Quaternary Science Reviews 136 (2016) 5–22

Contents lists available at ScienceDirect

Quaternary Science Reviews

journal homepage: www.elsevier.com/locate/quascirev

Realising consilience: How better communication between archaeologists, historians and natural scientists can transform the study of past climate change in the Mediterranean

Adam Izdebski [a, *], Karin Holmgren [b, c], Erika Weiberg [d], Sharon R. Stocker [e], Ulf Büntgen [f, g, h], Assunta Florenzano [i], Alexandra Gogou [j], Suzanne A.G. Leroy [k], Jürg Luterbacher [l], Belen Martrat [m], Alessia Masi [n], Anna Maria Mercuri [i], Paolo Montagna [o], Laura Sadori [n], Adam Schneider [p], Marie-Alexandrine Sicre [q], Maria Triantaphyllou [r], Elena Xoplaki [l]

[a] Jagiellonian University in Krakow, Institute of History, Gołębia 13, 31-007 Kraków, Poland
[b] Stockholm University, Department of Physical Geography, Stockholm, Sweden
[c] Navarino Environmental Observatory, Messinia, Greece
[d] Department of Archaeology and Ancient History, Uppsala University, Sweden
[e] University of Cincinnati, Department of Classics, USA
[f] Swiss Federal Research Institute WSL, Birmensdorf, Switzerland
[g] Oeschger Centre for Climate Change Research OCCR, Bern, Switzerland
[h] Global Change Research Centre AS CR, Brno, Czech Republic
[i] Università di Modena e Reggio Emilia, Laboratorio di Palinologia e Paleobotanica, Dipartimento di Scienze della Vita, Italy
[j] Hellenic Centre for Marine Research, Institute of Oceanography, Anavyssos, Greece
[k] Brunel University London, Institute for the Environment, UK
[l] Justus Liebig University of Giessen, Department of Geography, Giessen, Germany
[m] Spanish Council for Scientific Research (CSIC), Institute of Environmental Assessment and Water Research (IDÆA), Department of Environmental Chemistry, Barcelona, Spain
[n] Università di Roma La Sapienza, Dipartimento di Biologia Ambientale, Italy
[o] Istituto di Scienze Marine (ISMAR), Bologna, Italy
[p] UC-San Diego, Department of Anthropology, USA
[q] Universite Pierre et Marie Curie, Laboratoire d'oceanographie et du Climat: experimentation et approches numeriques (LOCEAN), Paris, France
[r] University of Athens, Faculty of Geology and Geoenvironment, Greece

ARTICLE INFO

Article history:
Received 30 March 2015
Received in revised form
21 October 2015
Accepted 23 October 2015
Available online 12 December 2015

Keywords:
Archaeology
Climate change
Consilience
History
Interdisciplinary collaboration
Mediterranean
Natural sciences
Palaeoecology

ABSTRACT

This paper reviews the methodological and practical issues relevant to the ways in which natural scientists, historians and archaeologists may collaborate in the study of past climatic changes in the Mediterranean basin. We begin by discussing the methodologies of these three disciplines in the context of the consilience debate, that is, attempts to unify different research methodologies that address similar problems. We demonstrate that there are a number of similarities in the fundamental methodology between history, archaeology, and the natural sciences that deal with the past ("palaeoenvironmental sciences"), due to their common interest in studying societal and environmental phenomena that no longer exist. The three research traditions, for instance, employ specific narrative structures as a means of communicating research results. We thus present and compare the narratives characteristic of each discipline; in order to engage in fruitful interdisciplinary exchange, we must first understand how each deals with the societal impacts of climatic change. In the second part of the paper, we focus our discussion on the four major practical issues that hinder communication between the three disciplines. These include terminological misunderstandings, problems relevant to project design, divergences in publication cultures, and differing views on the impact of research. Among other recommendations, we suggest that scholars from the three disciplines should aim to create a joint publication culture, which should also appeal to a wider public, both inside and outside of academia.

* Corresponding author.
E-mail address: adam.izdebski@fundusz.org (A. Izdebski).

http://dx.doi.org/10.1016/j.quascirev.2015.10.038

1. Introduction

This paper offers a discussion of the theoretical and practical issues involved in collaboration among the natural sciences and the humanities (or, the social sciences, as is the case for much archaeological research), focused on the study of human perceptions and actions in relation to climate and environmental change in the past. With growing interest in the interplay between climate, environmental change and society, there has been considerable discussion about these issues over the course of the last several decades and the number of papers published in this field is steadily increasing. Early descriptive efforts to correlate societal change with environmental and climate changes were hampered by lack of precise chronologies (e.g., Piperno et al., 1991; Núñez et al., 2002; Berglund, 2003), or by the fact that the data on climate and society were derived at a far distance from each other (e.g., Cullen et al., 2000; Haug et al., 2003). This resulted in considerable uncertainties with regard to the actual causal relations between different social and natural phenomena. Recent contributions have benefitted from more precise dating techniques and an increased understanding of the complex and non-linear couplings between human societies, environment and climate (e.g. Butzer, 2005, 2008, 2012; Cooper and Peros, 2010; Westerberg et al., 2010; Büntgen et al., 2011; Mercuri et al., 2011; Kennett et al., 2012; McCormick et al., 2012; Turner and Sabloff, 2012; Kaniewski et al., 2013; Haldon et al., 2014; Lane et al., 2014; Luterbacher and Pfister, 2015; see also the contributions published in this special issue of the *Quaternary Science Review*). However, one can still observe the persistent tendency in several contributions to oversimplify the social or natural processes, to focus on one-sided explanations, or to be based on observations of authors representing just one or two fields. This is not least the case when it comes to the Mediterranean region.

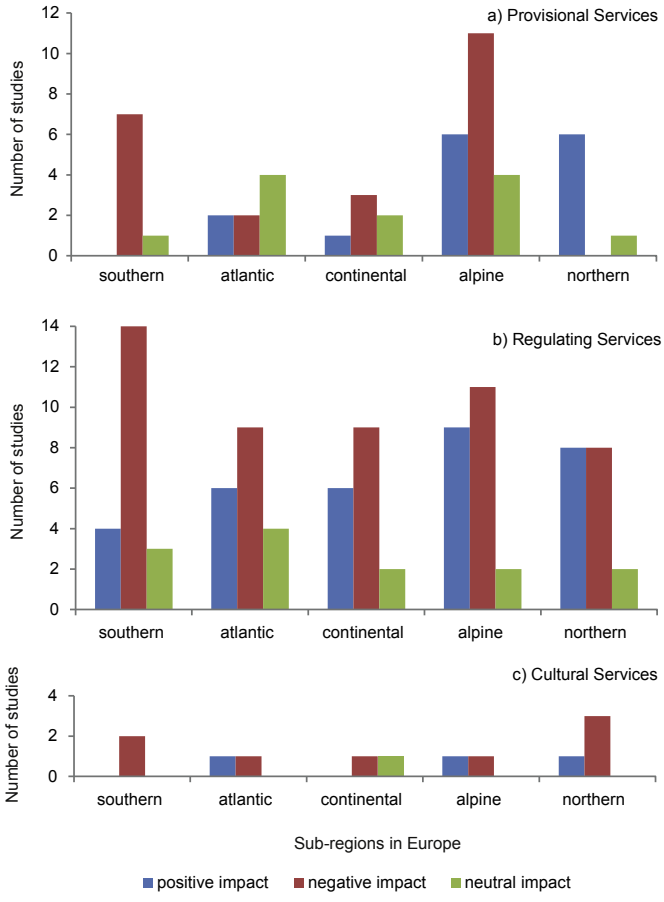

Fig. 1. Assessment of the impacts of climate change on ecosystems services in sub-regions of Europe (adapted from Kovats et al., 2014, 1288–1289). The European part of the Mediterranean region forms the southern sub-region. Provisional services include e.g. production of food, livestock, bioenergy and timber; regulating services include for instance climate regulation, biodiversity and water quality regulation; cultural services include for example tourism, recreation and cultural heritage.

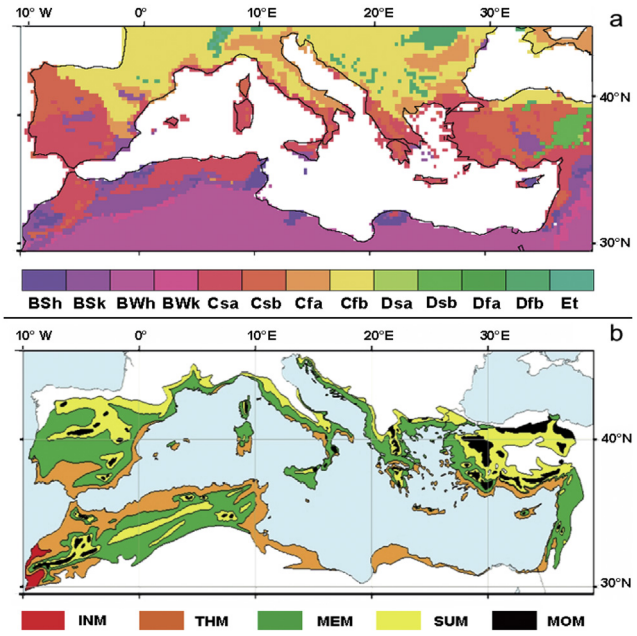

Fig. 2. Climate and vegetation types in the Mediterranean (from Sadori et al., 2013, modified). a) Köppen climate types in the Mediterranean region: subtropical steppe (BSh), midlatitude steppe (BSk), subtropical desert (BWh), midlatitude desert (BWk), Mediterranean climate with hot/warm summer (Csa/b), humid subtropical with no dry season (Cfa), maritime temperate (Cfb), humid continental with hot/warm summer (Dsa/b), continental with dry hot/warm summer (Dfa/b), and tundra (Et) (from Lionello, 2012, modified). b) Types of Mediterranean vegetation: infra-Mediterranean (INM), Thermo-Mediterranean (THM), Meso-Mediterranean (MEM), Sub-Mediterranean (SUM), Mountain-Mediterranean (MOM) (from Quézel & Médail, 2003, modified).

The present article originates from a multi-disciplinary meeting of scientists, archaeologists and historians interested in problematising and integrating the diverse views on the role that climate has played within Mediterranean societies of both the recent and remote past (Holmgren et al., 2014). The first part of the article consists of an outline of the methodological prerequisites and potential foundations of interdisciplinary collaboration, its second part is devoted to the existing challenges that may hinder communication between archaeology, history, and those disciplines within the natural sciences that deal with the past ("palaeoenvironmental sciences"); it concludes by proposing a series of possible solutions to these problems.

It is not a coincidence that this methodological review is produced by a group of scholars involved in the study of the Mediterranean domain. Over the past several years, there have been renewed efforts at demonstrating the exceptional character of this large region in terms of its combined natural and human history (cf. Braudel, 1949, for a classic view; Horden and Purcell, 2000, 2006; Grove and Rackham, 2003; Tabak, 2008; Broodbank, 2013; Harris, 2013; Goffredo and Dubinsky, 2014). During the last 10,000 years, the Mediterranean, and in particular its eastern part, has had an

exceptional history of human civilisation. An international community of Neolithic and Bronze Age specialists, historians and archaeologists of the Graeco-Roman world, Byzantinists, and Medievalists – to name only a few disciplines – have been studying Mediterranean cultures for centuries (Broodbank, 2013, 15–53). No single region exists in the world for which we possess a comparable body of knowledge – regarding both prehistoric and historic societies – that reaches so far back into the past and can be critically evaluated in such detail. At the same time, the physical environment of the Mediterranean has attracted the attention of geologists, geographers, climatologists and other natural scientists since the beginning of modern scientific investigation, which has resulted in a very detailed understanding of this region's landscapes from an earth-sciences perspective (e.g., Grove and Rackham, 2003; Lionello et al., 2006, 2012; Robinson et al., 2006; Roberts et al., 2008; Woodward, 2009; Finné et al., 2011; Magny et al., 2013; Walsh, 2014; Rohling et al., 2015). This is why the Mediterranean – while being especially attractive for researchers coming from so many disciplines – poses also a unique methodological challenge. Namely, in order to fully comprehend the interplay between climate, environment, and society, and to take account of the perspectives of all the disciplines involved and of the evidence they use, one needs to integrate the approaches of not just science and archaeology, but also of history and other disciplines that are primarily concerned with written sources. It is also this methodological challenge that makes the Mediterranean special as compared to many other regions of the world (cf. Cooper and Peros, 2010; Westerberg et al., 2010; Kennett et al., 2012; Turner and Sabloff, 2012; Lane et al., 2014).

Most of the regions of the Mediterranean are also highly sensitive to climatic changes (e.g., Jeftic et al., 1992; Lionello et al., 2012 and references therein; Kovats et al., 2014, among others; see also Fig. 1). The relationship between climate and the local environment, however, differs from one region to another, as this part of the world is characterised by a large variability of physical and natural contexts, on both local and regional level, as well as a high biodiversity (see Figs. 2 & 3). The mosaic of habitats scattered throughout the Mediterranean basin has been continuously transformed by climatic changes, while these same habitats have been utilised in parallel by human societies capable of transforming the landscape on a still larger scale. Together, the combined effects of cultural pressure and environmental factors have determined the disposition of Mediterranean landscapes throughout the course of history (e.g., Roberts et al., 2011; Mercuri, 2014; Mercuri and Sadori, 2014).

From a human perspective, these various landscapes, ranging from deserts and semi-deserts in the south to fertile river valleys in the north, formed the prerequisites for a world of interconnected habitats (Horden and Purcell, 2000). It is this potential for connectivity that facilitated the creation of social networks capable of utilising the diverse niches offered by the Mediterranean region. The multidimensionality and great temporal depth of the Mediterranean call for a holistic and multidisciplinary study requiring collaboration between a variety of research disciplines from both the natural sciences and the humanities-social sciences.

2. The foundations of collaboration: are our methodologies really different?

Interdisciplinary collaborations need effective research strategies and operable methodologies. Cooper and Peros (2010) addressed specifically the methodological challenges relating to the integration of data sets of different temporal and spatial scales across disciplines in the promotion of an archaeology of climate change in the Caribbean. Meyer and Crumley (2011) recently published a guideline for research design in historical ecology, emphasising among other things the need for *translation* between different scholarly languages, even within disciplines if working in an international group. While these methodological approaches are quite general, focusing mainly on archaeology, and are non-Mediterranean in their focus, McCormick (2011, 2012) has recently led similar initiatives for history, and with a Mediterranean scope. There is also an increasing number of archaeological projects in the Mediterranean region with explicit interdisciplinary intent.

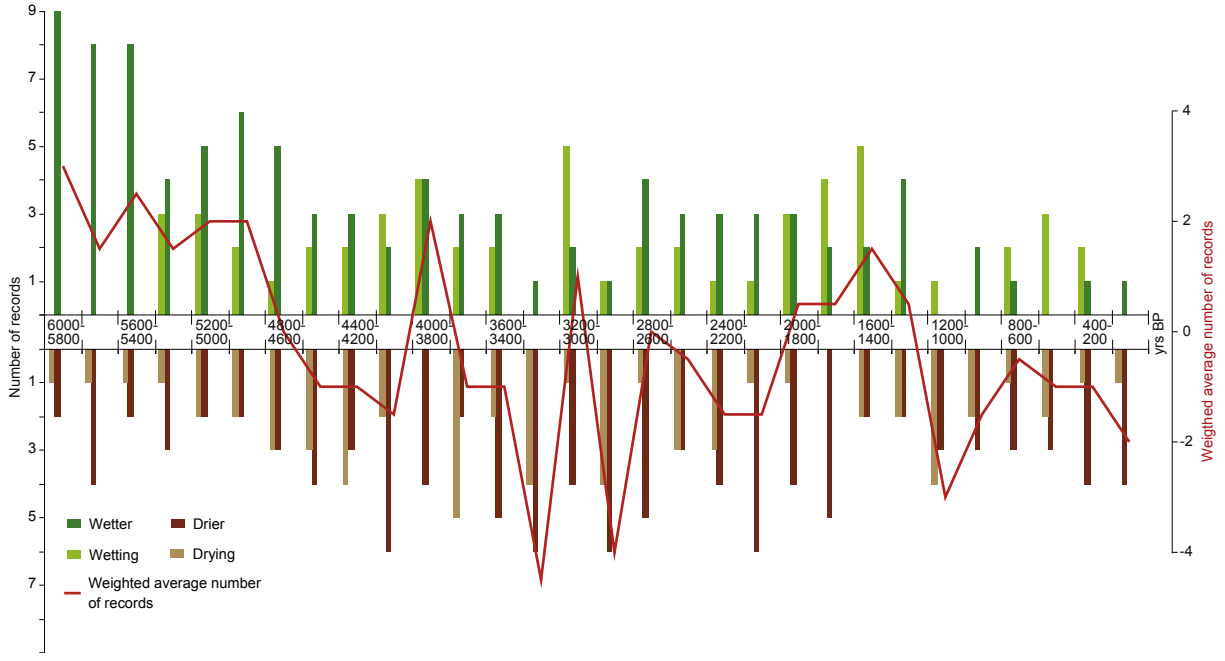

Fig. 3. General climate variability in the eastern Mediterranean region over the past 6000 years (after Finné, 2014). Each bar represents the number of palaeoclimate records in a 200-year time slice that shows wetter/wetting or drier/drying than average conditions.

The focus of these projects is on environmental and climatological issues, such as at Çatal Höyük and Sagalassos in Anatolia (Asouti and Austin, 2005; Boyer et al., 2006; Roberts and Rosen, 2009; Bakker et al., 2012; Kaptijn et al., 2013) or at several sites in Tuscany in Italy (e.g. Bowes et al., 2015), which have all produced many interdisciplinary publications. Butzer (2005, 2008, 2012) has furthermore single-handedly greatly improved the general awareness of the need for interdisciplinary studies connecting archaeology and the sciences in the Mediterranean region.

Interestingly, many of these cases, in the Mediterranean and elsewhere, appear to aim at widening the interdisciplinary capacity of the initiating discipline by inviting researchers from other disciplines to expand the interpretative scope of archaeology or history, making the scientists in effect consultants to archaeology or history. This has been a common strategy in archaeology for a long time, with only the spectrum of included disciplines changing or expanding over time. Similarly – although more recently and perhaps to a lesser extent – archaeologists and historians are invited as co-authors on scientific publications.

These are all very positive developments, but what is further needed, we believe, are research strategies that would be interdisciplinary from the very beginning, where all parties have an equal presence in the staging of the project and determining the research questions. Only on equal basis can we begin to construct a true "science of the past" (Cornell et al., 2010; cf. also Caseldine and Turney, 2010). In this section, we argue that an important step towards achieving this aim is a greater realisation that our disciplines and our methodologies are, in essence, not as dissimilar as we commonly tend to think.

2.1. The consilience project

Since the publication of Wilson's book (Wilson, 1998) on the unity of science, it has become customary to discuss interdisciplinary collaboration between the broadly-defined humanities and the natural sciences within the context of his idea of consilience (e.g., McCormick, 2011). Wilson's argument is based on the conviction that human knowledge is a unity. Therefore, when two or more research disciplines study the same problem, there exists a potential for mutual exchange and support. One discipline can fill gaps in our understanding of a given phenomenon that another discipline is not able to treat, and vice versa. In this way, according to Wilson, we should eventually reach a stage at which the very organisation of scientific disciplines will change, and researchers coming from different methodological backgrounds will be united in the study of the same questions.

Regrettably, this appealing vision of how scientists from different disciplines might collaborate is not easily put into practice. One of the principal dangers is well illustrated by Wilson's book itself: when seeking the "simplest possible explanation", Wilson often ends up proposing a sociobiological answer to the questions he asks. This is not surprising given that he himself is a sociobiologist; but it is discouraging for a humanities or social science scholar. Such situations are difficult to avoid. Because each discipline focuses on different types of evidence and has its own theoretical foundations, a sociobiologist and a humanities scholar will always have difficulty agreeing on questions and interpretations (Slingerland and Collard, 2011). On the other hand, when no effort is made to ensure a balance between disciplines, consilience runs the risk of reductionism, a fact that highlights its central precept, which is the meeting, or even merging, of totally different, almost unrelated ways of studying and understanding cultural and biological phenomena.

At first glance, Wilson's "consilience project" seems directly relevant to the collaboration between history, archaeology and the palaeoenvironmental sciences (such as the geosciences or palaeoecology). In such cases, representatives from the different disciplines may meet together to work on the same research questions, and might actually welcome a situation where their methods and approaches could be merged into a new, single discipline. However, there is one crucial problem with applying Wilson's ideas to the interdisciplinary collaboration discussed in this paper. In his book, Wilson does not express any interest in the past. His project is focused primarily on ways in which the social sciences, humanities (primarily, literary studies) and natural (primarily, biological) sciences can together study universal phenomena such as religion, morality or the creation of oral and written traditions. In this way, he leaves aside whole disciplines and research traditions, in particular those that deal with society's or nature's past. Any successful collaboration between history, archaeology and palaeoenvironmental sciences require novel theoretical foundations, ones that better understand the specific nature of these disciplines, as well as the common elements they share.

2.2. Palaeoenvironmental sciences as historiography

The reason for the similarities between history, archaeology and the palaeoenvironmental sciences is the fact that they all deal with the past. In all three disciplines, the object of investigation is no longer accessible: most of the human societies studied by historians or archaeologists disappeared long ago (although some have modern descendants), while the environmental conditions of interest to palaeoenvironmental scientists can no longer be observed first-hand. The lack of direct contact with the studied phenomenon has a strong influence on the methodologies of these disciplines: all require the search for traces of the past in the present. In order to say anything about the object of their study, they need not only a theory, but also a hermeneutics, i.e. a way of recognising, reading and talking about these traces of the past. In brief, they all study and write about the past, and they all produce historiographies, however dissimilar, based on the study of widely differing archives.

Since the publication of Hayden White's earliest essays in the 1970s, there has been a growing agreement among scholars involved in the study of the theory of history that the lack of direct access to the past means that historians actually work on representations of the past, rather than on the past itself. These representations in turn are surprisingly similar in character to the verbal fiction found in literary writing (Ankersmit, 2000; White, 1974). Thus, the discovery of new facts and explanations is always related to the invention of new ways by which a given aspect of the past may be represented linguistically, that is, described and presented.

Consequently, the rhetoric – that is, the rules that govern the use of language specific to each discipline – is a central element of all disciplines that deal with the past. Historians and archaeologists are dependent on the conventions of speaking and writing. In their work, they have to respect the strategies of constructing narrative depictions of the past that are implicitly or explicitly accepted by their colleagues. This also includes strategies of justification, such as the ways in which historians or archaeologists analyse their source material (White, 1978). During the last four decades, humanities scholars with an interest in the past have become increasingly aware that the goal of their work is to offer possible narratives ("stories") about the human past rather than arriving at any final truths. While these narratives are limited by the rules that govern their construction, they remain powerful tools that can be used to visualise the past and make it relevant to the society of the present. It is through these narratives that historians analyse and explain the complex socio-cultural worlds of the societies that preceded our own age.

This same modern hermeneutics also has the potential to explain the methodology of the earth sciences. Twenty years ago, Frodeman (1995) observed that geology is not just a derivative science, secondary to the classic experimental sciences such as physics, biology or chemistry. Rather than describing the laws of nature, the general applicability of which can be demonstrated with the help of replicable experiments, geology is concerned with processes and specific events from the past (Frodeman, 1995; Inkpen, 2009). Consequently, scholars in the earth sciences also search for traces of the past. They identify and make sense of such traces within the context of a theory that guides their research, just as historians and archaeologists are able to understand elements of the textual or material records of the past and to put them into a societal context, based on their knowledge of the period and its source material. Thus, unlike in chemistry or physics, the most widespread procedure in earth sciences is to search for proofs of a hypothesis, rather than attempting to falsify it through experiments. In this context, earth scientists will frequently utilise methods of the experimental sciences only at the initial stage; they will use the laboratory to process the material traces of the past, but not to reach their final interpretation of the phenomena they study. Earth scientists need a theory describing a geological, ecological or environmental past in order to conclude anything meaningful from the results of their laboratory analysis (Cleland, 2002). In other words, they need an overarching narrative that can provide the necessary framework into which they can accommodate their own part of the story about nature's past (cf. Latour, 1999).

To give a more concrete example from the field of palaeoclimatology, climate proxies might be viewed as an analogue to the source materials used by historians and archaeologists to construct their narratives of the past. The palaeoclimatologist seeks to elucidate past patterns of climate, for example, in temperature or the hydrological cycle (drought, precipitation, etc.). Absolute and accurate measurements of these and other climate parameters are only available for the last few hundred years; for earlier times scientists need to look for historical documents (e.g., Brázdil et al., 2005, 2010) or archives in nature. The latter comprise stratigraphic deposits that preserve biological and abiological signals that can be interpreted in terms of climate parameters. Examples of such natural archives are marine, coastal plain and lake sediments, ice cores, tree rings, corals and cave speleothems (see Luterbacher et al., 2012; Rohling et al., 2015 and references therein, for a review in the Mediterranean area). Like an archaeological excavation or a textual source, a single archive may contain several types of different climate proxies, such as pollen assemblages, other microfossils, trace elements, isotopes, organic biomarkers, etc. Variations over time in the composition and concentration of proxies occur as a result of climate changes, but also because of other factors (such as postdepositional alterations of the material, local environmental factors, and human influence). The challenge for the scientist is to separate the noise from the signal, describe the changes, understand the processes and, in ideal circumstances, quantify the climate-related variability from other factors that may have affected the proxy signal. These challenges closely resemble the ones met by archaeologists and historians when approaching their source material, be it the material from an excavation or a textual corpus, with their many layers and types of incomplete information (see also Table 1).

As with the hermeneutics, also the explanations offered by palaeoscientists resemble those of historians and archaeologists more strongly than those of typical experimental scientists (Izdebski, 2014). In fact, causative explanations of the type preferred in physics or chemistry are often impossible in the earth sciences, as there will rarely be enough information for a detailed reconstruction of the actual processes which led to a specific result in the past (although modelling tools can prove helpful in this context, see Arıkan et al., in this issue). It is possible, however, to offer the type of explanation characteristic of the historical sciences, i.e. an explanation rooted in historical narrative (although earth science applications do not take the form found in articles and monographs composed by historians). Historical narrative explanations concentrate either on the circumstances that accompanied the (historical) processes and events (these can be called robust-process explanations, e.g. explaining the beginning of World War I by examining the political situation in Europe in 1914), or on the sequence of events that led to a particular event (an actual-sequence explanation, e.g. explaining World War I by reconstructing the events which led to the murder of Archduke Ferdinand and the mutual declarations of war between the superpowers that followed). By substituting the “Roman Warm Period” for “World War I”, the same types of narrative explanations form the rhetorical frameworks for palaeoenvironmental writing as well (Kleinhans et al., 2005).

In conclusion, history, archaeology and the palaeoenvironmental sciences are surprisingly similar at the level of basic methodology. The discovery and explanation of new facts is guided by knowledge of the period and the corpus of source material that provides evidence for a historical, archaeological or palaeoenvironmental interpretation. Furthermore, all disciplines use narrative to represent and explain the past. These narratives, of course, are governed by the rules of rhetoric specific to each discipline; these rules determine how one must look for, prove, and represent a past event. However, the differences in rhetoric and research methods should not obscure the basic similarities. Scholars working on the past approach their subject and the reality of the past in a similar way; and a greater realisation of these similarities should be used to focus efforts on shaping a joint research agenda and negotiating a common rhetoric.

What make our disciplines different are our methods, habits, and cultural traditions, but not the essence of our work. Consilience is already there — the task is to find the means of realising it. The following sections will thus be devoted to the practical aspects of cooperation; it is here that we identify a number of key obstacles that hinder the process of merging what remain, at present, separate disciplines that seek answers to very similar questions.

3. The different narratives: how do history, archaeology and the palaeoenvironmental sciences conceive of the impacts of climate change?

The differences in the rhetoric of history, archaeology and the palaeosciences are already apparent in the overarching narratives used by researchers from each of these disciplines; in the case of climate change and its impact on society, historians, archaeologists and scientists all conceive of their subject in different ways. Thus, before engaging in a discussion of the more practical issues, it is important to focus on how climate change is represented in these three disciplines, and what reasons each of them have for being interested in this phenomenon. Once we understand how the climate change narrative relates to the central narratives of each discipline and to the stories they strive to tell about the past, it becomes possible to achieve the mutual understanding necessary for a genuine collaboration (cf. Butzer, 2005).

3.1. History and the societal impact of climate change

It is only recently that climate change and its societal impacts have become an independent subject of research within the discipline of history, and it still is not of central interest to most

Table 1
Classical discipline-specific versus an interdisciplinary approach to the study of climate and society in the Mediterranean region.

Discipline	Main domain	Common question	Research focus on	Interpretation dependent on	Risks
Archaeology	Humanities/ social sciences	Role that **climate** has played for **Mediterranean societies** of both the **recent and remote past**	Material remains of past societies (cultural, human, faunal, plant)	(1) Speaking and writing conventions of the discipline; (2) Questions seen as central within each discipline and domain; (3) Strategies of constructing narrative depictions of the past	**Mono-causality**: climate determinism and reductionism (**climate-centred perspective**) or no consideration of non-anthropogenic factors at all when explaining human history (**anthropocentric perspective**)
History	Humanities		Written record produced by past societies		
Palaeoenvironmental sciences	Natural sciences		Marine and lake sediments, ice cores, tree rings, corals, cave speleothems		

historians. An awareness of the effect that regional climatic conditions can have on a particular society, however, has existed for much longer, and can be linked to the development of historical geography, which highlights the importance of natural conditions for local economies in historical times. Consequently, numerous monographs on national and regional history include introductory chapters on environmental and climatic conditions (classic examples of such introductory chapters can be found in Geyer and Lefort, 2003; Kaplan, 1992; Martin, 1993; Toubert, 1973). However, most of these introductions approach the natural setting of their regional histories in a static manner, treating it as an environmental theatre that remains constant while human actions take place within it.

An interest in climate change and its role in history, rather than in the natural features of a studied cultural landscape, was, and still, is much less widespread among historians. While such an approach was first pursued some 50 years ago due to an interest in the climatic fluctuations that affected pre-modern agriculture, the impact of these fluctuations on society was not investigated in detail (Le Roy Ladurie, 1967). After half a century, this approach is still popular and, among the historians working in the field of "climatic history", one can see a strong focus on retrieving data concerning past climate conditions from textual sources (with most of research still being done by European scholars, in particular those studying Northern Europe – see an overview in Winiwarter et al., 2004; cf. also Pfister, 2010).

Indeed, starting from the early modern period (after AD 1500), the written record often provides data about extreme weather events (e.g., Pfister, 1999; Wetter et al., 2014) or the dates that harvests began in a given year (Le Roy Ladurie et al., 2006; Meier et al., 2007; Wetter and Pfister, 2011, 2013), and these turn out to be surprisingly accurate palaeoclimatic proxies (see Brázdil et al., 2005, 2010 for reviews). A continued interest in the reconstruction of climatic conditions is symptomatic of how historians approach the role of climate in human history. Even after the appearance, in the late 1970s, of the first publications that investigated the impact of climate on early modern societies (e.g., Pfister, 1978), the dominant approach still focused more on climate reconstruction than the impacts of climate change. This may have been due to the fact that at this early stage still little reliable scientific information was available on how climate had changed during the Holocene.

The situation becomes more promising when we consider the study of the role of climate in the past within the context of the entire field of 'environmental history'; the study of climate is just one of several sub-fields of this flourishing discipline of historical research and not necessarily the most developed one (McNeill, 2003). More importantly, from the very beginning the best work in environmental history, while making use of written sources and traditional methods of historical analysis, engaged actively with the scientific research in relevant fields, such as plant biology or palaeoecology, which is necessary if environmental factors are to play a role in our understanding of the human past (e.g., Cronon, 1983). In this way, scholars who specialise in this field started to bridge the gap between science and history, and the narratives they produced often took into account scientific perspectives on the problems they study.

Unfortunately, whereas the environmental history of some parts of the world boasts a great number of monographs and studies, and thus has achieved relative maturity (which applies in particular to North America, see Sackman, 2010), the Mediterranean remains relatively understudied. There are relatively few monographs written from the environmental history perspective that focus on this part of the world (McNeill, 1992; Hughes, 1993; Squatriti, 2002, 2013; Davis, 2007; Tabak, 2008; Mikhail, 2011, 2013; White, 2013), and the field of Mediterranean environmental history is still *in statu nascendi*. In fact, major contributions are also coming from outside of the environmental history community (e.g., Horden and Purcell, 2000).

If we focus on climate as such, major historical publications about its role in history have only started to appear during the last decade, and this also applies to the Mediterranean (such publications include Koder, 1994, among the earliest; Izdebski, 2011; White, 2011; McCormick et al., 2012; Parker, 2013; Haldon et al., 2014). Most of those studies tend to consider climate as one factor among many that affected human history, while their approach remains at the level of an initial exploration of the subject. The authors will usually start by identifying a period of "unusual climate" (typically years or decades of weather conditions unfavourable to agriculture and the wider economy) and then look for evidence of actual reactions. They concentrate on how historical societies coped with the environmental effects of climatic fluctuations, on the social and political institutions that were involved in this process, and finally on the significance of these phenomena for the central narrative of the history of a given period (such as the medieval or early modern periods). Whereas most of these studies focus primarily on economy and migration, they share no unified theoretical framework. The outcome of such exploratory research depends on the evidence available (that is, on the extant written record), both in terms of the issues that can be covered, the chronological resolution of the narrative, and the degree of certainty that can be attributed to the results.

A common characteristic of the historians' approach to the study of the societal impact of climate change is that they rarely aim to establish general laws that govern the ways in which societies respond to climate change. They consider climatic fluctuation as one of several factors that has influenced the course of history (others include political, economic, religious, and cultural processes and institutions). When an historian focuses too strongly on climatic factors, colleagues will often accuse the historian of "climate determinism" and "reductionism". Good examples are the reactions to recent studies concerning the impact of the Medieval Climate Anomaly (MCA) on the history of the Eastern Mediterranean: while

a cautious monograph by Bulliet (2009) was received in a generally positive way (e.g., Matthee, 2011; Paton, 2011; Zakrzewski, 2012), the far more deterministic approach of Ellenblum (2012) has met with considerably more reservations (Burke, 2013; Frankopan, 2013; White, 2013).

To some extent, the tendency to downplay the role of climate change is justified and understandable: we know so much about historical societies, especially from Classical Greece onwards, that historians often feel there is no need to consider non-anthropogenic factors in order to describe and explain human history. The observations that Jan de Vries made in the *Journal of Interdisciplinary History* in 1980 are, therefore, still valid: "Since few economic historians care to challenge the historical existence of climate change, *per se*, the fate of climate change as a significant variable in historical studies hinges on the successful development of a means of measuring its influence. It might be fair to say that historians are psychologically ready, even eager, for the rise of climatic change as a vehicle of long-term historical explanation, but do not possess the means of distinguishing its impact from among the many other variables at work on human society" (Vries, 1980, p. 624).

3.2. Archaeology and the societal impact of climate changes

Archaeology is the study of the past through the lens of material culture. Among the key issues that concern archaeologists are the type, scale and pace of changes that took place in the past, as suggested by variations within and between archaeological contexts. These contexts can be constructed horizontally (synchronically) on a societal, regional, local or specific level (such as a grave, a house or a room with its context) or vertically (diachronically), linked together through time in the construction of relative chronologies. Whether visible in the layering of strata in an excavation or in the development of a certain pottery shape, these sequences are archaeological visualisations of societal processes and changes that occurred in living circumstances and lifestyles over time. Any such evidence of continuity or change calls for interpretation.

Considerations of climate and climate change have a long history within Mediterranean archaeological interpretation, but the modes of application have changed in response to various theoretical and methodological developments (see Wiener, 2013). Archaeologically retrieved material is diverse, both thematically and chronologically, and engages a similarly diverse makeup of disciplines for its interpretation. Specialisation is common according to different historical periods (e.g., Bronze Age, Archaic, Roman), types of artefacts (e.g. pottery, inscriptions) or types of ecofacts (human, faunal and plant remains), with separate subdisciplines for environmental and biological archaeology. Geoarchaeological studies help to complete the picture through analyses of dialectics between archaeological and earth science archives in the formation of past landscapes. Archaeology thereby incorporates research specialities that span the humanities and the social as well as the natural sciences. Expertise from the natural sciences is further sought for areas such as provenance studies of pottery, analyses of sediments, and radiocarbon dating, while new interdisciplinary perspectives are continuously being added.

Notions of climate and climate change are traditionally and seamlessly incorporated into reconstructions of past landscapes and environments and, by extension, made relevant to the archaeological record. For the Mediterranean region, combining climate and environmental studies with archaeology has been a common practice at least since the evolution of the systemic thinking of processual archaeology (or New Archaeology), which was a response to the descriptive approach of cultural historical archaeology in the 1960s and 70s (for the general history of archaeological theory and method, see e.g. Hodder, 2012; Renfrew and Bahn, 2012). Processual archaeology emphasised the use of scientific methods and explanatory models focusing on social, economic, and political processes, such as human adaptations to their surroundings which would help archaeologists to identify and describe similar strategies and trajectories within and between regions (Malone and Stoddart, 1998). This trend was further amplified by the landscape approach to regional societal development sought by archaeological field survey projects that multiplied during the 1970s and 1980s (Alcock and Cherry, 2004; the surface survey methodology was pioneered by the South Etruria Survey in the 1950s: Ward-Perkins, 1962, 1964). Points of interest included hypothesised variations in rainfall, with drier or wetter conditions potentially affecting economic circumstances and land use in the past (e.g., van Andel et al., 1986; Bottema et al., 1990). Of continued scholarly interest in this respect is the impact of climate variations (or rather weather variations) on notable phases of increased sedimentation, although the impact always needs to be weighed against the possibility of human-induced and seismo-tectonically driven changes (Fuchs, 2007; Mercuri, 2008; Masi et al., 2013a, b; Pepe et al., 2013; Weiberg et al., 2015, this issue). Considerations of climate variability are often secondary to those dealing with the visible effects of landscape instabilities and environmental change, which in turn have been prioritised in explanations of cultural change (but see Whitelaw, 2000; Butzer, 2005 for cautions).

Since the 1990s, archaeologists have begun to make use of – or relate their conclusions to – actual climate archives. Most commonly, as in the historical ecology research framework developed in the 1990s (Crumley, 1994; McIntosh et al., 2000; Balée, 2006; Meyer and Crumley, 2011), such studies integrate the investigation of climate and environment with that of human societies in the assessment of diachronic variability in regional landscapes (Redman et al., 2004; for Mediterranean examples, e.g., Hassan, 2000, 2008; van der Leeuw 2000, 2009). In the Mediterranean area and elsewhere, however, some of the climate records most frequently referred to in a variety of archaeological studies relate to specific climatic events that have, in turn, been linked to episodes of accentuated cultural transformations, or periods of "collapse" (Dalfes et al., 1997; Mercuri et al., 2011; and the papers published in this special issue, such as Cremaschi et al., 2015; Xoplaki et al., 2015; Izdebski et al., 2015). In such cases, although most of the scholarship is produced by climate researchers in the natural sciences, the climate events are often used by archaeologists as a potential X-factor – the ultimate trigger for any visible cultural change (deMenocal, 2001; Weiss, 2000; Weiss et al., 1993; Weiss and Bradley, 2001 commonly referenced by other archaeologists; cf. Leroy, 2013).

Concurrently, in general archaeological theory, an increasingly vocal call occurred for greater contextuality and individuality, that is, an increased focus on regional and local diversity in the archaeological record and the ideas and intentions of the people that created it. This interpretative shift was part of the response to early processual archaeology, and included an increased emphasis on the people in the past as active participants in shaping their surroundings – rather than merely adapting to them – and thereby producing a heterogeneous archaeological record (Yoffee and Sherratt, 1993; Hodder, 2012). At first glance, this post-processual turn may seem to downplay the importance of climate, and many archaeological interpretations are constructed on a spatial level where there is little emphasis on climate considerations. On a communal, societal and supra-societal level, however, and by avoiding monocausal interpretations, a number of Mediterranean archaeologists do now engage more actively with climate archives and attempt to address issues of geographical variation, to evaluate critically potential causal links and to consider multivariate models for societal development and cultural change (for Mediterranean

studies, see, e.g., Weiberg and Finné, 2013; Arıkan, 2014; Schneider and Adalı, 2014). This, in turn, engenders a dialogue about the impacts of climate change and the differential capabilities of people, communities and societies in dealing with climate (and environmental) change and periods of rapid cultural transformation (cf. McAnany and Yoffee, 2010; Butzer, 2012).

In summary, considerations of climate and environment must play a role in archaeological interpretations and should be actively investigated by archaeologists. Most archaeologists today work with a large theoretical and methodological tool box and climate and climate change are viewed as one of many factors that influenced lives and induced societal changes in the past.

3.3. Palaeoenvironmental sciences and the societal impact of climate changes

The scientific interest in studying, and the general interest in understanding, past, present and future climate variability, has grown exponentially in recent decades, reflecting human concern about global climate change. This concern was fundamental to the formation of the Intergovernmental Panel on Climate Change (IPCC) in 1988. Since then, the IPCC has produced five assessment reports about the current knowledge and status of issues related to climate change (www.ipcc.ch). To gather the majority of leading, world-class scientists in a field and succeed in reaching a broad consensus about a number of controversial issues is a rare initiative and remains a very unusual working approach in the academic world.

Moreover, the development of IPCC and the current global warming has spurred rapid methodological development in techniques and approaches for the study of past climate at high-resolution scales. The iconic so-called "hockey stick" graph published by Mann et al. (1998; 1999) and referred to in the 2001 IPCC report (Folland et al., 2001; Fig. 4a), motivated other palaeoscientists to test and refine the analysis. This resulted in a more nuanced view of our current understanding of the pattern of past climate variability, summarised in the 2007 IPCC reports (Janssen et al., 2007, Fig. 4b) and 2013 (Masson-Delmotte et al., 2013, Fig. 4c).

Palaeoclimatology seeks to describe local, regional, and global patterns of climate and their variability over time, and to understand the processes behind these patterns and changes. This requires a synthesis of knowledge from several scientific disciplines, including meteorology, climatology, physics, sedimentology, geochemistry, palynology, hydrology, limnology, dendrochronology, statistics, climate modelling and the marine sciences. Palaeoclimatologists often work in teams with experts from different fields, and they are trained in synthesising data and information from the various fields. The subject has evolved from being mostly descriptive to including more quantitative methods, using data-modelling comparisons and statistical approaches.

The methodological development in the field of palaeoclimate, in combination with the global warming issue, has also inspired geoscientists to explore the connection between climate change and societal change from an historical perspective, often with the goal of learning for the future. However, when natural scientists engage in these kinds of syntheses, it is not infrequently done with a tendency to overestimate the role of climate in societal changes. Scientists often underestimate the multitude of other factors that, from the perspective of social sciences and humanities, also affect human societies, simply because their knowledge about these factors and the driving forces behind them is limited. When comparing high-resolution climate records with information about past history and archaeology, focus is often on proving the hypothesis that climate change related to a societal crisis/collapse. In these cases, scientists tend to discuss only the specific period in time where there is an assumed correlation and not periods lacking correlation, and there is a risk of subjectivity involved in the data collection and choice.

One recent example is the paper in the prestigious scientific journal *Science* entitled "Quantifying the Influence of Climate on Human Conflict" (Hsiang et al., 2013). The authors compiled a large number of studies concerning historic climate-societal relationships and concluded "We find strong casual evidence linking climatic events to human conflict across a range of spatial and temporal scales and across all major regions of the world". The paper has been widely cited both in the science community and in popular media. While the conclusions may not necessarily be wrong, examination of the evidence upon which the paper is built highlights the fact that certain aspects of the study need to be addressed further, and scientific methods need to be better developed before these kinds of conclusions can be convincingly drawn (Buhaug et al., 2014; cf. also an earlier paper by Fan, 2010). Arguments about the links between climate and societal changes should be careful when using correlations between large-scale regional climate syntheses and local historical and archaeological records, since local climate dynamics can differ significantly from regional averages. Moreover, on the scientific side the data are often affected by chronological uncertainties that hinder conclusions about causal relationships, while on the societal side an argument, in order to be conclusive, requires a plausible, historically-grounded model that would explain observed correlations. Even in cases where the chronological control is good enough for precise comparisons (e.g., varves, ice-cores, tree-rings, corals), the fact that two events happen at the same time should not be taken uncritically as solid evidence of causation. It is crucial to understand the formative processes behind each of the datasets invoked in such comparisons, where non-climatic factors are also taken into account. The paper by Hsiang et al. (2013) seems to have spurred such research efforts among social scientists who were highly critical of his conclusions (e.g., van de Vliert and Tol, 2014; Bollfrass and Shaver, 2015; Liu et al., 2015), in a similar way that the "hockey stick" stimulated research in the field of palaeoscience!

3.4. Summary

Interdisciplinary work in relation to climate change was initiated primarily on New World and Northern European material and the results of these studies provide a valuable point of departure for similar efforts in the Mediterranean region. The disciplinary overviews above make clear that it was only during the last decades that such research agendas have gradually gained force in the Mediterranean. It is clear, however, that we are still far from achieving a balanced and comprehensive approach to incorporating the potential impact of climate on societies, an approach that would be acceptable to all involved disciplines. As we have observed, simplifications are not limited to just one discipline, and the importance ascribed to climate varies from one scholarly community to another. Still, few archaeologists and historians are fully able to assimilate natural science perspectives on palaeoclimate and this can lead to overly simplistic correlations with the archaeological or historical record. There is a need, therefore, for an increased awareness among archaeologists and historians about the potential margins of error in climate data and for addressing the real-time impact of climate change on a chronological scale relevant to humans. Scientists, on the other hand, should acknowledge the complexity of past societies and collaborate with archaeologists and historians in order to fit their own data into the proper archaeological–historical, i.e. societal, context.

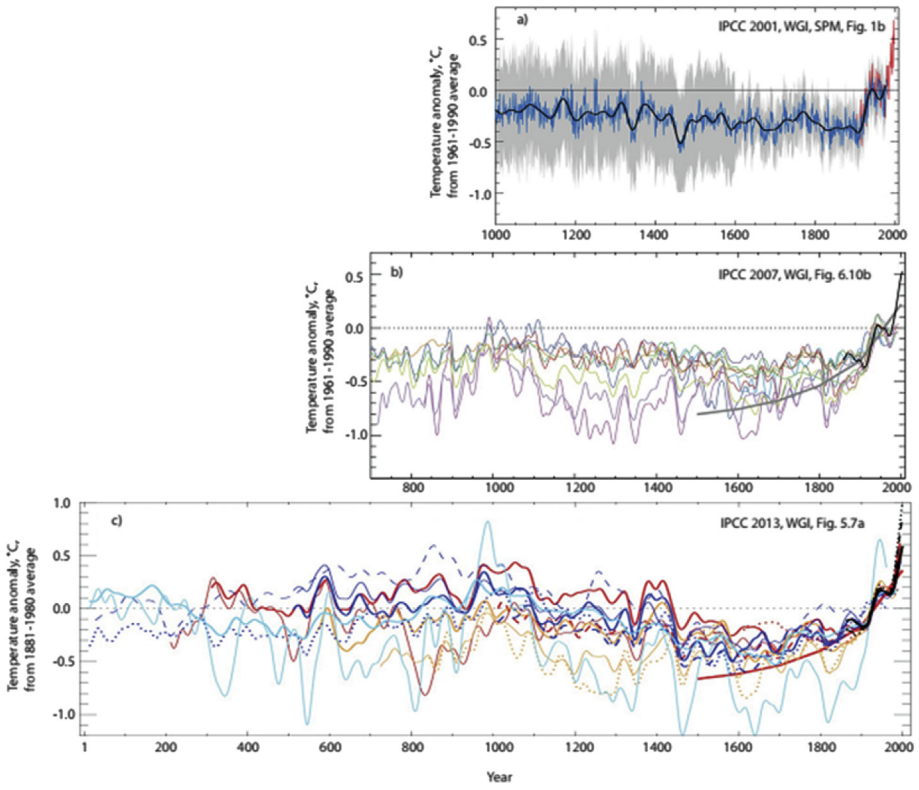

Fig. 4. Northern Hemisphere annual temperature reconstructions: a) IPCC 2001 (Folland et al., 2001), one reconstruction; b) IPCC 2007 (Janssen et al., 2007), multiple reconstructions using different data and techniques; c) IPCC 2013 (Masson-Delmotte et al., 2013), multiple reconstructions using different spatial extent. The instrumental record is compared with palaeoclimatic reconstructions (for details see the corresponding IPCC reports). The continuous development of new palaeoclimate records and improved analytical techniques demonstrate that the natural climate variability is not as simple as believed in 2001.

4. Communication and use of data: possibilities and obstacles

Regardless of our discipline, we tend to view our own data differently from the data of others (see Table 2). Even when we present our data to scholars from outside our own field, there is a tendency to speak at the level of our own discipline-specific interpretational frameworks; in other words, we avoid more descriptive ways of speaking that have the potential to facilitate interdisciplinary communication, especially at the beginning. This bias towards a language that already carries interpretation means that a considerable amount of specialist knowledge is already involved in the process of communication, and that the interpretation of data is heavily influenced by the explanatory models and narratives dominant in each discipline. In order to achieve fruitful collaboration, we believe it is necessary to communicate our data in the most straightforward way; in many instances, this would mean a simple description of the evidence (along with the relevant error associated with climate reconstructions), rather than interpretation. For most of us this necessitates stepping outside the comfort zone of our various research traditions and actively setting aside the disciplinary frames of reference that may obscure communication. It requires us to discuss and juxtapose the words, terms and definitions used in our different disciplines in order to cross the barriers of misunderstandings and develop new hypotheses (Leroy, 2006).

One of the first obstacles we encounter in our attempts to reconcile our various disciplinary frames of reference is the internal organisation of the disciplines themselves. While scientists tend to specialise according to a method of analysis, archaeologists and historians tend to specialise according to periods, regions, types of evidence or even the languages of their sources, often in combination. There are, for instance, three main specialist fields relating to the medieval Mediterranean, each based in different departments and taught in different ways: Western medievalists, who read Latin and the local languages of the Western European countries; Byzantinists, who read primarily Greek sources, notably from Eastern Mediterranean regions; and Arabists or Islamicists, who focus on the Arabic texts, from regions as different as the Iberian Peninsula, North Africa or the Levant. It would also be difficult to find an archaeologist willing to provide detailed comments on the full chronological sequence of a sediment core, even if the archaeologist in question was a specialist in the specific region from which the core was taken. From the point of view of a palaeoenvironmental scientist, these differences make it difficult to identify a specialist who could help to interpret the results of their own work. In order to find relevant specialists who can provide the necessary data from a completely different type of archive, be it natural or anthropogenic, it is first necessary to learn how the other disciplines operate.

Apart from these disciplinary differences, there are four specific points of concern which need to be addressed and developed in order to facilitate the processes of communication and collaboration. They are: terminologies, project design, publication cultures and research impact.

4.1. Terminologies

When we speak about our work and its results, we tend to employ the jargon common to our discipline, often not readily accessible to scholars from outside our own field. Any scholar who wishes to be involved with interdisciplinary research concerning the societal impacts of past climate change must familiarise

Table 2
Generalised overview of traditional ways of communicating and using data in archaeology, history and the palaeoenvironmental sciences.

Discipline	Specialisation by	Project design: primary focus	Project design: limited by	Common temporal scales	Publication culture: dominant genres	Publication culture: limitations
Archaeology	Archaeological periods, regions, materials, and methods	Social phenomena or locations which can be excavated or surveyed	Preservation of the material evidence determined by cultural and environmental processes	Decadal to centennial resolution (years BC/AD)	Archaeological article or monograph	Focused on social processes, but open to scientific methods
History	Historical periods, regions, languages (cultures) of the texts	A social phenomenon, a group of sources, preservation of textual evidence	Preservation and availability of the textual evidence determined by social processes	Annual to decadal resolution (years BC/AD): higher chronological resolution with relevance to human perception	Historical article or monograph	Very little place for the consideration of scientific evidence and reasoning
Palaeoenvironmental sciences	Methods of analysis and regions	Natural sites with palaeoclimate and palaeoenvironmental archives	Availability and preservation of natural archives determined by chemico-physical and anthropogenic factors	Decadal to centennial resolution (years BP, less often BC/AD): anomalies, abrupt events, versus gradual trends	Scientific article (in bibliometric journals)	Central role attributed to natural factors

themselves not only with the jargon of their own discipline – either in order to avoid it, or to address its meanings – but also with the jargons of other disciplines. Jargon tends to develop around specific concepts within a particular discipline, which can result in different terminology being used to define the same basic notions. Terminological differences appear within the elementary concepts of the climate and history debate commonly used within archaeology – terms such as collapse, decline, and complexity (Tainter, 2008; Butzer, 2012) – as well as in concepts from climate research such as event, proxy and trend. Each of these concepts can be understood in diverse ways depending on the disciplinary or theoretical context. In many cases, differences in terminology are related to issues of scale and pace of change: while palaeoclimatologists often work within centennial or even millennial time scales, archaeologists and historians generally strive for a tighter chronological resolution (cf. Walsh, 2004; Roberts, 2011).

While it is impossible to eliminate these differences – which are, for the most part, determined by the dominant scholarly agendas of each discipline and by the objects studied – it is important to arrive at a point where representatives of each discipline are aware of how the other relevant disciplines understand certain key concepts. There are certain themes that fall within a common terminology or even an interdisciplinary language. Meyer and Crumley (2011, p. 111–112) list complex adaptive systems, resilience, diversity, region and scale, as well as risk and vulnerability involving thresholds and tipping points, as part of their conceptual toolbox for historical ecology, and all these concepts are gaining a foothold in the humanities as well as the social and natural sciences (Gunderson and Holling, 2002; Redman and Kinzig, 2003; Folke, 2006; Sinclair et al., 2010; Smith, 2010). As such, they are already in interdisciplinary use – even if their definitions vary – and offer a good starting point from which to develop a common language for interdisciplinary communication.

Since the observation of temporal correlations is the starting point of any study on the impact of climate changes, we must strive to achieve a higher spatial and temporal resolution and reduce dating uncertainties (Weiberg et al., 2015, in this special issue). For the same reason, we must familiarise ourselves with the modes of expressing time, employed by the various disciplines. While a complete unification of chronological scales (e.g. historians adopting cal. BP (or b2k, before year 2000) instead of BC/AD (or BCE/CE), or vice versa) is unlikely at present, it would require little effort for the representative of one discipline to learn how another discipline conceives of chronology, and also become familiar with the terminology used to describe different chronological periods (see again Table 2).

4.2. Project design

In each discipline, research projects, whether small- or large-scale, are designed in different ways. Whereas environmental science and field archaeological projects usually focus on specific locations which can be cored, surveyed, or excavated to provide answers to a more generally stated problem or question, the starting point for historians is either a social phenomenon they wish to describe, or a fixed corpus of written or material sources they wish to study (these are also common strands within archaeology). The design of interdisciplinary projects must take into account what is feasible within each discipline.

Scientists rely on the availability of natural sites that contain palaeoclimatic and palaeoenvironmental archives, and on their state of preservation. The availability and preservation of such archives depend on various physical factors, as well as on the scale of anthropogenic influence. The ideal archive for reconstructing natural changes would theoretically be situated in an area with as

little human history as possible and a strong link to any climate parameter. The retrieval of archaeological material, on the other hand, is restricted to areas where humans lived; these areas may have little to do with the distribution of natural archives analysed by the scientists. In addition, the preservation of archaeological material is determined by a larger variety of mechanisms than those that control the preservation of palaeoenvironmental sites. The scope of historical research may be the most severely limited, as it is dependent largely on the preservation of textual evidence, the rarest of the data sets discussed here. Although many societies have produced some written records – both archival documents and texts of a more literary character – the almost random nature of their preservation through the centuries has been determined by innumerable factors; for a non-specialist, it is often impossible to know which questions a historian is capable of answering based on the surviving evidence. Because the potential scope for research in a given field is limited by different factors, it can be difficult to identify topics, areas or time frames that guarantee synergies between disciplines. The more we know about what our colleagues are looking for and what they are able to do, the easier it will be to engage in real collaboration through common projects (see Fig. 5).

Problems might arise during subsequent stages of a project, from sampling to the collection of information on contexts and chronologies (see for example, Mercuri et al., 2010; 2014). When one research team is unaware of the needs of the other, it might become impossible to support the necessary research required from another discipline according to its highest state-of-the-art standards. This could happen, for instance, because some materials were unintentionally damaged in the course of research done by a team from a different discipline, or because samples were not taken at the time when it was possible and necessary. In interdisciplinary collaboration, it is also important to pay as much attention as possible to the ways in which questions are asked. If they are not relevant to the methods and interpretational frameworks of another discipline, it may be impossible to answer them in a meaningful and satisfactory way. Interdisciplinary collaboration must begin with the direct involvement of representatives from all relevant disciplines and a jointly developed research agenda.

One approach to improve the study of climate change and its historical role in societal development within the Mediterranean region would be to focus on certain periods and areas with high data density and many different data types. Another step is to explore the evidence through interdisciplinary modelling of the environmental and social processes, addressing the relative role of the multitude of potential cultural and natural factors at play in bringing about a societal change (Lemmen and Wirtz, 2014). This could preferably be done by critically testing and contrasting alternative hypotheses about the impact of climatic variability on social phenomena. Another approach is to look not only at the role of climate change in societal collapses, but to seek success stories and to explore the adaptation strategies employed by resilient societies (Butzer, 2005, 2008). Such examples exist from other parts of the world (e.g., Westerberg et al., 2010; Lane et al., 2014), but are rather unexplored in the Mediterranean region, although the potential is there, thanks to high data availability, as demonstrated by several of the papers published in this special issue.

To conclude, the design of a truly interdisciplinary project needs to be as comprehensive as possible, both in terms of the methodology and the types of evidence involved. In the case of the Mediterranean, this means adopting not only a multi-proxy approach, but also a multi-archive one, making use of data from all the different disciplines that study humanity's and nature's past (see Fig. 6). A proper multi-proxy study of a natural site (or sites), that allows the establishment of temporal correlations between changes in the landscape and climate in a reliable manner, must be combined with a parallel study of all the other evidence that is available for the relevant area. This includes not only archaeology, either through a review of the existing research or as a specifically-designed archaeological sub-project on changes in the local or regional settlement patterns, land use and culture, but also history, which brings in textual, documentary and often also material records (as is the case with the numismatics) on relevant aspects of the past social life (demography, political and institutional developments, culture, religion, etc.).

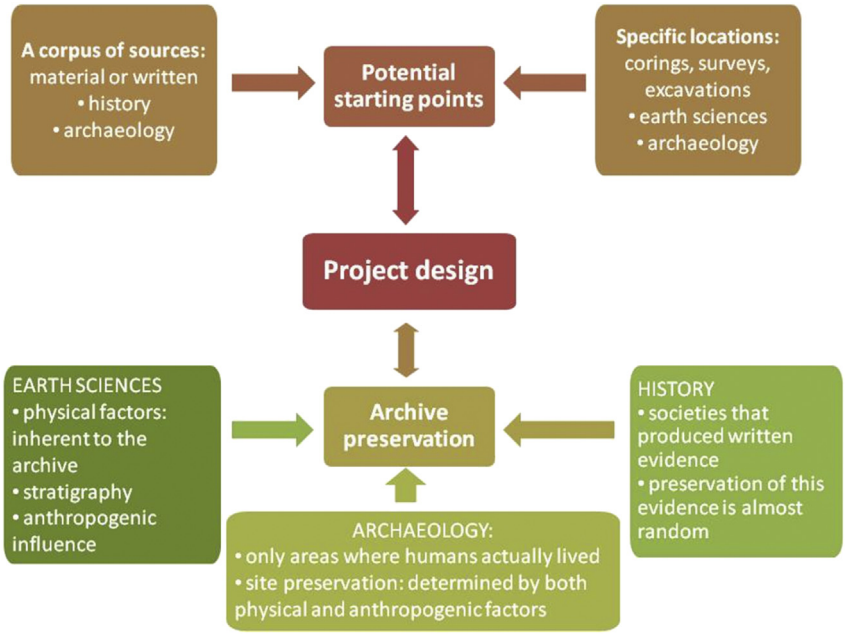

Fig. 5. Discipline-specific limitations of project design in the context of past environments and human occupation in the Mediterranean.

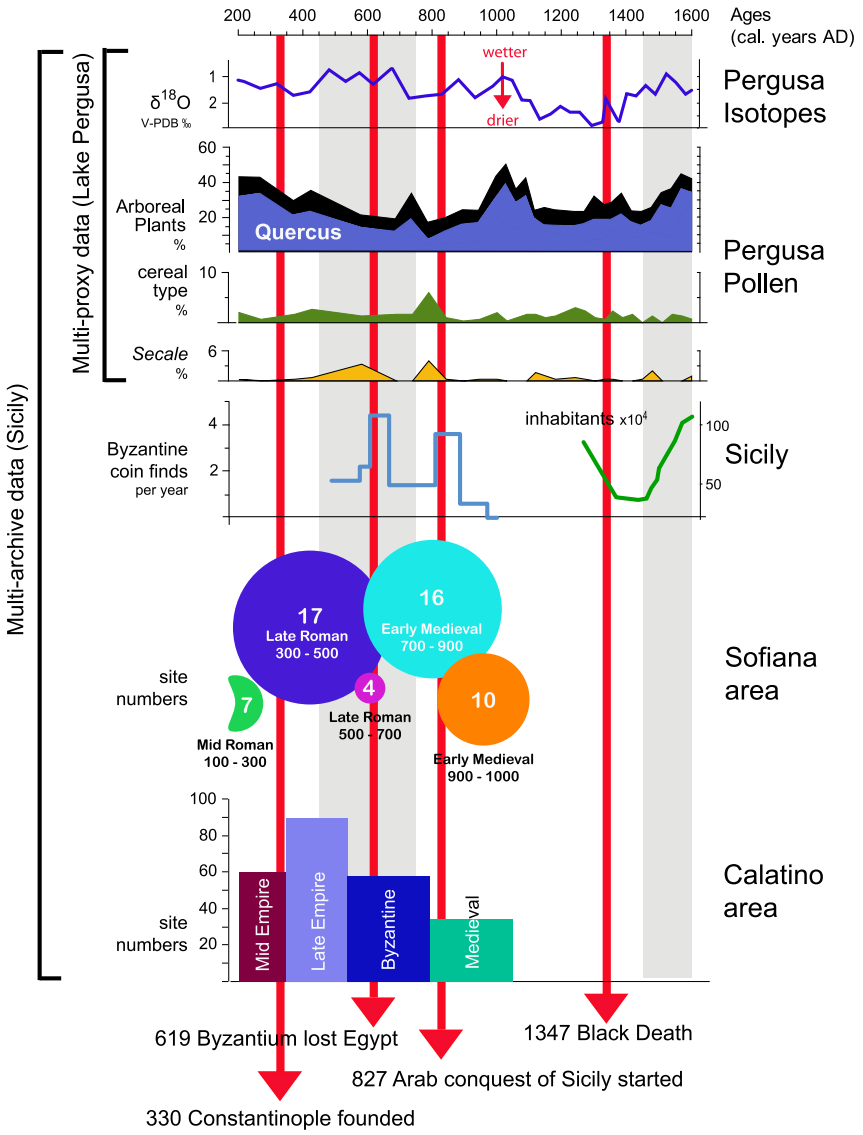

Fig. 6. An example of a multi-proxy and multi-archive study of the site of Lago di Pergusa and its region, Sicily (based on Sadori et al., 2015). The compilation of various sources of information about different aspects of environmental change and human activity elucidates the complexity of societal–environmental interactions and provides proper context for the scientific data. Coin finds: Morrisson, 2002; population estimates: Epstein, 1992; Beloch, 1937; site numbers in the Sofiana and Calatino area: Vaccaro, 2013 (circle size in the presentation of the Sofiana area reflect the differences in site numbers between different periods).

4.3. Publication cultures

History, archaeology and the palaeoenvironmenal sciences have completely different publication cultures. Monographs have irreplaceable value in the humanities, whereas journals with a high impact factor have nowadays become central for scientific research. As a consequence, the practitioners of the different disciplines are not generally interested in the same journals; they either write monographs or do not write them at all (and if they do, the archaeological monographs do not resemble the historical ones). In addition, many researchers do not read journals and books published by those from the other disciplines. Moreover, the wider communities of historians, archaeologists or environmental scientists do not necessarily value the journals of the other disciplines when it comes to promotion and evaluation procedures. Last but not least, each discipline has its own preferences with regard to the style of writing; while scientists tend to prefer brevity at the expense of fluidity, historians in particular tend to pay considerably more attention to the literary aspects of academic writing, while archaeologists take an intermediate position utilising both writing styles in archaeological publications. While this may seem to be a small issue, it can become a considerable problem when it comes to the actual writing of a collaborative research paper (see Fig. 7).

As Ankersmit (1994, p. 34) has succinctly put it, “it is necessary to distinguish between historical research (a question of facts) and historical writing (a question of interpretation)”. It is exactly at the point of writing a text that the final narrative, the interpretation, is composed. Although the final narrative is always based on the results of the actual research project, be it historical, archaeological or scientific, the communication of it must first of all be composed in compliance with the rules of the genre and according to the discipline-specific rhetoric (i.e., according to the narrative structures and interpretational frameworks that the genre allows). Consequently, choosing a scientific article as a means of communication forces an author to refer to the scientific narrative of the role that climate change played in human history. Such a narrative makes it natural to attribute the central role in the described natural-social processes to climate change. Moreover, the very

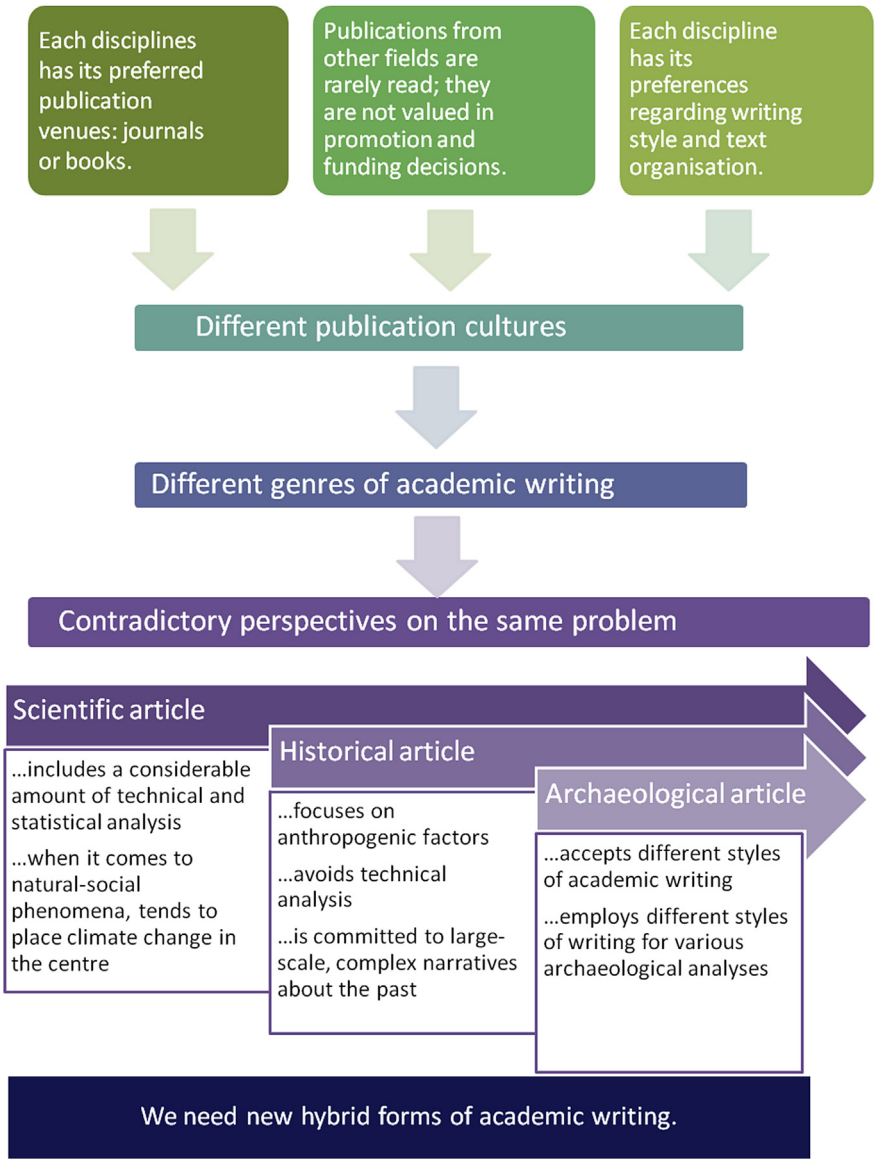

Fig. 7. Reasons for differences in publication cultures of disciplines involved in the study of the natural and human past in the Mediterranean and their methodological consequences.

structure of a typical journal article in the natural sciences leaves little room to consider various aspects of human agency, social institutions or the nuances of cultural or political change — that discussion cannot dominate the article. Yet in an historical article, it is necessary to focus on the anthropogenic factors, and it looks out of place when a technical analysis of the sort necessary to present scientific research is included. On the other hand, historiography is equipped to construct large-scale, complex narratives about the past as no other genre of academic writing is. Finally, of the three disciplines whose perspectives are reflected in this paper, archaeology is probably the one that is most accustomed to accepting different types of academic writing, since various categories of material analysed by archaeologists require completely different types of texts to present and interpret them.

Nevertheless, in conclusion, we are convinced that none of the existing genres of academic writing is ideal for the purpose of an interdisciplinary collaboration between history, archaeology and the geosciences. New, hybrid ways of writing have to be developed along with new narratives. In an ideal situation, it would be possible to employ different forms of writing, including the various discipline-specific ways of presenting and discussing data, within the same publication.

4.4. Research impact

Historians, archaeologists and scientists also have different preconceptions about the potential impact of their work. In each discipline there are different attitudes towards making value and expert judgments, policy suggestions, recommendations, predictions or projections. Scientists, since the birth of the IPCC (see Section 3.3), are expected to arrive at such recommendations in their work, and the demonstration of the potential to obtain such results is an essential component in the evaluation of project proposals for funding. Although similar changes are currently underway in the humanities and social sciences, where funding agencies increasingly support research that can prove societal benefits, this

remains a controversial issue. Archaeologists and historians in particular are usually trained to avoid making their work too overtly 'political'. On the other hand, they are specialists when it comes to influencing the collective memory of a society or the identity of a smaller social group, thus making their work relevant to the public.

Another example that illustrates the difference between the social and environmental sciences is how they approach the concept of resilience. Scientists, motivated by the global change debate and policies of funding agencies, are inclined to ask what kind of resilience is good for a society: short- or long-term, resilience with a high or low threshold; consequently, they tend to seek models that simplify social realities. Historians and archaeologists are not necessarily interested in answering those kinds of questions. Their disciplinary communities generally dislike value judgments, and they are instead interested in grasping as much as possible the social complexities that existed in the past.

In order to develop an interdisciplinary collaboration, we must become aware of these differences in the ways we evaluate our research. It is important not only for the sake of mutual understanding, but also because each of us will continue to be evaluated primarily by the practitioners of our own discipline. 'Committing' something that is not acceptable within one's own scholarly culture poses the risk of having to confront more or less serious personal consequences, and we need to be aware of that when collaborating with colleagues from other disciplines.

5. Immediate actions and mutual expectations: what can help in the first instance

We have, up to this point, discussed the key practical obstacles that might hinder the development of a more extensive and more permanent collaboration between history, archaeology, and the natural sciences; we will now suggest some of the actions that might be taken in order to change the current situation. Some of our recommendations may at first glance seem unrealistic; this is intentional. The purpose of the following sections is to provide directions for future work in all the disciplines involved in the study of the past and we must, therefore, begin by describing an ideal scenario, even if the realities of the present render it difficult to imagine in practical terms.

5.1. The scientific side: archaeologists' and historians' expectations of scientists

If historians and archaeologists are to engage more extensively with the results of palaeoclimatic research, proxies should ideally be translated into weather or climate reconstructions; where it is not possible, the authors of the data must be clear about what their data actually tell us, the uncertainties that accompany them, and the assumptions that must be made in order to use them as palaeoclimate proxies. They should also strive to distinguish clearly whether their results reflect changes in seasonality (intra-annual variability) or changes in mean annual conditions (inter-annual variability), and whether a given record reflects changes taking place over short or long periods. Furthermore, in order to help archaeologists and historians integrate their evidence with climate proxy reconstructions, scientists should also strive to reconstruct the actual environmental conditions for human activity (for example, the scale and rate of changes in humidity and temperature, and their relative importance within the context of the affected landscapes). In this way, it becomes possible to determine which climatic changes were drastic enough to have been perceived by societies at the time when they occurred, and which were not.

While both cyclic and non-cyclic climate variability is a fundamental aspect of the Earth's climate during the Holocene, it is necessary to know the extent to which a society living in a particular area would have experienced climatic fluctuations at a certain moment in time. One way of assessing this would be to determine which anomalies occurred rapidly enough to have been perceived in the time frame of a normal human life, and which lasted long enough to cause substantial disruptions in natural, and potentially socioeconomic systems (cf. Roberts, 2011). Once we have access to more precise climatic and environmental reconstructions for a given period and area, it will be possible to think about opportunities and challenges related to the use of climate data. A single, region-wide climatic change would have had different effects in each local environment (small regions characterised by relatively uniform environmental conditions), but these local regions and communities would, in turn, have been connected by social and communication networks that existed between them (cf. Horden and Purcell, 2000). We need to study these local environments together in order to fully understand the impact of climate on an entire society that, especially in the more recent past, relied on a wide range of local ecological-economic patterns that operated as a relatively coherent system.

5.2. The social side: the scientists' expectations of the archaeologists and historians

In order to improve their communication with scientists, archaeologists and historians should make it clear which aspects of climate are most important for the societies they study. Various climatic characteristics are recorded differently in each type of proxy and different proxies require their own analytical techniques: focusing on seasonality requires an approach that is different from that required by a focus on weather extremes, longer-term shifts in climate, or the identification of periods of inter-annual instability. This is necessary because societies living in different parts of the Mediterranean in different periods were most likely sensitive to different aspects of climate.

Instead of focusing exclusively on how to track the impact of climatic changes, historians and archaeologists should simply continue what they have been doing for generations. They should contribute to the interdisciplinary collaboration with their knowledge of the multitude of social, economic and cultural factors that may have affected societal changes in the past, and their aim, where possible, should be to contrast these processes quantitatively with climate data in order to obtain a more balanced view of the different factors that matter for human societies. For instance, it is possible to use climate data to identify longer periods of frequently recurring droughts. Their societal impact cannot be properly assessed without a knowledge of the social processes that might have affected a given society at exactly the same time. Such complex issues should be approached with new models and in more sophisticated ways than merely comparing different datasets with each other (although this is often necessary during the initial stage), and this is impossible without a deep understanding of how the society or societies in question actually functioned and changed through time. The same, of course, applies to all other environmental changes, not necessarily climate-driven; during the Late Holocene in particular, changes may have been caused by human action, yet we cannot fully recognise these without detailed historical and archaeological knowledge.

6. Conclusions: towards a common research agenda

There are many methodological similarities between the various disciplines engaged in the study of the past, and one of the most important is the use of narrative as a means of communicating

research results. In order to advance our understanding of how past societies responded to climate changes, historians, archaeologists and scientists should make use of this fact and join forces to create a joint narrative. The narratives currently employed within each field are naturally different, and the significance attributed to climate change in the explanatory models of each discipline varies considerably. Anyone wishing to engage in interdisciplinary study must be aware of these differences; ignoring them can only lead to further misunderstandings, as well as problems at the level of research and fundraising. The new collaborative narratives must therefore be capable of appealing to various audiences. They should, in the first instance, be acceptable and relevant to representatives of the three disciplines involved in the research — not only to those who work explicitly on climate and society, but to all historians, archaeologists, and scientists. New narratives are also important when it comes to sharing research with a wider audience. We need well-researched, integrated narratives that can be presented as fascinating stories and are intelligible to people of different educational and professional backgrounds. In the same way that grand narratives about the past – for instance, those dealing with the Second World War, democratic revolutions, or the origins of nation states – are capable of moving entire societies towards new goals, our narratives must be not merely accessible to the widest possible audience, but they must also inspire that audience to take action (cf. Guldi and Armitage, 2014).

Turning to the practical issues of interdisciplinary collaboration, it is clear that we must start transforming the way we speak. This transformation needs to take place at all levels, from the project design, to the final publication, to the communication of results to the general public. Thus, collaboration and exchange must begin as early as possible. We should aim to achieve a synergy between the disciplines from as early as the project design stage: several teams should work together and multi-proxy, multi-archive as well as system analytical approaches (including targeted archaeological and historical work) should become the rule. Any selection of new sites for collaborative efforts should not be guided by the needs of a single discipline, but rather by the potential for an interdisciplinary synergy. Furthermore, scientists, historians and archaeologists should work together to identify areas of uncertainty and obscurity in their knowledge: they need to identify chronological as well as geographical gaps in the evidence available to all disciplines. At the publication stage, representatives of the different disciplines should interpret their results together, and allow the approaches of each discipline to have a say in how results are explained and how the final narrative about the past is constructed. In this way, collaborators may strive to create a new, hybrid publication culture. Rather than simply founding new journals, it should be possible to achieve our goal by working on new practical solutions, as well as by raising awareness in the different disciplinary communities that the time has come for more flexible approaches to the creation, realisation and publication of interdisciplinary projects.

Acknowledgements

This paper emerged as a result of a workshop at Costa Navarino and the Navarino Environmental Observatory (NEO), Greece in April 2014, which addressed Mediterranean Holocene climate and human societies. The workshop was co-sponsored by IGBP/PAGES, NEO, the MISTRALS/PaleoMex program, the Labex OT-Med, the Bolin Centre for Climate Research at Stockholm University, and the Institute of Oceanography at the Hellenic Centre for Marine Research. We also acknowledge funding from the National Science Centre, Poland, within the scheme of the Centre's postdoctoral fellowships (DEC-2012/04/S/HS3/00226 (A.I)); the Swedish Research Council (grant numbers 421-2014-1181 (E.W.) and 621-2012-4344 (K.H.)); CSIC-Ramón y Cajal post-doctoral program RYC-2013-14073 and Clare Hall College, Cambridge, Shackleton Fellowship (B.M.); the EU/FP7 Project 'Sea for Society' (Science and Society - 2011-1, 289066). We would also like to thank the two anonymous reviewers for their constructive criticism, and Dr. Jesse Simon for editing and proofreading.

References

Alcock, S.E., Cherry, J.F., 2004. Side-by-side Survey: Comparative Regional Studies in the Mediterranean World. Oxbow Books, Oxford.
Ankersmit, F., 1994. Six theses on narrativist philosophy of historiography. In: History and Tropology: the Rise and Fall of Metaphor. University of California Press, Berkeley, pp. 33–44.
Ankersmit, F., 2000. The linguistic turn, literary theory and historical theory. Historia 45, 271–311.
Arıkan, B., Balossi Restelli, F., Masi, A., 2015. The Bronze Age comparative modeling of the surface processes and land use in the Malatya Plain (Turkey). Quat. Sci. Rev. (in this issue).
Arıkan, B., 2014. Macrophysical climate modeling, economy, and social organization in Early Bronze Age Anatolia. J. Archaeol. Sci. 43, 38–54.
Asouti, E., Austin, P., 2005. Reconstructing woodland vegetation and its exploitation by past societies, based on the analysis and interpretation of archaeological wood charcoal macro-remains. Environ. Archaeol. 10, 1–18. http://dx.doi.org/10.1179/env.2005.10.1.1.
Bakker, J., Paulissen, E., Kaniewski, D., De Laet, V., Verstraeten, G., Waelkens, M., 2012. Man, vegetation and climate during the Holocene in the territory of Sagalassos, Western Taurus Mountains, SW Turkey. Veg. Hist. Archaeobotany 21, 249–266.
Balée, W., 2006. The research program of historical ecology. Annu. Rev. Anthropol. 35, 75–98.
Beloch, K.J., 1937. Bevölkerungsgeschichte Italiens. Walter de Gruyter, Berlin.
Berglund, B.E., 2003. Human impact and climate changes—synchronous events and acausal link? Quat. Int. 105, 7–12.
Bollfrass, A., Shaver, A., 2015. The effects of temperature on political violence: global evidence at the Subnational level. PLoS One. http://dx.doi.org/10.1371/journal.pone.0123505.
Bottema, S., Zeist, W. van, Entjes-Nieborg, G. (Eds.), 1990. Man's Role in the Shaping of the Eastern Mediterranean Landscape. AABalkema, Rotterdam.
Bowes, K., Mercuri, A.M., Rattighieri, E., Rinaldi, R., Arnoldus-Huyzendveld, A., Ghisleni, M., Grey, C., Mackinnon, M., Vaccaro, E., 2015. Palaeoenvironment and land use of Roman peasant farmhouses in southern Tuscany. Plant Biosyst. 149, 174–218.
Boyer, P., Roberts, N., Baird, D., 2006. Holocene environment and settlement on the Çarşamba alluvial fan, south-central Turkey: integrating geoarchaeology and archaeological field survey. Geoarchaeology 21, 675–698. http://dx.doi.org/10.1002/gea.20133.
Braudel, F., 1949. La Méditerranée et le monde méditerranéen à l'époque de Philippe II. Colin, Paris.
Brázdil, R., Pfister, C., Wanner, H., von Storch, H., Luterbacher, J., 2005. Historical climatology in Europe – the state of the art. Clim. Change 70, 363–430.
Brázdil, R., Dobrovolný, P., Luterbacher, J., Moberg, A., Pfister, C., Wheeler, D., Zorita, E., 2010. European climate of the past 500 years: new challenges for historical climatology. Clim. Change 101, 7–40.
Broodbank, C., 2013. The Making of the Middle Sea: a History of the Mediterranean from the Beginning to the Emergence of the Classical World. Thames & Hudson, London.
Buhaug, H., Nordkvelle, J., Bernauer, T., Böhmelt, T., Brzoska, M., Busby, J.W., Ciccone, A., Fjelde, H., Gartzke, E., Gleditsch, N.P., Goldstone, J.A., Hegre, H., Holtermann, H., Koubi, V., Link, J.S.A., Link, P.M., Lujala, P., Loughlin, J.Ó., Raleigh, C., Scheffran, J., Schilling, J., Smith, T.G., Theisen, O.M., Tol, R.S.J., Urdal, H., von Uexkull, N., 2014. One effect to rule them all? A comment on climate and conflict. Clim. Change 127, 391–397. http://dx.doi.org/10.1007/s10584-014-1266-1.
Bulliet, R.W., 2009. Cotton, climate, and camels in early Islamic Iran: a moment in world history. Columbia University Press, New York; Chichester.
Büntgen, U., Tegel, W., Nicolussi, K., McCormick, M., Frank, D., Trouet, V., Kaplan, J.O., Herzig, F., Heussner, K.U., Wanner, H., Luterbacher, J., Esper, J., 2011. 2500 years of European climate variability and human susceptibility. Science 331, 578–582.
Burke, E., 2013. Ronnie Ellenblum. The collapse of the Eastern Mediterranean: climate change and the decline of the East, 950–1072. Am. Hist. Rev. 118, 1286.
Butzer, K., 2005. Environmental history in the Mediterranean world: cross-disciplinary investigation of cause-and-effect for degradation and soil erosion. J. Archaeol. Sci. 32, 1773–1800.
Butzer, K.W., 2008. Challenges for a cross-disciplinary geoarchaeology: the intersection between environmental history and geomorphology. Geomorphology 101, 402–411.
Butzer, K.W., 2012. Collapse, environment, and society. Proc. Natl. Acad. Sci. 109, 3632–3639.
Caseldine, C.J., Turney, C., 2010. The bigger picture: towards integrating palaeoclimate and environmental data with a history of societal change. J. Quat. Sci. 25, 88–93.

Cleland, C.E., 2002. Methodological and epistemic differences between historical science and experimental science. Philos. Sci. 69, 447–451.
Cooper, J., Peros, M., 2010. The archaeology of climate change in the Caribbean. J. Archaeol. Sci. 37, 1226–1232.
Cornell, S., Costanza, R., Sörlin, S., van der Leeuw, S., 2010. Developing a systematic "science of the past" to create our future. Global Environ. Change Governance Complex. Resil. 20, 426–427.
Cremaschi, M., Mercuri, A.M., Torri, P., Florenzano, A., Pizzi, C., Marchesini, M., Zerboni, A., 2015. Climate change versus land management in the Po Plain (Northern Italy) during the Bronze Age: new insights from the VP/VG sequence of the Terramara Santa Rosa di Poviglio (in this issue).
Cronon, W., 1983. Changes in the Land: Indians, Colonists, and the Ecology of New England, first ed. Hill and Wang, New York.
Crumley, C.L., 1994. Historical Ecology: Cultural Knowledge and Changing Landscapes. School of American Research Press, Santa Fe.
Cullen, H.M., deMenocal, P.B., Hemming, S., Hemming, G., Brown, F.H., Guilderson, T., Sirocko, F., 2000. Climate change and the collapse of the Akkadian empire: evidence from the deep sea. Geology 28, 379–382.
Dalfes, H.N., Kukla, G., Weiss, H. (Eds.), 1997. Third Millennium BC Climate Change and Old World Collapse. Springer, Berlin.
Davis, D.K., 2007. Resurrecting the Granary of Rome: Environmental History and French Colonial Expansion in North Africa. In: Ohio University Press Series in Ecology and History. Ohio University Press, Athens.
deMenocal, P.B., 2001. Cultural responses to climate change during the late holocene. Science 292, 667–673.
Ellenblum, R., 2012. The Collapse of the Eastern Mediterranean: Climate Change and the Decline of the East, 950–1072. Cambridge University Press, Cambridge.
Epstein, S.R., 1992. An Island for Itself: Economic Development and Social Change in Late Medieval Sicily. Cambridge University Press, Cambridge.
Fan, K., 2010. Climatic change and dynastic cycles in Chinese history: a review essay. Clim. Change 101, 565–573.
Finné, M., 2014. Climate in the Eastern Mediterranean during the Holocene and beyond – a Peloponnesian Perspective. Department of Physical Geography and Quaternary Geology, Stockholm University, Sweden. Dissertation No. 45.
Finné, M., Holmgren, K., Sundqvist, H.S., Weiberg, E., Lindblom, M., 2011. Climate in the eastern Mediterranean, and adjacent regions, during the past 6000 years – a review. J. Archaeol. Sci. 38, 3153–3173. http://dx.doi.org/10.1016/j.jas.2011.05.007.
Folke, C., 2006. Resilience: the emergence of a perspective for social–ecological systems analyses. Glob. Environ. Change 16, 253–267.
Folland, C.K., Karl, T.R., Christy, J.R., Clarke, R.A., Gruza, G.V., Jouzel, J., Mann, M.E., Oerlemans, J., Salinger, M.J., Wang, S.W., 2001. Observed climate variability and change. In: Houghton, J.T., Ding, Y., Griggs, D.J., Noguer, M., van der Linden, P.J., Dai, X., Maskell, K., Johnson, C.A. (Eds.), Climate Change 2001: the Scientific Basis. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, pp. 99–181.
Frankopan, P., 2013. Review of Ellenblum, the collapse of the eastern Mediterranean. Hist. Today 63 (2).
Frodeman, R., 1995. Geological reasoning: geology as an interpretive and historical science. Geol. Soc. Am. Bull. 107, 960–968.
Fuchs, M., 2007. An assessment of human versus climatic impacts on Holocene soil erosion in NE Peloponnese, Greece. Quat. Res. 67, 349–356.
Geyer, B., Lefort, J. (Eds.), 2003. La Bithynie au moyen âge, Réalités byzantines. Lethielleux, Paris.
Goffredo, S., Dubinsky, Z. (Eds.), 2014. The Mediterranean Sea: its History and Present Challenges. Springer, Dordrecht.
Grove, A.T., Rackham, O., 2003. The Nature of Mediterranean Europe: an Ecological History. Yale University Press, New Haven.
Guldi, J., Armitage, D., 2014. The History Manifesto. Cambridge University Press, Cambridge.
Gunderson, L.H., Holling, C.S. (Eds.), 2002. Panarchy: Understanding Transformations in Human and Natural Systems. Island Press, Washington.
Haldon, J., Izdebski, A., Roberts, N., Fleitmann, D., McCormick, M., Cassis, M., Doonan, O.P., Eastwood, W.J., Elton, H., Ladstätter, S., Manning, S., Newhard, J., Nichol, K., Telelis, I.G., Xoplaki, E., 2014. The climate and environment of Byzantine Anatolia: integrating science, history and archaeology. J. Interdiscip. Hist. 45, 113–161.
Harris, W.V. (Ed.), 2013. The Ancient Mediterranean. Environment between Science and History. Brill, Leiden.
Hassan, F.A., 2000. Environmental perception and human responses in history and prehistory. In: McIntosh, R.J., Tainter, J.A., McIntosh, S.K. (Eds.), The Way the Wind Blows, Historical Ecology Series, 121–140. Columbia University Press, New York, New York, USA.
Hassan, F.A., 2008. Human agency, climate change and culture: an archaeological perspective. In: Crate, S.A., Nuttall, M. (Eds.), Anthropology and Climate Change: from Encounters to Action, (Walnut Creek, Calif.), pp. 39–69.
Haug, G.H., Günther, D., Peterson, L.C., Sigman, D.M., Hughen, K.A., Aeschlimann, B., 2003. Climate and the collapse of Maya civilization. Science 299, 1731–1735.
Hodder, I. (Ed.), 2012. Archaeological Theory Today, second ed. Polity, Cambridge.
Holmgren, K., Sicre, M.-A., Gogou, A., Xoplaki, E., Luterbacher, J., 2014. Mediterranean Holocene climate and human societies. Workshop report. Past. Glob. Chang. Mag. 22, 54.
Horden, P., Purcell, N., 2000. The Corrupting Sea: a Study of Mediterranean History. Blackwell, Oxford.
Horden, P., Purcell, N., 2006. The Mediterranean and "the New Thalassology". Am. Hist. Rev. 111, 722–740.
Hsiang, S.M., Burke, M., Miguel, E., 2013. Quantifying the influence of climate on human conflict. Science 341, 1235367. http://dx.doi.org/10.1126/science.1235367.
Hughes, J.D., 1993. Pan's Travail: Environmental Problems of the Ancient Greeks and Romans. Johns Hopkins University Press, Baltimore.
Inkpen, R., 2009. The philosophy of geology. In: Tucker, A. (Ed.), A Companion to the Philosophy of History and Historiography, Blackwell Companions to Philosophy. Wiley-Blackwell, Chichester, pp. 318–329.
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. Millenium. Jahrbuch zu Kultur und Geschichte des ersten Jahrtausends n. Chr. 8, pp. 291–312.
Izdebski, A., 2014. Konwergencja nauk przyrodniczych i historycznych: teoretyczny potencjał i praktyczne trudności. Hist. Stud. Metodol. 44.
Izdebski, A., Pickett, J., Roberts, N., Waliszewski, T., 2015. The environmental, archaeological and historical evidence for climatic changes and their societal impacts in the Eastern Mediterranean in Late Antiquity. Quat. Sci. Rev. http://dx.doi.org/10.1016/j.quascirev.2015.07.022.
Janssen, E., Overpeck, J., Briffa, K.R., Duplessy, J.C., Joos, F., Masson-Delmotte, V., Olago, D., Otto-Bkiesner, B., Peltier, W.R., Rahmstorf, S., Ramesh, R., Raynaud, D., Rind, D., Solomina, O., Villalba, R., Zhang, D., 2007. Palaeoclimate. In: Solomon, S., Qin, D., Manning, M., Chen, Z., Marquis, M., Averyt, K.B., Tignor, M., Miller, H.L. (Eds.), Climate Change 2007: the Scientific Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge.
Jeftic, L., Millman, J.D., Sestini, G., 1992. In: Climatic Change and the Mediterranean: Environmental and Societal Impacts of Climatic Change and Sea Level Rise in the Mediterranean Region. Edward Arnold, London.
Kaniewski, D., Van Campo, E., Guiot, J., Le Burel, S., Otto, T., Baetman, C., 2013. Environmental roots of the Late Bronze Age crisis. PLoS One 8, e71004.
Kaplan, M., 1992. Les hommes et la terre à Byzance du VIe au XIe siècle: propriété et exploitation du sol. Publications de la Sorbonne, Paris.
Kaptijn, E., Poblome, J., Vanhaverbeke, H., Bakker, J., Waelkens, M., 2013. Societal changes in the in the Hellenistic, Roman and early Byzantine periods. Results from the Sagalassos Territorial Archaeological Survey 2008 (southwest Turkey). Anatol. Stud. 63, 75–95.
Kennett, D.J., Breitenbach, S.F.M., Aquino, V.V., Asmerom, Y., Awe, J., Baldini, J.U.L., Bartlein, P., Culleton, B.J., Ebert, C., Jazwa, C., Macri, M.J., Marwan, N., Polyak, V., Prufer, K.M., Ridley, H.E., Sodemann, H., Winterhalder, B., Haug, G.H., 2012. Development and disintegration of Maya Political Systems in response to climate change. Science 338, 789–791.
Kleinhans, M.G., Buskes, C.J.J., de Regt, H.W., 2005. Terra Incognita: explanation and reduction in earth science. Int. Stud. Philosophy Sci. 19, 289–317. http://dx.doi.org/10.1080/02698590500462356.
Koder, J., 1994. Historical aspects of a recession of cultivated land at the end of the late antiquity in the east Mediterranean. In: Evaluation of Land Surfaces Cleared from Forests in the Mediterranean Region during the Time of the Roman Empire, Paläoklimaforschung. Fischer, Stuttgart, pp. 157–167.
Kovats, R.S., Valentini, R., Bouwer, L.M., Georgopoulou, E., Jacob, D., Martin, E., Rounsevell, M., Soussana, J.-F., 2014. Europe. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Barros, V.R., C.B. Field, D.J. Dokken, M.D. Mastrandrea, K.J. Mach, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 1267–1326.
Lane, C.S., Horn, S.P., Kerr, M.T., 2014. Beyond the Mayan Lowlands: impacts of the Terminal classic drought in the Caribbean Antilles. Quat. Sci. Rev. 86, 89–98.
Latour, B., 1999. Pandora's Hope. Essays on the Reality of Science Studies. Harvard University Press, Cambridge.
Le Roy Ladurie, E., 1967. Histoire du climat depuis l'an mil. Flammarion, Paris.
Le Roy Ladurie, E., Daux, V., Luterbacher, J., 2006. Le climat de Bourgogne et d'ailleurs XIVe-XXe siècle. Hist. Econ. Soc. (HES) 3, 421–436.
Lemmen, C., Wirtz, K.W., 2014. On the sensitivity of the simulated European Neolithic transition to climate extremes. J. Archaeol. Sci. 51, 65–72. http://dx.doi.org/10.1016/j.jas.2012.10.023.
Leroy, S.A.G., 2006. From natural hazard to environmental catastrophe, past and present. Quat. Int. 158, 4–12.
Leroy, S.A.G., 2013. Natural hazards, landscapes, and civilizations. In: James, L.A., Harden, C.P., Clague, J.J. (Eds.), Geomorphology of Human Disturbances, Climate Change, and Natural Hazards. Academic Press, San Diego, pp. 190–203.
Lionello, P. (Ed.), 2012. The Climate of the Mediterranean Region from the Past to the Future. Elsevier, Amsterdam.
Lionello, P., Malanotte-Rizzoli, P., Boscolo, R. (Eds.), 2006. Mediterranean Climate Variability, Developments in Earth & Environmental Sciences. Elsevier, Amsterdam.
Liu, Y., Kostakos, V., Li, H., 2015. Climatic effects on planning behavior. PLoS One. http://dx.doi.org/10.1371/journal.pone.0126205.
Luterbacher, J., García-Herrera, R., Akcer-On, S., Allan, R., Alvarez-Castro, M.C., Benito, G., Booth, J., Büntgen, U., Cagatay, N., Colombaroli, D., Davis, B., Esper, J., Felis, T., Fleitmann, D., Frank, D., Gallego, D., Garcia-Bustamante, E., Glaser, R.,

González-Rouco, J.F., Goosse, H., Kiefer, T., Macklin, M.G., Manning, S., Montagna, P., Newman, L., Power, M.J., Rath, V., Ribera, P., Riemann, D., Roberts, N., Sicre, M., Silenzi, S., Tinner, W., Valero-Garces, B., van der Schrier, G., Tzedakis, C., Vannière, B., Vogt, S., Wanner, H., Werner, J.P., Willett, G., Williams, M.H., Xoplaki, E., Zerefos, C.S., Zorita, E., 2012. A review of 2000 years of paleoclimatic evidence in the Mediterranean. In: Lionello, P. (Ed.), The Climate of the Mediterranean Region: from the Past to the Future. Elsevier, Amsterdam, pp. 87–185.

Luterbacher, J., Pfister, C., 2015. The year without a summer. Nat. Geosci. 8, 246–248.

Magny, M., Combourieu Nebout, N., de Beaulieu, J.L., Bout-Roumazeilles, V., Colombaroli, D., Desprat, S., Francke, A., Joannin, S., Peyron, O., Revel, M., Sadori, L., Siani, G., Sicre, M.A., Samartin, S., Simonneau, A., Tinner, W., Vannière, B., Wagner, B., Zanchetta, G., Anselmetti, F., Brugiapaglia, E., Chapron, E., Debret, M., Desmet, M., Didier, J., Essallami, L., Galop, D., Gilli, A., Haas, J.N., Kallel, N., Millet, L., Stock, A., Turon, J.L., Wirth, S., 2013. North–south palaeohydrological contrasts in the central Mediterranean during the Holocene: tentative synthesis and working hypotheses. Clim. Past 9, 2043–2071.

Malone, C., Stoddart, S. (Eds), 1998. Special Section: David Clarke's 'Archaeology: the Loss of Innocence' (1973) 25 Years after. Antiquity 72 (277), 676–702.

Mann, M.E., Bradley, R.S., Hughes, M.K., 1998. Global-scale temperature patterns and climate forcing over the past six centuries. Nature 392.6678, 779–787.

Mann, M.E., Bradley, R.S., Hughes, M.K., 1999. Northern hemisphere temperatures during the past millennium: inferences, uncertainties, and limitations. Geophys. Res. Lett. 26, 759–762.

Martin, J.-M., 1993. La Pouille du VIe au XIIe siècle, Collection de l'École française de Rome, 179. Y. École française de Rome, Rome.

Masi, A., Sadori, L., Zanchetta, G., Baneschi, I., Giardini, M., 2013a. Climatic interpretation of carbon isotope content of Mid-Holocene archaeological charcoals from eastern Anatolia. Quat. Int. 303, 64–72.

Masi, A., Sadori, L., Baneschi, I., Siani, A.M., Zanchetta, G., 2013b. Stable isotope analysis of archaeological oak charcoal from eastern Anatolia as a marker of mid-Holocene climate change. Plant Biol. 15 (Suppl. 1), 83–92.

Masson-Delmotte, V., Schulz, M., Abe-Ouchi, A., Beer, J., Ganopolski, A., Gonzalez Rouco, J.F., Jansen, E., Lambeck, K., Luterbacher, J., Naish, T., Osborn, T., Otto-Bliesner, B., Quinn, T., Ramesh, R., Rojas, M., Shao, X., Timmermann, A., 2013. Information from paleoclimate archives. In: Stocker, T.F., Qin, D., Plattner, G.-K., Tignor, M., Allen, S.K., Boschung, J., Nauels, A., Xia, Y., Bex, V., Midgley, P.M. (Eds.), Climate Change 2013: the Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge.

Matthee, R., 2011. R. Bulliet. Cotton, climate, and camels in early Islamic Iran (review). Am. Hist. Rev. 116, 547–548. http://dx.doi.org/10.1086/ahr.116.2.547.

McAnany, P.A., Yoffee, N. (Eds.), 2010. Questioning Collapse: Human Resilience, Ecological Vulnerability, and the Aftermath of Empire. Cambridge University Press, Cambridge.

McCormick, M., 2011. History's changing climate: climate science, genomics, and the emerging consilient approach to interdisciplinary history. J. Interdiscip. Hist. 42, 251–273. http://dx.doi.org/10.1162/JINH_a_00214.

McCormick, M., Büntgen, U., Cane, M.A., Cook, E.R., Harper, K., Huybers, P., Litt, T., Manning, S.W., Mayewski, P.A., More, A.F.M., Nicolussi, K., Tegel, W., 2012. Climate change during and after the Roman Empire: reconstructing the past from scientific and historical evidence. J. Interdiscip. Hist. 43, 169–220. http://dx.doi.org/10.1162/JINH_a_00379.

McIntosh, R.J., Tainter, J.A., McIntosh, S.K. (Eds.), 2000. The Way the Wind Blows: Climate, History, and Human Action. Columbia University Press, New York.

McNeill, J.R., 1992. The Mountains of the Mediterranean World: an Environmental History, Studies in Environment and History. Cambridge University Press, Cambridge.

McNeill, J.R., 2003. Observations on the nature and culture of environmental history. Hist. Theory 42, 5–43. http://dx.doi.org/10.1046/j.1468-2303.2003.00255.x.

Meier, N., Rutishauser, T., Pfister, C., Wanner, H., Luterbacher, J., 2007. Grape harvest dates as a proxy for Swiss April to August temperature reconstructions back to AD 1480. Geophys. Res. Lett. 34, L20705.

Mercuri, A.M., 2008. Human influence, plant landscape, evolution and climate inferences from the archaeobotanical records of the Wadi Teshuinat area (Libyan Sahara). J. Arid Environ. 72, 1950–1967.

Mercuri, A.M., 2014. Genesis and evolution of the cultural landscape in central Mediterranean: the 'where, when and how' through the palynological approach. Landsc. Ecol. 29, 1799–1810.

Mercuri, A.M., Sadori, L., 2014. Mediterranean culture and climatic change: past patterns and future trends. In: Goffredo, S., Dubinsky, Z. (Eds.), The Mediterranean Sea: its History and Present Challenges. Springer, Dordrecht, pp. 507–527.

Mercuri, A.M., Sadori, L., Blasi, C., 2010. Archaeobotany for cultural landscapes and human impact reconstructions. Plant Biosyst. 144, 860–864.

Mercuri, A.M., Sadori, L., Uzquiano Ollero, P., 2011. Mediterranean and north-African cultural adaptations to mid-Holocene environmental and climatic changes. Holocene 21, 189–206.

Mercuri, A.M., Allevato, E., Arobba, D., Bandini Mazzanti, M., Bosi, G., Caramiello, R., Castiglioni, E., Carra, M.L., Celant, A., Costantini, L., Di Pasquale, G., Fiorentino, G., Florenzano, A., Guido, M., Marchesini, M., Mariotti Lippi, M., Marvelli, S., Miola, A., Montanari, C., Nisbet, R., Peña-Chocarro, L., Perego, R., Ravazzi, C., Rottoli, M., Sadori, L., Ucchesu, M., Rinaldi, R., 2014. Pollen and macroremains from Holocene archaeological sites: a dataset for the understanding of the bio-cultural diversity of the Italian landscape. Rev. Palaeobot. Palynol. http://dx.doi.org/10.1016/j.revpalbo.2014.05.010.

Meyer, W.J., Crumley, C.L., 2011. Historical Ecology: Using what Works to Cross the Divide. In: Atlantic Europe in the First Millennium BC: Crossing the Divide 109.

Mikhail, A., 2011. Nature and Empire in Ottoman Egypt: an Environmental History. Cambridge University Press, Cambridge.

Mikhail, A., 2013. Water on Sand: Environmental Histories of the Middle East and North Africa. Oxford University Press, Oxford.

Morrisson, C., 2002. Byzantine Money: its production and circulation. In: Laiou, A.E. (Ed.), The Economic History of Byzantium: from the Seventh through the Fifteenth Century. Harvard University Press, Dubmbarton Oaks, pp. 909–966.

Núñez, L., Grosjean, M., Cartajena, I., 2002. Human occupations and climate change in the Puna de Atacama, Chile. Science 298, 821–824.

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

Paton, M., 2011. Cotton, climate, and camels in early Islamic Iran: a moment in world history (review). Technol. Cult. 52, 180–181. http://dx.doi.org/10.1353/tech.2011.0021.

Pepe, C., Giardini, M., Giraudi, C., Masi, A., Mazzini, I., Sadori, L., 2013. Plant landscape and environmental changes recorded in marginal marine environments: the ancient Roman harbour of Portus (Rome, Italy). Quat. Int. 303, 73–81.

Pfister, C., 1978. Climate and economy in Eighteenth-Century Switzerland. J. Interdiscip. Hist. 9, 223–243.

Pfister, C., 2010. The vulnerability of past societies to climatic variation: a new focus for historical climatology in the twenty-first century. Clim. Change 100, 25–31. http://dx.doi.org/10.1007/s10584-010-9829-2.

Pfister, C., et al., 1999. Documentary evidence on climate in Sixteenth-Century Europe. Clim. Change 43, 55–110.

Piperno, D.R., Bush, M.B., Colinvuax, C., 1991. Paleoecological perspectives on human adaptation in central Panama. II. The Holocene. Geoarchaeology 6, 227–250.

Quézel, P., Médail, F., 2003. Ecologie et biogéographie des forêts du bassin méditerranéen. Elsevier, Paris.

Redman, C.L., Kinzig, A.P., 2003. Resilience of past landscapes: resilience theory, society, and the longue durée. Conserv. Ecol. 7, 14.

Redman, C.L., James, S.R., Fish, P.R., Rogers, J.D. (Eds.), 2004. The Archaeology of Global Change: the Impact of Humans on Their Environment. Smithsonian Books, Washington.

Renfrew, C., Bahn, P., 2012. Archaeology: Theories, Methods and Practice, sixth ed. Thames & Hudson, London.

Roberts, N., 2011. "Living with a moving target": long-term climatic variability and environmental risk in dryland regions. In: Miller, N.F., Moore, K.M., Ryan, K. (Eds.), Sustainable Lifeways. Cultural Persistence in an Ever-Changing Environment, Philadelphia, pp. 13–38.

Roberts, N., Rosen, A., 2009. Diversity and complexity in early farming communities of Southwest Asia: new insights into the economic and environmental basis of Neolithic Çatalhöyük. Curr. Anthropol. 50, 393–402. http://dx.doi.org/10.1086/598606.

Roberts, N., Jones, M.D., Benkaddour, A., Eastwood, W.J., Filippi, M.L., Frogley, M.R., Lamb, H.F., Leng, M.J., Reed, J.M., Stein, M., Stevens, L., Valero-Garce, B., Zanchetta, G., 2008. Stable isotope records of Late Quaternary climate and hydrology from Mediterranean lakes: the ISOMED synthesis. Quat. Sci. Rev. 27, 2426–2441.

Roberts, N., Brayshaw, D., Kuzucuoglu, C., Perez, R., Sadori, L., 2011. The mid-Holocene climatic transition in the Mediterranean: causes and consequences. Holocene 21, 3–13.

Robinson, S.A., Black, S., Sellwood, B.W., Valdes, P.J., 2006. A review of palaeoclimates and palaeoenvironments in the Levant and Eastern Mediterranean from 25,000 to 5000 years BP: setting the environmental background for the evolution of human civilization. Quat. Sci. Rev. 25, 1517–1541.

Rohling, E.J., Marino, G., Grant, K.M., 2015. Mediterranean climate and oceanography, and the periodic development of anoxic events (sapropels). Earth Sci. Rev. 143, 62–97.

Sackman, D.C. (Ed.), 2010. A Companion to American Environmental History. Wiley-Blackwell, Chichester.

Sadori, L., Bertini, A., Combourieu-Nebout, N., Kouli, K., Mariotti, M., Roberts, N., Mercuri, A.M., 2013. Palynology and Mediterranean vegetation history. Flora Mediterr. 23, 141–156.

Sadori, L., Giraudi, C., Masi, A., Magny, M., Ortu, E., Zanchetta, G., Izdebski, A., 2015. Climate, environment and society in Southern Italy during the last 2000 years. A review of the environmental, historical and archaeological evidence. Quat. Sci. Rev. http://dx.doi.org/10.1016/j.quascirev.2015.09.020 (in this issue).

Schneider, A.W., Adalı, S.F., 2014. "No harvest was reaped": demographic and climatic factors in the decline of the Neo-Assyrian Empire. Clim. Change 127, 435–446.

Sinclair, P., Nordquist, G., Herschend, F., Isendahl, C., 2010. The Urban Mind: Cultural and Environmental Dynamics. Department of Archaeology and Ancient History, Uppsala University, Uppsala.

Slingerland, E., Collard, M. (Eds.), 2011. Creating Consilience: Integrating the Sciences and the Humanities. Oxford University Press, Oxford.

Smith, M.E., 2010. Just how useful is archaeology for scientists and scholars in other disciplines? SAA Archaeol. Rec. 10, 15–20.

Squatriti, P., 2002. Water and Society in Early Medieval Italy, 400–1000. Cambridge University Press, Cambridge.

Squatriti, P., 2013. In: Landscape and Change in Early Medieval Italy: Chestnuts, Economy, and Culture. Cambridge University Press, Cambridge.
Tabak, F., 2008. The Waning of the Mediterranean, 1550–1870: a Geohistorical Approach. Johns Hopkins University Press, Baltimore, Md; London.
Tainter, J.A., 2008. Collapse, sustainability, and the environment: how authors choose to fail or succeed. Rev. Anthropol. 37, 342–371. http://dx.doi.org/10.1080/00938150802398677.
Toubert, P., 1973. Les structures du Latium médiéval: le Latium méridional et la Sabine du IXe siècle à la fin du XIIe siècle. École française de Rome, Rome.
Turner, B.L., Sabloff, J.A., 2012. Classic period collapse of the Central Maya Lowlands: insights about human–environment relationships for sustainability. PNAS 109, 13908–13914.
Vaccaro, E., 2013. Patterning the late antique economies of inland sicily in a Mediterranean context. Late Antiq. Archaeol. 10, 259–313. http://dx.doi.org/10.1163/22134522-12340034.
van Andel, T.H., Runnels, C.N., Pope, K.O., 1986. Five thousand years of land use and abuse in the Southern Argolid. Hesperia 55, 103–128.
van de Vliert, E., Tol, R.S.J., 2014. Harsh climate promotes harsh governance (except in cold-dry-wealthy environments). Clim. Res. 61, 19–28.
van der Leeuw, S., 2009. What is an 'environmental crisis' to an archaeologist. In: Fisher, C., Hill, B., Feinman, G. (Eds.), The Socio-natural Connection: Integrating Archaeology and Environmental Studies for 21st Century Conservation. University of Arizona Press, Tucson.
van der Leeuw, S., 2000. Land degradation as a socio-natural process". In: McIntosh, R., Tainter, J. (Eds.), The Way the Wind Blows: Climate, History and Human Perception. Columbia University Press, New York, pp. 364–393.
Vries, J. de, 1980. Measuring the impact of climate on history: the search for appropriate methodologies. J. Interdiscip. Hist. 10, 599–630. http://dx.doi.org/10.2307/203061.
Walsh, K., 2004. Caring about sediments: the role of cultural geoarchaeology in Mediterranean landscapes. J. Mediterr. Archaeol. 17, 223–245.
Walsh, K., 2014. The Archaeology of Mediterranean Landscapes: Human-environment Interaction from the Neolithic to the Roman Period. Cambridge University Press, Cambridge.
Ward-Perkins, J.B., 1962. Etruscan Towns, Roman Roads and Medieval Villages: the historical geography of Southern Etruria. Geogr. J. 128, 389–404. http://dx.doi.org/10.2307/1792035.
Ward-Perkins, J.B., 1964. Landscape and History in Central Italy, J.L. Myres Memorial Lecture. Blackwell, Oxford.
Weiberg, E., Finné, M., 2013. Mind or matter? People-environment interactions and the demise of the EH II Society. Am. J. Archaeol. 117, 1–31.
Weiberg, E., Unkel, I., Kouli, K., Holmgren, K., Andwinge, M., Avramidis, P., Baika, K., Bonnier, A., Dibble, F., Finné, M., Heymann, C., Izdebski, A., Katrantsiotis, C., Stocker, S., 2015. The socio-environmental history of the Peloponnese during the Holocene: towards an integrated narrative. Quat. Sci. Rev. (in this issue).
Weiss, H., 2000. Beyond the Younger Dryas: collapse as adaptation to abrupt climate change in ancient West Asia and the Eastern Mediterranean. In: Bawdon, G., Reycraft, R.M. (Eds.), Environmental Disaster and the Archaeology of Human Response. Maxwell Museum of Anthropology, Albuquerque, pp. 63–74.
Weiss, H., Bradley, R.S., 2001. What drives societal collapse. Science 291, 988.
Weiss, H., Courty, M.-A., Wetterstrom, W., Guichard, F., Senior, L., Meadow, R., Curnow, A., 1993. The genesis and collapse of third millennium north Mesopotamian civilization. Science 261, 995–1004.
Westerberg, L.O., Holmgren, K., Börjeson, L., Håkansson, T., Laulamaa, V., Ryner, M., Öberg, H., 2010. The development of the Engaruka irrigation system, Northern Tanzania. Physical and societal factors. Geogr. J. 176, 304–318. http://dx.doi.org/10.1111/j.1475-4959.2010.00370x.
Wetter, O., Pfister, C., 2011. Spring-summer temperatures reconstructed for northern Switzerland and southwestern Germany from winter rye harvest dates, 1454–1970. Clim. Past 7, 1307–1326.
Wetter, O., Pfister, C., 2013. An underestimated record breaking event – why summer 1540 was likely warmer than 2003. Clim. Past 9, 41–56.
Wetter, O., Pfister, C., Werner, J.P., Luterbacher, J., et al., 2014. The year-long unprecedented European heat and drought of 1540 – a worst case. Clim. Change 125, 349–363.
White, H., 1974. The historical text as literary artifact. Clio 3, 277–303.
White, H.V., 1978. Tropics of Discourse: Essays in Cultural Criticism. Johns Hopkins University Press, Baltimore.
White, S., 2011. The Climate of Rebellion in the Early Modern Ottoman Empire, Studies in Environment and History. Cambridge University Press, Cambridge.
White, S., 2013. The collapse of the Eastern Mediterranean: climate change and the decline of the East, 950–1072. Mediterr. Hist. Rev. 28, 70–72.
Whitelaw, T., 2000. Settlement instability and landscape degradation in the Southern Aegean in the Third Millennium BC. In: Halstead, P., Frederick, C. (Eds.), Landscape and Land Use in Postglacial Greece. Sheffield Academic Press, Sheffield, pp. 135–161.
Wiener, M., 2013. "Minding the Gap": gaps, destructions, and migrations in the Early Bronze Age Aegean. Causes and consequences. Am. J. Archaeol. 117, 581–592.
Wilson, E.O., 1998. Consilience. The Unity of Knowledge. Abacus, London.
Winiwarter, V., Armiero, M., van Dam, P., Dix, A., Eliasson, P., Holm, P., Jelecek, L., Lambert, R.A., Massard-Guilbaud, G., Gonzales de Molina, M., Myllyntaus, T., Oosthoek, J., Pfister, C., Racz, L., 2004. Environmental history in Europe from 1994 to 2004: enthusiasm and consolidation. Environ. Hist. 10, 501–530. http://dx.doi.org/10.3197/0967340042772685.
Woodward, J.C. (Ed.), 2009. The Physical Geography of the Mediterranean. Oxford University Press, Oxford.
Xoplaki, E., Fleitmann, D., Luterbacher, J., Wagner, S., Haldon, J., Zorita, E., Telelis, I., Toreti, A., Izdebski, A., 2015. The Medieval Climate Anomaly and Byzantium: a review of the evidence on climatic fluctuations, economic performance and societal change. Quat. Sci. Rev. http://dx.doi.org/10.1016/j.quascirev.2015.10.004.
Yoffee, N., Sherratt, A. (Eds.), 1993. Archaeological Theory: Who Sets the Agenda?. Cambridge University Press, Cambridge.
Zakrzewski, D., 2012. Cotton, climate, and camels in early Islamic Iran: a moment in world history (review). Nomadic Peoples 15, 148–150. http://dx.doi.org/10.1353/tech.2011.0021.