score

D3.2- Data usage document for the Reference datasets for baseline characterization and projections

DATE OF DELIVERY - 22/12/2021

AUTHORS:
Roberta Paranunzio, CNR
Iulia Anton, ITS
Tasneem Ahmed, ITS

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101003534

DOCUMENT TRACKS DETAILS

Project acronym	SCORE
Project title	Smart Control of the Climate Resilience in European Coastal Cities
Starting date	01.07.2021
Duration	48 months
Call identifier	H2020-LC-CLA-2020-2
Grant Agreement No	101003534
Deliverable Information	
Deliverable number	D3.2
Work package number	WP3
Deliverable title	Data usage document for the Reference datasets for baseline characterisation and projections
Lead beneficiary	LAMMA
Author(s)	Iulia Anton (ITS), Roberta Paranunzio (CNR), Tasneem Ahmed (ITS)
Due date	31/12/2021
Actual submission date	22/12/2021
Type of deliverable	Demonstrator
Dissemination level	Public

VERSION MANAGEMENT

Revision table			
Version	Name	Date	Description
V 0.1	Iulia Anton, ITS Roberta Paranunzio, CNR Tasneem Ahmed, ITS	10/12/2021	First draft
V 0.2	Salem Gharbia, ITS Luca Baldini, CNR	15/12/2021	Updated draft internally reviewed
V 0.3	Iulia Anton, ITS Roberta Paranunzio, CNR Tasneem Ahmed, ITS	20/12/2021	Updated draft after contribution from partners
V1.0	Salem Gharbia, ITS	22/12/2021	Final version

LIST OF ACRONYMS AND ABBREVIATIONS

Acronym / Abbreviation	Meaning / Full text
API	Application Programming Interface
C3S	Copernicus Climate Service
CCLL	Coastal City Living Lab
CDS	Copernicus Data Store
CFS	Coupled Forecast System Model
CMEMS	Copernicus Marine Environment Monitoring Service
CORDEX	The Coordinated Regional Climate Downscaling
CSV	Comma separated values
DGF	Direct Get File
EBA	Ecosystem-based Approach
EC	European Commission
ECMWF	European Centre for Medium-Range Weather Forecasts
EFAS	The European Flood Awareness System
EMODNET	European Marine Observation and Data Network
ERCC	Emergency Response Coordination Centre
ERSEM	European Regional Seas Ecosystem Model
ESA CCI	European Space Agency Climate Change Initiative
EU	European Union
EUMETSAT SAFs	European Organisation for the Exploitation of Meteorological Satellites - Satellite Application Facilities
FABM	Framework for Aquatic Biogeochemical Models
FAIR	Findability, Accessibility, Interoperability and Reusability
FTP	File transfer protocol
GCMs	Global Climate Models
ICT	Information and Communication Technology
IPCC	The Intergovernmental Panel on Climate change
LAT	Lowest Astronomical Tide
NCAR	National Center for Atmospheric Research
NCEP	National Centers for Environmental Protection
NEMO	Nucleus for European Modelling of the Ocean

NOAA	National Oceanic and Atmospheric
NetCDF	Network Common Data Form
POLCOMS	The Proudman Oceanographic Laboratory Coastal Ocean Modelling System
RCMs	Regional Climate Models
RCP	Representative Concentration Pathways
RCSMs	Regional Climate System Models
RPO	Research Performing Organisation
SIP	SCORE ICT Platform
SME	Small and Medium-sized Enterprise
SUB	Subsetting
WCRP	World Climate Research Program
WFS	Web Feature Services
WMS	Web Map Services
WP	Work Package

BACKGROUND: ABOUT THE SCORE PROJECT

SCORE is a four-year EU-funded project aiming to increase climate resilience in European coastal cities.

The intensification of extreme weather events, coastal erosion and sea-level rise are major challenges to be urgently addressed by European coastal cities. The science behind these disruptive phenomena is complex, and advancing climate resilience requires progress in data acquisition, forecasting, and understanding of the potential risks and impacts for real-scenario interventions. The Ecosystem-Based Approach (EBA) supported by smart technologies has potential to increase climate resilience of European coastal cities; however, it is not yet adequately understood and coordinated at European level.

SCORE outlines a co-creation strategy, developed via a network of 10 coastal city' living labs' (CCLLs), to rapidly, equitably and sustainably enhance coastal city climate resilience through EBAs and sophisticated digital technologies.

The 10 coastal city living labs involved in the project are: Sligo and Dublin, Ireland; Barcelona/Vilanova i la Geltrú, Benidorm and Basque Country, Spain; Oeiras, Portugal; Massa, Italy; Koper, Slovenia; Gdansk, Poland; Samsun, Turkey.

SCORE will establish an integrated coastal zone management framework for strengthening EBA and smart coastal city policies, creating European leadership in coastal city climate change adaptation in line with The Paris Agreement. It will provide innovative platforms to empower stakeholders' deployment of EBAs to increase climate resilience, business opportunities and financial sustainability of coastal cities.

The SCORE interdisciplinary team consists of 28 world-leading organisations from academia, local authorities, RPOs, and SMEs encompassing a wide range of skills including environmental science and policy, climate modelling, citizen and social science, data management, coastal management and engineering, security and technological aspects of smart sensing research.

EXECUTIVE SUMMARY

This document is a deliverable of the SCORE project, funded under the European Union's Horizon 2020 research and innovation programme under grant agreement No 101003534.

WP3 deals with regional and local projections, analyses, and modelling and uncertainties. The main objectives of this work package are:

- to identify, select, and organise a homogenous climate and marine data dataset to build on a reference (historical) baseline and projections for all project areas.;
- to downscale climate projections to produce data at a suitable spatial resolution for local-scale impact needs;
- to develop tools for statistical analysis for local urban-scale hazards;
- to model short-term hazards by means of hydraulic-hydrological models to simulate urban flooding scenarios;
- to model the long-term evolution of the coastline utilising climate projections and local morphodynamic processes.

Deliverable 3.2 (and 3.1 accordingly) is preliminary to support other project activities in WP3 and is intended to provide project partners with a description of the datasets' selection of climate and marine data for the baseline climate characterisation and projections to be subsequently analysed processed for local scale analysis. As there is a large amount of different climate data sets available, we constrict our analysis on those, which are officially available through EU institutions and/or supported by them. Thus, datasets and information included in this document build on previous European projects and ongoing initiatives e.g., the Copernicus Climate Service (C3S), the Copernicus Marine Service (CMEMS) and ECMWF's repositories which include both historical and projected data at a high spatiotemporal resolution to be used by all the CCLLs. This document is not meant to be a replication of what is already included in the official climate services websites and platforms but a tailored-data usage document for SCORE project activities. Specifically, main goals of this document are listed below.

- To provide a step-by-step procedure on how to access the identified datasets and handle data and information by means of use cases will be provided and on the base of procedures and indication included in Deliverable 3.1. Every step will be equipped with examples that will help the end-user practically understand how to interact with the dataset interface and handle the data.
- To provide a general overview and description of a set of selected datasets and variables in terms of usability, structure, interfaces and access, data format and metadata, for the (historical) characterisation and to build atmospheric, hydrological and oceanographic projections for all CCLLs.

This document and related dataset are drafted by CNR (WP3 partner and leader of Task 3.1 activity), ITSligo (WP3 and Task 3.1 partner) and LAMMA (WP3 leader) with inputs from all partners. In fact, to achieve a greater impact, all members of the WP3 have been asked to participate and give contributions based on their own experience and needs in terms of data analysis and modelling for the SCORE activities.

D3.2 is a demonstrator document that will be delivered at M6.

LINKS WITH OTHER PROJECT ACTIVITIES

In accordance with WP3, task 3.1 build on previous European projects and initiatives to provide a reliable and suitable selection of existing climate and marine datasets to be subsequently, wherever needed, downscaled and processed and thus used in the other WP3-related tasks and project areas. Task 3.1 is thus preliminary and transversal to a range of WPs in the framework of SCORE activities (Figure 1). Along with Deliverable 3.1, whose aim is to provide a collection of data samples and procedures produced in Task 3.1, Deliverable 3.2 will describe and showcase the most important parameters related to climate-change impact on coastal cities as identified by Deliverable 3.1 and WP1 and WP2 like e.g., sea levels, wind and precipitation extremes, air and sea temperatures, and river level extremes.

Data and procedures described in this document and included in Deliverable 3.1 will be used in the following WP3 tasks. Specifically, the retrieved data will be analysed and downscaled by means of ready-to-use tools and models for local-scale impact assessment (Task 3.2). Data from Task 3.1 (and downscaled time-series from Task 3.2) will be then analysed and processed in Task 3.3 to implement statistical analysis tools for local urban-scale hazards. Short-term hazard modelling (Task 3.4) and long-term evolution of the coastline modelling (Task 3.5) will benefit from data produced in Task 3.1, 3.2 and 3.3 then. Data from task 3.1 and subsequent will be finally exploited in the testing phase (Task 3.6). Specifically, Deliverable 3.2 will guide WP3 users in the data selection and download procedure. Deliverable 3.2 will provide a general overview of the data stored in the climate services in terms of e.g., spatial and temporal resolution and coverage, variables availability and time series lengths which are essential to deliver Task 3.2 on the Downscaling Analysis Tools. Users of Task 3.3, which are in charge of performing statistical analysis tools for urban-scale hazard, and Task 3.4 and 3.5 on short/long term modelling will benefit of use cases presented in Deliverable 3.2 as examples of application of processing and analysis of the data stored in the mentioned climate services.

Data and models provided by WP3 will be stored, curated, homogenised and processed, along with products generated by SCORE WPs (WP4, WP6, WP7 and WP8) in a fit-for-purpose SCORE ICT Platform (SIP) developed within WP5, while ensuring their findability, accessibility, interoperability and reusability (FAIR). To be easily integrated in SIP and for efficient storage, data and information selected in Task 3.1 should thus be as homogenous and standardised as possible, i.e., complying with relevant climate and forecast metadata conventions and standards. This would also facilitate the usage of data by end-users and partners.

Figure 1 WP3 and related-tasks connection to other WPs

TABLE OF CONTENT

INDEX OF FIGURES

INDEX OF TABLES

1.INTRODUCTION

The demand for tailored climate data and information by diverse specific users (such as stakeholders, decision-makers and scientists) and the public is growing worldwide together with the awareness of the challenges posed to the environment and society by climate change. In this context, climate services play a crucial role in developing and disseminating customised climate information and tools to diverse stakeholders based on relevant standards and conventions. Provided products are of help in conducting studies on climate related-hazards and related risks and vulnerabilities as well as building climate-resilient societies. Considering the ongoing digital transformation and in accordance with the Green Deal adaptation goals [1] (European Commission 2021), fostering the use of advanced and digital technologies and climate services to support the decision making (e.g., remote sensing, artificial intelligence, smart sensors and weather stations) is thus crucial.

In the framework of the SCORE project, but not limited to this, new tools like digital twins will enhance our understanding of current and future climate impact at the local scale. For this purpose, open, free and reliable climate data are needed. There is a range of national to European-scale services that provide data and information about climate change for large different user categories. As there are a large amount of different climate data sets available, we constrict our analysis on those which are officially available through EU institutions and/or supported by them like, e.g., the European Union's Earth Observation Programme Copernicus or the European Marine Observation and Data Network (EMODnet) initiative from the European Commission. The rationale to choose the most appropriated datasets and the climate services has been included in Deliverable 3.1 (D3.1 from now on). This document will provide information on how to use the data included in D3.1 and a specific description of the datasets. Local data, including local institutional climate monitoring infrastructures and low-cost sensors for citizen-science, will complement the information provided by the climate services and will be the object of other tasks and project activities linked to Task 3.1.

In the next sections, a summary of the main climate services for baseline characterisation and projections identified in D3.1 as the most suitable, comprehensive and fit-fur-purpose for SCORE activities is given. Therefore, this deliverable and Deliverable D3.1 contain complementary information. Then, a step-by-step guide on accessing the data on the mentioned platforms and climate services by means of use cases is provided. This section will be equipped with examples that will help the end-user practically understand how to interact with the dataset interface and handle the data. Afterwards, we list all potential data sets and the ones selected on the basis of the procedure included in D3.1. Then, we individually describe in detail a set of selected datasets identified as the most appropriate datasets on the basis of the procedure included in D3.1. The main properties of such datasets, in terms of data and metadata format, data quality, accessibility, availability of variables, are then provided. We also evaluate their use and discuss the advantages and disadvantages of individual data sets.

2. CLIMATE SERVICES AND DATASETS: AN OVERVIEW

2.1. Summary of the Climate Services of interest for SCORE activities

Based on the requirements stated in D3.1, climate services provide easy single-point access to different meteo/climate and marine datasets or assembling diverse repositories. Thus making all of them open access, have been preferred. This rationale has been adopted for users' ease access to data and uses, thus avoiding an otherwise time-consuming search on single databases. The main services and collaborative initiatives identified are the:

- Copernicus Climate Change Service (C3S) and the Climate Data Store (CDS)
- Copernicus Marine Environment Monitoring Service (CMEMS) portal
- European Marine Observation and Data Network (EMODnet) initiative

These comprehensive climate portals guarantee:

- a wide selection of different data and simulations across Europe;
- quality-checked data and metadata;
- the use of standardised data format convention;
- documentation to support data collection and use cases as examples of “hands-on” and data application;
- a constant updating when new tools and products come available;

Obviously, this does not exclude the fact that other repositories could be considered in the future and included throughout the project's life-cycle and depending on the specific users’ needs.

2.2. How to access and explore the data (by means of use cases)

2.2.1. Finding and using CDS data

This section will cover finding, downloading, and using Copernicus data from the CDS. Here, an example (use case) from a topic’s thematic area will be used to SCORE the project’s user through data manipulation for their analysis. These use cases have been chosen because of the need in SCORE activities to identify for the CCLLs urban key climate related-hazards in coastal areas at risk in the short and long term and assess related exposure and vulnerability (based on CCLLs stakeholders' interviews).

<u>Use case: Coastal flooding in Ireland.</u>

The two major coastal hazards identified from the CCLLs questionnaires are **coastal flooding,** and **coastal erosion** caused due to various driving agents like **sea-level rise** and **storm surges.**

Use case 1: Accessing and downloading CDS data

The Home page of the Copernicus climate change service (C3S [2]) website is shown in Figure 2.

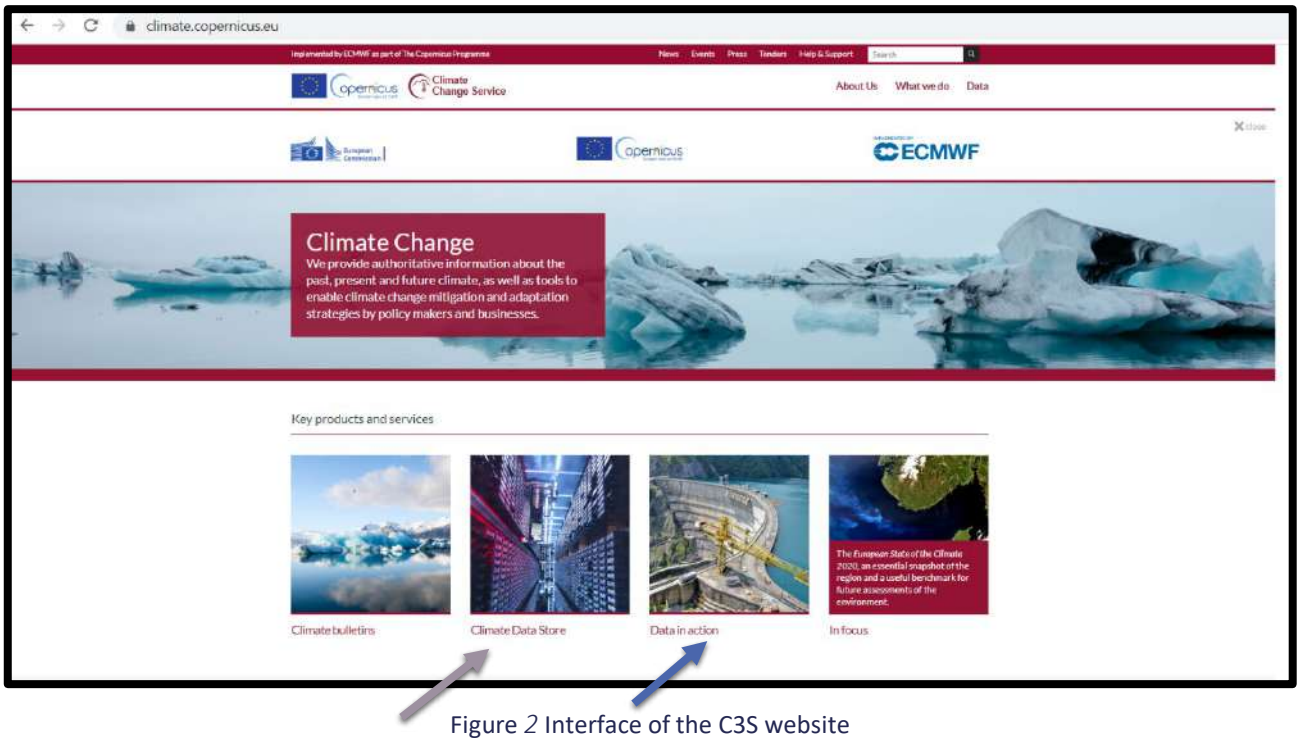


Figure 2 Interface of the C3S website

So, within the framework of the SCORE project, in order to inform adaptation for increasing climate resilience in different sectors by the end users', climate data is available in the ***Climate Data Store*** (CDS) (*shown by the grey arrow*). Various use cases on how data from the CDS has been employed to address various topics related to climate in provided under the ***Data in action*** (*shown by blue arrow*).

One of the many use cases in the C3S website is the one titled ***Coastal flooding in Ireland***.

This case looked into how sea level and storm surge data from the CDS could be used to address questions related to the impact of climate change on coastal flooding at local scales in the Republic of Ireland.

Since sea level and storm surge are our parameters of interest, both result in water level changes. So, as shown in Figure 3, the following steps will be followed in the CDS platform.

Step 1:

We will select *dataset* and type in *Water level changes*

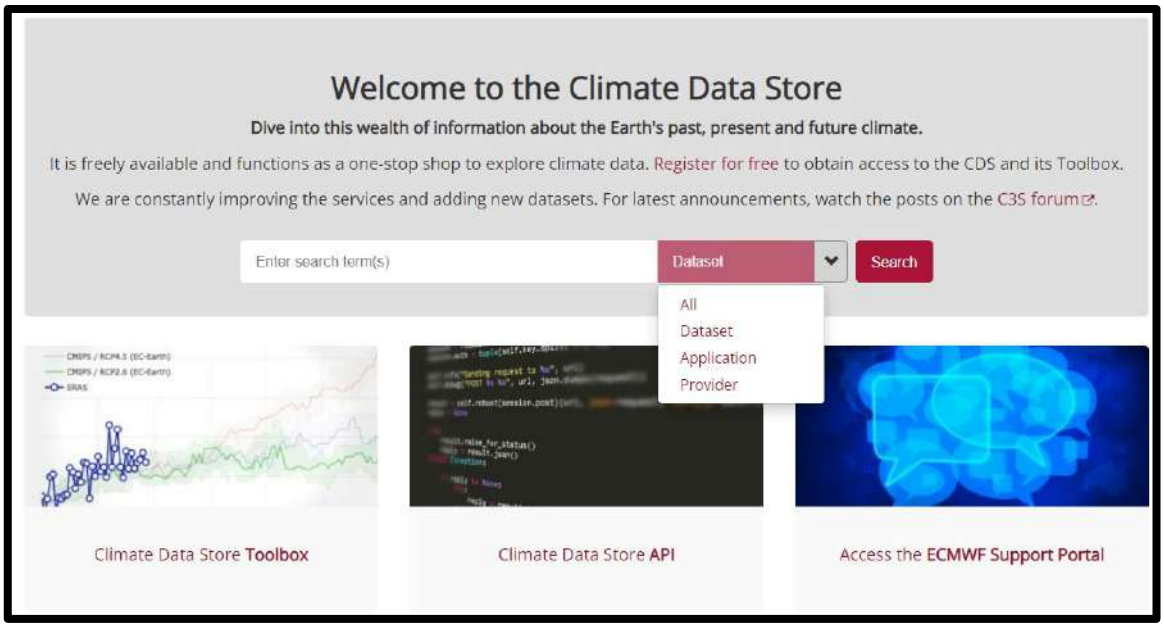


Figure *3* CDS Interface

Step 2:

The user will arrive at the search results page, as shown in Figure 4

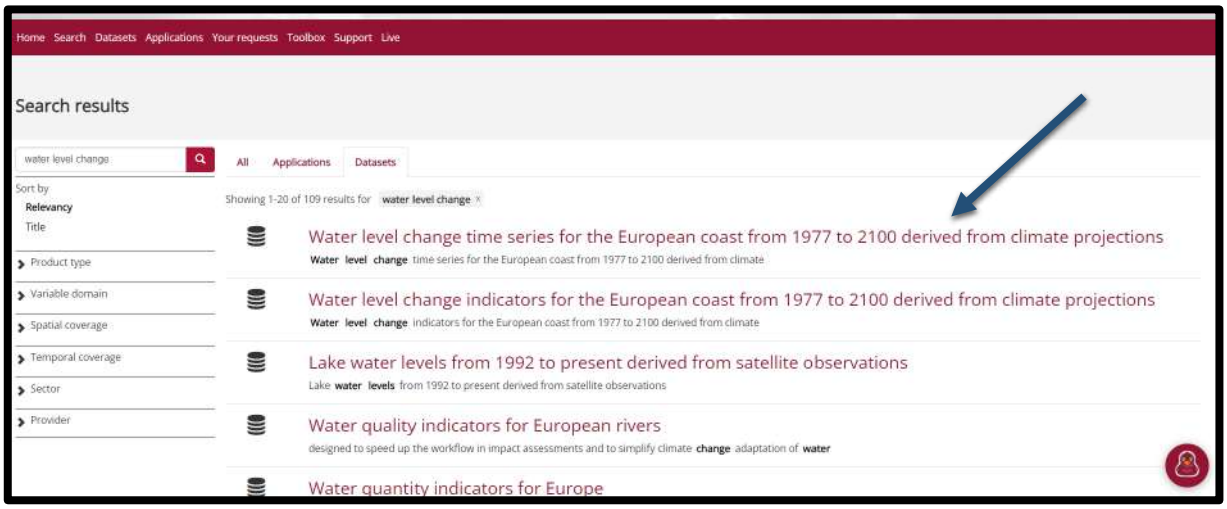


Figure *4* Search results

Datasets can be sorted by title or relevance. The users can choose several filters based on *product type, variable domain, spatial coverage, temporal coverage, sector* and *provider,* as shown in Figure 4. The CDS is progressively extending to include other Copernicus services like CMEMS, ESA CCI, EUMETSAT SAFs and others. We can also manually search the dataset using a keyword on the search bar (above the filters) along with the filters.

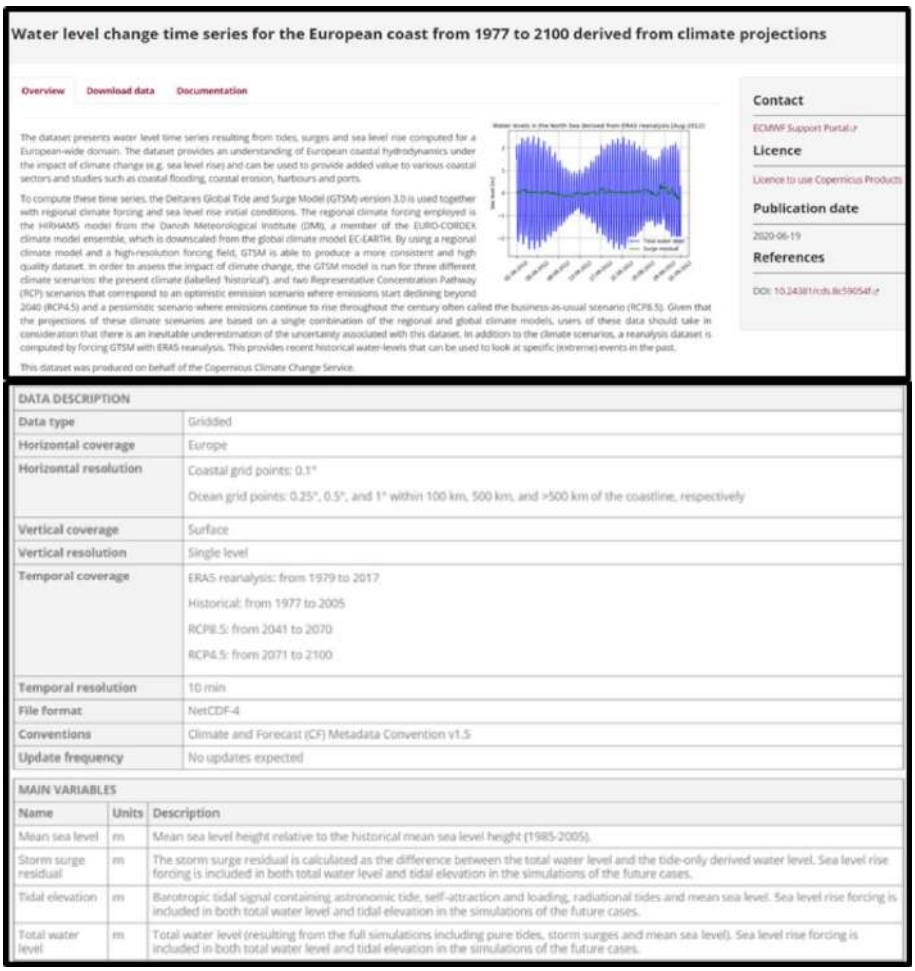
For time series analysis of the sea level rise and storm surge, the dataset *Water level change time series for the European coast from 1977 to 2100 derived from climate projections* is selected (as shown by the blue arrow).

This will direct the user to the page shown in Figures 5a and 5b. There are three sections here:

- an *Overview* providing an introduction to the repository and data description with the main features;
- a *Documentation page*, with further detailed information;
- *Download Data* page, where variables of interest, geographical area, temporal frame and format of the data can be selected.

Some datasets also include a Quality Assessment Page, with specific information on independent data quality assessment, access and user documentation for each variable included in the datasets.

In the *Overview* description of the variables are provided. The dataset presents water level time series resulting from tides, surges and sea-level rise computed for a European-wide domain, which helps to understand European coastline hydrodynamics as a result of climate change (e.g., sea-level rise) and other factors.



Water level change time series for the European coast from 1977 to 2100 derived from climate projections

Overview | Download data | Documentation

The dataset presents water level time series resulting from tides, surges and sea level rise computed for a European-wide domain. The dataset provides an understanding of European coastal hydrodynamics under the impact of climate change (e.g. sea level rise) and can be used to provide added value to various coastal sectors and studies such as coastal flooding, coastal erosion, harbours and ports.

To compute these time series, the Deltares Global Tide and Surge Model (GTSM) version 3.0 is used together with regional climate forcing and sea level rise initial conditions. The regional climate forcing employed is the HIRHAMS model from the Danish Meteorological Institute (DMI), a member of the EURO-CORDEX climate model ensemble, which is downscaled from the global climate model EC-EARTH. By using a regional climate model and a high-resolution forcing field, GTSM is able to produce a more consistent and high quality dataset. In order to assess the impact of climate change, the GTSM model is run for three different climate scenarios: the present climate (labelled 'historical'), and two Representative Concentration Pathway (RCP) scenarios that correspond to an optimistic emission scenario where emissions start declining beyond 2040 (RCP4.5) and a pessimistic scenario where emissions continue to rise throughout the century often called the business-as-usual scenario (RCP8.5). Given that the projections of these climate scenarios are based on a single combination of the regional and global climate models, users of these data should take in consideration that there is an inevitable underestimation of the uncertainty associated with this dataset. In addition to the climate scenarios, a reanalysis dataset is computed by forcing GTSM with ERA5 reanalysis. This provides recent historical water-levels that can be used to look at specific (extreme) events in the past.

This dataset was produced on behalf of the Copernicus Climate Change Service.

Contact
ECMWF Support Portal
Licence
Licence to use Copernicus Products
Publication date
2020-06-19
References
DOI: 10.24381/cds.8c59054f

DATA DESCRIPTION	
Data type	Gridded
Horizontal coverage	Europe
Horizontal resolution	Coastal grid points: 0.1° Ocean grid points: 0.25°, 0.5°, and 1° within 100 km, 500 km, and >500 km of the coastline, respectively
Vertical coverage	Surface
Vertical resolution	Single level
Temporal coverage	ERA5 reanalysis: from 1979 to 2017 Historical: from 1977 to 2005 RCP8.5: from 2041 to 2070 RCP4.5: from 2071 to 2100
Temporal resolution	10 min
File format	NetCDF-4
Conventions	Climate and Forecast (CF) Metadata Convention v1.5
Update frequency	No updates expected

MAIN VARIABLES		
Name	Units	Description
Mean sea level	m	Mean sea level height relative to the historical mean sea level height (1985-2005).
Storm surge residual	m	The storm surge residual is calculated as the difference between the total water level and the tide-only derived water level. Sea level rise forcing is included in both total water level and tidal elevation in the simulations of the future cases.
Tidal elevation	m	Barotropic tidal signal containing astronomic tide, self-attraction and loading, radiational tides and mean sea level. Sea level rise forcing is included in both total water level and tidal elevation in the simulations of the future cases.
Total water level	m	Total water level (resulting from the full simulations including pure tides, storm surges and mean sea level). Sea level rise forcing is included in both total water level and tidal elevation in the simulations of the future cases.

Figure 5 Overview of the data, data Description and main variables

From Figure 5, the *Main Variables* as seen are: *Mean sea level, storm surge residuals, tidal elevation total water level*. Under *Data Description,* details of the data like *Data type*, *Horizontal coverage*, *Horizontal resolution* etc., are described.

The *Documentation* details the procedure of time-series generation.

Step 3:
Once the user constructs the query, data can be downloaded from the CDS using a variety of options:

- the CDS web interface, submitting the form and downloading the result of the query via the Download Data tab (Figure 6);
- the CDS Application Programming Interface (API). Indeed, users can also use the API for automated searching and downloading of larger datasets, have more flexibility in changing variables, time period, etc. This Phyton-based service provides programmatic access to all data stored in the CDS. Instructions to access and use the CDS API and data request is provided at the following link.
- the CDS Toolbox (if the dataset is supported by the Toolbox). This is a set of software that enables users to develop their own applications via an on-line interface, making use of the CDS content. The CDS web interface is an interactive system: the user fills a web form to construct their valid query and can then choose between three options (see [3]).

Requested data can be visualised by "Your requests" button.

Further information can be retrieved on the ECMWF [4] website or by accessing the support tab on the C3S [2] website.

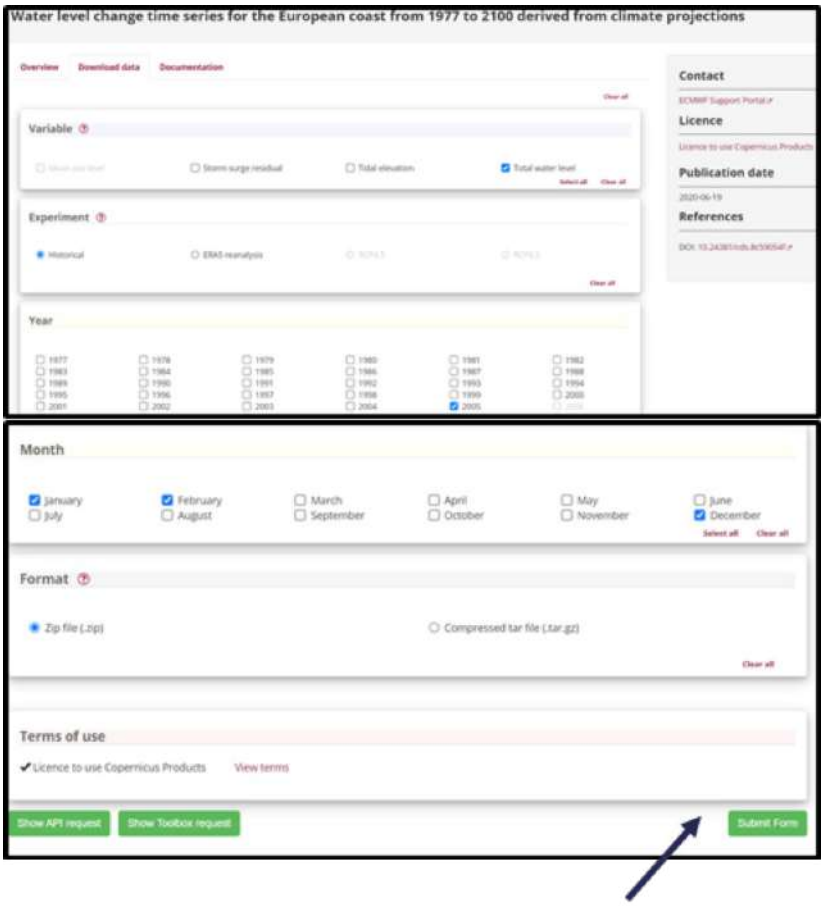


Figure 6 Download data page

A seen from Figure 6, the variables of interest (e.g total water level), Experiment (e.g. Historical), year (e.g. 2005), Month (e.g. Winter month (DJF)), format (e.g. Zip file) can be selected and clicking on the ***submit form*** (shown by the arrow) will retrieve the required dataset.

2.2.2. Finding and using CMEMS data

Here, a "hands-on" example of working with CMEMS [5] data will be provided.

Out of the several use cases, which can be accessed under ***Use Cases*** in the CMEMS interface as shown in Figure 7 (shown by the blue arrow), one of particular relevance to the SCORE project would be that of ***WAX-COAST: wave extreme value analysis at the coast*** for any location in the Mediterranean Sea.

This use case is provided by the Artelia group, an independent multidisciplinary engineering and project management company (see [6]) under their climate change resilience expertise. Data for this service has been retrieved from CMEMS as well as from EMODnet. However, only data retrieved from the CMEMS will be demonstrated in this case.

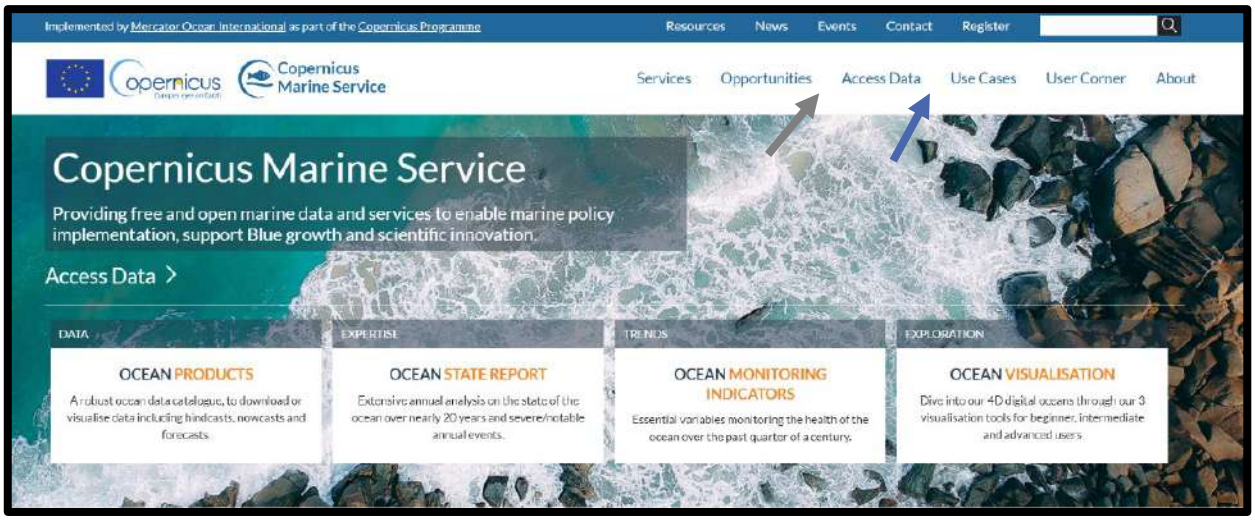


Figure 7 Interface of CMEMS

Step 1:

From Figure 7, the interface of the CMEMS leads the user to ***access data*** (shown by the grey arrow) and ***Use Cases*** (indicated by the blue arrow). The use cases will find the use case ***WAX-COAST: wave extreme value analysis at the coast***.

The CMEMS products employed in this use case are (Shown in Figure 8):

- *MEDITERRANEAN SEA WAVES ANALYSIS AND FORECAST* [7]
- *MEDITERRANEAN SEA PHYSICS REANALYSIS* [8]

For the purpose of demonstration, only the first product, ***MEDITERRANEAN SEA WAVES ANALYSIS AND FORECAST***, as shown in Figure 8, will be utilised.

Figure 8 Products utilised from the CMEMS listed at the bottom of the use case

Step 2:

We select this dataset (shown by the arrow in Figure 8) at the bottom of the *WAX-COAST: wave extreme value analysis at the coast* use case page.

This will direct the user to the page, as shown in Figure 9. There will be an overview of the product along with the product description like Geographical coverage, Observations/models, product type, etc., and the *Variables* it contains.

Step 3:

We click on the data access (shown by the arrow) to download data. This will direct the user to the page shown in Figure 10.

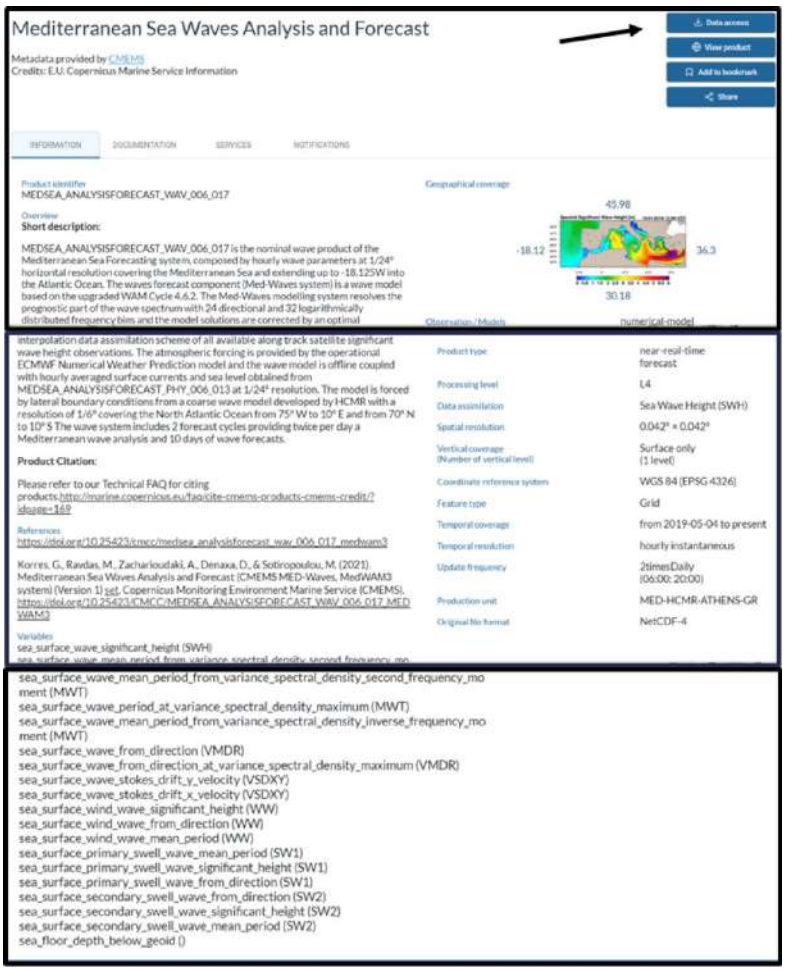


Figure 9 The selected product overview

Figure 10 Dataset selection

Here we choose the dataset marked by the arrow shown in Figure 10. The other dataset ending in ***statics*** will have to be retrieved via FTP and contain datasets not limited to the Mediterranean Sea.

Step 4:

After selecting the dataset, the user will have to log in or register themselves.

Step 5:

They are then directed to the parameters' selection page, as shown in Figure 11.

The selection can be made in terms of the *Geographical area*, *Time range* and *Variables*. There are three download options under *Download options* (shown by the black arrow), namely: Subsetting (SUB), Direct Get File (DGF) and File transfer protocol (FTP) and the user can choose any option. By default, however, clicking on the *Download* (shown by the blue arrow) will download the selected parameters in a NETCDF format.

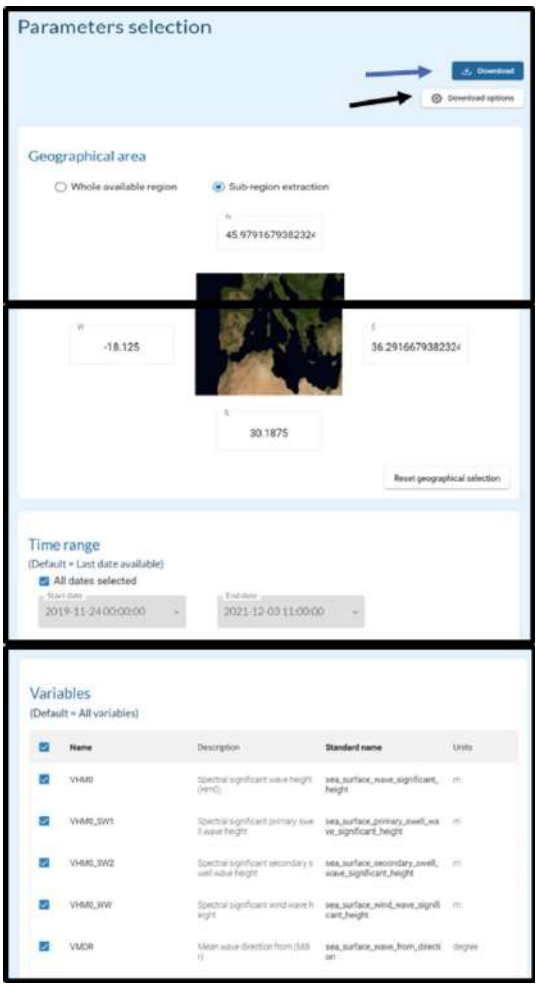


Figure 11 Parameters' selection and data download

2.2.3. Finding and using EMODnet data

EMODnet [9] provides data access under seven categories, namely, ***Bathymetry***, ***Biology***, ***Chemistry***, ***Geology***, ***Human activities***, ***Physics*** and ***Seabed Habitats*** and can be accessed under ***Data Portals*** (shown by the black arrow) as shown in Figure 12.

Figure 12 Interface of the EMODnet

Under ***Solutions, Use Cases*** can be found, which leads the user to the page shown in Figure 13.

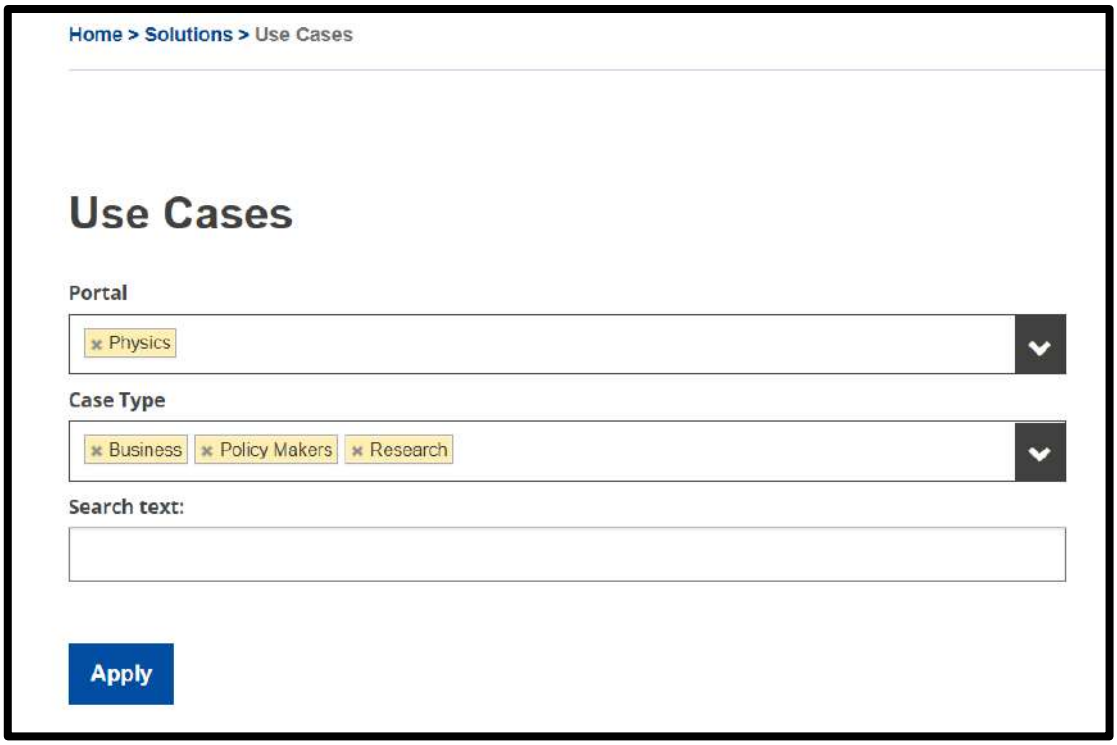


Figure 13 Use cases search page

As seen from Figure 8, for the CMEMS use case, data from the EMODnet Physics data portal was also utilised. So, continuing on that and relevant to the SCORE project, from Figure 13, under ***Portal,*** we can select ***Physics***. Under ***Case Type*** we can select ***Business***, ***Policy Makers*** and ***Research***. We can enter keywords in the ***Search text,*** but this could be left out for a broader generation of use cases.

Bathymetry could also have been selected, which could be helpful from the viewpoint of flood risk mapping etc. But in this example, ***Physics*** has been chosen to keep the retrieved variables like waves, sea level etc., consistent with

the previous use cases for **CDS** and **CMEMS** databases.

Out of the several Use cases, the one most relevant to the SCORE project is the one titled; ***EMODnet Physics' integrated wind, wave and sea level data supports Coastal Infrastructure Risks and Safety Management in South Italy [GRISIS research project]***. The GRISIS project - *Risk Management and Safety of Infrastructures at a regional scale* develops methodologies, techniques, and procedures to assess the risks and manage the safety of large civil infrastructures and networks of goods and services on a regional scale (see[10]).

Wind, wave and sea level data are valuable sources under the GRISIS multidisciplinary and holistic analysis of natural risks for coastal urban areas and built heritage.

So, wind, wave and sea level data can be accessed under the Physics portal as under:

Step 1:

Under ***Data Portals*** (Figure 12), ***Physics*** is selected which brings the user to the page as shown in Figure 14.

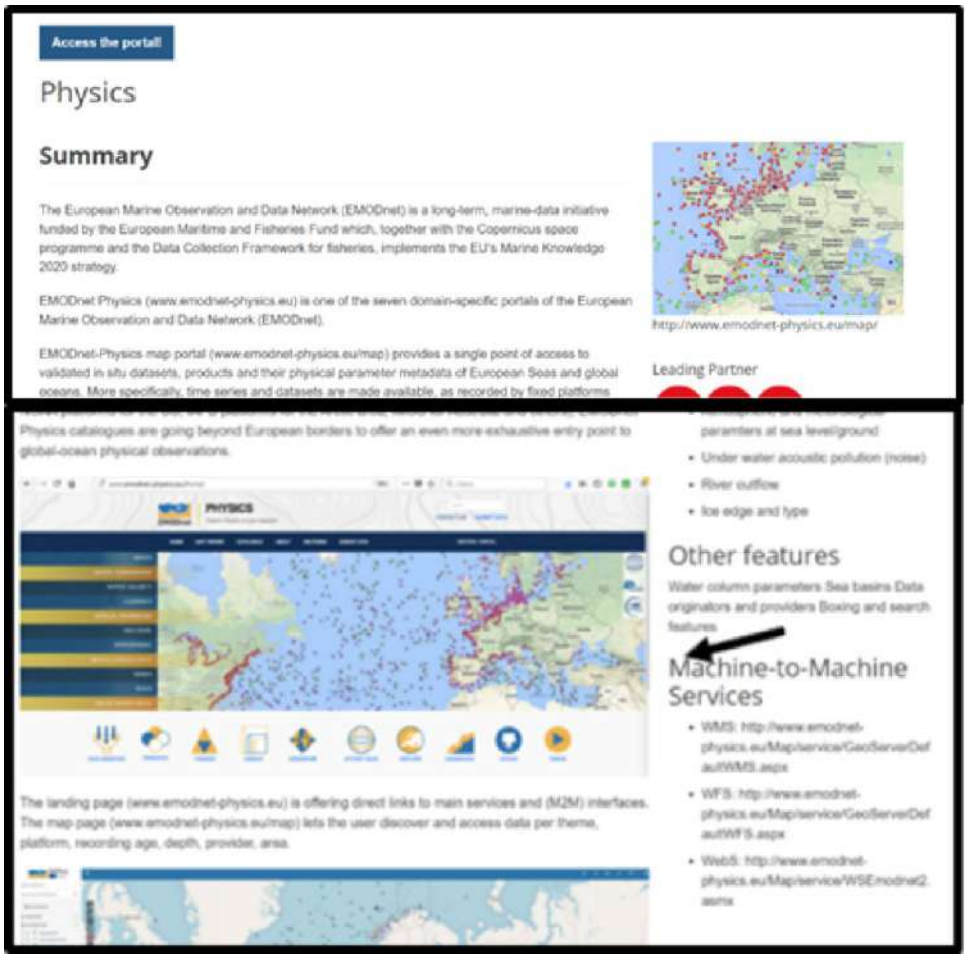


Figure 14 Physics data portal summary and different services available to retrieve data

The summary page gives an overview of the data available in the physics portal and the various ways in which it can be retrieved, including machine to machine services like WMS and WFS formats, as shown in Figure 14 (shown by the arrow).

Step 2:

Clicking on ***access the portal***, as seen in Figure 14a, will direct the user to the interactive page (see[11]) as shown in Figure 15.

Figure 15 Interactive portal

There are many options available to the user based on their requirements, as seen from Figure 15.

To simplify the use case, we select ***Waves***, as shown in Figure 16. From this point we will see a single point of access to validated in situ datasets, products, and their physical parameter information of the European seas and worldwide oceans.

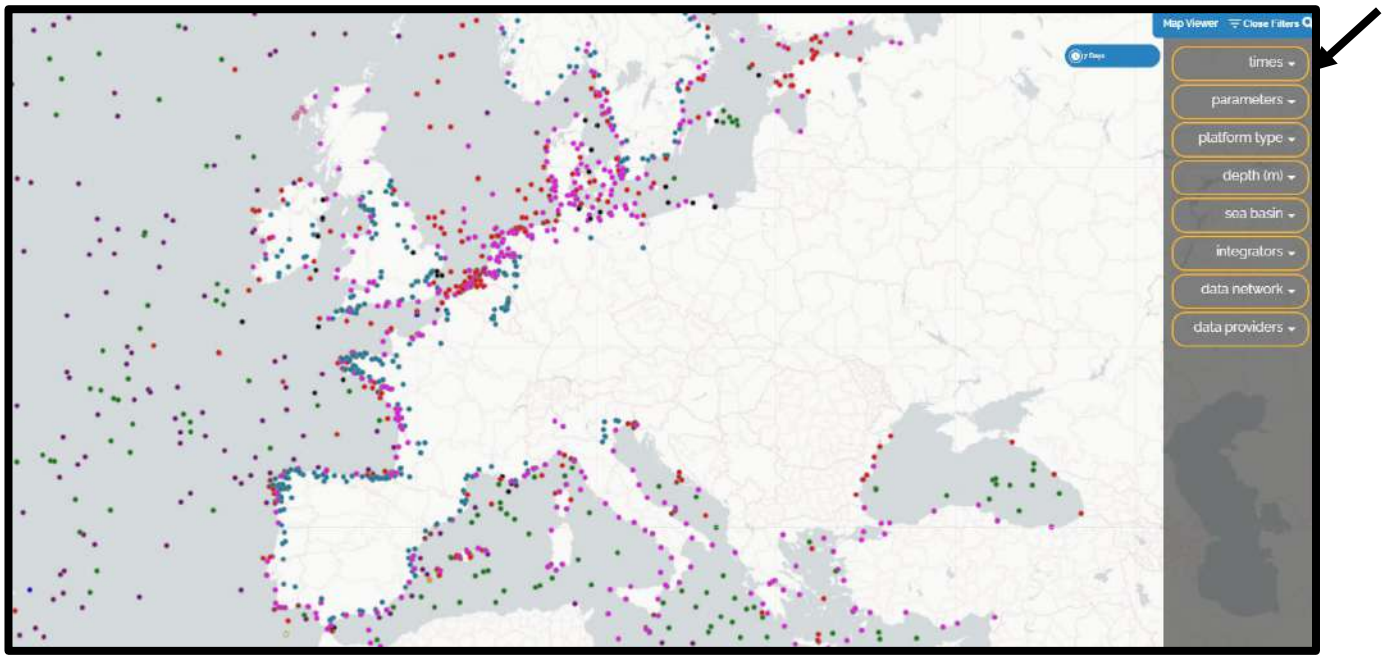


Figure 16 Map viewer

Clicking on any dot in a particular area of interest in Figure 16 will provide the user with a description of the platform selected, as shown in Figure 17. Choices can be narrowed down by utilising the filters available on the right panel of the Map viewer (indicated by the arrow).

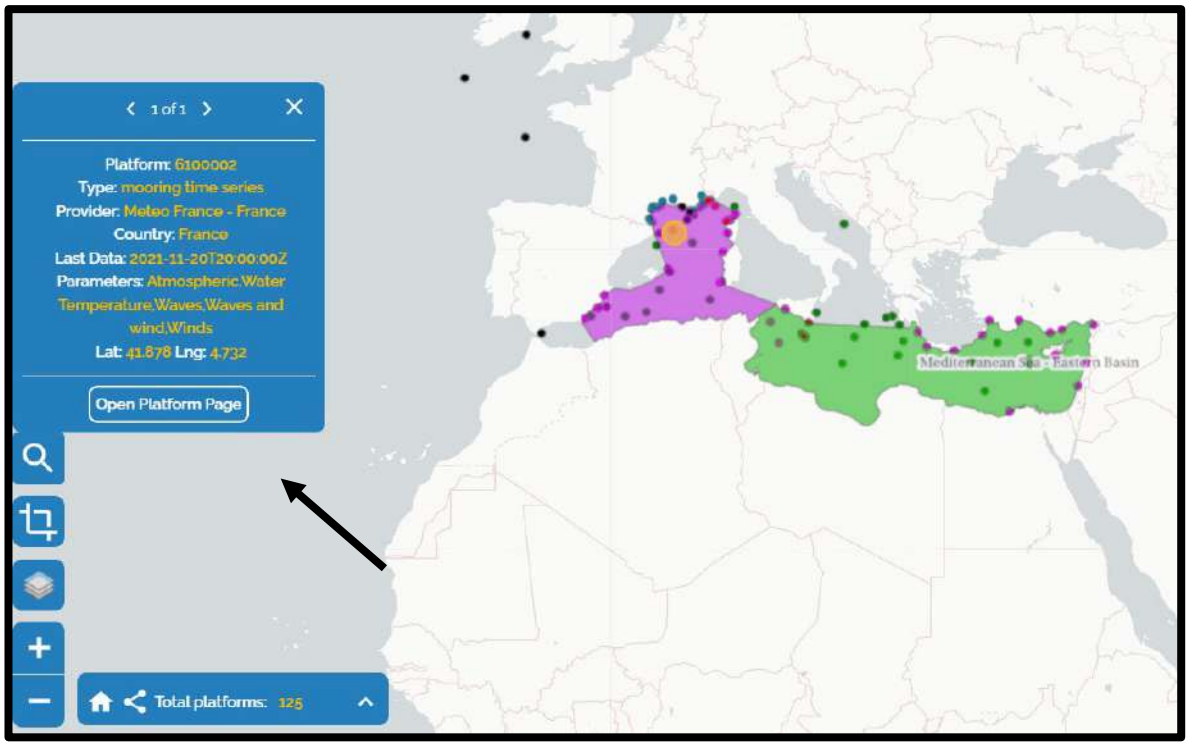


Figure 17 Platform selection

From Figure 17, as seen, the platform chosen is that of a tide gauge providing atmospheric, water temperature, wind and waves data in the Mediterranean Sea. Clicking on the *Open Platform Page* will direct the user to the page shown in Figure 18.

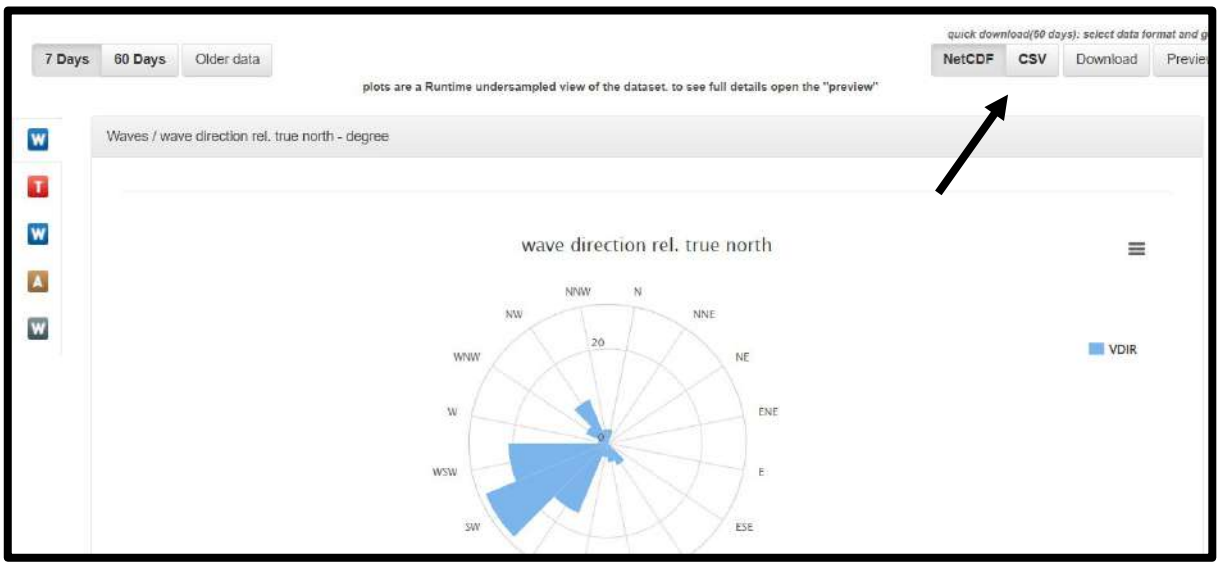


Figure 18 Platform page for the platform selected in figure 17

The platform pages for the different platforms chosen in the web viewer might vary; in this case, all the parameters as seen in Figure 17 can be downloaded in NetCDF or CSV format by the user (as shown by the arrow).

2.3. Reference datasets: general overview

Hereinafter a general overview of the main datasets selected from the European climate services and portals listed in Section 2.1 and for both the historical (baseline) characterisation and projections is provided. Further details on the reasons behind the selection and approach used are included in D3.1.

ERA5 family set is likely to be the main suggested dataset to characterise the reference baseline for the historic period. The set of suggested datasets is reported below.

- ERA5 family set, e.g. (but not limited to)
    - *ERA5 hourly data on a single level from 1979 on*
    - *ERA5-Land*
- ERA5-related datasets, e.g. (but not limited to)
    - *Water level change time series for the European coast from 1977 to 2100 derived from climate projections*
    - *Ocean surface wave time series for the European coast from 1976 to 2100 derived from climate projections*
    - *River discharge and related historical data from the European Flood Awareness System (EFAS)*
- *EMODnet Data Portals*
- Eventually, in case of missing variables/data and for specific users need *Climate Forecast System Version 2 – CFSv2.*

EURO-CORDEX and Med-CORDEX look to be the most appropriate reference datasets for climate projections to be used in the context of the SCORE project. The suggested datasets to be used in the framework of the SCORE project are the following.

- EURO-CORDEX and Med-CORDEX
- ERA5-related datasets, e.g. (but not limited to)
    - *Water level change time series for the European coast from 1977 to 2100 derived from climate projections*
    - *Ocean surface wave time series for the European coast from 1976 to 2100 derived from climate projections*
    - *Marine biogeochemistry data for the Northwest European Shelf and the Mediterranean Sea from 2006 up to 2100 derived from climate projections*

The excel file with the complete list of consulted datasets is accessible through the following link: SCORE-deliverable-D3.1-RP-v1.0.xlsx

The datasets highlighted in yellow are those identified as the most appropriate for SCORE activities.

3. SECTION FOR INDIVIDUAL SELECTED REFERENCE DATASETS

Hereinafter details and a brief description of the datasets selected as the most appropriate for SCORE activities are reported, along with specific information on data/metadata format, variables description and examples of scripts and codes to access and download data.

Moreover, the internal platform will include a set of fit-for-purpose and ready-to-use scripts and codes. These scripts have been extracted from the relevant C3S CDS, CMEMS, EMODnet and CFSv2 websites. The folder is continuously updated with new examples and tools based on SCORE users' needs (link to the folder: Scripts and Codes for Data Download).

Tables in the following sections provide, for each field, a direct linkage to further documentation and information retrieved e.g., by the website of the dataset/climate services providers, publications or use cases.

3.1. ERA5 dataset

ERA5 provides hourly estimates of a large number of atmospheric, land and oceanic climate variables. The data cover the Earth on a 30km grid and resolve the atmosphere using 137 levels from the surface up to a height of 80km. ERA5 includes information about uncertainties for all variables at reduced spatial and temporal resolutions. Quality-assured monthly updates of ERA5 (1979 to present) are published within three months of real-time. Preliminary daily updates of the dataset are available to users within five days of real-time (ERA5 [12]).

Currently, the family of ERA5 datasets (figure 18) includes the following datasets:

- **ERA5** - comprehensive reanalysis, from 1979 (will be soon backdated to 1950) to near real-time that takes in as many observations as possible in the high atmosphere and near the surface. A land surface model and a wave model are included in the ERA5 atmospheric model.
- **ERA5 back extension (preliminary version)**, from 1950 to 1978, is now available independently from ERA5 (1979 onwards). Although the quality of this dataset is excellent in many other areas, it appears to be plagued by tropical cyclones that are often overly powerful. As a result, until a new updated version of ERA5 1950 to near real-time is issued, the present release of the back extension is considered tentative.
- **ERA5.1** is a re-run of ERA5 for the years 2000 to 2006 alone, which was created to correct ERA5's reduced stratospheric cold bias during this time period. In the majority of the troposphere, ERA5 behaves similarly to ERA5.1.
- **ERA5-Land** is a land surface dataset developed at greater resolution (9km) and forced by ERA5 atmospheric parameters with lapse rate correction, but with no further data assimilation, from 1950 to current time (2-3 months in arrears).

ERA5 datasets are often accessed through the C3S Climate Data Store (CDS)ccess from the CDS disks is faster than from MARS, thereforeFor further information, check the CDS documentation.

In the following table, table 1, we present some useful information of ERA5 dataset related to the SCORE Project.

Table 1 ERA5 useful information

	Data accessibility and visualization/ Code/API	Data format and metadata	Parameter description	More information	Dataset application	License
ERA5 datasets	Dataset [13] Python code available on Sharepoint Further details on how to download and use CDS API across different operating platforms and the syntax format to retrieve datasets using Python can be found in the below link: https://cds.climate.copernicus.eu/api-how-to [14].	GRIB NetCDF (experimental)	Parameter database [15]	Specific information related to SCORE project Data documentation [16]	Flooding in Mediterranean Coastal Areas [17] Downscaling ERA5 reanalysis data for coastal climate applications [18]	License [19]

3.2. European Flood Awareness System (EFAS) dataset

The European Flood Awareness System (EFAS [20]), developed in collaboration between the European Commission and the European Centre for Medium-Range Weather Forecasts (ECMWF [4]), is a hydrological forecasting and monitoring system independent of administrative, political borders in the greater European domain. The goal of EFAS is to promote flood preparedness measures before big flood disasters occur, especially in large transnational river basins and across Europe. EFAS is a component of the Copernicus Emergency Management Service [21] and is the first operational European system for monitoring and forecasting floods across Europe.

It combines cutting-edge meteorological forecasts with a hydrological model, and because of its continental size setup, it can send information on upstream river conditions to downstream nations. It offers relevant national and regional agencies supplementary, added-value information (e.g. probabilistic, medium-range flood predictions, flash flood indicators, or impact projections) and is constantly upgraded (figure 19). EFAS also keeps the Emergency Response Coordination Centre (ERCC) [22] up to date on current and potential flood occurrences across Europe.

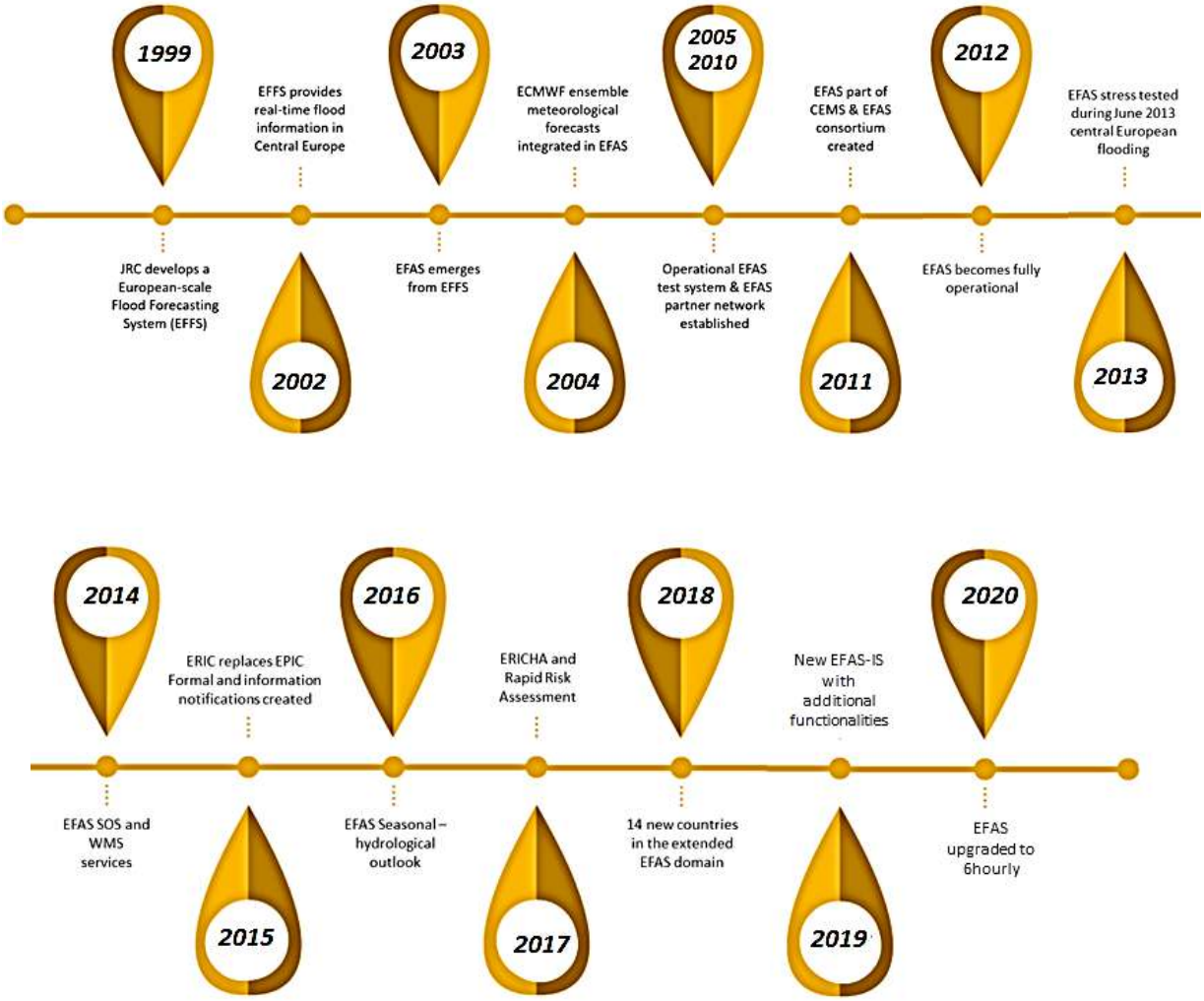


Figure 19 The upgrades of EFAS during the 1999-2020 period *[23]*

EFAS produces 6-hourly flood forecasts (since 2020) and monthly seasonal streamflow outlooks (since 2016). The system has been fully operational as part of the Copernicus Emergency Management Service since 2012.

In the following table, table 2, we present some useful information of EFAS dataset related to the SCORE Project.

Table 2 EFAS useful information

	Data accessibility and visualisation	Data format and metadata	Parameter description	More information	Known issues, pros and cons	Dataset application	License
EFAS	Dataset [24] Accessing the data through MARS [25] Python Code on SharePoint and here [26] Access via FTP [26](Slide 8)	GRIB2 NetCDF-4	Available data [27]	Specific information related to the SCORE project Data documentation [23] Live Map [28] Major upgrade of the EFAS [29]		The European Flood Alert System – Part 1: Concept and development [30] Daily ensemble river discharge re-forecasts and real-time forecasts from the operational Global Flood Awareness System [31] Hydrological Model Application in the Sirba River: Early Warning System and GloFAS improvements [32]	License [33]

3.3. EMODnet dataset

The European Marine Observation and Data Network (EMODnet [9]) collaborates with organisations sponsored by the EU's integrated maritime strategy. These organisations collaborate to watch the sea, process data according to international standards and make data layers and products available.

All marine data consumers, including policymakers, scientists, commercial enterprises, and the general public, benefit from this "gather once, use many times" mentality. An integrated maritime data policy is expected to save at least one billion euros per year while also opening up new potential for innovation and growth.

EMODnet provides access to European marine data across seven discipline-based themes: Bathymetry, Biology, Chemistry, Geology, Human Activities, Physics, Seabed Habitats.

In the following table, table 3, we present some useful information of EMODnet dataset related to the SCORE Project.

Table 3 EMODnet useful information

	Data accessibility and visualisation	Data format and metadata	Parameter description	More information	Dataset application	License
EMODnet	Dataset [34] REST API code on SharePoint and here [35]	ASCII, semi-colon separated fields Vertical reference: LAT	Parameters and format [36]	Specific information related to the SCORE project Product details [37]	EMODnet Physics' integrated wind, wave and sea level data supports Coastal Infrastructure Risks and Safety Management in South Italy [GRISIS research project]	License [38]

3.4. CORDEX dataset

The Coordinated Regional Climate Downscaling (CORDEX [39]) is supported by the World Climate Research Program (WCRP) and assessed by the Intergovernmental Panel on Climate change (IPCC). The CORDEX's vision is to enhance and manage regional climate downscaling science and applications through worldwide collaborations. Its goal is to assess the performance of regional climate models through a series of experiments aimed at providing regional climate forecasts.

The CDS-CORDEX subset consists of the following CORDEX experiments partly derived from the CMIP5 ones:

- **evaluation**: model simulations for the past with imposed "perfect" lateral boundary conditions following ERA-Interim reanalyses [40] (1979-2015).
- **historical**: model simulations for the past using lateral boundary conditions from Global Climate Models (GCMs). These experiments cover a period for which modern climate observations exist. These experiments show how the RCMs perform for the past climate when forced by GCMs and can be used as a reference period for comparison with scenario runs for the future.
- **scenario experiments RCP2.6, RCP4.5, RCP8.5**: ensemble of CORDEX climate projection experiments driven by boundary conditions from GCMs using RCP (Representative Concentration Pathways) forcing scenarios. The scenarios used here are RCP 2.6, 4.5 and 8.5, they provide different pathways of the future climate forcing.

Simulations using Regional Climate Models (RCMs) required lateral boundary conditions from the Global Climate Models (GCMs). CDS-CORDEX subset boundary conditions are currently derived from the CMIP5 global predictions.

The C3S EURO-CORDEX aims to fill the gaps between GCMs (known as "driving models"), RCMs and RCPs. This will allow for a better depiction of uncertainty from GCMs, RCMs, and RCP scenarios and a complete assessment of regional climate change signals. The horizontal resolution of the European domain is 0.11° x 0.11°, and data are available at sub-daily to monthly scale. C3S directly curated and quality-controlled part of the CORDEX simulations and funded itself further climate simulations on the European domain. This is intended to estimate climate change for the European region better and comprehensively study the regional climate change signals.

In addition to EURO-CORDEX, a specific sub-domain covering the Mediterranean area should be considered. The Mediterranean basin areas have quite a unique character that results both from their complex morphology and socio-economic conditions. For this, the Mediterranean region represents a good case study for climate regionalisation and has been chosen as an additional CORDEX sub-domain (MED), leading to the Med-CORDEX initiative endorsed by Med-CLIVAR and HyMeX. Med-CORDEX [41] takes advantage of new very high-resolution Regional Climate Models (RCM, up to 10 km) and of new fully coupled Regional Climate System Models (RCSMs), coupling the various components of the regional climate.

In the next table, table 5, we present some useful information of CORDEX dataset related to the SCORE project, which will be used for climate projections.

Table 4 CORDEX useful information

	Data accessibility and visualisation	Data format and metadata	Parameter description	More information	Dataset application	License
CORDEX	Data access [42] API Request on SharePoint	Compressed zip file (.zip) Compressed tar file (.tar.gz) Data format [43]	List of parameters [43]	Specific information related to the SCORE project User guide [43] Detailed information [43]	Regional climate downscaling over Europe: perspectives from the EURO-CORDEX community [44] Coastal upwelling trends under future warming scenarios from the CORDEX project along the Galician coast (NW Iberian Peninsula) [45]	Licence

3.5. Other Copernicus datasets

This section provides information on related datasets, including essential variables and data of interest for SCORE activities. This is just a selection of some datasets of interest for SCORE activities derived from the main repositories for both baseline characterisation and projections like, e.g., ERA5 and CORDEX. All these datasets are thus part of COPERNICUS services. Therefore, this list is not intended to be exhaustive since SCORE users could select other potential datasets based on their specific needs. A set of datasets is listed below as follows.

- **Marine biogeochemistry data for the Northwest European Shelf and the Mediterranean Sea from 2006 up to 2100 derived from climate projections** - Model forecasts of changes in marine physics and biogeochemistry, as well as the lower trophic levels of the marine food web, for the Northwest European Shelf and the Mediterranean Sea up to the year 2100 are included in this dataset. The dataset was created using the ERSEM v15.06 marine ecosystem model, which was coupled to the regional ocean circulation models POLCOMS and NEMO using the FABM coupler.
- **Ocean surface wave time series for the European coast from 1976 to 2100 derived from climate projections**- the dataset contains time series of the coastal wave climate based on ocean surface wave parameters estimated throughout a European region. This dataset helps to understand the wave environment on the Northwest European Shelf and in the Mediterranean Sea as a result of climate change. It adds value to a variety of coastal industries and research, including port, shipping, and coastal management.
- **Water level change time series for the European coast from 1977 to 2100 derived from climate projections**- the dataset contains water level time series resulting from tides, surges and sea level rise computed for a European-wide domain. The dataset may be used to bring value to many coastal sectors and studies, such as coastal floods, coastal erosion, harbours, and ports, by providing a knowledge of European coastal hydrodynamics under the effect of climate change (e.g. sea level rise).

In the following table, table 5, we present some useful information of the datasets mentioned previously.

Table 5 Some Copernicus-related datasets useful information

	Data accessibility and visualisation	Data format and metadata	Parameter description	More information	Dataset application	License
Marine biogeochemistry data for the Northwest European Shelf and Mediterranean Sea from 2006 up to 2100 derived from the climate projections	Data access [46] Data viewer [47] API request on SharePoint	NetCDF-4 Data format [43]	Parameters [48]	Specific information related to SCORE project User guide [48]	Climate-related hazard indices for Europe [49]	Licence [19]
Ocean surface wave time series for the European Coast from	Data access [50]	NetCDF-4	Parameters [48]	Specific information		Licence [19]

1976 to 2100 derived from the climate projections	API Request available on SharePoint			related to SCORE project User guide [48]		
Water level change time series for the European Coast from 1977 to 2100 derived from the climate projections	Data access [51] API Request available on SharePoint	NetCDF-4	Parameters [48]	Specific information related to SCORE project User guide [48]		Licence [19]

3.6. Other datasets (supporting the European datasets)

For the sake of completeness and for filling eventual gaps in the historical marine data, other extra-European datasets and services have been consulted. Based on the requirements of D3.1 for data retrieving, the Climate Forecast System Version 2 (CFSv2) has been identified as one of the most appropriate datasets to be used as a complement to those listed in the previous sections.

Specifically, the NOAA National Centers for Environmental Prediction (NCEP) developed the CFSv2, a fully coupled model representing the interaction between the Earth's seas, land, and atmosphere. All 6-hourly predictions and monthly means and variable time-series are included in the four-times-daily, 9-month control runs (all variables).

Outputs of the CFSv2 include:

- 2-D Energetics (EGY);
- 2-D Surface and Radiative Fluxes (FLX);
- 3-D Pressure Level Data (PGB);
- 3-D Isentropic Level Data (IPV);
- 3-D Ocean Data (OCN);
- Low-resolution output (GRBLOW);
- Dumps (DMP);
- High-and Low-resolution Initial Conditions (HIC and LIC).

The CFSv2 period of record begins on April 1, 2011, and continues onward.

In the next table, table 4, we present some useful information (or links to information) of CFSv2 dataset related to the SCORE Project.

Table 6 NCAR useful information

	Data accessibility and visualisation	Data format and metadata	Parameter description	More information	Known issues, pros and cons	Dataset application	License
CFSv2	Data access [52] Access via FTP	GRIB2	Parameters [53]	Specific information related to SCORE project File naming convention [54] CFSv2 upgrade [55] Video tour of RDA dataset [56] CFSv2 Operational Forecast [57] Updated version of CDSv2 [55]	Key strengths and limitations [58]	Impact of a Narrow coastal bay of Bengal sea surface temperature front on an Indian Summer Monsoon simulation [59]	No license information was provided. [60]

4. CONCLUSIONS AND RECOMMENDATIONS

This document describes the climate services and datasets selected for the baseline characterisation of the historical period and the climate projections. Specifically, this document would represent a guide for SCORE users, by means of use cases retrieved by the European main climate services identified in D3.1, to gather and download climate and marine data and information for SCORE activities.

The climate services described in this study represent single-point access to a number of diverse climate and marine datasets across Europe otherwise sparse. Thus, they complement capabilities existing at the national level and provide comprehensive climate information for various purposes and studies. This is possible by a constant collaboration from a network of organisations, supported by the EU, working together to provide updates and quality-checked data according to international standards and making the products freely available. As such, the climate services and datasets included in this document are not intended to be exhaustive but surely cover a wide range of the climate information of interest for SCORE activities available at the European level. Climate services are constantly updated with new tools and products, which has to be considered in the project life-cycle. Thus, this document and the related Deliverable 3.1 provide a snapshot of the climate information available to date, but the possibility to consider further new tools and updated data should not be excluded in the future. This is particularly true in the perspective that new climate projection information comes available.

In this document, we exclude data coming from:

- the official institutional environmental monitoring infrastructures available in the CCLLs areas (e.g., those managed by local environmental agencies, weather services, and consortia)
- citizen science low-cost sensors to be developed and deployed within WP 4

Nevertheless, they will constitute a valuable and essential complement to the information retrieved by the main climate services identified. They will be the object of other project activities related to task 3.1.

5. BIBLIOGRAPHY

[1] «European Commission(n.d.)*European Green Deal* ,» [Online]. Available: https://ec.europa.eu/clima/eu-action/european-green-deal_en.

[2] «Copernicus (n.d.)*Copernicus climate change service*,» [Online]. Available: https://climate.copernicus.eu/.

[3] «Copernicus(2016-2020) *CDS Toolbox Documentation*,» [Online]. Available: https://cds.climate.copernicus.eu/toolbox/doc/index.html.

[4] «European Centre for Medium-Range Weather Forecasts(n.d.), *Advancing global NWP through international collaboration* » [Online]. Available: https://www.ecmwf.int/.

[5] «Copernicus(n.d.)*Copernicus Marine Service*,» [Online]. Available: https://marine.copernicus.eu/.

[6] «Artelia Group(2021), *Climate Change Resilience*,» [Online]. Available: https://www.arteliagroup.com/en/expertise/challenges/climate-change-resilience.

[7] «Copernicus (n.d.)*Mediterranean Sea waves analysis and forecast dataset*,» [Online]. Available: https://resources.marine.copernicus.eu/product-detail/MEDSEA_ANALYSISFORECAST_WAV_006_017/INFORMATION.

[8] «Copernicus (n.d)*Mediterranean Sea Physics Reanalysis Dataset*,» [Online]. Available: https://resources.marine.copernicus.eu/product-detail/MEDSEA_MULTIYEAR_PHY_006_004/INFORMATION.

[9] «European Comission (n.d.)*The European Marine Observation and Data Network*,» [Online]. Available: https://emodnet.ec.europa.eu/en.

[10] «GRISIS - Gestione dei RIschi e Sicurezza delle Infrastrutture a Scala regionale,» [Online]. Available: http://151.1.25.86/GrisisWeb/Home.

[11] « EMODnet(2020)*EMODNET Physics Portal*,,» [Online]. Available: https://portal.emodnet-physics.eu/.

[12] « ECMWF(n.d.)*ERA5 - Reanalysis Dataset*,» [Online]. Available: https://www.ecmwf.int/en/forecasts/datasets/reanalysis-datasets/era5.

[13] « Copernicus (2021) *CDS - Dataset*,» [Online]. Available: https://cds.climate.copernicus.eu/cdsapp#!/dataset/reanalysis-era5-single-levels?tab=overview.

[14] « Copernicus (n.d.) *CDS Dataset - API*,» [Online]. Available: https://cds.climate.copernicus.eu/api-how-to.

[15] « ECMWF(2021) *Parameter Database*,» [Online]. Available: https://apps.ecmwf.int/codes/grib/param-db.

[16] « ERA5 Data Documentation,» [Online]. Available: https://confluence.ecmwf.int/display/CKB/ERA5%3A+data+documentation.

[17] Senatore, A., Davolio, S., Furnari, L., & Mendicino, G. (2020). Reconstructing Flood Events in Mediterranean Coastal Areas Using Different Reanalyses and

High-Resolution Meteorological Models. *Journal of Hydrometeorology*, *21*(8), 1865–1887. https://doi.org/10.1175/jhm-d-19-0270.1

[18] Capecchi V., Brandini C., Gozzini B., et all, «Downscaling ERA-5 reanalysis data forcoastal climate applications (and evaluationof uncertainty of coastal data),» in *5th International Conference on Reanalysis (ICR5)*, Rome, 2017.

[19] « Copernicus(2019)Licence for Copernicus Products,» [Online]. Available: https://cds.climate.copernicus.eu/api/v2/terms/static/licence-to-use-copernicus-products.pdf.

[20] « Copernicus(n.d.) The European Flood Awareness System,» [Online]. Available: https://www.efas.eu/en.

[21] « Copernicus(n.d.) Copernicus Emergency Management Service,» [Online]. Available: https://www.copernicus.eu/en/services/emergency.

[22] « European Comission(2021)Emergency Response Coordination Centre (ERCC),» [Online]. Available: https://ec.europa.eu/echo/what/civil-protection/emergency-response-coordination-centre-ercc_en.

[23] « ECMWF(2021)European Flood Awareness System,» [Online]. Available: https://confluence.ecmwf.int/display/COPSRV/European+Flood+Awareness+System.

[24] «EFAS Dataset,» [Online]. Available: https://www.efas.eu/en/data-access.

[25] Copernicus, «How to EFAS through MARS,» [Online]. Available: https://confluence.ecmwf.int/download/attachments/131396944/MARS_accessnew.pdf?version=1&modificationDate=1551886433648&api=v2.

[26] C. Barnard(2019), «EFAS Data Availability,» 2019. [Online]. Available: http://www.efas.eu/sites/default/files/AM/AM2019/Comp_EFAS_Data.pdf.

[27] «EFAS Available Data,» [Online]. Available: https://confluence.ecmwf.int/display/COPSRV/EFAS+available+data.

[28] «EFAS Live Map,» [Online]. Available: https://www.efas.eu/efas_frontend/#/home.

[29] ECMWF(2021), «Major upgrade european flood awareness system,» 2020-2021. [Online]. Available: http://www.ecmwf.int/sites/default/files/elibrary/2021/19914-major-upgrade-european-flood-awareness-system.pdf.

[30] Thielen, J., Bartholmes, J., Ramos, M. H., & de Roo, A. (2009). The European Flood Alert System – Part 1: Concept and development. *Hydrology and Earth System Sciences*, *13*(2), 125–140. https://doi.org/10.5194/hess-13-125-2009

[31] Harrigan, S., Zoster, E., Cloke, H., Salamon, P., and Prudhomme, C.: Daily ensemble river discharge reforecasts and real-time forecasts from the operational Global Flood Awareness System, Hydrol. Earth Syst. Sci. Discuss. [preprint], https://doi.org/10.5194/hess-2020-532, in review, 2020.

[32] Passerotti, G., Massazza, G., Pezzoli, A., Bigi, V., Zsótér, E., & Rosso, M. (2020). Hydrological Model Application in the Sirba River: Early Warning System and GloFAS Improvements. *Water*, *12*(3), 620. https://doi.org/10.3390/w12030620

[33] «Copernicus (2021) EFAS licence,» [Online]. Available: https://cds.climate.copernicus.eu/api/v2/terms/static/cems-floods.pdf.

[34] « EMODnet(2021) EMODnet Bathymetry Datase,» [Online]. Available: https://portal.emodnet-bathymetry.eu/.

[35] « EMODnet(2021) EMODnet Bathymetry REST service,» [Online]. Available: https://rest.emodnet-bathymetry.eu/.

[36] « EMODnet(2008) DTM exchange format specification,» 2008. [Online]. Available: https://www.emodnet-bathymetry.eu/media/emodnet_bathymetry/org/documents/euco-0901-002_dtm_exchange_format_specification_v1.6.pdf.

[37] « EMODnet(2021)QA/QC and DTM production details,» [Online]. Available: https://www.emodnet-bathymetry.eu/internal_html/qaqc-and-dtm-production-details/9.

[38] « European Comission(n.d.) EMODnet Licence,» [Online]. Available: https://emodnet.ec.europa.eu/en/terms-use.

[39] « WCRP(2021) The Coordinated Regional Climate Downscaling (CORDEX),» [Online]. Available: https://cordex.org/.

[40] « ECMWF(2021) ERA Interim Documentation,» 2021. [Online]. Available: https://confluence.ecmwf.int/display/CKB/ERA-Interim%3A+documentation.

[41] «Med-CORDEX(n.d.),» [Online]. Available: https://www.medcordex.eu/.

[42] « Copernicus (2021)CORDEX Dataset,» [Online]. Available: https://cds.climate.copernicus.eu/cdsapp#!/dataset/projections-cordex-domains-single-levels?tab=form.

[43] « ECMWF(2021) CORDEX: Regional climate projections,» [Online]. Available: https://confluence.ecmwf.int/display/CKB/CORDEX%3A+Regional+climate+projections#CORDEX:Regionalclimateprojections-DataFormat.

[44] Jacob, D., Teichmann, C., Sobolowski, S., Katragkou, E., Anders, I., Belda, M., Benestad, R., Boberg, F., Buonomo, E., Cardoso, R. M., Casanueva, A., Christensen, O. B., Christensen, J. H., Coppola, E., de Cruz, L., Davin, E. L., Dobler, A., Domínguez, M., Fealy, R., . . . Wulfmeyer, V. (2020). Regional climate downscaling over Europe: perspectives from the EURO-CORDEX community. *Regional Environmental Change*, *20*(2). https://doi.org/10.1007/s10113-020-01606-9

[45] Alvarez, I., Lorenzo, M. N., deCastro, M., & Gomez-Gesteira, M. (2016). Coastal upwelling trends under future warming scenarios from the CORDEX project along the Galician coast (NW Iberian Peninsula). *International Journal of Climatology*, *37*(8), 3427–3438. https://doi.org/10.1002/joc.4927.

[46] « Copernicus (2021) Marine biogeochemistry data for the Northwest European Shelf and Mediterranean Sea from 2006 up to 2100 derived from the climate projections,» [Online]. Available: https://cds.climate.copernicus.eu/cdsapp#!/dataset/sis-marine-properties?tab=form.

[47] « Copernicus (2021) Data Viewer - Marine biogeochemistry data for the Northwest European Shelf and Mediterranean Sea from 2006 up to 2100

derived from the climate projections,» [Online]. Available: https://cds.climate.copernicus.eu/cdsapp#!/dataset/sis-marine-properties?tab=app.

[48] Copernicus (2019), «User Guide for Products NEMO-ERSEM and POLCOMS-ERSEM,» 2019. [Online]. Available: http://datastore.copernicus-climate.eu/documents/sis-european-fisheries/SIS_Fisheries_User_Guides_for_Products_ERSEM_v1.1.pdf#%5B%7B%22num%22%3A22%2C%22gen%22%3A0%7D%2C%7B%22name%22%3A%22XYZ%22%7D%2C54%2C315%2C0%5D.

[49] Crespi A., Terzi S., Cocuccioni S. et all, European Environmental Agency,(2020) «Climate-related hazard indices for Europe,», Bologna (It).

[50] « Copernicus (2021) Ocean surface wave time series for the European coast from 1976 to 2100 derived from climate projections Dataset,» [Online]. Available: https://cds.climate.copernicus.eu/cdsapp#!/dataset/sis-ocean-wave-timeseries?tab=form.

[51] « Copernicus (2021) Water level change time series for the European coast from 1977 to 2100 derived from climate projections Dataset,» [Online]. Available: https://cds.climate.copernicus.eu/cdsapp#!/dataset/10.24381/cds.8c59054f?tab=overview.

[52] « UCAR (2021) CFSv2 Dataset,» [Online]. Available: https://rda.ucar.edu/datasets/ds094.0/#!access.

[53] « UCAR (2021)CFSv2 Dataset Description,» [Online]. Available: https://rda.ucar.edu/datasets/ds094.0/#!description.

[54] « UCAR (2021) Description of NCEP's CFSV2 File Naming Convention,» [Online]. Available: https://rda.ucar.edu/datasets/ds094.0/#docs/cfsv2_filenames.html.

[55] « UCAR (2021) The NCEP Climate Forecast System Version 2,» *Journal of Climate,* vol. 27, n. 6, p. 2185–2208, 2014.

[56] « UCAR (2015-2019) A video tour of an RDA data set home page,» [Online]. Available: http://ncarrda.blogspot.com/search/label/Tutorial+YouTube+Description.

[57] « NOAA (2018) Climate Forecast System Version 2 (CFSv2) Operational Forecasts,» NOAA, [Online]. Available: https://www.ncei.noaa.gov/access/metadata/landing-page/bin/iso?id=gov.noaa.ncdc:C00877.

[58] « UCAR (2020) Climate Forecast System Reanalysis (CFSR) - Summary,» [Online]. Available: https://climatedataguide.ucar.edu/climate-data/climate-forecast-system-reanalysis-cfsr.

[59] Saha, S., Moorthi, S., Wu, X., et all (2014). The NCEP Climate Forecast System Version 2. *Journal of Climate*, *27*(6), 2185–2208. https://doi.org/10.1175/jcli-d-12-00823.1.

[60] « UCAR (2021) CFSv2 - Licence,» [Online]. Available: https://catalog.data.gov/dataset/climate-forecast-system-version-2-cfsv2-operational-forecasts.

[61] « ECMWF (2021)The family of ERA5 datasets,» [Online]. Available: https://confluence.ecmwf.int/display/CKB/The+family+of+ERA5+datasets.

[62] « ECMWF (2021): Regional climate projections,» [Online]. Available: https://confluence.ecmwf.int/display/CKB/CORDEX%3A+Regional+climate+projections#CORDEX:Regionalclimateprojections-Listofpublishedparameters.