SYMPOSIUM 24'

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2021 2030 United Nations Decade of Ocean Science for Sustainable Development

Emerging Systems for a Sustainable Blue Economy:
Transforming Data into Actionable Intelligence

Jennifer Veitch
South African Environmental Observation Network (SAEON)

Francis Pavanathara
Indian National Centre for Ocean Information Services (INCOIS)

NRF National Research Foundation | SAEON South African Environmental Observation Network

science & innovation Department: Science and Innovation REPUBLIC OF SOUTH AFRICA

INCOIS

Indigenous early warning systems, Mozambique
Bol and van Niekerk, 2024

Kolu: A holistic conceptualization of all coastal hazards

Santha, 2014

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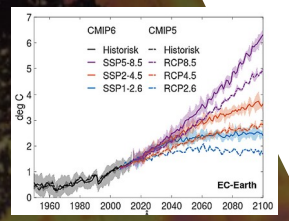
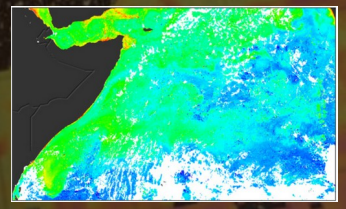
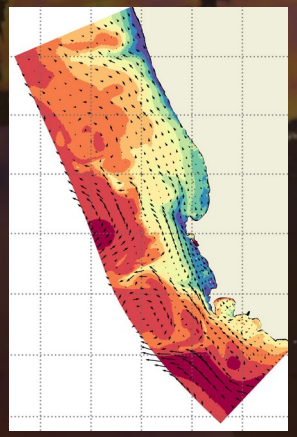
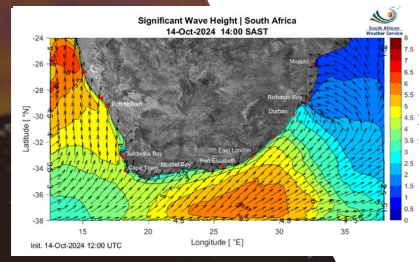
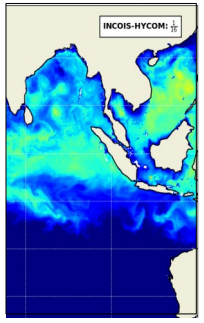
SYMPOSIUM OP'24











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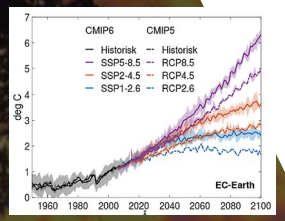
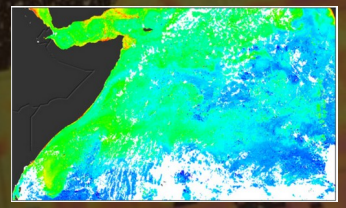
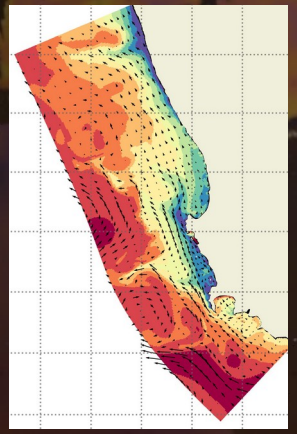
SYMPOSIUM OP'24

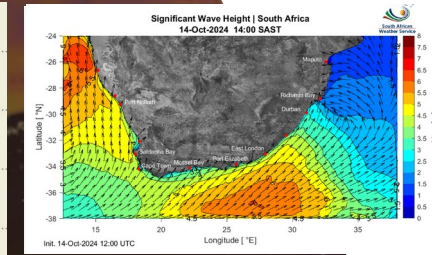
Actionable Intelligence: information that facilitates decision-making and action

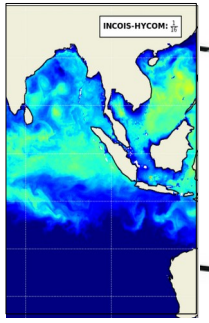
✦ Relevant ✦ Timely ✦ Clear ✦ Reliable











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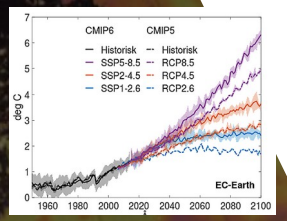
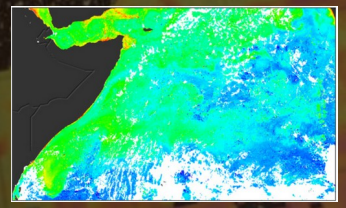
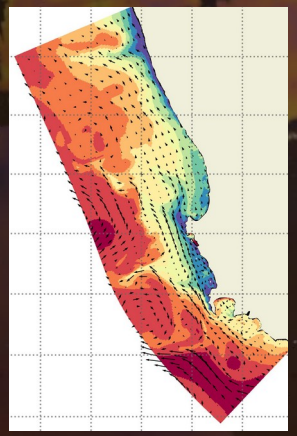
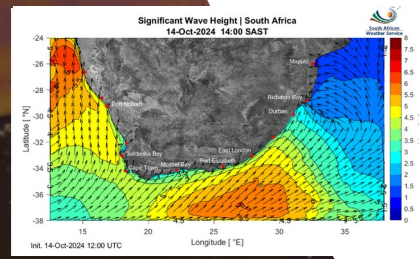
Actionable Intelligence: information that facilitates decision-making and action

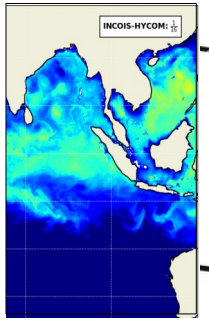
✦ Relevant ✦ Timely ✦ Clear ✦ Reliable











VALUE

CYCLE

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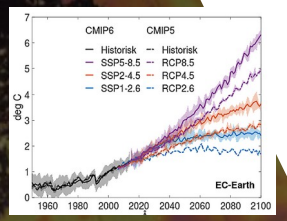
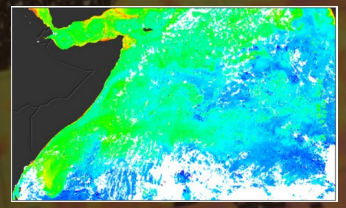
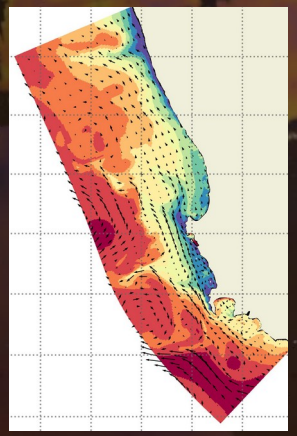
Emerging Systems for a Sustainable Blue Economy:
Transforming Data into Actionable Intelligence

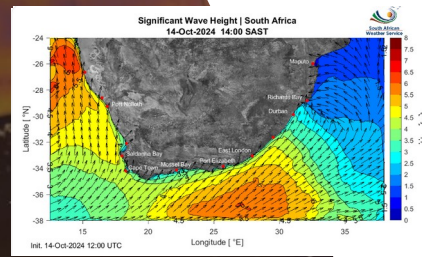
Blue Economy: 'The sustainable use of ocean resources for economic growth, jobs, improved livelihoods, while preserving the health of the ocean ecosystem' – World Bank.

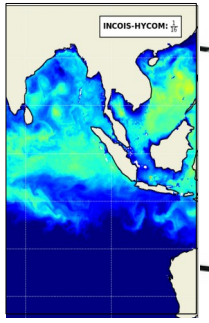
✦ Innovative ✦ Inclusive ✦ Resilient

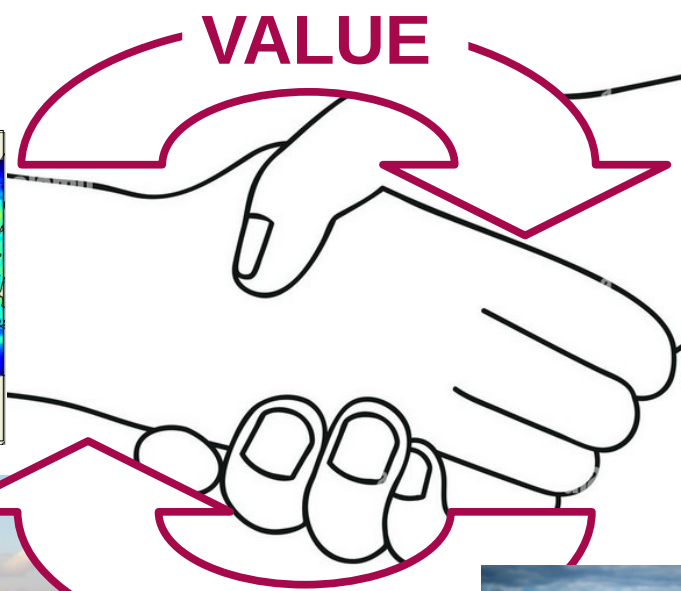












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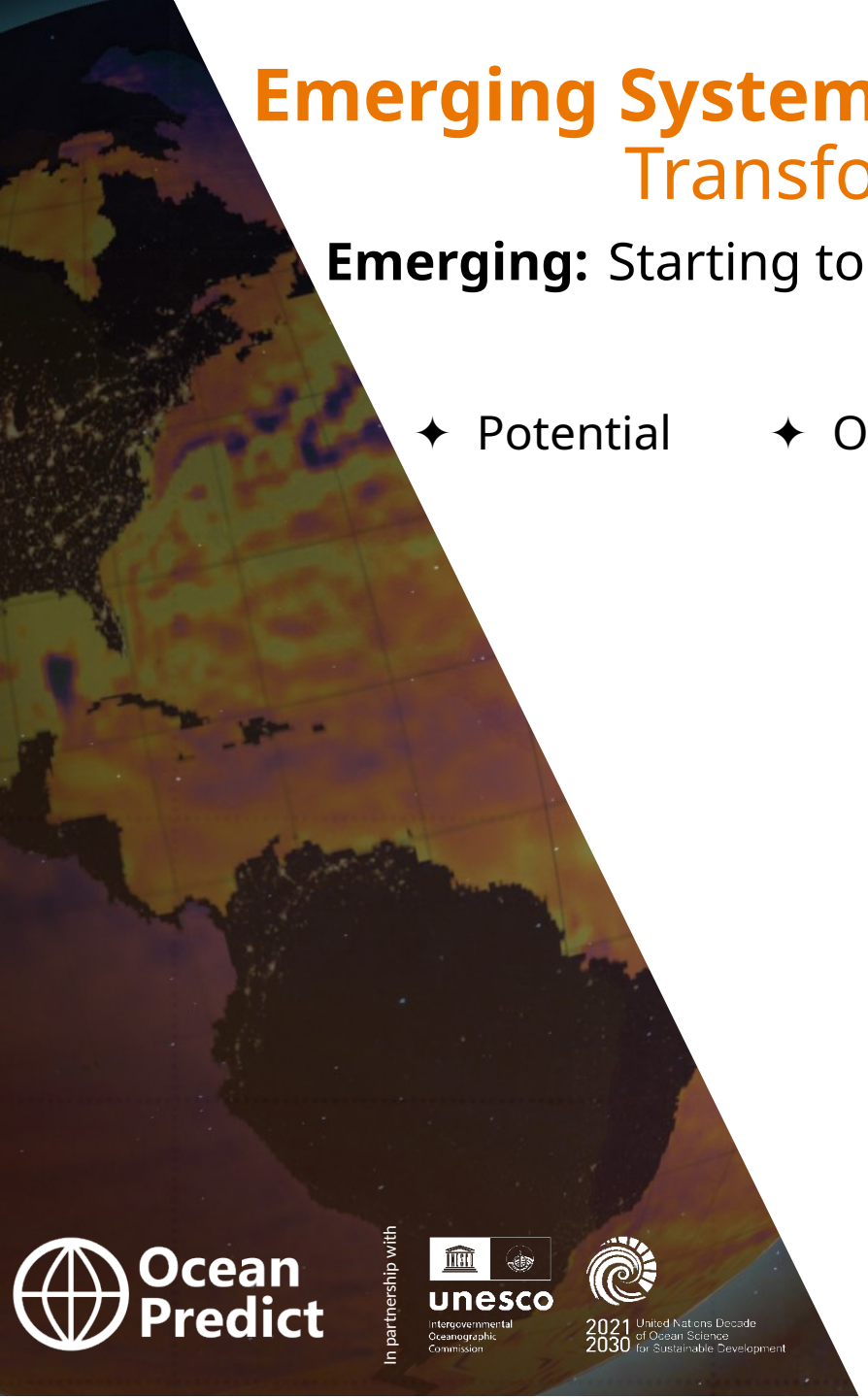

Emerging Systems for a Sustainable Blue Economy:
Transforming Data into Actionable Intelligence

Emerging: Starting to exist, grow or become known.

- ✦ Potential
- ✦ Opportunity
- ✦ Rapidly growing
- ✦ Often under-resourced

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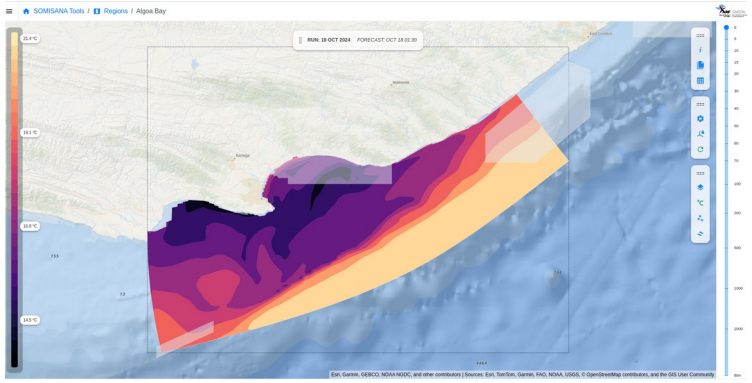
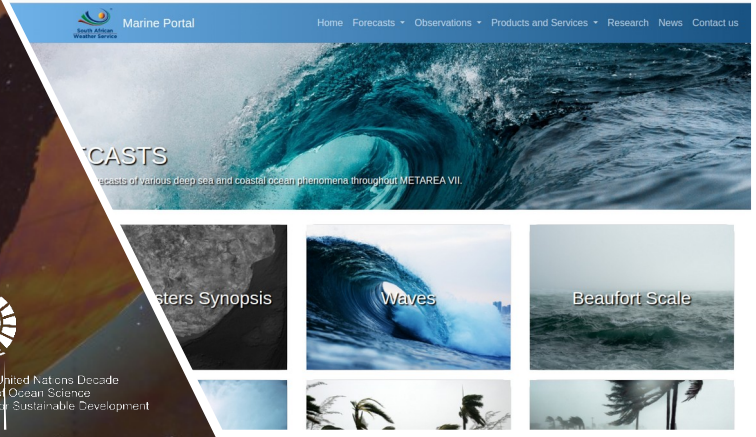
South Africa: SOMISANA est. 2019
A **sustained** and transformed critical mass of internationally recognized South African numerical ocean modelling experts who provide **accurate information** about the changing state of the ocean for **enhanced impact**.



South Africa: SAWS Marine Portal est. 2019
State-of-the-art forecasts of various deep sea and coastal ocean phenomena throughout METAREA VII



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Emerging Systems for a Sustainable Blue Economy:
Transforming Data into Actionable Intelligence

SYMPOSIUM OP'24

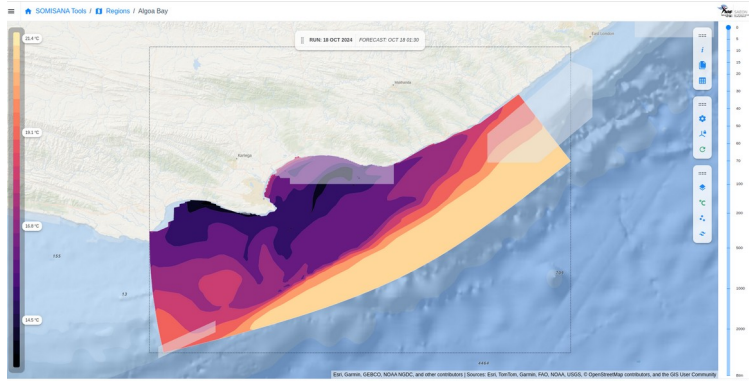
Emerging: Starting to exist, grow or become known.

India: INCOIS est. 1999

To provide **ocean data, information and advisory services** to society, industry, the government and the scientific community through sustained ocean observations and constant improvements through systematic and focused research in information management and ocean modelling.

South Africa: SOMISANA est. 2019

A **sustained** and transformed critical mass of internationally recognized South African numerical ocean modelling experts who provide **accurate information** about the changing state of the ocean for **enhanced impact**.



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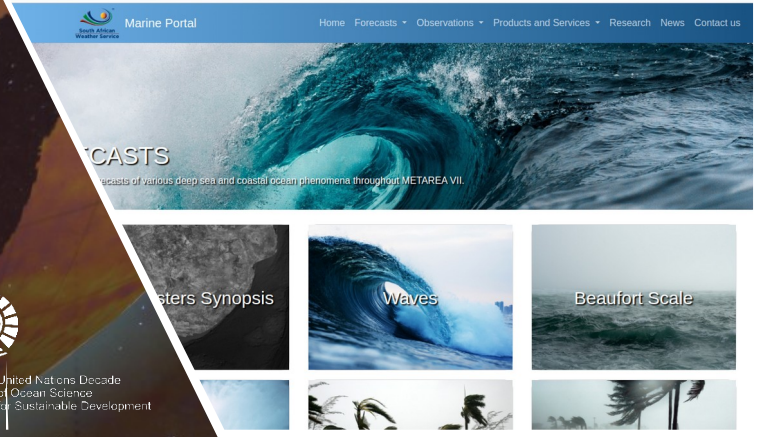

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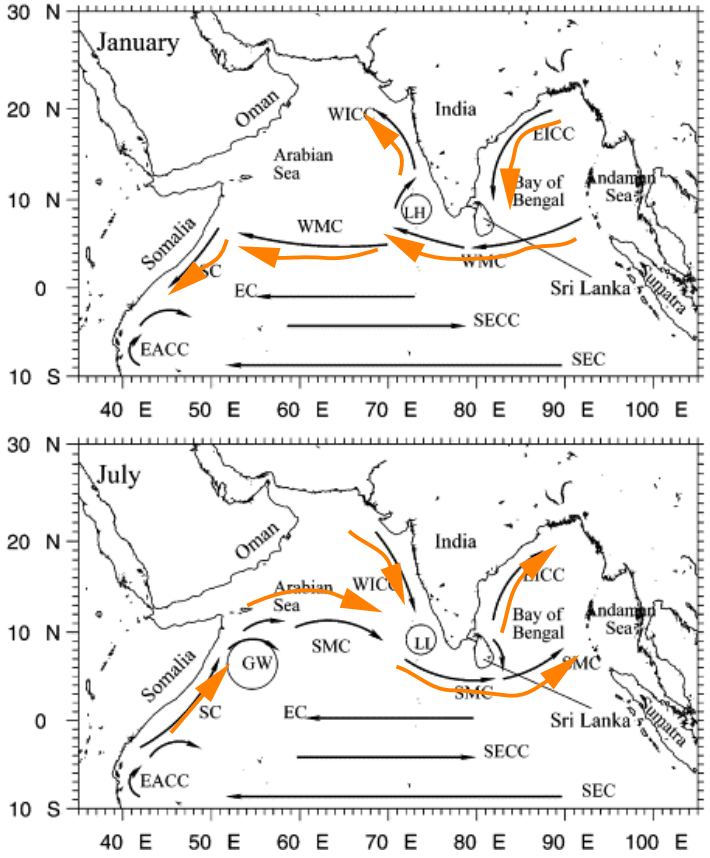
India’s forecast system and services journey

Maritime activities

India's forecast system and services journey

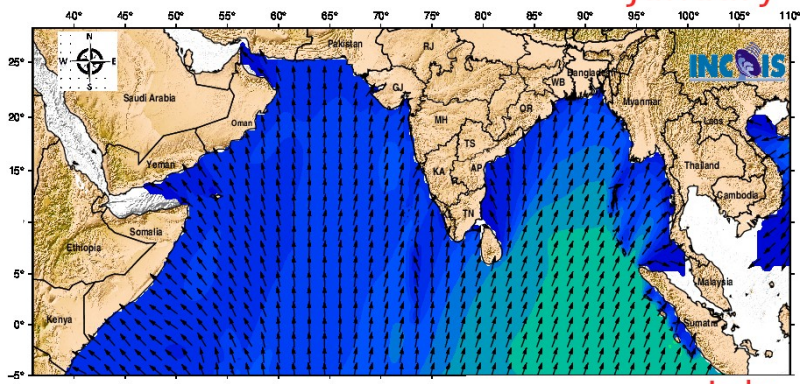
Unique marine environment: monsoonal system

Currents

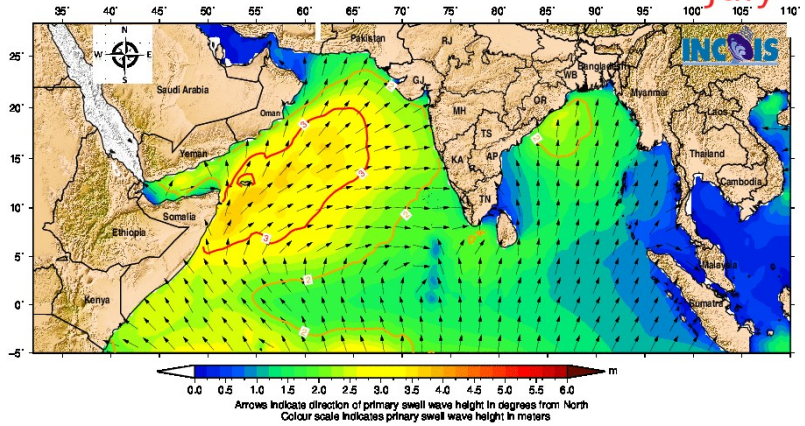


Waves

January

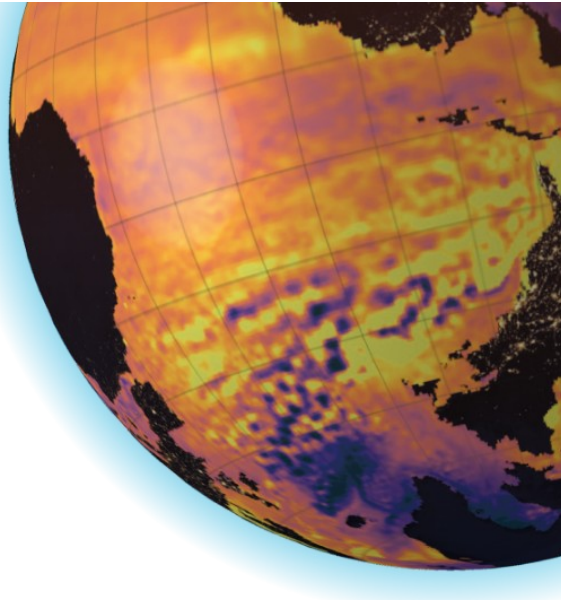


July



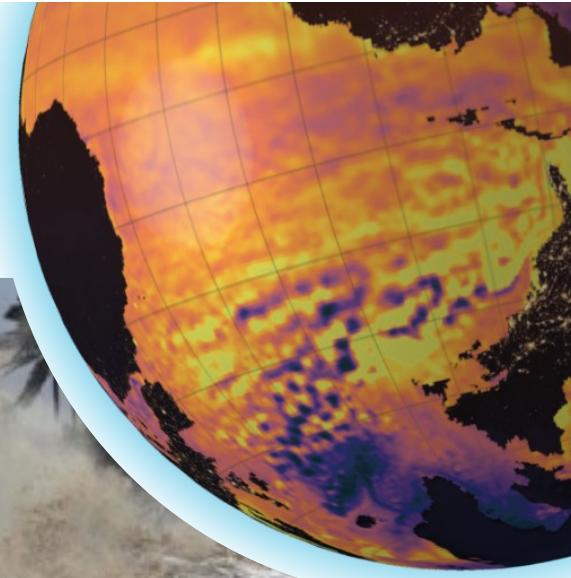
January

July



India’s forecast system and services journey

Extreme marine hazards



Swell surge in sea off Kanyakumari kills five medicos

Arockiaraj Johnbosco / TNN / Updated: May 6, 2024, 17:42 IST

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Representative photo

MADURAI: Five medical college students and interns from SRM Medical College Hospital and Trichy Government Medical College Hospital vacationing in Kanyakumari district drowned in the sea off Lemur Beach on Monday due to a swell surge, a phenomenon the India Meteorological Department has been warning for the southern Tamil Nadu coast.

The deceased have been P Sarvadarshith, 23, of Parakkai in Kanyakumari district, M Praveen Sam, 23, of Oddanchatram in Dindigul district, B Gayathiri, 25, of Neyveli, Venkatesh, 24, of Andhra Pradesh, and D Charukavi, 23, of Thanjavur.

Times of India, 6 May 2024

India’s forecast system and services journey

Extreme marine hazards

Cyclone Tauktae, May 2021

Deaths: 51

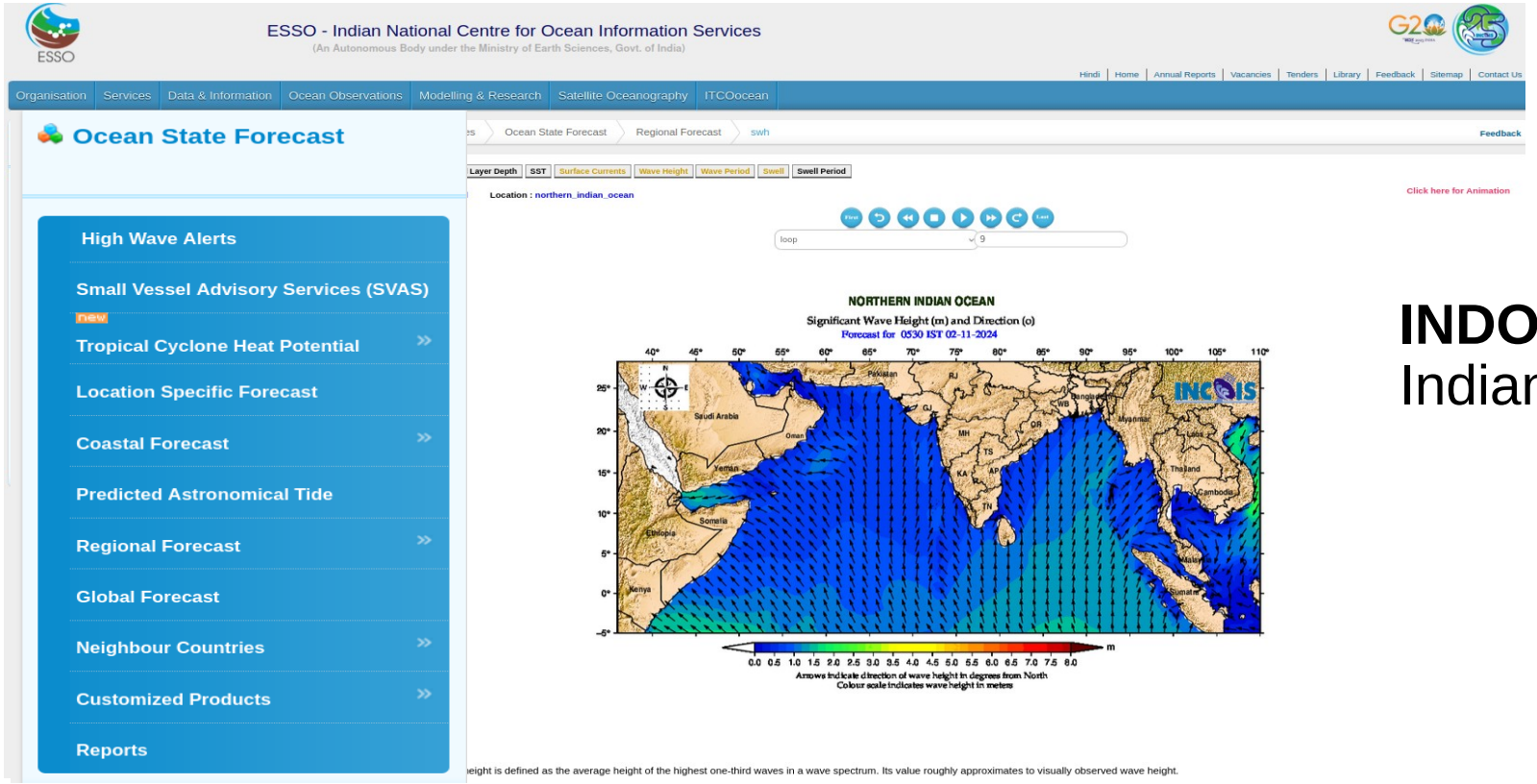
Missing: 21

Rescued: 180+

India's forecast system and services journey

INCOIS:

Indian National Centre for Ocean Information Services



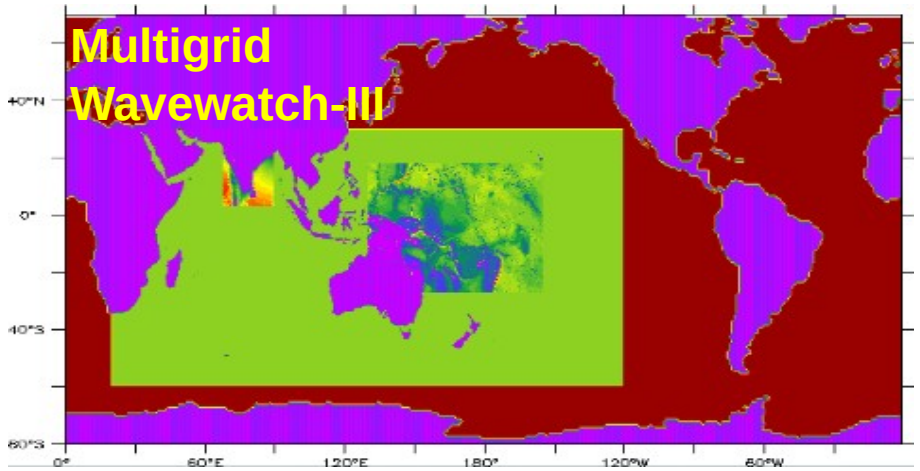
Catalyst: Government support and their recognition of the need for forecasting services

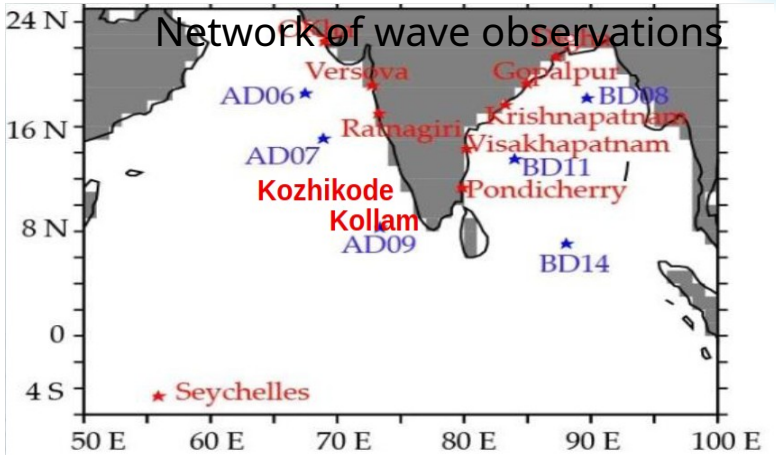
INDOFOS:
Indian Ocean Forecast System

India's forecast system and services journey

INCOIS: Wave forecasts (est. 2005)

Success:
Sophisticated multi-grid assimilated WW3 system that supports storm surge predictions





Low res. WAM forecasts → Multi-grid assimilated WW3 → Integrated coastal inundation prediction system

India's forecast system and services journey

INCOIS: Current forecasts (est. 2010)

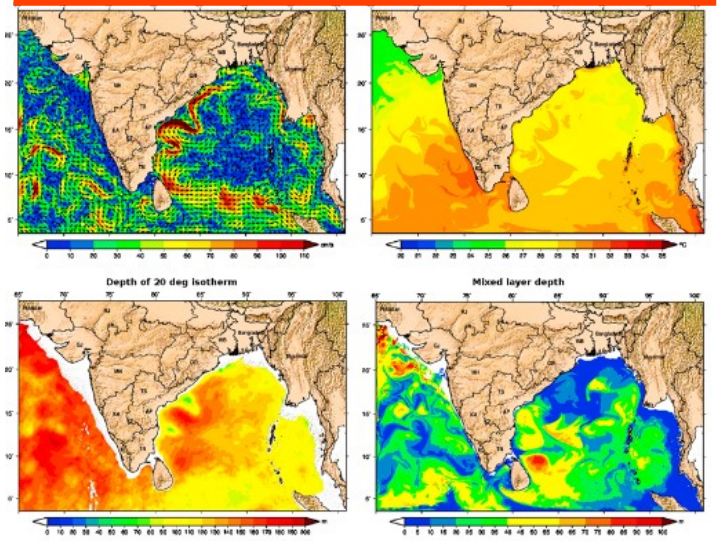
Simple approach:
Initial regional forecast system was unassimilated.

Indian Ocean Forecast System

Regional Ocean Analysis

Regional and coastal forecasts

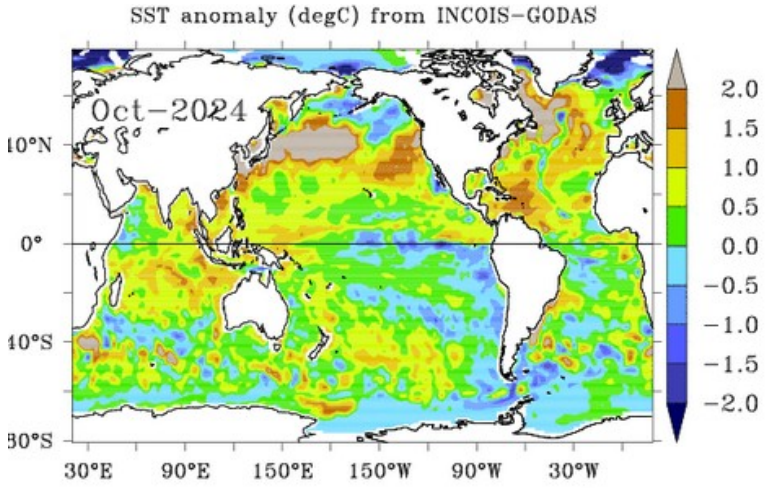
General circulation



Global Ocean Data Assimilation System

Ocean Initial Conditions

Ocean Analysis & Reanalysis



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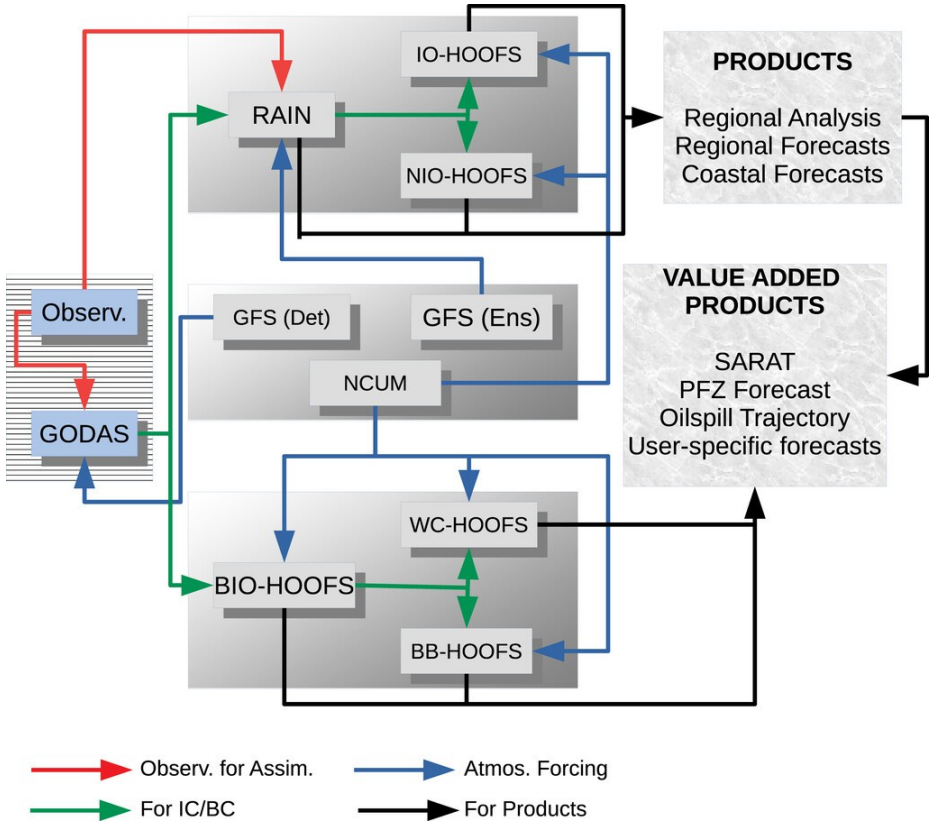
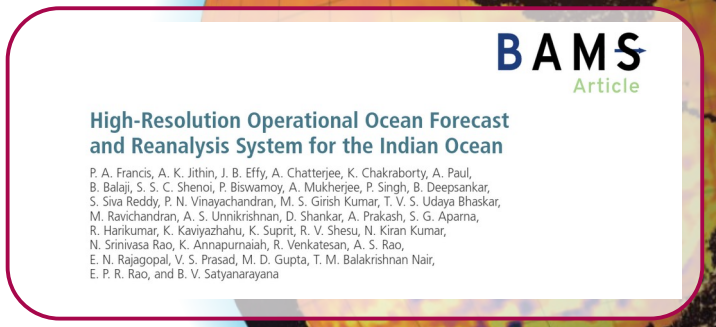
India's forecast system and services journey

INCOIS: Current forecasts, 2018



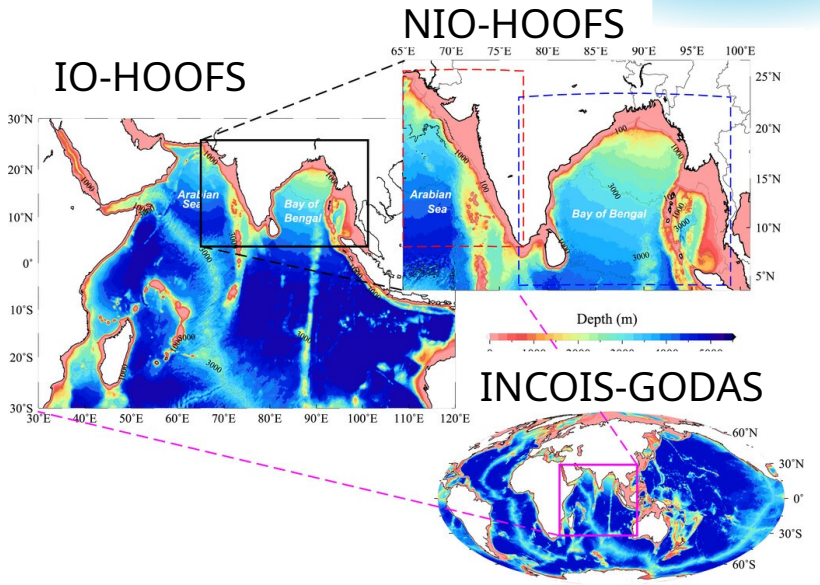


HOOFS:

High resolution Operational Ocean Forecast and reanalysis System

System Improvements:

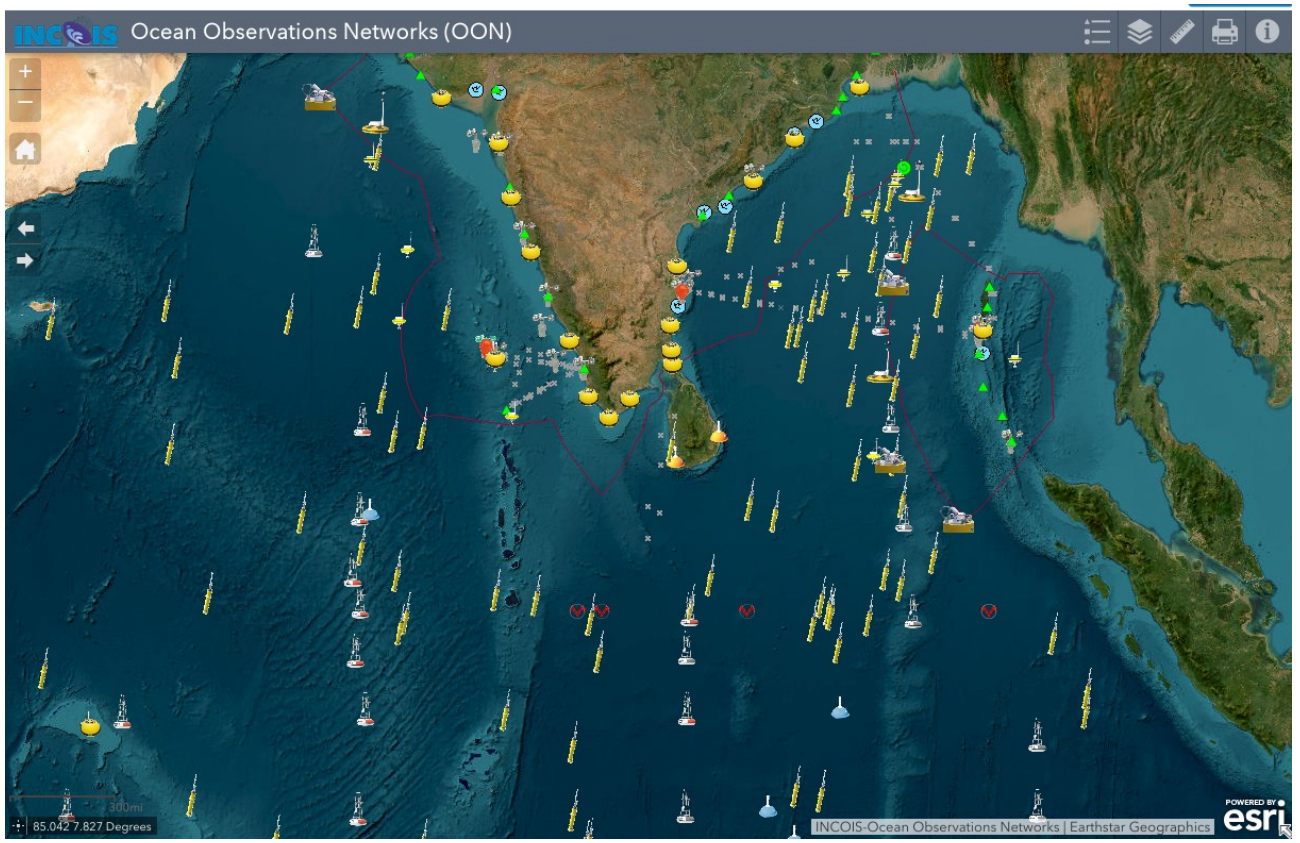
- Increased resolution (9 km for IO-HOOFS and 2.25 km for NIO-HOOFS)
- LEKF Data assimilation for IO-HOOFS
- Inclusion of tides
- Biogeochemical model



India’s forecast system and services journey

INCOIS: Observing Network

OBSERVATIONS!!!!



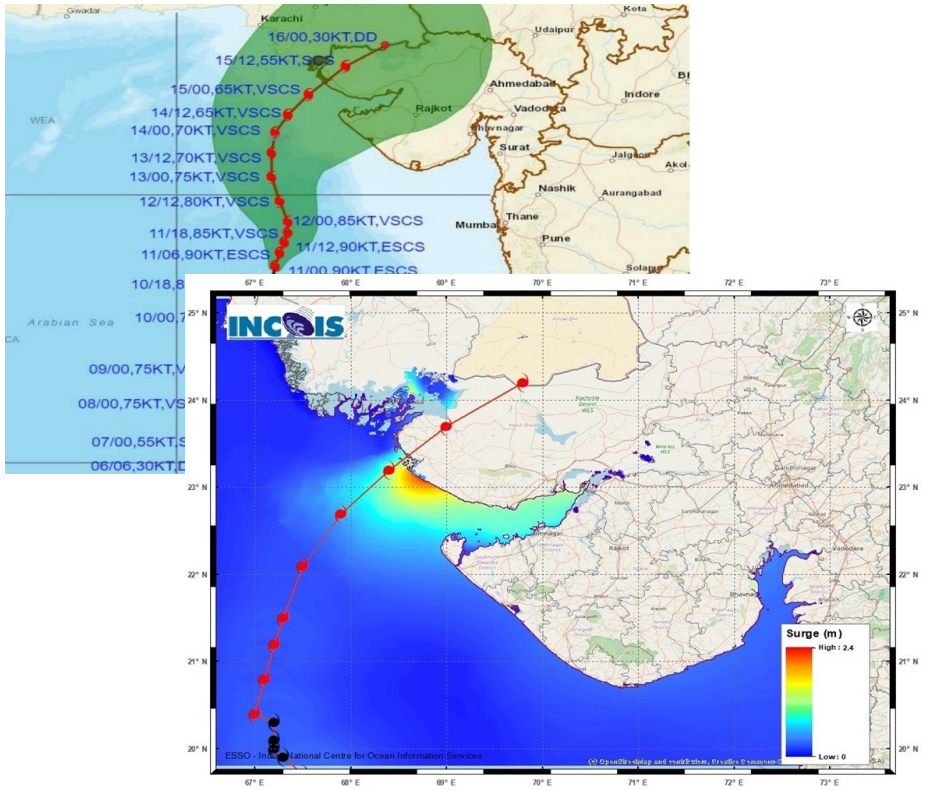
- Argo
- Moored Buoys
- Wave Rider Buoys
- XBT lines
- Drifters
- Wave drifters
- Ship-mount ADCPs
- Coastal ADCPs
- Coastal HF Radars
- Tide gauges
- GNSS network

India's forecast system and services journey

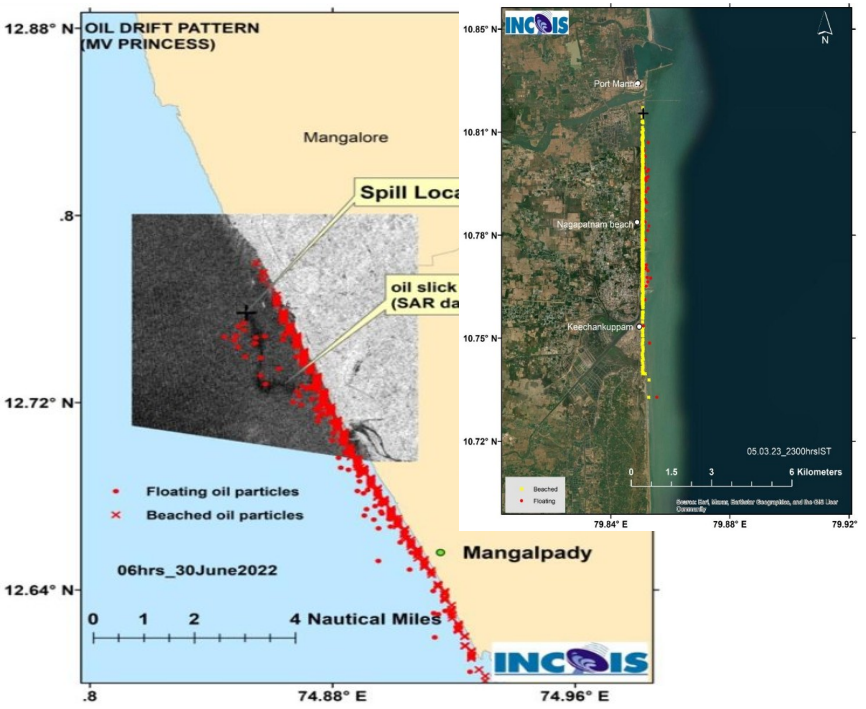
INCOIS: Downstream Applications

Adding value

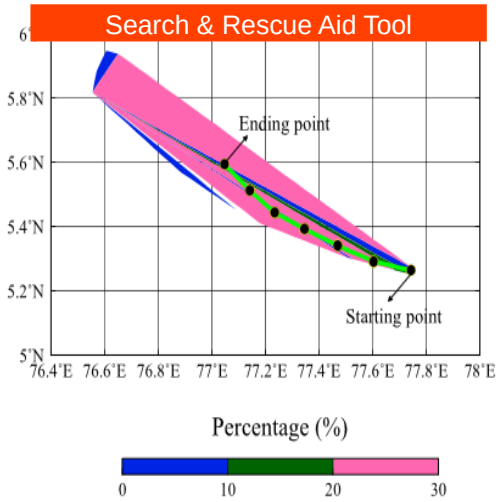
Storm surge prediction (2013)



Oil-spill tracking (2016)



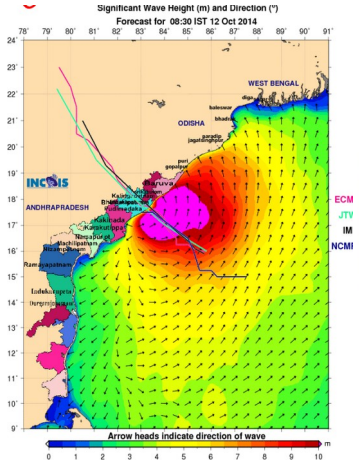
Search & Rescue

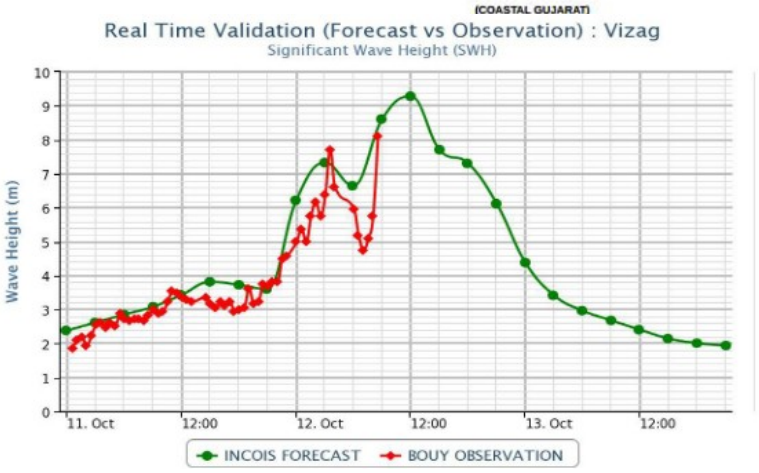


India's forecast system and services journey

INCOIS: Downstream Applications and their Dissemination

Effective hazard communication: both modern and traditional methods





India's forecast system and services journey

INCOIS: Regional Specialized Meteorological Centre

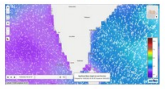
Regional Specialized Meteorological Centre (RSMC)
for Numerical Ocean Wave Prediction
and Global Numerical Ocean Prediction
Indian National Centre for Ocean Information Services (INCOIS)

The Indian Ocean is a vast stretch of seawater and a source of sustenance and livelihood for millions of people in the countries that border it. The marine resources of the Indian Ocean and the concept of the blue economy play a significant role in supporting the socioeconomic development and well-being of the populations living in this region.

Indian National Centre for Ocean Information Services (INCOIS) is an autonomous organization under the Ministry of Earth Sciences, Government of India. It was established in 1999 and has provided various ocean-related services since then. INCOIS started its wave forecast services from (25-05-2006) and augmented it with essential ocean variables from ocean general circulation models from (03-03-2015). INCOIS generates early warning advisories based on the state of the seas surrounding the Indian subcontinent and serves several island countries. These services are critical for the operational activities of offshore sea goers and onshore activities such as coastal tourism, ports and harbors etc.

INCOIS operationally runs a suite of wave and ocean general circulation models at different resolutions to provide early warning services to maritime stakeholders. Users of forecasts are equipped to take informed decisions based on the sea state conditions, avoiding loss of life and property. Thus, INCOIS services extensively contribute to the development of the blue economy in the region through its forecasts and advisory services. Forecasts of essential ocean variables at different time scales are thus crucial for a broad spectrum of users ranging from fishermen to offshore industries. Recognizing the role played by INCOIS in issuing forecasts for the region, the WMO Executive Council at its seventy-sixth session (EC-76) adopted the designation of RSMC Indian National Centre for Ocean Information Services (INCOIS) (India) for numerical ocean wave prediction and global numerical ocean prediction.

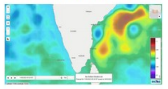
Waves



View Data Download

Model Name	Domain	Resolution	Forcing	Mixing	DA
WAVEWATCH-III	Four nested grids covering Global Ocean	Global Ocean (1 x1 deg), Indian Ocean (0.5 x0.5 deg), Northern Indian Ocean (0.25 x0.25 deg) and coastal (10 Km x10 Km)	ECMWF forecast winds (0.25x0.25deg)	NA	Optimal Interpolation method; Assimilates Sig. Wave Height (SWH) from SARAL/AltiKa, Jason-3, Sentinel-3a and Sentinel-3b and all available in-situ SWH observations in the Indian Ocean

Ocean Prediction



View Data Download

Model Name	Domain	Resolution	Forcing	Mixing	DA
HYbrid Coordinate Ocean Model (HYCOM) version-2.35	20E-120E & 43S-30N	6.9 km (1/16) degree nested to a 25 km (1/4) Global Hycom	Atmospheric forcing: GFS Rivers: NRL climatology	KPP mixing	Method: Tendral Statistical Interpolation (Reduced Order Kalman Filter) Variables: AVHRR-SST, + L2 & L3 Along Track altimeter data. Argo profiles of Temperature & Salinity

Terms & Conditions Disclaimer

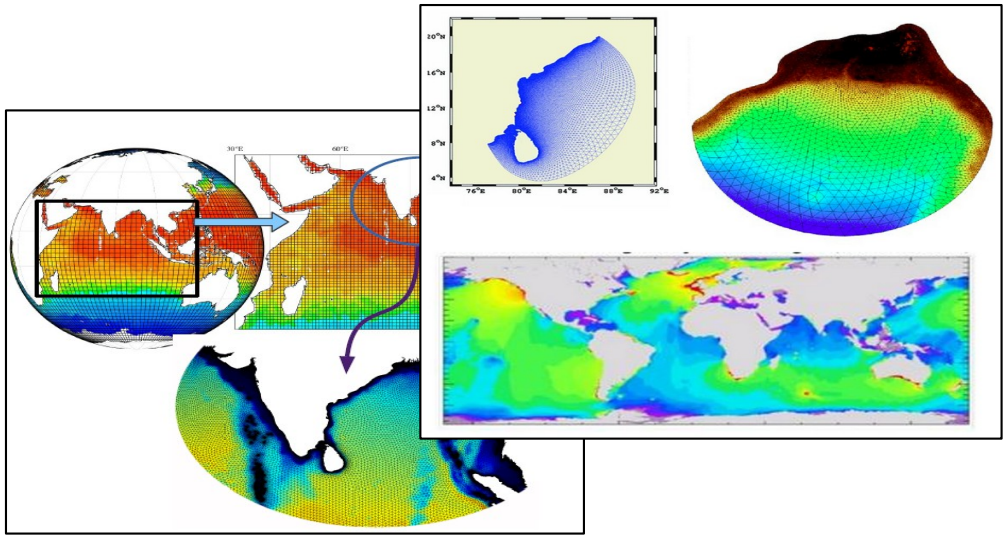
SUCCESS:
WMO Recognized Specialized Meteorological Centre for ocean circulation and global wave predictions.

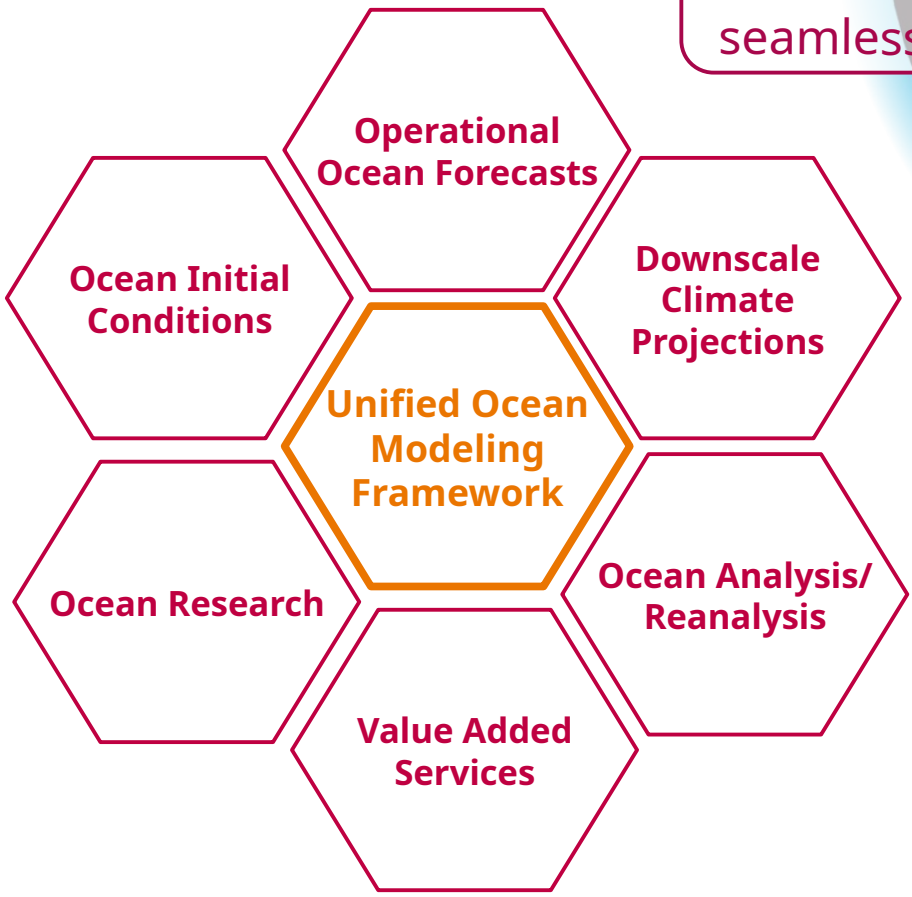
WORLD METEOROLOGICAL ORGANIZATION
Weather Climate Water

India's forecast system and services journey

INCOIS's next chapter

UPGRADES:
To make the system more seamless

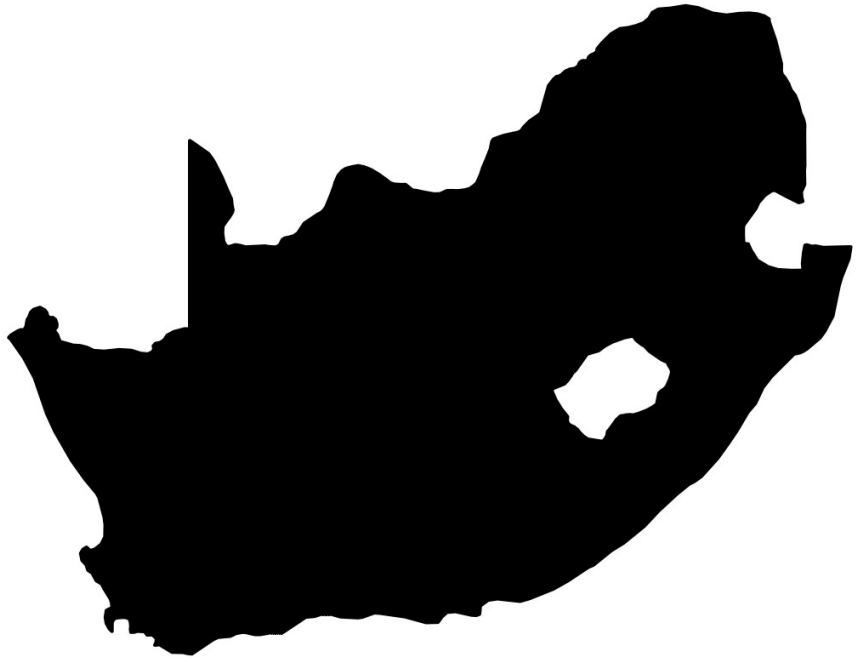


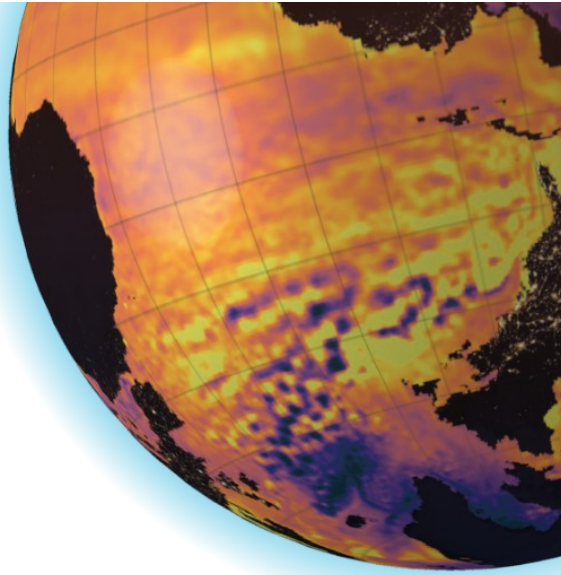


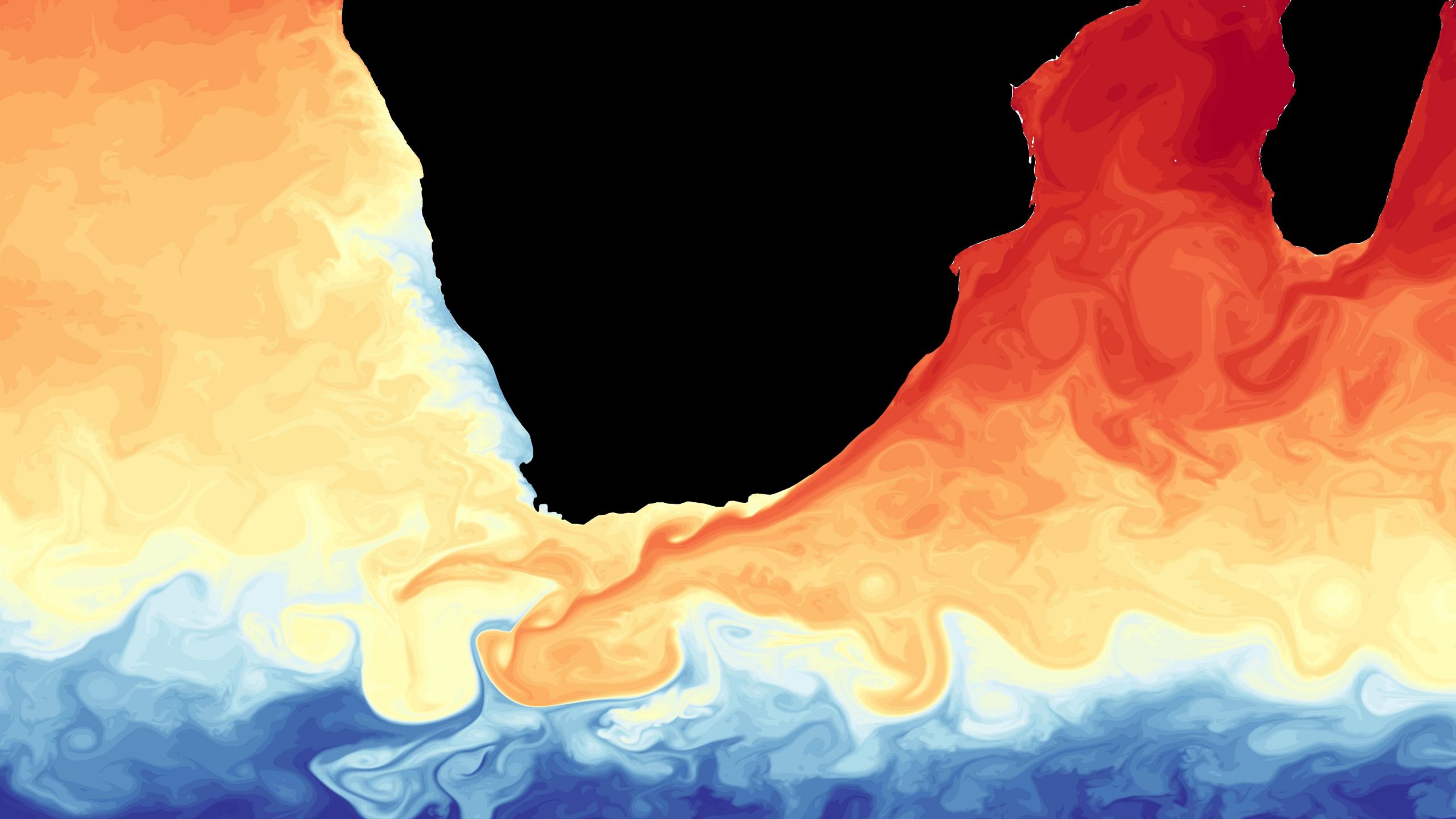
- MOM6
- FVCOM
- Wavewatch III
- ADCIRC

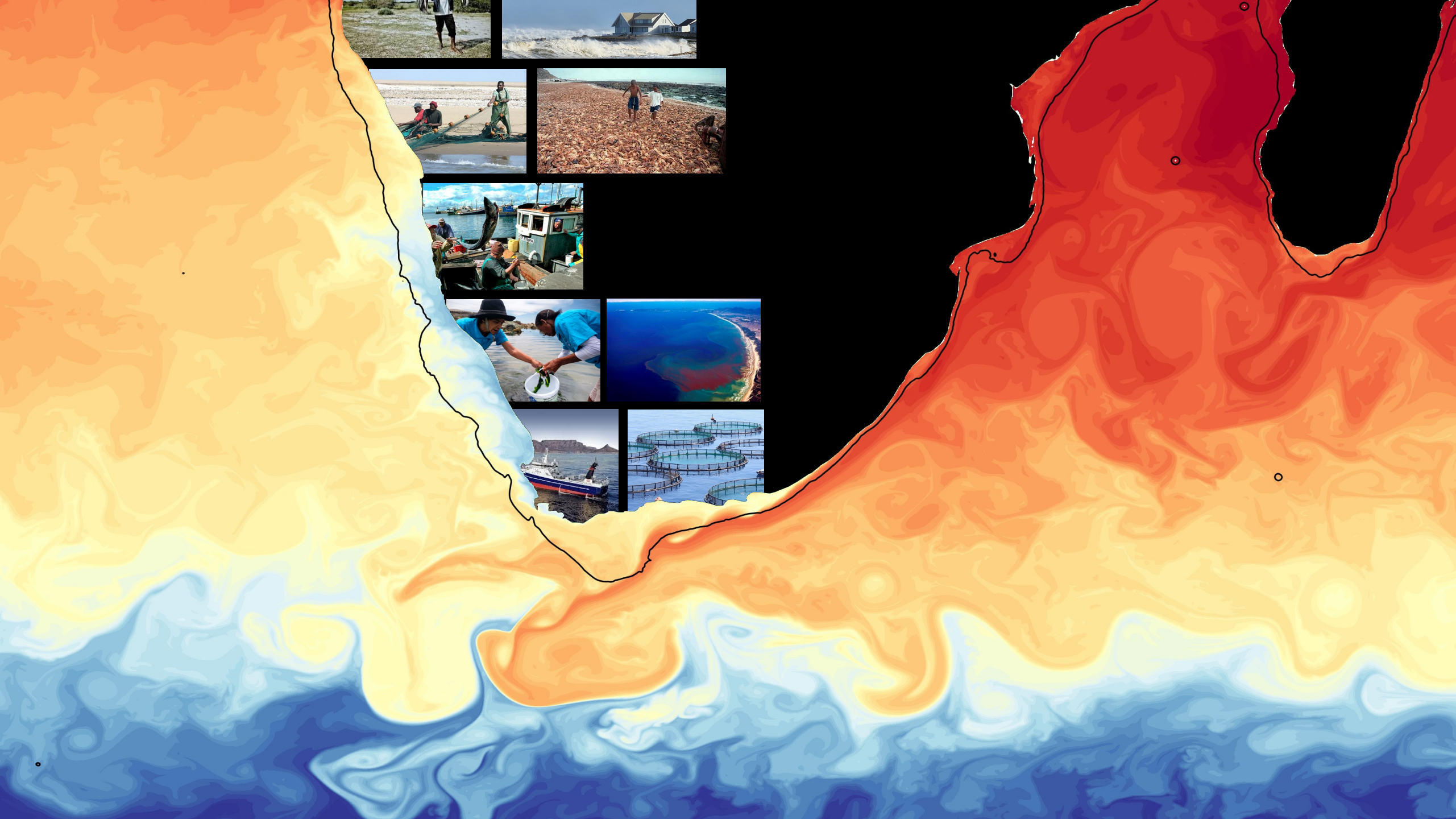
Under development:
- ROMS system to be replaced by MOM
- Coastal predictions with FVCOM systems.

South Africa’s forecast system and services journey







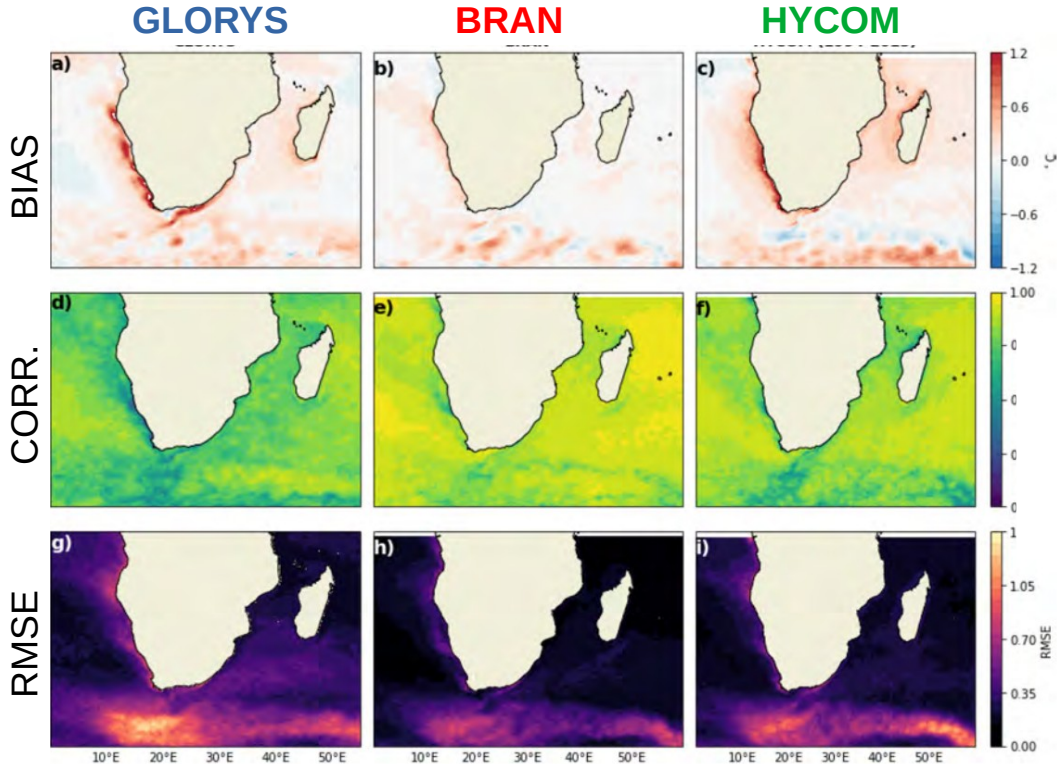


South Africa's forecast system and services journey

Global Reanalysis Systems

Opportunity: Locally optimized systems are needed.

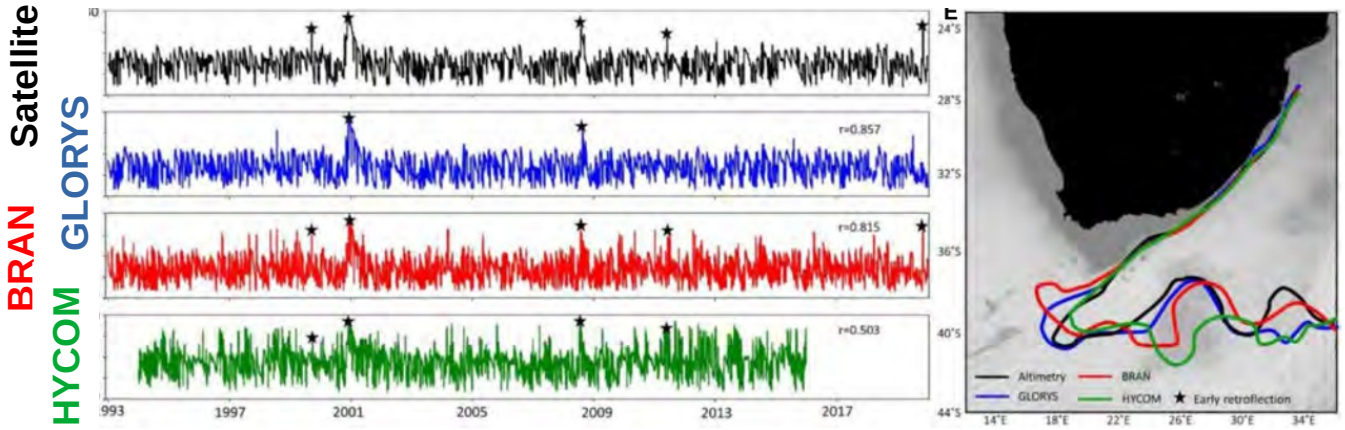
Sea Surface Temperature (vs OSTIA)



Pressure Points

- ✦ The Benguela upwelling system
- ✦ Intense frontal features
- ✦ The Agulhas retroflection and associated leakage

Longitudinal position of retroflection (★ = early)



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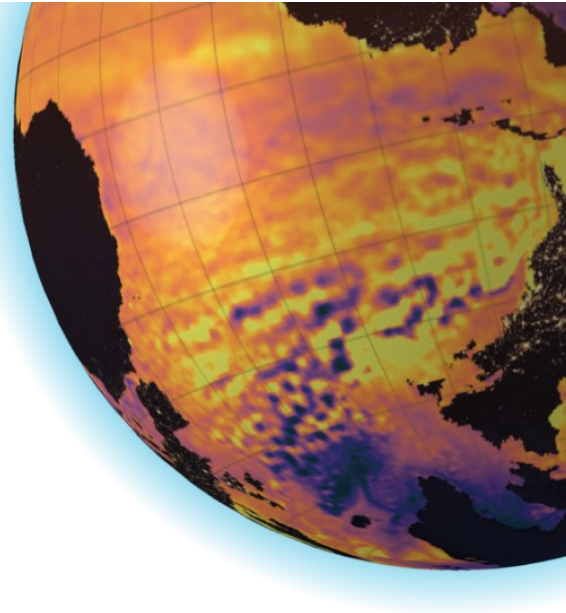
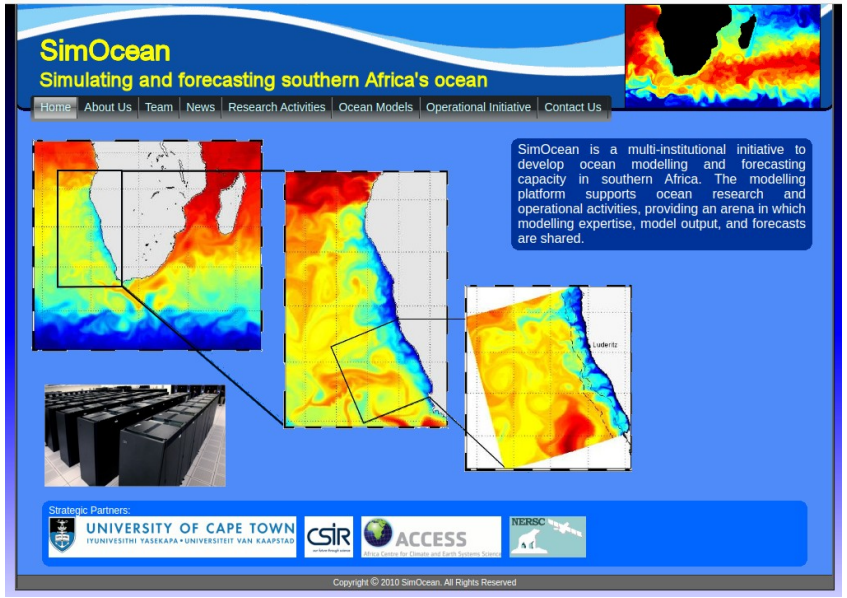
South Africa’s forecast system and services journey

Once upon a time ..



2010

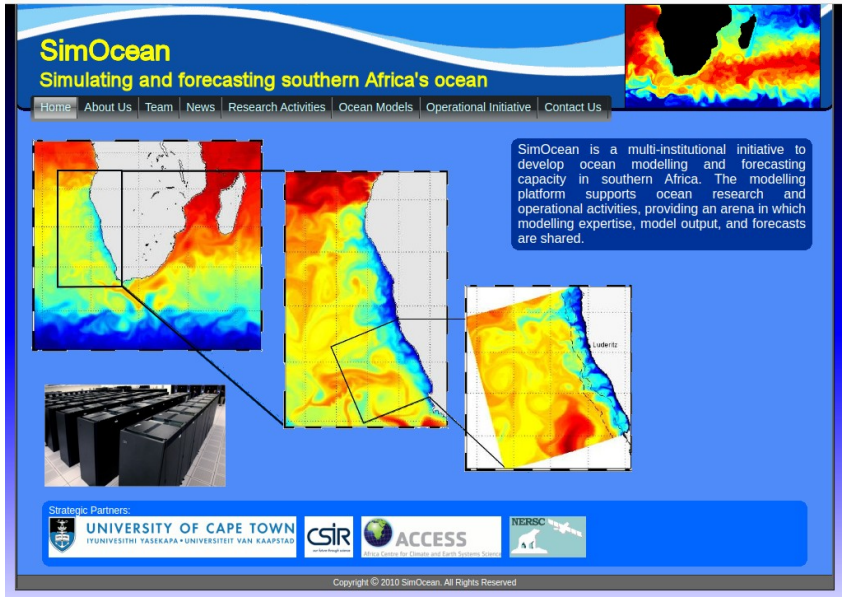


South Africa's forecast system and services journey

Once upon a time ..

Catalyst: High level recognition of the need for a sustainable Oceans Economy.

2010



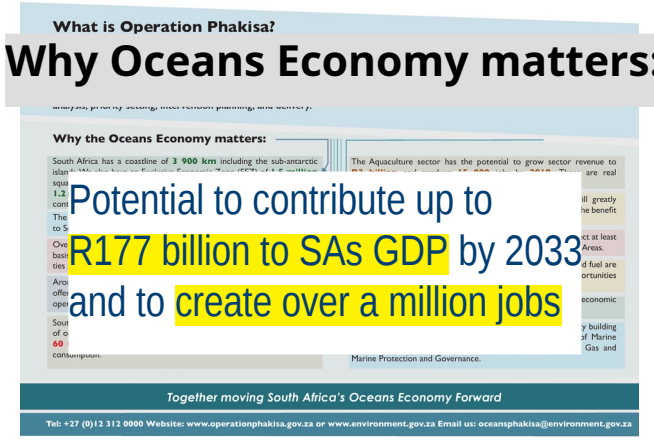
2014

OPERATION PHAKISA

planning | implementation | growth

OPERATION PHAKISA | OCEANS ECONOMY

Why Oceans Economy matters:



Six work streams:

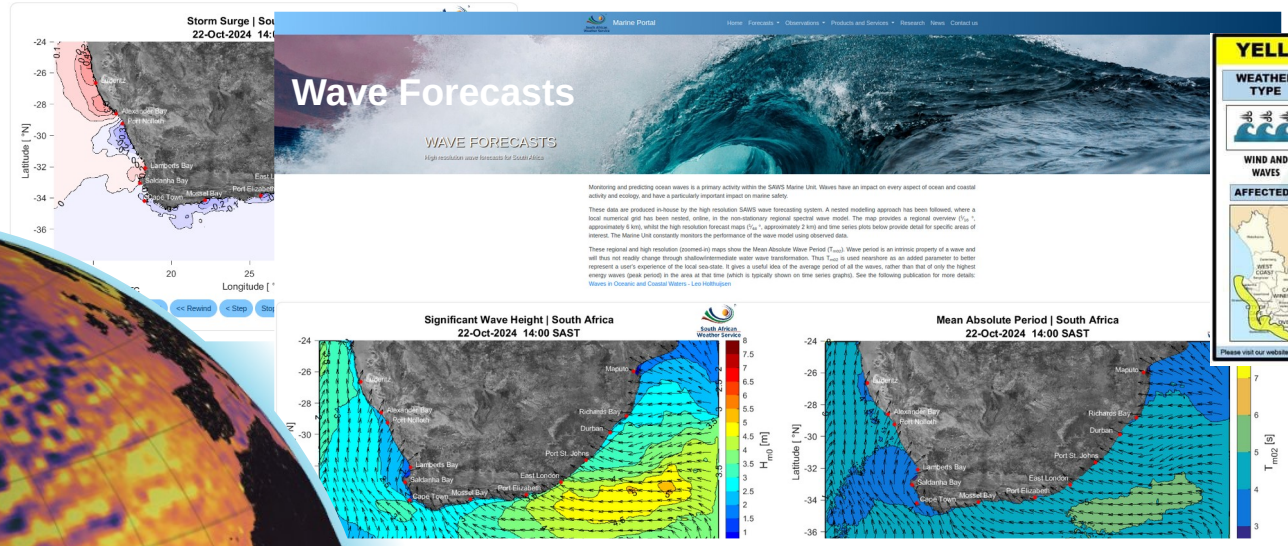
1. Marine Transport and Manufacturing
2. Offshore Oil and Gas Exploration
4. Marine Protection Services and Ocean Governance
5. Small Harbours
6. Coastal and Marine Tourism

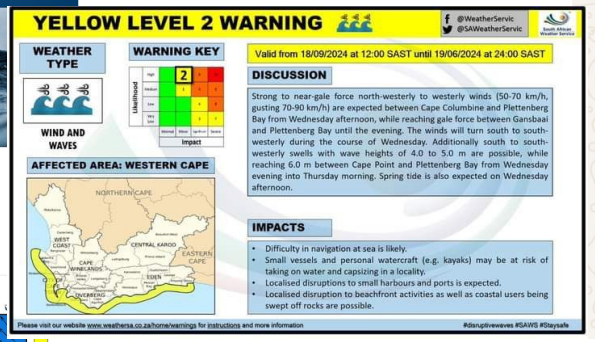
South Africa's forecast system and services journey

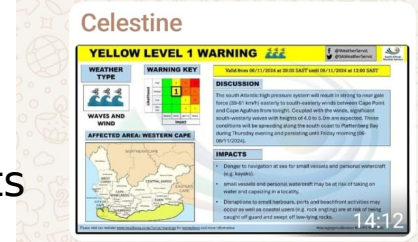
South African Weather Service (SAWS) Marine Portal

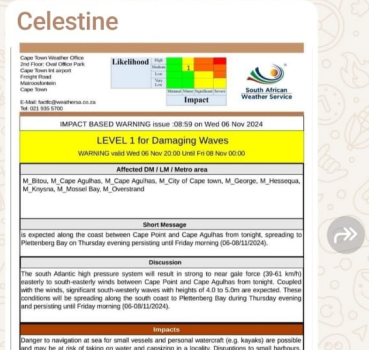
✦ **Public Good Services:** funded by the government and delivered to the public free of charge. These include general forecasts, severe weather warnings and advisories, seasonal outlooks for farmers

✦ **Commercial Services:** primarily aviation and ports









Success: Simple, yet effective end-user communication.

C.Ramjukadh: Co-development of operational rip hazard forecasts for the Cape Peninsula of South Africa
On Thursday **21 November, Session 7.2**

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South Africa's forecast system and services journey

Oceans & Coastal Information Management System (OCIMS)

- **Improve ocean protection and management** and promote the development of an environmentally conscious ocean economy through the **sharing of knowledge and data across** the public and private sectors
- **Encourage** cross-government **collaborations**, communities of practices and partnerships.
- Develop a **fit for purpose operational system** through continued consultations between developers and stakeholders.
- Remain **locally relevant** and **globally cognizant**.

Strength:
Consortium-Approach

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South African Weather Service

CSIR
Touching lives through innovation

NATIONAL OCIMS

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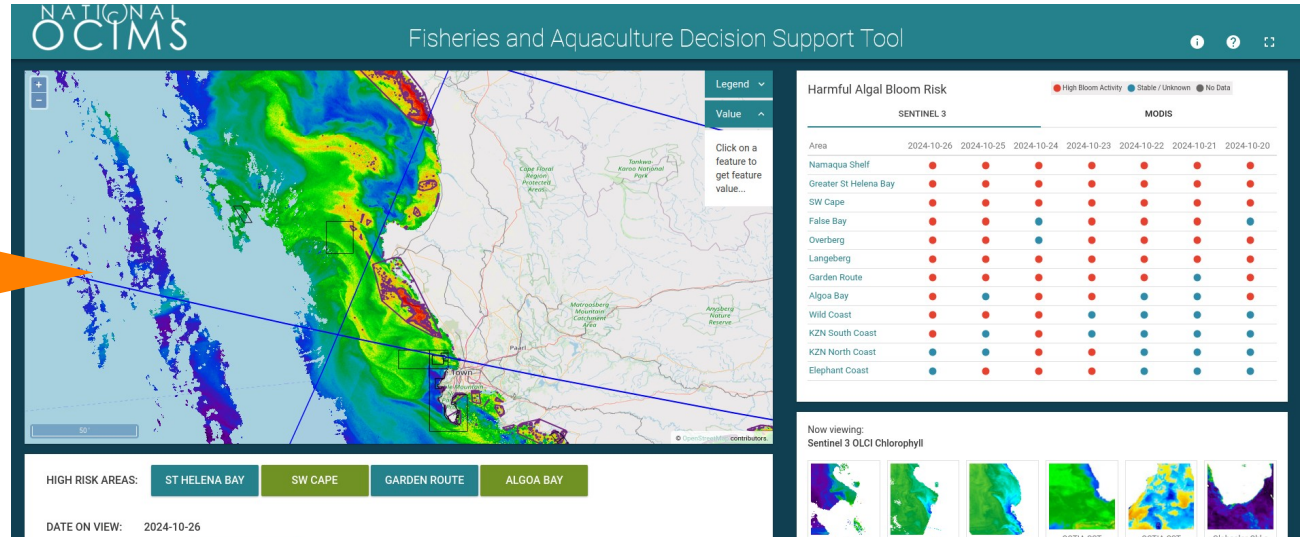
South Africa's forecast system and services journey

Oceans & Coastal Information Management System (OCIMS)



J.Veitch: The South African National Oceans and Coastal Information Management System's co-designed path from data production to actionable insights
On Monday **18 November, Session 6.2**

Success:
End-user co-designed tools

Strength:
Consortium-Approach

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Forestry, Fisheries and the Environment
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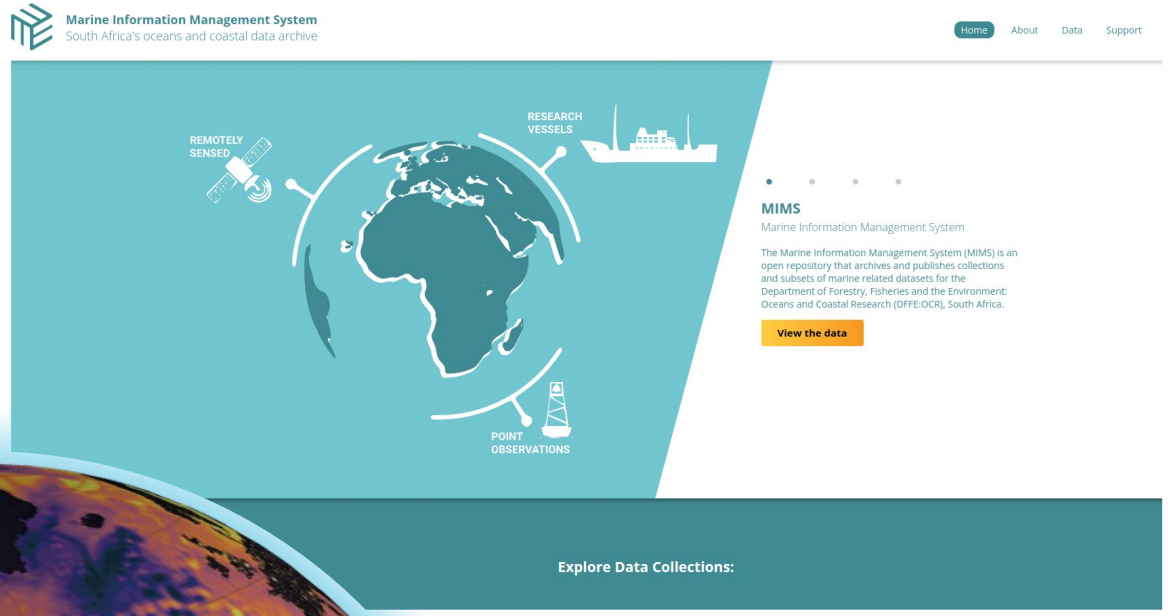
Marine Information Management System (MIMS)



- Following FAIR principles, MIMS is an **open repository** tasked with the long-term preservation of South Africa's ocean and coastal data
- An **accredited data unit of the IOC** and is the AfroBIS Node for sub-saharan Africa.
- Adheres to **best data management practices** and is designed with a inter-operability in mind

Opportunity: Open data repository is in place to support systems and services

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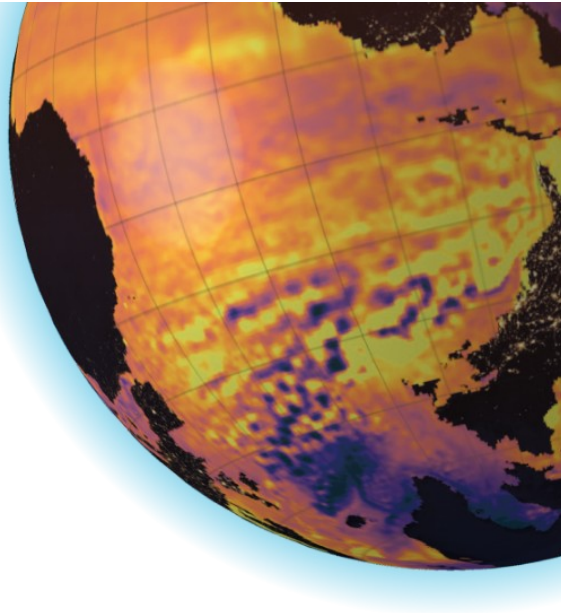
South Africa's forecast system and services journey

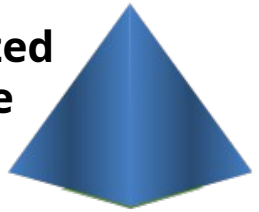
SOMISANA:

A Sustainable Ocean Modelling Initiative, A South African Approach



VISION

A **sustained and transformed** critical mass of **internationally recognized** South African numerical **ocean modelling experts** who provide **accurate information** about the changing state of the ocean for ***enhanced impact***



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South Africa's forecast system and services journey

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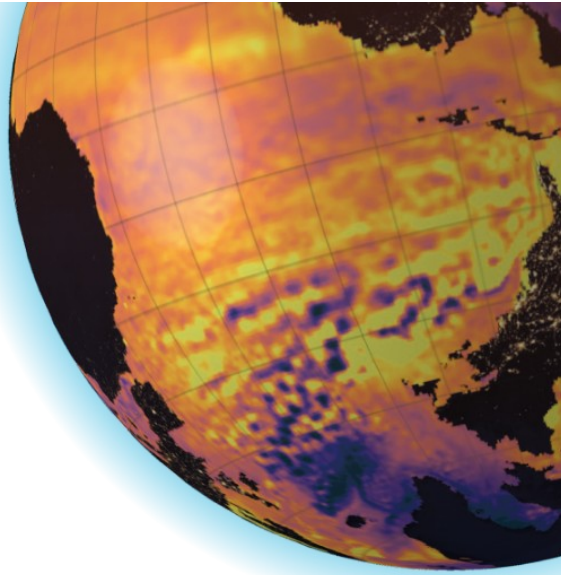

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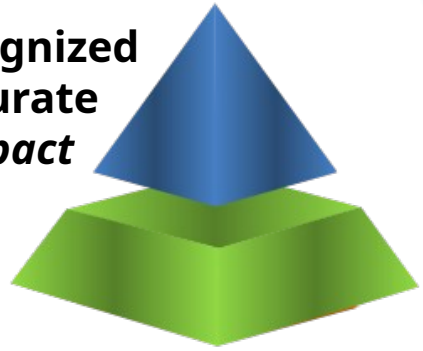

MISSION

An ocean modelling hub and platform that promotes the inclusive development of local expertise and that produces and provides state-of-the-art ocean information, tools and research that is **visible and accessible to all**

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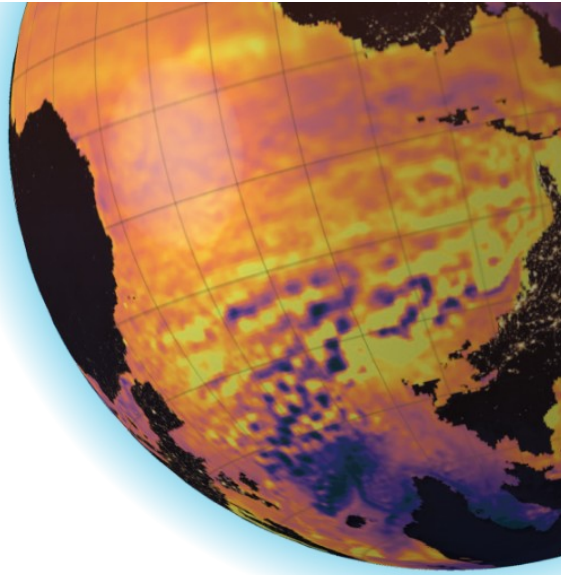

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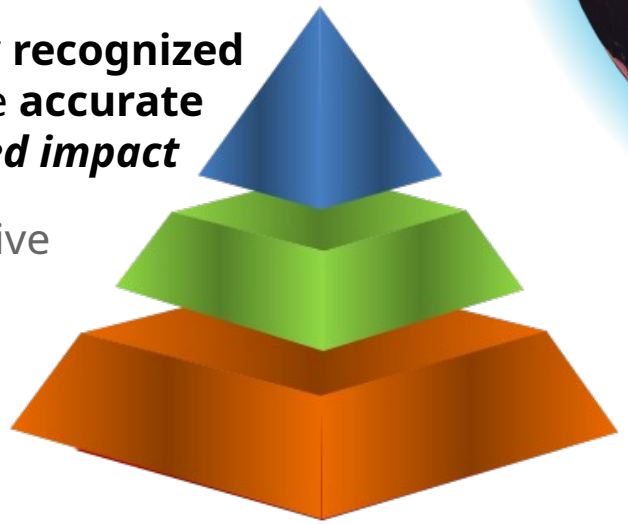

GOALS

1. Model Development

- ✦ Limited domain OFSs
- ✦ Optimized hindcast/reanalysis

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2. Capacity Development

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South Africa's forecast system and services journey

SOMISANA:

A Sustainable Ocean Modelling Initiative, A South African Approach

SOMISANA:
'to work together'

VISION

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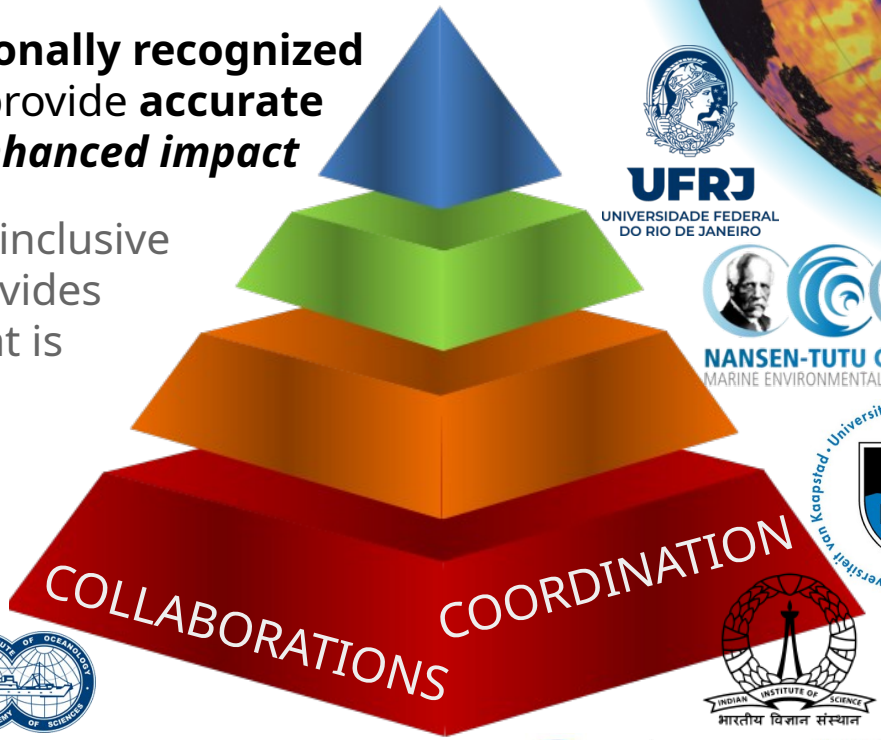

UFRJ Universidade Federal do Rio de Janeiro

Nansen-Tutu Centre Marine Environmental Research

LOPS

University of Cape Town · Universiteit van Kaapstad · Université de Yoseka

LEGOS

National OCIMS

CROCO Sud Coastal and Regional Ocean COmmunity model

FIO

Indian Institute of Science भारतीय विज्ञान संस्थान

University of Connecticut 1881

UBO Université de Bretagne Occidentale

Nelson Mandela University Change the World

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CSIR Touching lives through innovation

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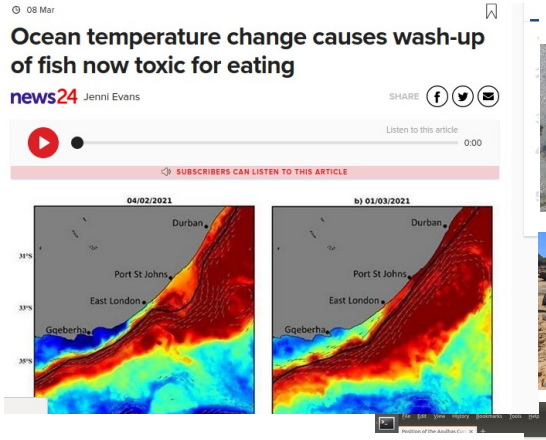
South Africa's forecast system and services journey

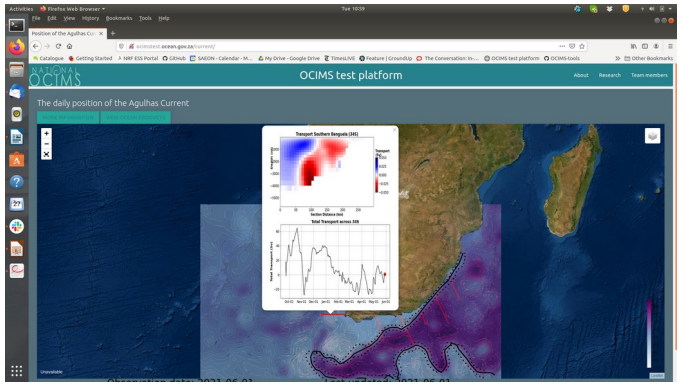
SOMISANA: Operational Products

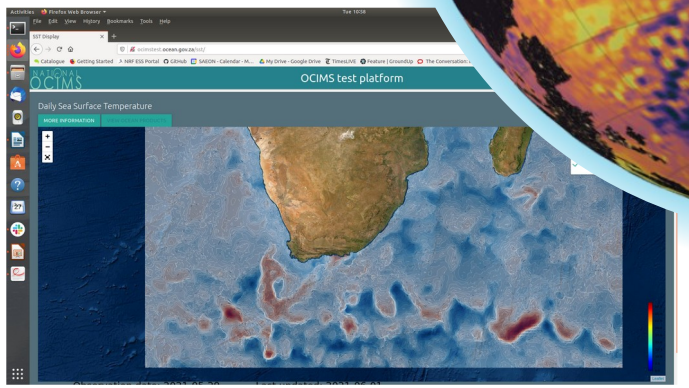
The low-hanging fruit

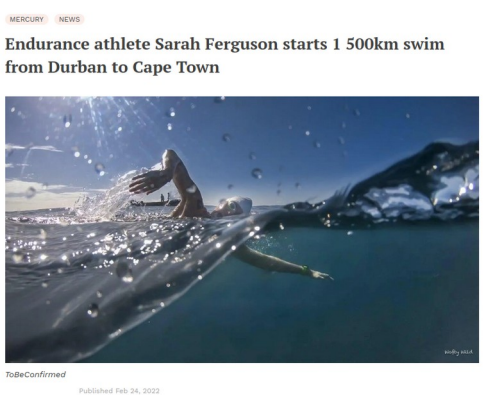
Lesson:
Simple can be impactful

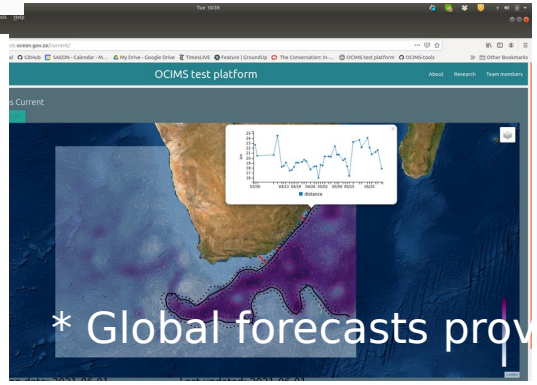
- **Adding value** to freely available forecast systems* and satellite products

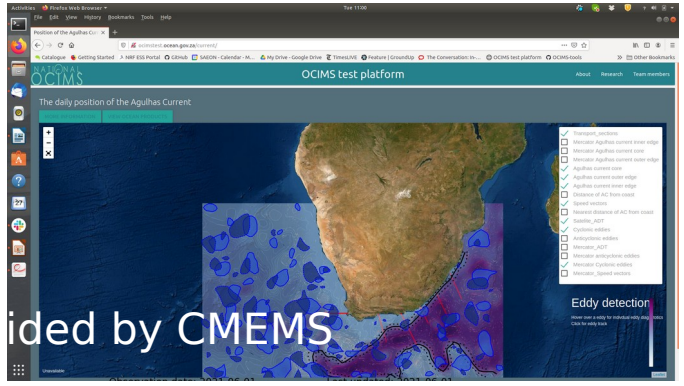


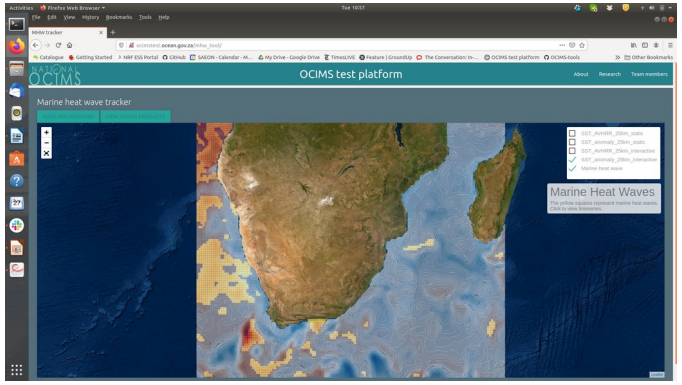












* Global forecasts provided by CMEMS

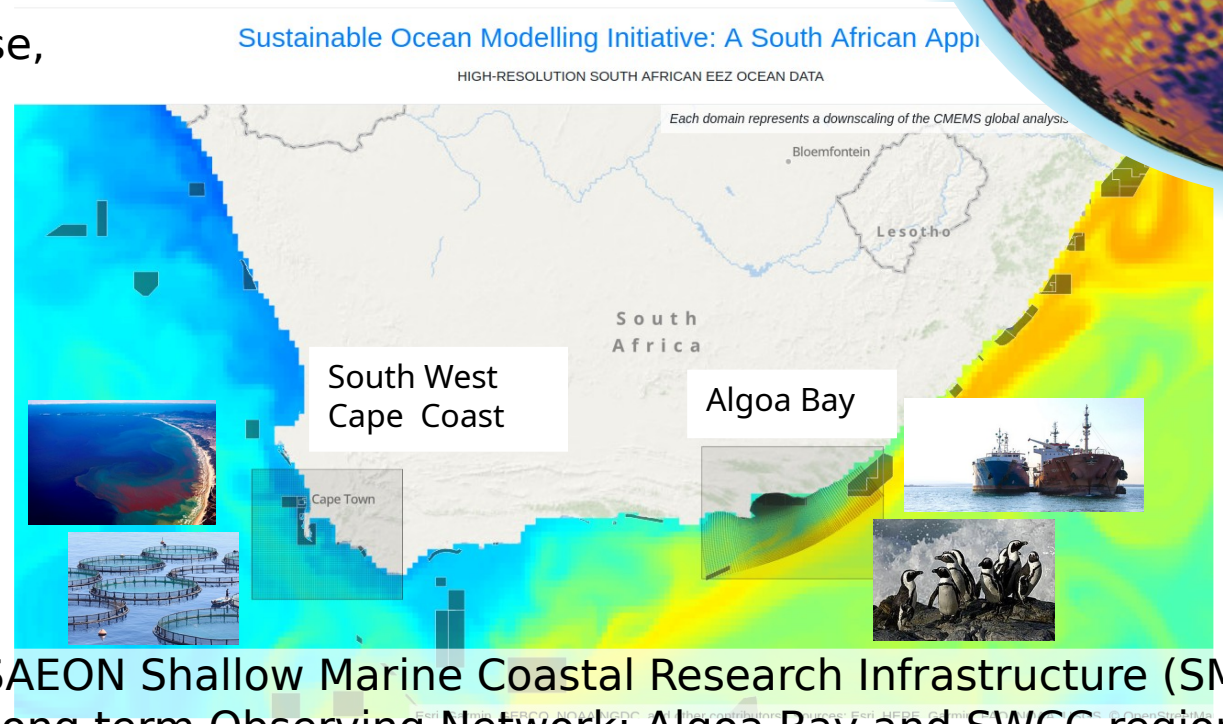
South Africa's forecast system and services journey

SOMISANA: Operational Forecast Systems

Downscaling Approach

Enabler: Reliable, accessible, quality global forecast products

- ✦ Limited area, **downscaled** forecasts of high-use, well-monitored and sensitive regions.
- ✦ Forced with **freely available** global ocean (CMEMS) and atmospheric (GFS) forecasts. 🙏
- ✦ **NO assimilation**
- ✦ Provide high resolution (~500m – 3 km), **5-day forecasts**



SAEON Shallow Marine Coastal Research Infrastructure (SMCRI) Long term Observing Network: Algoa Bay and SWCC region as 'Sentinel Sites'

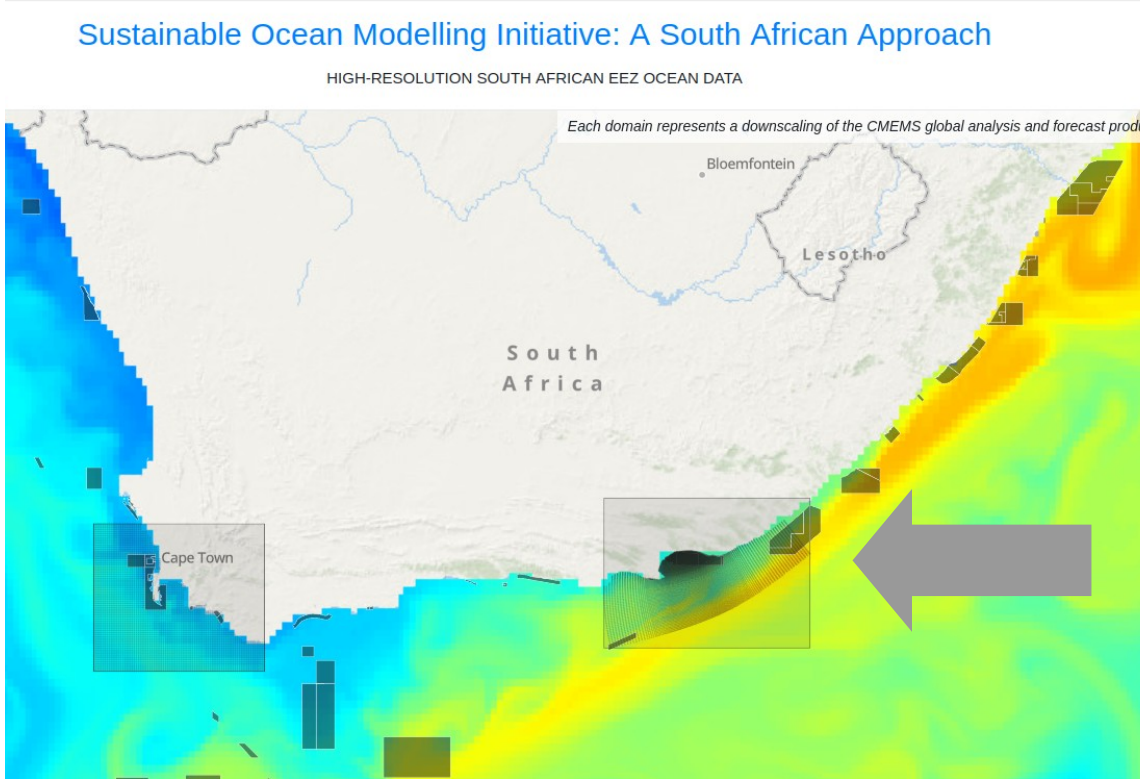
G. Fearon: A relocatable approach to regional ocean forecast systems: applications along South Africa's continental shelf
On **Wednesday 20 November, Session 2.2**

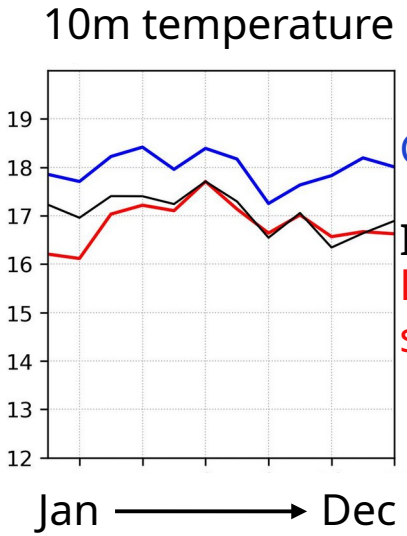
South Africa's forecast system and services journey

SOMISANA: Operational Forecast Systems

Downscaling Approach

Lesson:
Simple can be good





South Africa's forecast system and services journey

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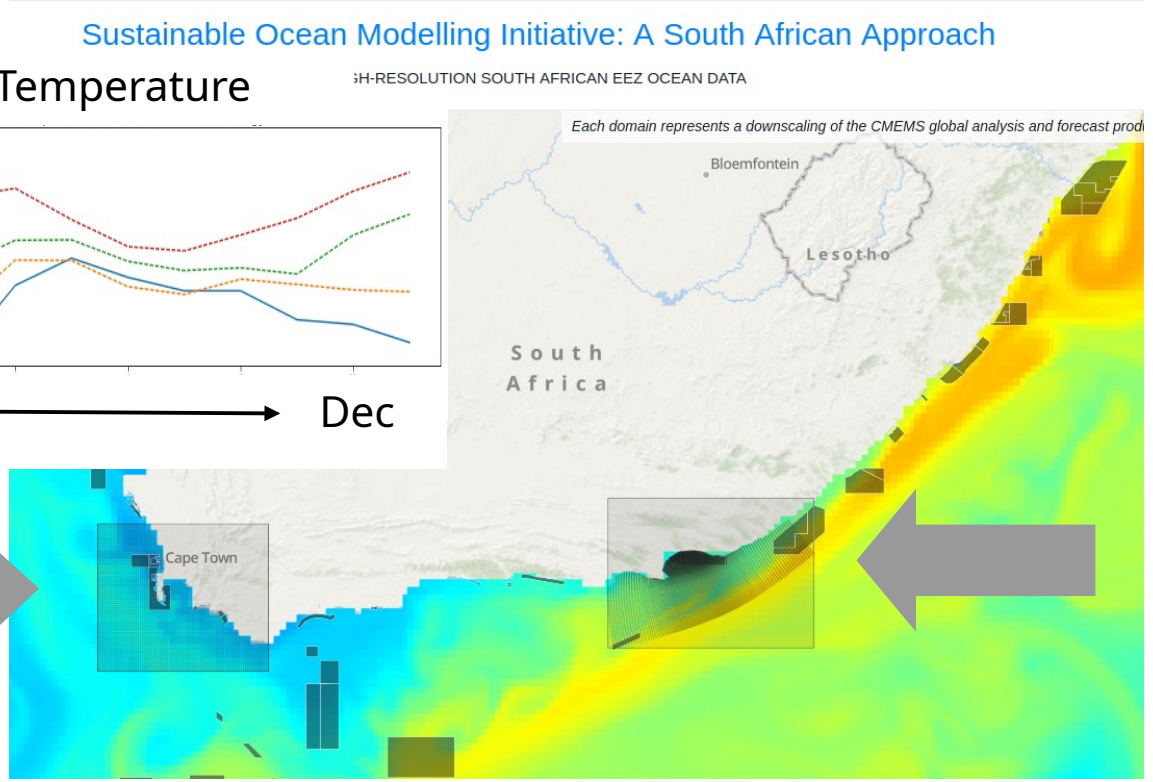
Downscaling Approach

Lesson:
Simple can be good

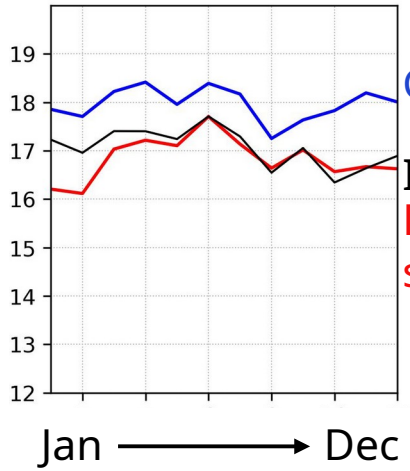
Global Reanalysis
Satellite

Downscaled System

In situ



10m temperature



Global Reanalysis

In Situ

Downscaled system

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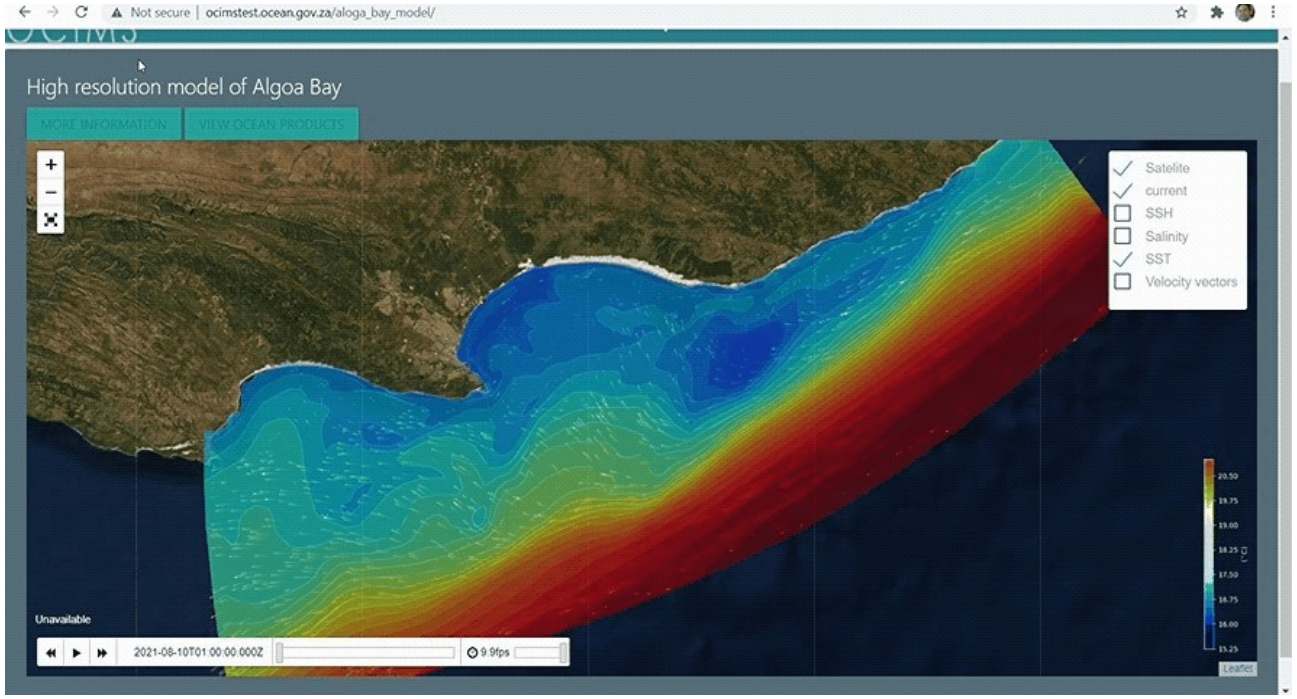
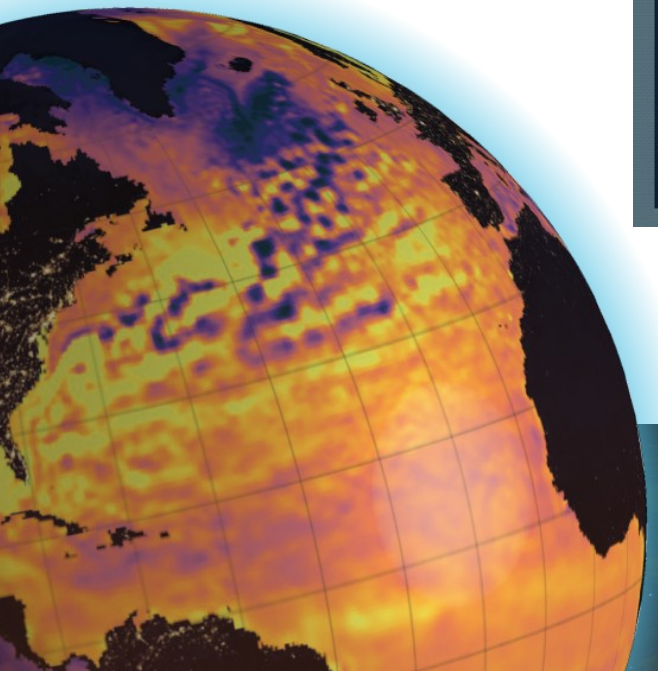
Visualization Portal, first iteration





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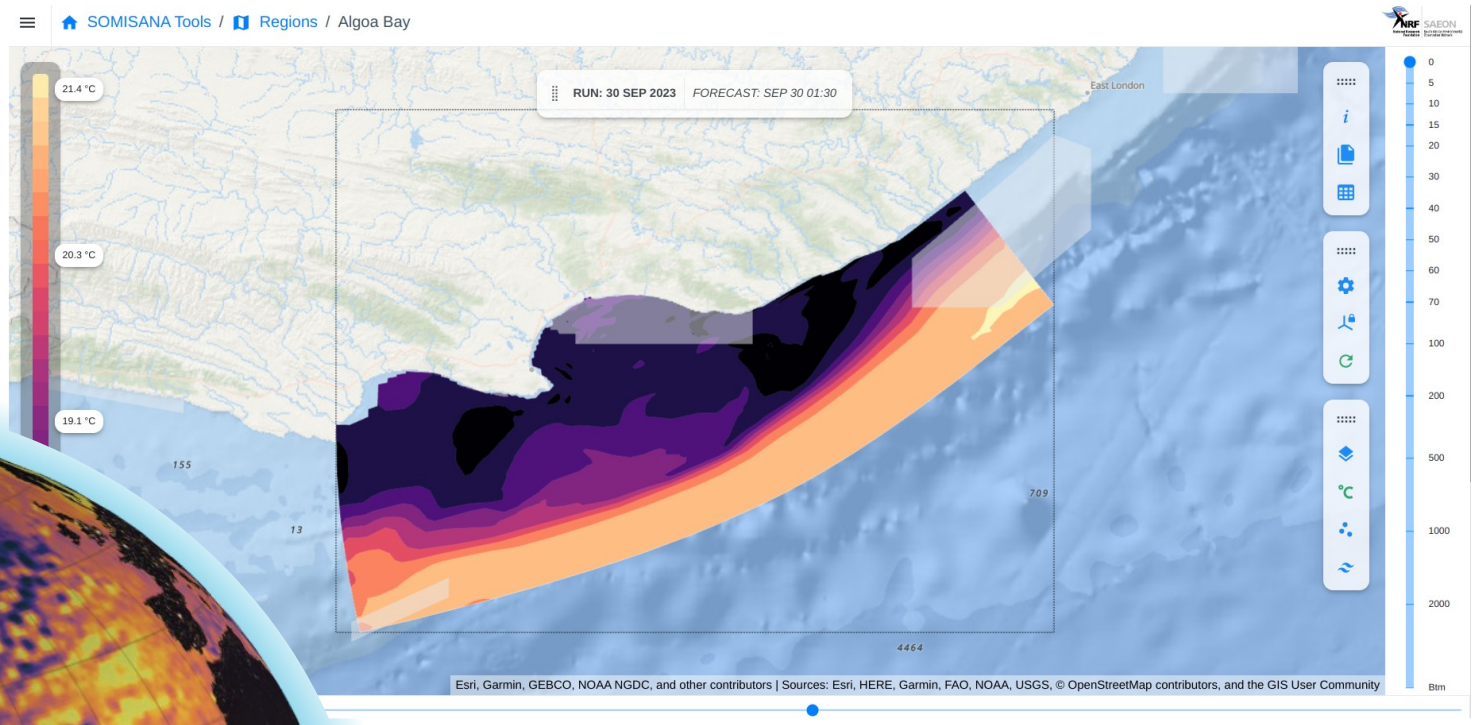
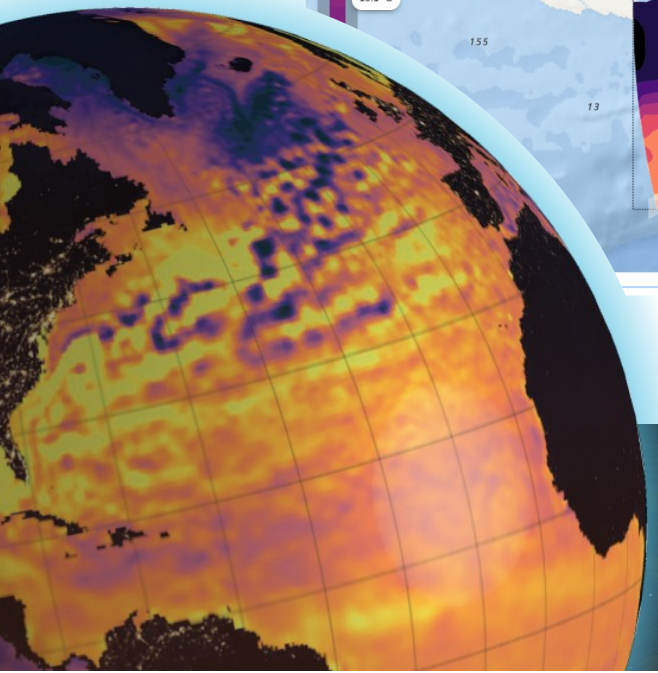
Visualization Portal, second iteration



Portal allows users to:

- ✦ zoom in and out

https://explore.somisana.ac.za/



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South Africa's forecast system and services journey

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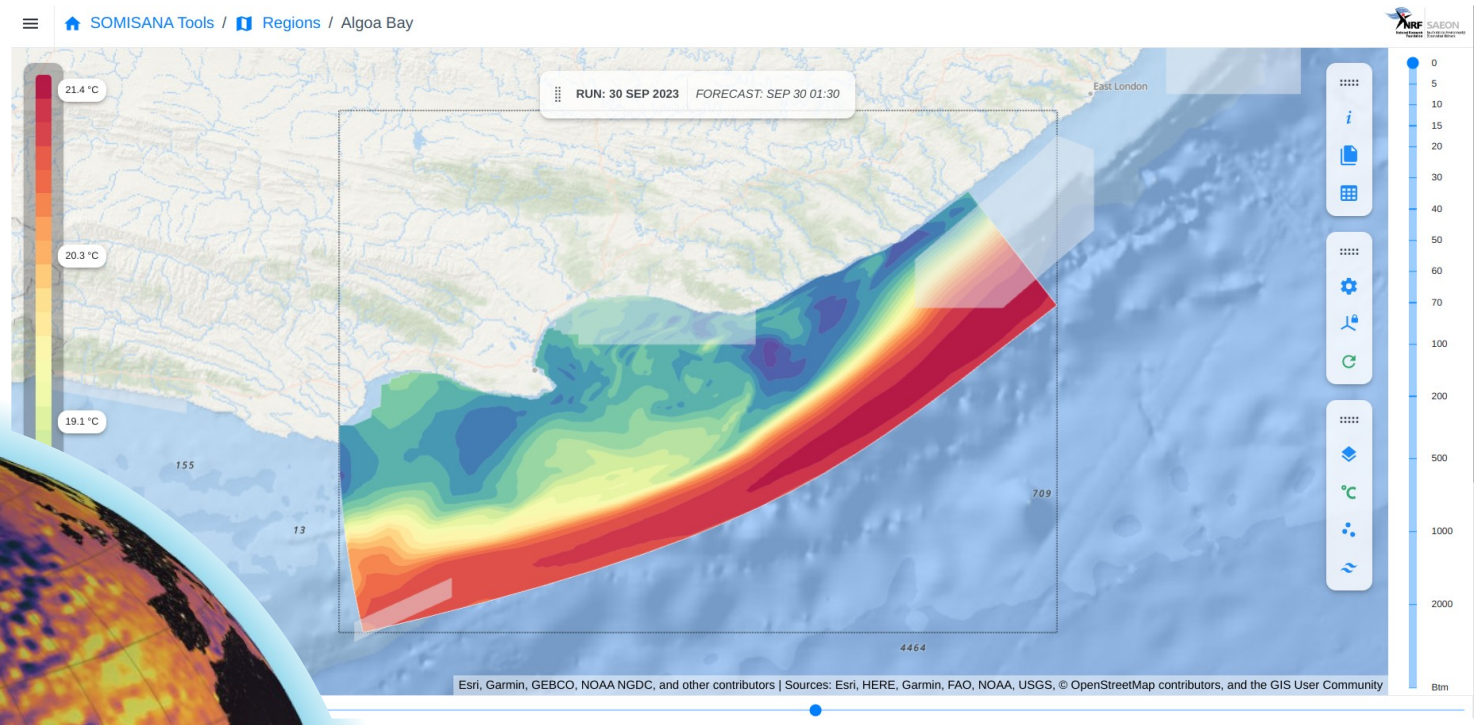
Visualization Portal, second iteration



Portal allows users to:

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- ✦ configure their colormapping, scale and range

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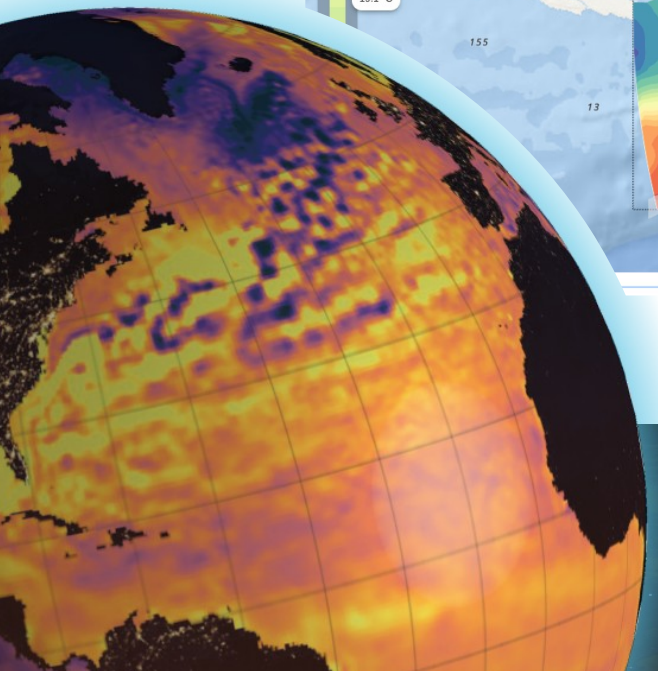

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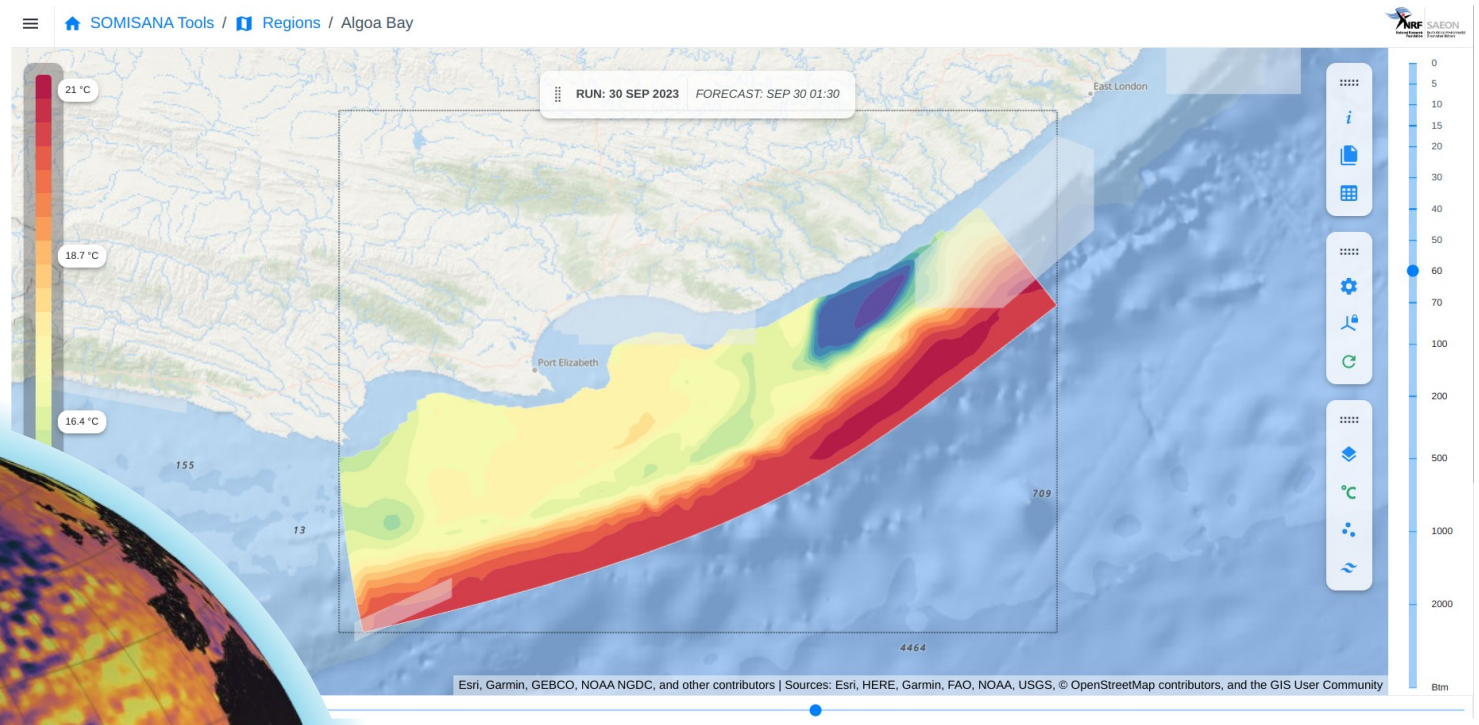
South Africa's forecast system and services journey

SOMISANA: Operational Forecast Systems

Visualization Portal, second iteration



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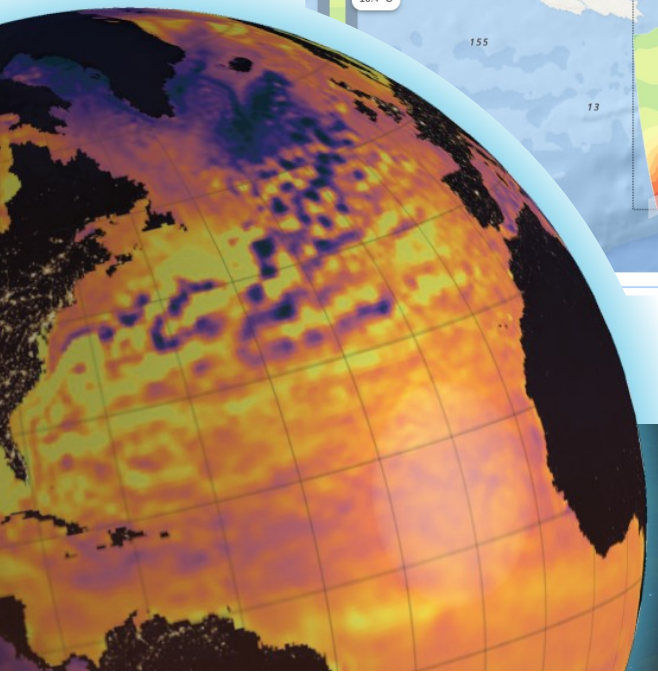
- ✦ configure their colormapping, scale and range
- ✦ select depth

https://explore.somisana.ac.za/



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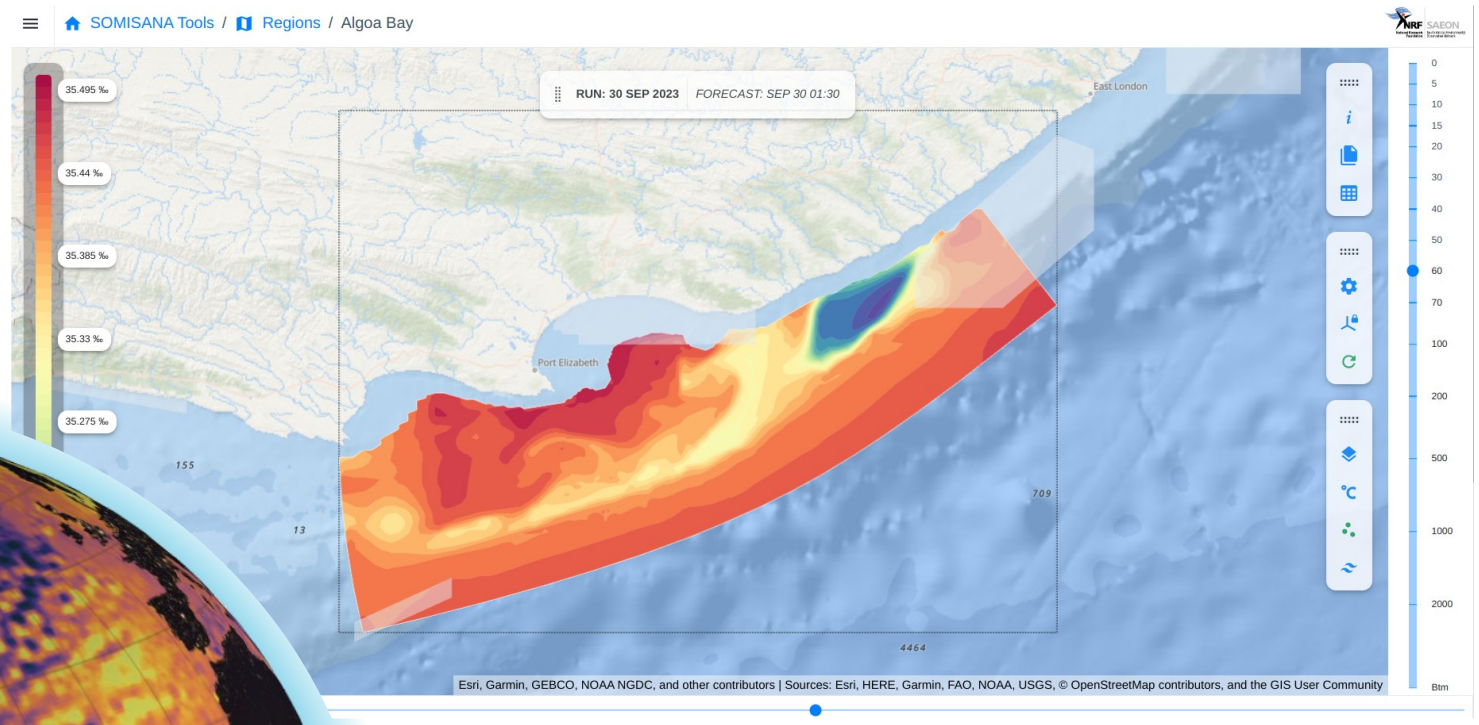
South Africa's forecast system and services journey

SOMISANA: Operational Forecast Systems

Visualization Portal, second iteration



Portal allows users to:

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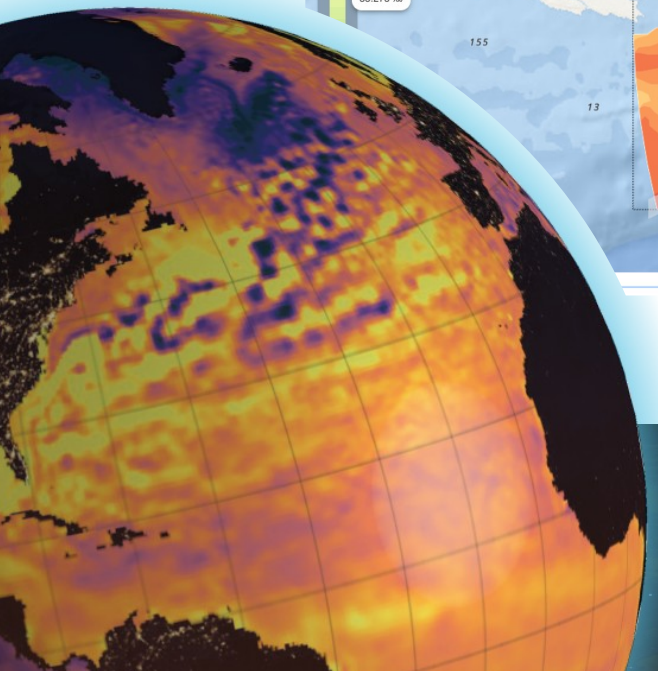
- ✦ configure their colormapping, scale and range
- ✦ select depth
- ✦ select variable

https://explore.somisana.ac.za/



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South Africa's forecast system and services journey

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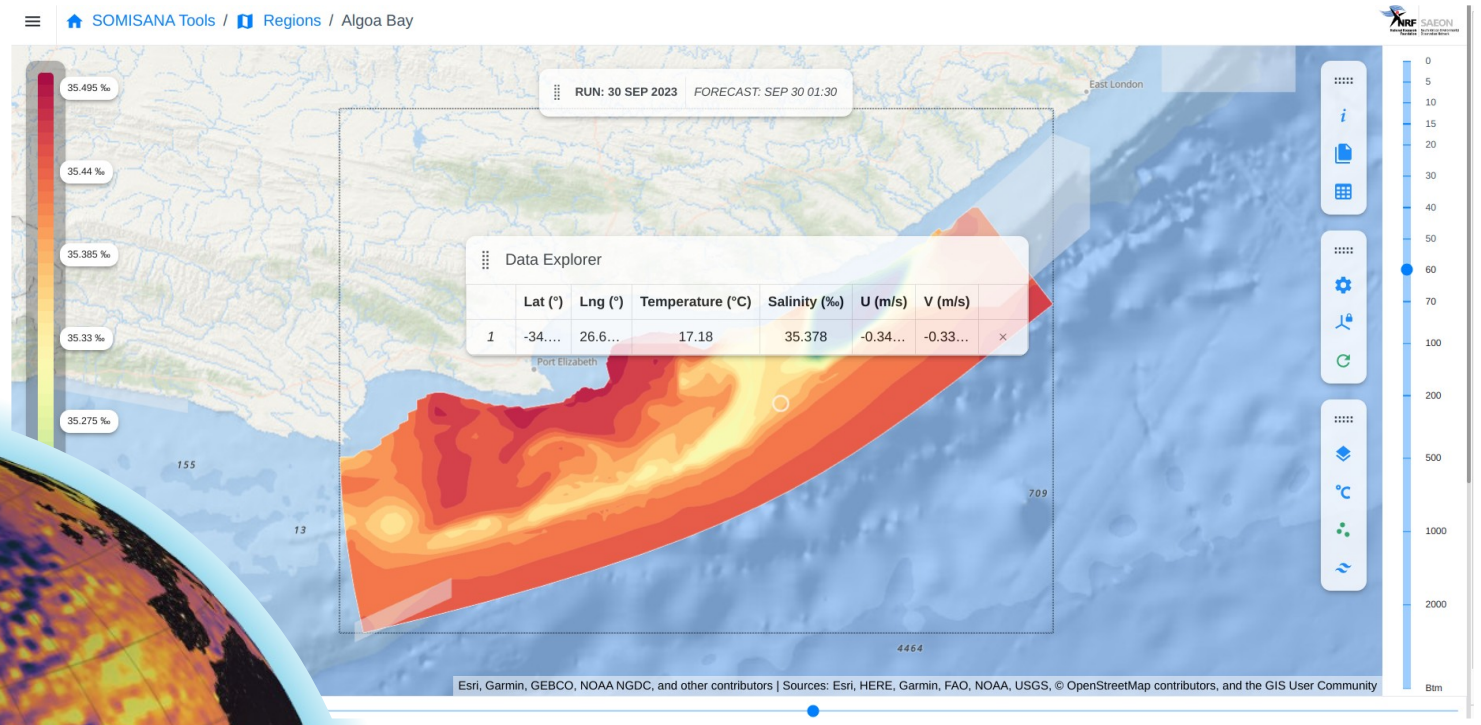

Portal allows users to:

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- ✦ select variable
- ✦ select a point to view data

https://explore.somisana.ac.za/

Success: A sophisticated web portal that operationally disseminates forecasts

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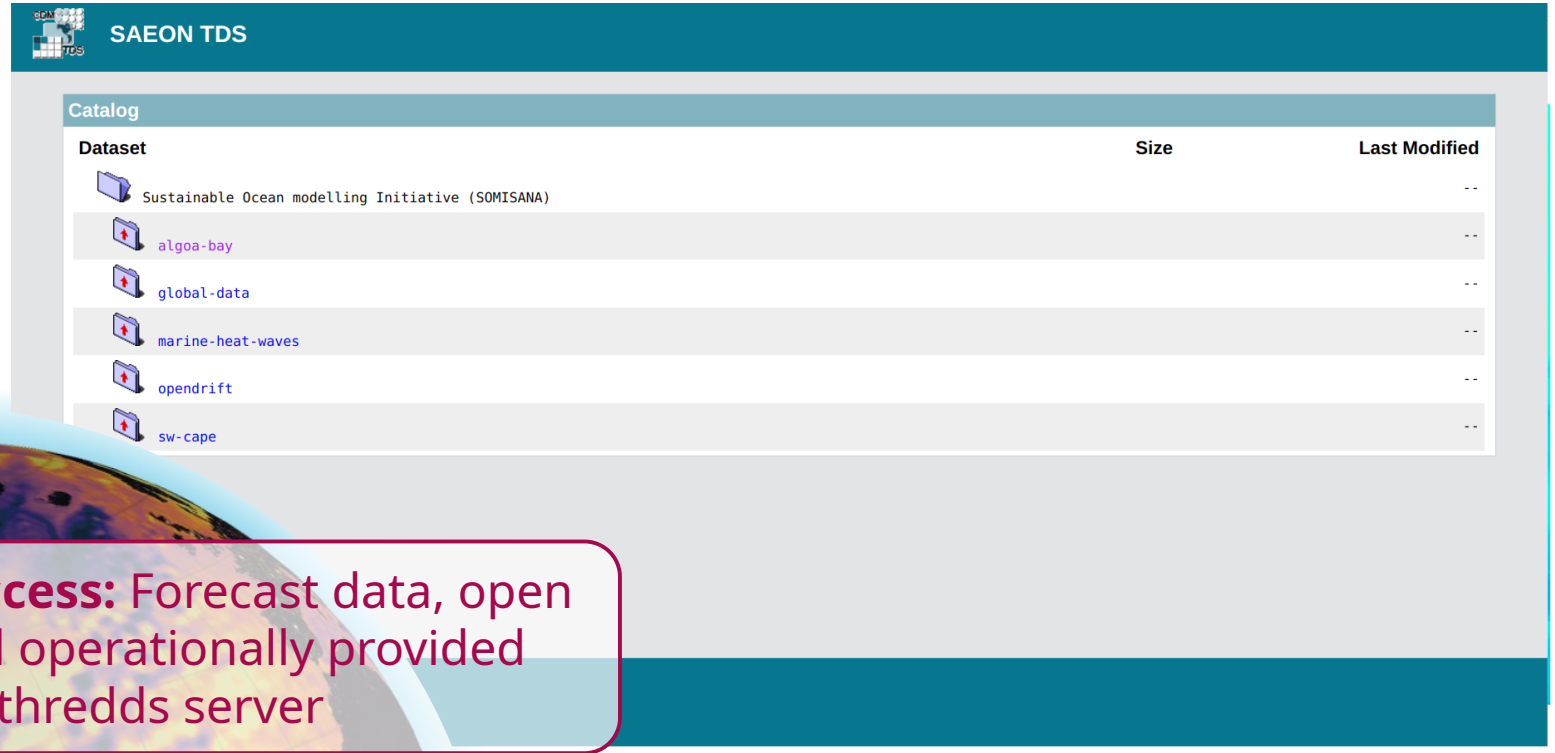
SOMISANA: Operational Forecast Systems

Data Access: thredds server



https://thredds.somisana.ac.za/

Portal allows users to:

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- ✦ select variable
- ✦ select a point to view data

Daily 5-day forecasts are freely provided on a thredds server

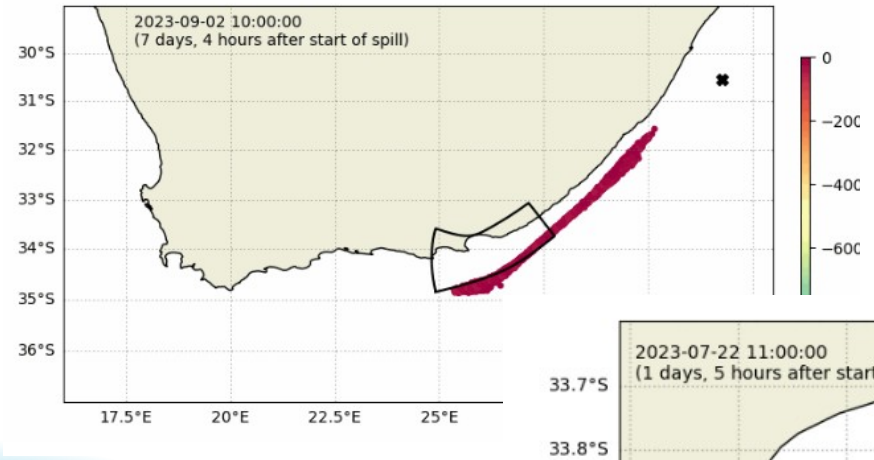
Success: Forecast data, open and operationally provided via thredds server

Success: A sophisticated web portal that operationally disseminates forecasts

South Africa's forecast system and services journey

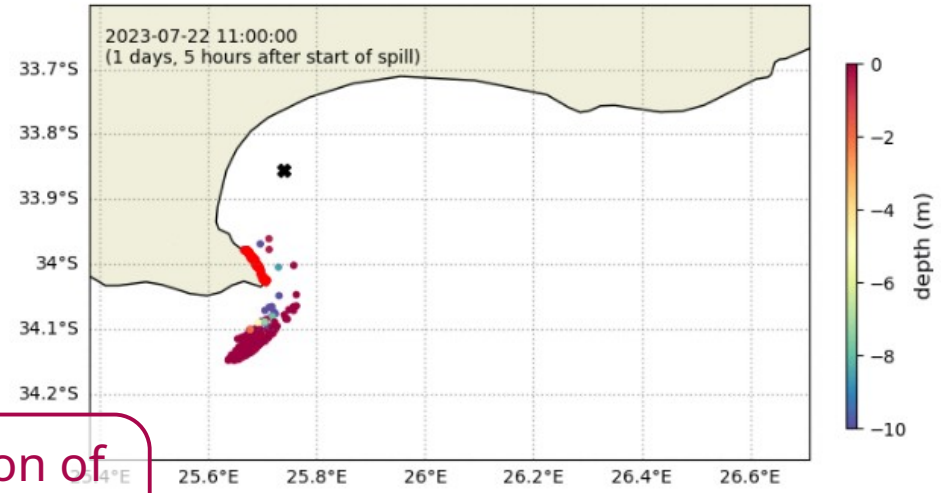
SOMISANA: Operational Forecast Systems

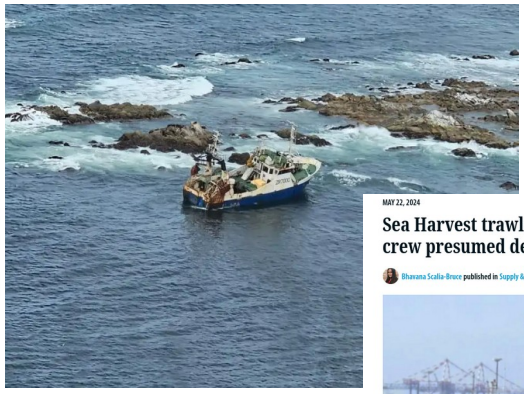
Added value product

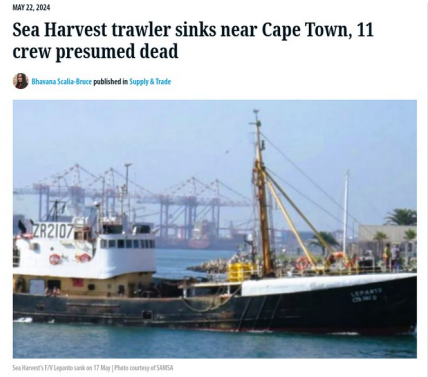


- We are able to model a forecast spill/drift trajectory and make the data available via a file server, but with no user interface.

- Seamlessly integrates with global forecasts







Success: Transformation of forecast information into actionable intelligence

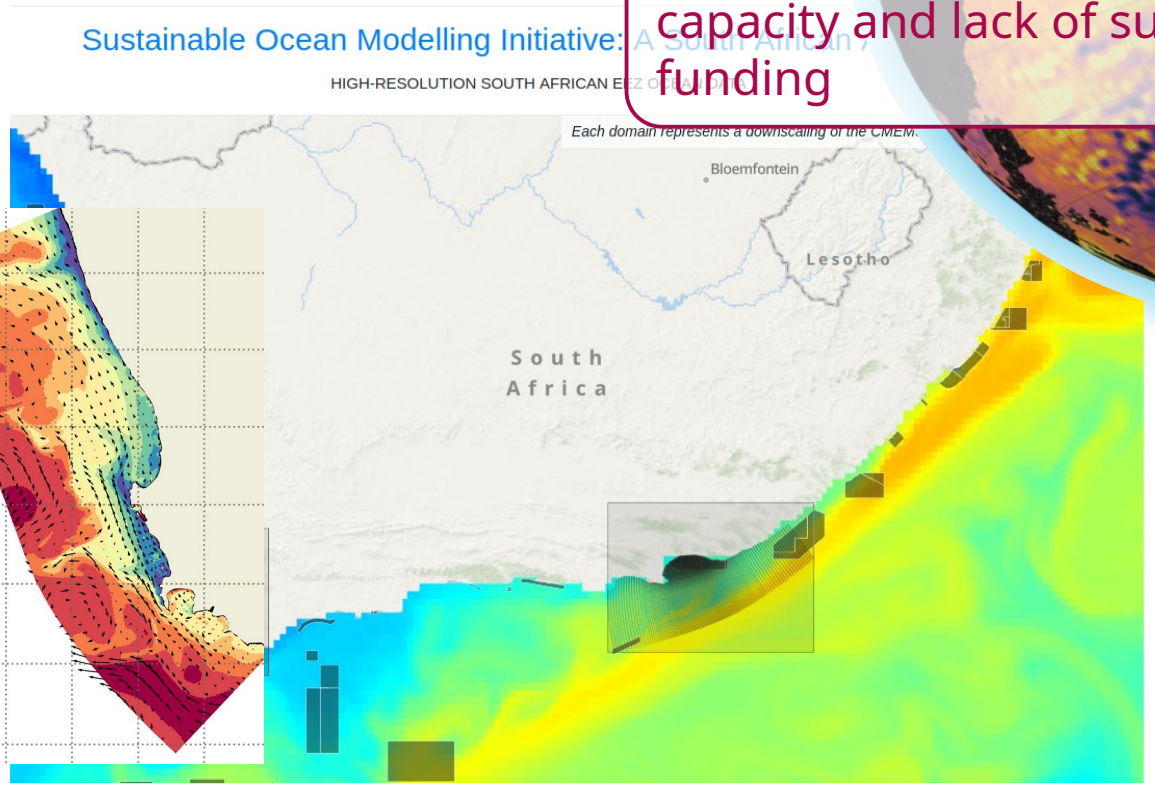
South Africa's forecast system and services journey

SOMISANA: Operational Forecast Systems

System Improvements

Threat: sub-critical human capacity and lack of sustained funding

- An operational South African west coast grid
- Implementation of high resolution atmospheric forecasts courtesy of the South African Weather Service
- Not currently integrated into the visualization portal
- **COMING SOON:** forecast skill assessments
- **COMING LATER:** various system improvements incl. data assimilation



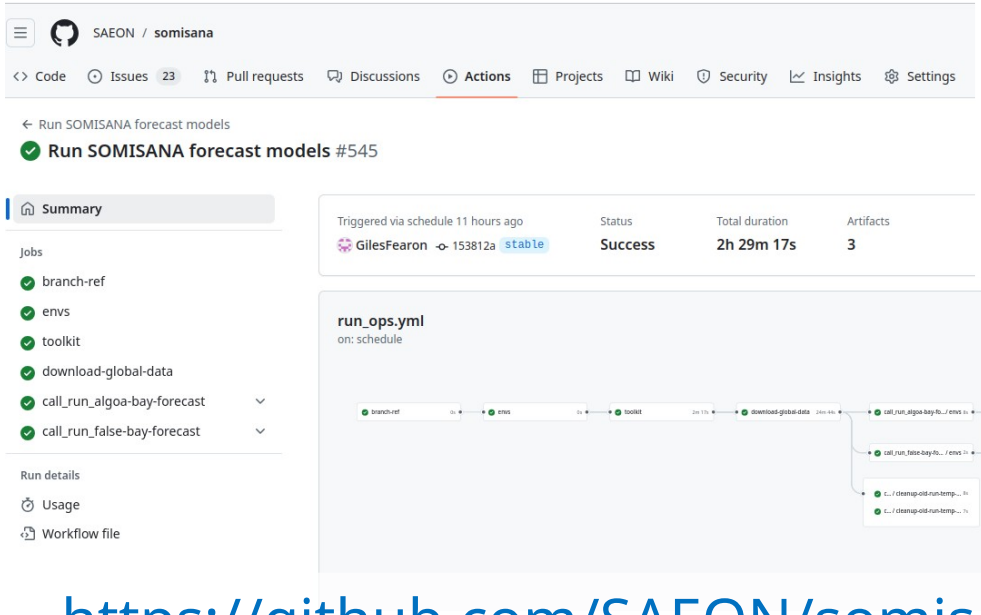
South Africa's forecast system and services journey

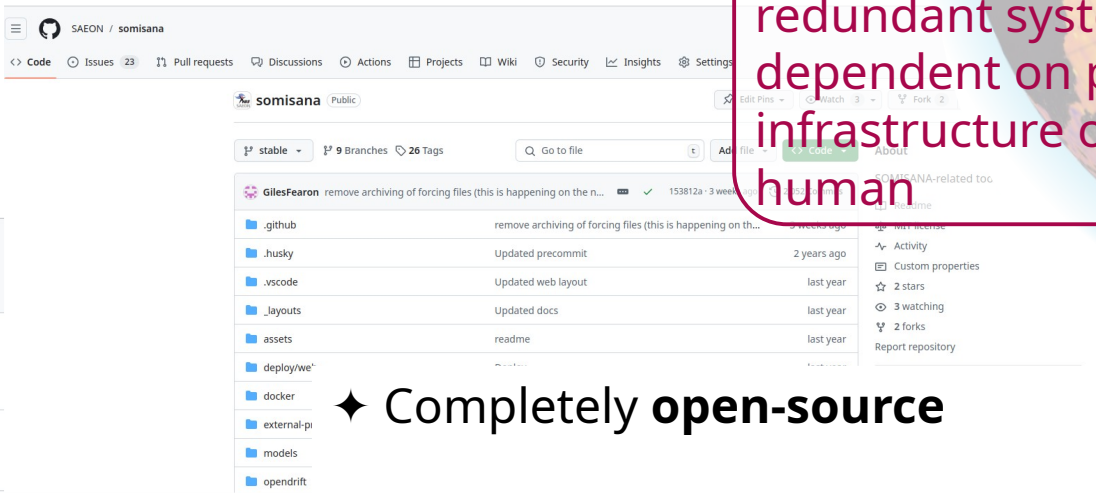
SOMISANA: Operational Forecast Systems

Safeguarding our system

Strategy: developing a fully redundant system that is not dependent on particular infrastructure or a particular human

⚠ Risk: Human Capacity





https://github.com/SAEON/somisana

- ✦ Completely **open-source**
- ✦ **Publishing** our full forecast **system workflow** on a gitrepo with **complete documentation**.
- ✦ System is fully **dockerized**
- ✦ Ongoing upskilling / **skills transfer**

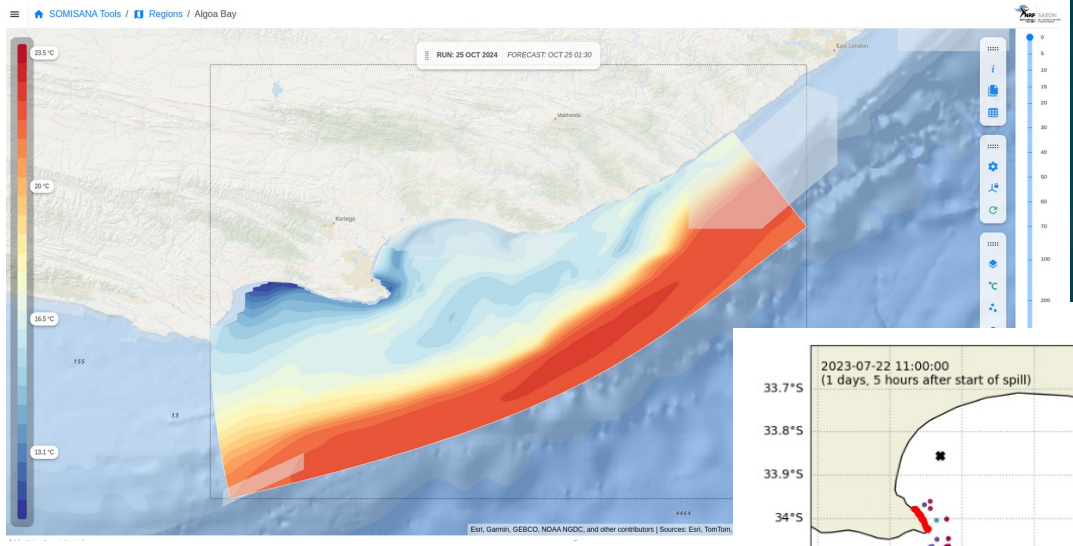
South Africa's forecast system and services journey

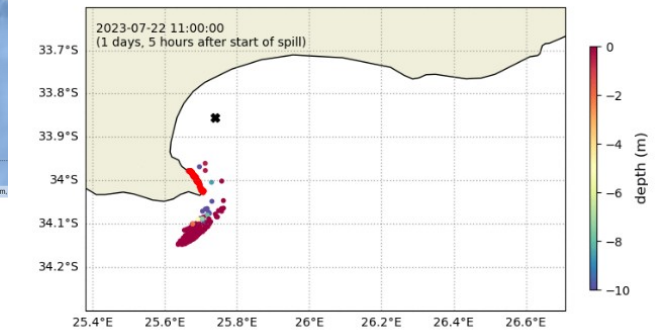
SOMISANA: Operational Forecast Systems

Safeguarding our system

⚠ Risk: Sustained Funding

Strategy: develop a system whose value far exceeds the cost of producing it.





To produce a system that provides services that are:

✦ Visible ✦ Robust ✦ Useful ✦ Trusted

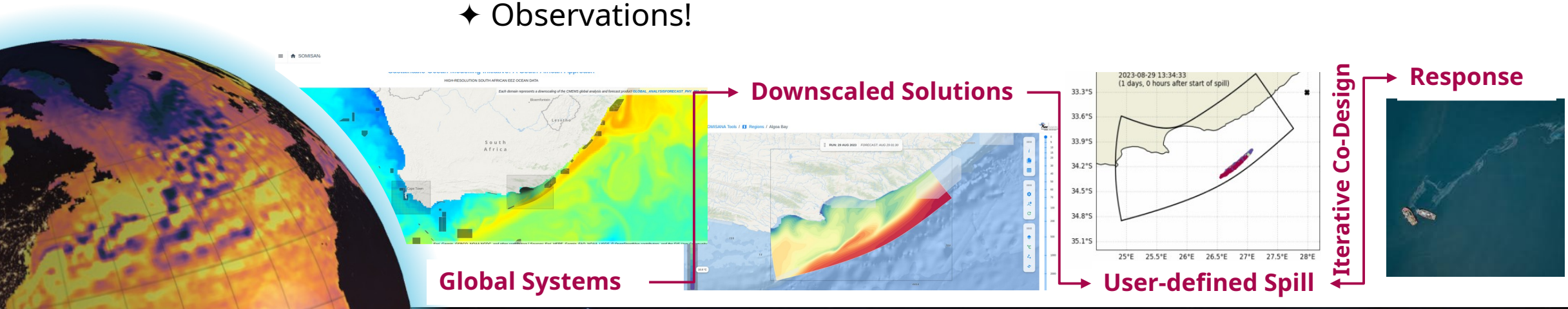
South Africa's forecast system and services journey

Moral of the story

Though **simple**, South Africa's forecast system **produces useful and actionable information**

It's success (now and in the future) depends on:

- ✦ High level support and funding
- ✦ Local, regional and international partners and collaborators
- ✦ Documented standards and best practices
- ✦ Open access and reliable global systems
- ✦ Stakeholder engagement and co-design
- ✦ Observations!



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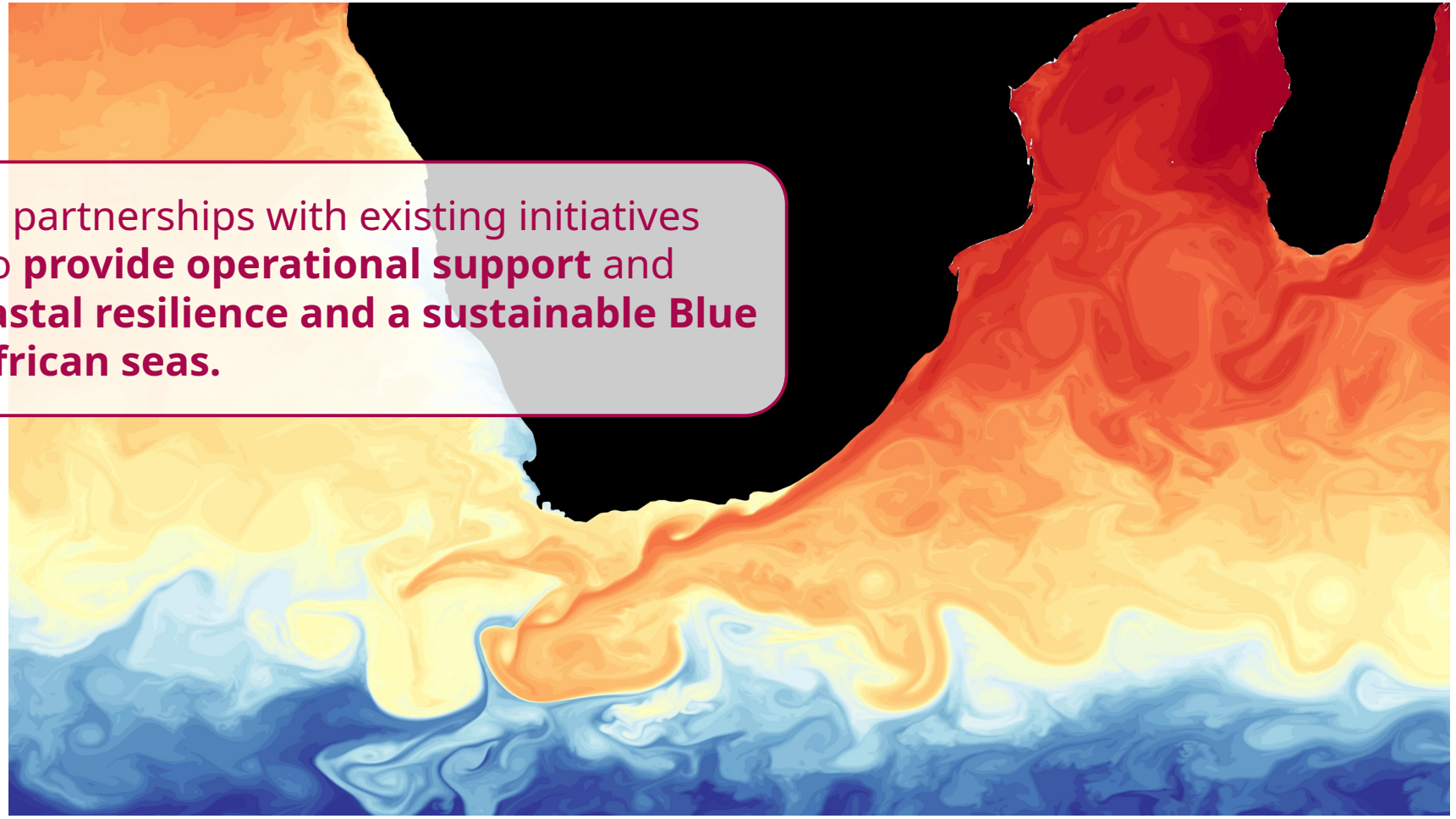
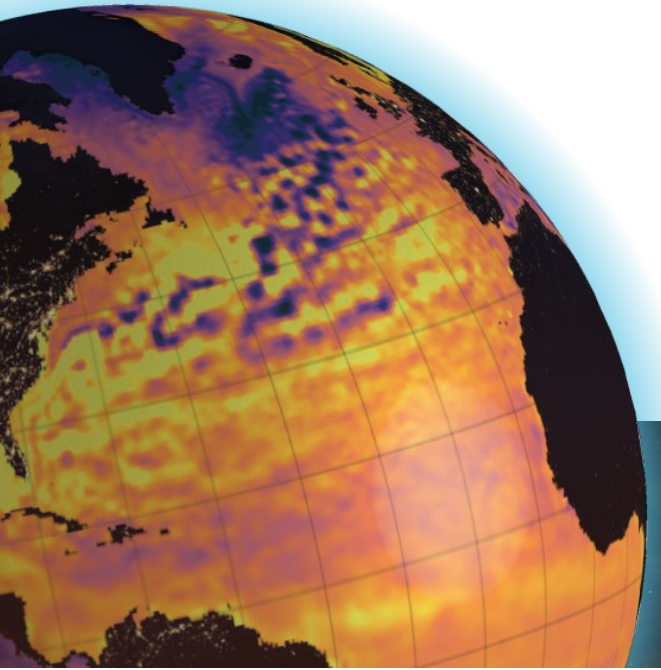
South Africa's forecast system and services journey

Way Forward



To **build connections** and partnerships with existing initiatives that **collectively** set out to **provide operational support** and actionable insights for **coastal resilience and a sustainable Blue Economy for southern African seas.**



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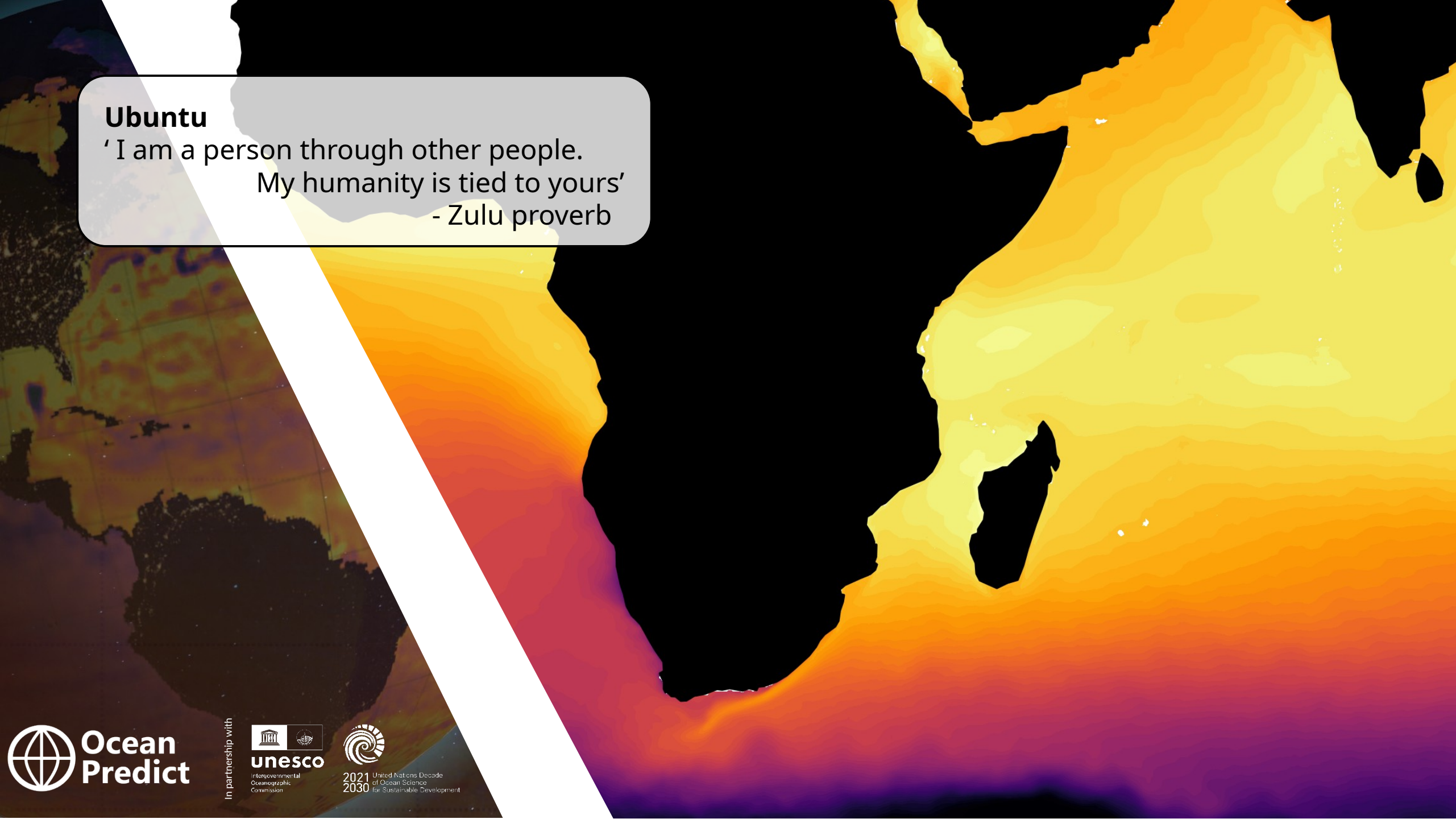

Ubuntu

‘ I am a person through other people.
My humanity is tied to yours’
- Zulu proverb

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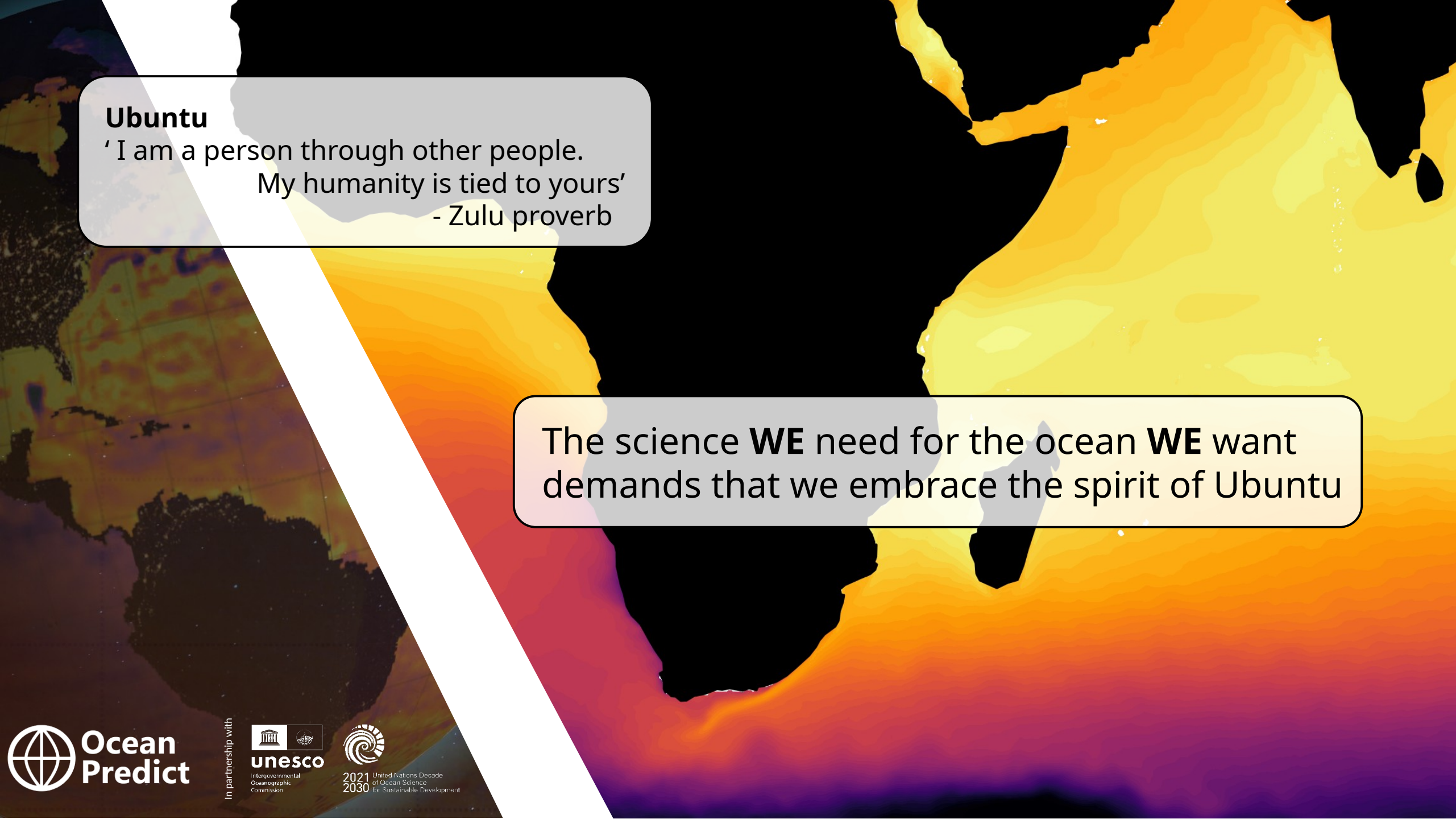

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The science **WE** need for the ocean **WE** want demands that we embrace the spirit of Ubuntu

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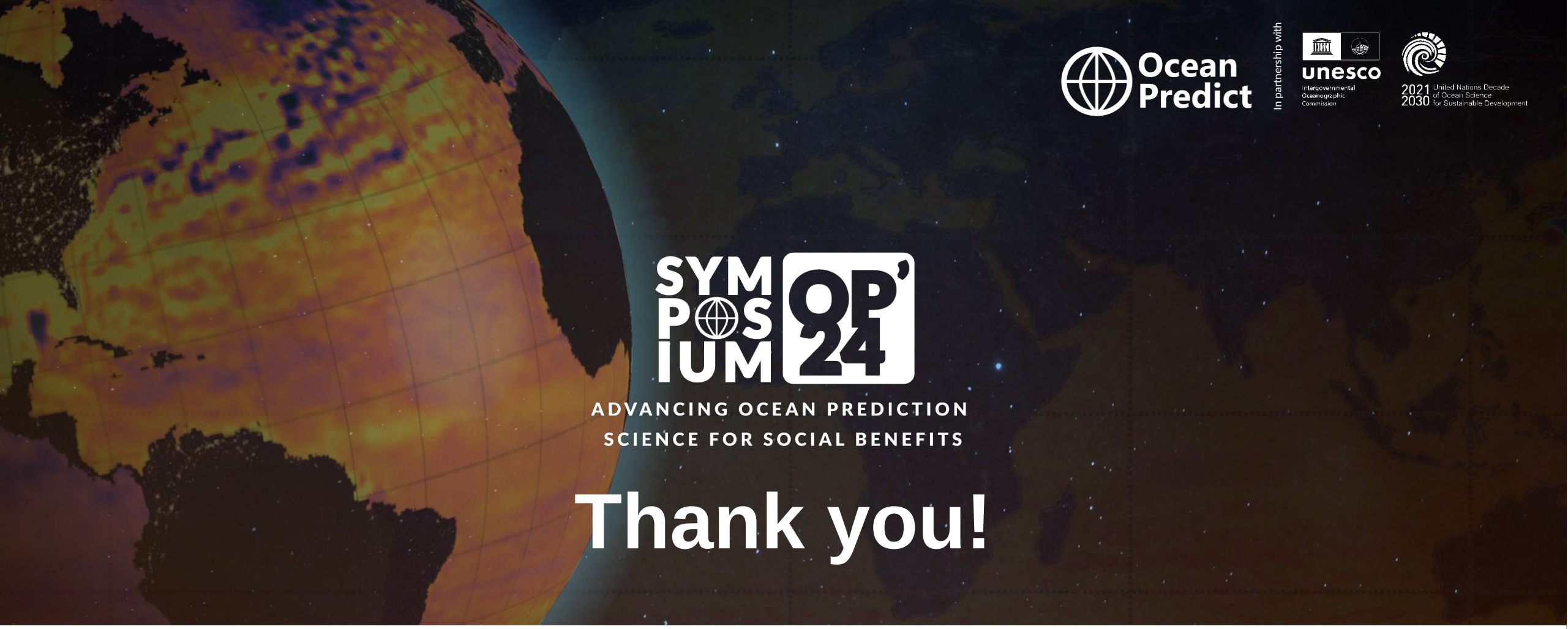

European Commission

Copernicus Marine Service

EU4oceanobs
INTERNATIONAL OCEAN GOVERNANCE
EU COMPONENT TO GLOBAL OCEAN OBSERVATIONS

MERCATOR OCEAN INTERNATIONAL

esa

Australian Government
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CENTRE NATIONAL D'ÉTUDES SPATIALES

Met Office

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Canada