OceanPredict '19
GODAE OceanView Symposium | 6-10 May 2019 Halifax, Canada
Advancing the science and application of ocean predictions

POSTER ABSTRACTS

Theme 6:
User Application and Societal Benefit

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P91 - **Abstract ID: 3543049**

Simulation of juvenile Atlantic salmon movement in the Gulf of St. Lawrence using an individual-based model

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We examine the effect of environmental conditions and swimming behaviors on the movement of Atlantic salmon (Salmo salar) post-smolts (juveniles) in the Gulf of St. Lawrence (GSL) using an individual-based model (IBM). The IBM uses time-varying, three-dimensional currents produced by an ocean circulation model combined with a numerical particle-tracking scheme in which swimming behaviours can be specified. The aim of our experiments using this IBM was to gain insight into movements of post-smolts documented in a past field study. In that study, a post-smolt in a river on the north shore of the GSL in June 2010 was later observed at the Strait of Belle Isle (SBI) to the northeast of the river mouth. Two other post-smolts, released later in June 2010, were detected near Anticosti Island (AI) to the southwest of the river mouth. Results of our experiments using the IBM suggest that, for both the post-smolt(s) that moved to the SBI and towards AI, the ambient near-surface circulation patterns favoured their movements. In the case of movement towards AI, a variety of swimming behaviors in combination with the simulated circulation result in travel times that agree well with observations. For movement towards the SBI, an efficient swimming strategy is necessary in addition to a favourable circulation pattern in order for simulated travel times to be similar to observations. Two successful strategies suggested by our experiments for movement towards the SBI are: (a) swimming with currents in favourable directions and against currents in unfavorable directions, and (b) swimming towards a series of target locations that define a migration route. The possibility that Atlantic salmon post-smolts originating from rivers on the north shore of the GSL may sometimes be confined to the GSL instead of migrating to the open ocean is consistent with past observational studies.

Keywords: Applications - Fisheries, Systems - Ocean Prediction Systems types (forecasting, analysis, scales, assessment, regions, ecosystem, ice, wave, etc.), Models - Ocean model configurations, Models - Numerical methods, Applications - Acoustic applications

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P92 - **Abstract ID: 3546292**

Metadata and data management principles for underwater acoustic data

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Underwater acoustic data are of value to a variety of players including researchers, commercial organizations, government agencies and defense forces. Their application is varied and includes the detection and identification of marine mammals, assessing the impact of shipping traffic on marine life and tracking underwater noise emission related to offshore projects. It is crucial that said datasets are discoverable and described with rich metadata, so as to adhere to FAIR principles - findability, accessibility, interoperability, and reproducibility - and obtain maximum value from all research.

MERIDIAN (Marine Environmental Research Infrastructure for Data Integration and Application Network) is a newly formed research network with a special focus on underwater acoustic data. Our mandate is to develop open source software solutions for the analysis and visualization of acoustic data in liaison with the community and to set up a data discovery service focusing on Canadian acoustic data sets.

Here, we present the work-to-date performed by MERIDIAN towards building a robust national underwater acoustic data discovery service and data management recommendations. In consultation with underwater acoustic experts, we have developed a metadata profile for underwater acoustic data. This freely available profile is interoperable with other profiles and conventions based on the ISO 19115 standard such as the U.S. Integrated Ocean Observing System Metadata Convention for Passive Acoustic Recordings. We also discuss our data management toolkits, researcher feedback to date, and remaining challenges for this MERIDIAN project. Ultimately we hope our metadata profile, discovery portal, recommendations and other tools will be widely used by researchers, the general public, and other ocean data management initiatives, for example the Canadian Integrated Ocean Observing System, which did not consider acoustic data to be in scope for the pilot phase of their project.

Keywords: Systems - Ocean product and data formats, Systems - Service providers, Systems - Ocean product distribution/dissemination and accessibility, Systems - Implementation of Ocean Prediction Systems, Applications - Ocean products for scientific, economic and societal use

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OceanPredict '19
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P93 - **Abstract ID: 3550003**

Deep learning detection and classification of whale species using a unique data representation

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Analyzing underwater acoustic data is one of the primary methods researchers use to study many aspects of wild marine mammals including abundance and migratory patterns. Passive acoustic monitoring (PAM) is a commonly used and non-invasive way of collecting underwater acoustic data. PAM is often carried out using moored acoustic recorders equipped with hydrophones. These recording devices may be deployed for months or years at a time before resurfacing; producing very large amounts of data. Human analysis of acoustic data is inefficient due to the immense quantity of data, and as a result, research into automated detection and classification systems (DCS) has been expanding internationally.

In this work, we present an end-to-end deep learning implementation of a DCS that is capable of detecting and classifying three distinct species of marine mammals: Blue, Fin, and Sei whales. Fin, Blue, and Sei whales are often capable of producing very similar vocalizations in terms of frequency and duration which makes the task of classification especially difficult. The DCS makes use of a deep convolutional neural network (CNN) commonly known as ResNet-50 and trained on a data set of roughly 30,000 hand annotated whale vocalizations collected around the Scotian Shelf and Roseway Basin. The aforementioned data set is constructed using a unique representation which builds upon the traditional spectrogram representation of an acoustic signal through interpolation and stacking. The result is an input with multiple channels (i.e., N-dimensional as opposed to 2-dimensional) and significantly improves the performance of the model.

Keywords: Applications - Acoustic applications, Applications - Ocean products for scientific, economic and societal use, , ,

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P94 - Abstract ID: 3552979

Operational oceanography system for fishery management and its application in the Central North Pacific Ocean

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We developed regional ocean environment analysis system, Scalable Kit of Under-sea Information Delivery system (SKUIDs), to provide potential fishing ground information to fishing operators. The system is used for quasi-operational habitat monitoring/management and economical optimization of fishing operation at sea. Key components comprising the analysis system are a four dimensional data assimilation system, statistical analysis scheme for detecting potential fishing ground at an oceanic frontal scale and the web-based visualization system for delivering the information to fishing vessels. In this presentation, we discuss general performance of the operational system and its effectiveness over the neon flying squid (ommastrephes bartramii) summer fishing operation in the Central North Pacific Ocean.

Keywords: Applications - Fisheries, DA - Data assimilation applications, DA - Variational data assimilation, Systems - Ocean Prediction Systems types (forecasting, analysis, scales, assessment, regions, ecosystem, ice, wave, etc.), Systems - Service providers

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P95 - Abstract ID: 3553537

Where did that come from? Visualizing the direction of arrival in large acoustic datasets

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Man-made noise is affecting the hearing, communication and behavior of marine life. Researchers need to understand the effects of sound in order to advise regulators on conservation strategies. The MERIDIAN (Marine Environmental Research Infrastructure for Data Integration and Application Network) project at Dalhousie University is working with JASCO Applied Sciences to design a tool for visualizing new types of soundscape data that include the direction of arrival of sounds. Direction helps users distinguish between animals and track the movement of vessels and wildlife, but needs to be presented in a user-friendly and intuitive way. While underwater acoustic data is normally presented in the form of 2D Time versus Frequency spectrograms which use color to indicate intensity, a new approach is needed to incorporate the direction. Here we take advantage of human-computer interaction, 3-dimensional views, and animation capabilities. The accuracy of directional data can also be subject to environmental conditions surrounding the hydrophones, and this uncertainty should also be presented to the user in a meaningful, accurate manner. AIS (Automatic Identification System) data and active learning a user-in-the-loop Machine Learning approach - are used to assess and predict directional certainty. Active learning combines human domain knowledge and machine learning strategies to label data. Active learning algorithms are able to improve labeling by querying a human user with uncertain data instances. These instances, labeled by the user, are then used to better train the algorithm. This system will help researchers and data analysts to analyze, annotate, and report information.

Keywords: Systems - Visualisation, Applications - Acoustic applications, Systems - General ocean monitoring (including those based on ocean DA and prediction systems), Applications - Ocean products for scientific, economic and societal use,

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P96 - Abstract ID: 3555808

Discovering Canadian underwater acoustic datasets

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Underwater acoustic data is important for understanding the oceans and how sound affects the marine environment. To record underwater sounds produced by fish, marine mammals, and ships, as well as to capture the complexity and interactions of the marine soundscape, hydrophones and other acoustic recording devices are used. These devices capture massive amounts of unstructured data, which is difficult to manage. Thus it is important to capture rich descriptive metadata so the data can be reused by others. Having a service that comprehensively lists existing underwater acoustic datasets would greatly improve discoverability, and avoid duplication of effort.

Currently, there is no such service or cataloging application which collects and lists underwater acoustic dataset from multiple sources in Canada. There is also no service or cataloging application to date which captures rich discipline specific metadata and provides a robust search interface to discover national data sources of underwater acoustic data.

The Canadian Integrated Ocean Observing System (CIOOS), built through a public, private and academic partnership, is planning to create a federated, nationwide ocean observing system portal for discovering ocean observation data, programs, and projects. However, CIOOS does not consider acoustic data to be in scope for the pilot phase of the project. At MERIDIAN (Marine Environmental Research Infrastructure for Data Integration and Application Network) we are working on closing this gap by building a discovery service that lists existing Canadian underwater acoustic datasets . The heart of our discovery service is based on GeoNetwork, an open-source geospatial cataloging application. In order to describe the datasets in an appropriate and discipline specific manner we are introducing a metadata standard based on two well established standards, namely ISO 19115 and Darwin Core. To accommodate our custom metadata convention we implemented a plugin for our GeoNetwork instance that allows us to populate, validate and search all metadata elements as needed. By combining GeoNetwork with Elastic Search, a customizable search engine framework, we are able to create a web interface which facilitates keyword, map and subject based search as well as facet based discovery of underwater acoustic data. Our service will allow researchers, data scientists, and other users to discover and if applicable access dataset that stored in various locations in Canada.

Keywords: Applications - Acoustic applications, Applications - Ocean products for scientific, economic and societal use, , ,

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OceanPredict '19
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P97 - **Abstract ID: 3564000**

Applications of machine learning to the detection and classification of underwater acoustic signals

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Sound can travel much larger distances underwater than light or any other form of electromagnetic radiation. Thus, many marine species have evolved to rely primarily on sound for underwater navigation, prey detection, and communication. This is being used by researchers who listen to the sounds generated by marine animals, for example, to detect the presence of an endangered species or to study a social behavior. In recent years, increasing numbers of underwater listening and recording devices are being deployed worldwide, generating vast amounts of data that easily exceed our capacity for manual analysis. MERIDIAN (Marine Environmental Research Infrastructure for Data Integration and Application Network) is developing software packages and tools for the automated detection and classification of sounds using state-of-the-art machine-learning techniques from computer vision and natural language processing. Current projects include the development of neural networks for detecting grunts produced by Arctic Cod, and neural networks capable of differentiating between the songs of three species of whales (right whale, fin whale, and sei whale). The detectors and classifiers we are developing are based on Convolutional and Recurrent Neural Networks. We are evaluating different network architectures and the most successful will be available in an open-source library, which aims to facilitate the use of deep learning techniques by ocean scientists. Pre-trained models for the detection and classification of several marine species will also be released under open-source licenses. Finally, we are developing an interactive application that allows the human expert to load pre-trained models and continue training the neural network, interacting with the model as it learns from new data and the users feedback. This way, users will be able to start with a general pre-trained model and interactively improve it if necessary, for example, a whale detector trained in a region with shipping noise could be adapted to perform well in a new region, where seismic noise is prevalent in the background. In this contribution, the first preliminary results from this work will be presented.

Keywords: Applications - Acoustic applications, Applications - Ocean products for scientific, economic and societal use, Applications - Environmental assessment, ,

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P99 - Abstract ID: 3579058

Vulnerability Assessments Modelling, Adaptation and Resilience to Climate Change And Ocean Warming In West African Coast

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Coastal ecosystems are considered to be sensitive to different environmental forcings, particularly sea-level rise and an increase in storm intensity. Human produced greenhouse gases (GHGs) concentrations in the atmosphere are currently rising at alarming rates. These gases are the major driver for changing climate scenarios highlighted by an approximate 1C increase in sea surface temperatures. In addition to driving global warming, GHGs are readily absorbed by the oceans, resulting in changes in seawater chemistry and a decrease in seawater pH (acidification). In addition, the phases of the El Nio Southern Oscillation affect the climatic (e.g rainfall) trends and pattern in the study area. The study was conducted in the Gulf of Guinea region of the North Atlantic which stretches from the Senegal in the West to Gabon to the South-Eastern part of Africa. It is home to a large number people and economic activities with over fifty (50) million African population. In order to ensure the preservation of preserving natural resources and ecological features, a modified methodological approached was developed to evaluate risk of coastal inundation from sea level rise and storm surge at specific sites, areas of importance for natural, and infrastructural resources. Monthly annual sea surface temperature data were obtained the National Oceanic and Atmospheric Administration (NOAA) and Advanced very-high-resolution radiometer (AVHRR) over the Gulf-of-Guinea region between 1972 to 2017 (45 years) were analysed in relation to three El Nino-Southern Oscillation (ENSO) phases. The tools were developed using the ArcGIS 10.5 and Idrisi Terrset software to enable users conduct risk analyses of coastlines by classifying vulnerable areas, and also to produce outputs for further analysis. The recommendations from this research thus enhance the capacity and knowledge of governments and other policy makers in the region to prepare for, and adapt to climate change and its extreme events. A coastal spatial planning designed and then the Integrated Coastal Zone Management framework for West Africa coastal region was developed. Lastly, results from this research would help to improve weather prediction thus developing the economy as well as saving lives and properties during climate-related hazards such as drought, forest fires and floods.

Keywords: Applications - Climate change research, Applications - Environmental assessment, Observations - Observation impacts, Models - Future trends in ocean modelling, Systems - Ocean reanalysis

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P100 - **Abstract ID: 3590708**

Ocean monitoring and reporting activities of the Copernicus Marine Environment Monitoring Service

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COPERNICUSis the European Earth observation and monitoring program, which aims to give the European Union autonomous and operational capability in space-based observation facilities (see the Sentinel missions) and in situ (measurements in the atmosphere, in the ocean and on the ground), and to operate six interlinked environmental monitoring services for the oceans, the atmosphere, territorial development, emergency situations, security and climate change. Mercator Ocean, the French center of global ocean analysis and forecast, has been entrusted by the EU to implement the Copernicus Marine Environment Monitoring Service (CMEMS) which provides an open and free access to regular and systematic information about the physical state and dynamics of the ocean and marine ecosystems for the global ocean and six European regional seas.

The CMEMS ocean monitoring and state-of-the-art ocean reporting (state, variability and change) for the global ocean and European seas is part of the production center service elements in order to establish a unique reference of value-added expert information at a regular frequency. This is achieved through two principal activities:

- Annual release of the peer-reviewed CMEMS Ocean State Report containing a state-of-the-art value-added synthesis of the ocean state, variability and change from the past to present.
- Ocean Monitoring Indicators and related operational framework on the CMEMS web portal. In particular, CMEMS has developed several indicators based on global or regional ocean reanalyses. For a series of indicators, consistency estimates are available, based on a multiproduct approach inheritated from CLIVAR/GODAE IV-TT ORA IP.

This activity is aiming to reach a wide audience from the scientific community, over climate and environmental service and agencies, environmental reporting bodies, decision maker to the general public. We will give here an overview on the CMEMS ocean monitoring and reporting activity, highlight main outcomes, and introduce future plans and developments.

Keywords: Applications - Ocean products for scientific, economic and societal use, Applications - Climate change research, Applications - Environmental assessment, Applications - Sustainable use of ocean resources for economic growth (blue economy), Applications - Ocean literacy

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P101 - **Abstract ID: 3598016**

A stochastic simulation methodology for preliminary evaluation of environmental susceptibility to oil spills originated in large marine areas

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A methodology based on numerical modeling for evaluation of environmental assets susceptibility to oil spills that may occur in large marine areas is developed. The methodology was thought to meet the goals of the Sedimentary Area Environmental Assessment Study (SAEAS), a broad multidisciplinary analysis instituted by a joint effort of the ministry of the environment and the ministry of mines and energy of Brazil. The SAEAS is supposed to be accomplished before the bidding rounds for exploration and production of Oil and Gas and aims to anticipate environmental issues of the permitting processes, or even to withdraw from the bidding rounds exploratory blocks that have unacceptable environmental risks identified.

Oil fate modeling studies are critical parts of the permitting processes, conducted by the Brazilian Institute for the Environment and Renewable Natural Resources (IBAMA). The permitting processes start after the granting of exploratory blocks in bidding rounds conducted by the National Agency of Petroleum (ANP). IBAMAs specifications for oil fate modeling are quite standard and follows the state of art of oil spill modeling, requiring stochastic simulations with models that address the three-dimensional surface and subsurface transport and fate processes and can be applied to both surface and subsurface releases.

The proposed methodology is based on stochastic modeling of oil slicks trajectories. Rather than using a sophisticated approach, such as the methodology required for the permitting process, we used a simplified and less computationally costly approach. Parallel computing techniques were used to enable the calculation of hundreds of thousands of oil slick trajectories originated in hundreds of positions distributed along the entire sedimentary basin, considering different environmental conditions. The massive number of oil slick trajectories allows the preparation of probabilistic maps of oil presence and minimum arrival time for spills that may occur anywhere within the sedimentary basin, as well as backtrack calculations to identify the potential origins of spills that may affect valuable environmental assets.

The methodology was applied for the Sergipe-Alagoas basin, an area of 31,750 Km2 with high environmental sensitivity, many important estuarine regions and important conservation units. This basin is the study area of the pilot experience of SAEAS. Input data are a 4-year hindcast simulation of currents with a resolution of 1/36 and winds from global reanalysis. Probabilistic analyses were accomplished considering more than 380,000 oil slicks trajectories. Comparisons are presented with results obtained with the OSCAR model, considering different types of oils and spill volumes.

Keywords: Applications - Oil & gas industries, Applications - Environmental assessment, Models - Numerical methods, Systems - Prediction system performance & evaluation,

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GODAE OceanView Symposium | 6-10 May 2019 Halifax, Canada
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P102 - **Abstract ID: 3616638**

Uncertainty in surface drift prediction from observational data using fuzzy numbers

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Predicting the trajectory of a free-drifting object at the ocean surface requires accurate information on currents, wind, and waves in the affected area, but such information is not always available with the precision required for reliable predictions. In this study the uncertainties associated with near-real time measurements of these environmental conditions that are reported from offshore platforms are explored. The principles of fuzzy arithmetic are used to assess the effect of these uncertainties on trajectory prediction and the ability of the measurements to help inform oil spill response and search and rescue. Comparisons are presented for scenarios in the open Pacific Ocean (Ocean Station Papa) and Juan de Fuca Strait, a narrow coastal waterway in southern British Columbia. Further, the relative importance of current, wind, and wave forcing on trajectories, and the effectiveness of various physical parameterizations aimed to reduce uncertainty associated with reported environmental measurements are assessed.

Keywords: Systems - Probabilistic forecasting, Systems - Implementation of Ocean Prediction Systems, Observations - Estimates of measurement errors, Applications - Search and rescue, Applications - Marine pollution

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P103 - **Abstract ID: 3616763**

Insight into Designing the Next Generation of Ocean Observing Systems from AtlantOS

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The AtlantOS project has, with partners including the Global Ocean Observing System (GOOS) and the GEO Blue Planet Initiative, worked over the last several years to integrate disparate ocean observing programs into a more comprehensive and fit-for-purpose Atlantic Ocean observing system: utilizing the Framework for Ocean Observation; ensuring a focus on Essential Ocean Variables; encouraging the collection of compatible metadata; enhancing links between the biological and coastal observation communities; prioritizing free and open access to data; supporting sensor development; and standardizing language and best practices. These actions have greatly increased the ability of the Atlantic observing networks to deliver consistent ocean data, in more varied locations, with lower time latency, and at greater resolution and accuracy, a step change in consistent and coordinated delivery for the basin.

Creating a truly efficient and fit-for-purpose observing system, which maximizes impact and benefit, requires a focus on how well the observations being measured meet the needs of various end-users, including government, the private sector, civil society, and science. For ocean modelling, and the climate, weather, and scientific users relying on accurate knowledge of current and future ocean states, one measure of impact is which observations most improve forecast skill.

In AtlantOS, a series of Observing System Evaluation (OSE) and Observing System Simulation Experiments (OSSE) trials were run, and new ocean simulation techniques developed. This allowed us to begin to quantify the importance of different ocean observation data types in reducing model error and uncertainty, and improving forecasts. Results from these experiments, as well as from an ensuing workshop where observation networks synthesized these impact assessments with earlier work on cost and feasibility, have created an integrated future plan for ocean observing in the Atlantic Ocean.

When done systematically, OSE and OSSEs have the potential to not only inform the optimal mix of different ocean observation networks, but also to help tailor the observation strategies of individual networks. Another key insight is that the value of OSE and OSSEs is significantly enhanced if the observing and modelling communities cooperate in creating and analyzing these experiments to identify coherent model and observing system improvements. The dynamic and interactive nature of this interplay can lead to significant advances for both communities. One anticipated outcome of the OceanObs19 conference is an international framework to coordinate and share the findings of OSE and OSSE activities for the benefit of basin scale and global ocean observing networks.

Keywords: Observations - Observing system needs and future challenges, Observations - Observing system assessments and design, DA - Observation impact assessment methods, Evolution - Enhancing community collaboration (observations, modelling, operations, users), Applications - Ocean products for scientific, economic and societal us

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P104 - **Abstract ID**: 3756862

Monitoring and prediction of coastal storm impacts in the Estuary and Gulf of St. Lawrence

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Coasts in the Estuary and Gulf of St. Lawrence (EGSL) are facing increasing sea levels. Coastal hazards are further amplified by sea ice reduction during cold seasons. Recent storm-related floods have been caused by wave-induced water levels, affecting many communities. Coastal management needs operational tools for effective adaptation strategies in the EGSL, but their implementation is not straighforward due to regional variabilities in offshore/nearshore morpho/hydrodynamics. In this paper, we present the integration of Wavewatch3 (offshore wave) hindcast and original wave runup parametrizations derived from five beaches in the EGSL, resulting in coastal Total Water Level (TWL) timeseries for any given location along the coastline. Video analysis indicate that wave runup (discrete vertical excursion induced by wave setup and swash) is significantly affected by the location of the beach and therefore varying dominant wave climate within the EGSL. A wave energy threshold based on significant wave height separates sheltered beaches from more open beaches, justifying the use of distinctive formulations in TWL forecasting. Newly developed runup formulations, offshore wave forcing and TWL estimations are validated on two different beaches during overwash events in the upper Estuary and the Gulf. On both sites, the model clearly indicate erosion and flooding potential whitin a 3-hours time window. Predicting TWL in the EGSL is crucial for effective coastal management and we demonstrate a relatively simple application for accurate prediction of coastal storm impacts. The method performs well at the regional scale and has great potential for further operational applications, including numerical simulation of nearshore waves and water levels for a better understanding of coastal and hinterland flooding processes.

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