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

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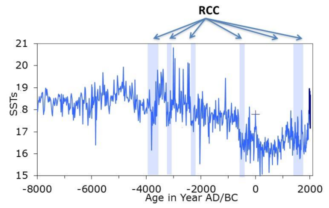
Objectives and challenges

- **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

Continental data ArcheoMed-Paleomex (2012-2015)
Continental data ArcheoMed-Paleomex (2016-2020)
Marine Data

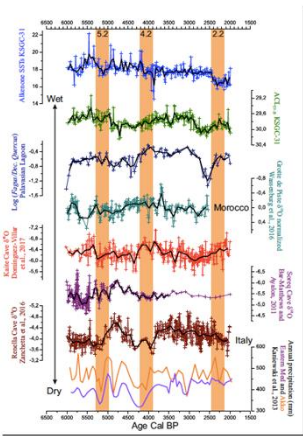
- **Long marine sequences ….**
- **Analyses of long pollen and fire signature series for high resolution climate changes analyses** (e.g. modern analogs - Peyron et al., 2017; Vannière et al., 2015)
- **High resolution analyses of lake and fluvial sequences** (ex. 8.2 tripartition in Berger et al., CP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

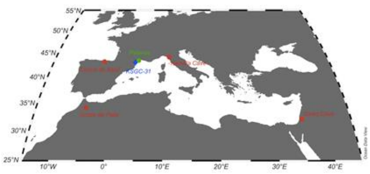
⇒ **Climate modelisation**

⇒ **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





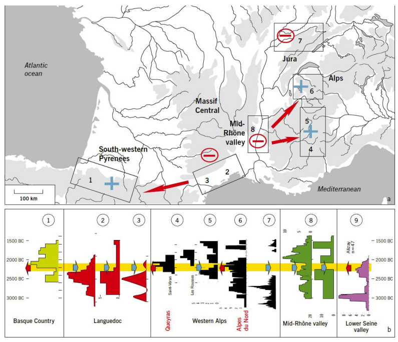
Sea surface temperatures and land-derived input time series were generated from the Gulf of Lions inner-shelf sediments (NW Mediterranean Sea) using alkenones and high-molecular-weight odd-carbon numbered n-alkanes. The SST record depicts three main phases: a warm Early Holocene (~ 18 ± 0.4 °C) followed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



Map of the micro-regions documenting the Late Neolithic III to Early Bronze Age transition around 4.2 ka cal BP (c. 2.2 ka BC) (from Carozza et al. 2015) : 1 Western Pyrenees; 2 Languedoc plateau (Boussargues-Les Vautes); 3 Languedoc (Fontbouisse Culture); 4 southern Alps (Queyras, Saint-Véran); 5 central-western Alps (CPDF); 6 northern Alps (multi-source CPDF); 7 Jura/Swiss Plateau/Bavaria; 8 mid-Rhône valley; 9 Normandy (Alizay site, CPDF). Red minus signs – depopulated areas; blue plus signs – densely populated area; red arrows – direction of possible mobility of people around the 4.2 ka cal BP event. b Comparison of temporal dynamics of the same micro-regions illustrating spatial re-organisation throughout France. Blue arrows – sharp decline; red arrows – growth.

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).

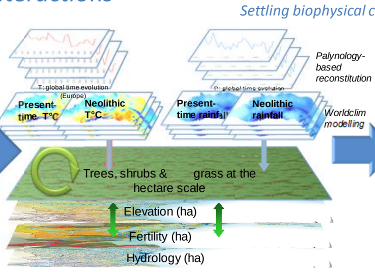
⇒ **Change of settlement from lowland area to mountainous areas may have resulted in a spatial reorganization at a regional level, but not in a global societal collapse.**

Modelling Climate/Environment/Society interactions

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

However,
- Paleo-environmentalists provide climate and landscape reconstitutions 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 reconstitutions 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.

Settling biophysical conditions and socio-economic rules at the ha scale and the season level



Agriculture
CROPS
- Cereals, Legumes & Flax

CROPPING PRINCIPLES
- Field expansion based on Chayanovrati
- Manpower constrained sequential procedure

Livestock-keeping
SPECIES
- Cattle, Sheep, Goat, Pig

LIVESTOCK INTERACTIONS
- Products: High meat diet, Milk, Hair?
- Ruminant food : field refuse, meadow/ forest leaf, foddering
- Pig food : household refuse & acorns

Hunting / Gathering
- Seasonal activities
- Decrease over time

HUNTING
- Focus on large game: Boars & wild ruminants

GATHERING
- Mushrooms & fruits

Social rules
ARCHAEOLOGY
- Household size
- House spatial distribution & Hamlet size

SOCIO-ANTHROPOLOGY
- Marriage, inheritance
- Food distribution
- Nuclear units within enlarged kinship groups

Colonizing
MOTIVATION
- Demography
- Social rules: Primogeniture of the settlers? Groups or families?

PATTERN
- Local dissemination along amenities' selection
- Long-distance colonization based on best patch selection

Historical trajectories
BIOPHYSICAL SCENARIOS
Impacts of climate evolutions
Farming systems' constraints

+ANTHROPOLOGICAL SCENARIOS
Collapse of mutual exchange of kinships
Contagion by famine migration

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

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

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