
Operational oceanography centres
according to the produced data:

Observations and models



**MERCATOR
OCEAN**
INTERNATIONAL

A map to display operational oceanography centres

Mercator Ocean international works in collaboration with international institutions and scientific working groups to set up international standards to monitor the ocean and develop operational oceanography. Making an inventory of the operational oceanography and ocean forecasting services is the first step to define where and how new capacities are needed. Thus, Mercator Ocean has gathered in map different operational oceanography centres.

Operational Oceanography can be defined as “Operational oceanography provides estimates of ocean variables (temperature, currents, etc.) for the past, present, and future, global-to-coastal marine environments, and physical and biogeochemical properties. There is a systematic focus on operational observing systems, estimates of the current state, short-range predictions and ocean reanalyses. It provides routine and supported product and information at pre-determined and agreed upon service levels to enable marine policy implementation, support Blue Growth and scientific innovation”.

Architecture of an Operational oceanography centre relies on 3 phases: pre-processing phase where the data is collected, processing phase where the models are elaborated and integration phase which allows distribution of the data to downstream users. Operational Oceanography analyses ocean’s physical (temperature, salinity etc.), sea ice and biogeochemical variables and delivers data that can be used for many societal and political purposes.

Classification of operational oceanography centres:

To classify the different centres in the world, 3 classes of criteria have been elected.

- Data produced by centers, (observations or models),
- their spatial coverage,
- their levels of achievement.



Data produced by centres

The data produced by operational oceanography centres have been distinguished into observations (satellites and insitu) or models.



Spatial data set

Another major factor that helps to distinguish ocean modelling centres is the spatial coverage provided by their models. Some centres provide global models which require important computing capacities, while others provide regional models often with a more precise definition.

-  **Regional data production centers**
-  **Global data production centers**

Technical criteria to fulfil operational objectives

	Operational Oceanography Centres
Pre-processing phase	
Capacity to produce information (models)	
capacity to retrieve information (observations)	
Modelled the ocean	
Modelled biogeochemistry	
Processing Phase	
Validation and verification	
Data assimilation	
Sufficient geographic and time coverage	
Integration	
Product catalogue available	
Service catalogue available	
Human interaction with users	
Quantified compliance with service commitments	
Regular information updates	
Adapt to a large number of user	

This table provides the technical criteria that operational oceanography centres should set up to be fully operational.

Worldwide, centres are at different steps of constructions and provide ocean data and models with different levels of operability.

3 categories have been selected depending on the level achieved by each services:

- Service under construction,
- Criteria partially met,
- Criteria fully met.



Services under construction



Criteria partially met



Criteria fully met

Selected Centers (non-exhaustive list)

Anacim

ANACIM is the meteorological centre located in Senegal. It provides seasonal forecasts to understand the link between ocean surface temperature anomalies (in Pacific [related to the major global phenomenon El Nino] and Atlantic) and global climate conditions (precipitation and temperature).

The results of temperature and precipitation numerical models comparable to those used to make short-term forecasts are integrated with those of ocean modelling to make seasonal forecast. Indeed, it has been shown that there is a link between ocean surface temperature anomalies and global climate conditions in Senegal.

Bluelink (CSIRO)

With Bluelink partners, CSIRO delivers ocean modelling services, via:

- a Relocatable Ocean Atmosphere Model (ROAM) system, a fine resolution prediction system which includes ocean, waves, atmosphere and surf modelling tools at regional scales,
- the Bluelink ReANalysis (BRAN), a global ocean hindcast that is the key to understanding ocean circulation.
- the Consortium for Sea-Ice Modelling in Australia (COSIMA) developing ocean and sea ice model configurations.

CIOH

CIOH aims at producing operational oceanographic data necessary to plan and develop naval operations and to understand the physical, chemical and biological dynamics of oceanic and coastal currents in the Colombian Caribbean Basin. It processes and analyses information of both oceanographic and atmospheric conditions in the Colombian Caribbean.

It provides real-time observations of waves and tides and 5-day forecasts.

CMCC

The CMCC delivers ocean data through many ocean models:

- The Biogeochemical Flux Model (BMF) is a generalized biogeochemistry model based on a biomass continuum description of lower trophic levels in the marine environment,

- The CMCC Global Ocean Physical Reanalysis System (C-GLORS) simulates the state of the ocean in the last decades,
- The climate model CMCC-Med is a coupled model atmosphere-ocean-sea-ice focuses on the Mediterranean region,
- The CMCC–CESM–NEMO is the physical basis of the new CMCC Earth System Model where all the climate components (atmosphere, ocean, land and sea-ice) are fully coupled,
- The CMCC-ESM is a coupled-model that accounts for interactive dynamics of atmosphere, ocean, sea-ice and land components, with the inclusion of the marine biogeochemistry to fully represent the global carbon cycles,
- LIM is a numerical model of sea ice designed for climate studies and operational oceanography,
- MEDLISK is a freely available oil transport and transformation community model,
- NEMO is a pan-European community ocean-modeling framework owned and maintained by a consortium of institutes including the CMCC. It is in use in a wide variety of applications whose prime objectives are oceanographic and climate research, operational ocean forecasts and seasonal weather forecasts.
- SANIFS is a coastal-ocean operational system providing short-term forecasts in the Southern Adriatic Northern Ionian coastal Forecasting System,
- VISIR is a numerical model for computing optimal maritime tracks.

CLS

CLS processes environmental data and positions from over 100,000+ beacons each month, as well as ocean observations from environmental satellites. CLS uses over 80 satellite instruments on a daily basis. It provides solutions for ocean challenges related to the Blue Economy, the policy-makers and the civil society.

CMEMS

The Copernicus Marine Environment Monitoring Service (CMEMS) provides in situ and satellite observations and models in its catalogue. It is a European Union service that provides data about the physical and biogeochemical ocean and sea ice. It is composed of many data providers that build ocean models and provide observations about the global ocean and about each European sea. The data provided are of 3 orders: reanalysis, near-real-time and forecasts.

It provides more than 200 ocean products, ocean monitoring indicators and ocean expertise for decision-makers.

It is designed to serve EU policies and international legal commitments related to ocean governance, to cater for the societal needs related to global ocean knowledge and to boost the Blue Economy.

DMI

DMI ocean forecast models are forced by weather forecasts and they calculate:

- hydro dynamics (sea current, sea temperature, salinity, sea ice)
- storm surge (sea level)
- waves
- drift and spreading of oil/dissolved substances or lost cargo
- marine ecology (nutrients, oxygen, ..)

DMI ocean model are regional: they cover a limited body of water. They analyse sea water in the North Sea, the Baltic Sea, the Danish Waters and the Greenland Waters.

ECMWF

The ECMWF models 4 ocean variables:

- Potential temperature
- Salinity
- Sea level anomaly
- Sea ice concentration

Thanks to its expertise in atmosphere monitoring, its delivers daily and weekly forecast and analysis about ocean-waves components and ocean general circulation components.

ECCC

Environment and Climate Change Canada (ECCC) is the Canadian institution dedicated to climate change. It works in collaboration with Fisheries and Ocean Canada (DFO) and the Department of National Defense (DNF) to elaborate ocean models on global scales, specifically on Canadian ocean waters. It predicts water temperature, salinity, currents and ice on a daily basis for forecasts and near-real time data as well as seasonal to inter-annual climate forecasts.

BSH

The German Federal Maritime and Hydrographic Agency (BSH) is a maritime service provider in Germany. It performs following functions:

- Collecting and archiving marine observation data and
- providing this data to the scientific community and the public.

It provides in situ observation data about water level, tide currents, temperature and sea ice.

FMI

The Finnish Meteorological Institute includes real-time observations, forecasts and analyses as well as expert services. It offers customized weather services in the Baltic Sea, other European and Arctic seas. The three main variables it analysis are sea ice, water level and waves.

DFO

Together with ECCC, the Canadian Department of Fisheries and Ocean works to develop and implement coupled computer models. These models provide numerical estimate of ocean and ice conditions in the past, present and future.

It has developed

- an atmosphere-ice-ocean prediction system for the Gulf of St. Lawrence, which produces daily estimates of the ice ocean conditions and 48-hr forecasts four times a day;
- a Global Ice Ocean Prediction System (GIOPS), which is now in place to provide estimates of sea ice and ocean conditions and daily 10-day forecasts over the world's oceans and
- a Regional Ice Ocean Prediction System (RIOPS), which provides estimates of sea ice and ocean conditions and daily 48-hr forecasts over the Arctic and North Atlantic oceans.

HNODC

The Hellenic National Oceanographic Data Centre (HNODC) provides database that comprises physical, chemical and biological parameters in the water column. It stores a mass volume of more than 320.000 station data concerning physical, chemical and biological oceanographic information and is currently hosting data from the POSEIDON system, which is a monitoring, forecasting and information system for the Greek seas.

OGS

OGS activities cover 4 oceanographic components:

- Physical Oceanography (Experimental, Autonomous Systems, Coastal)
- Biogeochemistry
- Marine Biology
- Modelling of marine system

The NODC database contains more than 300 thousand vertical profiles of physical and biochemical variables.

INCOIS

The Indian National Centre for Ocean Information Services (INCOIS) provides both in situ and satellite observation data as well as participates to elaborate ocean models. It mainly focuses on the Indian ocean. The models it participates to are:

- High-resolution Operational Ocean Forecast and reanalysis System (HOOFS)
- Regional analysis of Ocean Information (RAIN),
- HYbrid Coordinate Ocean Model (HYCOM)
- Indian National Centre for Ocean Information Services-Global Ocean Data Assimilation System (INCOIS-GODAS)
- Tsunami,
- Storm surge.

INIOAS

The Iranian National Institute for Oceanography and Atmospheric Science (INIOAS) aims to prompt the Iranian government to establish and develop marine research laboratories in the institutes and centres at the coasts of the Persian Gulf, the Gulf of Oman and the Caspian Sea.

It is composed of 4 centres; among these, the Ocean Engineering and Technology Research Center carries out research on

- modeling, hind casting and forecasting wind waves,
- studying and modelling the process of wave propagation from deep water to shallow water,
- tsunami Modeling
- water level changes
- wave- structure interaction
- current-structure interaction
- estuarine hydrodynamic modelling and
- current pattern modelling in the sea and coastal areas.

It mainly provides observation data about the Gulf of Oman, the Caspian Sea and the Persian Gulf.

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JMA

The Japan Meteorological Agency (JMA) provides forecast about the ocean states and develops tsunami warning information based on in situ observations. It provides analysis and short-term forecasts regarding the Japan sea and North Pacific waves, sea level, heat content, ocean temperature and polar sea ice.

KHOA

The Korean Hydrographic Ocean Agency (KHOA) mainly provides observational data about the ocean. It provides data on the Korean sea about following items:

Oceanographic Observation:

- Tidal observation
- Water temperature/Salinity observation
- Tidal benchmark surveys
- Sea parting surveys

Hydrographic Survey:

- Types and methods
- Current hydrographic surveys and plans
- Coastline surveys
- Coastal waters surveys

MOi

Mercator Ocean International (MOi) produces various ocean models about

- ocean climate information (data used for model calibration in the study of ocean temperature dynamics by attempting to bridge the gap between machine learning and data assimilation techniques, ocean heat transport analysis and seasonal forecasts for the polar regions);
- information production for ocean and ice services;
- generating information for ocean health and marine diversity;
- weather hazard monitoring and
- CO-development of ocean models (analysis of boundary conditions for the Madeira Ocean Forecast System; Mercator Ocean native data is also used in Arctic physical model nesting, Arctic, IBI and NWS models).

Météo France

Météo France models marine in real-time and forecasts data mostly related to the ocean atmosphere interferences. It provides wave, sea temperature and wind data.

NOC

The National Oceanography Center (NOC) is organised into five main areas: Marine Geoscience, Ocean Biogeochemistry and Ecosystems, Marine Systems Modelling, Marine Physics and Ocean Climate, and Ocean Technology and Engineering.

It models:

- the ocean circulation and heat transport,
- marine ecosystems,
- sea-ice,
- turbulence,
- surface waves,
- sediment transport,
- tides and storm surges.

It combines satellites and insitu observations to model:

- ocean circulation,
- surface processes,
- coastal ocean processes,
- sea level and ocean climate.

Met-ocean

Met-ocean delivers in-real time observations and forecasts for the following physical ocean variables:

- Waves, winds and currents
- Rain, visibility, thunderstorm
- Tidal prediction interface

It provides customized services adapting for example:

- Forecast parameters on scalable maps
- Satellite imagery
- Integration of measured real time data
- Historical data download
- User specified hazard levels

NERSC

The NERSC models physical ocean processes, marine ecosystem and data assimilation with applications towards operational oceanography, marine research and climate research.

It also delivers in situ and satellite observations of sea level, ocean currents, mesoscale ocean dynamics and sea ice.

Through the Copernicus Marine Arctic MFC, the NERSC provides 10-day prediction as well as reanalyses over the past 25 years of the ocean currents, temperature, salinity, primary production, sea ice and waves.

NOAA

The NOAA provides a full range of data related to ocean observations and models. It monitors the physical (wind, waves, sea level, temperature, salinity, tides, etc.) and the biogeochemical ocean and sea ice. Moreover, it monitors both the global ocean's and United States' waters on a global and regional scale.

It also monitors the effect of climate change on the ocean to provide answers regarding impacts of global warming on population.

It runs 6 ocean models :

- Hycom
- NCOM Global
- NCOM regional
- Adaptive Ecosystem Climatology
- NCEP Real Time Ocean Forecasts Systems
- CO-OPS OFS Center for Operational Oceanographic Products and Services Operational Forecast System

NMEFC

The NMEFC provides real-time observations and forecasts with ocean observations and models for 5 different areas:

- China sea: current, salinity, temperature and waves
- Global ocean, India Sea, and Pacific Sea: current, salinity, temperature, waves and wind
- Polar region: level500, precipitation and wind

NMI

The Norwegian Meteorological Institute (NMI) monitors and forecasts the following variables in the Norwegian seas and the High North using observations and numerical models:

- waves,
- water levels,
- ocean currents,
- sea ice,
- ocean temperature,
- salinity
- ocean climate

It is responsible for ice monitoring and ice forecasting for the sea around Svalbard, the Barents Sea and the Norwegian coast. (In winters, with sea ice in the Skagerrak and the Oslo Fjord, maps for these areas are also produced).

IPMA

The main mission of Portuguese Institute for Sea and Atmosphere (IPMA) is to analyse the interaction between physical oceanography and meteorology. It develops and validates SWAN model for Mainland Portugal area. Moreover, it provides real-time observations and short-term forecasts of the physical ocean, covering the Iberic Peninsula, Madeira and Selvagens and the Azores.

Variables monitored are :

- significant wave height
- sea peak period
- surface currents
- sea surface temperature
- sea surface height

PdE

Puertos del Estado (PdE) provides real-time information and forecast regarding the Spanish water (IBI + Mediterranean). It utilises physical and biogeochemical models, comprising measurement networks (buoys, tide gauges and high-frequency radars), prediction services (waves, sea level, currents and water temperature) and climate ensembles, which describe both the current maritime climate and its scenarios for change in the 21st century.

REMO

REMO is the operational oceanography collaboration project started in collaboration with many institutions in Brazil:

- Universidade Federal do Rio de Janeiro
- Universidade Federal da Bahia
- Petrobras
- Centro de Hidrografia da Marinha

Its objective is to build an operational oceanography service that provides hydrodynamic numerical models and observation data for the South Atlantic Ocean and sub-regions off the Brazilian coast.

The data observed are :

- Wind
- Temperature (Air e SST)
- Atmospheric Pressure and Relative Humidity
- Wave (Hs e Tp)
- Current (Intensity and Direction)

SODEXAM

SODEXAM provides an ocean operational forecast product about swell surge: An alert is triggered when it reaches more than 4 meters in the Atlantic ocean Coastline close to Côte d'Ivoire.

SMHI

The Swedish Meteorological Hydrographic Institute (SMHI) analyses the ocean through numerical modelling, remote sensing, marine biology and marine observations, with a focus on seas surrounding Sweden – Baltic Sea, Kattegat and Skagerrak; however, increasing interest is also being shown towards the Arctic Ocean and the North Sea.

It provides ocean forecasts about:

- significant wave height
- sea level
- ice extent (ice concentration, thickness, and ridges)
- currents
- sea-surface temperature

University of Cape Town

The university of Cape Town has developed a research centre to analyse the ocean and make forecasts regarding it through numerical modelling.

Its research activities concern both the physical and biogeochemical ocean on the following areas:

- Agulhas Current
- Ocean Atmosphere Interactions
- Benguela Current
- Southern Ocean
- Global Climate System
- Rainfall Variability & Extreme Events
- False Bay

University of Pernambuco

The Centro de Estudos e Ensaios em Risco e Modelagem Ambiental of Pernambuco University is designing an operational oceanography service to start modelling the physical ocean in the Brazilian seas.