Project of Strategic Interest NEXTDATA

Scientific report for the period from
1-1-2013/31-12-2013

WP 1.5 Paleoclimate data from marine sediments

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1. Planned activities and expected results

The research activities of the second year of the project, as specified in the Executive Plan, encompass:

- the NEXTDATA-2013 oceanographic cruise aboard the R/V Urania CNR, which took place from 12 to 22 September 2013, in the continental shelf areas of the Gulf of Taranto and of the Sicily Channel;
- the beginning of analysis (planktonic foraminifera, calcareous nannofossils, pollens, paleomagnetic analysis, tephrostratigraphic analysis, chronological analysis, stable isotopic analysis) of the cores collected during the NEXTDATA-2013 oceanographic cruise, also in collaboration with researchers from other research institutions and universities;
- the integrated high-resolution study of the cores labelled C5 (7,11 meters long and recovered through a Kullenberg gravity corer system at a water depth of - 93 meters), and C5_SW104 (1,08 meters long and recovered through the gravity corer system SW104 at a water depth of - 93 meters), acquired with the CNR R/V Urania in February 2013 in the Gulf of Gaeta (central Tyrrhenian Sea), a site of interest already identified in the first year of the project as a target for high-resolution paleoclimatic studies;
- review of existing literature data on marine cores of the Mediterranean basin, in order to produce a complete list of the available data and an outline of the main climatic oscillations of the last two millennia;
- transmission of data acquired by NextData to the General Portal;
- organization of the Congress of the Italian Association for the Study of the Quaternary - AIQUA 2013 entitled *The Coastal Marine Environment of the Mediterranean today and in the recent geological past: to know in order to understand*, held in Naples on 19, 20 and 21 June 2013, supported by the NextData Project.

M1.5.2 Milestone (PM24): Analysis of available sedimentary cores from of the Mediterranean basin and possible retrieval of marine continuous sequences in continental shelf environments.

2. Deliverables planned for the reporting period

D1.5.2: Report for the Mediterranean area, on the recognized (based on literature data) climatic oscillations of the last two millennia from marine cores; transmission of data to archives and to the General Portal.

3. Activities actually carried out during the reporting period

The research activities developed within the WP1.5 during the second year of the project allowed us to collate much information from the literature concerning the last 2000 years, with particular reference to the Mediterranean. This information will be very useful in the execution of paleoclimate studies.

Specifically, we have identified 26 marine cores from various areas of the Mediterranean basin which have been included in the WP 2.4 Geodatabase: 3 cores from the Adriatic Sea, 1 core from the Gulf of Lion, 10 cores from the Gulf of Taranto, 1 core from the Gulf of Salerno, 3 cores from the Sicily Channel, 1 core near Israel, 1 core in the northern Aegean Sea and 6 cores in the Alboran Sea (Figure 1). This study showed that the marine sedimentary records

recovered and analysed for the last 2000 years are very few and therefore provide an insufficient geographical coverage (Figure 1).

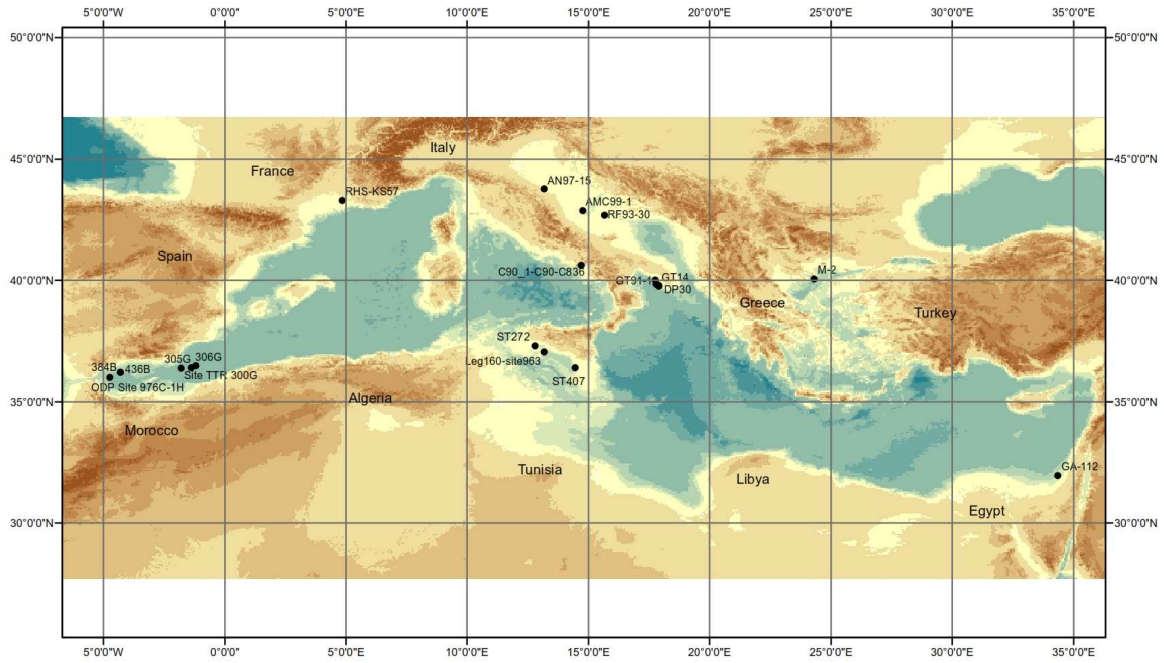

Fig. 1. Location map of the Mediterranean marine cores containing useful information for paleoclimate studies for the last 2000 years.

In these cores several parameters have been measured (unfortunately, not all parameters were measured in all cores), and they are useful for the estimation of the Sea Surface Temperature (SST) and for assessment of the responses of flora and fauna to climatic forcing. In addition, the deep review of the literature data allowed us to define a series of intervals corresponding to the main climatic changes recognisable at Mediterranean scale.

The study of literature data for extra-Mediterranean area is focused on the Atlantic area near the Portugal Margin. This study allowed us to identify only seven cores providing useful data for paleoclimatic study of the last two millennia (Figure 2).

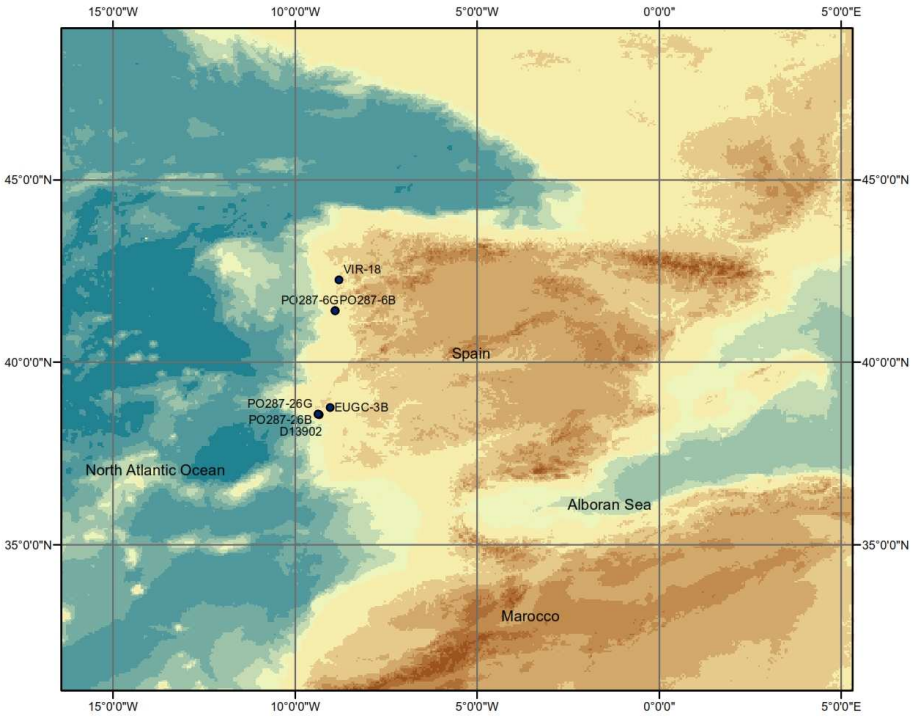

Fig. 2. Location map of the extra-Mediterranean marine cores containing useful information for paleoclimate studies for the last 2000 years.

In recent years, several Italian pollen sites have been studied in order to reconstruct the history of vegetation and climate of the last few thousand years, although some Italian regions are still largely unexplored (e.g., Sardinia, Campania, Marche). Although the network of published pollen sites in Italy offers fundamental information on the history of Italian vegetation, there has as yet been no synthesis work aimed at providing a detailed understanding of the mechanisms and dynamics involved in the vegetation changes at regional and supra-regional scales during the past 3000 years.
As part of the NextData Project, a pollen database from the Italian peninsula was created with the intent of evaluating the variability of vegetation features (composition, structure, and density) during the last 3000 years, with particular attention to:

- extent, duration and rate of vegetation change;
- assessment of the synchrony or diachrony of climatic fluctuations over the Italian territory;
- estimate of the importance of natural and anthropogenic factors in the modification of the vegetational landscape during the past thousands of years;
- correlation of vegetation and environmental changes with centennial-scale climatic fluctuations recognized in Italy and other Mediterranean countries (e.g., Little Ice Age).

We have also fostered partnerships with foreign research groups which are leading integrated analysis of marine cores in selected areas of the Mediterranean basin, to identify the climatic oscillations of the last 2,000 years.

We have re-analyzed the available data ($\delta^{18}O$ *G. ruber* and quantitative distribution of planktonic foraminifera) for C90_1m - C90 cores (a site of interest identified during the first year of the project) collected in the Gulf of Salerno (Southern Tyrrhenian Sea) by the CNR-IAMC and made available to the NextData Project. This new phase of the study has led us to publish the paper LIRER F., SPROVIERI M., VALLEFUOCO M., FERRARO L., PELOSI N., GIORDANO L.,

CAPOTONDI L., (2014): Planktonic foraminifera as bio- indicators for monitoring the climatic changes occurred during the last 2000 years in the SE Tyrrhenian Sea. *Integrative Zoology*, DOI: 10.1111/1749-4877.12083. This study allowed to identify and date, in marine continental shelf records (103 meters of water depth), a sequence of climate events during the last 2,000 years: *Roman Period, Dark Age, Medieval Classic Anomaly, Little Ice Age, Industrial Period, Modern Warm Period*.

During the second year of the project the following analyses have been conducted on the cores C5, C5_SW104, C6 and C6_SW104, collected in the Gulf of Gaeta (Central Tyrrhenian Sea) by IAMC-CNR aboard the CNR R/V Urania in February 2013:

1) Analysis of planktonic foraminifera (C5, C5_SW104 and C6 cores) and calcareous nannofossils (C5 and C5_SW104 cores) amounting to a total of 634 levels, performed in collaboration with Dr. Antonio Cascella (INGV Pisa).
2) Oxygen and carbon isotope analyses on *Globigerinoides ruber* amounting to a total of 558 levels.
3) Paleomagnetic measurements carried out at the INGV Laboratory of Paleomagnetism (Rome) in collaboration with Dr. Fabio Florindo and Dr. Pontus Lurcock. The total number of levels which were analyzed for each core are: 703 levels for the C5 core, 665 levels for the C6 core, 132 levels for the C5_SW104 core and 106 levels for the C6_SW104 core. The following parameters were measured for each level: the magnetic susceptibility (with both loop and point sensors), the NRM, the remaining NRM after each of 11 stages of demagnetization, the ARM intensity, and the ARM intensity after each of 10 stages of demagnetization. For the C5_SW104 core, the IRM magnetization and the S-ratio were measured too. Furthermore, the same measurements have been carried out on 14 discrete samples from the C5_SW104 core.
4) Tephrostratigraphic analyses were performed at the CNR-IAMC and at the Dipartimento di Scienza della Terra e delle Risorse dell'Università Federico II di Napoli, in collaboration with Dr. Paola Petrosino. We identified several tephra layers (C5 and C5_SW104 cores), but only 3 of them were analyzed for the purposes of the project (the last 2000 years).
5) The radionuclides dating was performed at the CNR-ISMAR of Bologna in collaboration with Dr. Luca Bellucci. The ^{210}Pb and ^{137}Cs dating was carried out at 12 levels within the first 60 cm (C5_SW104, C6_SW104 and C13_SW104).
6) Pollen analyses have been carried out at the Dipartimento di Biologia Ambientale - Botanica, of the Università La Sapienza in Rome, in collaboration with Dr. Donatella Magri and Dr. Federico Di Rita. The samples from the C5_SW104 core were analysed and those from the C5 core are still in progress.

Furthermore, in this second year of the project almost all the paleomagnetic measurements on the 8 cores (C2, C5, C7, C8, C9, C10, C11, C13) collected in the Gulf of Gaeta (Central Tyrrhenian Sea) by the CNR-IAMC of Naples aboard the R/V Urania of the CNR in February 2013, were completed (Figure 3).

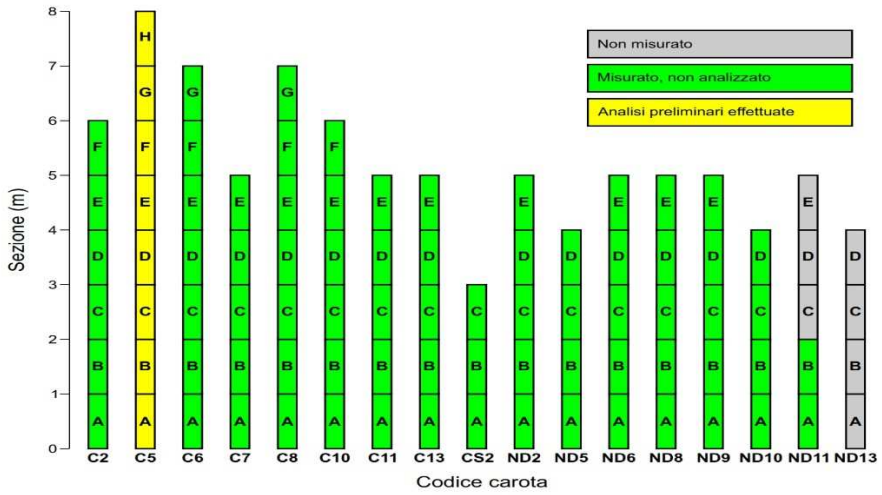

Fig. 3. Paleomagnetic analyses completed during the second year of the project.

The NEXTDATA-2013 oceanographic cruise aboard the CNR R/V Urania was held from September 12 to September 22, 2013, in the continental shelf environments of the Gulf of Taranto and of the Sicily Channel.
Preliminary data (stratigraphic columns, photographs, seismic lines and magnetic susceptibility measurements of the collected cores) gathered during this oceanographic cruise have been reported in two Technical Reports published on *CNRSOLAR* and transmitted to the NextData homepage:

BONOMO S., LIRER F., FERRARO L., ALBANO L., ALBERICO I., ANZALONE E., BARRA R., CAPPELLI C., CASCELLA A., CASTELLANO M., CAVALLINA C., DI STEFANO E., D'ORIANO C., FERRARO R., FRANCESCONI M., GAZZOLA R., GIORDANO L., LURCOCK P. C., MARGARITELLI G., MARSELLA E., PELOSI N., PUNZO M., VALLEFUOCO M., SORGATO S., TARALLO D., ZARCONE G., (2013). *Final Report of the Oceanographic Survey NextData2013 - Strait of Sicily - Gulf of Taranto (12-19 September 2013). CNRSOLAR* identification code 3691TR2013.

BONOMO S., LIRER F., FERRARO L., ALBANO L., ALBERICO I., ANZALONE E., BARRA R., CASCELLA A., CASTELLANO M., DI STEFANO E., D'ORIANO C., FERRARO R., GIORDANO L., LURCOCK P. C., MARGARITELLI G., MARSELLA E., PELOSI N., PUNZO M., VALLEFUOCO M., SORGATO S., TARALLO D., ZARCONE G., (2014). *Core description collected during Oceanographic Survey: NextData 2013 (12 – 19 September 2013)* - Strait of Sicily - Gulf of Taranto. *CNRSOLAR* identification code 4517TR2014.

During this oceanographic cruise, 8 cores (ND2, ND5, ND6, ND8, ND9, ND10, ND11, ND13) were collected through the WS104 and the Kullenberg gravity corer systems, and 5 of them have been evaluated as suitable for study of the climatic oscillations of the last 2,000years (Table 1).

Core	Latitudine	Longitudine	Mediterranean basin	water depth	Oceanographic Cruise
ND2	36°33'52''	14°52'59''	Sicilian Continental Shelf	-89 meters	NEXTDATA 2013
ND13	36°35'10''	14°26'55''	Sicilian Continental Shelf	-165 meters	NEXTDATA 2013
ND9	39°49'24''	17°52'47''	Gulf of Taranto	-172 meters	NEXTDATA 2013
ND5	35°20'06''	15°24'45''	South-east ofMalta	-335 meters	NEXTDATA 2013
ND11	37°01'57''	13°10'54''	Strait of Sicily	-475 meters	NEXTDATA 2013

Tab. 1. Marine cores collected during the NEXTDATA-2013 oceanographic cruise.

These cores are stored at the Core Repository of the CNR-IAMC in Naples. For each site of interest, identified in the first year of the project, we have gathered 3 cores. Of these, one will be made available to the national and international scientific community for further studies at the end of the project. During the oceanographic cruise, magnetic susceptibility measurements have been performed on all these cores and analyses of magnetic mineralogy are in progress at the INGV Paleomagnetism Laboratory in Rome (Figure 3).

Finally, the Congress of the Italian Association for the Study of the Quaternary - *AIQUA 2013* entitled *The Coastal Marine Environment of the Mediterranean today and in the recent geological past: to know in order to understand*, was held in Naples at the Università degli Studi di Napoli "Parthenope" on 19, 20 and 21 June 2013, supported by the Project NextData. The scientific contributions of the congress have been published in the journal *Miscellanea INGV*, vol. 19 ISSN 2039-6651, 2013, edited by ANZALONE E., LIRER F., FERRARO L., DI FIORE V., PAPPONE G., MARSELLA E., D'ARGENIO B. This volume has been made available on the NextData Project homepage and on the official website of the journal (http://istituto.ingv.it/l-ingv/produzione-scientifica/miscellanea-ingv/). The congress included 9 thematic sessions regarding the Quaternary, one of them entitled "Climate and Paleoclimate" with the following convenors: L. CAPOTONDI (CNR-ISMAR of Bologna), D. MAGRI (University of Rome La Sapienza) and C. PASQUERO (University Milano Bicocca).

3.1 Research activities

3.2 Application, technological and informatics developments

None in the reference period.

3.3 Training activities

In the second year of the NextData Project a Research Fellowship has been created for Dr. Giulia Margaritelli, in order to conduct "paleoclimate and paleoecological analysis of sediments in the Mediterranean basin over the last 2,000 years, based on the integration of quantitative data derived from planktonic and benthic foraminiferal assemblages".

In January 2013, a postdoctoral position was also created for Dr. Pontus C. Lurcock at INGV in Rome, in collaboration with Dr. Fabio Florindo, aimed at studying paleomagnetism and magnetic mineralogy of drilled sequences within the Project NextData, and at development of software to perform stratigraphic correlation and stacking of the corresponding paleointensity curves.

3.4 Dissemination and disclosure activities

The CNR-IAMC organized, with the sponsorship of the NextData Project, the Congress of the Italian Association for the Study of the Quaternary - AIQUA 2013 entitled *The Coastal Marine Environment of the Mediterranean today and in the recent geological past: to know in order to understand*. The scientific contributions of the congress have been published in the journal *Miscellanea INGV*, vol. 19 ISSN 2039-6651, 2013. This volume has been made available on the NextData Project homepage and on the official website of the journal (http://istituto.ingv.it/l-ingv/produzione-scientifica/miscellanea-ingv/).

During this congress there were 9 thematic sessions on the Quaternary:

- Coastal and open ocean oceanography.
- Bio-monitoring of coastal marine environments.

- Climate and paleoclimate.
- Relative sea level changes and their impact on coastal morphology.
- Relationships between tectonic events and sedimentation in recent coastal areas.
- Geological cartography and land-sea correlations.
- Geodynamic and paleoenvironmental evolution of the continental margins.
- Marine Geohazards of the Italian seas.
- Seismic and volcanic hazards.

The NextData Project has been included in the Section *ongoing RCMNS Project* of the 2013 RCMNS (Regional Committee on Mediterranean Neogene Stratigraphy) Bulletin, edited by the Natural History Museum of Vienna.

3.5 Participation in conferences

AIQUA Congress 2013 – Napoli 19-21 June 2013, oral presentation: Planktonic foraminifera as bio- indicators for monitoring the climatic changes occurred during the last 2000 years in the SE Tyrrhenian Sea, by LIRER F., SPROVIERI M., VALLEFUOCO M., FERRARO L., PELOSI N., CAPOTONDI L., Volume *Miscellanea INGV*, vol. 19 SSN 2039-6651, page 46.

QUA Congress 2013 – Napoli 19-21 June 2013, poster contribution: Palaeomagnetism and rock magnetism of late Holocene sediments from the eastern Tyrrhenian Sea, by LURCOCK P., FLORINDO F., *Miscellanea INGV*, vol. 19 SSN 2039-6651, page 47.

Urbino Summer School in Paleoclimatology (USSP), 2013, poster contribution: Palaeomagnetism and rock magnetism of late Holocene sediments from the eastern Tyrrhenian Sea, by LURCOCK P. and FLORINDO F.

AGU Fall Meeting, San Francisco, 9-13 December 2013, poster contribution: A Holocene Enviromagnetic Record from the Eastern Tyrrhenian Sea, by LURCOCK P. C. and FLORINDO F.

4. Results obtained during the reference period

4.1 Specific results (databases, measurements results, models output, etc)

We have re-analyzed the available data ($\delta^{18}O$ *G. ruber* and quantitative distribution of planktonic foraminifera) published by Lirer et al. (2013) in *Quaternary International* vol. 292, 71-85, for C90_1m - C90 cores collected in the Gulf of Salerno (Southern Tyrrhenian Sea) at –103 meters water depth.

This study, focused on the time window of the last 2000 years, (from top of Pompeii volcanic event dated at 79 AD to top of core), allowed us to recognize and date the main climatic oscillations of this time interval (Figure 4): *Roman Period* (top interval ca. 530 AD), *Dark Age* (ca. 530 – ca. 840 AD), *Medieval Classic Anomaly* (ca. 840 – ca. 1240 AD), *Little Ice Age* (ca. 1240 – ca. 1850 AD), *Industrial Period* (ca. 1850 – ca. 1940 AD), *Modern Warm Period* (ca. 1940 AD).
These climatic oscillations, calibrated with high-resolution age models, were identified by comparing the $\delta^{18}O$ *G. ruber* signal with the reconstructed Total Solar Irradiance and with the planktonic foraminiferal turnovers between carnivorous (*Globigerinoides ruber*, *G. quadrilobatus*, *Orbulina* spp., *Globigerinatella siphonifera*) and herbivorous-opportunistic species (*Turborotalita quinqueloba*, *Globigerinita glutinata*, *Globigerina bulloides*). Details are reported in Lirer et al. (2014): Planktonic foraminifera as bio-indicators for monitoring the climatic changes occurred during the last 2000 years in the SE Tyrrhenian Sea. *Integrative*

Zoology, DOI: 10.1111/1749-4877.12083. This is the first article on paleoclimate published by the NextData Project.

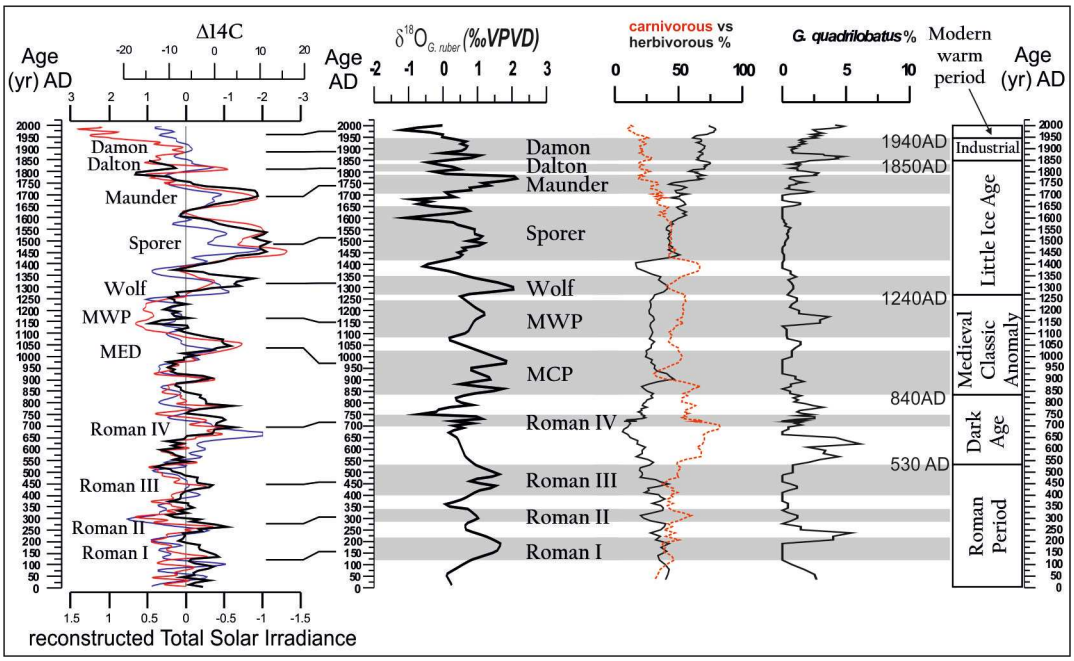

Fig. 4. Succession of climatic events recognized during the last 2000 years in a marine sediment core from Gulf of Salerno (figure modified after Lirer et al., 2014). The planktonic foraminifer *Globigerinoides quadrilobatus* (warm water and oligotrophic taxon) increases in abundance during the warm climatic phases.

The study of cores C5 and C5_SW104, recovered from the Gulf of Gaeta (central Tyrrhenian Sea), revealed a good correspondence with data reported from Gulf of Salerno (southern Tyrrhenian Sea) by Lirer et al. (2014), with the highest time resolution during the interval of last 150 years.
The radionuclide chronology (^{210}Pb e ^{137}Cs) integrated with tephrochronology (the recognition for the first time of the tephra layer related to the Vesuvius eruption 1906 AD) allowed us to estimate a sedimentation rate of ca. 0.48 cm/year for the last 200 years.

This age model allowed us to produce: i) a detailed paleoclimatic reconstruction for the last 200 years (core C5_SW104) combining oxygen stable isotope data (δ^{18}O *G. ruber*), calcareous plankton (planktonic foraminifera and calcareous nannofossils) and pollen content (Figure 5) and ii) a reconstruction of the Sea Surface Temperature (SST) for the last 200 years using the algorithm of Shackleton (1974) with a δ^{18}O water of 1.4‰ (datum of Pierre 1999).

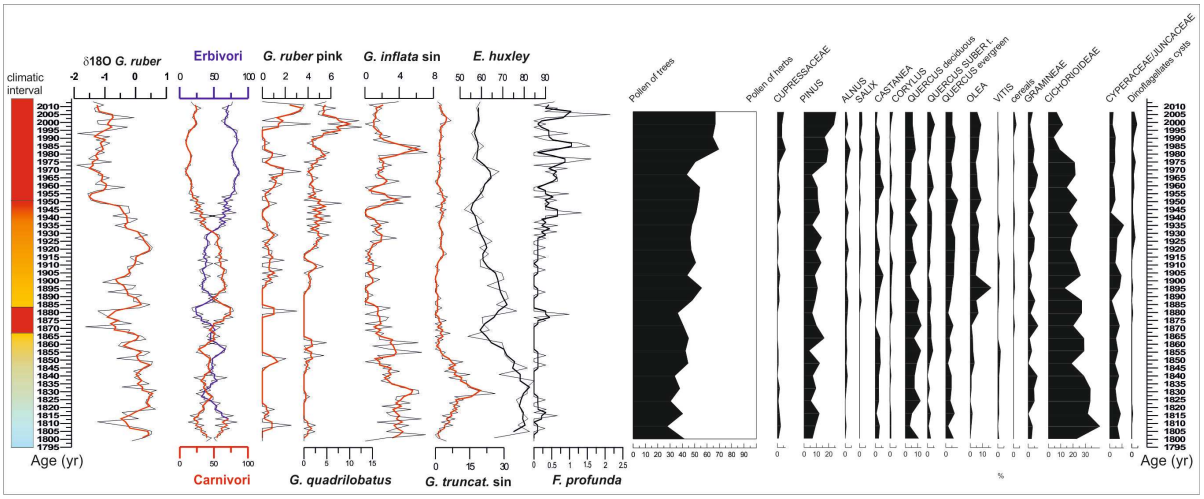

Fig.5. Paleoclimatic reconstruction of the last 2000 years (core C5_SW104, Gulf of Gaeta) comparing $\delta^{18}O$ *G. ruber* signal, planktonic foraminiferal distribution pattern (*G. ruber* pink, *G. quadrilobatus*, *G. inflata* sin, *G. truncatulinoides* sin), calcareous nannofossil abundances (*E. huxley*and, *F. profunda*) and the pollen content (curves in black colour).

The paleoclimatic reconstruction of core C5_SW104 (Figure 5) allowed us to recognize the following intervals:

1) From ca. 1800 to ca. 1865 AD, the $\delta^{18}O$ *G. ruber* signal combined with an increase in the abundance of planktonic foraminifera *Globorotalia inflata* sin and *G. truncatulinoides* sin and of calcareous nannofossils *Emiliana huxleyi* indicate a cold-temperate phase.

2) Between ca. 1865 and ca. 1882 AD, the $\delta^{18}O$ *G. ruber* record indicates a short warm interval associated with a turnover from carnivorous to herbivorous-opportunistic planktonic foraminiferal species and an increase in abundance of calcareous nannofossil *Florisphaera profunda*.

3) At ca. 1935 AD, $\delta^{18}O$*G. ruber* data indicate a gradual warming with a concomitant turnover from carnivorous to herbivorous-opportunistic planktonic foraminiferal species, also associated with the increase of calcareous nannofossil *F. profunda*.

4) From ca. 1950 AD to the present day, the modern warm climatic phase and oligotrophic conditions are documented by a further strong increase in *G. ruber* pink and *G. quadrilobatus* abundances.

The pollen analysis carried out on the same core (Figure 5) revealed a two-step increase in arboreal vegetation. This is mostly related to a rise of *Olea*, *Quercus* evergreen and riparian trees (*Alnus* and *Salix*) from ca. 1882 AD, and an increase in conifers (*Pinus* and *Cupressaceae*) from ca. 1980 AD. The short lived warm interval documented by $\delta^{18}O$ between ca. 1865 and ca. 1882 AD may have triggered the increase in *Olea* and the coeval general decrease in deciduous trees. Among herbs, Cyperaceae, along with ferns, show a progressive decline in the upper part of the record, especially from 1935 AD to the present, suggesting a reduction of wetlands. Since 1920 AD, significant increases in dinoflagellate cysts may reflect both a nutrient loading and temperatures increases, as also documented by $\delta^{18}O$ and micropaleontological records.

The reconstructed SST from oxygen stable isotope data ($\delta^{18}O$ *G. ruber*) were compared with the Mediterranean SST anomaly (instrumental data) for the last 150 years of Marullo et al. (2011). This comparison revealed a similarity between the two records (Figure 6). This similarity disappears after ca. 1985 AD, probably due to a strong anthropogenic impact on the marine coastal environment of the Gulf of Gaeta.

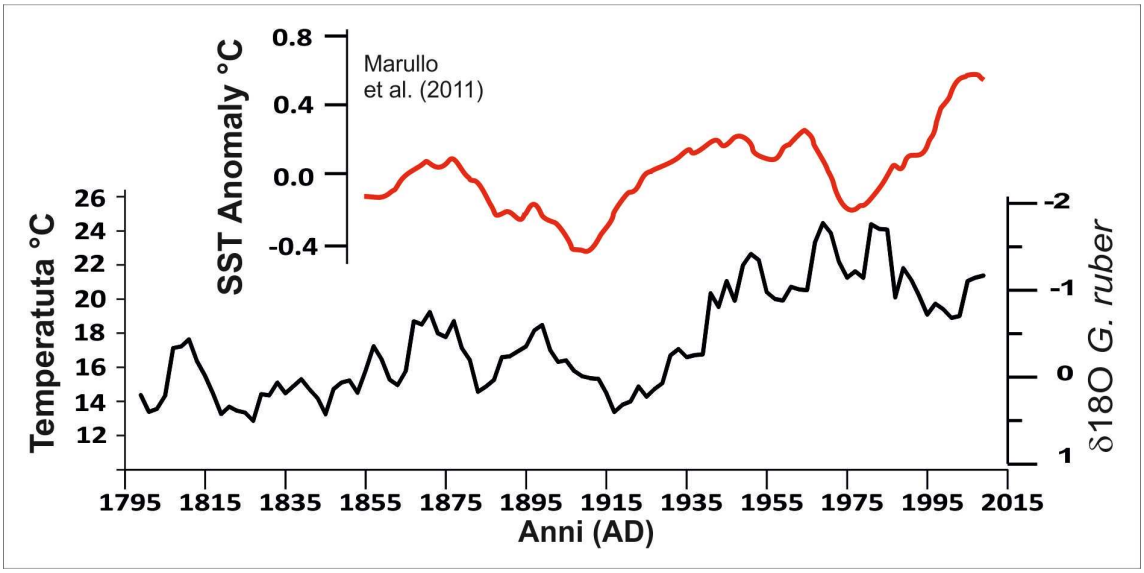

Fig. 6. Temporal behaviour of the reconstructed *Sea Surface Temperature* (SST) for core C5_SW104 of Gaeta Gulf (black curve) and the Mediterranean SST anomaly (red curve) from *Marullo et al.* (2011).

Moreover, the reconstructed SST of Gulf of Gaeta for the last 200 years was compared with the reconstructed SST of Gulf of Salerno, showing a good correlation (Figure 7). At ca. 1930 AD both datasets reflect a progressive warming, correlated with sunspot oscillations and global atmospheric temperatures.

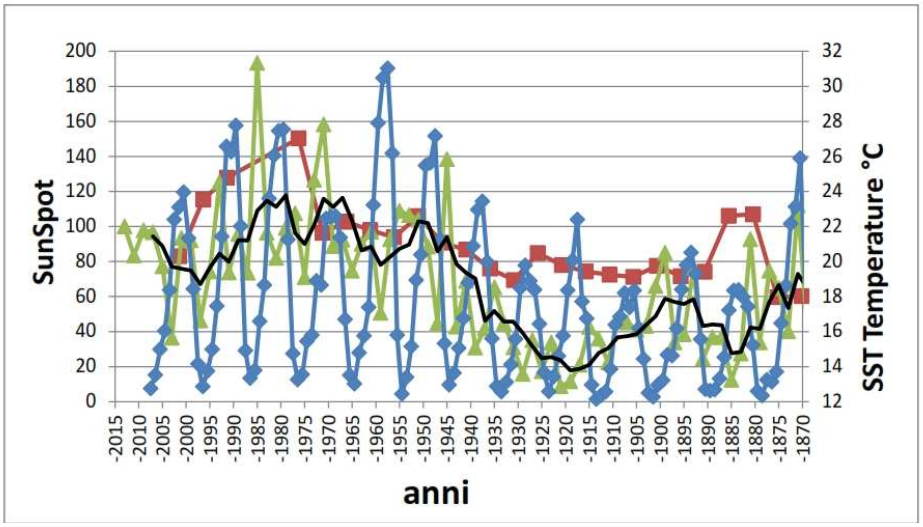

Fig. 7. Temporal behaviour of the SST of Gulf of Salerno (averaged yearly values: red curve, core C90_1m), Gulf of Gaeta (green curve with superimposed three-point moving average (black curve), core C5_SW104) and annual sunspot number (blue curve).

An integrated study for the time interval of the last 2000 years has been performed on core C5 collected from Gulf of Gaeta (central Tyrrhenian Sea). All the analyses (planktonic foraminifera, calcareous nannofossils, $\delta^{18}O$ of *G. ruber*, paleomagnetism and tephrochronology) have been completed. The AMS ^{14}C dating is still in progress.
The comparison between the $\delta^{18}O$ *G. ruber* signals from Gulf of Gaeta (central Tyrrhenian Sea) and Salerno (south Tyrrhenian Sea) show a correlation of trend and values (Figure 8). This parallelism also allowed to reconstruct the climatic phases for the last 2000 years for the Gulf of Gaeta (cores C5 and C5_SW104). Combining the planktonic turnovers between carnivorous (*Globigerinoides ruber*, *G. quadrilobatus*, *Orbulina* spp., *Globigerinatella siphonifera*) and herbivorous-opportunistic species (*Turborotalita quinqueloba*, *Globigerinita glutinata*, *Globigerina bulloides*) and the distribution pattern of calcareous nannofossil *F. profunda*, the following climatic phases were identified: *Roman Period, Dark Age, Medieval Classic Anomaly, Little Ice Age* and *Industrial Period.*

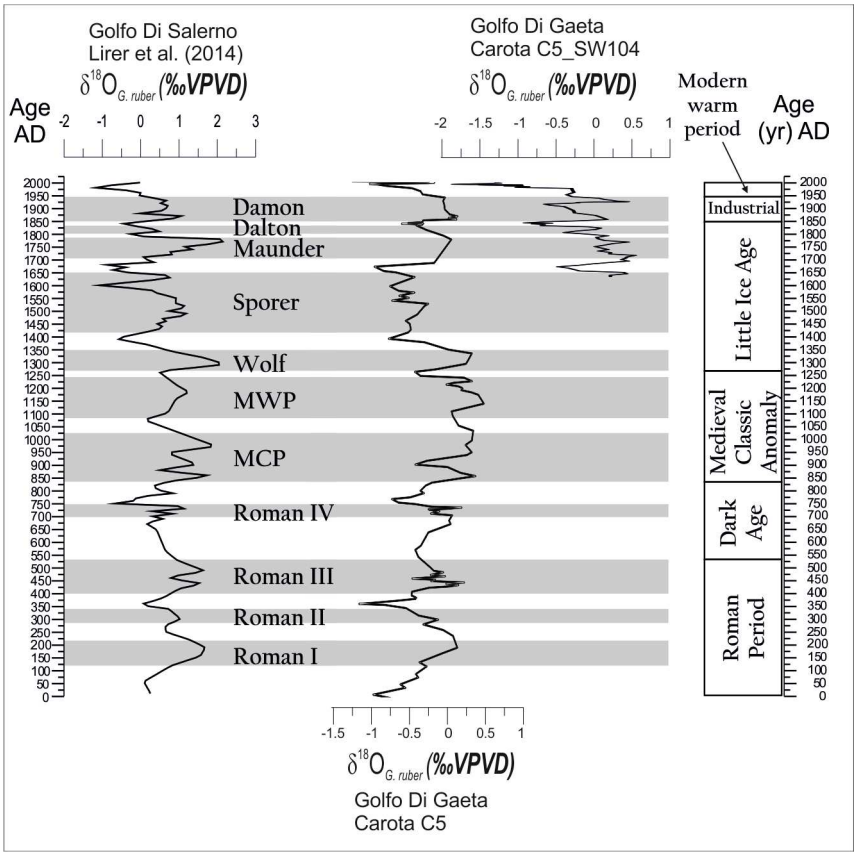

Fig. 8. Comparison between $\delta^{18}O$ *G. Ruber* signals (3 points moving average) from Salerno Gulf (Lirer et al. 2014) and from Gaeta Gulf (cores C5 and C5_SW104). MCP: *Medieval Cold Period*; MWP: *Medieval Warm Period*. The chronology of the paleoclimatic interval is according to Lirer et al. (2014).

Tephrostratigraphic analysis of core C5 has been carried out on three pyroclastic levels identified within the record through magnetic susceptibility and microscope observations. In order to chemically characterize these tephras and recognize their source area, an aliquot of the glass fraction was picked and mounted on epoxy resin in thin sections, then polished. Samples were analysed in terms of major oxides (%) through SEM (Scanning Electron Microscope)/EDS (Energy Dispersive Spectrometry) techniques. The results obtained may be summarized as follows:

- Scoria sample, representative of the younger tephra (sample level 57–58 cm in core C5_SW104 and sample level 5–6 cm/at 53 cm in core C5 section G), has a generally tephriphonolitic composition which is typical of products erupted during the latest activity of Vesuvius. In particular, this tephra can be related to the 1906 event.

- The tephra deposits sampled at 450 cm (core C5/section C/2–3 cm) and at 650 cm (core C5/section A/20–21 cm), display a trachyphonolitic composition which is typical of Campi Flegrei products. In particular, tephra at 450 cm b.s.f., the glass fraction of which is represented by very light pumices, can be correlated with the Agnano Monte Spina event (4.4–4.6 ka; Smith et al., 2011) whereas tephra at 620 cm b.s.f., mostly composed of glass shards, is probably related to the proximal products of the Neapolitan Yellow Tuff (ca. 15 ka; Deino et al., 2004).

The measurements of paleomagnetic inclination and of the relative intensity (RPI) performed on core C5 (Gulf of Gaeta) have the following characteristics: i) well defined inclination, with a mean MAD (maximum angular deviation) of 0.99°; ii) high quality of RPI data according to the criteria stipulated by Tauxe (1993). The lack of correlation between RPI and ARM suggests that the RPI profile corresponds to the magnetic field rather than to the mineralogical variation in the core. The mean inclination of the characteristic remnant magnetization is 57.5°, close to the inclination of 60.1° predicted for the site latitude by a geometric axial dipole (GAD) model. This provides further confirmation that the paleomagnetic data measured in core C5 are representative of a geomagnetic signal, not related to an artificial signature due to variation in the magnetic mineralogy.

A detailed review of literature data focused on paleoclimatic studies for the last 2000 years from marine core sediments available for the Mediterranean basin allowed us to collate 26 marine cores (recovered in the continental shelf and in deep marine environments) from different sectors of the Mediterranean area: 3 cores from the Adriatic Sea, 1 core from the Gulf of Lion, 10 cores from the Gulf of Taranto, 1 core from the Gulf of Salerno, 3 cores from the Strait of Sicily, 1 core close to Israel, 1 core from the north Aegean Sea and 6 cores from the Alboran Sea. The literature data allowed us to identify a succession of intervals corresponding to important climatic phases during the last two millennia and recognisable at a Mediterranean scale. This scheme is based only on the 5 marine sites that documented high-resolution analyses suitable for identification of short-term paleoclimatic phases of the last two millennia.

A review of the pollen literature data in Italy allowed to collate 39 sites. Here we report some preliminary results from about nineteen pollen sites from peninsular Italy, Sicily, and Sardinia, whose chronology is supported by radiometric dates. Although we present only changes in the degree of forestation, represented by the percentage (average calculated over 500 years) of the pollen of arboreal plants (AP), significant environmental fluctuations can be observed:

- 3000 years BP: most of the Italian peninsula was forested (AP > 70%), while the diagrams from Sicily and Sardinia show a rather open vegetation cover.
- 2750-2250 years BP: a deforestation pattern is outlined in large areas of southern Italy and Sicily, while in north-central Italy there were no significant variations in forest cover.

- 2250-1750 years BP: the Italian peninsula generally shows a modest but widespread recovery of arboreal vegetation,
- 1750-1250 years BP: a strong deforestation trend is recorded, especially in central and northern Italy, with the exception of a few sites in the Adriatic side of the peninsula,
- 1250-750 years BP: there is a new forest recovery in the Tyrrhenian side of the Italian peninsula contrasting with a decline observed on the Adriatic side and Sicily.
- 750-250 years BP: a further general deforestation is highlighted, albeit not affecting some southern sites.

4.2 Publications

LIRER F., SPROVIERI M., VALLEFUOCO M., FERRARO L., PELOSI N.,GIORDANO L., CAPOTONDI L., (2014): Planktonic foraminifera as bio-indicators for monitoring the climatic changes occurred during the last 2000 years in the SE Tyrrhenian Sea. *Integrative Zoology Journal*, DOI: 10.1111/1749-4877.12083

BONOMO S., LIRER F., FERRARO L., ALBANO L., ALBERICO I., ANZALONE E., BARRA R., CAPPELLI C., CASCELLA A., CASTELLANO M., CAVALLINA C., DI STEFANO E., D'ORIANO C., FERRARO R., FRANCESCONI M., GAZZOLA R., GIORDANO L., LURCOCK P. C., MARGARITELLI G., MARSELLA E., PELOSI N., PUNZO M., VALLEFUOCO M., TARALLO D., ZARCONE G., (2013): *Final Report of the Oceanographic Survey NextData 2013* - Strait of Sicily - Gulf of Taranto (12-19 September 2013). *CNRSOLAR*, identification code 3691TR2013.

BONOMO S., LIRER F., FERRARO L., ALBANO L., ALBERICO I., ANZALONE E., BARRA R., CASCELLA A., CASTELLANO M., DI STEFANO E., D'ORIANO C., FERRARO R., GIORDANO L., LURCOCK P. C., MARGARITELLI G., MARSELLA E., PELOSI N., PUNZO M., VALLEFUOCO M., TARALLO D., ZARCONE G., (2014): *Core description collected during Oceanographic Survey: NextData 2013* (12 – 19 September 2013) - Strait of Sicily - Gulf of Taranto. *CNRSOLAR*, identification code 4517TR2014.

GRANT K.M., ROHLING E.J., BRONK C., RAMSEY, CHENG H., EDWARDS R.L., FLORINDO F., HESLOP D., MARRA F., ROBERTS A.P., TAMISEA M., WILLIAMS F., (submitted to *Nature*). Sea-level variability over five glacial cycles.

4.3 Availability of data and modelling output (format, support, etc.)

Planktonic foraminiferal quantitative data from cores: C90_1m-C90-C836 (Gulf of Salerno, southern Tyrrhenian Sea), C5, C5_SW104 and C6 (Gulf of Gaeta, central Tyrrhenian Sea). These data have been uploaded to the General Portal;

- Quantitative calcareous nannofossil data from cores: C90_1m-C90-C836 (Gulf of Salerno, southern Tyrrhenian Sea), C5 e C5_SW104 (Gulf of Gaeta, central Tyrrhenian Sea). These data have been uploaded to the General Portal.
- Planktonic foraminifer *(Globigerinoides ruber)*$\delta^{18}O$ and $\delta^{13}C$ data from cores: C90_1m-C90-C836 (Gulf of Salerno, southern Tyrrhenian Sea), C5 and C5_SW104 (Gulf of Gaeta, central Tyrrhenian Sea). These data have been uploaded to the General Portal.
- Quantitative pollen data of core C5_SW104 (Gulf of Gaeta, central Tyrrhenian Sea). These data have been uploaded to the General Portal.
- Radionuclide data from cores: C90_1m (Gulf of Salerno, southern Tyrrhenian Sea) and C5_SW104 (Gulf of Gaeta, central Tyrrhenian Sea). These data have been uploaded to the General Portal.

- Magnetic susceptibility data from cores: C5, C5_SW104, C6 e C13_SW104 (Gulf of Salerno, southern Tyrrhenian Sea); ND9 and ND10 (Gulf of Taranto), ND11, ND2 and ND13 (Sicily channel), ND5 and ND6 (south continental shelf of Malta Island). These data have been uploaded to the General Portal.

4.3 Completed Deliverables

D1.5.2: Report for the Mediterranean area, on the recognized (based on literature data) climatic oscillations for the last two millennia, from marine cores; transmission of data to archives and to the General Portal.

The literature data from marine core sediments available for the Mediterranean basin and useful for the paleoclimatic reconstruction of the last 2000 years, are based on 26 marine cores from different sectors of the Mediterranean area: 3 cores from the Adriatic Sea, 1 core from the Gulf of Lion, 10 cores from the Gulf of Taranto, 1 core from the Gulf of Salerno, 3 cores from the Strait of Sicily, 1 core close to Israel, 1 core from the north Aegean Sea and 6 cores from the Alboran Sea. Additional cores have been collected during this year by the NextData Project (cores C5, C5_SW104, ND2, ND13, ND9, ND5, ND11) (Figure 9). This review of the marine core literature data revealed that the available marine sedimentary records for the last 2000 years are rather few and quite scattered around the Mediterranean area.

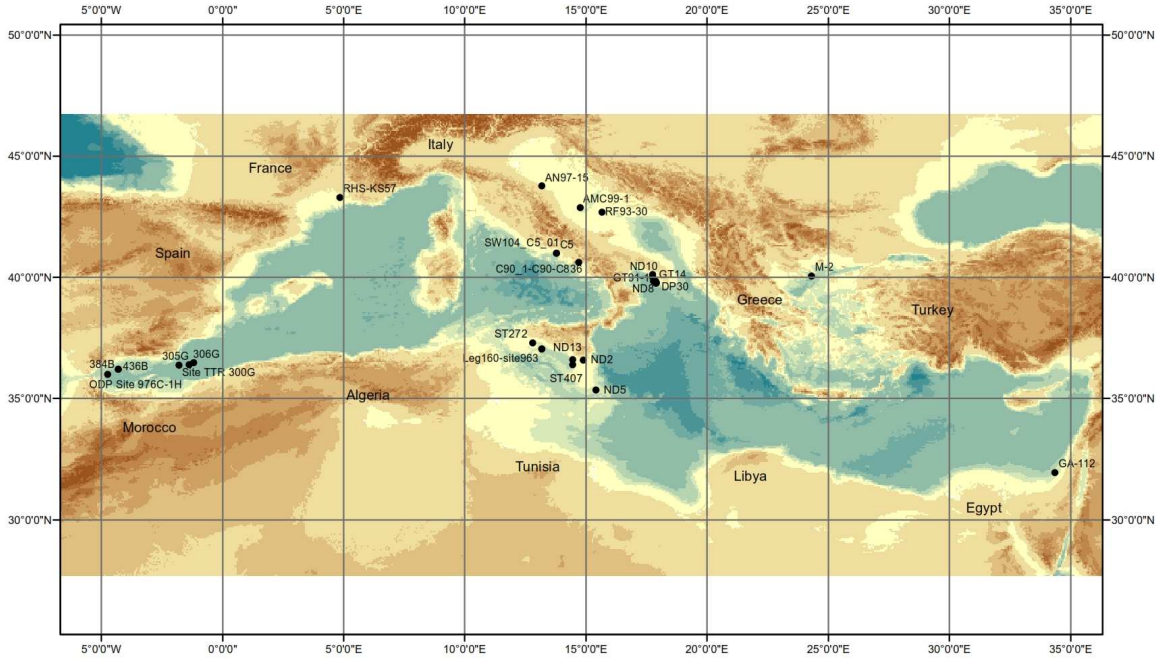

Fig. 9. Location map of Mediterranean marine cores (literature data and new collected cores for NextData Project) containing data useful for paleoclimatic study of the last 2000 years.

Several proxy records are documented in the scientific literature (but unfortunately, not all parameters were measured in all cores) useful for the reconstruction of the Sea Surface Temperature (SST) and to understand the response of the flora and fauna to climatic forcing. Specifically, the reconstructions of the SST are based on the following marine records: 1) two box cores from the Alboran Sea at 1022 and 1108 meters water depth; 2) four gravity cores from the Gulf of Taranto at 173/174 meters water depth; and 3) one gravity core from northern Aegean Sea at 1018 meters water depth.

The other marine sites identified in the literature contain different types of proxies (flora, fauna, and a few geochemical data) useful for paleoclimatic and paleoceanographic reconstructions of the last 2000 years.
The review of data available from the scientific literature allowed us to identify a succession of intervals corresponding to important climatic phases during the last two millennia and recognisable at Mediterranean scale (Table 2). The chronologies proposed by different authors for identifying the paleoclimatic phases are comparable (Table 2). Nevertheless, these ages must be carefully evaluated to understand the synchrony of the climatic phases as well as how these phases are recorded in the marine sediments from the different sectors of the Mediterranean area. Moreover, a standard codification of these climatic phases is necessary to facilitate the correlation between different Mediterranean and extra-Mediterranean areas.

Nieto Moreno PhD thesis (2012) western Alborean Sea		Lirer et al. (2014) south Tyrrhenian Sea (Salerno Gulf)		Grauel et al. (2013) centralMediterranean (Taranto Gulf)		Piva et al. (2008) Adriatic Sea		Gogou et al. (2012) (Aegean Sea)	
Climatic phase	Age (yrAD)	Climatic phase	Age (yr AD)	Climatic phase	Age (yrAD)	Climatic phase	Age (yr AD)	Climatic phase	Ageyr AD)
		Modern warm Period	1940 AD upwards						
Industrial Period	1800AD upwards	Industrial Period	1850AD - 1940AD						
Little Ice Age	1300AD - 1800AD	Little Ice Age	1240AD - 1850AD	Little Ice Age	1400AD - 1850AD	Little Ice Age	1400/1450AD -1840AD	Little Ice Age	1300AD - 1850 AD
Medieval Classic Anomaly	800AD - 1300AD	Medieval Classic Anomaly	840AD - 1240AD	Medieval Warm Period	800AD - 1200AD	Medieval Warm Period	600AD – 1200 AD	Medieval Warm Period	900AD - 1300AD
Dark Age	650AD - 800AD	Dark Age	530AD - 840AD	Dark Age Cold Period	500AD - 750AD	Dark Age Cold Period	350 AD – 600 AD	Dark Age	500AD - 900AD
Roman Humid Period	300AD - 650BC	Roman Period	top 530AD	Roman Classic Warm Period	1AD-200AD	Roman Warm Period	150 AD – 350 AD	Roman Warm Period	0AD-500 AD

Tab. 2- Succession of paleoclimatic phases recognizable in the Mediterranean area during the last two millennia.

5. Comment on any discrepancies between activities / results / deliverables planned and actually realized

The research activities for the second year of the project were in accordance with the Executive Plan.

In addition, we started a new research activity, not reported in the original version of the executive plan, focused on a re-analysis of literature data on pollen content in Italy in collaboration with Dr. Donatella Magri and Dr. Federico Di Rita of the Dipartimento di Biologia Ambientale - Botanica at the Università di Roma "La Sapienza".

6. Planned activities for the following period

The research activities for the third year of project include a new oceanographic cruise NEXTDATA-2014 aboard the CNR R/V Urania from 4 to 16 July 2014. During this oceanographic cruise, new marine sedimentary cores will be recovered in the continental shelf area of the southern part of the Adriatic Sea with the goal of recognizing in other important sectors of the Mediterranean, the succession of climatic phases as reported in Table 2. In addition, water samples will be taken during this cruise to measure the $\delta^{18}O_w$ values necessary for reconstruction of the SST.

The integrated analyses (calcareous plankton, pollens, stable isotope, tephrostratigraphy and paleomagnetism) on the marine cores recovered during the past oceanographic cruise NEXTDATA-2013 will continue. In particular, the cores collected in the Strait of Sicily (two cores) and one from the Gulf of Taranto will be studied at high resolution. This multidisciplinary study will allow us to identify and to date the main climatic phases previously recognised in the Gulf of Salerno (southern Tyrrhenian Sea) and Gulf of Gaeta (central Tyrrhenian Sea) over the last 2000 years. The succession of these climatic phases will be compare with datasets from other Mediterranean geological settings and from extra-Mediterranean areas (e.g. with NGRIP high resolution data or data available for the Atlantic sector of the Portugal margin). This approach could allow us to understand the timing of the response of the Mediterranean to global climatic forcing.
Moreover, for the last 100 years we will try to compare the reconstructed SST from marine cores with the SST reconstructed from Mediterranean corals (*Cladocoraca espitosa*). This research activity has been performed in collaboration with Dr. Paolo Montagna of CNR-ISMAR Bologna.
In addition, we will focus on the identification of the anthropogenic impact on marine ecosystems and on the identification of the main periodicities occurring in the different proxy records (calcareous plankton, pollens, SST, oxygen isotope, petrophysical parameters) with reference to well-known frequencies of climatic oscillation (e.g. solar forcing). Moreover, we will also measure oxygen stable isotope ratios on other two foraminiferal species: *Globigerina bulloides* (planktonic) and *Uvigerina mediterranea* (benthic) for SST reconstruction.

During the third year of the project, core C5 (Gulf of Gaeta) will be correlated with the other cores recovered during the oceanographic cruise NEXTDATA-2013 using variations in magnetic susceptibility, PSV inclination and relative paleointensity. Moreover, the paleomagnetic data of core C5 will be correlated with available well dated records from the Mediterranean area and with geomagnetic paleofield models. Rock magnetic measurements will be carried out on core C5 to produce a record of enviromagnetic variation.

For the pollen data, new detailed maps will be produced by the Project NextData, with increases both in the resolution of the time-windows and in the number of sites included in the database. In addition, this type of representation will be applied to individual taxa or vegetation types. This will better define the relationship between the observed vegetation changes and the climatic fluctuations (e.g. Roman Warm Period, Dark Age, Medieval Anomaly, Little Ice Age) recognized by independent proxy data, studied at a regional or continental scale.

During the third year the acquired numerical data will be uploaded to the General Portal

In addition, two PhD projects will be created for the Project NextData:

- PhD thesis focused on “Study of the calcareous nannofossils as bio-indicators of the climatic oscillation recorded in the Mediterranean during the last 2000 years”. PhD School “Science applied at Sea, Environment and territory” – curriculum “Science of Sea, Earth and Climate” XXIX cycle at Università degli Studi di Napoli Parthenope;
- PhD thesis focused on “Study of the climatic oscillation recorded in the Mediterranean during the last 2000 years using the planktonic foraminifera”. PhD School in Science and Technology for Physics and Geology XXIX cycle at Università degli Studi di Perugia.
- Extension of the postdoctoral grant for Dr. Pontus C. Lurcock focused on the study of the paleomagnetism and magnetic mineralogy of sequences recovered during the

Project NextData and development of software for stratigraphic correlation and stacking of relative paleointensity curves.

The NextData Project will make two presentations at the European Geosciences Union (EGU) General Assembly 2014:

- Scientific session, *CL2.17 Studying the climate of the last two millennia*, oral contribution: Paleoclimate changes occurred during the last two centuries in the Gulf of Gaeta (central-eastern Tyrrhenian Sea): a contribution of NextData Project" by LIRER et AL. Vol. 16, EGU2014-12119, 2014.
- Scientific session, *EMRP3.1 Open session on Rock magnetism and Paleomagnetism*, poster presentation: New stability test for high-resolution palaeomagnetic data, by LURCOCK P. C. and FLORINDO F., Vol. 16, EGU2014-194-1, 2014.