SeaLoc: A pilot forecasting system providing sea characteristics and other support services on high local resolution

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Abstract
SeaLoc project aims in developing an integrated forecasting system with accompanying services for the Greek seas. Further development, however, can facilitate the whole Mediterranean region. It will provide interaction both with specialists as well as with everyday users through the internet and specialized applications, whose output will be in a format ready to be utilized by relevant target groups. The specialized applications will focus on identified needs of each target group, providing easy-to-comprehend thematic indices alongside the actual forecasts. The system consists of in-house wind and wave predictions as well as other crucial Copernicus Marine products (currents, salinity, SST, nitrate, plankton and dissolved oxygen). The great impact of the project derives from the fact that it combines current forecasting research developments along with available Copernicus Marine data/ services in an effort to bridge the gap between science and end-users. Additionally, the high spatial and temporal resolution in selected areas of marine-dependent financial importance, make SeaLoc a great decision-support tool towards local development and financial growth. Sectors than can benefit from such a tool are: coastal and marine tourism, fishing, aquaculture, shipping, coastal constructions, energy harvesting and others.
Keywords: marine forecasting; marine services; applied oceanography; high resolution oceanography

1. Introduction

High resolution and user-friendly oceanographic forecast data-as-services, are a prerequisite for many applications both professional and recreational. Whereas, scientific/ research developments in the field of sea parameter forecasting are remarkable today, only little of these breakthroughs reach users outside the scientific community. This gap has been identified and addressed through two consecutive funded projects (Greek NSRF 2007-2013 and 2014-2020), namely WaveForUs (Krestenitis *et al*., 2015) and its successor SeaLoc. OMIKRON SA has played a key role in both projects, while is also the leading partner of the latter. The core innovation of these efforts derives from the fact that two (2) private Greek SMEs are actively involved in sea forecast research, in order to bridge the gap between specialized scientific knowledge and public use. SeaLoc project aims in developing an integrated forecasting system with accompanying services for the Greek seas. It integrates in-house weather and sea wave forecasts in high spatial and temporal resolution, along with selected Copernicus Marine products. When finalized, it will provide interaction both with specialists as well as with everyday users through the internet and specialized applications, whose output will be in a user-friendly formats. The specialized applications will focus on the identified needs of each target group, providing easy-to-comprehend thematic indices alongside the actual forecasts. SeaLoc project, which is implemented by two (2) Greek SMEs (OMIKRON SA and DRAXIS SA) started in May 2018 and will be concluded in May 2021.

2. Method

2.1. In-house forecasts

The two collaborating Greek SMEs, OMIKRON SA and DRAXIS SA, having expertise in sea wave and weather forecasts respectively, have structured an in-house operational chain of processes for weather and sea wave forecast production, in high spatial and temporal resolution, on a daily basis. There are three forecasting domains with descending spatial resolutions. The weather forecasts are run on the following nesting domains: Mediterranean [lon min: -6,66, lon max: 36,00, lat min: 30,00, lat max: 47,36] with 18x18 km res., Greek Seas [lon min: 10,00, lon max: 27,46, lat min: 34,00, lat max: 42,02] with 6x6 Km res. and Aegean [lon min: 21,99, lon max: 27,45, lat min: 34,89, lat max: 41,31] with 2x2 km res.. The sea wave forecasts are run on the following nesting domains: Mediterranean [lon min: -7,00, lon max: 43,17, lat min: 30,00, lat max: 48,17] with 18,5x18,5 km res., Greek Seas [lon min: 13,36, lon max: 33,14, lat min: 33,74, lat max: 43,13] with 3,68x3,68 Km res. and Aegean [lon min: 22,43, lon max: 27,24, lat min: 37,42, lat max: 41,12] with 1,84x1,84 km res.. For the weather forecast the system uses the numerical weather model WRF-ARW (WRF4.0.1, MMML, 2019) which is set-up

appropriately for the aforementioned weather domains. It runs daily and produces wind (m/sec) at 10m height, every day at 12.00am with a forecasting span of the order of three days and hourly time steps. For the sea wave forecast the system uses the numerical third generation sea wave model WAVEWATCH III® (v. 5.16; WW3DG, 2016) which is set-up appropriately for the aforementioned sea wave domains. It runs daily by using the above mentioned winds as input, and produces significant wave height (m) and wave direction (degrees) every day at 07.00am with a forecasting span of the order of two days and hourly time steps. For the bathymetry, the wave model has been input with EMODnet's bathymetry, which has been analyzed to coincide with the spatial resolution of the aforementioned wave forecasting domains.

2.2. External products

SeaLoc system utilizes the Copernicus Marine platform, in order to enrich the information to be be serviced. Specifically, three (3) Mediterranean domain datasets, with 4,6x4,6 km spatial resolution, have been integrated, namely: (a) Med. Sea Physical Analysis and Forecasting Product (CMEMS-MED-PUM-006-013; Lecci *et al*., 2018), (b) Med. Sea Biogeochemistry Analysis and Forecasting Product (CMEMS-MED-PUM-006-014; Lecci *et al*., 2019) and (c) Med. Sea Waves Analysis and Forecast Product (CMEMS-MED-PUM-006-017; Korres *et al*., 2019). From CMEMS-MED-PUM-006-013, the system acquires (i) surface current velocity (m/sec), (ii) salinity (psu), (iii) sea surface temperature (^{o}C), (iv) potential bottom temperature (^{o}C), (v) sea surface elevation (m). The forecasting span is of the order of one day and the time steps are hourly. From CMEMS-MED-PUM-006-014 the system acquires (i) dissolved oxygen (nmol O_2/m^3), (ii) nitrate (nmol N/m^3) and (iii) phytoplankton carbon biomass (mol C/m^3). The forecasting span is of the order of one day and the time steps correspond to daily means. From CMEMS-MED-PUM-006-017 the system acquires (i) significant wave height (m) and (ii) mean wave direction (degrees). The forecasting span is of the order of one day and the time steps are hourly.

2.3 Daily operational cycle

All structural components of SeaLoc are conjoined into a prototype operational chain of processes (see Figure 1). The two in-house models interoperate with internally developed background processes (linux and ftp services), so as (a) the weather model to input the sea wave model for the daily forecast runs and (b) the output forecast parameters to input the visualization processes. Also, the CMEMS products are acquired with the use of an internally developed software (Visual Studio VB.net) which automatically downloads and stores the data, daily. Each daily operational cycle is concluded at approximately 10.00am. Additional features such as web software development and specialized services provision are designed to be finalized in the next project months.

3. Results

All structural components of SeaLoc, have been optimized to run on a daily basis, in order to check the system's performance as well the quality of its outputs. Currently, the final operational output is a set of commonly used visualization formats, i.e. *.kmz, *.tiff and *.png for all in-house or external datasets along with the arithmetic ascii data files. The automated visualization process has been developed by using ArcPy (Python programming). Figure 2 shows an example of a *.kmz visualization of significant wave height applied on a google earth background.

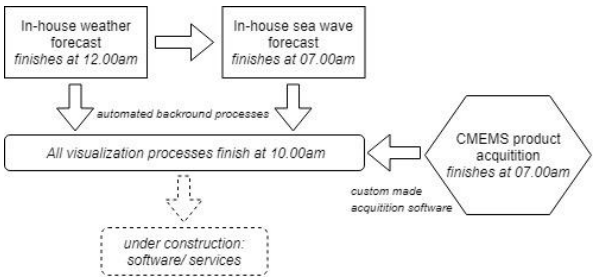

Figure 1. SeaLoc daily operational cycle

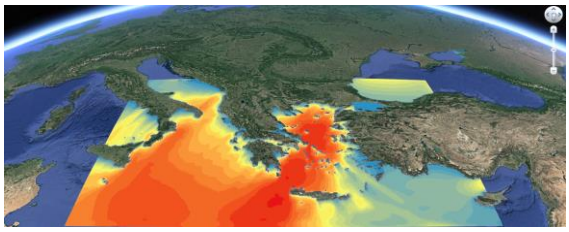

Figure 2. Example of a *.kmz visualization of sig. wave height

4. Discussion on future steps

The next steps of SeaLoc project implementation include (a) the finalization of the operational chain processes, (b) cal/ val of collocated satellite/ buoy data, (c) the enrichment with static/ descriptive open data, (d) the development of specialized services (e.g. empirical indices) for meeting the needs of target-groups and (e) dissemination and user engagement activities.

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