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***Abstract*—In recent years, the interest in the study of seas and oceans has dramatically increased as they are considered of primary importance for forecasting catastrophic events or for supporting blue economy, as well as the marine tourism, improving the tourist reception or enhancing any marine-related activity. This led to the development of IT platforms that allow to monitor the marine environment and provide a number of services to different kinds of final users, whether they are private individuals interested in the status of the seas, or companies whose business depends on the marine environmental monitoring. The main limitations of current platforms are due to such a difference between free trials, which often focus only on specific aspects of deep waters, and subscriptions, which provide analyzes whose reliability is generally not proportional to the costs. This paper presents SmartWave, a project funded by Regione Sicilia (European Regional Development Fund), that aims to develop a novel IT platform to observe and predict phenomena that characterize the marine environment, while also providing the consumer with a unified portal to collect, access and analyze marine-related information. To achieve this goal, one of the main challenges of this project is to aggregate and standardize heterogeneous data from multiple sources in order to offer very accurate information to private or business consumers.**

***Index Terms*—Marine environmental monitoring, cloud computing, web-gis**

I. Introduction and State-Of-Art

Nowadays, seas and oceans represent a valuable source of growth and prosperity for the citizens of the entire world. According to the latest European Union report, the seas and oceans provide us not only with food, jobs, transport and recreation, but also pharmaceuticals, minerals and sources of renewable energy. In this context, the knowledge of meteorological parameters is of uppermost importance in the economy of the sea and, specifically, for the identification and assessment of coastal risk, the proper design of coastal defense works, the construction of new port facilities, and more generally the management of activities related to the economy of the sea, also referred as *Blue Economy*. International competitions, such as the American's Cup, are an example of how the monitoring of the marine environment and the blue economy are closely interconnected: the meteorological information is of interest both for the participants, who must adopt the appropriate navigation strategies, and for the audience, who wants to enjoy the competition in a safe and controlled environment.

All these factors have led over the years to the development of novel solutions among which one of the most interesting is Copernicus[1]. This project provides global and publicly accessible data obtained from satellites ground-based, airborne, and seaborne measurement systems in order to help service providers in the development of platforms able to monitor the marine environment, and behind. These platforms not only focus on spatial analysis, decision making and future planning, but they also provide to end users integrated Web-based applications visualizing the final results of scientific efforts via maps and graphs [1]. A reliable example is represented by Windy[2], a platform that exploits one of the Copernicus services and allows both commercial and private entities to access to visual information about various weather elements, such as cloud cover, wave swell, temperature and wind speeds. Another interesting tool is the Marine Environment and Monitoring Service [2], which provides state of the art long time series, analysis and forecast products about the physical state of the ocean and marine ecosystems. Finally, MetOcean[3] is a very complete platform that offers several services, from the weather forecast to long waves analysis, to study marine phenomena and support an accurate management of seas and oceans; its main drawback is that most of the provided services are not for free. Although these platforms represent valid options, what currently still represents an obstacle to any sea-related activity is the lack of solutions that allow people for an easy, precise, and open access to information about the marine weather climate. Indeed, free global marine weather data providers are focused on offshore wave characterization, while nearshore data providers often have questionable reliability and high costs. In addition, the large amount of data handled by these types of providers often requires specific technologies and analytical methods to extract the data of interest to the user. This results in limited interest in available products from the target market.

In this paper, we present an early description of an innovative platform, funded by Regione Sicilia (European Regional Development Fund), that aims to provide marine weather information to support all activities related to the sea and

[1]https://www.copernicus.eu/en
[2]https://www.windy.com/
[3]https://www.metocean.co.nz

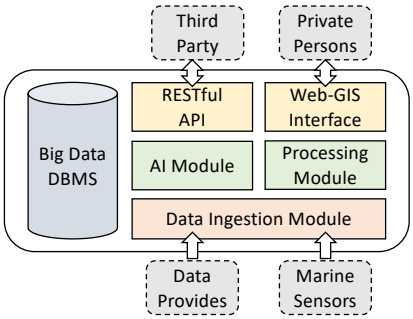

Fig. 1: Conceptual architecture for the considered scenario.

the blue economy. In particular, the SmartWave platform will provide all the information on a global scale, at different levels of accuracy, both offshore and shallow nearshore, and will be accessible through a WebGIS portal.

The innovation of the solution we propose lies in the ability to collect, consult and analyze in a single portal meteorological heterogeneous data collected from various sources and related to any offshore or nearshore area. This task represents one of the main characteristics of the proposed system that differentiates it from other platforms, which often work only on specific data retrieved by homogeneous sensors. Indeed, the SmartWave project foresees the homogenization of such heterogeneous data in order to provide a single standard both to consumers who require data for a specific marine area, and to the system itself that will be facilitated in the processing phase.

II. System Architecture

The main goal of the proposed system consists in collecting, aggregating and analyzing various kinds of marine data in order to provide to the blue economy's stakeholders high quality information. In this sense, the system is required to be highly flexible to collect and manage different representation formats, as well as to support heterogeneous data processing through properly chosen cutting edge statistical and Artificial Intelligence (AI) algorithms. All these requirements can be satisfied by adopting the cloud computing paradigm [3], which guarantees high computational and storage resources, as well as an efficient delivery of different kinds of services to the consumers. In particular, the logic of the system we present adopts the flexible and modular architecture shown in Fig. 1.

The lowest layer of the architecture is represented by the *Data Ingestion Module* (DIM), which aims to collect and aggregate marine offshore and nearshore data from (i) sensors deployed into the marine environment, by leveraging the existing sensing networks, and (ii) third party providers whose data can be acquired by means of specific services or custom APIs. Given the high degree of data heterogeneity, it is crucial to have a uniform representation of the data for future elaborations. To this aim, the DIM internally employs several plug-in modules, each of which is able to work with different data formats. When a new data format has to be included into the system, it can be extended with a new module, without having to redesign the entire architecture. It is important to note that this approach may cause the system to have data containing redundant information, e.g. multiple wind vectors about the same area; nevertheless, this aspect is very useful for providing more accurate information, resulting in a better user experience while using the proposed system.

After uniforming data, the DIM shares them with the middle layer which is composed of modules able to interact with a *Big Data*-based DBMS and perform expensive analysis in terms of computation and resource consumption. Here, the *AI module* can be used for different tasks, from the marine environmental monitoring to the optimization of the marine resources through the reinforcement learning approach [4]; for instance, AI can be employed to monitor issues related to pollution, habitat, species, and climate change impact in order to ensure sustainability and a healthy ocean. In addition, the adoption of the Big Data paradigm [5], combined with analytics performed by the *Processing Module*, has the potential to enable the platform to forecast critical situations in a faster and more effective way, thus giving companies, or private users, insights about marine weather evolution allowing for the selection of appropriate measures, in a timely manner.

At the highest level, the platform deals with the data presentation allowing consumers for accessing to real-time data, the history of the marine weather, or forecasted information. Here, the platform is able to serve consumers that can be grouped in two macro-categories, i.e. private persons and third party entities. For the first ones, the platform will present a *Web-GIS interface* that provide easily accessible graphical information through a standard web browser; the system will exploit the features of the web standard to improve the user experience while maintaining a broad compatibility, such as the possibility to center the map in the preferred location, or select a specific area of interest by drawing a circle. For third party consumers, the platform will offer the *RESTful API* enabling a direct interaction with the data and services offered by the platform itself, using machine-readable data. For example, these APIs could be used by Public Authorities that need high-level data for safety purposes or by company that need raw data to carry out their own processing.

III. Application Scenarios

The platform we propose aims to provide a plethora of services in order to not only allow consumers to visualize, manipulate and extract every kind of information they want, but also to forecast and manage critical situations. The offered services will be made accessible to different users according to the desired needs [6]; simple consumers will be able to access the information of interest through a visual representation, such as a Web-GIS interface; companies will instead be able to use the Rest API provided by the system in order to allow complete analysis separate from the system itself.

A. Services for private users

The information about weather and sea are important for people who need to travel for both work and leisure. Indeed,

the knowledge about what the weather will be like before a journey allows the travelers to take all the necessary precautions to avoid unpleasant consequences. For example, if before going offshore by boat, the data regarding the height of the waves state that they will be dangerously high on the route to be followed, the traveler can take the proper measures by choosing the appropriate boat or postponing the departure, thus avoiding displeasing situations. This particular situation is not the only one possible, indeed same reflections could be made in case of strong winds, heavy rains or storms. The system will be designed to provide updated information on the weather and the sea, this will be useful to the user also for onshore activities, for example, marine sports, fishing or simply to control the actual weather on the coast. Furthermore, the platform will allow the user to plan his activities by setting days and areas of interest. He will be notified if there are alerts in the days and areas selected, receiving advice and suggestions and/or will be provided with the weather conditions.

B. Services for business consulting

The importance of data and data analytics became central in business organizations with different objectives. In order to pursue these purposes, a company must have the tools to make informed decisions based on relevant data. The service provided by the platform may be a great support for decision making for every kind of business operating in the marine environment (onshore or offshore) or, generally, for the ones that see their services strongly influenced by weather conditions. The availability of data and the analyses on the data offered by the platform fit perfectly with what a business needs. Some examples could be airlines as well as shipping companies, these actors must absolutely exploit data analysis to avoid going through potentially dangerous situations. In these cases, to simplify the work to this kind of businesses, the functionality of the platform will be highly useful. Indeed, it will be possible to select a route, or draw one, on the map and be updated on weather conditions (i.e. wind, wave height, and so on). Moreover, the platform will notify in advance if there may be critical situations on the selected route. When there is a storm in progress, a route (by air or by sea) is certainly not safe, whether people or goods are being transported.

C. Services for Public Authorities

Public Authorities often have to take decisions concerning coastal area administration with the purpose to keep them safe or, more generally, for public works issues. Some of the factors of primary importance in the economy of the sea are the knowledge and the ability to understand and exploit meteorological parameters and indicators, as they result crucial in identifying and assessing coastal risk. Being able to assess coastal risk is a key factor for the realization of port and maritime infrastructure, such as for the proper design of coastal defense projects. The platform will be a great support for taking this type of decision as it can provide all the knowledge needed in this scenario, through all the data and analyses which are very useful for risk assessment. Furthermore, the verified Public Authorities registered on the platform will be updated on weather conditions especially when critical conditions are expected. Some examples could be: the forecast of high swells, or the forecast of strong thunderstorms, the announcement of a weather warning in time can make the difference between a simple atmospheric event and a catastrophe.

IV. Challenges

In this paper, we introduced SmartWave a Work-in-Progress project, funded by the Regione Sicilia, and with an expected completion date of late 2022. This project aims to overcome the limitations of current marine monitoring platforms, which lack solutions that can guarantee open, accurate, reliable and user-friendly services to the final consumers. To achieve this goal, the SmartWave project plans to equip the platform with the latest technologies provided by IT, such as big data and artificial intelligence, in order to offer highly flexible and high-performance services. These requirements raise enormous challenges to be addressed within the project, from modeling and analyzing marine data to forecasting catastrophic events, all while maintaining the platform scalable, efficient, and secure [7]. In addition to these challenges, there is also an additional issue, i.e., the homogenization of raw data from heterogeneous sources, an aspect that often is not properly addressed by competitors. In this sense, one of the main goals of the project is the definition of a data ingestion module able to homogenize the data [8] and make them available to the higher levels of the architecture for future elaborations.

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