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Marine response to climate changes during the last five millennia in the central Mediterranean Sea

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ABSTRACT

We present a high-resolution paleoclimatic and paleoenvironmental reconstruction of the last five millennia from a shallow water marine sedimentary record from the central Tyrrhenian Sea (Gulf of Gaeta) using planktonic foraminifera, pollen, oxygen stable isotope, tephrostratigrapy and magnetostratigrapy. This multiproxy approach allows to evidence and characterize nine time intervals associated with archaeological/cultural periods: Eneolithic (base of the core–ca. 2410 BCE), Early Bronze Age (ca. 2410 BCE–ca. 1900 BCE), Middle Bronze Age–Iron Age (ca. 1900 BCE–ca. 500 BCE), Roman Period (ca. 500 BCE–ca. 550 CE), Dark Age (ca. 550 CE–ca. 860 CE), Medieval Climate Anomaly (ca. 860 CE–ca. 1250 CE), Little Ice Age (ca. 1250 CE–ca. 1850 CE), Industrial Period (ca. 1850 CE–ca. 1950 CE), Modern Warm Period (ca. 1950 CE–present day). The reconstructed climatic evolution in the investigated sedimentary succession is coherent with the short-term climate variability documented at the Mediterranean scale.
By integrating the planktonic foraminiferal turnover from carnivorous to herbivorous–opportunistic species, the oxygen isotope record and the pollen distribution, we document important modification from the onset of the Roman Period to the present-day. From ca. 500 CE upwards the documentation of the cooling trend punctuated by climate variability at secular scale evidenced by the short-term $\delta^{18}O$ is very detailed. We hypothesise that the present day warm conditions started from the end of cold Maunder event. Additionally, we provide that the North Atlantic Oscillation (NAO) directly affected the central Mediterranean region during the investigated time interval.

1. Introduction

Over the last millennia, the Mediterranean Sea was affected by very significant shifts in climate (i.e., Luterbacher et al., 2012; Maselli and Trincardi, 2013; Büntgen et al., 2016). The most common phases may be correlated with the major archaeological subdivisions found in the literature: Roman Period, Dark Age, Medieval Climate Anomaly and Little Ice Age (i.e., Luterbacher et al., 2012; Büntgen et al., 2016 and references therein).

However, it is worth noting the consensus, over the last two millennia, concerning the used and the chronology of terms Little Ice Age (LIA), Medieval Climate Anomaly (MCA) and Dark Age (i.e., Luterbacher et al., 2012 and references therein). This consensus is basically related to Pages 2k Network research activities (mostly tree ring data, i.e., Büntgen et al., 2016 and references therein). Recently, marine data also contributed to recognition of these events (i.e., Lirer et al., 2014; Holmgren et al., 2015; Cisneros et al., 2016). No agreement exists about the climatic variability during the second half (first 400 years CE) of the Roman Period (Table 1). In fact, despite of the data available for this part of the Roman Period (i.e., Moreno et al., 2012; Grauel et al., 2013; Lirer et al., 2014; Goudeau et al., 2015; Cisneros et al., 2016; Gogou et al., 2016), other factors as local overprint (i.e., Cisneros et al., 2016), a non-uniform response of climate signals among the various basins (Gogou et al., 2016) and the sensitivity of

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Table 1
Table with ages and nomenclature of the climatic events documented in marine Mediterranean records for the last five millennia compared with the archaeological periods reported by Roberts et al. (2011). The acronym LBA corresponds to Late Bronze Age.

Nieto-Moreno et al. (2011)		Nieto Moreno et al. (2012)		Lirer et al. (2014)		Grauel et al. (2013)		Goudeau et al. (2015)		Piva et al. (2008a)		Gogou et al. (2012)		Roberts et al. (2011)	
West Algerian–Balearic basin		Western Alborean Sea		South Tyrrhenian Sea		Ionian Sea		Ionian Sea		Adriatic Sea		Aegean Sea		Italy	
Climatic phase	Ages	Climatic phase	Ages	Climatic phase	Ages	Climatic phase	Ages	Climatic phase	Ages	Climatic phase	Ages	Climatic phase	Ages	Achaeological Period	Ages
				Modern Warm Period	1940 CE–upwards			Present	1904 CE–1958 CE						
		Industrial Period	1800 CE–upwards	Industrial Period	1940 CE–1850 CE										
Little Ice Age	1800 CE–1300 CE	Little Ice Age	1800 CE–1300 CE	Little Ice Age	1850 CE–1240 CE	Little Ice Age	1850 CE1400 CE	Little Ice Age	1850 CE–1400 CE	Little Ice Age	1840 CE–1400 CE	Little Ice Age	1850 CE–1300 CE		
Medieval Classic Anomaly	1300 CE–800 CE	Medieval Classic Anomaly	1300 CE–800 CE	Medieval Classic Anomaly	1240 CE–840 CE	Medieval Warm Period	1200 CE–800 CE	Medieval Classic Anomaly	1200 CE — 800 CE	Medieval Warm Period	1200 CE–600 CE	Medieval Warm Period	1300 CE–900 CE		
Dark Age	800 CE–350 CE	Dark Age	800 CE–300 CE	Dark Age	840 CE–530 CE	Dark Age	750 CE–500 CE			Dark Age	600 CE–350 CE	Dark Age	900 CE–500 CE		
Roman Humid Period	350 CE–650 BCE	Roman Humid Period	300 CE–650 BCE	Roman period	Top–530 CE	Roman Warm Period	200 CE–1 CE	Roman Humid Period	450 BCE–0 CE	Roman Warm Period	350 CE–100–BCE	Roman Warm Period	500 CE–0 CE	Roman Period	Top–ca. 500 BCE
LBA/Iron Age	650 BCE–1650 BCE							Bronze Age	500 BCE–1500 BCE	Iron Age	ca. 100 BCE–1500 BCE			Greek–Etrurian	ca. 500 BCE–750 BCE
										Late Bronze Age	ca.1500 BCE–1850 BCE			Early Iron Age	ca. 750 BCE — 1050 BCE
										Ancient Bronze Age	ca.1850 BCE –2600 BCE			Late Bronze Age	ca.1050 BCE–1450 BCE
										Copper Age	ca.2600 BCE –2800 BCE			Middle Bronze	ca.1450 BCE–1750 BCE
														Early Bronze	ca.1750 BCE–2250 BCE