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International MedCLIVAR-ICTP-ENEA Summer School on the Mediterranean Climate System and Regional Climate Change

13 - 22 September 2010

Paleo: Mediterranean paleoclimate evidence. Sources and reconstructions

XOPLAKI Elena Cyprus Meteorological Service L. Nikis 28, 1086 Lefkosia Lefkosia

CYPRUS

Mediterranean paleoclimate evidence Sources and reconstructions

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MedCLIVAR

Mediterranean Climate Variability



DEVELOPMENTS IN

MEDITERRANEAN CLIMATE VARIABILITY

P. LIONELLO, P. MALANOTTE-RIZZOLI AND R. BOSCOLO (EDITORS)



Constigning Releval

Mediterranean climate variability, 2006

Chapter 1

Mediterranean Climate Variability Over the Last Centuries: A Review

Jürg Luterbacher,¹ Elena Xoplaki,¹ Carlo Casty,¹ Heinz Wanner,¹ Andreas Pauling,² Marcel Küttel,² This Rutishauser,² Stefan Brönnimann,³ Erich Fischer,³ Dominik Fleitmann,⁴ Fidel J. González-Rouco,⁵ Ricardo García-Herrera,⁵ Mariano Barriendos,⁶ Fernando Rodrigo,⁷ Jose Carlos Gonzalez-Hidalgo,⁸ Miguel Angel Saz,⁸ Luis Gimeno,⁹ Pedro Ribera,¹⁰ Manola Brunet,¹¹ Heiko Paeth,¹² Norel Rimbu,¹³ Thomas Felis,¹⁴ Jucundus Jacobeit,¹⁵ Armin Dünkeloh,¹⁶ Eduardo Zorita,¹⁷ Joel Guiot,¹⁸ Murat Türkes,¹⁹ Maria Joao Alcoforado,²⁰ Ricardo Trigo,²¹ Dennis Wheeler,²² Simon Tett,²³ Michael E. Mann,²⁴ Ramzi Touchan,²⁵ Drew T. Shindell,²⁶ Sergio Silenzi,²⁷ Paolo Montagna,²⁷ Dario Camuffo,²⁸ Annarita Mariotti,²⁹ Teresa Nanni,³⁰ Michele Brunetti,³⁰ Maurizio Maugeri,³¹ Christos Zerefos,³² Simona De Zolt,³³ Piero Lionello,³³ M. Fatima Nunes,³⁴ Volker Rath,³⁵ Hugo Beltrami,³⁶ Emmanuel Garnier³⁷ and Emmanuel Le Roy Ladurie³⁸

Symposium on

Climate Extremes **During Recent Millennia** and their Impact on **Mediterranean Societies**

13-16 September 2008 Athens Greece



"Climate Extremes During Recent Millennia and their Impact on Mediterranean Societies"









Types of climatic evidence

	Natura	I Archives	Societal Archives				
<i>Direct Data</i> - Measurements				<i>Descriptions</i> - Weather diaries	<i>Measurements</i>Temperature,		
-			ents	 Natural disasters … 	precipitation, pressure		
<i>Indirect or proxy data</i>	Organic	Inorganic	docum	<i>Organic</i> - Phenological data	<i>Inorganic</i> - Flood marks		
	 Tree rings 	Ice coresBoreholesVarves	Historical	 (Grape) Harvest 	 Icing and break-ups Duration of snow cover 		
			-	Religious Sources			
				- Inscriptions, Paintings	- Rogation processions 		

Pfister 1999

Spatial distribution of proxies 1000, 1500 and 1750



Measurements
Tree ring information
Borehole

- ***** Ice
- Other proxies

Jansen et al., 2007, IPCC

Outline

Natural proxies
Documentary proxies
Use and application of proxy information for the study of the Mediterranean past climate

Conclusions

Natural proxies in the Mediterranean

Red Sea corals



High resolved proxy for temperature, aridity, SSTs

Thomas Felis

Red Sea corals



Modern reef (Gulf of Aqaba, northernmost Red Sea)

Thomas Felis

AO/NAO and coral d18O seasonality (northernmost Red Sea)



Corals in Red Sea



Felis et al. 2000

Vermetids





Non tropical corals, seasonal to multi-decadal proxy ^for seawater chemistry, productivity, SSTs, sea level



Silenzi et al. 2004 Montagna et al. 2006

Speleothems

Temperature or precipitation indicators of annual to decadal resolution



Central Alps, Italian Alps, Sardinia, Turkey, ...



Speleothem-based climate reconstructions

Dominik Fleitmann





Uranium Series Dating

Back to ~400.000 kyr B.P. (Before Present) Absolute ages Small age uncertainties



Oxygen and carbon isotopes

"Environmental isotopes" Oxygen isotope ratios in speleothems directly reflect climate (e.g., Amount of rainfall)

Carbon isotope ratios often reflect the type of vegetation above the cave

Trace Elements

Sub-monthly resolution possible Mg, Na, K, Sr, Ba concentrations in speleothem calcite often reflect climate S reflects atmospheric sulfur contents of the atmosphere

Annual Band Thickness

"Tree rings" Thickness reflects amount of precipitation

Speleothem Fluid Inclusions

Trapped groundwater and precipitation Noble gas concentrations and Hydrogen isotopic compositon.

Paleotemperatures & Atmospheric gas conc.

Speleothem-based climate reconstructions



Dominik Fleitmann





Tree ring-based climate reconstructions





Touchan et al. 2005

Tree ring-based climate reconstructions



Till and Guiot 1990





Spatial distribution of 847 tree ring width sites and correlation with JJA temperature (left) and precipitation (right)



→ Pyrenees and Alpine sites reflect summer temperatures
 → Sites in the south reflect hydroclimatic evidence (seasonal dependent)

Luterbacher et al. 2011; Büntgen, pers. comm.

Drought reconstructions in Morocco based on Altas Cedar trees; drought during MCA



Esper, Luterbacher, Xoplaki et al. 2007

Varved sediments



Ray Bradley

Lake sediments from the Mediterranean





Tinner et al. in prep.

Documentary proxies in the Mediterranean

Documentary data to study past climate

- narrative sources

 (annals, chronicles, memories)
- visual daily weather records
- personal correspondence
- newspapers
- scientific papers
- epigraphic records
- economic records

 (books of accounts,
 correspondence, reports on
 natural disasters)



Pfister 1999, Brazdil et al. 2005

Documentary sources containing climate information



Earliest continuous diary dates in Spain: F. Salvà, Barcelona, January 1780

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Barriendos, pers. comm.

Other documentary sources



Files and plans of public works



Early cartography





Old pictures



Early photography

Eduardo Rama

Early instruments







Pisa pressure; November 1657 - May 1658



Camuffo et al. 2010

Damage report in irrigation Barcelona (left) & Barcelona flood 1862 (right)

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Luterbacher et al. 2006

1000-yr of the Venice lagoon freezing



Camuffo 1997

Rogation ceremony

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Girona, April 1642 Saint Narcisus first bishop in Girona



Luterbacher et al. 2006

1907 – 2007, 100 years from the Segre flood







Arabic chronicles

Annals "palatinos"

Different meteorological notices appear in the document written by the Arab historian Al-Razi narrating the most outstanding events of the caliphate of Cordoba in the period 971-975. The chronicles of al-Razi report numerous weatehr related events. The most important are those related to agriculture- heavy rains, storms, hurricane force winds, hail, and frost. Also cited are the filoxox S of the River Guadalquivir because of their great social impact.

EL CALIFATO DE CORDOBA EN EL «MUQTABIS» DE IBN HAYYAN.

ANALES PALATINOS DEL CALIFA DE CORDOBA AL-HAKAM II, POR (ĪSĀ IBN AHMAD AL-RĀZĪ

(360-364 H. = 971-975 J. C.)

TRADUCCION DE UN MS. ARABE DE LA REAL ACADEMIA DE LA HISTORIA POR EMILIO GARCIA GOMEZ de la Real Academia Fapatiola y de la Academia Nacionale dei Lineri



SOCIEDAD DE ESTUDIOS Y PUBLICACIONES MADRID, 1967

Jose Vaquero

Nilometer (instrument that measures the height of the Nile waters during its periodical flood)



Pharaonic and medieval Egypt depended solely on winter agriculture and hence on summer floods. The rise of the waters of the Nile was measured regularly from the earliest times.

compiled the annual maxima and minima of the water level recorded at nilometers, back to the 7th century.

Luigi Mayer, R. Brown Historic Gallery, Pall Mall 1802

Annual record of flood (above) and low-water (below) at Roda Island, Cairo, based on Nilometer



MCA (~950-1250) characterised by a low variability in flood record and low proportion of weak nile floods

Record suggest that MCA was a period during which periodicities possibly linked to solar periods ,lose' their temporal stability

De Putter et al. 1999



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Ricardo García-Herrera



Ship log data – CLIWOC



Copyright: Nicholas Pocock's painting of the East India Company's Hindostan. By courtesy (until 2013) of the National Maritime Museum, Greenwich (UK) http://icoads.noaa.gov/reclaim/images/BHC1097_Pocock_E_Indiaman.jpg

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García-Herrera et al. 2005

Use and application of proxy information for the study of the Mediterranean past climate

Combination of documentary data to reconstruct precipitation, Barcelona 1501-1851



Number of catastrophic floods in Catalonia



Location of proxies



Mediterranean temperature reconstructions



Distribution of proxies (documentary & natural) over the Mediterranean area



Luterbacher et al. 2006, updated

Reconstruction methodology (PCA-multivariate regression)



Luterbacher et al. 2004

Mediterranean winter temperature from 1500



Winter ∏ 1973-2002 minus 1961-1990



Mediterranean winter precipitation from 1500



Mediterranean summer temperature from 1500



Reconstruction: Winter 1753



Küttel et al. 2010

Reconstruction: Winter 1753

Instr only









Instr & CLIWOC

Küttel et al. 2010

Annual Mediterranean temperature reconstruction



CCA1, 1750-2006 The EA/WRUS-like pattern



CCA2, 1750-2006 The NAO-like pattern



Conclusions

- The Mediterranean offers a broad spectrum of long instrumental, documentary and natural proxies
- Additional high quality and high resolution records are needed
- Multiproxy reconstructions allow insight in spatial and temporal details about past climate variations and related atmospheric circulation
- Future research should focus on developing stronger integration and exchange between the paleo-data researchers and dynamical/modelling communities

Thank you very much for your attention!