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Editorial

Long-Term Climate Variability in the Mediterranean Region

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Received: 12 October 2020; Accepted: 27 October 2020; Published: 30 October 2020

Abstract: The Mediterranean region is an area where prediction at different timescales (subseasonal to decadal or even longer) is challenging. In order to help constrain future projections, the study of past climate is crucial. By improving our knowledge about the past and current climate, our confidence in understanding the future climate will be improved. In this Special Issue, information about long-term climate variability in the Mediterranean region is assessed, including in particular historical climatology and model applications to assess past climate variability, present climate evolution, and future climate projections. The seven articles included in this Special Issue explore observations, proxies, re-analyses, and models for assessing the main characteristics, processes, and variability of the Mediterranean climate. The temporal range of these articles not only covers a wide period going from the present day to as far back as 25 centuries into the past but also covers projections of future climate over the next century.

Keywords: Mediterranean climate; historical climatology; documentary sources; dendroclimatology; dynamical downscaling; extreme events; future climate projections

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The Mediterranean climate is complex and is influenced by many factors and regions, including the North Atlantic; the continental regions of Europe and Asia, including distant areas such as Siberia or the Himalayas; the Indian Ocean and the tropical Pacific, which have well-known impacts from El Niño Southern Oscillation (ENSO) or South Asian Monsoon (SAM) (among others); and finally, the African continent, influenced by the Sahara desert and the regions affected by the Sahel monsoon [1–4]. Not only does the Mediterranean climate have remote geographical drivers, the affected timescales can vary greatly, while the availability of relevant instrumental data may not be long enough to resolve many of those timescales. However, the Mediterranean has the advantage of being a densely populated region since ancient times, and this population has left multiple records of its activity that, on many occasions, are closely related to weather conditions and can be used to better understand the climate of the past [5].

The articles published in this Special Issue take advantage of these historical records to identify and describe specific extreme events of the past. One example is the landslide that occurred in January 1831 in the Pedregoso mountains (Cabeza Del Buey, SW Spain) [6]. As the title says, this article describes the conditions that led to the torrential rains that resulted in land-slippage within a specific region of south-west Iberia. This landslide has not been previously documented and was only described in the local press, even though it involves an estimated amount of dislodged material in the order of 10,000 m^3. Although there is a lack of historical data in the region, García-Garrido et al. [6], using different reconstruction techniques, have found that the landslide was preceded by a prolonged period of unusually high precipitation consistent with a negative North Atlantic Oscillation (NAO) weather pattern during the winter of 1829/1830. In fact, that winter was characterized by one of the most negative values of the NAO index observed in the 200-year period spanning 1821–2019. This multidisciplinary work represents the first attempt to report and describe the main triggering mechanism for an historical landslide in the Extremadura region that might be used for other locations in the Mediterranean.

Other articles included in the Special Issue describe interannual variability of past extreme events, such as the work of Bravo-Paredes et al. [7]. In this study, ecclesiastical archives are analyzed to identify centennial episodes of intense droughts in the Extremadura region, south-west Spain (1824–1931) during a period in which instrumental information is very scarce or indeed non-existent, in some cases. The study recovered 37 pro-pluvia rogations (pro-pluvia rogations are prayers, mainly in western Christian countries and most of the time with processions, that were celebrated during dry periods to ask God for rain) from 14 ecclesiastical sources. Remarkably, since the climate of Extremadura is strongly dominated by the NAO, pro-pluvia rogations have been associated to the NAO index. Bravo-Paredes et al. [7] also found a connection between pro-pluvia rogations within a certain month and positive values of the NAO index for the two preceding months. This lends some support for the rogation ceremonies of Extremadura being used as a proxy for positive values of the NAO index. A third article utilizing historical documentation to reconstruct the south Iberian climate in the late 18th and early 19th centuries, is Rodrigo [8]. The data used in this study were from newspapers, which published weekly summaries of the weather conditions in Spain over this period. The study focuses on the southern provinces, providing 2788 new records, some of them corresponding to areas with no previously recorded data in Andalusia. From these records, the paper shows that this region and period were characterized by cold and dry winters, cold and wet springs, warm and dry summers, and variable autumn conditions; it was cold and humid in the western Andalusia, while warm and dry in the eastern Andalusia.

Other proxies of past climate are introduced in this Special Issue. Dendroclimatic proxies are used to verify the robust influence of certain circulation patterns on rain or drought conditions in different regions of the Mediterranean. Casas-Gómez et al. [9] analyze the stability and seasonal influence of the NAO and the Westerly Index (WI) throughout the 20th century until present using dendroclimatic data representative of intense drought events in mountain areas in the western, central, and eastern Mediterranean basin. Their results indicate that the drought variability and the inferred drought-sensitive tree species (e.g., C. atlantica) are influenced by the NAO and the WI, showing that tree-ring width data is a feasible proxy to long-term reconstructions of WI variability in the western Mediterranean region. Spatial variability of drought severity suggests a complex association between NAO and WI, likely modulated by an east/west Mediterranean climate dipole.

In addition to proxy data and early observations, climate model simulations are also important for understanding, analyzing, and characterizing climate variability. In this issue, several articles are presented in which model simulations are used to provide added information about the climate of the past [10], in characterizing the current climate [11], or for studying its possible future climate evolution [12]. In the first case, Zerefos et al. [10] used current data and high spatial resolution simulations to explain the meteorological and climatic conditions, which helped the ancient Greeks to defeat the Persians in the naval battle of Thermopylae 25 centuries ago. The article uses the power of current models to interpret historical data, including the persistence in time of different regional wind regimes, such as the Etesians or local breezes, throughout the centuries. Vegas-Cañas et al. [11] show an interesting application of dynamical downscaling using a mesoscale weather prediction model (WRF) to characterize, with very high spatial resolution, complex orography, such as the Sierra de Guadarrama in the center of the Iberian Peninsula. Their results show that the model tends to underestimate the observational mean temperatures and anomalies at high-altitude stations. The variability of daily temperature anomalies for both observations and, to a lesser extent, simulations increases with height. They also show that in some cases the WRF model outperforms the reanalysis, showing smaller biases with respect to observational temperature anomalies. The study of temperature trends over the Sierra de Guadarrama and its surroundings, for the period 2000–2018, shows a significantly pronounced warming in the area during autumn. When extended to recent decades, observations show that this warming has been happening since the first half of the 20th century, especially during the period 1970–2018, but not as intensely as during the 2000–2018 period. The Vegas-Cañas et al. [11] results can be applied to, for example, the generation of local climatologies of a longer duration and with very high spatial resolution anywhere in the Mediterranean basin. Finally, Portero Serrano et al. [12] use models and high spatial resolution data based on dynamical downscaling to explore projections of extreme (thermal) events into the 21st century over Iberia. Their results show that the variability of maximum temperatures will decrease over western Iberia, while the Mediterranean area will show an increase in this variability. They have found an increase in the frequency of warm events for the southwestern corner of the Peninsula, a region where the maximum temperatures will be higher at the end of the century. However, they have found that in the Mediterranean region, warm events will last longer.

Author Contributions: M.C.A.-C. and P.R. have designed this research. M.C.A.-C. has written the manuscript and P.R. has actively participated in the writing. All authors have read and agreed to the published version of the manuscript.

Funding: We thank the Junta de Andalucía for providing support to the PAIDI RNM-356 research group.

Acknowledgments: We thank all authors and reviewers for this Special Issue, and Colin Chen and Pacey Chen for their editorial help.

Conflicts of Interest: There are no conflict of interest associated with this paper.

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