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

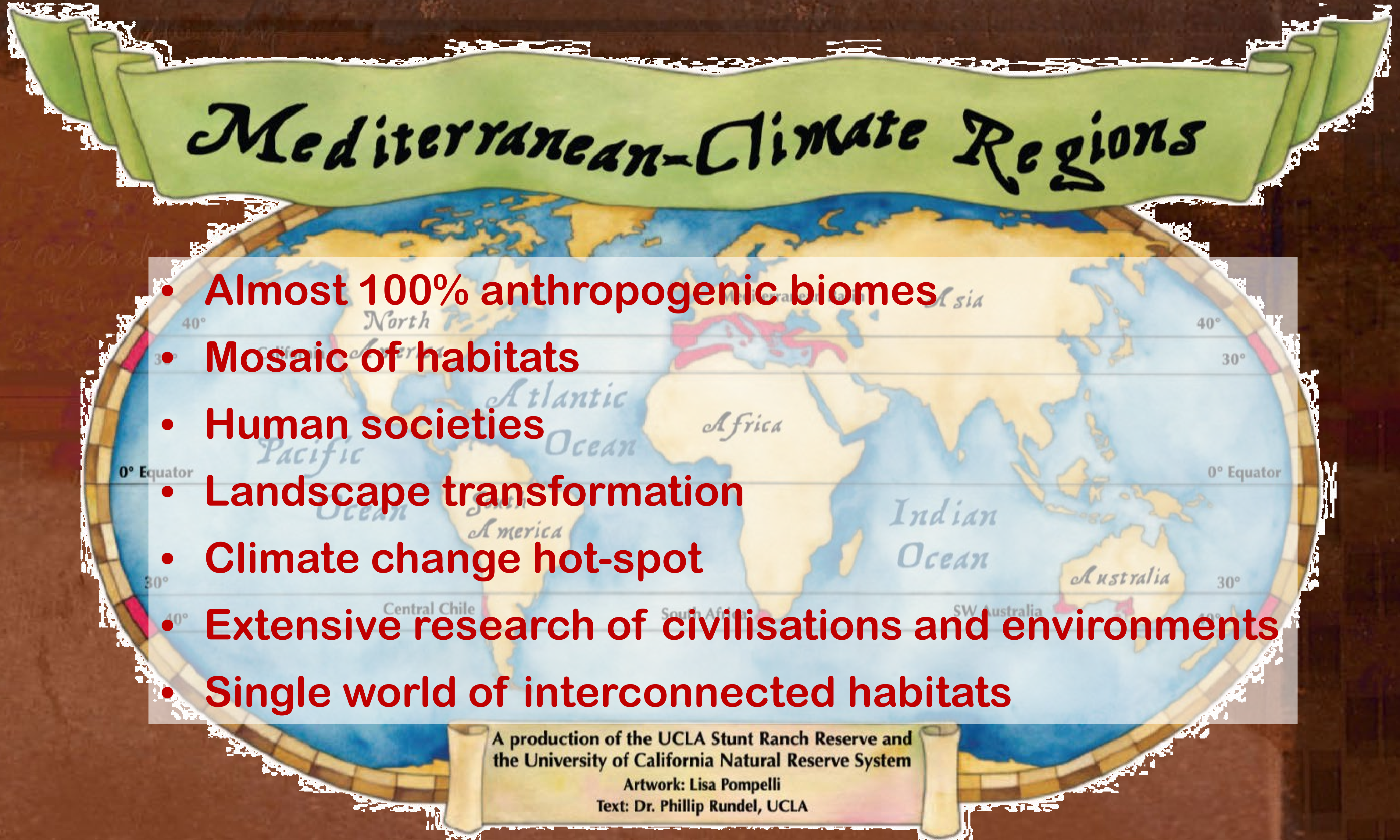
Elena Xoplaki, Justus Liebig University Giessen, Germany
elena.xoplaki@geogr.uni-giessen.de

Dominik Fleitmann, Juerg Luterbacher,
Sebastian Wagner, Eduardo Zorita, John Haldon,
Ioannis Telelis, Andrea Toreti, Adam Izdebski

Department of Geography Giessen
Climatology, Climate Dynamics & Climate Change

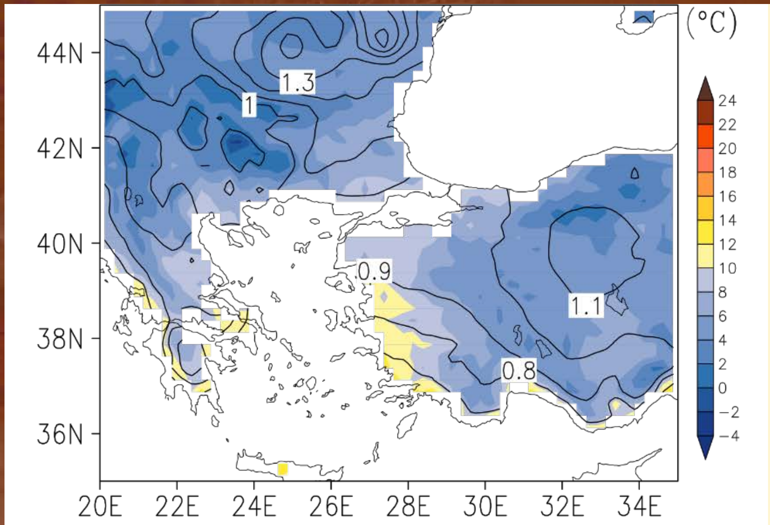
Outline

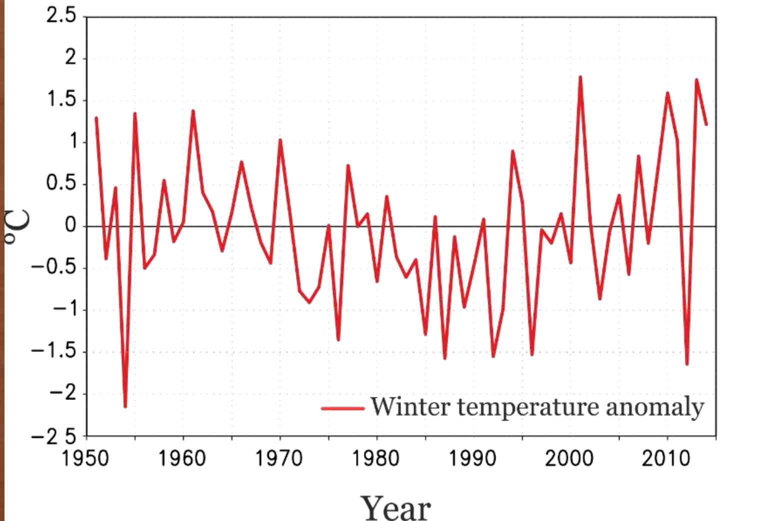
- Climate of the Byzantine lands
- Medieval Climate Anomaly (MCA; AD 850-1300) and Byzantium
- Impacts of climate and its variability on the Byzantine state & economy
- Economic performance of Byzantium
  - Historical evidence: changes in the general economic situation
  - Archaeological data: regional demographic and economic histories
- Palaeoclimate evidence for the medieval Byzantine region
  - Documentary, textual evidence, natural proxies
- The Middle Byzantine climate simulated by climate models
- Climatic changes and societal change in Byzantium
- Conclusions



- Almost 100% anthropogenic biomes
- Mosaic of habitats
- Human societies
- Landscape transformation
- Climate change hot-spot
- Extensive research of civilisations and environments
- Single world of interconnected habitats

Winter (October to March) mean climate





Temperature gradient: coastal – inland areas, higher latitude, complex orography

Large variability over north-eastern Balkans and Central Turkey

High temporal variability, upward trend (not significant) during the second half of studied period

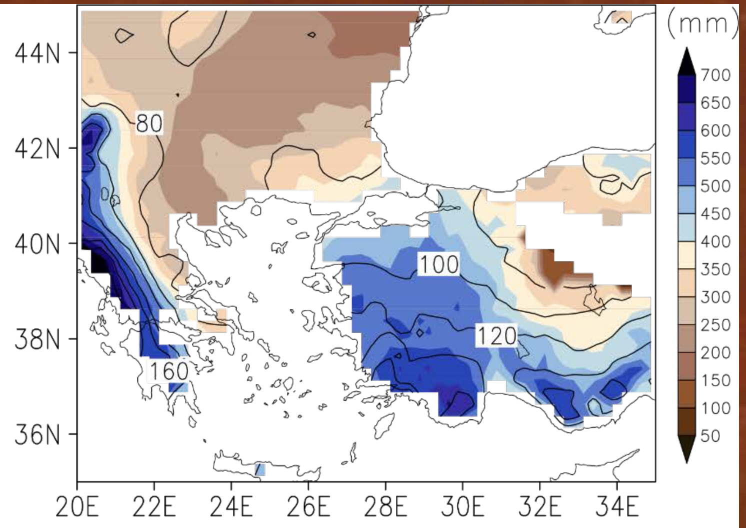
Spatial mean distribution (average winter values, °C) and standard deviation 1951-1980
E-OBS v10.0 (0.25° x 0.25°)

Temporal variability
Extended winters 1951-2014
Deviations (°C) from 1951-1980

Winter (October to March) mean climate

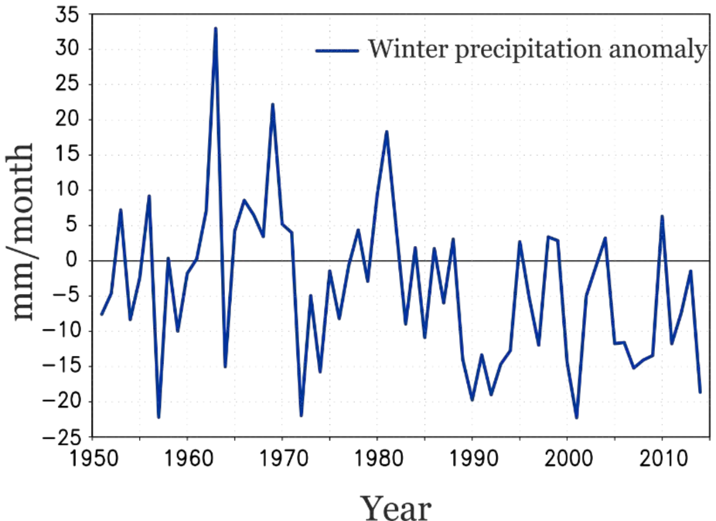
The Mediterranean wet season contributes the most to the annual precipitation totals

Precipitation pattern:
High spatial variability; western coasts receive maximum rainfall amounts with high temporal variability # leeward/rainshadow areas



Spatial mean distribution (average winter totals, mm) and standard deviation
1951-1980
E-OBS v10.0 (0.25° x 0.25°)

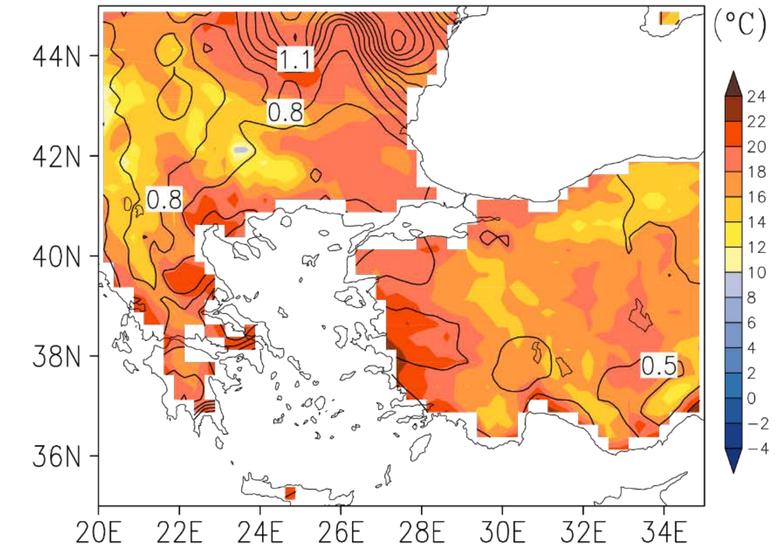
High temporal variability during the recent past decades;
Statistically significant decreasing trend of -10 mm/decade

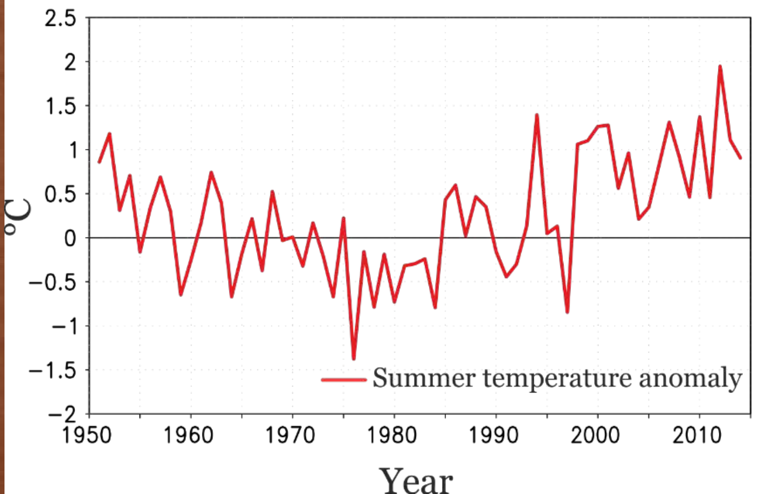


Temporal variability
Extended winters 1951-2014
Deviations (mm) from 1951-1980

Summer (April to September) mean climate

Statistically significant warming





Temperature gradient: coastal – inland areas, strong influence of the orography

Smaller temporal variation wrt. Winter. Highest variability over northeastern E. Mediterranean

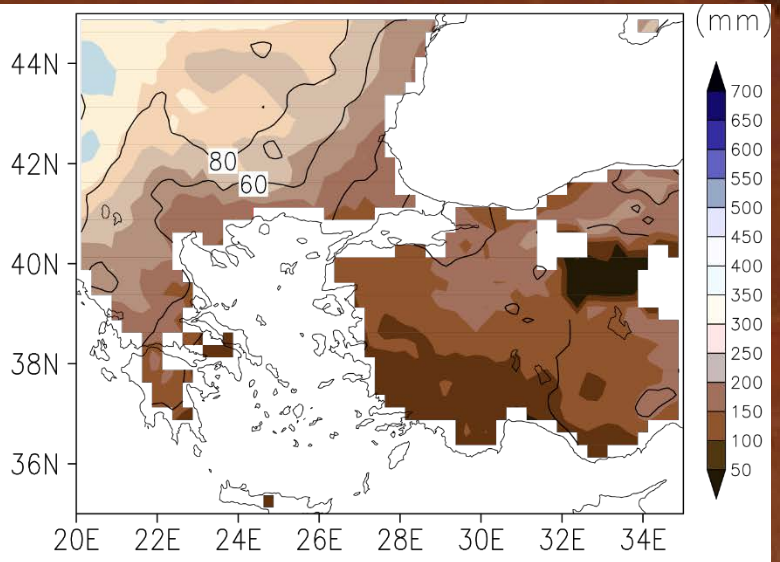
Statistically significant summer warming trend (0.13 °C/dec.) during the last decades & temperature extremes, heat waves

Spatial mean distribution
(average summer values , °C)
and standard deviation
1951-1980
E-OBS v10.0 (0.25° x 0.25°)

Temporal variability
Extended summers 1951-2014
Deviations (°C) from 1951-1980

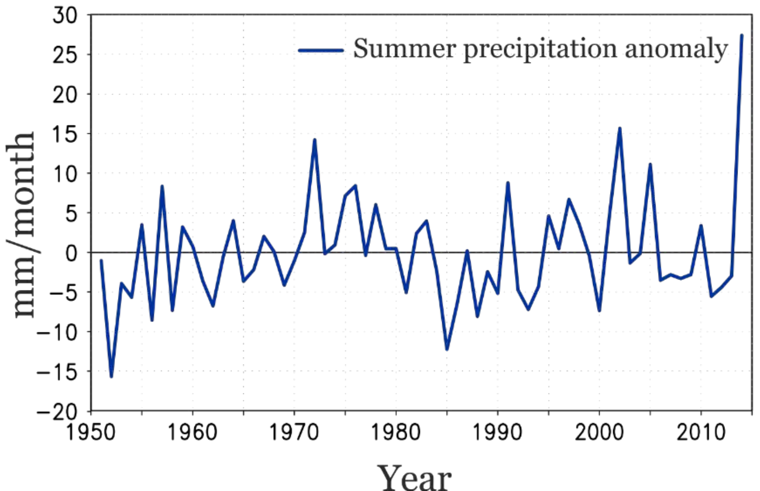
Summer (April to September) mean climate

Precipitation pattern:
Lower rainfall amounts compared to winter
Lower spatial variability



Spatial mean distribution (average summer totals, mm) and standard deviation
1951-1980
E-OBS v10.0 (0.25° x 0.25°)

Smaller temporal variability
During the warmest months (June to August), precipitation amounts are mainly due to convective activity connected with thunderstorms



Temporal variability
Extended summers 1951-2014
Deviations (mm) from 1951-1980

Climatology of the Byzantine lands

The temperature and precipitation patterns during both extended winter and summer seasons present high spatial and temporal variability, which is characteristic for the area and, thus, suggesting the complexity of the impacts that might be connected to changes in climate conditions.

Aim and approach

- To contribute to the identification of causal relationships between climatic and socio-economic changes
- Through a detailed, interdisciplinary and comparative analysis that takes advantage of new evidence on medieval climate and society in Byzantium and existing textual, environmental, climatological and climate-model based evidence

The Medieval Climate Anomaly

"...multidecadal periods during the Medieval Climate Anomaly (950–1250) were in some regions as warm as in the mid-twentieth century and in others as warm as in the late twentieth century..."

"...these regional warm periods were not as synchronous across regions as the warming since the mid-twentieth century..."

Intergovernmental Panel on Climate Change AR5
Working Group I, Masson-Delmotte et al., 2013

Byzantium during the MCA

- An expanding society with thriving economy and complex political-cultural institutions, and societal organisation among the most complex achieved by pre-modern societies
- Byzantines' written, material evidence to investigate potential societal impacts of climate variability for a period of prosperity, 9th to 12th century AD
- Recovery after the crisis of the "Dark Ages" till after the fall of Constantinople in 1204
- Northern regions of the Eastern Mediterranean

The history of Byzantium 800-1300 AD

Year AD	Key events and reigns
838	Sack of Amorion (central Anatolia), the last of the serious Byzantine defeats at the hands of the Arabs
867–886	Basil I, founder of the Macedonian dynasty and the initiator of a major legal reform
962–965	Cilicia conquered by Nicephorus II
972-975	Byzantines invaded Syria and Palestine under the command of the emperor John I Tzimiskes
976-1025	Basil II, conquest of Armenia and Bulgaria, the height of the Byzantine political power
1071	The Seljuk Turks defeat the Byzantines at Mantzikert, civil war leading to loss of much of Anatolia
1081-1118	Alexios I Komnenos; reconquest of most of Western Anatolia; political stability regained
1204	The Fourth Crusade and the fall of Constantinople to the Latins; political disintegration of the empire
1261	Byzantines from Nicaea recaptured Constantinople under Michael VIII Palaiologos

Climate impact on Byzantine society

- Preindustrial society, dependent on agriculture
- Cereal cultivation
- Vine and olive cultivation
- Weather variability and tax income

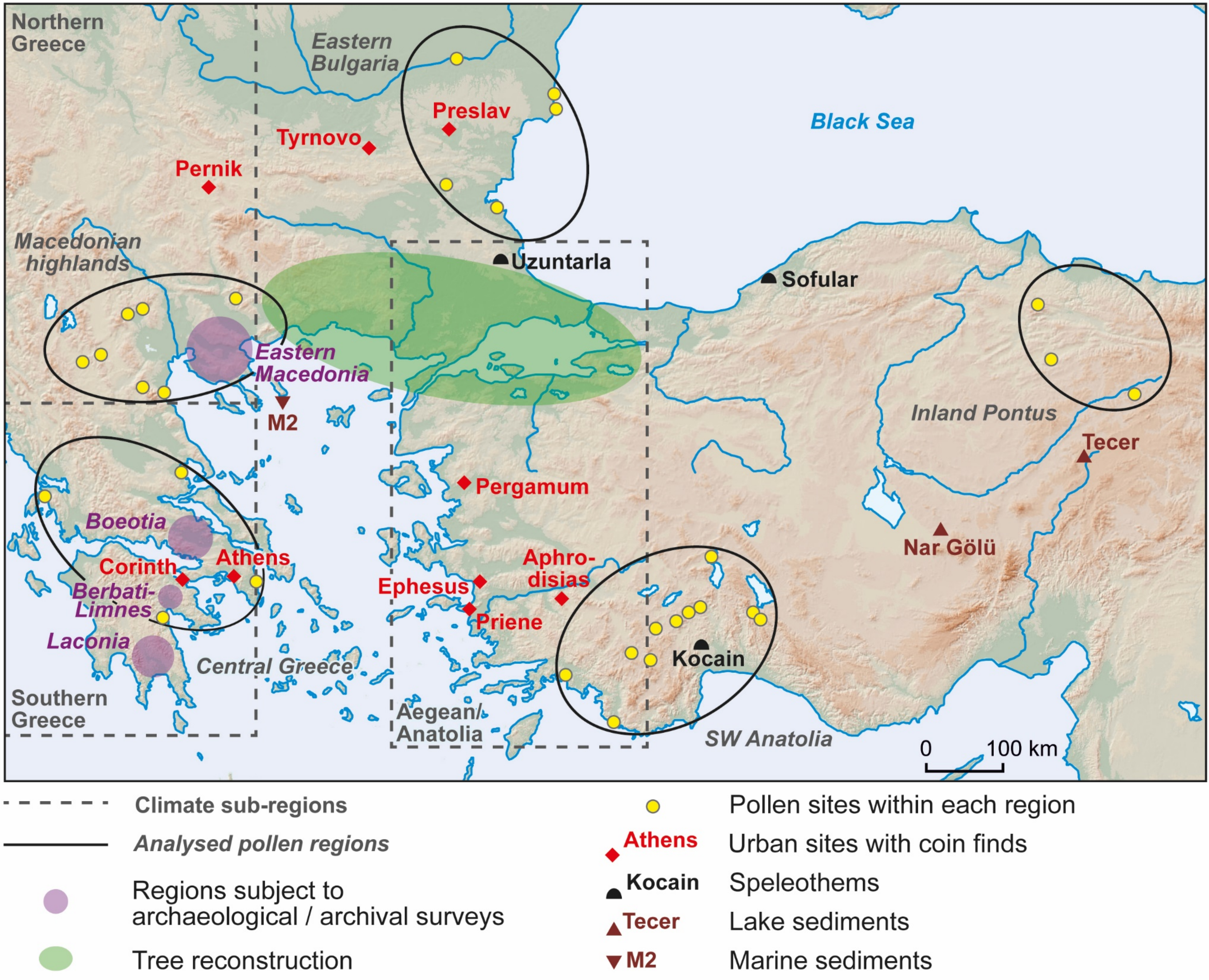
Important crops for the Byzantines

Crop	Key season	Weather conditions ensuring good harvest	Threatening weather conditions	Role in society	Impact of adverse climate conditions
Cereals (wheat, barley)	November-April	Regular, adequate spring rainfall	Prolonged winter, spring drought, early summer heat stress	Basis of diet (40-50% annual calorie intake)	Subsistence crisis, social instability
Vine	April-September	Sunny summers	Spring hoar frost; summer heat; late summer rain	Wine widely traded; local, regional specialisation in vine cultivation	Local- or regional-scale economic crisis
Olive	April-December	Dry climate; adequate spring rainfall	Prolonged frost in winter (below -10° C)	Olive oil consumption by all strata of society; local, regional specialisation	Local- or regional-scale economic crisis

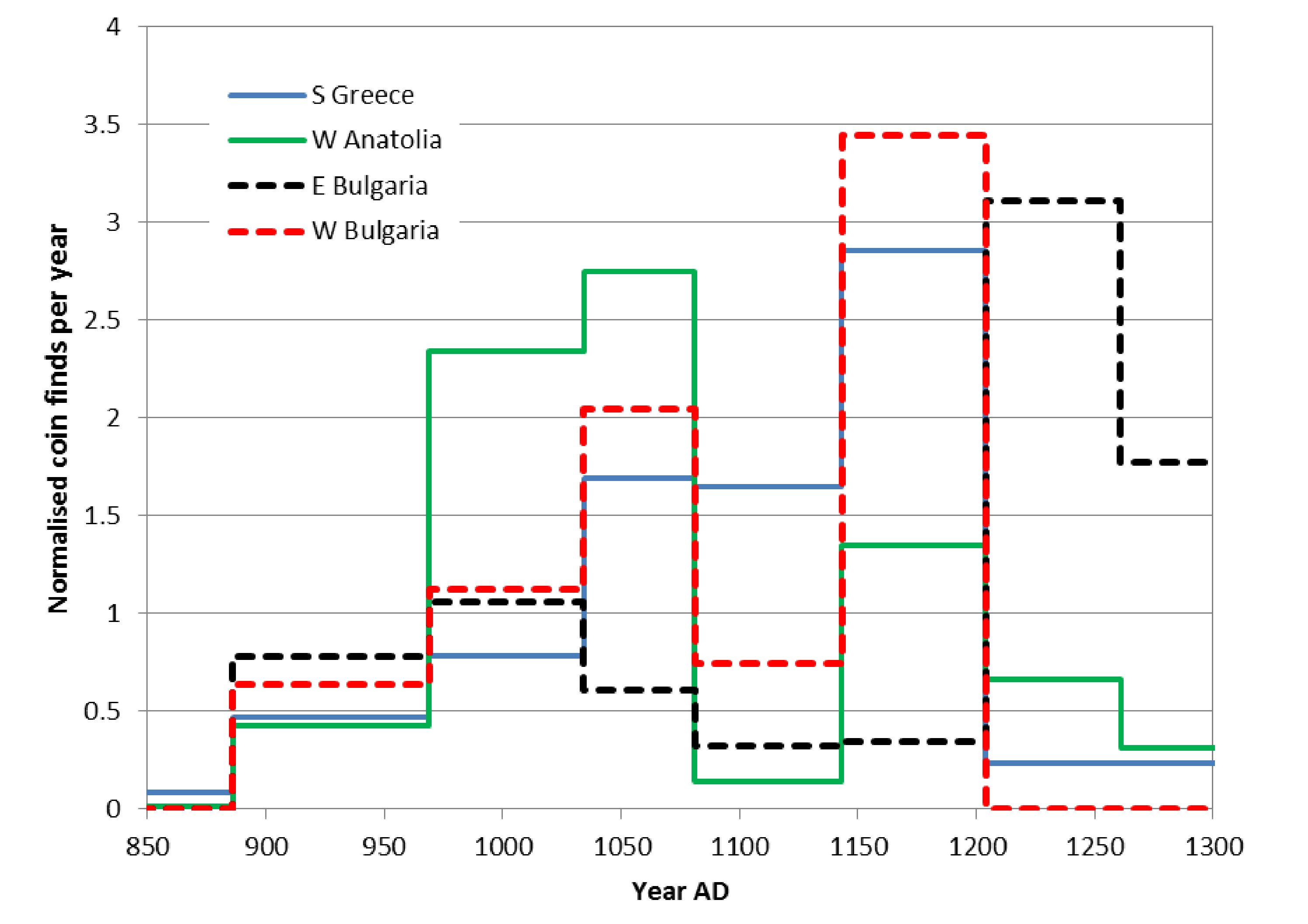
Available evidence for the study of Byzantium's economic performance

Type of evidence	Phaenomena recorded	Economical relation	Character of information	Chronological precision
Historical – narrative	taxation system, social relations, long-term economic situation	usually indirect	qualitative	approximate, long-term (100-300 yrs)
Historical – archival	population, cultivated lands, agricultural production structure, scale	often direct	qualitative & quantitative	ca. 10-50 yrs when quantified
Archaeological – coin finds	monetary circulation on a given site/region	direct	quantitative	regnal periods, ca. 10-40 yrs
Archaeological – sites numbers	regional, settlement intensity, population levels (indirectly), cultivation scale	rather indirect	quantitative	100-300 yrs
Palaeoenvironmental – palynology	regional, relative changes of anthropogenic plants	direct	quantitative	100-200 yrs

Medieval Byzantine lands



Monetary circulation on urban sites



Southern Greece
Athens and Corinth (Morrisson, 1991)

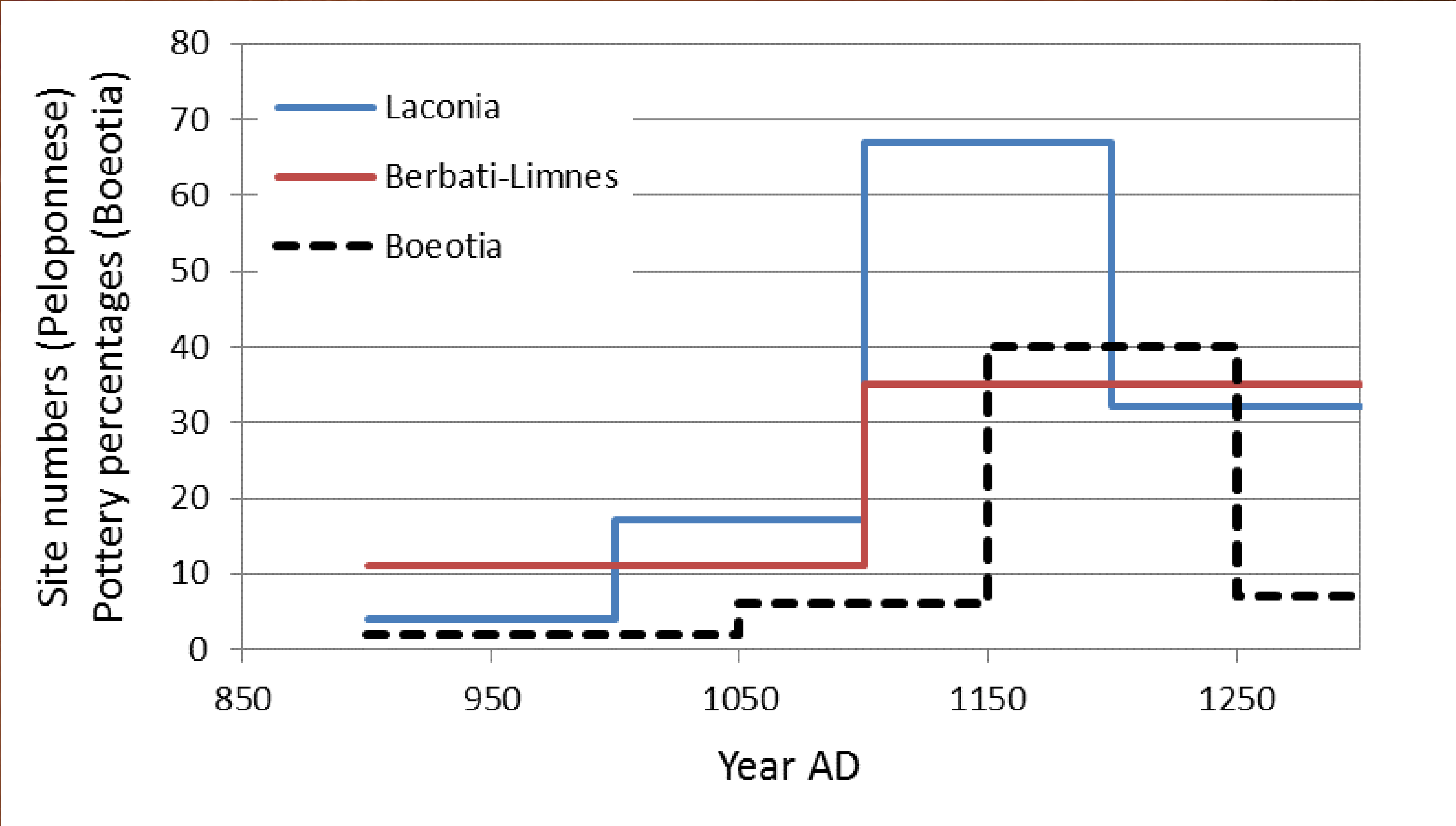
Western Anatolia
Aphrodisias, Ephesus, Pergamum, Priene (Morrisson, 1991, 2002)

Eastern Bulgaria
Preslav and Tyrnovo (Morrisson, 2002)

Western Bulgaria
Pernik (Morrisson, 2002)

AD 811-886 was considered to show the minimal value of the frequencies of the coin finds per year

Settlement density from the archaeological survey evidence

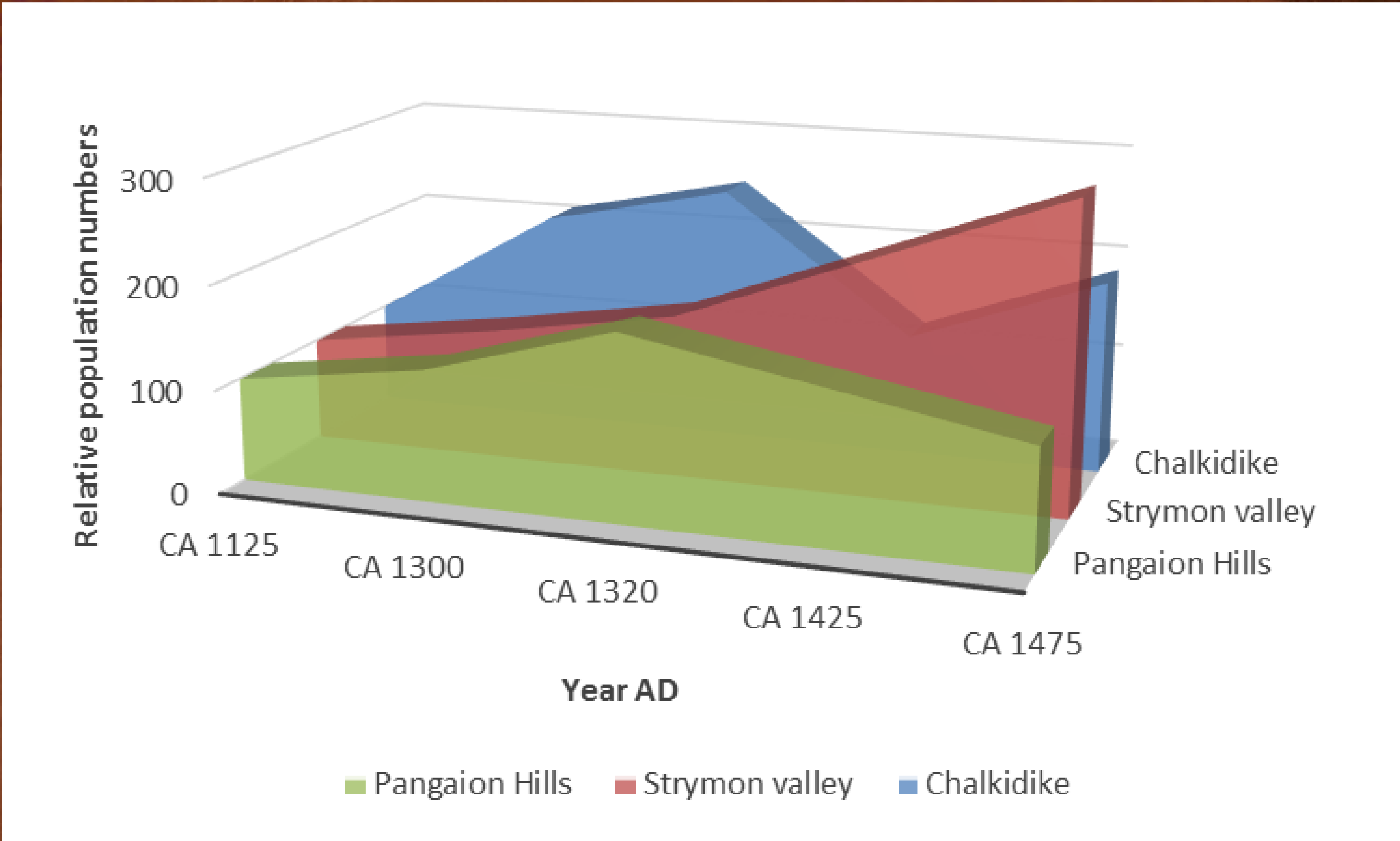


Laconia
Southeastern Peloponnese (Armstrong, 2002)

Berbati-Limnes
Northeastern Peloponnese (Hahn, 1996)

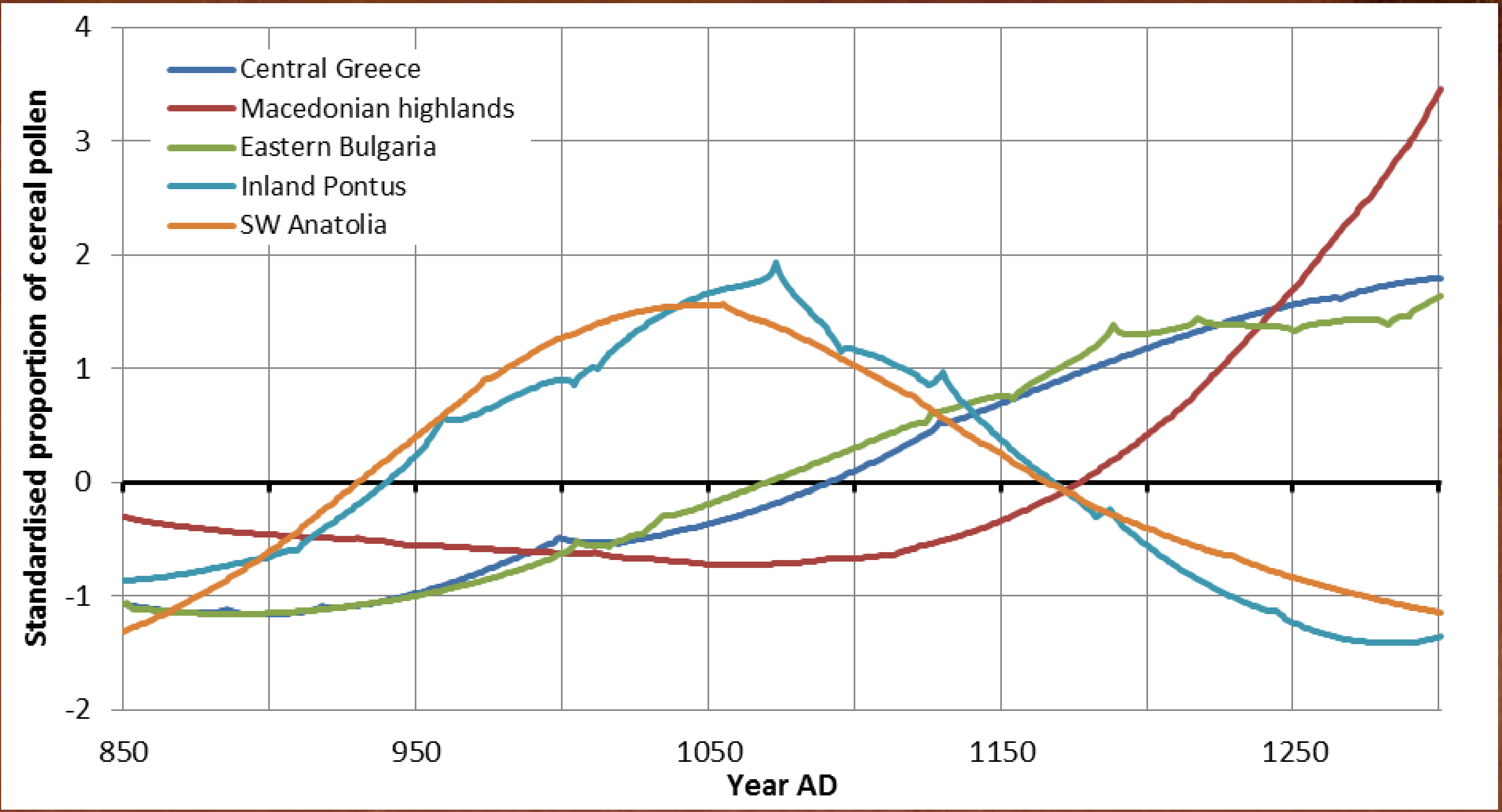
Boeotia
Central Greece (Vionis, 2008)

Population changes in Eastern Macedonia



Relative changes in population numbers compared to the early twelfth century population levels (Lefort 1991)

Proportions of cereal pollen



Relative average proportions of cereal pollen in selected regions of the Balkans and Anatolia.
Annual values have been standardised with respect to the period 800-1300 AD (Izdebski et al., 2015)

Palaeoclimate documentary/textual evidence – medieval Byzantine region

Textual data:

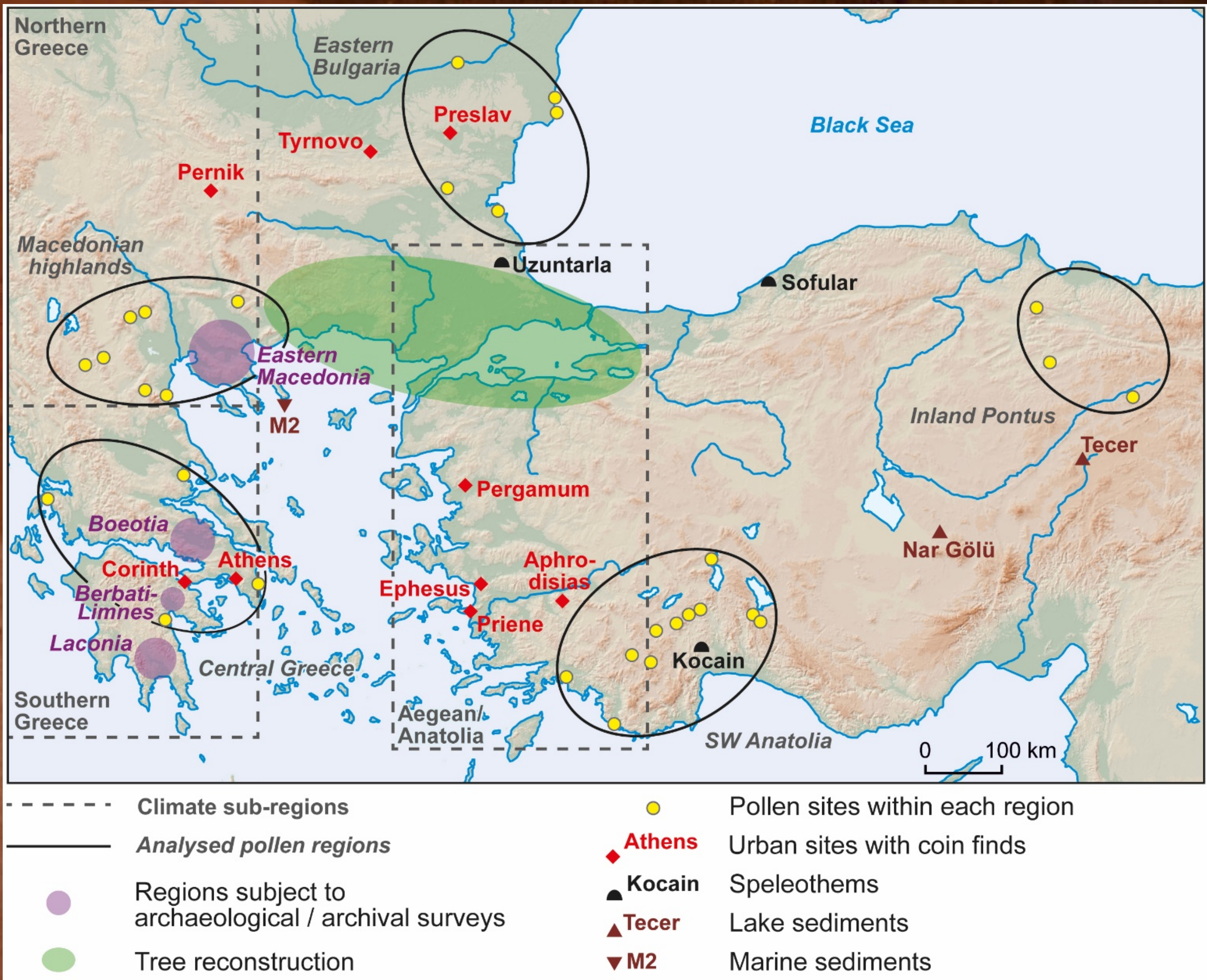
- ☑ high temporal resolution
- ☑ disentanglement of temperature and precipitation effects
- ☑ coverage of all months of the year
- ☑ high sensitivity to anomalies and natural hazards
- ☑ wealth of the Byzantine literary tradition

- ☒ usually discontinuous and heterogeneous
- ☒ various socio-cultural parameters may affect the perception of the observers
- ☒ bias to the inclusion or exclusion of climatological information in the texts
- ☒ climate-related accounts from Byzantine sources are rare
- ☒ narrative content and qualitative character do not allow the application of sophisticated statistical methods or the deduction of monthly indices for medieval palaeoclimatic reconstructions

Documentary/textual historical-climatological data Telelis (2000, 2008)

Palaeoclimate natural proxies evidence – medieval Byzantine region

- small number of records providing detailed information on climatic fluctuations during the period 850-1300 AD in the Eastern Mediterranean
  - M2 (annual SSTs)
  - Tree rings (May-June precipitation)
  - Uzuntarla Cave (effective moisture)
  - Sofular Cave (effective moisture)
  - Kocain Cave (snow cover and more effective recharge of the aquifer above the cave at times of enhanced snow cover)
  - Nar Gölü Lake (winter precipitation and spring and summer evaporation rates)
  - Tecer Lake (winter precipitation and spring and summer evaporation rates)



The Middle Byzantine climate simulated by climate models I

- Two Coupled Model Intercomparison Project Phase 5 with highest spatial resolution from 850 AD - CCSM4 & MPI-ESM-P
  - External forcing
    changes in orbital, solar (0.1% between present day and the Maunder Minimum), volcanic (Gao et al., 2008; Crowley and Unterman, 2011), greenhouse gas and land use (Pongratz et al., 2008)
    - CCSM4 (atmosphere: CAM4, ocean: POP; Landrum et al., 2013)
    - MPI-ESM-P (atmosphere: ECHAM6, ocean: MPI-OM; Giorgetta et al., 2013)

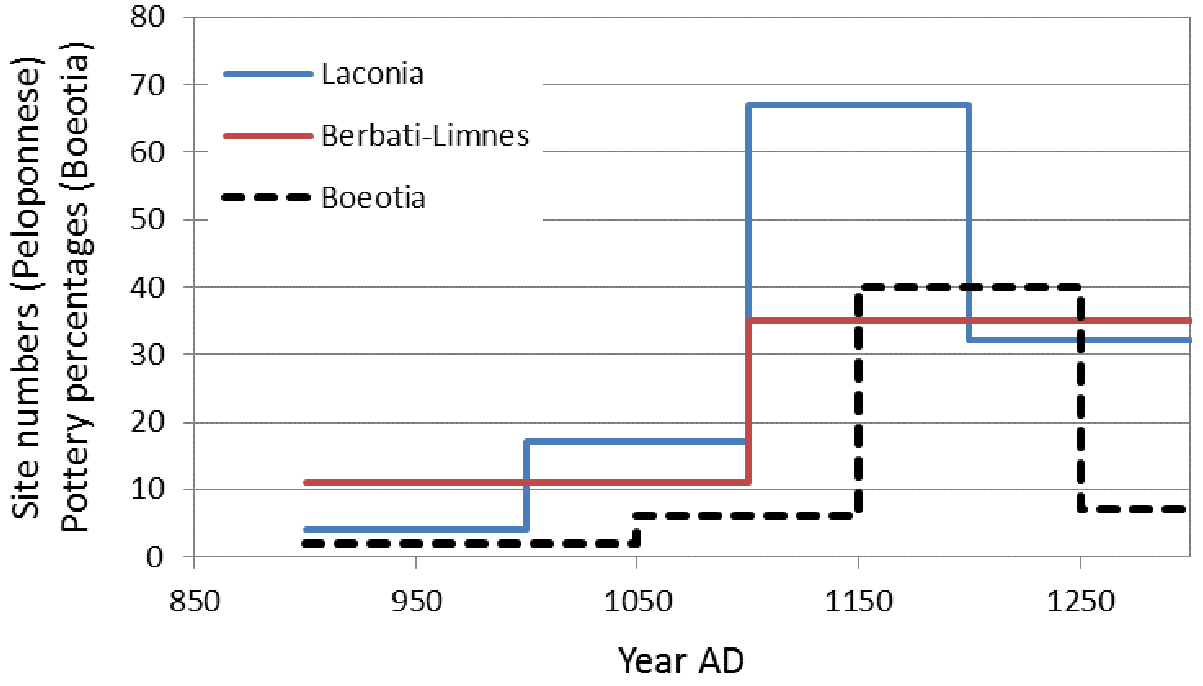
The Middle Byzantine climate simulated by climate models II

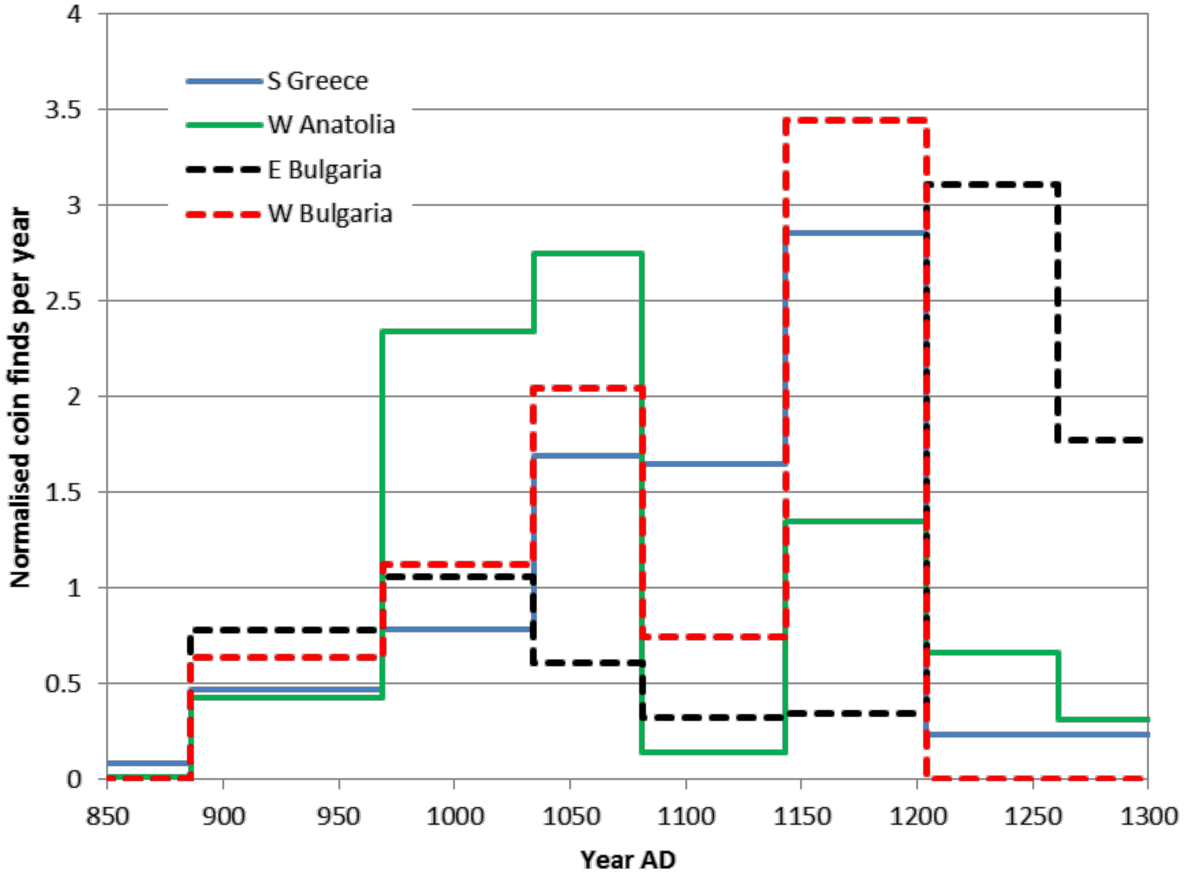
- ECHO-G-MM5 (Wagner et al., 2007; Gómez-Navarro et al., 2013)
  - External forcing
    orbital, solar, GHG; no volcanic reconstruction prior to 850 AD. Solar constant 0.3% difference to the MM
  - Realistic representation of topography and the coastline for the Eastern Mediterranean
  - Increased horizontal and vertical resolution
    - Forced by AOGCM ECHO-G, from 1 AD (atmosphere: ECHAM4, ocean: HOPE-G)
    - 45 km resolution domain implemented in the regional simulations

1100-1200 AD, Southern Greece

- most prosperous times
- demographic expansion
- significant monetary exchange

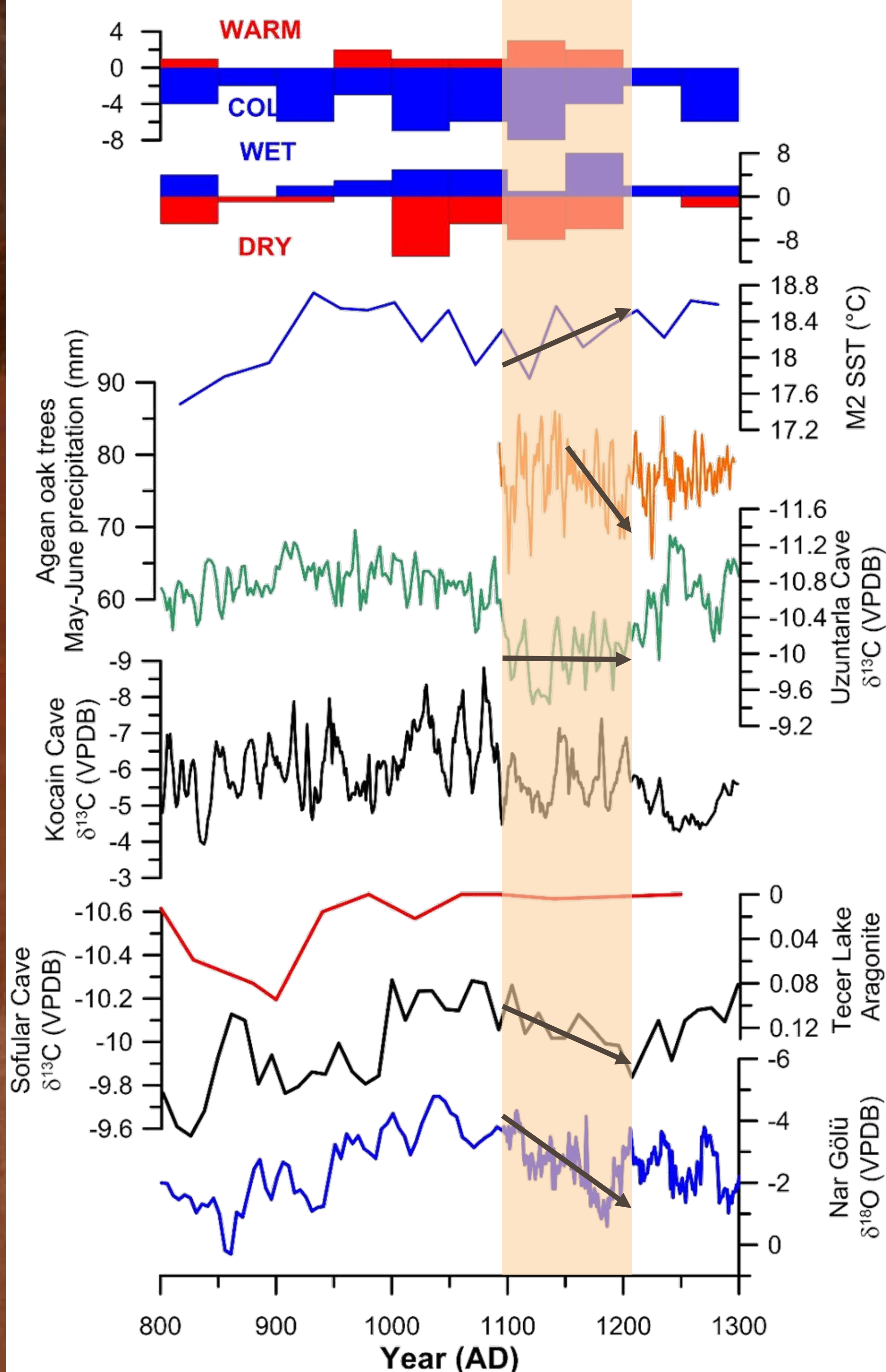
- Byzantine Empire was relatively strong in terms of political power





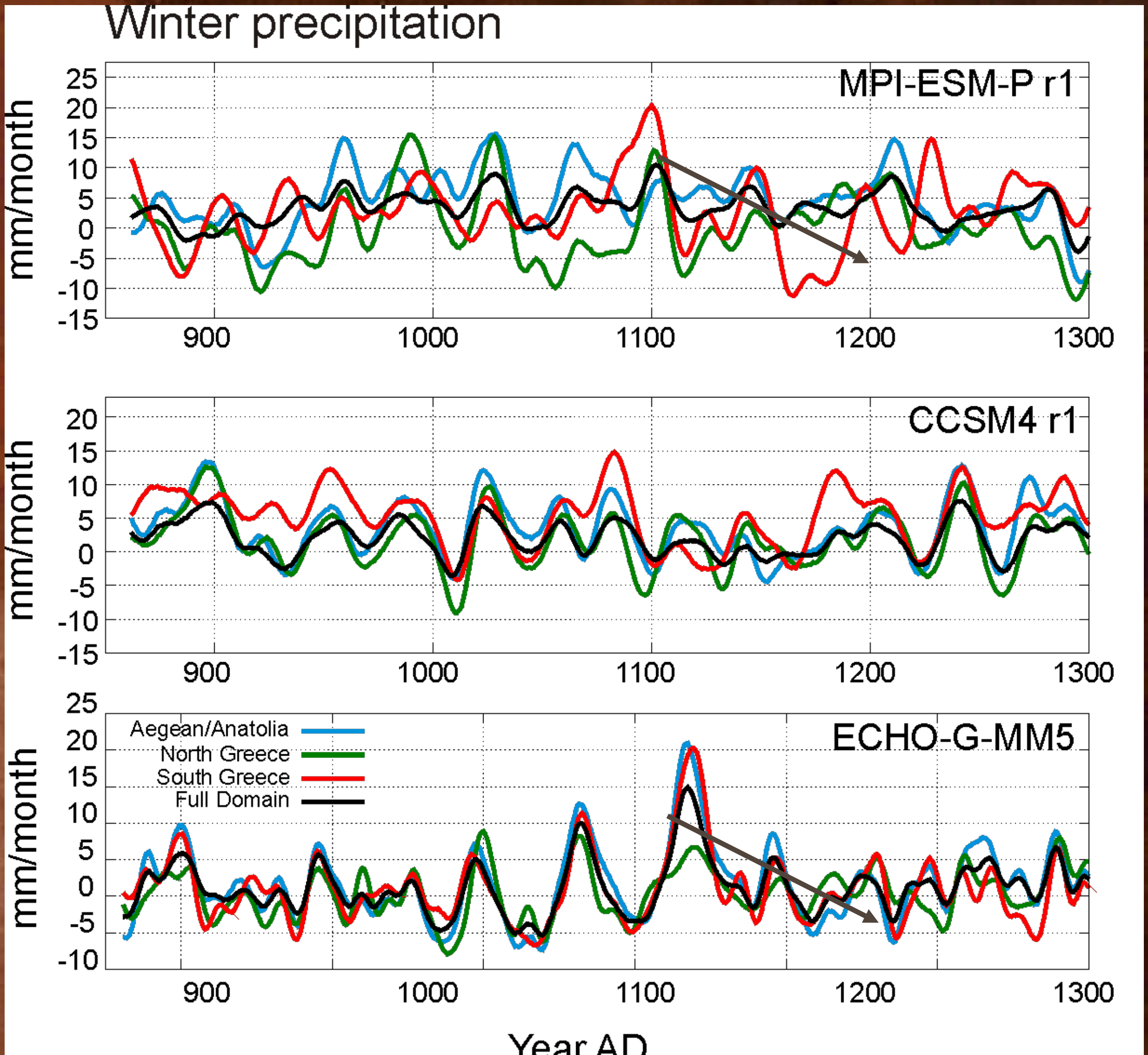
1100-1200 AD, S. Greece

- higher SSTs
- reduced precipitation



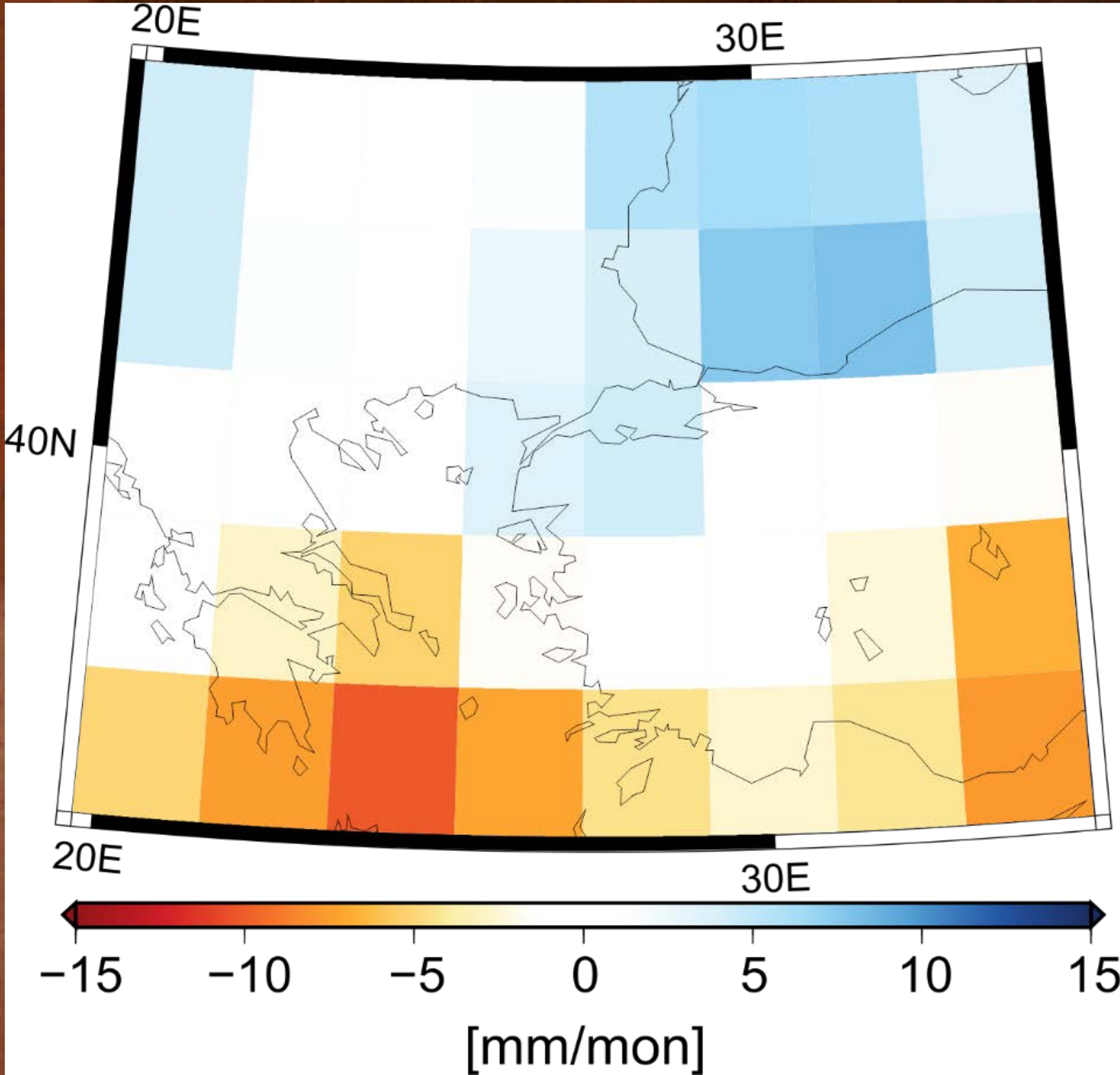
1100-1200 AD, S. Greece

- higher SSTs
- reduced precipitation
- winter dryness



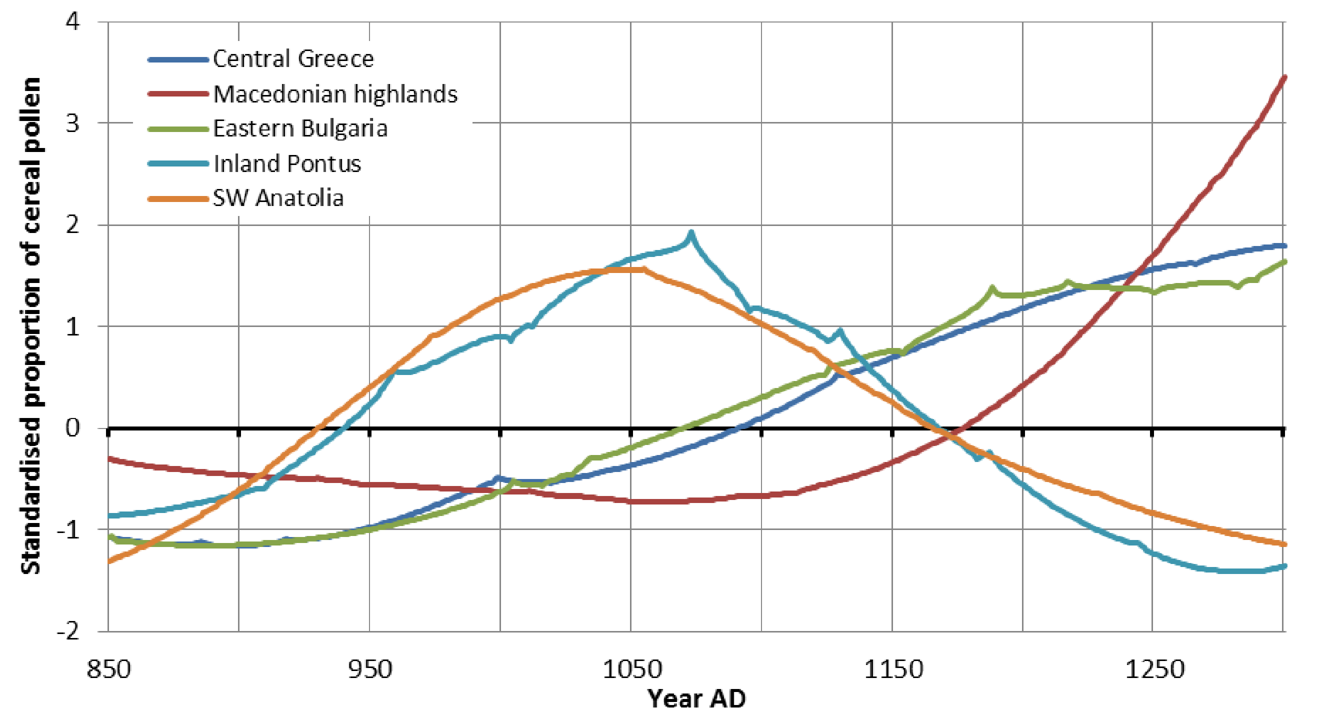
1100-1200 AD, S. Greece

- higher SSTs
- reduced precipitation
- winter dryness
- dry 1175-1200 AD



1100-1200 AD, S. Greece

- higher SSTs
- reduced precipitation
- winter dryness
- dry 1175-1200 AD
- In C. Greece and Macedonia, the economic growth continued throughout the whole century



1100-1200 AD, S. Greece

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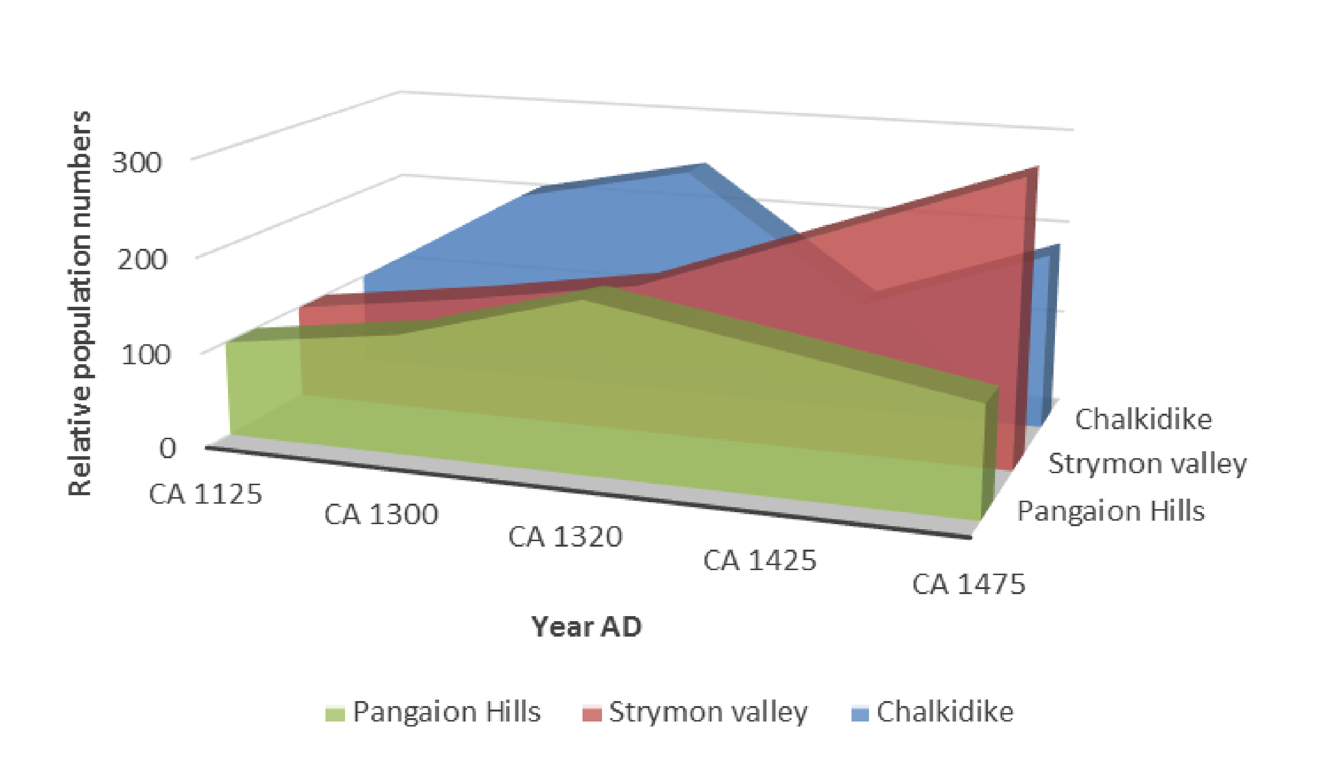
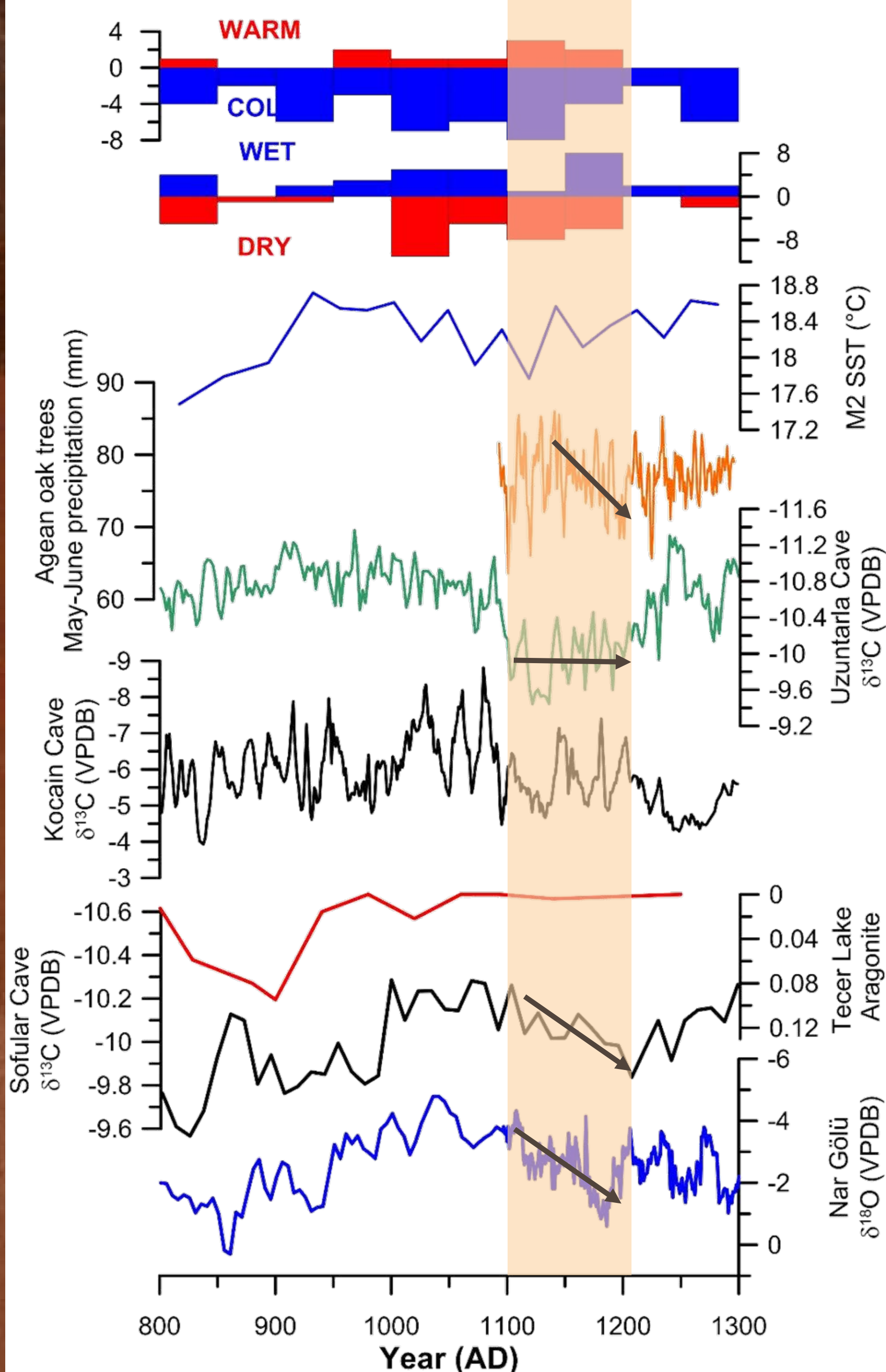
↳ resilient Byzantine society of Southern Greece to the 12th century unfavourable climatic conditions



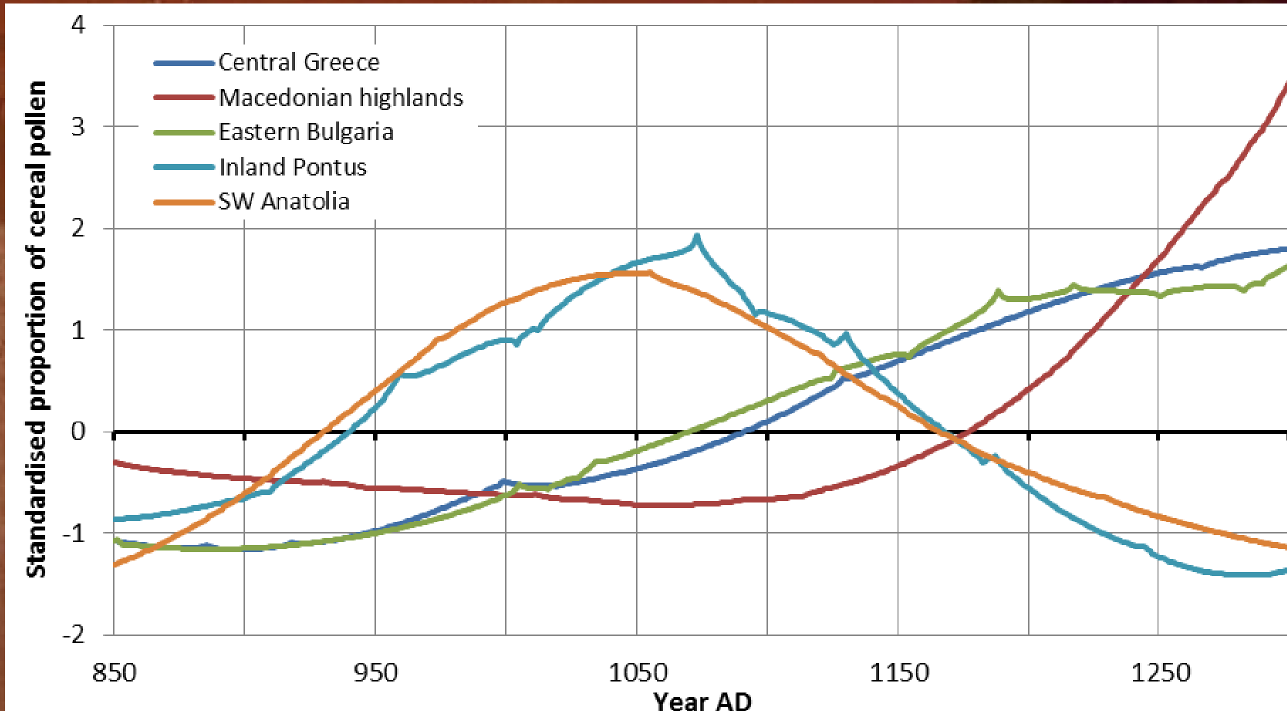
1100-1200 AD, Anatolia

- After the Turkish conquest, drier conditions prevailed almost everywhere across the Byzantine Empire



1100-1200 AD, Anatolia

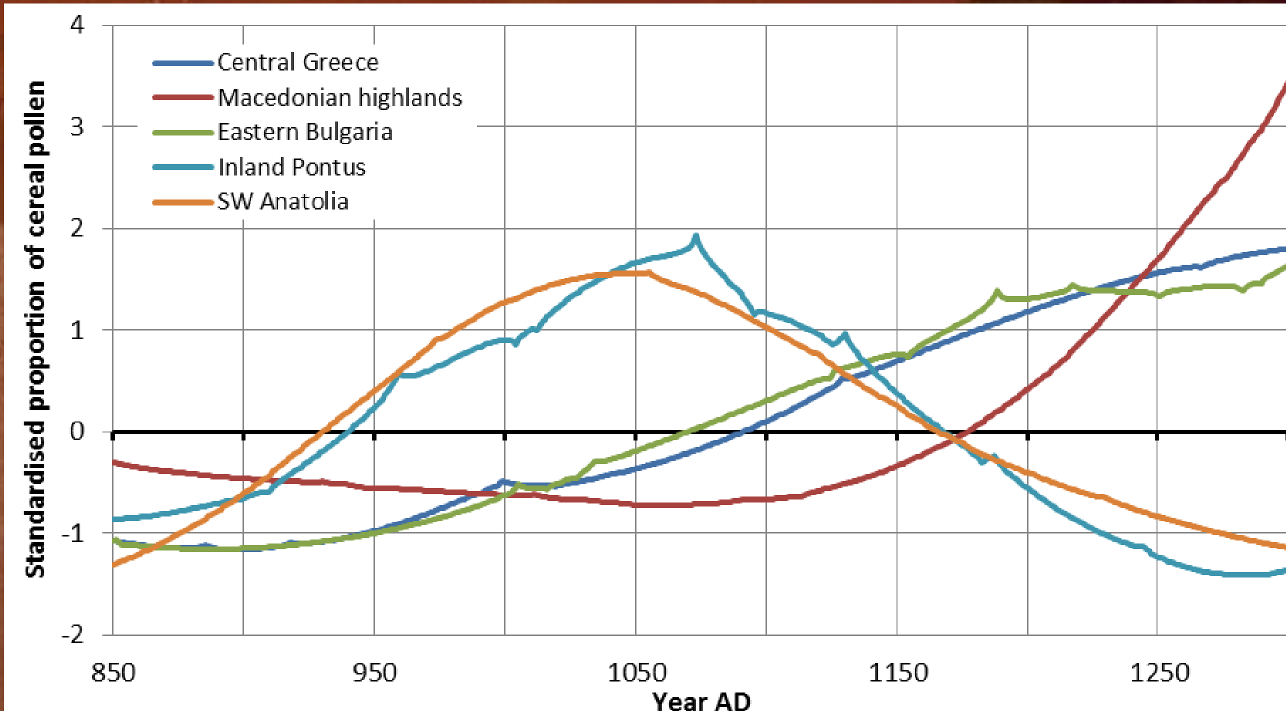
- After the Turkish conquest, drier conditions prevailed almost everywhere across the Byzantine Empire
- An important decline in agricultural production occurred in Anatolia before 1100 AD



1100-1200 AD, Anatolia

- After the Turkish conquest, drier conditions prevailed almost everywhere across the Byzantine Empire
- An important decline in agricultural production occurred in Anatolia before 1100 AD
- The invasion of the Seljuk tribes and the migration of the Turkoman nomads into Central Anatolia (after AD 1071) brought the economic system of Anatolia to a collapse

➢ What was the role of climate to the Seljuk expansion?



Conclusions I

- Twofold palaeoclimatic and archaeological-historical approach: palaeoclimatic addressing the events and assessing the temporal and spatial characterisation of climatic changes; archaeological-historical discussing the complex dynamics of the Byzantine society
- Comparative use of palaeomodels in combination with palaeoclimate information and societal evidence: natural and textual proxies, historical, palaeoenvironmental, archaeological data, better knowledge of the drivers behind the climate system and the coupled climate-society system
- Cautious interpretation: complexity and spatio-temporal heterogeneity, specific characteristics of the archives, climate signal and response, and discontinuity and multi-factorial character of the societal evidence

Conclusions II

- 12th century: climax, considerable agricultural productivity, substantial monetary exchange, demographic growth. Warmer temperatures, high precipitation variability and drier winter conditions did not affect the Byzantine socio-economic system
- Climate as contributing factor to the socio-economic changes
- The Byzantine socio-economic system was vulnerable to climatic changes only when it was experiencing considerable internal or/and external political and military pressures
- Resilience of the Byzantine society to the impacts of climate variability: direct and indirect links between climate and socio-economic changes

Thank you!

Can medieval societies teach us how to adapt to climate change?

This mosaic from the Hagia Sophia in Istanbul depicts the 12th Century Byzantine emperor John II (left). A new interdisciplinary study suggests that medieval Constaninople likely fell because of political rifts, not food insecurity. Photo: Myrabella via W

APR 2016 6

by Michelle Kovacevic

A new study takes a comprehensive look at the fall of Constantinople, and if climate change contributed to the collapse.

In AD 1204, Constantinople fell. That year, tens of thousands of Latin crusaders on their way to conquer Muslim-controlled Jerusalem made a side trip to the Eastern Roman Empire, or Byzantium, where they had made a deal to help prince Alexios IV become emperor. The Byzantine elite at Constantinople, not happy with these backroom wheelings and dealings, rebelled, and Alexios was strangled to death.

At least that's the story that the history books tell you. What's not really been explored is how much the increasingly arid weather contributed to Constantinople's unrest during this time.

Just over 800 years later, neighbouring Syria is seeing similar societal unrest, exacerbated by drought. It begs the question: What might we learn from the way climate affected Byzantine political, economic and social systems so that we can better manage similar conditions today?

A recent study led by Elena Xoplaki in *Quaternary Science Reviews* examines