Title: Palaeoclimatic reconstructions from marine and continental proxies: an integrated compositional approach

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Research program

Climate change is undoubtedly a topic of fundamental importance in the context of current scientific research, because of its environmental, economic and social implications. However, the extent to which the current dynamics are related to human activities, and how much they are attributable to natural changes, is still a matter of debate. It is clear, in this regard, how important it is to define a picture of climate changes that occurred in a relatively stable epoch such as the Holocene but in time intervals for which the anthropogenic impact can be considered as negligible. With regard to the millenary Holocene climate variability, there are synthesis studies at both global and regional scale for the Mediterranean area (e.g. Mayewsky et al., 2004; Wanner et al., 2008; Peyron et al., 2013, 2017), however, there is not yet a unified picture of the climatic events that have followed one another. This is mainly due to a) problems in defining the chronology of the different successions, where even limited chronological uncertainties can lead to erroneous correlations, and b) sensitivity of climate proxies to changes of limited magnitude, so that problems arise regarding the distinction between signal and noise related to random variations. In this regard, a correct statistical approach to data analysis is essential in order to avoid systematically biased reconstructions.

Among the various paleoclimatic proxies, those based on the determination of fossil associations from marine and continental environments have had wide application. The basic assumption of these techniques can be formulated in relation to the strong control that climatic and/or environmental conditions exert on the associations, so that a signal can be recorded that can be extracted with the appropriate analysis techniques.

In short, transfer functions aimed at extracting the paleoclimatic signal from fossil associations can be related to non-parametric (e.g. modern analogues) or parametric (e.g. multiple regression, neural networks) techniques. In recent years, transfer functions developed in the framework of statistical analysis of compositional data (CoDA) (Aitchison, 1986) have been proposed by Di Donato et al. (2018; 2020).

These methods represent a basis for paleoclimatic investigations, aimed at obtaining quantitative reconstructions of climatic parameters. In particular, surface water temperatures (SST) will be reconstructed from marine micropaleontological proxies for the Mediterranean area. Continental proxies (pollen) will allow reconstructing temperatures (annual coldest month, warmest month) and precipitation (annual, summer) for the same areas.

Proposal for a PhD position

The research will be carried out following two main lines: a) acquisition of new micropaleontological (planktonic foraminifera) and palynological data from already available or newly acquired marine cores (on the basis of an already started collaboration with the CNR-ISMAR of Naples), b) preparation of a literature database on which to apply transfer functions.

The time interval considered is that corresponding to the Lateglacial and the Holocene, with emphasis on the variability of the last 5000 years.

With regard to the available cores, it is expected to detail the record of two cores recovered respectively in the Gulf of Taranto, whose data have been partially published (Di Donato et al., 2019) and the Gulf of Naples. For these cores an age model based on an integrated eco- and tefro-stratigraphic approach and 14C dating is already available. In order to integrate the reconstructions, isotopic and geochemical analyses ($^{18}O/^{16}O$, $^{13}C/^{12}C$ and Mg/Ca on foraminifer shells) (in collaboration with CNR-ISMAR) will be carried out on newly acquired samples in order to obtain palaeosalinity estimates of surface water from isotopic data and geochemical based SST estimates. The same approach will be used for newly acquired cored in order to integrate and extend the paleoclimatic dataset.

As far as the compilation of a database of literature data is concerned, it is planned to acquire data related to planktonic associations and pollen from cores in the Mediterranean and North Atlantic area. The revision of the SST record acquired with CoDA methods will allow to draw up a summary of the main SST variations during the last glacial-interglacial cycle which will then be compared with reconstructions obtained with different methods. At the same time, the reconstruction of climatic parameters from continental environment will allow land-sea correlation, aimed at detecting synchronicity or diachrony in the response of different ecosystems to rapid climate changes.

For the data analysis a collaboration with the Compositional Data Analysis Group (CoDA) of the University of Girona (Spain) is foreseen.