GEORGIOS SYLAIOS

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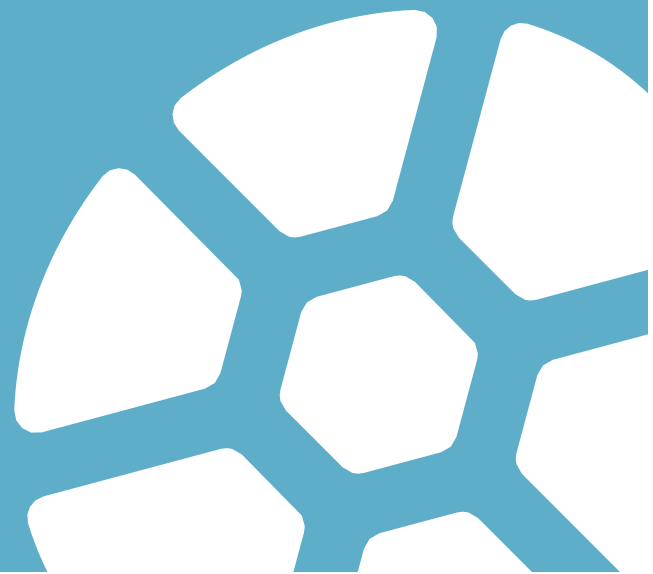
Towards a Digital Twin for Ocean Health



What is a Digital Twin?

“A digital twin is a **virtual replica** that serves as the **real-time digital representation** of a **physical object or process**”.

“Digital twins are the result of **continual improvement** in the creation of **product design** and **engineering activities**”.
source: Wikipedia.

What are the elements of a DT?

- Smart Sensors for RT data collection
- Systems for data transfer and data feeds
- Decentralized or centrally-stored in cloud
- High resolution/high in accuracy simulations to virtual copies
- Interactive platforms to display RT 3D/4D spatial-temporal data
- Integrating IoT, AI and software analytics
- Augmented reality (AR) systems as visualization technologies
- Optimize machines, products, processes, services
- Monitoring, diagnostics, prognostics

Where DTs are used?

- Manufacturing
- Automotive
- Construction
- Utilities
- Healthcare

DIGITAL TWINS IN ILIAD

Iliad’s Digital Twin of the Ocean provides a **virtual environment representing the ocean, capable of running complex, predictive management scenarios**. The innovative system integrates cross discipline sensors, models and digital infrastructures.

Interoperable, data-intensive, and cost-effective Digital Twins of the Ocean

ILIAD IN A SEASHELL

Enabling an ecosystem of interoperable digital twins for the ocean trough:

- Connecting to existing ocean data infrastructures
- Enhance ocean data infrastructures with additional observation technologies and citizen science

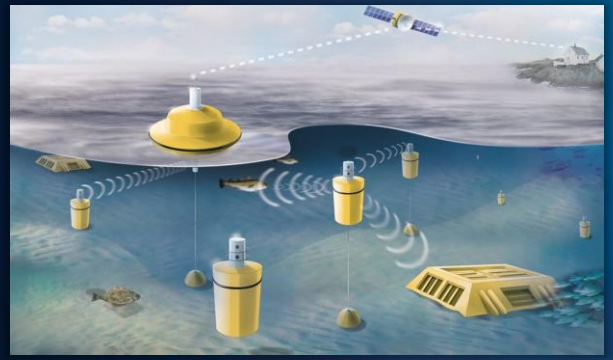
Create an open marketplace accessible for all providers and users by:

- Development of innovative methods in open frameworks and platforms
- Enable model evaluations & comparisons for many Earth science applications from weather, energy, aquaculture to climate and more

Provide solutions to address future societal challenges by:

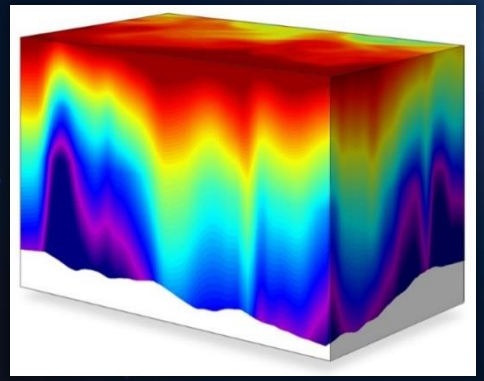
- Assembling a broad and diverse user community of existing and new users,
- Supporting the communities in testing and using the project's innovative technological solutions

ILIAD Digital Twin Ingredients and Novelties

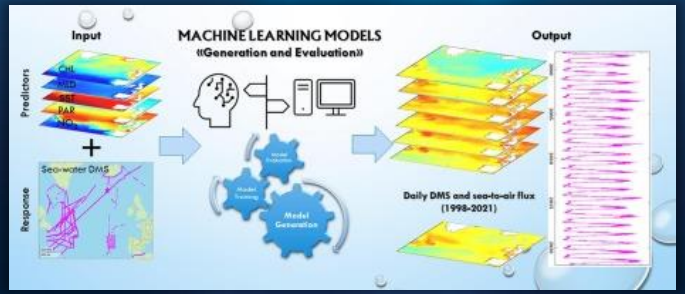


Sensors
- Gliders
- Drones
- MPS
- Drifters
- Ecosounders
- LiDAR
- Low-cost Sensors

Existing Resources
- Satellites
- Sensor Networks
- Databases
- Large-scale Models

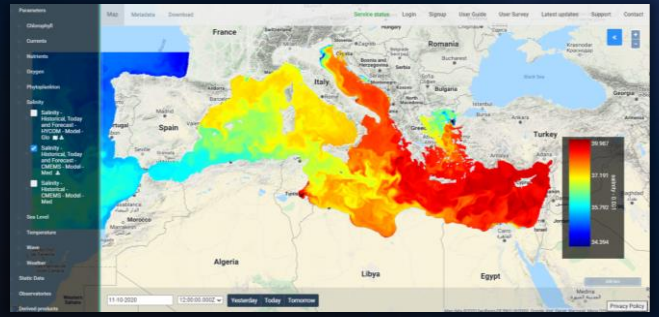


Models
- Coupled,
- Downscaled
- Hydrodynamic
- Wave
- Ecosystem
- Oil Spill
- GFD to CFD



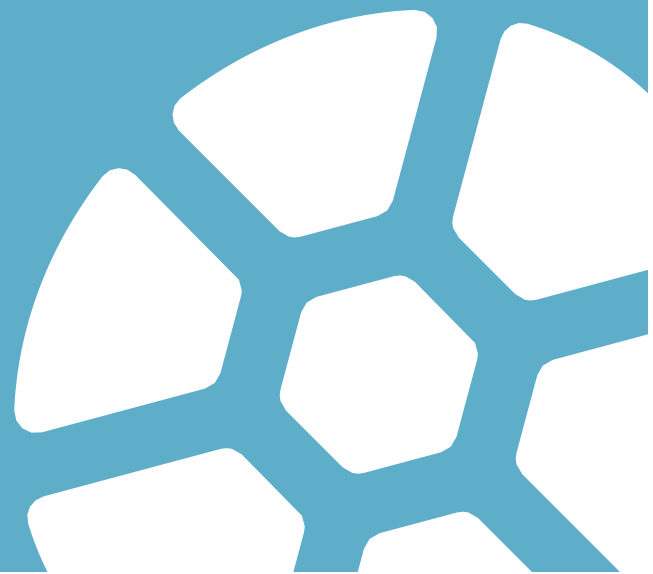
AI Algorithms
- Data Fusion
- Data Analytics
- Data-driven Models
- Machine Learning
- Pattern Recognition
- Event Detection

Citizen Science
- Networks
- Reporting Apps
- Social Networks
- Semantics
- Humans as Sensors

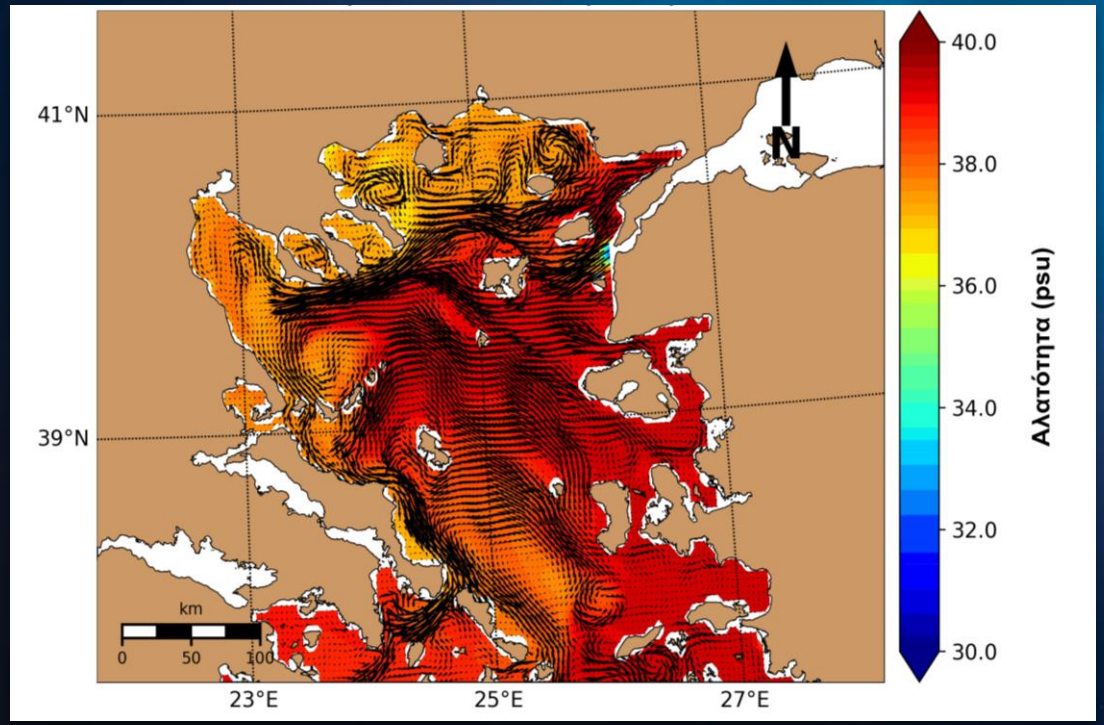


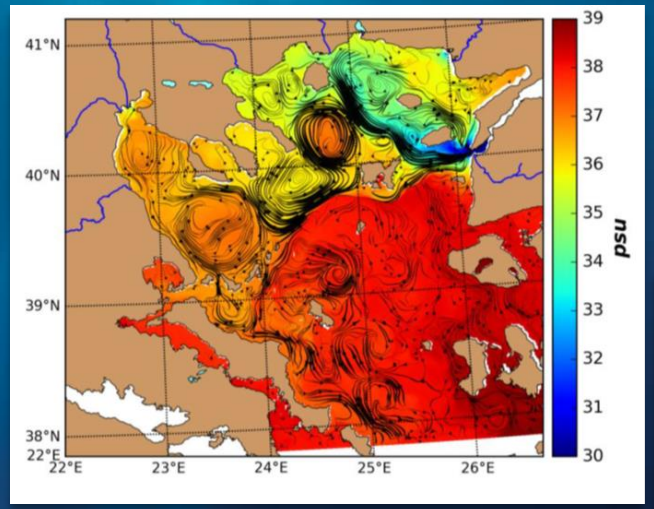
DTO Platform
- Federated
- Interoperable
- Data Collector
- Simulator
- Control Room

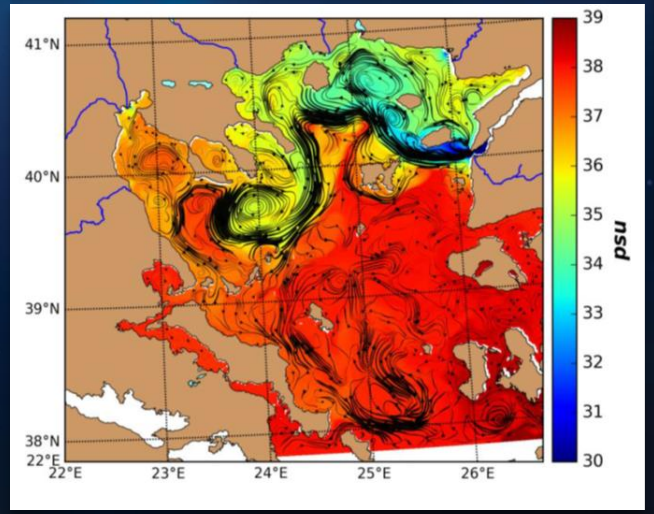
Towards the Digital Twin for Oil Spill Incidents in the Thracian Sea

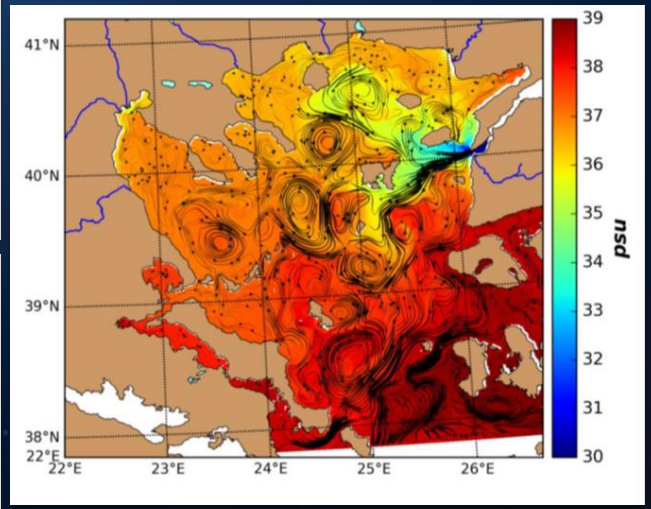


Forecasting Numerical Models with Data Assimilation

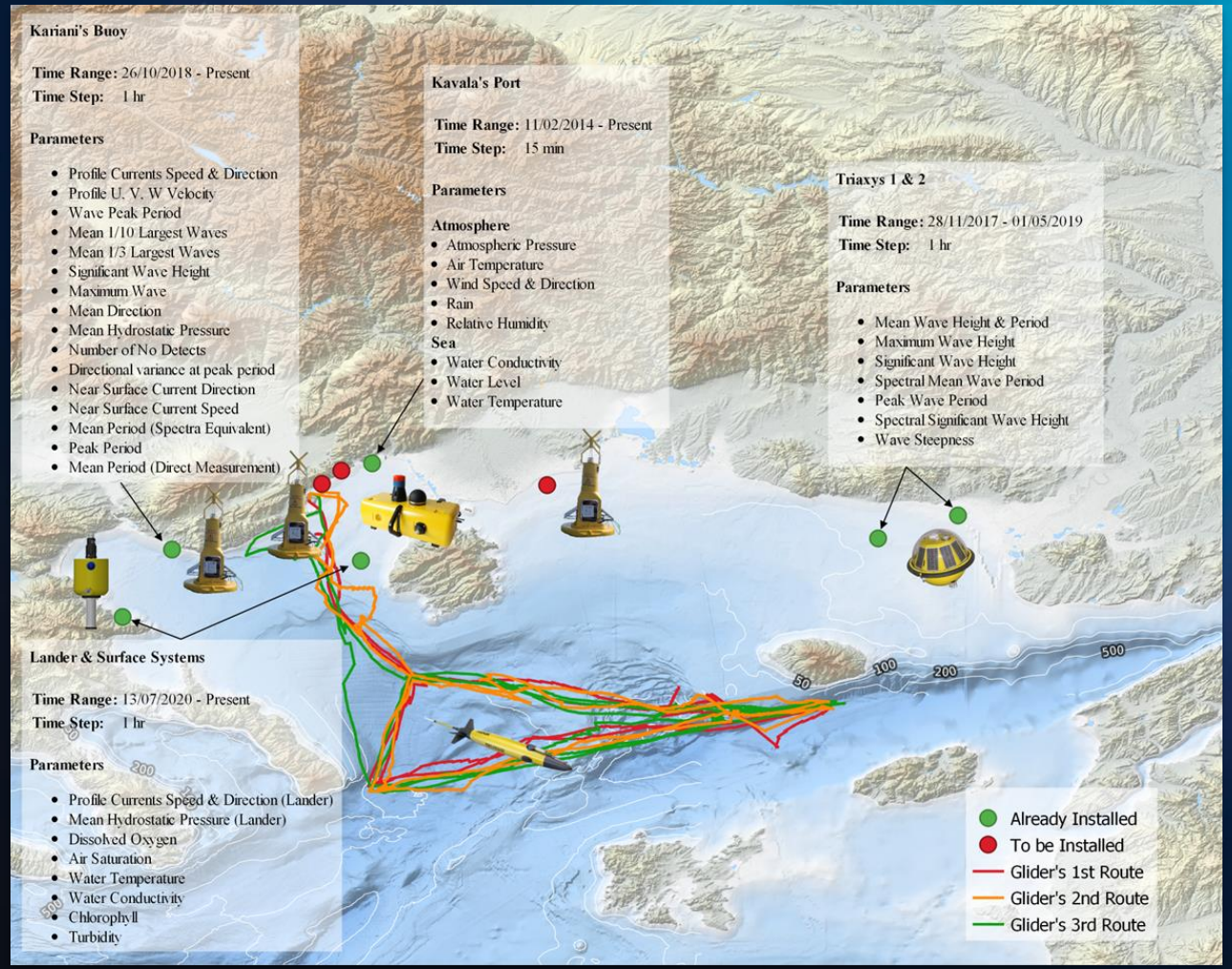








Sensors at Sea – RT Data Transfer to DUTH Server



- **4 ADCPs** for 3D currents, waves and SPM monitoring
- **1 surface water quality station** (SST, S, DO, Chl, pH, SPM)
- **2 Wave riders** (wave height, period and direction)
- **Glider surveys** (T, C, S, σ_t, CDOM, SPM, DO)

Instrumentation Deployed in Thracian Sea

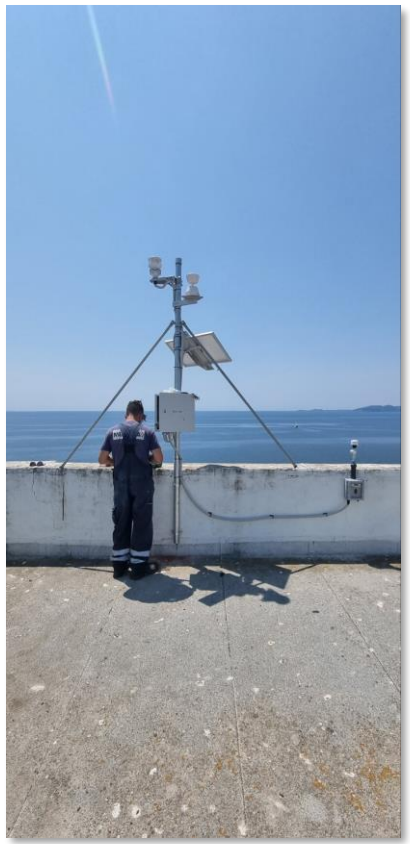
4 oceanographic stations deployed in Kariani, Palio, Perigiali and Avdira, collecting and transferring RT oceanographic data on

a) **waves** (significant wave height, wave period and wave direction),

b) **currents** throughout the water column,

c) **water quality** (temperature, salinity, dissolved oxygen, SPM).

Coastal Atmospheric Conditions

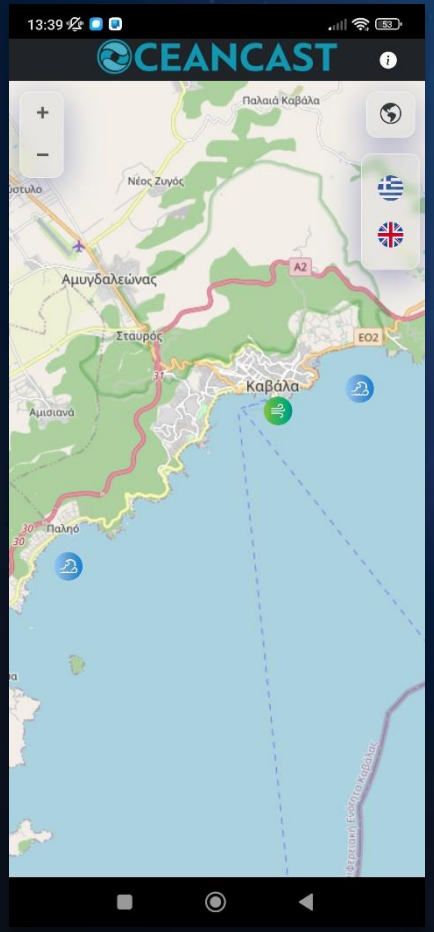


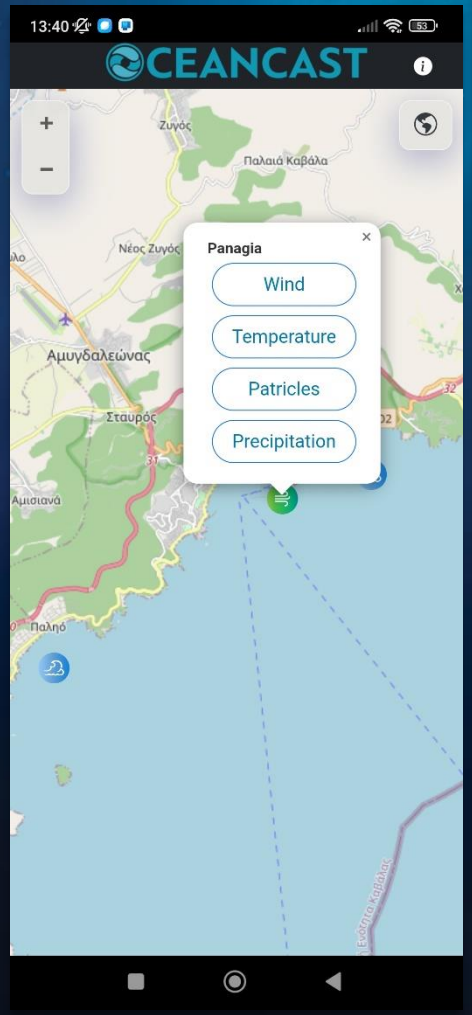
1 meteorological station installed in Kavala coastal zone for the RT measurements:

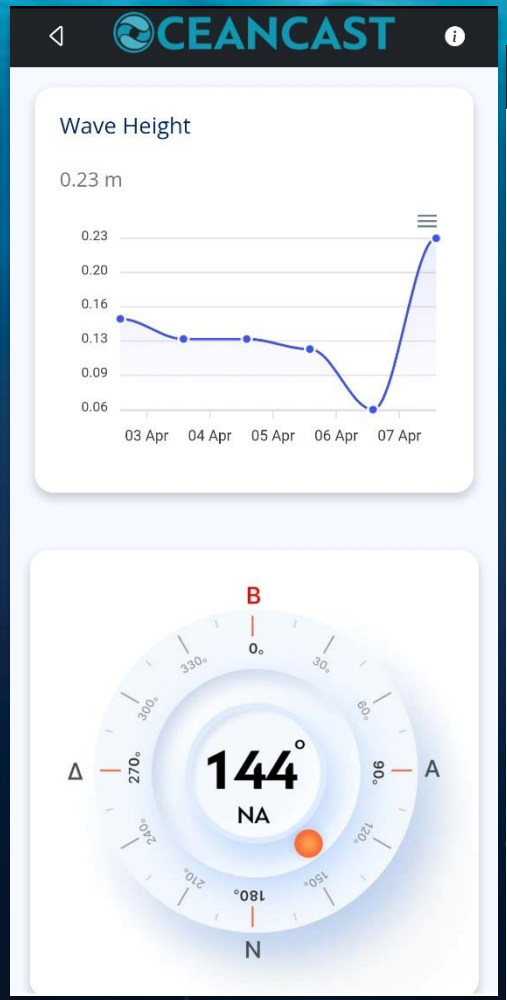
a) air temperature, wind speed and direction, barometric pressure, relative humidity, dew point temperature, precipitation,

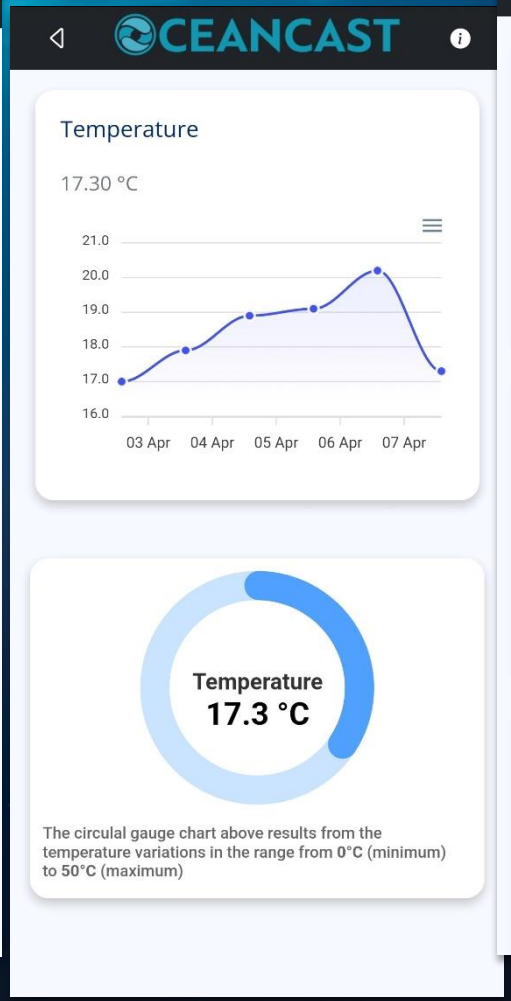
b) air quality (PM10 concentration).

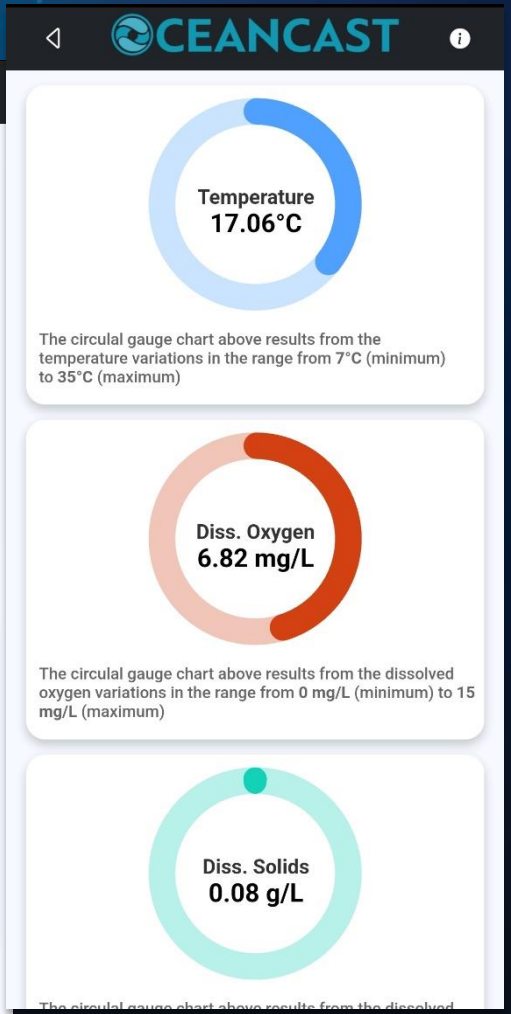
Mobile Oceancast App







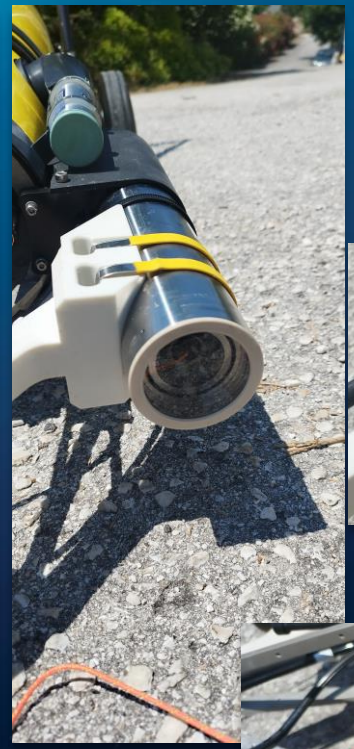




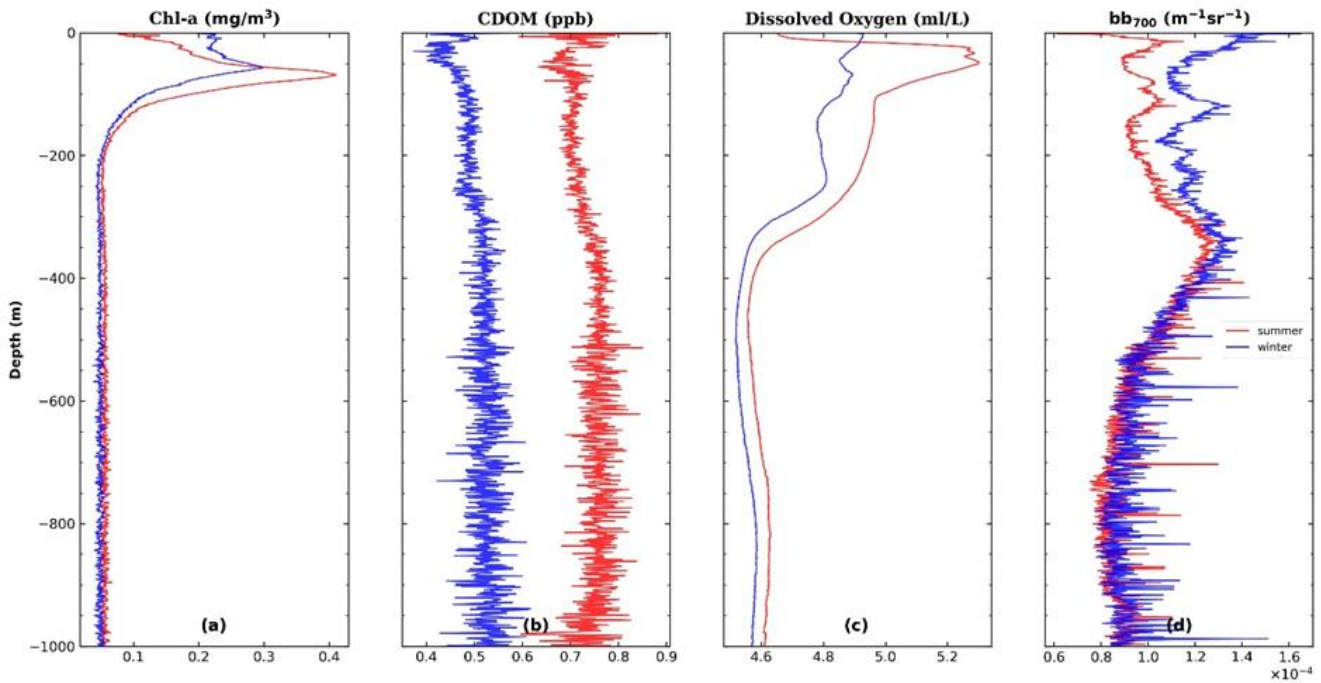
Glider Surveys in Thracian Sea – summer 2023

Glider equipped with sensor payload consisting of:

- CTD sensor
- CDOM, SPM, Chl-a
- ADCP
- Plankton UPV6 Camera



Hydrography, Water Column Dynamics and Subsurface Chlorophyll Maximum in North Aegean Trough



Algorithms for Oil Spill Detection

Satellite Image

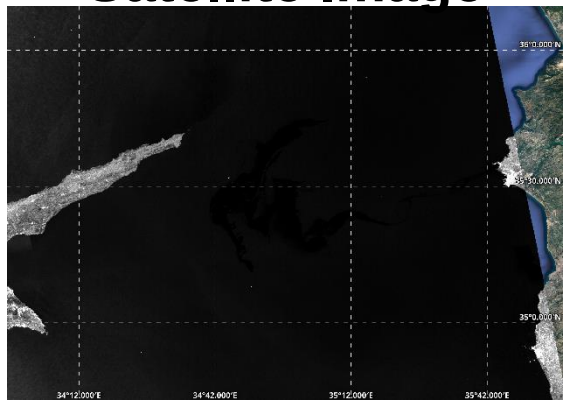
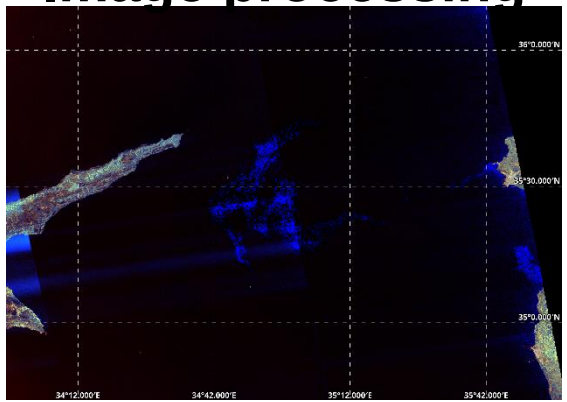
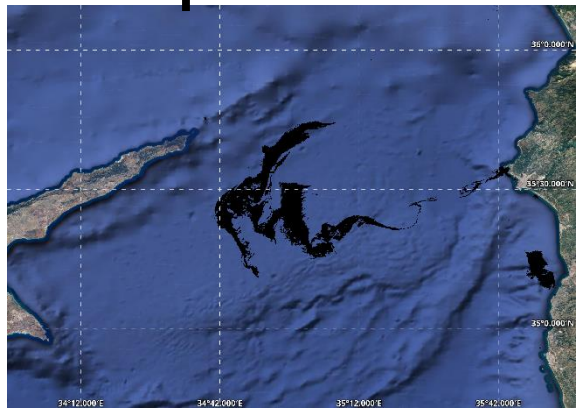


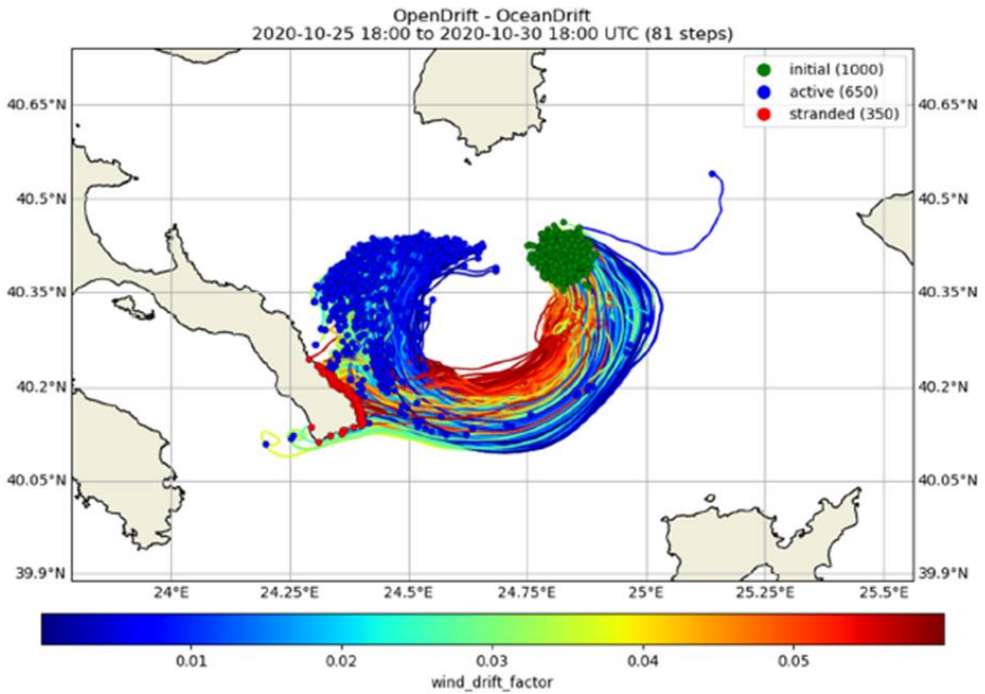
Image processing

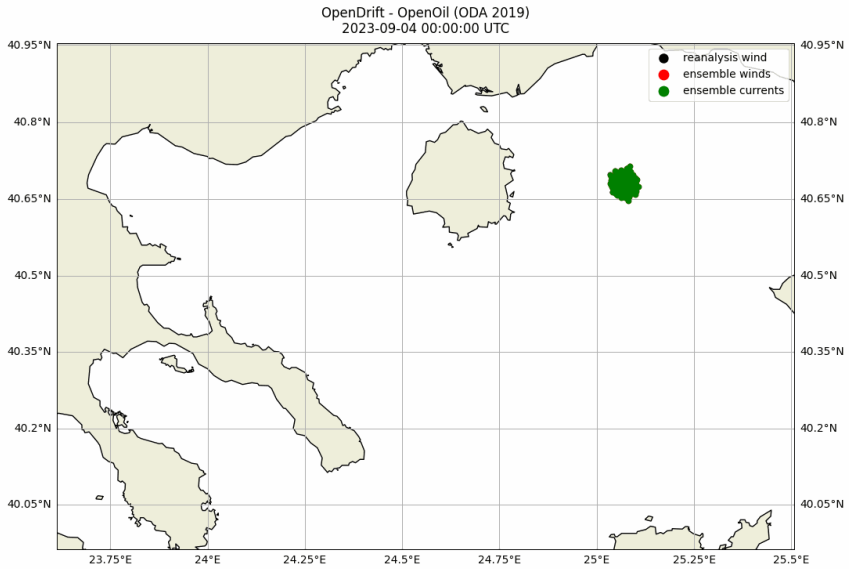


Oil spill detection

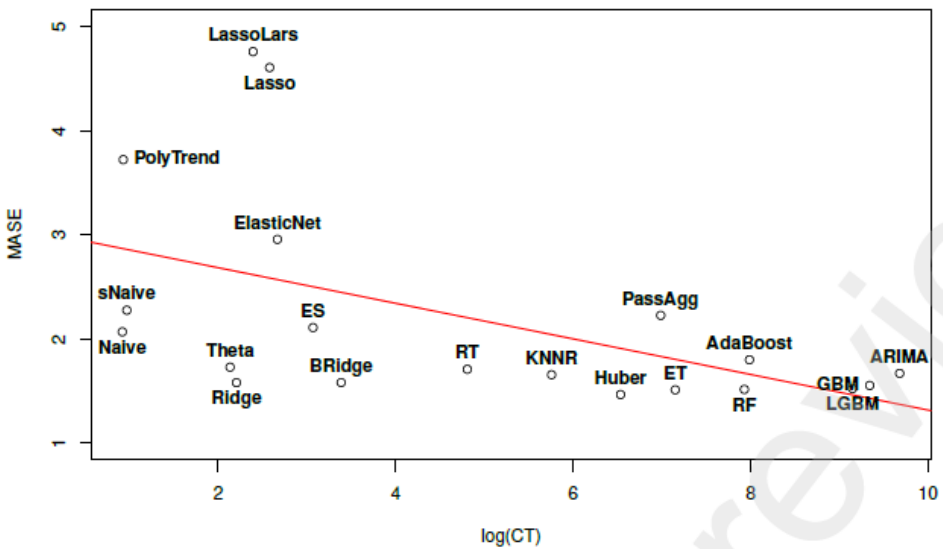


Operational Oil Spill Modeling





ML in Operational Oil Spill Modeling



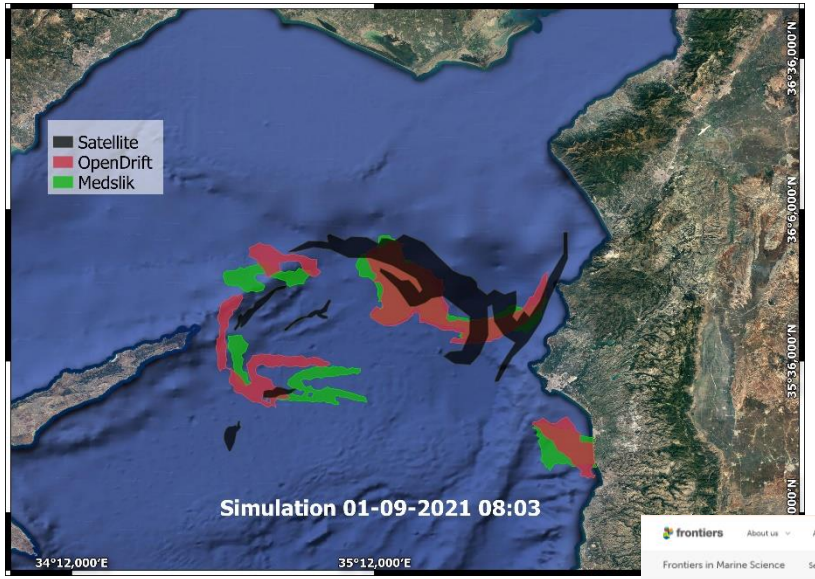
Time Series and Regression Methods for Univariate Environmental Forecasting: An Empirical Evaluation

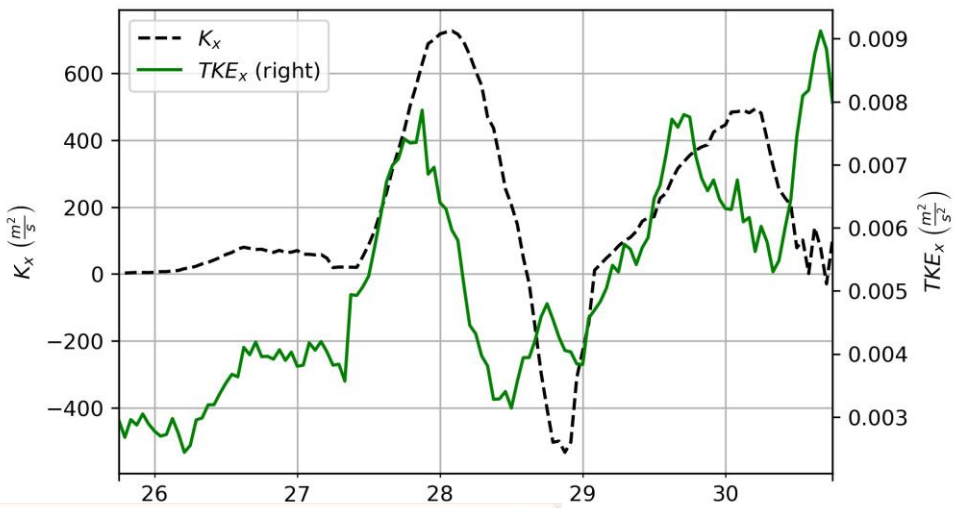
Dimitrios Effrosynidis[a,*], Evangelos Spiliotis[b], Georgios Sylaios[c], Avi Arampatzis[a]

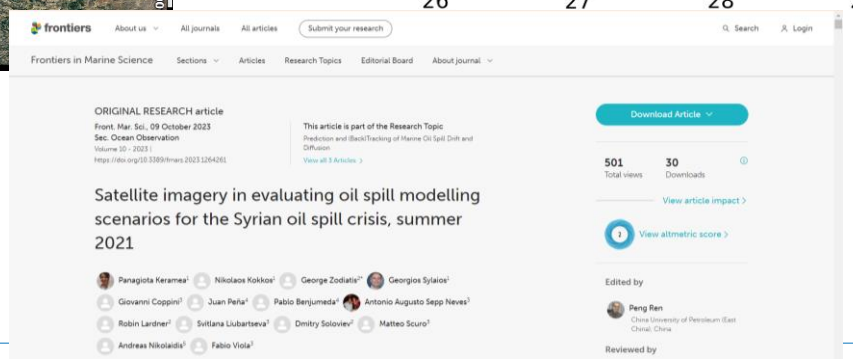
Test ML models in terms of prediction accuracy and computational time

Univariate ML algorithms to forecast wind and ocean parameters with variable look-back and forecasting windows

Oil Spill Modeling Validation and Meta-Analysis





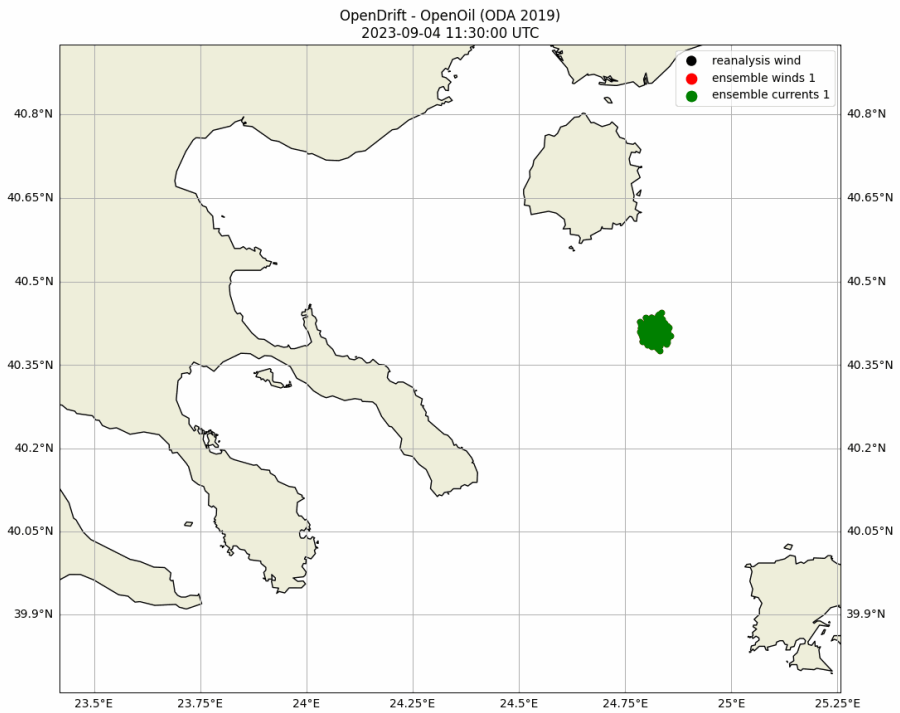

frontiers

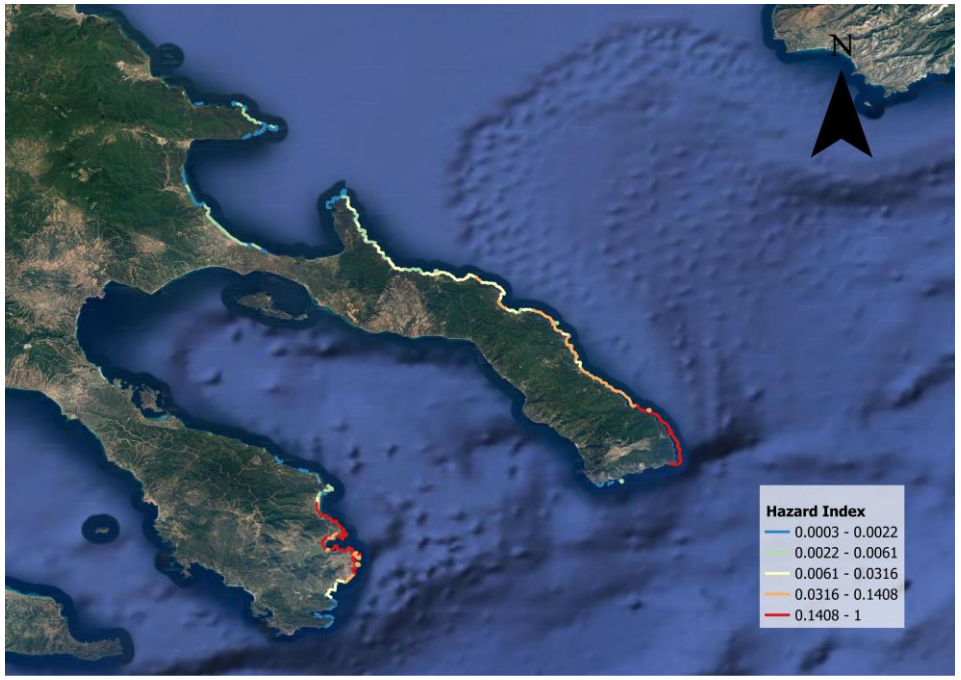
Frontiers in Marine Science

ORIGINAL RESEARCH article

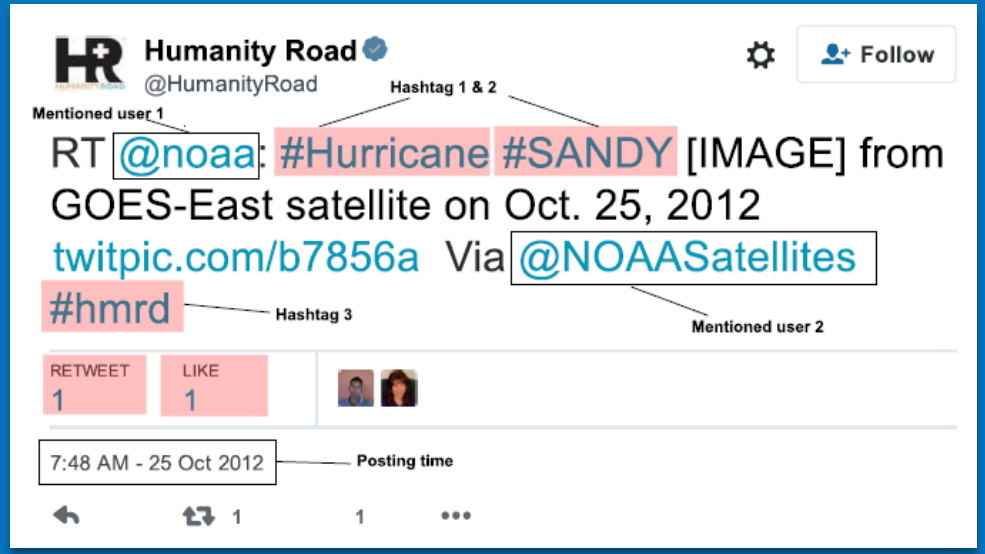
Satellite imagery in evaluating oil spill modelling scenarios for the Syrian oil spill crisis, summer 2021

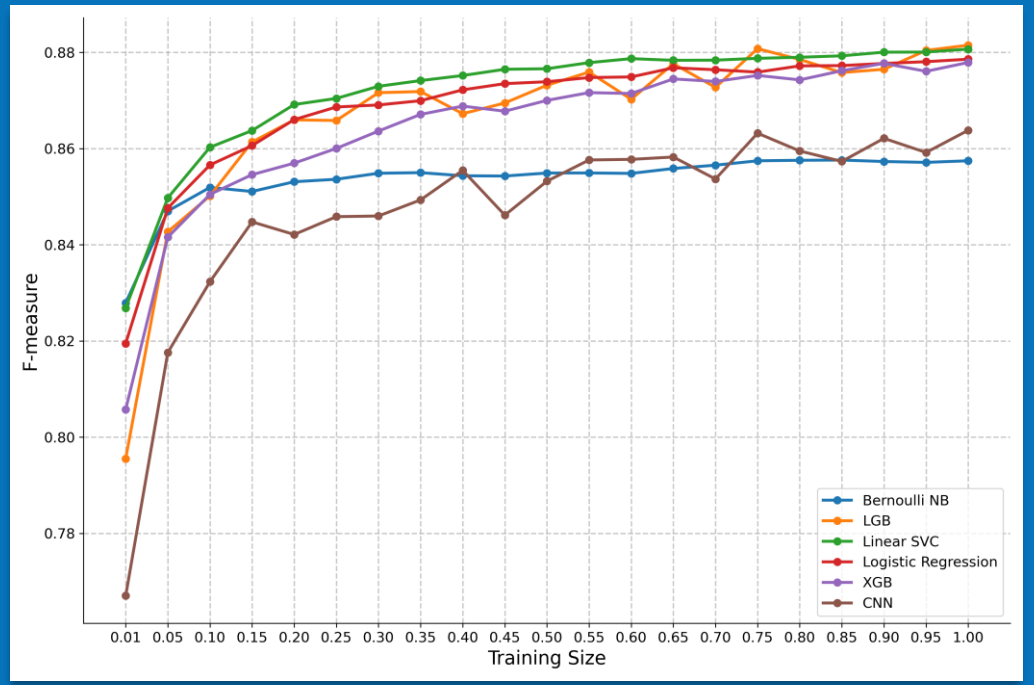
Uncertainty Analysis and Hazard Assessment





Citizen Science: Scanning Twitter Posts for Oil Spill and Other Disaster Posts





The Oil Spill DT

ALMOST DONE !

Scan Satellite Images for Oil Spills

Scan Social Media Posts For Oil Spills References

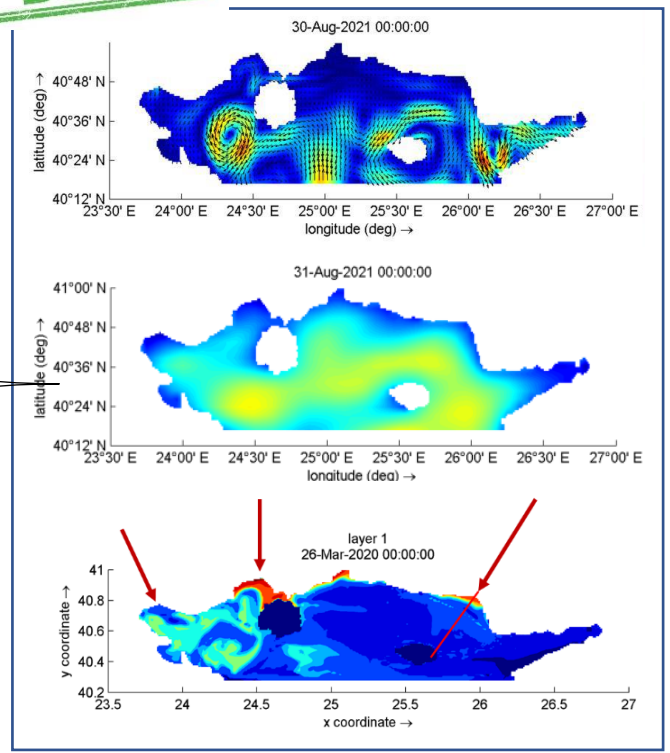
TBC TO BE COMPLETED

Use Citizen Science Apps For Oil Spills Records

Event Identification Pack

DONE

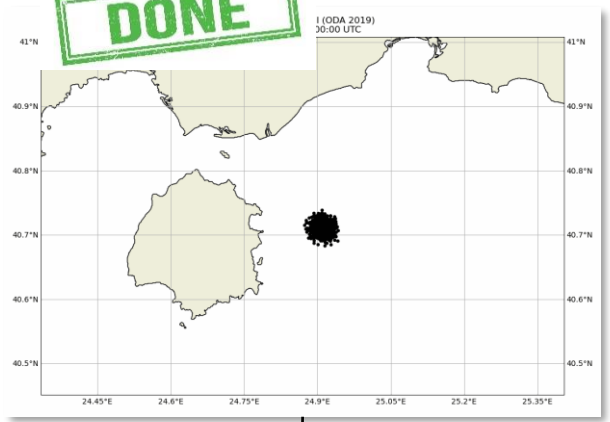
ODYSSEA Package



DONE

ML Models for Localized Wind Speed & Direction Forecasting

DONE

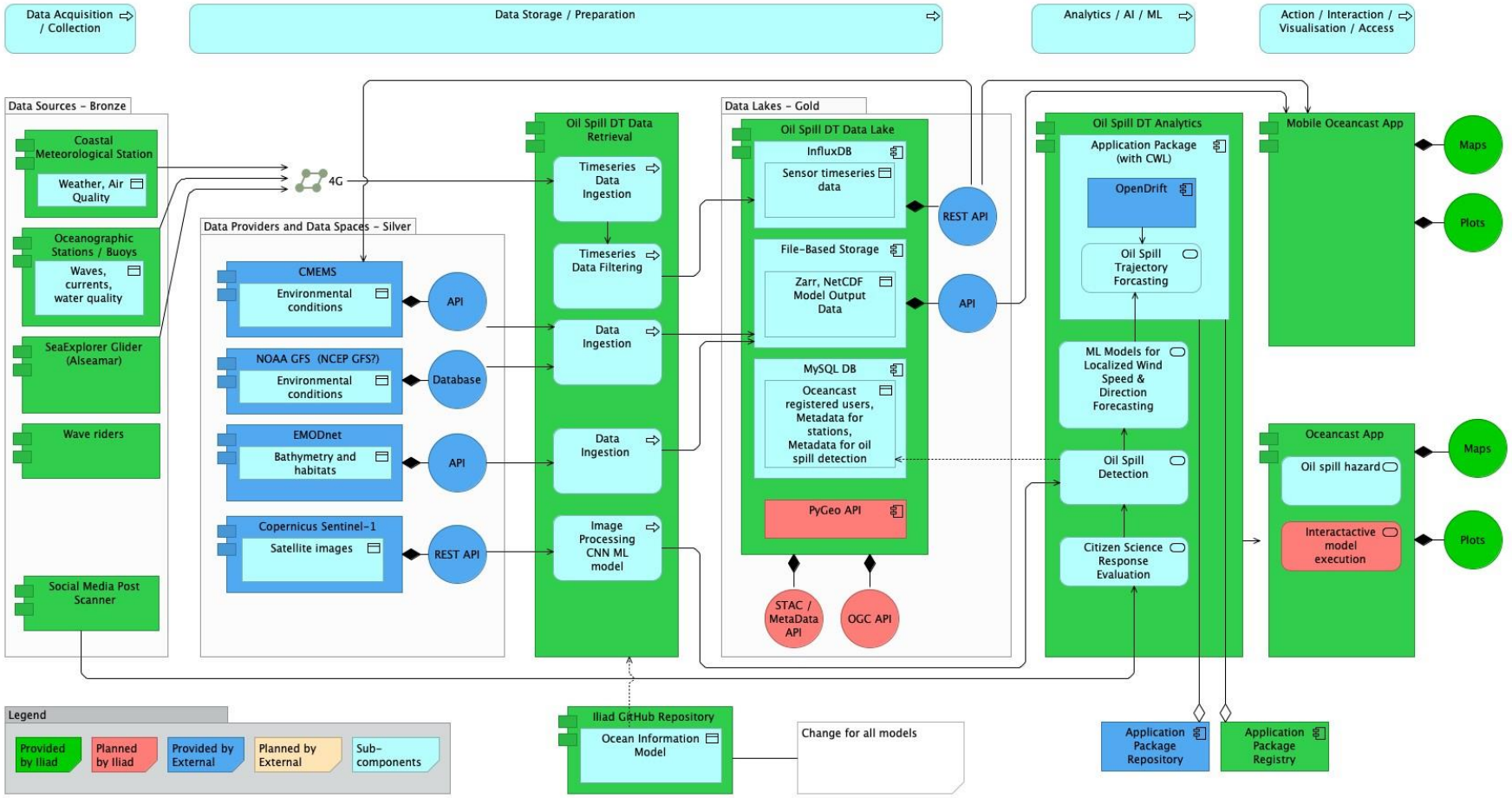


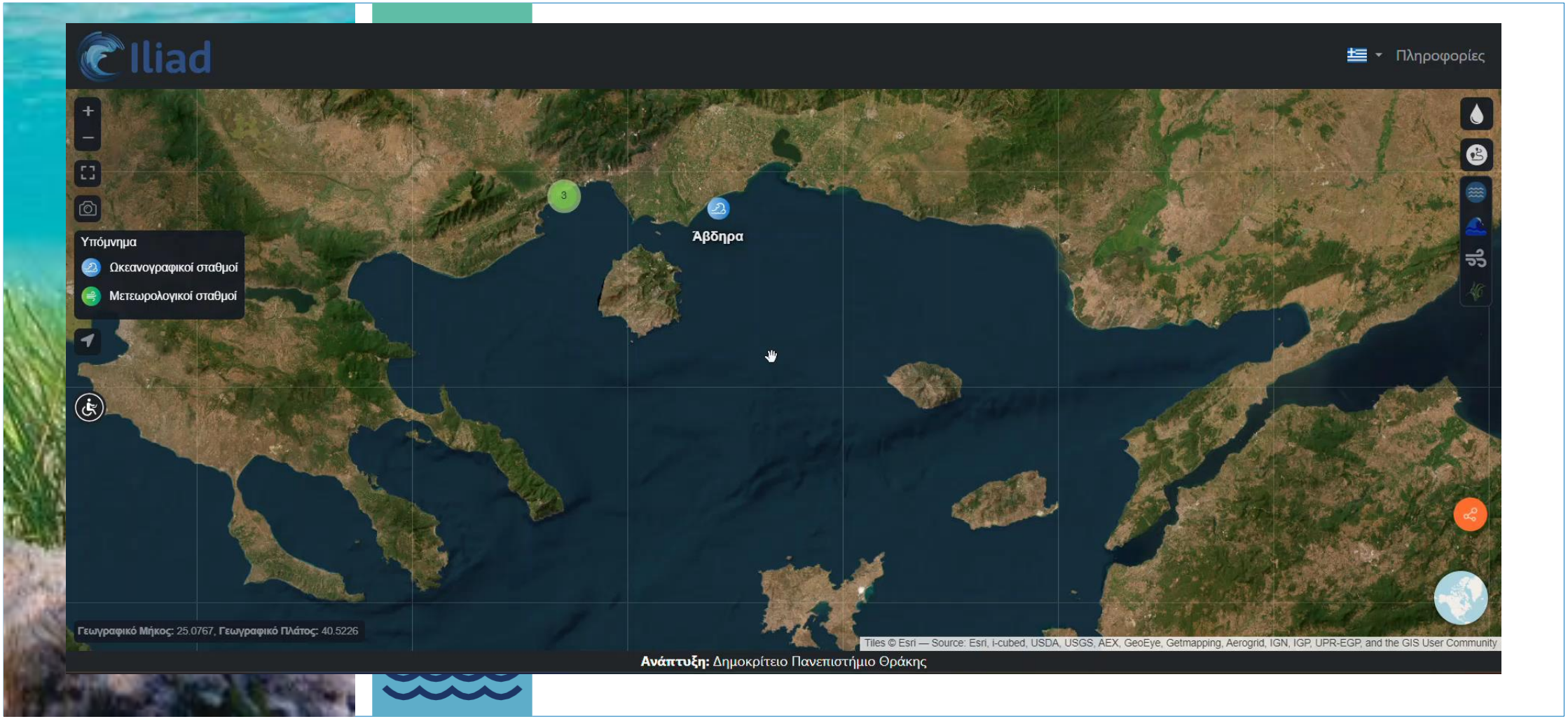
Alarm and Aid Authorities' Response

Use Sensors, Citizen Science Apps & SM posts to Evaluate Clean up

DONE

The Thracian Sea Digital Twin Architecture




Iliad
Πληροφορίες
3
Άβδηρα
Υπόμνημα
Ωκεανογραφικοί σταθμοί
Μετεωρολογικοί σταθμοί
Γεωγραφικό Μήκος: 25.0767, Γεωγραφικό Πλάτος: 40.5226
Tiles © Esri — Source: Esri, i-cubed, USDA, USGS, AEX, GeoEye, Getmapping, Aerogrid, IGN, IGP, UPR-EGP, and the GIS User Community
Ανάπτυξη: Δημοκρίτειο Πανεπιστήμιο Θράκης

THANK YOU!

Professor Georgios Sylaios
Democritus University of Thrace