

An update on South Africa's Operational Forecast System

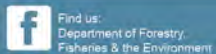
Jennifer Veitch^{1,2}, Giles Fearon¹, Zach Smith¹, Nkululeko Memela¹, Matthew Carr³

¹Egagasini Node, South African Environmental Observation Network, Cape Town, South Africa.

²Nansen-Tutu Centre, Marine Research Institute, University of Cape Town, Department of Oceanography, Cape Town, South Africa.

³University of Cape Town, Department of Oceanography, Cape Town, South Africa.

OceansPredict Science Team Meeting, 7 November 2023



www.dffe.gov.za

<https://ocims.environment.gov.za/>



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The catalyst for operational services: Operations Phakisa and the Oceans Economy

RECAP

An initiative to 'fast-track' the implementation of solutions highlighted as issues in the National Development Plan 2030

Six work streams:

1. Marine Transport and Manufacturing
2. Offshore Oil and Gas Exploration
4. Marine Protection Services and Ocean Governance
5. Small Harbours
6. Coastal and Marine Tourism



OPERATION PHAKISA | OCEANS ECONOMY

What is Operation Phakisa?
Operation Phakisa (meaning hurry up in Sesotho) was launched by President Jacob Zuma in July 2014, deriving the concept from Malaysia's Big Fast Results Methodology. It is a results-driven approach to development, involving various sectors such as business, labour, academia, civil society and government. Operation Phakisa involves setting clear plans and targets, on-going monitoring of progress and making these results public. The methodology consists of eight sequential steps. It focuses on bringing key stakeholders from the public and private sectors, academia as well as civil society organisations together to collaborate in: detailed problem analysis; priority setting; intervention planning; and delivery.

Why the Oceans Economy matters:

- South Africa has a coastline of **3 900 km** including the sub-antarctic islands. We also have an Exclusive Economic Zone (EEZ) of **1.5 million square km**, which is more than double South Africa's landmass of **1.2 million square km**. Our EEZ has also doubled following the extended continental shelf claim.
- The Oceans Economy has the potential to contribute up to **R177 billion** to South Africa's GDP by 2033 and create over one million jobs.
- Over **30 000** vessels pass through South Africa's coast on an annual basis with **13 000** vessels docking in our ports, providing opportunities for job creation.
- Around **80** oil rigs are estimated to be in the range of Western Cape, offering significant potential for repairs in our ports, as well as land based operational support.
- South Africa has potential resources of approximately **9 billion** barrels of oil which is equivalent to 40 years of oil consumption. We also have **60 trillion** cubic feet of gas which is equivalent to 375 years of gas consumption.
- The Aquaculture sector has the potential to 'grow sector revenue' to **R3 billion**, and produce **15 000 jobs** by 2019. These are real opportunities for local and rural economic development.
- The implementation of Marine Spatial Planning legislation will greatly enhance the orderly and coordinated use of the ocean space to the benefit of all.
- Operation Phakisa: Oceans Economy initiative undertakes to protect at least **5%** of our ocean space by creating a network of Marine Protected Areas.
- 300 million** tonnes of cargo and **1.2 million** tonnes of liquid fuel are transported along South Africa's coast, providing economic opportunities around our ports.
- Coastal and Marine Tourism has the potential to further enhance economic activities and create jobs along the coast.
- A coordinated Oceans Economy skills development and capacity building plan will equip potential entrants into the priority sectors of Marine Transport and Manufacturing, Aquaculture, Offshore Oil and Gas and Marine Protection and Governance.

Together moving South Africa's Oceans Economy Forward

Tel: +27 (0)12 312 0000 Website: www.operationphakisa.gov.za or www.environment.gov.za Email: oceansphakisa@environment.gov.za

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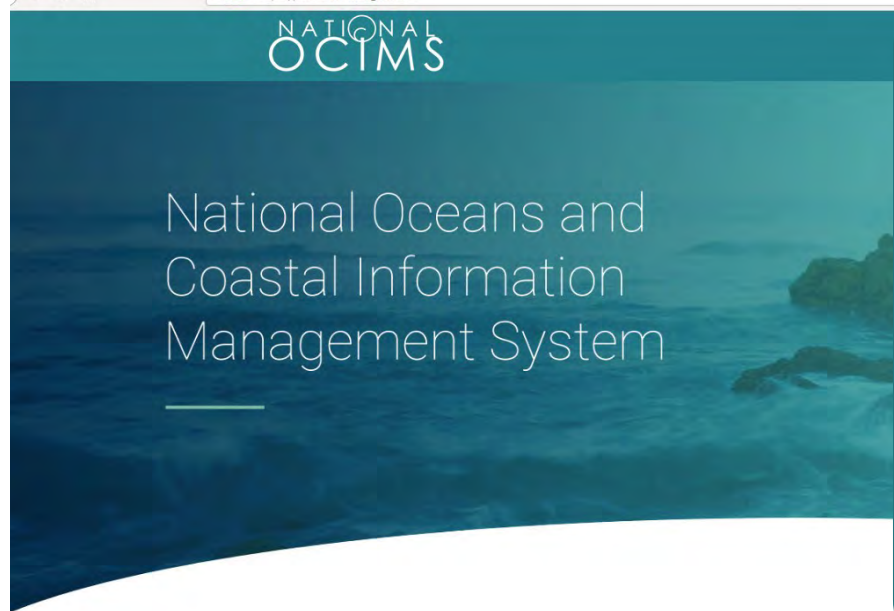
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A portal for downstream applications:

The National Oceans and Coastal Information Management System

RECAP



- Coastal Operations at Sea Support
- Coastal Flood Hazard Support
- Integrated Vessel Tracking Support
- Fisheries and Aquaculture Support
- Marine Spatial Planning Support
- Water Quality Support
- Marine Predators Support

The National Oceans and Coastal Information Management System (OCIMS) provides decision support for the effective governance of South Africa's oceans and coasts.

Decision support for effective governance of SA's Oceans and Coasts

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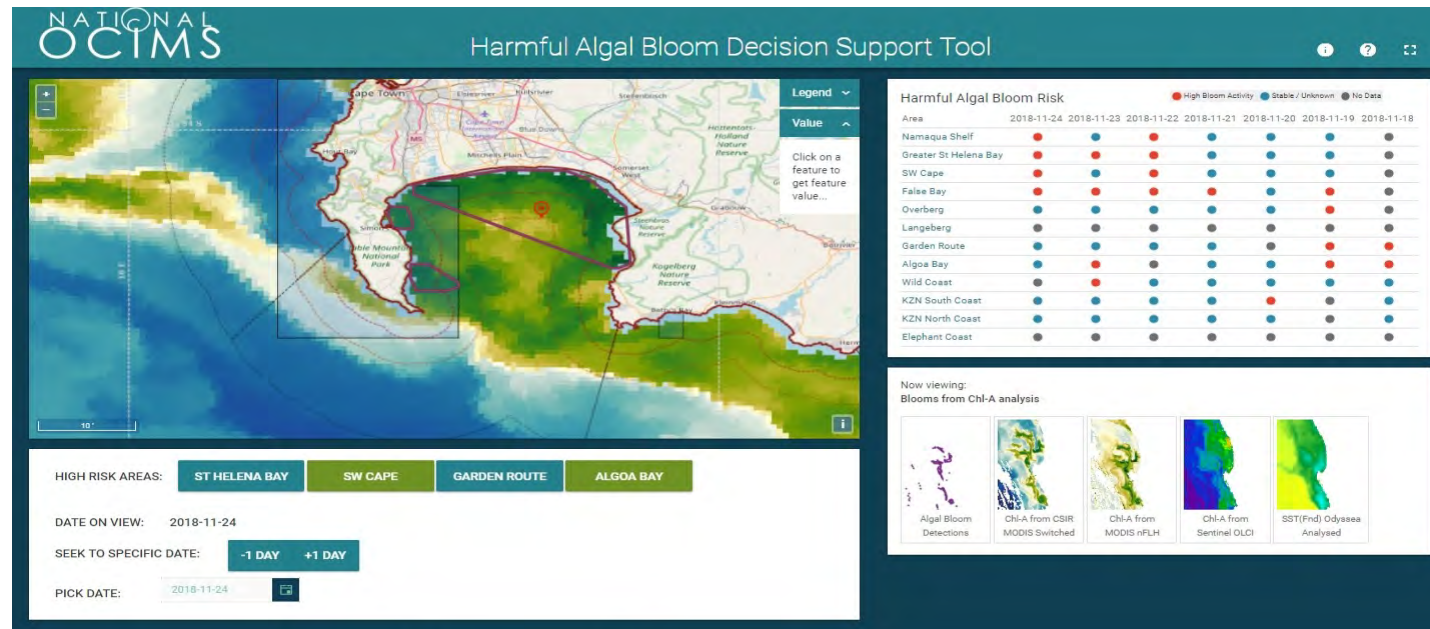
The National Oceans and Coastal Information Management System

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2016: HAB event costs the aquaculture industry R70m



Fisheries and Aquaculture Support



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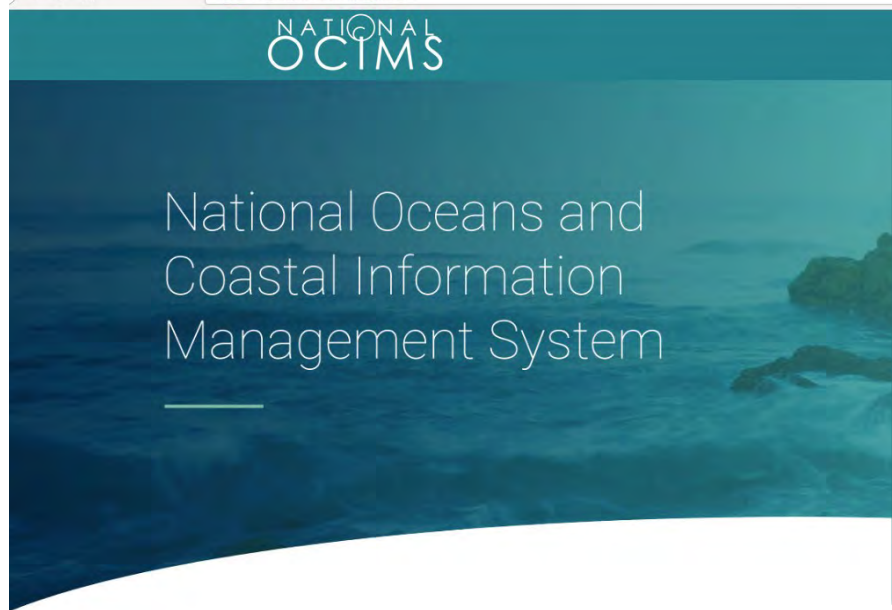
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The National Oceans and Coastal Information Management System

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We have a sophisticated front-end for stakeholder decision support tools (DeSTs), as well as an excellent engagement program with them to support the co-design.

But no optimized forecast systems!

Challenge:
Not enough capacity

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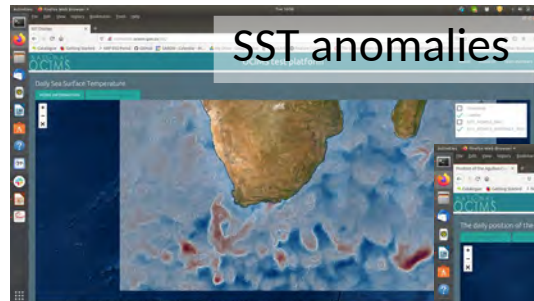
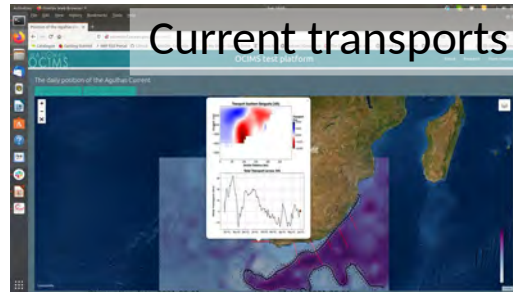
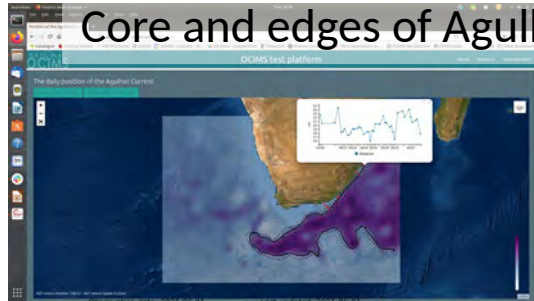
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Operational forecast services:

1. Adding value to existing global services*

RECAP



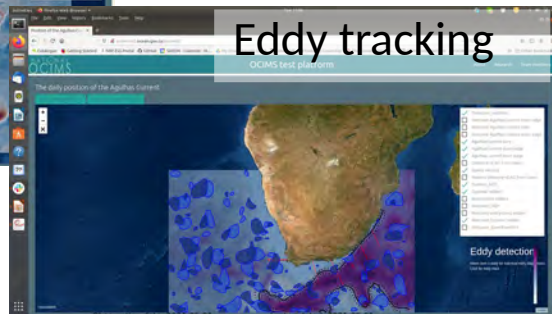
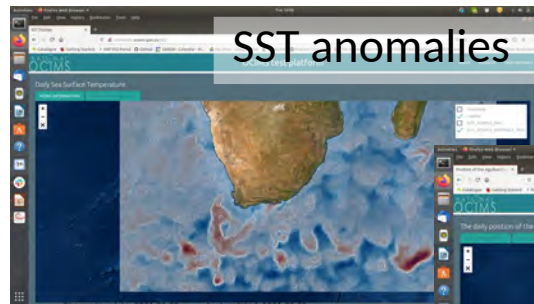
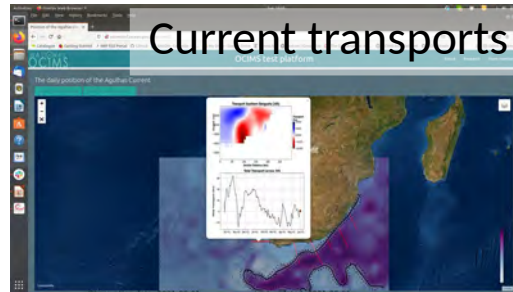
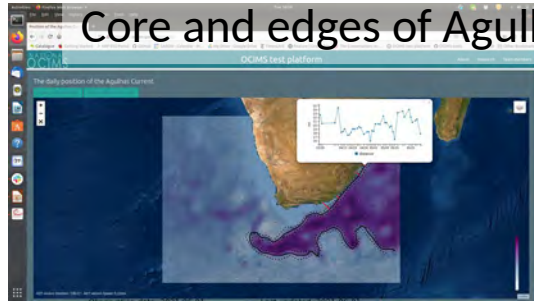
Solution:
Start small – pick the low hanging fruit!

* Copernicus Marine Services

Operational forecast services:

1. Adding value to existing global services*

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news24 Jenni Evans

Ocean temperature change causes wash-up of fish now toxic for eating

04/02/2021

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01/03/2021



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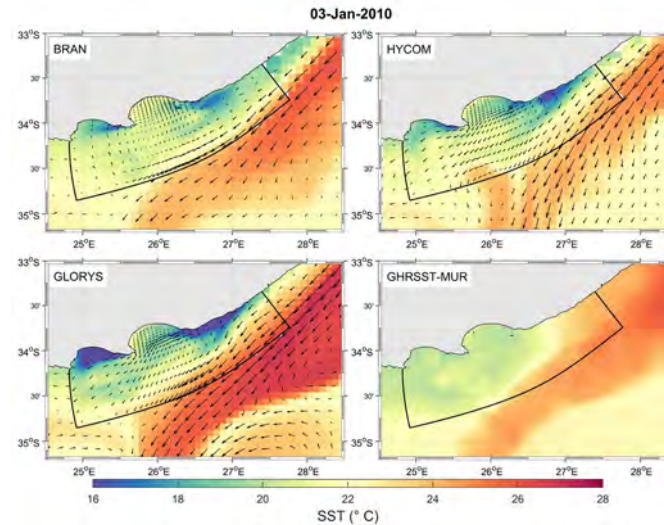
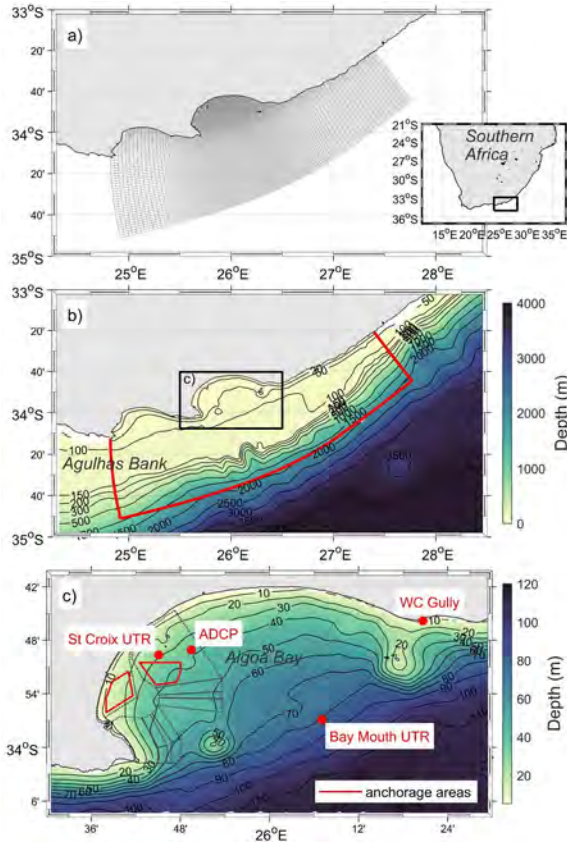
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Operational forecast services:

2. Downscaling existing global services

RECAP



Developed with the Coastal and Regional Ocean Community Model (CROCO)

Curvilinear grid developed with Delft3D tools

Horizontal resolution: 500 m to 3 km

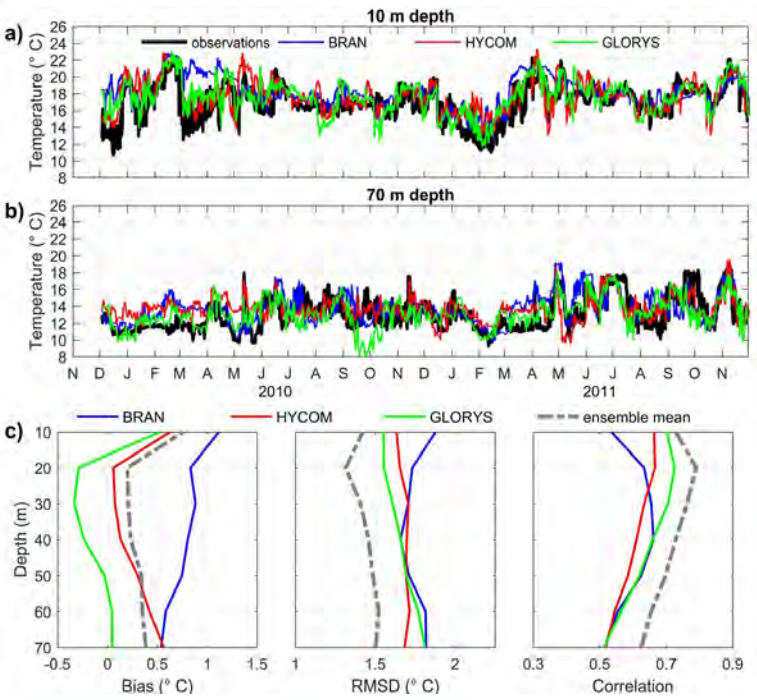
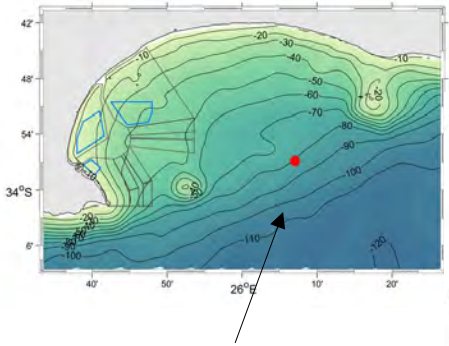
NO assimilation

Ocean boundaries: CMEMS 1/12° forecasts
Atmospheric forcing: GFS 1/3° forecasts

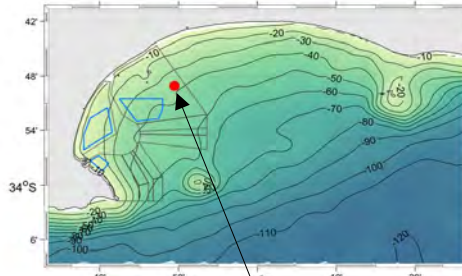
Operational forecast services:

2. Downscaling existing global services

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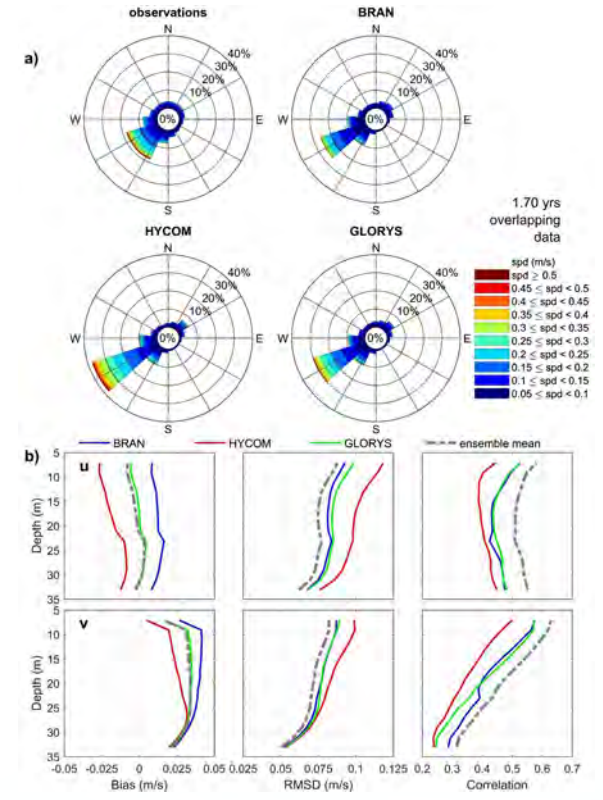


Temperature
Measurements courtesy of
SAEON Elwandle coastal
node



Currents
Observations courtesy of
Lwandle Marine
Environmental Services (on
behalf of PetroSA)

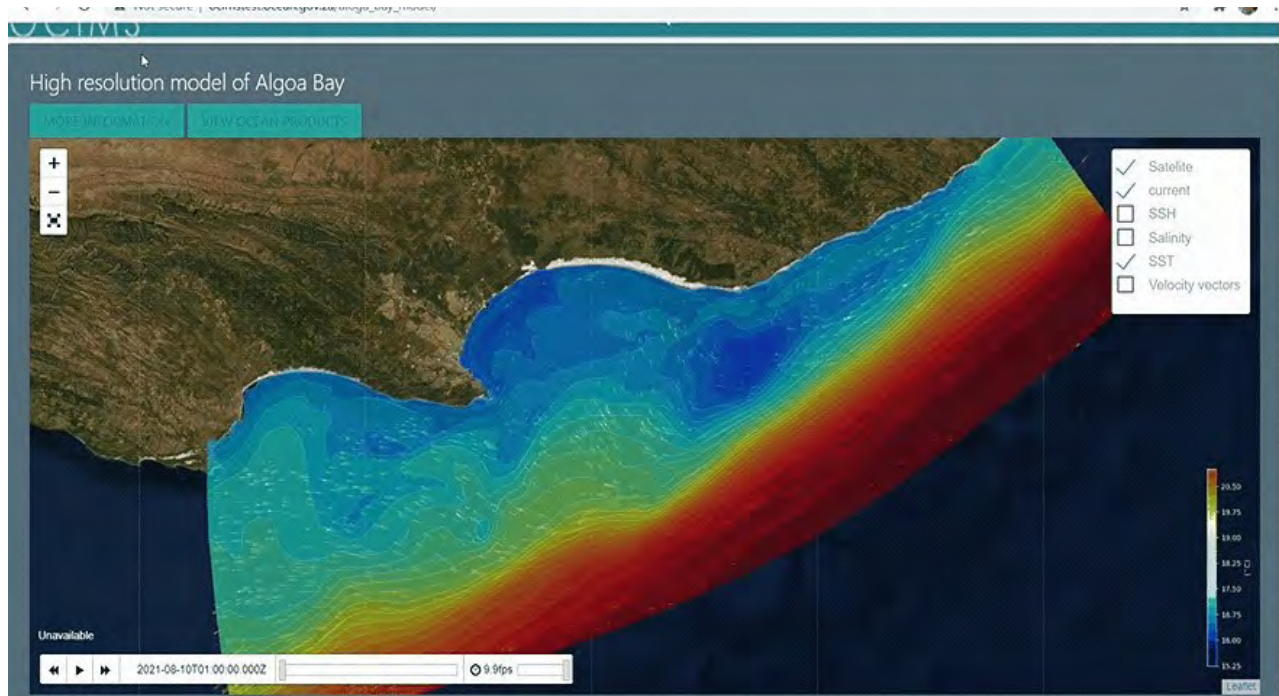
Hindcasts evaluated
but no forecast skill testing
currently done.



Operational forecast services:

2. Downscaling existing global services*

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Forecast generated daily: 5 days into the past, and 5 days into the future

Surface outputs visually disseminated operationally, allowing the user to select variable.

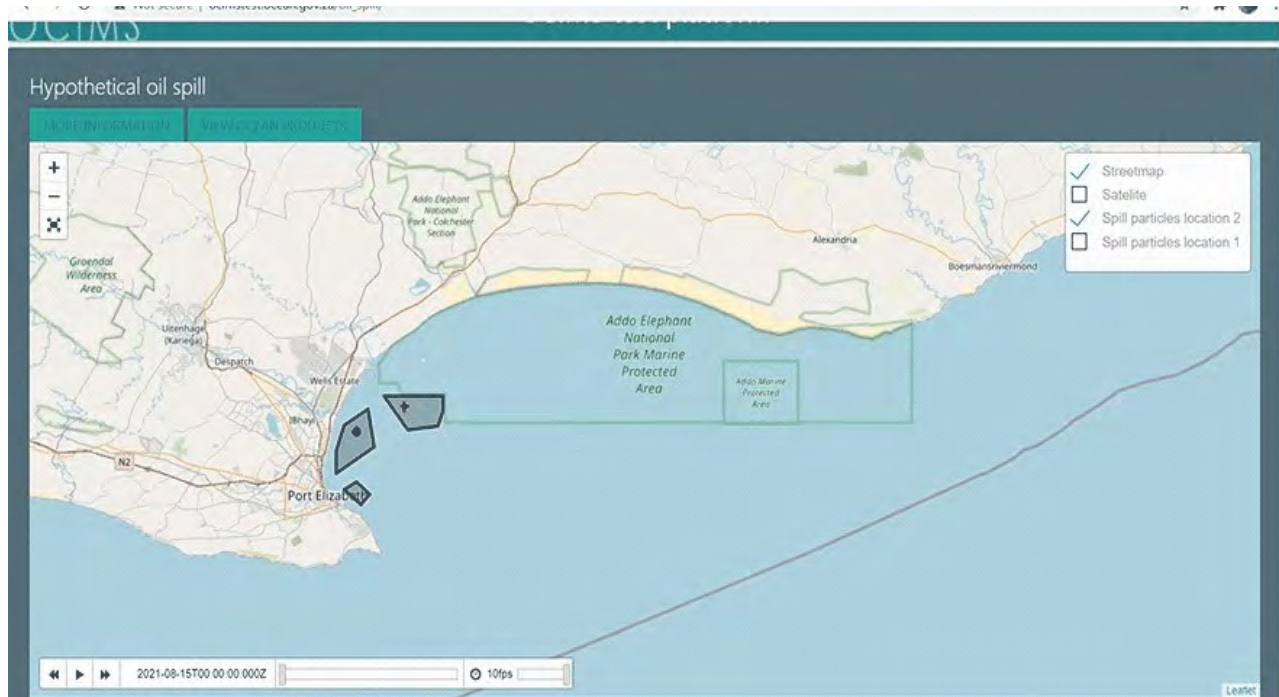
Algoa Bay hosts an oil bunkering industry as well as one of our largest MPAs and NB bird colonies. This product provides support in the case of an oil spill.

* Copernicus Marine Services

Operational forecast services:

RECAP

2. Downscaling existing global services* and a downstream application



Hypothetical oil spill released daily from two oil-bunkering sites.

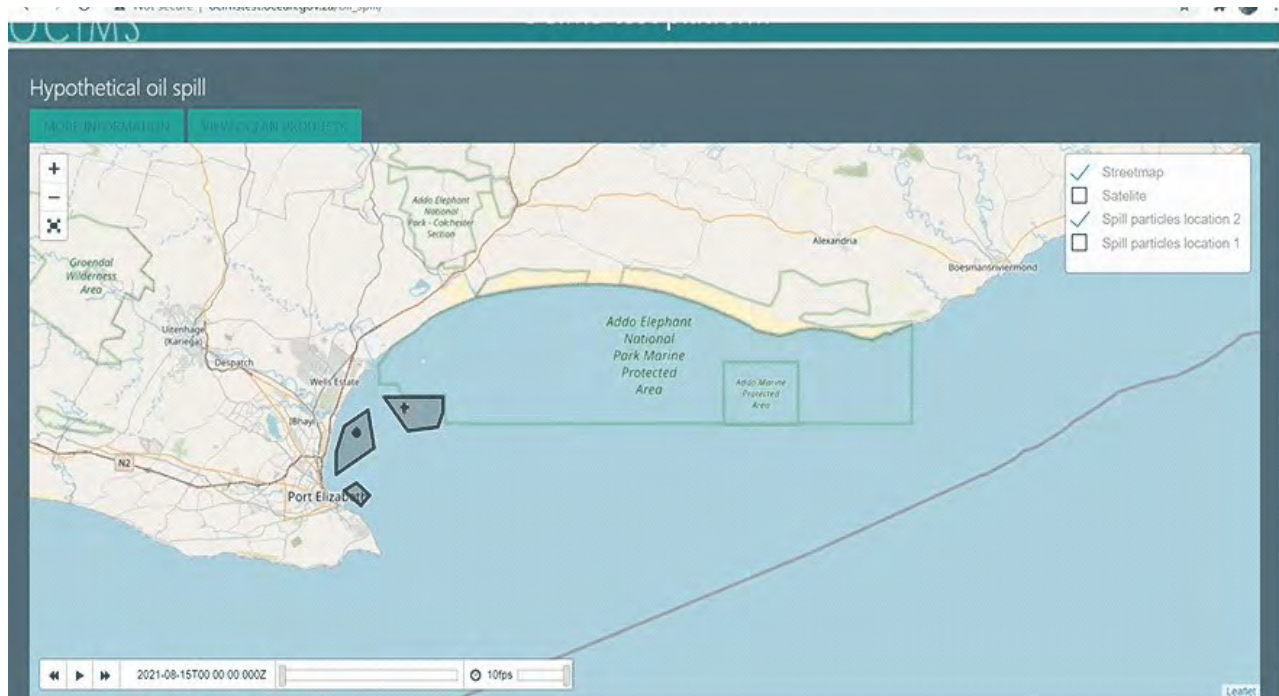
Particles advected using OceanParcels and forced using downscaled surface currents and GFS winds.

* Copernicus Marine Services

Operational forecast services:

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Hypothetical oil spill released daily from two oil-bunkering sites.

Particles advected using OceanParcels and forced using downscaled surface currents and GFS winds.

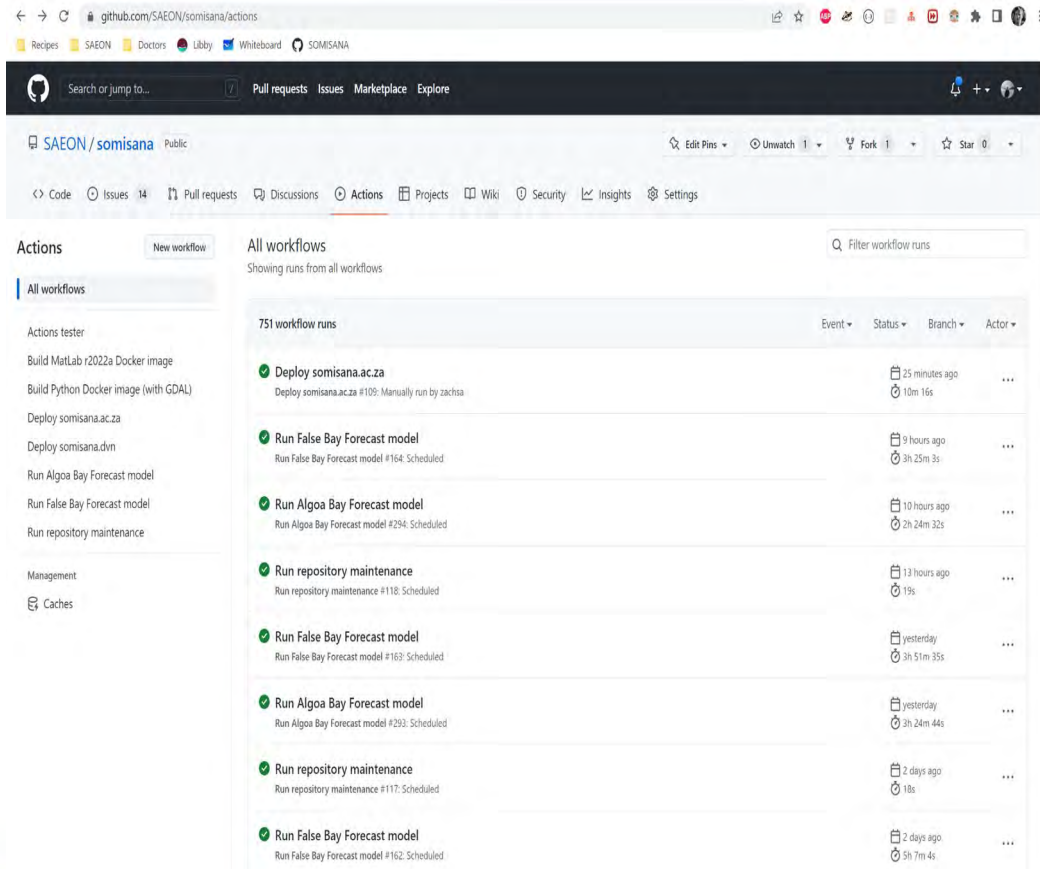
We developed something very simple, but that nevertheless provided useful information about the state of the ocean.

However, we did not consider workflow best practices!

* Copernicus Marine Services

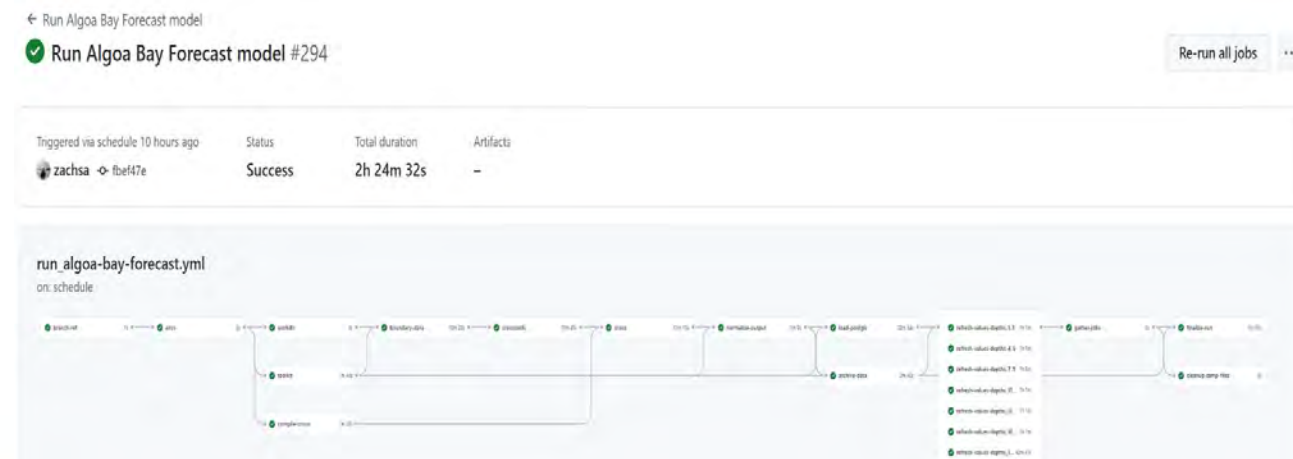
Operational forecast services: updates

1. Refactoring of the model workflow



GitHub repo is used to manage the automated model workflow, from pre- to post-processing as well as dissemination

Model tools are dockerized for ease of re-deployment

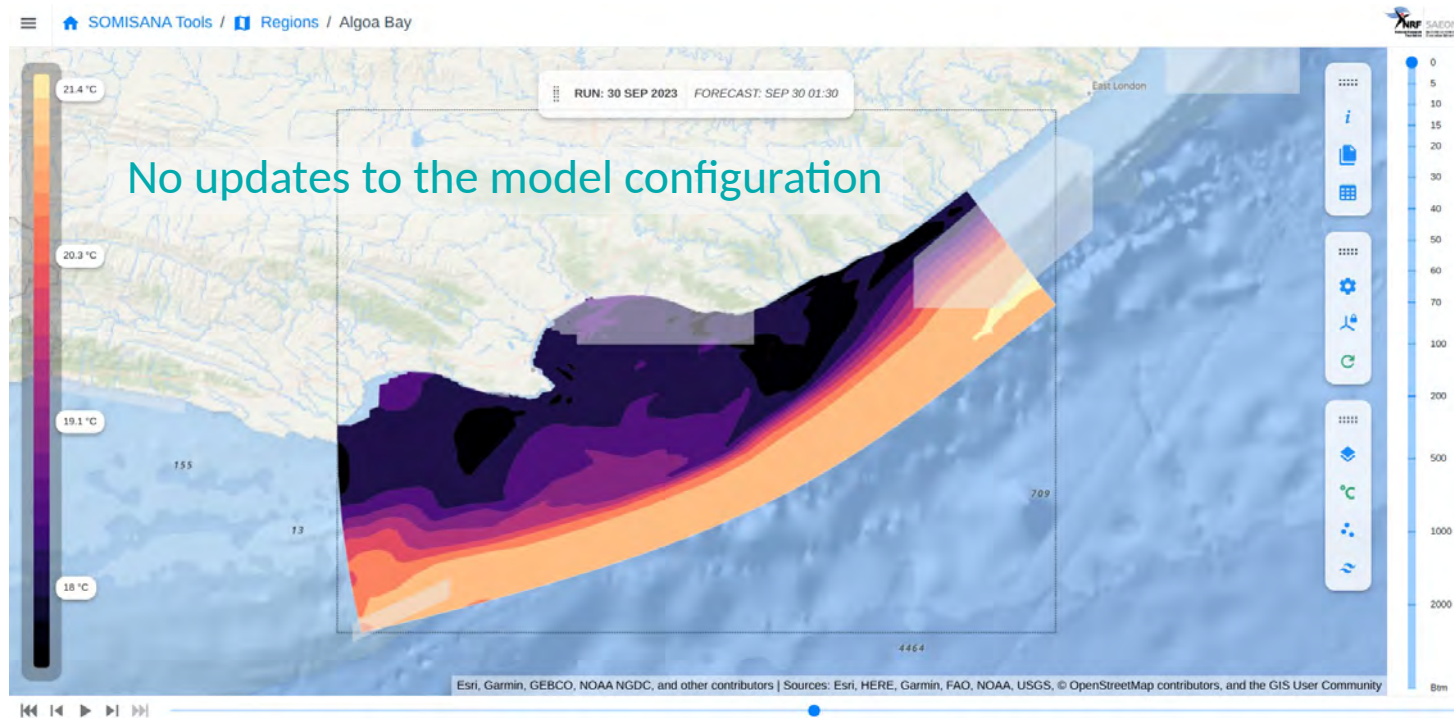


Operational forecast services: updates

2. A more sophisticated portal for visualizations*

Portal allows users to:

- zoom in and out



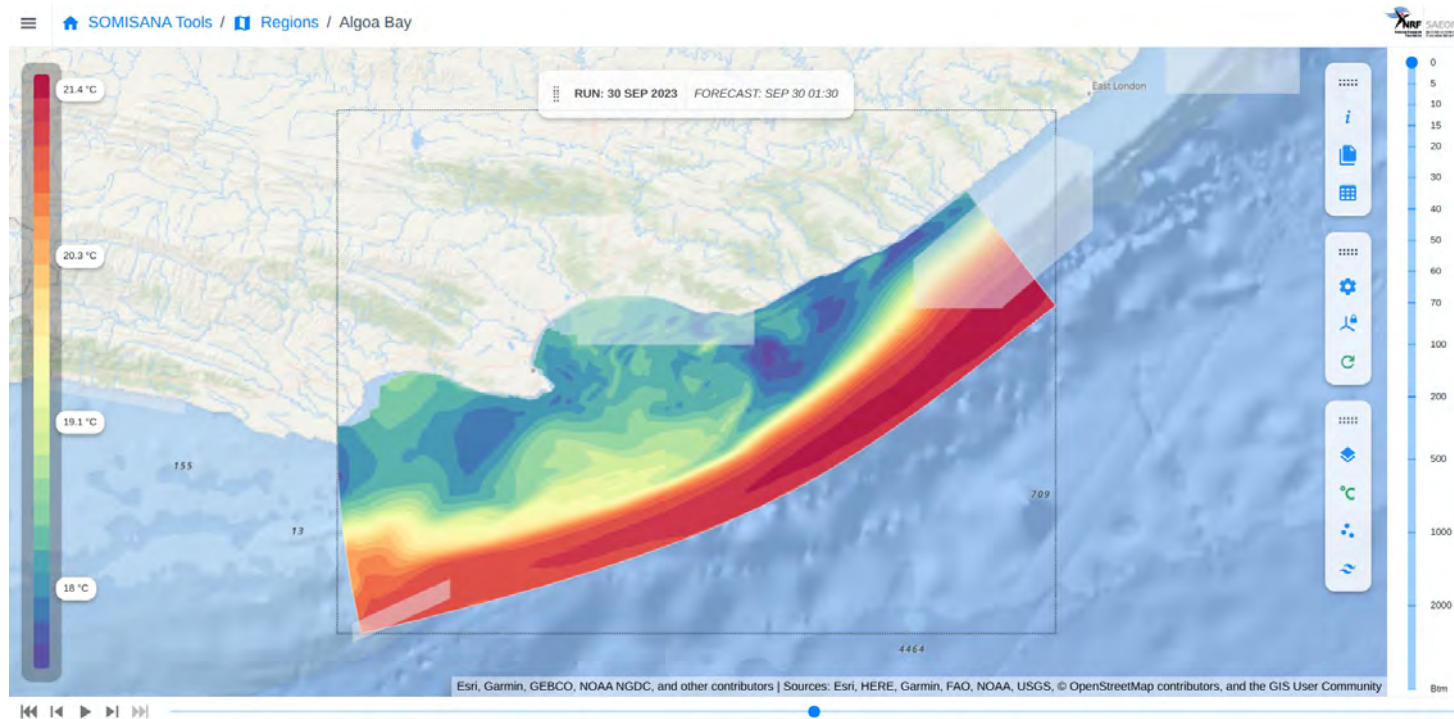
* <http://explore.somisana.ac.za>

Operational forecast services: updates

2. A more sophisticated portal for visualizations*

Portal allows users to:

- zoom in and out
- configure their colormapping, scale and range



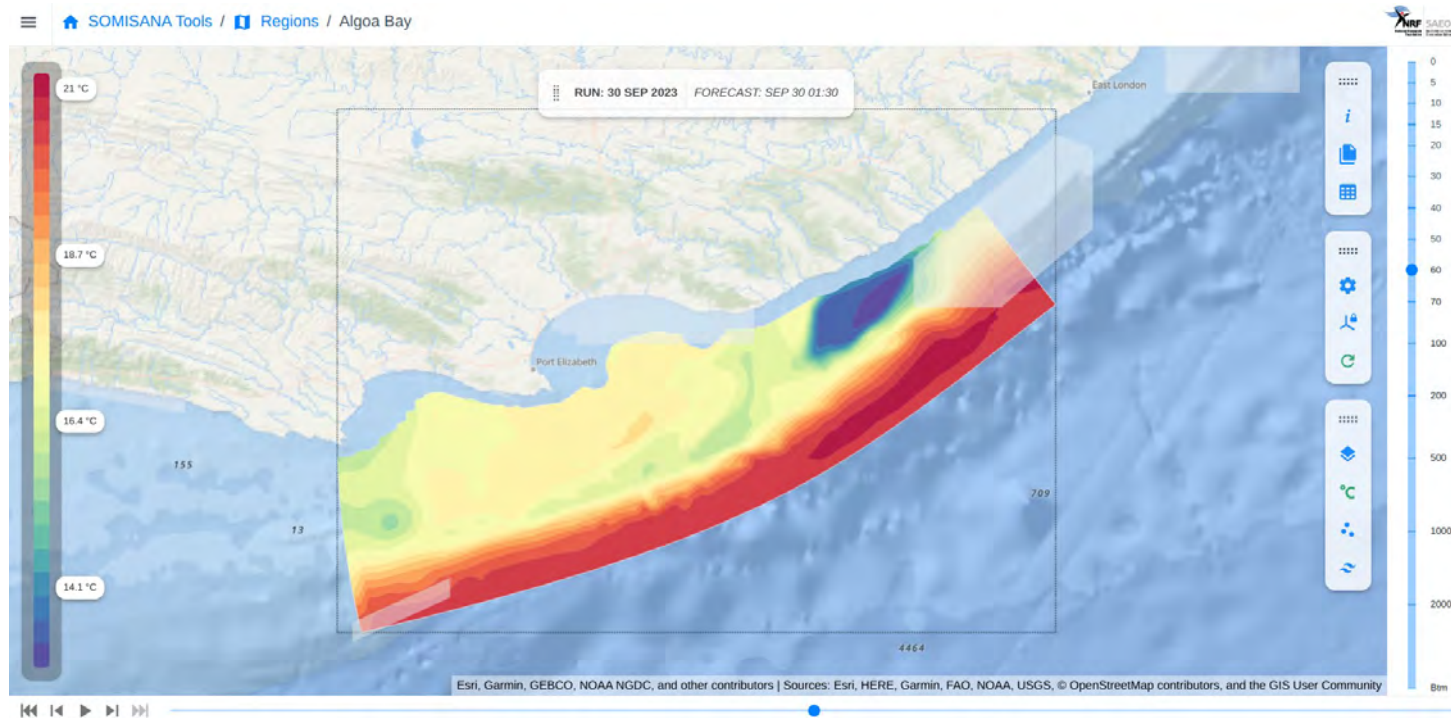
* <http://explore.somisana.ac.za>

Operational forecast services: updates

2. A more sophisticated portal for visualizations*

Portal allows users to:

- zoom in and out
- configure their colormapping, scale and range
- select depth



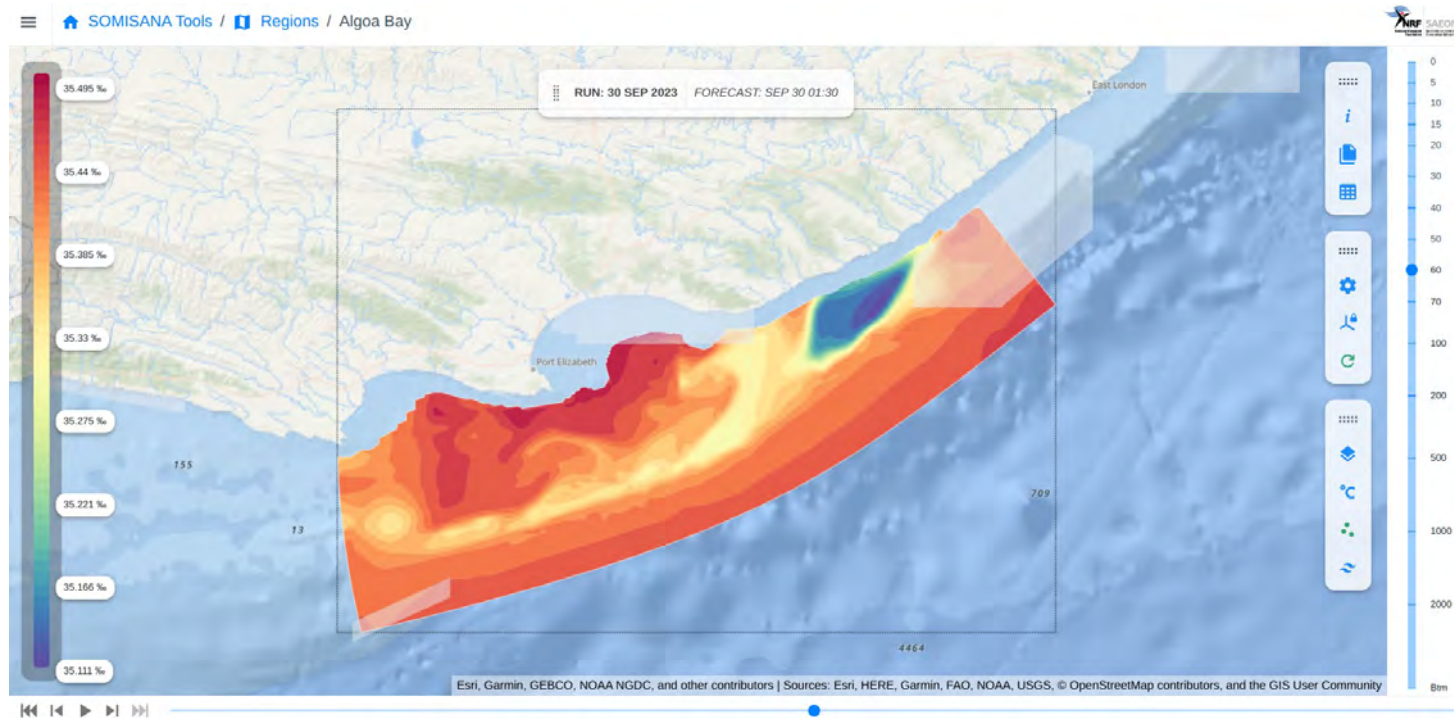
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Operational forecast services: updates

2. A more sophisticated portal for visualizations*

Portal allows users to:

- zoom in and out
- configure their colormapping, scale and range
- select depth
- select variable (temp, salt, currents, SSH)



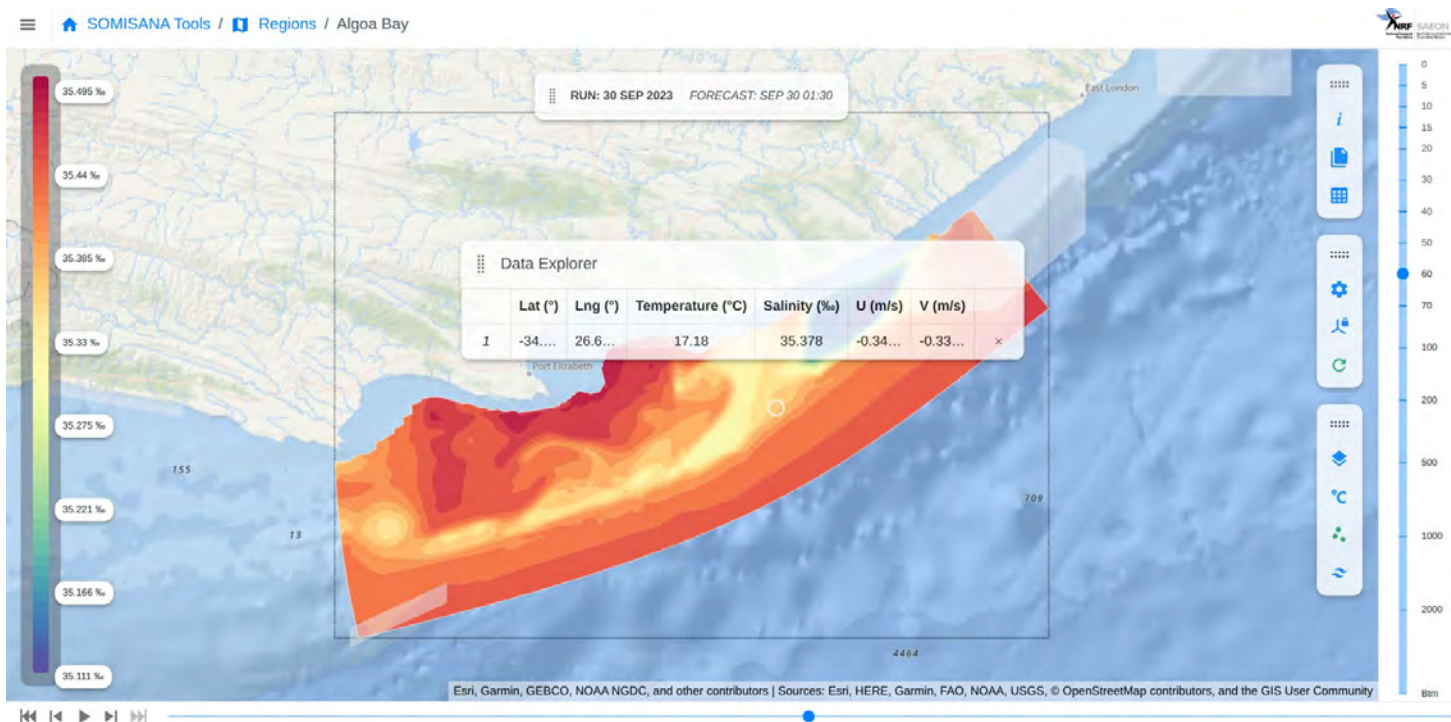
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Operational forecast services: updates

2. A more sophisticated portal for visualizations*

Portal allows users to:

- zoom in and out
- configure their colormapping, scale and range
- select depth
- select variable (temp, salt, currents, SSH)
- select a point to view data



* <http://explore.somisana.ac.za>

Operational forecast services: updates

3. A second downscaled forecast system

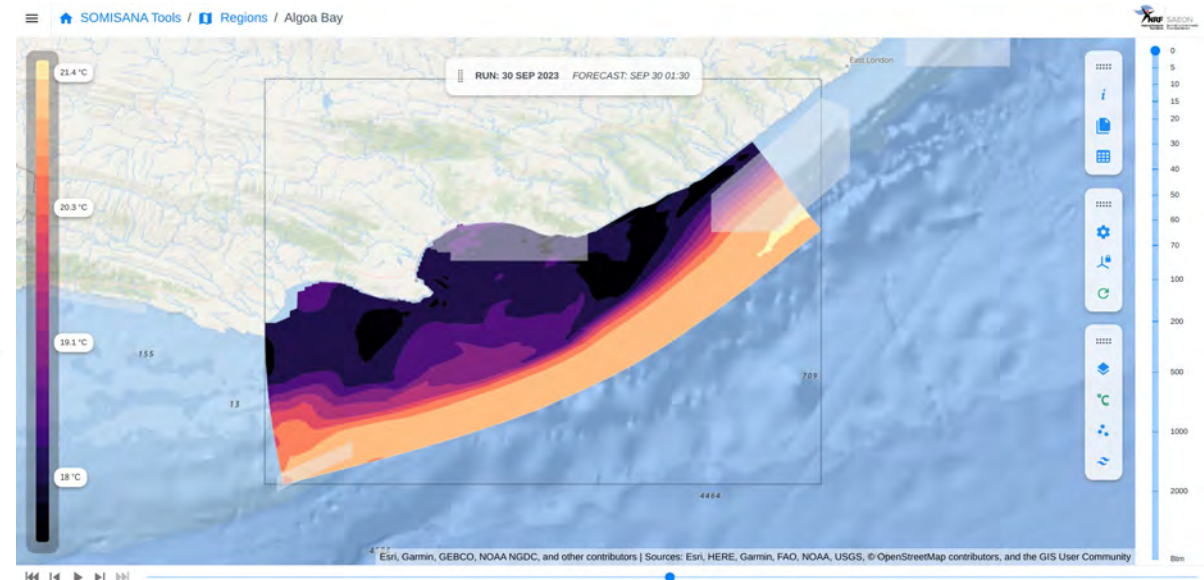
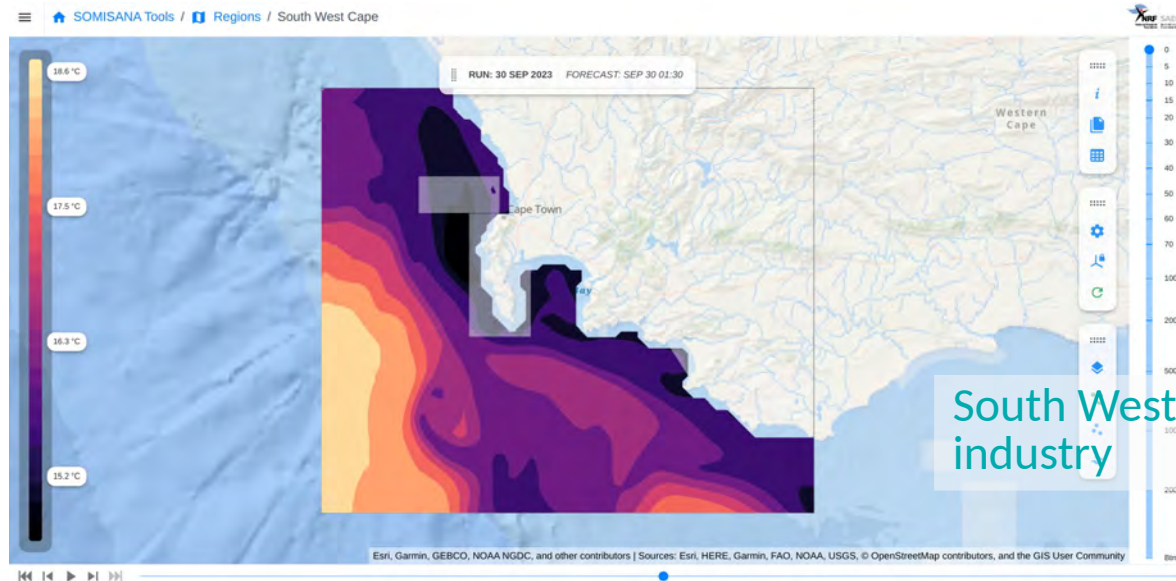
Model: CROCO

Horizontal resolution: 3 km

NO assimilation

Ocean boundaries: CMEMS 1/12° forecasts

Atmospheric forcing: GFS 1/3° forecasts



South West Cape Coast (SWCC) in support of the aquaculture industry

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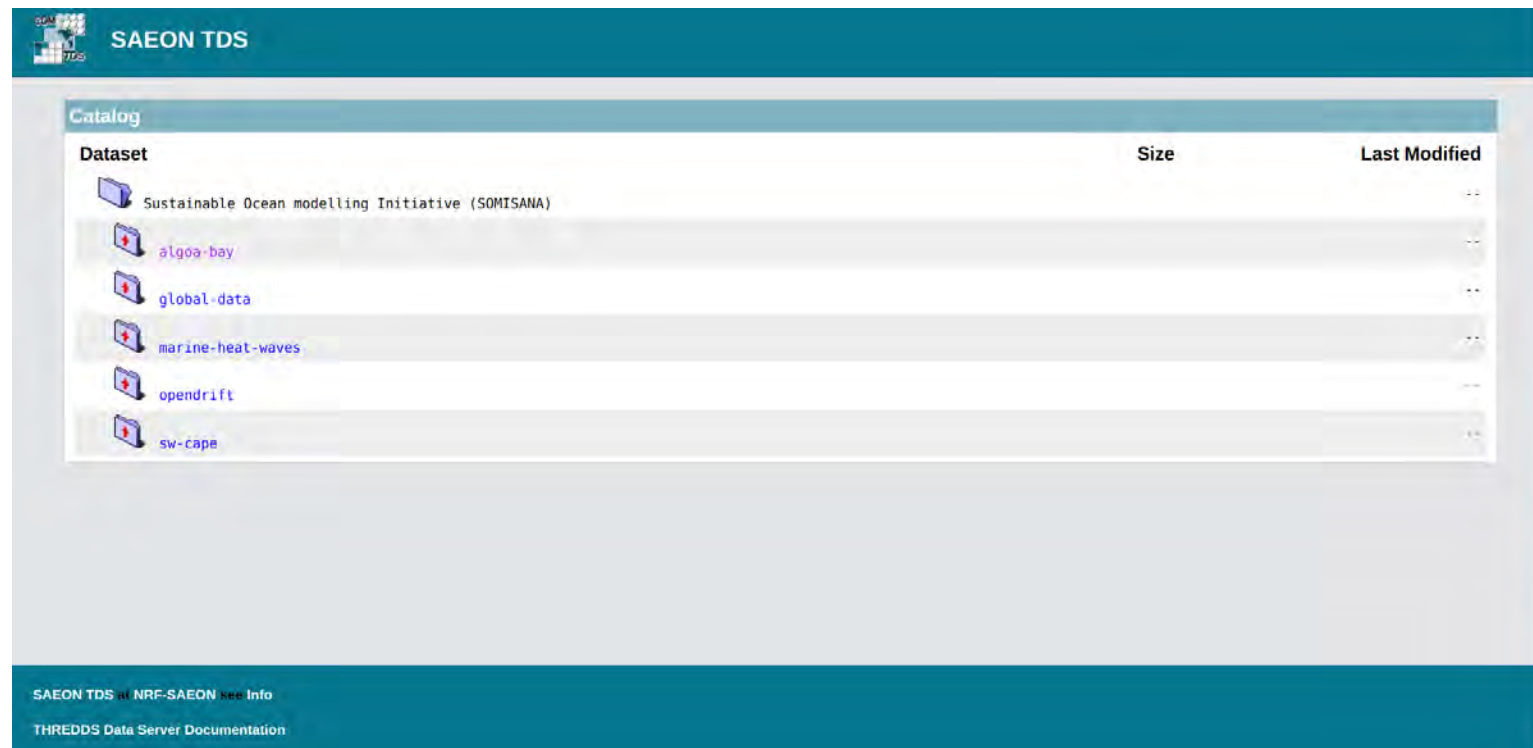
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Operational forecast services: updates

4. Operational provision of outputs via a thredds server

Daily 5-day forecasts are provided as netcdf files on a thredds server

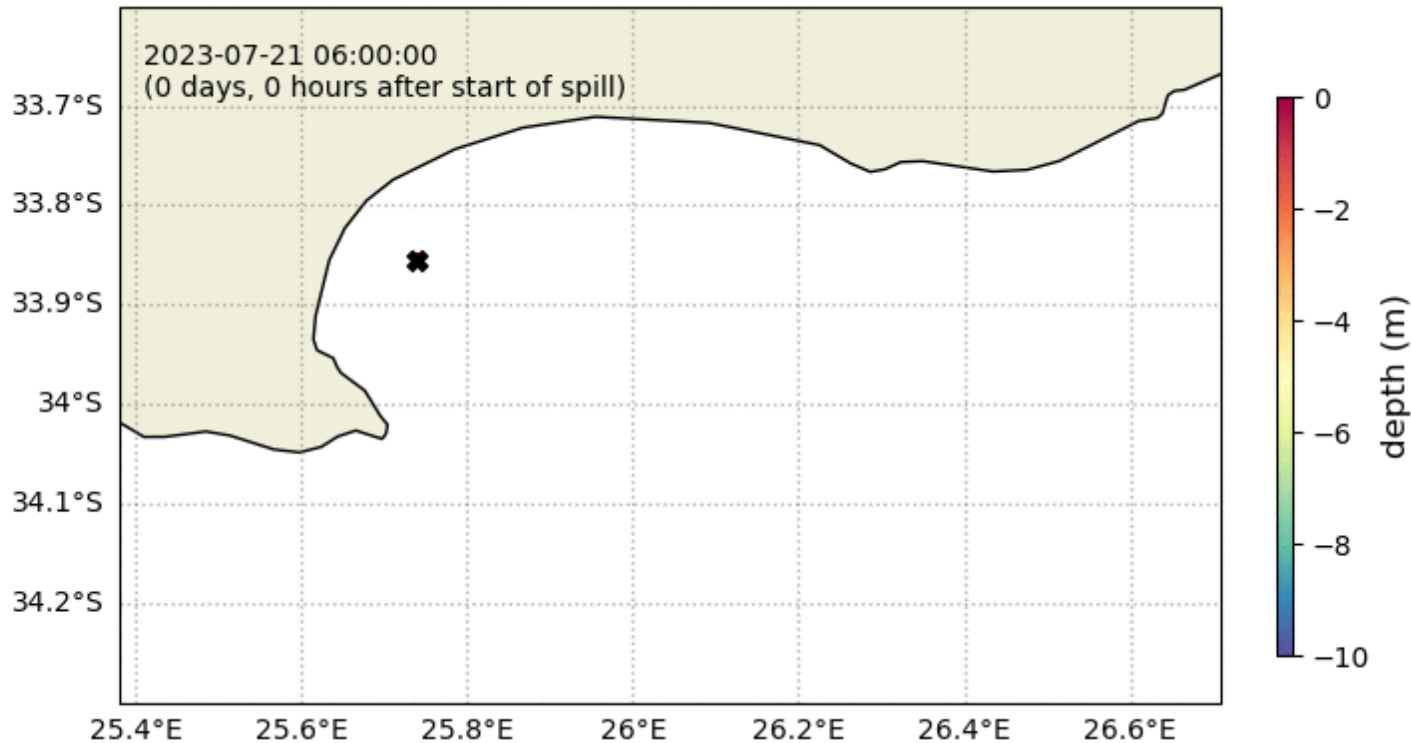


The screenshot shows the SAEON TDS Thredds server interface. At the top, there is a header with the SAEON TDS logo and name. Below this is a 'Catalog' section with a table of datasets. The table has three columns: 'Dataset', 'Size', and 'Last Modified'. The datasets listed are: 'Sustainable Ocean modelling Initiative (SOMISANA)', 'algoo-bay', 'global-data', 'marine-heat-waves', 'opendrift', and 'sw-cape'. At the bottom of the interface, there are links for 'SAEON TDS', 'NRF-SAEON', 'Info', and 'THREDDS Data Server Documentation'.

Dataset	Size	Last Modified
Sustainable Ocean modelling Initiative (SOMISANA)		--
algoo-bay		--
global-data		--
marine-heat-waves		--
opendrift		--
sw-cape		--

Operational forecast services: updates

5. An OpenDrift application

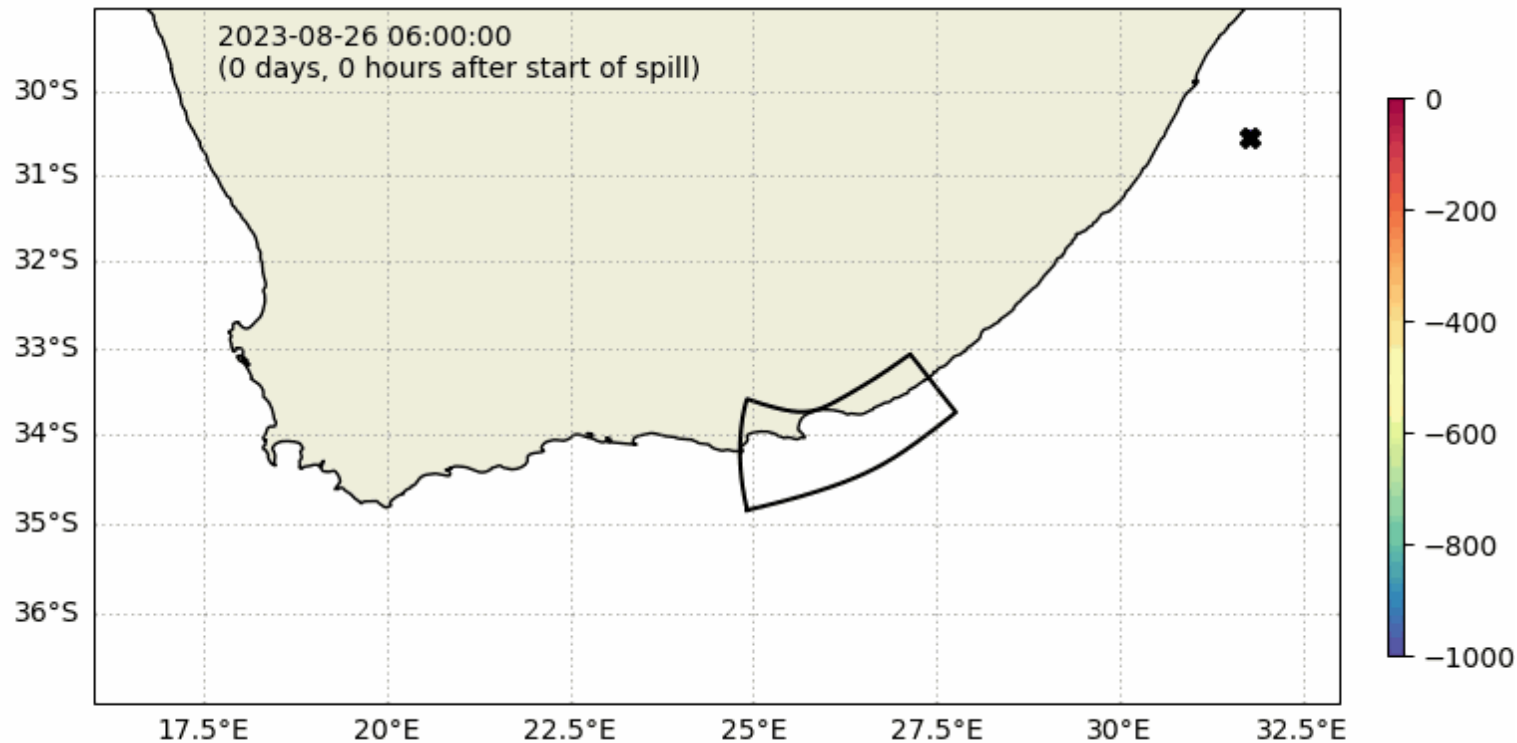


- Oil spills from bunkering sites in Algoa Bay
- Current we are able to model a spill in real time, and make the data available via a file server), but no user interface.

<https://mnemosyne.somisana.ac.za>

Operational forecast services: updates

5. An OpenDrift application: using both global and local forecast product



- Oil spills from deepwater blowouts
- Current we are able to model a spill in real time, and make the data available via a file server), but no user interface.

<https://mnemosyne.somisana.ac.za>

Operational forecast services: updates

6. Ongoing stakeholder engagement activities

The iterative CO-DESIGN of Downstream Applications (i.e. OCIMS DeSTs) is facilitated through an annual 2-day event in Cape Town, and one-day 'roadshow' events that are hosted in other cities.

These include stakeholders from various sectors:

- fisheries and aquaculture industries
- NSRI (coastguard) and maritime safety authorities
- port authorities
- the South African navy and hydrographic office
- conservation organizations
- offshore oil and gas industry
- municipalities
- research institutes

SAEON participates in OCIMS Stakeholder Engagement Workshop

By Zach Smith, Systems Developer, Egagasini Node, NRF-SAEON



As part of its commitment to advancing the South African marine science community, SAEON recently participated in the annual National Oceans and Coastal Information Management System (OCIMS) stakeholder workshop. With an array of presentations and constructive dialogues, SAEON underscored its pivotal role in fostering oceanographic data and technological innovation.

SAEON's participation highlighted the work of the uLwazi, Egagasini and Elwandle nodes in marine information management and high-resolution ocean forecasting, which forms a fundamental part of the Sustainable Ocean Modelling Initiative: A South African Approach (SOMISANA).

The stakeholder workshop marked the start of important collaborative work that spans some of South Africa's premier institutions. SAEON's numerical modelling is informed by high-resolution wind data from the South African Weather Service (SAWS), high-resolution bathymetry data from the South African Navy Hydrographic Office (SANHO) and close cooperation with the Council for Scientific and Industrial Research (CSIR).



The stakeholder workshop marked the start of important collaborative work that spans some of South Africa's premier institutions (Photo: DFFE)



Egagasini: Charting high-resolution ocean forecasts

The node's senior operational ocean modeller, Dr Giles Fearon, and operational ocean modeller, Nkululeko Memela, recently joined the OCIMS effort under the SAEON umbrella, and under the guidance of Dr Jennifer Veitch (numerical ocean modeller) and Professor Juliet Hermes, manager of the Egagasini Node.



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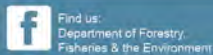
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We've made good progress, but we still have a long LOTTD

- Extend the spatial extent of our forecast models either to produce additional limited area domains or to encompass the entire South African continental shelf
- Implement SAWS* high resolution atmospheric forecasts as surface forcing for our models
- Forecast skill testing protocols
- Implement an ensemble of forecasts based on different forcings to improve predictive skill
- Downscaling to port and estuarine scales (using Delft3D Flexible Mesh)
- Implement data assimilation in our models (depends on availability of real-time ocean observations)
- **and more... to be informed by our stakeholder needs (and our capacity!)**

*The South African Weather Service, who are partners on the OCIMS project. In order to facilitate sharing of data a high-level MOU has been developed with them.



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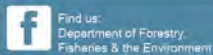
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- Extend the spatial extent of our forecast models either to produce additional limited area domains or to encompass the entire South African continental shelf
- Implement SAWS* high resolution atmospheric forecasts as surface forcing for our models

All to be guided by best practices to support transparency, interoperability, open science and efficiency

- Downscaling to port and estuarine scales (using Delft3D Flexible Mesh)
- Implement data assimilation in our models (depends on availability of real-time ocean observations)
- **and more... to be informed by our stakeholder needs (and our capacity!)**

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