ScienceDirect

Quaternary Science Reviews
Volume 30, Issues 27–28, December 2011, Pages 3880-3891

Short term climate variability during “Roman Classical Period” in the eastern Mediterranean

Liang Chen [a], Karin A.F. Zonneveld [a b], Gerard J.M. Versteegh [b]

Show more

Share Cite

https://doi.org/10.1016/j.quascirev.2011.09.024
Get rights and content

Abstract

To obtain insight into character and potential forcing of short-term climatic and oceanographic variability in the southern Italian region during the “Roman Classical Period” (60 BC–AD 200), climatic and environmental reconstructions based on a dinoflagelate cyst record from a well dated site in the Gulf of Taranto located at the distal end of the Po-river discharge plume have been established with high temporal resolution. Short-term fluctuations in accumulation rates of the Adriatic Surface Water species *Lingulodinium machaerophorum*, the freshwater algae *Concentricystes* and species resistant to aerobic degradation indicate that fluctuations in the trophic state of the upper waters are related to river discharge of northern and eastern Italian rivers which in turn are strongly related to precipitation in Italy.

The dinoflagellate cyst association indicates that local sea surface temperatures which in this region are strongly linked to local air temperatures were slightly higher than today. We reconstruct that sea surface temperatures have been relatively high and stable between 60 BC–AD 90 and show a decreasing trend after AD 90. Fluctuations in temperature and river discharge rates have a strong cyclic character with main cyclicities of 7–8 and 11 years. We argue that these cycles are related to variations of the North Atlantic Oscillation climate mode. A strong correlation is observed with global variation in $\Delta^{14}C$ anomalies suggesting that solar variability might be one of the major forcings of the regional climate. Apart from cyclic climate variability we observed a good correlation between non-cyclic temperature drops and global volcanic activity indicating that the latter forms an additional major forcing factor of the southern Italian climate during the Roman Classical Period.

Highlights

► High resolution marine sediments covering “Roman Classical Period”. ► Dinoflagelate cysts records reveal climatic perturbations. ► Sea surface temperatures are higher than today. ► Nutrients are mainly from river discharge. ► Cyclic climate changes are linked to North Atlantic Oscillation and solar forcing.

Introduction

The current abrupt rise in global temperature within the last century has resulted in major concern about future climate change (IPCC, 2007). Although it is obvious that anthropogenic activities influence climate, natural processes steer climate as well (Stott etal., 2000, Carslaw etal., 2002). This has resulted in intensive discussions in the academic

community and general society alike about to what extent these natural processes might be responsible for the present change of climate. Unfortunately, to date, the character and influence of the natural forcing mechanisms are far from clear.

One of the most intriguing questions within the climate debate is if the present temperature rise is unique in the late Holocene or if there have been pre-industrial time intervals where comparable climatic perturbations occurred. One of these time intervals where historical records suggest that climate conditions might have been similar to today is the so called “Roman Warm Period” (≈BC 200–AD 400) (Lamb, 1977). This period also referred to as the“Roman classical period” is known for the expansion of the Roman culture all around the Mediterranean region and throughout a large part of Europe. However, to date it is not clear if this period was warmer, comparable or cooler than today (Bianchi and McCave, 1999, deMenocal et al., 2000, Frisia et al., 2005, Giraudi, 2009, Taricco et al., 2009). Furthermore, it is not clear which forcing mechanisms steered the short-term climate fluctuationsthat are known for this time interval. Here we aim to obtain more insight into this by reconstructing past marine environment and climate variability in one of the central regions of the Roman occupation - southeastern Italy. For this we establish detailed reconstructions of past changes in climate and marine environment based on fossil sedimentary dinoflagellate cyst associations.

Dinoflagellates are primarily unicellular organisms with twodistinctive flagella and a characteristic nucleus (Fensome et al., 1993). Together with diatoms and coccolithophorids, dinoflagellates constitute the majority of the marine eukaryotic phytoplankton. As part of their life cycle, many dinoflagellate species can produce cysts of which the walls have a high preservation potential. Organic walled dinoflagellate cysts (dinocysts) have been shown to be a suitable proxy for establishing environmental and climatic reconstructions as the cyst associations reflect even small changes in upper water conditions such as sea surface temperature (SST), salinity (SSS) and nutrient availability (De Vernal et al., 1997, Marret et al., 2001, Dale et al., 2002, Sangiorgi et al., 2002, Pospelova et al., 2006).

Here we present reconstructions that base on well dated marine sediments from the southeastern Gulf of Taranto which are characterized by high sedimentation rates and low bioturbation, the linear interpolation of the radiocarbon dates allows an approximately 4 year resolution detection of paleoenvironmental change. We show that changes in dinoflagellate associations reflect changes in past river discharge, upper water nutrient availability and SST. To obtain insight into the cause and origin of the variability of these signals, we compare our records with temperature and precipitation reconstructions from other lower resolution studies in the region based on e.g. pollen and speleothems. Furthermore, we compare them with climate forcing factors such as solar activity, volcanism and African dust input. By comparing our results with historical records we are able to speculate about the potential relationship between climate and cultural developments.

Section snippets

Ocean circulation

The ocean circulation of Gulf of Taranto is strongly related to that of the Adriatic Sea. Surface waters in the southeastern part form the distal part “river-discharge” waters that can be traced along the whole eastern Italian coast. The main source of these waters is from the Po river (Fig. 1). The Po-river is the largest Italian river with a length of about 673 km that drains the southern part of the Alps and the northern part of Italy. It supplies high amounts of freshwater, nutrients and…

Material and sample preparation

Samples have been analyzed from the section 8 (722–910 cm) of the piston core DP30PC which was retrieved during the RV Pelagia, DOPPIO cruise, 2008 (39° 50.07′ N, 17°48.05′ E, water depth 270 m). The core is located at the margin of the ocean where increased salinity in the water column can be observed along onshore-offshore transect (Fig. 1, Fig. 3). The studied section of the piston core is composed of homogeneous olive-gray silt (Fig. 4). Sediments were subsampled at every 2.5 mm. After…

Results

The degradation index (kt) varies from 1.4 to 4.3 in the studied interval. It shows relatively low values between and BC 60 and 60 AD (Fig.5), and stays relatively stable throughout the whole sequence.

Accumulation rates of the dinoflagellate cyst *Lingulodinium machaerophorum* and freshwater alga *Concentricystes* show no increasing or decreasing trend through the studied interval but fluctuate around the mean of 8.6 cyst/cm^2/y and 0.8 cyst/cm^2/y respectively. Their accumulation rates fluctuate…

Preservation and relocation

During the last decade it has became clear that post-depositional aerobic organic matter (OM) degradation can severely alter the dinoflagellate cyst signal (Versteegh and Zonneveld, 2002, Zonneveld etal., 2010b). The reconstructed degradation index (kt) shows an average value of 3.3 indicating that the environmental signal from heterotrophic dinoflagellate cysts have been altered due to degradation. This implies that only the accumulation rates of cyst species that are resistant to aerobic…

Conclusion

To obtain insight into character and potential forcing of short-term climatic and oceanographic variability in the southern Italian region during the “Roman Classical Period” (60 BC–200 AD), detailed high temporal resolution climatic and environmental reconstructions based on a dinoflagelate cyst record from a well dated site in the Gulf of Taranto located at the distal end of the Po-river discharge plume have been established.

Changes in cyst accumulation rates are shown to reflect short-term…

Acknowledgments

The study is funded by ESF (European Science Foundation) MOCCHA project (Multidisciplinary study of continental/ocean climate dynamics using high-resolution records from the eastern Mediterranean). We thank all the group members in Historical Geology and Palaeontology, Bremen University for the laboratory help and fruitful discussions. We thank Anna-Lena Grauel, Stefano M. Bernasconi and the AMS ^{14}C Dating Laboratory at ETH Zurich for preparing, measuring and calibrating the AMS ^{14}C-dates. We…

Recommended articles

Research data for this article

PANGAEA

Data Publisher for Earth & Environmental Science

Data associated with the article:

(Table 1) Radiocarbon dates of core DP30PC ↗

Raw counts of dinoflagellate cysts of sediment core DP30PC ↗

Further information on research data ↗

References (119)

A. Asioli

Sub-millennial scale climatic oscillations in the central Adriatic during the Lateglacial: palaeoceanographic implications
Quaternary Science Reviews (2001)

W.H. Berger
Solar modulation of the North Atlantic Oscillation: assisted by the tides?
Quaternary International (2008)

M.W. Binford
Climate variation and the rise and fall of an Andean civilization
Quaternary Research (1997)

A. Boldrin *et al.*
Po River plume on the Adriatic continental shelf: dispersion and sedimentation of dissolved and suspended matter during different river discharge rates
Marine Geology (2005)

N. Combourieu-Nebout *et al.*
Ahigh-resolution record of the last deglaciation in the Central Mediterranean Sea: palaeovegetation and palaeohydrological evolution
Quaternary Science Reviews (1998)

B. Dale *et al.*
Dinoflagellate cysts as environmental indicators in surface sediments from the Congo deep-sea fan and adjacent regions
Palaeogeography Palaeoclimatology Palaeoecology (2002)

A. De Vernal *et al.*
Organic-walled dinoflagellate cysts: palynological tracers of sea-surface conditions in middle to high latitude marine environments
Geobios (1997)

D. Degobbis *et al.*
An annotated nitrogen budget calculation for the Northern Adriatic Sea
Marine Chemistry (1986)

C. de Jager *et al.*
Quantifying and specifying the solar influence on terrestrial surface temperature
Journal of Atmospheric and Solar-Terrestrial Physics (2010)

A.D. Erlykin *et al.*
Correlations of clouds, cosmic rays and solar irradiation over the earth
Journal of Atmospheric and Solar-Terrestrial Physics (2010)

View more references

Cited by (32)

Macroecological patterns of the terrestrial vegetation history during the end-Triassic biotic crisis in the central European Basin: A palynological study of the Bonenburg section (NW-Germany) and its supra-regional implications
2020, Global and Planetary Change

Citation Excerpt :

…Alternating higher abundances between Leiosphaeridia and Botryococcus in the Triletes Beds attest to interchanging episodes of stronger marine influence and increased freshwater influxes leading to more brackish conditions, respectively, suggesting a deltaic environment for the Triletes Beds. The appearance of Concentricystes, regarded a freshwater indicator at least in quaternary deposits (Chen et al., 2011; Horton et al., 2005; Norris, 1965), together with the sudden peak of Botryococcus at the base of the Triletes Beds and an influx of Chlorophyceae (Fig. 4) coinciding with the appearance of reworked palynomorphs (aquatic and terrestrial) at the top of the Triletes Beds (Figs. 4 and 5) suggests an elevated riverine influx. Given the coincidence with other reworked taxa we cannot exclude that occurrences of Plaesiodictyon mosselanum and Concentricystes are the result of reworking.…

Show abstract

Influence of solar activity changes on European rainfall

2019, Journal of Atmospheric and Solar-Terrestrial Physics

Show abstract

Signatures of global climatic events and forcing factors for the last two millennia from the active mudflats of Rohisa, southern Saurashtra, Gujarat, western India

2019, Quaternary International

Show abstract

Mid–late Holocene monsoonal records from the partially active mudflat of Diu Island, southern Saurashtra, Gujarat, western India

2017, Quaternary International

Citation Excerpt :

…The global climatic variability during last 2000 yr BP has been extensively studied (Barber et al., 2000; Briffa, 2000; Proctor et al., 2000; Agnihotri et al., 2002; Mangini et al., 2005; Rühland et al., 2006; Warrier et al., 2014) due to the influence of both natural and anthropogenically induced climatic perturbations. The climatic history of this period has been divided into five periods viz. Roman warm period (RWP), Dark Ages of Cold Period (DACP), Medieval Warm Period (MWP), Little Ice Age (LIA) and Modern Warming (MW) (Lamb, 1965; Norgaard-Pedersen and Mikkelsen, 2009; Oppo et al., 2009; Chen et al., 2011). The MWP, LIA and MW has been the focus of discussion in most of the previous studies (Agnihotri et al., 2002; Rühland et al., 2006; Warrier and Shankar, 2009; Veena et al., 2014; Warrier et al., 2014; Singh et al., 2015).…

Show abstract

The environmental elements of foundations in Roman cities: A theory of the architect Gaetano Vinaccia

2017, Sustainable Cities and Society

Citation Excerpt :

…Previous research on this topic reiterated similar results (Ljungqvist, 2010; Eddy, 1979). Chen et al. (2011) studies on climate variability during the Roman Classical Period in the eastern Mediterranean, demonstrated a warmer period from 60 B.C. to 200 A.D., through the analyses of dinoflagellate cysts in the Adriatic Sea. Chen et al.’s (2011) results stated that air temperatures during the Roman period were similar to those of today.…

Show abstract

Dinoflagellate cyst based modern analogue technique at test - A 300 year record from the Gulf of Taranto (Eastern Mediterranean)

2016, Palaeogeography, Palaeoclimatology, Palaeoecology

Show abstract

View all citing articles on Scopus

View full text