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

Pierre-Yves le Traon, Angélique Melet, Karina von Schuckmann, Fabrice Hernandez, Yann Drillet, Marie Drévilleon, Laurence Crosnier, Mercator Ocean
Products are gathered in a unique catalogue

- online catalogue [http://marine.copernicus.eu](http://marine.copernicus.eu)
- common format (Netcdf)
- INSPIRE compliant
- Open and Free
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
CMEMS Portfolio gathers 14 marine parameters

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>MODEL</th>
<th>SATELLITE (surface ocean)</th>
<th>INSITU</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>25years in the past</td>
<td>Today</td>
<td>10-day forecast</td>
</tr>
<tr>
<td>Sea Surface Height</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Temperature</td>
<td>x</td>
<td>x</td>
<td>x</td>
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<tr>
<td>Salinity</td>
<td>x</td>
<td>x</td>
<td>x</td>
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<tr>
<td>Waves</td>
<td>x</td>
<td>x</td>
<td>x</td>
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<tr>
<td>Currents/velocity</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Mixed Layer Depth</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Sea ice</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Turbidity/Transparency</td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Reflectance</td>
<td></td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Nutrients</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Primary Production</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Oxygen</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Plankton</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Wind</td>
<td></td>
<td></td>
<td>x</td>
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</tbody>
</table>
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
Strong technical coordination is necessary:
- Change management / review processes
- Engineering
- towards cloud / big data technology
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
CMEMS gathers 16 ocean reanalyses

- ¼° daily
- 1° 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
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
THE OCEAN STATE REPORT

Content and expected audience

Essential Variables

Ocean climate

European Seas

Remarkable events

Scientific community

Policy and decision makers, Blue Economy

European and international agencies and organisations, Regional Sea Conventions

General public awareness

Marine Monitoring
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
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
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 DEVELOPPEMENT:

- Update on summary #1 with new content
- Addition of a discussion on thematic questions
- Development of topical information sheets & associated communication campaign
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<tr>
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</thead>
<tbody>
<tr>
<td>7. Sea ice</td>
<td>7. Western Boundary Currents</td>
<td>8. Major Baltic inflows</td>
<td></td>
</tr>
<tr>
<td>10. Air-to-sea carbon flux</td>
<td>10. OFC in the Arctic</td>
<td></td>
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<tr>
<td>11. Surface wind</td>
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</tbody>
</table>
Heat content using GREP ensemble mean (ORAS5+GLORYS2V4+CGLORS+GLOSEA5) + CORA + ARMOR3D shading = where signal > spread
Oceana Monitoring Indicators

Other sources C3S, CCI

CMECS

3D or 2D observations
3D global (re)analyses
3D or 2D observations
3D regional (re)analyses

CMECS physical and biogeochemical gridded ocean synthesis

Quality info doc (QUID) User Manual (PUM) Scientific context sheet

1D (time series) or 2D (map) OMI

OMIs can combine various upstream datasets; time series length depending on scientific evaluation

Multi-year reprocessed 1993 to YEAR-1
Near Real Time YEAR-1 to MONTH-1

1993 to YEAR-1
1993 to MONTH-6
1993 to MONTH-1
# GODAE OceanView analyses

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

- **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)
Real time Ocean monitoring with multi ORA

Yan Xue, NOAA/CPC

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

NCEP | JMA
---|---
ECMWF | GFDL
NASA | BOM
MET | MERCATOR
ENS. Mean | SN. Ratio

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

NCEP | JMA
---|---
ECMWF | GFDL
NASA | BOM
MET | MERCATOR
ENS. Mean | SN. Ratio

mercator-ocean.eu / marine.copernicus.eu
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).
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