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Climate History of Byzantium at the Crossroads

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Abstract This chapter is meant as a basic introduction to the field of climate history of Byzantium as of AD 2022. After explaining what climate history is, it discusses the source base and the big questions of the field, as well as it outlooks for the future.

Keywords Byzantium. Eastern Roman Empire. Climate history. History of climate and society. Mediterranean. Environmental history.

Summary 1 Introducing Climate History. – 2 Climate History of Byzantium. Source Base. – 3 Climate History of Byzantium. The Big Questions. – 4 Climate History of Byzantium. The Future.

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1 Introducing Climate History

Natural phenomena, including weather, have been present in historical accounts ever since historical writing emerged in Classical Greece. As we all well know from our own experience, benign or inclement weather can facilitate or derail human action. It is thus no surprise that the earliest accounts of human experience already included references to weather conditions, often connected to divine agency.

Climate history as a field also looks at extreme weather events and their impacts on human action, but its goals can be defined more broadly (White, Pfister, Mauelshagen 2018; Degroot et al. 2021). Generally speaking, climate historians (who could be historians by training, but also archaeologists or natural scientists) work, first, on reconstructing past climate variability and, second, on understanding the role this variability played for historical societies. They deal with several temporal and spatial scales. The smallest of them is a local extreme weather event that lasts a few hours (such as torrential rain), but studies in climate history could also look at whole regions or countries, discussing changes in climatic conditions (such as the average temperature or rainfall) that occurred in these areas over several generations or centuries. Consequently, climate historians look at a very broad variety of phenomena also on the human side of the equation: from specific military operations or cataclysmic events to infrastructural and institutional developments that might have unrolled over several decades. This results in the field of climate history being highly diverse and forces it to rely on a wide range of natural scientific, material and written evidence. To some extent, it also raises the bar for reaching general conclusions, especially if we think about pronouncing statements about how specific historical societies (such as the 'Byzantines') coped with weather shocks and climate variability.

Even if there has been a continued tradition of climate determinism within the social sciences and the humanities, reaching deep into the past – determinism both geographical (for instance, associating racial or cultural traces with specific climates) and historical in character (explaining historical changes through climate or weather disasters) – climate history as a field emerged only in the second half of the twentieth century. At that time, pioneering historians such as Emmanuel Le Roy Ladurie started noticing that weather conditions – which could, for instance, determine harvest time and quality – were highly variable over time and that they can be reconstructed from the written record (Le Roy Ladurie 1959; 1961; 1967). Hence, the foundation of climate history was the realisation that climate was not a constant background to human history – as previously assumed even by Braudel in his monumental *The Mediterranean in the Age of Philip II* (Braudel 1949, with some qualifying observations in the 1966 edition) – but that it varied over historical timescales and thus it also continuously redefined natural conditions for human activity. Crucially, it was a discovery made by historians using historical sources. Only as the time progressed, and the natural sciences developed new methods to reconstruct past climate conditions on the fine-grained timescales of centuries, decades, and years, did the study of climate history begin to require more substantial engagement with the natural scientific data on the part of historians and archaeologists.

Thus, for decades historians had to rely solely on the written documentation for the study of past climate. Consequently, climate history initially focused on reconstructing past climate and weather conditions, an activity that is known as historical climatology (Brázdil et al. 2005) (in contrast to palaeoclimatology, which is the natural-science-dominated reconstruction of past climate conditions and explanation of past climate dynamics, relying heavily on physics, chemistry and often also biology [Bradley 2014]). Historical climatology developed complex methodologies for collecting testimonies of past weather conditions from historical sources (narrative as well as documentary), and of synthesising them into tentative climate reconstructions. The other branch of climate history, recently named "history of climate and society" (Degroot et al. 2021), focuses on the interaction of human societies with the past weather and climate conditions, as reconstructed by historians and natural scientists. While these research questions were on the radar of climate historians from the very beginning of the discipline, and constitute the ultimate goal of their research, they were subject to a more systematic scrutiny only as more data on past climates was being collected. The foundations for this sub-field were laid by Christian Pfister, a Swiss early modern historian, who published his first groundbreaking study in the late 1970s, still relying primarily on the written evidence (Pfister 1978; 1988a; 1988b).

Today, climate history *aka* history of climate and society is an interdisciplinary field that could not exist without a continuous dialogue and cooperation between historians and social and natural scientists, in particular historians, archaeologists, and climatologists (Haldon et al. 2014; Izdebski et al. 2016; Haldon et al. 2018a). It has become standard to rely primarily on the natural scientific data for past climate when studying the interplay between climatic change and human activities, especially for premodern societies, which also includes Byzantium. Even if the scientific climate data has its own limitations, it has become a widely accepted view that engaging with the 'archives of nature' makes it possible to overcome the cultural bias of the 'archives of societies' (written and material evidence), and a proper study in climate history combines the two.

Natural scientific data on past climate are called proxies, a term that is used for measurements of physical or chemical properties of natural remains that exist today and contain 'traces' of past climate conditions. It could be living or dead trees, stalactites or stalagmites (speleothems), sediments in all kinds of locations, particularly lakes (in lay terms, sediments are 'the mud at the bottom'), and many more, including human bones. Everything that grows or accumulates over time contains traces of the past in its structure, and it is 'just' a matter of finding proper scientific methods to read this information and relate it to specific aspects of climate. Moreover, improvements in the dating methods, and the increase in scientists' interest in the most recent millennia, have resulted in the incredible increase in the availability of proxy-based reconstructions of past climatic conditions for the historical times (or the Late Holocene, the last 3,000 years).

Written sources, material evidence, and natural archives are subject to different limiting factors when it comes to their availability, and achieving the coincidence of them all often happens to an extent by chance (Haldon et al. 2014; Izdebski et al. 2016; Haldon et al. 2018a). Since the history of climate and society depends on the availability of both palaeoclimatic data (ideally, from the 'archives of nature') and historical evidence, studies in this field usually assume the form of case studies. These are not always the case studies historians would dream of in order to answer the 'big questions' on the impact of climate on a specific historical society, and there are many potentially exciting stories of past climate impacts that would perhaps never advance to a scientifically rigorous form, simply because there is no natural archive that could yield the necessary proxies or no detailed historical record that would help to contextualise the proxies in a satisfactory way. Even in ideal situations, when all the three types of evidence are available, it remains a challenge to establish historical causation and offer certainty with respect to the 'agency' of climate in the historical process (Sessa 2019). With historical causality remaining an elusive goal even outside of the context of climate, new approaches and theoretical frameworks are being developed, moving away from a linear 'impacts' model' to a networked model in which the agency of climate is explored through embedding a specific climate 'event' into an entire social-ecological system which it 'encountered' in a specific time and place (Zanchetta et al. 2021).

2 Climate History of Byzantium. Source Base

Since the early 2010s, several Byzantinists became interested in the role of climate in the history of Byzantium. In parallel, due to the vulnerability of the Mediterranean region to future climate change and its crucial role as the crossroad between Europe and the Middle East, natural scientists have been producing a steadily growing number of natural proxies for this part of the world since the beginning of the twenty-first century Together with the initiatives fostering interdisciplinary dialogue, such as Princeton's *Climate Change and History Research Initiative*,[1] this creates fertile grounds for the development of the climate history of Byzantium. Its mature stage and broader success is visible in the presence of Byzantine case studies (or even Byzantinists' leadership roles) in recent high-impact reviews summarising the state of the art in climate history (Haldon et al. 2018a; Degroot et al. 2021). Byzantium – or the Eastern Roman Empire, in particular in Late Antiquity – has become known as one of the more advanced case studies in the history of climate and society, on equal terms with such famous 'climate change heroes' as the Maya or the Norse communities of Iceland and Greenland.

The basis for that is the good availability of the natural proxy data (described in detail in Luterbacher et al. forthcoming). The most important natural proxies for Byzantine history mainly come from three types of natural archives: trees, caves, and lakes.

Trees can be used to achieve reconstructions of climatic conditions that are significant for the trees' growing season (they allow the approximation of the key limiting factor for tree growth, such as the summer temperature for the Bosnian pine, or the late spring precipitation for the Greek juniper). Because dendro-reconstructions are based on the analysis of tree rings, they are annually resolved: in other words, when dendroclimatology comes into play, we are able to say what was the summer temperature or May-June precipitation in a particular year. In the case of Byzantium, the two most important and longest (reaching farthest back) proxy reconstructions of that kind are the summer temperatures for Greece (Esper et al. 2020, starting 730 AD) and May-June precipitation in the northern Aegean area (Touchan et al. 2007, starting 1097 AD).

In caves, climatologists examine speleothems, that is the mineral formations that grow on cave ceilings, floors, and walls, such as stalactites. Their physical and chemical properties allow for the reconstruction of a variety of climatic conditions, depending on the climate zone; in the Mediterranean, they are most often used to approximate winter hydroclimate conditions (snow cover or rainfall). For the Eastern Roman world of Late Antiquity and the Middle Ages, there is more speleothem-based climate proxy data for Anatolia than for the Balkans, with the most important speleothem coming from the Sofular Cave east of Constantinople (Göktürk et al. 2011). The published Balkan speleothems stopped growing in Late Antiquity and do not reach into the Middle Ages; there is, however, a very good speleothem record available for northern Italy (Zanchetta et al. 2021).

1 https://cchri.princeton.edu.

Speleothems can be dated relatively precisely with uranium-thorium dating, yet their resolution ('precision/accuracy') is not as high as that of the tree-based reconstructions, usually around a few decades.

As regards lakes, for climate proxies we rely on the analyses of the chemical and biological composition of the sediments, that is the matter accumulating at the bottom of the water body. Like cave formations, lake-originating climate proxies are used to approximate winter conditions, mostly rainfall. The most important lake for which this kind of analysis is available is Lake Nar in Cappadocia (Anatolia), which thanks to having varved sediments (with annual layers visible to the human eye) offers palaeoclimate data with decadal precision for Central Anatolia. Several other lakes, which are not as precise in terms of chronology as Lake Nar is, are located in other parts of Turkey, Greece, North Macedonia, Albania, and Italy.

In addition to the proxies based on the archives of nature, Byzantinists can rely on a large database of descriptions of climatic conditions in Byzantine sources collected in the 1990s by Ioannis Telelis (Telelis 2004, summarised in Telelis 2008). While Telelis' analyses made clear that the written sources cannot be relied upon for the reconstruction of medium- or long-term trends, they provide very important record of short-term weather extremes, and – perhaps even more importantly – evidence on the cultural perception of climate variability, and its entanglement in the life of the Byzantine society, state, and economy. Thanks to this combination of a rich base of natural proxies and easily accessible written evidence, the history of climate and society in Byzantium has been flourishing in the recent decade and promises to continue to develop in the 2020s.

The study of the history of climate and society in Byzantium is also particularly advanced when compared to several case studies from other parts of the world thanks to its engagement with climate modelling (Xoplaki et al. 2016; 2018; 2021). In very simple terms, in this case we do not deal with proxies – reconstructions – coming from specific locations, but with mathematical simulations of past climate conditions. They use more or less the same set of complex equations that are used to predict future climate change. In a way, these are 'predictions' of past climate conditions, and just like the future predictions are based primarily on different possible scenarios of greenhouse gases' emissions, the modelling of the past is based on the available reconstructions of the sun's activity or the timing and magnitude of volcanic eruptions. While models cannot tell us what were the 'real' conditions on the ground, unlike proxies, they give us a range of possibilities and they help us connect the actual climate extremes and trends, visible in the proxies and in the written sources, with more general atmospheric phenomena and forcing factors influencing climate (such as volcanic eruptions). This exploration of the model-proxy dialogue in the historical context makes the climate history of Byzantium particularly interesting for climate historians working on other parts of the world.

3 Climate History of Byzantium. The Big Questions

What are then the most debated questions and hypotheses which draw on this rich basis of natural and historical data? They revolve mainly around two periods of Byzantine history: Late Antiquity and the High Middle Ages (the Middle Byzantine period). For both, historians, archaeologists and natural scientists formulated complex arguments for both ‘negative’ or ‘positive’ role of climate in historical developments (see Izdebski 2022).

The most spectacular of this hypotheses is of course the idea that climate variability contributed – or perhaps even caused – the collapse of the (Eastern) Roman Empire. Since the 2010s, the main proponent of this hypothesis has been Kyle Harper (2017), but these ideas are actually based on the earlier research of dendroclimatologist Ulf Büntgen who led a larger team of historians and climate scientists. Based on a tree-ring reconstruction of summer temperatures – for the Alps and the Altai – they established that there occurred a multi-decadal period of colder summers in the Northern Hemisphere, starting in 536 CE, which they called the Late Antique Little Ice Age (LALIA) (Büntgen et al. 2016). With a simple graph, which showed several chronological coincidences between the LALIA summer cold phase and several historical processes (such as the ‘expansion of the Slavs’, numerous migrations in the Eurasian Steppe, or the rise of the Arabic Empire), they suggested causal connections between the cooling and societal change.

Harper went much further and extended the LALIA in time, to stand for a longer period of what would have been in his view adverse climate, starting already around 450 CE, and elaborated the historical argument surrounding its damaging impact on the Roman Empire. Thus, in part contrary to the initial idea of Büntgen, in Harper’s version the LALIA became a longer, more severe, and more universal period of weather hardships, akin to the Little Ice Age of the early modern period (such as in Parker 2013; however, the idea of severity and universality of the Little Ice Age is also a matter of ongoing debate: Pfister et al. 2018). The Büntgen-Harper thesis, even if it made it to the headlines and attracted popular attention, remains a matter of controversy (overview of the debate: Haldon et al. 2018c; 2018d; 2018b; Harper 2018); in particular, the role of the volcano-induced climatic downturn of 536 has been reevaluated, with the indications that it might have been much less of a challenge for Mediterranean societies than it has been for the northern European (Newfield 2018).

The main positive hypothesis about the role of climate in the development of the Eastern Roman Empire has been advanced on the macroregional scale by Adam Izdebski (2011; Izdebski et al. 2016). It is based on the now relatively solid evidence that there was a period of particularly wet conditions in Late Antiquity, roughly from the mid/late fifth to the early/mid seventh century CE (depending on the region) (Labuhn et al. 2018; Xoplaki et al. 2021). Izdebski and several other colleagues connected these changes to the widespread expansion of the rural settlement and, in particular, the introduction of often intensive farming on lands previously uncultivated or little used, and prone to dryness (such as the Konya plain in Central Anatolia or many semi-arid areas in the Levant). This hypothesis remains, for now, less debated than the Büntgen-Harper vision of the LALIA's damaging impact on the Roman Empire; it should be noted, however, that the wetter period hypothesis does not necessarily contradict the LALIA's negative role. Rather, it points out to the potentially advantageous role of climate variability for the economic growth in the Eastern Roman Empire of Late Antiquity.

Building on this hypothesis, and on the idea of the sequence of dry-wet-dry conditions in the Eastern Mediterranean during Late Antiquity, John Haldon proposed a third hypothesis on the role of climate in the Eastern Roman history in this period (in his 2016 monograph on the seventh century transformation of the Eastern Roman Empire: Haldon 2016; reformulated with a stronger natural science focus, in Roberts et al. 2018). Following Izdebski's observation on the shift of the focus of agricultural activities in much of Anatolia from mixed farming to cereal production in the seventh-eighth centuries CE (Izdebski 2013), Haldon demonstrated the role of the state administration in bringing about this change and framed the agricultural change as a response to the supply needs of the army and the capital. Crucially, Haldon noticed that climate conditions at the time might have also encouraged Anatolia farmers to refocus their activities on cereal production. Haldon's hypothesis demonstrates that there is still space for exploring connections between climate variability and political or economic transformations that took place at the end of Antiquity. Its entanglement in the rise and development of the Arab Empire, and the Abbasid revolution, for instance, still awaits in-depth scrutiny.

For the Middle Byzantine period, the most influential hypothesis has been the catastrophic vision of the eleventh century developed by Ronnie Ellenblum (2012). He consciously rejected the natural proxies, as useless for the kind of short-term *histoire événementielle* he was interested in. Thus, based on the written evidence from the Arabic, Syriac and Byzantine sources, Ellenblum argued that in the tenth and eleventh centuries there occurred an accumulation of catastrophic weather extremes, which significantly weakened the big states of the Eastern Mediterranean, including Byzantium, and put in place a domino effect of social collapse, which for Byzantium culminated in the loss of Anatolia in the later eleventh century. Ellenblum's hypothesis remains highly controversial, in particular with regard to Byzantium; in large parts, it has been rejected, for instance, by Johannes Preiser-Kapeller, who observed that while weather extremes might have indeed occurred frequently in this period, their broader impact on the fate of the Byzantine State was limited (Preiser-Kapeller 2015).

The second hypothesis on the role of climatic variability in the Middle Byzantine period has been advanced by an interdisciplinary team led by climatologist Elena Xoplaki (Xoplaki et al. 2016). In their wide-ranging study, which made use of natural scientific, archaeological, and historical data, Xoplaki and her team investigated several regions of the Byzantine world during different time intervals throughout the Medieval Climate Anomaly (850-1300 CE). While they refrained from arguing for strong causal connections between climate and societal change, partly because of the team's macro-scale approach, Xoplaki and others detected no obvious negative impact of climatic variability on Byzantium during this period, except, perhaps, the weather anomalies caused by the Samalas volcanic eruption in the 1260s. In this way, they supported Preiser-Kapeller's re-evaluation of the Ellenblum hypothesis with respect to Byzantium. They also pointed out to the possibly positive role of wetter climatic conditions in Anatolia in the economic recovery and agricultural expansion in this part of the Byzantine world in the tenth-eleventh centuries.

4 Climate History of Byzantium. The Future

During the last decade, the climate history of Byzantium continued to flourish, advancing and revising several hypotheses on the role of climatic variability in the history of the Eastern Roman Empire. Surely, all of them will continue to be debated and will be further revised and improved. Hopefully, the field will move beyond debating the existing 'big' hypothesis and break them down into more concrete and manageable questions.

To begin with, in the coming years we should expect more natural proxies to be published, filling in the geographical gaps in our record, in particular in the Balkans, and improving the already good data situation in Anatolia. It is to be expected that the increased availability of climate proxy data will actually complicate the overall picture, as it will allow researchers to reconstruct different regional trajectories of climatic variability (as already demonstrated on the microscale by Labuhn et al. 2018). Significant differences and lack of spatial correlation is to be expected with regard to precipitation, to a large extent determined by local conditions, such as orography. Connecting these regional, or even local, past climatic phenomena to social life will require abandoning or downscaling the big hypotheses described above and undertaking more focused studies, limited in time and space, but thus promising to bring concrete and solid insights into the interplay between climate and society in Byzantium. Many of such regional/local projects will definitely try to tie together purpose-created evidence coming from several disciplines, taking a holistic view of (local) societies as social-ecological systems, in which climate and weather are in a way integrated (as outlined in Haldon, Rosen 2018; Izdebski 2022).

At the same time, we should expect growing research interest in other periods, in particular the late medieval period (see, for instance, Preiser-Kapeller, Mitsiou 2019). More attention will probably be given as well to cultural history, engaging closely with the textual evidence and asking questions about Late Antique and Byzantine perceptions of climate and weather, and the complex interplay between the natural and the cultural processes (Sessa 2019; Zanchetta et al. 2021). Going forward, climate history of Byzantium will look more closely at the interaction of the different ethnic and social groups, in particular the elites, and the Byzantine state, with climate extremes, and the role of gender in this process (which is, as of yet, almost completely unexplored). Through these detailed studies, the field will gradually overcome its 'inchoate problems' of adopting simple positive/negative narratives, and will move on to looking into interaction between climate and society, and climate/weather's entanglement in social life and the cultural sphere. Altogether, we will come closer to developing a comprehensive history of the Byzantines' living with a variable climate, moving away from just adding climate as a factor to the existing 'big narratives'.

Bibliography

Bradley, R.S. (2014). *Paleoclimatology. Reconstructing Climates of the Quaternary*. 3rd ed. Amsterdam: Elsevier.

Braudel, F. (1949). *La Méditerranée et le monde méditerranéen à l'époque de Philippe II*. Paris: Colin.

Braudel, F. (1966). *La Méditerranée et le monde méditerranéen à l'époque de Philippe II*. 2ème éd. Paris: Colin.

Brázdil, R. et al. (2005). "Historical Climatology in Europe. The State of the Art". *Climatic Change*, 70(3), 363-430. https://doi.org/10.1007/s10584-005-5924-1.

Büntgen, U. et al. (2016). "Cooling and Societal Change during the Late Antique Little Ice Age from 536 to around 660 AD". *Nature Geoscience*, 9(3), 231-6. https://doi.org/10.1038/ngeo2652.

Degroot, D. et al. (2021). "Towards a Rigorous Understanding of Societal Responses to Climate Change". *Nature*, 591(7851), 539-50. https://doi.org/10.1038/s41586-021-03190-2.

Ellenblum, R. (2012). *The Collapse of the Eastern Mediterranean. Climate Change and the Decline of the East, 950-1072*. Cambridge: Cambridge University Press.

Esper, J. et al. (2020). "Eastern Mediterranean Summer Temperatures since 730 CE from Mt. Smolikas Tree-Ring Densities". *Climate Dynamics*, 54(3), 1367-82. https://doi.org/10.1007/s00382-019-05063-x.

Göktürk, O.M. et al. (2011). "Climate on the Southern Black Sea Coast during the Holocene. Implications from the Sofular Cave Record". *Quaternary Science Reviews*, 30(19-20), 2433-45. https://doi.org/10.1016/j.quascirev.2011.05.007.

Haldon, J. et al. (2014). "The Climate and Environment of Byzantine Anatolia. Integrating Science, History and Archaeology". *Journal of Interdisciplinary History*, 45(2), 113-61. https://doi.org/10.1162/jinh_a_00682.

Haldon, J. (2016). *The Empire that Would not Die. The Paradox of Eastern Roman Survival, 640-740*. Cambridge (MA): Harvard University Press.

Haldon, J. et al. (2018a). "History Meets Palaeoscience. Consilience and Collaboration in Studying Past Societal Responses to Environmental Change". *Proceedings of the National Academy of Sciences*, 115(13), 3210-18. https://doi.org/10.1073/pnas.1716912115.

Haldon, J. et al. (2018b). "Plagues, Climate Change, and the End of an Empire. A Response to Kyle Harper's The Fate of Rome (1). Climate". *History Compass*, 16(12), e12508. https://doi.org/10.1111/hic3.12508.

Haldon, J. et al. (2018c). "Plagues, Climate Change, and the End of an Empire. A Response to Kyle Harper's The Fate of Rome (2). Plagues and a Crisis of Empire". *History Compass*, 16(12), e12506. https://doi.org/10.1111/hic3.12506.

Haldon, J. et al. (2018d). "Plagues, Climate Change, and the End of an Empire. A Response to Kyle Harper's The Fate of Rome (3). Disease, Agency, and Collapse". *History Compass*, 16(12), e12507. https://doi.org/10.1111/hic3.12507.

Haldon, J.; Rosen, A. (2018). "Society and Environment in the East Mediterranean ca 300-1800 CE. Problems of Resilience, Adaptation and Transformation. Introductory Essay". *Human Ecology*, 46, 275-90. https://doi.org/10.1007/s10745-018-9972-3.

Harper, K. (2017). *The Fate of Rome. Climate, Disease, and the End of an Empire*. Princeton: Princeton University Press. Princeton History of the Ancient World.

Harper, K. (2018). "Integrating the Natural Sciences and Roman History. Challenges and Prospects". *History Compass*, 16(12), e12520. https://doi.org/10.1111/hic3.12520.

Izdebski, A. (2011). "Why did Agriculture Flourish in the Late Antique East? The Role of Climate Fluctuations in the Development and Contraction of Agriculture in Asia Minor and the Middle East from the 4th till the 7th c. AD". *Millennium. Jahrbuch zu Kultur und Geschichte des ersten Jahrtausends n. Chr.*, 8, 291-12.

Izdebski, A. (2013). *A Rural Economy in Transition. Asia Minor from Late Antiquity into the Early Middle Ages*. Warsaw: Taubenschlag Foundation. Journal of Juristic Papyrology Supplement Series 18.

Izdebski, A. et al. (2016). "Realising Consilience. How Better Communication between Archaeologists, Historians and Natural Scientists Can Transform the Study of Past Climate Change in the Mediterranean". *Quaternary Science Reviews*, 136, 5-22. https://doi.org/10.1016/j.quascirev.2015.10.038.

Izdebski, A. et al. (2016). "The Environmental, Archaeological and Historical Evidence for Regional Climatic Changes and Their Societal Impacts in the Eastern Mediterranean in Late Antiquity". *Quaternary Science Reviews*, 136, 189-208. https://doi.org/10.1016/j.quascirev.2015.07.022.

Izdebski, A. (2022). *Ein vormoderner Staat als sozioökologisches System. Das oströmische Reich 300-1300*. Dresden: Sandstein. Forschungen zur Geschichte und Kultur des östlichen Mitteleuropa 59.

Labuhn, I. et al. (2018). "Climatic Changes and Their Impacts in the Mediterranean during the First Millennium A.D.". Izdebski, A.; Mulryan, M. (eds), *Environment and Society in the Long Late Antiquity*. Leiden: Brill, 65-88. Late Antique Archaeology 12.

Le Roy Ladurie, E. (1959). "Histoire et Climat". *Annales. Histoire, Sciences Sociales*, 14(1), 3-23. https://doi.org/10.3406/ahess.1959.2795.

Le Roy Ladurie, E. (1961). "Aspects historiques de la nouvelle climatologie". *Revue Historique*, 225(1), 1-20.

Le Roy Ladurie, E. (1967). *Histoire du climat depuis l'an mil*. Paris : Flammarion.

Luterbacher, J. et al. (forthcoming). "Palaeoclimatology of Byzantine lands (300-1500 A.D.)". Izdebski, A., Preiser-Kapeller, J. (eds), *A Companion to the Environmental History of Byzantium*. Leiden: Brill.

Newfield, T.P. (2018). "The Climate Downturn of 536-50". White, Pfister, Mauelshagen 2018, 447-93. https://doi.org/10.1057/978-1-137-43020-5.

Parker, G. (2013). *Global Crisis. War, Climate Change and Catastrophe in the Seventeenth Century*. New Haven: Yale University Press.

Pfister, C. (1978). "Climate and Economy in Eighteenth-Century Switzerland". *Journal of Interdisciplinary History*, 9, 223-43. https://doi.org/10.2307/203226.

Pfister, C. (1988a). "Fluctuations climatiques et prix céréaliers en Europe du XVI^e^ au XX^e^ siècle". *Annales. Histoire, Sciences Sociales*, 43(1), 25-53. https://doi.org/10.3406/ahess.1988.283474.

Pfister, C. (1988b). *Klimageschichte der Schweiz 1525-1860. Das Klima der Schweiz von 1525-1860 und seine Bedeutung in der Geschichte von Bevölkerung und Landwirtschaft*. Bern: Haupt.

Pfister, C. et al. (2018). "Early Modern Europe". White, Pfister, Mauelshagen 2018, 265-96.

Preiser-Kapeller, J. (2015). "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". *Jahrbuch der österreichischen Byzantinistik*, 65, 195-242.

Preiser-Kapeller, J.; Mitsiou, E. (2019). "The Little Ice Age and Byzantium within the Eastern Mediterranean, ca. 1200-1350. An Essay on Old Debates and New Scenarios". Bauch, M.; Schenk, G.S. (eds), *The Crisis of the 14th Century*. Berlin; New York: De Gruyter, 190-220. https://doi.org/10.1515/9783110660784-010.

Roberts, N. et al. (2018). "Not the End of the World? Post-Classical Decline and Recovery in Rural Anatolia". *Human Ecology*, 46, 305-22. https://doi.org/10.1007/s10745-018-9973-2.

Sessa, K. (2019). "The New Environmental Fall of Rome. A Methodological Consideration". *Journal of Late Antiquity*, 12(1), 211-55. https://doi.org/10.1353/jla.2019.0008.

Telelis, I.G. (2004). *Μετεωρολογικα φαινομενα και κλιμα στο βυζαντιο*. Athens: Akadēmia Athēnōn.

Telelis, I.G. (2008). "Climatic Fluctuations in the Eastern Mediterranean and the Middle East AD 300-1500 from Byzantine Documentary and Proxy Physical Paleoclimatic Evidence. A Comparison". *Jahrbuch der österreichischen Byzantinistik*, 58, 167-207.

Touchan, R. et al. (2007). "May-June Precipitation Reconstruction of Southwestern Anatolia, Turkey during the Last 900 Years from Tree Rings". *Quaternary Research*, 68(2), 196-202. https://doi.org/10.1016/j.yqres.2007.07.001.

White, S.; Pfister, C.; Mauelshagen, F. (eds) (2018). *The Palgrave Handbook of Climate History*. London: Palgrave Macmillan. https://doi.org/10.1057/978-1-137-43020-5.

Xoplaki, E. et al. (2016). "The Medieval Climate Anomaly and Byzantium. A Review of the Evidence on Climatic Fluctuations, Economic Performance and Societal Change". *Quaternary Science Reviews*, 136, 229-52. https://doi.org/10.1016/j.quascirev.2015.10.004.

Xoplaki, E. et al. (2018). "Modelling Climate and Societal Resilience in the Eastern Mediterranean in the Last Millennium". *Human Ecology*, 46, 363-79. https://doi.org/10.1007/s10745-018-9995-9.

Xoplaki, E. et al. (2021). "Hydrological Changes in Late Antiquity. Spatio-Temporal Characteristics and Socio-Economic Impacts in the Eastern Mediterranean". Erdkamp, P.; Manning, J.G.; Verboven, K. (eds), *Climate Change and Ancient Societies in Europe and the Near East. Diversity in Collapse and Resilience*. Cham: Springer International Publishing, 533-60. Palgrave Studies in Ancient Economies. https://doi.org/10.1007/978-3-030-81103-7_18.

Zanchetta, G. et al. (2021). "Beyond One-Way Determinism. San Frediano's Miracle and Climate Change in Central and Northern Italy in Late Antiquity". *Climatic Change*, 165(1), no. 25. https://doi.org/10.1007/s10584-021-03043-x.