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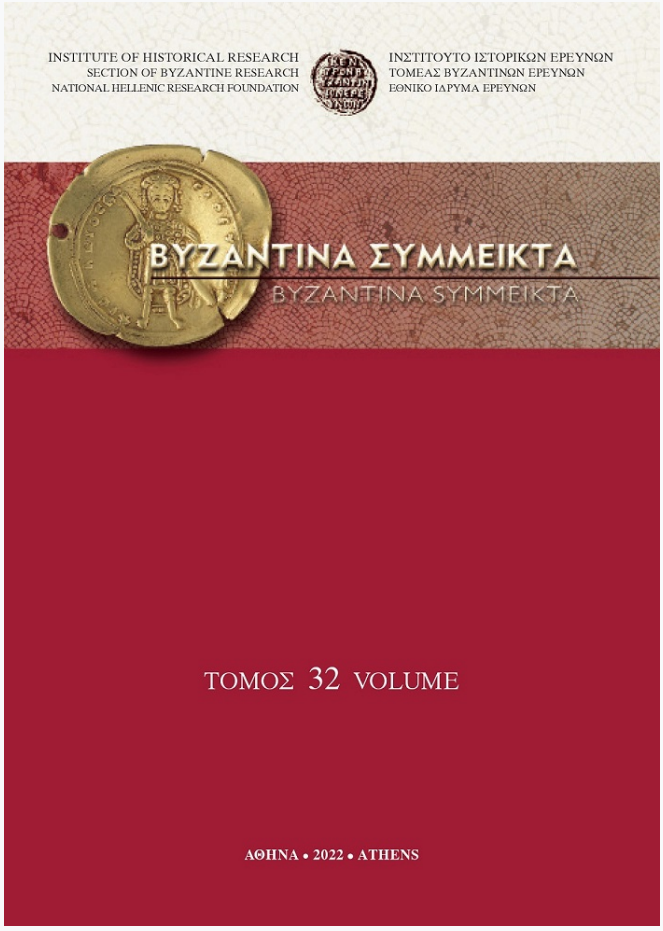

Byzantine Textual Sources for Climatic and Environmental Developments

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ΙΝΣΤΙΤΟΥΤΟ ΙΣΤΟΡΙΚΩΝ ΕΡΕΥΝΩΝ
ΤΟΜΕΑΣ ΒΥΖΑΝΤΙΝΩΝ ΕΡΕΥΝΩΝ
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ΒΥΖΑΝΤΙΝΑ ΣΥΜΜΕΙΚΤΑ
BYZANTINA SYMMEIKTA

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Ioannis Telelis

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Ioannis Telelis

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1. INTRODUCTION

Environmental history has been recognized as a new and growing field in the scholarship of medieval studies[1]. In a recent scholarly survey which discusses the developments in the field of medieval environmental history, an initial conclusion is that it is no longer possible to offer a comprehensive discussion of the many topics and regions studied by medievalists in the context of environmental history[2]. Nowadays, the work of medievalists interested in investigating the environmental history of pre-modern Europe is a challenging interdisciplinary endeavour; it comprises the exploitation of various –usually heterogeneous– data sets derived from a miscellany of physical and anthropogenic sources, aiming to challenge the clarification

1. The publication of the monographs: J. Aberth, *An environmental history of the Middle Ages. The crucible of nature,* London 2013, and R. C. Hoffmann, *An environmental history of medieval Europe* (Cambridge Medieval Textbooks), Cambridge 2014, verifies that medieval environmental history of Europe has become a hot scientific topic in historical science. This trend is also reflected in the creation of ENFORMA (Environmental History Network for the Middle Ages, http://www.medievaleh.org/), a networking portal for researchers interested in medieval environmental history, with a growing activity since 2009.

2. For a synthetic overview of the developments regarding the integration of environmental history into the medieval studies, see E. Arnold, An Introduction to Medieval Environmental History, *History Compass* 6.3 (2008), 898-916. Especially in Byzantine history, see I. Telelis, Environmental History and Byzantine Studies: A Survey of Topics and Results., in T. Kolias – K. Pitsakis – K. Synelli (eds.), *Aureus. Τόμος αφιερωμένος στον καθηγητή Ευάγγελο Κ. Χρυσό*, Athens 2014, 737-760.

of the various levels and degrees of interaction between people and nature during the Middle Ages[3].

In order to define the scientific space for medieval environmental history, medievalists have made significant progress towards the integration of the ecological sciences into the intellectual approaches of modem environmental historians for the sake of an advanced epistemological paradigm that goes far beyond the traditional fields of medieval philology and history. Indeed, as medievalists increasingly take advantage of theoretical frameworks and questions posed by modern environmental historians for their own research field, they manage to contextualize a growing variety of concepts and sources from various scientific disciplines within the framework of environmental history more and more[4]. In this context, traditional types of historical sources –such as the medieval texts and documents– did not lose anything from their value as evidence for the inquiries of medieval environmental history; on the contrary, they gained in significance because they provide an essential reservoir of historical evidence engaging "old" sources into the "new" approaches adopted by medieval environmental historians[5].

As climate is one of the most important topics in environmental history research, historical climatology emerged as a rather new branch of science situated at the interface between history and climatology, aiming to implement the integration of traditional types of sources into the advanced methods of work established by environmental historians[6].

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3. For a sense of the multi-directionality of medieval environmental history, see the topics covered by the study of Hoffmann [as in n. 1].

4. Cf. Arnold [as in n. 2].

5. For the place of the traditional historical and archaeological sources in the schema of sources from which medieval environmental history draws material, see Hoffmann [as in n. 1], 14, fig. 0.5.

6. For a detailed reference article on the evolution of historical climatology and its recent trends, see R. Brazdil – C. Pfister – H. Wanner – H. V. Storch – J. Luterbacher, Historical Climatology in Europe – The State of the Art, *Climatic Change* 70, no 3 (2005), 363-430, with some updates in: R. Brazdil, Recent progress and future potential of historical climatology in Europe, *Quaternary International* 279-280 (2012), 65. For a review of the progress in this scientific branch since 1978, as well as an updated definition of it on the base of theoretical and empirical advances in the study of social ecodynamics, see F. Mauelshagen, Redefining historical climatology in the Anthropocene, *The Anthropocene Review* 1.2 (2014), 171-204, esp. 175, fig. 2.

Climate history is a key topic for the study of the interaction between nature and people. Historical climatology has generated a good deal of interest both for the exploitation of all available types of evidence towards the direction of understanding the climatic trends during the Middle Ages, and the contextualization of climatic change within the broader European environmental history. Hence, historical climatology explores the climate extremes, the natural hazards, the vulnerability of past societies and economies to them, and the past discourses and social representations of weather and climate The reconstruction of temporal and spatial patterns of weather, climate and weather-related natural hazards for the period prior to the establishment of national meteorological networks, as well as the investigation of textual/documentary paleoclimatic evidence through the application of methods borrowed both from climatology and history are the two major topics for historical climatology research[7]. By exploring past climate change and the consequent human adaptation to it, the warm climate period around 950–1250 A.D., known as the "Medieval Warm Period" –now more commonly referred to as the "Medieval Climate Anomaly" (MCA)–, as well as the cold climate period around 1300-1850 A.D. –known as the Little Ice Age (LIA)–, have become key topics for paleoclimate research, historical climatology and environmental history[8]. And this because, on the one hand, these climatic phases shaped the environmental background of the second millennium A.D., a millennium during which the effects of accelerated human activity on the globe have dramatically affected the balance of

7. Cf. C. Pfister – R. Brazdil – M. Barriendos, Reconstructing past climate and natural disasters in Europe using documentary evidence, *PAGES Newsletter* 10.3 (2002), 6-8.

8. For the MCA as a paleoclimate research topic, see E. Xoplaki - D. Fleitmann - H. Diaz (eds.), *Medieval climate anomaly,* Bern 2011. For some facets of MCA implications in environmental history, see F. L. Cheyette, The disappearance of the ancient landscape and the climatic anomaly of the early Middle Ages: a question to be pursued, *Early Medieval Europe* 16, no. 2 (2008), 127-165. On the LIA, see J. M. Grove, *Little ice ages. Ancient and modern. Second Edition. Volume II* (Routledge Studies in Physical Geography and Environment, 5), New York 2004, 591-641; newer study: J. Preiser-Kapeller – E. Mitsiou, The Little Ice Age and Byzantium within the Eastern Mediterranean, ca. 1200–1350: An Essay on Old Debates and New Scenarios, in M. Bauch – G. J Schenk (ed.), *The Crisis of the 14th Century: Teleconnections between Environmental and Societal Change?* [Schriftenreihe Das Mittelalter. Perspektiven mediävistischer Forschung. Beihefte, Band 13], Berlin – Boston 2020, 190-220.

the ecosystems, and on the other hand, they are approached as important factors to understand human societies' adaptation to environmental change during the High Middle Ages and Early Modern Time.

Textual sources of the European late medieval and early modern history are among the primary archives that have fuelled historical climatology with documentary weather –and climate– related evidence[9] for the reconstruction of European past climate and natural disasters[10]. Even though the exploitation of this type of historical evidence can be traced back to a number of late 19th and early 20th century studies[11], critical approach of the sources and rigorous analysis of preinstrumental documentary paleoclimatic evidence were achievements of historical climatological studies published

9. The blanket term "documentary evidence" includes all kinds of man-made climate-related records and may comprise several types of direct and proxy data (e.g. narrative written records, visual daily weather records, personal correspondence, special prints, official economic records, newspapers, pictorial documentation, epigraphic data, early instrumental observations, early scientific papers and communications). For the climate-related historical records and the types of data they include, see Pfister et al. (as in n. 7); Brazdil et al. (as in n. 6), 370-377; C. de Freitas, Climatic Data, Historical Records, in S.G. Philander (ed.), *Encyclopedia of global warming & climate change,* 2nd ed., Thousand Oaks 2012, 311-313.

10. Modern scholarly concept of natural disasters comprises the environmental hazards with severe social implications and cultural connotations. This hybrid character of natural disasters makes them equally objects of the natural and social sciences, cf. D. Groh - M. Kempe - F. Mauelshagen (eds.), *Naturkatastrophen. Beiträge zu ihrer Deutung, Wahrnehmung und Darstellung in Text und Bild von der Antike bis ins 20. Jahrhundert* (Literatur und Anthropologie, 13), Tübingen 2003, esp. 14-15: Einleitung (Naturkatastrophen – wahrgenommen. gedeutet, dargestellt).

11. Commonly known as "weather compilations", these studies present a considerable amount of useful information about medieval climate together with spurious, inaccurate, or unauthenticated material derived from documentary sources. Cf. R. Hennig, *Katalog bemerkenswerter Witterungsereignisse von den älteren Zeiten bis zum Jahre 1800* (Veröffentlichungen des Königlichen Preussischen Meteorologischen Instituts 3, 2, 4), Berlin 1904; C. Easton, *Les hivers dans l'Europe Occidentale. Étude statistique et historique sur leur température, discussion des observations thermométriques 1852-1916 et 1757-1851, tableaux comparatifs, classification des hivers 1205-1916, notices historiques sur les hivers remarquables, bibliographie,* Leyden 1928; C. Weikinn, *Quellentexte zur Witterungsgeschichte Europas von der Zeitwende bis zum Jahr 1850. 1. Hydrographie. I. Teil: Zeitwende 1500,* Berlin 1958. For critical observations on their material, see W. Bell – A. Ogilvie, Weather compilations as a source of data for the reconstruction of European climate during the medieval period, *Climatic Change* 1.4 (1978), 331-348.

after the 1970s[12]. Indeed, modern studies in historical climatology have attempted to raise shortcomings of earlier works on the one hand[13], and refine and/or complete existing databases for historical climatological research through the integration of indirect multidisciplinary paleoclimate evidence into direct observations, on the other[14]. Furthermore, the most important result from the progress in the field of historical climatology was the consolidation of an advanced interdisciplinary methodology to exploit scientifically documentary data. This methodology combines standard procedures of paleoclimate research (e.g. calibration and verification) with overlapping and comparing documentary-based series to instrumental measurement[15]. Without doubt, the development of historical climatology forced scientists interested in the reconstruction of medieval climate to widen their focus by applying the rules of historical sources' criticism to the medieval textual sources.

Medieval studies and historical climatology had already been taking on an interesting scientific discourse when Byzantinists started exploring the Byzantine sources from the point of view of historical climatology. The idea for sifting the extant textual sources of Byzantine history for references to particular manifestation of weather and climate was introduced in early 1990s[16]. This idea reflected the growing interest of historians and

12. See the review article of M. Ingram – D. Underhill – G. Farmer, The Use of Documentary Sources for the Study of Past Climates, in R. L. Rotberg and T. K. Rabb (eds.), *Climate and history: Studies in interdisciplinary history,* Princeton 1981, 180-213.

13. Cf. P. Alexandre, *Le climat en Europe au Moyen Age. Contribution à l'histoire des variations climatiques de 1000 à 1425, d'après les sources narratives de l'Europe occidentale* (Recherches d'histoire et de sciences sociales, 24), Paris 1987, 13-23.

14. Established by Christian Pfister, Euro-Climhist (https://www.euroclimhist.unibe.ch/en/, formerly CLIMHIST-CH), is a scientific European database that provides a comprehensive scientific tool for managing, analyzing and displaying high-resolution climatic proxy evidence from natural and documentary archives of the European climate history. For a review of natural proxy evidence (tree rings, speleothems, lake, river, and marine sediments, boreholes, and pollen records) with focus on the Mediterranean region, see J. Luterbacher – R. Garcia-Herrera – S. Akceron, A Review of 2000 Years of Paleoclimatic Evidence in the Mediterranean, in P. Lionello (ed.), *The Climate of the Mediterranean Region. From the past to the future,* Burlington 2012, 87-185.

15. Cf. Brazdil et al., Historical Climatology [as in n. 6], 377-383 for case studies.

16. Cf. the early book of: J. Koder, *Der Lebensraum der Byzantiner. Historisch-*

archaeologists in merging paleoclimatic evidence derived from various fields of environmental science (dendrochronology, palynology, glaciology etc.) with the wealth of pre-instrumental observations hidden in the traditional historical sources, while modern historical climatology and environmental history started to culminate[17]. In this context, byzantinists interested in geographically focused historical analysis of the Byzantine Empire got gradually accustomed to the scientific terminology and methodology of environmental sciences and started emphasizing the need for systematic collection and scrutiny of Byzantine documentary paleoclimate records[18]. The aim was to trace patterns of possible climatic change across the Byzantine space and time in order to outline spatial and temporal coherence/variation models for the MCA and the LIA, the two major periods of last millennium's climatic shift that have been attested almost solely by evidence derived from central and western Europe, and the North Atlantic region[19].

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geographischer Abriss ihres mittelalterlichen Staates im östlichen Mittelmeerraum (Byzantinische Geschichtsschreiber Ergänzungsband, 1), Graz 1984 and the papers of: B. Croke, Climatic Change in Antiquity, *Ancient History: Resources for Teachers* 20, no. 3 (1990), 168-75; ID, Climatology and Byzantine studies (summary), *Byzantine Studies in Australia, Newsletter* 24 (1990), 7; P. Farquharson, Byzantium, planet earth and the solar system, in P. Allen and E. Jeffreys (eds.), *The Sixth century, end or beginning?* (ByzAustr. 10), Brisbane 1996, 263-69.

17. Articles published in the volume: R. L. Rotberg and T. K. Rabb (eds.), *Climate and history* [as in n. 12], represent the new approach of historical climatology in the context of historical science. In the context of Dendrochronology, see P. I. Kuniholm, Dendrochronology, in: *ODB*, 182-192.

18. This need was emphasized by: I. Telelis – E. Chrysos, The Byzantine Sources as Documentary Evidence for the Reconstruction of Historical Climate, in B. Frenzel – C. Pfister – R. Gläser (eds.), *European climate reconstructed from documentary data. Methods and results* (ES F project European palaeoclimate and man. Special issue 2), Stuttgart 1992, 17-31; J. Koder, Climatic Change in the Fifth and Sixth Centuries?, in P. Allen and E. Jeffreys (eds.), *The Sixth century* [as in n. 16], 270-285; D. Stathakopoulos, Reconstructing the climate of the Byzantine world: State of the problem and case studies, in J. Laszlovszky – P. Szabo (eds.), *People and nature in historical perspective* (CEU Medievalia, 5), Budapest 2003, 241-250.

19. See I. Telelis, Medieval Warm Period and the beginning of the Little Ice Age in Eastern Mediterranean. An approach of physical and anthropogenic evidence, in K. Belke – F. Hild – J. Koder – P. Soustal (eds.), *Byzanz als Raum. Zu Methoden und Inhalten der historischen Geographie des östlichen Mittelmeerraumes* (Veröffentlichungen der Kommission für die Tabula Imperii Byzantini. Denkschriften, 7), Vienna 2000, 223-243.

More recently, there are attempts to correlate Byzantine textual data with archaeological and paleoenvironmental high-resolution data in order to integrate them into longer-term, low resolution data series for identifying with greater precision the role that environmental change played in societal change in certain areas of the Byzantine Empire[20].

The present article deals with the progress made up to date in investigating the Byzantine textual sources from a historical and paleoclimatological point of view. It discusses general concepts affecting the ideological outlook of references to weather, climate, and relevant disasters, in the context of the genres of Byzantine textual sources that include them. Then, it presents an overview of the documentary paleoclimate evidence encountered in the Byzantine sources, by giving emphasis to the categories of phenomena mentioned in the sources. Finally, it discusses problems associated with the analysis and interpretation of the evidence in terms of a historical climatology of Byzantium and, eventually, a Byzantine environmental history.

2. COMMON PRIMARY SOURCES AND CONTEXTS

What Byzantine textual sources seem to be telling us about weather and climate? The answer to this question is primarily related to conceptual, historical and philological characteristics of the Byzantine sources. Because the extent of the Byzantine culture's textual production –already published and still unedited, pending in manuscripts– is immense, it is reasonable to admit that this extensive literary tradition can potentially provide numerous reports of weather, climate, and natural disasters, for the period 4th–15th century A.D. Theoretically, Byzantinists and climatologists are obliged to investigate every piece of the Byzantine literary and documentary sources

20. Examples of recent studies on climate and Byzantine society interactions, which integrate different types of proxy evidence: A. Izdebski, *A rural economy in transition. Asia Minor from Late Antiquity into the Early Middle Ages* (Journal of Juristic Papyrology Supplement volume, 18), Warsaw 2013; J. Haldon – N. Roberts – A. Izdebski, The Climate and Environment of Byzantine Anatolia: Integrating Science, History, and Archaeology, *Journal of Interdisciplinary History* 45.2 (2014), 113-61; M. McCormick – U. Büntgen – M. A. Cane, Climate Change during and after the Roman Empire: Reconstructing the Past from Scientific and Historical Evidence, *Journal of Interdisciplinary History* 43. 2 (2012), 169-220.

to collect isolated references to weather–and climate– related events without neglecting even the most seemingly incongruous texts. Nevertheless, the probability for uncovering passages with paleoclimatological significance is restricted by the nature of the Byzantine texts and the formation of their specific characteristics. Cultural and social parameters played an important role in the diversification of the Byzantine literary genres and the construction of their literary features. This fact was decisive for some genres of the Byzantine literature to become more inclined to report natural phenomena than others. Early compilations of historical events –including natural disasters– focused on Byzantine prose texts[21]. Byzantine historiography on the one hand and Byzantine hagiography on the other, are the main literary genres that have attracted scientific interest for uncovering paleoclimatological information[22].

2.1. *Byzantine Historiography*

The two main groups of the Byzantine historiographic tradition –i.e. historical texts represented by the scholarly works of the Byzantine historiographers, and chronicles represented by the popular works of the Byzantine chronographers)– comprise texts composed on different narrative bases, while their authors were influenced by different social and cultural perspectives[23]. As a third group of this tradition we may consider the texts

21. Older historical compilations that include references on natural disasters compiled from Byzantine historiography: E. Muralt, *Essai de chronographic byzantine de 395 a 1057*, 2 vols., St. Petersbourg 1855-1871; Hennig, *Katalog bemerkenswerter Witterungsereignisse* [as in n.11]; Easton, *Les hivers* [as in n.11]; Weikinn [as in n.11].

22. Cf. I. Teleles, *Μετεωρολογικά φαινόμενα και κλίμα στο Βυζάντιο* (Πονήματα 5: 1-2), Athens 2004, 51-59; Cf. P. Giannopoulos, Περιβάλλον και προπαγάνδα στο Βυζάντιο. Πολιτική εκμετάλλευση φυσικών φαινομένων από την εικονόφιλη φιλολογία, in *Ιστορίας μέριμνα. Τιμητικός τόμος στον καθηγητή Γεώργιο Ν. Λεοντσίνη*, v. A1, Athens 2011, 272-289.

23. We adopt here the conventional division of Byzantine historiography into "histories" and "chronicles" as a starting point. This division was in use already since the Byzantine times (adopted by authors such as Theophanes the Confessor or Photios) and was sanctioned by Karl Krumbacher and later scholars. See A. Kazhdan, Historiography, in *ODB*, 938-939; J. Ljubarski, New Trends in the Study of Byzantine Historiography, *DOP* 47 (1993), 131-138. Even though Byzantinists have admitted in theory that Byzantine historiography was a unity, in practice they cannot help separating it into history and chronography. Cf. E.

of the Byzantine ecclesiastical historiographers[24]. Despite variations in register, style and content, these literary groups convey significant potentials in recording weather and climate events[25]. Reports on weather and climate, as well as accounts on unusual natural phenomena and disasters (e.g. eclipses of the sun and moon, appearance of comets, earthquakes, famines, pests and epidemics, frosts, floods, droughts, storms, and hurricanes), were recognized by Byzantine historiographers and chronographers as important and memorable events in the context of their narrations. Therefore, miscellaneous details on the occurrence of such events and the effects they had on people can be encountered in the sources[26].

Moreover, certain cultural features were responsible not only for the selection and the ideological outlook of references to weather, climate, and relevant disasters that the Byzantine chronographers, historiographers, and ecclesiastical historiographers incorporated into their historical writings, but also for the selection of the details they included:

i. Having a perception of time as a *continuum* and following a rather strict chronological framework in their narratives, Byzantine chroniclers recorded historical memory in their texts by including annalistic entries compiled from earlier sources and subordinated to the Creation era chronology[27].

Bourbouhakis – I. Nilsson, Byzantine Narrative: the Form of Storytelling in Byzantium, in L. James (ed.), *A companion to Byzantium* (Blackwell Companions to the Ancient World. Ancient History), Chichester 2010, 263-274, here 265-269.

24. For ecclesiastical history as a subgenre of Byzantine historiography, see Kazhdan, Ecclesiastical historians, *ODB*, 670-671; J.-O. Rosenqvist, *Die byzantinische Literatur. Vom 6. Jahrhundert bis zum Fall Konstantinopels 1453,* Berlin 2007, 10; A. Karpozilos, *Βυζαντινοὶ ἱστορικοὶ καὶ χρονογράφοι*, Τόμος Α΄ (*4ος-7ος αι.*), Athens 1997, 25-256.

25. See H. Hunger, *Die hochsprachliche profane Literatur der Byzantiner. Erster Teil: Philosophie. Rhetorik. Epistolographie. Geschichtsschreibung. Geographie* (Byzantinisches Handbuch 12.5), Munich 1978, 257, 262, 268-70.

26. Cf. A. Karpozilos, Natural phenomena, *ODB*, 1440.

27. For an analysis of the literary features of Byzantine chronography, see C. Mango, The Tradition of Byzantine Chronography, *Harvard Ukrainian Studies* 12/13 (1988/1989), 360-372; M. Kouroumali, World chronicle, in R.S. Bagnall – K. Brodersen – C. Champion (eds.), *The Encyclopedia of Ancient History,* Hoboken 2013, 7136-7137. For the computational system of calculating time, used officially by the Byzantines from the late 7th century A.D. until the Fall of Constantinople in 1453, see M. Kouroumali, Byzantine era, in R. S. Bagnall – K. Brodersen – C. Champion, *The Encyclopedia of Ancient History*, 1229.

Occasional laconic records to weather, climate events and natural hazards were components of a brief and sometimes rigorously succinct manner of storytelling, which was also responsible for the inclusion and/or exclusion of environmental details relevant to these events.

ii. Having in mind to produce popular narrations intended to a wide audience, the Byzantine chroniclers used to record occurrences of various "extraordinary" events aiming to excite the imagination of the readers. Among them we find references to extreme weather events and natural disasters, which sometimes were deployed by the chroniclers as fixed topics in their annalistic entries, because of the influence that such information had for the delight, entertainment or curiosity of the intended audience[28].

iii. The Christian worldview was a dominant cultural factor, responsible both for the selection of weather and climate events that Byzantine chroniclers or ecclesiastical historiographers included in their texts, and for the formulation of them in their narrative context. Taking as granted God's invisible intervention in the development of mankind, Byzantine chroniclers mostly were oriented to narrate events that would verify this religious principle. Natural hazards that befell mankind were events which were understood by the Byzantines as expressions of divine will and act and could or should be attributed to the wrath of God. Their function was twofold: either to provide a palpable proof of God's will, that would be perceived by people as sign for the approaching end of the world and a motivation for people to repent for their sins, or to verify the manifestation of the divine punishment This eschatological view is reflected in narrative patterns of disparate consecutive calamities that afflicted people and were functioning as *θεομηνία*, combined with religious or political changes[29].

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28. Cf. Rosenqvist, *Die byzantinische Literatur* [as in n. 24], 11.

29. Indeed, the term *θεομηνία*, literally "the wrath of God", had also the meaning of "natural disaster". The study of narratives of natural disasters in the late antique secular historiography suggests that historiographers and chroniclers of that time adopted an apocalyptic pattern of interpretation borrowed from the early Byzantine church historiographers. Within this pattern, the fear of the end of the world and the Biblical eschatological concept were dominant. See M. Meier, Perceptions and Interpretations of Natural Disasters during the Transition from the East Roman to the Byzantine Empire, *The Medieval History Journal* 4.2 (2001), 179-202; Id., Natural Disasters in the *Chronographia* of John Malalas: Reflections on their Function An Initial Sketch, *The Medieval History Journal* 10.1-2 (2007), 237-266.; G. Sidéris, Quelques

iv. In both cases we might approach Byzantine historiographers' texts as imitation of classical predecessors' historical writings that aimed at the pursuit of truth, or, as literary products that reflected authors' perception of historiography as a means of individual and dynastic propaganda, the element of factual accuracy was substantial for the Byzantine historian[30]. In this context, references to weather and climate events were used as narrative links in a "larger story" usually related to major public events, initiatives or deeds of significant political or military personages in sequences of facts relevant to warfare, communication, or logistics. In these cases such references functioned as historically reliable background details while their ideological outlook was less "colored" compared to features (i)-(iii) mentioned above.

2.2. *Byzantine Hagiography*

A second genre of the Byzantine prose literature which conveys significant potentials for recording weather and climate events, useful for paleoclimate reconstructions, is hagiography. Texts such as Saints' Lives (Vitae Sanctorum), Narrations *(Narrationes),* Collections of Miracles *(Miracula)* or Passions *(Passiones)* of Byzantine holy men or women, are hagiographical writings that served the spiritual edification of the Byzantine audience (readers or listeners)[31]. In parallel to their religious content, these texts

aspects des catastrophes naturelles à Byzance et de leurs effets sur la société (seconde moitié du Vie siècle – milieu du Xe siècle), in L. Buchet – C. Rigeade – L. Seguy – M. Signoli (eds.), *Vers une anthropologie des catastrophes. Actes des 9e journées Anthropologiques de Valbonne,* Antibes 2009, 163-178; E. Watts, Interpreting Catastrophe: Disasters in the Works of Pseudo-Joshua the Stylite, Socrates Scholasticus, Philostorgius, and Timothy Aelurus, *Journal of Late Antiquity* 2.1 (2009), 79-98.; P. Allen – N. Bronwen, *Crisis management in Late Antiquity (410-590 CE)* (Supplements to Vigiliae Christianae, 121), Leiden 2013.; N. Drocourt, Le millénaire byzantin: Quelles sources pour quelles catastrophes?, in F. Clément (ed.) *Histoire et nature. Pour une histoire écologique des sociétés méditerranéennes (Antiquité et Moyen Âge),* Rennes 2011, 97-125; M.-H. Congourdeau, Les Byzantins face aux catastrophes naturelles sous les Paléologues, *RÉB* 67 (2009), 151-163.

30. See S. Papaioannou, Byzantine *historia*, in K. A. Raaflaub (ed.), *Thinking, recording, and writing history in the ancient world,* Wiley Blackwell 2014, 297-313, here 298-301.

31. Cf. M. Hinterberger, Byzantine hagiography and its literary genres. Some critical observations, in S. Efthymiadis (ed.), *The Ashgate Research Companion to Byzantine Hagiography,* v. II, Genres et Contexts, Farnham 2014, 25-60.

included a great deal of information not only on social relations, economic life, state administration, attitudes, and ideas of the Byzantines, but also on natural environment[32]. Like in the case of Byzantine historiography, we can identify certain cultural features responsible for the selection, the construction, and the ideological outlook of references to weather, climate, and relevant disasters, also in the Byzantine hagiographical texts:

i. Given that the construction of Saints' religious and ascetic identities was taking place mostly in the sociocultural milieu of the Byzantine countryside -which was a cluster of pre-modern agrarian local economies, vulnerable to natural disasters-, natural environment formed the background of human action on the one hand, but on the other hand, it could be handled by the hagiographers as a literary tool to cover up specific needs and purposes for the composition of their hagiographical narratives For example, stories about rain miracles[33], or narratives about miraculous rescues in stormy conditions during land- or sea-transport constitute two striking categories of such "literary" use of environmental events reflecting accordingly the notion of human struggle against natural disasters[34].

ii. Despite the anecdotal character of some hagiographical narrations pertaining to miraculous meteorological phenomena, as mentioned right above, certain accounts on weather and climate could include factual accuracy

32. Cf. M. Kaplan – E. Kountoura-Galaki, Economy and society in Byzantine hagiography: realia and methodological questions, in S. Efthymiadis (ed.), *The Ashgate Research Companion to Byzantine Hagiography* [as in previous n.], 389-418. The Dumbarton Oaks Hagiography Database (http://www.doaks.org/research/byzantine/resources/hagiography-database) is a powerful online tool for accessing texts, translations and historical information from Byzantine Saint's Lives (8th-10th centuries). The keyword category "natural disasters" is characteristic for the environmental topics that this database covers.

33. Narrations about miraculous rainfalls, which ended a period of drought and distress after the intervention of a holy man, have been identified in various Saints' lives. For a survey of the early Byzantine rain miracles, see D. Stathakopoulos, Rain miracles. An essay in typology, *JÖB* 52 (2002), 73-87.

34. These narratives share common features of content and structure and construct certain literary formulas (*τόποι*) in the corpus of Greek medieval Saints' lives. Cf. T. Pratsch, *Der hagiographische Topos. Griechische Heiligenviten in mittelbyzantinischer Zeit* (Millennium-Studien zu Kultur und Geschichte des Ersten Jahrtausends n. Chr., 6), Berlin 2005, 273-80; A. P. Kazhdan, Holy and unholy miracle workers, in: H. Maguire (ed.), *Byzantine magic,* Washington D.C. 1995, 72-82, at 75.

in cases where the environmental event had the character of incidental or collateral information rather than of a narrative feature deliberately used in a miraculous tale[35].

3. OVERVIEW OF BYZANTINE TEXTUAL EVIDENCE ON WEATHER AND CLIMATE

The character of the Mediterranean natural environment is largely determined by its climate, which is fundamentally featured by the well-known seasonal pattern of hot, dry summers and mild, wet winters. Rain and flood, drought, warm spells, heat waves, cold spells, snow, frost, hail, stormy weather, and wind waves are weather events which form the climatic conditions of the Mediterranean region, the habitat of the Byzantines. Weather phenomena are determined not only by the cyclonic circulation due to seasonal patterns, but also by the complexity of the physical reality that characterizes the diverse Mediterranean environment from the hot and dry semi-arid landscapes of the southern regions zone through the wet and rich in vegetation lands of the northern areas[36].

In addition to being subject to regular climatic cycles, the Mediterranean environment is also a world of sudden weather events and unpredictable disasters. Climatic natural hazards, which cause instability in the equilibrium of the ecological mechanisms and, consequently, jeopardize the balance of food resources or threaten human lives and infrastructure, are perceived by people as natural disasters[37]. Such disasters inevitably left imprint

35. For a discussion on the contrast between miracle accounts with a propensity for the truthfulness of what they recount and those which put the emphasis on edification rather than on building a credible report, see S. Efthymiadis, Collections of Miracles (Fifth-Fifteenth Centuries)", in S. Efthymiadis (ed.), *The Ashgate Research Companion to Byzantine Hagiography,* [as in n. 31], 103-142.

36. See P. Lionello – P. Malanotte-Rizzoli – R. Boscolo – P. Alpert – V. Artale, The Mediterranean Climate: An Overview of the Main Characteristics and Issues, in P. Lionello – P. Malanotte-Rizzoli – R. Boscolo (eds.), *Mediterranean Climate Variability* (Developments in Earth & Environmental Sciences, 4), Amsterdam 2006, 1-26.

37. The terms "natural hazard" and "natural disaster" are synonymous. Nevertheless, they have different connotations: the former designates an environmental event: the latter refers to an environmental event which takes place in social, economic and political structures and perceptions. For this distinction, see Groh et al. [as in n. 10], 14-15.

within living memory[38]. Numerous meteorological disturbances have been recorded by Byzantine historiographers, chroniclers and hagiographers for the period A.D. 300–1500. This section illustrates representative textual evidence on weather events and climatic natural disasters, and explores their diversity in the Byzantine cultural and environmental context. The aim is to highlight the types of weather and climate phenomena that emerge as memorable from the Byzantine sources. The ideological outlook of the references –as identified above for each genre of textual sources– and the perception of the phenomena are exemplified. The usefulness of the obtained environmental information for historical climatology research in terms of potentials, limitations, and problems they pose for possible paleoclimate reconstructions is also assessed[39].

3.1. *"Normal" weather: was it at all?*

The study of narratives that include reports on weather and climate in Byzantine primary textual sources has shown that the corpus of the relevant accounts is mainly a *florilegium* of references to weather extremes and natural disasters. Information on "normal" weather conditions is sparse, usually contextualized into reports of calamities. John Skylitzes, Ephraem Ainios, John Zonaras and the Orthodox Syrian chronographer Michael Syrus delivered references to favourable weather conditions and moderate rains, aiming either to emphasize the contrast to climatic disasters that preceded or followed the "normal" weather, or to combine them with divine blessing. In A.D. 819, Syria, mild winter with moderate rains is recorded in counterpoint to northern winds, which blew in January for eight days

38. For a discussion of historical natural disasters as a topic in the study of climate-society interactions, cf. the collected articles in Groh et al. [as in n. 10].

39. Further below, references to weather events and natural disasters from Greek Byzantine sources, as well as from Latin, Arabic, Syrian, Armenian and Coptic historiographic sources (which could be considered as supplementary and informative for the Byzantine history), are drawn from the catalogue of meteorological phenomena (A.D. 300-1500) published in: Teleles, *Μετεωρολογικά φαινόμενα και κλίμα στο Βυζάντιο*, [as in n. 22], 74-710 (hereafter quoted as "T." with entry number). The reader can seek there the full references and passages of the original textual sources. Textual evidence of weather events referred to in the next paragraphs is by no means exhaustive. The aim is to provide documentation for contents and contexts under discussion.

and caused withering of plants and a subsequent crop failure and famine[40]. In A.D. 1029, during the reign of Romanos III Argyros, in Constantinople (?), God sent moderate rain, which resulted abundance of crops, especially of olives. This event is recorded in counterpoint to a preceding three-years lasting drought during the reign of Constantine VIII (A.D. 1025–28), which caused the drying up of wells and rivers[41]. During the 17 months of the peaceful reign of Theodora (A.D. 1055–56) the regularity of weather conditions was followed by abundance of crops[42].

3.2. *Rain: blessing or trouble?*

Rain plays a significant role in the Mediterranean climatic regime because of its seasonality (scarceness for several months during the yearly cycle, excess during wet seasons). This meteorological variable is important for the ecological balance, for the agricultural production, and animal husbandry. Moderate and adequate rainfalls are very much desired for a good agricultural production and, hence, for people's prosperity in the arid and semiarid environmental conditions of the eastern Mediterranean and the Middle East.

Generally, information on moderate rainfalls is sparse in the Byzantine sources. Accounts on moderate rains are usually included into references to "normal" weather[43]. Notwithstanding the sparseness of evidence on moderate rains, there is a category of narratives in the Byzantine hagiography emphasizing the perception of rain as blessing. They are narrations on miraculous rainfalls, which end a period of drought and distress after the intervention of a Saint[44]. The following case from Byzantine hagiography is typical:[45] A severe drought ravaged Cyprus in the first half of the 4th

40. T. 293, 294. Cf. similar reports of mild winters versus drought or harsh cold: T. 539, 540, T. 555, 556, T. 579, 580.

41. T. 440, T. 437.

42. T. 476.

43. See above, chapter 3.1.

44. Cf. above chapter 2.2.1. The historicity of such rainfalls as environmental events may be disputed because of the place that such information has in certain literary formulaic narrations and the fact that the described events are sometimes extremely difficult to date and geographically locate.

45. For an analysis of the rain miracles' narratives of the early Byzantine period, see Stathakopoulos, Rain miracles [as in n. 33].

century A.D.; famine was imminent. The earth was scourged from the lack of rain. St. Spyridon begged God for mercy on mankind that He should send his blessing through the rain for the crops to grow. The prayer was answered at once; ample rain fell for many days in such a degree that St. Spyridon asked God to stop the rain. The wish of the Saint was granted[46].

Contrary to situations where rain was perceived as blessing, reports of excessive rainfalls and their negative effect to crops, livestock and food resources, are common. The schema of excessive/sudden rains that caused flooding, damage of crops and, possibly, food crisis, and economic distress is encountered mainly in the Byzantine historiography[47]. Sudden bursts of rain could cause unexpected torrential overflowing of streams and rivers. Flooding could also affect negatively safety during land transportation and endanger movement of individuals, groups, and troops from one location to another[48]. On the other hand, rain and the consequent flooding could cause destruction of infrastructure and human loss. Reports on heavy rains and flooding that caused damage to houses, warehouses, walls, graveyards, camps, hydraulic or irrigation facilities, and, subsequently, perish of people and/or domestic animals, are encountered in Byzantine historiography and hagiography, sometimes including interesting socio-economic and environmental details[49]. The case of a severe flood of river Skirtos (Daysan) at Edessa (Şanliurfa, Turkey) in April A.D. 525, which caused significant destruction and casualties in the city, is typical: There are numerous historiographic narratives reporting that the river engulfed the city "by the wrath of God" in the form of river-water that flooded like the sea, because of excessive rains. The inhabitants perished together with their houses. After the anger of God had ceased, there was found near the river a large stone tablet, on which an inscription was carved: "The river Skirtos (= Leaper)

46. T. 6; cf. Stathakopoulos, Rain miracles [as in n. 33], 75.

47. T. 134, 380, 441, 564, 575, 622, 657.

48. For a discussion on this topic and the relevant Byzantine textual evidence, see I. Telelis, Weather and climate as factors affecting land transport and communications in Byzantium, *Byz.* 57 (2007) 432-462, here 452-458.

49. T. 44, 64, 76, 79, 100, 108, 134, 136, 149, 171, 173, 191, 192, 202, 230, 241, 254, 256, 290, 319, 325, 326, 333, 363, 380, 385, 393, 402, 412, 450, 464, 491, 495, 509, 516, 517, 522, 552, 561, 565, 570, 581, 599, 602, 628, 635, 697, 706.

will leap terrible leapings for the citizens"[50]. This last detail reflects the fear of disaster which flood could cause. To cope with such fears the Byzantines might apply to holy men, who had the gift to mediate between man and God and protect people from the negative impact of rain and flood[51].

3.3. *Drought: a major climatic disturbance*

Lack of rain and drought is a climatic disturbance of critical importance for medieval and premodern economies, because it is the leading cause of harvest failure and food crisis. Considering the fragile nature of farming, at least in the marginal Mediterranean lands that relied on fickle autumn and spring precipitation to yield a single crop of winter wheat or barley for peasants' subsistence, the accident of lack of rain and drought has proven as the climatic factor that left significant imprint in the Byzantine historical record. Complaints about lack of rain, drought and probably famine are relatively frequent in the Byzantine sources. Furthermore, among the historical accounts specifying the reason for a shortage or famine, the lion share of them point to lack of rainfall and drought[52].

Information on lack of rain and/or drought is conveyed in various contexts by authors of Byzantine historiography and hagiography. Apart from hagiographical narratives where a drought (usually accompanied by famine) functions as the physical background that gives rise to the manifestation of an alleviative rainfall challenged by the miraculous action of a Saint[53], there are several reports of drought in the Byzantine historiography reflecting authors' political and social preconceptions. Without going into

50. T. 128 (accounts by: John of Ephesus, Prokopios, Zacharias of Mytilene, Chronicle of Edessa, John Malalas, Evagrios, Jacob of Edessa, Theophanes, Ellas of Nisibis, Leo Grammatikos, George Kedrenos, John Zonaras, Michael the Syrian, Nikephoros Kallistos Xanthopoulos); cf. detailed discussion in: A. Palmer, Procopius and Edessa, *Antiquité Tardive* 8 (2000), 127-136, here 130-135.

51. T. 139, 186,192, 226, 321.

52. For the early Byzantine period, drought-induced subsistence crises form the largest group in the category of crises with climatic cause (33 among 44 events); see D. Stathakopoulos, *Famine and Pestilence in the Late Roman and Early Byzantine Empire. A Systematic Survey of Subsistence Crises and Epidemics* (Birmingham Byzantine and Ottoman Monographs, 9), Aldershot 2004, 37.

53. See above, chapter 3.2.

detail, it may be noted that, in Byzantine historiographic texts mainly, drought records were usually formed within elliptical reports, where the phenomenon is reported among other hardships or perils (earthquake, famine, pestilence, apparition of comets etc.), either within an eschatological context or within a context of critics against emperors, who were accused of lacking in piety and having lost favour with God[54]. Nevertheless, there are descriptions of drought in the Byzantine sources that include details about the environmental implications of the phenomenon, as well as people's concepts and attitudes related to the hardships they experienced. Droughts are usually described as resulting reduction of water in streams and lakes or drying up of wells[55]. Invasions of swarms of locusts are also mentioned during periods of drought[56]. People's reactions are combined with the pressure that the scarcity of drinkable water might cause, especially to urban populations. Case: Lack of water in Constantinople in November A.D. 563 resulted in fights around the fountains[57]. On the other hand, people could be relieved from the psychological pressure that a natural disaster might cause if the catastrophe could be predicted. Case: drought with famine and pestilence that befell Antioch in 440s A.D. had been foreseen by the Saint Symeon Stylites the Elder[58]. Moreover, examination of the relevant narratives yields a number of instances concerning communal prayer services and processions for deliverance from drought, or fervent pleas for God's mercy upon the communities. Such practices functioned in favour of ending meteorological stress by mitigating the psychological pressure that the implications of a drought caused to people[59].

54. T. 8, 29, 51, 77, 142,170, 257, 272, 299, 304, 312, 411, 506, 576, 625, 686.

55. T. 30, 118, 126, 227, 257, 272, 275, 281, 356, 437,459, 514, 553, 623.

56. T. 118, 140, 372, 443. On the climatic factors affecting locust attacks in the Mediterranean region, see D. Camuffo – S. Enzi, Locust invasions and climatic factors from the Middle Ages to 1800, *Theoretical and Applied Climatology* 43,1-2 (1991), 43-73. Cf. also Stathakopoulos, *Famine* [as in n. 52], 41-45.

57. T. 179. See also T. 180, 187, 272.

58. T. 82: cf. Stathakopoulos, *Famine* [as in n. 52], 232.

59. T. 63, 137, 140, 222, 245, 261, 354, 454, 498, 623, 675, 677.

3.4. *Cold against warm: severe winters versus hot summers*

Next to the climatic parameter of precipitation, which is reflected in the Byzantine sources from reports of lack of rain and drought, the most documented weather events in relation to the parameter of temperature are those of cold spells. Accounts describing cold weather conditions or the prevalence of severe winters with much cold, ice, and snow, are ascribed in various contexts of reference. Short-term cold episodes (e.g. a cold day or night, or a short period of cold weather), usually referring to a local geographical scale, are mostly recorded in historiographic narratives describing the difficulties experienced by soldiers during military campaigns. Wintry weather with low temperatures could bring hardship and affect logistics of moving troops and strategic planning[60]. On the other hand, in some hagiographical narratives cold weather constructed the physical framework within which the authors praised the virtue of the holy men (mainly the Stylites) and emphasized their physical and spiritual strength, as well as their patience in front of bodily hardships[61].

However, the most important paleoclimatological information regarding temperature can be obtained from references to severe winters, because they provide indications for a whole season and may apply to a regional geographical scale. The Mediterranean winter can be unpleasant at times. This emerges from brief or detailed references to severe winters and reports on excessive cold and ice during winter season. Elliptical reports, where severe winters are mentioned among other hardships or perils within an eschatological context or a context of critics against emperors, are very few compared to those including drought[62]. In other cases, the authors are more inclined to report details about the severity of a winter and its consequences. Apart from the use of exaggerated statements denoting that a severe winter was memorable[63], there are reports of harsh winters including interesting environmental and sociocultural details. References to freezing of water surfaces (rivers, lakes, sea) during winter season are of

60. For a discussion on this topic and the relevant Byzantine textual evidence, see Telelis, Weather and climate [as in n. 48], 444-452.

61. E.g. T. 26, 66, 96, 97, 107, 157, 197, 317, 368, 369, 377.

62. E.g. T. 312. Brief reports of severe winters: T. 38, 48, 80,168,199, 240, 276.

63. E.g. T. 87,271, 451, 603, 624, 631, 640.

paleoclimatological interest because they imply below-freezing temperatures for a sustained period and, thus, give regional paleoclimatological insight for winter temperature trends. Loss of people, perish of animals and damage to crops because of the severity of the cold were mentioned[64]. In parallel, there are cases where the sources emphasize the fact that the freezing cold turned waterways into solid fords and made the surface of rivers easy to cross[65].

References to high temperatures in the Byzantine sources are not as frequent as those of cold. This discrepancy has its explanation to the general climatic regime of the southern and eastern Mediterranean, where high temperatures, especially during summer season, are quite common. Reports of heat waves are contextualized in historiographic passages as natural disasters with impact to agricultural production.[66] Summer high temperatures in combination with the constraint of adequate water supplies could sap travelers' endurance and make campaigning military forces suffer[67]. In hagiographical texts, heat is mentioned as a cause of bodily hardship for Byzantine Saints during their ascetic life, but also as an opportunity for them to illustrate their supernatural power through the manifestation of miracles[68].

64. E.g. T. 88, 129, 141, 162, 168, 183, 211, 228, 229, 232, 236, 243, 247, 249, 265, 271, 282, 315, 334, 335, 364, 366, 373. The exceptional long term climatic anomaly of A.D. 536/7 (T. 148) caused by a persistent dust veil, which darkened the skies between Europe and Asia Minor, left significant textual evidence regarding Its environmental and social implications. For this special case study, cf. A. Arjava, The Mystery Cloud of 536 CE in the Mediterranean Sources, *DOP* 59 (2005), 73-93; P. Gräslund – N. Price, Twilight of the gods? The 'dust veil event' of AD 536 in critical perspective", *Antiquity* 86 (2012), 428-443.

65. Cases of freezing of water surfaces: T. 21, 25, 33, 52, 53, 58, 68, 176, 265, 271, 283, 361, 367, 377, 389, 407, 428, 432, 439, 443, 451, 467,471, 474, 482, 574, 591, 601, 624, 633. The winters A.D. 763-64 (T. 271) and 927-28 (T. 373) were exceptionally cold and the Byzantine sources provide extensive descriptions about them. For these case studies, cf. respectively: Telelis and Chrysos, The Byzantine Sources as Documentary Evidence [as in n. 18], 21-29; Stathakopoulos, Reconstructing the climate [as in n. 18], 255-256.

66. E.g. T. 201, 481, 694.

67. Cf. Telelis, Weather and climate [as in n. 48], 458.

68. E.g. T. 1, 84, 106,152,175, 210, 355, 359, 375, 419.

3.5. *Stormy weather: damage, peril or proof of sanctity?*

Stormy weather events –including wind storms and sea tempests, gales with thunderbolts and lightning, hail storms– are recorded quite often in the Byzantine sources. These events had a short-term and local scale character. Their destructive impact on infrastructure or agriculture and the fact that they often caused victims were leading factors that led the authors of Byzantine historiographic and hagiographic sources to include them in their narrations in various ways.

Historiographic references on sudden onset of strong wind or outbreak of windstorms are often involved with damage to buildings and monuments, having in most cases a geographical focus on Constantinople. Damage or destruction of statues, columns of stylite monks, churches, and roofs of buildings or the Hippodrome is recorded[69]. Sea tempests are mostly related to the risk or the fact of shipwreck during maritime travel. Historiographic sources describe tempest as a danger of death by drowning for crews and passengers of fleets or commercial vessels in larger narratives with factual accuracy[70] In hagiographical narratives of travel tempest is usually inscribed into a miraculous context. The audience is intended to recognize Saints' sanctity and transcendental power emerging from his miraculous intervention. Usually, the Saint achieves his and other passengers' rescue contrary to the perilous situation caused by a tempest[71]. Gales (thunderbolts and lightning included) are mentioned in historiographic sources either as cause of damage to buildings and monuments (usually in Constantinople), sometimes interpreted by the authors as omens[72], or as natural events having negative impact to military campaigns and troop movements[73]. Hagiographical reports of gales are mostly combined with a miraculous tale. The natural event either portrays the physical endurance and moral patience

69. E.g. T. 34, 35, 37, 62,112,119,147,172, 196, 200, 207, 221, 224, 246, 294, 296, 340, 343, 365, 383.

70. T. 13, 72, 125, 144, 145, 154, 165, 198, 235, 251, 274, 278, 288, 291, 295, 307, 390, 408, 413, 449, 462, 494, 496, 517, 549, 557, 558, 573, 589, 598, 654, 658, 660, 662, 690, 693, 699.

71. T. 69, 150, 151, 188, 216, 284, 305, 314, 322, 337, 342, 350, 382,442, 524. Cf. Pratsch, *Der hagiographische Topos* [as in n. 34], 257-259.

72. E.g. T. 5, 23, 49, 72,105,121, 161, 353, 492, 611.

73. E g. T. 17, 57, 59, 74, 92, 207, 218, 409, 433, 507, 632, 661, 691, 692, 702.

inspired by the ascetic strength of the saint, or functions as proof of his supernatural power through the manifestation of miracles[74]. Furthermore, there are a few cases where hagiographical reports of gales are side-details in larger narratives[75].

Analogous contexts of reference can be detected also in the Byzantine textual evidence of hailstorms. Historiographic narratives usually focus on harm to plants and crops caused by hailstorms. Furthermore, they may emphasize the ominous character of the hail, which portrays the wrath of God[76]. On the other hand, hagiographical narratives include accounts on hailstorms mainly in a miraculous context[77]. The case of Saint Theodore of Sykeon (7th century A.D.) is characteristic for the miraculous power of a Byzantine saint upon a meteorological phenomenon. Theodore of Sykeon is reported to have saved the crops of villages in Anatolia from damage by hail by uttering prayers and the magic power of the cross. Theodore of Sykeon was also able not only to stop, but also to call forth a hailstorm for the punishment of sinful villagers[78].

4. EVALUATION OF BYZANTINE TEXTUAL EVIDENCE FOR PALEOCLIMATE RECONSTRUCTIONS

Common primary sources of the Byzantine textual tradition include a variety of references to weather, climate and natural disasters, with diverse contents and in varying contexts[79]. The value of these references for the purposes of historical climatology depends both on the quantitative and the qualitative characteristics of the data base this material constructs.

For a historical climatological analysis of the textual paleoclimate data, the temporal and the spatial distribution of paleoclimate information obtained from Byzantine textual evidence must be considered. A temporal distribution of the material over the period 4th–15th centuries shows that the available evidence is rather sporadic compared to the thematic extent

74. E.g. T. 131, 158,167, 192, 226, 255, 268, 301, 310, 358, 379, 587, 657.

75. E.g. T. 34, 50, 93,102, 452.

76. E.g. T. 41, 70, 91, 269, 313, 357, 396, 397, 400, 425, 438, 446, 448, 455, 461, 472, 516, 528, 537, 546, 548, 554, 611,648, 649.

77. E.g. T. 10, 95, 657.

78. T. 138, 192 193 194.

79. Cf. above, chapter 3.

and volume of the Byzantine textual production in total. Moreover, it does not cover the long interval of the Byzantine history with the same intensity for all periods. There are periods with relatively abundant textual evidence (e.g. 4th–6th and 10th–13th centuries), while for other periods the evidence is sparse. Thus, the discontinuity arising from the obtained evidence makes the construction of a systematic paleoclimatic data series a difficult task, and raises the critical question whether the increased documentation of weather events during some periods may reflect possible climatic trends[80].

On the other hand, there are qualitative characteristics that enforce the discontinuity of the obtained textual paleoclimate data. The spatial coverage of the available evidence is characterized by a strong locational bias: a considerable amount of records refer to Constantinople, the capital of the Byzantine Empire, while for other areas of the Byzantine territories information is rare. Furthermore, many references contain chronological and geographical ambiguities. The dating control is usually unsatisfactory, and the anticipated high temporal resolution of the textual evidence (often down to the single day)[81] loses from its statistical value, because in most cases the weather and climate-related events are hard to date precisely. Moreover, as already discussed[82], the evidence may be biased by the perception of the authors/observers, who were mostly oriented towards the recording of extreme events and natural disasters, usually outlined within anecdotal and sketchy narratives.

Obviously, these shortcomings contained in the Byzantine textual evidence reduce the value of the paleoclimate information that can be extracted for the purposes of historical climatology and discourage the application of sophisticated statistical methods for ambitious climatic reconstructions. Even though historical-climatological studies of the

80. For a discussion on the relevant statistics, see Teleles, *Μετεωρολογικά φαινόμενα και κλίμα στο Βυζάντιο*, [as in n.22], 783-794; I. Telelis, Historical-Climatological Information from the Time of the Byzantine Empire (4th-15th Centuries A.D.), *History of Meteorology* 2 (2005), 41-50.

81. The advantages and pitfalls included by medieval and early modern documentary paleoclimate evidence has been exhaustively discussed by C. Pfister – R. Brazdil – R. Glaser, Documentary Evidence on Climate in Sixteenth Century Europe, *Climatic Change* 43 (1999), 55-110.

82. Cf. above, chapter 2.

Medieval Europe have developed statistical methods appropriate to paleoclimatic data sets obtained from medieval and early modern textual sources[83], analogous studies in the field of historical climatology of the Byzantine textual sources have suggested the adoption of simpler statistical techniques to cope with the low density and quality of the data[84].

Admittedly, available by now textual evidence for climatic and environmental developments obtained from Byzantine sources constructs a data set, which raises more questions than answers. Existing chronological gaps and geographical voids in the extracted paleoclimate information involve significant uncertainties and unknowns that affect scientific conclusions regarding textual evidence-based paleoclimate reconstructions for the Byzantine period. So far, research in historical climatology of the Byzantine Empire has made possible to obtain a rather hypothetical view of approximate climatic trends during the Late Antiquity and the Middle Ages in the Eastern Mediterranean and the Middle East. The next step is to proceed to a comparative interdisciplinary study of textual, paleoenvironmental, and climate model-based knowledge about the character and extent of climatic variability in Byzantium. To achieve a clearer definition of the representativeness and the real value of the Byzantine textual evidence on climate, the existing data base must be enriched with evidence that may be derived from unexploited genres of Byzantine documentary sources (e.g. papyri, archival documents, epistolography, legislative texts). The expansion of the textual evidence in parallel with the ever-growing paleoenvironmental, and climate model-based data will definitely enrich evidence-informed hypotheses on climate impact and societal responses in Byzantium, one of the important pending topics of Byzantine environmental history.

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83. For a reconstruction of medieval climatic fluctuations for the period A.D. 1000-1425 on the basis of decennial Indices from the number of months in which the weather is mentioned as being "mild", "harsh", "rainy" or "dry" in hundreds of narrative sources from France, Germany and northern Italy, see Alexandre, *Le climat* [as in n. 13]; Y. Zhongwei - P.Alexandre – G. Demaree, Narrative warm/cold variations in continental western Europe, A.D. 708 – 1426, *Science in China Series D: Earth Sciences* 40, issue 5 (1997), 509-517. Cf. also Pfister et al., Documentary Evidence [as in n. 81]; Pfister – Brazdil – Barriendos, Reconstructing past climate and natural disasters [as in n. 7].

84. Cf. Telelis, Medieval Warm Period [as in n. 19]; ID. Climatic fluctuations in the Eastern Mediterranean and the Middle East AD 300-1500 from Byzantine documentary and proxy physical paleoclimatic evidence - a comparison, *JÖB* 58 (2008), 167-207.

Βυζαντινες Κειμενικες Πηγες σχετικα με τις Κλιματολογικες και τις Περιβαλλοντολογικες Αλλαγες

Το παρόν άρθρο πραγματεύεται την πρόοδο που έχει πραγματοποιηθεί στη διερεύνηση των βυζαντινών κειμενικών πηγών από ιστορική και παλαιοκλιματολογική άποψη. Αναλύει γενικές έννοιες που επηρεάζουν την ιδεολογική προοπτική των αναφορών στον καιρό, το κλίμα και τις φυσικές καταστροφές, στο πλαίσιο των ειδών των βυζαντινών κειμενικών πηγών που τις περιλαμβάνουν. Στη συνέχεια, παρουσιάζει επισκόπηση των τεκμηριωμένων παλαιοκλιματικών στοιχείων που συναντώνται για το Βυζάντιο, δίνοντας έμφαση στις κατηγορίες των φαινομένων που αναφέρονται στις πηγές. Τέλος, συζητά προβλήματα που σχετίζονται με την ανάλυση και την ερμηνεία των στοιχείων με όρους ιστορικής κλιματολογίας του Βυζαντίου και, τελικά, βυζαντινής περιβαλλοντικής ιστορίας.