INDIAN OCEAN RIM ASSOCIATION

The Status of Ocean Modeling in IORA

Information Brief

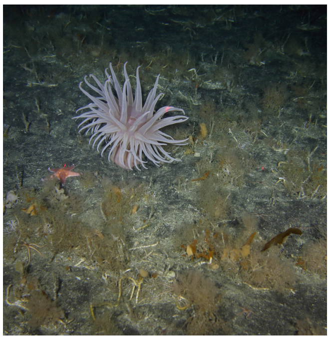
science & innovation
Department:
Science and Innovation
REPUBLIC OF SOUTH AFRICA

NRF National Research Foundation | SAEON South African Environmental Observation Network

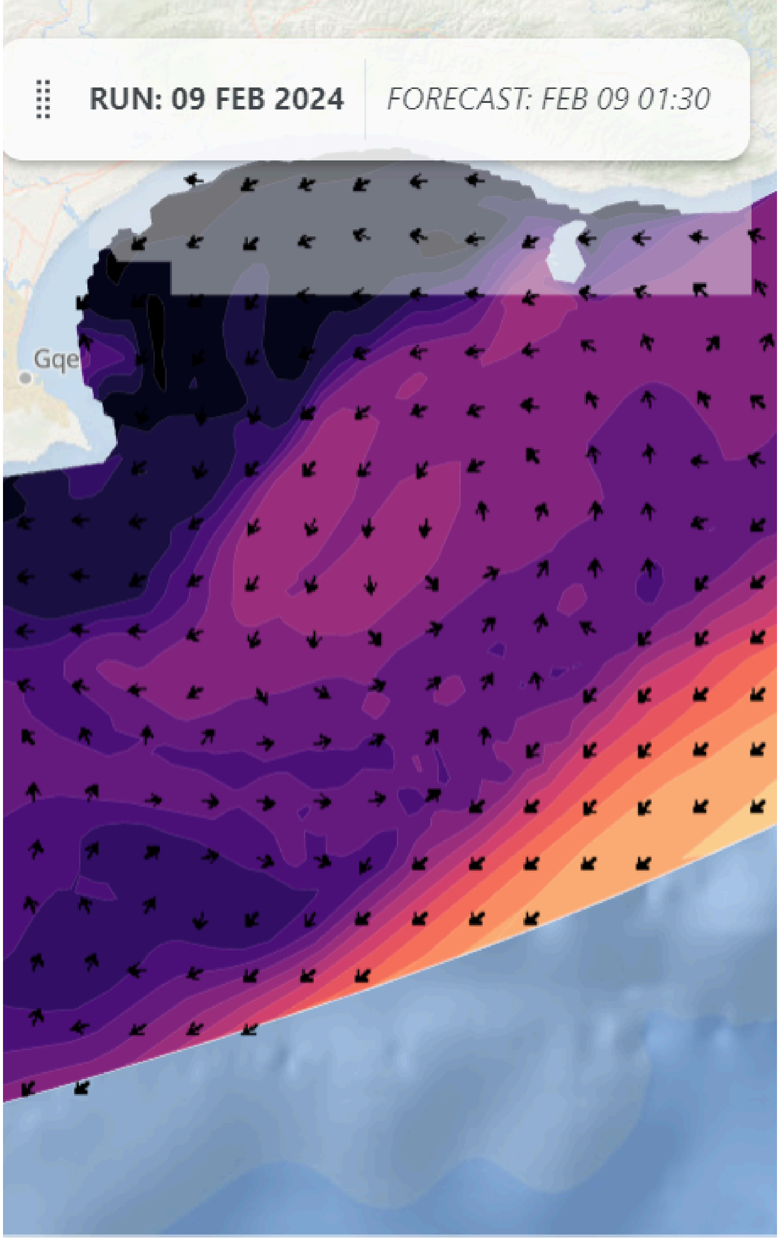
EXECUTIVE SUMMARY

The Indian Ocean Rim Association (IORA) recognises the critical role of the ocean in shaping climate patterns and impacting maritime safety within its member states. As the effects of climate change become increasingly pronounced, the development and utilisation of local-scale ocean models have emerged as essential tools for understanding and mitigating these challenges.

This report provides an overview of the current status of ocean modeling capabilities within the IORA Member States. It emphasises the significance of developing local-scale ocean models to effectively address the challenges posed by climate change and improving maritime safety.



INTRODUCTION



NUMERICAL MODELING PLAYS A CRUCIAL ROLE IN UNDERSTANDING AND PREDICTING THE COMPLEX DYNAMICS OF THE OCEAN AS IT PROVIDES INFORMATION, THROUGHOUT THE WATER COLUMN, THAT IS BOTH TEMPORALLY AND SPATIALLY COHERENT. IT IS A POWERFUL TOOL IN UNDERSTANDING VARIABILITY IN AND LINKAGES BETWEEN VARIOUS ASPECTS OF THE MARINE ENVIRONMENT, INCLUDING CURRENTS, TEMPERATURE, SALINITY, NUTRIENT DISTRIBUTION AND ECOSYSTEM INTERACTIONS.

Ocean modeling, also known as ocean simulation, refers to the development of computer-based simulations that replicate the behaviour and characteristics of the Earth's ocean. Ocean models are created using mathematical equations and computational methods to mimic the complex dynamics of the ocean systems to predict various aspects of ocean dynamics, including ocean circulation patterns, temperature, salinity, sea-level rise, nutrient distribution, and the movement of marine species. Ocean models provide a more detailed representation of oceanic properties with a focus on physical, chemical and biological processes.

The Indian Ocean is a vital body of water that connects Asia, Oceania, and Africa to the rest of the world. It is warming faster than any of the global oceans and its climate is uniquely driven by the presence of landmasses at low latitudes, which causes monsoonal winds and reversing currents. The Indian Ocean Region (IOR) hosts a diverse range of coastal and marine ecosystems. The well-being and economic prosperity of the communities along its coasts heavily depend on the health and resources of the Indian Ocean. The Indian Ocean is vital to global energy flows and, therefore, has a large potential role in the supply side of global energy security. However, the IOR faces vulnerabilities such as resource overuse, ocean acidification, and the adverse effects of climate change.

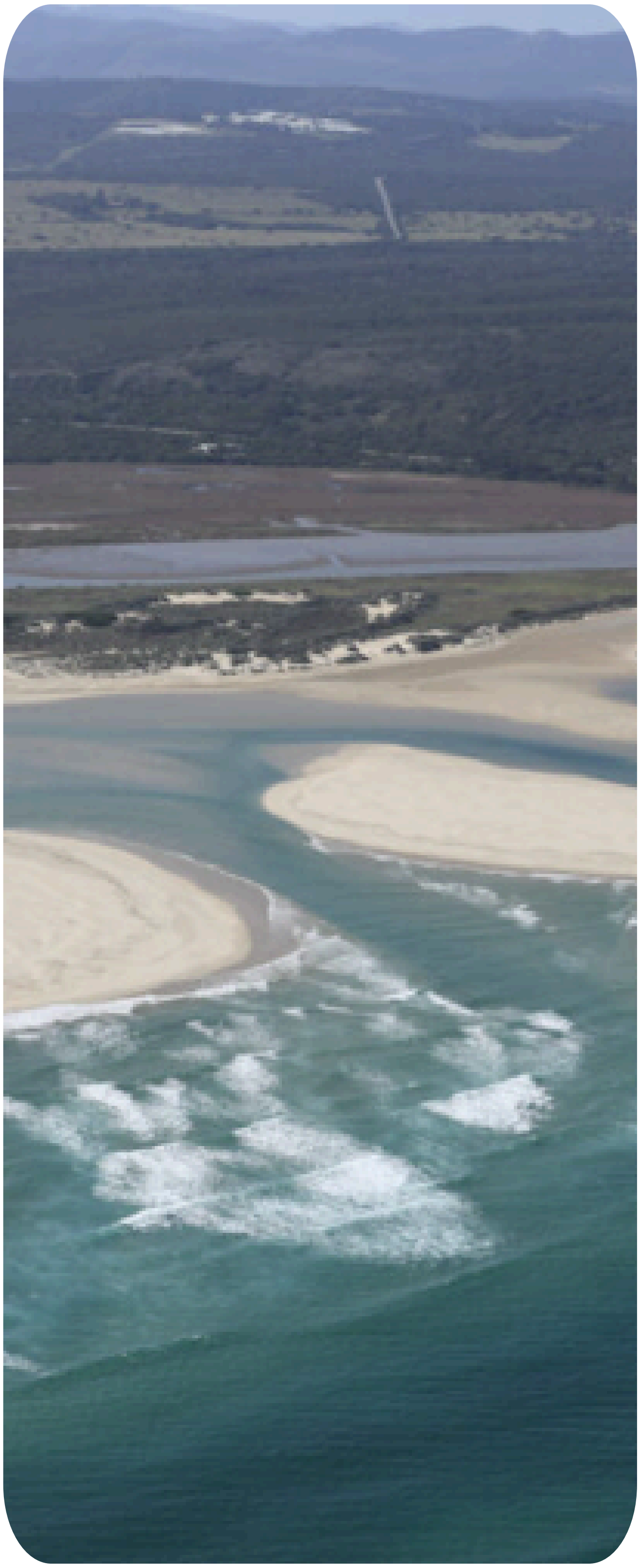
PURPOSE OF THE REPORT

This report offers an overview of the current status of *ocean modeling within the member states of IORA, highlighting the importance of creating local-scale ocean models to effectively tackle climate change and ensure maritime safety. It aims to support policymakers with evidence for the need to enhance ocean monitoring and forecasting collaborations as a priority within IORA.

The main objective of the report is to raise awareness among policymakers, stakeholders, researchers, and government officials within IORA regarding the significance of local-scale ocean models. It provides examples of operational oceanographic activities and resources in the region to support IORA member states.

A public web platform (under ongoing development) showcasing the region's ocean modeling activities has been developed to encourage dialogue and collaboration. This will provide information on various models used in the region and contact details of institutions engaged in ocean modeling, to encourage collaboration among ocean modelers in the Indian Ocean region.

Information was collected through an online survey circulated to Member States through the IORA Secretariat, and an online web search. For the Member States summaries only information that was readily available online are listed. Any omissions are unintended, and every effort was made to source accurate information.



*For the purpose of this report, the focus will only be on physical oceanographic models.

WHY ARE OCEAN MODELS IMPORTANT?

Local-scale ocean models offer greater detail than regional or basin-scale models by taking into consideration region-specific topography, coastal dynamics, and localised atmospheric variables. This accuracy is critical for precisely modeling and forecasting occurrences like monsoons, upwelling, and storm surges, all of which have significant consequences for climate resilience and maritime safety. Their accuracy and ability to account for local conditions make them vital instruments for protecting coastal populations and promoting sustainable resource management.

Local-scale ocean models can provide invaluable insight in addressing maritime safety and security challenges taking place in the Indian Ocean. They provide region-specific insights by mimicking local maritime conditions, assisting in a variety of duties ranging from tracking oils spills, predicting conditions for the development of harmful algal blooms, and identifying potential fishing zones, to optimising search and rescue operations. Ocean models are, therefore, an important component for the development of Blue economies, with support for various industry requirements, e.g., aquaculture, oil and gas, offshore renewable energy, shipping, etc.

Marine connectivity and ocean resources play a pivotal role in the socio-economic development and environmental sustainability of the member states within IORA. These countries rely substantially on maritime connectivity for international trade, utilising ports and shipping routes to create economic growth and stability. The vast ocean biodiversity comprises diverse marine ecosystems and species, which play a significant role in supporting food security. The rich variety of marine life not only ensures a stable food supply through fisheries but also acts as a reservoir for scientific research and innovation. In essence, the significance of marine connectivity and ocean biodiversity in IORA member states encompasses economic stability, cultural heritage, scientific advancement, and environmental resilience, underlining their pivotal role in the region's sustainable development.

PAST EFFORTS IN DEVELOPMENT OF OCEAN MODELING NETWORKS IN IORA

In May 2013, Australia hosted the meeting "Indian Ocean Rim Association for Regional Cooperation (IOR-ARC)
Meeting of Ocean forecasting officials to build capacity to progress, validate and apply Indian Ocean Forecasting Systems'. Member State participants included Australia, Bangladesh, India, Indonesia, Iran, Kenya, Madagascar, Malaysia, Mauritius, Oman, South Africa, Sri Lanka, Thailand, and one Dialogue Partner, the United Kingdom. The aim of the meeting was to conduct national needs and gap analyses with a view to develop a regional statement, identify priority actions (including including low, medium, and high cost activities), and identifying potential national and international funding agencies which could support activities.

The outcomes of the meeting included the 'Meeting Communique and Resolutions', and recognition of the need to strengthen ocean monitoring and forecasting capabilities in the 13th Meeting of the Council of Ministers of the Indian Ocean Rim Association Perth Communiqué.

"More can also be done in IORA to foster collaboration and build capacity in areas of oceanic research. We endorse work undertaken in IORA to strengthen ocean monitoring and forecasting and seasonal climate forecasting capacities and knowledge of climate change adaptation practices."

- Perth Communique, 1 November 2013

In December 2013, Mauritius circulated a concept note 'Towards an Enhanced Ocean Observatory and forecasting System for the development of the Ocean Economy'. The concept note proposed the development of an 'Ocean Observatory', to foster partnerships between stakeholders from government, private sector and academia, and boost ocean-related science and technology, whilst facilitating the process between research and development and commercialisation.

The specific objectives of the proposal were as follows:

• To raise awareness on the immense potential of the ocean economy among the IOR-ARC Member States through knowledge sharing workshops and educational activities. This will encourage Member States to explore more options for their broader involvement in project implementation and enhance their respective national capacities;
• To support and interact fully with existing Ocean Observational network and applications (e.g., Indian Ocean Global Ocean Observation System (IOGOOS), IndOOS (Indian Global Ocean Observation System), (Indian Ocean Panel (IOP), Sustained Indian Ocean Biogeochemical and Ecological Research SIBER, Blue Link (Australia)).

• To provide an Inter-Governmental support mechanism to the regional initiatives for the enhancement of the network.
• To build the capacity of the communities and research institutions of the IOR-ARC Member States in the fields related to the development of the ocean economy, to ocean observation and forecasting.
• To support the establishment of a freely and accessible information system, including national databases on oceanic parameters as well as socio-economic indicators.
• To provide support for technology transfer in the field of ocean observation.

In November 2016, Sri Lanka hosted the 'Experts Group Meeting on Ocean Forecasting to Build Capacity for Indian Ocean Operational System'. While it was recognised that there were existing regional ocean models, there was a need for some member states in developing and operating their own sub-regional local scale models and operational ocean forecasts for local scale phenomenon such as storm surges and unfavourable wave conditions to secure the safety of fishermen, other ocean users, and infrastructure.
The aim of the meeting was to share information on available technology and knowledge, discuss the required human resources that could be developed through training and workshops, and compare the different sub regional ocean forecasting models generated by the different member states, with the view to integrate them into an Indian Ocean Regional Modeling platform.

At the 11th Western Indian Ocean Marine Science Association Symposium, held in Mauritius in 2019, academics from South Africa and Mauritius convened a special session on 'Identifying the potential for multi-disciplinary and multi-institutional collaborations in ocean modeling initiatives in the Southwest Indian Ocean (SWIO) region'. The aim of the session was to forge multi-disciplinary and mulit-institutional collaborations as well as to identify ways in which models (existing and future) could be used to augment research and operational observing systems in the SWIO region. The session also intended to provide a platform for early career scientists, both numerical modelers and users of model output, to interact and to identify ways of promoting a SWIO 'hub' of modeling excellence.
While the meeting report indicated that there were too many matters to discuss to be able to move forward with potential solutions in any real way, its big success was the connections that were made.

These activities, and others, emphasise the continued need for development of an IORA Ocean Modeling (or 'Ocean Observatory') platform.

Indian Ocean Rim Association for Regional Cooperation (IOR-ARC)
Ocean Forecasting Workshop to Build Capacity to Progress, Validate and Apply Indian Ocean Forecasting Systems
27-31 May 2013, Perth, Australia

Supported by the Commonwealth Scientific and Industrial Research Organisation in co-partnership with the Australian Bureau of Meteorology, the Perth Programme Office of the Intergovernmental Oceanographic Commission of UNESCO and the Government of India. Further assisted by the South African Weather Services, the Indian National Centre for Ocean Information Services, the Bay of Bengal Large Marine Ecosystems Project and the Indian Ocean Global Ocean Observing System Regional Alliance.

Meeting Communiqué and Resolutions

Marine ocean and climate science representatives from IOR-ARC member countries met in Perth, Australia to examine the status of ocean observations, modeling and associated forecasting of the ocean's behaviour (i.e. understanding and forecasting the three-dimensional 'underwater' weather, i.e. from the ocean floor to the surface waves and from the open ocean to the shelf/coastal zone). This meeting highlighted the disparate ability of Indian Ocean Rim countries to monitor, analyse and predict marine environmental conditions in the Indian Ocean, but also highlighted their unified desire to focus and facilitate an international cooperative effort in the sustainable management of our oceans and increased safety at sea, through the framework and under the umbrella of IOR-ARC.

Significant progress has been made in the fields of ocean observations and forecasting which provide sophisticated and detailed information on all the world's oceans that are relevant at global and regional scales. This information addresses a wide-range of societal, economic and environmental needs such as those relating to: food security; natural resource exploitation and management; biodiversity conservation; maritime and coastal safety and transport; risk management for hazard mitigation and toxic spill response; energy security and associated maritime industry support; national security; climate change and coupled ocean-climate science and applications. The benefits of global oceanographic research and knowledge are increasingly transferable through ocean-climate applications and capacity building activities.

To date the Indian Ocean community has experienced many challenges in developing its capacity in ocean forecasting systems and management. There have been multiple interactions at local and regional scales, however progress is most evident within countries with the economic capacity for strategic national investments, thereby creating a wide disparity amongst the IOR-ARC member countries. Even within the leading countries further investments are essential to broaden and strengthen understanding and to keep up with continuously evolving world's best practice.

The representatives of IOR-ARC member countries present at the Perth workshop voiced a critical and immediate need to raise capacity within the Indian Ocean oceanographic community so that available oceanographic information, tools, knowledge and capacities can be fully realised and utilised and thereby provide the societal, economic and environmental benefits. In addition, there is a tremendous opportunity to leverage previous, current and prospective efforts to build capacity in the region to enhance and extend this information and to incorporate local expertise and local observations.

On this basis, the IOR-ARC constituency of ocean research, applied practitioners, manager and users, proposed to accelerate and sustain capacity development in order to harness what is available now and in the imminent future for the delivery of the benefits across a range of high-priority community issues.

To facilitate this effort, IOR-ARC member countries and their associated leaders, as well as relevant regional and sub-regional intergovernmental and scientific organisations are requested to:

• note the increased marine and related climatic impacts over the past decade of the Indian Ocean on the IOR-ARC communities and the real need for timely and accurate information, together with appropriate expert interpretation and efficient communication, to realise societal, economic and environmental benefits;

• endorse and support regional efforts in cooperation for developing sustained ocean observing and forecasting systems that would address high priority marine and related climatic societal imperatives for IOR-ARC constituent communities;

• support and facilitate (either directly through the provision of human and financial resources and/or via advocacy through related Ministerial levels) the development of a multi-year integrated Indian Ocean forecasting capacity building proposal for submission to major relevant regional and/or global funding organisations;

• support and facilitate the building of IOR-ARC capacity through harnessing global oceanographic expertise and the transfer thereof to regional practitioners, managers and users in the application of ocean tools for ocean prediction and associated applications;

• support and facilitate the free, open and timely collaborative sharing of information as a critical step towards achieving full capacity in ocean forecasting and management.

OPPORTUNITIES FOR OCEAN MODELING COLLABORATION

UNITED NATIONS OCEAN DECADE OCEANPREDICTION DECADE COLLABORATIVE CENTRE

The vision of the United Nations Ocean Decade OceanPrediction Decade Collaborative Centre (OP-DCC) is for a connected community who provide services from many robust forecast systems around the world that adhere to a common set of tools standards and best practices. It was established in response to the fact that while there are a number of core services worldwide, they are not sufficiently connected or interoperable and there does not exist a widely endorsed document that describes common tools and best practices for building, disseminating and validating new forecast systems. The OP-DCC has two types of collaboration structures: Regional Hubs and the OceanForecasting Co-Design team.

There are nine regional hubs that are loosely based on the UNEP regional seas classification and the Global Ocean Observing System (GOOS) regional alliances. The overarching objective of the Regional Hubs is to act as focal points of OP-DCC activities and to support their objectives which are to: contribute to the coordination and cooperation of various ocean forecasting-related Decade actions, collaborate in mapping the ocean forecasting landscape as well as to identify gaps and ways forward, design and organize regional events for capacity building and ocean literacy, advocate for the regional implementation of best practices, standards and tools and to promote the use of forecasting systems for decision-making purposes.

Three regional hubs are established to support the Indian Ocean: West Pacific & Marginal Seas of South and East Asia, Indian Seas and African Seas.

The other collaboration structure of the OP-DCC is the OceanForecasting Co-Design team, which is formed by experts on different topics of the ocean forecasting value chain and who are focused on alignment for co-design. They are doing this by mapping the global landscape of ocean forecasting, identifying the relevant building blocks and designing an optimal ocean forecasting architecture that integrates digital twinning concepts.

MEMBER STATE SUMMARY

Australia

The Bureau of Meteorology, which is Australia's national weather, climate and water agency, offers services to assist Australians in dealing with the harsh realities of their natural environment, including drought, floods, fires, storms, tsunami and tropical cyclones through regular forecasts, warnings, monitoring and advice spanning the Australian region and Antarctic territory.
The Commonwealth Scientific and Industrial Research Organisation (CSIRO) is an Australian Government agency responsible for scientific research, and offers research information on oceanography and climate in Australia.

Comoros

Comoros does not have a national ocean modeling centre. However, the Government of India provides the web-based Integrated Ocean Information and Forecast System for Comoros. This is an integrated high resolution ocean forecasting system for developed through the Indian National Centre for Ocean Information Services (INCOIS), Hyderabad and the Regional Integrated Multi-Hazard Early-warning Systems (RIMES), Thailand.

Bangladesh

The Bangladesh Meteorological Department offers an online platform which provided marine forecasts as well as information on climate and weather forecasts around Bangladesh.

India

The Indian National Centre for Ocean Information Services (INCOIS) offers ocean modeling information with data assimilation on past, present and future state of the ocean, it produces weather forecasts by using atmospheric models, to understand the ocean and marine environment.
The Digital Ocean platform offers information in ocean data management which includes a set of applications developed to organise and present heterogeneous oceanographic data by adopting rapid advancements in geospatial technology. It facilitates an online interactive web-based environment for data integration, 3D and 4D (3D inspace with time animation) data visualisation, data analysis to assess the evolution of oceanographic features, data fusion and multi-format download of disparate data from multiple sources viz., in-situ, remote sensing and model data, all of which is rendered on a georeferenced 3D Ocean.

Mauritius

The Mauritius Ocean Observatory E-Platform, offers comprehensive resources for ocean data and modeling information. It provides valuable insights into oceanographic research and modeling activities specific to Mauritius. It is a platform for geospatial data to support the Marine Spatial Planning initiative of the Republic of Mauritius, including ocean exploration and sustainable development.

Mozambique

The National Coastal Forecasting System for Mozambique (FEWS-INAM) was developed by National Meteorological institute (INAM) in collaboration with Deltares. This system downscales from the NOAA global service and provides information via a mobile app, text messages and daily bulletins.

The Government of India provides provides the Integrated Ocean and Information System for Mozambique, developed by the INCOIS project Hyderabad and Regional Integrated Multi-Hazard Early-warning Systems

France/Reunion

France has much modeling capability developed, and contributes to the European Union Copernicus Platform.
The University of Reunion has an ocean modeling programme which follows a 4-layered downscaling approach. Model data can be accessed on the University of Reunion's data catalogue which hosts various environmental datasets.

Seychelles

The Seychelles Meteorological Authority offers weather forecasts, warnings, recommendations of response and related information for the general public in a timely and usable manner, in order to ensure the safety of life and property.
Information is also provided by the Indian National Centre for Ocean Information Services (INCOIS) - Seychelles RIMES, which offers ocean-related information for Seychelles, including ocean modeling, forecasts, wind, wave, currents, and these forecasts are updated daily on an operational basis.

Singapore

Singapore National Environment Agency - Weather and Marine Surface Wind offers real-time weather updates and marine surface wind information. It's a valuable resource for individuals, businesses, and maritime operations, offering current weather conditions, wind speeds, and directions specifically tailored for maritime activities in Singapore.
Singapore National Environment Agency - Marine Shipping Bulletin offers marine shipping bulletins. These bulletins are essential for ships and vessels by providing crucial information about weather conditions, sea states, and potential hazards, ensuring the safety of maritime navigation in Singapore's waters.

South Africa

OCIMS (National Oceans and Coastal Information Management Systems) offers a data management platform, for researchers and scientists to use the system to access diverse oceanographic data. It facilitates research, analysis, and modeling efforts related to South African oceans. The platform also provides various decision support tools regarding the state of coastal environments, ecosystems, and related research and monitoring efforts in South Africa. The platform's purpose is to centralise and organise oceanographic data for scientific purposes.

SOMISANA (Sustainable Ocean modeling Initiative: A South African Approach), an initiative by the NRF-SAEON, aims to leverage global advancements in modeling by developing regional ocean models that run with higher resolution compared to global ocean models. Local capacity means models can be adapted to work better for the surrounding oceans, taking advantage of available observations for data assimilation and verification purposes.

The South African Weather Service (SAWS) uses the NOAA global service, as well as currents from the CMEMS forecasts to run
an operational regional and coastal wave and storm surge model. SAWS also disseminates regional information based on CMEMS forecasts.

CSIR - Ocean modeling and Forecasting: serves as a hub for ocean modeling and forecasting research. It provides information about ongoing research projects, methodologies, and findings related to oceanography and climate modeling, specifically tailored for South African waters.

Sri Lanka

The Department of Meteorology in Sri Lanka offers general weather information, which includes current weather conditions, forecasts, and meteorological data. It also offers a section for special weather information, which includes alerts, warnings, and advisories related to extreme weather events, ensuring public safety during emergencies.
The National Aquatic Resources Research and Development Agency (NARA) showcases ongoing research projects related to aquatic resources in Sri Lanka. It provides insights into scientific studies, conservation efforts, and advancements in aquatic research conducted by NARA in Sri Lanka.

The Indian National Centre for Ocean Information Services (INCOIS) - Sri Lanka RIMES offers an online portal providing ocean-related information for Sri Lanka. This platform provides valuable information on ocean modeling, forecasts, and data specific to Sri Lanka's coastal regions.

Tanzania

Tanzania National Oceanographic Data Centre (TzNODC) offers a central hub for oceanographic data and information specific to Tanzania's marine environment. It provides archival marine and coastal datasets, research findings and resources relevant to oceanography. Researchers, scientists, and policymakers can access valuable data for scientific analysis, environmental monitoring, and decision-making processes concerning Tanzania's coastal and marine areas.

Thailand

The Ocean modeling and Early-Warning System for the Gulf of Thailand conducted by Deltares offers an online platform which focuses on developing sophisticated ocean models and early warning systems specific to the Gulf of Thailand. The aim is to enhance understanding of oceanographic patterns, predict potential hazards such as storms, tsunamis, or sea level changes, and provide timely warnings to mitigate risks for coastal communities, fisheries, and other stakeholders in the Gulf of Thailand region. The project represents a collaborative effort between experts and researchers to improve ocean monitoring and forecasting capabilities in Thailand.

United Arab Emirates

The Al Bahar platform is an initiative created by the National Centre of Meteorology that offers information on sea conditions, marine observations, tropical storms, weather warnings and resources on satellites and radars.

Case Studies

South Africa

The South African Environmental Observation Network (SAEON) established the SOMISANA (Sustainable Ocean modeling Initiative: a South African Approach) initiative in 2019 with the vision to facilitate a sustained and transformed critical mass of internationally recognized South African numerical ocean modeling experts who provide accurate information about the changing state of the ocean for enhanced impact. Its core project, in collaboration with the South African Weather Service (SAWS) and the Council for Scientific and Industrial Research (CSIR), is to provide operational ocean information to be integrated into the National Oceans and Coastal Information Management System (OCIMS) that is championed by the Department of Forestry, Fisheries and the Environment (DFFE) and provides decision support tools for stakeholders for improved governance and sustainable development of the oceans economy.

The SOMISANA initiative has developed operational ocean forecast systems for two high-use pilot sites around the South African coastline that provide 5 day forecasts of the ocean conditions that are used to support various operations at sea. The forecast system is fully automated and freely disseminates the forecasts routinely via a user-defined visual interface as well as a server on which the data is uploaded. Incorporated into the forecast system, is a particle-tracking module that allows for the future trajectories of potential oil spills, or various other floating objects, to be provided to stakeholders.

One of the SOMISANA pilot sites is Algoa Bay, which is on the southeast coast of South Africa. It lies adjacent to the intense Agulhas Current, which serves as a 'shipping highway', and as such it hosts a couple of oil bunkering, or ship-to-ship refueling operations. However, Algoa Bay is also home to one of South Africa's largest marine protected areas (MPAs) and a number of important bird colonies. While the SOMISANA forecast system for this region was specifically designed to support timeous cleanup operations in the event of an oil spill related to the bunkering operations in this region, it serves other purposes, including: search and rescue operations, the optimization of shipping routes and support for the aquaculture and fishing industries. Most recently, the system was utilized to provide the DFFE with the forecast trajectory of a potential oil spill that may have ensued after a fishing vessel ran aground in a pristine region of the South African coastline.

Australia

Bluelink is a platform created by the Commonwealth Scientific and Industrial Research Organisation (CSIRO), and the Bureau of Meteorology and Department of Defense, with the purpose of developing and maintaining world-leading global, regional, and littoral ocean forecast systems to support Defence applications and maintaining a national ocean forecasting capability for Australia.

The Bluelink infrastructure comprises four key components: computing resources (for prediction and assessment systems), data transfers (for data management and monitoring), observing systems, and expert training. Forecast services require significant compute resources and secure, reliable data transfers. They rely on specialized software for ocean assimilation and modeling and publicly-available observing systems like satellite data and Argo profiles. Environmental forecasting is shifting towards ensemble prediction, increasing the need for compute resources and data transfer. Sustaining state-of-the-art systems involves engagement with research sectors and expert training.

Bluelink produces a comprehensive suite of ocean forecasts. It is used by maritime industries to predict marine scenarios ranging from local beach conditions to regional currents and waves, and oceanic circulation on a global scale.

With Bluelink partners, CSIRO provides scientific services, delivered via:

- a Relocatable Ocean Atmosphere Model (ROAM) system, a fine resolution prediction system at regional scales, and
- The Bluelink ReANalysis (BRAN), a global ocean hindcast that is the key to understanding ocean circulation.

Case Studies

India

The coastal fisheries in India are crucial to the national economy, supporting nearly seven million people directly. However, locating fishery resources is time-consuming and costly, affecting profitability. Satellite-derived data on sea surface temperature (SST) and chlorophyll-a (Chl-a) have been used to predict potential fishing zones (PFZ), benefiting fishermen by reducing search time and fuel costs. Efforts by oceanographers and remote sensing specialists, using satellite-derived data on sea surface temperature (SST) and chlorophyll-a (Chl-a), led to the development of PFZ advisory services, which were provided on a daily basis. However, cloud cover during monsoon seasons posed challenges. The lack of data on subsurface properties and integrating subsurface indicators also hinders scientific accuracy. Integrating subsurface indicators into PFZ identification could enhance scientific accuracy, which requires advanced numerical ocean modeling. The depletion of nearshore fisheries resources also made it important to assist fishermen to carry out pelagic fishing activities in deep waters which required multi-day fishing efforts, and, therefore, accurate forecasting of the PFZ advisories over 3–5 days.

To address these issues, a coupled physical-biogeochemical model was developed to provide PFZ forecasts for 3-5 days, integrating SST and Chl-a data with high-resolution ocean dynamics modeling. In-situ measurements collected over a decade were used to validate the model's accuracy in reproducing marine ecosystem dynamics. While the model tended to overestimate PFZ lengths compared to satellite data, it offers gap-free information and complements satellite-based advisories. The goal is to provide both real-time advisories and seasonal outlooks for sustainable fishery management.

The PFZ has been incorporated into an mobile android application, Thoondil, for the fishermen which includes a compass, weather details, rescue plan, offline maps that provide the route to the nearest ports, and incidence reporting.
Studies have shown that the use of PFZ advisory service has lead to reductions in diesel use, and therefore, reductions in CO_2 emissions

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Online Map

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