Project of Strategic Interest NEXTDATA

Scientific Report for the reference period **01/01/2012-31/12/2012**

Unit INGV

The activities of INGV are carried out in the WP 1.3, WP 1.5, WP 2.2 e WP 2.4 .

WP 1.3- Marine observation system and climate recontructions (Resp. Nadia Pinardi, INGV)

Partners: INGV

1. Scheduled activities, expected results and Milestones (as indicated in Executive Plan)

First year of activity aims at studying the feasibility and the implementation of a first space-time of a one hundred years "Reconstruction-Reanalysis" (RR) of the Mediterranean Sea climate variability with a spatial resolution of few kilometers and a temporal resolution of few hours. To this end, the available data of SEADATANET, EMODNET and MyOcean programs, including in situ and satellite data, will be collected and processed with a uniform quality control technique. The data assimilation system will be calibrated and prepared for providing the high resolution RR.

The milestone for the first year of activity is:
M1: to define the RR system configuration and the data assimilation procedure.

2. Deliverables expected for the reference period

D1.3.1: "Historical marine data and Quality Control (QC) procedure for the Mediterranean Sea Reconstruction/Reanalysis (RR)"
D1.3.2: "Implementation of the numerical model and the data assimilation scheme of the Mediterranean Sea Reconstruction/Reanalysis (RR) System"

3. Activities which have been actually conducted during the reference period

3.1 Research Activities

Due to the sparseness of observations in the first fifty years of the last century, as shown in Figure 2a and better described later (D1.3.1 and D2.2.1), it is not possible to bring about a proper reanalysis in the first part of the period under investigation. We will refer more properly for the first fifty years to a reconstruction of the Mediterranean climate variability. A reanalysis is possible in the last fifty years thanks to increasing data availability with time as shown in Figure 2b-c. Therefore the present activity is renamed "Reconstruction-Reanalysis" (RR) of the Mediterranean Sea climate variability.
A detailed analysis of RR quality will be evaluated during the third year of activity, as reported in the project document of work, both from a quantitative point of view, as in *Adani et al. 2011*, and a qualitative point of view, referring to the wide existing literature. The expected RR quality will vary according to the availability of observations. The constant data search/discovery and update of our database will improve progressively the final RR quality. This can be obtained also thanks to the technical advancements introduced in the RR system, like the Ocean General Circulation Model (OGCM) and the data assimilation technique.

The RR feasibility study concerned a quality control of different components of the Mediterranean RR system (schematized in Figure 1) based on the previous INGV reanalysis production for the past 25 years (1985-2010). Table 1 summarizes the INGV Mediterranean Reanalysis system developments:

I. **MedReanV2** (*Adani et al 2011*) produced in the framework of CIRCE Project (http://www.circeproject.eu/)
II. **MedReanV4** in production within the framework of **MyOcean Project** (implementation project of the GMES Marine Core Service)
III. Mediterranean RR system under investigation

All the technical details included in Table 1 will be described in D1.3.2 deliverable *(Implementation of the numerical model and the data assimilation scheme of the Mediterranean Sea Reconstruction/Reanalysis (RR) System).*

One of the main tasks of the first year of WP1.3 activity was the review, update and collection of the existing **historical marine data for the RR period 1912-2011**. Deliverable D1.3.1 describes in details the work done. Observations are a fundamental component of the Mediterranean RR system (Figure 1) since an integrated observing and prediction system relies on the observational component in different phases:

- model initialization;
- model calibration;
- data assimilation;
- validation and quality assessment of model results.

The RR system needs in situ temperature and salinity observations along the water column and remote sensed observations of altimetry (SLA) to be assimilated in the numerical model (see Figure 1 from D.1.3.1). Sea Surface Temperature (SST) satellite observations are not assimilated but they are used to correct interactively the surface heat flux on the base of the difference between modeled SST and observed SST. In situ temperature and salinity profiles are also used to compute statistical gridded products, like monthly climatology, used to initialize the RR system but also for future quality assessment of RR results.
These data sets have been collected in synergy with WP2.2 from European Marine databases (SeaDataNet, GMES) and have been archived, as described in deliverable D2.2.1, in a specific format to be assimilated in the RR system. A brief description of remote sensed observations (SLA, SST) is given and further details are included in deliverables D1.3.1 and D2.2.1. None

Quality Control (QC) procedure has been implemented for these data since their quality assessment has been already carried out from **MyOcean SST-TAC** and **Sea Level TAC**. It will follow a brief description of the in situ data set (see also D.2.2.1) and the QC strategy adopted.

The second main task of the first year of the project was the design of the feasible technical improvements to include in the **RR system** regarding the **Ocean General Circulation Model (OGCM) and the data assimilation scheme implementations**. Deliverable D1.3.2 describes in details the work done.

The RR system consists of daily three-dimensional variational analysis followed by a 1-day OGCM integration, as implemented by *Adani et al. 2011*. The data assimilation scheme is the **OceanVar** (*Dobricic and Pinardi, 2008*). The differences with previous reanalysis efforts (**MedReanV2** and **MedReanV4**) are schematized in Table1. It will follow a description of the principal characteristics of the OGCM and the OceanVar data assimilation scheme to be used in the Mediterranean Sea RR production scheduled in the next year of the project. **RR system calibration** was carried out for the years 1985-1987 considering MedReanV2 as our reference product skill.

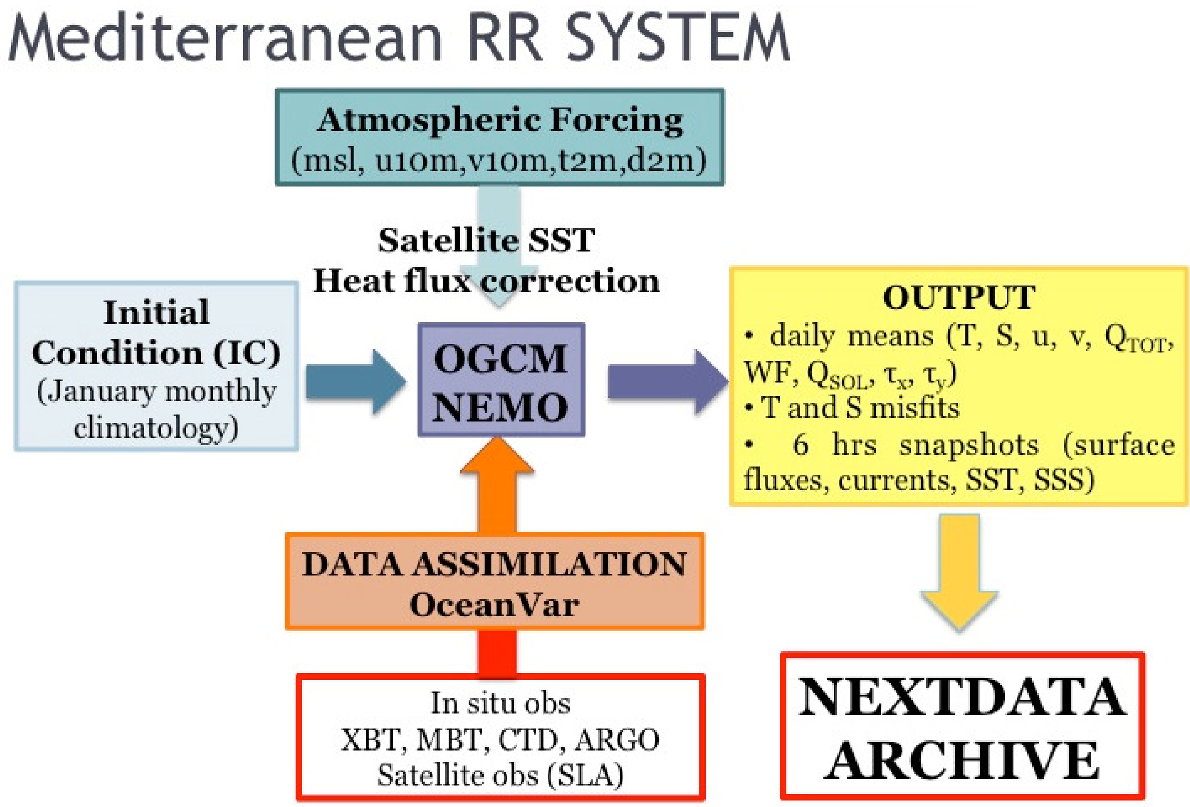


Figure 1. Schematic of the Mediterranean Reconstruction/Reanalysis (RR) system and its components: (center) the Ocean General Circulation Model (OGCM) based on NEMO code (Madec, 2008); (left) the Initial Conditions (IC); (top) the atmospheric forcing (mean sea level perssure-msl, u and v wind components at 10 meters u10m, v10m, air temeperature at 2 meters-t2m, dew point temperature-d2m); (bottom) the OceanVar assimilation scheme (Dobricic and Pinardi 2008) and in situ and satellite (SLA-sea level anomaly) observations collected in the dedicated archive by WP2.2; (right) RR output fields of 3D temperature, salinity, currents, 2D total heat flux at the air-sea interface, water flux-WF, solar radiation-Qsol, momentum flux components-τ, misfits between model and observations, and snapshots every 6 hours of 2d surface temperature, salinity, currents and the total heat flux components. All these model data will populate the NEXTDATA archive.

	MedReanV2 (1985-2007)	MedReanV4 (1985-2010)	RR (1912-2011)
Project	CIRCE *Adani et al. 2011*	MyOcean	NEXTDATA
OPERATIONAL SYSTEM	Sys3a2(OPA8.1) *Tonani et al.2008*	Sys4c1 (OPA9.0) *Oddo et al.2009*	(NEMO3.4)
LBC (Atlantic Box)	closed	open	open
Initial Condition IC	MedAtlas Climatology (obs 1995-1999) *Maillard et al. 2005*	SDNV2aa climatology (obs until1987)	SDNV2aa climatology (obs until1987)
ATM Forcing	ERA15 1.125° (1985-1992) ECMWF analysis 0.5° (1993-2007)	ERAInterim 0.75° (1985-2010)	**AMIP** 1.125° (1912-1957) **ERA40** 1.125° (1958-1978) **ERAInterim** 0.75° (1979-2011)
Total Cloud Cover TCC	NCEP–NCAR (1985–92) ECMWF analyses 0.5° (1993-2007)	ERAInterim 0.75° (1985-2010)	**AMIP** 1.125° (1912-1947) **NCEP–NCAR**(1948-1978) **ERAInterim** 0.75° (1979-2011)
Precipitations	NCEP–NCAR (monthly climatology)	CMAP (monthly climatology)	**AMIP** (montly climatology) **NCEP–NCAR** (monthly climatology) **CMAP** (monthly climatology)
SST	SST reconstruction (1985-2007) *Marullo et al.2007*	SST reconstruction (1985-2007) *Marullo et al.2007* MyOcean data (2008-2010)	**HadISST1** (1912-1985) **SST reconstruction**(1985-2007) *Marullo et al.2007* **MyOcean data** (2008-2011)
Partial Cells	NO	YES	YES
True Stress	NO	YES	YES

Tab.1 INGV Mediterranean Reconstruction/Reanalysis system developments: 1) MedReanV2 already available from Adani et al. (2011) within the framework of CIRCE Project (http://www.circeproject.eu/); 2) MedReanV4 in production within the framework of MyOcean Project; 3) RR100 NEXTDATA developing system for the Mediterranean Sea.

Historical Marine Data

Altimetry data come from MyOcean Sea Level TAC (Thematic Assembly Centre) and are delayed time (DT) SLA data "upd" version. The Delayed Time component of SSALTO/DUACS system is responsible for the production of processed Jason-1, Jason-2, T/P, Envisat, GFO, ERS1/2 data in order to provide a homogeneous, inter-calibrated and highly accurate long time series of SLA. The time period of satellite altimetry monitoring starts from 1985 (GeoSat) but RR will assimilate data starting from 1992.

Satellite SST data set is a time concatenation of SST products specific for the Mediterranean Sea characterized by horizontal maps already optimally interpolated onto the RR model grid at 1/16th of a degree:

1. **reprocessed data** (1985-July 2008) of the recent AVHRR Pathfinder SST (*Marullo et al., 2007*);
2. **MyOcean SST** (July2008-2011) L4 High Resolution Mediterranean SST products (*Buongiorno Nardelli et al. 2013*).

For the time period preceding 1985 we will consider the Met Office Hadley Centre's sea SST data set, **HadISST1** (*Rainer et al., 2003*) at 1 degree of horizontal resolution available from 1870 to date. This choice is consistent with the idea to use AMIP (Atmospheric Model Intercomparison Project - *Gates, 1992*) type of atmospheric forcing for the pre-ERA40 period starting from mid-1957. Details will follow later in the report, when Model implementation is described.

I**n situ temperature and salinity** data sets considered for the RR production were collected from three main sources:

1. **SeaDataNet** (SDN hereafter) European infrastructure (DG-Research – FP6) provides data from 1900 up to nowadays;

2. **MEDAR-MEDATLAS** dataset covering the period 1985-1999 (*Maillard et al. 2005*);

3. **MFS** (Mediterranean Forecasting System) and **MyOcean** In situ TAC for data starting from 1999.

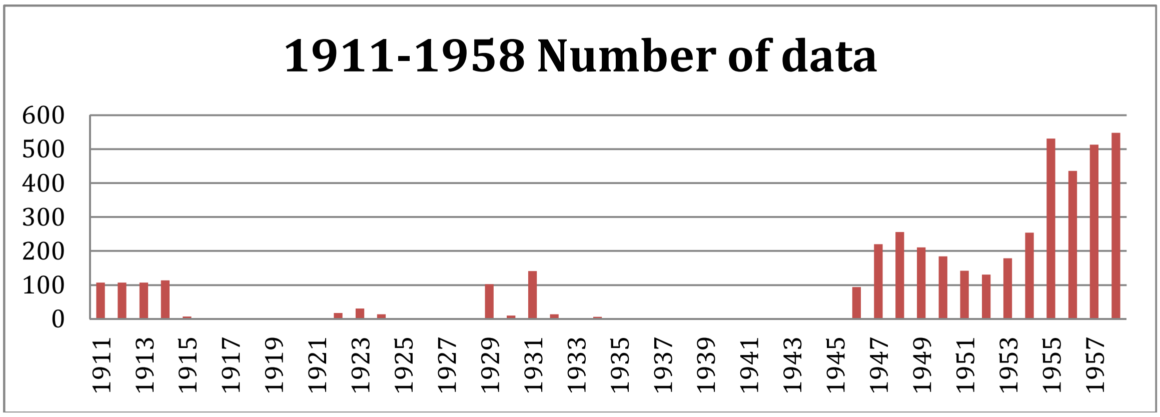
The merging of these data sets was necessary due to missing data within the SDN infrastructure. SDN historical database gathers in situ data from about forty NODCs (National Ocean Data Center) and its data population started and progressively increased on the first phase project implementation. The second phase of SDN project (started in September 2011) is now devoted to the assessment of the quality of the database content and the duplicate elimination. Potential duplicates were thus identified and excluded from successive usage and analysis.
Looking at the annual data distribution of the number of temperature and salinity observations within SDN database from 1990 to 2012 (Figure 2c), it is evident the decrease of the number of observations for the recent years due to a time lag between the sampling and the insertion of the data inside the SDN infrastructure, which is a common characteristic of historical databases. This required the use of **MFS and MyOcean in situ TAC operational observations to integrate the SDN data set in the recent period**. We intend for MFS operational observations, near real time (NRT) observations collected in the Mediterranean Sea within different precursor projects spanning a time period 1999-2009 when MyOcean Project started. Precursor European projects are:

- **MFSPP** (Mediterranean ocean Forecasting System Pilot Project) **1998-2001** EU-MAST project MA 53-CT98-0171;
- **MFSTEP** (Mediterranean ocean Forecasting System Towards Environmental Prediction) **2003-2005** DG-Research – FP5 EU Contract Number EVK3-CT-2002-00075;
- **MERSEA** (Marine Environment and Security for the European) Strand 1 **2001-2003**;
- **MERSEA** Integrated Project **2004-2008**.

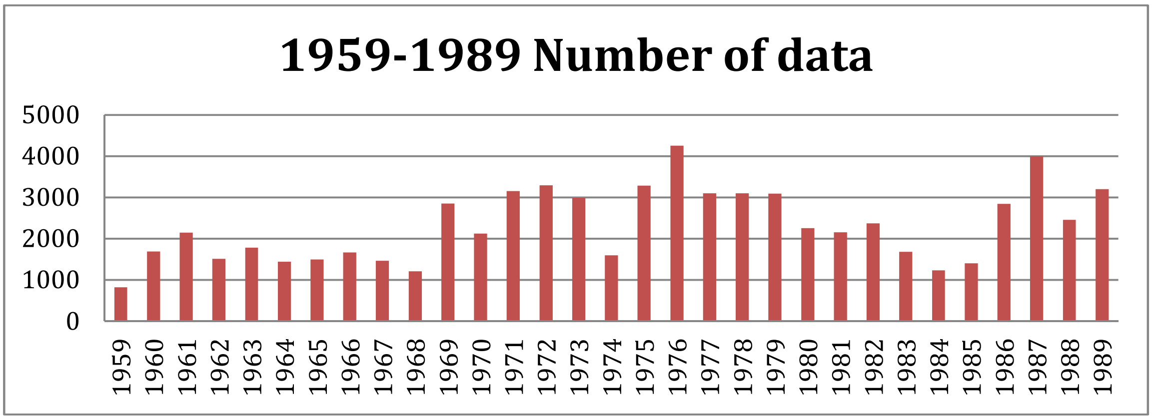
Another check has been implemented to verify the presence of MEDAR-MEDATLAS data set (assimilated in **MedReanV2** from *Adani et al., 2011*). Missing data have been integrated to obtain the most extensive dataset.

The time period 1911-1946 is characterized by very few observations (Figure 2a) and in many years there are no observations at all. Data availability starts and systematically increases from 1946. The sparseness of observations between 1912 and 1946 will allow to assimilate very few observations but a Mediterranean Sea climate reconstruction will be possible thanks to the use of AMIP type of atmospheric data as surface forcing fields and of the HadlSST1 data to correct the surface heat flux as it is better explained in the deliverable D1.3.2.

(a)



(b)



(c)

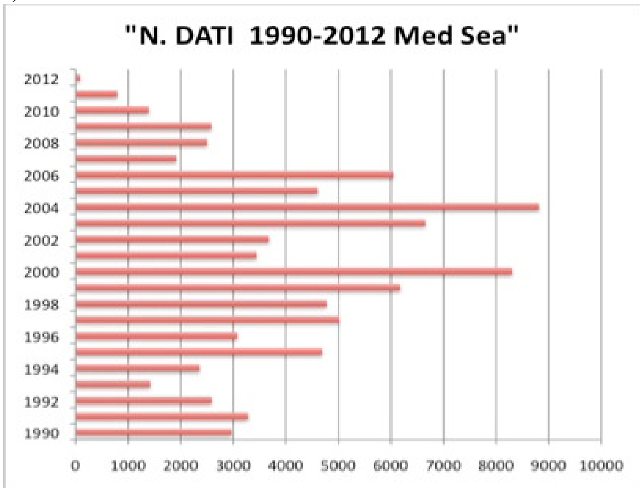


Figure 2. Annual distribution of T&S data within SDN infrastructure for the Mediterranean Sea: (a) for the time period 1911-1958; (b) for the time period 1959-1989; (c) for the time period 1990-2012.

Data Quality Control

Quality Control analysis has been applied to in situ data, since remote observations have already passed through specific and detailed MyOcean SST and Sea Level TACs QC processes.

The downloaded in situ observations have been selected through the **general quality indexes** applied consistently by SDN, MFS, MyOcean and MEDAR-MEDATLAS automated basic quality check. In particular we selected the **profiles with general flags equal to 1 related to their right positioning in space and time (longitude, latitude, time)**.

A **visual inspection** of the downloaded data has been performed using ODV (Ocean Data View) software that can easily manage big amount of data and it has been developed to be compliant with SDN and MEDAR-MEDATLAS data format. **General depth flags**, associated to each profile, equal to 0, 1, 2 have been then chosen to refine our data set in order to do not discard too many observations.

Key	Entry Term	Abbreviated term	Term definition
0	no quality control	none	No quality control procedures have been applied to the data value. This is the initial status for all data values entering the working archive.
1	good value	good	Good quality data value that is not part of any identified malfunction and has been verified as consistent with real phenomena during the quality control process.
2	probably good value	probably_good	Data value that is probably consistent with real phenomena but this is unconfirmed or data value forming part of a malfunction that is considered too small to affect the overall quality of the data object of which it is a part.
3	probably bad value	probably_bad	Data value recognised as unusual during quality control that forms part of a feature that is probably inconsistent with real phenomena.
4	bad value	bad	An obviously erroneous data value.
5	changed value	changed	Data value adjusted during quality control. Best practice strongly recommends that the value before the change be preserved in the data or its accompanying metadata.
6	value below detection	BD	The level of the measured phenomenon was too small to be quantified by the technique employed to measure it. The accompanying value is the detection limit for the technique or zero if that value is unknown.
7	value in excess	excess	The level of the measured phenomenon was too large to be quantified by the technique employed to measure it. The accompanying value is the measurement limit for the technique.
8	interpolated value	interpolated	This value has been derived by interpolation from other values in the data object.
9	missing value	missing	The data value is missing. Any accompanying value will be a magic number representing absent data.
A	value phenomenon uncertain	ID_uncertain	There is uncertainty in the description of the measured phenomenon associated with the value such as chemical species or biological entity.

Tab. 2: Quality indexes defined by SeaDataNet.

Then a **gross range check** has been applied to avoid unrealistic temperature (4 <T<30C°) and salinity (15<S<40psu) values. Duplicate check has been done applying specific tolerances on time (0.1 days), longitude (0.02deg) and latitude (0.02deg). Then an ODV built-in spike detector has been applied before saving the full data set with the relative quality flags in a spreadsheet file compatible with DIVA software used to compute temperature and salinity monthly climatology (D1.3.2).

Observed profiles were then written on ASCII files to be read from the OceanVar data assimilation scheme. **A further QC was performed during this phase considering the quality indexes associated to temperature, salinity and depth at each vertical level.** Only the profiles having more than the 75% of "good" data will be assimilated in the reanalysis. We defined good data the vertical records whose three (T ,S, depth) flags were all equal to one. For example, if a temperature and salinity profile contains 10 vertical records only the vertical records with all three quality flags equal to 1 were selected. Only if the number of the selected records is more than the 75% of its original number the profile passes to the next phase and thus it will be assimilated in the RR. In this case the profile should possess 8 good vertical records.

The circulation model for the Mediterranean RR

Second component of the RR system (Figure1) is the **ocean general numerical model (OGCM)** first implemented by *Tonani et al. 2008* based on OPA8.1 code (*Madec, 2008*), then developed and upgraded to OPA9.2 code (NEMO) by *Oddo et al. 2009*. First model implementation was used to produce **MedReanV2** (*Adani et al 2011*) while second model implementation is now running for **MedReanV4** reanalysis production (see Table 1).

The OGCM domain covers the entire Mediterranean Sea extending also into the Atlantic with a 1/16th of a degree horizontal resolution, 72 unevenly spaced vertical z-levels. The OGCM uses vertical z coordinates with **vertical partial cells** to better fit the bottom depth shape (*Oddo et al. 2009*). Figure 3, extracted from *Madec* (*2008*), shows how varies the bottom shape representation with standard vertical coordinates (a) and with vertical partial cels (b).

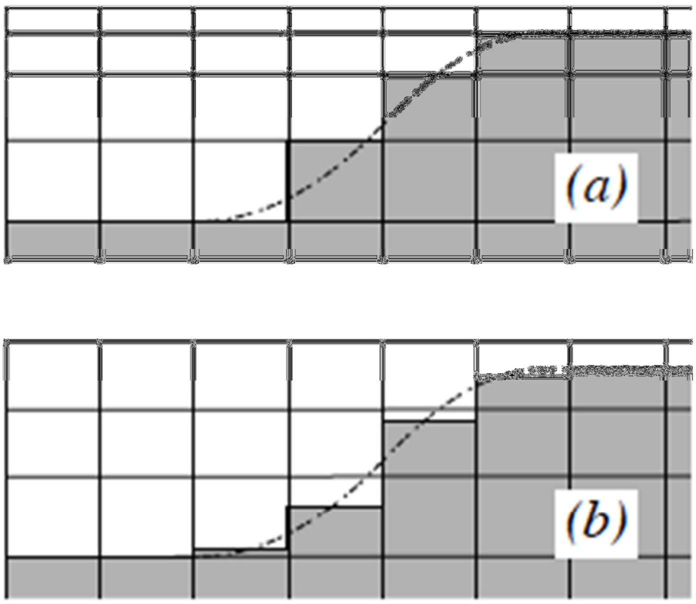


Figura 3. Il fondo del mare rappresentato in (a) da coordinate z standard, (b) da coordinate con partial cell sul fondo. Figura estratta da Madec 2008 – fig 3.5 –pag 44.

The Atlantic part of the domain (Atlantic box) presents three lateral boundaries where the model is nested within monthly mean climatological fields computed from 10 years of daily output (1993-2003) of the 1/4 degrees global model MERCATOR-1/4 (*Drevillon et al., 2008*).

Air-sea fluxes are computed through bulk formulae which need the following input atmospheric data: 1) air temperature at 2m; 2) dew point temperature; 3) zonal and meridional wind components at 10m; 4) mean sea level pressure; 5) total cloud cover. A specific study on the air-sea fluxes parameterization has been done. We evaluated for RR production the usage of:

- extrapolation technique for air temperature and specific humidity from 2 to 10m, as required by the bulk formulae;
- **true stress** which considers the wind speed relative to marine currents to compute the momentum flux.

To evaluate the air temperature and specific humidity extrapolation we used COSMO-Med data that provide values at 10m of the variables. We used NEMO routine turb_core_2z.f90 that computes turbulent transfer coefficients of surface fluxes according to *Large and Yeager (2004)* to extrapolate COSMO air temperature and specific humidity values from 2m to 10m and we compared the results with COSMO data at 10m.
To evaluate the introduction of true stress in the momentum flux parameterization we performed two simulations for the time period 1985-1987 with and without true stress computation and we validated model results with in situ temperature and salinity profiles and with satellite SST.

The **Initial Condition (IC)** definition needed the production and analysis of many temperature and salinity climatologies that consider different temporal periods to be able to better represent the mean hydrodynamic conditions of the initialization period. A new temperature and salinity monthly climatology (named SDN_v2aa) has been calculated utilizing the extensive historical data set from 1900 to 1987, which only partially comprehends MEDAR-MEDATLAS data (1985-1999) used instead in MedReanV2 IC (*Adani et al., 2011*). We considered all the observations available in January from 1900 to 1987 to compute the initial condition (January monthly climatology) because we did not want the climatology to be affected by the Eastern Mediterranean Transient (EMT), since it is not clear yet that an equivalent of the EMT has occurred before 1993. Mediterranean observations have been blended to the World Ocean Atlas climatology (WOA) in the Atlantic Box. The climatology has been computed with DIVA software tool (Data-Interpolating Variational Analysis), which allows to spatially interpolate observations on a regular grid in an optimal way.

The **atmospheric forcing** is the third component of the RR system (Figure1 and Table 1). After previous experiences (*Adani et al. 2011*) we will consider in RR a concatenation of the latest ECMWF (European Centre for Medium-Range Weather Forecasts) atmospheric reanalysis data products that have been archived by WP2.2:

- **ERAInterm** (*Dee et al. 2011*) data cover the time period **1979-nowadays** with horizontal resolution of **0.75°;**
- **ERA40** *(Uppala et al. 2005)* data cover the time period **September 1957-August 2002** with horizontal resolution of **1.125°.**

Both data sets present 6 hours of temporal resolution.
For the hundred years RR production is taken into consideration the quality of **AMIP** type (*Gates, 1992*) of forcing in order to cover the entire period of study. AMIP type of data (*Cherchi and Navarra, 2007)* are available starting from **1900 up to 2003** and were created through a set of experiments performed with the ECHAM4 atmospheric GCM on a T126 grid (**1.125°** of horizontal resolution) forced by HadISST1 (*Rayner et al. 2003*) interpolated onto model grid. AMIP data have 12 hours of temporal resolution. In particular 7 experiments are available in our archive with similar characteristics but they must be analyzed and compared to the ECMWF reanalysis products to choose the best one to use.

During this year we started also the **implementation of the higher resolution OGCM** based on the upgraded NEMO3.4 parallel code. The increment of model horizontal resolution goes from 1/16th to 1/24th of a degree. DBDB1 bathymetry has been interpolated on model grid and particular investigation was dedicated to model topography (coastline, minimum depth) and vertical discretization definition. We tried various configurations with different number of vertical levels (72, 81, 91, 101) to be able to represent in an optimal way the ambient stratification and its seasonal variability. The OGCM configuration with 91 vertical levels was selected. A preliminary simulation has been performed to assess that the input data (bathymetry, initial condition, atmospheric data, river outflow data) are read correctly and that the surface fluxes are computed correctly.

The Data Assimilation Scheme

Fourth component analyzed is **data assimilation scheme** that uses both in situ (temperature and salinity profiles) and remote sensed data (Sea Level Anomaly) to correct the OGCM results. **OceanVar** is a three-dimensional variational scheme, set up by *Dobricic and Pinardi,* (*2008*) for the operational forecasting system (*Dobricic et al 2007*), that allows to correct model fields for all dynamic variables (T, S, sea level, u and v current components).
The assimilation cycle to be used in the RR system differs from the operational one described in *Dobricic et al* (*2007*). The assimilation cycle is daily, as implemented by *Adani et al. (2011)* in the **MedReanV2**, and takes into consideration the observations within the 24 hours time interval that spans from 12:00 of day J and 12:00 of day J+1. The correction estimated is applied at model restart at 12:00 of day J+1.

OceanVar **calibration analysis** was performed in order to handle an increasing number of observations. Another issue encountered was the different observation distribution pattern that characterizes the operational prediction system, for which the OceanVar has been originally designed, and the RR system. The different data distribution pattern are related to the different characteristics of the NRT observations used for the forecast production and the DM observations considered for the RR production, that include high resolution surveys regularly spaced on monitoring arrays or transects.

Many experiments have been conducted to tune **horizontal correlation length scales**, the **instrumental error**, to evaluate the possible usage of **vertical super observations** (average computation within vertical layers to avoid redundant information) and to improve the **horizontal filter** that spreads vertical corrections in the horizontal introducing a multi-scale approach. This RR system calibration focused mainly on August/September 1987 when a lot of observations are available thanks to an extensive POEM surveys (*Malanotte-Rizzoli and Robinson, 1988*) which sampled intensively the Eastern Mediterranean. The evaluation of the results has been done using in situ and satellite SST observations but also comparing the obtained circulation with the reference extensive literature about the Eastern Mediterranean circulation in that period, in particular *Robinson at al. 1991*.

3.2 Applications; technological and computational aspects

None in the reference period.

3.3 Formation

None in the reference period.

3.4 Dissemination

None in the reference period.

3.5 Participation in conferences, workshops and meetings

None in the reference period.

4. Results obtained during the reference period

4.1 Specific Results

The OGCM analysis of **air-sea fluxes** parameterization brought about two important results.

First the air temperature and specific humidity extrapolation from 2 to 10m before the bulk formula computation is:

- an advantage for air temperature during winter time when extrapolated values at 10m are close to COSMO 10m, while it produces too high temperatures during the summer season when our model results present already a positive bias versus observed SST;
- an advantage for specific humidity computation during fall/winter seasons but it creates very low values during spring/summer seasons.

We thus concluded to avoid the extrapolation of air temperature and specific humidity from 2m to 10m.

Second the true stress analysis did not produce significant differences in terms of temperature and salinity misfits computed from in situ and satellite observations, we thus decided to keep the true stress implementation.

Data Assimilation calibration results allowed to:

- identify a code bug on the vertical misfit interpolation;
- to discard vertical super observation computation;
- to reduce the correlation length scale in order to minimize the occurrence of overshooting phenomena in the 3D correction field estimation;
- to improve the horizontal filter;
- to test a multi-scale horizontal filter which selects the horizontal correlation length scale on the base of the observed variability.

4.2 Pubblications

None in the reference period.

4.3 Availability of data and models output (format, media, etc.)

None in the reference period.

4.4 Completed deliverables

D1.3.1: "Historical marine data and Quality Control (QC) procedure for the Mediterranean Sea Reconstruction/Reanalysis (RR)"

D1.3.2: "Implementation of the numerical model and the data assimilation scheme of the Mediterranean Sea Reconstruction/Reanalysis (RR) System"

5. Comment on differences between expected activities, results, deliverables and those actually performed

The first year of WP1.3.1 activity focused on the design of a new Reconstruction/Reanalysis (RR) system aimed at studying the Mediterranean Sea climate variability in past century. The results of the higher resolution OGCM at 1/24th of a degree are still preliminary to be implemented within the RR system. The AMIP data analysis and their full validation with the ECMWF reanalysis products (ERA40, ERAInterim) has not been possible during this first year of activity but will be performed soon and included in the next year report. These data should force the RR before 1958, when ERA40 data become available.

6. Expected activities for the following reference period

The activities conducted during the first year and the results obtained so far bring about a partial re-formulation of our activities **for the following reference period** with respect to what has been indicated in the project Executive Plan (**Production of Med RR at 1/24 starting from 1912**). While further time will be dedicated to the higher resolution RR system implementation/calibration and the validation of the AMIP atmospheric forcing, we will begin **an interim** RR production covering the time perios 1958-2011 using the 1/16 of a degree configuration.

In the meantime further efforts will be invested on:

- higher resolution RR system implementation;
- AMIP data quality assessment;
- the improvement of OceanVar data assimilation scheme for the higher resolution RR system;
- the estimation of a new monthly climatology on the $1/24^{th}$ of a degree to initialize the higher resolution RR system.

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WP 1.5 (Paleoclimate data from marine sediments) – WP 2.4 (Archive of paleoclimatic data from sediment cores)

1. Scheduled activities, expected results and Milestones (as indicated in Executive Plan)

In collaboration with Dott. Fabrizio Lirer (WP1.5) and Dott.ssa Luciana Ferraro (WP2.4), Dott. Fabio Florindo worked to identify potential keysites in the Mediterranean Basin, which could preserve marine records in a sedimentary facies suitable for high-resolution studies.
In addition to marine records, they are planning to investigate lacustrine records characterised by a detailed record of paleoenvironmental and paleoclimatic changes occurred during the past 5000/10000 years.
Finally, we are working at the identification of data available from National and International archives in selected sectors from extra Mediterranean regions. If sites of interest are identified, it will be possible to proceed eventually to request the materials contained in the core repository.

2. Deliverables expected for the reference period

D1.5.1: Report on the definition of the available measurements and of the keysites for new holes.
D1.5.2: Report on the sediment cores available from the core repository; transmitting information to the archives and to the General Portal.
D2.4.1: Data sediment cores and keysites archive; transmitting data to the General Portal.

3. Activities which have been actually conducted during the reference period

3.1 Research Activities

The research activities within the WP1.5 first year were focused on the analysis, for the Mediterranean Basin, of a large amount of bibliographic data in order to detect keysites for the recovery of marine sediments, which could contain the Holocene record and in particular of the last millennia. This study of the literature data was conducted in close collaboration with the WP 2.4 research team.
The study of the literature data led us to identify the following sites of interest: the Gulf of Gaeta; the Gulf of Salerno; Malta continental shelf; Malta continental shelf; the Gulf of Taranto; the southern Ionian Sea.
Furthermore, a proposal for ship-time was advanced to O/V Urania of CNR, relating to the period of July 2013 (or alternatively May 2013), in order to recover the marine sediments in the sites located in the Southern Mediterranean Sea, in the Ionian Sea and in the Gulf of Taranto. As regards the Gulf of Gaeta, it was requested an additional ship-time to O/V Urania of CNR, for the period of February 2013. As regards the Gulf of Salerno was collected a core with a length of 1,20 meters at a water depth of -103 meters. This core was already opened and it will be sampled with u-channels for paleomagnetic analyses.
In addition to the above identified areas of the Mediterranean basin, we focused our attention

on some paleolakes that have great potential in terms of continuous record of changes in paleoclimate and paleoenvironment during the last 10,000 years. One of these is Giuturna Lake (lat 41.731179, long 12.623889) located in the Alban Hills south-east of Rome.

3.2 Applications; technological and computational aspects

None in the reference period.

3.3 Formation

None in the reference period.

3.4 Dissemination

None in the reference period.

3.5 Participation in conferences, workshops and meetings

AGU fall meeting 2012.

4. Results obtained during the reference period

4.1 Specific Results

None.

4.2 Publications

None in the reference period.

4.3 Availability of data and models output (format, media, etc.)

None in the reference period.

4.4 Completed deliverables

Both deliverables for the first year were completed.

5. Comment on differences between expected activities, results, deliverables and those actually performed

None.

6. Expected activities for the following reference period

The activities expected for the second year of the project enclose two new oceanographic cruises aboard the O/V Urania, belonging to the CNR, to collect cores at the identified sites of interest, relating to the period of July 2013 (or alternatively May 2013), in order to recover the marine sediments in the sites located in the Southern Mediterranean Sea, in the Ionian Sea

and in the Gulf of Taranto. As regards the Gulf of Gaeta, it was requested an additional ship-time to O/V Urania of CNR, for the period of February 2013.
The recovering of the cores will be followed by several study phases and proxy analysis.
As regards the Gulf of Salerno a core was already collected in 2006 (aboard the O/V Tethis), and it is available within the NEXTDATA project (at present the IAMC-CNR core repository in Naples contains this core); the core is 1,20 meters in length and it was recovered at a water depth of -103 meters. It was already opened and it will be sampled with u-channels for a paleomagnetic investigation (secular variation and environmental magnetism) by Dr. Fabio Florindo, from INGV in Rome. The secular variation curve will be calibrated with AMS 14C datations and radionuclide dating. This process should provide a very reliable and detailed chronology for the last 500 years, which represents the starting point for paleoclimatic interpretations. Environmental magnetic data, with the detailed chronology can make an important contribution to our understanding of environmental and climate changes during the investigated period.
We will continue working to identify additional key sites in the Mediterranean Basin and in key areas outside the Mediterranean, which could preserve marine records in a sedimentary facies suitable for high-resolution studies. In addition, we will carried out a seismic and magnetic geophysical survey of the Giuturna Lake aimed to locate the best site for drilling.
Finally, dott. Fabio Florindo will continue the investigation of the aggradational sequences of the Paleo-Tiber River in the area of Rome pointing out the relationships among climate, sea-level forcing, tectonics and sedimentary processes during the past 800 kyrs.

WP 2.2: Archive of marine observation networks and climate reconstructions

(Resp. Claudia Fratianni, INGV)

Partners: INGV

1. Scheduled activities, expected results and Milestones (as indicated in Executive Plan)

The activities of the first year of the project concern the development, realisation and organization of historical marine data archives, subjected to a specific quality control for data assimilation, and of atmospheric data that will be used in the production of Mediterranean Sea Reconstruction-Reanalysis (RR) for the past 100 years. In addition, a specific portal will be designed together with the structure of the RR database using the existing reanalysis for the past twenty years. Meetings with potential users will be organized in order to define the details of the archive and the data access protocols.

The milestone defined for the first year is as follows:
M2.2.1 (PM12): Meeting to discuss the specific RR portal and specific products.
The meeting was held in December at INGV in Bologna and it was attended by private Company CLU s.r.l., which will henceforth be in charge of the design and architecture of the specific portal for the future.

2. Deliverables expected for the reference period

The deliverables due for the first year are:
D2.2.1: Report on specific in-situ and satellite data for RR and atmospheric parameters.
D2.2.2: Report on user-friendly catalogue and database.

3. Activities which has been actually conducted during the reference period

Most of the planned activity was carried out during the first year. Specifically, a reference database was created for the historical marine data and for the atmospheric data required for the production of the RR, starting from the information already collected for the production of the previous reanalysis versions, as shown in Table 1 and proceeding in the search for new and updated datasets to cover the time interval of the RR.

3.1 Research activity

The activity was conducted in close collaboration with WP1.3 which, wherever necessary, developed specific data quality controls, as described in D1.3.1 and D1.3.2. This was done in order to create a reference database broad enough to contribute in increasing the quality of the RR.

	MedReanV2 (1985-2007)	MedReanV4(1985-2010)	RR(1912-2011)
Initial conditions	MedAtlas Climatology (obs 1995-1999) *(Maillard et al. 2005)*	SDNV2aa climatology (obs until1987)	SDNV2aa climatology (obs until1987)
Atmospheric forcings	ERA15 1.125° (1985-1992) ECMWF analyses 0.5° (1993-2007)	ERAInterim 0.75° (1985-2010)	AMIP1.125° (1912-1957) ERA40 1.125° (1958-1978) ERAInterim 0.75° (1979-2011)
Total Cloud Cover	NCEP–NCAR (1985–92) ECMWF analyses 0.5° (1993-2007)	ERAInterim 0.75° (1985-2010)	AMIP 1.125° (1912-1947) NCEP–NCAR(1948-1978) ERAInterim 0.75°(1979-2011)
Precipitations	NCEP–NCAR (monthly climatology)	CMAP (monthly climatology)	AMIP (montly climatology) NCEP–NCAR (monthly climatology) CMAP (monthly climatology)
SST	SST reconstruction (1985-2007) *(Marullo et al.2007)*	SST reconstruction (1985-2007) *(Marullo et al.2007)* DT data (2008-2010)	HadISST (1912-1985) SST reconstruction (1985-2007) *(Marullo et al.2007)* MyOcean data (2008-2011)
SLA	ERS1, ERS2, EnviSat, TOPEX/Poseidon, Jason1 *(Pujol and Larnicol 2005)*	AVISO multisensor "UPD" data reprocessed in 2010	MyOcean multisensor "UPD" data reprocessed in 2012
XBT	<1999 MEDATLAS, MATER Ship of Opportunity *(Manzella 2007)* 2000-2007 MFS observations	SeaDataNet MFS observations (1985-2010)	SeaDataNet MFS - MyOcean observations (1912-2011)
ARGO	MedArgo Program 2001-2007 *(Poulain et al. 2007)*	All observations 2001-2010	All observations 2001-2011
CTD	MEDATLAS, MATER (<1999) 2000-2007 MFS observations (2000-2007)	SeaDataNet MFS observations (1985-2010)	SeaDataNet MFS - MyOcean observations (1912-2011)

Table 1: Table of datasets utilised for the production of reconstructions and reanalysis at INGV. The systems are described in D1.3.1.

The datasets stored for the production of the RR are as follows:

- satellite sea surface temperature (SST) observations;
- satellite sea level anomaly (SLA) observations;
- in situ temperature and salinity observations;
- surface atmospheric variables;
- temperature and salinity initial conditions.

Satellite SST observations:

The creation of a satellite SST dataset covering the whole RR period focused mainly on the analysis of the available data for the period before 1985. Starting from this date, there exist specific SST products created for the Mediterranean Sea consisting of daily time series of mean sea surface temperature maps optimally interpolated onto the RR model grid at 1/16th of a degree. As from 1985, the dataset is a result of the concatenation of the following products:

- 1985-20080710: reconstruction data built from the most recent AVHRR Pathfinder SST time series (Marullo et al., 2007).
- 20080711-20111231: in the framework of MyOcean project, SST TAC/OSI TAC (Sea Surface Temperature/Ocean and Sea Ice Thematic Assembly Center)) produce and disseminate SST daily maps, as described in D2.2.1.

The Met Office Hadley Centre SST dataset (HadSST1) was archived for the period earlier than 1985. It consists of monthly SST data on a regular grid of 1° x 1° starting from 1870 (Rayner et all, 2003). This choice is consistent with the idea to use AMIP (Atmospheric Model Intercomparison Project – Gates, 1992) type of atmospheric forcing for the pre-ERA40 period which starts from mid-1957. AMIP data are obtained from ECHAM4 model simulations forced by HadSST1.

Satellite SLA observations:

The SLA dataset was updated to the latest version released on April 2012 and completing the time series till April 2012.
These data are produced and disseminated in the framework of Sea Level TAC of MyOcean Project.
The dataset consists of mono altimeter satellite along-track sea surface heights anomaly computed as difference between sea surface height and the mean over the period 1993-1999. (http://catalogue.myocean.eu.org/static/resources/myocean/pum/MYO2-SL-PUM-008-001-005-v3.2.pdf).
The coverage depends on the duration of the missions:

- Jason 2: from October 2008
- Jason 1 (new orbit): from February 2009
- Jason 1: April 2002 - October 2008
- Envisat (new orbit): from October 2010
- Envisat: October 2002 - October 2010
- ERS-1: October 1992 - May 1995
- ERS-2: May 1995 - April 2003
- GFO: January 2000 - September 2008
- T/P (new orbit): September 2002 - October 2005
- T/P: September 1992 - April 2002

Each satellite is characterised by a repeat cycle and by a ground track which, overall, guarantee relatively uniform coverage of the Mediterranean Sea.
The information stored for each satellite is that required by the assimilation system, i.e.: time in Julian days starting from 1 January 1950, longitude, latitude, and sea level anomaly value expressed in metres.

Temperature and salinity vertical profiles in situ observations

The dataset is the result of the homogenization of data collected in various projects, namely MedarMedatlas, SeaDataNet, MFS and MyOcean in order to eliminate duplicates. The dataset is composed of vertical temperature and salinity profiles collected by means of bottles, thermometers, XBT, MBT, CTD and ARGO measurements subjected to a specific quality control for use in the data assimilation system, as described in D1.3.1. The composition of the reference dataset for the in situ observations is described in D2.2.1.

Surface atmospheric variables

The parameters required to force the RR production system are as follows:

1. Mean sea level pressure (MSLP)
2. Temperature at 2 metres (T2m)
3. Zonal and meridional wind component (U10,V10)
4. Total cloud cover (TCC)

5. Dew point temperature at 2 metres (D2m)
6. Precipitation (P)

The creation of the reference dataset calls for the concatenation of different starting datasets in order to take account of the foregoing parameters and ensure time coverage of the RR, as shown in Table 1. The parameters (MSLP, U, V, TCC, T2m, and D2m) were retrieved from the reference datasets and stored in monthly or daily binary files which will be read by the oceanic model and which will contain the foregoing variables at the spatial and temporal resolution of the original model. The precipitation parameter was archived instead as netCDF file containing the monthly precipitation values interpolated from the original grid to the oceanic model grid at 1/16th of a degree.

The specific original datasets (AMIP, NCEP-NCAR, ERA-40, ERAINTERIM, and CMAP) are described in D2.2.1.

<u>Temperature and salinity gridded fields (Initial Conditions)</u>
The initial conditions are stored in the form of two separate files in netCDF format, one for salinity and one for temperature. The method utilised to create the files is described in D1.3.1.

3.2 Applications; technological and computational aspects

Once they have been checked, the data are stored in a dedicated filesystem as shown in Figure 1.

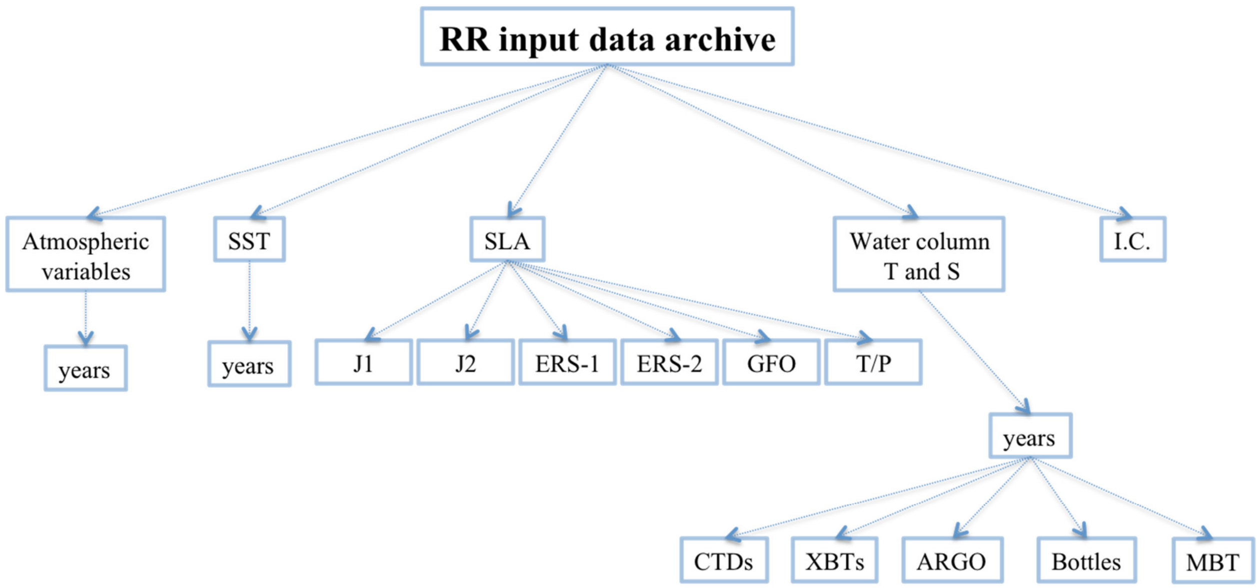

Figure 1. Organization of RR system input data archive directories.

All the datasets, divided by years and/or instruments, are written on format to be read from OceanVar data assimilation scheme and from numerical model:

- ASCII: T and S observed profiles; SLA satellite observations;
- binary: surface atmospheric forcing;
- netCDF: SST satellite observations; T,S gridded fields;precipitations.

The specific RR data access portal was designed in parallel with the implementation of the reference database. In the creation of the specific RR portal the most recent guidelines of the

European Community INSPIRE Directive were followed in order to create infrastructure that is compatible with the European Community framework. The specific portal will be linked to the general project portal, which will contain all the information relative to the metadata of the products that will be made available, while the property and network services will reside on the specific local portal, as shown in Figure 2.

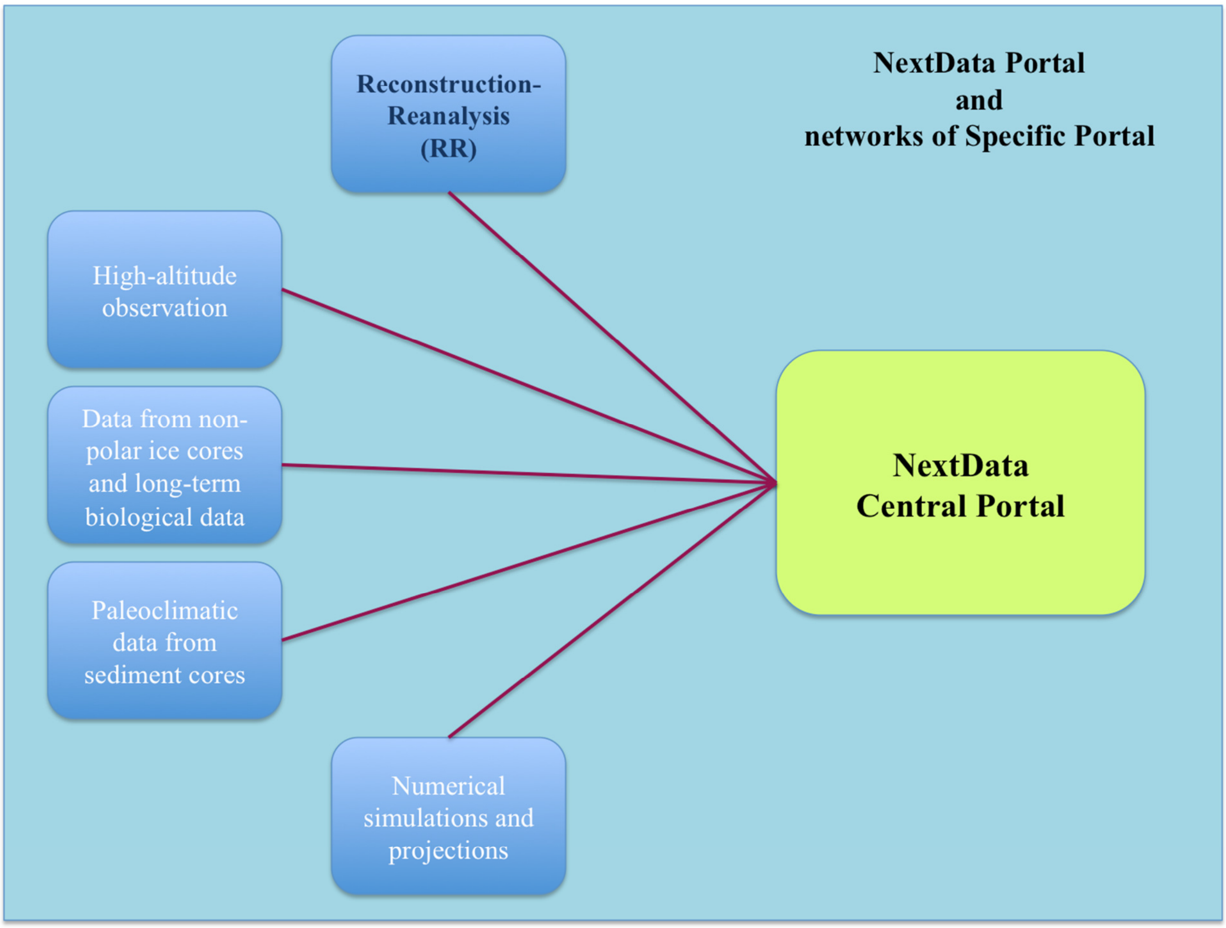

Figure 2. General diagram of the information flows between the General Portal and the Specific Portal of the RR.

The specific portal will supply the services defined in the INSPIRE Directive: discovery, view, downloading and transformation, as shown in Figure 3.

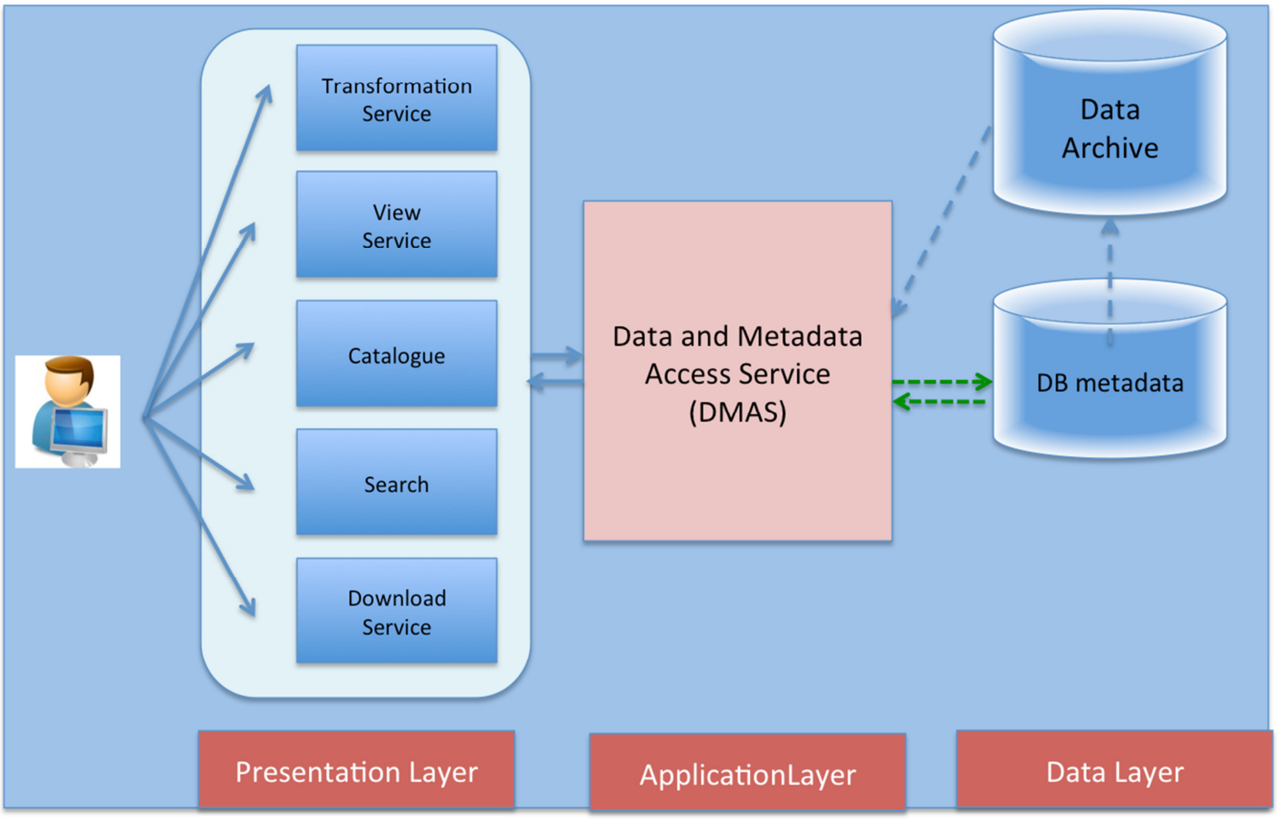

Figure 3. Specific RR portal architecture.

The specific RR portal architecture is composed of 3 closely interconnected layers:

- **Presentation Layer**: this layer contains the network services (Transformation, View, Search, Download, Catalogue) that it has been decided to implement.
- **Application Layer**: includes the Data and Metadata Access Service (DMAS).
- **Data Layer**: includes the physical archive of the data and the metadata database.

The user will access a graphic interface (web page) that will provide a simple method of consulting the catalogue, searching, viewing and downloading RR products.

The heart of the entire architecture is constituted by the DMAS, which performs a dual function. On the one hand, it manages the metadata required to perform search and discovery functions in the data archive, and on the other hand it provides the facility to access the data archive by means of the metadata database. The data archive is the physical storage in which the products will be located, and it will consist of a filesystem. This solution was adopted in view of the enormous quantity of data to be handled and the need for a tool that is separate from database management systems.

The user can consult the catalogue of available products, which will include the parameters indicated in Table 2. This catalogue was designed on the basis of the currently produced reanalyses, which cover the last 20 years, and it may be subject to updates in versions that will be released subsequently during the project.

Variables	Geographical coverage	Spatial resolution	Number of levels	Temporal resolution	Temporal coverage
Temperature	6° W - 36.25° E 30.19° N – 45.94° N	0.0625°	33	24 hr average field	1912-2011
Salinity	6° W - 36.25° E 30.19° N – 45.94° N	0.0625°	33	24 hr average field	1912-2011
Sea Surface Height	6° W - 36.25° E 30.19° N – 45.94° N	0.0625°	1	24 hr average field	1912-2011
Horizontal velocity (meridional and zonal component)	6° W - 36.25° E 30.19° N – 45.94° N	0.0625°	33	24 hr average field	1912-2011
Surface fluxes	6° W - 36.25° E 30.19° N – 45.94° N	0.0625°	1	6hr	1912-2011
Surface S,T and currents	6° W - 36.25° E 30.19° N – 45.94° N	0.0625°	1	6hr	1912-2011

Table 2: List of the RR products made available in the framework of the project.

Temperature, salinity and horizontal velocity fields:

These are 3-dimensional fields, given as daily means centred at 24 UTC of each day. The vertical levels are in metres and the geographical coordinates are in degrees and tenths of a degree.
A study will also be performed into how to filter the signal of inertial currents by means of a high-pass filter to eliminate bias from the daily mean.

Surface horizontal temperature, salinity, and velocity fields:

These are 2-dimensional fields, given as instantaneous fields (snapshots) every 6 hours.

Free surface elevation fields:

These are the 2-dimensional fields, given as daily means centred at 24 UTC of each day.

Air-sea interface fluxes fields:
These are 2-dimensional fields, given as instantaneous fields (snapshots) every 6 hours. They include the heat fluxes with all their components (net short wave radiation, net long wave radiation, sensible heat and latent heat), momentum (zonal and meridional wind stress) and surface water flux (difference between precipitation, run-off and evaporation).

The RR products are released on the regular lat/lon grid of 1/16th of a degree, equivalent to approximately 6.5 km. The reference domain is shown in Figure 4.

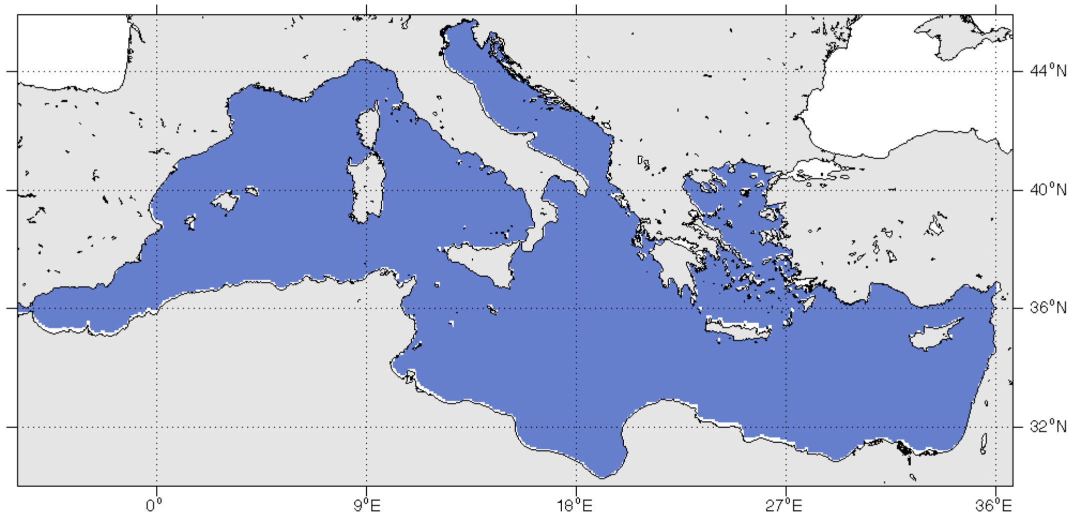

Figure 4. RR products domain.

The three-dimensional parameters will be made available on 33 levels corresponding to the IODE standard levels.

The Portal interactive viewing options will be possible only for mean fields such as:

- Monthly mean
- Annual mean

This choice is justified by the large volume of daily data that will not allow to have good performances in terms of request/response time of the Portal. So interactive visualization will be allowed only for mean fields.

It will be possible to download the selected products in NetCDF (Network Common Data Form) format, a binary format supported by specific libraries and widely used in the scientific field (*www.unidata.ucar.edu/software/netcdf/*). The convention adopted is CF-1.0.

3.3 Formation

None.

3.4 Dissemination

None.

3.5 Participation in conferences, workshops and meetings

None.

4. Results obtained during the reference period

4.1 Specific results (database, measurement results, models output, etc.)

The reference database of historical marine data and atmospheric data was created for use in the production of the RR, as described in heading 3.

4.2 Publications

The release of publications during the reference period was not envisaged.

4.3 Availability of data and models output (format, media, etc.)

No products planned.

4.4 Completed deliverables

Both deliverables for the first year were completed.

5. Comment on differences between expected activities/results/deliverables and those which have been actually realised

The meetings with potential users to define the details of archive and data access protocols will be postponed to the second year. First contacts are taken with the WP involved in archiving and releasing of reanalysis and simulation gridded products in order to find a common management.

6. Activities planned for the next period

In the second year of the project the discussion on the archive organization and on the products release will be opened to the external community to the project.
The historical marine data archive will be updated following the dataset updates.
In the second year of the project the archive will be created with the produced RR data and a second version of the catalogue will be implemented on the basis of the new products. In addition, the interactive system for viewing and downloading the archive will be developed.
On the base of the obtained results, it will be evaluated when to organize an encounter with the national community of the end users with the release of the beta archive version and the specific portal.