ECLISEA

European advances on CLImate Services for Coasts and SEAs

Climate datasets and related Coastal Exposure databases

Work Package 1 - Deliverable 1.A

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1. Introduction

This report is the deliverable 1.A (D1.A) of the ECLISEA project and contains the available and useful climate datasets and related coastal exposure datasets to estimate coastal impacts. ECLISEA is a project that aims to advance coastal and marine climate science and associated services through developing innovative research of sea surface dynamics. To achieve the objectives, ECLISEA is structured in 6 Work-packages (WPs) and this report is a deliverable of the WP1. The WP1 has the objective to review existing coastal climate data in Europe and to document insights on stakeholders needs regarding coastal climate information. WP1 is divided in different activities to achieve the objectives. D1.A contains the information about the first activity of the WP1. The report contains relevant information about useful datasets and limitations for the development of tasks related to WP2 to 5 during the progress of the project.

Previously to the report, in order to review the available climate datasets and related coastal exposure databases of each partner, each partner has filled in information in a summary table about the useful datasets developed by the partner institution. The external datasets have been collected on the basis of (i) known information by members of the project, and (ii) exploring current available data information on main web portals in Europe.

The aim of the report is to review of existing climate information from available sea surface datasets and related coastal databases. The report is structured as follows: the available observational datasets from in-situ and remote sources are described in Section 2. The different historical climate datasets from hindcasts and reanalyses are presented in Section 3. The Section 4 describes the available climate datasets under future climate change scenarios. Finally, Section 5 provides information about the Coastal and Exposure datasets.

2. Climate Observational datasets

The Climate observational datasets have been classified in two groups. The first group are in-situ records that include the buoy and tide-gauge records. The second group are the remote observations that are provided by satellite missions and have been post-processed by different institutions.

2.1 In-situ records

2.1.1 Buoys

There are a number of buoy networks over the European seas. Buoys provide complete and accurate information of the bulk sea-state wave parameters, directional buoys can provide directional wave information, and the records have continuous and high resolution time temporal resolution (usually hourly data). The disadvantages are that buoys only provide information at the location where it is moored, there are coastal areas with no buoys, and their records can have gaps, can require further control quality and/or are too short to provide climate information. Buoy records are nevertheless essential to validate and calibrate wave simulations from numerical models (e.g. wave hindcast outputs). Different information about buoy programmes, networks and institutions have been recompiled in this section.

The buoy networks are coordinated by international programmes. The international programmes include different institutions. The most important programmes are the Data Buoy Cooperation Panel (DBCP) and the Joint Technical Commission for Oceanography and Marine Meteorology (JCOMM).

JCOMM is an intergovernmental body of technical experts that provides a mechanism for international coordination of oceanographic and marine meteorological observing, data management and services. JCOMM combines the expertise, technologies and capacity building capabilities of the meteorological and oceanographic communities. The creation of this Joint Technical Commission results from a general recognition that worldwide improvements in coordination and efficiency may be achieved by combining the expertise and technological capabilities of World Meteorological Organization (WMO) and UNESCO's Intergovernmental Oceanographic Commission (IOC).

The DBCP is an official joint body of the World Meteorological Organization (WMO) and the Intergovernmental Oceanographic Commission (IOC). It increases the quantity, quality and timeliness of atmospheric and oceanographic data over ocean areas to improve global forecasts of weather and ocean conditions, plus contribute to climate study and oceanographic research.

The different buoy networks and related institutions are included in the international coordination programmes and are presented hereunder. The following networks and institutions are included in this report: buoy networks of the Spanish Port Authority, Hydrographic Institute of Portugal, POSEIDON marine monitoring network, Italian

national data buoy network (RON), the Irish Weather Buoy Network, MARNET monitoring network, Finnish Meteorological Institute, Rijkswaterstaat Waterinfo, Meteo France, CANDHIS and Monitoring Network Flemish Banks.

Spanish Port Authority

The best spatially distributed and easily accessible buoy network in Spain operates under the responsibility of the Spanish Port Authority (Puertos del Estado). The data referring to the Spanish waters are obtained through the Spanish Operational Marine Climate Monitoring and Forecasting System, comprising in a deep water (RedExt) and a coastal buoy network (RedCos). The standard records have hourly time resolution. The buoy locations from RedExt and RedCos networks are shown in Figure 1. Coordinates and starting date of the buoy records from the RedExt network are listed in the Table 1. The real time records of the buoys and additional information are shown in the website of the Spanish Port Authority. More details about the Spanish network are listed below.

Variable:	wave sea-state parameters
Data type:	buoy record
Data format:	txt
Data frequency:	hourly
Access:	by contact
Website:	http://www.puertos.es/
Contact:	Pilar Gil (pilar@puertos.es)

Available data:

Table 1: Positions and the corresponding measurement periods of the Spanish buoy Networks.

Name	Latitude (degrees)	Longitude (Degrees)	Starting date
Bilbao-Vizcaya_Ext	43.64	-3.05	1990
Cabo_de_Peñas_Ext	43.75	-6.16	1997
Estaca_de_Bares_Ext	44.12	-7.67	1996
Villano-Sisargas_Ext	43.5	-9.21	1998
Cabo_Silleiro_Ext	42.12	-9.43	1998
Golfo_de_Cadiz_Ext	36.48	-6.96	1996
Alboran_Ext	36.27	-5.03	1997
Cabo_de_Gata_Ext	36.57	-2.32	1998
Cabo_de_Palos_Ext	37.64	-0.33	2006
Valencia_I	39.46	-0.26	2004
Valencia_II_Ext	39.52	0.21	2005
Tarragona_Ext	40.68	1.41	2004

Cabo_Begur_Ext	41.92	3.64	2001
Mahon_Ext	39.72	4.42	1993
Dragonera_Ext	39.56	2.1	2006

Figure 1: Positions of the Spanish buoys from Puertos del Estado.

Hydrographic Institute of Portugal

The data of the buoys located in Portuguese waters are operated under the responsibility of the Hydrographic Institute of Portugal, except the buoy located in Açores and Madeira that are operated by the University of Açores and APRAM.

The real time records of the buoys are shown in the web site of the Hydrographic Institute of Portugal. More details about the Portuguese network are listed below.

Variable:	water parameters
Data type:	buoy record
Data format:	txt
Data frequency:	hourly
Access:	by contact
Website:	http://www.hidrografico.pt/boias-ondografo.php
Contact:	mail@hidrografico.pt

Available data:

Table 2: Positions of the Portuguese buoys operates by the Hydrographic Institute of Portugal.

Name	Latitude (degrees)	Longitude (Degrees)
Leixões	41.317	-8.983
Nazaré	39.560	-9.211
Sines	37.921	-8.929
Faro Costeira	36.905	-7.898
Faro Oceânica	36.386	-8.067

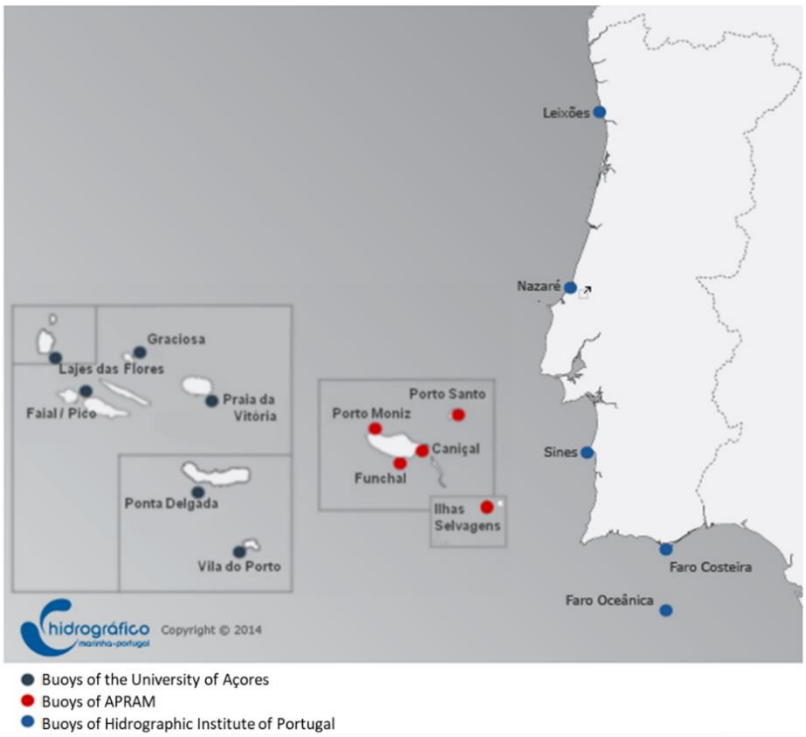

Figure 2: Positions of the all Portuguese buoys.

POSEIDON marine monitoring network

The buoys of the Hellenic waters can be obtained through the POSEIDON marine monitoring network. The POSEIDON network operates, since 1999, under the responsibility of the Hellenic Centre for Marine Research. The wave measurements have a recording period of 600 seconds, sampling frequency 1Hz and recording interval of 3 hours. The real time records of the buoys are shown in the web site of POSEIDON marine monitoring network. The locations of the buoys (name, latitude, longitude) in the Hellenic waters, the corresponding measurement time periods and more detailed information are listed below.

Variable: wave parameters

Data type: buoy record

Data format: txt

Data frequency: 3 hours

Access: By contact

Website: http://www.poseidon.hcmr.gr/

Contact: http://www.poseidon.hcmr.gr/listview.php?id=66

Literature: Soukissian, T.H., Chronis, G.T., Nittis, K. (1999), POSEIDON: Operational marine monitoring system for Greek seas, Sea Technology, 40 (7), pp. 31-37.

Available data:

Table 3: Positions and the corresponding measurement periods of POSEIDON marine monitoring network buoys.

Name	Latitude (degrees)	Longitude (Degrees)	Recording period
Athos	39.96	24.72	2000-2017
Avgo	35.62	25.64	2000-2006
E1M3A	35.79	24.92	2007-2017
Kalamata	36.97	22.11	2007-2011
Lesvos	39.15	25.81	2000-2011
Mykonos	37.51	25.46	2000-2017
Petrokaravo	37.61	23.57	2007-2011
Pylos	36.83	21.61	2007-2017
Santorini	36.25	25.49	2000-2011
Skyros	39.11	24.47	2007-2011
Zakynthos	37.95	20.61	2007-2011

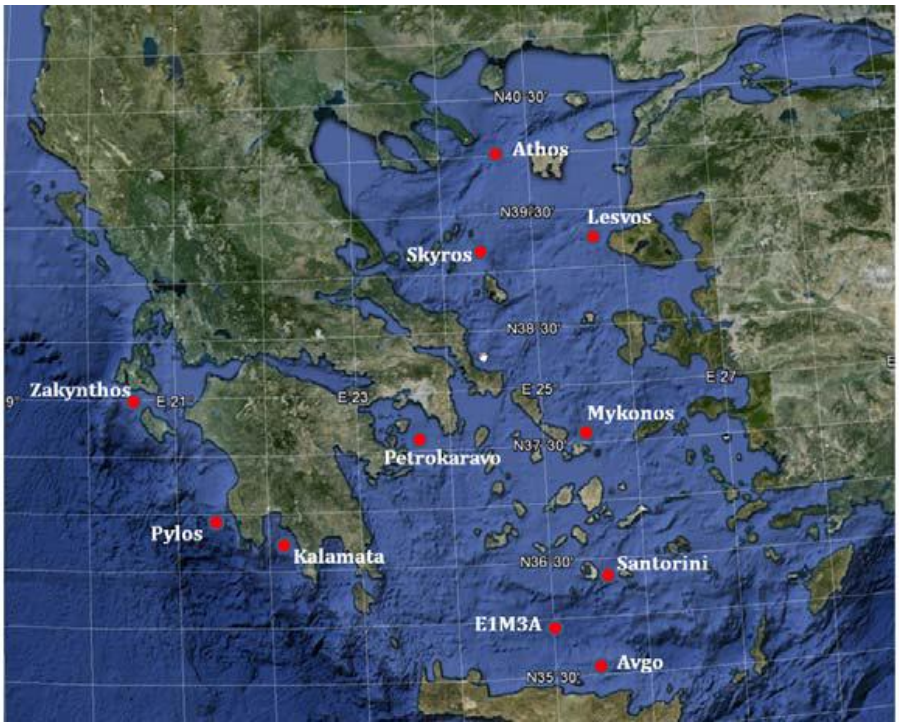

Figure 3: Positions of the POSEIDON system buoys.

Italian national data buoy network (RON)

The Italian Data Buoy Network (Rete Ondametrica Nazionale, RON), owned and managed by ISPRA, was created in 1989. Initially, RON was composed by 8 buoys and in 2002 was increased to 15 buoys covering all the Italian coast. Most pf the buoy records are available until 2014. All the information about the RON is shown in the website of ISPRA. The locations of the Italian buoys are shown in the Figure 4 and more details are listed below:

Variable:	wave parameters
Data type:	buoy record
Data format:	txt
Data frequency:	hourly
Access:	Private
Website:	http://dati.isprambiente.it/dataset/ron-rete-ondametrica-nazionale/
DOI:	Doi: 10.2495 / AFM120291
Contact:	reteondametrica@isprambiente.it

Literature: Bencivenga M, Nardone G, Ruggiero F, Calore D (2012) The Italian data buoy network (RON). In: Advances in fluid mechanics IX. Edited by WIT, UK. Doi: 10.2495 / AFM120291.

Available data:

Table 4: Position and the corresponding measurement periods of POSEIDON marine monitoring network buoys.

Name	Latitude (degrees)	Longitude (Degrees)	Recording period
Catania	37.440	15.147	1989-
Mazara	37.518	12.533	1989-
Palermo	38.258	13.333	2002-
Crotone	39.024	17.220	1989-
Cetraro	39.453	15.918	1999-
Siniscola	40.617	9.892	2002-2011
Alghero	40.549	8.107	1989-
Ponza	40.867	12.950	1989-
Monopoli	40.975	17.378	1989-
Civitavecchia	42.245	11.554	2002-
Ortona	42.407	14.537	1989-2011
Ancona	43.824	13.719	1999-
La Spezia	43.929	9.828	1989-
Venezia	45.333	12.517	2002-
Cagliari	39.115	9.405	2002-

Figure 4: Positions of the RON buoys.

WaveNet monitoring Network

WaveNet, Cefas' strategic wave monitoring network for the United Kingdom, provides a single source of real-time wave data from a network of wave buoys located in areas at risk from flooding. In operation since 2002, WaveNet collects and processes data from the Cefas-operated Datawell Directional Waverider buoys, tethered at strategic locations around the UK coastline. The WaveNet system also gathers wave data from a variety of third party platforms and programs (industry and public sector-funded), all of which are freely available for visualization on the WaveNet website (http://wavenet.cefas.co.uk).

The historical data of the WaveNet buoys provided by Cefas can be download in WaveNet website. The locations of the buoys operate by Cefas are shown in the Figure 5 and more details are listed below:

Variable:	wave parameters
Data type:	buoy record
Data format:	txt
Data frequency:	hourly
Access:	Public and private (depend on institution)
Website:	http://wavenet.cefas.co.uk
Contact:	wavenet@cefas.co.uk

Available data:

Table 5: Position and the corresponding measurement periods of WaveNet buoys provides by Cefas.

Name	Latitude (degrees)	Longitude (Degrees)	Recording period
Blackstones	56.062	-7.057	2009-2018
Dowsing	53.531	1.055	2003-2018
Hastings	50.746	0.753	2002-2018
Moray-Firth	57.967	-3.333	2008-2018
Tyne	54.919	-0.749	2006-2018
West-Gabbard	51.983	2.082	2002-2018
West-of-Hebrides	57.292	-7.914	2009-2018
Firth of Forth	56.188	-2.504	2008-2018
Hinkley	51.233	-3.159	2008-2018
Liverpool	53.534	-3.355	2002-2018
NVOWF DWR	52.975	2.516	2017-2018
Poole Bay	50.634	-1.719	2003-2018
Scarweather	51.433	-3.933	2005-2018
Sizewell	52.208	1.685	2008-2018
South Knock	51.571	1.579	2010-2018
Southwold	52.313	1.784	2010-2018
SW Isles ofScilly	49.817	-6.544	2014-2018
Torness Power Station	55.980	-2.410	2014-2018
West Pembrokeshire	51.840	-5.839	2014-2018

Figure 5: Positions of the Cefas buoys.

Irish Weather Buoy Network

The Irish Weather Buoy Network is designed to improve weather forecasts and safety at sea around Ireland. The buoy network provides vital data for weather forecasts, shipping bulletins, gale and swell warnings as well as data for general public information and research. Buoy data are also helpful for validating the operational models. The Irish Weather Buoy Network operates under the responsibility of the Irish Marine Institute and the buoy records are available in the web site of the institution. More details are listed below:

Variable:	wave parameters
Data type:	buoy record
Data format:	txt
Data frequency:	hourly
Access:	Public
Website:	http://www.marine.ie/
Contact:	institute.mail@marine.ie

Available data:

Table 6 Position and the corresponding measurement periods of Irish Weather Buoy Network.

Name	Latitude (degrees)	Longitude (Degrees)	Recording period
FS1	51.400	-7.900	2003-2008
M1	53.127	-11.200	2001-2007
M2	53.484	-5.431	2001-2018
M3	51.217	-10.551	2002-2018
M4-Archive	54.667	-9.067	2003-2007
M4	54.998	-9.992	2007-2018
M5	51.689	-6.701	2004-2018
M6	53.075	-15.881	2006-2018

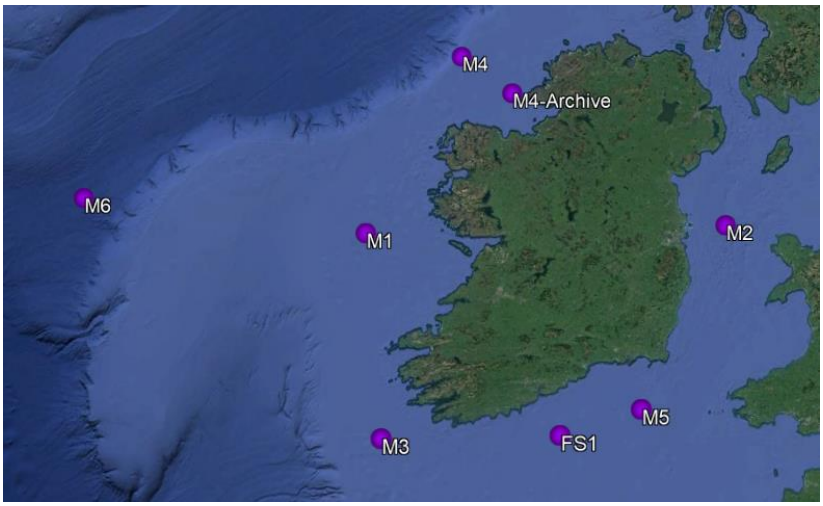

Figure 6: Positions of the buoys of the Irish Weather Buoy Network.

MARNET monitoring network

The German Federal Maritime and Hydrographic Agency (BSH) operates a Marine Environmental Monitoring Network in the North Sea and Baltic Sea (MARNET) which presently comprises twelve automated measuring stations and six marine buoys that provide wave parameters. The real time records are available in the website but the historical buoy records are not available in the web site. Figure 7 shows all the stations of the MARNET monitoring network and more details are listed below.

Variable:	wave parameters
Data type:	buoy record
Data format:	txt
Data frequency:	hourly
Access:	Unknow
Website:	http://www.bsh.de
Contact:	Susanne.Tamm@bsh.de

Available data:

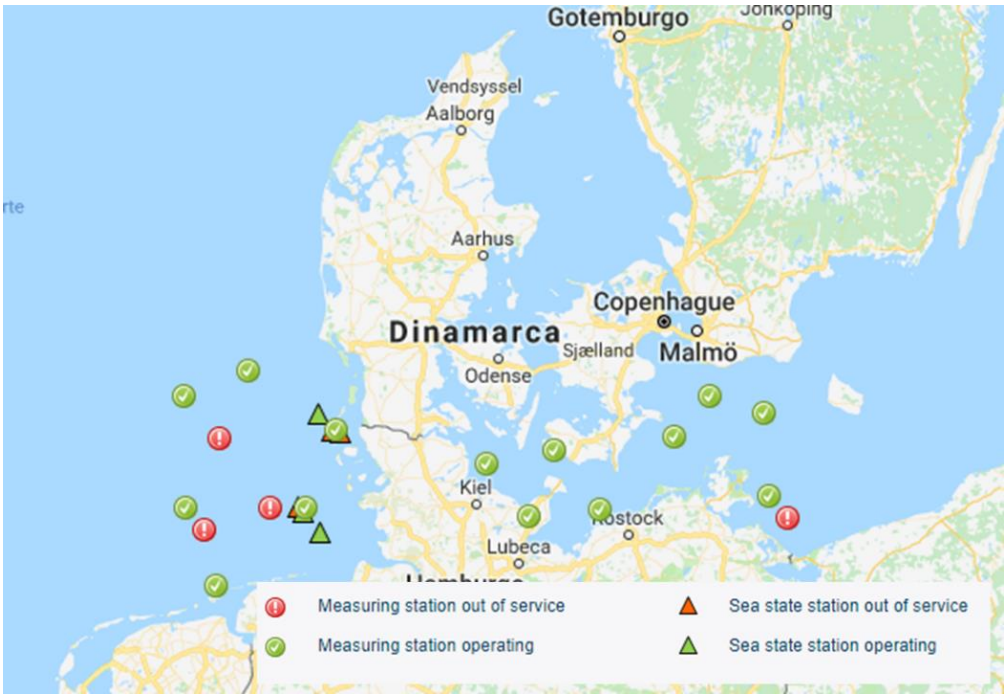

Figure 7: Location of the buoys and measuring station of MARNET monitoring network.

Finnish Meteorological Institute

The Finnish Meteorological Institute (FMI) has four wave buoys in the Baltic Sea. They are located in the Northern Baltic Proper, in the Gulf of Finland, in the Bothnian Sea and in the Bay of Bothnia. FMI also operates a wave buoy that is moored outside of Suomenlinna, although the buoy is owned by the City of Helsinki. Also, the buoys are removed before the sea freezes and redeployed in the spring when the ice has melted.

The locations of the buoys (name, latitude, longitude), the starting periods of the measurements and more detailed information are listed below

Variable:	wave parameters
Data type:	buoy record
Data format:	txt
Data frequency:	hourly
Access:	Unknow
Website:	http://en.ilmatieteenlaitos.fi
Contact:	waves@fmi.fi

Available data:

Table 7: Position and the start day of the measurements of the Finnish Meteorological Institute buoys.

ID	Name	Latitude (degrees)	Longitude (Degrees)	Starting date
1	Northern Baltic Proper	59.25	21	1996
2	Gulf of Finland	59.96	25.24	1990
3	Bothnian Sea	61.8	20.23	2011
4	Bay of Bothnia	64.68	23.24	2012
5	Helsinki Suomenlinna	60.12	24.97	2016

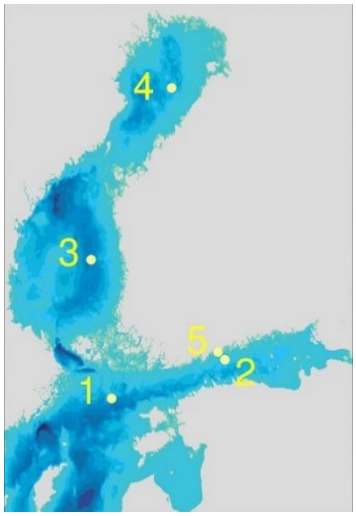

Figure 8: Location of the Finnish Meteorological Institute buoys.

Rijkswaterstaat Waterinfo

Rijkswaterstaat Waterinfo covers the Dutch coast and measures the water level, the wave height and the water quality, among other things. The buoy Network is operated by Rijkswaterstaat and the real time records of the buoys are shown in the website and the historical records are available by contact. The Figure 9 shows all the buoys with wave parameters information. More detailed information are listed below.

Variable:	water parameters
Data type:	buoy record
Data format:	csv
Data frequency:	hourly
Access:	Public
Website:	https://waterinfo.rws.nl

Contact: https://www.rijkswaterstaat.nl/formulieren/contact-rijkswaterstaat-english.aspx

Available data:

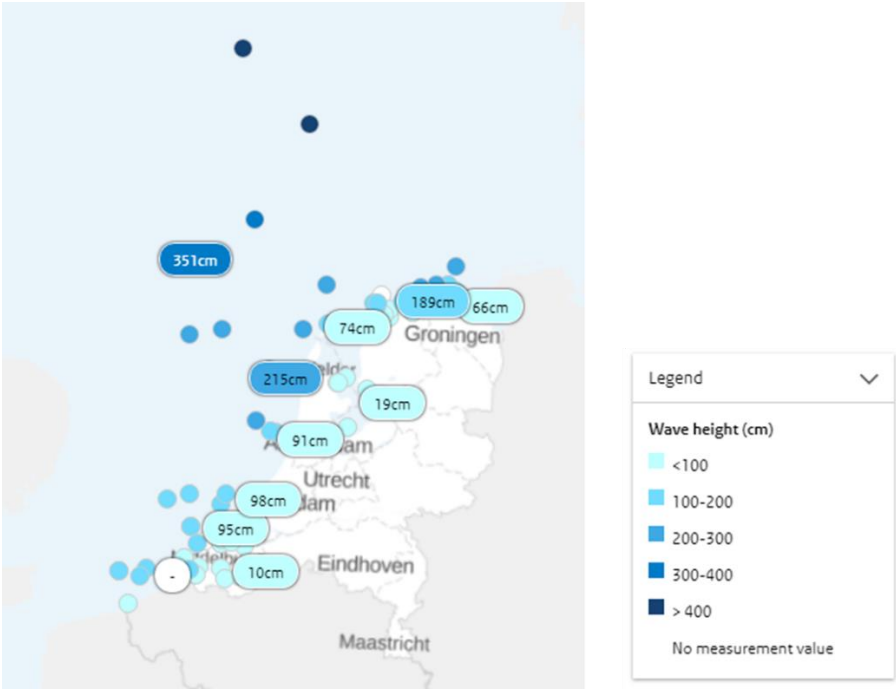

Figure 9: Location of the Rijkswaterstaat Waterinfo buoys.

Meteo France

Météo-France maintains in operational conditions four buoys in the French coast at deep waters. The buoys historical records are available by contact and the Table 8 shows the detailed information of the buoys. Figure 10 shows the buoy locations and more detailed information are listed below.

Variable:	wave parameters
Data type:	buoy record
Data format:	txt
Data frequency:	hourly
Access:	Public by contact
Website:	http://esurfmar.meteo.fr/real-time/
Contact:	cmm_op@meteo.fr

Available data:

Table 8: Position and the corresponding measurement periods of Meteo France buoys.

Name	Latitude (degrees)	Longitude (Degrees)	Recording period
Côte d'Azur	7.8	43.4	1990-2018
Lion	4.7	42.1	2001-2018
Brittany	-8.5	47.5	1996-2018
Gascogne	-5	45.2	1998-2014

Figure 10: Positions of Meteo France buoys.

CANDHIS

Candhis (National Center for Archiving Swell Measurements) refers both to the French national network of coastal in situ measurements of waves, the website and database archiving measures. The real time records of the buoys and climate reports are shown in the web site of Candhis (http://candhis.cetmef.developpement-durable.gouv.fr/).

All the available bouys of the French national network are shown in Figure 11. Locations and more detailed information are listed below.

Variable: wave parameters

Data type: buoy record

Data format: txt

Data frequency: hourly

Access: Unknow

Website: http://candhis.cetmef.developpement-durable.gouv.fr/

Contact: Candhis.DTecEMF@cerema.fr

Available data:

Figure 11: Positions of CANDHIS buoys.

Flemish Banks Monitoring Network

The Monitoring Network is named after the group of irregular sandbanks located in front of the western half of the Flemish coast. These sandbanks complicate navigation in that area. The Flemish Banks Monitoring Network consists of a monitoring network at sea, weather parks ashore, and a computer network in Oostende. The network at sea, consisting of measuring piles and wave measurement buoys, and the meteo parks ashore, are equipped with hydro-meteorological sensors. The central computer network gathers and processes the data and exchanges it with international monitoring networks, research institutes, universities etc.

The Monitoring Network have different buoys located in the Flemish coast (shown in Figure 12). More information about the Flemish Banks Monitoring Network are listed below.

Variable: wave parameters

Data type: buoy record

Data format: txt

Data frequency: hourly

Access: Unknow

Website: https://meetnetvlaamsebanken.be/

Contact: http://www.afdelingkust.be/en/contact

Available data:

Figure 12: Positions of Flemish Banks Monitoring Network buoys.

2.1.2 Tide gauges

The tide gauges measure the change in sea level relative to a vertical datum. Many public and private institutions have installed tide gauges in different locations around the European coast. The sea level records collected from tide gauges are of interest for research purposes (to validate ocean models, to measure global weather patterns, the mean sea level, and trends) and many coastal activities (safe navigation, sound engineering, and habitat restoration and preservation). Hence the interest to create international networks and programmes that include the tide gauges operated by different institutions have been increasing. Four international programs are currently available and integrate global and regional sea level networks for application to climate, oceanographic and coastal sea level research.

The international programs that have been included in the present report are the Permanent Service for Mean Sea Level (PSMSL), University of Hawaii Sea Level Center (UHSLC), Global Sea Level Observing System (GLOSS) and Global Extreme Sea Level Analysis version 2(GESLA-2).

PSMSL

Established in 1933, the Permanent Service for Mean Sea Level (PSMSL) has been responsible for the collection, publication, analysis and interpretation of sea level data

from the global network of tide gauges. It is based in Liverpool at the National Oceanography Centre (NOC), which is a component of the UK Natural Environment Research Council (NERC).

PSMSL data have many applications, the most familiar application is global and regional sea level rise and variability. The PSMSL data set is the main source of information on long term changes in global sea level during the last two centuries. The data have been employed intensively in studies such as those of Intergovernmental Panel on Climate Change (IPCC)

The dataset is available from PSMSL website and is also distributed by GLOSS. Details are listed below.

Variable:	water level
Data type:	tide gauge record
Data format:	txt
Data frequency:	monthly, annual.
Access:	Public
Website:	http://www.psmsl.org/
Contact:	psmsl@noc.ac.uk

Available data:

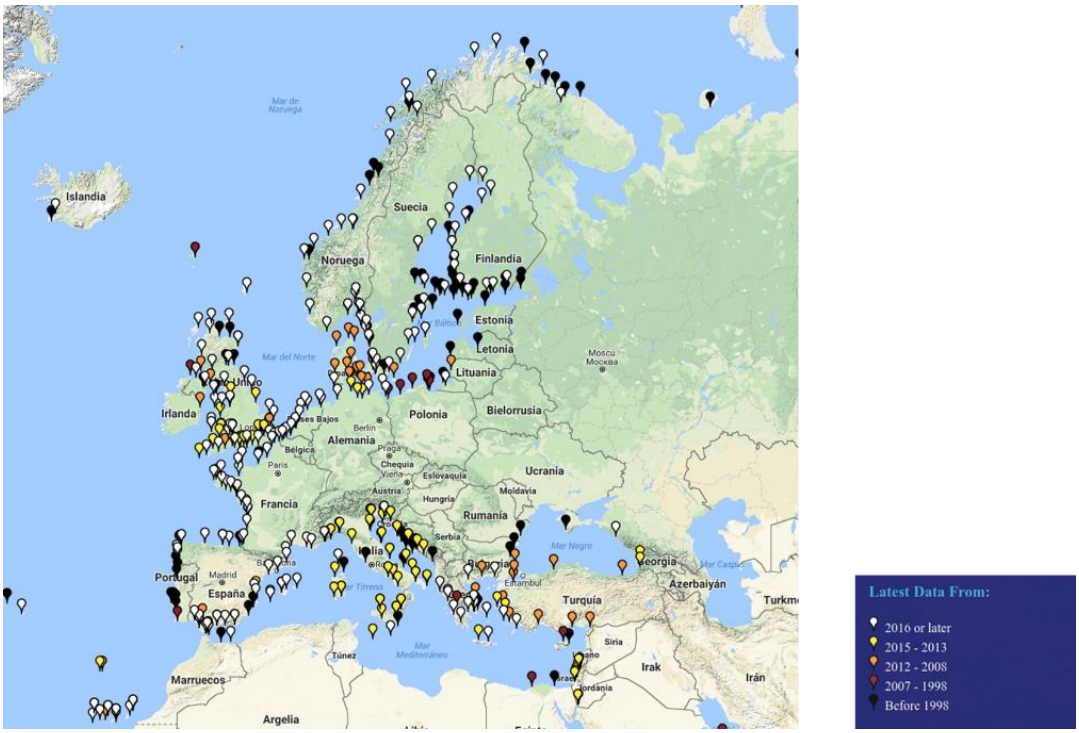

Figure 13: position of PSMSL tide gauges.

UHSLC

The UHSLC serves multiple roles in support of real-time oceanographic operations as well as climate and oceanographic research. The UHSLC collaborates with agencies within host countries to install and maintain a global network of tide gauge stations that range in utility from tsunami warning to global sea level rise. The growing UHSLC network consists of more than 80 stations. The data are routinely processed, analyzed, and distributed at varying levels of temporal resolution and quality control that fill multiple end-user needs.

UHSLC datasets are used for assimilation into operational numerical models, the calibration of satellite altimeter data, the production of oceanographic products, and research on various time-scales from decadal climate fluctuations to short-term extreme event. The UHSLC offers tide gauge data with two levels of quality-control (QC), where more rigorous QC requires more effort and a greater time-lag.

- Fast Delivery (FD) data are released within 1-2 months of data collection and receive only basic QC focused on large level shifts and obvious outliers. FD data are replaced in the data stream by RQD (see below) as the latter becomes available.
- Research Quality Data (RQD) receive thorough QC and are considered to be the final science-ready data set. This final QC process is time-consuming, and as a result, the RQD are released 1-2 years after data is received from the data originators by the UHSLC.

The dataset is available from UHSLC website and is also distributed by GLOSS with DOI identifier listed below.

Variable:	water level
Data type:	tide gauge record
Data format:	txt
Data frequency:	hourly, daily
Access:	Public
Website:	https://uhslc.soest.hawaii.edu/
DOI:	doi:10.7289/V5V40S7W
Literature:	Caldwell, P. C., M. A. Merrifield, P. R. Thompson (2015), Sea level measured by tide gauges from global oceans — the Joint Archive for Sea Level holdings (NCEI Accession 0019568), Version 5.5, NOAA National Centers for Environmental Information.

Available data:

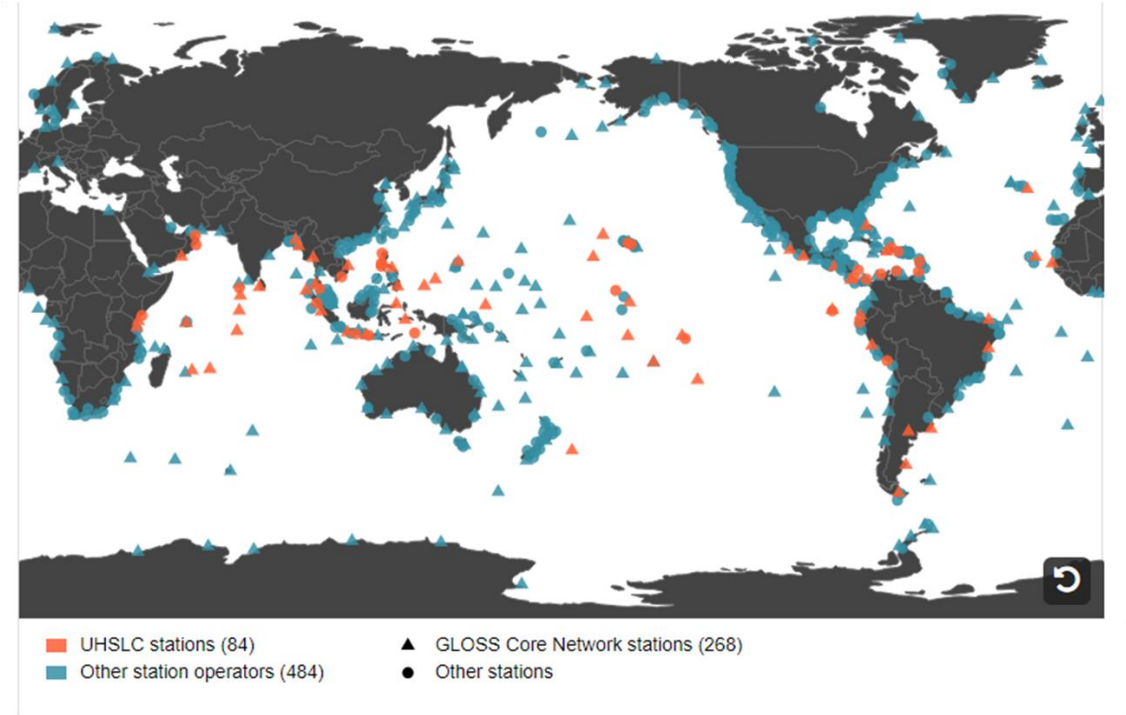

Figure 14: position of UHSLC tide gauges.

GLOSS

The Global Sea Level Observing System (GLOSS) is an international programme conducted under the auspices of the Joint Technical Commission for Oceanography and Marine Meteorology (JCOMM) of the World Meteorological Organisation (WMO) and the Intergovernmental Oceanographic Commission (IOC). GLOSS aims at the establishment of high quality global and regional sea level networks for application to climate, oceanographic and coastal sea level research. The programme became known as GLOSS as it provides data for deriving the 'Global Level of the Sea Surface'.

The main component of GLOSS is the 'Global Core Network' (GCN) of 290 sea level stations around the world for long term climate change and oceanographic sea level monitoring. The present definition of the GCN (the definition is modified every few years) is called GLOSS10.

The GLOSS10 data are available through the GLOSS Station Handbook. The GLOSS Station Handbook has been constructed in order to provide further information on each of the tide gauges in GLOSS. The Handbook files also provide links to data available from each site. The dataset is available from GLOSS website, the details are listed below.

Variable:	water level
Data type:	tide gauge record
Data format:	txt
Data frequency:	hourly, daily, monthly, annual
Access:	Public

Website: http://www.gloss-sealevel.org/

Contact: psmsl@noc.ac.uk

Literature: IOC, 2012 Global Sea Level Observing System (GLOSS) Implementation Plan – 2012. UNESCO/IOC, 41pp. 2012. (IOC Technical Series No.100).

Available data:

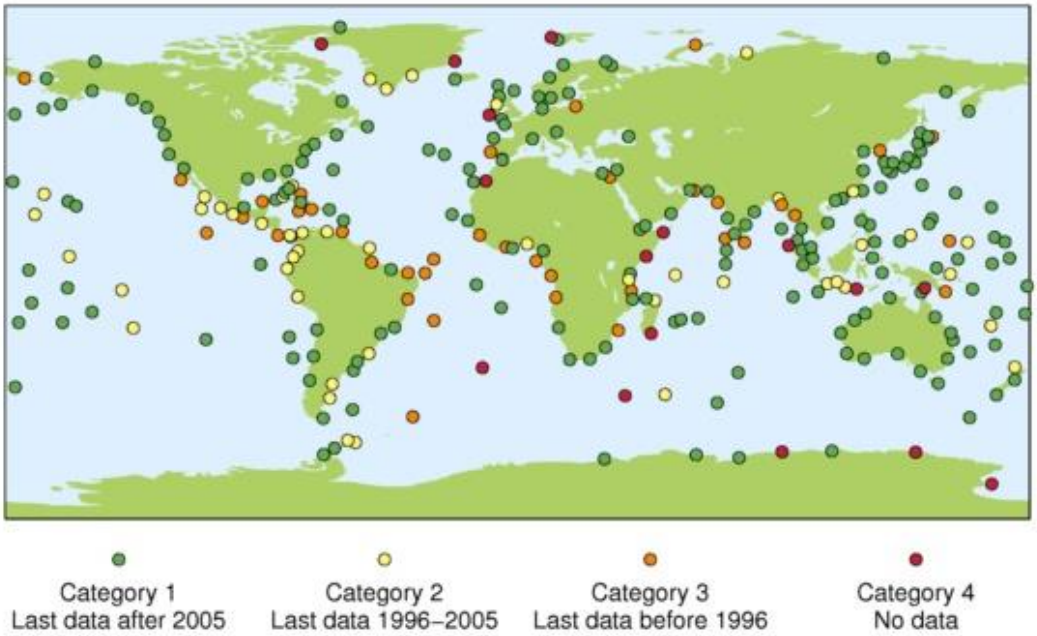

Figure 15: position and category of GLOSS10 tide gauges.

GESLA-2

The GESLA (Global Extreme Sea Level Analysis) project grew out of the interests of several people in learning more about the changes in the frequency and magnitude of extreme sea levels. The first formal GESLA data set (denoted GESLA-1) was assembled by Philip Woodworth (National Oceanography Centre Liverpool) and John Hunter (University of Tasmania) around 2009 and contained a quasi-global set of 'high frequency' (i.e. hourly or more frequent) measurements of sea level from tide gauges around the world.

The Global Extreme Sea Level Analysis Version 2 (GESLA-2) contains higher-frequency sea level information from stations distributed worldwide (39151 station-years of data from 1355 station records). The dataset is fundamental to scientific research in sea level variability and also to practical aspects of coastal engineering. The dataset is available from GESLA website and is also distributed by the British Oceanographic Data Centre with DOI identifier listed below.

Variable:	water level
Data type:	tide gauge record
Data format:	txt
Data frequency:	hourly
Access:	Public and private (depend on institution)
Website:	http://gesla.org/
DOI:	doi:10.5285/3b602f74-8374-1e90-e053-6c86abc08d39
Contact:	gesla.help@gmail.com
Literature:	Woodworth, P.L., Hunter, J.R. Marcos, M., Caldwell, P., Menendez, M. and Haigh, I, (2017), Towards a global higher-frequency sea level data set, *Geoscience Data Journal, 3*, 50–59, doi:10.1002/gdj3.42.

Available data:

Figure 16: position of GESLA-2 tide gauges.

2.2 Remote observations

The Remote observations of satellite altimeters give important information about the sea surface dynamics. The satellite data need to be post-processed to get the variables that describe the sea surface dynamics and these post-processed datasets are available in

different websites. Different websites have been reviewed to get the information about the products and to select the suitable product for the project:

- Copernicus Marine Environment Monitoring Service (CMEMS): http://marine.copernicus.eu
- Physical Oceanography Distributed Active Archive Center (Podaac): https://podaac.jpl.nasa.gov/
- AVISO+: https://www.aviso.altimetry.fr
- Centre ERS d'Achivage et de Traitement (CERSAT): http://cersat.ifremer.fr
- LEGOS-CTOH: http://ctoh.legos.obs-mip.fr/

2.2.1 Wave height altimeter measurements

The providers of the post-processed satellite products have been reviewed. The Podaac provide several products derived with a processing level 2 that contain measurements of the significant wave height. These products however only include one mission, so the temporal and spatial coverage is limited. The use of products from several missions require intercalibration of the data.

CMEMS contains a product that provide information of the significant wave height, but only provide information of two mission (Jason-3 and Sentinel 3A) and is active since June 2017. The temporal coverage is not enough to characterize the wave climate.

AVISO+ provides significant wave parameters along the track of the missions Janson-1, Janson-2, Janson 3, SARAL and Topex-Poseidon but the significant wave records are not intercalibrated. The AVISO+ products along the track have the same problem that the Podaac products. AVISO+ also provides gridded wave product that contain post-processed significant wave height of several satellite missions that have been intercalibrated and averaged in 1°x1° boxes.

Finally, CERSAT provides a product that include 9 satellite missions that have been intercalibrated and provide the significant wave height along the track. The product is Global altimeter SWH data set.

The details of each product are listed below.

Table 9: Satellite datasets details

Dataset name	Variables name	Domain name	Spatial resolution	Start year	End year	Time resolution	Level	Missions
Global altimeter SWH data set	Significant wave height	Global	Irregular	1991	2017	irregular	L3	SARAL/AltiKa, SARAL/AltiKa, CryoSat-2, TOPEX/Poseidon, Jason-1, Jason-2, ERS-1, ERS-2, GeoSat Follow-On (GFO) and Envisat
AVISO+ Gridded Wave products	Significant wave height	Global	1 x 1 degree	2009	ongoing	daily	L4	Jason-2, SARAL, Jason-3

Global altimeter SWH data set

Altimeter SWH measurements are presently available almost continuously over a 23-year time period from the nine altimeter missions ERS-1&2, TOPEX-Poseidon, GEOSAT Follow-ON (GFO), Jason-1, Jason-2, ENVISAT, Cryosat and SARAL. The product has been developed by IFREMER and is available in the portal of CERSAT. Each altimeter data product has specific characteristics (format, flags). In order to facilitate the access to SWH altimeter measurements and the use of this long time series, data were extracted from the original products, screened according to quality flag values, corrected and gathered into homogeneous daily data files. The details of the product are shown:

Variable:	significant wave height
Data type:	satellite altimeters
Data format:	NetCDF
Data frequency:	Irregular
Access:	Public
Website:	ftp://ftp.ifremer.fr/ifremer/cersat/products/swath/altimeters/waves/
Contact:	pierre.queffeulou@ifremer.fr
Literature:	Queffeulou P., 2013-b, Merged altimeter wave height data base. An update. Proceedings of ESA Living Planet Symposium, 9-13 September 2013, Edinburgh, UK, ESA SP-722 December 2013, ESA Communications, ESTEC, PO Box 299, 2200 AG Noordwijk, The Netherlands.

AVISO+ Gridded Wave products

The data along satellite tracks are processed using the last 2 days of available IGDR data for each satellite, a merged map is generated if a minimum of 2 missions are available in the box of 1°x1°. The data are cross-calibrated using OSTM/Jason-2 as reference mission. First, sigma0 and waves histogram are calibrated, then the OSTM/Jason-2 wind algorithm is applied to cross-calibrated sigma0 and the mapping methods in the same as for mon-omission gridded maps. The details of the product are shown:

Variable:	significant wave height
Data type:	satellite altimeters
Data format:	NetCDF
Data frequency:	daily
Access:	Public

Website: https://www.aviso.altimetry.fr/

Contact: https://www.aviso.altimetry.fr/en/services/contact.html

2.2.2 Sea level data from satellite

Sea level climate variable from satellite measurement is usually referred as sea surface height. The providers of the post-processed satellite products have been reviewed. The products that are suitable for different activities of the project are listed below. Details of the selected satellite dataset are shown in the Table 10.

Table 10: Satellite SSH datasets details

Dataset name	Variables name	Domain name	Geographical coverage		Spatial resolution	Start year	End year	Time resolution
			Lat interval	Lon interval				
GLOBAL OCEAN GRIDDED L4 SEA SURFACE HEIGHTS AND DERIVED VARIABLES REPROCESSED	SLA	Global	[-90,90]	[-180,180]	0,25 x 0,25 degree	1993	2017	Daily
MEDITERRANEAN SEA GRIDDED L4 SEA SURFACE HEIGHTS AND DERIVED VARIABLES REPROCESSED	SLA	Mediterranean Sea	[30,46]	[-6,37]	0,125 x 0,125 degree	1993	2017	Daily
SL_cci ECV v2.0	SLA, MSL	Global	[-90,90]	[-180,180]	0,25 x 0,25 degree	1993	2015	Monthly
RADS	SLA	Global	[-90,90]	[-180,180]	Irregular	1991	2017	Irregular
GLOBAL OCEAN ALONG-TRACK L3 SEA SURFACE HEIGHTS REPROCESSED	SLA	Global	[-90,90]	[-180,180]	7 x 7 km	1993	2017	Irregular

Global Ocean Gridded L4 Sea Surface Heights and Derived Variables Reprocessed

For the Global Ocean - Multimission altimeter satellite gridded sea surface heights and derived variables computed with respect to a twenty-year mean. Previously distributed by Aviso+, no change in the scientific content. All the missions are homogenized with respect to a reference mission which is currently OSTM/Jason-2. It processes data from all altimeter missions: Jason-3, Sentinel-3A, HY-2A, Saral/AltiKa, Cryosat-2, Jason-2, Jason-1, T/P, ENVISAT, GFO, ERS1/2. It provides a consistent and homogeneous catalogue of products for varied applications, both for near real time applications and offline studies.

The Sea Level Anomaly (SLA) is computed with an optimal and centered computation time window (6 weeks before and after the date). Two kinds of datasets are proposed: filtered (nominal dataset) and unfiltered. The details of the product are shown:

Variable: SLA

Data type: satellite altimeters

Data format: NetCDF

Data frequency: Daily

Access: Public

Website: http://marine.copernicus.eu/services-portfolio/access-to-products/?option=com_csw&view=details&product_id=SEALEVEL_GLO_PHY_L4_REP_OBSERVATIONS_008_047

Mediterranean Sea Gridded L4 Sea Surface Heights and Derived Variables Reprocessed

For the Mediterranean Sea - Multimission altimeter satellite gridded sea surface heights and derived variables computed with respect to a twenty-year mean. Previously distributed by Aviso+, no change in the scientific content. All the missions are homogenized with respect to a reference mission which is currently OSTM/Jason-2. It processes data from all altimeter missions: Jason-3, Sentinel-3A, HY-2A, Saral/AltiKa, Cryosat-2, Jason-2, Jason-1, T/P, ENVISAT, GFO, ERS1/2.

The SLA is computed with an optimal and centered computation time window (6 weeks before and after the date). Two kinds of datasets are proposed: filtered (nominal dataset) and unfiltered. The details of the product are shown:

Variable: SLA

Data type: satellite altimeters

Data format: NetCDF

Data frequency: Daily

Access: Public

Website: http://marine.copernicus.eu/services-portfolio/access-to-products/?option=com_csw&view=details&product_id=SEALEVEL_MED_PHY_L4_REP_OBSERVATIONS_008_051

SL_cci ECV v2.0

The first version of the Sea Level Climate Change Initiative (SL_cci) products was initially distributed in September 2012. A full reprocessing of the sea level ECV has been produced and is now available for the users. This v2.0 dataset covers the period Jan. 1993 to Dec. 2015 and provided the time series of gridded SLA. The SLA grids are calculated after merging all the altimetry mission measurements together into monthly grids with a spatial resolution of 1/4 of degree. The details of the product are shown:

Variable:	SLA
Data type:	satellite altimeters
Data format:	NetCDF
Data frequency:	monthly
Access:	Public by contact
Website:	http://www.esa-sealevel-cci.org/products
DOI:	doi.org/10.5194/essd-9-557-201
Contact:	info-sealevel@esa-sealevel-cci.org
Literature:	Quartly, G. D., Legeais, J.-F., Ablain, M., Zawadzki, L., Fernandes, M. J., Rudenko, S., Carrère, L., García, P. N., Cipollini, P., Andersen, O. B., Poisson, J.-C., Mbajon Njiche, S., Cazenave, A., and Benveniste, J.: A new phase in the production of quality-controlled sea level data, Earth Syst. Sci. Data, 9, 557-572, https://doi.org/10.5194/essd-9-557-2017, 2017.

RADS

The Radar Altimeter Database System (RADS) 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. RADS does not dedicate special attention to coastal areas it is an important database for coastal applications mainly because it covers the longest time period (from 1991 until today), but also because the user is allowed to individually decide which corrections he wants to apply. The geophysical and range corrections within RADS generally are the most recent available. The RADS database assemble data from 11 missions and provides its own software to facilitate the download process. Additionally, RADS offers a data acquisition form on their homepage.

Data from eleven altimeter missions are presently available in the RADS, forming the basis for a prototype Level 2 sea level CDR. More of 20 years of "reference missions" (TOPEX/Poseidon, Jason-1, and Jason-2) are complemented by “mesoscale missions” (GFO, ERS-1, ERS-2, and Envisat), the “polar mission” CryoSat-2 and the last missions (Sentinel-3, Jason-3 and SARAL). The details of the product are shown:

Variable:	SLA
Data type:	satellite altimeters
Data format:	ascii
Data frequency:	Irregular
Access:	Public

Website: http://rads.tudelft.nl/rads/rads.shtml

Contact: e.n.doornbos@tudelft.nl

Literature: Scharroo, R., E. W. Leuliette, J. L. Lillibridge, D. Byrne, M. C. Naeije, and G. T. Mitchum, RADS: Consistent multi-mission products, in Proc. of the Symposium on 20 Years of Progress in Radar Altimetry, Venice, 20-28 September 2012, Eur. Space Agency Spec. Publ., ESA SP-710, p. 4 pp., 2013.

Global Ocean Along-Track L3 Sea Surface Heights Reprocessed

For the Global Ocean - Monomission altimeter satellite along-track sea surface heights computed with respect to a twenty-year mean. Previously distributed by Aviso+, no change in the scientific content. All the missions are homogenized with respect to a reference mission which is currently OSTM/Jason-2. It processes data from all altimeter missions: Jason-3, Sentinel-3A, HY-2A, Saral/AltiKa, Cryosat-2, Jason-2, Jason-1, T/P, ENVISAT, GFO, ERS1/2. The SLA is computed with an optimal and centered computation time window (6 weeks before and after the date). Two kinds of datasets are proposed: filtered (nominal dataset) and unfiltered. The details of the product are shown:

Variable: SLA

Data type: satellite altimeters

Data format: NetCDF

Data frequency: Irregular

Access: Public

Website: http://marine.copernicus.eu/services-portfolio/access-to-products/?option=com_csw&view=details&product_id=SEALEVEL_GLO_PHY_L3_REP_OBSERVATIONS_008_045

3. Historical Climate datasets

The Historical Climate datasets have been classified by the features of the variables, resulting three groups: Sea level datasets, wave hindcast and atmospheric datasets.

3.1 Sea level datasets

A review of the available sea level climate datasets along the European coast have been performed. All the selected sea level datasets cover a temporal period higher than 20 years. The Table 11 contains all the details of the datasets that have been included in this report.

Table 11: Sea level datasets

Dataset name	Variables name	Domain name	Geographical coverage		Spatial resolution	Start Time	End Time	Time resolution	Institution
			Latitude interval	Longitude interval					
GOST	Sea level (astronomical tide + storm surge)	Europe	[25,73]	[-31,45]	0,064 x 0,114 degree	1979	2014	hourly	IH Cantabria
coastDat	Water levels & currents	North Sea & Baltic Sea	[39.92,64.7]	[-19.9,35.51]	12,8 km	1948	2015	hourly	HZG
		North Sea	[48.52,62.04]	[-7.96,14.55]	6,4 km				
		Southern North Sea	[49.5,56.44]	[-3.23,9.2]	3,2 km				
		South-Eastern North Sea	[51.12,55.74]	[1.74,9.76]	1,6 km				
		Baltic Sea	[51.4,67.1]	[3.1,34.9]	6,4 km	1958	2011	hourly	
					3,2 km				
					1,6 km				
LEGOS sea level reconstruction	Mean sea level	quasi global	[-50,70]	[-180,180]	1 x 1 degree	1960	2012	monthly	LEGOS
LEGOS historical sea level hindcast	SLA	global	[-90,90]	[-180,180]	1 x 1 degree	1900	2015	annual	
AWI sea level reconstruction	Mean sea level	global	[-90,90]	[-180,180]	1 x 1 degree	1901	2007	monthly	AWI

CSIRO sea level reconstruction	Mean sea level	quasi global	[-65,65]	[-180,180]	1 x 1 degree	1950	2012	monthly	CSIRO
CCAR sea level reconstruction	Mean sea level	quasi global	[-75,89]	[-180,180]	0.5 x 0.5 degree	1950	2008	weekly	CCAR
GECCO2	SLA, T, S, MDT, SST	global	[-90,90]	[-180,180]	1 x 1 degree	1960	2013	monthly	ECCO
ORA-S4	SLA, T, S, SST	global	[-90,90]	[-180,180]	1 x 1 degree	1958	2014	monthly	ECMWF
Soda2.1.6	SLA, T, S, SST	global	[-90,90]	[-180,180]	0.5 x 0.5 degree	1958	2008	monthly	University of Maryland
GLOBAL OCEAN PHYSICS REANALYSIS GLORYS2V4	sea surface height above the geoid, SST, Salinity	Global	[-90,90]	[-180,180]	0,25 x 0,25 degree	1993	2015	monthly-mean daily-mean	GLO-MERCATOR - TOULOUSE-FR
BALTIC SEA PHYSICS REANALYSIS FROM SMHI	sea surface height above the sea level, SST, Salinity	Baltic Sea	[53,66]	[9,30]	5,5 x 5,5 km	1989	2015	monthly-mean daily-mean hourly-mean	SMHI
MEDITERRANEAN SEA PHYSICS REANALYSIS (1955-2015)	sea surface height above sea level, SST, Salinity	Mediterranean sea	[30,46]	[-6,36]	0,065 x 0,063 degree	1995	2014	monthly-mean	MED-INGV-BOLOGNA-IT
MEDITERRANEAN SEA PHYSICS REANALYSIS (1987-2015)	sea surface height above sea level, SST, Salinity	Mediterranean sea	[30,46]	[-6,36	0,065 x 0,063 degree	1987	2015	monthly-mean daily-mean	MED-INGV-BOLOGNA-IT

GOST

The hourly surge database named GOST-Europe provide hourly records of the sea level (Surge + tide elevations). The selected model for obtaining storm surge levels is the Regional Ocean Model System (ROMS), developed by Rutgers University. The model was set-up for Europe using an orthogonal grid, with a horizontal resolution ranging between 3.5 to 11 km. Wind stress and atmospheric pressure from CFSR, together with TPXO7.2 harmonic constants were used as surface drivers. The inverted barometer effect is imposed at the open boundaries of the domain. Bathymetry data were extracted from ETOPO1 and interpolated to ROMS grid.

Surge elevations were validated using measures from tide gauges and also altimetry data. A good agreement between modeled and measured data was found. Some technical details of GOS database can be found in Cid et al. (2014). The surge and current data will be provided with 39 years length (1979 - 2017).

Variable:	Sea level (surge+tide elevations)
Data type:	model data
Data format:	NetCDF
Data frequency:	hourly
Access:	Public by contact
Contact:	ihdata@ihcantabria.com
Literature:	Cid, A., Castanedo, S., Abascal, A. J., Menéndez, M., & Medina, R. (2014). A high resolution hindcast of the meteorological sea level component for Southern Europe: the GOS dataset. Climate Dynamics, 43(7-8), 2167-2184.

coastDat

The hourly met-ocean data base coastDat is a simulation-based data collection developed mainly for the assessment of long-term changes. Most of the data are available for the North and Baltic Seas while some data also exist for other areas such as the Bohai or Laptev Seas. Parameter comprise a large variety of atmospheric data (wind, pressure, temperature etc.) together with tide-surges and wind generated ocean waves (spectral data and parameter derived from integrated spectra such as significant wave height or periods). Depending on region the data set covers the period 1948-2017. For details see www.coastdat.de where a listing of data sets by their DOI's is available.

Variable:	Sea (tide surges), currents and the forcing wind field.
Data type:	model data
Data format:	NetCDF

Data frequency:	hourly
Access:	Public or by contact
Website:	http://www.coastdat.de/
Contact:	Dr. Ralf Weisse (ralf.weisse@hzg.de) Dr. Elke Meyer (elke.meyer@hzg.de) Dr. Beate Geyer (beate.geyer@hzg.de)
Literature:	Weisse, Ralf; Storch, Hans von; Callies, Ulrich; Chrastansky, Alena; Feser, Frauke; Grabemann, Iris et al. (2009): Regional Meteorological-Marine Reanalyses and Climate Change Projections: Results for Northern Europe and Potential for Coastal and Offshore Applications. In: Bull. Amer. Meteor. Soc. 90 (6), S. 849–860. DOI: 10.1175/2008BAMS2713.1. Weisse, Ralf; Bisling, Peter; Gaslikova, Lidia; Geyer, Beate; Groll, Nikolaus; Hortamani, Mahboubeh et al. (2015): Climate services for marine applications in Europe. In: Earth Perspectives 2 (1), S. 3887. DOI: 10.1186/s40322-015-0029-0. Gaslikova, L., & Weisse, R. (2013). coastDat-2 TRIM-NP-2d Tide-Surge North Sea. World Data Center for Climate (WDCC) at DKRZ. https://doi.org/10.1594/WDCC/coastDat-2_TRIM-NP-2d Weidemann, H. (2015). coastDat-2 TRIM-NP-2d-Baltic_Sea. World Data Center for Climate (WDCC) at DKRZ. https://doi.org/10.1594/WDCC/coastDat-2_TRIM-NP-2d-Baltic
Link for more:	http://www.coastdat.de/publications/index.php.en#tab-13

LEGOS sea level reconstruction

LEGOS sea level reconstruction is based on optimal interpolation of tide gauge records with EOFs of satellite altimetry and ocean models. The tide gauge records are monthly mean sea level data from the Revised Local Reference (RLR) of the PSMSL, the ocean model and altimetry data are from DRAKKAR/NEMO OGCM, over 1958–2007, from the SODA ocean reanalysis over 1958–2007 and the altimetry-based gridded sea level over 1993–2009. More details about LEGOS sea level reconstruction can be found in Meyssignac et al. 2012.

Variable:	Mean sea level
Data type:	hybrid model (statistical and numerical model)
Data format:	NetCDF
Data frequency:	monthly

Access:	Public
Website:	ftp://ftp.legos.obs-mip.fr/pub/2D_sealevel_reconstruction/
Contact:	Dr. Benoit Meyssignac (benoit.meyssignac@legos.obs-mip.fr)
Literature:	Meyssignac B., Becker M., Llovel W., Cazenave A. (2012) An assessment of two-dimensional past sea level reconstructions over 1950-2009 based on tide gauge data and different input sea level grids. Survey in Geophysics, 33, 5:945-972. doi:10.1007/s10712-011-9171-x.

LEGOS historical sea level hindcast

LEGOS historical sea level hindcast contains the twentieth-century regional sea level changes are estimated from 12 climate models from phase 5 of the Climate Model Intercomparison Project (CMIP5). The output of the CMIP5 climate model simulations was used to calculate the global and regional sea level changes associated with dynamic sea level, atmospheric loading, glacier mass changes, and ice sheet surface mass balance contributions. The contribution from groundwater depletion, reservoir storage, and dynamic ice sheet mass changes are estimated from observations as they are not simulated by climate models. All contributions are summed, including the glacial isostatic adjustment (GIA) contribution, and compared to observational estimates from 27 tide gauge records over the twentieth century (1900–2015). More details about this dataset can be found in Meyssignac et al. 2017.

Variable:	SLA
Data type:	ensemble of model outputs
Data format:	matlab files
Data frequency:	monthly
Access:	Public by contact
Contact:	Dr. Benoit Meyssignac (benoit.meyssignac@legos.obs-mip.fr)
Literature:	Meyssignac, B.; Slangen, A.A.; Melet, A.; Church, J.A.; Fettweis, X.; Marzeion, B.; Agosta, C.; Ligtenberg, S.R.M.; Spada, G.; Richter, K.; et al. Evaluating Model Simulations of Twentieth-Century Sea-Level Rise. Part II: Regional Sea-Level Changes. J. Clim. 2017, 30, 8565–8593.

AWI sea level reconstruction

Sea level reconstruction based on optimal interpolation of tide gauge records with EOFs of satellite altimetry and neural network for gap filling.

Variable:	Mean sea level

Data type:	statistical model
Data format:	NetCDF
Data frequency:	monthly
Access:	Public by contact
Contact:	Dr. Manfred Wenze (manfred.wenzel@awi.de)
Literature:	Wenzel, M., and J. Schröter (2014), Global and regional sea level change during the 20th century, J. Geophys. Res. Oceans, 119, 7493–7508, doi:10.1002/2014JC009900.

CSIRO sea level reconstruction

Sea level reconstruction based on optimal interpolation of tide gauge records with EOFs of satellite altimetry. The dataset is available in the website.

Variable:	Mean sea level
Data type:	Statistical model
Data format:	NetCDF
Data frequency:	monthly
Access:	Public
Website:	http://www.cmar.csiro.au/sealevel/sl_data_cmar.html
Literature:	Church, J. A., & White, N. J. (2011). Sea-Level Rise from the Late 19th to the Early 21st Century. Surveys in Geophysics, 32(4–5), 585–602. http://doi.org/10.1007/s10712-011-9119-1

CCAR sea level reconstruction

The Reconstructed Sea Level dataset contains sea level anomalies derived from satellite altimetry and tide gauges. Cyclostationary empirical orthogonal functions (CSEOFs), derived from satellite altimetry, are combined with historical sea level measurements from tide gauges to create the Reconstructed Sea Level dataset spanning from 1950 through 2009.

Variable:	SLA
Data type:	Statistical model
Data format:	NetCDF
Data frequency:	Weekly
Access:	Public
Website:	http://dx.doi.org/10.5067/RECSL-000V1

Literature: Hamlington, B. D., R. R. Leben, R. S. Nerem, W. Han, and K.-Y. Kim (2011), Reconstructing sea level using cyclostationary empirical orthogonal functions, Journal of Geophysical Research, 116, C12015, doi:10.1029/2011JC007529

GECCO2

The GECCO2 ocean synthesis is the German contribution of the Estimating the Circulation and Climate of the Ocean project (ECCO, www.ecco-group.org). The synthesis uses the adjoint method to adjust the initial temperature and salinity in 1948 together with the air temperature, humidity, precipitation, and zonal and meridional wind every 10 days to bring the model into consistency with the data, which derive from the EN3v2 data base AVISO along track SLA , GOCO mean dynamic topography, HadISST, AMSRE SST, and the WOA09 climatology. The global model is based on the MITgcm model, has 50 levels, and uses zonally 1 degree and meridionally varying higher resolution. The background atmospheric state is taken from the 6 hourly NCEP/NCAR Reanalysis 1.

Variable: SLA

Data type: model data

Data format: NetCDF

Data frequency: monthly

Access: Public

Website: https://icdc.cen.uni-hamburg.de/1/daten/reanalysis-ocean/gecco2.html

Contact: Dr. Benoit Meyssignac (benoit.meyssignac@legos.obs-mip.fr)

Literature: Köhl, A. (2015). Evaluation of the GECCO2 ocean synthesis: transports of volume, heat and freshwater in the Atlantic. Quarterly Journal of the Royal Meteorological Society, 141(686), 166–181. http://doi.org/10.1002/qj.2347.

ORAS4

The Ocean ReAnalysis System 4 (ORAS4) uses version 3.0 of the NEMO ocean model in the so-called ORCA1 horizontal discretization. The version of ORCA1 used in ORAS4 has been developed jointly by the National Oceanography Centre, Southampton (NOCS) and the Met Office. It has 42 vertical levels, 18 of which are in the upper 200 m. The first level has a 10 m thickness.

The ocean model is forced by atmospheric-derived daily surface fluxes, instead of being computed using a bulk formula within NEMO. Daily fluxes of solar radiation, total heat flux, evaporation-minus-precipitation and surface wind stress are taken from the ERA-40 reanalysis (Uppala et al., 2005) from September 1957 to December 1989, ERA-

Interim reanalysis (Dee et al., 2011) from January 1989‡ to December 2009, and the ECMWF operational archive from January 2010 onwards.

Variable:	SLA
Data type:	model data
Data format:	NetCDF
Data frequency:	monthly
Access:	Public
Website:	http://icdc.cen.uni-hamburg.de/1/projekte/easy-init/easy-init-ocean.html?no_cache=1
Literature:	Balmaseda, M. A., Mogensen, K., & Weaver, A. T. (2013). Evaluation of the ECMWF ocean reanalysis system ORAS4. Quarterly Journal of the Royal Meteorological Society, 139(674), 1132–1161. http://doi.org/10.1002/qj.2063.

Soda2.1.6

Simple Ocean Data Assimilation (SODA) reanalysis version 2.1.6 is forced by atmospheric reanalysis ERA-40 and ERA-Interim. The ocean model is based on Parallel Ocean Program physics with an average 0.25°x0.4°x40-level resolution. Observations include virtually all available hydrographic profile data, as well as ocean station data, moored temperature and salinity time series, surface temperature and salinity observations of various types, and nighttime infrared satellite SST data. The output is in monthly-averaged form, mapped onto a uniform 0.5°x0.5°x40-level grid. For more information on the SODA product, see the literature.

Variable:	Sea surface height
Data type:	model data
Data format:	NetCDF
Data frequency:	monthly
Access:	Public
Website:	http://iridl.ldeo.columbia.edu/SOURCES/.CARTON-GIESE/.SODA/.v2p1p6/
Literature:	Carton, J. A., Giese, B. S., Carton, J. A., & Giese, B. S. (2008). A Reanalysis of Ocean Climate Using Simple Ocean Data Assimilation (SODA). Monthly Weather Review, 136(8), 2999–3017. http://doi.org/10.1175/2007MWR1978.1.

Global Ocean Physics Reanalysis GLORYS2V4

The Mercator Ocean (Toulouse, FR) GLORYS2V4 reanalysis is performed with NEMOv3.1 ocean model in configuration ORCA025_LIM (¼ degree resolution). The vertical grid has 75 levels with partial steps at the bottom. The ERA-Interim atmospheric surface forcing includes a large-scale correction for downward (shortwave and longwave) radiative and rainfall fluxes. This simulation uses the LIM2 thermodynamic-dynamic sea ice model with an Elastic-Viscous-Plastic rheology formulation. The data assimilation technique is a multi-data and multivariate reduced order Kalman filter based on the Singular Extended Evolutive Kalman (SEEK) filter formulation. A bias correction scheme for temperature and salinity is also included. The increments are applied using an Incremental Analysis Update. The assimilated observations are delayed time along track satellite Sea Level Anomaly, Sea Ice Concentration, Sea Surface Temperature, and in situ profiles of temperature and salinity from CORA4 data base.

Variable:	Sea surface height
Data type:	model data
Data format:	NetCDF
Data frequency:	monthly mean, daily mean
Access:	Public
Website:	http://marine.copernicus.eu/services-portfolio/access-to-products/?option=com_csw&view=details&product_id=GLOBAL_REANALYSIS_PHY_001_025

Baltic Sea Physics Reanalysis From SMHI

The Baltic Sea Physics reanalysis is produced by SMHI (the Swedish Meteorological and Hydrological Institute) with the circulation model HIROMB (High-Resolution Operational Model for the Baltic) that has been the operational ocean and sea ice forecasting model used at SMHI since the mid 1990s. The model domain covers the North Sea as well as the Baltic Sea. At the lateral boundary in the western English Channel and along the Scotland-Norway boundary, the sea levels are prescribed using a coarse (24 nautical miles resolution) storm-surge model called NOAMOD (North Atlantic Model). Climatological monthly mean values of salinity and temperature are used at the boundary, and it is assumed there is no sea ice.

The meteorological forcing is from the HIRLAM (High-Resolution Limited Area Model) model with 22 km resolution. The data assimilation method used is 3D Ensemble Variational (3D EnVar). The variables assimilated are charts of SST, Sea Ice Concentration and Sea Ice Thickness from the Swedish Ice Service at SMHI as well as in-situ measurements of T/S (Temperature and Salinity) profiles from the ICES data base.

Variable:	Sea surface height

Data type: model data

Data format: NetCDF

Data frequency: monthly mean, daily mean, hourly mean

Access: Public

Website: http://marine.copernicus.eu/services-portfolio/access-to-products/?option=com_csw&view=details&product_id=BALTICSEA_REANALYSIS_PHY_003_008

Mediterranean Sea Physics Reanalysis (1955-2015)

The 60 years reanalysis has been produced by combining, every day, the output of the ocean model, forced by atmospheric surface fluxes and relaxed to SST, and quality controlled ocean observations. The hydrodynamics are supplied by the Nucleos for European Modelling of the Ocean (NEMO) with a variational data assimilation schema (OceanVar) thanks to which salinity and temperature profiles and satellite Sea Level Anomaly along track data are jointly assimilated to estimate the initial conditions for numerical ocean model. The model horizontal grid resolution in 1/16˚ (ca. 6-7 km) and the unevenly spaced vertical levels are 72. The sixty years reanalysis is forced with atmospheric surface variables from an AMIP dataset and the SST inputs from Met Office Hadley Centre SST dataset (HadSST1).

Variable: Sea surface height

Data type: model data

Data format: NetCDF

Data frequency: monthly mean

Access: Public

Website: http://marine.copernicus.eu/services-portfolio/access-to-products/?option=com_csw&view=details&product_id=MEDSEA_REANALYSIS_PHY_006_009

Literature: Fratianni, C., Simoncelli, S., Pinardi, N., Cherchi, A., Grandi, A., & Dobricic, S. (2015). "Mediterranean RR 1955-2015 (Version 1)". set. E.U. Copernicus Marine Service Information.DOI: https://doi.org/10.25423/MEDSEA_REANALYSIS_PHY_006_009.

Mediterranean Sea Physics Reanalysis (1987-2015)

The Mediterranean Forecasting System, physical reanalysis component, is a hydrodynamic model, supplied by the Nucleous for European Modelling of the Ocean

(NEMO), with a variational data assimilation scheme (OceanVAR) for temperature and salinity vertical profiles and satellite Sea Level Anomaly along track data.The model horizontal grid resolution is 1/16˚ (ca. 6-7 km) and the unevenly spaced vertical levels are 72. The model is forced by momentum, water and heat fluxes interactively computed by bulk formulae using the 6-h, 0.75° horizontal-resolution ERAInterim reanalysis fields from the European Centre for Medium-Range Weather Forecasts (ECMWF) and the model predicted surface temperatures

Variable: Sea surface height

Data type: model data

Data format: NetCDF

Data frequency: monthly mean, daily mean

Access: Public

Website: http://marine.copernicus.eu/services-portfolio/access-to-products/?option=com_csw&view=details&product_id=MEDSEA_REANALYSIS_PHYS_006_004

Literature: Simoncelli, S., Fratianni, C., Pinardi, N., Grandi, A., Drudi, M., Oddo, P., & Dobricic, S. (2014). "Mediterranean Sea physical reanalysis (MEDREA 1987-2015) (Version 1)". set. E.U. Copernicus Marine Service Information. DOI: https://doi.org/10.25423/medsea_reanalysis_phys_006_004.

3.2 Wave hindcast

A review of the available wave hindcast along the European coast have been performed. All the selected wave hindcast datasets cover a historical period of more than 20 years. To know the wave parameters provided by each wave hindcast, see detailed information. The Table 12 contains the important details of the datasets that have been included in this report.

Table 12: Wave hindcast datasets.

Dataset name	Domain name	Geographical coverage		Spatial resolution	Start Time	End Time	Time resolution	Institution
		Latitude interval	Longitude interval					
GOW	Europe	[-12,45]	[30,72]	0,125 x 0,125 degree	1979	2017	hourly	IH Cantabria
	Black Sea	[26.5,42]	[40.18,47.5]	0,0625 x 0,0625 degree	1979	2014	hourly	
coastDat	North Sea	[-4.75,13.25]	[50.5,59.5]	0.05 x 0.075	1949	2014	hourly	HZG

				degree				
	North Sea	[-3,10.5]	[51,56]	0.05 x 0.1 degree	1958	2007	hourly	
	Baltic Sea	[9,31.5]	[53.5,66]	0.05 x 0.1 degree	1958	2002	hourly	
Bobwa-h	English Channel, Bay of Biscay	[-10,0]	[43,52]	0,5°x0,5° and 0,1°x0,1°	1958	2002	6-h	BRGM
MARINAdb Wave Parameters	Europe	[-20,42]	[26,66.05]	0,05 x 0,05 degree	1996	2015	hourly	DEMOKRITOS

GOW

The GOW dataset, developed by IH Cantabria, provide hourly time series produced by the numerical model Wavewatch III (WWIII). WWIII is a third-generation wave model developed at NOAA-NCEP. WWIII solves the spectral action density balance equation for wave number direction spectra. The model can generally be applied to large spatial scales and outside the surf zone. Parameterizations of physical processes include wave growth and decay due to the actions of wind, nonlinear resonant interactions, dissipation ('whitecapping') and bottom friction. Wave interactions with currents were not considered in the GOW hindcast. The wind fields used to force waves come from the global re-analysis CFSR. The bathymetry used in the wave reanalysis originates from ETOPO. The bathymetric portion was generated by combining quality-controlled ship depth soundings, with predicted depths between the sounding points guided by satellite-derived gravity data.

GOW is a historical reconstruction of wind-generated offshore waves for more than 30 years, allowing a statistical characterization of wave climate. The data provided comes from a European spatial domain. The wave hindcast outcomes provide hourly time series of significant wave height, mean wave period, peak frequency, mean wave direction and mean directional spread for all the grid points of the computed grid. The forcings of wind and ice for the model WWIII are from the global reanalysis CFS (Saha et al. 2008). More details can be found in Perez et al. 2015 and Reguero et al. 2012.

Variables:	Significant wave height, mean wave period from variance spectral density second frequency moment, wave peak period, wave mean direction.
Data type:	model data
Data format:	NetCDF
Data frequency:	hourly
Access:	Public by contact
Contact:	ihdata@ihcantabria.com

Literature:	Perez, J., Menendez, M., Camus, P., Mendez, F. J., & Losada, I. J. (2015). Statistical multi-model climate projections of surface ocean waves in Europe. Ocean Modelling, 0, 1–10. https://doi.org/10.1016/j.ocemod.2015.06.001. Reguero, B. G., Menéndez, M., Méndez, F. J., Mínguez, R., & Losada, I. J. (2012). A Global Ocean Wave (GOW) calibrated reanalysis from 1948 onwards. Coastal Engineering, 65, 38–55. http://doi.org/10.1016/j.coastaleng.2012.03.003.

coastDat

For the coastDat wave hindcast, the simulations have been performed with the wave model WAM (WAMDI-Group 1988). Atmospheric forcing of the dataset (North Sea domain for 1949-2014 period) was obtained from an atmospheric hindcast with COSMO-CLM (Rockel et al. 2008) driven by the NCEP/NCAR Reanalysis 1 dataset. For the datasets (North Sea domain for 1958-2007 period and Baltic Sea domain for 1958-2002 period), the atmospheric forcing was obtained from an atmospheric hindcast with SN-REMO (Meinke et al. 2004) driven by the NCEP/NCAR Reanalysis 1 dataset.

Variables:	Significant wave height, mean wave period, wave peak period, wave mean direction and the forcing wind field.
Data type:	model data
Data format:	NetCDF
Data frequency:	hourly
Access:	Public or by contact
Website:	http://www.coastdat.de/
Contact:	Dr. Ralf Weisse (ralf.weisse@hzg.de) Dr. Elke Meyer (elke.meyer@hzg.de) Dr. Beate Geyer (beate.geyer@hzg.de)
Literature:	Groll, N. & Weisse, R. (2016). coastDat-2 North Sea wave hindcast for the period 1949-2014 performed with the wave model WAM. World Data Center for Climate (WDCC) at DKRZ. https://doi.org/10.1594/WDCC/coastDat-2_WAM-North_Sea. Weisse, R. (2015). coastDat-1 Waves Baltic Sea. World Data Center for Climate (WDCC) at DKRZ. https://doi.org/10.1594/WDCC/coastDat-1_Waves_Baltic_Sea.

Groll, N., & Weisse, R. (2017). A multi-decadal wind-wave hindcast for the North Sea 1949–2014: coastDat2, Earth Syst. Sci. Data, 9, 955-968, https://doi.org/10.5194/essd-9-955-2017.
Weisse, R., & Günther, H. (2007). Wave climate and long-term changes for the Southern North Sea obtained from a high-resolution hindcast 1958–2002. Ocean Dynamics, 57(3), 161–172. http://doi.org/10.1007/s10236-006-0094-x.

Bobwa-h

The Bay Of Biscay Wave Atlas-Hindcast (bobwa-h) has been computed with a wave modelling system based on the WAVEWATCH III code and forced by 40-yr European Centre for Medium-Range Weather Forecasts Re-Analysis (ERA-40) wind fields. The tides are not included, they may affect the wave parameters in the English Channel.

Variables:	Significant wave height, mean wave period, wave peak period, wave mean direction and wave peak direction.
Data type:	model data
Data format:	NetCDF
Data frequency:	6-hourly
Access:	Public
Website:	http://bobwa.brgm.fr/
Contact:	Dr. Gonéri Le Cozannet (G.LeCozannet@brgm.fr)
Literature:	Charles, E., Idier, D., Thiébot, J., Le Cozannet, G., Pedreros, R., Ardhuin, F., … Planton, S. (2012). Present Wave Climate in the Bay of Biscay: Spatiotemporal Variability and Trends from 1958 to 2001. Journal of Climate, 25(6), 2020–2039. https://doi.org/10.1175/JCLI-D-11-00086.1

MARINAdb Wave Parameters

MARINA wave parameters dataset has been computed with the 3rd generation wave model WAM. The wind fields to force the model has been obtained with the limited area model SKIRON. For more information of the product, see Kalogeri et al. (2017).

Variables:	Significant Wave Height, Mean Wave Direction, Peak Frequency, Mean (Energy) frequency, Maximum wave Height, Wave Direction, Maximum Wave Height, Maximum Wave.
Data type:	model data

Data format: NetCDF

Data frequency: hourly

Access: Public by contact

Contact: Dr. George Emmanouil (gemman@ipta.demokritos.gr)

Literature: Kalogeri, C., Galanis, G., Spyrou, C., Diamantis, D., Baladima, F., Koukoula, M., & Kallos, G. (2017). Assessing the European offshore wind and wave energy resource for combined exploitation. Renewable Energy, 101, 244–264. https://doi.org/10.1016/j.renene.2016.08.010

3.3 Atmospheric datasets

Regional atmospheric hindcast and global reanalysis are included in this section. The regional atmospheric hindcasts cover the European coast and have better spatial resolution than the global reanalysis, although the temporal period is shorter. The Table 13 contains the details of the atmospheric datasets that have been included in this report.

Table 13: Atmospheric datasets.

Dataset name	Domain name	Geographical coverage		Spatial resolution	Start Time	End Time	Time resolution	Institution
		Latitude interval	Longitude interval					
SeaWind II	Europe	[19,68]	[-38,60]	0,125 x 0,125 degree	1985	2017	hourly	IH Cantabria
EPER NCSRD	Europe - Mediterranean basin	[25,50]	[-10,50]	0,20 x 0,20 degree	1980	2009	6-hourly	DEMOKRITOS
MARINAdb Atmospheric Parameters	Europe	[26,66.05]	[-20,42]	0,05 x 0,05 degree	1996	2015	hourly	DEMOKRITOS
ERA-Interim	Global	[-90,90]	[-180,180]	0,75 x 0,75 degree	1979	ongoing	6-hourly	ECMWF
CFS Hourly products	Global	[-90,90]	[-180,180]	0.312 x ~0.312 degree	1979	2010	hourly	NCEP
CFSv2 Hourly products	Global	[-90,90]	[-180,180]	0.205 x ~0.204 degree	2011	ongoing	hourly	NCEP

SeaWind II

SeaWind II dataset, a 15-km horizontal resolution hindcast product has been driven by the ERA-Interim Reanalysis (1985–2017). The Weather Research and Forecasting (WRF)

model with the Advanced Research WRF dynamical solver (ARW) has been employed to create the dynamically downscaled wind product. SeaWind II hindcast has been obtained from a daily re-forecast running mode and the Yonsei University (YSU) Planetary Boundary Layer (PBL) parameterization scheme after a sensitivity analysis. More technical details about SeaWind II dataset can be found in Menéndez et al. (2014).

Variables:	Wind speed and direction at 10 m height and other atmospheric variables.
Data type:	model data
Data format:	NetCDF
Data frequency:	hourly
Access:	Public by contact
Contact:	ihdata@ihcantabria.com
Literature:	Menendez, M., García-Díez, M., Fita, L., Fernández, J., Méndez, F. J., & Gutiérrez, J. M. (2014). High-resolution sea wind hindcasts over the Mediterranean area. Climate Dynamics, 42(7–8), 1857–1872. https://doi.org/10.1007/s00382-013-1912-8

EPER NCSRD

EPER NCSRD hindcast has been driven by the ERA-Interim Reanalysis (1980-2009) and applying dynamical downscaling using the model WRF-ARW. The hindcast covers the European region with a spatial resolution of 0.20° x 0.20°. More technical details can be found in Politi et al. (2017).

Variables:	Wind speed and direction at 10 m height, SST, surface pressure, temperature at 2m.
Data type:	model data
Data format:	NetCDF
Data frequency:	6-hourly
Access:	Public by contact
Contact:	Dr. George Emmanouil (gemman@ipta.demokritos.gr)
Literature:	Politi, N., Nastos, P. T., Sfetsos, A., Vlachogiannis, D., & Dalezios, N. R. (2017). Evaluation of the AWR-WRF model configuration at high resolution over the domain of Greece. Atmospheric Research. https://doi.org/10.1016/j.atmosres.2017.10.019

MARINAdb Atmospheric Parameters

MARINAdb atmospheric parameters dataset has been computed with the limited area model SKIRON. The initial and boundary fields are from 0.15° reanalysis fields from LAPS (every 3 h), except the daily SST fields that is from NCEP reanalysis. For more information of the product, see Kalogeri et al. (2017).

Variables:	Zonal and Meridional Wind Components, Air pressure, Air Density, Turbulent Kinetic Energy at 10, 40, 80, 120 and 180m
Data type:	model data
Data format:	Ascii
Data frequency:	hourly
Access:	Public by contact
Contact:	Dr. George Emmanouil (gemman@ipta.demokritos.gr)
Literature:	Kalogeri, C., Galanis, G., Spyrou, C., Diamantis, D., Baladima, F., Koukoula, M., & Kallos, G. (2017). Assessing the European offshore wind and wave energy resource for combined exploitation. Renewable Energy, 101, 244–264. https://doi.org/10.1016/j.renene.2016.08.010

ERA-Interim

ERA-Interim is a global atmospheric reanalysis from 1979, continuously updated in real time. The data assimilation system used to produce ERA-Interim is based on a 2006 release of the IFS (Cy31r2). The system includes a 4-dimensional variational analysis (4D-Var) with a 12-hour analysis window. The spatial resolution of the data set is approximately 80 km (T255 spectral) on 60 vertical levels from the surface up to 0.1 hPa. ERA-Interim data can be downloaded from the ECMWF Public Datasets web interface or from MARS.

Variables:	Wind speed and direction at 10 m height and other atmospheric variables.
Data type:	model data
Data format:	NetCDF
Data frequency:	6-hourly
Access:	Public
Website:	http://www.coastdat.de/
Literature:	Dee, D. P., Uppala, S. M., Simmons, a. J., Berrisford, P., Poli, P., Kobayashi, S., … Vitart, F. (2011). The ERA-Interim reanalysis: configuration and performance of the data assimilation system.

Quarterly Journal of the Royal Meteorological Society, 137(656), 553–597. https://doi.org/10.1002/qj.828

CFS hourly products

The National Centers for Environmental Prediction (NCEP) Climate Forecast System Reanalysis (CFSR) was initially completed over the 31-year period from 1979 to 2009 and has been extended to March 2011. NCEP has created selected time series products at hourly temporal resolution by combining either 1) the analysis and one- through five-hour forecasts, or 2) the one- through six-hour forecasts, for each initialization time.

Variables:	Wind speed and direction at 10 m height and other atmospheric variables.
Data type:	model data
Data format:	NetCDF
Data frequency:	hourly
Access:	Public
Website:	https://rda.ucar.edu/datasets/ds093.1/
Literature:	Saha, S., et al. 2010. NCEP Climate Forecast System Reanalysis (CFSR) Selected Hourly Time-Series Products, January 1979 to December 2010. Research Data Archive at the National Center for Atmospheric Research, Computational and Information Systems Laboratory. https://doi.org/10.5065/D6513W89.

CFSv2 hourly products

The National Centers for Environmental Prediction (NCEP) Climate Forecast System (CFS) is initialized four times per day (0000, 0600, 1200, and 1800 UTC). NCEP upgraded CFS to version 2 on March 30, 2011. This is the same model that was used to create the NCEP Climate Forecast System Reanalysis (CFSR). Selected CFS time series products are available at 0.2, 0.5, 1.0, and 2.5 degree horizontal resolutions at hourly intervals by combining either 1) the analysis and one- through five-hour forecasts, or 2) the one-through six-hour forecasts, for each initialization time. Beginning with January 1, 2011, these data are archived as an extension of CFSR.

Variables:	Wind speed and direction at 10 m height and other atmospheric variables.
Data type:	model data
Data format:	NetCDF
Data frequency:	hourly

Access:	Public
Website:	https://rda.ucar.edu/datasets/ds094.1/
Literature:	Saha, S., et al. 2011, updated monthly. NCEP Climate Forecast System Version 2 (CFSv2) Selected Hourly Time-Series Products. Research Data Archive at the National Center for Atmospheric Research, Computational and Information Systems Laboratory. https://doi.org/10.5065/D6N877VB.

4. Climate projections datasets

The climate projections datasets inform about climate changes in the future. The interest of the project are the coastal climate projections datasets. The coastal climate projections collect the changes in the variables associated to the sea surface dynamics, such as mean sea level, storm surges, oceanographic currents and waves parameters.

The selected climate projections datasets are spatially focused around the European coast, although a global climate projection dataset have been added. The selected global climate dataset includes the mean sea level projections used in preparing the IPCC AR5 report (2014). The other datasets gather the changes along the European coast in the wave parameters, storm surge, water levels. The Table 14 summaries the selected climate projection datasets available for ECLISEA project.

Table 14: Climate projections datasets.

Dataset name	Variables name	Domain name	Geographical coverage		Spatial resolution	Temporal coverage		Time resolution	CMIP Phase	Forcing		Institution
			Latitude interval	Longitude interval		Historical (control period)	Future			GCM/RCM	Scenario	
IPCC-AR5	Mean Sea level	Global	[-90,90]	[-180,180]	1 x 1 degree		2007-2100	Annual	CMIP5	Ensemble of 21 GCMs and for each GCMs	RCP2.6, RCP 4.5, RCP 6.0 RCP 8.5	IPPC
IH-GOW REGIONAL PROJECTIONS	Hs, Tm02, Wave energy flux	Europe	[30,72]	[-12,45]	0,125 x 0,125 degree	1975-2004	2010-2039, 2040-2069, 2070-2099	daily	CMIP5	Ensemble of 17 GCMs	RCP2. 6, RCP 4.5, RCP 8.5	IH Cantabria
IH-DAC REGIONAL PROJECTIONS	daily maximum surge level	Europe	[30,72]	[-12,45]	2 x 2 degree	1992-2014	2010-2099	daily	CMIP5	Ensemble of 8 GCMs	RCP2.6 RCP8.5	IH Cantabria
coastDat	Hs, wave period, wave direction	North Sea	[51,58.5]	[-3.25,10.25]	0.05 x 0.1 degree	1961-1990	2071-2100	hourly	CMIP3	GCMs: HadM3H, ECHAM4/OPYC3; RCM: RCAO	A2, B2	HZG
	Hs, wave period, wave direction	North Sea	[51,58.5]	[-3.25,10.25]	0.05 x 0.075 degree	1961-2000	2001-2100	hourly	CMIP3	GCM: ECHAM5/MPI-OM; RCM: COSMO-CLM	A1B, B1	
	Hs, wave period, wave direction	North Sea	[51,58.5]	[-3.25,10.25]	0.05 x 0.075 degree	1961-2000	2001-2100	hourly	CMIP3	GCM: ECHAM5/MPI-OM; RCM: REMO and HIRHAM	A1B	
	Hs, wave period, wave direction	Baltic Sea	[53.5,66]	[9,31]	0.05 x 0.075 degree	1961-2000	2001-2100	hourly	CMIP3	GCM: ECHAM5/MPI-OM (2 initial conditions); RCM: COSMO-CLM	A1B, B1	
	Storm surge & currents	North Sea	[39.92,64.7]	[-19.9,35.51]	12,8 km	1961-2000	2001-2100	hourly	CMIP3	GCM: ECHAM5/MPI-OM; RCM: COSMO-CLM	A1B, B1	
	Storm surge & currents	North Sea	[39.92,64.7]	[-19.9,35.51]	12,8 km, 6,4 km, 3,2 km, 1,6 km	1971-2005	2006-2100	hourly	CMIP5	GCM: EC-Earth; RCM: RCA	RCP8.5	
Bobwa	Hs, tm02, mean wave direction	English Channel, Bay of Biscay	[43.52]	[-10,0]	0,5°x0,5° and 0,1°x0,1°	1961-2000	2061-2100	6-h	CMIP3		A2, A1B and B1	BRGM
LISCoAsT	SS, ESL	Europe	[27,71]	[-29,41]	along Europe coastline	1969-2004	2009-2099	8 return periods)	CMIP5	Ensemble of 8 GCMs	RCP4.5 RCP8.5	JRC

4.1 Mean sea level rise projections

IPCC-AR5

The Fifth Assessment Report (AR5) of the Intergovernmental Panel on Climate Change (IPCC) includes mean sea level projections in Section 13 for the Representative Concentration Pathway (RCP) scenarios and the Special Report on Emission Scenarios (SRES) A1B scenario. This dataset contains the files used in preparing the IPCC AR5 report.

Furthermore, extra files (https://icdc.cen.uni-hamburg.de/1/daten/ocean/ar5-slr.html) are also included in the dataset. These extra files which contain the ocean and ice components, sums and uncertainties as used in preparing the IPCC AR5 report (2014), with some slight modifications. The extra files provide the information of each component of the mean sea level, the 5% and 95% (upper and lower 90% confidence interval) uncertainty estimates for the various fields and the results of the total sea level rise with the upper and lower 90% confidence interval for the scenarios RCP 2.6, 4.5, 6.0 and 8.5. The spatial resolution is $1^{o}x1^{o}$ at a global scale from 2007 until 2100 at yearly resolution. More information is provided in the ftp site with the extra files and in the section 13 of the IPCC AR5 report.

Variables: Mean sea level.

Data type: model and ensemble data

Data format: NetCDF and txt

Access: Public

Files:

http://www.climatechange2013.org/images/report/WG1AR5_Ch13SM_datafiles.zip

Extra files: ftp://ftp-icdc.cen.uni-hamburg.de/ar5_sea_level_rise/

Literature: Church, J. A., P. Clark, A. Cazenave, J. Gregory, S. Jevrejeva, A. Levermann, M. Merrifield, G. Milne, R.S.Nerem, P. Nunn, A. Payne, W. Pfeffer, D. Stammer, and A. Unnikrishnan (2013), Sea level change, in Climate Change 2013: The Physical Science Basis, edited by T. F. Stocker, D. Qin, G.-K. Plattner, M. Tignor, S. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex, and P. Midgley, Cambridge University Press, Cambridge, UK and New York, NY. USA.

Church, J.A., P.U. Clark, A. Cazenave, J.M. Gregory, S. Jevrejeva, A. Levermann, M.A. Merrifield, G.A. Milne, R.S. Nerem, P.D. Nunn, A.J. Payne, W.T. Pfeffer, D. Stammer and A.S. Unnikrishnan, 2013: Sea Level Change Supplementary Material. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K.

Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Available from www.climatechange2013.org and www.ipcc.ch.

4.2 Regional Wave Climate Projections

IH-GOW Regional Projections

This database has been produced at IH Cantabria using a statistical downscaling framework. The dataset contains the Significant wave height, wave mean period from variance spectral and wave energy flux at a European scale (the Atlantic Ocean at 0.5°x0.5° and in the area close to the European coastline at 0.125°x0.125°). The IH-GOW Regional Projections are estimated from an ensemble of 17 Global Circulations Models (GCMs) for a historical period (from 1975 to 2004) and three future periods (from 2010 to 2039, from 2040 to 2069 and 2070 to 2099) for the RCP2.6, RCP4.5 and RCP8.5 scenarios.

The multi-model projection methodology is present in Perez et al. (2015) and is based on a statistical downscaling approach. The statistical relation between the predictor (atmospheric conditions) and the predictand (multivariate wave climate) is based on a weather type (WT) classification. This atmospheric classification is developed by applying the k-means clustering technique over historical offshore sea level pressure (SLP) fields. Each WT is linked to sea wave conditions from a wave hindcast. This wave hindcast with hourly resolution from 1979 to 2013 has been generated using WaveWatch III wave model in a multigrid configuration: a global grid (1° latitude x 1.5° longitude), a grid covering the Atlantic Ocean (0.5°x0.5°) and a grid in the area close to the European coastline (0.125°x0.125°), with small grids covering the archipelagos of Cape Verde, Canary Islands and Azores (0.125°x0.125°), forced by winds and ice coverage from CFSR reanalysis. This link is developed by associating atmospheric conditions from reanalysis with multivariate local waves. This predictor–predictand relationship is applied to the daily SLP fields from GCMs in order to project future changes in regional wave conditions. The GCMs used in the multi-model projection are selected according to skill criteria. The application of this framework uses CMIP5-based wave climate projections in Europe. The low computational requirements of the statistical approach allow a large number of GCMs and climate change scenarios to be studied. More details are listed below:

Variables:	Significant wave height, wave mean period from variance spectral density second frequency moment, Wave energy flux.
Data type:	Statistical downscaling model based on weather types
Data format:	NetCDF
Data frequency:	daily
Access:	Public by contact
Contact:	ihdata@ihcantabria.com

Literature: Perez, J., Menendez, M., Camus, P., Mendez, F. J., & Losada, I. J. (2015). Statistical multi-model climate projections of surface ocean waves in Europe. Ocean Modelling, 0, 1–10. https://doi.org/10.1016/j.ocemod.2015.06.001.

coastDat

The coastDat wave projections have been developed by simulations with the wave model WAM (WAMDI-Group 1988) that has been forced by wind fields from regional climate models (RCMs). The boundary conditions used to drive RCMs are obtained from global simulations with the GCMs of the phase 3 of CMIP. Each climate projection dataset has been developed by a selection of RCMs, GCMs, and emission scenarios.

The first coastDat wave projection dataset covers the North Sea (spatial resolution of 0.05 x 0.1 degree) for a historical period (from 1961 to 1990) and a future period (from 2071 to 2100). The RCM is the regional coupled atmosphere-ocean model RCAO (Jones et al. 2004), which is forced by the GCMs HadAM3H and ECHAM4/ OPYC3 under two emission scenarios A2 and B2. Details are described in Grabemann & Weisse (2008).

The second coastDat wave projection dataset for the North Sea (spatial resolution of 0.05 x 0.075 degree, Groll et al. (2014)) and the dataset for the Baltic Sea (spatial resolution of 0.05 x 0.075 degree, Groll et al. (2017)) have been driven with the same RCM (COSMO-CLM, Rockel et al. 2008) under the scenarios A1B and B1. The datasets cover a historical period (from 1961 to 2000) and a future period (from 2001 to 2100).

The third coastDat wave projection dataset in the North Sea has a spatial resolution of 0.05 x 0.075 degree, covering a historical period (from 1961 to 2000) and a future period (from 2001 to 2100). The RCMs are the REMO (Jacob et al. 2007) and HIRHAM (Christensen et al. 2007) forced under the scenario A1B. The details are described in Grabemann et al. (2015).

More details about the coastDat climate projection datasets are listed below.

Variable:	Significant wave height, mean wave period, wave peak period, wave mean direction and the forcing wind field.
Data type:	model data
Data format:	NetCDF
Data frequency:	hourly
Access:	By contact
Website:	http://www.coastdat.de/
Contact:	Dr. Ralf Weisse (ralf.weisse@hzg.de) Dr. Elke Meyer (elke.meyer@hzg.de) Dr. Beate Geyer (beate.geyer@hzg.de)
Literature:	Grabemann, I., & Weisse, R. (2008). Climate change impact on extreme wave conditions in the North Sea: an ensemble study.

Ocean Dynamics, 58(3–4), 199–212. https://doi.org/10.1007/s10236-008-0141-x.
Grabemann, I., Groll, N., Möller, J., & Weisse, R. (2015). Climate change impact on North Sea wave conditions: a consistent analysis of ten projections. Ocean Dynamics, 65(2), 255–267. https://doi.org/10.1007/s10236-014-0800-z.
Groll, N., Grabemann, I., & Gaslikova, L. (2014). North Sea wave conditions: An analysis of four transient future climate realizations. Ocean Dynamics, 64(1), 1–12. https://doi.org/10.1007/s10236-013-0666-5.
Groll, N., Grabemann, I., Hünicke, B., & Meese, M. (2017). Baltic sea wave conditions under climate change scenarios. Boreal Environment Research, 22, 1–12.

Bobwa

This database has been generated dynamically by Bureau de Recherches Géologiques et Minières (BRGM, France). The dataset contains the Significant wave height, wave mean period and mean direction along the English Channel and Bay of Biscay coast. Bobwa has been generated with the WaveWatch III model forced by the GCM ARPEGE-Climat for a historical period (from 1961 to 2000) and a future period (from 2061 to 2100) for the A2, A1B and B1 scenarios.

The climate wave projections have been generated with the WWIII model. The wave model is implemented on two nested domains: North Atlantic Ocean (spatial resolution of 0.5°) and the Bay of Biscay (spatial resolution of 0.1°) and more details are described in Charles et al. (2012).

Variables:	Significant wave height, mean wave period and mean wave direction.
Data type:	model data
Data format:	NetCDF
Data frequency:	6-hourly
Access:	By contact
Contact:	Dr. Déborah Idier (d.idier@brgm.fr) Agnes Tellez Arenas (a.tellez@brgm.fr)
Literature:	Charles, E., Idier, D., Delecluse, P., Déqué, M., & Le Cozannet, G. (2012). Climate change impact on waves in the Bay of Biscay, France. Ocean Dynamics, 62(6), 831–848. https://doi.org/10.1007/s10236-012-0534-8

4.3 Storm surge projections

IH-DAC Regional Projections

This database is generated by IHCantabria using a multivariate linear regression model fitted using the historical atmospheric data from a reanalysis and simultaneous historical storm surge data (Cid et al., 2017). The historical surge database corresponds to the Dynamic atmospheric Correction (DAC), produced by CLS Space Oceanography Division using the MOG2D model from Legos and distributed by Aviso, with support from Cnes (http://www.aviso.altimetry.fr/). ERA-Interim reanalysis (Dee et al., 2011) from the ECMWF, which is the DAC forcing field, is used to define atmospheric predictor. Projected changes of storm surge during twenty-first century are computed for scenarios RCP 2.6 and 8.5 for the whole 21st century using 8 GCMs at spatial resolution of 2 degree in the North Atlantic Ocean, relative to present climate 1992-2014.

Variables:	daily maximum surge level
Data type:	statistical downscaled data
Data format:	NetCDF
Data frequency:	daily
Access:	By contact
Contact:	Dr. Alba Cid (alba.cid@unican.es)
	Paula Camus (camups@unican.es)
Literature:	Cid, A., Camus, P., Castanedo, S., Méndez, F.J., Medina, R. (2017). Global reconstructed daily surge levels from the 20th Century Reanalysis (1871–2010). Global and Planetary Change, 148, pp. 9-21.

coastDat

The coastDat dataset also contains storm surge projections. The storm surge projections have been developed by the hydrodynamical model TRIM-NP in a 2D mode. The model has been driven by RCMs forced by different atmospheric data. The RCM at North Sea has been forced by atmospheric data of the phase 3 of CMIP. The RCM at Baltic Sea has been forced by data of the phase 5 of the CMIP.

The storm surge projections in the North Sea (spatial resolution of 12.8 km, Gaslikova et al., 2013) have been driven with the same RCM (COSMO-CLM, Rockel et al. 2008) under the scenarios A1B and B1, for the historical period from 1961 to 2000 and future period from 2001 to 2100.

The storm surge projections for the Baltic Sea have four nested domains (with spatial resolution from 12.8, 6.4, 3.2 to 1.6 km). The historical period covers from 1971 to 2005, and the future period is from 2006 to 2100. The RCM is RCA that has been forced with GCM EC-Earth in the scenario RCP 8.5. More details about the coastDat climate projection datasets are listed below.

Variables:	Storm surge, water level, currents and the forcing wind field.

Data type:	model data
Data format:	NetCDF
Data frequency:	hourly
Access:	By contact
Website:	http://www.coastdat.de/
Contact:	Dr. Ralf Weisse (ralf.weisse@hzg.de)
	Dr. Elke Meyer (elke.meyer@hzg.de)
	Dr. Beate Geyer (beate.geyer@hzg.de)
Literature:	Gaslikova, L., Grabemann, I., & Groll, N. (2013). Changes in North Sea storm surge conditions for four transient future climate realizations. Natural Hazards, 66(3), 1501–1518. https://doi.org/10.1007/s11069-012-0279-1.

LISCoAsT

Large Scale Integrated Sea-level and Coastal Assessment Tool (LISCoAsT) is an integrated assessment tool that develops dynamic scenarios of catastrophic coastal hazards. These dynamic scenarios are climate projection datasets along the European coast. LISCoAsT provides a dataset with European Extreme Storm Surge level (ESSL, Vousdoukas et al. 2016).

The ESSL are estimated from an ensemble of 8 climatic models for a historical period (from 1969 to 2004) and a future period (from 2009 to 2099) for 8 return periods (5, 10, 20, 50, 100, 200, 500, 1000) according to the Peak Over Threshold approach for the RCP4.5 and RCP8.5 scenarios.

The peak-over threshold (POT) approach was applied to identify extreme events along the European coastline (every 25 km) to the dynamical simulations of storm surge at a regular grid of 0.2° resolution, including Europe and a large extent of the North Atlantic (spanning from 40°W to 47°E and from 26°N to 73°N).

The Delft3D-Flow model was forced by the 6-h output of 8 climate models available at the CMIP5 database, namely the ACCESS1-0, ACCESS1-3, (CSIRO-BOM Australia), CSIRO-Mk3.6.0 (CSIRO-QCCCE, Australia), EC-EARTH (EC-EARTH consortium), GFDL-ESM2M (NOAA Geophysical Fluid Dynamics Laboratory USA), HadGEM2- CC (Met Office Hadley Centre UK), and MPI-ESM-LR, MPI-ESM-MR (Max-Planck-Institut für Meteorologie Germany).

The performance of the modelling strategy (i.e. combination of the CMIP5 atmospheric forcing with Delft3D model) in reproducing the storm surge level (SSL) time series for the baseline period were compared with the ones of the validated ERA-INTERIM forced SSL hindcast. A bias correction was applied to the climate change projections before applying the POT approach.

Variables:	Extreme storm surge level.
Data type:	model data
Data format:	NetCDF
Data frequency:	8 return periods (5, 10, 20, 50, 100, 200, 500, 1000)
Access:	Public
Website:	http://data.jrc.ec.europa.eu/collection/LISCOAST
Contact:	Luc Feyen (luc.feyen@ec.europa.eu)
Literature:	Vousdoukas, M. I., Voukouvalas, E., Annunziato, A., Giardino, A., & Feyen, L. (2016). Projections of extreme storm surge levels along Europe. Climate Dynamics, 47(9–10), 3171–3190. https://doi.org/10.1007/s00382-016-3019-5.

4.4 Compounded water level projections

LISCoAsT

LISCoAsT also provide a dataset with the Extreme Sea level (ESL, Vousdoukas et al. 2017). The ESL dataset presents the distribution of the total water level (TWL) design conditions at the European coastline. The TWL is estimated from the dynamical simulation of the major hydrodynamic sea level components (being the mean sea level, tides, storm surges and waves) as derived from an ensemble of 6 climatic models for a historical period (from 1969 to 2004) and a future period (from 2009 to 2099) for the RCP4.5 and RCP8.5 scenarios. The dataset contains the design conditions for both the TWL and the episodic component (storm surge level and wave height) that may affect the coastline during intense storm events. The spatial domain covers the area [71.3589° N, 41.5208° E, 26.9813° S, -29.0571° W].

The wave component is extracted from the Global Wave Projections obtained using the third-generation spectral wave model Wavewatch III driven by atmospheric forcing from six Coupled Model Intercomparison Project Phase 5 (CMIP5) climate models for both RCP trajectories: ACCESS1.0, ACCESS1.3 (CSIRO-BOM), CSIRO-Mk3.6.0 (CSIRO-QCCCE Australia), EC-EARTH (EC-EARTH consortium), GFDL-ESM2G, and GFDL-ESM2M (NOAA Geophysical Fluid Dynamics Laboratory, USA). The simulations were performed on a global 1.5° grid, combined with several nested finer sub-grids. The model was validated on the grounds of the skill of a hindcast covering 35 years between 1980 and 2014, forced by ERA-Interim wind data.

Present-state tidal elevations along the European coastline were obtained from the TOPEX/POSEIDON Global Inverse Solution. Dynamic simulations of tidally forced ocean circulation were performed for each RSLR scenario using a flexible mesh setup of the DFLOW FM model covering the period from 1990 to 2110 and considered the six possible RSLR scenarios resulting from the combination of the best, worst, and ensemble mean cases for each of the RCP4.5 and RCP8.5. The maximum tide was considered as

representative. The TOPEX/POSEIDON baseline values were then combined with the projected relative changes to obtain the final projections affected by changing sea levels.

Global relative sea level rise (RSLR) values for different RCPs and time slices were produced after combining SLR from Hinkel at al. (2014) with land uplift/subsidence projections.

Variables:	Total water level.
Data type:	model data
Data format:	NetCDF
Data frequency:	8 return periods (5, 10, 20, 50, 100, 200, 500, 1000)
Access:	Public
Website:	http://data.jrc.ec.europa.eu/collection/LISCOAST
Contact:	Luc Feyen (luc.feyen@ec.europa.eu)
Literature:	Vousdoukas, M. I., Mentaschi, L., Voukouvalas, E., Verlaan, M., & Feyen, L. (2017). Extreme sea levels on the rise along Europe's coasts. Earth's Future, 5(3), 304–323. https://doi.org/10.1002/2016EF000505.

5. Coastal and exposure datasets

The coastal and exposure datasets, which are particularly important for the study of coastal impacts (WP4), are described in this section. The selected coastal and exposure datasets are focused in the European region and are summarized in the Table 15. The datasets contain information of the coastal geomorphology, lithology, shoreline, bathymetry, elevations and other variables.

Table 15: Coastal exposure datasets.

Dataset name	Variables name	Geographical coverage		Spatial resolution	Creation date	File formats
		Latitude interval	Longitude interval			
Eurosion	Coastal geomorphology, lithology, shoreline changes, presence of coastal works, tides, waves and observed sea levels	[30,60]	[-10,30]	Not specified (vector format) but beaches with sizes of 200m are included	2002-2004	Shapes (vectors)
Litto3D	nearshore topo-bathymetric data	Along the coasts of France (boundaries follow the boarder); a few gaps		1 m	TBC (2010-ongoing)	Raster
EMODnet	topo-bathymetric data	[25,69]	[-36,42]	0.125 arc-minutes (230 x 230 m)	2015-2016	ESRI ASCII, XYZ, EMODnet CSV, NetCDF, GeoTiff and SD
EU-DEM v1.1	Digital Surface Model	[-21.5,72]	[-54,93]	25 m	2016	GeoTIFF
MDT05	Digital Terrain Model	[27.5,44]	[-20,5]	5 m	2008	ASCII matriz ESRI (.asc)

5.1 Litto3D

Litto3D® is a continuous reference digital elevation model on the French coast. Litto3d has been carried out relief surveys and measurements of deep sea for a precise knowledge of the French coast. It uses airborne laser survey equipment (bathymetric LIDARs) to measure depths in inaccessible foreshore areas, in addition to multibeam echosounders on board ships.

The coastal strip that covers the model is:

- At sea, up to the 10 m isobath and at most up to 6 nautical miles from the coast.
- On land, up to altitude +10 m and at least 2 km inland.

In total, the surface that covers the Litto3D program is approximately 45,000 km2. Litto3D® data are available on the SHOM circulation area: "Products / littoral altimetry" (http://diffusion.shom.fr/pro/amenagement/altimetrie-littorale.html). More details about the Litto3D datasets are listed below.

Variables: nearshore topo-bathymetric data

Data type:	model data
Data format:	Raster
Access:	Public by contact
Website:	http://professionnels.ign.fr/litto3d
Contact:	litto3d@shom.fr
Literature:	Litto3D® Version 1.0. (2015), 1–32. http://professionnels.ign.fr/doc/DL_Litto3D.pdf

5.2 EMODnet Digital Bathymetry (DTM)

EMODnet Digital Terrain Model (DTM) is generated for European sea regions (36 °W – 42 °E, 25 °N – 69 °N) from selected bathymetric survey data sets and composite DTMs, while gaps with no data coverage are completed by integrating the GEBCO Digital Bathymetry. It is planned to make use also of Satellite Derive Bathymetry (SDB) data to cover gaps.

The DTM is based upon more than 7700 bathymetric survey data sets and Composite DTMs that have been gathered from 27 data providers from 18 European countries and involving 169 data originators. The gathered survey data sets can be discovered and requested for access through the Common Data Index (CDI) data discovery and access service that also contains additional European survey data sets for global waters. The Composite DTMs can be discovered through the Sextant Catalogue service. Both discovery services make use of SeaDataNet standards and services and have been integrated in the EMODnet Bathymetry web portal (http://www.emodnet-bathymetry.eu). In addition, the Bathymetry Viewing and Download service of the EMODnet bathymetry portal gives users wide functionality for viewing and downloading the EMODnet digital bathymetry such as:

- Water depth (refering to the Lowest Astronomical Tide Datum - LAT) in gridded form on a DTM grid of 1/8 arc minute of longitude and latitude (230 meters)
- Option to view depth parameters of individual DTM cells and references to source data
- Option to download DTM in 16 tiles in different formats: ESRI ASCII, XYZ, EMODnet CSV, NetCDF (CF), GeoTIFF and SD
- Layer with a number of high resolution DTMs for coastal regions
- Layer with wrecks from the UKHO Wrecks database.

The original datasets themselves are not distributed but described in the metadata services, giving clear information about the background survey data used for the DTM, their access restrictions, originators and distributors and facilitating requests by users to originator.

Variables:	topo-bathymetric data, shoreline.
Data type:	GIS database
Data format:	ESRI ASCII, XYZ, EMODnet CSV, NetCDF, GeoTIFF and SD
Access:	Public
Website:	http://www.emodnet-bathymetry.eu/
Literature:	Marine Information Service (2016). EMODnet Digital Bathymetry (DTM). Marine Information Service. http://doi.org/10.12770/c7b53704-999d-4721-b1a3-04ec60c87238.

5.3 EUROSION

The coastal and exposure EUROSION dataset is result of an European project. EUROSION project was commissioned by the General Directorate Environment of the European Commission. The implementation of the project started in January 2002 and achieved its objectives in May 2004.

The dataset covers the European coast (10 °W – 30 °E, 30 °N – 60 °N) and provide information of the coastal geomorphology, lithology, shoreline changes, presence of coastal works, tides, waves and observed sea levels. The layers are provided at scale 1:100,000, in vector format.

The information on geomorphology and lithology is reliable, the precision of the positioning of the coastline is limited to representations up to 1:100000, the information on shoreline changes is during the 80s and 90s and the information on sea level, tides and waves is outdated, but consistent all across Europe.

Most of the data layers of information are freely accessible and may be downloadable from the European Environment Agency website (https://www.eea.europa.eu/data-and-maps/).

Variables:	Coastal geomorphology, lithology, shoreline changes, presence of coastal works, tides, waves and observed sea levels
Data type:	GIS database
Data format:	shapes
Access:	Public
Website:	http://www.eurosion.org/
Literature:	EUROSION: Living with coastal erosion in Europe: Sediment and Space for Sustainability, Part IV – A guide to coastal erosion management practices in Europe: Lessons Learned, Tech. Rep. 27, European Commission, 2004

Yates, M. L. and Le Cozannet, G.: Brief communication "Evaluating European Coastal Evolution using Bayesian Networks", Nat. Hazards Earth Syst. Sci., 12, 1173-1177, https://doi.org/10.5194/nhess-12-1173-2012, 2012.

5.4 EU-DEM v1.1

European Digital Elevation Model (EU-DEM) is a digital surface model (DSM) of EEA39 countries representing the first surface as illuminated by the sensors. It is a hybrid product based on SRTM and ASTER GDEM data fused by a weighted averaging approach.

The EU-DEM v1.1 is a resulting dataset of the EU-DEM v1.0 upgrade which enhances the correction of geo-positioning issues, reducing the number of artefacts, improving the vertical accuracy of EU-DEM using ICESat as reference and ensuring consistency with EU-Hydro public beta.

The EU-DEM v1.1 is available but it has not been validated yet. The following corrections and improvements have been implemented in EU-DEM v1.1:

- systematic correction of geo-positioning issues (found and corrected for Malta and Lampedusa islands);
- bias adjustment with ICESat;
- screening and removal of artefacts, including the presence of blunders (i.e. negative or positive anomalies); more than 75.000 artefacts have been detected and corrected;
- consistency with the upgraded version of EU-Hydro, in order to produce a better river network topology.

EU-DEM v1.1 is available in GeoTIFF 32 bits format. It is a contiguous dataset divided into 100x100 km tiles, resulting in a total of 1992 tiles of 4000x4000 pixel at 25m resolution with vertical accuracy: +/- 7 meters RMSE. The tiles have been grouped in big regions.

Variables: Elevation.

Data type: Digital surface model

Data format: GeoTIFF

Access: Public

Website: https://land.copernicus.eu/pan-european/satellite-derived-products/eu-dem/view

Contact: copernicus.land@eea.europa.eu

Literature: Tøttrup, C. (2014). EU-DEM Statistical Validation Report. European Environmental Agency, (August). https://land.copernicus.eu/user-corner/technical-library/eu-dem-2013-report-on-the-results-of-the-statistical-validation.

5.5 MDT05

MDT05 is a Digital Model Terrain with a spatial resolution of 5m. MDT05 covers all the Spanish country and has been obtained by interpolation of LIDAR datasets. The file format is ASCII matrix ESRI. The geodetic reference system is ETRS89 and the projection is UTM.

Variables:	Elevation.
Data type:	Digital terrain model.
Data format:	ASCII matrix ESRI
Access:	Public
Website:	http://centrodedescargas.cnig.es/CentroDescargas/index.jsp

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Dee, D. P., Uppala, S. M., Simmons, a. J., Berrisford, P., Poli, P., Kobayashi, S., … Vitart, F. (2011). The ERA-Interim reanalysis: configuration and performance of the data assimilation system. Quarterly Journal of the Royal Meteorological Society, 137(656), 553–597. https://doi.org/10.1002/qj.828.

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