

# The Copernicus Marine Environment Monitoring Service: an integrated view on the ocean state



Marine Monitoring

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Implemented by





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# Copernicus Marine Service Portfolio

## Products are gathered in a unique catalogue

- online catalogue <http://marine.copernicus.eu>
- common format (Netcdf)
- INSPIRE compliant
- Open and Free

The screenshot shows the homepage of the Copernicus Marine Environment Monitoring Service. At the top, there is the European Commission logo and the text 'COPERNICUS MARINE ENVIRONMENT MONITORING SERVICE' with the tagline 'Providing PRODUCTS and SERVICES for all marine applications'. A search bar is located on the right. Below the header, there are navigation tabs: ABOUT US, BENEFITS, NEWS, SCIENCE & LEARNING, TRAINING, and SERVICES PORTFOLIO. A 'SHORT-CUT TO SERVICES' sidebar on the right lists options like 'REGISTER NOW', 'VALIDATION STATISTICS', 'ONLINE TUTORIALS', and 'COLLABORATIVE FORUM'. The main content area features 'ACCESS TO PRODUCTS' with a 'FIRST VISIT?' button and a 'Select your:' section with filters for AREA, PARAMETERS, TIME COVERAGE, and OBSERVATIONS/MODELS. A 'LATEST NEWS FLASH' section is also visible.

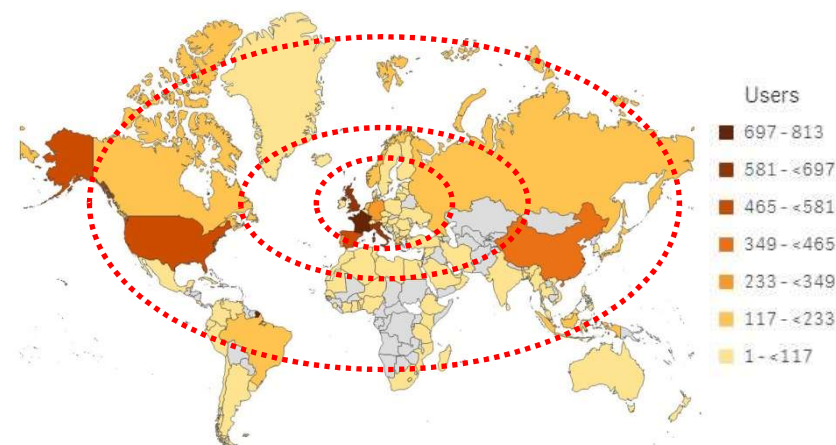
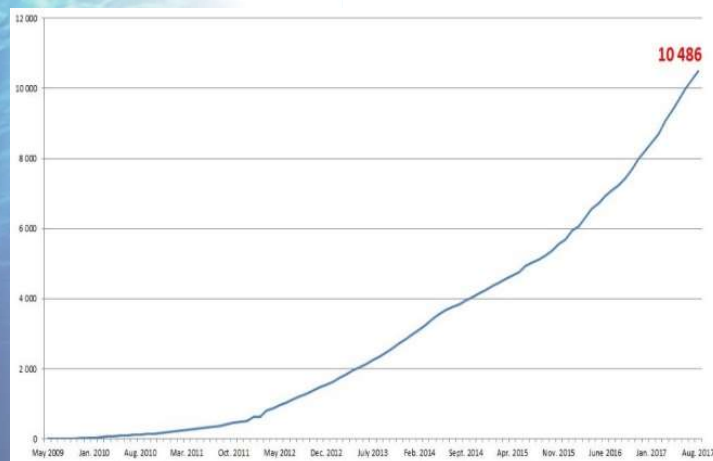
The screenshot displays the 'ONLINE CATALOGUE' interface. It features a search bar with 'CATALOGUE PDF' and 'FIRST VISIT?' buttons. Below the search bar, it states 'Found 28 products matching your criteria.' The interface is divided into sections for 'YOUR SEARCH', 'AREA', 'PARAMETER', and 'TIME COVERAGE'. The 'AREA' section lists various regions like Global Ocean, Arctic Ocean, and the Baltic Sea. The 'PARAMETER' section lists parameters such as Ocean Temperature, Ocean Salinity, and Ocean Currents. The 'TIME COVERAGE' section lists options like All time coverages, Forecast Products, and Near Real Time Products. The main content area shows three product cards: 'BALTIC SEA PHYSICS ANALYSIS AND FORECAST', 'BALTIC SEA BIOGEOCHEMISTRY ANALYSIS AND FORECAST', and 'BALTIC SEA PHYSICS REANALYSIS FROM SMHI (1989-2013)'. Each card includes a brief description, a map, and buttons for 'MORE INFO' and 'ADD TO CART'.



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# A Constant Growth Of Subscribers

More than **10 000 subscribers** (~ + 200 new subscribers/month)



**Downloads (2017) : 290 000+**  
**Downloaded Volume (2017) : 371 Tb**  
**User satisfaction (2017) : 4,7/5**



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# CMEMS Portfolio gathers 14 marine parameters

MFC: Monitoring and  
Forecasting Centres

TAC: observations Thematic  
Assembly Centres

PARAMETER	MODEL			SATELLITE (surface ocean)		INSITU	
	25years in the past	Today	10-day forecast	25years in the past	Today	25years in the past	Today
Sea Surface Height	x	x	x	x	x	x	x
Temperature	x	x	x	x	x	x	x
Salinity	x	x	x			x	x
Waves	x	x	x				
Currents/velocity	x	x	x			x	x
Mixed Layer Depth	x	x	x			x	x
Sea ice	x	x	x	x	x		
Turbidity/Transpare ncy				x	x		
Reflectance				x	x		
Nutrients	x	x	x			x	
Primary Production	x	x	x			x	
Oxygen	x	x	x			x	
Plankton	x	x	x			x	
Wind				x	x		







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# CMEMS integration levels

Number of independent marine data/algorithms used to build product

**CMEMS MFC products**



**CMEMS TAC products**



**Satellite ground segment products**  
**Raw insitu products**



*Includes high quality reprocessing and re-analyses*

Level of integration of marine information into 3D gridded ocean estimates



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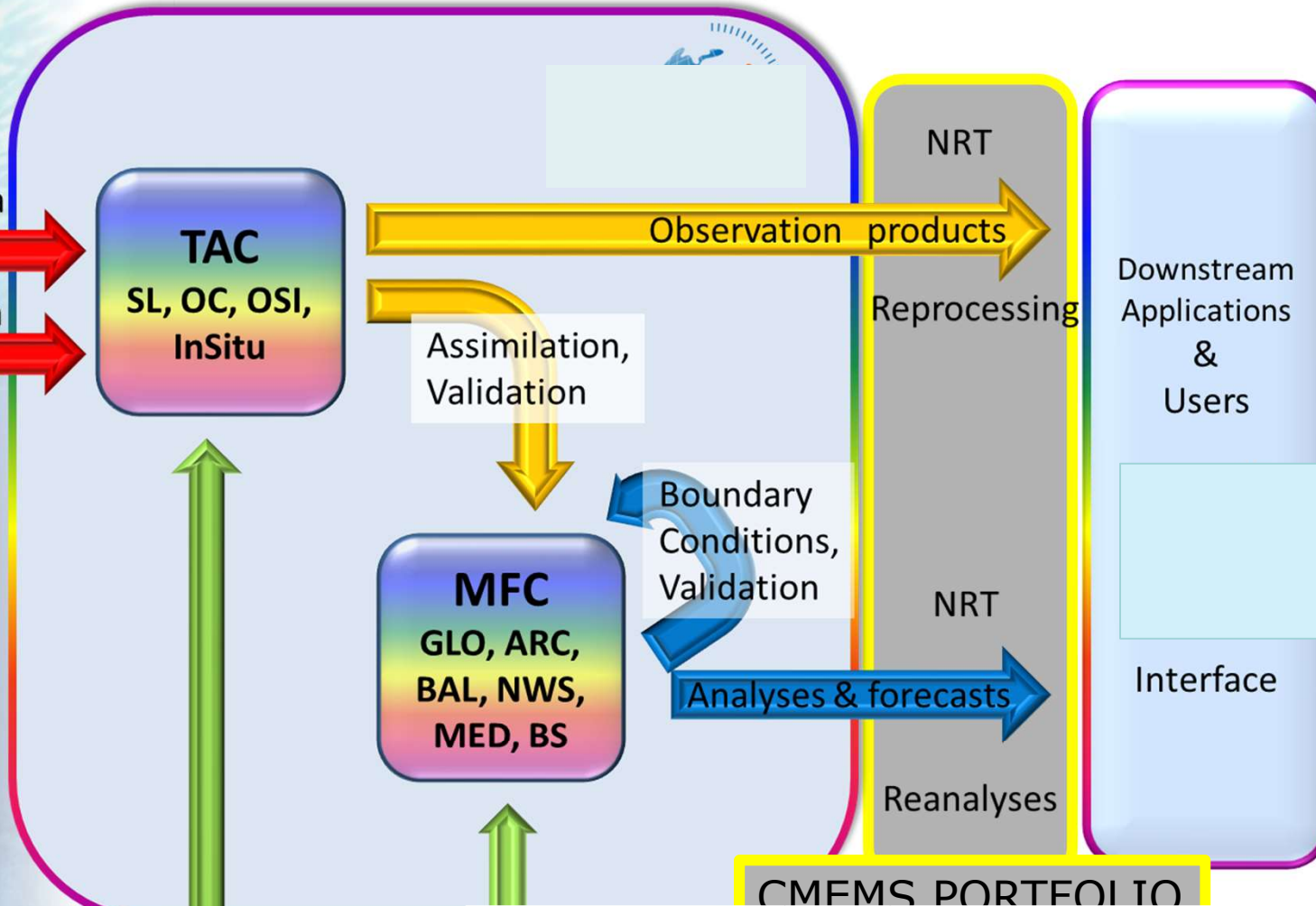


Space data

InSitu data



# CMEMS Production Function



Ancillary data, Forcing fields

Strong technical coordination is necessary:

- Change management / review processes
- Engineering
- towards cloud / big data technology



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# CLOSE TO 100 USE-CASES ON LINE

- Developing Gambia's Capacity In Climate Risk Management
- Met-Ocean conditions for the Oil & Gas industry and Ocean Energy sector
- Ship routing to save fuel and reduce CO2 emissions
- Improving sonar communication between defence vessels
- Turtles monitored thanks to what they eat

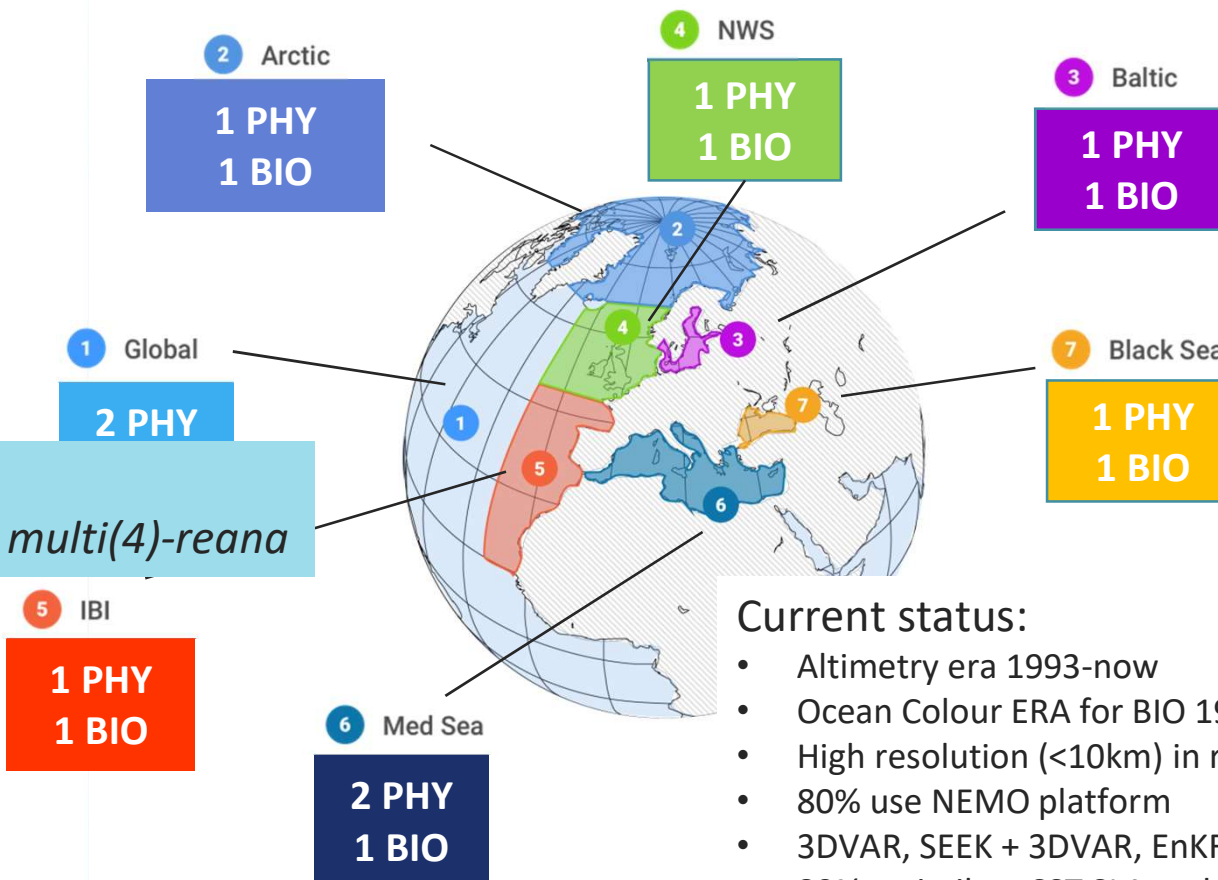




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# CMEMS gathers 16 ocean reanalyses

- ✓  $\frac{1}{4}^\circ$  daily
- ✓  $1^\circ$  monthly multi(4)-reana



## Current status:

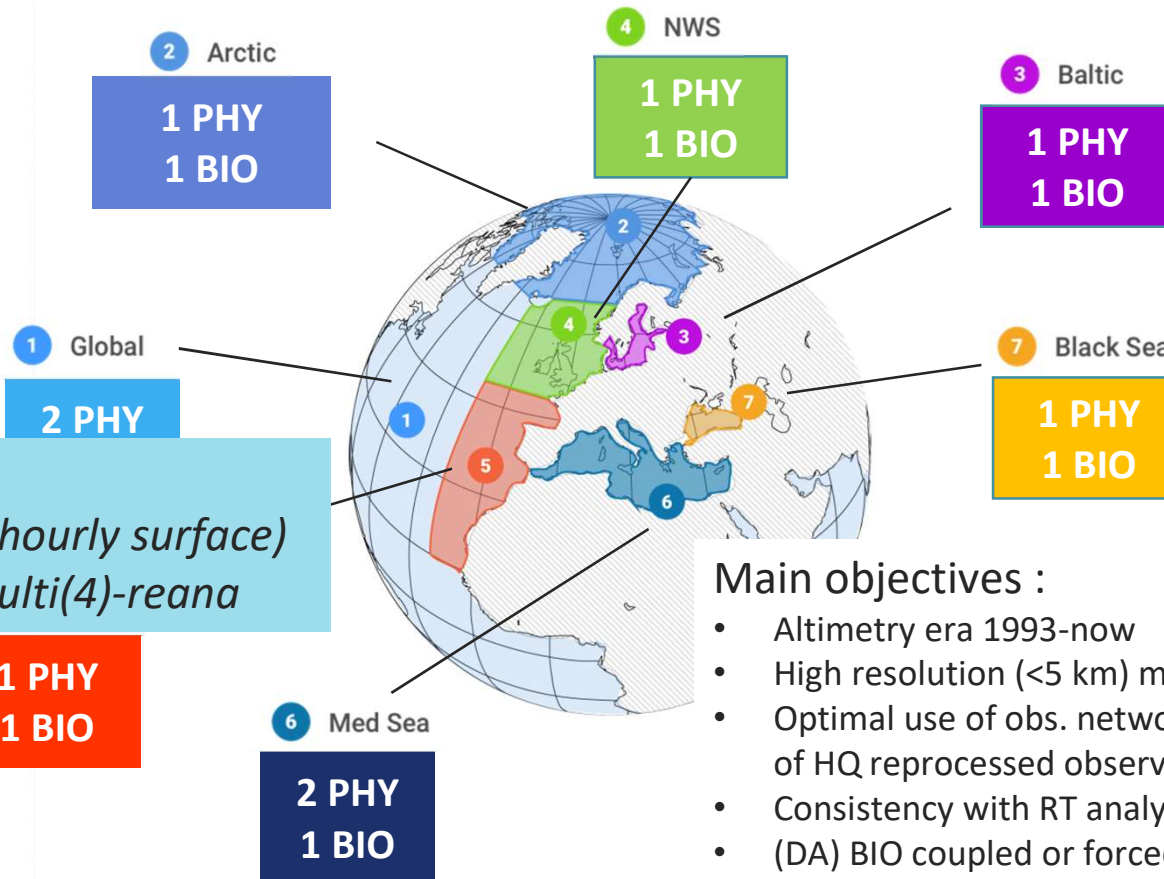
- Altimetry era 1993-now
- Ocean Colour ERA for BIO 1997-now
- High resolution (<10km) in regions
- 80% use NEMO platform
- 3DVAR, SEEK + 3DVAR, EnKF ...
- 80% assimilate SST SLA and in situ (+ sea ice)
- 30% BIO assimilate Ocean Colour





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# CMEMS gathers 16 ocean reanalyses



In 2018:

- ✓ 1/12° daily (hourly surface)
- ✓ 1/4° daily multi(4)-reana

## Main objectives :

- Altimetry era 1993-now
- High resolution (<5 km) models
- Optimal use of obs. network, assimilation of HQ reprocessed observations
- Consistency with RT analysis
- (DA) BIO coupled or forced by PHY
- Agreement on validation metrics
- Maximum consistency in between regions
- Maximum cross use of CMEMS products

See strategy document on [marine.copernicus.eu](http://marine.copernicus.eu)



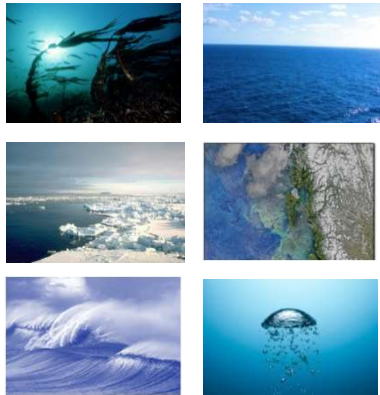


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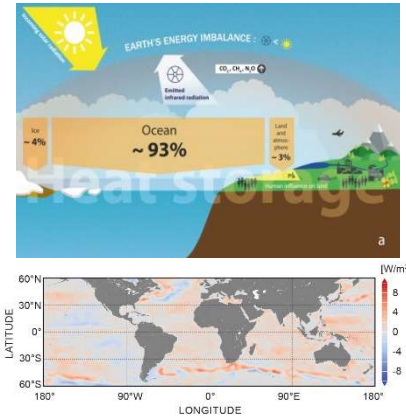
# THE OCEAN STATE REPORT

## Content and expected audience

### Essential Variables



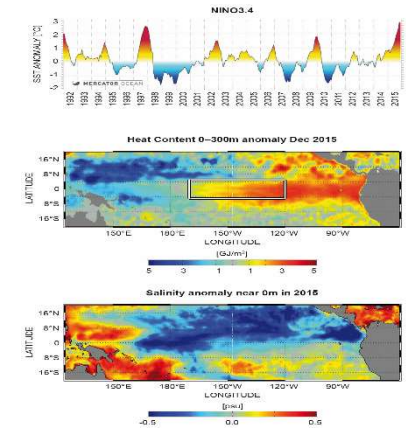
### Ocean climate



### European Seas



### Remarkable events



Scientific community

Policy and decision makers, Blue Economy

14 LIFE BELOW WATER

European and international agencies and organisations, Regional Sea Conventions

General public awareness





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## Ocean State Report #1

- ❖ Written by 80 scientific experts
- ❖ Collaboration of more than 25 European institutions
- ❖ Fundamental step forward into the development of regular Copernicus Marine Service annual reporting



- ❖ Published in the Journal of Operational Oceanography
- ❖ Independent peer review
- ❖ Open access

### ACHIEVEMENTS:

- ❖ Currently more than 6200 views since publication
- ❖ Essential element of side event at UN Ocean conference (JUN 2017)
- ❖ Presented at COP23 (EC Pavillon)
- ❖ Mentioned as Copernicus achievement

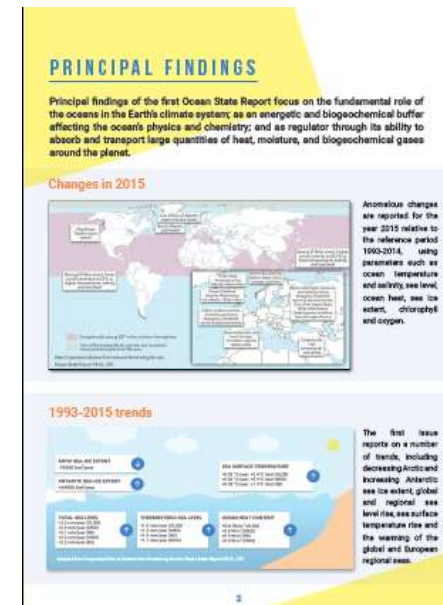


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# Ocean State Report #1

- ❖ Summary proposed through the Copernicus Marine Service
- ❖ Available on the Copernicus Marine Service web portal

## Summary of outcomes targeted at policy makers over 8 pages







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## Ocean State Report # 2



### ISSUE #2: THE COPERNICUS MARINE ENVIRONMENT MONITORING SERVICE OCEAN STATE REPORT 2017

- ❖ Strengthened and increased collaboration of European marine experts
- ❖ Innovative and new uncertainty assessment through multi-product approach

### SUMMARY FOR POLICY MAKERS UNDER DEVELOPEMENT:

- ❖ Update on summary #1 with new content
- ❖ Addition of a discussion on thematic questions
- ❖ Development of topical information sheets & associated communication campaign

## CHAPTER 1: ESSENTIAL VARIABLES

1. Sea surface temperature
2. Subsurface temperature
3. Sea surface salinity
4. Subsurface salinity
5. Sea level
6. Currents
7. Sea ice
8. Ocean colour
9. Nutrients
10. Air-to-sea carbon flux
11. Surface wind

## CHAPTER 2: CHANGES IN OCEAN CLIMATE

1. Ocean Heat Content
2. Steric Sea Level
3. Mass and Heat Transports
4. OMZ
5. Oligotrophic Gyres
6. ENSO
7. Western Boundary Currents
8. AMOC
9. Changes in the North Atlantic
10. OFC in the Arctic

## CHAPTER 3: CHANGES IN THE REGIONAL EUROPEAN SEAS

1. Extremes variability
2. North Atlantic - Arctic exchanges
- 3.
4. Characterization of Mediterranean Outflow Water
5. Water Masses Formation events in the Mediterranean Sea
6. Ventilation of the Western Mediterranean Deep Water
7. Decline of the Black Sea oxygen inventory
8. Major Baltic inflows
9. Eutrophication and coastal hypoxia in the Baltic Sea

## CHAPTER 4: REMARKABLE EVENTS DURING 2016

1. Extreme sea ice conditions
2. Enhanced convection in the Labrador Sea
3. A persisting cold and fresh anomaly in the Northern Atlantic
4. Lowest sea level since 1886 in the Baltic Sea
5. Unusual salinity pattern in the South Adriatic Sea in 2016

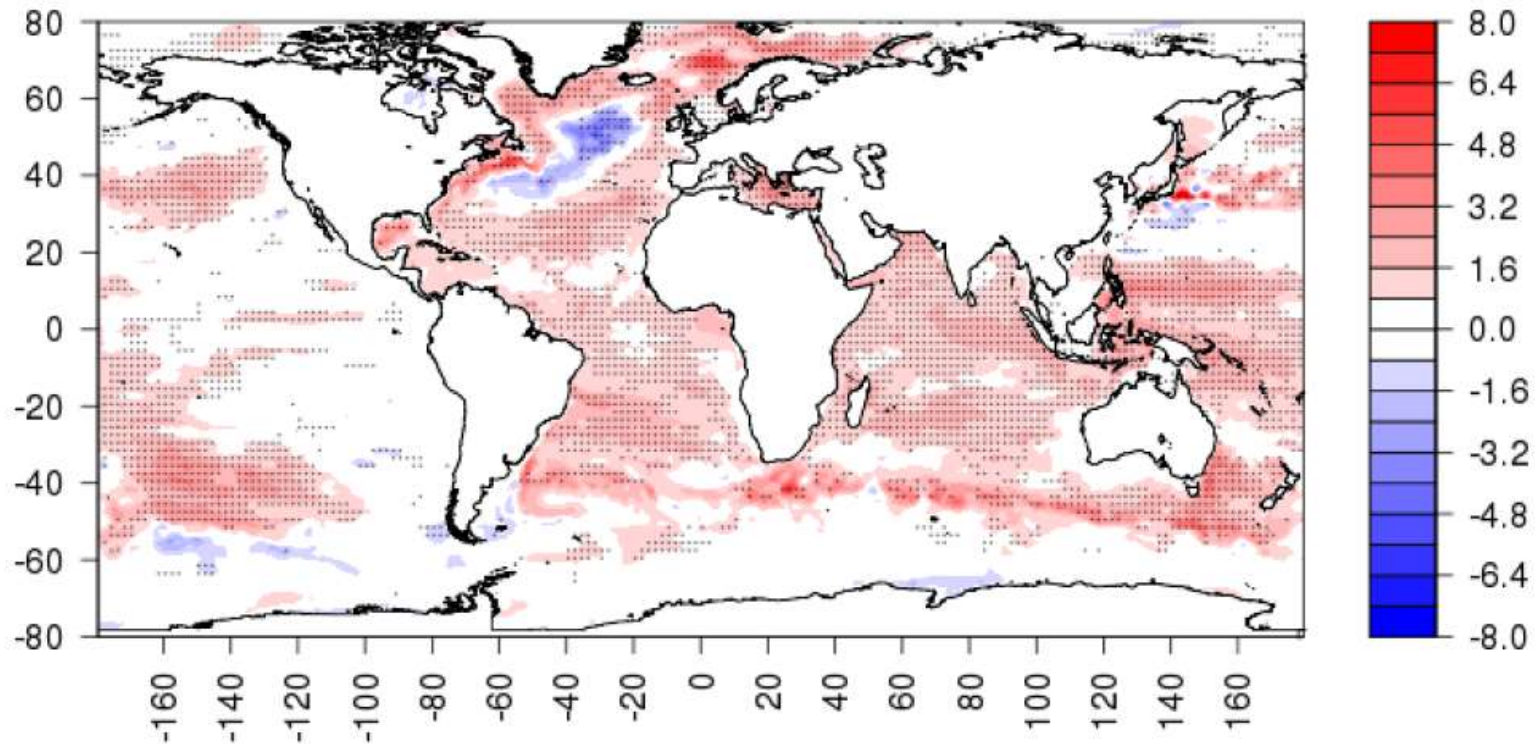


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## Ocean State Report # 2

Heat content using GREP ensemble mean  
(ORAS5+GLORYS2V4+CGLORS+GLOSEA5) + CORA + ARMOR3D  
shading = where signal > spread

**Global Ocean Heat Content Trend 1993-2016 [0-700m] [W/m<sup>2</sup>]**



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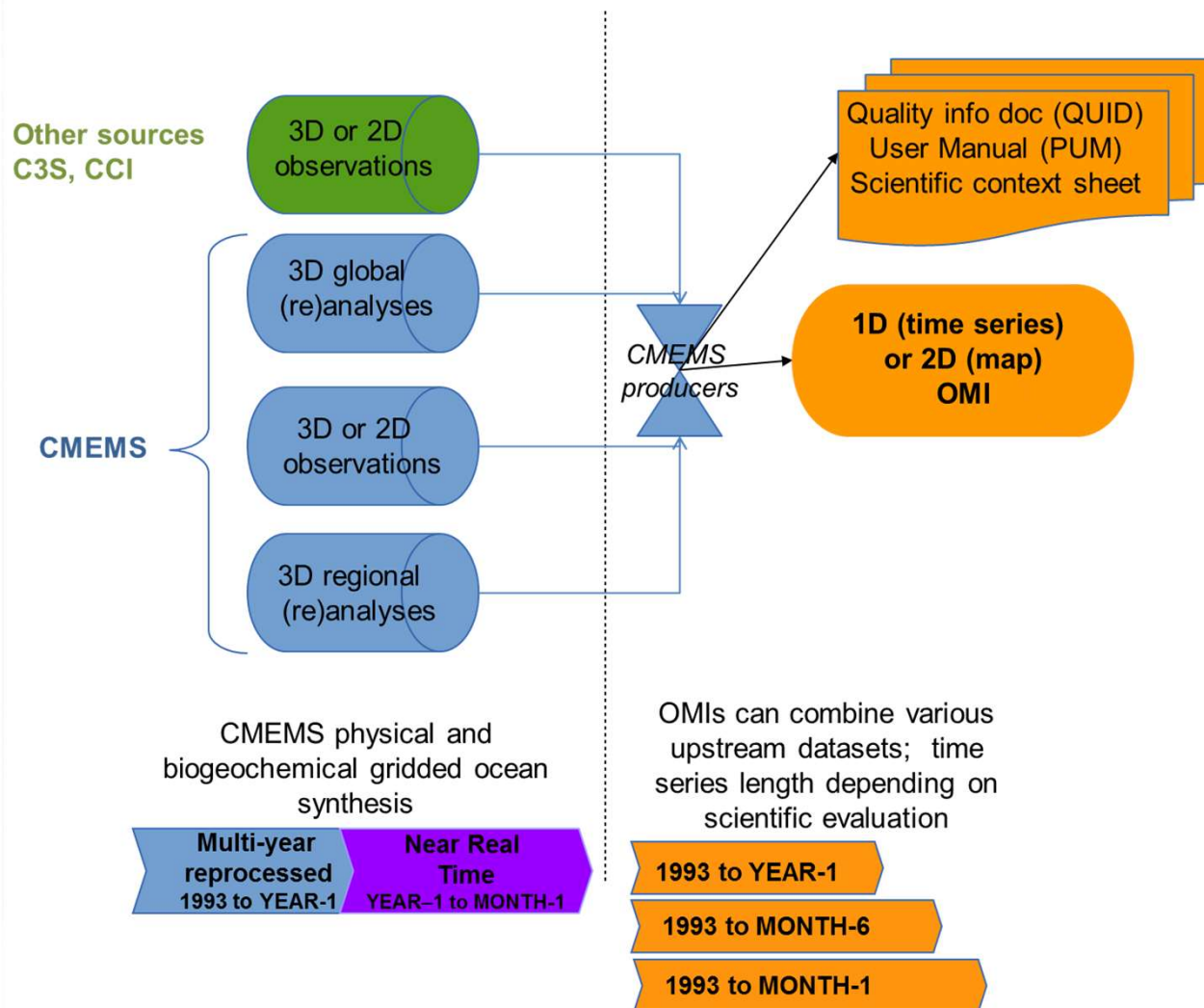
Copernicus  
Europe's eyes on Earth

MERCATOR OCEAN  
WORLD OCEANOGRAPHY



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# Ocean Monitoring Indicators



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Copernicus  
Europe's eyes on Earth

MERCATOR OCEAN  
WORLD LEADERS





# GODAE OceanView analyses

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Location: Home

Ocean Forecasting

Development and Forecasting System approach. GODAE national forecasting exchange knowledge

Documents

News

Calendar

Contacts

Members Login

Username:

Password:

Systems linked to GODAE OceanView	Current GOVST representatives	Country
<a href="#">BLUElink</a> (Bureau of Meteorology)	Gary Brassington	Australia
<a href="#">CONCEPTS</a> (Fisheries and Oceans Canada/ Environment Canada)	Natacha Bernier	Canada
<a href="#">ECCO</a> (JPL/NASA)	Tony Lee	USA
<a href="#">ECMWF</a> (Europe)	Magdalena Balmaseda	Int
<a href="#">FOAM</a> (Met Office)	Matt Martin	UK
<a href="#">HYCOM/NCODA</a> (Multi-institutional)	Pat Hogan and Eric Chassignet	USA
<a href="#">INCOIS</a> (Indian National Center for Ocean Information Services)	Abhisek Chatterjee	India
<a href="#">NMEFC</a> (National Marine Environmental Forecasting Center)	Guimei Liu	China
<a href="#">Mercator Ocean</a> (French Operational Oceanography Centre)	Yann Drillet	France
<a href="#">MFS</a> (Mediterranean Forecasting System)	Giovanni Coppini	Italy
<a href="#">MOVE/MRI.COM</a> (Japan Meteorological Agency)	Tsurane Kuragano	Japan
<a href="#">REMO</a> (Rede de Modelagem e Observacao Oceanografica - Network for Oceanographic Modeling and Observations)	Clemente Tanajura	Brazil
<a href="#">RTOFS</a> (National Centre for Environment Prediction - NCEP)	Avichal Mehra	USA
<a href="#">TOPAZ</a> (NERSC)	Laurent Bertino	Norway

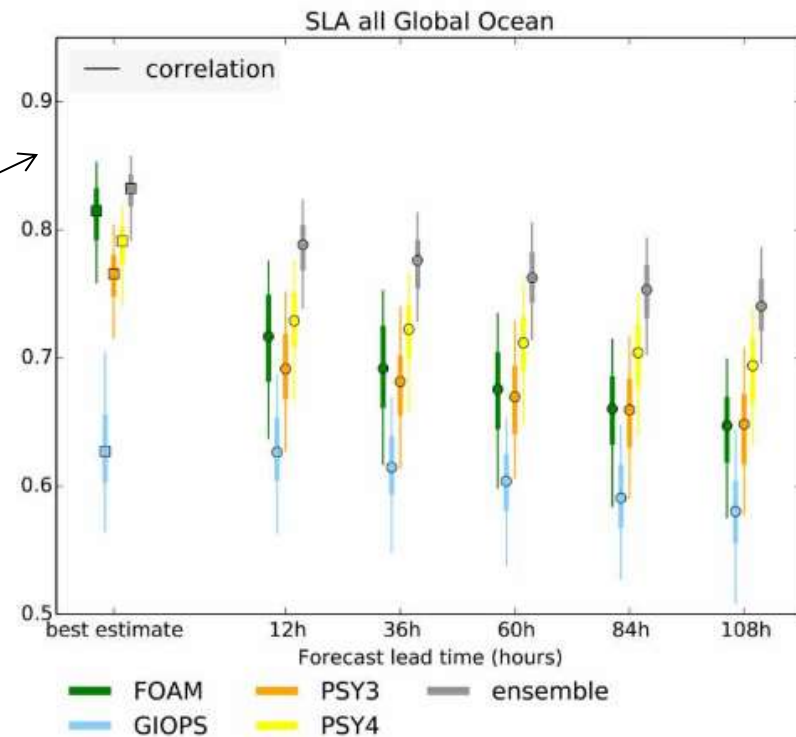




✓ Intercomparison of real time analyses and forecast: Ryan et al JOO 2015

✓ Intercomparison/validation to assess uncertainties among ocean reanalyses (model errors and bias, observing system reliability over time)

- **GODAE/CLIVAR/GSOP ORA-IP**, Balmaseda et al (2015) *JOO*
- **Multi ORA** NRT intercomparison, Xue et al (2017) *Clim. Dyn.*
- **CMEMS multi-reanalysis ensemble product GREP** based on ORCA025 GLORYS/C-GLORS (CMCC)/GLOSEA5 (UKMO)/ORAS5 (ECMWF)
- Intercomparison of high resolution reanalyses is planned (HYCOM and GLORYS12)
- Evaluation of Ocean Syntheses COST Action <http://eos-cost.eu>



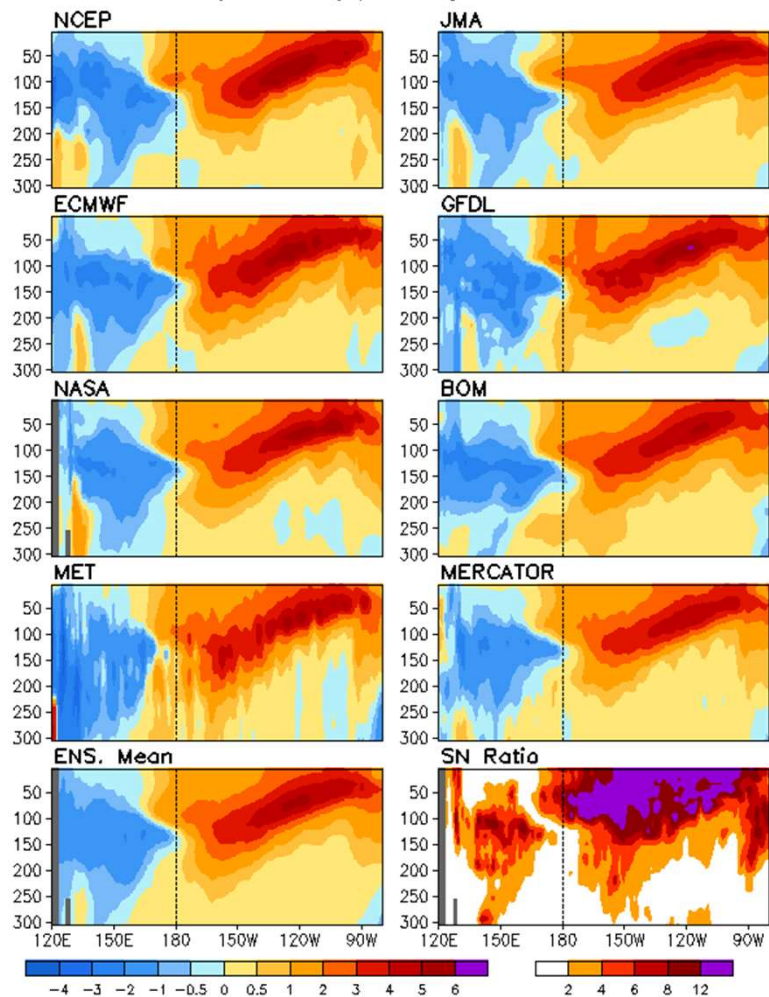




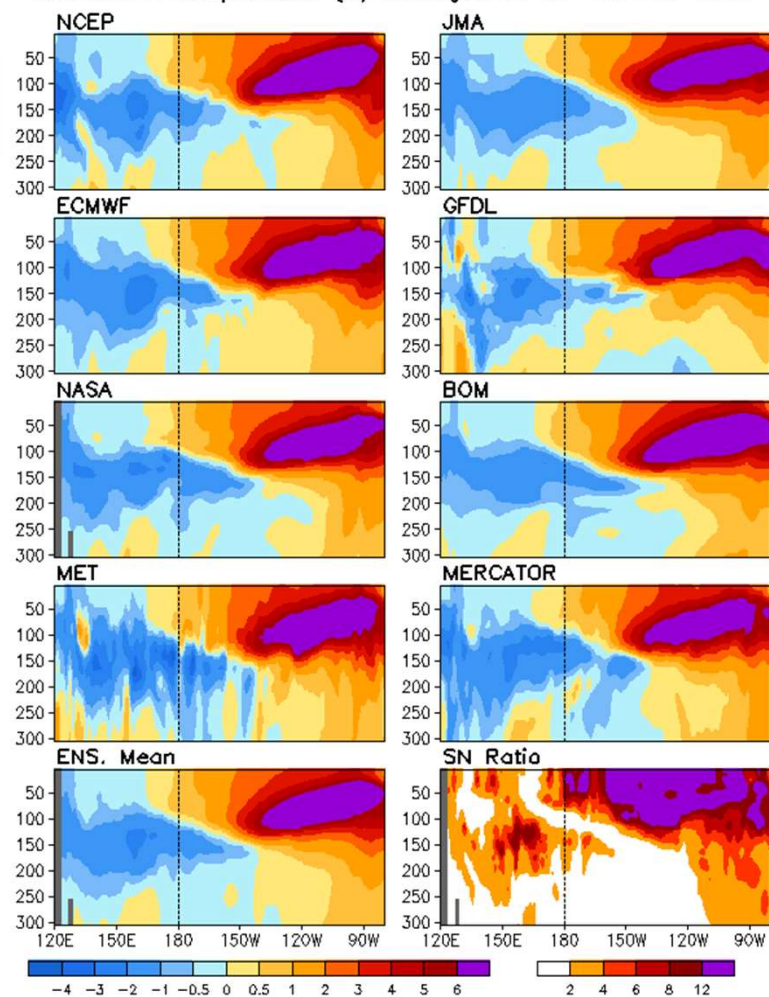
# Real time Ocean monitoring with multi ORA

Yan Xue, NOAA/CPC

Anomalous Temperature (C) Averaged in 1S-1N: JUL 2015



Anomalous Temperature (C) Averaged in 1S-1N: JUL 1997





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G O D A E O S E - V a I T T

In the framework of GODAE Observing System Evaluation task team, several operational ocean monitoring and forecasting centres are carrying out dedicated studies to evaluate the impact of observations on ocean analyses and forecasts.

Recent and future studies dedicated to the impact of tropical Atlantic ocean networks, considering the other in situ and satellite observations available (in NRT):

- Ocean data impacts in Global HYCOM (art. Cummings et al., 2014) (NOAA)
- Impact of moorings in the Atlantic (*ECMWF, MetOffice, Mercator, CLS – AtlantOS H2020*)
- Impact of PIRATA moorings on the South Atlantic region Metarea V (36S-7N, 20W until Brazil) (REMO, *Brazilian Navy operational system*).







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## s u m m a r y

- Ocean (re)analyses are 3D gridded products combining many sources of ocean information (as much as possible)
- Used when and where no observations available, or when a consistent gridded dataset is needed
- Available from CMEMS and GODAE operational oceanography centres, multi product approach is beneficial
- Analysis systems can help to design the observation network (OSEs, OSSEs, sensitivity studies / reanalyses)
- Resolution is increasing -> dissemination issues are increasing -> clouds and PaaS