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Ref. Ares(2024)4472544 - 20/06/2024

UNITED

DELIVERABLE 2.3

AUTOMATION AND SCHEDULING TOOLS

Work Package 2

Technology

August 12th, 2023

Funded by the European Union (H2020 Grant Agreement no 862915).Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them

Grant Agreement number	**862915**
Project title	**UNITED: multi-Use platforms and co-locatioN pilots boostIng cost-effecTive, and Eco-friendly and sustainable proDuction in marine environments**
Deliverable title	Automation and scheduling tools
Deliverable number	2.3
Deliverable version	Resubmission
Contractual date of delivery	March 31st, 2022
Actual date of delivery	August 12th, 2023
Document status	Final version
Document version	Version 2.0
Online access	Yes
Diffusion	Public
Nature of deliverable	Other
Work Package	WP2 – Technology
Partner responsible	HIDROMOD
Contributing Partners	HIDROMOD, Deltares
Author(s)	Adelio Silva, Pedro Galvão
Editor	Ghada El Serafy
Approved by	Roderik Hoekstra
Abstract	This document describes the automation and scheduling tools provided by the UNITED data platform
Keywords	Scheduling, automation, data services, data platform
Change log	Resubmission 1 - change in cover page and introduction tables; addition of a paragraph at the end of the introduction about the benefits for the users; addition of a section on economic, technological and environmental benefits;

	addition of three paragraphs in the conclusion related to the benefits

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACRONYMS

CMEMS	Copernicus Marine Service
DWD	German Weather Service - Deutscher Wetterdienst
DSS	Decision Support System
EMODNET	European Marine Observation and Data Network
EO	Earth Observation
GLOSS	Global Sea Level Observing System
ICT	Information and Communication Technologies
ICON	Icosahedral Nonhydrostatic Meteorological Model
METAR	Meteorological Aerodrome Report
MUCL	Multi Use and Co-Location
NOAA	National Oceanic and Atmospheric Administration
SOC	Service Oriented Computing

EXECUTIVE SUMMARY

The ICT solutions proposed in UNITED are based on integrated data systems gathering both forecasting capabilities and remote and in-situ measurement data. It also includes a series of process-based or statistical models with the objective to improve the operations of the MUCLs through both automated and on-demand processes to monitor, maintain, or execute tasks.

The present document provides a description of the procedures adopted in UNITED to schedule (automatize) and/or ask for on-demand tasks. This includes the necessary actions to import data from both internal and external providers (e.g., Copernicus Service, GFS, etc.) and the required associated operational 'chain'. It also describes specific implementations already made in the framework of the UNITED project.

1. INTRODUCTION

Automation and scheduling allow for a more cost effective and safe platform, reducing the number of personnel required for on-site operations, and allowing for greater platform utility during inclement weather conditions. The ICT solutions proposed in UNITED are based on integrated data systems with monitoring networks, both in-situ measurement devices and remote sensing datasets and forecasting capabilities. This Deliverable describes the automated services and procedures, based on the technologies described in D2.1, implemented in the framework of UNITED. Also, as stated in D2.1, it should be noticed that the below described capabilities are subject to continuous development and are updated on a regular basis to continue to be in line with the state of the art and properly fulfil new users' requirements.

Automation and scheduling play crucial roles in delivering operational services by improving efficiency, reducing errors, and ensuring timely execution. Some of the benefits of automation and scheduling in delivering operational services are for instance:

- Task Automation: Automation eliminates manual, repetitive tasks by using software or robotic processes. By automating routine activities, operational services can be delivered faster and with greater accuracy. For example, automating data entry, report generation, or invoice processing can save time and reduce the risk of human error.
- Workflow Optimization: Automation allows for streamlining and optimizing workflows by defining clear processes and automating the flow of tasks. By mapping out the entire operational service process and automating the handoffs and approvals, efficiency and consistency are improved. Workflow optimization ensures that each task is completed in a logical sequence and that the necessary resources are allocated appropriately.
- Resource Allocation: Scheduling tools help allocate resources effectively by determining the best time, location, and person to perform specific tasks. By considering factors such as employee availability, skill sets, and equipment availability, operational services can be scheduled in a way that maximizes productivity and minimizes downtime. This ensures that the right resources are assigned to the right tasks at the right time.
- Service Level Agreement (SLA) Compliance: Automation and scheduling assist in meeting SLAs by ensuring that service delivery targets are achieved within the defined timeframes. Scheduling tools can prioritize tasks based on their urgency and allocate resources, accordingly, enabling operational services to be delivered in a timely manner. Automated reminders and notifications also help prevent delays and ensure adherence to SLAs.
- Exception Handling: Automation and scheduling systems can identify and handle exceptions or deviations from the standard operational service processes. If an issue arises or a task falls behind schedule, the system can automatically trigger alerts or notifications to the relevant stakeholders. This enables timely intervention and corrective actions, minimizing disruptions and ensuring smooth service delivery.
- Data Analysis and Reporting: Automation enables the collection and analysis of data related to operational services, providing insights into performance, trends, and areas for improvement. By automatically generating reports and dashboards, decision-makers can access real-time information and make data-driven decisions to optimize service delivery.

Overall, automation and scheduling empower operational services by reducing manual effort, improving efficiency, ensuring compliance, and providing valuable insights for continuous improvement. By leveraging these technologies, organizations can enhance their operational capabilities and deliver services more effectively and reliably. For the users the benefits include:

- The provision of audited and validated information (reliability assurance)
- Better forecast services and lower risks in decision making thereby optimizing the safe use of the marine environment and improving business margins;
- Information focused on user' specific requirements through a single access point;
- Reducing of risks of environmental hazards;
- On time alerts based on user's defined constraints
- Improved relations with the local society (better public image)

2. SETTING UP A SERVICE

The implementation of a service implies to set up a chain of procedures that can pick up data from different providers, run models and algorithms, and apply the necessary methods to make it available in readable formats and implement analysing tools and filters to transform it into useful information capable of fulfilling the requirements of different users. Along this process, it is of prime importance to guarantee the observation of quality assurance procedures in each step to avoid the dissemination of erroneous or low-quality information.

2.1. Methods

The first link of the chain is to identify the available data sources and implement the appropriate data retrieving services. According to the implemented approach, the data importing service is done through the development of specific plugins for each of the available data sources. In this way, in presence of a new data source, the process to include it only requires the writing of a new plugin.

In this first stage a set of data sources covering different data formats and spatial and temporal resolution scales was selected to demonstrate the effectiveness of the selected approach.

2.2. Analysis and Querying

The next link in the chain deals with the fundamental aspects of how to store the data and the procedures to adopt to assure the data quality. Once these procedures are defined, it is also necessary to implement a set of procedures to apply filters to the data to move from data to information. These procedures must take in consideration both the possible extractable information and, of course, the user needs. The adopted methods to solve these issues were described more in detail in D2.1.

2.3. Exploitation & Dissemination

The final link in the chain is the ability to deliver information to real users. This step involves for one side the perspective of the developers (in a sense they can try to make a proposal of the kind of information that may be obtained from the available data) and the perspective of users (in a sense they will need to receive information in forms that are adequate to their activity).

The first aspect is highly related to the experience of the developers, while the second highly depends on the user's feedback. This feedback may be obtained through the Advisory Board meetings and direct contact with different potential users. Most of the time, being these products and services new to them it is necessary to perform this task several times as the perception of the benefits in using the services improve with the availability of practical examples.

3. BUILDING A SERVICE CHAIN

3.1. General overview

UNITED Services are provided following a Service Oriented Computing (SOC) approach. Such services rely upon the use of several information elements that correspond to the parameters of the associated environmental models. The required information elements may stem from numerous information sources available on the web or privately managed networks, e.g., weather forecasts provided by open sites or privately operated sensor data and historical information data sources.

All these needs, which includes the capability to deal with large volumes of exchanged information, decentralized control of service compositions, integration of distinct types of service and information sources, call for novel approaches that can facilitate the provision of adaptable service chains. This document outlines an approach supporting the adaptation and distributed execution of environmental service chains based on information collected from several sources.

A Service Chain is the technical implementation of a pre-defined methodology that defines the data workflow and processing steps necessary to provide information fitted to the end-user needs. The implementation of such a concept implies breaking down, in unitary blocks, the technical procedures needed to go from data to processed information useful to end-users. Each service chain will follow the generic workflow presented below:

- A set of procedures that cover all key processes.
- Monitoring processes to ensure they are effective and keeping adequate records. This requirement is related with Log module of the HiSea platform.
- Checking output for defects, with appropriate and corrective action where necessary. This requirement is related to the validation methodology to be developed to ensure quality Service Cases.

For each of the Service Cases, technical requirements need to be defined. At first, information and products useful for the end-users need to be identified. Then, since added value products need to be generated, the characteristics of the final products to be delivered by the platform need to be identified. Those characteristics include:

- Formats.
- Spatial and temporal resolution.
- Accuracy of the products (reanalysis and forecasts);
- Actualization frequency.
- Exploitation requirements. The end-user may want a static product (table or an image) or something we can explore dynamically (e.g., zoom, overlap layers) or even do simple queries (e.g., configure alerts).

Based on this, it is possible to better define the necessary technical steps to generate a specific service used in a Service Case (e.g., wave conditions windows that are inadequate to ship operations). To assure the effectiveness of each of the available products, it is necessary to implement quality validation procedures and take efficient corrective actions if a problem is detected. The product quality validation may be achieved by means of implementation of unitary technical procedures in the different steps of the production chain, such as

- Download a file from ftp or similar action.
- Convert a file to a new format.
- Read and write from a database.
- Interpolate from a grid to another.
- Prepare the input files of a numerical model.
- Run a numerical model.
- Write files.

- End-user uploading data.
- Etc.

The resulting service chain platform will be able to deliver a set of relevant products and services which will bring added value such as:

- supplying forecasting services with enhanced functionality at reduced costs and allowing improved access to historical data
- the standardisation and wider (potentially global) availability of data archives
- the incorporation of data collection and analysis services into projects offering data services to third parties
- incorporating measured or modelled data into model compositions via web services, in real time, if required
- offering project data analyses results as websites.

Within UNITED different models and algorithms are being used along the service chain. They start to be used at the data pre-processing level to handle the data acquired from different data providers (this usually means different formats, different time and space resolutions and even different levels of accuracy) and merge them to provide a harmonized view of the processes to be addressed. This, beyond the formatting harmonization process, also means to perform another type of analysis to identify the potential existence of data gaps, data outliers or trends that may indicate a loss of accuracy along time.

Once all data sets are considered ready to be used another set of algorithms may be used to perform different types of statistical analysis or to extract some relevant indicators for the user activity. Similar statistical analysis algorithms are also used to keep a continuous check on the model's performance by means of a comparison against the available data.

Finally, in the last phase of the service chain, in the presence of all data sets and model results another set of algorithms is used to extract focused information from the large amount of data gathered along the whole process. This information may be the result of combining different data sets (for instance analyse several parameters to derive an indicator that may trigger an alert) or just the result of the analysis of a single data set (for instance transform a continuous time series in a sequence of coloured indicators).

3.2. Data

As referred to before, in UNITED, several different data sources, (Earth Observation (EO), local sensors, modelling, etc.) later detailed on this document, may be used to derive the information. The data sets produced from these different data sources usually require some type of treatment (transformation/adaptation) to make them usable by the common user either because they are too complex or too large. In the context of UNITED, these kinds of procedures are being applied to EO data, global and regional modelling data (from Copernicus, NOAA, etc.) and to some data sets being acquired by local sensors in "near" real time. In this chapter some of these procedures are detailed.

UNITED is making most use of Copernicus Marine Environment Monitoring Service both through the direct use of some EO data sets (SST, Cl-a, Turbidity, etc.) and global or regional modelling results.

Another part of UNITED data is coming from local sources (via data from monitoring or models). These data sets mostly refer to:

- Meteorology
- Waves
- Currents
- Water level
- Water turbidity
- Water temperature

- Salinity
- Oxygen level
- pH
- Chlorophyll-a

Some of these parameters are measured over an area with a low time frequency (case of satellite data or drones' missions for instance), over an area with a high time frequency (case of radars), locally with a high time frequency (case of sensors) or locally with a low time frequency (case of local sampling).

As a results, different algorithms are required to fit the data to the areas of interest, transform signals in an easy-to-use parameter (ex. transform a frequency acquired by a satellite in turbidity), adjust formats, check for consistency, etc.

In most cases, automatic data discovering and uploading procedures are set-up to guarantee that the users always have access to the most up-to-date data sets. In these cases, a service is looking at regular intervals if new data sets have been published and, if it is the case, it automatically initiates the data uploading process.

3.3. Data pre-processing tools

As previously referred there may have many data sources being imported from different providers that require to be properly processed to be possible to make them available to be used in the platform. The procedures taking place in this phase involves proper actions to, i) assure that all data sets are kept in standard formats; ii) assure a first automatic screening to detect eventual issues that require some action (data gaps, outliers, etc.); iii) assure that the data that will be required to be used by the high resolution models has the proper spatial and temporal resolution.

The available pre-processing tools include (among others) algorithms for outliers' identification (and removal), noise reduction, data association or spatial alignment for instance.

3.4. Models and algorithms

The platform offers the capability to execute models and algorithms on demand or at scheduled intervals. The work cycle for a model/algorithm execution is assumed to follow a sequence as shown in Figure 1:

- Data Preparation or model input
    - Boundary conditions
    - Initial conditions
- Model Execution
- Data Extraction

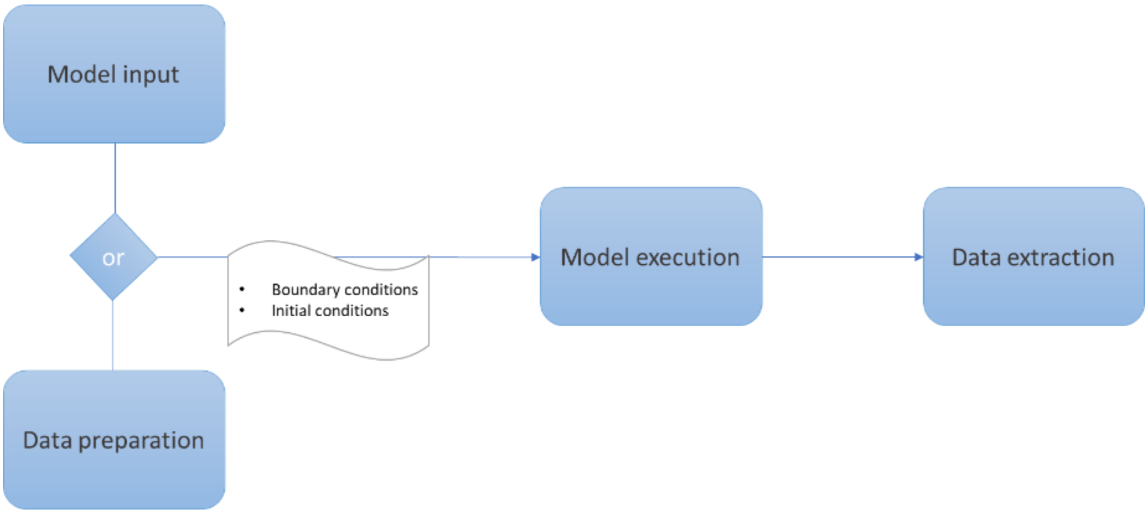

Figure 1: Model execution workflow

In the case of model's execution, the initial conditions may be obtained from the results of previous executions. This will be referred to as "Hotstart", as opposed to "Coldstart" when initial conditions are set from other sources or default values.

These models can simulate different processes such as waves, hydrodynamics and water quality. In all cases, Copernicus global or regional models' data is being used to define the boundary and initial conditions and to keep a continuous validation process.

3.5. Post-processing tools

Post-Processing methods are used to evaluate the data gathered by the data sources as well as the outputs of the various predictive models and algorithms that are employed to extrapolate predictive data.

In the post-processing phase, data analysis helps to evaluate how well the data satisfies the assumptions of specific statistical analysis, and often gives preliminary indications of trends and sets the stage for further trend analysis. Visual inspection of spatial data is recommended before proceeding with more detailed analysis techniques. For instance, spatial pattern analysis can be used to describe the distribution of the value of certain parameter across the area of interest, and ensemble forecasting may help to indicate the range of possible future states of the atmospheric forcing fields.

3.6. Warnings and alerts

The alarms service allows the detection of a threshold exceedance and triggers the respective notifications to selected users. The alarms service is part of a wide risk assessment and analysis tool which delivers a logical and systematic procedure focused on the identification of the events that could generate a dangerous situation related to a specific activity. The user can set up a threshold (or group of thresholds) and receive alerts whenever the predefined value(s) are exceeded.

The goal is to identify the conditions that can affect daily operations and, for each site, specify thresholds which identify potential operation restrictions. Then, a specific algorithm assesses these potential restrictions affecting that area in the upcoming hours or days, providing alerts and information on safe operation windows. Notifications may be sent through the web and mobile app or via SMS.

4. UNITED SERVICES

4.1. General overview

The provision of UNITED services relies on ICT HiSea platform, developed in the framework of the previous EU HiSea project (for details check Deliverable D2.1). HiSea platform is capable of properly managing different types of data (including near real time data from monitoring networks, in-situ data from local sampling, and remote sensing data), models and algorithms (providing both diagnostic and forecasting capabilities) and publish/distribute information in fitted to use forms.

Although some of the services may be provided on demand (to simulate scenarios for instance), most of the services are required to be processed in an automated way. This is the case of the forecasting or alert services, or data acquisition from different sensors and/or external data bases for instance.

The definition of these automated (and on demand) services was (and is keeping being) agreed with the pilots to assure that they effectively deliver information of their interest. For the moment the automated services include the data acquisition process (the platform automatically acquires new data from identified data sources as soon as it is available) and the provision of information about proper operational windows (that meet the restrictions defined for each site). This last feature is materialized on a decision support system (DSS).

4.2. Economic, technological and environmental benefits

The UNITED services have a beneficial economic impact as they contribute to increase the safety and contributes to optimize operations. As a by-product, the results can also provide benefits in what concerns water quality (by providing an effective hydrodynamic forecast upon which it may be simulated in real time the probable fate of an identified pollutant).

Being the sea storms are responsible for a multitude of incidents in the seas and their prevention is certainly a step forward for the protection of the EU maritime environment. In relation to this, there is an increased demand for improved forecasting of hydro/meteo reliable data relevant to determining the operational limits.

This demand can be at least partly met due to significant improvements achieved in the fields of measurement and forecasting of hydro/meteo parameters, availability of very powerful computing resources at historically low costs and proliferation of technology to communicate these forecasts in a near real-time fashion to a wide variety of onshore and offshore users.

The knowledge that the project can generate would be very beneficial for other groups, which would further develop the ideas and methods spearheaded in the project. The close contact with users would guide through the most demanding ideas and would ensure a constant linkage to their demanding operational requirements and stimulate the development of innovative and efficient technical solutions. As a result, the innovation capacity is enhanced as project outcomes would be exploited in a foreseeable future.

The project builds upon previous experiences in providing operational services capable to provide advanced sea storm forecasts and real time forecasts of pollutants transport and dispersion.

The services also contribute to answer some of the concerns identified in the National Ocean Strategy 2013-2020 Action Plan, namely in the Programmatic Area of the Ocean, in what concerns the need to create and operationalize a numerical modelling infrastructure that may provide forecasts of the sea water level taking in consideration of the combined effects of meteorological pressure, wave climate and tides.

They also have the potential to contribute to the achievement of the Good Environmental Status (GES) in the European marine and coastal waters by contributing to sea safety trough an improved sea storms forecasting system and to an increased efficiency in responding to sea pollution events, the outputs from the project are directly contributing for this objective.

4.3. Implemented services to date

The following pages provide a list of all the automated data acquisition services for each pilot. There are being acquired data sets from providers such as CMEMS, EMODNET, DWD, NOAA and GLOSS (a list of the parameters is described in Table 1 to Table 5). Once acquired the data is subject to a first screening (as part of the quality check) and provided to the users in an intuitive way (see examples in Figure 1 to Figure 5).

The DSS details are provided in Deliverable D2.5. The DSS executes autonomously in the platform daily at 00:10, taking as input the forecasted values of waves (period, height, and direction), weather (wind speed, atmospheric pressure), and currents (intensity and direction). Other parameters (restrictions) may be added if required.

Note that the below described services represent the status at the time of production of this document but as also stated in D2.1, these types of systems must be kept alive and subject to continuous updating and adaptation of the users. So, new services will be added as they are required.

Table 1: Data services available for the German pilot

Provider	Name	OBSERVATION / MODELS	TEMPORAL RESOLUTION	UPDATE FREQUENCY	SPATIAL RESOLUTION
CMEMS	FORECAST_PHY_004_013	numerical-model	hourly; daily-mean; 15-min (33 levels)	daily (12h)	0.014° x 0.03°
CMEMS	FORECAST_PHY_LR_004_001	numerical-model	daily mean (24 levels)	daily (12h)	0.111° x 0.067°
CMEMS	OBSERVATIONS_013_036	River flow	Minutes	daily	Point
	OBSERVATIONS_013_036	Sea level	Minutes	daily	Point
	OBSERVATIONS_013_036	Waves	Minutes	daily	Point
CMEMS	FORECAST_WAV_004_014	numerical-model	hourly	daily (12h)	0.014° x 0.03°
CMEMS	FORECAST_BGC_004_002	numerical-model	daily mean	daily (12h)	0.111° × 0.067°
CMEMS	L3_NRT_OBSERVATIONS_009_036	Satellite observations	daily mean	daily(18:00)	0.3km × 0.3km
CMEMS	L4_NRT_OBSERVATIONS_009_037	Satellite observations	daily mean	daily (20:00)	1km × 1km
CMEMS	L4_NRT_OBSERVATIONS_010_025	Satellite observations	daily mean	daily (12:00)	0.02° × 0.02°
CMEMS	L4_NRT_OBSERVATIONS_010_001	Satellite observations	daily mean	daily (08:00; 12:00 UTC)	0.05° × 0.05°
DWD	ICON 7 km	numerical-model	hourly	daily (00h, 12h)	7 km x 7 km
DWD	ICON 3 km	numerical-model	hourly	daily (00h, 12h)	3 km x 3 km
NOAA	GFS 25 km	numerical-model	hourly	daily (00h, 06h, 12h, 18h)	25 km x 25 km
METAR	Westerland, Germany	Meteorology	hourly	near real time	Point
METAR	Esbjerg Airport (Denmark)	Meteorology	hourly	near real time	Point
GLOSS	Cuxhaven	Sea level	minutes	near real time	Point
GLOSS	Helgoland Binnenhafen	Sea level	minutes	near real time	Point
GLOSS	Hörnum	Sea level	minutes	near real time	Point
GLOSS	Borkum Fischerbalje	Sea level	minutes	near real time	Point
EMODNET	Hoernum	Sea level, water temperature	minutes	near real time	Point
EMODNET	Radar Station Sylt	Radar Station (Currents)	minutes	near real time	Point
EMODNET	NOO	Water Temperature,Waves	minutes	near real time	Point
EMODNET	Butendiek	Waves	minutes	near real time	Point
EMODNET	FINO3WR	Water Temperature, Waves	minutes	near real time	Point
EMODNET	NsbIII	Meteorology, Water conductivity, BioGeoChemic, Water salinity,Water Temperature	minutes	near real time	Point
EMODNET	NsbII	Meteorology, Water conductivity, BioGeoChemic, Water salinity,Water Temperature	minutes	near real time	Point

Table 2: Data services available for the Dutch pilot

Provider	Name	OBSERVATION / MODELS	TEMPORAL RESOLUTION	UPDATE FREQUENCY	SPATIAL RESOLUTION
CMEMS	FORECAST_PHY_004_013	numerical-model	hourly; daily-mean; 15-min	daily (12h)	0.014° x 0.03°
CMEMS	FORECAST_PHY_LR_004_001	numerical-model	daily mean (24 levels)	daily (12h)	0.111° x 0.067°
CMEMS	OBSERVATIONS_013_036	River flow	instantaneous	daily	Point
CMEMS	OBSERVATIONS_013_036	Sea level	instantaneous	daily	Point
CMEMS	OBSERVATIONS_013_036	Waves	instantaneous	daily	Point
CMEMS	FORECAST_WAV_004_014	numerical-model	hourly	daily (12h)	0.014° x 0.03°
CMEMS	FORECAST_BGC_004_002	numerical-model	daily mean	daily (12h)	0.111° × 0.067°
CMEMS	L3_NRT_OBSERVATIONS_009_036	Satellite observations	daily mean	daily(18:00)	0.3km × 0.3km
CMEMS	L4_NRT_OBSERVATIONS_009_037	Satellite observations	daily mean	daily (20:00)	1km × 1km
CMEMS	L4_NRT_OBSERVATIONS_010_025	Satellite observations	daily mean	daily (12:00)	0.02° × 0.02°
CMEMS	L4_NRT_OBSERVATIONS_010_001	Satellite observations	daily mean	daily (08:00; 12:00 UTC)	0.05° × 0.05°
DWD	ICON 7 km	numerical-model	hourly	daily (00h, 12h)	7 km x 7 km
DWD	ICON 3 km	numerical-model	hourly	daily (00h, 12h)	3 km x 3 km
NOAA	GFS 25 km	numerical-model	hourly	daily (00h, 06h, 12h,	25 km x 25 km
METAR	Goeree Le, Netherlands	Meteorology	minutes	near real time	Point
METAR	Euro, Netherlands	Meteorology	minutes	near real time	Point
METAR	P11-b, Netherlands	Meteorology	minutes	near real time	Point
METAR	Hoorn-a, Netherlands	Meteorology	minutes	near real time	Point
METAR	K14-fa-1c, Netherlands	Meteorology	minutes	near real time	Point
METAR	K13-a, Netherlands	Meteorology	minutes	near real time	Point
GLOSS	Hoek van Holland	Sea level	minutes	near real time	Point
GLOSS	Scheveningen	Sea level	minutes	near real time	Point
GLOSS	Europlatform	Sea level	minutes	near real time	Point
EMODNET	IJmondstroompaal	Currents	minutes	near real time	Point
EMODNET	Ijmuiden	Sea Level, Water Temperature	minutes	near real time	Point
EMODNET	MATROOS - Monster	Radar (Currents)	minutes	near real time	Point
EMODNET	HoekVanHollandNAP	Water salinity, Water Temperature	minutes	near real time	Point
EMODNET	EurogeulE13	Waves	minutes	near real time	Point
EMODNET	Europlatform	Sea Level, Water Temperature, Waves, Winds	minutes	near real time	Point
EMODNET	IJmuidenMunitiestort	Water Temperature, Waves	minutes	near real time	Point

Table 3: Data services available for the Belgian pilot

Provider	Name	OBSERVATION / MODELS	TEMPORAL RESOLUTION	UPDATE FREQUENCY	SPATIAL RESOLUTION
CMEMS	FORECAST_PHY_004_013	numerical-model	hourly; daily avrg; 15-min (33 levels)	daily (12h)	0.014° x 0.03°
CMEMS	FORECAST_PHY_LR_004_001	numerical-model	daily mean (24 levels)	daily (12h)	0.111° x 0.067°
CMEMS	OBSERVATIONS_013_036	Sea level	minutes	near real time	Point
CMEMS	OBSERVATIONS_013_036	River flow	daily avrg	daily	Point
CMEMS	OBSERVATIONS_013_036	Waves	minutes	near real time	Point
CMEMS	FORECAST_WAV_004_014	numerical-model	hourly	daily (12h)	0.014° x 0.03°
CMEMS	FORECAST_BGC_004_002	numerical-model	daily avrg	daily (12h)	0.111° × 0.067°
CMEMS	L3_NRT_OBSERVATIONS_009_036	Satellite observations	daily avrg	daily(18:00)	0.3km × 0.3km
CMEMS	L4_NRT_OBSERVATIONS_009_037	Satellite observations	daily avrg	daily (20:00)	1km × 1km
CMEMS	L4_NRT_OBSERVATIONS_010_025	Satellite observations	daily avrg	daily (12:00)	0.02° × 0.02°
CMEMS	L4_NRT_OBSERVATIONS_010_001	Satellite observations	daily avrg	daily (08:00; 12:00 UTC)	0.05° × 0.05°
DWD	ICON 7 km	numerical-model	hourly	daily (00h, 12h)	7 km x 7 km
DWD	ICON 3 km	numerical-model	hourly	daily (00h, 12h)	3 km x 3 km
NOAA	GFS 25 km	numerical-model	hourly	daily (00h, 06h, 12h, 18h)	25 km x 25 km
METAR	Ostend–Bruges International	Meteorology	minutes	near real time	Point
METAR	Koksijde Air Base	Meteorology	minutes	near real time	Point
GLOSS	Ostend	Meteorology	minutes	near real time	Point
GLOSS	Vlakte v/d Raan	Meteorology	minutes	near real time	Point
GLOSS	Breskens Handelshaven	Meteorology	minutes	near real time	Point
EMODNET	Westhinder	Sea Level, Water Temperature, Waves, Winds	minutes	near real time	Point
EMODNET	Kwintebank	Water Temperature, Waves	minutes	near real time	Point
EMODNET	OostendNorth	Water Temperature, Waves	minutes	near real time	Point
EMODNET	Wandelaar	Water Temperature, Waves, Winds	minutes	near real time	Point
EMODNET	WandelaarTG	Sea Level, Winds	minutes	near real time	Point
EMODNET	ScheurWielingenTG	Sea Level, Winds	minutes	near real time	Point
EMODNET	ThorntonbankSouth	Water Temperature, Waves	minutes	near real time	Point

Table 4: Data services available for the Danish pilot

Provider	Name	OBSERVATION / MODELS	TEMPORAL RESOLUTION	UPDATE FREQUENCY	SPATIAL RESOLUTION
CMEMS	FORECAST_PHY_003_006	numerical-model	hourly; daily avrg; 15-min (33 levels)	daily (12h)	2 km x 2 km
CMEMS	OBSERVATIONS_013_036	Sea level	minutes	daily	Point
CMEMS	OBSERVATIONS_013_036	River flow	daily avrg	daily	Point
CMEMS	OBSERVATIONS_013_036	waves	minutes	daily	Point
CMEMS	FORECAST_WAV_004_014	numerical-model	hourly	daily	Point
CMEMS	FORECAST_BGC_003_007	numerical-model	daily avrg	daily (12h)	2km × 2km
CMEMS	L3_NRT_OBSERVATIONS_009_036	Satellite observations	daily avrg	daily(18:00)	0.3km × 0.3km
CMEMS	L4_NRT_OBSERVATIONS_010_025	Satellite observations	daily avrg	daily (12:00)	0.02° × 0.02°
CMEMS	L4_NRT_OBSERVATIONS_010_001	Satellite observations	daily avrg	daily (08:00; 12:00 UTC)	0.05° × 0.05°
DWD	ICON 7 km	numerical-model	hourly	daily (00h, 12h)	7 km x 7 km
DWD	ICON 3 km	numerical-model	hourly	daily (00h, 12h)	3 km x 3 km
NOAA	GFS 25 km	numerical-model	hourly	daily (00h, 06h, 12h,	25 km x 25 km
METAR	Copenhagen Airport	Meteorology	minutes	Near real time	Point
EMODNET	Kobenhavn	Sea Level, Water Temperature	minutes	Near real time	Point
EMODNET	Flinten7BS	Sea Level, Water Temperature	minutes	Near real time	Point
EMODNET	DrogdenCU	Sea Level, Water Temperature	minutes	Near real time	Point
EMODNET	Ale	Meteorology, Water Temperature	minutes	Near real time	Point

Table 5: Data services available for the Greek pilot

Provider	Name	OBSERVATION / MODELS	TEMPORAL RESOLUTION	UPDATE FREQUENCY	SPATIAL RESOLUTION
CMEMS	FORECAST_PHY_006_013	numerical-model	hourly; daily avrg; 15-min (141 levels)	daily (16h)	0.042° × 0.042°
CMEMS	FORECAST_WAV_006_017	numerical-model	hourly	daily (12h)	0.042° × 0.042°
CMEMS	FORECAST_BGC_006_014	numerical-model	daily avrg	daily (22:00h)	0.042° × 0.042°
CMEMS	L3_NRT_OBSERVATIONS_009_040	Satellite observations	daily avrg	daily(20:00)	0.3km × 0.3km
CMEMS	L4_NRT_OBSERVATIONS_009_041	Satellite observations	daily avrg	daily(20:00)	0.3km × 0.3km
CMEMS	L4_NRT_OBSERVATIONS_010_001	Satellite observations	daily avrg	daily (08:00; 12:00 UTC)	0.05° × 0.05°
DWD	ICON 7 km	numerical-model	hourly	daily (00h, 12h)	7 km x 7 km
DWD	ICON 3 km	numerical-model	hourly	daily (00h, 12h)	3 km x 3 km
NOAA	GFS 25 km	numerical-model	hourly	daily (00h, 06h, 12h, 18h)	25 km x 25 km
METAR	Athens International Airport	Observations	minutes	instantaneous	Point

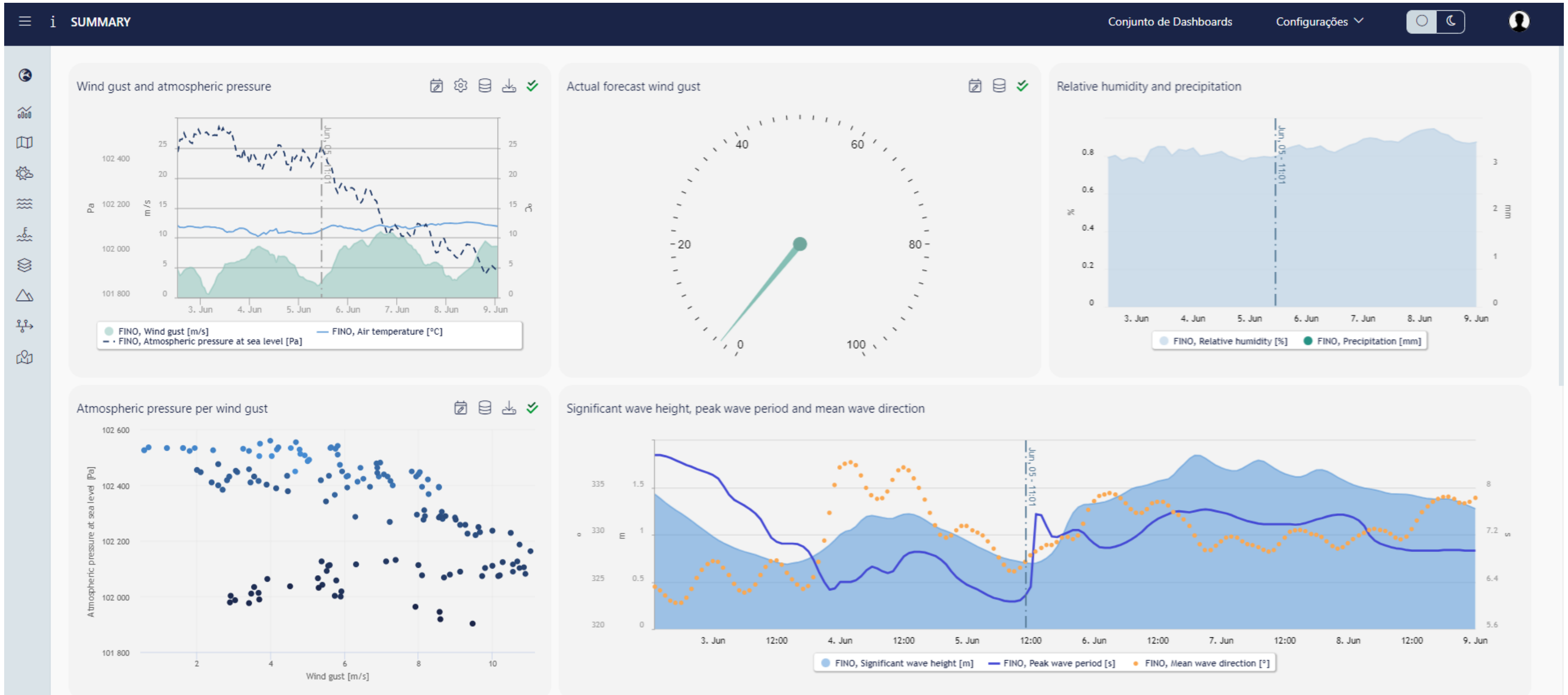

Figure 2: Example of a dashboard summarizing meteo-oceanographic information.

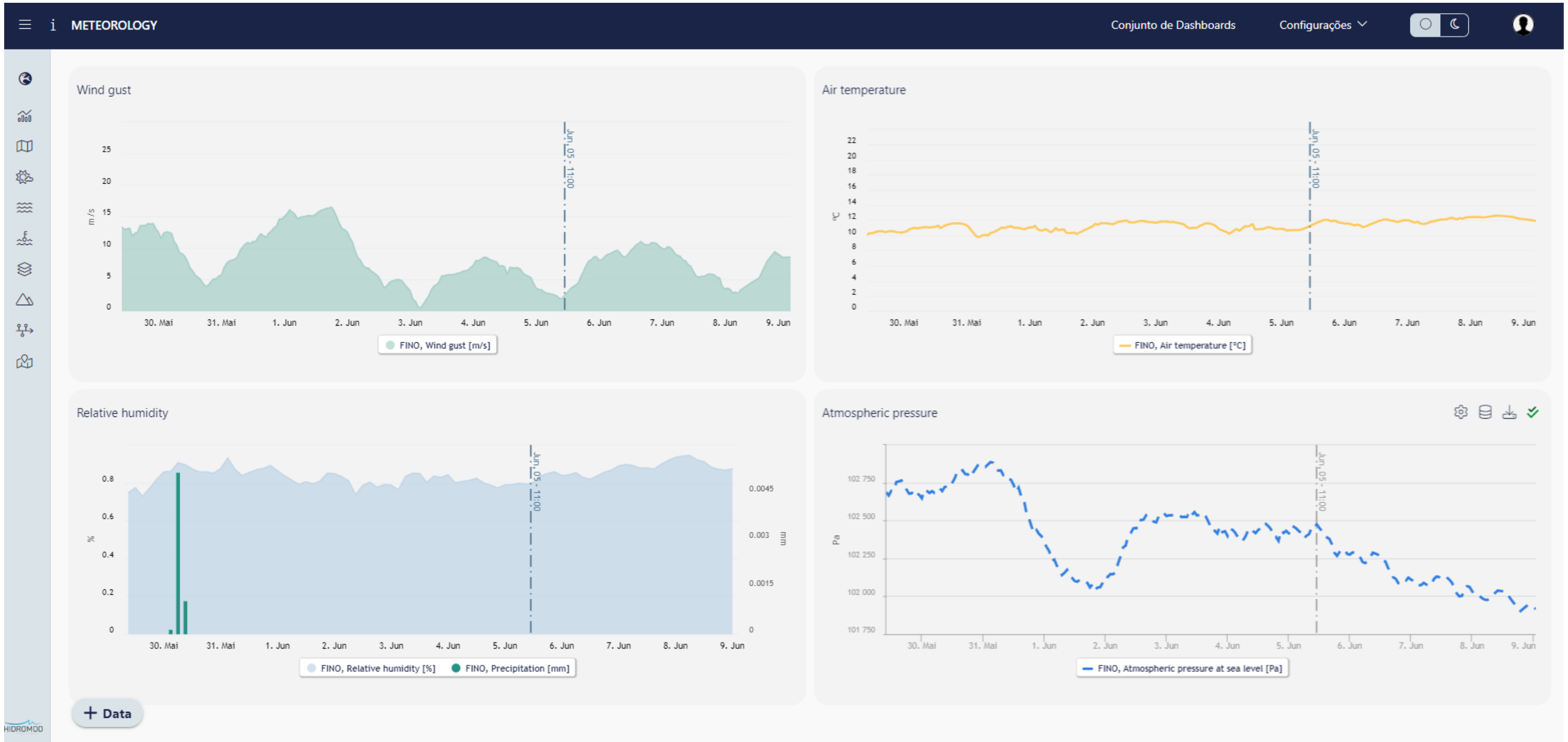

Figure 3: Example of a dashboard summarizing meteorologic information.

Figure 4: Example of a dashboard identifying some key relations between the water quality and the meteo-oceanographic conditions.

Figure 5: Example of a dashboard detailing meteorologic information.

5. CONCLUSIONS AND RECOMMENDATIONS

This document provides an overview of the automated data acquisition and distribution services already implemented in UNITED, based on the technologies described in D2.1. These services are based on integrated data acquired both from external data providers and from in-situ measurement devices and include both remote sensing data and local data.

The presently available services represent the result of a dialog with the different pilots, and they have the purpose of answering concrete questions and concerns. As new concerns and questions are identified by the users, the flexibility of the platform to accommodate a new service chain assures an easy and smooth integration of new services as required. This versatility is not limited to the UNITED pilots, which assume here a role of demonstrators, but is also extendible to other sites for which there may be identified a need and for which there is proper data available. This goal of assuring that the technology implemented and tested in the framework of the project may indeed benefit the whole industry and it is not limited to the demonstration sites.

At this point the platform is fully ready to acquire data sets from the most diverse origins and providers and workout these data sets to produce and distribute user fitted information. To further test and demonstrate the available capabilities it is important to increase the dialog with the pilots to identify new services that may be useful to them and, in this way, work as examples for other new potential users. Building awareness and demonstrating the added value of automated services takes time and consistent effort, so, to attract new users and demonstrate the added value of automated services, some strategies may be followed:

- Clearly communicate the benefits: Highlight the advantages and value propositions of Ocean Digital Twins in a concise and compelling manner. Clearly explain how it can solve specific problems or improve existing processes. Focus on key benefits such as increased efficiency, cost savings, enhanced decision-making, and improved resource utilization.
- Develop engaging content: Create informative and visually appealing content to educate potential users about the capabilities and features of Ocean Digital Twins. This can include blog posts, whitepapers, case studies, infographics, and videos. Use real-world examples and success stories to illustrate the solution value.
- Target relevant industries: Identify industries and sectors where Ocean Digital Twins can have the most impact and focus your marketing efforts on those areas. Tailoring the messaging and content to address the specific pain points and challenges faced by these industries may result in easy to understand showcases to explain how the proposed solutions can be effective.
- Offer free trials or demos: Provide prospective users with an opportunity to experience the benefits of Ocean Digital Twins firsthand. Offer free trials or demonstrations to showcase the functionality and value of your automated services. This allows potential customers to explore the platform, understand its capabilities, and assess its suitability for their specific needs.
- Provide testimonials and references: Collect testimonials and feedback from existing users who have experienced positive results with Ocean Digital Twins (in this case the pilots). These testimonials may be used to build trust and credibility with potential customers.
- Partner with influencers and industry experts: Collaborate with influencers and experts in relevant industries who can endorse and promote your automated services. Their credibility and reach can help increase awareness and attract new users. Consider hosting webinars, podcasts, or panel discussions featuring these influencers to further amplify your message.
- Engage in targeted advertising and marketing campaigns: Utilize digital marketing channels such as social media advertising, search engine marketing, and targeted email campaigns to reach the target audience. Leverage data analytics and user profiling to identify potential customers and deliver tailored messages that highlight the benefits of Ocean Digital Twins.
- Attend industry events and conferences: Participate in relevant trade shows, conferences, and industry events to showcase Ocean Digital Twins. Use these opportunities to connect with potential customers, network with industry professionals, and deliver engaging presentations or demonstrations.
- Provide exceptional customer support: Offer excellent customer support to ensure that users have a positive experience with your automated services. Address their queries promptly, provide comprehensive

documentation, and offer training resources to help them maximize the value of Ocean Digital Twins. Satisfied customers are more likely to recommend your solution to others.

- Continuously iterate and improve: Gather feedback from users and iterate on the available solutions based on their needs and suggestions. Regularly release updates and enhancements to demonstrate the commitment to delivering ongoing value and staying ahead of the competition.

As stated in this document introduction, the benefits for users that may be drawn from these type of services have the potential to offer relevant added value in terms of safety and economic return (avoid unnecessary risks or better plan the location of new businesses for instance) while also contributing for a better public image by demonstrating the care with environment. Of course, the success of such a system depends on whether it is embraced by users. To this end, the accuracy and the reliability of the provided information are of crucial importance to attract and retain users. After implementing a coherent and effective service chain which results in an operational service, UNITED assures that the service remains continuously available and reliable.

For example, it would not be very useful to have a service that is running 99% of the time but fails in the crucial moment when it may be most needed (such as a storm occurrence for instance) or keeps issuing false alerts.

To demonstrate the system performance on these issues, UNITED assures the maintenance of a proper auditing plan is of major importance. By this way it is possible to keep the existing users informed about the system performance, demonstrate to new users the service level that they can expect to receive and adopt timely corrective or preventive measures to assure a continuous service improvement.

REFERENCES

HISEA Deliverable 3.6. Report on technical requirements for the service platform

HiSea Deliverable 5.1. Web and Mobile Clients Prototype I

HiSea Deliverable 5.2. Web and Mobile Clients Prototype II

HiSea Deliverable 5.3. Service Tools Prototype_I

HiSea Deliverable 54. Service Tools Prototype_II

UNITED Deliverable 2.1. Toolbox for data analysis, visualization, and planning for decisions makers

UNITED Deliverable 2.5. Strategic and cooperative Decision Support