Project - My-Wave

Availability of in-situ and satellite data and methodology of data transfer for wave ensemble prediction system validation

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GLOSSARY AND ABREVIATIONS

ARPAL	Agenzia Regionale per la Protezione Ambientale della Liguria (Liguria Regional agency for environmental protection)
CAMERI	Coastal and Marine Engineering Research Institute Ltd
CNMCA	Centro Nazionale di Meteorologia e Climatologia Aeronautica (Italian National Meteorological and Climatological Air Force Centre)
CNR	Consiglio Nazionale delle Ricerche (Italian National Research Council)
ECMWF	European Centre for Medium-Range Weather Forecasts
EPS	Ensemble Prediction System
GTS	Global Telecommunication System
IPC	Israel Ports Development and Assets Company Ltd
ISMAR	Istituto di Scienze Marine (Institute of Marine Science, Italy)
ISPRA	Istituto Superiore per la Protezione e la Ricerca Ambientale (Italian National Institute for the Environmental Protection and Research)
JCOMM	Joint technical Commission for Oceanography and Marine Meteorology
RADS	Radar Altimeter Database System
RON	Rete Ondametrica Nazionale (Italian national wave buoys network)
UKMO	United Kingdom Met Office
USAM	Ufficio Generale Spazio Aereo e Meteorologia (General Office for Air Space and Meteorology, part of the Italian Air Force Staff)
WMO	World Meteorological Organisation

APPLICABLE AND REFERENCE DOCUMENTS

Applicable Documents

	Ref	Title	Date / Issue
DA 1	MyWave-A1	MyWave: Annex I – “Description of Work	September 2011
DA 2			

Reference Documents

	Ref	Title	Date / Issue
DR 1			
DR 2			

I INTRODUCTION

I.1 Work Package and report objectives

Work Package 3 will apply different ensemble techniques in wave forecast, assessing, for two separate and different areas, their performance and increased information with respect to a deterministic approach. The technique will be applied both at large and local scales, in the latter case for three specific harbours.

Different approaches can be followed in producing a meteorological, hence wave, ensemble. Two approaches will be followed in WP3, at two different scales, North-Atlantic, with focus on the European coasts, and the Mediterranean Sea. The results will be intercompared, also with respect to the deterministic approach, in order to assess the different level of information provided to the users and their related reliability. The results will be provided both on the open sea/ocean and coastal waters, as also for harbour management.

This report documents Subtask 3.3.2, which deals with the collection and distribution of in-situ and remotely sensed measured data for wave ensemble prediction system (EPS) validation. The UKMO system will comprise models covering both areas designated in WP3, namely the Northern Atlantic Ocean (including a focus region around the United Kingdom) and the Mediterranean Sea, while the USAM-CNMCA EPS will describe the Mediterranean Sea, though by means of a different approach.

A common period of testing will be defined then, for a full cross-comparison between the two different ensemble approaches, on the Mediterranean Region, in order to obtain objective scores offering clear indications on the capability of the different systems to provide, in the long term, the best results in the Mediterranean Sea.

Whitin this work-package ISPRA is responsible for the organisation and collection of measured data to be used for wave ensemble prediction systems (EPS) validation procedure. Buoy data over the Atlantic Ocean and the Mediterranean Sea have been complemented with selected remotely sensed altimeter and scatterometer data.

An effort has also been made to provide information about all the GPS available stations for wave data measurements.

II AVAILABLE BUOY DATA

II.1 Italian RON Buoy System

The Italian Rete Ondametrica Nazionale (RON) buoy network has been working since 1989. An extensive set of wave data collected in the first decade of measurement is public and available on the internet at the following address: http://www.idromare.it/. This network, owned and managed by ISPRA, was completely renewed by Envirtech in 2009 to acquire more oceanographic parameters and to increase nautical capabilities, reducing accidental buoy adrift events. The major changes consisted in the number of buoys (increased from 10 to 15), the buoy model (from TRIAXYS to WATCHKEEPER), and the parameter measurements made available. Figure 1 shows the 15 buoys position. All buoys are deep sea moored (80-100m), with the exception of the buoys located in the Adriatic Sea, where the water basin becomes shallow moving from south to north. The new buoys are relatively big (see Figure 2) with a diameter of 1.7 m, a height exceeding 3.0 m and a weight typically around 540 kg. The buoys are equipped with accelerometers. Both a standard Fourier and a zero-crossing analysis are carried out on board on 20 min periods, 48 times a day. Meteorological parameters are also recorded, in particular 30 min wind speed at ~3 m height is measured by means of a Ultrasonic 2-D GILL WINDSONIC anemometer at each station. Wave data is transmitted via GTS to the WMO network with only a few minutes delay. It is important to consider that real time data is submitted only to a relatively weak quality control procedure. Near real-time information is always available at: http://www.telemisura.it/

Figure 1 - RON Buoy System

Figure 2 - Watchkeeper buoys (AXYS Technologies)

The Italian Data Buoy Network collects directional sea wave data, meteorological data, sea surface temperature and in some cases quality parameters. Acoustic Doppler Current Profilers (ADCP) and hyperspectral probes will be added in the future. The network will be also the main framework for tsunami wave study in the central Mediterranean Sea, within the Mediterranean Tsunami Assessment System (MeTAS) project, and an early technological platform to study low-frequency sea motion detected in open sea using high-precision, multichannel, multisatellite GPS/Glonass/Galileo receivers and sea bottom instrumentation equipped with nano-resolution pressure sensors.

The network buoys transmit data to shore stations within 15 NM and a small dataset via Inmarsat. All shore stations are connected to the control centre based in Rome, using 2 Mbps xDSL channels, implementing a virtual private network. Users can access data via the Web, GTS, the Italian Broadcast Teletext Service (Rai-1 televideo) and via scheduled FTP uploads. At the control centre, a server array based on six quad-processors nodes, in a cluster configuration, processes and stores all data collected using a Microsoft SQL Server.

The parameters presently available on GTS are the following:

- Hm0: Significant Wave Height (m)
- Tp: Peak Period (s)
- Tm: Mean Period (s)
- Dmt: Mean Wave Direction (deg N)
- Dmp: Peak Mean Total Direction (deg N)
- Dmw: Mean Wind-Waves Direction (deg N)
- Tmp: Water Temperature (deg C)

The following Table 1 shows the shore stations names, the buoys' positions and relative sea bottom depths.

Buoy Code	Shore Station	Geographical coordinates			Depth [m]
		WGS84	LAT	LON	
61207	Catania	37.434 - 15.147	37° 26' 24'' N	15° 08' 48'' E	90
61208	Mazara	37.518 - 12.533	37° 31' 05'' N	12° 32' 00'' E	85
61209	Palermo	38.258 - 13.333	38° 15' 30'' N	13° 20' 00'' E	145
61210	Crotone	39.024 - 17.220	39° 01' 25'' N	17° 13' 12'' E	80
61211	Cetraro	39.451 - 15.917	39° 27' 12'' N	15° 55' 06'' E	100
61212	Siniscola	40.617 - 9.892	40° 37' 00'' N	09° 53' 30'' E	130
61213	Alghero	40.549 - 8.107	40° 32' 55'' N	08° 06' 25'' E	85
61214	Ponza	40.867 - 12.950	40° 52' 00'' N	12° 57' 00'' E	115
61215	Monopoli	40.975 - 17.378	40° 58' 30'' N	17° 22' 40'' E	85
61216	Civitavecchia	42.133 - 11.689	42° 14' 41'' N	11° 33' 14'' E	62
61217	Ortona	42.407 - 14.536	42° 24' 24'' N	14° 32' 12'' E	72
61218	Ancona	43.825 - 13.719	43° 49' 26'' N	13° 43' 10'' E	70
61219	La Spezia	43.929 - 9.828	43° 55' 45'' N	09° 49' 40'' E	85
61220	Venezia	**45.333 - 12.517**	45° 20' 00'' N	12° 31' 00'' E	17
61221	Cagliari	39.110 - 9.454	39° 06' 54'' N	09° 24' 18'' E	150

Table 1 - RON Buoy Network

II.2 ARPAL Buoy

Another Italian buoy available on GTS is the ARPAL buoy positioned west of the Gulf of Genoa.

ARPAL buoy data have been extracted from the official web page: http://servizi-meteoliguria.arpal.gov.it/boacapomele.html.

Figure 3 - ARPAL buoy

This buoy is a FUGRO Oceanor SEAWATCH Midi 185, moored at 90 m depth (see Figure 3), equipped with standard meteorological sensors (2 anemometers, pressure, humidity and temperature), as listed below:

- Wind sensor1: Young 05103 Wind Monitor;
- Wind sensor 2: Gill WindSonic
- Air Pressure: Vaisala BAROCAP PTB330
- Humidity and temperature: Vaisala HUMICAP® Humidity and Temperature Probe HMP155;
- Wave sensor: Oceanor Wavesense 3

The buoy is also equipped with a current profiler and measures sea temperature at 0.5 m.

Figure 4 - ARPAL buoy location

The following Table 2 shows the station name, the buoy's position and relative sea bottom depth.

Buoy Code	Shore Station	Geographical coordinates WGS84	LAT	LON	Depth [m]
61200	ARPAL	**43.922 - 8.181**	43° 55' 00'' N	08° 10' 50'' E	90

Table 2 - ARPAL Buoy

II.3 Puertos del Estado Buoy System

The available buoys managed by Puertos del Estado (Spain) are listed below, in Table 3, together with the relative shore stations name and buoys' positions.

The listed buoys location is also shown in the following Figure 5.

Buoy Code	Shore Station	Geographical coordinates		
		WGS84	LAT	LON
61196	PdE	**41.920 - 3.640**	41° 55' 12'' N	03° 38' 24'' E
61198	PdE	**36.570 - -2.320**	36° 34' 12'' N	02° 19' 12'' W
61280	PdE	**40.680 - 1.470**	40° 40' 48'' N	01° 28' 12'' E
61281	PdE	**39.520 - 0.200**	39° 31' 12'' N	00° 12' 00'' E
61417	PdE	**37.650 - -0.330**	37° 39' 00'' N	00° 19' 48'' W
61430	PdE	**39.560 - 2.100**	39° 33' 36'' N	02° 06' 00'' E

Table 3 - Puertos del Estado Buoy System

This buoy data has been extracted from MyOcean catalogue.

Figure 5 - Puertos del Estado buoys location

II.4 Ifremer Buoy System

One buoy is available also from Ifremer (France), whose relative shore station name and buoy's position is specified in the following Table 4.

The buoy location is shown in Figure 6.

Buoy Code	Shore Station	Geographical coordinates		
		WGS84	LAT	LON
61284	Ifremer	**43.319 - 4.866**	43° 19' 08" N	04° 51' 58" E

Table 4 - Ifremer Buoy System

This buoy data has been extracted from MyOcean catalogue.

Figure 6 - Ifremer buoy location

II.5 MeteoFrance Buoy System

The available buoys managed by MeteoFrance (France) are listed in Table 5, together with the relative shore stations name and buoys' positions.

The listed buoys location is also shown in the following Figure 7.

Buoy Code	Shore Station	Geographical coordinates		
		WGS84	LAT	LON
61001	MeteoFrance	**43.425 - 7.890**	43° 25' 30'' N	07° 53' 24'' E
61002	MeteoFrance	**42.100 - 4.700**	42° 06' 00'' N	04° 42' 00'' E

Table 5 - MeteoFrance Buoy System

This buoy data has been extracted both from MyOcean catalogue and the respective national dissemination centre.

Figure 7 - Meteo-France buoys location

II.6 HCMR Buoy System

The available buoys managed by HCMR (Greece) are listed in Table 6, together with the relative shore stations name and buoys' positions.

The listed buoys location is also shown in the following Figure 8.

Buoy Code	Shore Station	Geographical coordinates		
		WGS84	LAT	LON
61277	-	**37.523 - 25.462**	37° 31' 23'' N	25° 27' 43'' E
68422	PYLOS	**36.829 - 21.608**	36° 49' 44'' N	21° 36' 29'' E
-	SARON	**37.610 - 23.569**	37° 36' 36'' N	23° 34' 08'' E

Table 6 - HCMR Buoy System

This buoy data has been extracted from MyOcean catalogue.

Figure 8 - HCMR buoys location

In order to extend the observational structure, ISMAR has also managed to obtain the data from two buoys from the Israel Ports Development and Assets Company Ltd and Coastal (IPC) and Marine Engineering Research Institute Ltd (CAMERI). This has been possible through a specific agreement signed by ISMAR in order to get the data for MyWave Project research purposes.

The available buoys managed by IPC/CAMERI authorities (Israel) are listed in Table 7, together with the relative shore stations name and buoys' positions.

The listed buoys location is also shown in the following Figure 9.

Buoy Code	Shore Station	Geographical coordinates		
		WGS84	LAT	LON
-	HAIFA	**31.875 - 34.650**	31° 52' 30'' N	34° 39' 0'' E
-	ASHDOD	**32.844 - 34.939**	32° 50' 38'' N	34° 56' 20'' E

Table 7 - IPC/CAMERI Buoys

This buoy data has been extracted from MyOcean catalogue.

Figure 9 - IPC/CAMERI buoys location

As far as the Atlantic wave EPS is concerend, the baseline for validation comprised quality controlled in-situ measurements provided to the Met Office via the JCOMM-WFVS. A map of the in-situ sites used in the comparison is given in Figure 10. In all cases the observed data are matched up with a 'nearest neighbour' data value from the model (i.e. the model data were not interpolated in space or time).

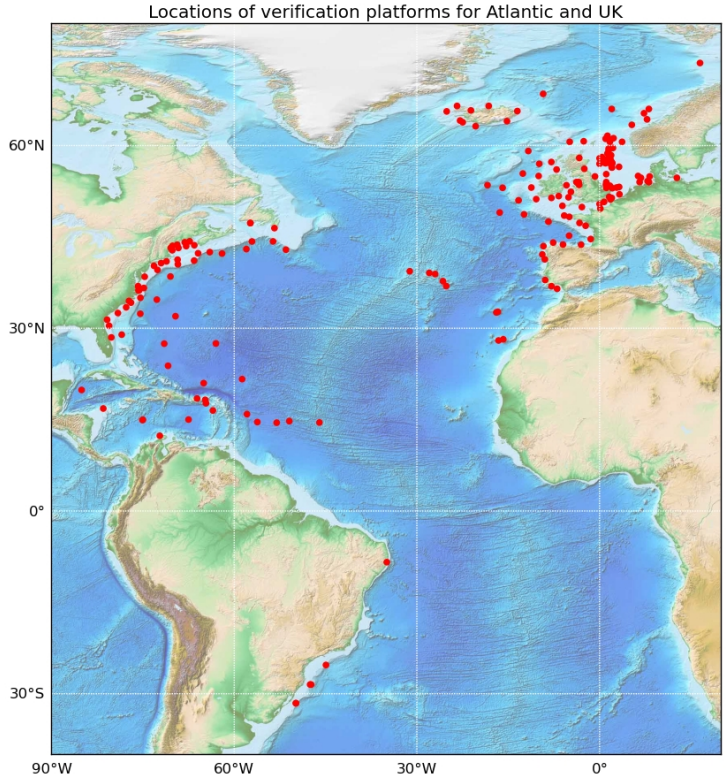

Figure 10 - In-situ wind and wave measurement locations with data available for the verification tests. Data were excluded from Caribbean platforms in Atlantic testing

III AVAILABLE SATELLITE DATA

In the Mediterranean Sea, buoy data are complemented with selected remote sensing data. In particular, after a first attempt to use GLOBWAVE data, wave altimeter data is extracted from the Radar Altimeter Database System (RADS), at the address: http://rads.tudelft.nl/rads/rads.shtml. The following sources have been selected: CNES/NASA Jason-2, ESA/NOAA CryoSAT-2 and CNES/EUMETSAT Saral-Altika.

Scatterometer data instead are available from OSI SAF ASCAT-A Coastal Wind Product and OSI SAF ASCAT-B 25-km Wind Product, operated by EUMETSAT, and OSI SAF OSCAT 50-km Wind Product, operated by ISRO. The first two scatterometer (ASCAT-A/B) are on the European Metop-A/B satellites, the latter is from the OSCAT Indian scatterometer (on Oceansat2). All datasets are extracted from the KNMI archive, where they are well verified and continuously monitored, see e.g. http://www.knmi.nl/scatterometer/ascat_osi_co_prod/ascat_app.cgi?cmd=monitor.

III.1 Altimeter data

Wave altimeter data over the Mediterranean Sea have been extracted from the RADS archive and processed in order to provide controlled numerical fields to be used in OI procedures. This archive is DEOS' effort in establishing a harmonised, validated and cross-calibrated sea level data base from satellite altimeter data. It operates within the framework of the Netherlands Earth Observation NETwork **NEONET**, an internet facility, funded by the Dutch government (BCRS and SRON), for exploitation of remote-sensing expertise and data.

The retrieved altimeters are listed below, in Table 8:

Altimeters		
mission	source	launched
Jason-2	CNES/NASA Jason-2	20/06/2008 onwards
CryoSAT-2	ESA / NOAA CryoSAT-2	08/04/2010 onwards
Saral-Altika	CNES/EUMETSAT Saral-Altika	25/02/2013 onwards

Table 8 - Selected altimeter data

III.2 Scatterometer data

Available scatterometer data is retrieved from the KNMI Data Centre, at the address https://data.knmi.nl/. The main sources are listed below, in Table 9.

The KNMI Data Centre (KDC) provides access to weather, climate and seismological datasets of KNMI. The Data Centre is evolving and data is continuously added. The portal interface allows to search for specific data and to view and download it using different services. For each dataset descriptive information is also available (metadata), including a point of contact.

The KDC is built using international standards for services (OGC) and metadata (ISO).

Scatterometers		
mission	source	launched
OSI SAF ASCAT-A Coastal Wind Product	EUMETSAT	19/10/2006 onwards
OSI SAF ASCAT-B 25-km Wind Product	EUMETSAT	17/09/2012 onwards
OSI SAF OSCAT 50-km Wind Product	ISRO	23/09/2009 onwards

Table 9 - Selected scatterometer data

All observational and model data are collected in a dedicated storage area arranged within ISMAR server, which provides access to all the interested partners.

IV DATA COLLECTION AND DISTRIBUTION

All the available data over the Mediterranean Sea are hosted on a dedicated CNR/ISMAR server, provided by various institutions on a monthly basis, starting from July 2013. This storage area is accessible operationally by all the interested partners, in order to perform the relative wave EPS validation procedures (ISMAR, UKMO, PdE, ISPRA).

As far as the Atlantic Ocean is concerned, the available observational data are directly collected by UKMO, via the JCOMM-WFVS, in order to perform the Atlantic wave EPS validation.

As far as the Mediterranean region is concerned, each partner directly storages his production and/or data. Each user can also access the storage area to download the needed information. The data flow has been organized so that CNMCA provides daily EPS forecasts (both wind and wave parameters) on the whole Mediterranean Sea, boundary conditions (wind and wave spectra) for PdE harbour EPS forecasts production and full spectra in correspondence to the available buoy locations, while ISPRA and ISMAR provide buoy, altimeters and scatterometers observational data on a monthly basis.

UKMO and ISMAR use EPS forecasts data and satellite/in situ measurements, while PdE uses CNMCA and UKMO wind fields and boundary conditions.

As far as the in-situ observational data is concerned, ISPRA has identified and managed to gather information from 28 buoy stations in the Mediterranean Region: 2 Meteo-France Buoys (France), 4 HCMR Buoys (Greece), 15 Ron Buoys (Italy), 1 ARPAL Buoy (Italy) and 7 PDE Buoys (Spain). ISMAR has also managed to obtain the data from two buoys from the Israel Ports Development and Assets Company Ltd and Coastal (IPC) and Marine Engineering Research Institute Ltd (CAMERI). This has been possible through a specific agreement signed by ISMAR in order to get the data for MyWave Project research purposes.

Buoy data are complemented with selected remote sensing data, obtained both from altimeters and scatterometers on a regular and continuous way.

UKMO data exchange comprises of gridded wind fields and 2D spectral wave boundary conditions routinely provided to Puertos del Estado (PdE) (4 x daily) for forcing their Barcelona (the only one located in the Mediterranean Sea), Tenerife and Gijon (on the Atlantic coast) harbour models. Re-

gridded Mediterranean wave fields are also being generated for inter-comparison of forecasts with CNMCA wave ensemble prediction system (see Barcelona harbour application). Both datasets are made available via the Met Office's external FTP server.

This data flow permits UKMO and ISMAR to produce their own validation reports and, subsequently, the intercomparison report, with reference to the agreed metrics.

For the analysis of the system performance, both UKMO and ISMAR will consider six months of daily operational products and compare them with all the measured data made available according to the procedure previously described. The final result will provide a clear idea of the systems performance and possibly a reasoned stimulus to further advance. Each measurement is identified by date-time and geographical coordinates (when considering scatterometer data, each measure is referred to the centre of the area covered along the satellite track). The model data, available at 1-hour interval, are linearly interpolated in space and time in order to match the available observations. This co-located data will then be the reference for the following analysis.

The analysis of the performance will evaluate both overall and seasonal performance, since the reference period includes both winter and summer seasons.

The parameters of interest collected for this subtask are:

- Significant Wave Height (m)
- Mean Period (s)
- Peak Period (s)
- Wave Direction (deg.)
- Wind Speed (m/s)
- Wind Direction (deg.)

The subtask was structured in order to collect data until December 2013 but it is possible to take into account an extension of the procedure operativity.

V QUALITY CONTROL AND DATA ORGANIZATION

The following relevant time series have been extracted from the aquired buoy data archive: wind speed and direction for wind data and significant wave height, mean period, peak period and mean direction for waves data.

Before implementing the validation procedure, a data quality check turned out to be necessary, mainly due to different formats of the collected data, uneven distribution of sampling frequencies, different information levels, reference units and precision, and wind reference height.

Each series has been quality checked in order to guarantee complete uniformity as well as the maximum reliability. The checking procedure consisted in several operations:

- **date and format control**: data records were checked in order to verify that all expected dates were present and no date was duplicated, eventually adding or removing the appropriate records;

- **outliers/spikes control**: time series were checked record by record evaluating the maximum admissible rate of change, on a statistical basis;

- **missing value**: coherence within all parameters measurements has also been evaluated. Missing/not reliable data flag is “NA”

VI REFERENCES

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