Climate and Societies in the Mediterranean during the Last Two Millennia

Current State Of Knowledge and Research Perspectives

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ABSTRACTS BOOK

MARCH 8

Session I (* speaker)

How To Integrate Solar And Volcanic Forcing In Studies Of Historical Climate-Society Interactions?

Volcanism and Variability: The Volatile Nile as Driver of Revolt and Socioeconomic Stress in Ptolemaic Egypt, 305-30 BCE

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We present results from a joint study by historians and natural scientists demonstrating the link between Nile flood suppression via the impacts of volcanic eruptions on the African monsoon, and Ancient Egyptian political history. We use ice-cores, climate modelling, ancient papyri and inscriptions to show that these eruptions had profound effects on Ptolemaic Egypt, the most

powerful state of the ancient Hellenistic world, founded in 305 BCE by Alexander the Great's key general, Ptolemy, and ending almost three centuries later with Cleopatra's suicide in 30 BCE. Modern historians have followed the explanation of the Greek historian Polybius (died c.118 BCE) in laying blame for the state's decline on the immorality and drunkenness of the Ptolemaic kings. Climate has never been considered. Yet Egypt, as one of the world's great hydraulic civilizations, was uniquely bound to the Nile, and a low flood ("Nile failure") was greatly feared, promoting famine, disease and political instability through Egypt's many millennia. We analyse the remarkable annual measurements of the Nile taken at the "Nilometer" at Roda island near Cairo from 622 to 1902 CE, and find that this provides strong evidence of the Nile's response to eruptions. We show how a sequence of explosive eruptions catalysed revolts against Ptolemaic rule in Egypt, also constraining Ptolemaic interstate warfare with their great Near Eastern rival, the Seleukid Empire. Volcanically-induced hydrological shocks also promoted societal stress by necessitating sales of hereditary land, and state coping responses through issuance of priestly decrees to reinforce state authority. These shocks are now implicated in the state's long decline, occurring in the context of growing demographic and fiscal pressures, costly military mobilizations, and preferential cultivation of drought-vulnerable free-threshing wheat to serve urban and export demand.

Climate and societal impacts of a volcanic double event at the dawn of the Middle Ages

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Volcanic activity in the middle of the 6th century led to the coldest decade of the Common Era, and has been speculatively linked to large-scale societal crises around the world. Using a coupled aerosol-climate model, with eruption parameters constrained by recently re-dated ice core records and documented observations of the aerosol cloud, we have reconstructed the radiative forcing resulting from a sequence of two major volcanic eruptions in 536 and 540 CE. We estimate that the radiative forcing from this volcanic "double event", averaged over the Northern Hemisphere and over a decade, was larger than that of any period within at least the last 1200 years. Earth system model simulations including the estimated volcanic forcing are used to explore the temperature and precipitation anomalies associated with the eruptions, and compared to available proxy records, including temperature reconstructions based on dendrochronological (tree ring) data. Special attention is placed on

the apparent decadal-scale cooling signal implied by many tree ring records, and whether the climate model simulations reproduce such long-term climate anomalies. Finally, the climate model results are used to explore the probability of socioeconomic crisis resulting directly from the volcanic radiative forcing in different regions of the world.

Reassessing the climatic impacts of the 1257 eruption in Europe and in the Northern Hemisphere using historical archives and tree rings

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The eruption of Samalas in Indonesia in 1257 is among the largest sulphur-rich eruptions of the Common Era with sulphur deposition in ice cores reaching twice the volume of the Tambora eruption in 1815. Stratigraphic and sedimentological analyses of deposits confirm the exceptional magnitude (Me 7, VEI 7) of the Samalas eruption with ≥40 km3 of dense magma. Scarcity of annually resolved proxy records extending back to the 13th century has so far prevented robust documentation of climatic perturbations induced by the 1257 Samalas eruption.

The development of new tree-ring chronologies in poorly studied regions of the Northern Hemisphere, as well as the discovery of new historical evidence from Europe and Japan now allow to shed a new light on the climatic aftermath of the Samalas eruption. In this keynote we reassess the societal and economic impacts induced by the Samalas eruption in Western Europe.

Narrative sources, grape harvest dates and tree rings suggest that the year 1258 stands along with the year 1816, amongst the coldest summer ever

experienced in Western Europe since the past millennium. Although diminished sunlight, cold condition, incessant rain did ruin annual harvest in England, France, Germany, Italy, and Spain, leading to severe food shortages, the climatic impacts of the 1257 Samalas eruption did not triggered in Europe several consecutive years of crop failures. Tree-ring and historical records indeed indicate a significant improvement of weather conditions from 1259 in most of the regions hit by adverse weather in 1258.

The 1430s: A period of extraordinary internal climate variability during the early Spörer Minimum and its impacts in North-western and Central Europe

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During the Late Middle Ages climate variability repeatedly caused severe impacts on society. There were different reasons for this variability. In the case of the 1430s an outstanding number of extremely and very cold winter and spring seasons occurred which were linked to internal climate variability. Due to the cold temperatures the cultivation period was considerably shorter in those years. In addition, rain periods during the harvesting in 1436 and 1438 caused crop failures in North-western and Central Europe which lead to a supra-regional subsistence crisis. In this paper the weather impacts during the 1430s on society in parts of Europe will be examined looking at the following questions: What kind of weather anomalies occurred during the period investigated and what kind of impacts did they cause on society? In order to answer these questions a large number of medieval chronicles will be examined.

Session II

Sources And Methodologies For Studying Past Climate History: From Natural To Textual Archives

Towards a methodology for reconstructing outstanding extreme events. The example of 1540

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In view of Global Warming it is predicted that outstanding heat waves and droughts will be more intense, more frequent and longer lasting. Studying the past is the best way to get the needed details of such low-probability high-impact events in view of assessing their societal impacts in the past and in the future.

The paper draws on the case of the outstanding eleven months long European heat and drought in 1540 to discuss the strengths and weaknesses of evidence from archives of nature and archives of societies that are used to deal with this issue. Moreover the consequences of the drought for the affected societies and past people's perceptions are outlined. The ultimate objective is getting insights in the agreement and disagreement of different data types in view of better dealing with such events further back in time as well as getting a sufficient basis for possible analogue cases in the future.

Multidisciplinary approach to climatic reconstruction. Present research and potentialities in Mediterranean countries (Spain) focusing on hydroclimatic extremes

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Climatic reconstruction from different proxy-data sources has a diversity of research fields. Mediterranean Basin offers interesting framework for it, with countries preserving old documentary heritages but most of them poorly explored. For example, historical climatology research in Spain only covers around 4% of main cities with large documentary series.

Present and future research on this field could be focused on hydrometeorological extremes by two reasons. First, by prevalence of documentary evidences of rainfall extremes (floods and droughts) and related impacts. Second, by severe uncertainties showed by climatic modelling concerning deterioration of water resources in close future due to increase of extreme patterns as droughts and torrential rainfalls.

Research can be developed in a multidisciplinary framework. At present, palaeoclimatic reconstruction is based more commonly on multi-proxy approaches to enrich and improve analytical capacities. Study of historical floods is a good example with research groups coordinated around Europe.

Focusing on Spanish case, flood events are also studied in a multidisciplinary context with interesting results, combining historical information with geological evidences for a better meteorological, hydraulic and hydrological

reconstruction of complete rainfall events producing floods. Many of present methodological developments and results will be shown in this presentation.

On the other hand, drought events are studied from different paleaoclimatic especialities but still exists an absence of integration. Most evident step would be integrating historical and dendroclimatic information about drought events, considering different origin of both data: agricultural activity on lowlands (rogation ceremonies, official and private reports) and high mountain forests (old trees generating long dendroclimatic chronologies).

When hydrometeorological extremes will be sufficiently studied, next steps of research could face more complex aspects, as biological risks (plagues, epidemics) or social and economic disturbances, giving a detailed evaluation of climatic variability and extremes on occurrence of historical processes.

The role of textual archives and first instrumental records to detect optimal periods for vector-borne diseases in late 18th century Catalonia

The "Maldà" climate anomaly repercussion over public health in two Catalan cities (Barcelona and Girona)

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The aim of this communication is to show a methodology that could be useful for better detect the presence of vector-borne or bacterial diseases all along 18th and 19th centuries over different chronologies and regions. The current climate change dynamics will have an impact reflected into changes in temperature and precipitation at global scale. But, more concretely, cross-disciplinary research developed by multidisciplinary teams and reported by the IPCC (Intergovernmental Panel on Climate Change) has shown that vector-borne disease will spread over European countries with the consequent impact over the public health.

The possibility into developing interdisciplinary studies offers to historians the opportunity for analyzing the repercussion over the society of endemic and epidemic malaria-yellow fever scenarios in past societies. In the late Eighteenth century the climatic oscillation known as "Maldà Oscillation" is the climatic context to better understand the natural adaptive patterns of a silent disease, especially concerning malaria. Moreover, this methodology has per objective to analyze from a concrete historical context the hygienic measures proposed by physicians and applied (or not) by local-state authorities, to detect problematic natural areas (flooded orchards, irrigation patterns, geomorphological

particularities that could have been potential zones for the development of endemic-epidemic malaria and yellow fever. Another point of interest is centered in the demographic impact of those vector-borne diseases and the social reactions to epidemics and political-hygienic measures and the repercussion of the epidemic context over the economic plan.

The construction of historical-epidemic studies will let us develop further comparative studies over regions that had suffered same problematic situations with similar or totally different scenarios. The historical compilations of epidemics, as e.g., Doctor Joaquin de Villalba's –military physician of Aragon on 19th centuries- are more important concerns, where his message goes directly linked to the medical pursuit of the historical reconstruction of endemics, epidemics, and epizootic illnesses "to show taking as an example past situations to better affront future cases" (Villalba, 1803).

The earliest meteorological observations: Florence and Vallombrosa in the Medici Network (1654-1670)

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The oral presentation introduces the earliest temperature observations belonging to the two main stations i.e. Florence and Vallombrosa, of the Medici Network, the first international network of meteorological observations, established in 1654–1670 period (Camuffo & Bertolin, 2012).

The meteorological observations in all the eleven stations, constituting the Network, were scheduled every 3-4 h, and included measures of outdoor temperature, in the shade and in the sunshine, to evaluate solar heating, state of the sky, wind direction and precipitation frequency. Very careful indications were provided by the secretary of the Network Lorenzo Antinori to the observers for each station about operational methodology, and in-situ exposure of thermometers to cross compare and interpret the readings.

The observations were made with the newly invented spirit-in glass thermometer, also known as Little Florentine Thermometer, a masterpiece of science and technology for that time. The Little Florentine Thermometers, constituting the instruments of measure in the Medici Network, were all built identically, with the same scale based on the range of temperature in Florence. Such earlier meteorological instrument will be presented in detail during the oral presentation: how it was made, its linearity, calibration and performances.

In addition a discussion will be made on the interpretation and analysis of these earliest temperature observations: how the observational time, originally expressed in Ora Italica has been transformed in Central European time, and

how the readings have been transformed into modern units of temperature (°C). Finally an assessment concerning the change in the climate in Florence and Vallombrosa since the middle of the LIA will be provided comparing the reconstructed series with the nowadays reference period (1961-1990).

References:

Camuffo D. and Bertolin C., (2012), The earliest temperature observations in the world: the Medici Network (1654-1670), *Climatic Change*, 111 (2): 335-363.

Drought and Crisis in the Classical Ottoman Empire: New Evidence, Confirmation, and Revisions

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A decade ago, tree ring-based spring-summer precipitation reconstructions for the Eastern Mediterranean indicated extraordinary droughts during the late 16th century. My examination of Ottoman and European historical evidence found eye-witness descriptions confirming the extent and severity of the drought. Analysis of Ottoman tax records and imperial orders helped clarify the nature of Ottoman vulnerabilities to extreme weather and climate, characteristic of this phase in the Little Ice Age. That investigation became the basis for a 2011 book, *The Climate of Rebellion in the Early Modern Ottoman Empire* (White, 2011), which also explored the larger environmental, economic, and political consequences of the Ottoman crisis of the 1590s-1600s. During the past six years, new evidence from paleoclimatology, historical climatology, and Ottoman economic history has shed more light on the nature of this crisis and its impacts. In this presentation, I will review this new evidence and its implications for my thesis. I will make the case that some of its essential arguments have been confirmed, and other points can now be revised and refined. Finally, a there remains a lot of work left for new researchers in Ottoman historical climatology.

Reference:

White S., (2011), *The Climate of Rebellion in the Early Modern Ottoman*, Cambridge University Press, 377 p.

The Dantean Anomaly project: A comparative approach to a period of increasing extreme events and their societal impact

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The Great Famine (1315-1321) was a part of a period of rapid climatic change called the Dantean Anomaly (1309-1321). This project will examine this decade regarded as the tipping point of the Little Ice Age from a perspective of climate history in Italy, France and Central Europe. Although these regions offer an abundance of fiscal, administrative and narrative sources, they have been overlooked in recent scholarship thus far. The project's aim is not only to reconstruct extreme meteorological events and their socio-economic impact but also to clarify the vulnerability and resilience of the societies in question. These responses depended largely on economic and political preconditions of the respective communities, as climatic impact is determined largely by cultural factors. Beyond existing historical research, the point of reference for all three case studies is scientific data, which will correct and enhance the documentary data. The project will contribute significantly to the emerging climate-historical paradigm within medieval studies and environmental history. In addition, a trans-regional comparison will clarify the importance of natural factors in the crisis of the 14th century and also contribute to calibrating the data from the natural sciences in order to underline the importance of the humanities in reconstructing and understanding past climate change. Intermediate results of this study will be contrasted with comparable phenomena from the Middle East and from Southeast Asia. With this range, the global dimension of the late medieval climatic deterioration will become clearer and will open the floor for further questions.

MARCH 9

Session III

Climate As Catalyst For Subsistence Crises, Epidemics And Violence

Late Holocene delta geomorphology and ancient coastal settlements: from Taman Peninsula to the Balearic Islands

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River deltas began forming around 7000 years BP because of the stabilization of mean sea level and high sedimentary inputs at base-level. The natural variety of wetland environments on clastic coasts, in particular deltas, explains in major part the important disparities in harbour contexts. These different geomorphological contexts led to specific pressures and potentialities for maritime activities. In this presentation, I will describe an investigation of four different sites using a combination of earth science and archaeological tools.

At the deltaic scale, we investigate 7000 years of environmental changes on the Kuban delta (Taman Peninsula, Russia). We show that the local inhabitants faced significant natural constraints that have undoubtedly dictated the development and decline of some cities, in particular during archaic and classical periods.

At the local scale (ancient settlements), we show that the natural environment, such as lagoons or estuaries were particularly attractive for ancient population looking for good mooring areas. We focus on the potentialities and constraints of such environments for the development of harbours in three different sites: Akko (Haifa Bay, Israel), Pollentia (Mallorca, Balearic archipelago) and Halmyris (Danube delta, Romania).

Famine, migrations and conflicts 3200 years ago: did climate have an influence on social upheavals?

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In Mediterranean history, 1200 BCE stands out as a symbolic date. Its significance lies in its association with the significant upheavals that destabilized economic systems at a regional-scale, leading to the dislocation of mighty Empires and, finally, to the “collapse” of a societal model. Recent studies have suggested that a centuries-long regional drought event, termed the 3.2 kyr BP event, could be one of the main forcing agents behind this spiral of decline. A climate shift would have directly impacted the primary or secondary subsistence systems (dry farming agro-production, pastoral nomadism and fishing) and adversely affected the outlying nomad habitats, forcing rain-fed cereal agriculturalists into habitat-tracking when agro-innovations are not available. While, in the Mediterranean and Western Asia,

severe climate changes have frequently occurred during the Holocene, the 3.2 kyr BP event may represent one of the last records of climate pressures responsible for profound social changes, fueling debates on causal links between climate shifts and societal upheavals. Drought seems to have accelerated changes in the East Mediterranean Old World by sparking famine, invasions and conflicts, which led to the political, economic and cultural "chaos" identified as "the Late Bronze Age collapse".

Climate change and the Eastern Roman Empire. Learning from the complex societies of the past

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A number of recent studies revealed that the Eastern Roman Empire, or Byzantium, was relatively resilient in the face of climatic changes. In AD 350-700, it went through a period of multi-decadal drought without any major crisis, and then managed to benefit from long-term wetter conditions. In AD 900-1200, it sustained economic growth despite highly unstable climate, and - paradoxically - even the profound political crisis of the late 12th c. seems unrelated to the harsh conditions of AD 1175-1200.

However, this vision remains simplistic, as it focuses on the key political institutions or the productive base of the economy; there is a whole spectrum of social and economic actors between these two extremes. In a highly complex society, resilience, or the ability to maintain the same structure in new conditions, cannot be attributed to the society as a whole. Rather, some elements are able to remain relatively unchanged, while others have to change in order to make the resilience possible. In particular, climate renders certain lifestyles or social-ecological models less viable, demanding much greater effort for their continuation. This leads to re-allocation of resources, which in turn involves changes in the social structure.

In this paper, I will present selected cases from the history of Byzantium illustrating two aspects of the ways in which complex societies could adapt to climatic changes. First, I will focus on the role played by the socio-economic structure and the ability of elites to control resources. This is particularly clear in the rising significance of village societies and aristocracies in Late Antiquity, at the expense of the cities. Second, I will show how a moment of climate-induced crisis has the potential to shift the balance between different groups within the same society. Such transformation occurred in Byzantium in the 920s-930s or in the 1260s.

The Byzantine case shows that adaptation to climate change, and the resilience of political institutions or productive potential, involves profound social change. Different social actors negotiate what has to be changed and what is maintained. The history of how Byzantium coped with unstable climate makes us more aware of the types of social transformation that could be involved in adaptation to climate, in both the past and in the future. As well as seeing the danger of climate-caused poverty along the global North-South divide, we should also recognize the threats that it can pose to social cohesion in complex social systems.

War, economic crisis and plague: teleconnections between Arid Central Asia and the Mediterranean in the thirteenth and fourteenth centuries

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This paper summarises findings and arguments presented in *The Great Transition: Climate, Disease and Society in the Late-Medieval World* (Campbell, 2016). Its premise is that, historically, Mediterranean societies have been at least as much influenced by climate changes occurring outside the region as those taking place within. For Europe as a whole and the Mediterranean in particular, developments within the parched and thinly peopled interior of Arid Central Asia have been especially influential. During the first half of the 13th century atmospheric circulation patterns characteristic of the Medieval Climate Anomaly shaped creation of the Mongol empire and reinvigoration of the Silk Road as an artery of Eurasian commerce. During the second half of that century ecological changes arising from onset of the Wolf Solar Minimum combined with strong volcanic forcing then reactivated plague from its long-dormant enzootic state within its reservoir region of the Tibetan-Qinghai Plateau and initiated the succession of transformations that launched the Second Pandemic on its destructive path. In the 14th century the military, commercial and biological consequences of these developments would be felt throughout the Mediterranean and, above all, in populous and commercially advanced Italy, where they greatly compounded, and were in turn amplified by, subsistence problems arising from concurrent changes in climatic conditions within the Mediterranean basin. Collectively, these developments ended Latin Christendom's high-medieval twin commercial and demographic boom and initiated an era of commercial retrenchment and population decline by the end

of which the once-dynamic commercial economies of the Mediterranean had lapsed from leaders to laggards.

Reference:

Campbell B.M.S., (2016), *The Great Transition: Climate, Disease and Society in the Late Medieval World*, Cambridge University Press, 479 p.

Droughts and floods in the Spanish Mediterranean during the Little Ice Age. Thoughts and proposals

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Iberian Peninsula suffered during the Little Ice Age long periods of extreme water shortages which were interrupted, in autumn and spring, by plentiful rainfalls followed by floods with disastrous consequences. Both the persistence of drought and the raise in storm activity caused damage in Mediterranean environmental conditions which were noticeable in three periods: 1570-1630, 1760-1800 and 1830-1870. The first and last periods had similar intensities, but was remarkable the increase of catastrophic rainfall frequencies and the decrease of drought stages. In the last quarter of eighteenth century, during the known “Maldà” oscillation, coincided both extreme dryness and heavy downpours. 1560-1570, 1620-1630, 1750-1760 and 1820-1830 were periods of prevalent or hard drought, whilst moderate droughts occurred during 1700-1710, 1760-1770 and 1840-1860. These circumstances caused that the crops were bad or they were lost, and bring about subsistence crisis which were aggravated occasionally by the emergence of agricultural pests, diseases -plagues or tertian fevers- or natural phenomena of calamitous effects.

Resilience to Droughts and Energy Transition in Northwestern Mediterranean during the Dalton Minimum

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Both urban and rural Mediterranean societies have always coped with persistent droughts causing agricultural, economical but also health disasters; these hydrological-climatological constraints are key factors of the dynamics of coupled human and ecological systems in this part of the world. However,

recent academic works revealed the high amplitude of climatic fluctuations throughout the 18th century together with intense and recurring droughts during the first half of the 19th century ; stressing that the Little Ice Age can no longer be described as a coherent wet and cold climatic episode. These fluctuations were induced by an intense inner period of the LIA in Western Mediterranean starting in the mid-16th century and characterized by several decades-long rainy periods and many droughts. And, though it reached its "peak of intensity" in the 19th century, a detailed chronology revealed a clear contrast between a very dry period, around the years 1800 to 1834, then a wetter spell from 1845. Regarding their origin, these events match with the Dalton Minimum, a 60 year-long period of low solar activity, lasting from 1780 to 1840. In addition, early in the 19th century, two major volcanic eruptions took place, injecting large amounts of sulfur dioxide into the stratosphere, which, increased planetary albedo, affecting the global climate.

Questions can be asked about the impact of such fluctuations at the dawn of the Industrial Revolution but mostly at a time of energy source transition. Can we highlight the specific role of climate variability among other cumulative and synergistic socio-economic driving forces, frequently acting in conjunction with each other? Second, have extreme climate events during the 18th century acted as a major driver - a catalyst - for a rapidly implemented energy transition process in Southeastern France (in the Lower Provence area) and Northwestern Spain (in Catalonia), when compared with Northern European countries? At last, have the first three dry decades of the 19th century been responsible of the shift of much South-European manufacturing from water to steam power? Indeed, in the case of the city of Marseille this transition occurred during the decade 1835-1843 and by 1855 it was a "steam-powered city".

First, after describing the hydro-climatic context in Northwestern Mediterranean and the impact of changes in solar irradiance versus volcanic eruptions on global climate during the Dalton Minimum, we will analyze the exact part played by water power in manufacturing industries in Southern France and Northwestern Spain at this time. Then, we will focus on the real influence of recurring drought episodes on both the energy production and the use of water power but also in terms of perception by city officials, engineers, business leaders or manufacturers as well as on planned energy systems in two major cities of these regions in a comparative perspective: Marseille and Barcelona.

POSTERS (* speaker)

1. A multi-secular database (A.D. 1300-2000) on the historical flood variability in the Lower Rhone Valley

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The HISTRHONE database (https://histrhone.cerege.fr) was built from a wide range of over a thousand different records distributed along seven centuries. A long historical and public recording prospection work was the basis of this project. The technical realization was conducted at the SIGéo laboratory, European Centre for Research and Education in Environmental Geosciences (CEREGE), in Aix-en-Provence (France).

For the poster, we will strive to develop three major aspects:

1. The wide range of research in documentary and historical sources survey: narrative sources available since the 14th century - technical sources, or similar, since the 17-18th centuries - Instrumental daily observations available since the end of the 18th c., or 1816, 1829 yr. according the places of observation.
2. The effort to make possible a cross-historical analysis of the data. From the four types of increase of the river flow (1009 events in total in the series), the three most severe flooding (517 events) can be subject to a safe statistical analysis since the 15th c.
3. The flood data analysis is related with a large quantity of metadata. The ices of river (174 episodes identified), the droughts and the rains (HISTRHONE include two complementary databases on the ice events and the drought episodes).

Such databases require comparisons with the other sites of flood studies and future prospects with the climate variability and forcing factors determining these evolutions.

2. Historical climate Data Rescue in the Mediterranean area at Météo-France

Sylvie JOURDAIN[1] & **Émeline ROUCAUTE***[1]

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As part of its mission to preserve the climate heritage, Météo-France is involved in the process of preservation and recovery of historical climate data. This rescue of historical climate data entails not only exhaustive searches and preservation efforts of such archives, but also the characterization and dissemination of the associated data and meta-data. Three international projects will be used to illustrate how this work is undertaken for the

Mediterranean area: WMO-Medare (Mediterranean Data Rescue), ACRE (Atmospheric Circulation Reconstructions over the Earth) and Era-Clim (European Reanalysis of Global Climate Observations).

3. Temperature observations in Bologna, Italy, from 1715 to 1815: three centuries of changing climate and methodological procedures to recover and analyze early instrumental series

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The poster presents the recovery and analysis of the observations taken in Bologna, Italy, from 1715 to 1815, three times a day, with a number of early thermometers (i.e. Stancari air thermometers, Little Florentine thermometer, Florentine Stick thermometer, Réaumur spirit and mercury thermometers), some of them operating in parallel (Camuffo *et al*., 2016; Camuffo *et al*., 2017).

Few of these early thermometers had unknown scales and temperature units, as well as a series of problems as deviations from linearity for the bulb shape or the thermometric liquid.

However, thanks to the availability of parallel readings over the time, it was possible to compare and interpret them.

Thanks to the analysis of the data fingerprints and their variability it was possible to reconstruct where instruments were located and the observers. It was also possible to relate the indoor climate of historical buildings to the outdoor one, and transform indoor readings as they were taken outdoors, expressed in Celsius.

This research work therefore, besides the evidence of the climate in the 1730-1770 decades, that constituted the coldest period, the 18th century being generally cold and with an impressive frequency of extremely severe winters, and the evidence that we are living in the warmest period since the 1980; it provides a methodological example of procedures to recover and analyse early instrumental series.

References:

Camuffo D., Della Valle A., Bertolin C. and Santorelli E., (2016), The Stancari Air Thermometer and the 1715-1737 record in Bologna, Italy, *Climatic Change*, 139 (3): 623-636.

Camuffo D., Della Valle A., Bertolin C. and Santorelli E., (2017), Temperature observations in Bologna, Italy, from 1715 to 1815, and three centuries of changing climate, *Climatic Change* (in print).

4. Climate, environment and public health in Catalonia. Endemic and epidemic malaria (1750-1850), from sanitarian policies to environmental issues

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The aim of this poster is to show a synthesis of the hypothesis, methodology and some preliminary results involved in the current thesis. The climate instability known as "Oscillation Maldà" (Barriendos & Llasat, 2003) is characterized by the extreme and simultaneous emergence of severe droughts and floods, storms, snows, that occurred since 1760 until the last decade of the 18th century. This climatic instability could have had a direct impact on the spread of epidemic malaria and its prevalence in endemic forms. Because of that, the principal objective of this thesis is to focus on 1770 until 1824 to detect the interaction of malaria along other bacterial or vector-borne diseases such as cholera or yellow fever in two cities from NE Catalonia (Barcelona and Girona). Another objective is to analyze the social outcomes of recurring epidemic situations. More concretely, crossing textual sources from municipal, ecclesiastical and private archives will let us better understand how was faced the epidemic context along climate instability. That is, how physicians along political authorities and institutions managed those situations to preserve Public Health. Moreover, the societal reactions and demographic impact of the detected epidemics is another interesting aspect as a consequence of the exposed problematic.

The conjunction of the exposed elements in a relational database may be useful to integrate research done by multidisciplinary research teams to analyze interactions between climate, epidemics and societies in a holistic perspective.

Reference:

Barriendos M. and Llasat M.C., (2003), The Case of the "Maldá" Anomaly in the Western Mediterranean Basin (AD 1760-1800): An Example of a Strong Climatic Variability, *Climatic Change*, 61 (1): 191-216.

5. Recent hydrological variability of the Moroccan Middle-Atlas Mountains inferred from sedimentological and geochemical analyses of lake sediments

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The frequency and/or intensity of extreme precipitation events and droughts is expected to increase in the Mediterranean basin in the 21st century (Giorgi & Lionello, 2008). Future adaptation to water availability in Moroccan regions will require a precise knowledge of its response to hydrological variability over the past century. The Moroccan Middle-Atlas Mountains is considered as the "Moroccan water tower" and contains several natural lake systems of tectono-karstic origin functioning as "pluviometer". This region suffers from scarcity of observational data that prevent a coherent management of water resources. In this context, the precise study of the lacustrine sedimentary infill can provide some key information about past hydrological changes. In this work, we focused on the micro-scale analysis of well-dated sedimentary deposits of Lake Azigza (32°58'N, 5°26'W, 1,470 meters a.s.l.). A combined approach based on elemental, mineralogical and geochemical measurements coupled to microfacies characterization of the sediments was conducted. We were able to provide proxies of runoff intensity and lake level changes calibrated to hydro-climate observations available for the last 50 years. These proxies were then applied to the entire sedimentary sequences covering the last 150 years providing a record of local hydrological changes for the pre-instrumental period in a vulnerable area.

Reference:

Giorgi F. and Lionello P., (2008), Climate change projections for the Mediterranean region, *Global and Planetary Change*, 63 (2-3): 90-104.

6. Oxygen isotopes from Sudanese mummies as natural archives for reconstructing long-term and seasonal Nile river fluctuations and past climate in Northeast Africa (3700-500 B.P.)

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The oxygen isotope compositions of bones (n = 11) and teeth (n = 20) from 12 Sudanese individuals buried on Sai Island (Nubia) were analyzed to investigate the registration of the evolution of the Nile environment from 3700 to 500 years BP and the potential effects of ontogeny on the oxygen isotope ratios. The isotopic compositions were converted into the composition of drinking water, ultimately originating from the Nile. δ18O values decrease during ontogeny; this is mainly related to breastfeeding and physiology. Those of neonates present very large variations. Neonates have a very high bone turnover and are thus able to record seasonal δ18O variations of the Nile waters. These variations followed a pattern very similar to the present one. Nile δ18O values increased from 1.4 to 4.4‰ (Vienna Standard Mean Ocean Water) from the Classic Kerma (~3500 BP) through the Christian period (~1000 BP), traducing a progressive drying of Northeast Africa.

7. Assessment of post-industrial sea-level rise acceleration along the Mediterranean coastlines

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Global sea-level rise is the result of an increase in the ocean volume, which evolves from changes in ocean mass due to melting of continental glaciers and ice sheets, and expansion of ocean water as it warms. Our understanding of current rates of sea-level rise from tide gauge and satellite data, requires correction for glacial isostatic adjustment (GIA) effects that are both calibrated to, and independently tested by, observations of former sea levels. We then reconstructed the Holocene (last 12.0 ka) sea-level histories in 21 regions located in the Western Mediterranean. At basin scale, RSL rose rapidly from 12.0 to 6.0 ka BP. Younger data showed a significant decrease in the rising rates in the last 6.0 ka. Preliminary comparison with long-term tidal gauge data (>50

years) indicates a significant acceleration (0.3 to 1.3 mm/y) sea-level rising rates in the last 100 years. Results of this study are relevant for understanding how GIA operates in the far field of late-Pleistocene ice sheets and to assess current and future sea level rise hazards, which are particularly magnified in low-lying or subsiding coastal areas.

8. Geoarchaeology of the Danube delta and palaeo-environment of ancient settlements (Histria, Enisala, Babadag and Halmyris)

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This poster will present the preliminary results of A*MIDEX-GEOMED and COFUND DOC2AMU geoarchaeological projects in the Danube Delta. Our research is based on a multiproxy approach, in order to understand the relation between the dynamic of human settlements and the evolution of the geomorphological context. In this respect, for the archaeological sites in discussion - Histria, Enisala, Babadag and Halmyris - we corroborated the archaeological data with the bio-sedimentological informations. The fluvial and deltaic sediments are rich archives that can provide high-resolution data in order to reconstruct the palaeo-environmental evolution and the human impacts - by analyzing palaeo-ecological signals we can see how, since Neolithic, human activity is an active factor in shaping the landscape. This multidisciplinary study aims to highlight the role of the constraints and the potentialities into the development of these human settlements which inhabited such a changing and challenging environment as is the Danube Delta.

9. The ancient harbors of cap Bon (Tunisia): geomorphology, climate context and recent discoveries

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Ancient ports are navigation spaces subject to specific constraints, which were built, first, to accommodate boats but also to facilitate loading, unloading and storage operations. During the past two decades, ancient ports have attracted the interest of archaeological and geological communities. The

growing corpus of studied sites demonstrates that ancient ports are rich archives of past societies and their environments, and provide a picture of coastal changes and processes that have had an impact on these shores. Ancient ports are therefore both natural and built landscapes.

It is within this framework that our study has focused on the ancient ports of the North coast of the Cap Bon in Tunisia. There are differences between the ports of the peninsula of Cap Bon.

The objectives of this study are:

1. To relocate the ancient ports of the North coast of Cap Bon (Sidi Daoud, Degla, Mraissa).

2. To understand the evolution of coastal sites in antiquity and maritime relationships between the different ports, in particular with the port of Ostia.

3. To analyze the archaeological material (ceramics, different structures... etc.), to date the creation of the ports and their locations in the coastal landscape.

4. To establish a general synthesis of the ancient ports of the North coast of Cap Bon from textual, archaeological and geomorphological archives. We will propose a typology of the natural geomorphological features and ancient port infrastructure.

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The eruption of Mount Vesuvius
(Joseph TURNER, between 1817 and 1820)