SYMPOSIUM OP'24 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 modes 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.

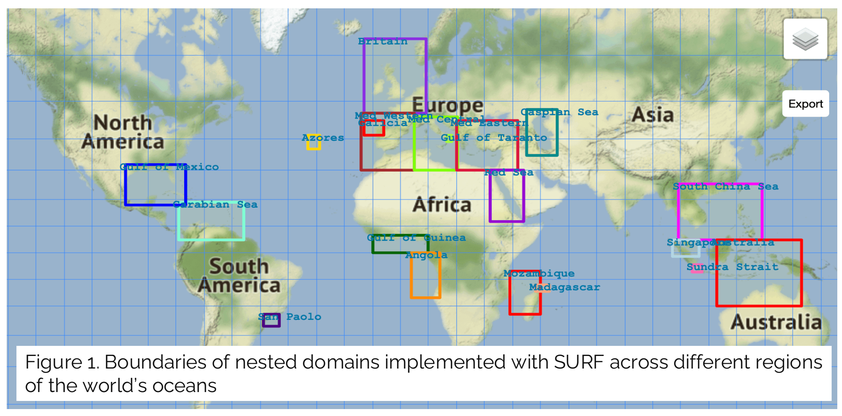

Figure 1. Boundaries of nested domains implemented with SURF across different regions of the world's oceans

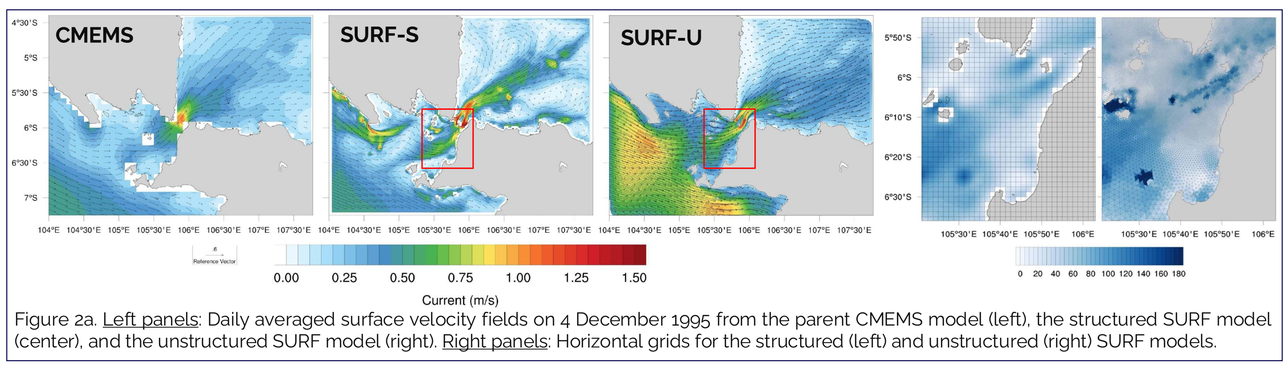

Figure 2a. Left panels: Daily averaged surface velocity fields on 4 December 1995 from the parent CMEMS model (left), the structured SURF model (center), and the unstructured SURF model (right). Right panels: Horizontal grids for the structured (left) and unstructured (right) SURF models.

• *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.

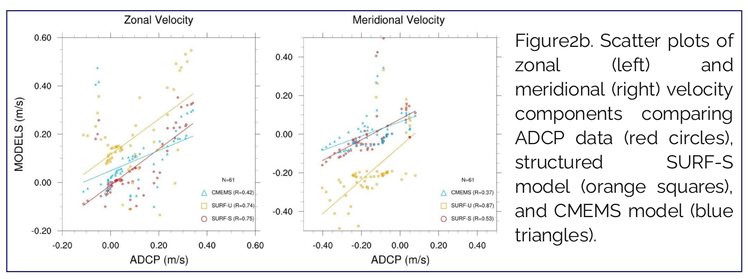

Figure2b. Scatter plots of zonal (left) and meridional (right) velocity components comparing ADCP data (red circles), structured SURF-S model (orange squares), and CMEMS model (blue triangles).

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.

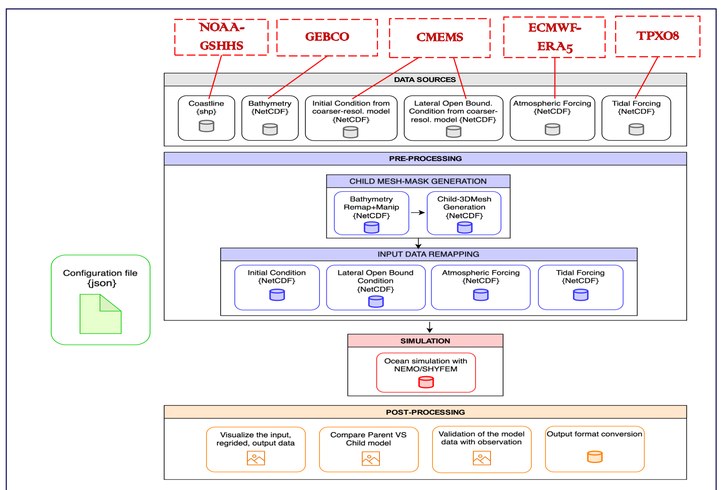

Figure 3: SURF Workflow Diagram

• *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.

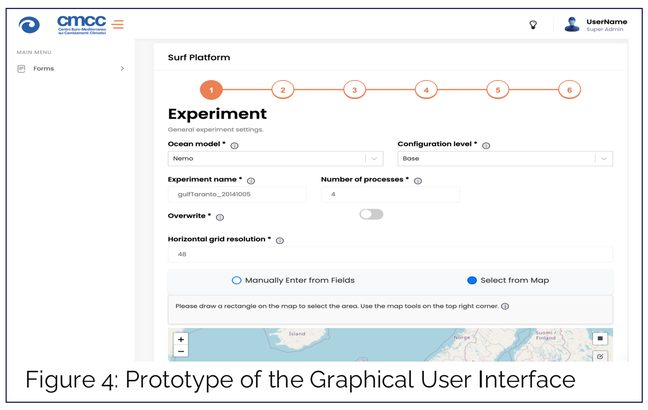

Figure 4: Prototype of the Graphical User Interface

• *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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