2019 MED COAST MARMARIS, TURKEY

MEDCOAST 19

PROCEEDINGS OF THE FOURTEENTH INTERNATIONAL MEDCOAST CONGRESS ON COASTAL AND MARINE SCIENCES, ENGINEERING, MANAGEMENT & CONSERVATION

Erdal Özhan • editor

Volume 1

The Fourteenth MEDCOAST Congress on Coastal and Marine Sciences, Engineering, Management and Conservation

MEDCOAST 19

Volume 1

22 - 26 October 2019
Grand Yazici Club Turban Hotel,
Marmaris, Turkey

Organized by:

MED COAST

Mediterranean Coastal Foundation

Published by: Mediterranean Coastal Foundation (MEDCOAST Foundation)
Beskopru Mah. 274. Sok., No 2/B, Ortaca 48600, Mugla Turkey.
Telephone : 90 2522844450
Email: medcoast@medcoast.net
Web: www.medcoast.net

Citation: Özhan, E. (Editor), 2019, *Proceedings of the Fourteenth International MEDCOAST Congress on Coastal and Marine Sciences, Engineering, Management and Conservation, MEDCOAST 19, 22-26 October* 2019, Marmaris, Turkey, Mediterranean Coastal Foundation (MEDCOAST), Ortaca, Muğla, Turkey, vol 1-2, 904 p.

ISBN: 978-605-85652-9-6 (The whole set)
978-605-69747-0-0 (Volume 1)

Printed by: Uzun Dijital Matbaa, Ankara.

Editorial Assistance: A. Aras Özhan and S. Can Özhan.

Cover design: Seha Can Özhan.

TABLE OF CONTENTS

VOLUME I

Integrated Coastal Management, Ocean and Coastal Governance

Legal Aspects of Greek ICM & MSP: Review & Analysis
Z. I. Konstantinou and D. Latinopoulos 1

Satoumi and ICM
T. Yanagi 13

A Study of Multi-level Management System for Coastal Areas by Network Governance
T. Hidaka 23

Implementing the 1st MSFD Cycle in the Mediterranean: Lessons Learnt
T. Paramana, O. Chalkiadaki, G. Katsouras and M. Dassenakis 33

Construction of Regional Environmental Governance in Seas of East Asia
X. Gao and K. Furukawa 45

Coastal Management Tools & Instruments

OPENCoastS: on Demand Forecast Tool for Management
M. Rodrigues, J. Rogeiro, S. Bernardo, A. Oliveira, A. B. Fortunato, J. Teixeira, P. Lopes, A. Azevedo, J. Gomes, M. David and J. Pina 57

High Resolution Information Services at Sea
G. El Serafy, A. Spinosa, A. Mangin, A. Silva, S. van Dam, D. Pape, R. C. Peris and E. Geropanagioti 69

Conceptual Modelling of Heterogeneous Data for Geoinformation Systems
L. Lomakina, A. Surkova), D. Zhevnerchuk, S. Skorynin, I. Chernobaev, A. Subbotin, D. Gordeev, S. Romanov and M. Sementsov 77

ODYSSEA: Operating Integrated Observatory Systems
G. El Serafy, L. Meszaros, S. Wanke and G. Sylaios 89

Identification of Result Processing Systems for Ecosystem Monitoring
L. S. Lomakina, D. V. Zhevnerchuk,, A. S. Surkova, A. S. Zakharov, O. S. Rassadin, O. K. Kanev, K. M. Noskov, P. S. Kulyasov and D. S. Martynov 101

Use of Remote Sensing for Coastal Management

Analysis of Coastal Zone by Using UAV Data
E. Boyko, A. Pogorelov and T. Volkova 113

The Current State of the Azov Sea Coastal Zone based on Landsat Data
O. E. Arkhipova 121

Monitoring and Analyses of Black Sea Coastline Relief by ALS and UAV
E. Boyko and A. Pogorelov 131

Use of Satellite Data in Marine Early Warning System
M. Dimitrova, V. Galabov, A. Kortcheva and J. Marinski 139

Various Coastal Management Issues

Building with Nature, a Promising Strategy in Coastal Management
F. van der Meulen, Ç. Coşkun Hepcan, H. Alphan and R. van Zetten 151

Environmental Indicator Approach for Dredging
J. Lednova, G. Gogoberidze, V. Zhigulsky, M. Shilin and A. Chusov 161

A New Paradigm for UK Water Safety
A. T. Williams and C. Nelson 173

HES Indicator of the Coastal Zone of the Sea of Azov
O. Arkhipova and E. Chernogubova 183

Coastal Resources Management

Management of the Nile Delta Ground Water Aquifer
M. Moawad and M. Abd-El-Mooty 191

Bycatch in Pelagic Trawling off the Western Coasts of the Black Sea
E. Petrova, V. Mihneva, F. Tserkova, S. Valchev and A. Hyusein 203

Sea Ports in the Sustainable Development of the Azov-Black Sea Coast
A. Turluchev, A. Filobok, T. Volkova and A. Ponomarenko 215

Marine Aggregates Deposits of Kissamos Bay, Crete, Greece
M. Anastasatou, A. Karditsa, S. Petrakis, A. Tsoutsia, V. Kapsimalis, P. Foutrakis, T. Hasiotis, G. Rousakis, A. Evangelopoulos, S. Poulos and M. Stamatakis 221

Coastal and Marine Tourism

Tourist Potential of Specially Protected Areas of the Black Sea Coast
J. Antipceva, T. Volkova, D. Lipilin and E. Yarotskaya 233

Tourism on the Russian Coast of the Black Sea: Rural Tourism
T. Volkova 241

Evaluation of a Tourist Loading by Means of Remote Sensing Methods
M. Belikov, T. Volkova and E. Boyko 249

Marine Cruise Tourism in the South of Russia
A. Turluchev, A. Filobok, T. Volkova, M. Belikov and A. Ponomarenko 257

Coastal Landscapes

Geospatial Analysis of Coastal Scenery Components
H. Alphan 265

Coastal & Marine Ecosystems

The *Posidonia oceanica* Matte: a Reservoir of Environmental Information
B. Monnier, J. Lapaquellerie, C.-F. Boudouresque, F. Cantaloube, M. Á. Mateo, P. Clabaut, G. Pergent and C. Pergent-Martini 275

Spontaneous *Posidonia oceanica* Recovery
M. Cotugno, M. Lorenti, M. B. Scipione and M. C. Buia 287

Biogeochemistry of Oxygen Deficiency in Nearshore Black Sea Regions of Crimea
N. Orekhova and S. Konovalov 297

Biotic and Abiotic Influence on Bioluminescence Field in Summer
V. P. Evstigneev, I. M. Serikova and N. F. Kyrylenko 307

Biochemical Index of Microbial Productivity in Coastal Waters
A. Sysoev, I. Sysoeva, O. Mashukova and O. Danilova 319

Changes of the Plankton in the Gelendzhik Bay
V. S. Arkhipkin, T. V. Polyakova and A. V. Polyakova 329

Modelling of Flexible Phytoplankton Stoichiometry
E. Vasechkina 339

Coastal & Marine Ecosystem Impacts

Impacts of Lithodynamic Processes to Avifauna
V. Krylenko, S. Krylenko, A. Lukinykh and M. Krylenko 351

Environmental Status of Lakonikos Gulf In Connection to MSP
M. Dassenakis, S. Poulos, P. Megalofonou, T. Paramana, A. Karditsa, S. Petrakis and N. Milatou 361

Temporal Evolution of Ecological Status in Algerian Coastal Waters
A. Sengouga, S. Boumaza, C. Zerrouk, A. Misraoui and R. Semroud 373

Microalgae and Cetaceans in Black Sea Dolphinaria
E. Gol'din 379

Using Technical Aquaculture for Monitoring
A. Chusov, J. Lednova, V. Mikheev, M. Shilin and I. Mushket 389

Climate Change

Consequences of Climate Change for Marine Coastal Habitats
C. Pergent-Martini, M. C. Buia, B. Monnier and G. Pergent 399

Climate Change Impact on Water Column in Corsica
S. Gobert, L. Fullgrabe, Q. Fontaine, M. Leduc, M. Marengo, M. Patrissi, A. Donnay, L. Iborra, J. Richir, M. Garrido and P. Lejeune 411

Impact of Climate Change on Non-native Species
P. Francour, V. Raybaud, C. Pergent-Martini and J. Donini 423

Climate Change and the Marine Environment in Corsica: The Report Card Project
G. Pergent, F. Simard, D. Laffoley, J. Baxter, C. Pergent-Martini and M. del Mar Otero 435

Consequences of Climate Change for Freshwaters of Corsica
C. Mori, A. Orsini, F. Colonna, S. Orsini and I. Souleiman 445

Black Sea: Hydrometeorological Extremes
G. Surkova, N. Sokolikhina, V. Arkhipkin, E. Semenov and A. Krylov 457

Social Vulnerability in a Changing Climate
R. van Zetten 467

Sea Level Rise

Sea Level Rise and Vertical Land Motion in the Eastern Mediterranean
B. Mohamed and K. Alam El-Din 479

VOLUME II

Water and Sediment Pollution

Impact of Polychlorinated Biphenyls on the *M. leidyi* Bioluminescence
O. Mashukova, M. Silakov, L. Malakhova and E. Skuratovskaya 487

Analysis of Metals in the Solid-liquid Phases from Mediterranean Sea, Egypt
M. A. M. Abdallah 499

Heavy Metals in Water and Sediments of El-Mex Bay, Egypt
M. A. M. Abdallah and A. A. Mohamed 509

Coastal Hazards

Tsunami Hazard Assessment for French West Indies
N. Zahibo, B. Dudon, E. Pelinovsky, A. Zaytsev and A. Kurkin 515

Seiches and Meteotsunami in the Gulf of Genoa
P. Picco, L. Repetti and A. Santucci 523

Coastal Sedimentation

Composition of the Anapa Bay-Bar Sediments
R. Kosyan, V. Krylenko, E. Fedorova and A. Kosyan 531

Dynamics of Eolian Forms on Blagoveschensky Butte
V. Krylenko and M. Krylenko 543

Satellite-Derived Suspended Sediment Distribution
A. Tsapanou, A. Karditsa and S. Poulos 553

Geomorphological Zoning of the Azov-Black Sea Coast of Krasnodar Region
J. Antipceva, T. Volkova and A. Mishchenko 565

Recent Dynamics of an Accumulative Coast Composed of Pyroclastics from an Underwater Volcanic Eruption
N. Dunaev, R. Kosyan, T. Repkina, A. Baranskaya and V. Afanasiev 573

Coastal Sediment Transport

Sedimentary Dynamics of a Tidal Inlet
M. Abo Halima, A. Soliman and M. R. Soliman 585

Sediments Granulometric Composition Dynamics in the Kalamitsky Gulf
K. I. Gurov, V. V. Fomin, D. V. Alekseev and E. V. Ivancha 597

Modulational Instability of Long Internal Waves
T. Talipova and E. Pelinovsky 607

Modelling of Storm-Induced Deformations of a Coastal Profile
I. Leont'yev and T. Akivis 615

Coastal Oceanography

Characterising Sea Water Temperature of Marsalforn Bay, Gozo, Malta
R. Grima and A. S. Micallef 627

Coastal Dynamics

Morphological and Permafrost Factors of Coastal Dynamics at Kara Sea
D. Aleksyutina, N. Belova, A. Baranskaya and S. Ogorodov 639

Wave Energy Trends Uncertainty in Dependence to Data Source
N. Shabanova, P. Shabanov and S. Ogorodov 651

Ice-free Period Detection Uncertainties over Coastal Zones
P. Shabanov, N. Shabanova and S. Ogorodov 663

Coastal Hydrodynamics

Blue Bay Waters Thermohaline Structure Simulation
S. Mukhametov and V. Arkhipkin 675

Internal Breathers in a Flow
T. Talipova, O. Kurkina, E. Pelinovsky and A. Giniyatullin 685

Probabilistic Wave Runup Characteristics
E. Pelinovsky and S. Gurbatov 693

Storm Surge Analysis for French West Indies
N. Zahibo, Y. Krien, G. Arnau, B. Yalciner, A. Zaytsev, A. Yalciner, O. Cabuk, G. Ozyurt Tarakcioglu, G. Guney Dogan, E. Pelinovsky and A. Kurkin 703

Wave Hydrodynamics

The Effect of Wave Nonlinearity on the Rogue Wave Lifetimes and Shapes
A. Kokorina and A. Slunyaev...711

Pressure Field under Strongly Nonlinear Waves
E. Pelinovsky, A. Slunyaev, J. Touboul, A. Kokorina, E. Didenkulova, T. Talipova and A. Zaytsev 723

Internal Waves

Statistics of Field Data on Internal Waves
M. Kokoulina, O. Kurkina, E. Rouvinskaya, A. Kurkin and A. Giniyatullin........733

Effects of Dissipation on Internal Wave Dynamics
E. Rouvinskaya, O. Kurkina, A. Kurkin and A. Giniyatullin..............................745

Wind Waves

In Situ Wave Measurements in the Sea of Okhotsk
E. Didenkulova and A. Zaitsev 755

Filtering of Frequency-directional Wave Spectra by Underwater Channels
I. G. Kantarzhi and A. S. Anshakov 763

Statistics of Free and Bound Components of Deep-Water Waves
A. Slunyaev, A. Kokorina and I. Didenkulova...775

Wind Wave Climate

Extreme Wave Analysis Using Century Based Wave Climate Data
B. Öztunalı Özbahçeci, A. R. Turgut and S. Abdalla..787

Maximum Waves in the Black Sea
B. Divinskii, V. Fomin, R. Kosyan and D. Lazorenko 799

Wave Climate in the Sea of Okhotsk at Cape Terpeniya
E. Didenkulova and A. Zaitsev 811

Coastal Engineering

An Application of Artificial Submerged Reef Breakwater
A. Awad, A. Soliman and M. R. Soliman...819

Numerical and Experimental Modelling for Earthen Embankment Failure
G. Abo-Zaid, M. Khairy-El-Tahan and R. M. Kansoh...829

Urgent Issues of Anti-Deformation Measures to Protect Coastal Railways
E. Ashpiz, A. Savin, R. Tlyavlin and G. Tlyavlina 841

Marine Engineering

Vibration Protection of Offshore Platform Equipment
B. Gordeev, A. Ermolaev, E. Titov and D. Titov 853

Vibration Influence on Equipment in Coastal Areas
A. Ermolaev, S. Okhulkov, E. Titov and D. Titov 863

Dynamic Analysis of Moored Floating Objects
I. Kantardgi and A. Gogin 869

Experimental Study of Autonomous Complexes Motion
P. Beresnev, A. Kurkin, D. Tyugin, I. Orlov, V. Filatov and V. Belyakov 881

Impact of Coastal Topography on Autonomous Robots
P. Beresnev, A. Kurkin, A. Rodin, D. Porubov, I. Orlov and V. Filatov 893

k on the Enclosed
obe, Japan.

main_j.php

ism for Coastal and
ip in Environmental
City, Philippines.

what-we-

Pacific (WESTPAC),

Proceedings of the Fourteenth International MEDCOAST Congress on Coastal and Marine Sciences, Engineering, Management and Conservation MEDCOAST 2019, 22-26 October 2019, Marmaris, Turkey, E. Özhan (Editor)

OPENCoastS: on-Demand Forecast Tool for Management

Marta Rodrigues[(1)], João Rogeiro[(1)], Samuel Bernardo[(2,3)], Anabela Oliveira[(1)], André B. Fortunato[(1)], Joana Teixeira[(1)], Pedro Lopes [(1)], Alberto Azevedo[(1)], Jorge Gomes[(2)], Mário David[(2)] and João Pina[(2)]

[(1)] *National Laboratory for Civil Engineering, 1700-066 Lisbon, Portugal*
Tel: + 351 21 844 3000
E-mail: mfrodrigues@lnec.pt
[(2)] *LIP, no: 2, Av. Prof. Gama Pinto 1649-003, 1600-078 Lisbon, Portugal*
[(3)] *Tel: + 351 21 049 3600*
E-mail: sbernardo@lip.pt

Abstract

Coastal forecast systems have become reliable tools to support daily coastal management and strategic long-term planning. However, the availability of these systems for most coastal areas remains scarce, in particular for small estuaries and coastal bays, which limits the efficiency of management for these areas from both economic and environmental perspectives. Building a new forecast system or maintaining in operation an existing one requires considerable effort, from both financial and personnel points of view. Accurate forecasts require a team comprising experts in coastal processes and computer science and the availability of robust and large computational resources to maintain the predictions available on a daily basis. Herein, a new concept in forecast tools is presented, building the foundations for forecast systems to be built and made available for all coastal systems worldwide. Denoted OPENCoastS, this freely available web service builds forecasts systems for the coastal area selected by the user and maintains them in operation using the European Open Science Cloud infrastructure. Forecasts are based on the SCHISM community model's simulations using a computational grid uploaded by the user, to predict the 2D barotropic or 3D baroclinic circulation in the coastal area of interest. An open grid repository is also available for testing the platform and to promote shared work. The

web platform includes the whole forecast workflow: system configuration, system management and forecasts viewer. Forecast accuracy can be controlled by the user at configuration stage by: i) the selection of the forcings from the several sources available (including Meteo France and NOAA's atmospheric predictions and ocean boundary conditions from CMEMS and FES2014, among others); and ii) the choice of several model parameters. The quality of the predictions can be assessed by automatic comparison with user-selected EMODNET data stations. Default settings are also provided to facilitate the uptake of the OPENCoastS platform by people less familiar with the use of the SCHISM model. An example of the application of OPENCoastS to simulate 3D hydrodynamics is provided for the Ria Formosa coastal lagoon.

Introduction

Timely information about the coastal waters status is of utmost importance to support both daily and strategic management of these systems. To address this need, forecast systems of coastal conditions have been under development at global, regional and local scales for the last three decades (e.g., Brassington et al., 2007; Baptista et al., 2008), being nowadays a common working tool for many coastal stakeholders (e.g., Boulay and Batt, 2015). Current forecast systems range from simple tidal predictions to complex circulation forecasts including wave and current interactions (Fortunato et al., 2017) and water quality (e.g., Oliveira et al., 2014; David et al., 2015). The need to guarantee the accuracy of the predictions have also reinforced the linkage between real time monitoring networks such as EMODnet (http://www.emodnet.eu/) and the exploitation of citizen science in the context of emergency events (Loftis et al., 2019).

Building forecast systems is not however a trivial task as it requires: a) a multidisciplinary team comprised of both coastal processes and modelling experts and IT personnel; b) the availability of computational resources adequate to provide the predictions in a timely way on a daily basis; and c) the availability of ways to disseminate the forecast results to the end-users, targeted to their specific needs (e.g. a web portal where the users can visualize their predictions, an email server to address alerts, among others). When multiple forecasts systems are in operation, the effort for keeping them running in a reliable way and to keep them up-to-date with new features or new versions of the supporting modelling tool can often be too large. As a result, many coastal systems do not take advantage of this very important tool and many managers have to take short and long term management decisions without adequate knowledge of their system's dynamics.

To address this problem, a new paradigm in coastal forecasting was developed - a coastal forecast service, where users can build, in a friendly way, their forecast systems for their own sites. Denoted OPENCoastS, this service allows for a simple creation of a forecast system, requiring only the availability of a computational grid for the domain chosen (Oliveira et al., 2019a, b). An open grid repository is also available for testing the platform and to promote shared work (Oliveira et al., 2019b, repository link: https://github.com/LNEC-GTI/OPENCoastS-Grids). OPENCoastS builds on-demand circulation forecast systems for selected coast areas and maintain them running operationally for the time frame defined by the user, starting in one month period with the possibility of extending it on request. This daily service has multiple options, for the physics being simulated (2D barotropic or 3D baroclinic circulation), the choice of

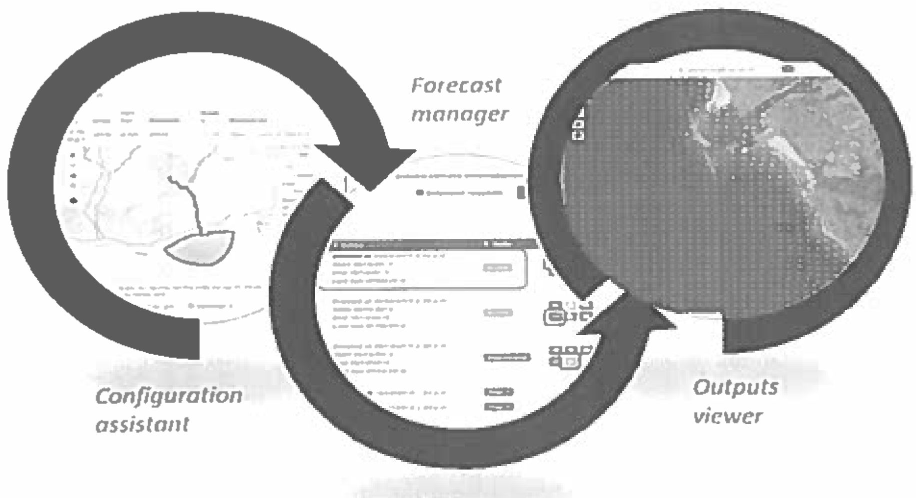

Fig. 1: The three components of OPENCoastS service.

forcings (between several regional and global providers) or model parameters (default or user choice of selected parameters). Outputs include forecasts of water levels and velocities (and 3D fields of velocity, salinity and temperature in the 3D option) along with comparison with user selected online data sets from EMODnet or user defined virtual sensors. The forecasts are produced for periods of 48 hours, based on numerical simulations of all relevant physical processes.

The service comprises three components (Fig. 1): a configuration assistant, to build the forecast; a forecast manager, to view and alter existing forecasts; and a viewer to visualize results, compare them with in-situ data and download output files. All three components are freely available through a web portal at https://opencoasts.ncg.ingrid.pt/. To facilitate the uptake of the service by users from both research and management communities, several training events are being promoted and training tools are freely available at http://opencoasts.lnec.pt/index_en.php.

This paper is organized as follows. First, an overview of OPENCoast's main features are presented, along with the new functionalities built for the 3D simulations. Then, the flexibility and usability of the service is demonstrated in the application to a case study, the 3D baroclinic circulation of the Faro lagoon. Finally, the paper closes with some concluding remarks and directions for further developments.

The OPENCoastS Service: Main Features and New Functionalities

OPENCoastS is a new Web platform developed under the concept of open science, provided to users as an open-access service integrated in the thematic services and marketplace of the project EOSC-Hub (https://www.eosc-hub.eu/services/OPENCoastS). The service is composed by a frontend (the web platform) and a backend (that deals with all computing tasks) - Fig.2. The frontend was developed with the Django Python Web framework and uses a PostGIS spatial object relational database and the ncWMS2 software to provide the forecasts outputs as Web Map Services (WMS), with UGRID-compliant NetCDF files.

The backend is responsible for generating the forecast results, handling all tasks of the simulation chain established for each forecast deployment. This component is based on the Water Information Forecast Framework, WIFF (Fortunato et al., 2017), which simplifies the assembly and execution of the recurring tasks needed for every simulation. WIFF was developed by LNEC and is a generic forecasting platform, adaptable to any geographical location, which integrates a set of numerical models that run periodically.

To provide local forecasts for any coastal region in the world, OPENCoastS uses several oceanic and atmospheric forecast providers. This linkage is necessary to provide reliable and accurate predictions at local scales forced by robust systems that are integrated with global monitoring networks through data assimilation. Users can select the physical processes to be accounted for (tides, tides + storm surges, tides + storm surges), model resolution and area of coverage. Comparison with elevation data is provided through an automate request to EMODnet-Physics (http://www.emodnet.eu/physics), that identifies the data stations within the computational domain. Afterward, the user only needs to select data stations to be used for the time series comparison.

Forecast systems typically entail computationally demanding tasks. The OPENCoastS platform has been deployed in the INCD infrastructure, and are under deployment at the CSIC/IFCA infrastructure. These cloud infrastructure providers are available within the European Open Science Cloud, EOSC (https://www.eosc-portal.eu/), supporting the OPENCoastS service through the EOSC-hub project (https://www.eosc-hub.eu/). The EOSC provides several types of services, including computing from EGI (cloud and grid), storage from EUDAT, and authentication and authorization infrastructure (AAI) from EGI. The OPENCoastS platform is being integrated with some of these services in the framework of EOSC-hub Thematic Services, and is already using authentication and computing services in EOSC. More details on the core service are available in Oliveira et al. (2019a, b).

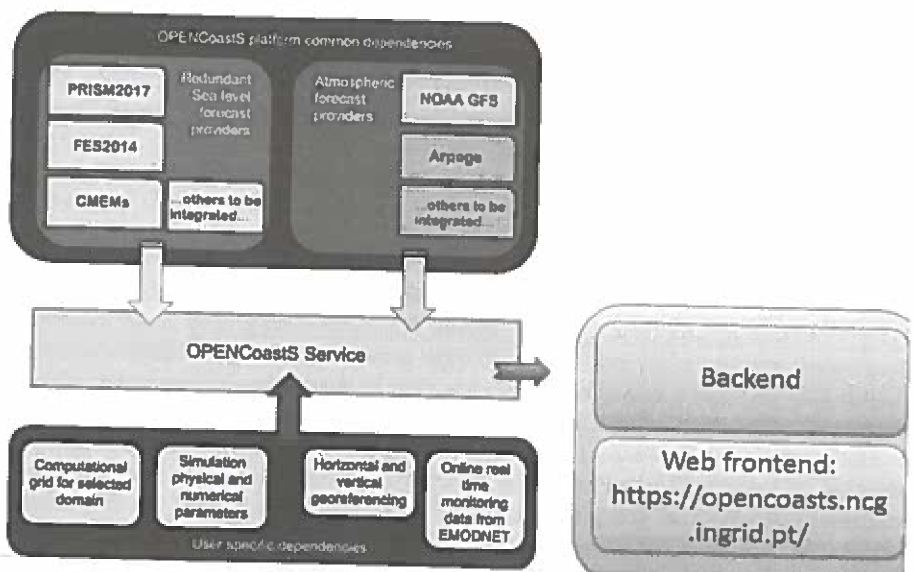

Fig. 2: The OPENCoastS architecture and building blocks.

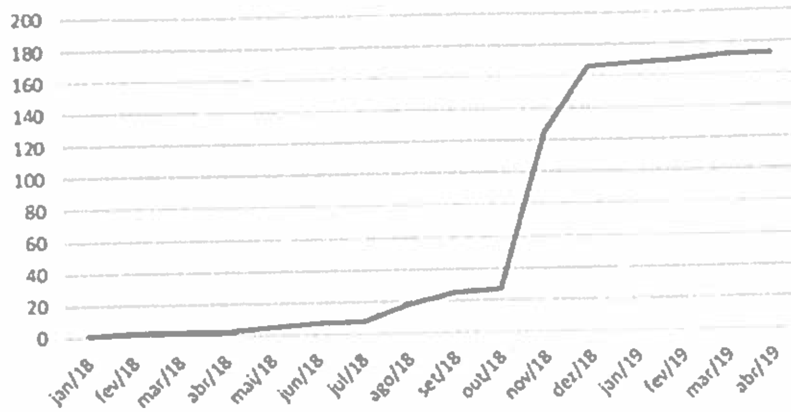

Fig. 3: Evolution on OPENCoastS users for the 1st year of service operation.

As of last April, OPENCoastS had already over 175 users (Fig. 3) and supported over 140 service applications to forecast simulations in all continents.

The new version of OPENCoastS, presented herein, offers new functionalities: the possibility to create forecasts for 3D baroclinic circulations, predicting water level and 3D velocities, salinities and temperatures. To address this new feature, several new functionalities have been included.

Forcings options were enlarged to address providers of boundary conditions for salinity. Therefore, both global and Iberian CMEMs were included in the ocean forcings. Given the importance of river inputs on salinity and temperature fields, new possibilities were added for the riverine forcings. To increase the accuracy of the simulations at the riverine end, the possibility of including a source of river forecasts in the OPENCoastS predictions was also included, by providing a web service with a specific file format. The viewer was also improved with new features to view and download 3D results. The application of the OPENCoastS service to forecast the 3D circulation in the Faro lagoon (Fig. 4) illustrates some of those new items (Fig. 5 to 8).

3D Circulation Prediction in the Faro Lagoon

The Faro lagoon is the most important coastal ecosystem in the southern coast of Portugal (Fig. 4). This coastal lagoon provides several goods and services, which support important economic activities in the region (Newton et al., 2014), and its ecological value is well recognized (Newton et al., 2014).

This coastal waterbody is a mesotidal lagoon that connects to the Ocean Atlantic through six inlets (Ancão, Faro-Olhão, Armona, Fuzeta, Tavira and Lacém inlets - Fig. 4). This lagoon has a complex network of channels interconnected with the inlets, allowing the recirculation of water within the system and a permanent exchange with the adjacent ocean. To simulate the circulation in the Faro lagoon the application of Fabião et al. (2016) was extended and updated for SCHISM (Zhang et al., 2016). In particular, the horizontal grid was extended to include the Gilão River and the bathymetry was updated with the most recent data available, namely data from

Fig. 4: Faro lagoon location and morphology.

topographic and bathymetric surveys performed during 2011 along the Portuguese coast with LiDAR equipment (Silva et al., 2012). The updated horizontal grid has about 98000 nodes/193000 elements, while the vertical grid has 11 levels (7 S levels and 4 Z levels). The model was first calibrated against water levels data from 1980 and validated against water levels, velocities, salinity and water temperature data from 2011 and 2017. For further details regarding the model implementation and validation see Rosa et al. (in preparation).

Based on the model application of Rosa et al. (in preparation), a new forecast system was implemented for the Faro lagoon coast using the OPENCoastS service. To deploy this system, seven steps were followed using the Configuration Assistant:

1) The selection of the run type and of the model: 3D baroclinic, SCHISM model;
2) The input of the horizontal and vertical grids (Fig. 5);
3) The definition of the boundary conditions (Fig. 6 and Fig. 7): the Faro lagoon forecasts are forced by tides, salinity and water temperature from CMEMS-IBI(http://marine.copernicus.eu/services-portfolio/access-to-products/?option=com_csw&view=details&product_id=IBI_ANALYSIS_FORECAST_PHYS_005_001)at the ocean boundary, by monthly climatology of the river flow and the water temperature at the Gilão River and by the atmospheric forecasts from NOAA/NCEP-GFS at the surface (https://www.ncdc.noaa.gov/data-access/model-data/model-datasets/global-forcast-system-gfs);
4) The definition of stations for data analysis: three virtual stations were selected along the Faro lagoon (Faro-Olhão inlet, CC-Cais Comercial and Tavira inlet);
5) The definition of input parameters (e.g. time step);
6) The definition of additional data (e.g. spatially-varying parameters like the friction coefficient or initial conditions for salinity and water temperature);
7) The submission of the forecast system.

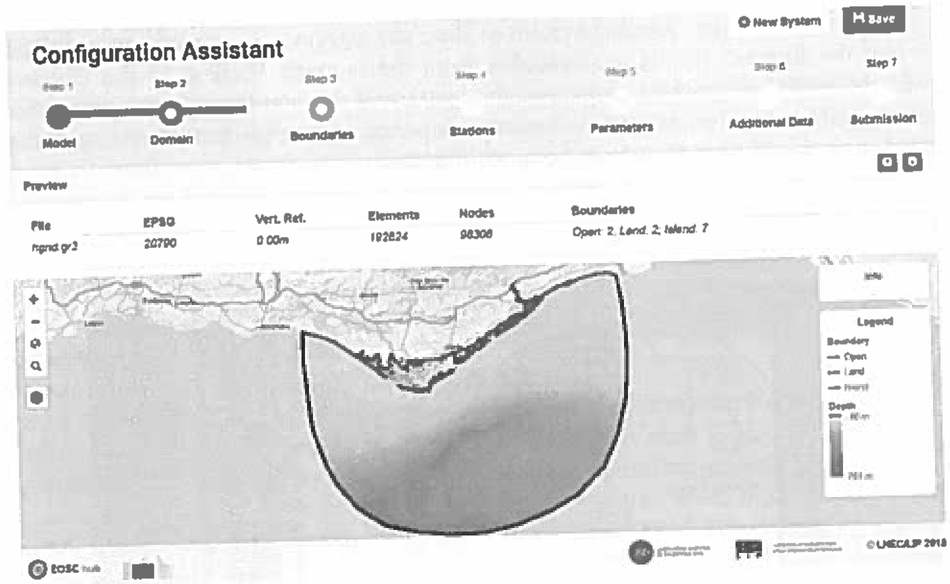

Fig. 5: Configuration Assistant - overview of the horizontal domain of the Faro lagoon forecast system.

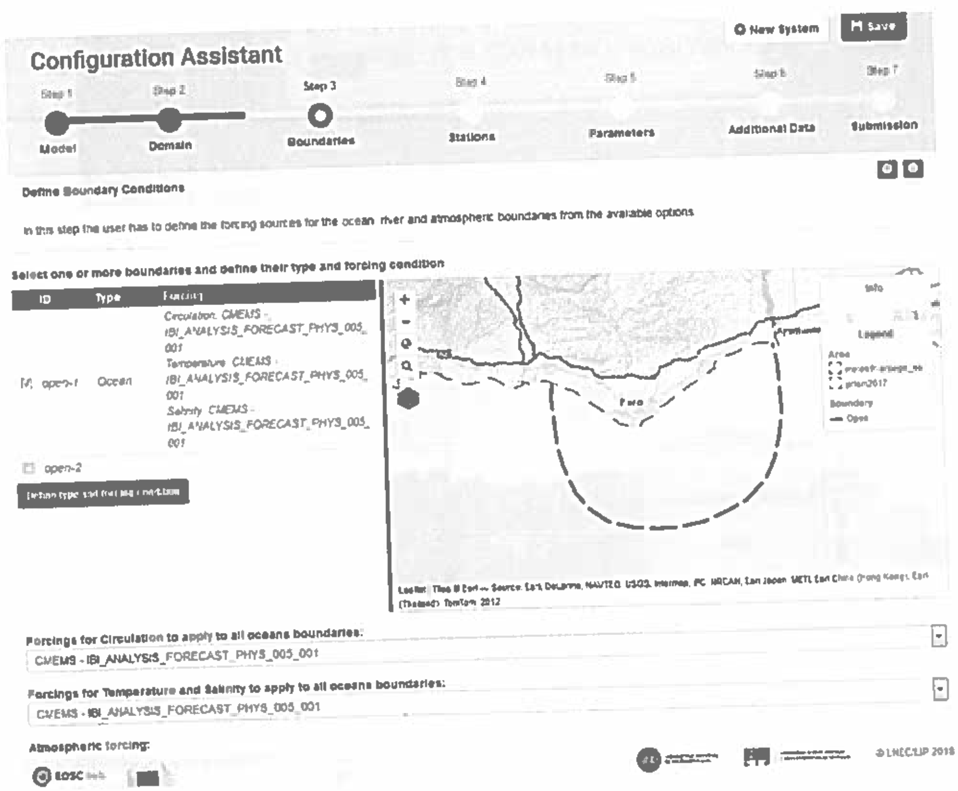

Fig. 6: Configuration Assistant - example of the definition of the boundary conditions at the oceanic boundary of the Faro lagoon forecast system using the CMEMS-IBI model option.

The 3D baroclinic forecast system of the Faro lagoon is in operation since June 2019 and the forecast results are available from the Outputs Viewer. In the Outputs Viewer the user can generate maps and time series of the simulated variables (water levels, and 3D velocities, salinity and water temperature), see the model results at the selected stations and also download the model forecasts (Fig. 8).

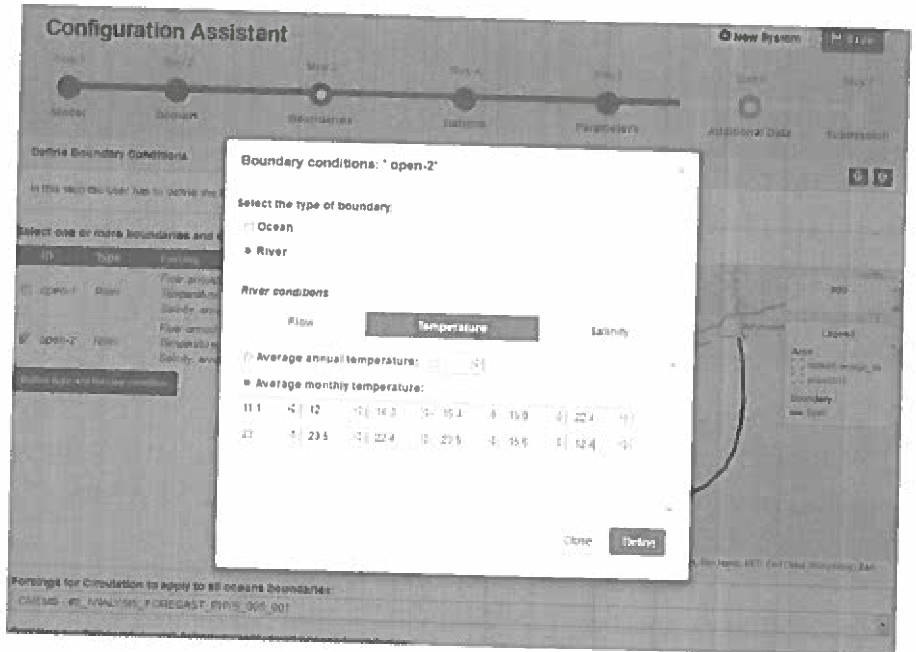

Fig. 7: Configuration Assistant - example of the definition of the boundary conditions at the river boundary of the Faro lagoon forecast, including river flow, salinity and water temperature boundary conditions.

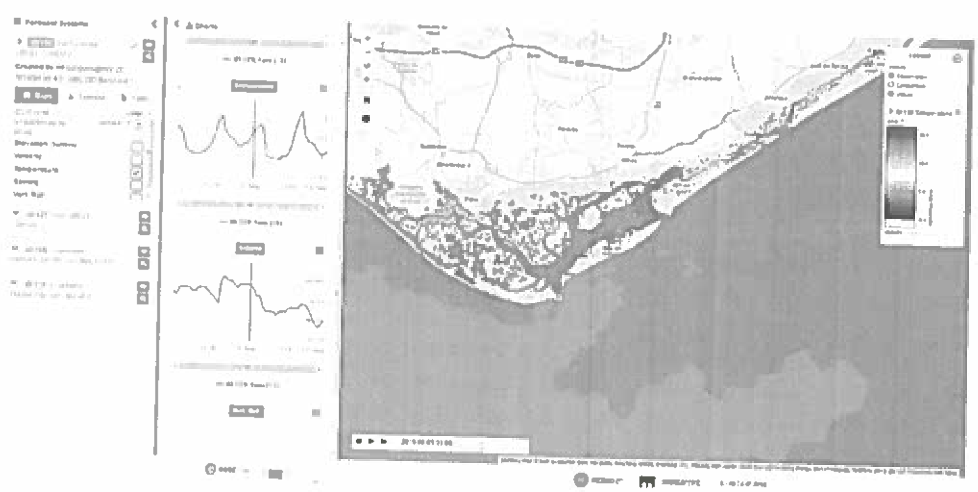

Fig. 8: Outputs Viewer – example of the outputs viewer with time series of salinity and water temperature and maps of water temperature.

Conclusions

The concept of coastal forecast systems, materialized in the OPENCoastS web platform has been in operation for over one year and attracted users and applications from all continents. Herein, we presented the new version of this system that can now be used to predict 3D baroclinic circulation in any coastal system worldwide. This development is part of the development roadmap of OPENCoastS (Fig. 9) for this and the next year and precludes the extension of the concept to water quality.

Besides the outlined expansion plans from the point of view of the coastal processes, other features have also been requested by users. While development timelines are not so rigid as the ones above, the tasks below are also in the development team agenda: integrate automatic error calculation for the selected data sets as data is collected; integrate other sources of data for comparison such as satellite or radar data; integrate a grid generator as a pre-step in the configuration assistant; integration of other coastal models; and production of a daily newsletter with digested results pre-configured at configuration stage and sent it to the system's stakeholders.

Finally, the concept of OPENCoastS can now be easily expanded to other type of waterbodies such as the drainage networks or hydrographic basins, to build a OPENWater service. Challenges for this endeavour are the distinct process time and spatial scales involved and the availability of forcing conditions. Linkage with systems such as those proposed by Campuzano et al. (2016) are a possible avenue.

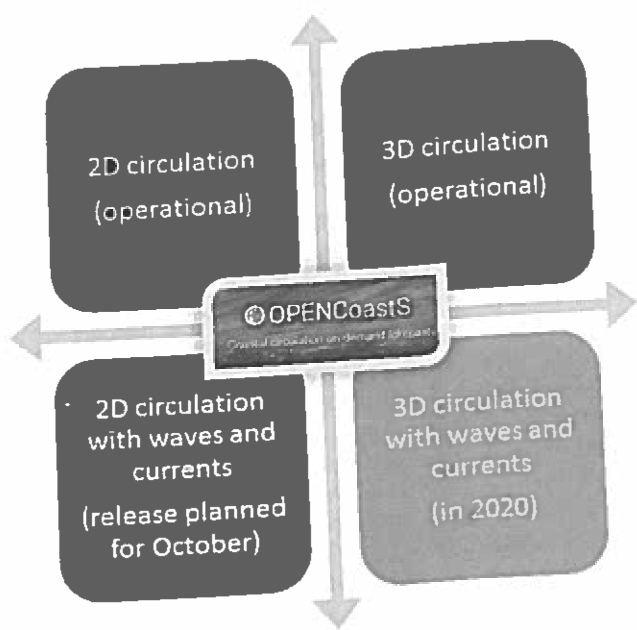

Fig. 9: OPENCoastS development roadmap: services available and timelines for the next ones.

Acknowledgements

This work was partially funded by the European Commission through the H2020 project EOSC-hub (Grant Agreement No 777536), by the Lisboa2020 Operational Program through the INCD project (LISBOA-01-0145-FEDER-022153) and by the Fundação Portuguesa para a Ciência e a Tecnologia through project UBEST (PTDC/AAG-MAA/6899/2014). This work made use of results produced with the support of the Portuguese National Grid Initiative; more information in https://wiki.ncg.ingrid.pt. The authors thank Dr. Alexandra Rosa for the collaboration in the implementation and validation of the 3D hydrodynamics model of the Faro lagoon.

References

Baptista, A.M., Howe, B., Freire, J., Maier, D. and Silva, C.T. (2008), "Scientific Exploration in the Era of Ocean Observatories", *Computing in Science & Engineering*, 10(3), 53-58.

Boulay, S.O.C. and Batt, L. (2015), "Marine weather forecasting and monitoring at the Port of Sydney and Botany Bay, NSW, Australia", In: *Proceedings of the Australasian Coasts & Ports Conference 2015*, 15-18 September 2015, Auckland, New Zealand, 5 pp.

Brassington, G.B., Pugh, T., Spillman, C., Schulz, E., Beggs, H., Schiller, A. and Oke, P.R. (2007), "BLUElink development of operational oceanography and servicing in Australia", *Journal of Research and Practice in Information Technology*, 39(2), 151-164.

Campuzano, F., Brito, D., Juliano, M., Fernandes, R., de Pablo, H. and Neves, R. (2016), "Coupling watersheds, estuaries and regional ocean through numerical modelling for Western Iberia: a novel methodology", *Ocean Dynamics*, 66 (12), 1745-1756.

David, L.M., Rodrigues, M., Fortunato, A.B., Oliveira, A., Mota, T., Costa, J., Rogeiro, J., Jesus, G., Gomes, J.L., Menaia, J., David, C., Póvoa, P., Frazão, A. and Matos, R. (2015), "Demonstration system for early warning of faecal contamination in recreational waters in Lisbon", In: Hulsmann A. et al. (Eds.), *Climate Change, Water Supply and Sanitation: Risk Assessment, Management, Mitigation and Reduction*, IWA Publishing, London, United Kingdom, Chapter 1- Demonstrations, subchapter 1.4, 10 pp.

Fabião, J., Rodrigues, M., Fortunato, A., Jacob, J. and Cravo, A. (2016), "Water exchanges between a multi-inlet lagoon and the ocean: the role of forcing mechanisms", *Ocean Dynamics*, 66(2), 173-194.

Fortunato, A.B., Oliveira, A., Rogeiro, J., Tavares da Costa, R., Gomes, J.L., Li, K., Jesus, G., Freire, P., Rilo, A., Mendes, A., Rodrigues, M. and Azevedo, A. (2017), "Operational forecast framework applied to extreme sea levels at regional and local scales", *Journal of Operational Oceanography*, 10(1), 1-15.

Loftis, J.D., Mitchell, M., Schatt, D., Forrest, D.R., Wang, H.V., Mayfield, D. and Stiles, W.A. (2019), "Validating an Operational Flood Forecast Model Using Citizen Science in Hampton Roads, VA, USA", *Journal of Marine Science Engineering*, 7, 242.

Newton, A., Icely, J., Cristina, S., Brito, A., Cardoso, A.C., Colijn, F., Riva, S.D., Gertz, F., Hanse, J.W., Holmer, M., Ivanova, K., Leppakoski, E., Canu, D.M., Mocenni, C., Mudge, S., Murray, N., Pejrup, M., Razinkovas, A., Reizopoulou, S., Pérez-Ruzafa, A., Schernewski, G., Schubert, H., Carr, L., Solidoro, C., Viaroli, P. and Zaldívar, J.M. (2014), "An overview of ecological status, vulnerability and future perspectives of European large shallow, semi-enclosed coastal systems, lagoons and transitional waters", *Estuarine, Coastal and Shelf Science*, 140, 95-122.

Oliveira, A., Jesus, G., Gomes, J.L., Rogeiro, J., Azevedo, A., Rodrigues, M., Fortunato, A.B., Dias, J.M., Tomas, L.M., Vaz, L., Oliveira, E.R., Alves, F.L. and den Boer, S. (2014), "An interactive WebGIS observatory platform for enhanced support of integrated coastal management", *Journal of Coastal Research*, Special Issue 70, 507-512.

Oliveira, A., Fortunato, A.B., Rogeiro, J., Teixeira, J., Azevedo, A., Lavaud, L., Bertin, X., Gomes, J., David, M., Pina, J., Rodrigues, M. and Lopes, P. (2019a) OPENCoastS: an open-access service for the automatic generation of coastal forecast systems, in review in *Environmental Modelling & Software*.

Oliveira, A., Rodrigues, M., Rogeiro, J., Fortunato, A.B., Teixeira, J., Azevedo, A. and Lopes, P. (2019b), "OPENCoastS: An open-access app for sharing coastal prediction information for management and recreation", In: Rodrigues J. et al. (Eds.), *Proceedings of the 19th International Conference on Computational Science – ICCS 2019*, 12-14 June, Faro, Portugal, ICCS 2019. Lecture Notes in Computer Science, Springer, Cham, 11540, 794-807.

Rosa, A., Jacob, J., Rodrigues, M., Fortunato, A.B. and Cravo, A. (2019, in preparation), "Calibration and validation of the 3D hydrodynamics model of the Ria Formosa. Report 8", Project UBEST – Understanding the biogeochemical buffering capacity of estuaries relative to climate change and anthropogenic pressures, 39 pp.

Silva, M., Patrício, P., Mariano, A.C., Valério, M. and Morais, M. (2012), "Obtenção de Dados LIDAR para as Zonas Costeiras de Portugal Continental", In: *Atas das 2as Jornadas de Engenharia Hidrográfica*, 20-22 June, Lisboa, Portugal, 19-22 (in Portuguese).

Zhang, Y., Ye, F., Stanev, E.V. and Grashorn, S. (2016), "Seamless cross-scale modelling with SCHISM", *Ocean Modelling*, 102, 64-81.