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## **Climate Change and social transformations in the past (12ka BP): from field data acquisition towards socio-ecological modeling**

Laurent Lespez, Maria-Angela Bassetti, Jean-François Berger, Jean-Michel Carozza, Laurent Carozza, Nathalie Combourieu Nebout, Laurent Dezileau, Arthur Glais, Matthieu Ghilardi, Catherine Kuzucuoğlu, et al.

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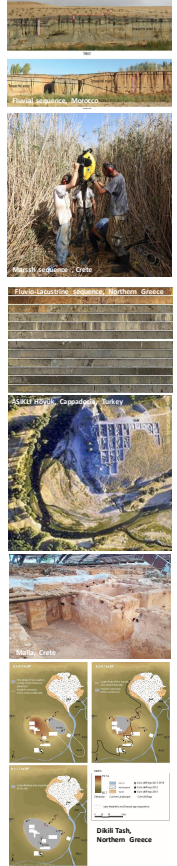
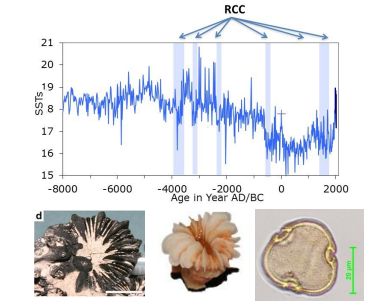
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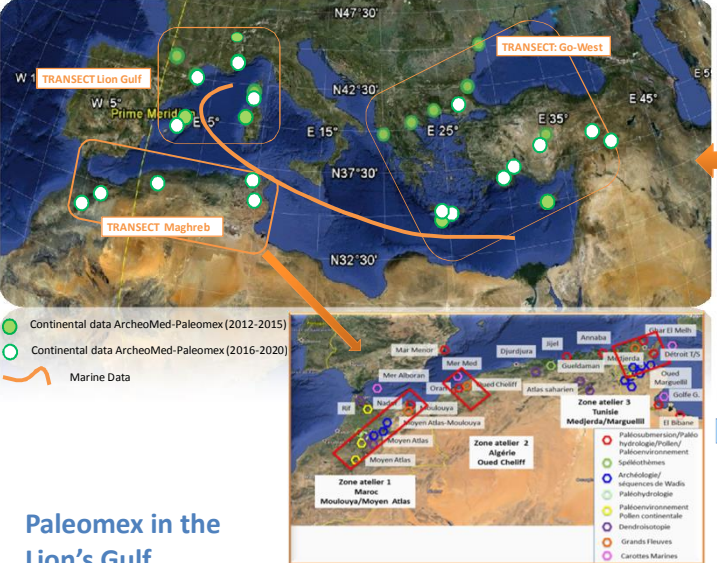
1. LGP-UMR CNRS 8591 - Université de Paris Est - Créteil et Université de Paris 1, 2. CEFREM-UMR CNRS 5110, 3. EVS-UMR CNRS 5600 - Université Lyon 2, 4. LIENS, UMR 7266, CNRS - Université de La Rochelle, 5. GEODE-UMR CNRS 5602 - Université Toulouse 2 « Jean Jaurès », 6. Géosciences Montpellier UMR CNRS 5243, 7. LETG Caen UMR CNRS 6554 - Université de Caen Normandie, 8. CEREGE-UMR CNRS 7330 - Université d'Aix-Marseille, 9. ISEM Montpellier, 10. Laboratoire EDYTEM - UMR CNRS 5204, Université Savoie Mont Blanc, 11. Chrono-Environnement-UMR CNRS 6249, Université de Franche-Comté, Besançon, 12. LOCEAN, Sorbonne universités, 13. GEOGLOB, Université de Sfax, Sfax, Tunisie.

**Objectives and challenges**

- “ Climatic trends in Mediterranean areas during the Holocene (from 12 ka BP)
- “ Definition of the spatial and temporal variability of the Rapid Climate Changes (RCCs)
- ⇒ Climate change and impact on cultural and political dynamic?
- Neolithic (9.2, 8.2 and 6-5 ka BP)
- Bronze Age (4.2 ka cal BP)
- Final Bronze Age and Historical periods (3.2-2.8 and 1.3 et 0.7 ka cal. BP)



**Methods : 4 transects – multiproxies analyses**

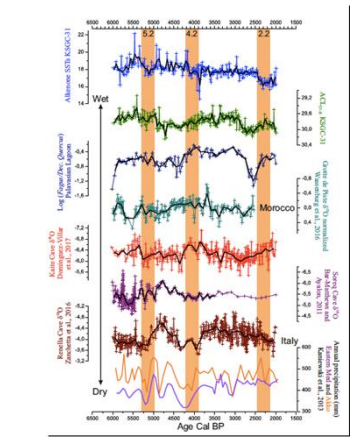


- Long marine sequences ....
- Analyses of long pollen and fire signature series for high resolution climate changes analyses (e.g. modern analogs - Peyron et al., 2017; Vannière et al., 2015)
- High resolution analyses of lake and fluvial sequences (ex. 8.2 tripartition in Berger et al., CP 2016)
- Socio-political changes : cultural areas, settlement, political changes (e.g. Carozza et al., 2015; Lespez et al., 2016a, b)

⇒ Climate modelisation  
 ⇒ Climate-Environment-Societies interactions (ex. Saqalli, M., Tilman B. 2015.)

**Paleomex in the Lion's Gulf**

Improve climate and environmental change: seesaw across the Mediterranean basin



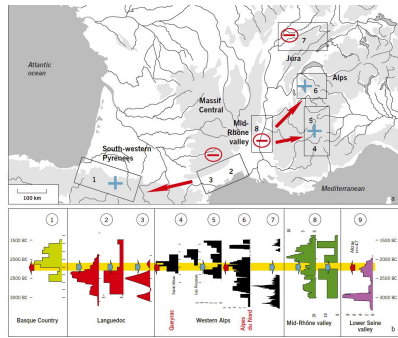
Sea surface temperatures and land-derived input time series were generated from the Gulf of Lions inner-shelf sediments (NW Mediterranean Sea) using alkenones and high-molecular-weight odd-carbon numbered n-alkanes. The SST record depicts three main phases: a warm Early Holocene (~18 ± 0.4 °C) followed by a cooling of ~3 °C between 7000 and 1000 BP, and rapid warming from ~1850 AD onwards.

Several superimposed multi-decadal to centennial-scale cold events of ~1 °C amplitude were also identified.

Concentrations show a broad increase from the Early Holocene towards the present with a pronounced minimum around 2500 BP and large fluctuations during the Late Holocene.

Sediments of the inner shelf seems to be originated mainly from the Upper Rhone River watershed, primarily delivered during positive North Atlantic Oscillation (NAO).

**Conceptual model of Climate/Environment/Society interactions**



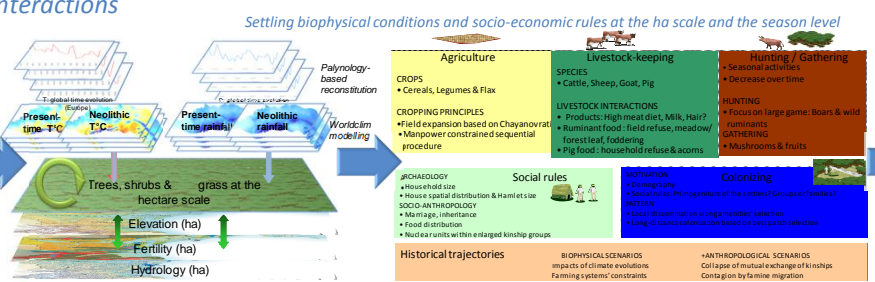
**4.2 ka BP climatic event and settlement pattern changes from the Late Neolithic to the Early Bronze Age in western Mediterranean?**

- Effects of RCC lasting 3-4 centuries around the 4.2 ka BP event, c. 2.2 ka BC recorded in the lake, fluvial and soil systems
- A temporal tripartite structure with 2 wet periods in Southern France
- Change in the human settlement system around 2.3-2.2 ka BC:
  - In lowland areas, the number of settlements decreased significantly along the river systems during a period of very high hydrosedimentary discharges, dryness, and fire activity.
  - Environmental changes (glacial retreat) permitted the exploitation of copper ore resources at very high altitudes of above 2,400 m allowed for an exploitation of alpine copper, as in Saint-Véran (SE France) and archaeological findings have revealed a growth in human pressure in mountain areas, specifically in the Pyrenees (SW France).
- ⇒ Change of settlement from lowland area to mountainous areas may have resulted in a spatial reorganization at a regional level, but not in a global societal collapse.

**Modelling Climate/Environment/Society interactions**

Dynamic and spatially-explicit modeling is the only way for combining together biophysical elements such as climate, soils, and land cover, with archaeological and socio-anthropology/socio-economy based hypotheses in the functioning of the Neolithic societies.

However, Paleo-environmentalists provide climate and landscape reconstructions with a century-scale temporal precision while, to understand the consequences on rural populations, one should translate these data into the seasonal cropping and hunting/gathering activities; Archaeologists provide site-specific habitat and activity descriptions for specific time periods while, to extend such reconstructions for applying it on a regional level, the one occupied by the same culture, a generic and adaptable behavior rationality should be hypothesized, combining social constraining rules and production practices.



We propose a spatially explicit (scale 1ha) and temporally defined (scale: 1 season) multi-agent modelisation.

The GAMA platform [gama-platform.org/](http://gama-platform.org/) built in Toulouse (France) is the software reference for such a collective and long-term modelling process

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