Ocean Predict

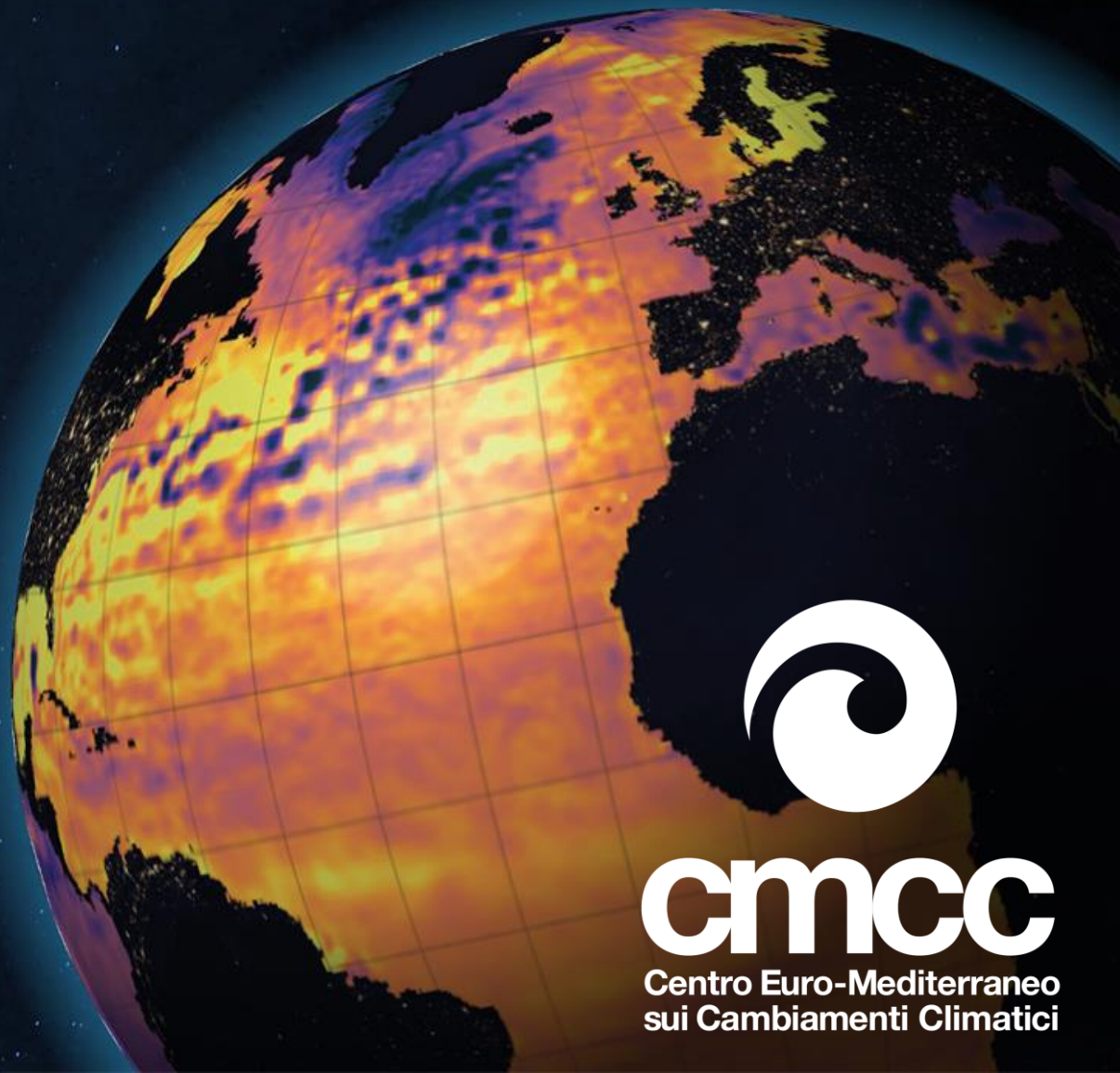
SYMPOSIUM OP'24

In partnership with unesco Intergovernmental Oceanographic Commission

2021 2030 United Nations Decade of Ocean Science for Sustainable Development

WITOIL

an open and accessible oil spill simulation platform on a digital twin.



Speaker: Francesco Trotta

cmcc
Centro Euro-Mediterraneo sui Cambiamenti Climatici

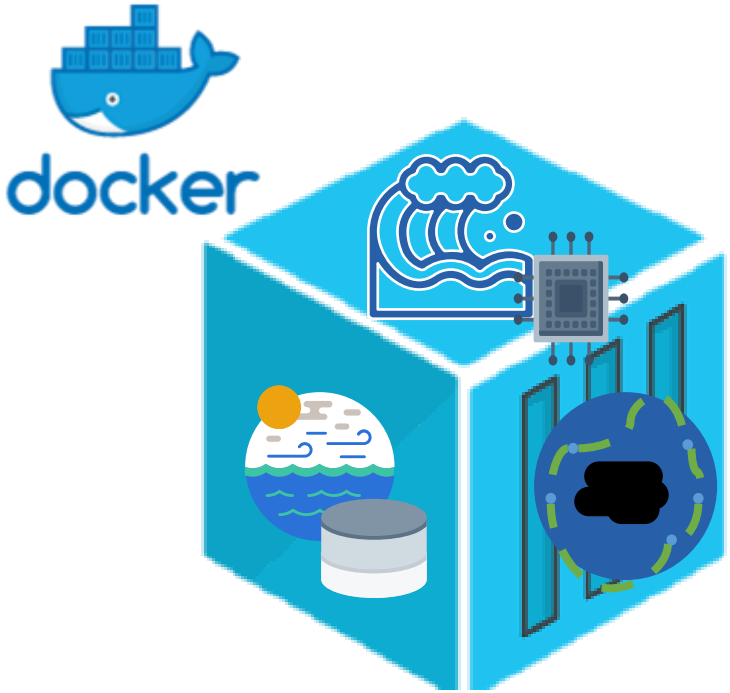
WITOIL

Where Is The Oil

- **WITOIL** is a **Digital Twin platform** for simulating the transport and transformation of oil spills.
- The oil spill model used is the **MEDSLIK-II**
- One of the Key Feature of the platform is the **Interactivity**
  (allows users to easily explore real-time scenarios, analyze oil spill evolution, and evaluate response strategies)
- This capability **enhances decision-making processes**, supporting effective environmental protection.

WITOIL Cloud
Container-Based Approach

The application has been **containerized** and deployed on the **EDITO Infra Cloud**



- It has been packaged into a **Docker container**, enabling it to run in a fully self-contained environment
- It includes everything the application requires:
  - the operating system,
  - the fortran code MEDSLIKII,
  - the python script for pre/postprocessing
  - all its dependencies

WITOIL Cloud
Container-Based Approach

European Digital Twin Ocean
EDITO Model Lab

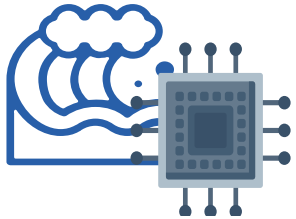
The application consists of two main components:

Backend

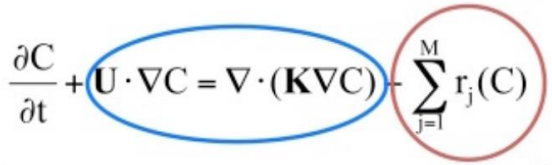
Frontend

DOWNLOAD INPUT DATA
Currents, Temperature, Winds

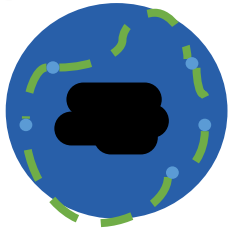
On-the-fly data download
(using Copernicus Marine Services and Climate Data Store API)



DATA PREPROCESSING
Transforming files into MEDSLIK-II input



MEDSLIK-II SIMULATION



DATA POSTPROCESSING
Visualization results

WITOIL Cloud
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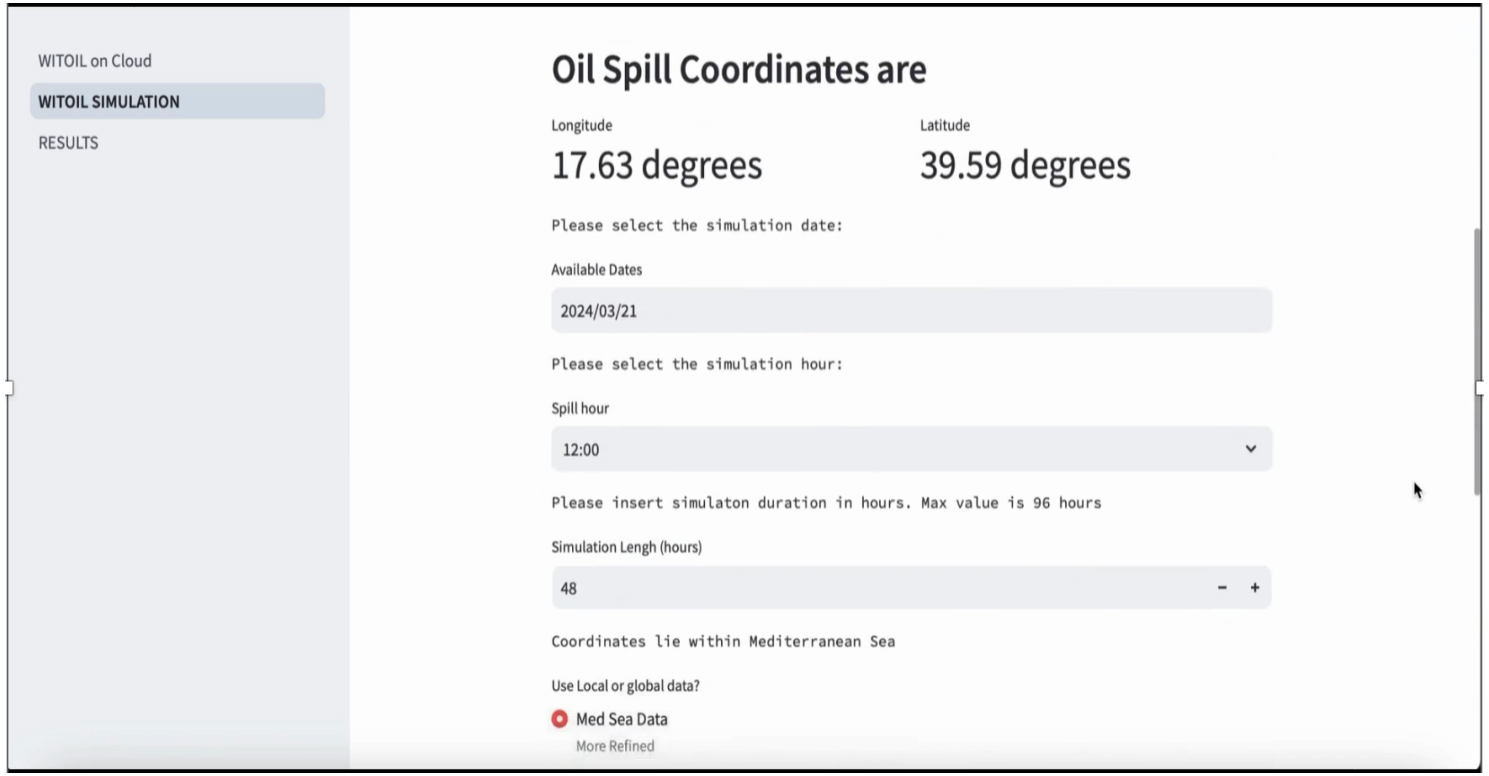
The application consists of two main components:

Backend

Frontend

An interactive Graphical User Interface (GUI) built with **Streamlit** provides a seamless and user-friendly experience.



Streamlit

It enables users to:

- easily interact with the backend,
- manage workflows
- input parameters,
- visualize simulation results.

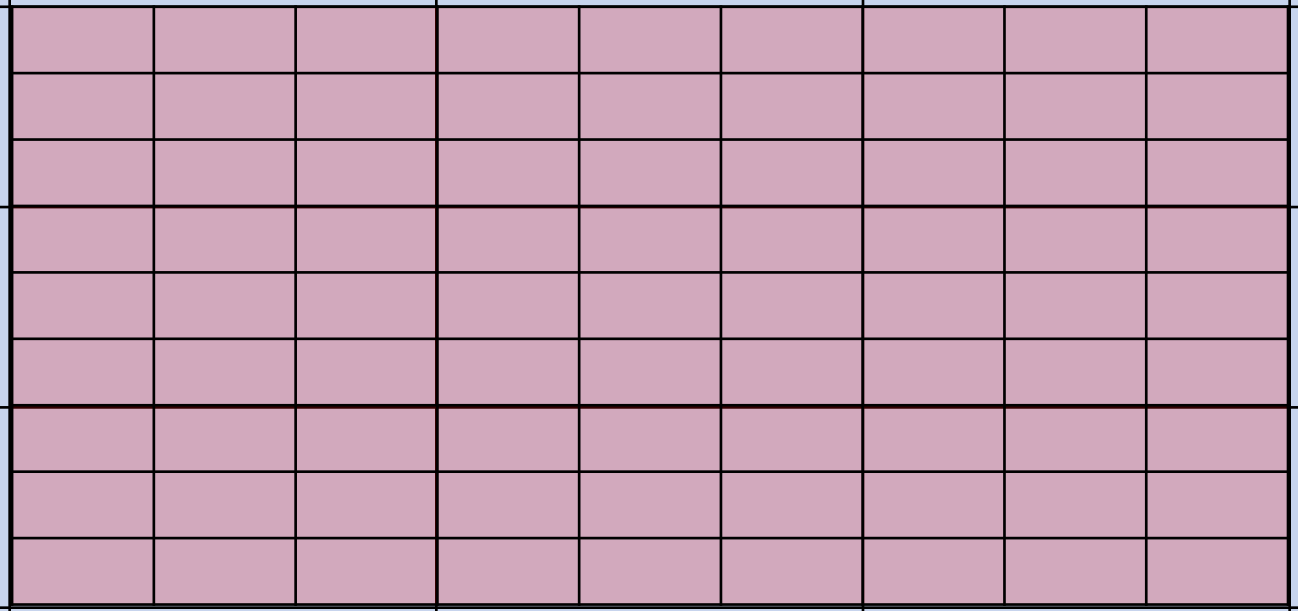
Demonstration in the Witoil Service

Case Study: Manilla Oil Spill accident

Two experiments with two different Ocean Input Data

(1) from **Global-CMEMS** Product (1/12)

(2) from **SURF-NEMO** Results (1/36)



Case Study: Manilla Oil Spill accident

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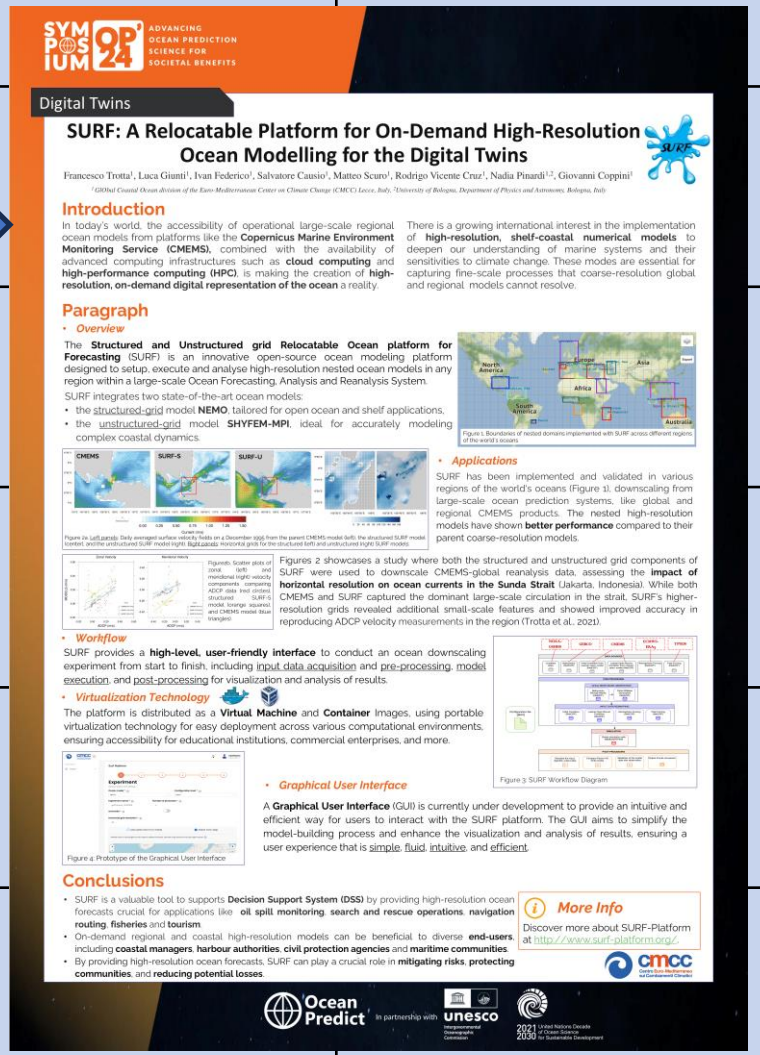
POSTER SECTION



SYMPOSIUM OP24 ADVANCING OCEAN PREDICTION SCIENCE FOR SOCIETAL BENEFITS

Digital Twins

SURF: A Relocatable Platform for On-Demand High-Resolution Ocean Modelling for the Digital Twins

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Introduction

In today's world, the accessibility of operational large-scale regional ocean models from platforms like the **Copernicus Marine Environment Monitoring Service (CMEMS)**, combined with the availability of advanced computing infrastructures such as **cloud computing** and **high-performance computing (HPC)**, is making the creation of **high-resolution, on-demand digital representation of the ocean** a reality.

There is a growing international interest in the implementation of **high-resolution, shelf-coastal numerical models** to deepen our understanding of marine systems and their sensitivities to climate change. These models are essential for capturing fine-scale processes that coarse-resolution global and regional models cannot resolve.

Paragraph

- *Overview*

The **Structured and Unstructured grid Relocatable Ocean platform for Forecasting** (SURF) is an innovative open-source ocean modeling platform designed to setup, execute and analyse high-resolution nested ocean models in any region within a large-scale Ocean Forecasting, Analysis and Reanalysis System.

SURF integrates two state-of-the-art ocean models:

- the structured-grid model **NEMO**, tailored for open ocean and shelf applications,
- the unstructured-grid model **SHYFEM-MPI**, ideal for accurately modeling complex coastal dynamics.

Figure 1: Boundaries of nested domains implemented with SURF across different regions of the world's oceans

- *Applications*

SURF has been implemented and validated in various regions of the world's oceans (Figure 1), downscaling from large-scale ocean prediction systems, like global and regional CMEMS products. The nested high-resolution models have shown **better performance** compared to their parent coarse-resolution models.

Figures 2 showcases a study where both the structured and unstructured grid components of SURF were used to downscale CMEMS-global reanalysis data, assessing the **impact of horizontal resolution on ocean currents in the Sunda Strait** (Jakarta, Indonesia). While both CMEMS and SURF captured the dominant large-scale circulation in the strait, SURF's higher-resolution grids revealed additional small-scale features and showed improved accuracy in reproducing ADCP velocity measurements in the region (Trotta et al., 2021).

- *Workflow*

SURF provides a **high-level, user-friendly interface** to conduct an ocean downscaling experiment from start to finish, including input data acquisition and pre-processing, model execution, and post-processing for visualization and analysis of results.

Figure 3: SURF Workflow Diagram

- *Virtualization Technology*

The platform is distributed as a **Virtual Machine** and **Container** Images, using portable virtualization technology for easy deployment across various computational environments, ensuring accessibility for educational institutions, commercial enterprises, and more.

Figure 4: Prototype of the Graphical User Interface

- *Graphical User Interface*

A **Graphical User Interface** (GUI) is currently under development to provide an intuitive and efficient way for users to interact with the SURF platform. The GUI aims to simplify the model-building process and enhance the visualization and analysis of results, ensuring a user experience that is simple, fluid, intuitive, and efficient.

Conclusions

- SURF is a valuable tool to supports **Decision Support System (DSS)** by providing high-resolution ocean forecasts crucial for applications like **oil spill monitoring**, **search and rescue operations**, **navigation routing**, **fisheries** and **tourism**.
- On-demand regional and coastal high-resolution models can be beneficial to diverse **end-users**, including **coastal managers**, **harbour authorities**, **civil protection agencies** and **maritime communities**.
- By providing high-resolution ocean forecasts, SURF can play a crucial role in **mitigating risks**, **protecting communities**, and **reducing potential losses**.

More Info

Discover more about SURF-Platform at http://www.surf-platform.org/.

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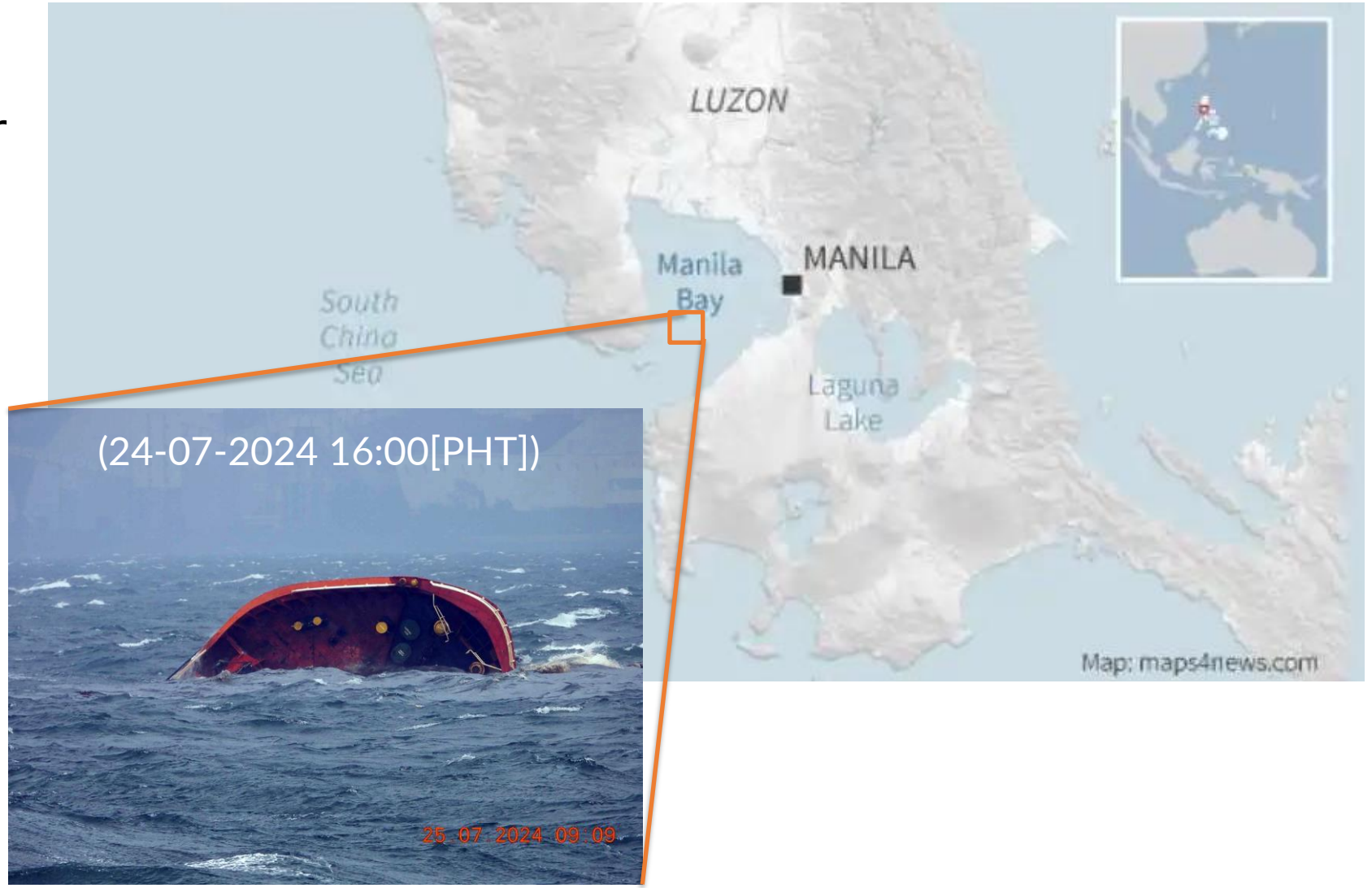
Manilla Oil Spill accident

- On **July 24, 2024, at 16:00 (PHT)**, the oil tanker **Terranova** sank in **Manila Bay**, resulting in a significant oil spill.

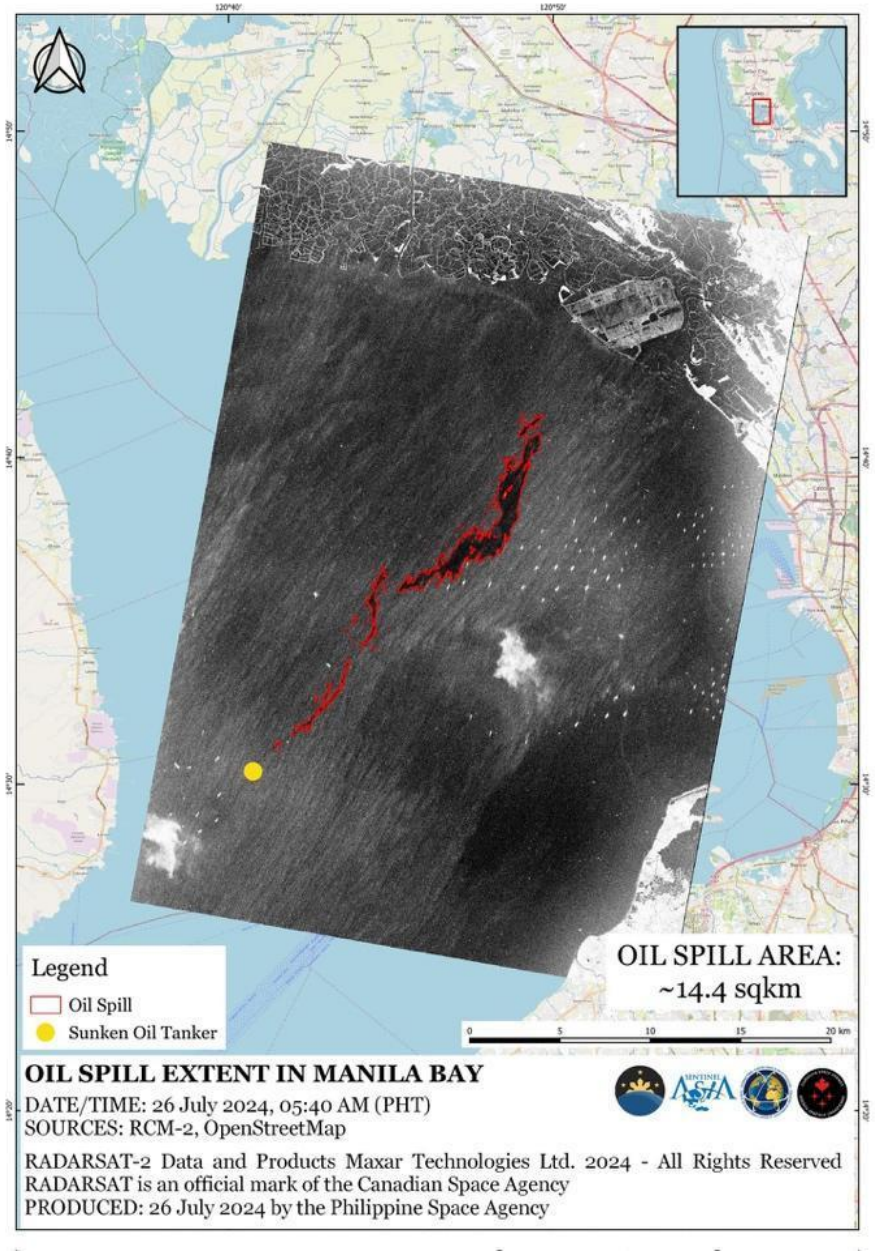
- The tanker was transporting ~ **1.5 million liters of oil**.



Satellite Image of the Oil Spill

- **Satellite image** of the oil spill from RadarSAT-2 [**26/07/2024 05:40 (PHT)**] distributed by the Philippine Space Agency

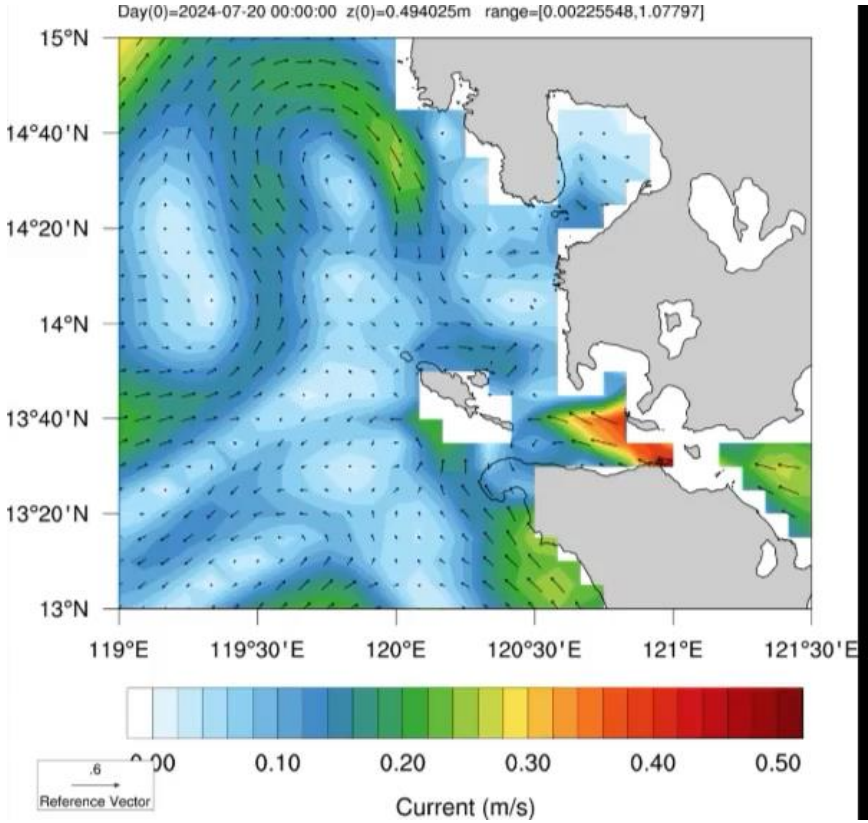
- The slick drifts to the **North-East** of the position of the tanker **Terranova**



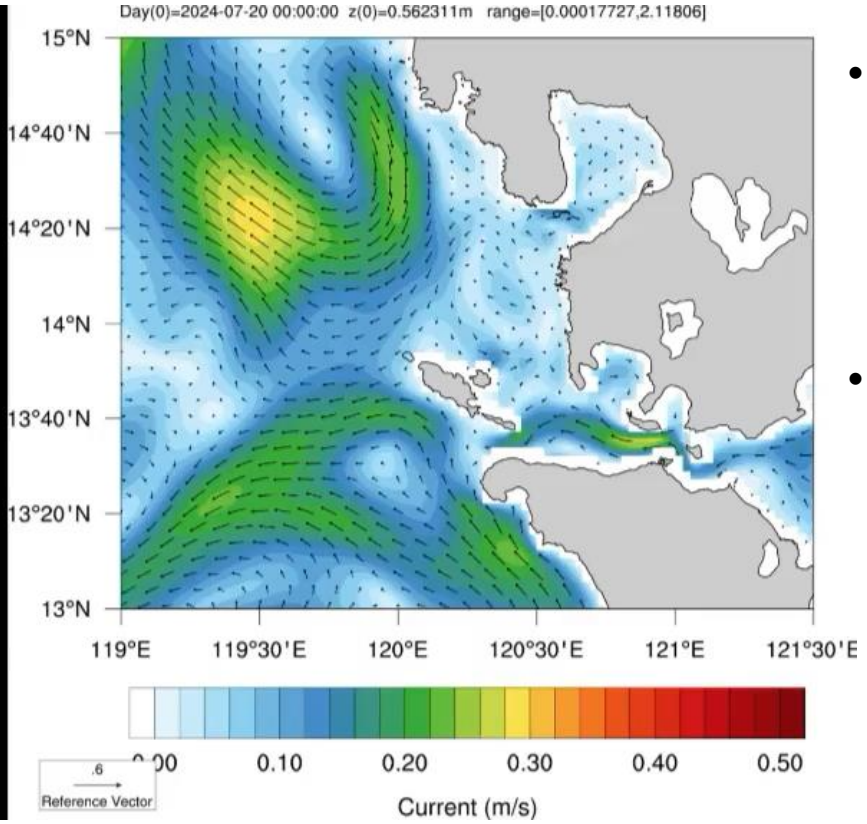
Parent vs. Child Current in Manila Bay

The (daily mean) **surface velocity** derived from the CMEMS-GLOB Model (1/12) and the SURF-NEMO Relocatable Model (1/36).

CMEMS-GLOB (1/12)



SURF-NEMO (1/36)



- Nested model shows an increase in surface current speed and the presence of finer-scale motion.
- Coastlines geometry are better resolved through high-resolution grid

Observed vs. Simulated Oil Spill Drift

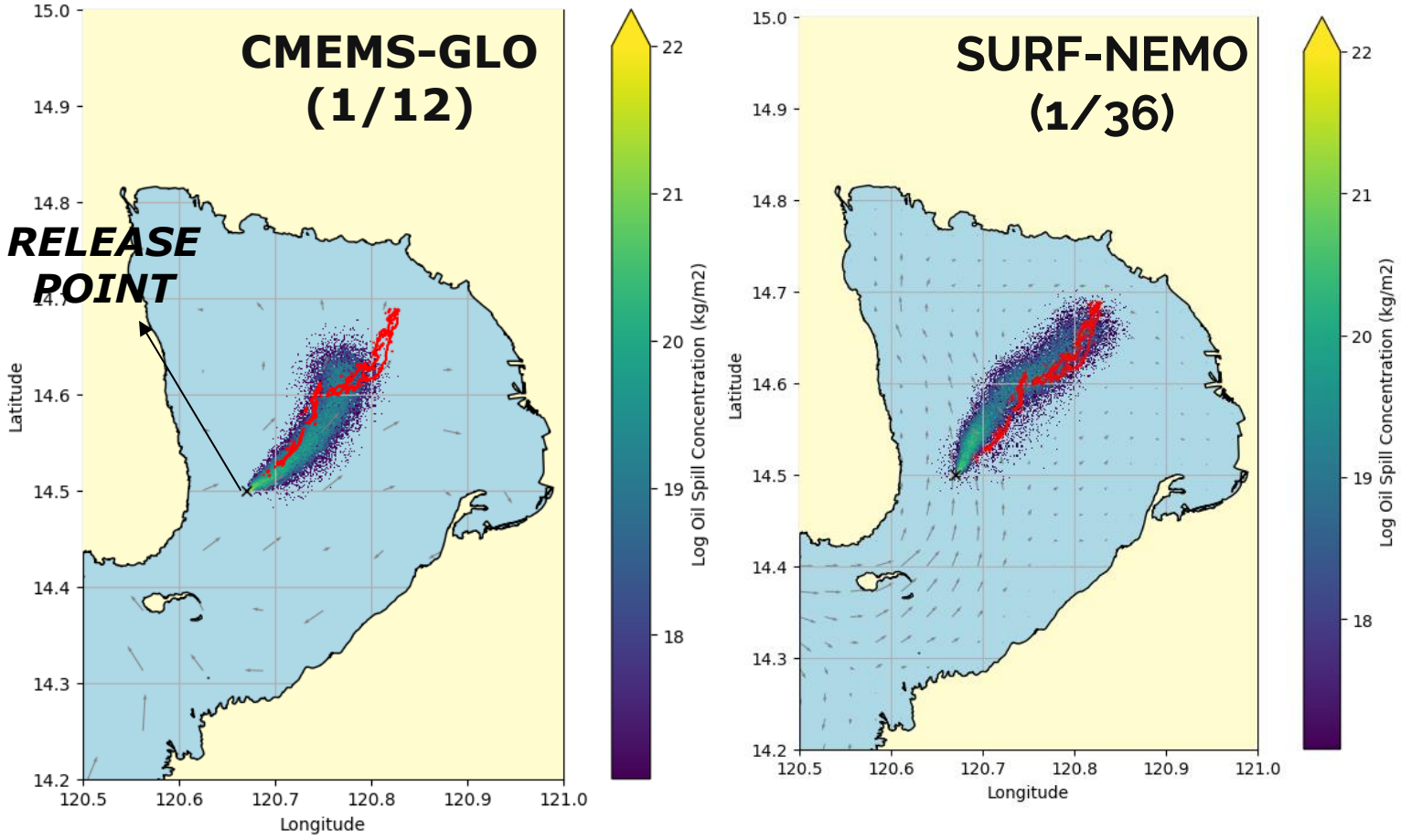
Snapshots of the Simulated drift on **26/07/2024 05:40 (PHT)** forced by CMEMS-GLOB, SURF-NEMO

The oil spill simulation was:

- **initiated** at the estimated time of the ship's sinking on **July 24, 2024, at 16:00**,
- simulating a continuous spill at a rate of approximately **10 tons per hour**.

Red line shows the satellite image

By utilizing a nested higher res. model, the oil slick drifts further north, aligning more closely with the satellite observations and enhancing the accuracy of oil spill trajectory predictions.



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Copernicus Marine Service

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