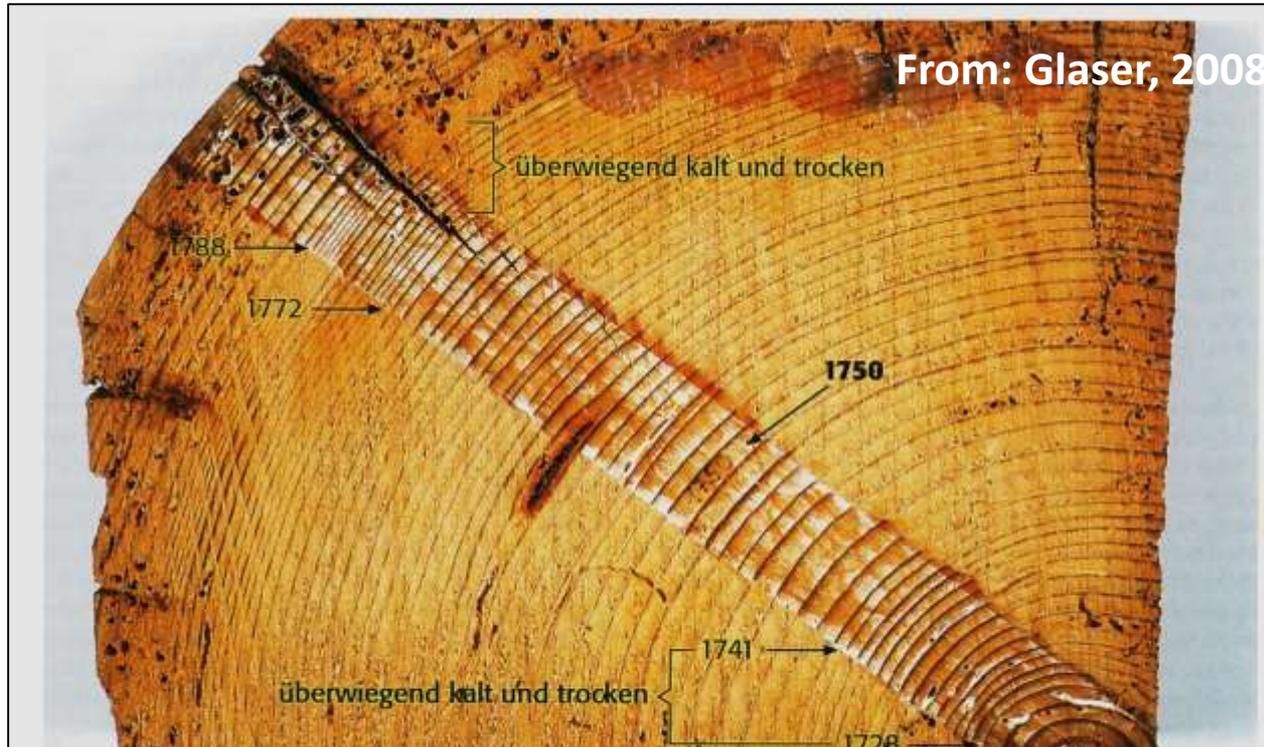
Fig. 8. Spatial distribution of documentary/textual historical-climatological data from Byzantine sources collected by Telelis (2000, 2008). Each plot corresponds to a 50-year period, except for the last MCA century, AD 1201–1300, due to information availability. Events with monthly, seasonal and annual duration are presented. The symbols background colours denote their temporal resolution.

E. Xoplaki et al., The Medieval Climate Anomaly and Byzantium. *Quaternary Science Reviews*

# Instrumental measurements of precipitation, temperature or pressure in the Mediterranean before the 20th century (cf. LUTERBACHER et al. , 2012 – 2k-Project)

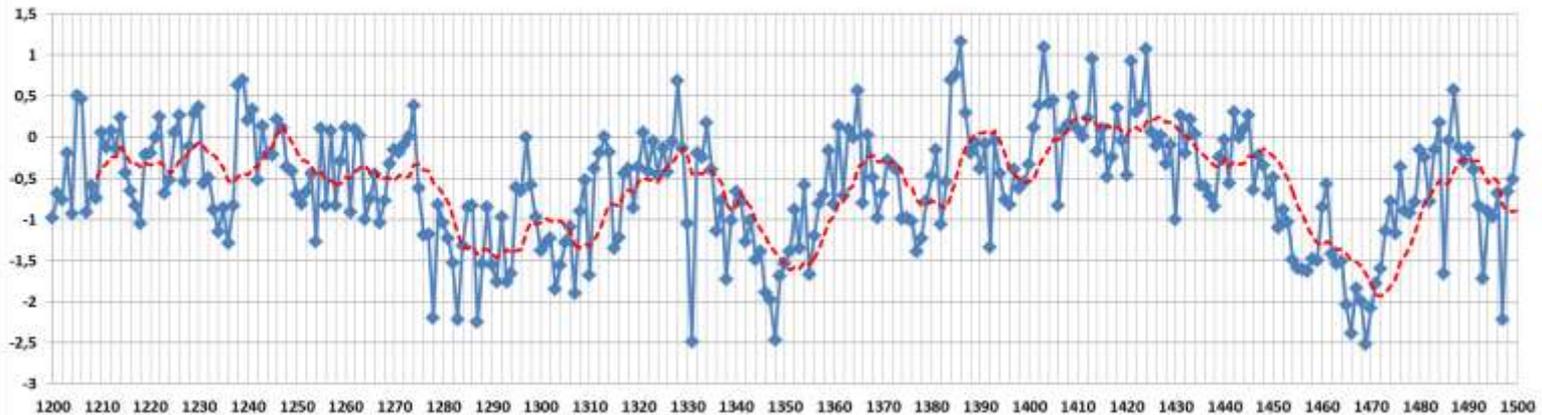


# Tree rings as climate archives

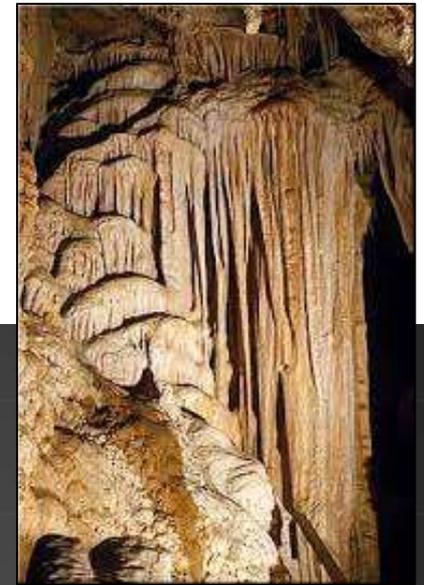


## Baumringe als Klimaproxy für Österreich, 1200-1500

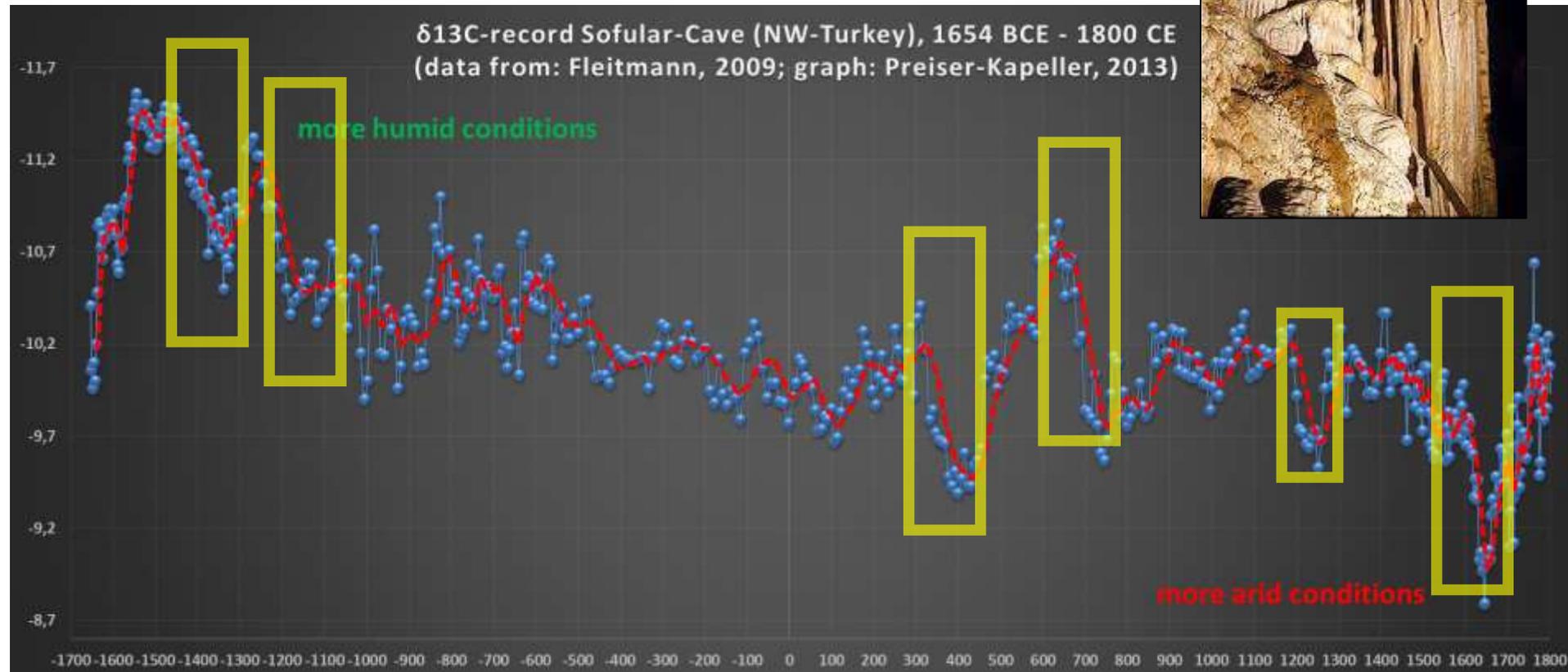
(Daten: Büntgen u. a. 2011; Grafik: J. Preiser-Kapeller, 2016)



# Climate Proxies from Speleothems for NW Asia Minor, 1654 BCE-1800 CE

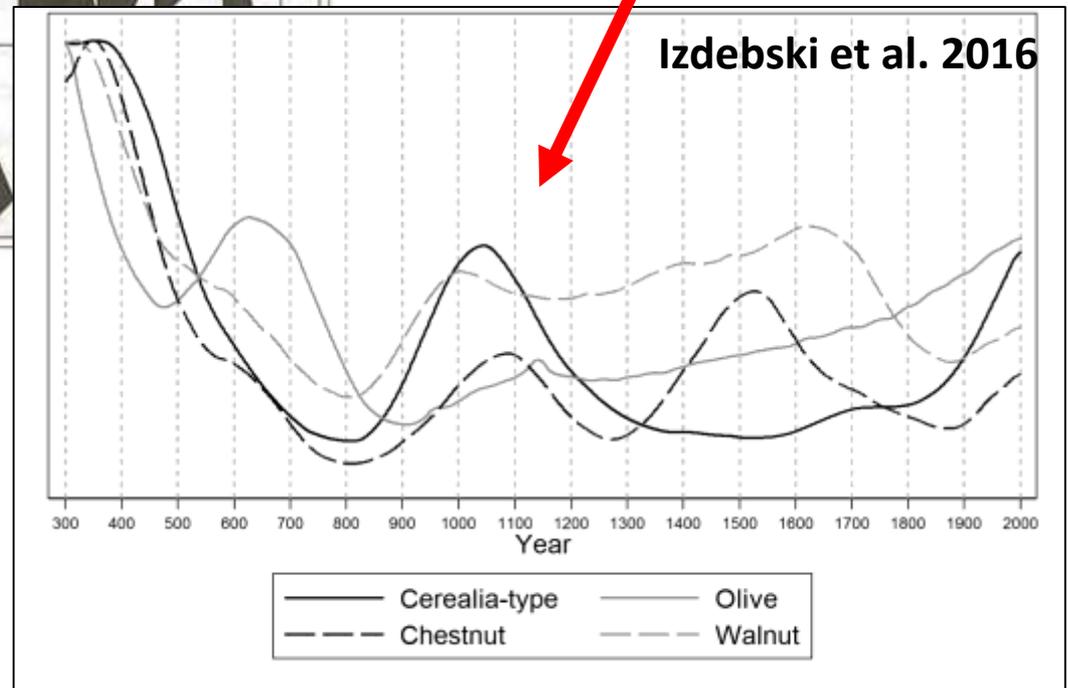
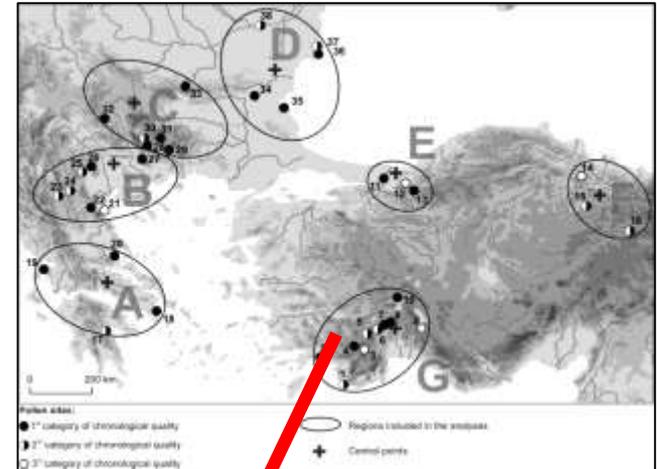
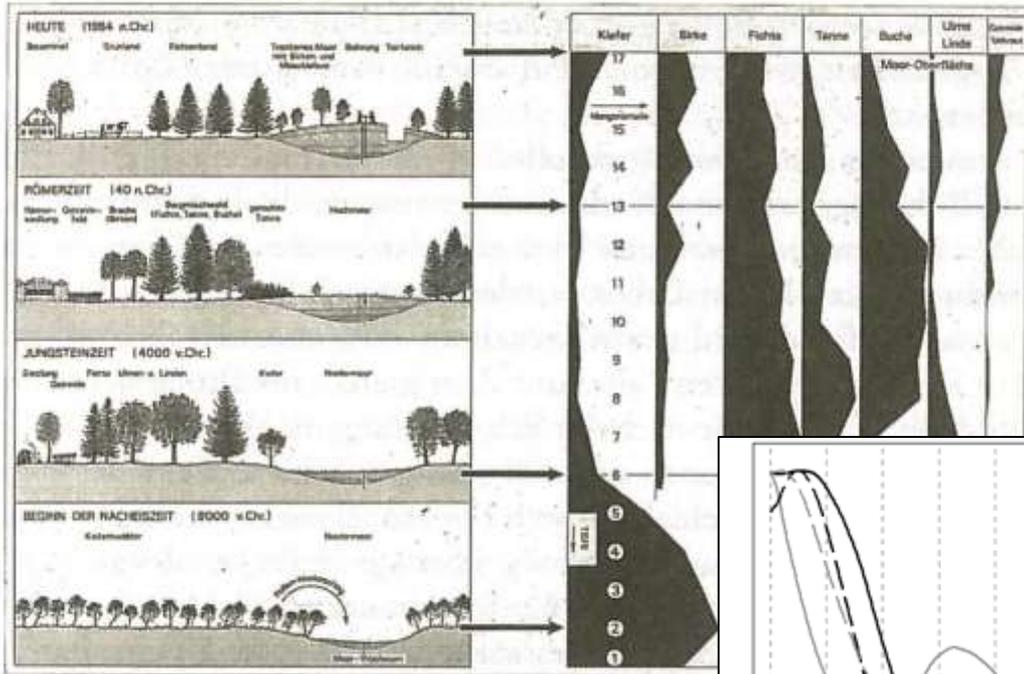


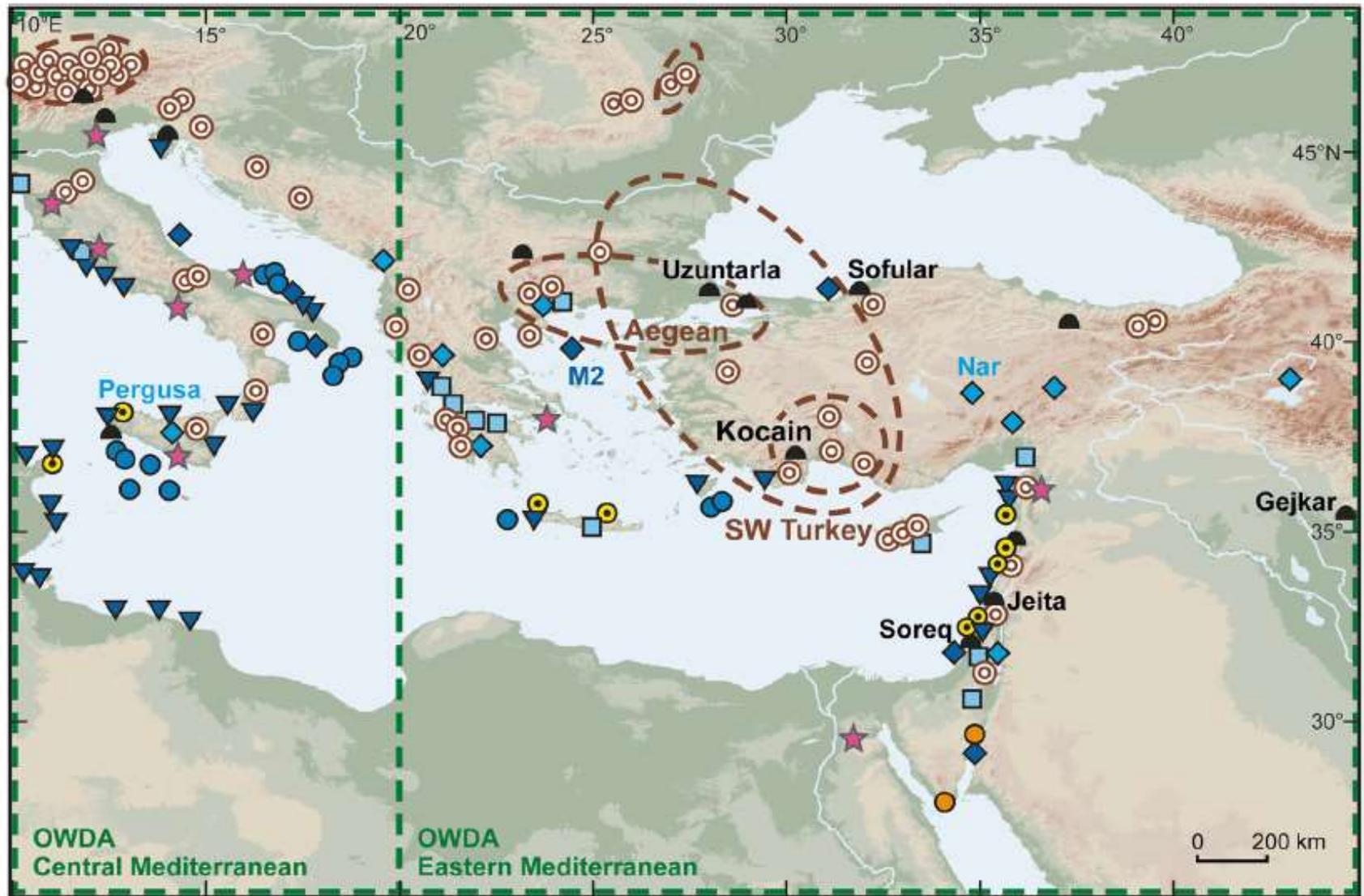
$\delta^{13}\text{C}$ -record Sofular-Cave (NW-Turkey), 1654 BCE - 1800 CE  
(data from: Fleitmann, 2009; graph: Preiser-Kapeller, 2013)



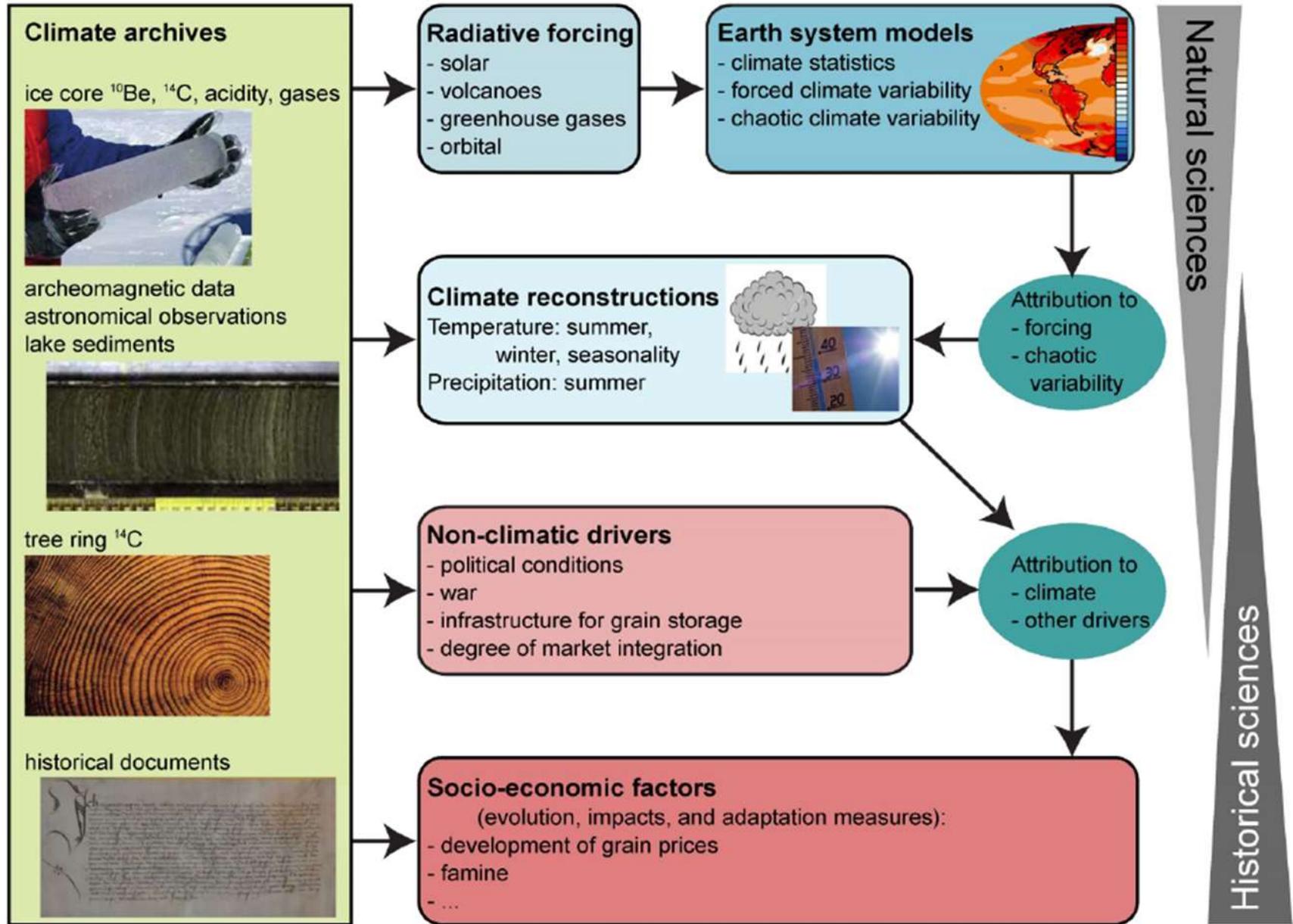
**red: 50-years moving average**

# Pollen analyzes and sediments as archives of climate and human activity

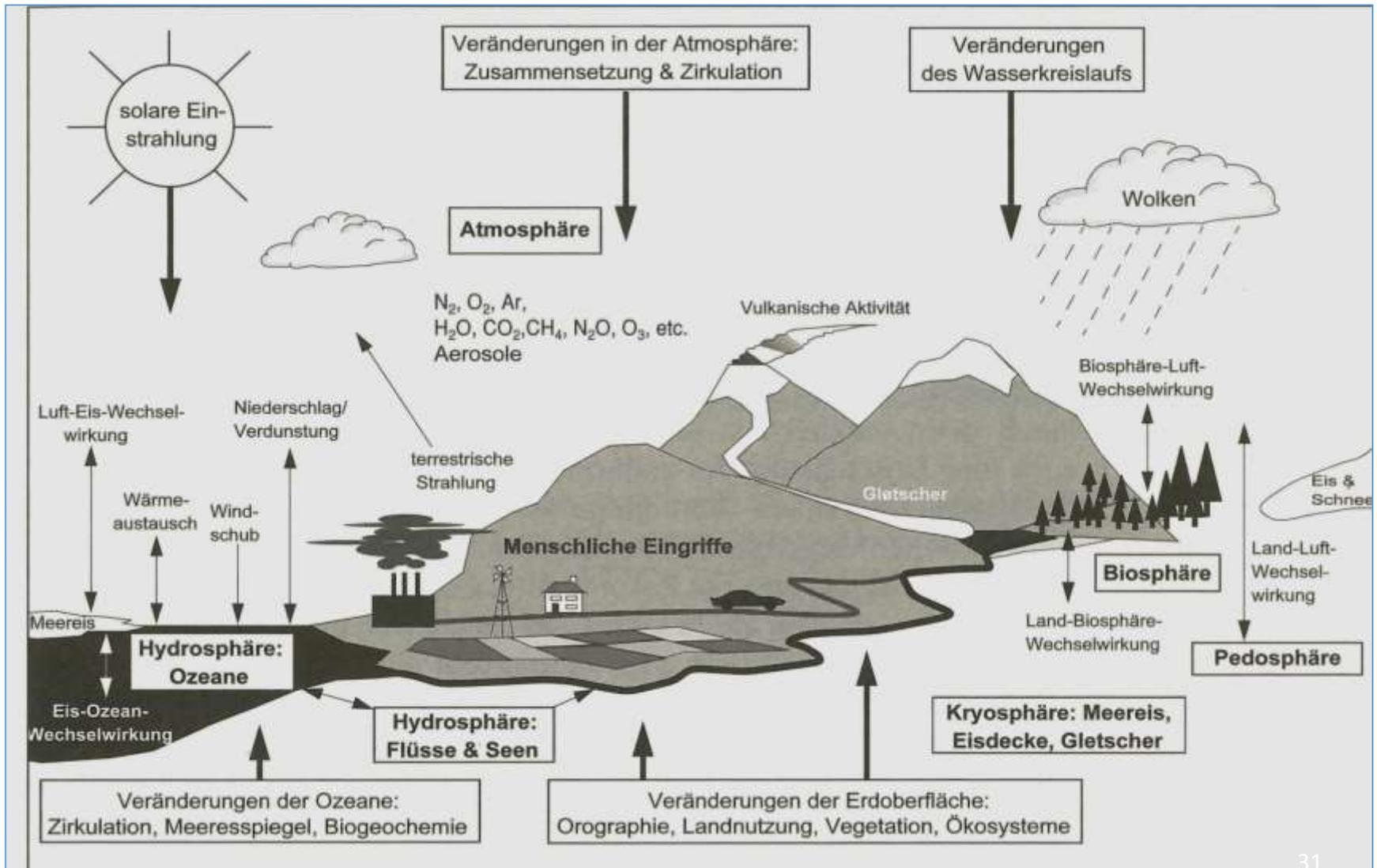




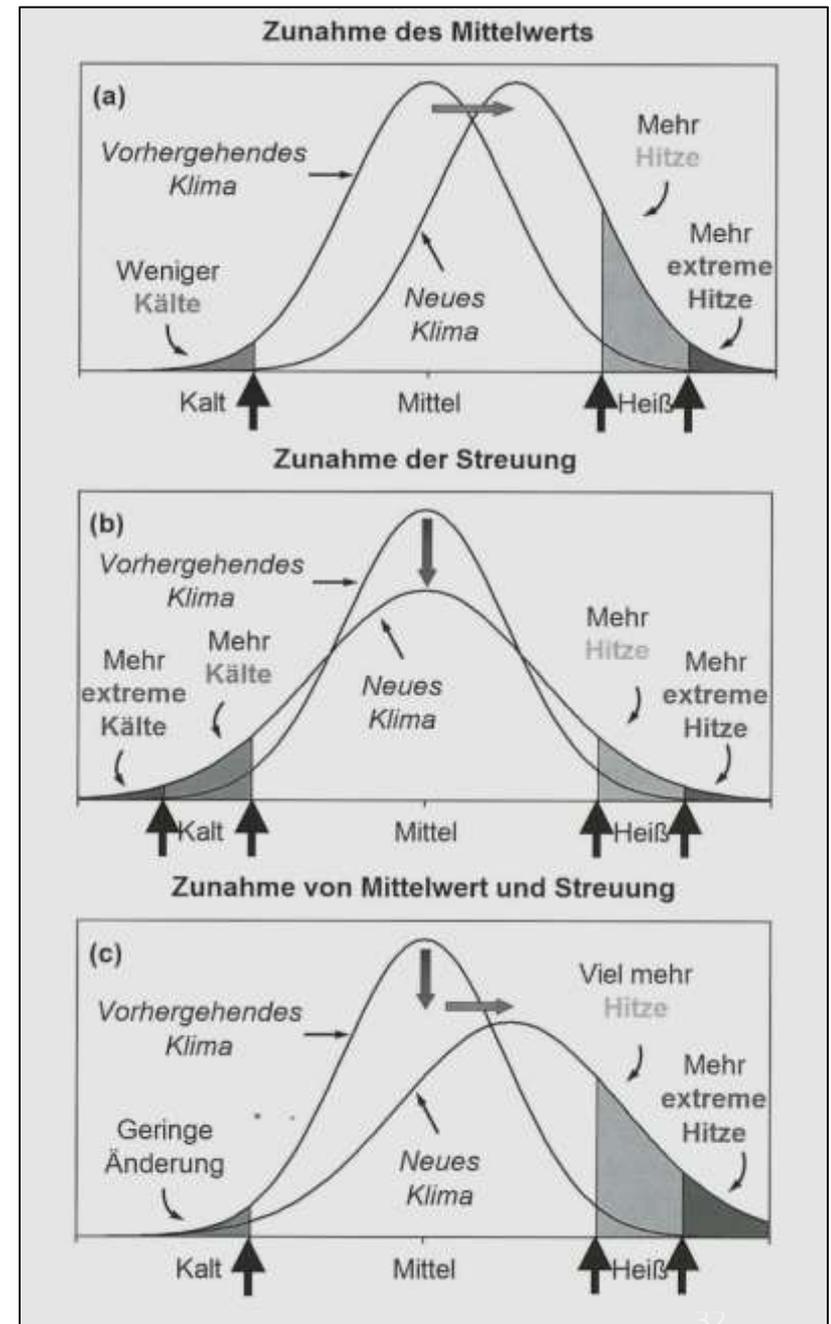
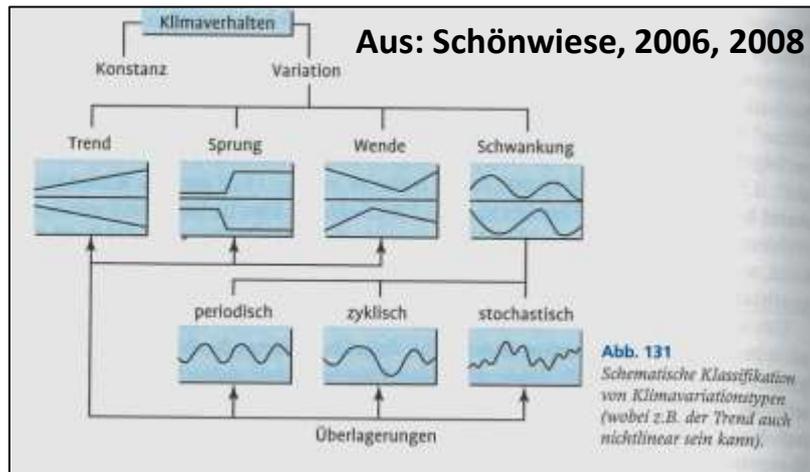
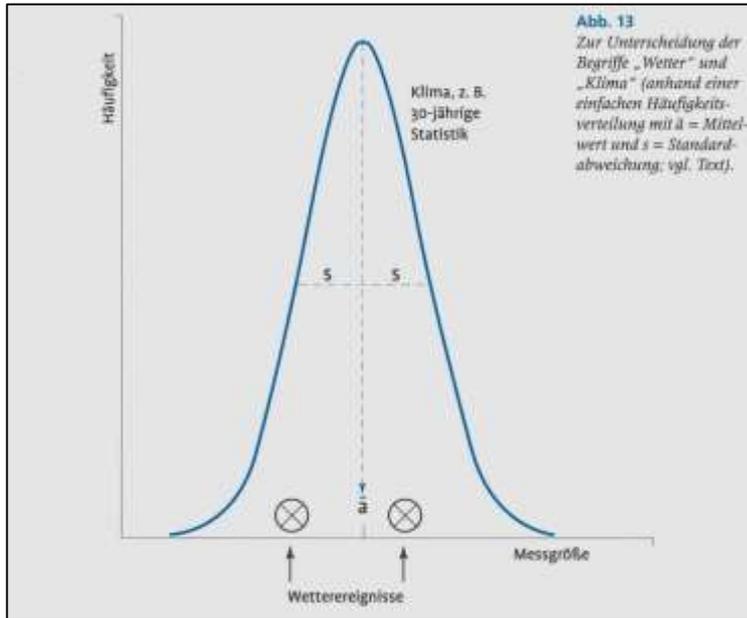
- |               |                     |                    |                       |
|---------------|---------------------|--------------------|-----------------------|
| ★ Documentary | ▼ Sea level markers | □ Fluvial deposits | ● Vermetids           |
| ▲ Speleothems | ◆ Lake sediments    | ● Deep sea corals  | ⊖ Tree reconstruction |
| ⊙ Tree rings  | ◆ Marine sediments  | ● Tropical corals  | ⊞ scPDSI (OWDA)       |



# The climate as a complex system



# Weather, climate and climate change



# Teleconnections between climate systems and global history

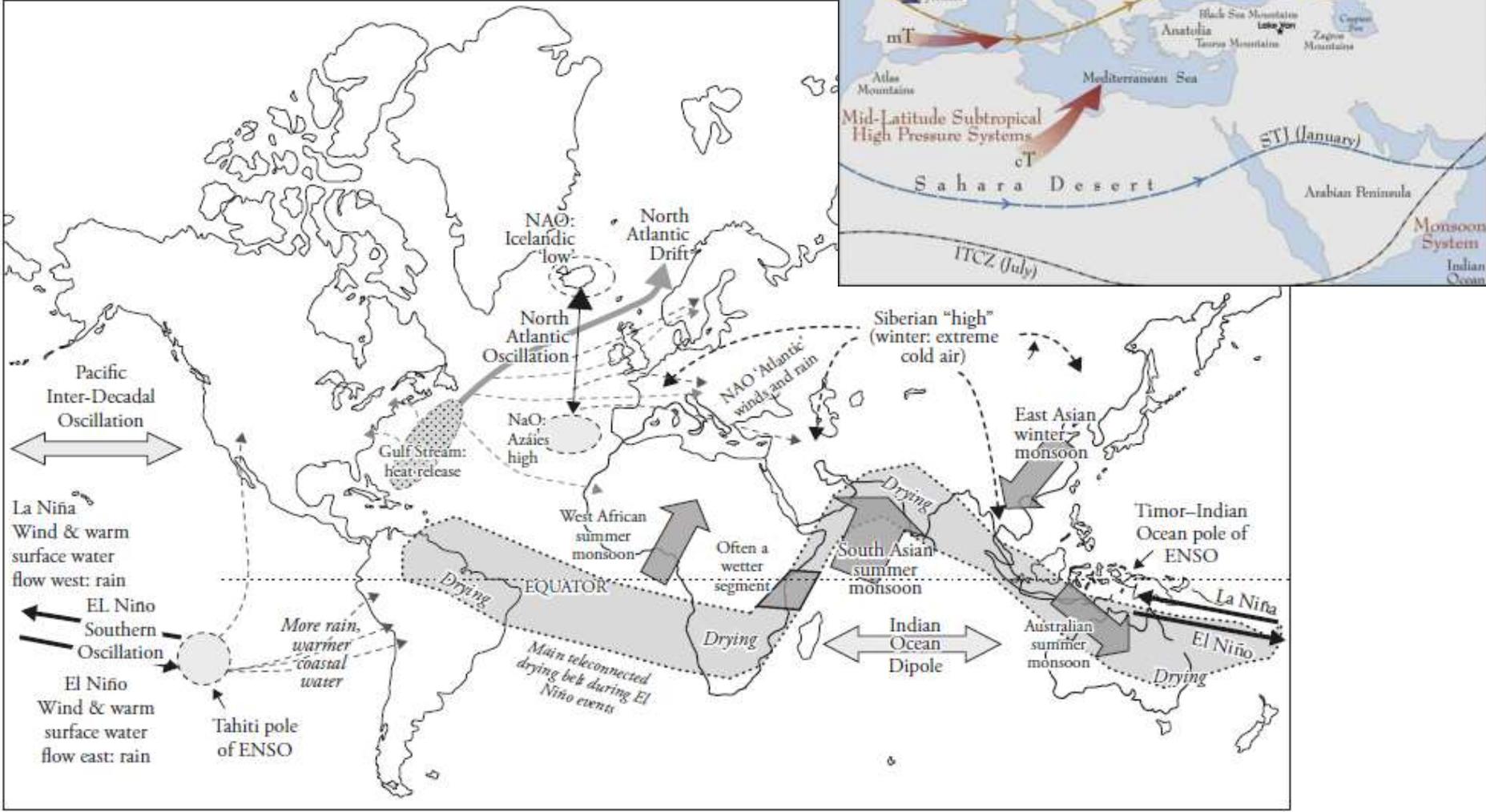
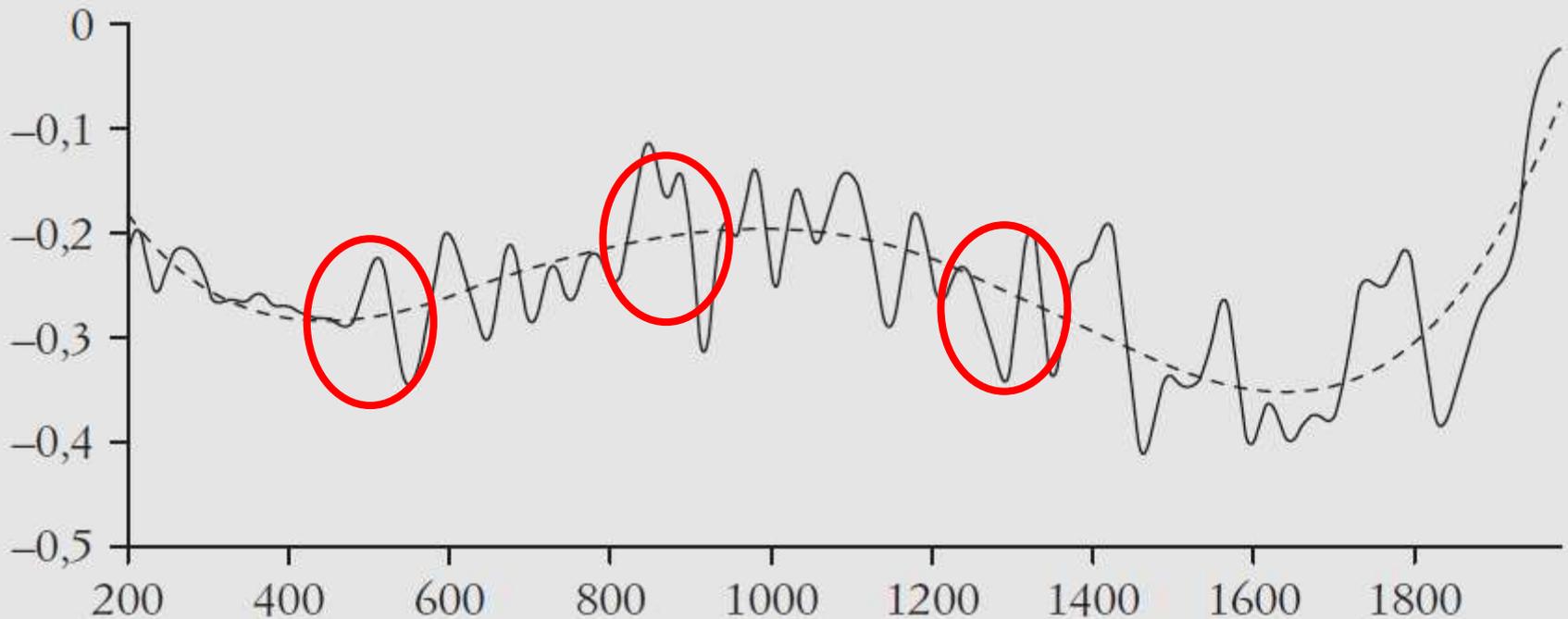


FIGURE 2.3 Map of world climate oscillations

From: McMichael, Climate Change and the Health of Nations (2017)

**Climate history globally (and schematically):  
from the "Roman Climate Optimum" to the "Late antique cold period" and the "Medieval Climate Optimum" to the  
"Little Ice Age"**



Northern Hemisphere Temperatures (200-2000 CE) (Winter Temperatures (1961-90 = 0); from: E. LO CASCIO – P. MALANIMA, Cycles and Stability. Italian Population before the Demographic Transition (225 B. C.–A. D. 1900). *Rivista di Storia Economica* 21/3 (2005)

# The "Roman Climate Optimum" in Central Europe

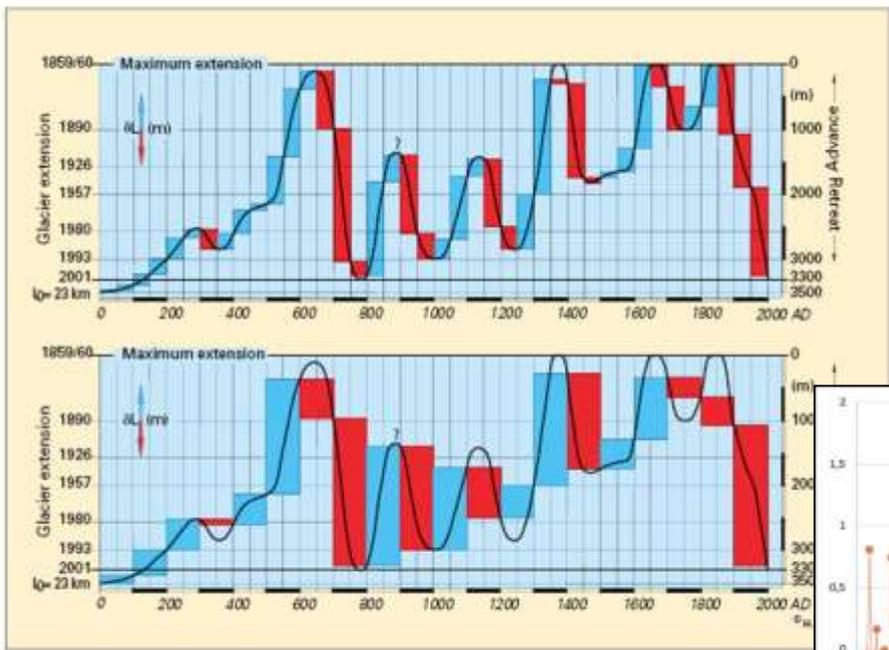
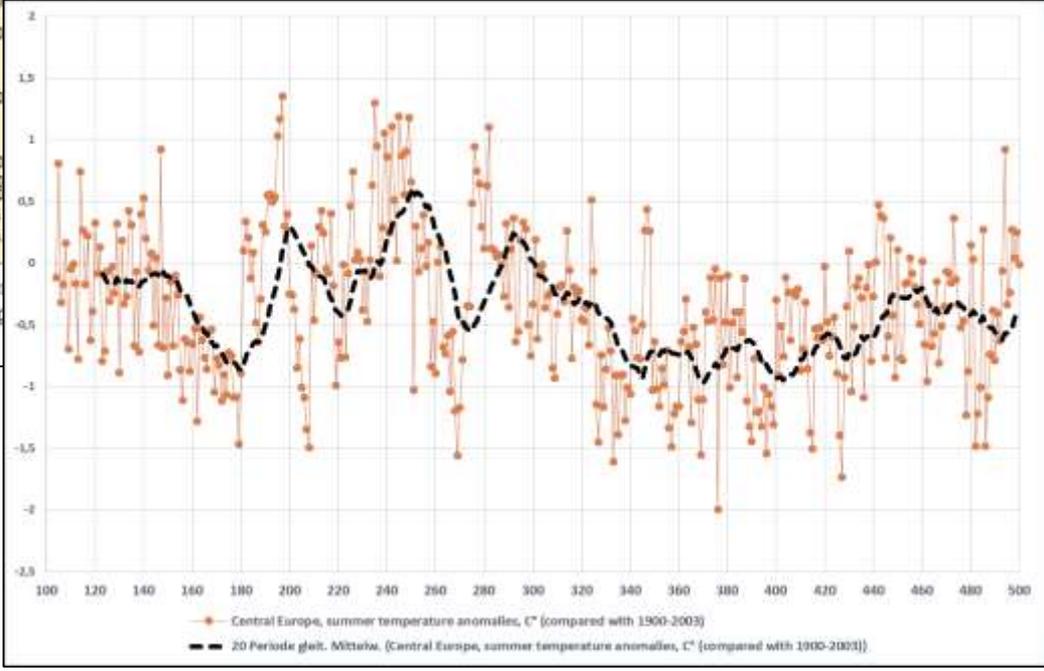


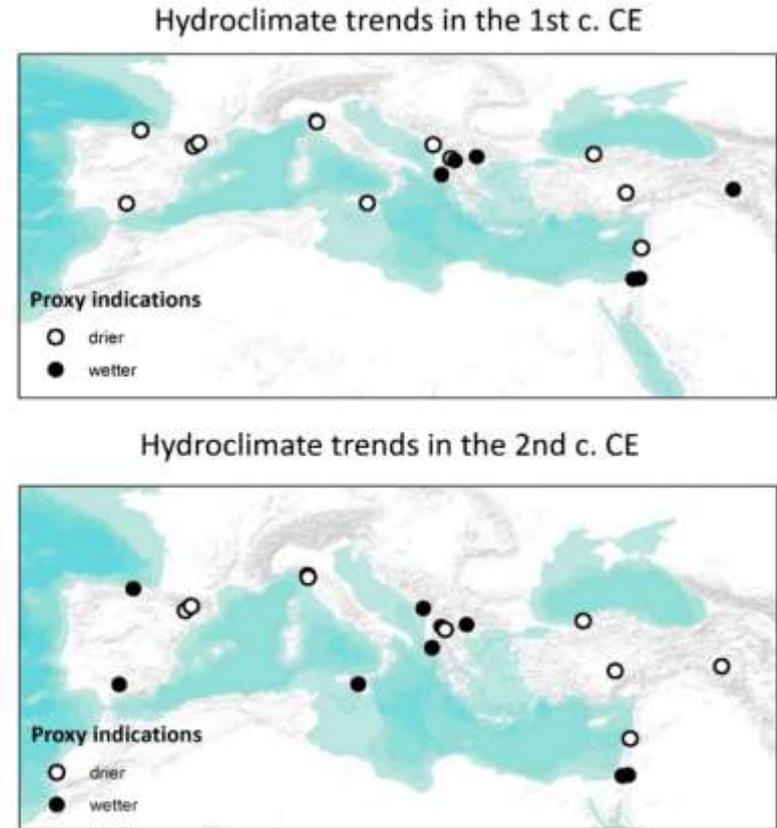
Fig. 2: Fluctuations of the Great Aletsch Glacier during the last 2000 years reconstructed from historical documents and dendrochronologically/absolutely dated fossil wood. Average balance calculated for time intervals of 50 years (on top) and of 100 years (below).



# Not so „optimum“ everywhere in the Roman Mediterranean

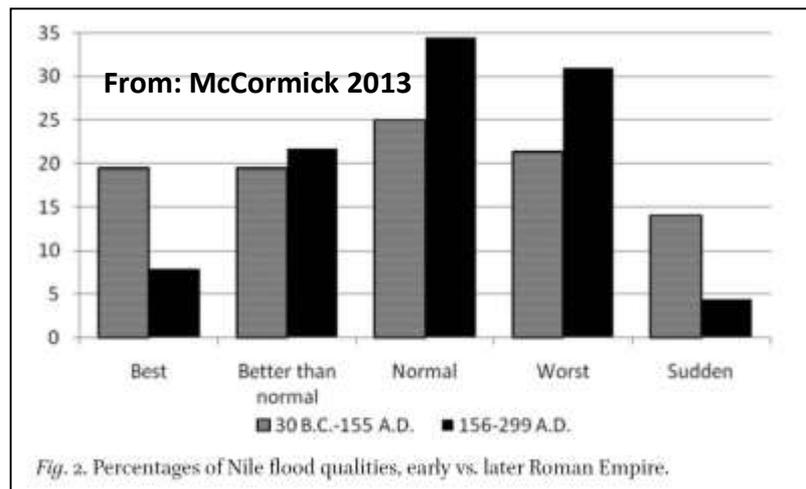
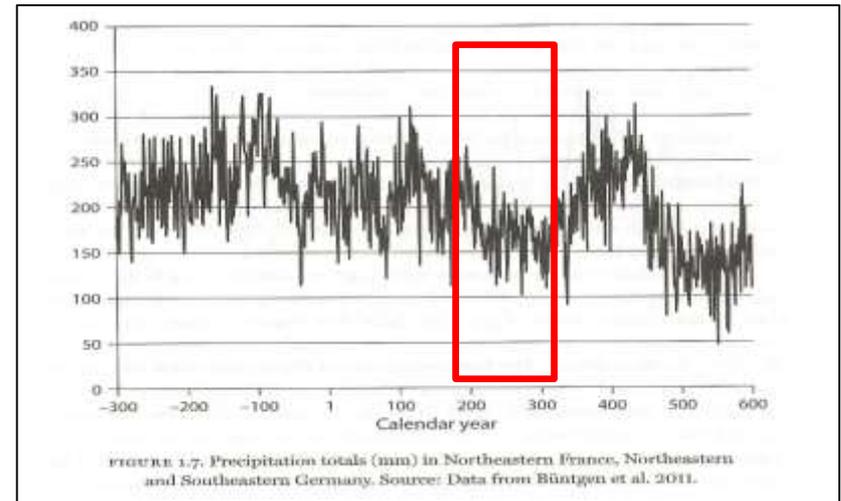
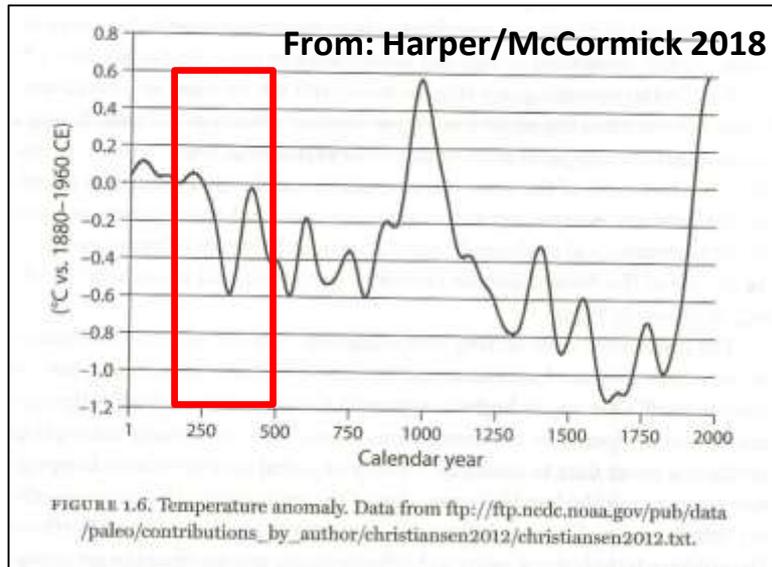
“The map shows that in each century some regions were experiencing drier conditions (i.e., decreased average precipitation levels), whereas others were experiencing wetter conditions. Although there were places, such as Palestine, where wetter conditions did indeed prevail over the entire two centuries, in many other places it was quite different. To claim that the Roman Climate Optimum was warm, wet, and stable in both the southern and northern halves or in much of the Roman Empire (...) is a clear exaggeration.”

Haldon et al., Review of Harper, 2018

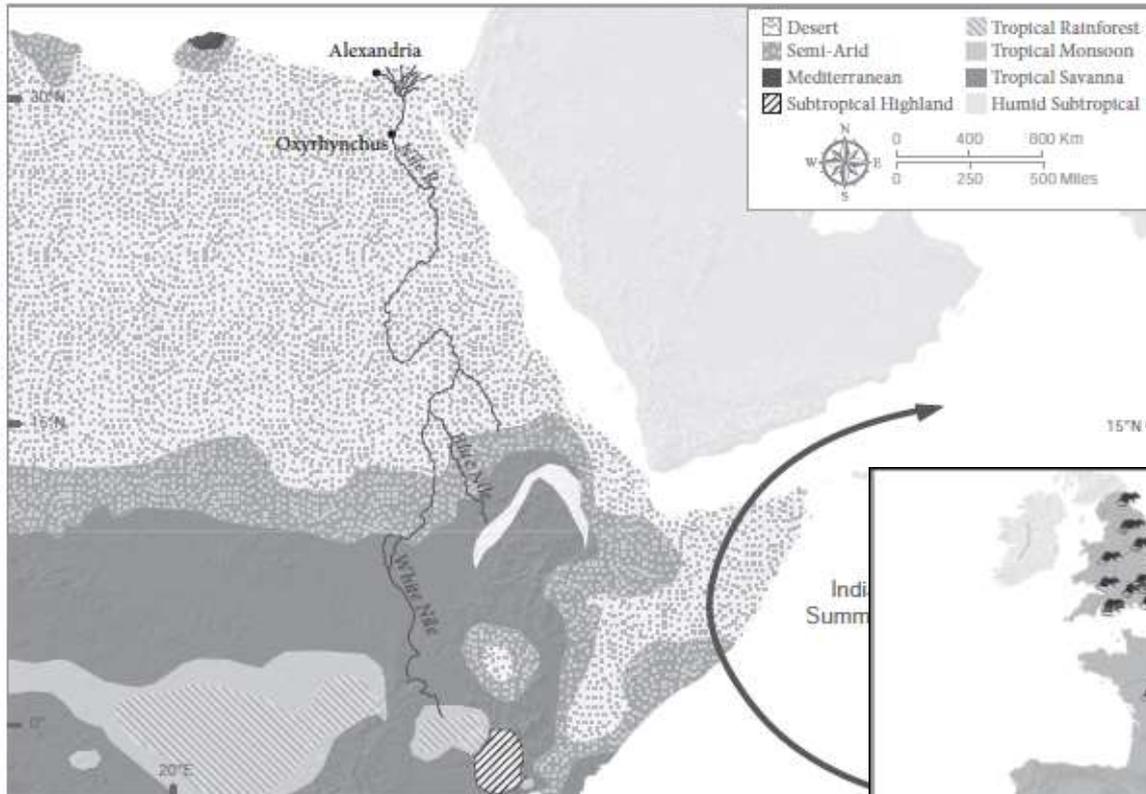


**Map 1** Patterns of dryness and wetness across the Mediterranean at the times of the early Roman Empire. Drier/wetter indicates mean conditions for a given century as compared with the first-millennium CE average for a given site (map based on analysis in Labuhn et al., 2018; basic data accessible in Roberts et al., 2012).

# The beginning of the transition to the “late antique cold period”, 2nd-3rd cent. CE: from the "Antonine plague" to the imperial crisis of the 3rd century?



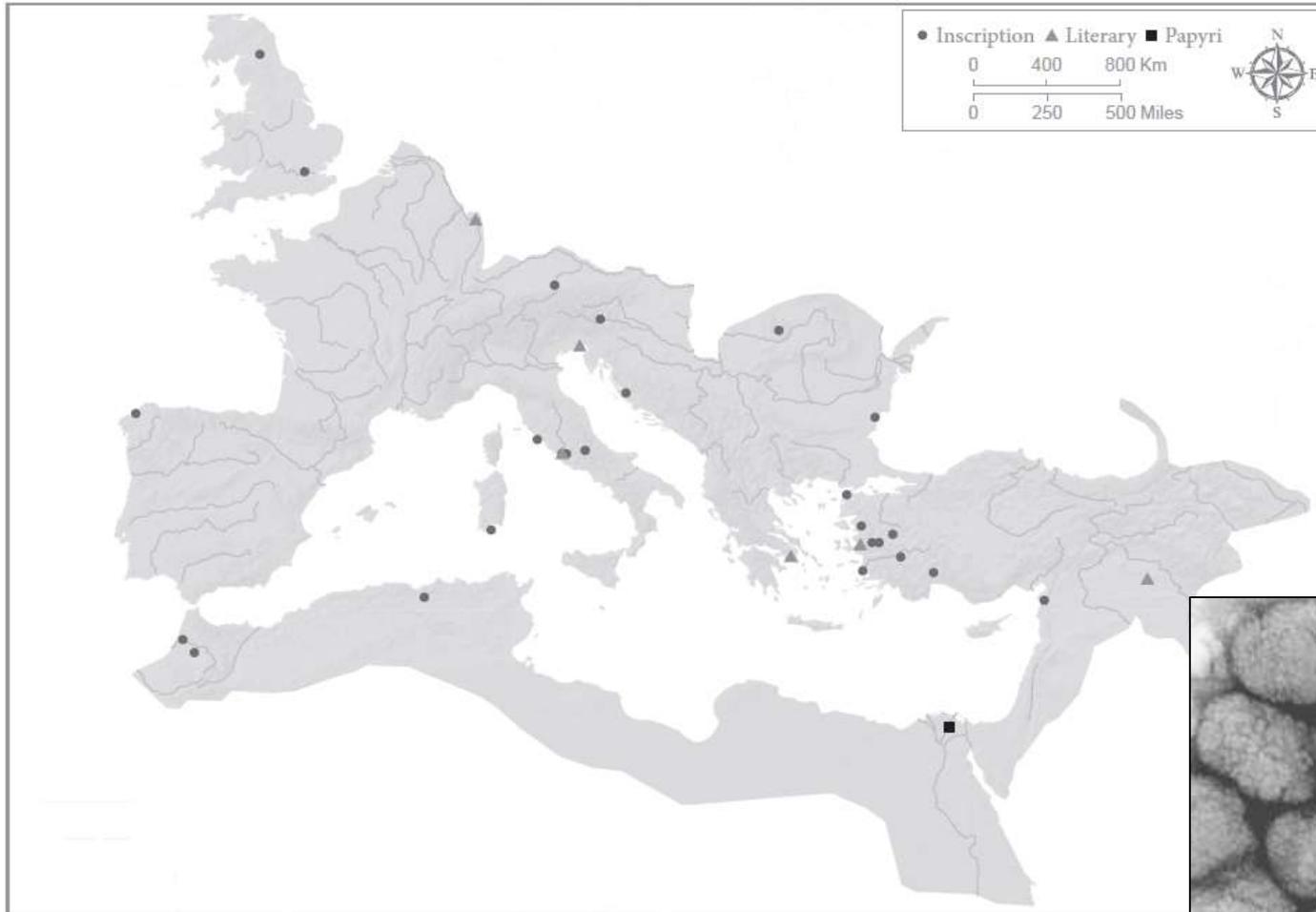
# Biotransfers and a new „disease ecology“ in the Imperium Romanum (Harper 2017)



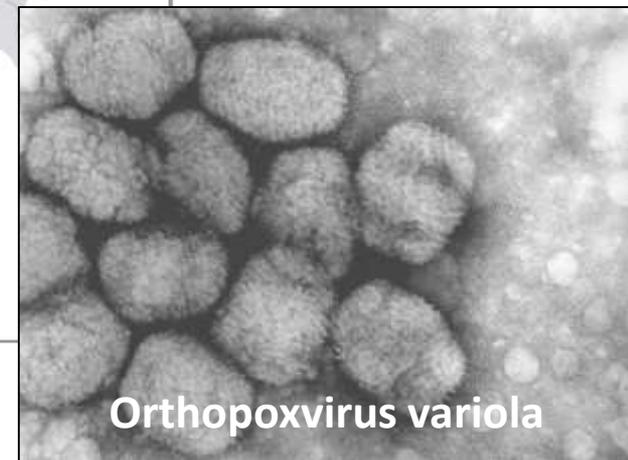
Map 11. Nile Hydrology and Climate Mechanisms



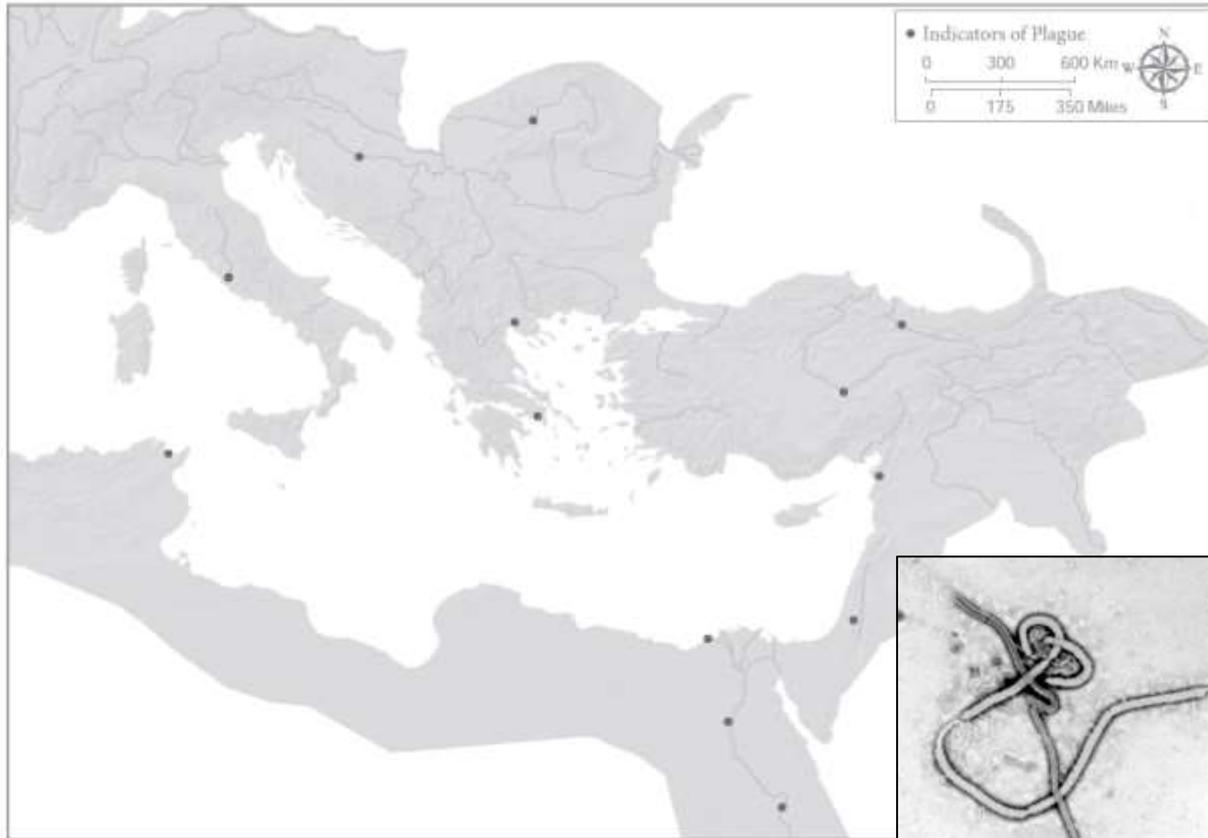
**“Germs are far deadlier than Germans” [?]  
(Harper, Fate of Rome, p. 18) –  
the Antonine Plague, 165-180 CE**



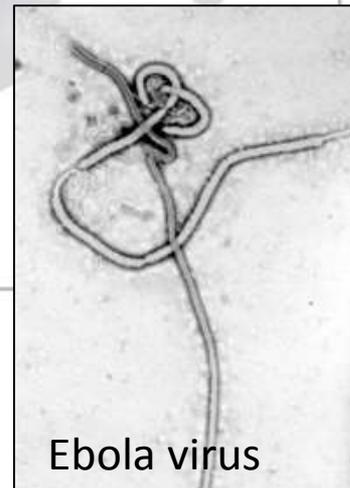
*Map 10. Possible Indications of Antonine Plague*



# The „Plague of Cyprian“ (249-262 CE), Egypt, and the Crisis of the 3rd century



Map 12. Indications of Plague of Cyprian

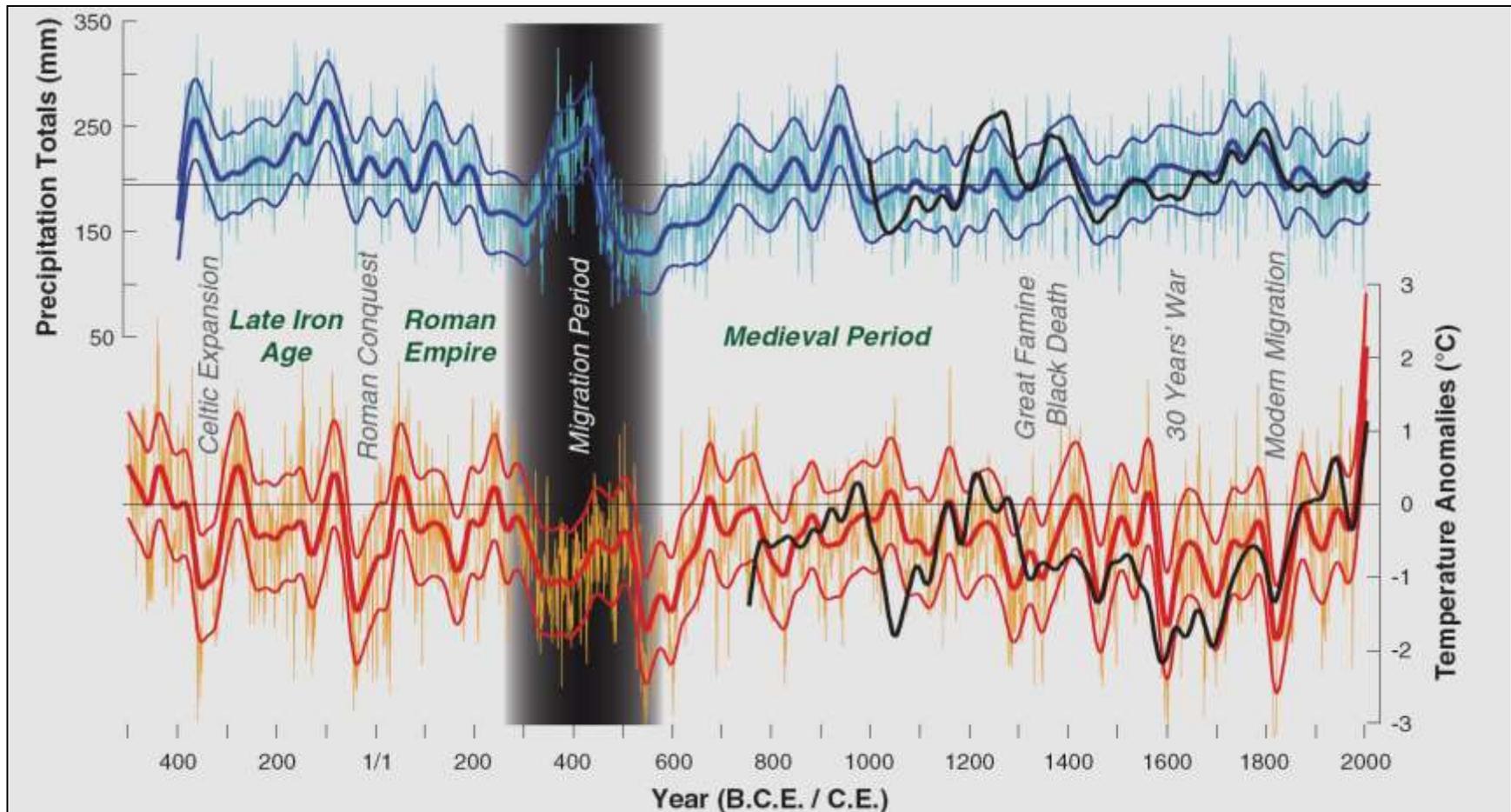


Ebola virus

“We possess roughly 22,000 papyri dated to the third century CE (according to a search in the online database papyri.info, which includes all edited papyri). (...) Should we thus not expect to find multiple references among the papyri to a mass mortality event of that scale? We do not.”

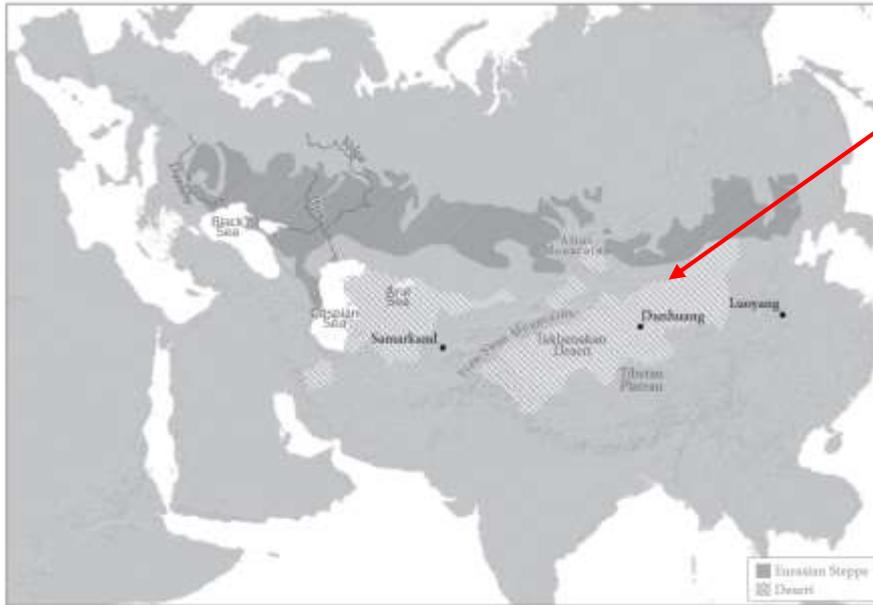
Haldon et al., Review of Harper, 2018

# The transition between antiquity and the Middle Ages in Western Europe seen from a climatic point of view: The “*Vandal minimum*”?



Reconstruction of the course of precipitation and temperature conditions in Central Europe, 400 BCE – 2000 CE (from: U. BÜNTGEN et al., 2500 Years of European Climate Variability and Human Susceptibility. *Science* 331 [February 2011] 578-582).

# The Huns, the “Völkerwanderung” and the climate (4th-5th centuries CE)



Map 16. The Eurasian Steppe

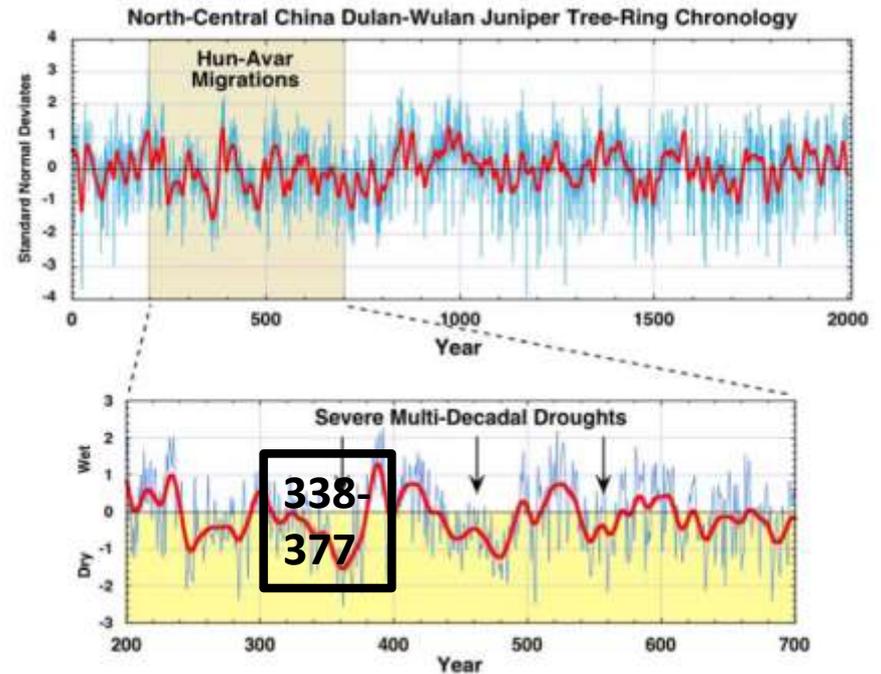
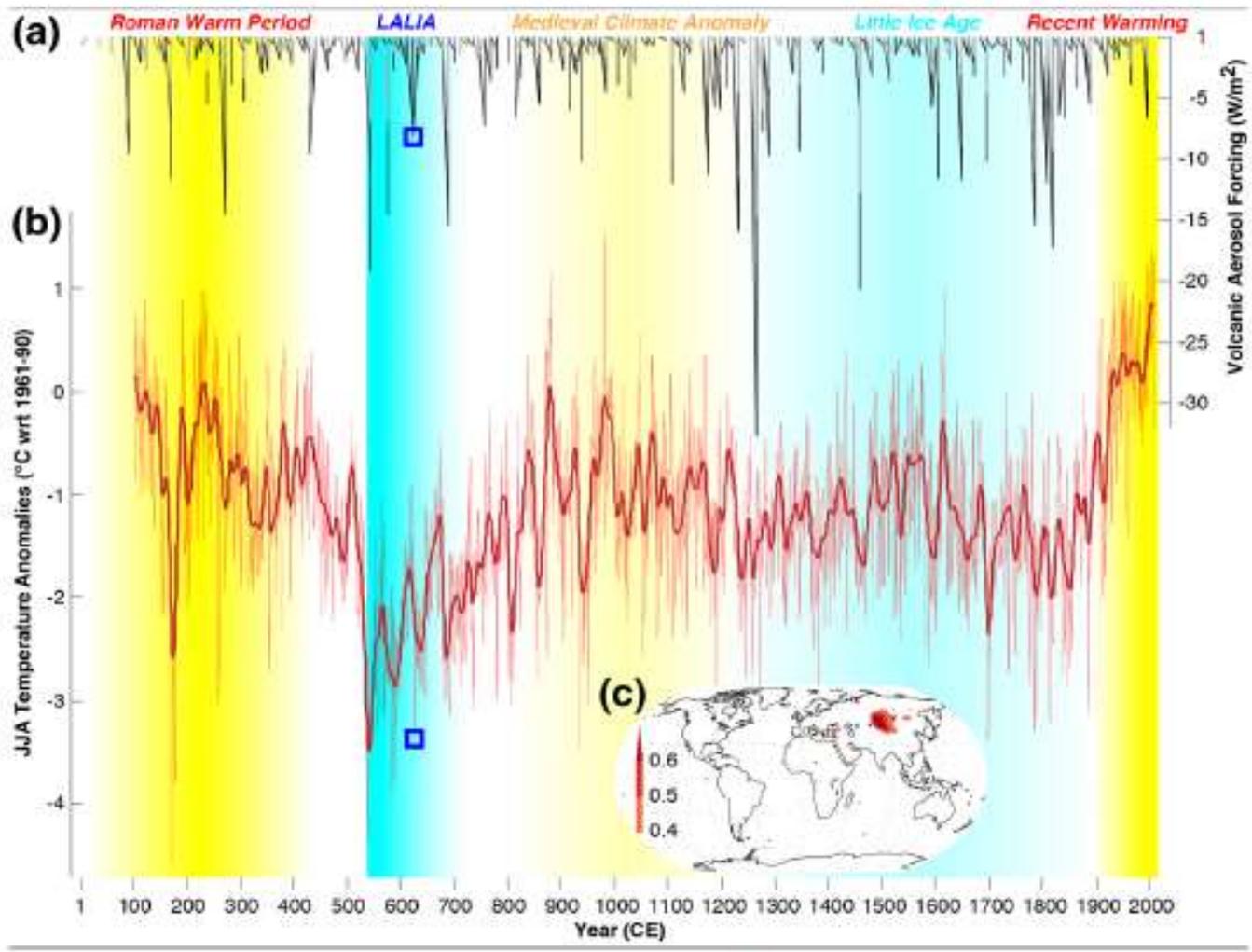


Fig. 1. The Dulan-Wulan annual tree-ring chronology from north-central China and the occurrence of severe droughts during the times of the Hun-Avar migrations into late-Roman Europe. Three multi-decadal droughts, among the worst of the past 2,000 years, are indicated in the 4th, 5th, and 6th centuries AD at around known times of invasion by these nomadic peoples from central Asia. The lower plot illustrates this more clearly.

From: Cook 2013

# Volcanic forcing and temperature reconstructions from the Altai



**Fig. 3** **a** Ice core-derived hemispheric (light gray) and global (dark gray) estimates of volcanic aerosol forcing (Sigl et al. 2015). **b** Reconstructed June–August temperature means from the Russian Altai (Büntgen et al. 2016), with the smoothed curve referring to 20-year low-pass filtering (dark red). The blue boxes indicate 626 CE and the colored background shadings suggest the timing of major climatic episodes during the last two millennia. **c** Spatial field correlations (1950–2011) of the Altai summer temperature reconstruction against the global “Berkeley” dataset (Rohde et al. 2013) of gridded 1° latitude/longitude June–August temperature means (see Fig. S2 for details)

# The late antique climate change in global perspective

From: Harper 2017

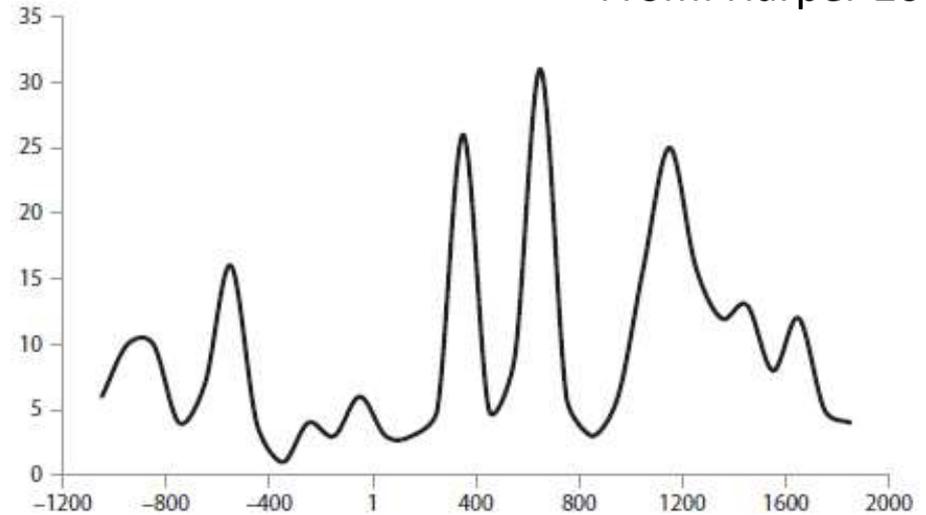


Figure 4.2. El Niño Events per Century (data from Moy et al. 2002)

corr Dec–Feb NINO3.4 index  
with Dec–Feb CRU TS3.22 temperature 1901:2013

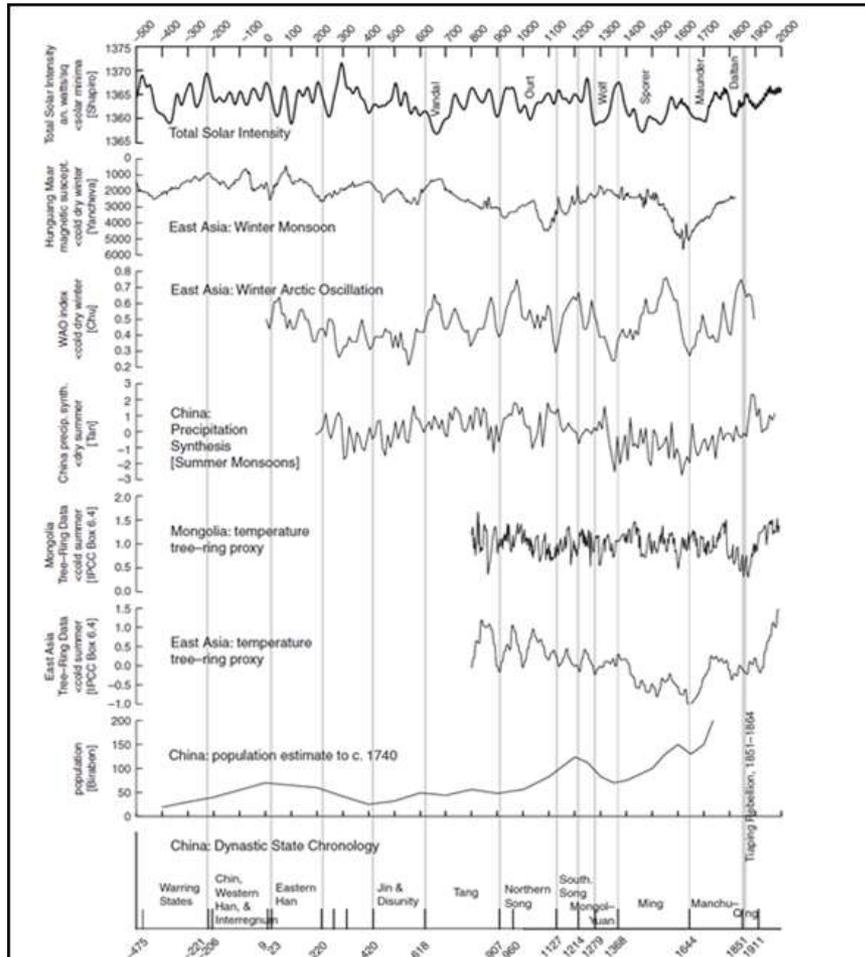
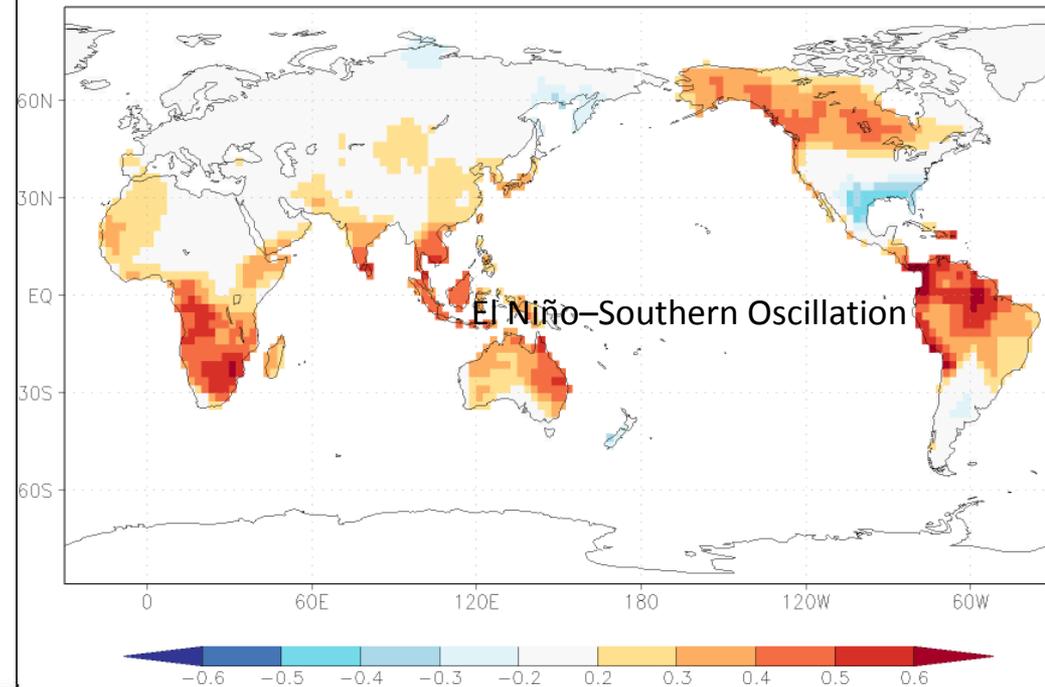
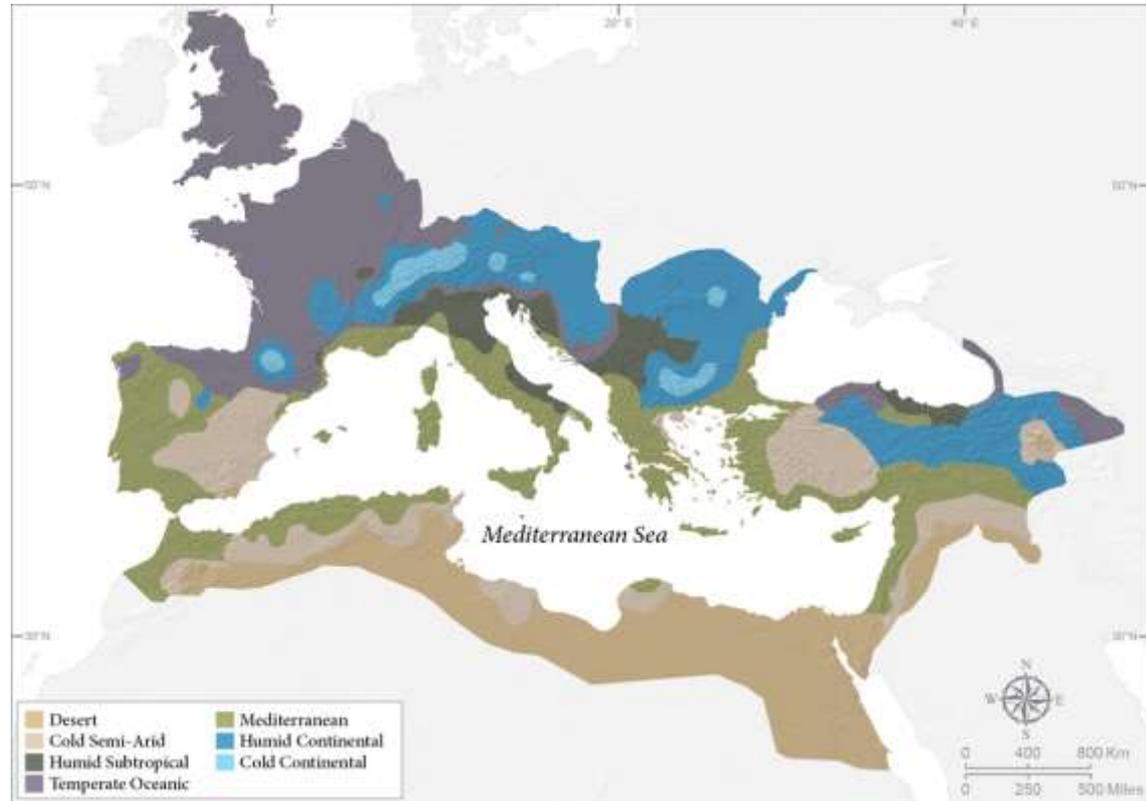
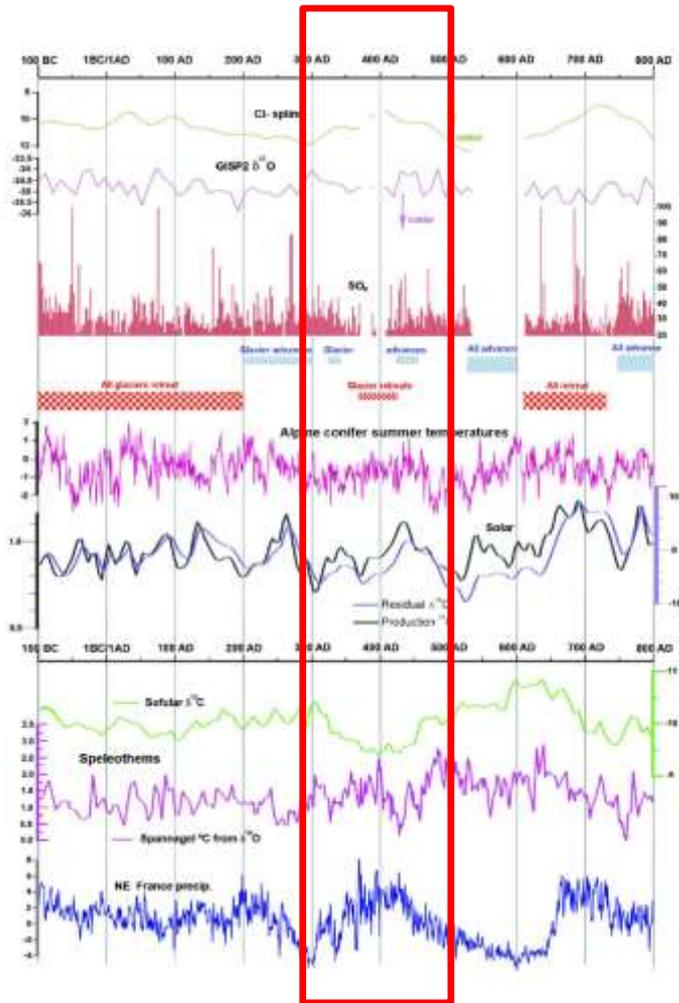


Figure III.5c. Climatic change and the dynastic state in China, 475 BC–AD 1911.

Again, dynastic crises in China align with climatic downturns, which were manifested in erratic summer monsoons, flooding and especially cold and dry winter monsoons from Siberia.

Brooke 2014

# Different climate signals and regional diversity in the Roman Empire for the 4th-5th cent. CE

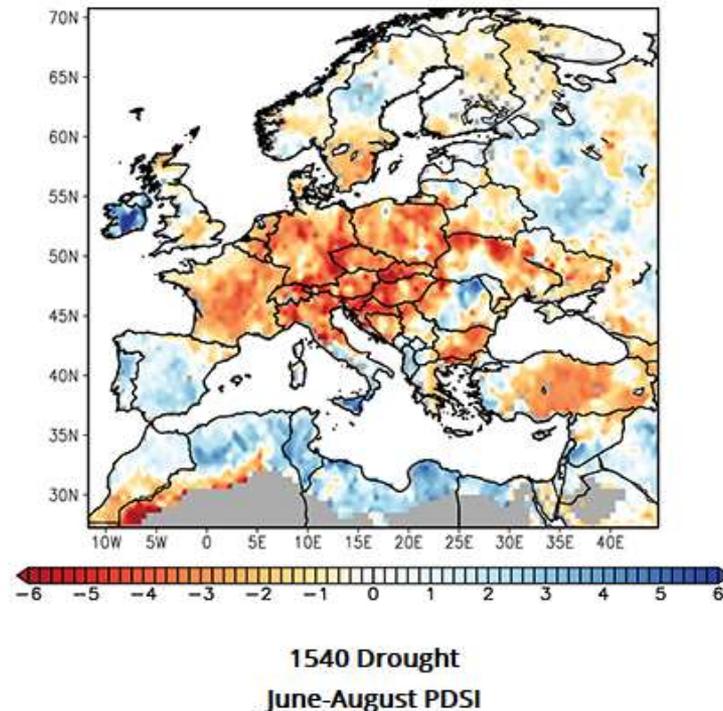


McCormick et al. 2012

<https://www.vox.com/the-big-idea/2017/10/30/16568716/six-ways-climate-change-disease-toppled-roman-empire>

# Old World Drought Atlas

[Home](#) [Maps](#) [Time Series](#) [Help](#)



Welcome to the Old World Drought Atlas. This web application provides access to summer (June-August) reconstructions of the self-calibrating Palmer Drought Severity Index (PDSI) on a 0.5° latitude/longitude grid centered over Europe, North Africa, and the Middle East from AD 0000-2012. The reconstructions are derived from 106 tree-ring chronologies. For further details on the reconstructions, see Cook et al. (2015, link below).

Maps and time series can be created using tools under the "Maps" and "Time Series" menus, respectively. For details on how to create maps and time series, see the "Help" menu. An animation that runs through each year of the reconstruction from AD 0000-2012 is available via the link below.

- [Old World Drought Atlas Animation AD 0000-2012](#)

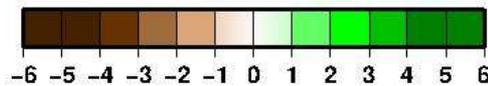
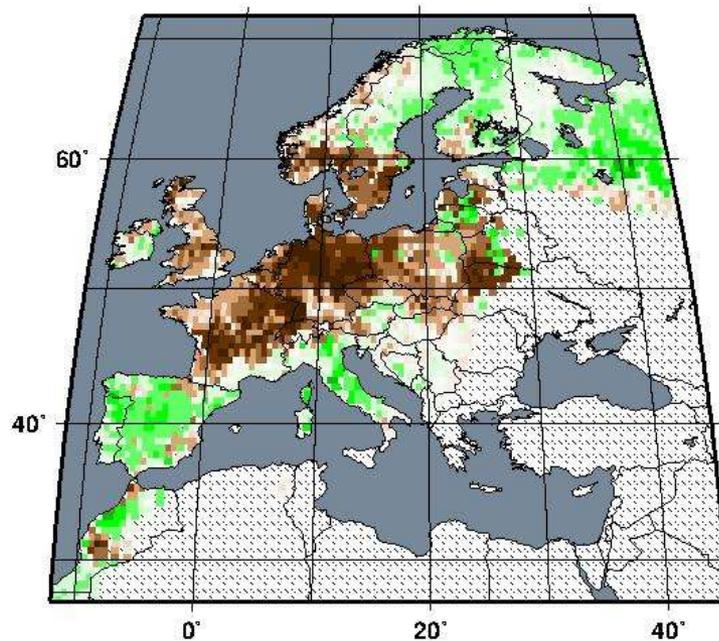
Questions, comments, or suggestions may be sent to [Dorian J. Burnette](#).

Citation: Cook, E.R., R. Seager, Y. Kushnir, K.R. Briffa, U. Buntgen, D. Frank, P.J. Krusic, W. Tegel, G. van der Schrier, L. Andreu-Hayles, M. Baillie, C. Baittinger, N. Bleicher, N. Bonde, D. Brown, M. Carrer, R. Cooper, K. Cufar, C. Dittmar, J. Esper, C. Griggs, B. Gunnarson, B. Gunther, E. Gutierrez, K. Haneca, S. Helama, F. Herzig, K-U. Heussner, J. Hofmann, P. Janda, R. Kontic, N. Kose, T. Kyncl, T. Levanic, H. Linderholm, S. Manning, T. M. Melvin, D. Miles, B. Neuwirth, K. Nicolussi, P. Nola, M. Panayotov, I. Popa, A. Rothe, K. Seftigen, A. Seim, H.

# Precipitation and drought data from the *OWDA*, 300-500 CE

TREE-RING RECONSTRUCTED DROUGHT

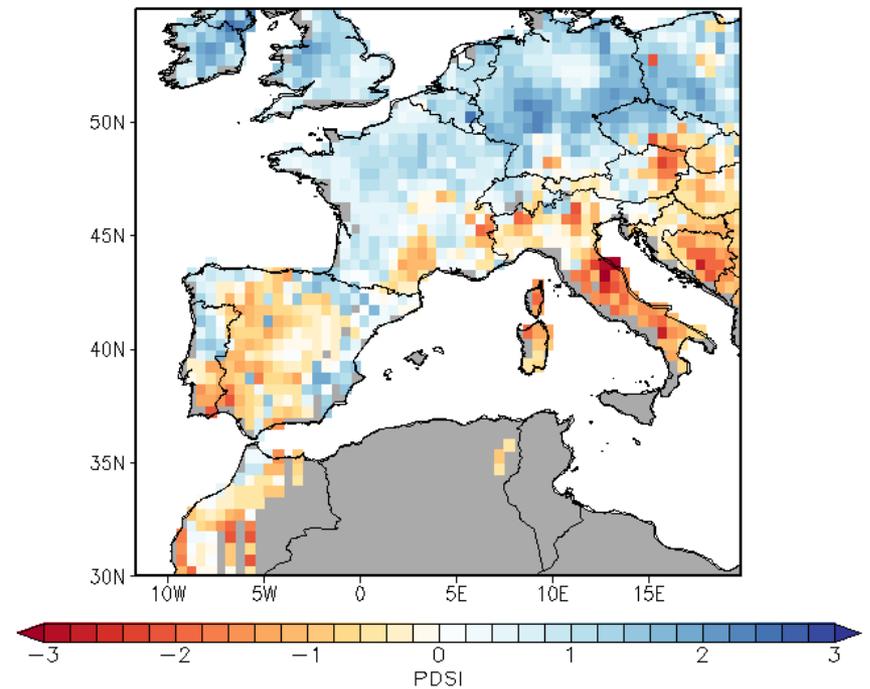
476



scPDSI

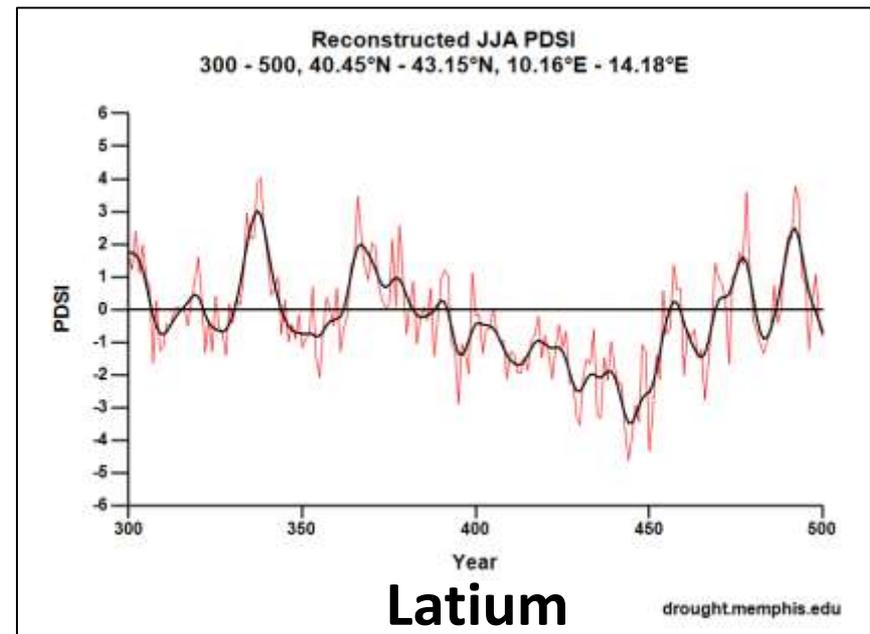
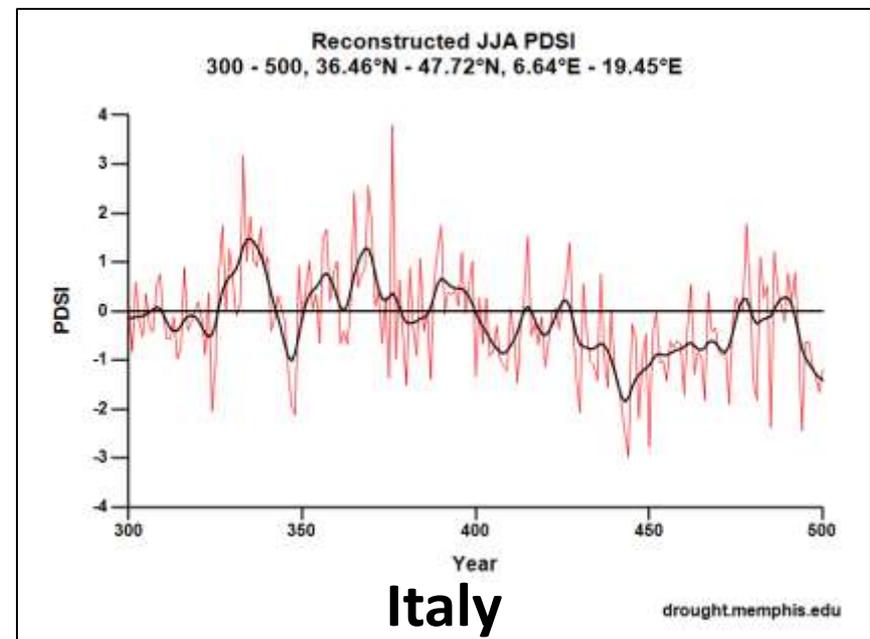
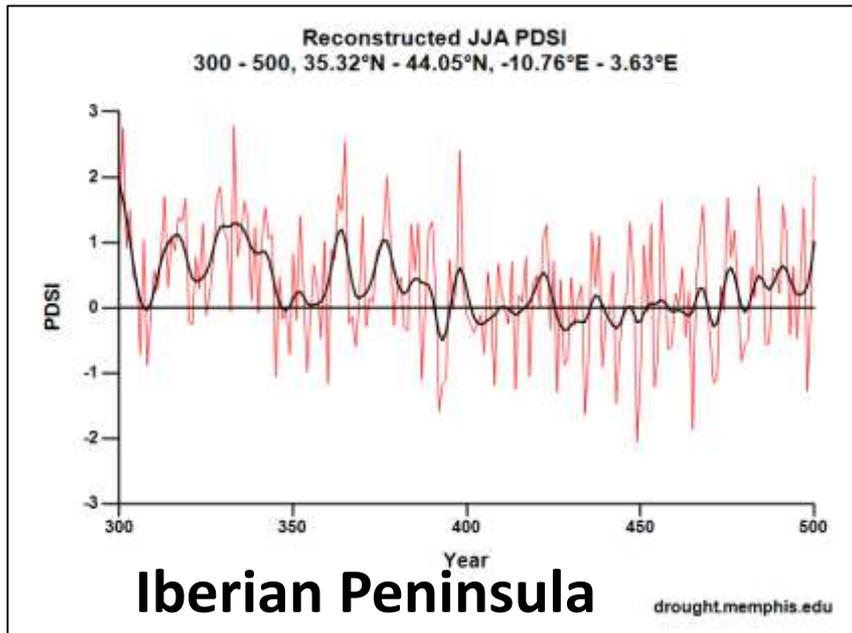
Reconstructed JJA PDSI

400 - 450



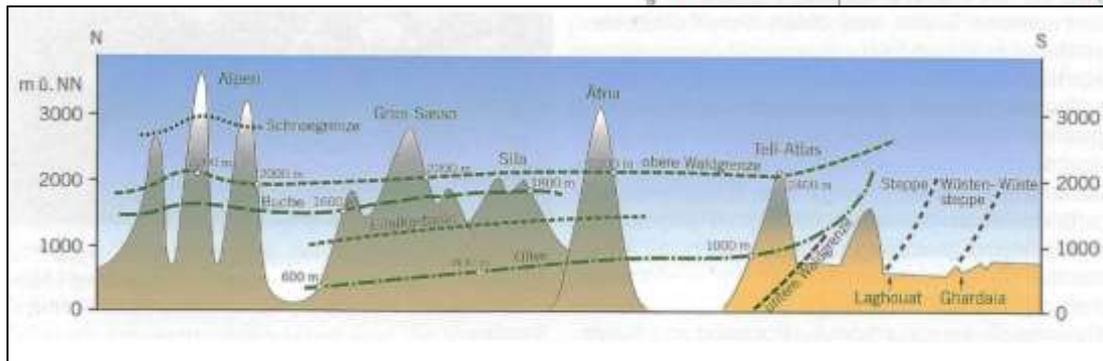
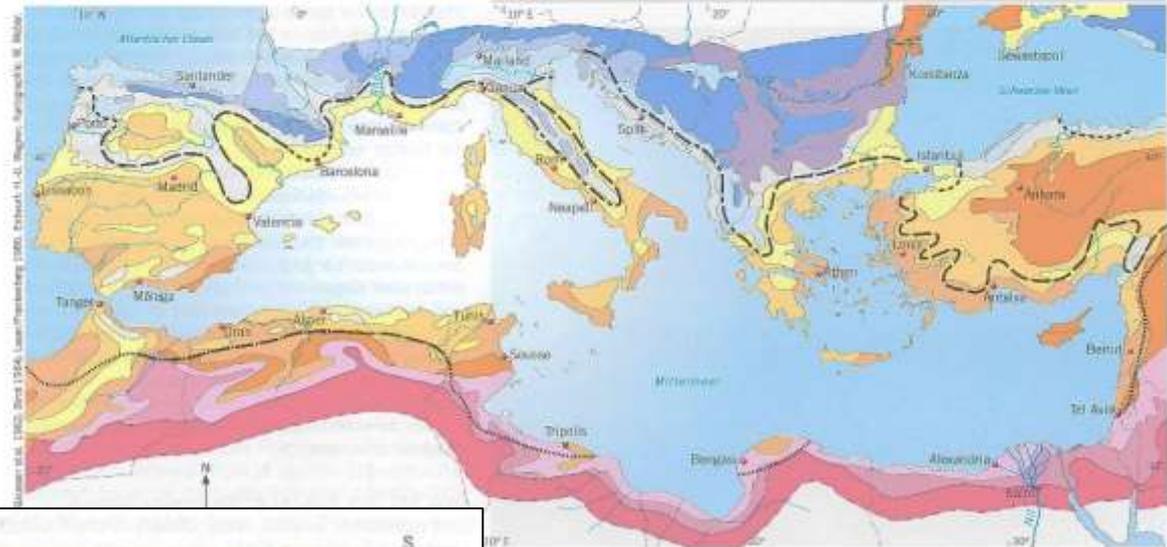
drought.memphis.edu

# Precipitation and drought data from the *OWDA*, 300-500 CE



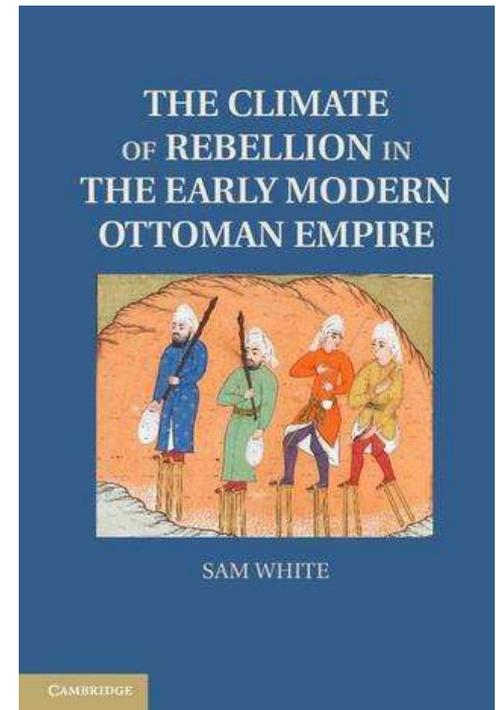
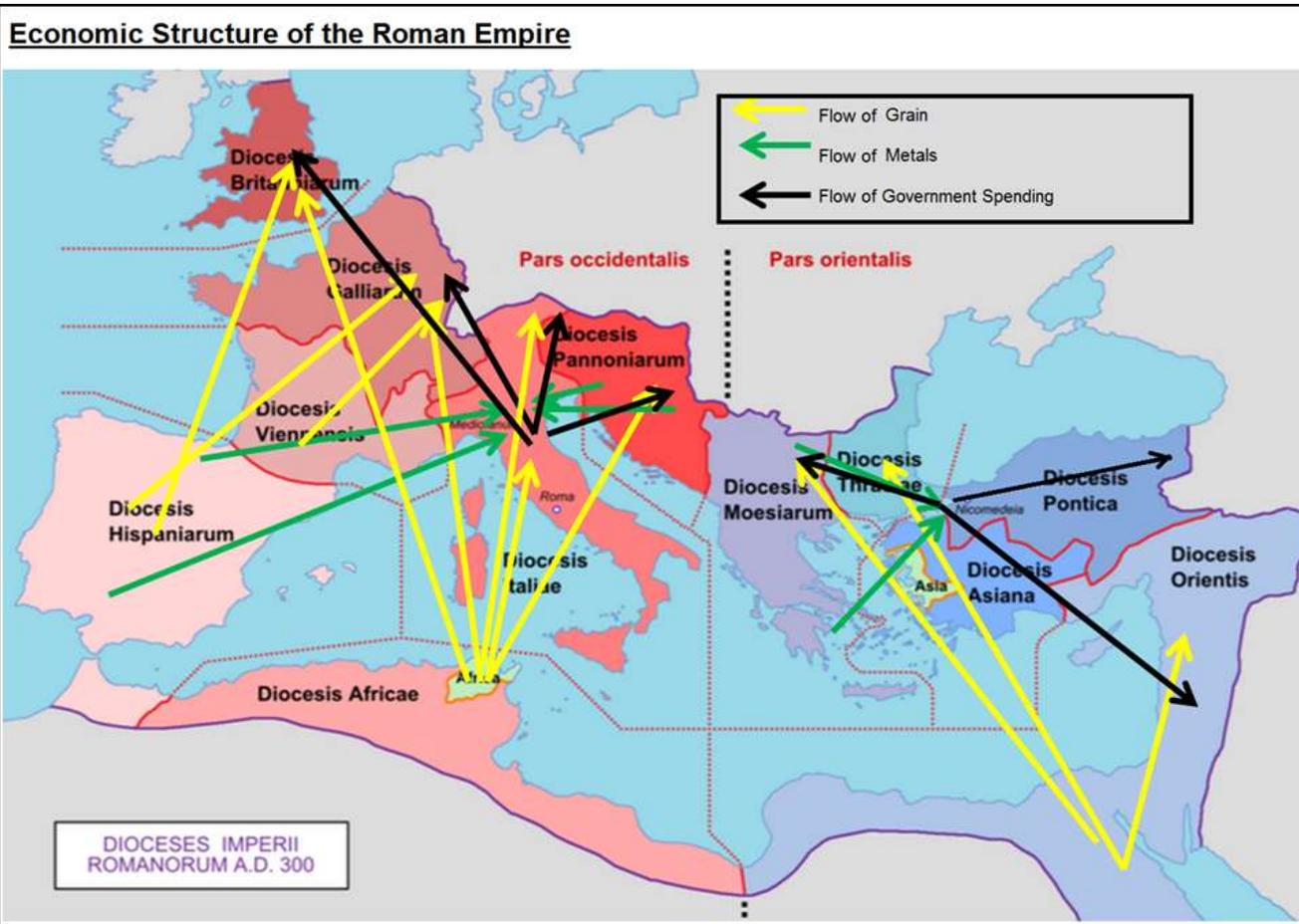
# A Mediterranean of „micro-regions“ und „micro-ecologies“ (Horden/Purcell, The Corrupted Sea)

		bioklimatische Trockenstage	zählige Monate	Grenze der Verbreitung des Ökotyps
1	Wartungsluft kontinental Somme kalter und arkt. Monate 2-4			--- Sommerkälte und Winterkälte
2	humid, kalt, 1-4 Monate < 10° C	0	1	----- Sommerkälte
3	humid, kühl temperat, kältester Monat 0-10° C	0	2	----- Winterkälte
4	humid, Subtropen mit kurzer Trockenperiode	0	1-2	----- Trockenheit
5	mediterran-humid	0-40	2-3	----- Winterkälte und Trockenheit
6	submediterran-subhumid	40-75	3-4	
7	submediterran-temperat	75-100	4-5	
8	mediterran-temperat	100-150	5-6	
9	mediterran-subarid	150-200	6-7	
10	and mit mediterranem Klimatypenregung	>200	7-8	
11	vollarid		9-10	
12	überarid		11	
				□ nicht bearbeitete Gebiete

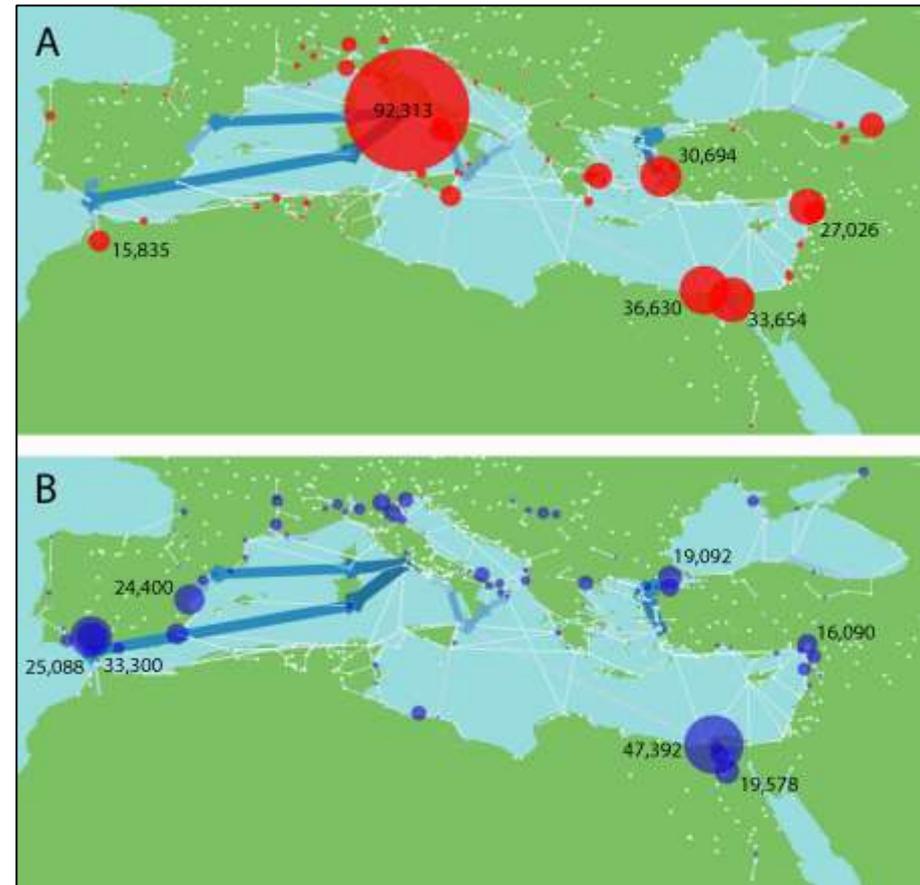
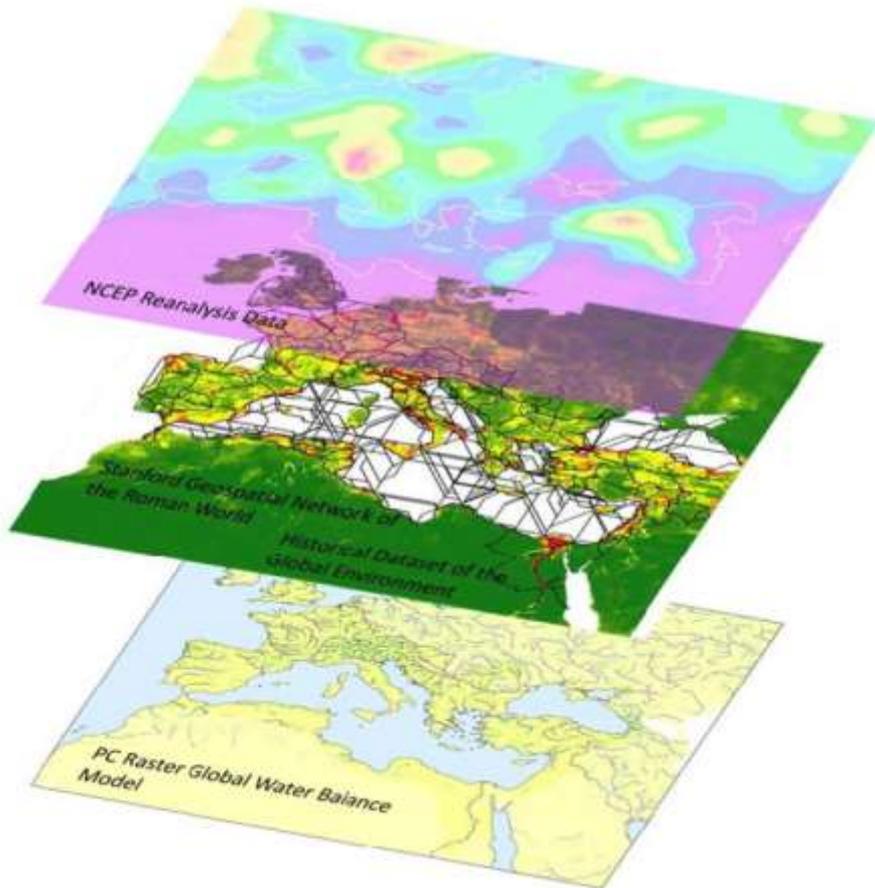


From: Wagner 2011

*„Imperial Ecology “ – “particular flows of resources and population directed by the imperial center on which its success and survival depended” (Sam White 2011)*



# The Imperium Romanum as „virtual water network“

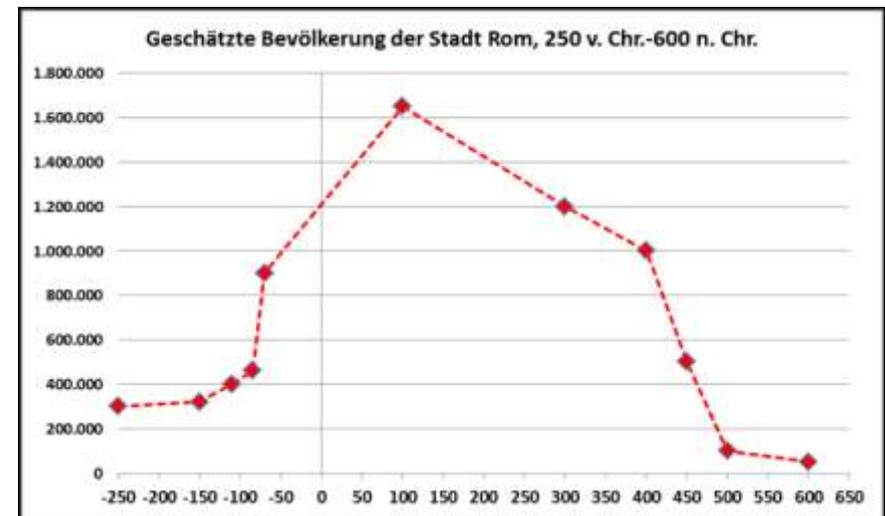
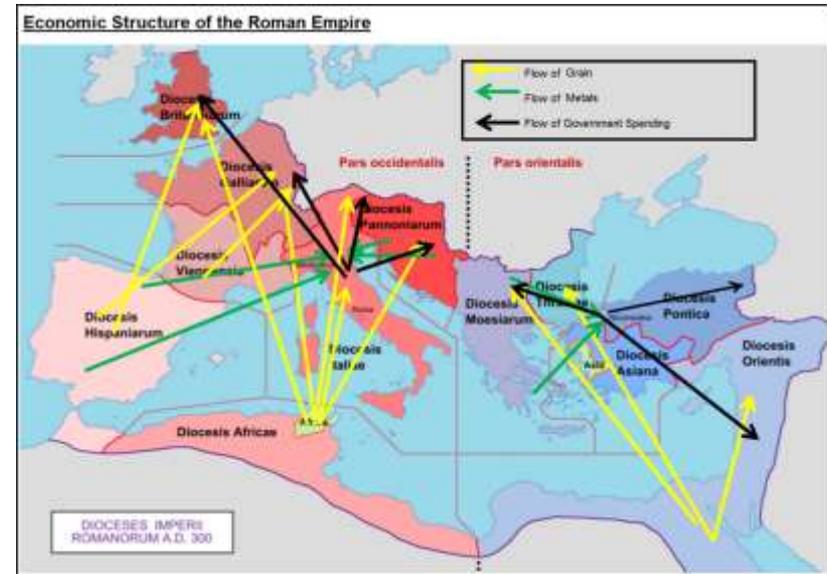


Brian J. Dermody et al., A virtual water network of the Roman world. *Hydrology and Earth System Sciences*, 2014  
<http://www.hydrol-earth-syst-sci.net/18/5025/2014/hess-18-5025-2014.html>

# The „urban metabolism“ of the imperial centre as one core of the imperial ecology

Imperial Rome was “an example of a system that could only maintain its size (...) on the basis of a political system that guaranteed the supply flows. The drastic shrinking was not due to an ecological collapse but to an institutional breakdown. The metabolism of such large systems is not robust because it cannot maintain itself without a huge colonized hinterland. It has to reduce its population to a size that is in balance with its economically and ecologically defined hinterland.”

P. Baccini – P. H. Brunner, *Metabolisms of the Anthroposphere. Analysis, Evaluation, Design.* Cambridge, Mass. – London 2012, 58.



# The urban metabolism and forest management to north of Rome, 1st-5th cent. CE (*dendrophori*; B. Graham )



<http://edh-www.adw.uni-heidelberg.de/iiif/edh/HD016837.manifest.json>

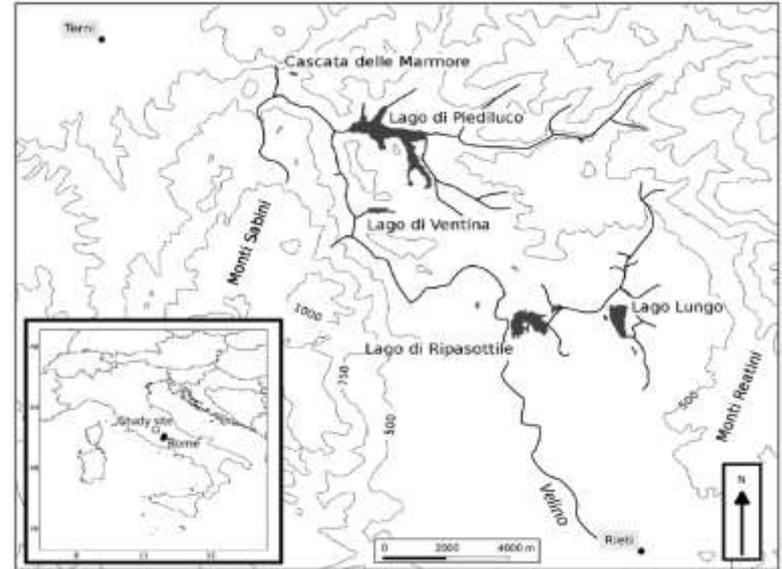


Fig. 1. Kees Basin study site map.

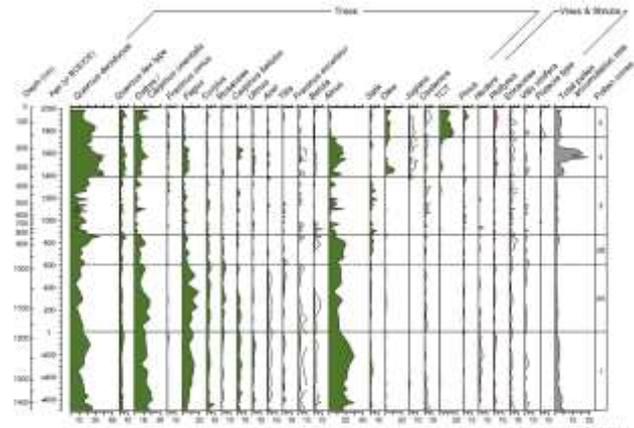
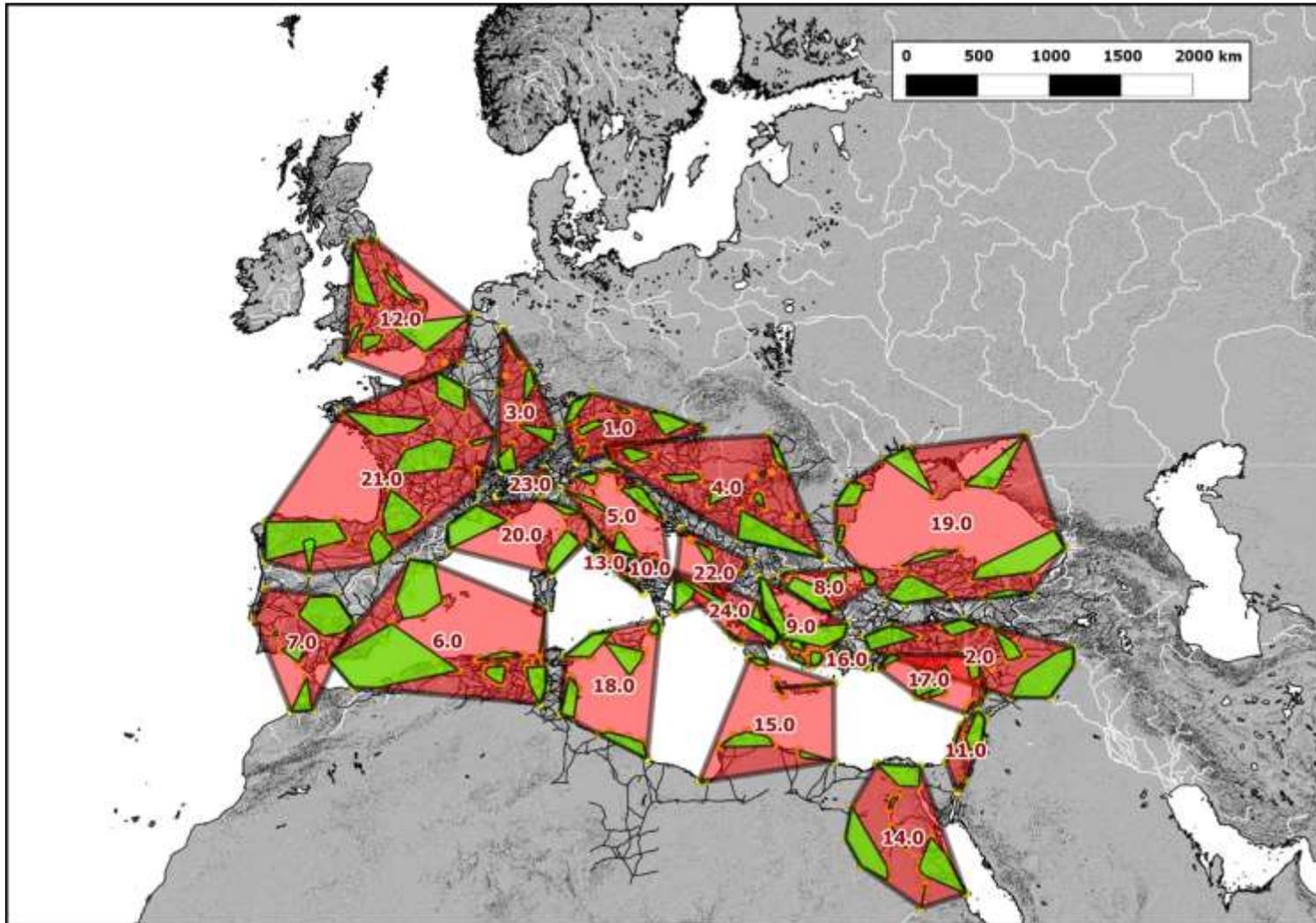


Fig. 11. Selected pollen taxa of trees, shrubs and herbs and total pollen accumulation rates (indicated bars represent 10% aggregates).

S. Mensing et al., 2700 years of Mediterranean environmental change in central Italy: a synthesis of sedimentary and cultural records to interpret the past impacts of climate on society, *Quaternary Science Reviews* 116 (2015) 72-94.

Benjamin Graham and Raymond Van Dam, *Modelling the Supply of Wood Fuel in Ancient Rome*. (Late Antique Archaeology 12) (Leiden 2018), pp. 148-159

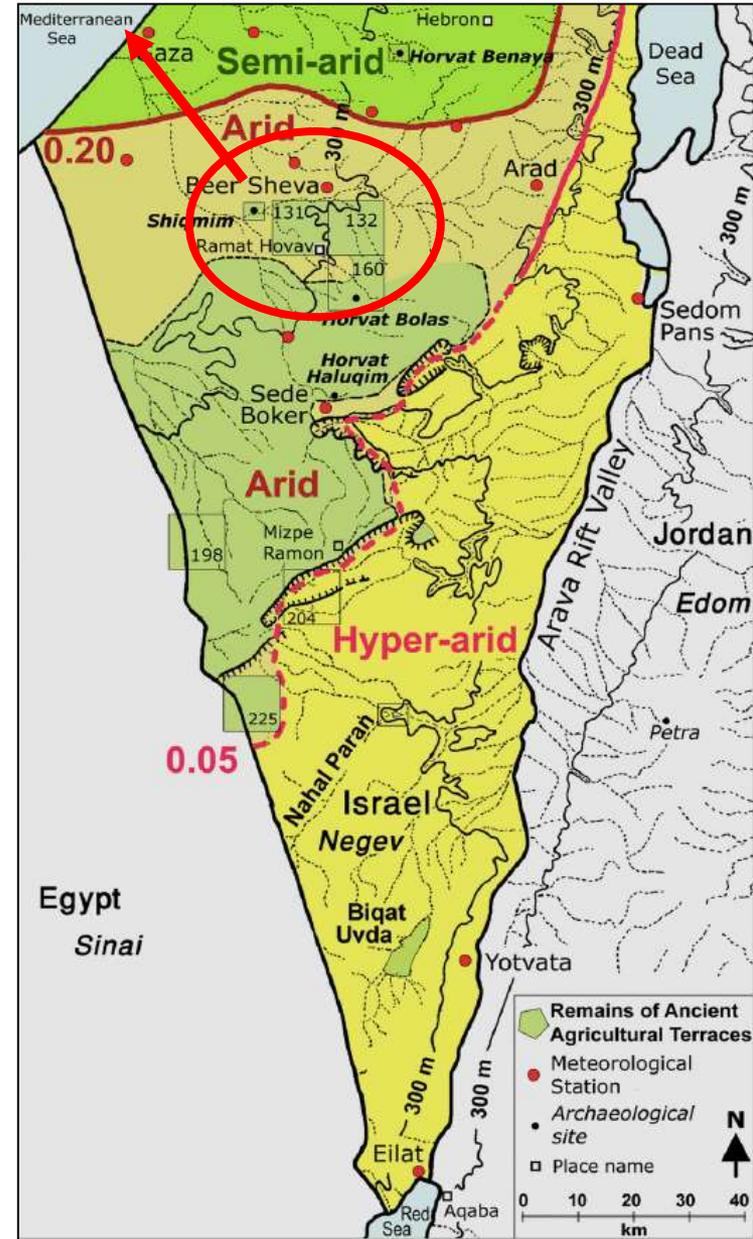
# The collapse of the imperial system in the Roman West: „*institutional breakdown*“?



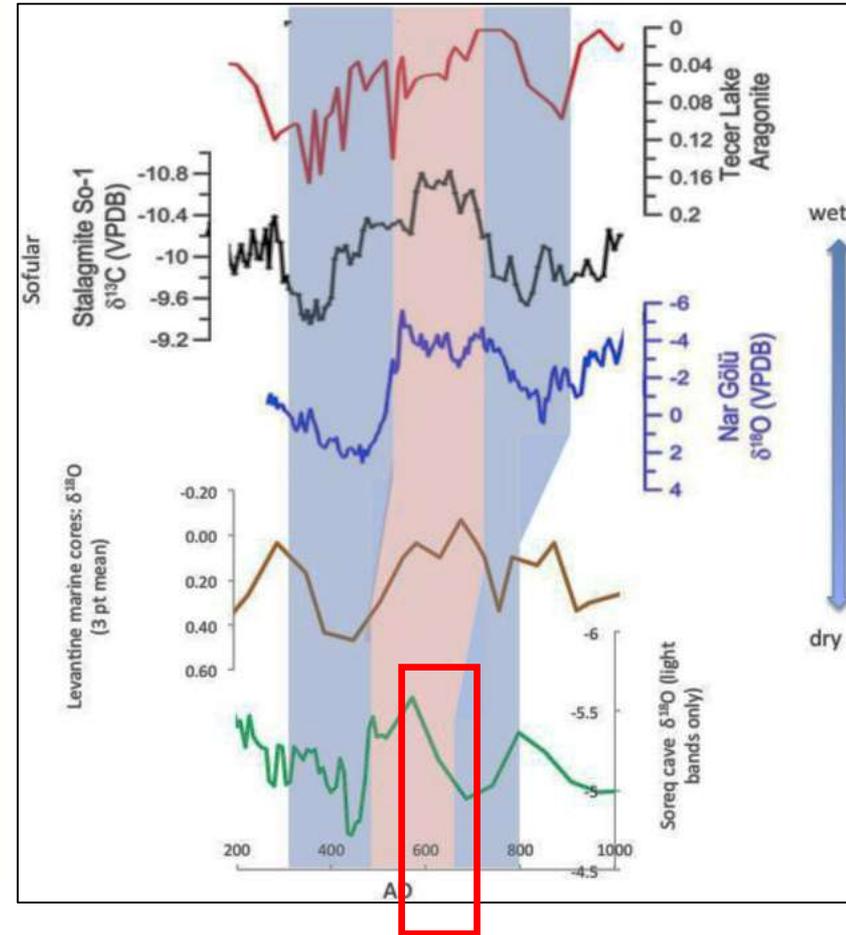
# The Roman East: Shivta, settlement and agriculture in the late antique Negev



Nabatean-Byzantine cultivated terraces in Nahal Horsha, western Negev Highlands. Aerial photograph from the northeast (Photo: Uzi Avner).



# The end of settlement and agriculture in the Negev around 540 CE



J. Ramsay et al. / Journal of Archaeological Science: Reports 9 (2016) 718–727

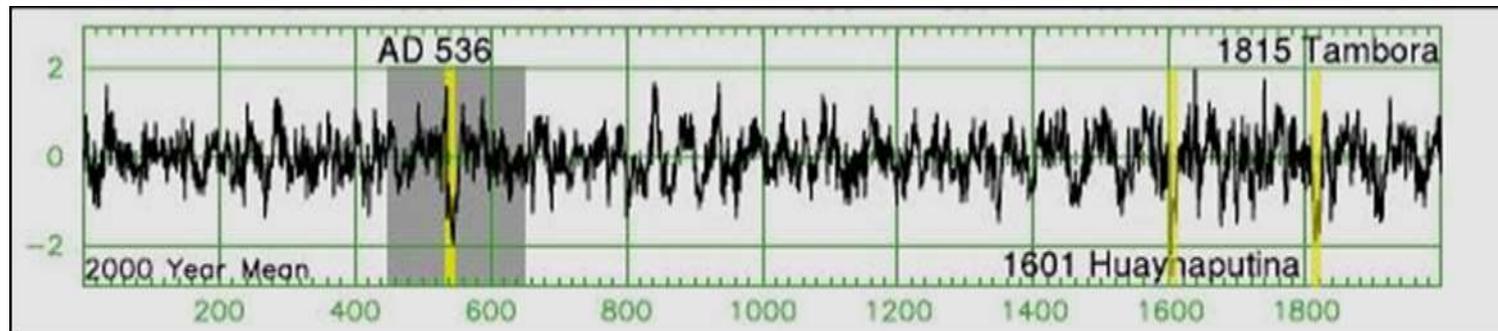
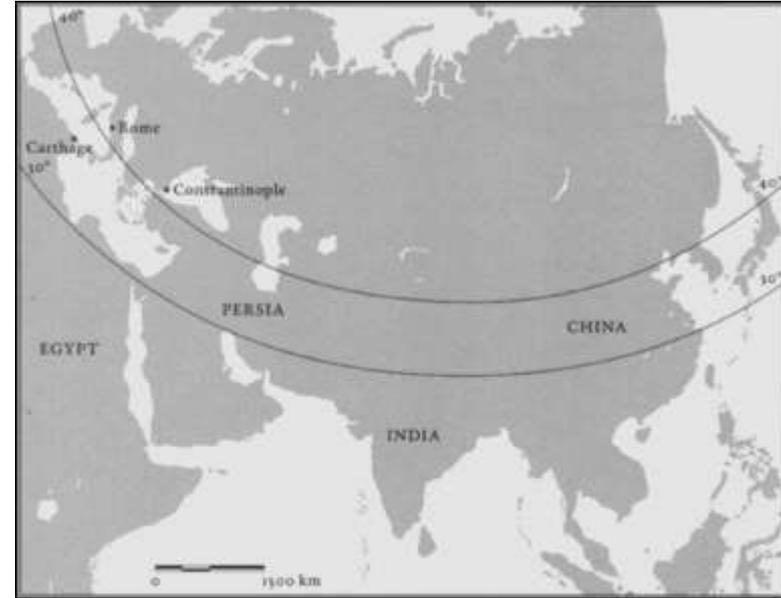
Y. Tepper et al. / Journal of Arid Environments 145 (2017) 81-89

<https://doi.org/10.1016/j.quascirev.2015.07.022>  
(Izdebski u. a. 2016)

# The *Dust Veil*-event of 536 CE

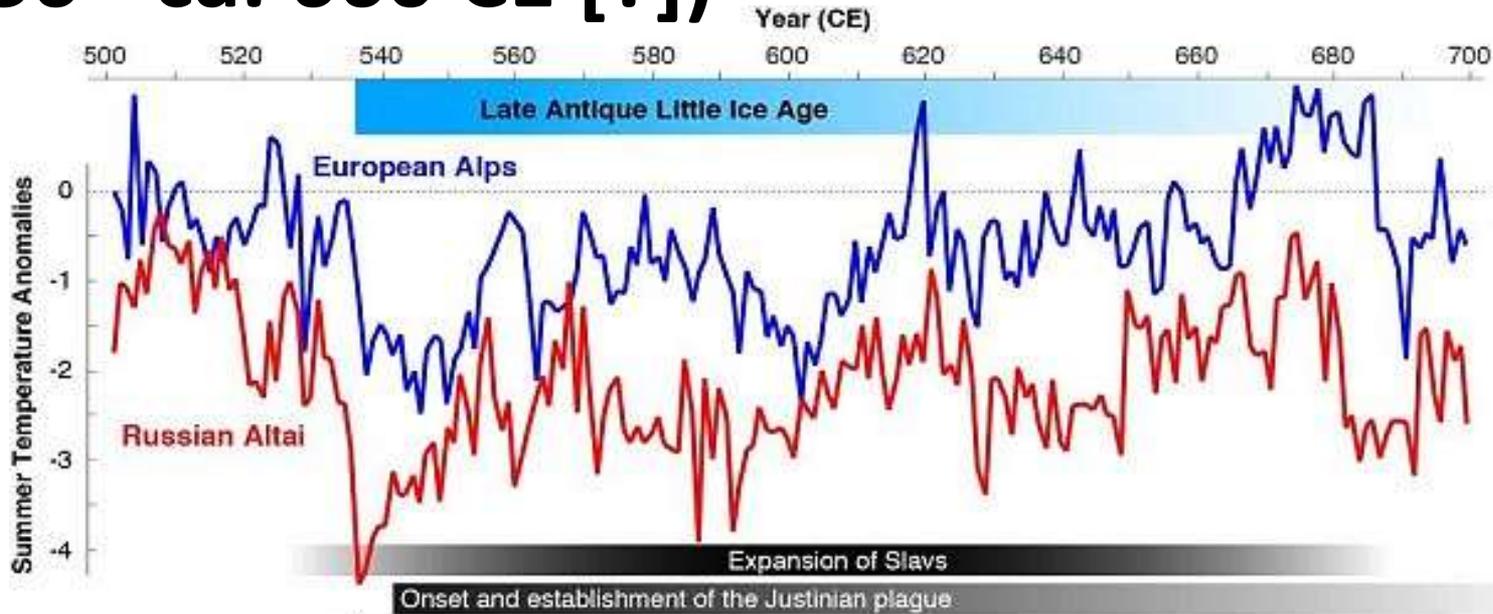
*“And it came about during this year that a most dread portent took place. For the Sun gave forth its light without brightness, like the Moon, during this whole year, and it seemed exceedingly like the Sun in eclipse, for the beams it shed were not clear nor such as it is accustomed to shed. And from the time when this thing happened men were free neither from war nor pestilence nor any other thing leading to death.”*

(Procopius, IV.14, 328–29)

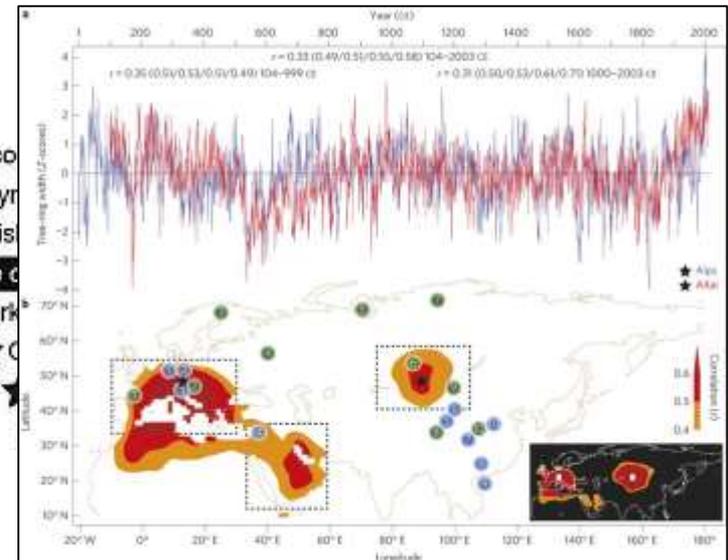


<https://www.historicalclimatology.com/blog/something-cooled-the-world-in-the-sixth-century-what-was-it>

# The „Late Antique Little Ice Age“ (LALIA) (536 - ca. 660 CE [?])



- ★ Collapse of Northern Wei Dynasty
- ★ Replacement of the Rouran by the Türks
- ★ Avars reach Black Sea
- ★ Lombards' Invasion of Italy
- ★ Türks conquer Sogdian silk towns, co
- ★ Unification under Sui Dyn
- ★ Establish
- ★ Rise c
- ★ Türk
- ★ C



U. Büntgen et al., Cooling and societal change during the Late Antique Little Ice Age from 536 to around 660 AD, Nature Geoscience, online 8. Februar 2016:

<http://dx.doi.org/10.1038/ngeo2652>

# The connection between climate-cooling and the "Justinianic plague"

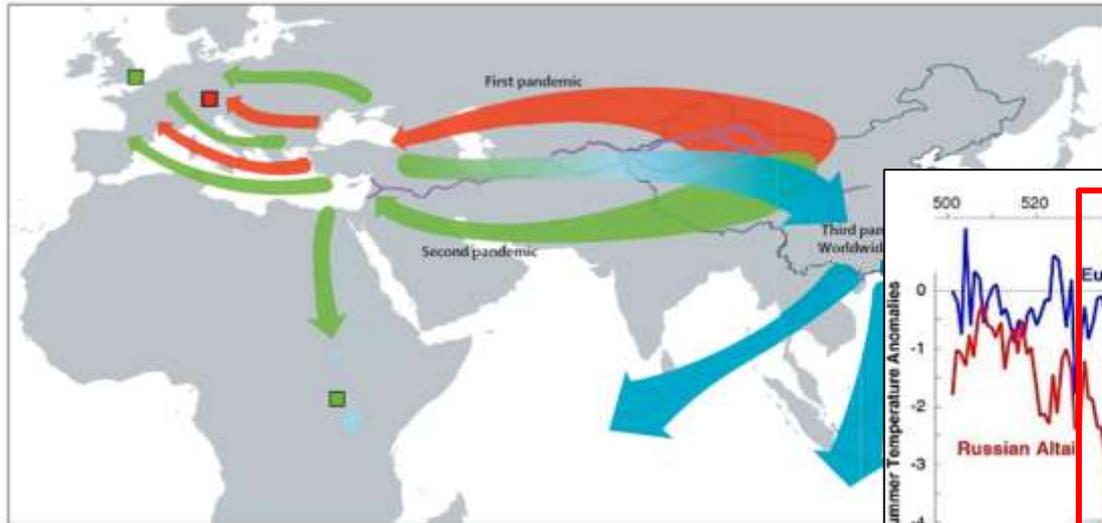
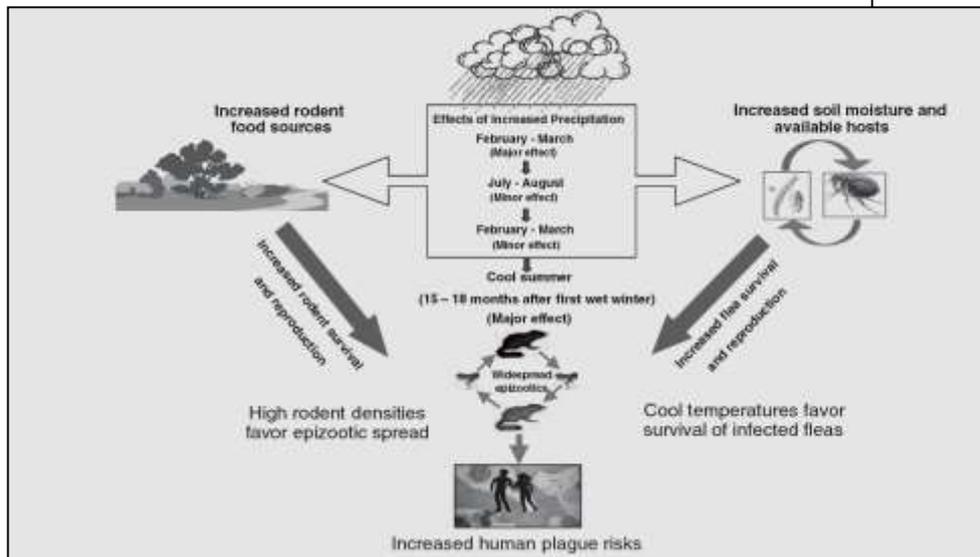
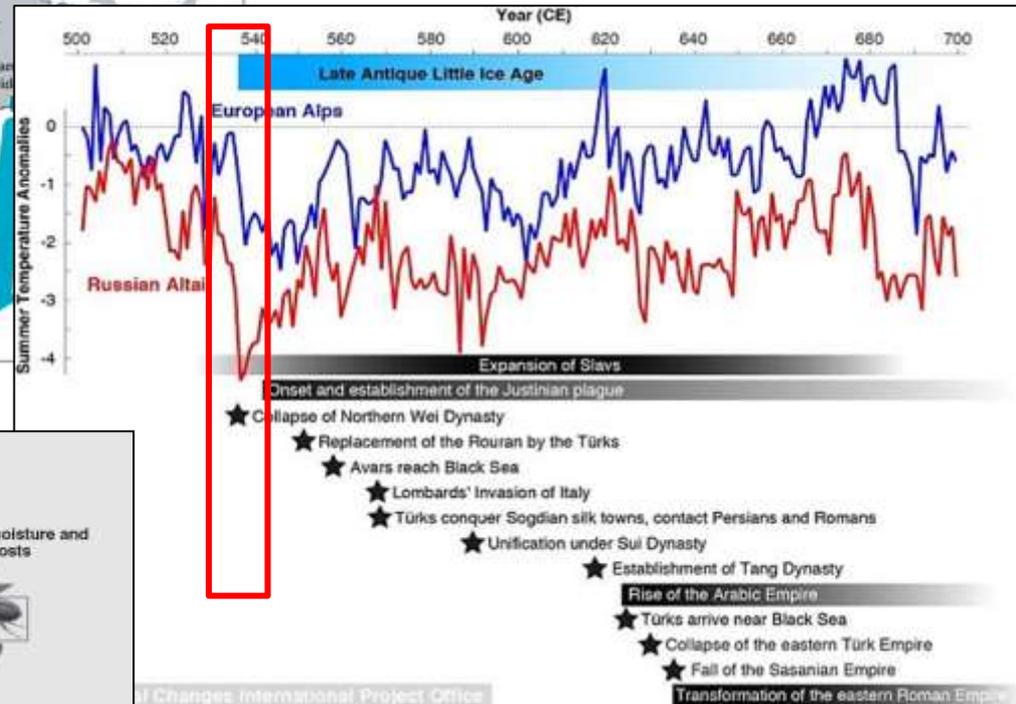
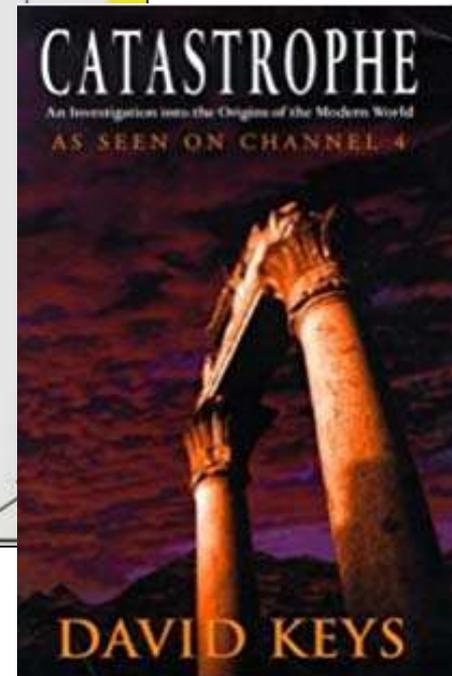
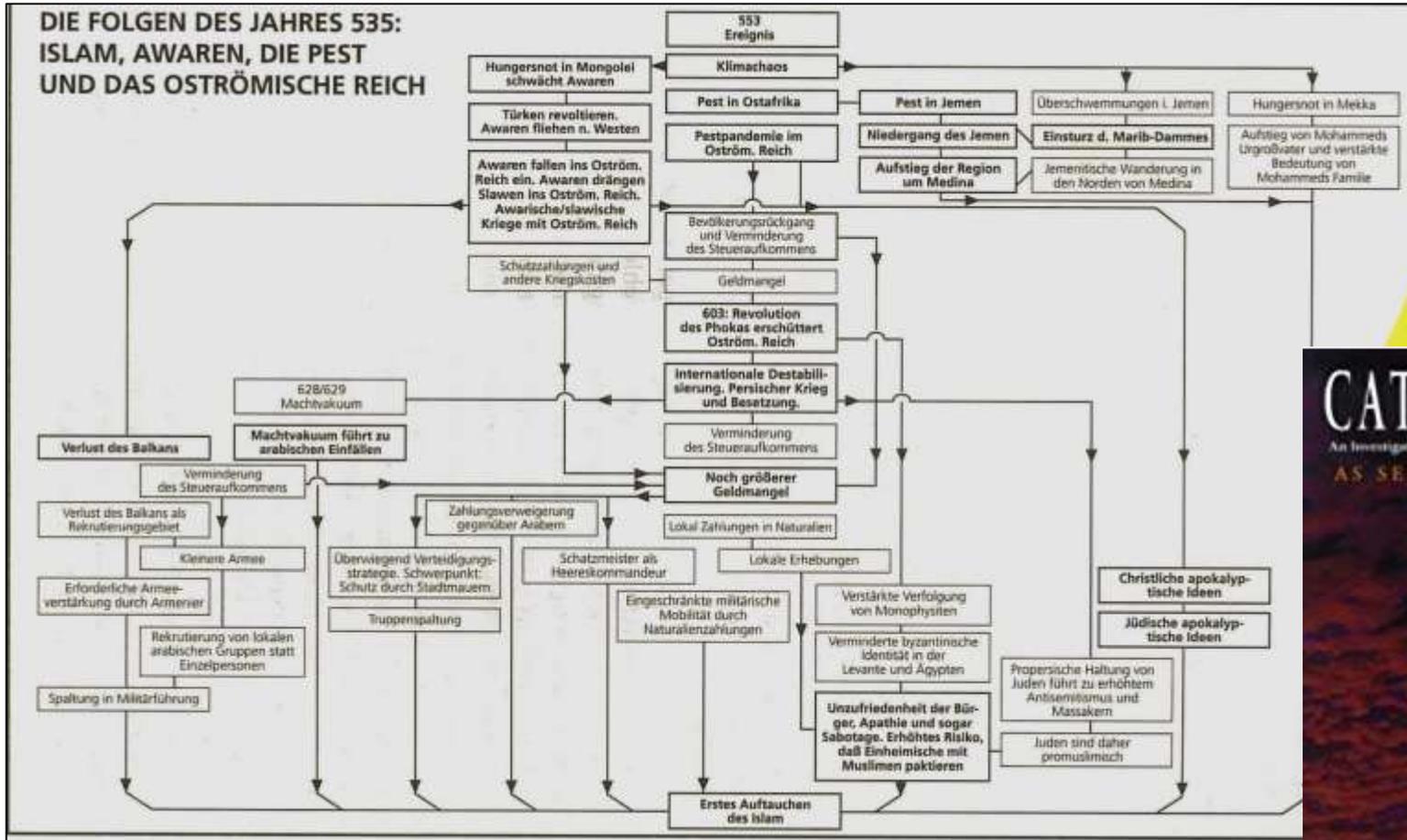


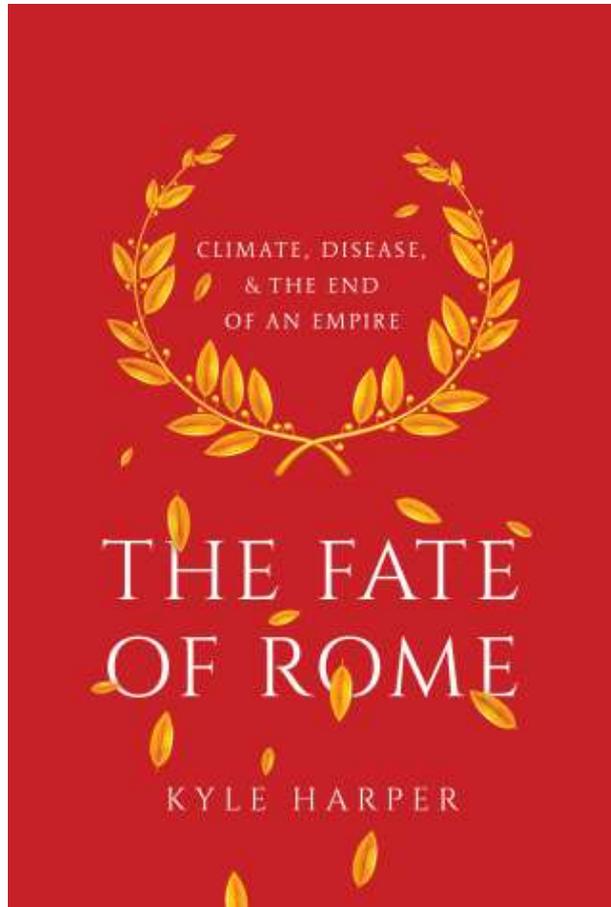
Figure 4: Hypothetical scenario for the geographic spread of *Yersinia pestis*



# Monocausal explanatory models (Keys, 2000)



# „Climate, Disease and the End of an Empire“ (Harper 2017)



2017

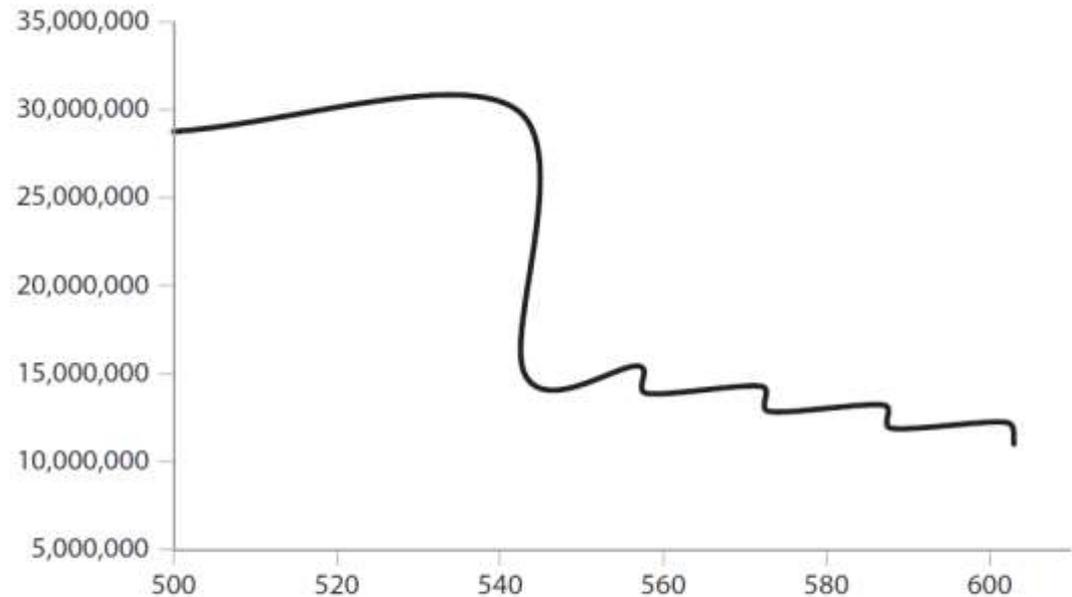


Figure 6.6. Notional Model of the Eastern Roman Population, ~AD 500–600

<https://vimeo.com/235744243>

## Plagues, climate change, and the end of an empire: A response to Kyle Harper's *The Fate of Rome* (1): Climate

John Haldon<sup>1</sup>  | Hugh Elton<sup>2</sup>  | Sabine R. Huebner<sup>3</sup>  | Adam Izdebski<sup>4,5</sup>  | Lee Mordechai<sup>1,6</sup>  | Timothy P. Newfield<sup>7</sup> 

<sup>1</sup>History Department, Princeton University, Princeton, NJ

<sup>2</sup>Ancient Greek and Roman Studies, Trent University, Peterborough, ON, Canada

<sup>3</sup>Institute of Ancient History, Department of Classical Civilizations, Basel University, Basel, Switzerland

<sup>4</sup>Max Planck Institute for the Science of Human History, Jena, Germany

<sup>5</sup>Institute of History, Jagiellonian University, Kraków, Poland

<sup>6</sup>The Medieval Institute, University of Notre Dame, Notre Dame, IN

<sup>7</sup>Departments of History and Biology, Georgetown University, Washington, D.C.

### Correspondence

John Haldon, History Department, Dickinson Hall, Princeton University, Princeton, NJ 08544.

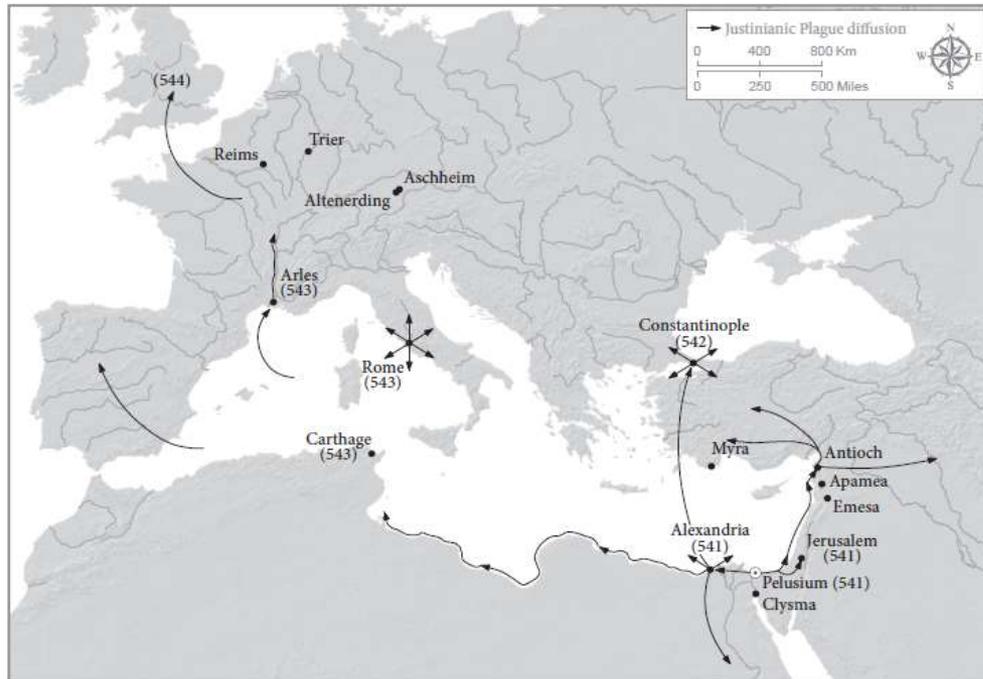
Email: jhaldon@princeton.edu

### Abstract

Kyle Harper's *The Fate of Rome*, written for a popular audience, uses the environment to explain the decline and fall of the Roman Empire. The book asserts that Rome fell as a result of environmental stress, in particular through a combination of pandemic disease and climate change. Although we agree that the environment can and should be integrated within traditional historical accounts, we challenge the book's claims on several issues. These include Harper's use of primary sources and secondary literature, his approach to analyzing palaeoclimate data, his interpretations of the impact of disease on the Roman state and society, and his synthesis of social, economic, and environmental history. Throughout this and the following two sections of this review, we demonstrate that several major flaws undermine the book's overarching argument, casting serious doubts on its conclusions.

## 1 | INTRODUCTION

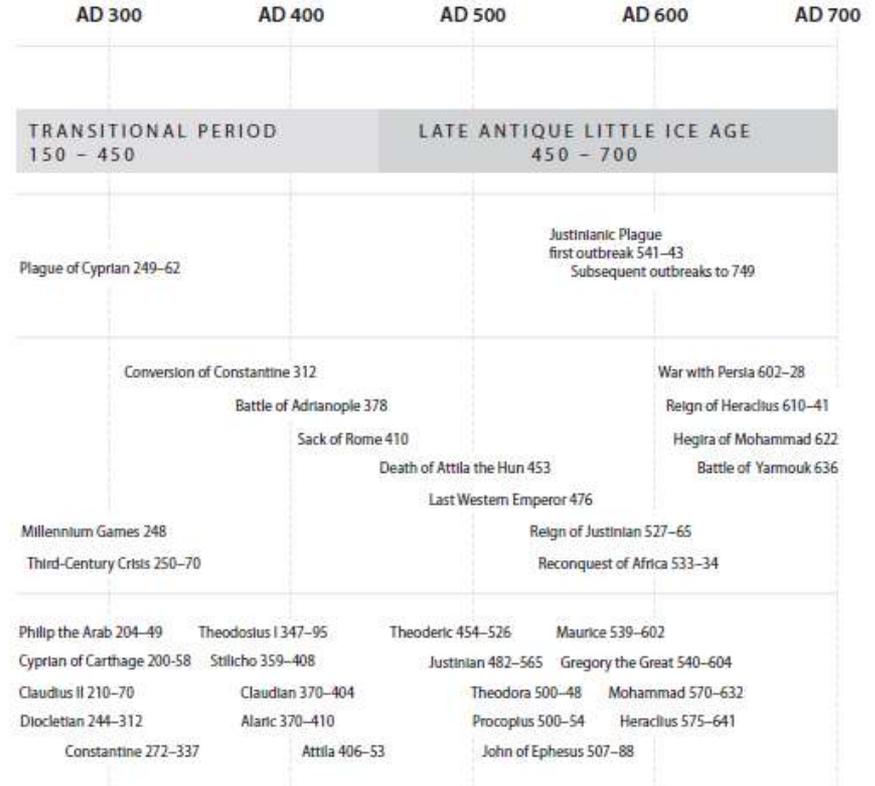
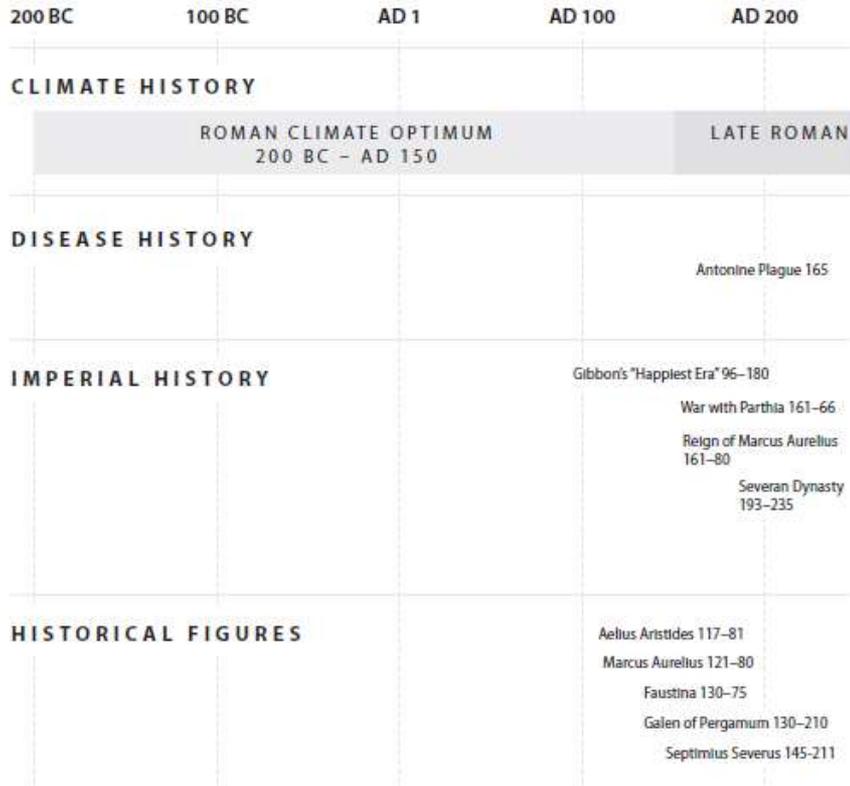
The debate around the decline and fall of the Roman Empire is centuries old, but Kyle Harper's 2017 book *The Fate of Rome* puts the story into a very different context from that which usually prevails. Harper has written a carefully structured and eminently readable account of the factors that contributed to the end of the Roman Empire in both west and east. The style and pace draw the reader in. His descriptions directly engage with a modern readership (whether lay or specialist)—as when, for example, he refers to the marriage between Justinian and Theodora as 'it would be as though a sitting president married a Kardashian' (p. 203). In our contemporary times, in which criticism of the humanities as aloof and disconnected from everyday realities is common, Harper does a very good job of making his subject accessible to broad audiences. And the argument leads the reader inexorably toward his conclusions



Map 19. *The Itinerary of Y. pestis: From Pelusium to Pandemic*

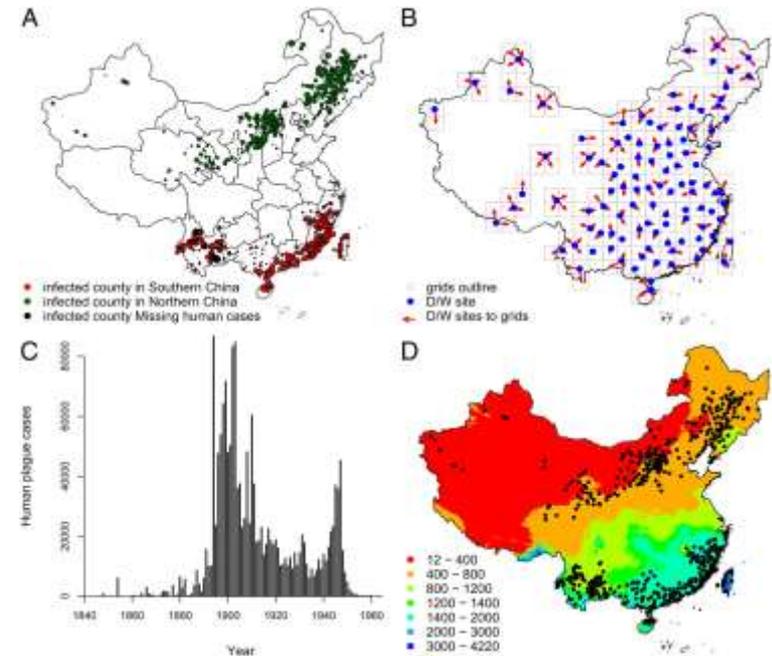
# The extended „LALIA“ of Harper

## TIMELINE



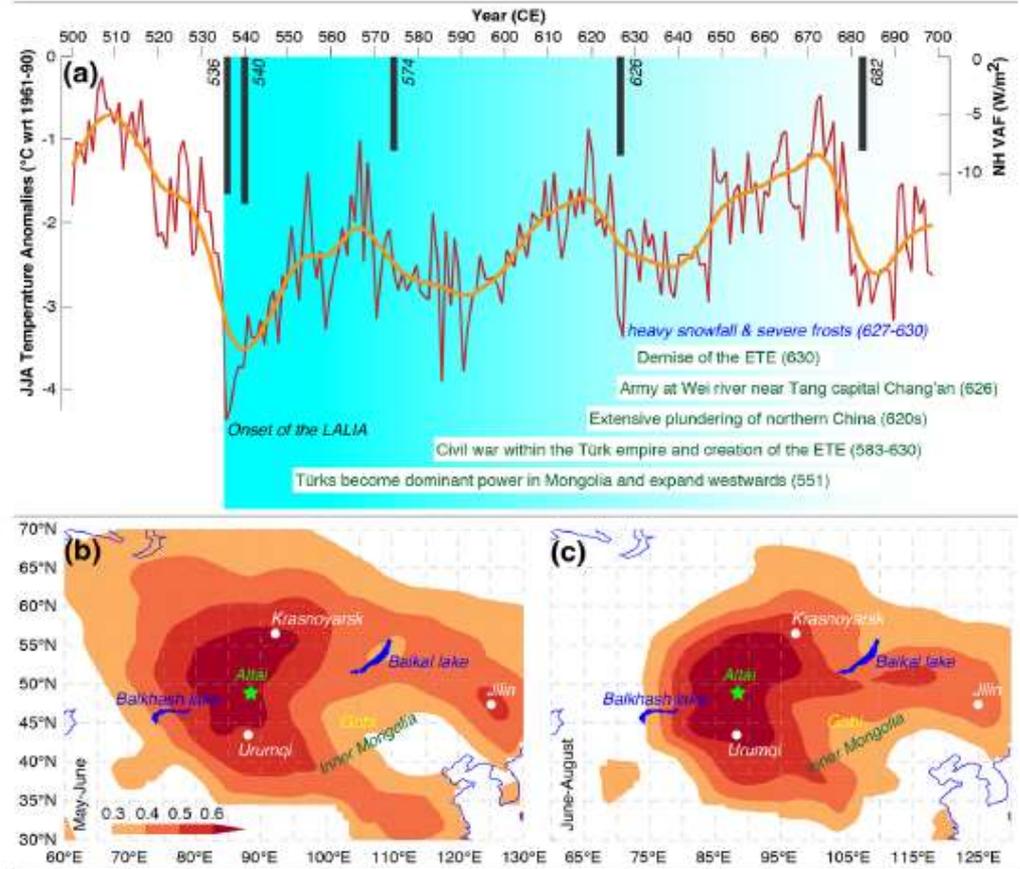
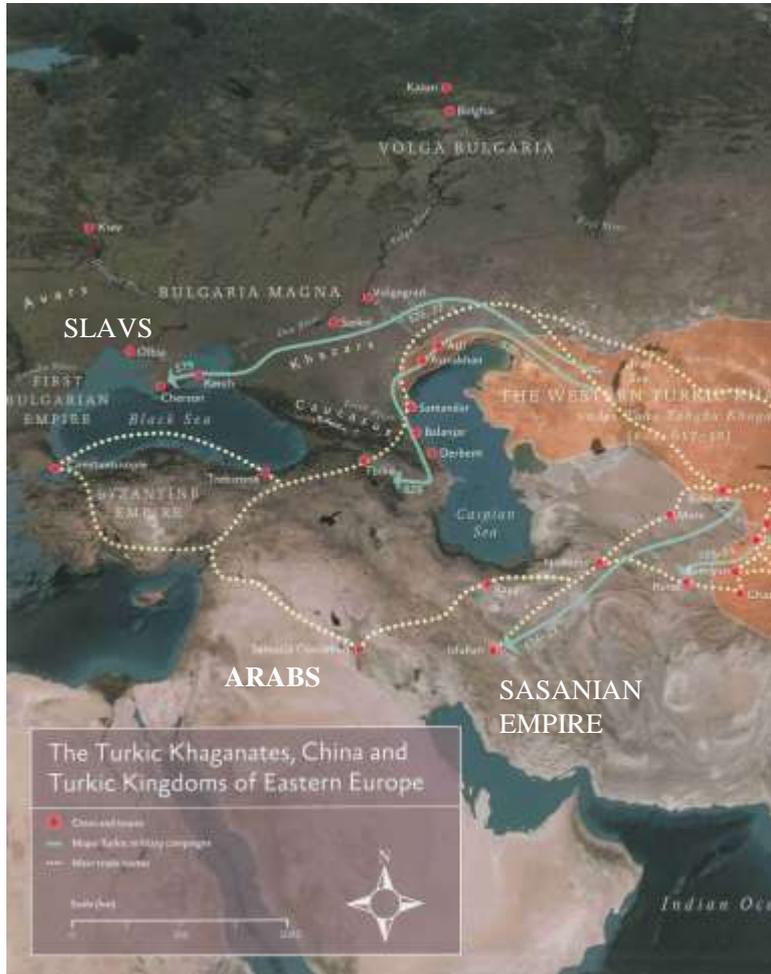
# Lee Mordechai and Merle Eisenberg: *Re-Visiting the Justinianic Plague and its Impacts* (Princeton 2018)

“The evidence for the maximalist interpretation of plague is weak, ambiguous, and should be rejected. (...) Work on the Justinianic Plague often shows a strong tendency towards catastrophism as well as representative bias and confirmation bias. Our talk concludes that the Justinianic plague had an overall limited effect. Although on some occasions the plague might have caused high mortality in specific places, leaving strong impressions on contemporaries, it neither caused widespread demographic decline nor kept Mediterranean populations low. Any direct mid- or long-term effects of plague were minor at most.”



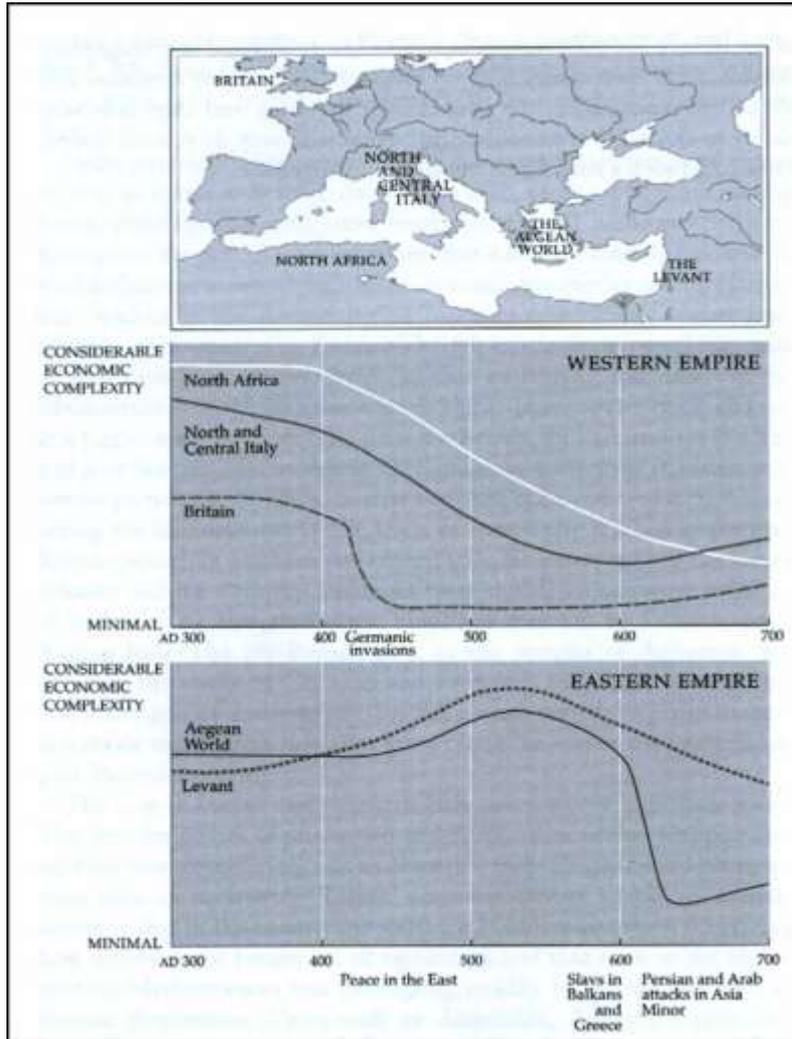
Victims of the 3rd pandemic in Manchuria in the winter of 1910/1911

# New changes at the borders of empires from the second half of the 6th century onwards: Turks, Avars, Bulgars, Khazars, Lombards, Slavs, Tibetans, Arabs

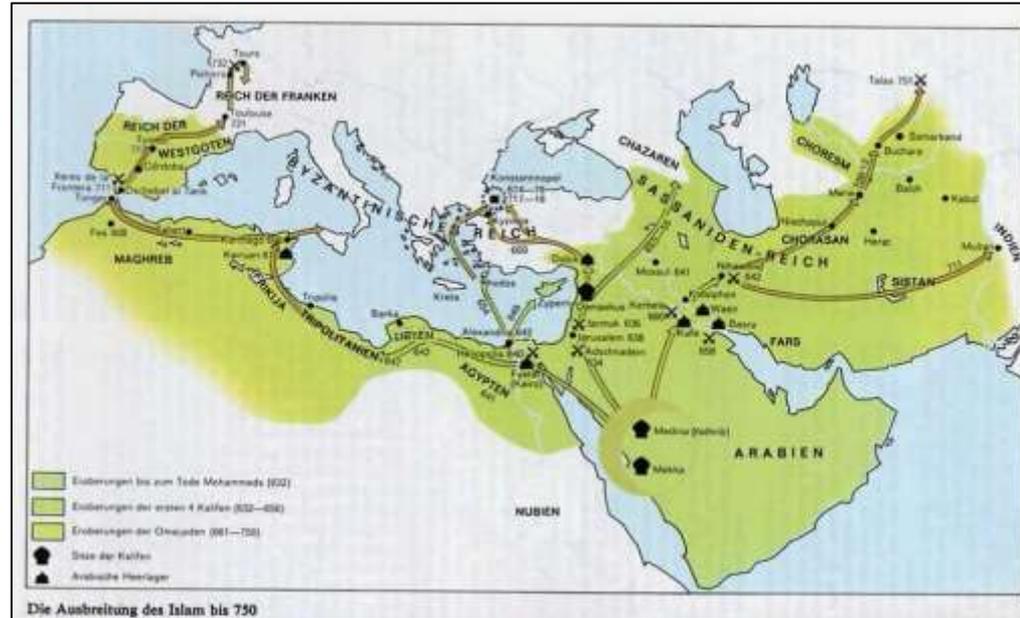


**Fig. 4** a Changes in Northern Hemisphere volcanic forcing and central Asian summer temperature between 500 and 700 CE, with the blue shading referring to the Late Antique Little Ice Age (LALIA; Büntgen et al. 2016). Important steps of the Eastern Türk Empire (ETE) as well as documentary evidence of snowfall and frost events are provided. b-c Spatial field correlations (1970–2011) of the Altai summer temperature reconstruction against the gridded 1° latitude/longitude "Berkeley" dataset (Rohde et al. 2013) of May–June and June–August temperature means (left and right)

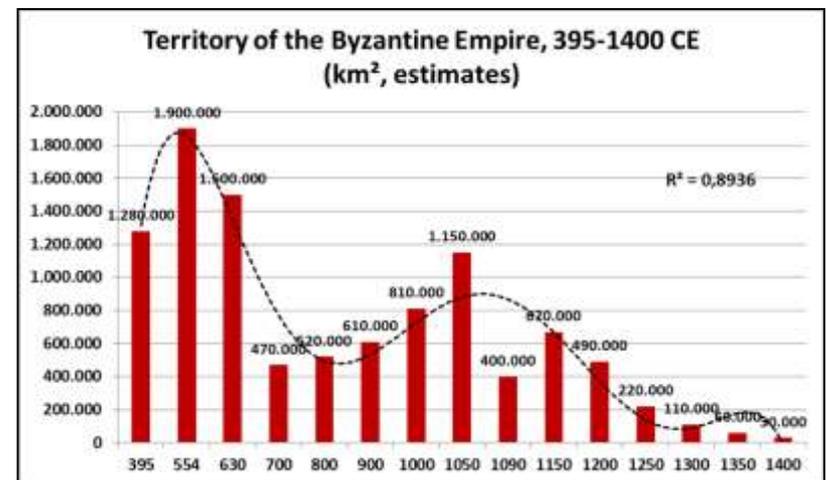
# The crises of the 6th and 7th centuries, the Arab expansion and the "end of antiquity"?



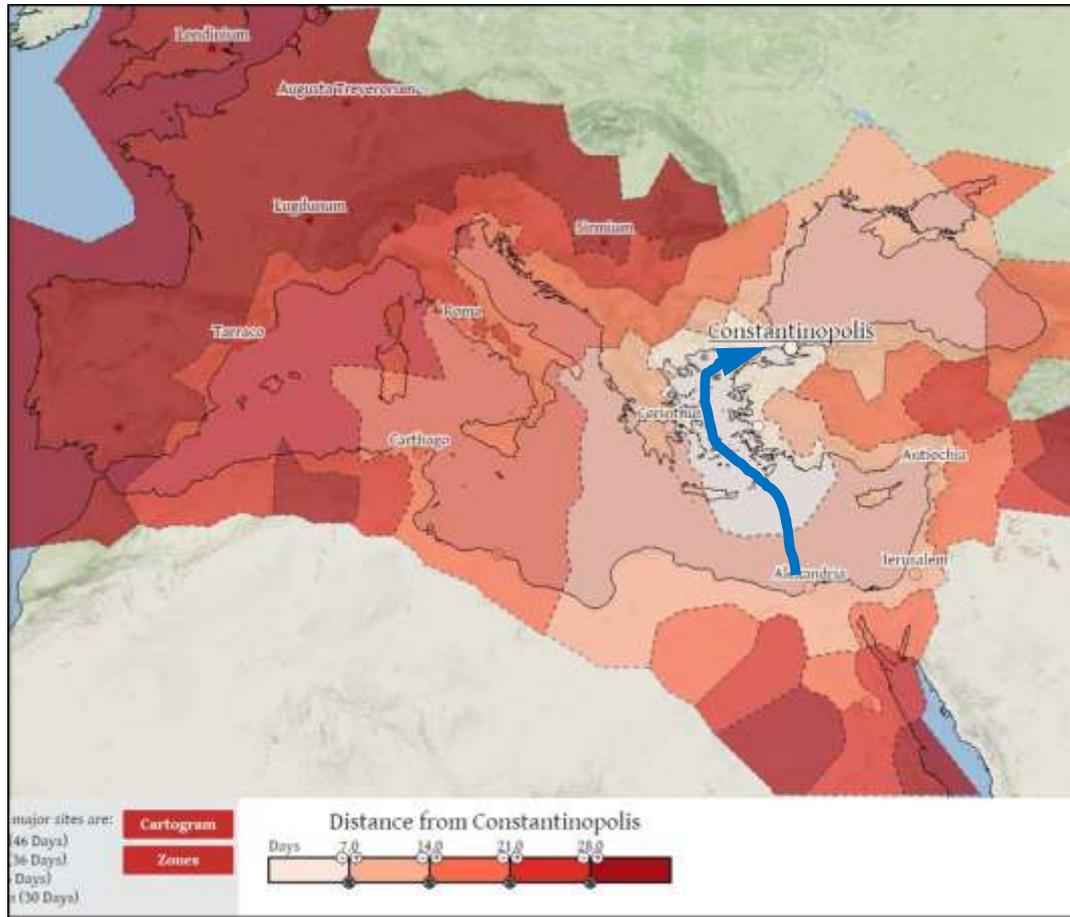
Ward-Perkins 2005



Die Ausbreitung des Islam bis 750



# The urban metabolism, Egypt and the imperial ecology (4th-7th cent. CE): 163,000 tons/y at 540 CE



<http://orbis.stanford.edu/>

# The emergence of the Byzantine-Arab Frontier (*al-thughūr*)

*“When a great and innumerable army of Arabs gathered and surged forwards to invade Roman territory, all the regions of Asia and Cappadocia fled from them, as did the whole area from the sea and by the Black Mountain and Lebanon as far as Melitene and by the river Arsanias [Murat Nehri] as far as Inner Armenia [the region of Theodosiupolis/Erzurum]. All this territory had been graced by the habitations of a numerous population and thickly planted with vineyards and every kind of gorgeous tree; but since that time it has been deserted and these regions have not been resettled.”*

**J.-B. Chabot, *Anonymi auctoris chronicon ad annum Christi 1234 pertinens* (CSCO 109). Louvain 1937 (reprint 1965), 156–157; *The Seventh Century in the West-Syrian Chronicles*, introd., transl. and annotated by A. Palmer. Including two seventh-century Syriac Apocalyptic Texts, introd., transl. and annotated by S. Brock with added Annotation and an historical Introduction by R. Hoyland. Liverpool 1993, 62.**



# The pollen record in the Nar Gölü (Cappadocia; Haldon et al. 2014)

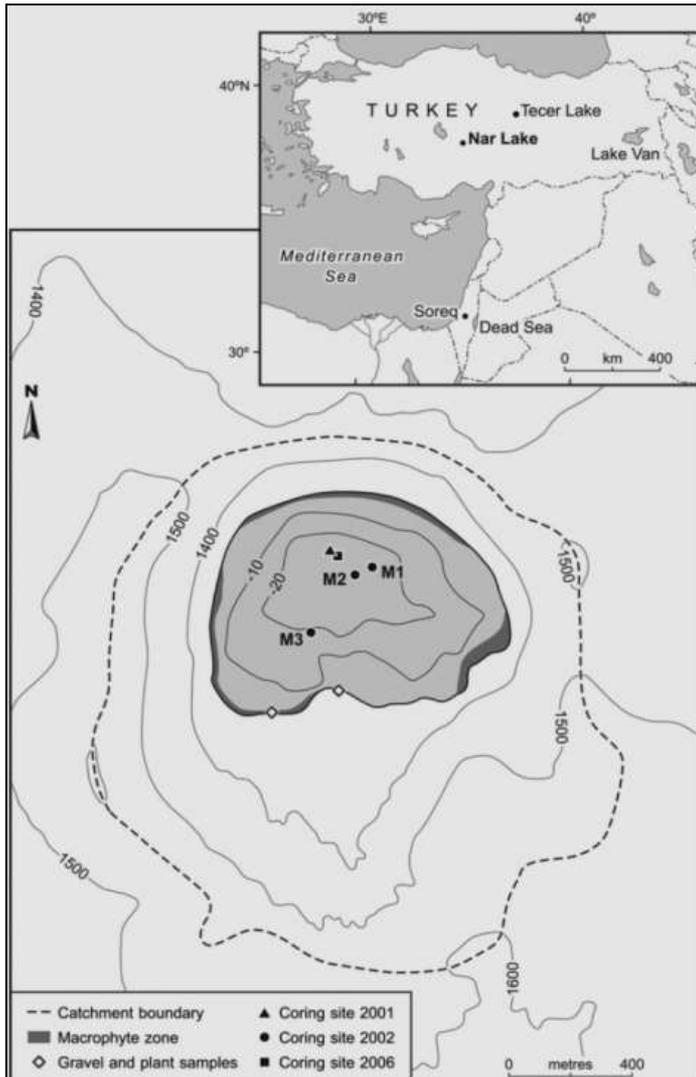
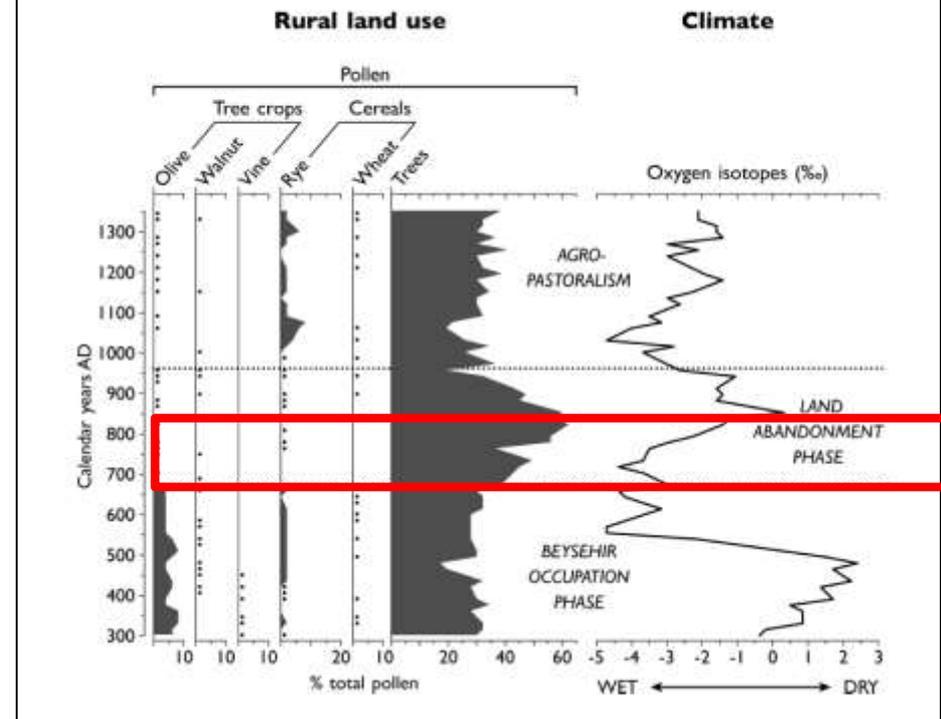
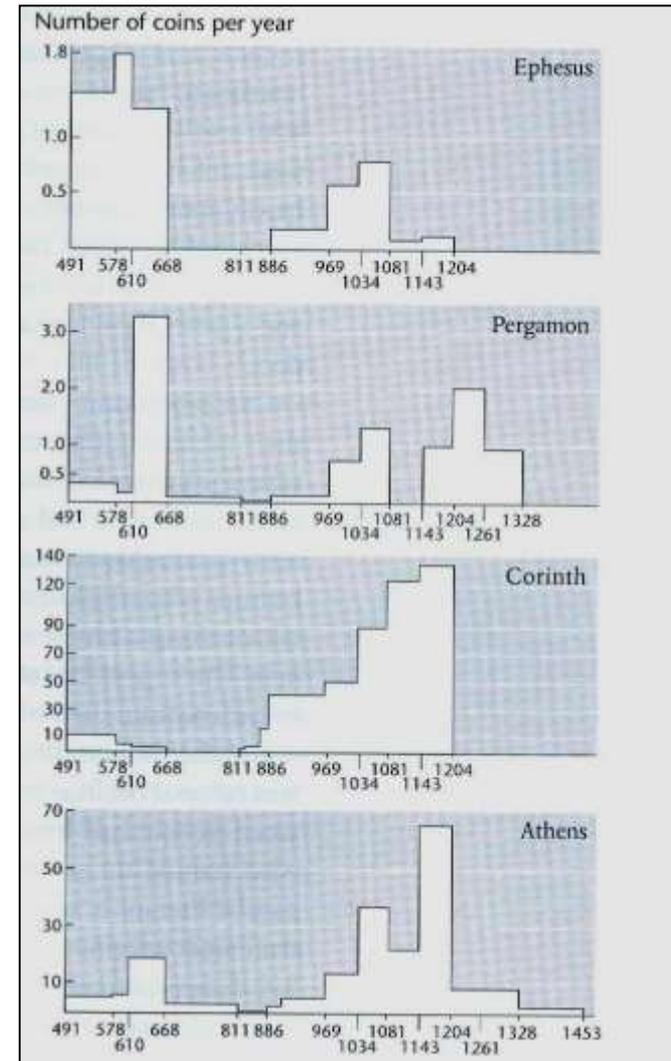
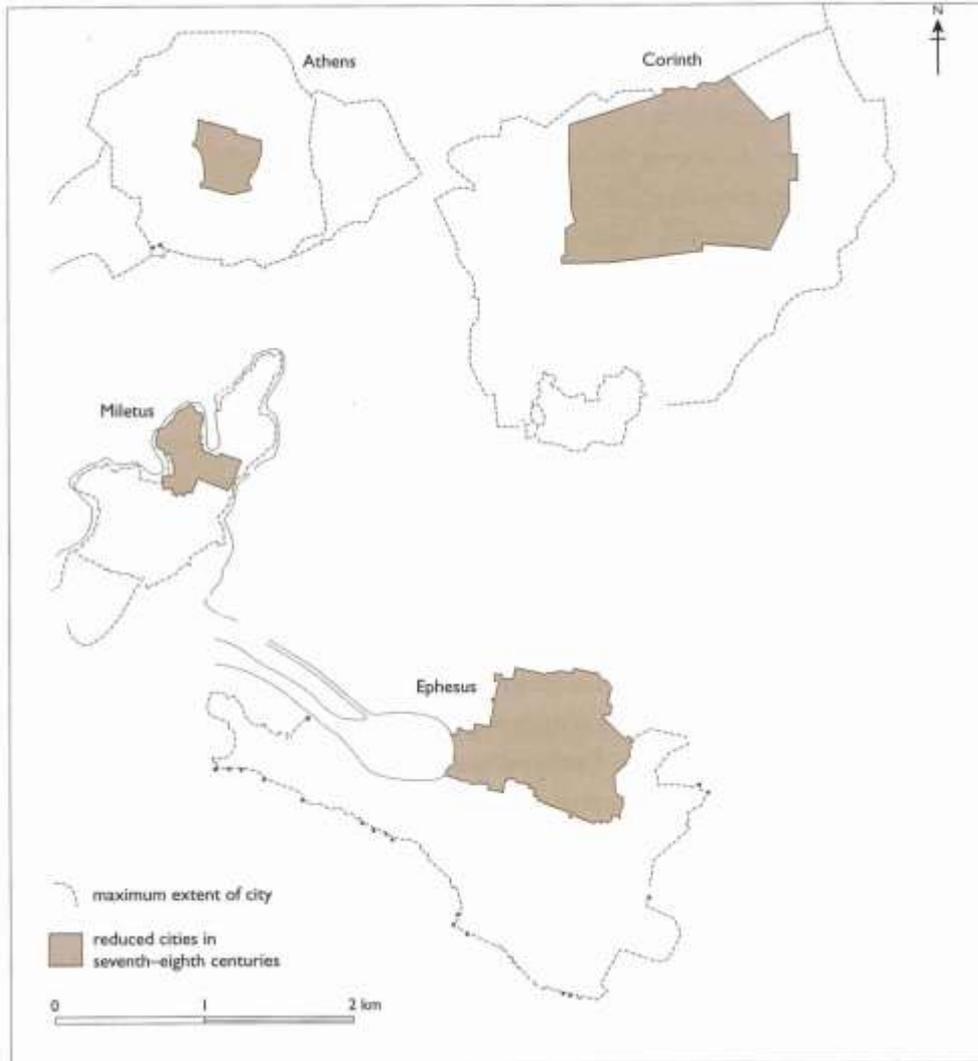


Fig. 4 Synthetic Summary Diagram of Vegetation, Land Use, and Climatic Change from Nar Gölü, Cappadocia, 300–1400 C.E.



# The shrinking of cities and coinage in the Byzantine Empire, 7th-9th cent. CE



# Extreme events: volcanic eruptions, climate forcing („year without summer“, 1815), and ice cores in Greenland (McCormick / Dutton / Mayewski 2007)

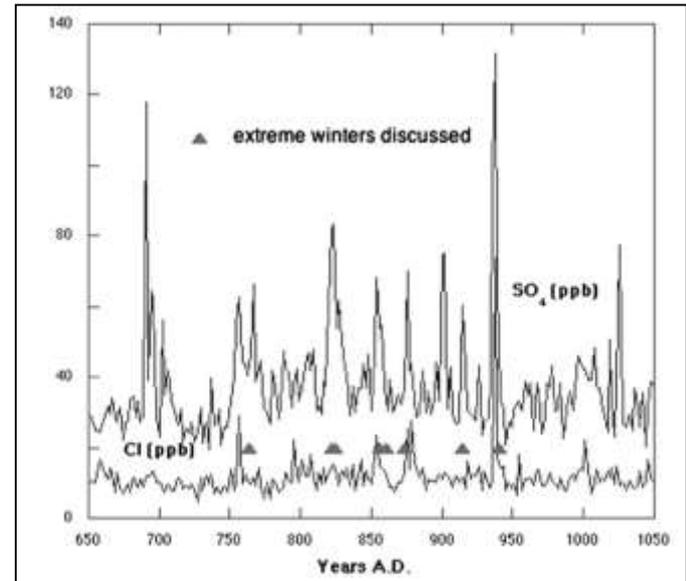
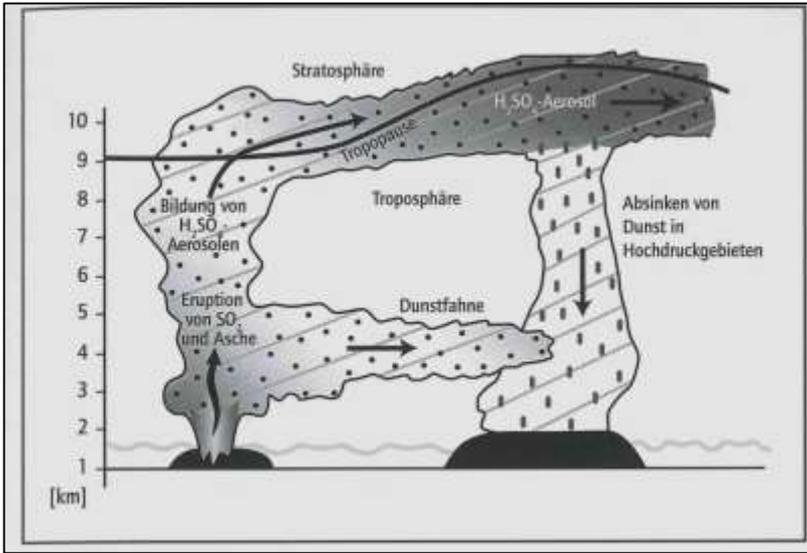
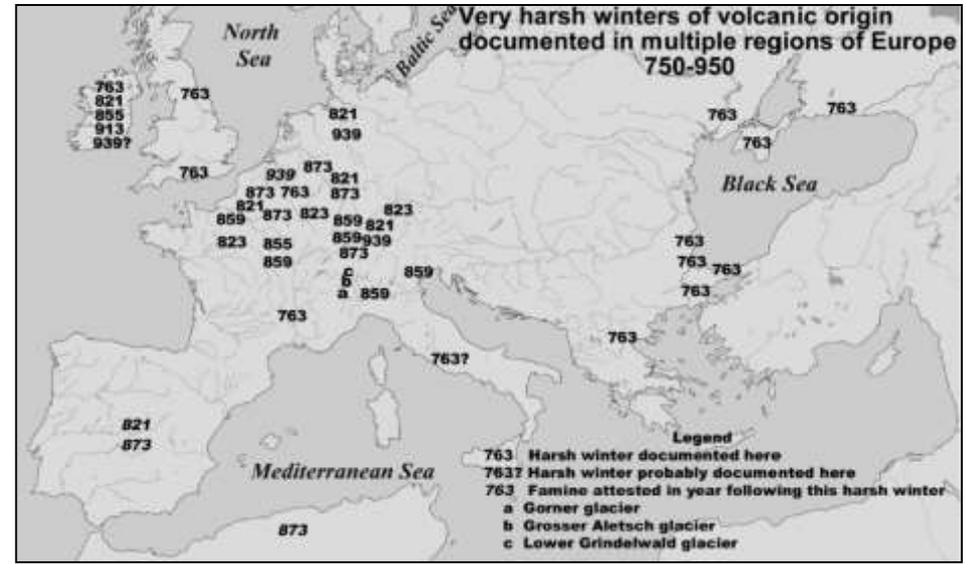
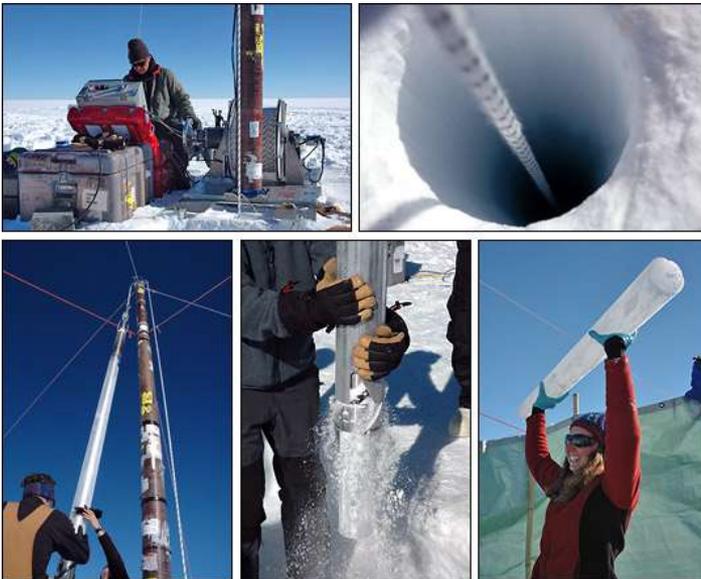


Fig. 5. GISP2 (see Fig. 3 for location) ice core SO<sub>4</sub><sup>2-</sup> and Cl<sup>-</sup> time series covering the period A.D. 650–1050 and historically documented multiregional climate anomalies between 750 and 950, as discussed in the text.



# 763 CE: Icebergs at the Bosphorus

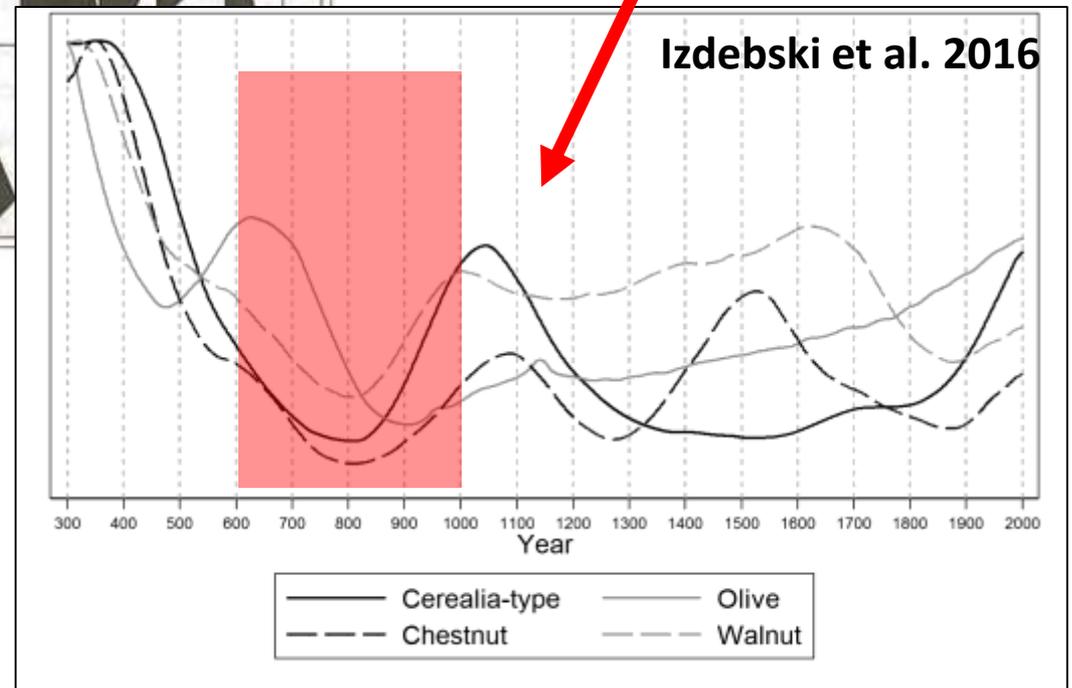
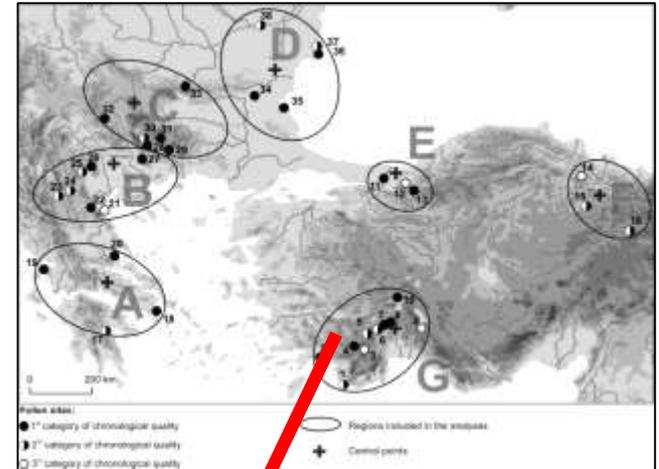
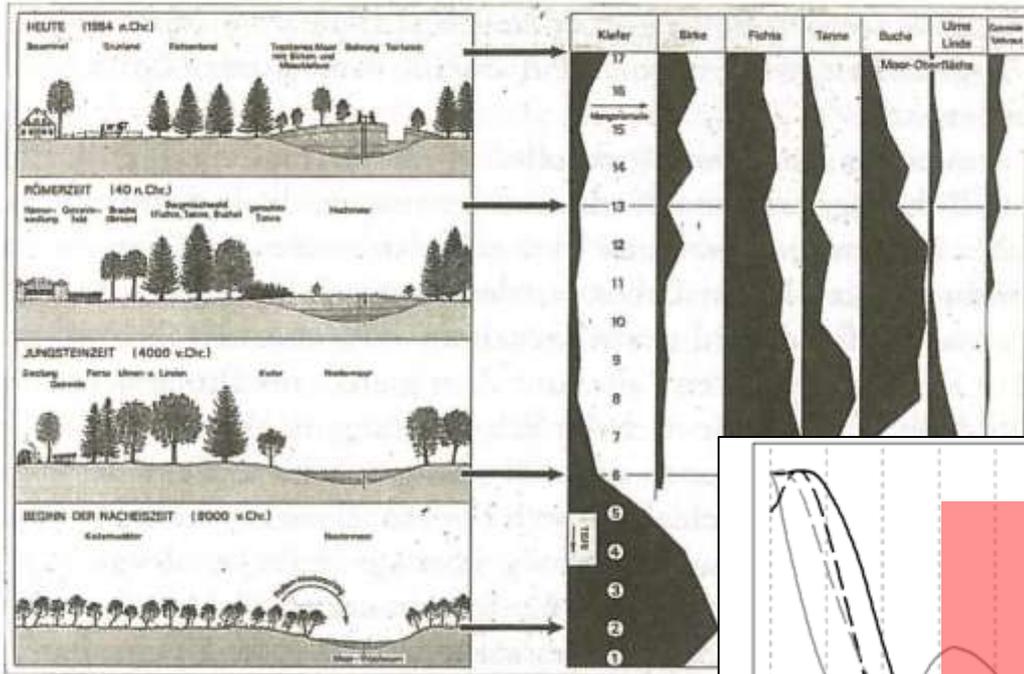
*In the same year, starting in early October, there was very bitter cold, not only in our land, but even more so to the east, the north, and the west, so that on the north coast of the Pontos to a distance of 100 miles the sea froze from the cold to a depth of thirty cubits. The same happened from Zikchia to the Danube, including the river Kouphis, the Danastris, the Danapris, and Nekropelai, and the rest of the coast as far as Mesembria and Medeia. All this ice was snowed upon and grew by another twenty cubits, so that the sea became indistinguishable from land: (...) In the month of February of the same 2nd indiction this ice was, by God's command, split up into many different mountain-like sections which were carried down by the force of the winds to Daphnousia to and Hieron and, by way of the Straits reached the City and filled the whole coast as far as the Propontis, the islands, and Abydos. Of this I was myself an eyewitness, for I climbed on one of those [icebergs] and played on it together with some thirty boys of the same age. Some of my wild and tame animals also died. Anyone who so wished could walk with-out hindrance as on dry land from Sophianai to the City and from Chrysopolis to St Mamas and to Galata. One of the icebergs struck the jetty of the Acropolis and crushed it. Another huge one struck the wall and shook it greatly so that the houses on the inside partook of the quake. It then broke into three pieces and ringed the City from the Mangana to the Bosphorus, rising in height above the walls.*

The Chronicle of Theophanes Confessor, A. M. 6255 (transl. MANGO/SCOTT, p.600-601)

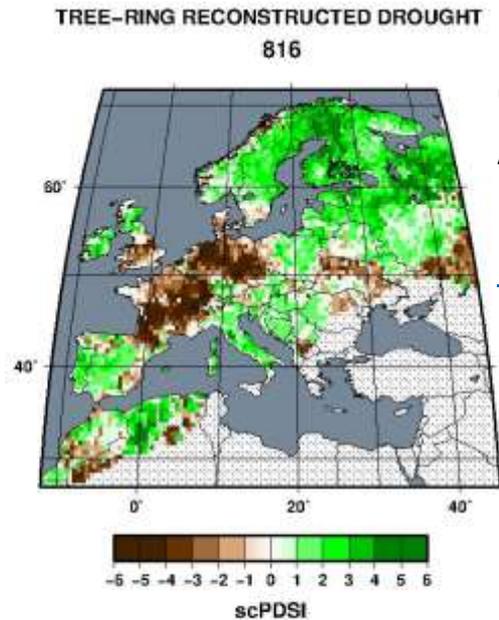


**A frozen Bosphorus in the winter of 1929**

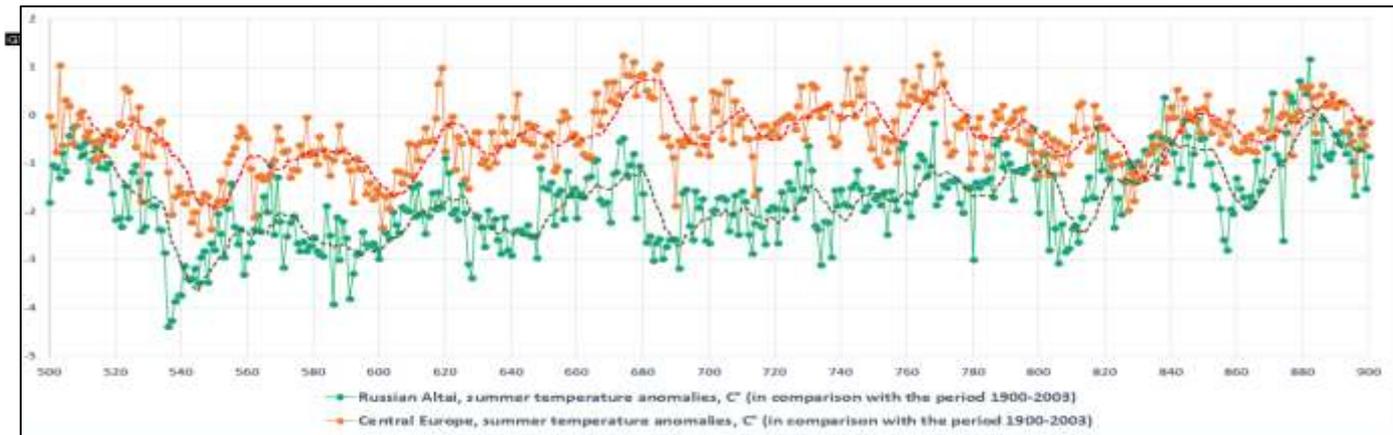
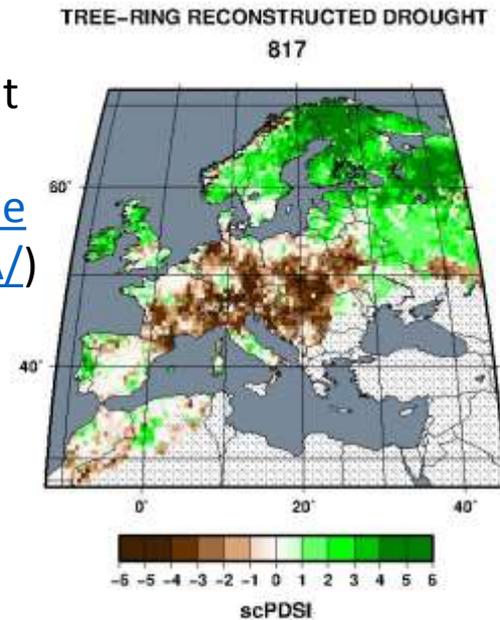
# Pollen analyses and sediments as archives of climate and human activity



# Climate history and the transition from the late antique cold period to the medieval climate anomaly in the 9th century CE

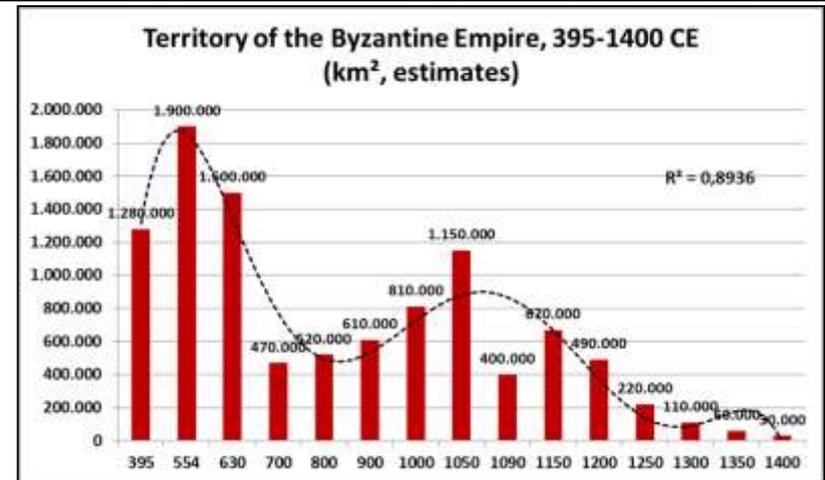


Old World Drought  
Atlas  
(<http://drought.mphs.edu/OWDA/>)

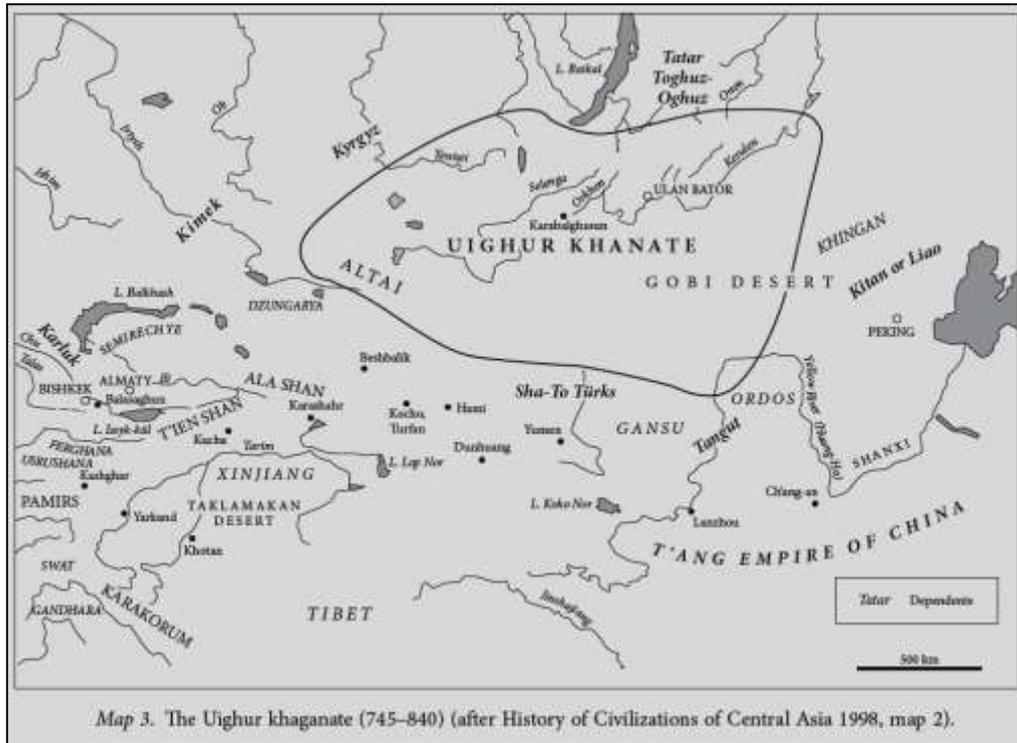


Comparison of Summer Temperatures in Central Europe and Central Asia, 500-900 CE (Preiser-Kapeller 2017)

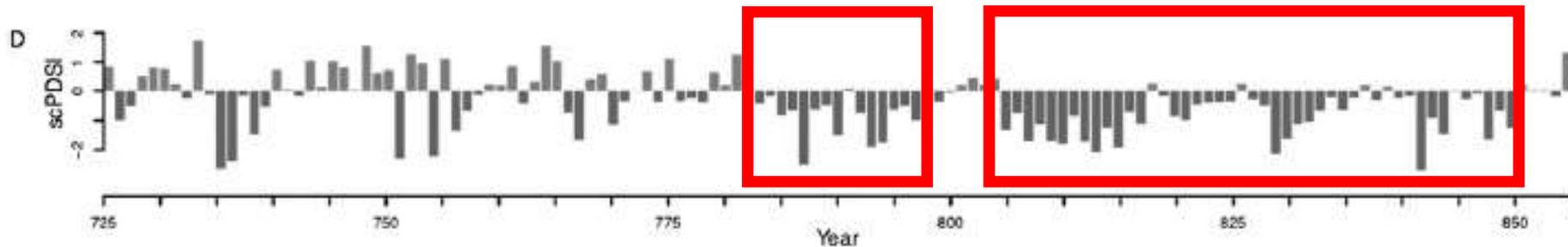
# The 9th century as the end of the long late antiquity (see also Preiser-Kapeller 2018)?



# The extreme winter of 839-840 CE, Kyrgyz attacks, the capture of Karabalgasun and the collapse of the Uyghur Empire

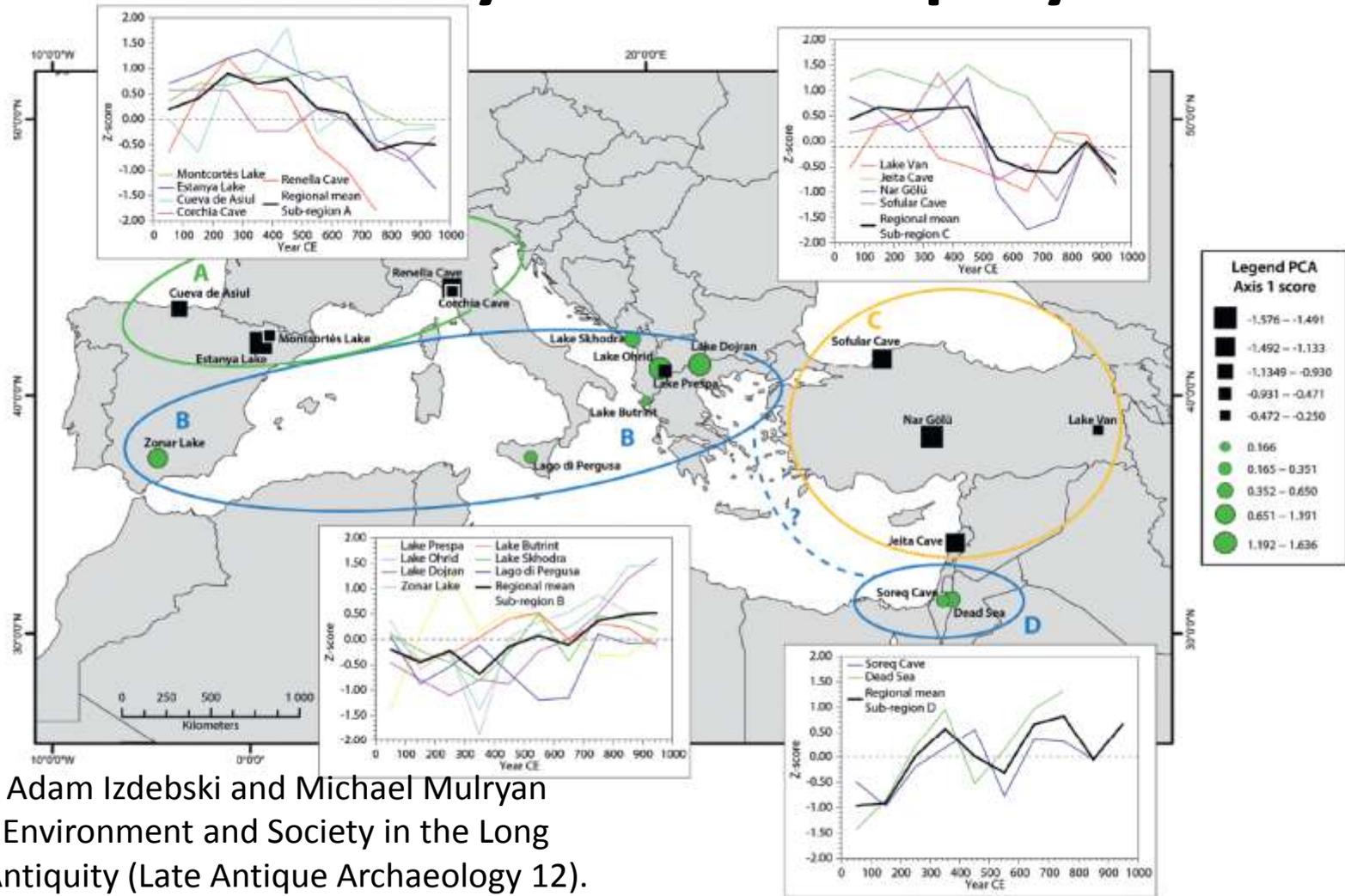


di Cosmo et al., Journal of Interdisciplinary History, XLVIII:4 (Spring, 2018), 439-463



Tree-ring reconstruction of June-September scPDSI during the Uyghur period, with positive values in gray and negative values in black

# Summary: Environmental and climatic history of late antiquity



From: Adam Izdebski and Michael Mulryan (eds.) Environment and Society in the Long Late Antiquity (Late Antique Archaeology 12). Leiden, October 2018.

FIGURE 6 Results of Principal Component Analysis (PCA) of hydro-climate proxies: squares and circles on the map show Axis 1 scores for each site. The sub-regions A, B, C and D are defined based on similar Axis 1 scores of the sites. The inset graphs show z-scores of individual proxy records averaged for each century, together with the mean z-score for the respective sub-region. Higher values represent drier conditions and vice versa.

# Further perspectives: empires as ecosystem

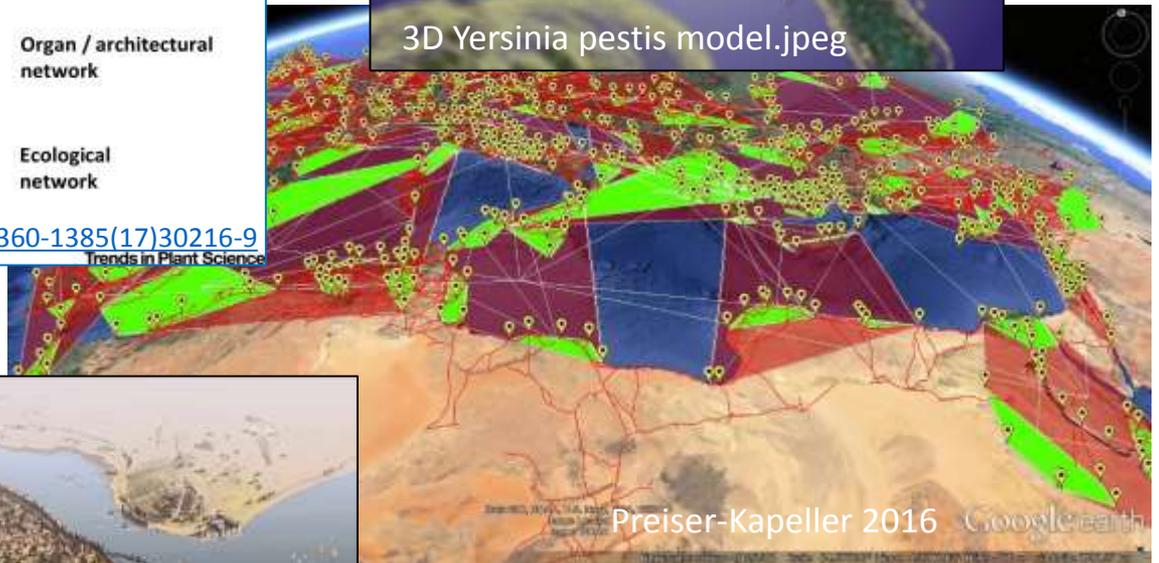
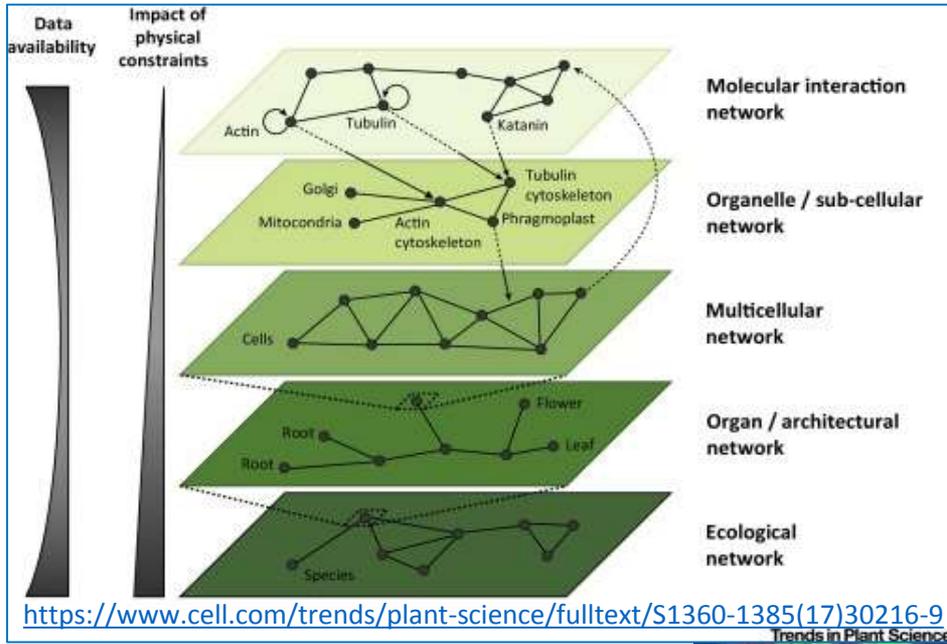
*Analyzing the Ottoman Empire as an ecosystem opens up Ottoman historical realities in all their complexities to reveal sets of relationships among resources, peoples, ideas, animals, and places in which all the elements of the system are connected to and dependent upon one another. A change or perturbation in any one part of the environment affects all others. The idea of the Ottoman Empire as an ecosystem of collective dependence and determination foregrounds how the smallest and largest of imperial actors were connected, across time and space, through means of exchange, administration, and mutual reliance. The example of irrigation in Ottoman Egypt we have examined in this book clearly shows how farmers in sometimes very remote parts of the empire were in constant dialogue with the palace in Istanbul and how the two worked together to make the countryside productive. Peasants used the empire and the empire used the peasants. A volcano in Iceland, rats in northern India, timber stocks across the Mediterranean, water buffalos in villages throughout Egypt – all of these impacted the Ottoman Empire and must be brought into our analytical frame to properly understand the empire's history. (...) An ecological approach to the Ottoman Empire reveals how the empire's variegated geographies, overlapping chronologies, and connected histories functioned across space and time and how small changes in one part of the empire affected places, ideas, and peoples across the imperium and beyond.*

**Alan Mikhail, Under Osman's Tree. The Ottoman Empire, Egypt and Environmental History. Chicago 2017, 199-200.**

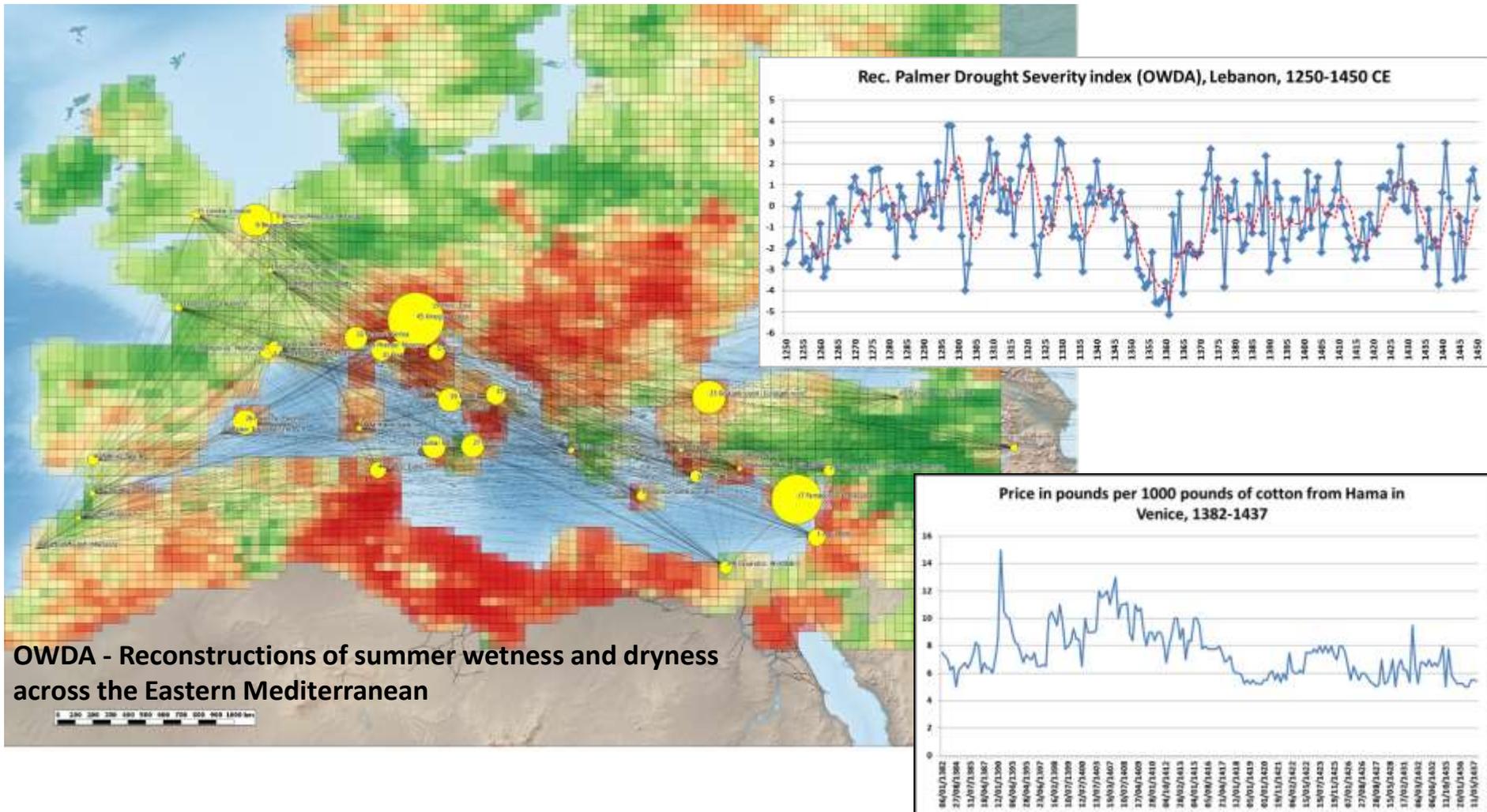


Barberini Diptych (6th cent.;  
Louvre)

# Further perspectives: entanglements and interplays between ecological networks across scales from the cell to the capital



# Further perspectives: combining network models with data of paleo-environmental and socio-economic dynamics



OWDA - Reconstructions of summer wetness and dryness across the Eastern Mediterranean



<http://climatechangeandhistory.princeton.edu>



<http://oeaw.academia.edu/JohannesPreiserKapeller/Talks>

**Thank you very much for your attention!**