The Copernicus Marine Environment Monitoring Service

Marine Monitoring

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Mercator Ocean

EGU, April 12 2018

European Commission | Copernicus | Implemented by | MERCATOR OCEAN

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Outline

- The Copernicus Marine Service today
- Copernicus Marine service evolution: strategy and R&D activities
- R&D achievements for CMEMS Phase 1 (2015-2018)
- Main evolutions foreseen for CMEMS Phase II (2018-2020) and longer term perspectives
- Conclusions

Copernicus Marine Service - Drivers

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Increasing & pressing ocean monitoring needs:

- To understand and predict the evolution of our weather and climate.
- For a better and sustainable management of the oceans and its resources.
- For an increasing number of ocean services and the development of the blue economy.

Blue Growth and Societal Challenges

Recognized at the highest levels (e.g. UN/Agenda 2030/SDG, IPCC/Ocean&Cryosphere, OECD/the future of ocean economy, G7/future of the oceans and seas).

SUSTAINABLE DEVELOPMENT GOALS

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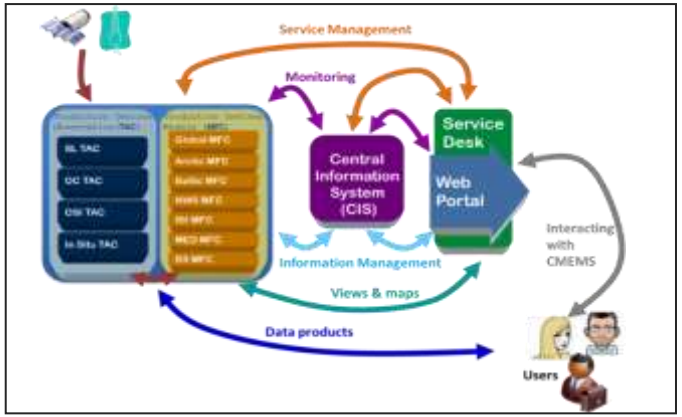
The Copernicus Marine Service - Today

A state of the art, innovative and user driven Copernicus service

- **Operational** and **scientifically assessed**
- **Observations** (satellite, in-situ) and **models** (analyses/forecasts)
- **Physics** and **Biogeochemistry**
- A **network** of European producers
- A **unique catalogue**: **Worldwide** and **European-wide** coverage
- A **central information system** to search, view, download products and monitor the system
- A **service desk** to support users who relies on a network of technical & marine experts
- **Generic** to serve a **wide range of downstream applications**. More than **12 000 subscribers.**



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The Copernicus Marine Service

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MULTI-YEAR
10 to 45 years

REAL-TIME
Daily, hourly

FORECAST
2 to 10 days

1 Global
2 Arctic
3 Baltic
4 NWS
5 IBI
6 Med Sea
7 Black Sea

ESSENTIAL MARINE VARIABLES

- Physics
- Sea-ice
- Waves
- Biogeochemistry

OBSERVATIONS
In-situ & Satellites

NUMERICAL MODELS &
data assimilation

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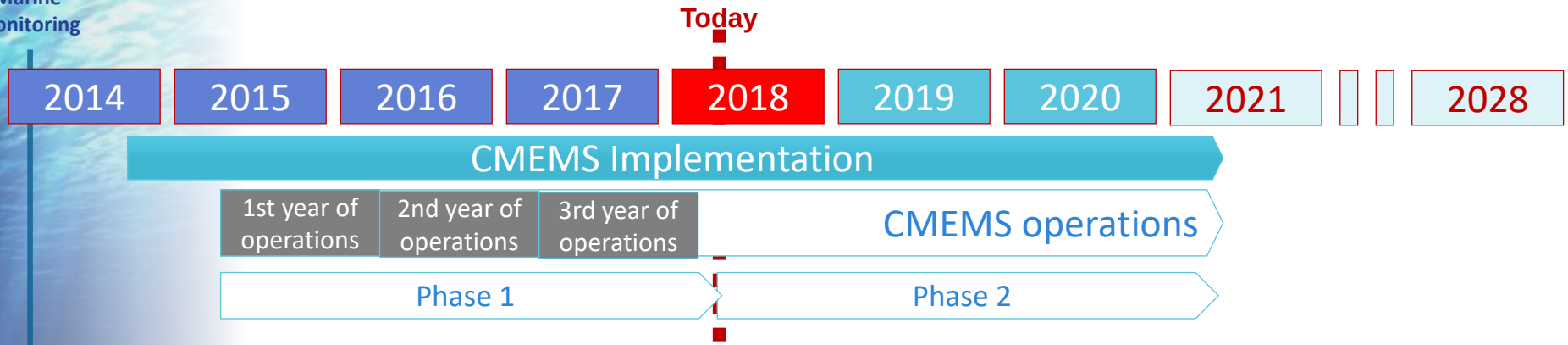
TIMELINE



April 2018 :

- a 4th annual cycle for CMEMS implementation
- Start of the 2nd phase of the operational phase (April 2018-April 2021)

User uptake: a constant growth of subscribers

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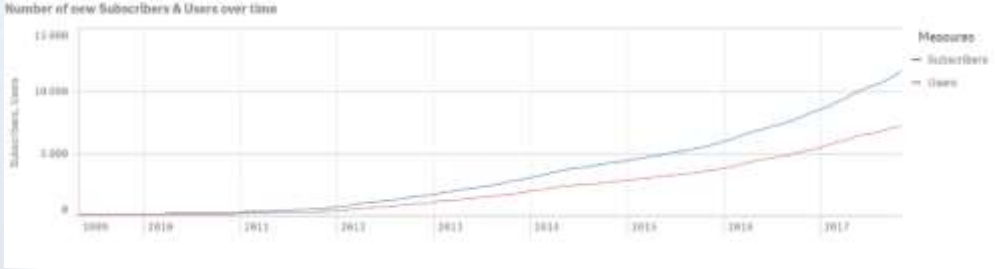
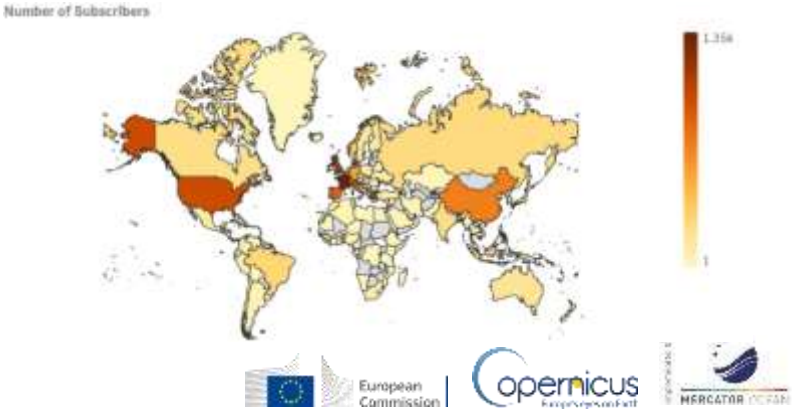
More than 12 000 subscribers (~ + 200 new subscribers/month)



- 12 000 Subscribers
- 4000 Different Entities among which 1000 Business Companies
- Downloads/month: 35 000

  Download = Pair User/Dataset per Day
- Volume/month: 50 Tb
- 98% products on time
- Satisfaction of Users: 4,7/5



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The essential role of R&D

The Copernicus Marine Service exists now as an operational service **thanks to more than 10 years of investment in R&D** precursor projects and **international R&D cooperation** in operational oceanography.

Maintaining a **state of the art, leading and innovative** Copernicus Marine Service responding to **user needs** and taking full advantage of **scientific/technological advances** similarly requires **continuous service evolution**.

MERSEA

myOcean

myOcean

GODAE OceanView

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CMEMS Service Evolution Activities

Activities carried out by Mercator Ocean with the support of the CMEMS Science and Technological Advisory Committee (STAC) include:

- **Preparation of a CMEMS service evolution high level strategy and R&D priorities.** This strategy guides service upgrade over the period 2015-2025 with a focus for the next 4 years. It identifies short term (< 1 year – Tier 1), mid-term (1 to 2 years – Tier 2) and long term (3 to 10 years – Tier 3) R&D priorities.

- **Define/agree on/monitor short term and part of mid-term R&D (Tier-1&2)** within CMEMS production centers (TACs and MFCs).

- **Organize other mid-term (Tier-2) R&D activities through tenders for CMEMS service evolution** and the corresponding evaluation, selection and monitoring processes.

- **Interface with EC for longer term (Tier-3) R&D activities** (Horizon 2020).

Service Evolution: Roadmap

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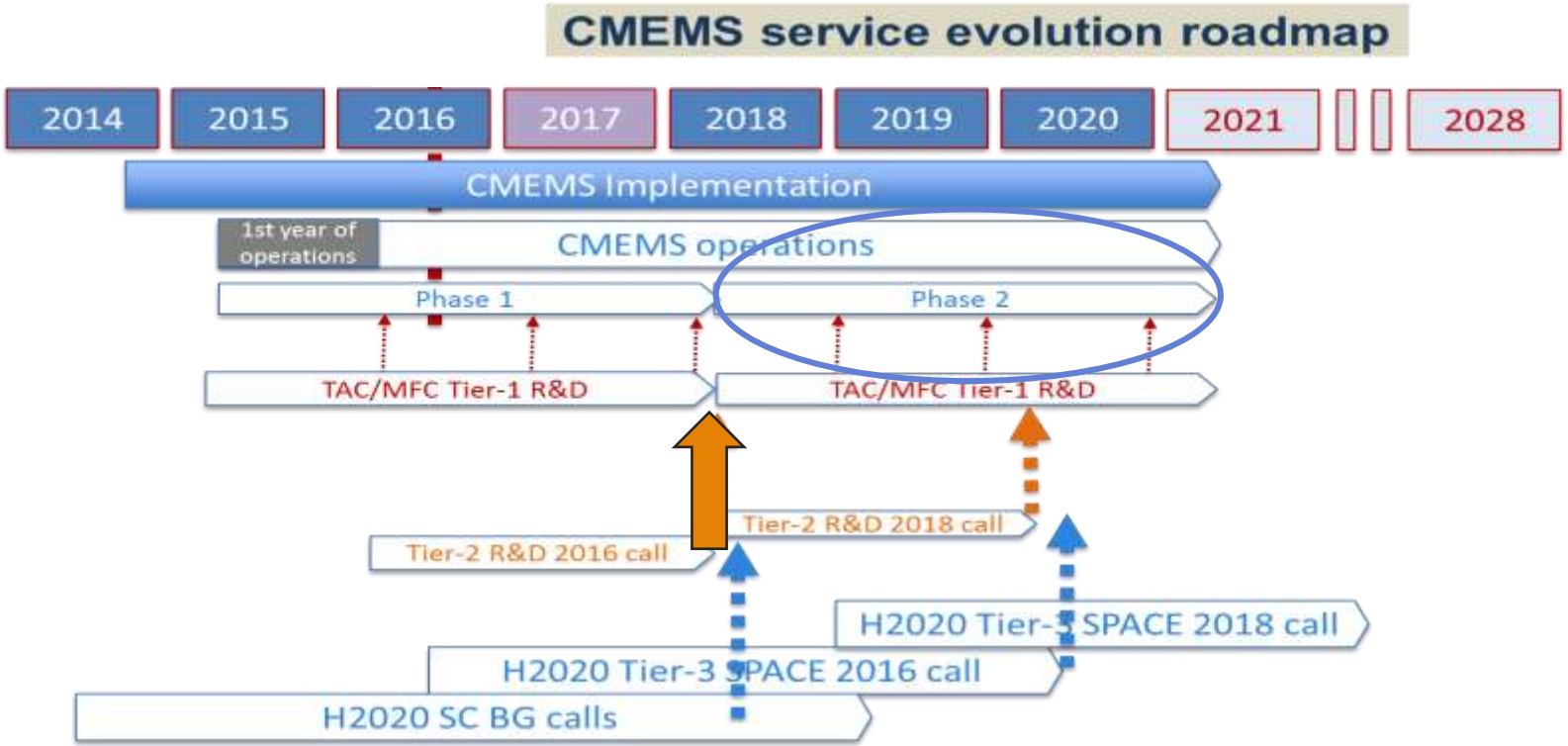
Operations

R&D

Tier 1

Tier 2

Tier 3



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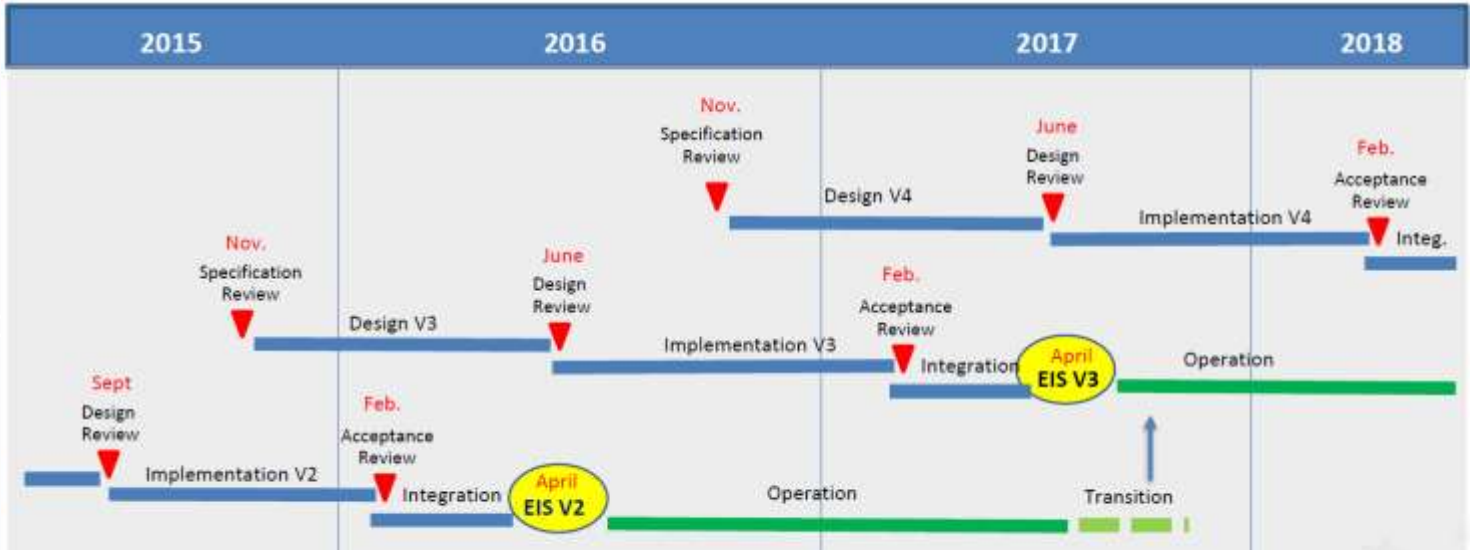
CMEMS : Continuous improvements

Tier-1 R&D

- System versioning. A main version every year.
- Prepare the next version while continuing operating the previous one
- A formal review process to manage the development and entry into service.



Continuous service improvement demands a well-designed and robust architecture. Rigorous change/transition management process to minimise the impacts of the evolutions for the users.

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Phase 1 R&D Achievements - Highlights

Important R&D advances have been achieved during CMEMS Phase 1 (April 2015 – April 2018) and significantly improved service is or will be soon proposed to the users:

- **wave observations and models,**
- **improved resolution,**
- **wave/circulation coupling,**
- **better use of existing satellite and in-situ observations,**
- **uptake of Sentinel 1 data (sea ice, wave) and Sentinel 3 (altimetry, sea surface temperature, ocean colour) data,**
- **longer time series of reprocessed in-situ and satellite data and ocean reanalyses,**
- **improved and more homogenized product quality assessments,**
- **ocean monitoring indicators and ocean state report.**

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R & D achievements from TACs and MFCs

Tier-1 R&D

https://www.mercator-ocean.fr/en/science-publications/mercator-ocean-journal/mercator-ocean-journal-56-special-issue-cmems/

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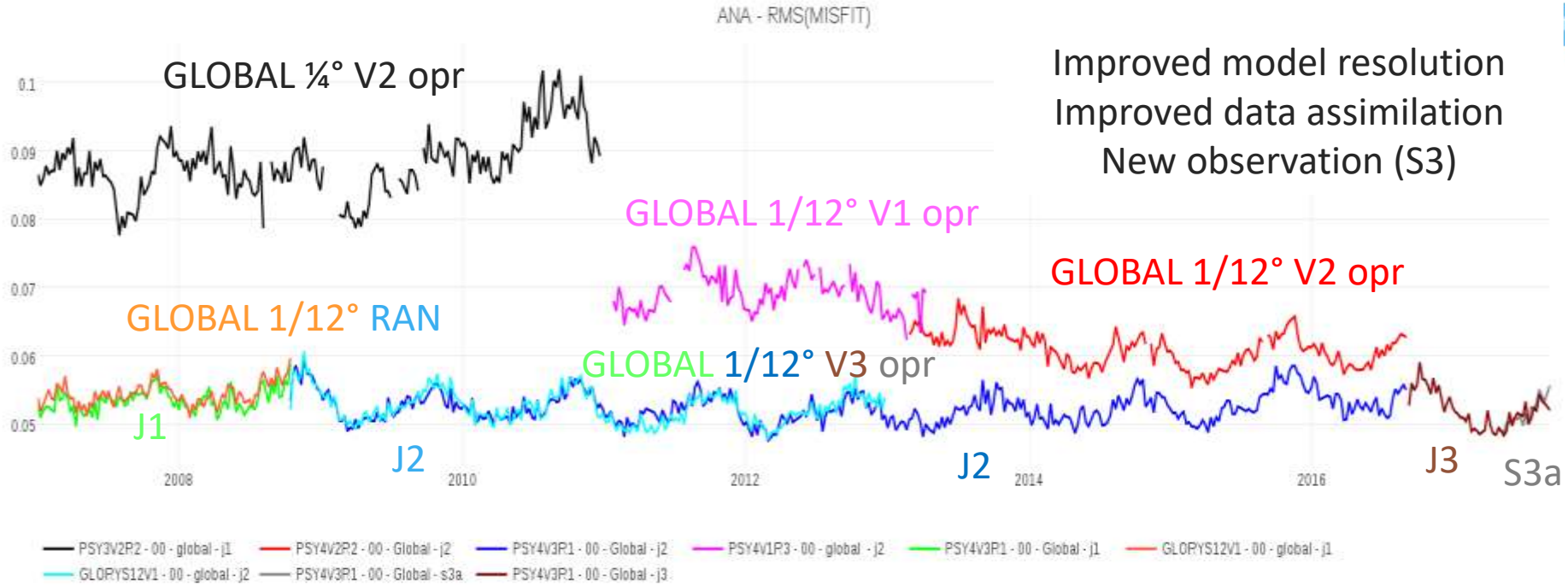
Evolution of sea level analysis errors - global system



Improved model resolution
Improved data assimilation
New observation (S3)

GLO MFC team

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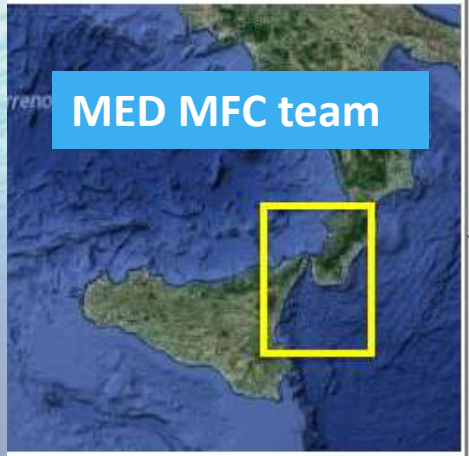
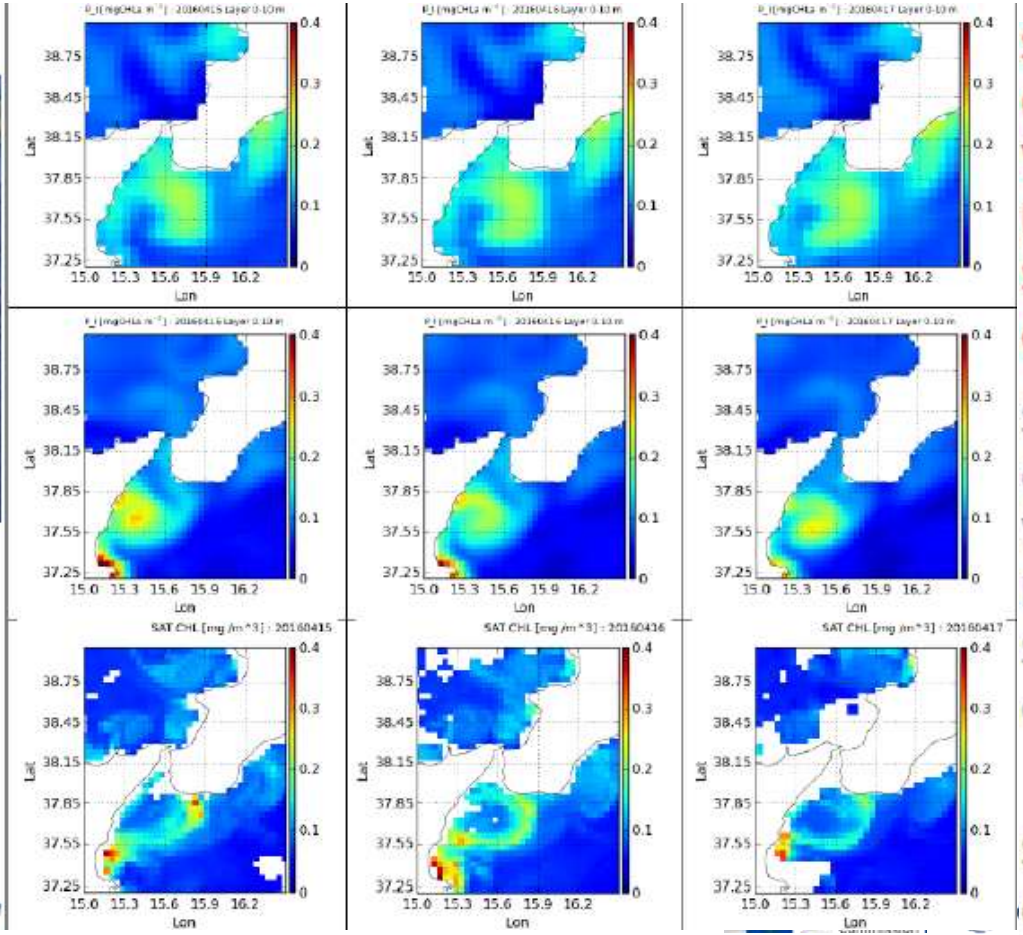
Biogeochemical modelling – Med Sea MFC

MESSINA STRAIT



MedBFM2 is able to catch the structure of the events; a 3-day example:
- Low chl waters entering from the north through the Messina Strait
- Local coastal bloom occurring in the Sicilian coast



Surface Chlorophyll V2 (1/16°) Messina Strait is closed

Surface chlorophyll V3.2 (1/24°) Messina Strait is open

Sat chlorophyll

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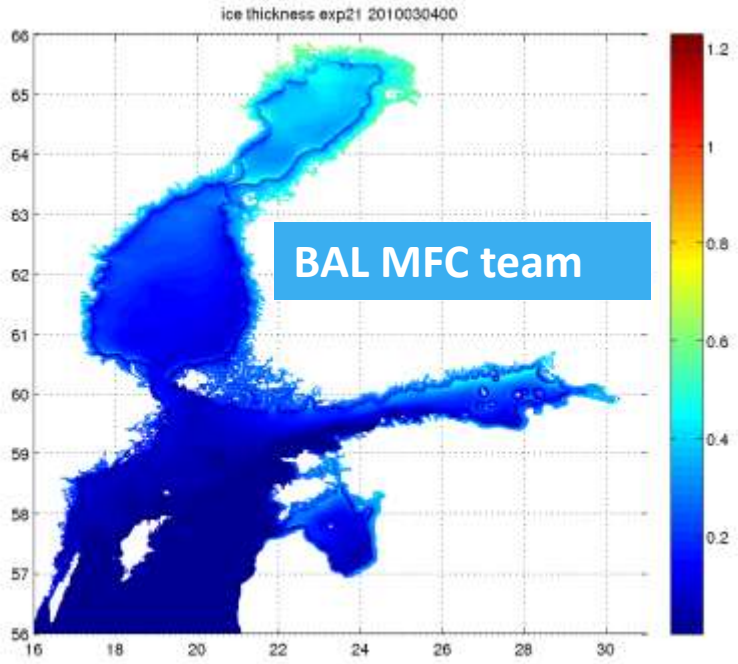
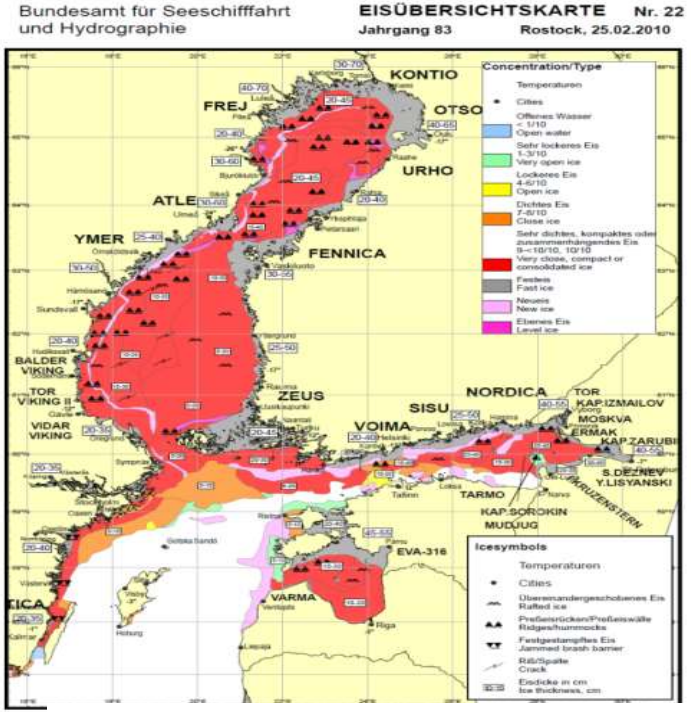
Sea ice modelling in the Baltic Sea

Ice HBM model performance in the northern Baltic for a given day in winter 2010. The modelled fast ice visible in the near coastal zone of higher ice thickness corresponds well to the observed fast ice.



Ice thickness calculated by HBM



Observed ice map (BSH)

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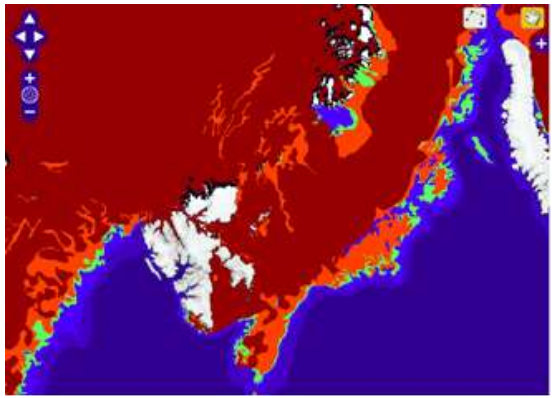
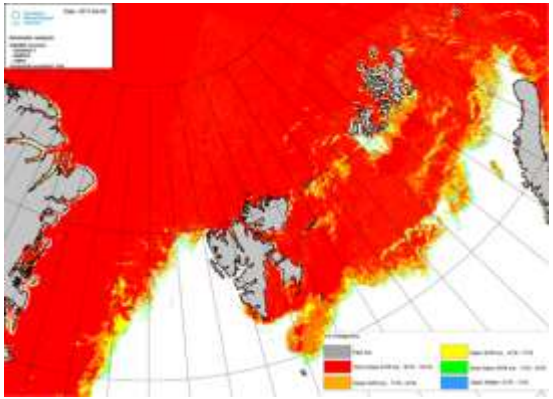
Use of S1 for improved sea ice services

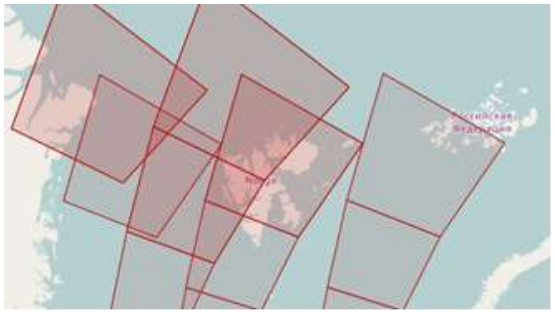


Manual analysis from MET Norway ice analysis (CMEMS operational product).

OSI TAC team

Automatic analysis





Sentinel 1 daily coverage over the Svalbard area

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CMEMS Service Evolution R&D projects (Tier 2) 1st Call

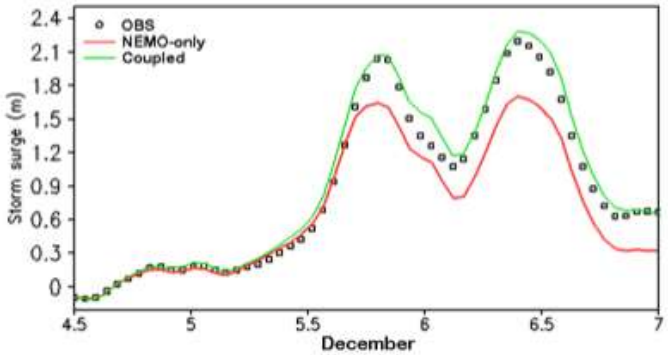
Evaluation of projects by the STAC in January 2016 after external reviews : 12 projects selected. Projects completed in March 2018.

Tier 2 (mid-term) R&D = (potential) impact on operational service in less than 3 years

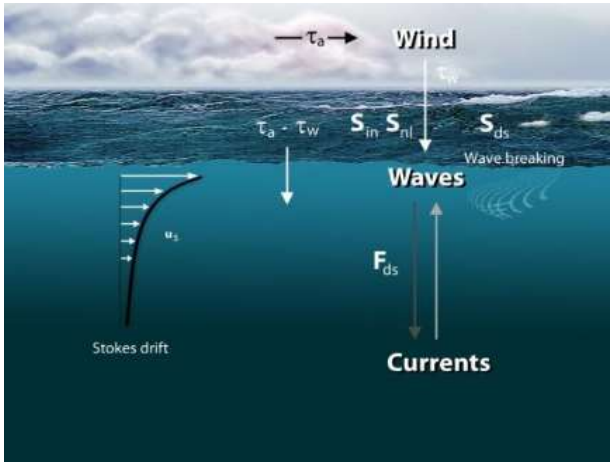
A. Melet

WAVE2NEMO

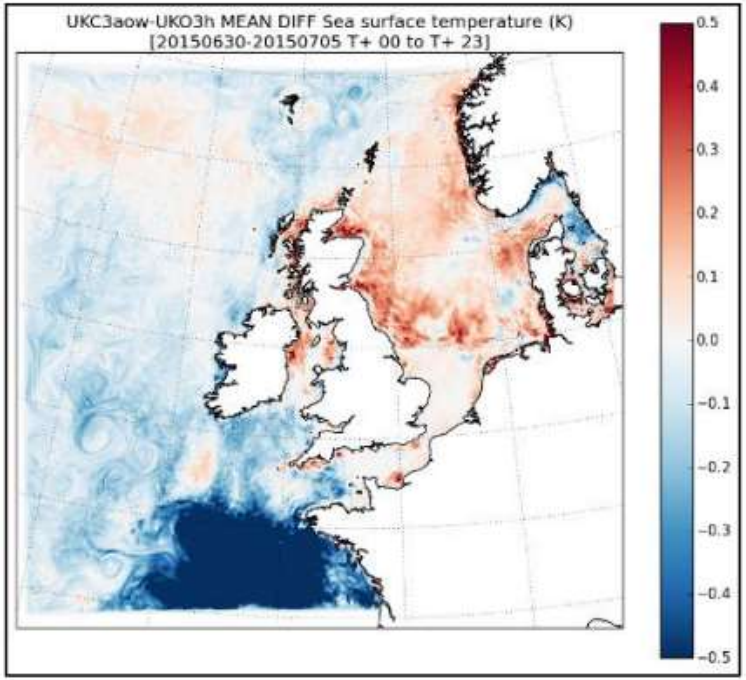
PI: J. Staneva, HZG



Time series of surge: observations (black circles), NEMO-only (red) and coupled model (green) at Helgoland station during storm Xaver in December, 2013 (Staneva et al., 2017).



Results from CMEMS SE R&D projects



Example change in simulated sea surface temperature (in degrees K) due to wave and atmosphere feedback processes at km- scale resolution over a few days in summer

Ocean-Wave-Atmosphere Interactions in Regional Seas (OWAIRS)

PI: H. Lewis, Met Office

Results from CMEMS SE R&D projects

A new ecosystem variable for marine resources sector

GREENUP: Green matrix uploaded

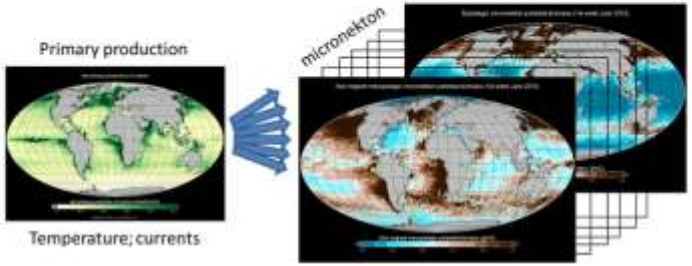
GREENUP proposes a new CMEMS product covering a key ecosystem component at the mid-trophic level (MTL), i.e., the micronekton, to better address the Marine Resources area of benefit.

The project objectives are :

- Model improvements
- Simulations with new CMEMS forcings
- Model validation and feedback on CMEMS products
- Tests and feedback from micronekton product users

CMEMS, Marine Copernicus

PI: P. Lehodey, CLS



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Impact of the first SE R&D projects on CMEMS

Addition of new products in CMEMS catalogue:

- Observations from European HF radars.
- Data on phytoplankton functional types
- Micronekton products

Upgrades of CMEMS operational modelling systems through:

- Enhanced representation of coupling effects (ocean-wave-sea-ice-atmosphere)
- Upgraded data assimilation capabilities of SST observations, of satellite derived phytoplankton functional types, of multi-platforms biogeochemical variables.
- Enhanced capabilities in regional ocean uncertainty quantification and model ensemble consistency verification to move toward ensemble assimilation capabilities.

In addition, CMEMS products have been analysed in several projects to lead to:

- Improved estimates of ocean surface currents through combined used of satellite altimetry and SST observations.
- Estimates of new derived variables (e.g. vertical velocities)

Tier-2 R&D

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2nd SE R&D Call – high level priorities

Five overarching themes & priority topics

Lot 1	**1 Ocean circulation modelling, mesoscale and other interactions, ocean-wave and ocean-ice coupling (R&D areas 1, 2, 3 and 4).**
	1.1 Predictability studies to assess the feasibility of developing open & coastal forecasts with lead-time of a few days to weeks, with assessment of prediction skill;
	1.2 Improved methods for analysing and predicting upper ocean currents;
	1.3 New methods to assimilate satellite sea ice observations (e.g. type, thickness, SAR imagery), together with impact assessments.
Lot 2	**2. Biogeochemistry and ecosystems in the marine environment (R&D area 5).**
	2.1 Improved modelling and assimilation capabilities for the representation of biogeochemistry and marine food web from primary production to higher trophic levels (plankton to fish), including estimations of uncertainty;
	2.2 Relationships between optical properties and biomass for direct assimilation of optical properties into biogeochemical models;
	2.3 Improving CMEMS monitoring and modelling products to better support aquaculture management applications.
Lot 3	**3. Interactions with the coastal ocean (R&D area 6).**
	3.1 Improved and standardised inputs of freshwater flows and river inputs of particulate and dissolved matter and homogenised river forcing approaches in models;
	3.2 Improve the interfaces/interactions between coastal monitoring and modelling systems and CMEMS.
Lot 4	**4. Ocean-atmosphere coupling, reanalysis and indicators, and climate change (R&D areas 7 and 8).**
	4.1 Advanced assimilation methods to provide improved estimations of upper ocean properties consistent with sea-surface observations and air-sea fluxes;
	4.2 Development of methods for inferring the future state (seasons to decades) of the marine environment (physics and biogeochemistry) at regional and coastal scales, as well as changes in ecosystems, based on climate model predictions and projections (and associated tests for quality and reliability);
	4.3 Development of Ocean Monitoring Indicators based on CMEMS and other products; specific needs include indicators (i) for the physical ocean state (ii) for the health of the ocean, (iii) for fishery and aquaculture management and (iv) for other applications (e.g. maritime transport, marine renewable energy).
Lot 5	**5. Cross-cutting developments on observation, assimilation and product quality improvements (R&D areas 9, 10, 11 and 12).**
	5.1 Metrics for ocean analysis/reanalysis and forecasting produced using ensemble techniques;
	5.2 Development and application of advanced assimilation methods, including to identify/understand model bias and forcing errors, with a focus on ocean reanalyses;
	5.3 New high resolution ocean colour products from Sentinel 2 and synergy with Sentinel 3 OLCI products.

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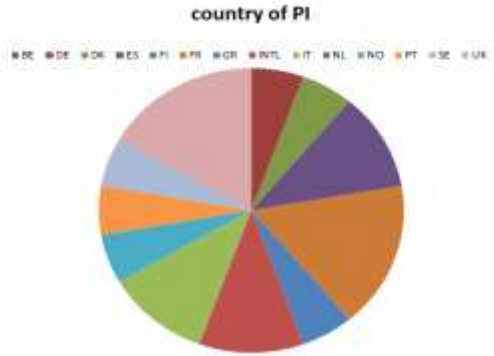
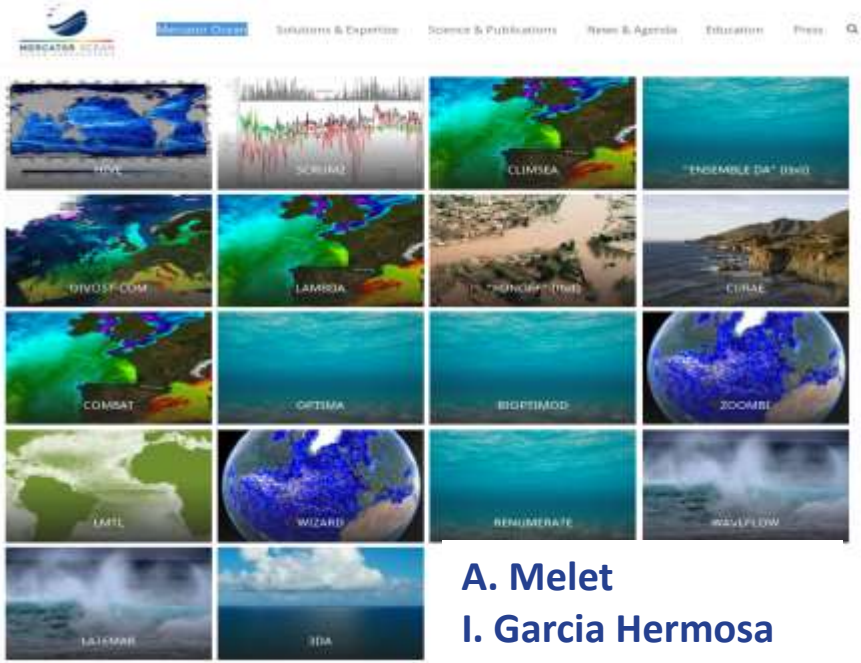
CMEMS Service Evolution R&D projects (Tier 2) 2nd Call

Evaluation of projects by the STAC in January 2018 after external reviews : 18 projects selected. Start in April 2018.

10 countries





A. Melet
I. Garcia Hermosa

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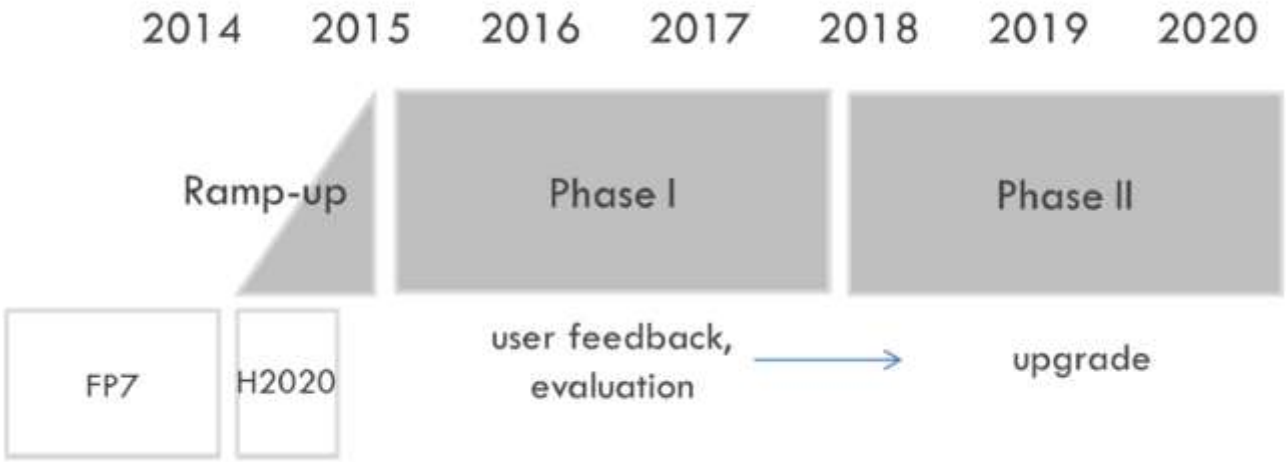
From CMEMS Phase I to CMEMS Phase II

Main objectives : ensure continuity of service, increase user uptake, continuous improvements, full uptake of Sentinel capabilities, upgrade of products and services based on phase I outcomes and user feedbacks.



CMEMS Phase I and Phase II from Technical Annex of the EU-Mercator Ocean Delegation Agreement for the implementation of the Copernicus Marine Service (2014)

Main foreseen evolutions /products (1)

Maritime transport and marine safety

- Improved models (resolution, tides), ocean/wave coupling.
- improved assimilation schemes.
- new observed surface current products.
- new ice products (thickness) and assimilation.

Biogeochemistry: ocean health monitoring and marine resource management

- Improved CMEMS biogeochemical (BGC) products (satellite, in-situ, models).
- Assimilation of ocean colour in all BGC models. Assimilation of BGC Argo.
- Carbon, CO2 fluxes and pH from in-situ observations and models.
- New micronekton products (off line).

Coastal : better meet requirements from coastal zone users

- Improving satellite products (e.g. OC), new in-situ observations (HF Radars)
- Improved models (e.g. resolution, tides) to facilitate the coupling with downstream coastal models.
- Strengthening interfaces with downstream coastal models.

Main foreseen evolutions /products (2)

Ocean and Climate

- Longer time series (> 30 years) for reprocessed observations and ocean reanalyses – closer to real time : Circulation, Sea Ice, Waves, Carbon (CO2) and biogeochemistry. Global/Regional.

Improved assessments (expertise)

- New Ocean Monitoring Indicators and Ocean State Reports: from climate to ocean health assessment and applications (e.g. fishery and aquaculture management, marine renewable energy).

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Longer term perspectives

Some of the identified issues for the post 2020 time period

- **Very high resolution** (e.g. 1/36° global, 1/108° regional) modelling (ocean & ice), new data assimilation methods (e.g. ensemble methods, probabilistic forecasting), extended range (e.g. one month).
- **Ocean/Wave/Atmosphere coupling** (for improved ocean analyses/forecasts)
- **Coastal :** operational interfaces with downstream coastal systems / coproduction with member states, joint offer from the Marine and Land Services.
- **Carbon / Biogeochemistry / Higher trophic levels** (up to fish) Improved modelling and assimilation capabilities for the representation of ocean biogeochemistry and the marine food web from primary production to higher trophic levels (plankton to fish)
- **Climate (Ocean)**: long term ocean reanalyses, long-term (seasonal/decadal) projections & scenarii for coastal ocean and ecosystems (in interaction with C3S).
- **Service / integrated platform** (DIAS new paradigm – follow up)

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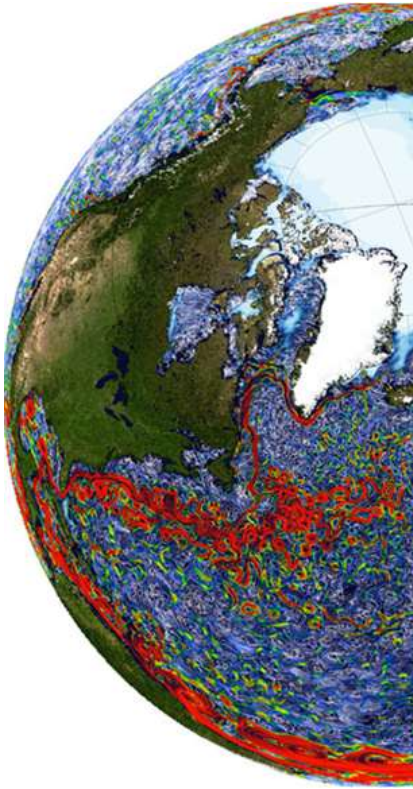
Conclusions

- **Copernicus Marine Service: a successful initial phase.** operational, user uptake, innovation and R&D achievements.
- A **service evolution strategy** based on user needs and science/technology advances.
- Maintaining **state of the art systems**, improving the offer and developing user base remain key issues.
- **Essential role of R&D activities** (Tier-1, 2 and 3) and establishing solid links with research community.
- **CMEMS Phase II (2018-2020)** = service **continuity and evolutions** based on R&D advances and evolution of observing systems (Sentinels).
- Strategy for the **post 2020 evolution** is being elaborated.



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