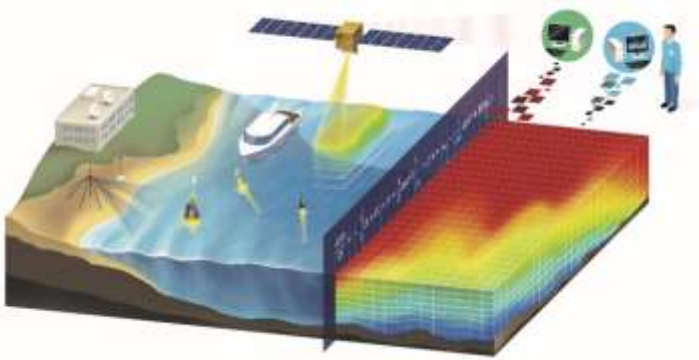
Use of SWOT data in the Mercator Ocean and Copernicus Marine global and regional forecasting systems

P.Y. Le Traon, M. Benkiran, E. Remy, Mercator Ocean International
Y. Faugère, CLS/CNES, G. Dibarboure, CNES

SWOT Applications workshop - December 7&8 2023

Mercator Ocean International updates

Ocean Prediction Center - about 120 people



- Collaboration French institutions / Operational Oceanography (CNRS, Ifremer, IRD, Météo-France, SHOM). 1997.
- New European shareholders (Italy/ CMMC & CNR, Spain / Puertos , UK / Met Office, Norway / Nansen) in 2017. Germany (Hereon) in 2024.
- **Transformation into an IGO in 2025**.

- EU Entrusted Entity for the implementation of the **Copernicus Marine Service** (2014-2021). Agreement renewed in July 2021 for 2021-2028.
- In charge for the EC of the European offices of the G7 FSOI and GEO Blue Planet (2020-2023). New agreement from 2023 -2027.
- In charge of the development of the first EU Digital Ocean Twin. 2022. Two projects EDITO Infra and EDITO model lab from end of 2022.
- UN Decade Collaborative Centre for Ocean Prediction. Agreed in 2022. First year in 2023.

Copernicus Marine Service

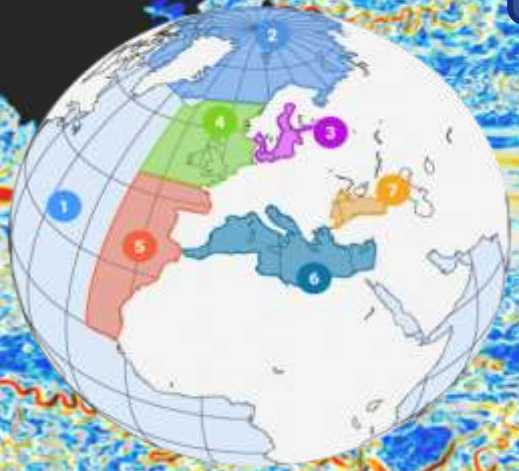
The EU Copernicus Marine Service

Global & Regional Ocean Monitoring and Forecasting

MULTI-YEAR
10 to 45 years

REAL-TIME
Daily, hourly

FORECAST
2 to 10 days



ESSENTIAL OCEAN VARIABLES

BLUE OCEAN	WHITE OCEAN	GREEN OCEAN
Physics	Sea Ice	Biogeochemistry

OBSERVATIONS
In situ & Satellites

NUMERICAL MODELS
& data assimilation

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

marine.copernicus.eu

Free and Open

LARGE UPTAKE FROM ALL SECTORS

1. POLAR ENVIRONMENT MONITORING
2. CLIMATE & ADAPTATION
3. OCEAN HEALTH
4. MARINE CONSERVATION & BIODIVERSITY
5. SCIENCE & INNOVATION
6. POLICIES & OCEAN GOVERNANCE & MITIGATION
7. EDUCATION, PUBLIC HEALTH & RECREATION
8. EXTREMES, HAZARDS & SAFETY
9. MARINE FOOD
10. COASTAL SERVICES
11. TRADE & MARINE NAVIGATION
12. NATURAL RESOURCES & ENERGY

- ❑ 64,000 subscribers
- ❑ Web site: 750,000 single visitors/year

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Copernicus Marine Service and SWOT

- **Copernicus Marine Service**: a long term EU capability for global and regional ocean monitoring and forecasting. A strong user base (> 64,000 registered users).

- The integration of SWOT data in Copernicus Marine Service will allow demonstrating its impact for a wide range of ocean applications.

- Main **contribution of SWOT will be to constrain model at small scales (< 150-200 km) through data assimilation**.

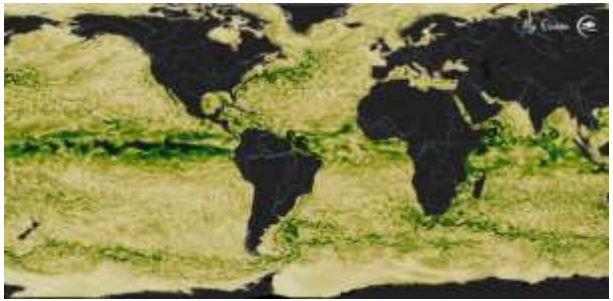
- Most impacted fields will be surface and upper layer velocities => improved ocean currents, better positioning of fronts => impact for **marine safety, pollution monitoring, ship routing, offshore industry, coastal applications.**

Developing an Effective assimilation of SWOT data in Mercator Ocean Systems-II (DESMOS-II)

Principal Investigator: P.Y. Le Traon, Mercator Ocean International

Co-Investigators: M. Benkiran, Mercator Ocean International, Y. Faugère, CLS

- Prepare the assimilation of SWOT in Mercator Ocean and Copernicus Marine Service models. Use of OSSEs with global and regional models and an end-to-end SWOT simulator that includes high level data processing steps such as intercalibration with conventional altimeters.



- Perform data assimilation tests in regional configurations with data from the fast sampling phase (1 day repeat phase).
- Assimilation of SWOT data in its nominal phase (21 day repeat) in an offline mode.
- Near real time demonstration in Spring 2024 and if successful include SWOT data in operational Mercator Ocean and Copernicus Marine systems in 2025.

SWOT SDT DESMOS-II project (2020-2024) (+2 year extension required)

The main objective of the MOi and CLS DESMOS-II proposal was to prepare the assimilation of SWOT data in Mercator Ocean and Copernicus Marine Service high resolution ocean models, to contribute to SWOT Cal/Val activities and to perform the first tests of assimilation of real SWOT data.

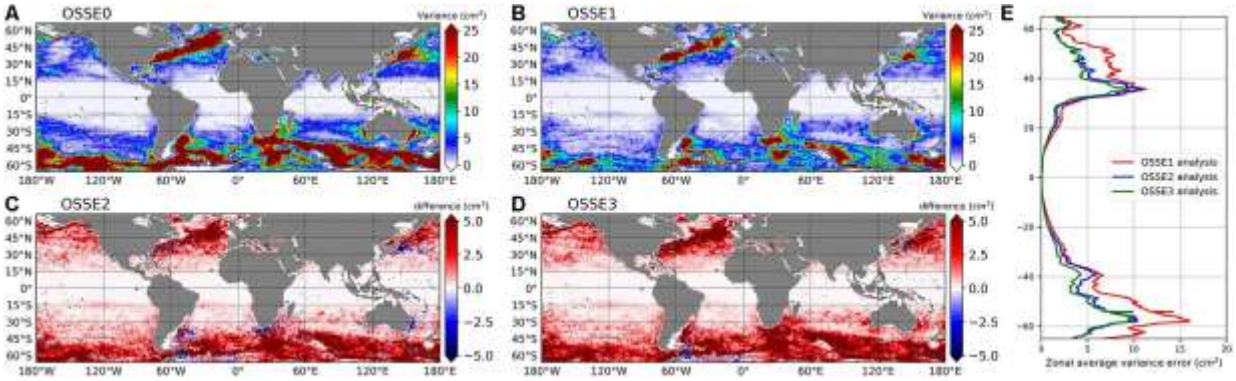
1. Task 1: Design of advanced calibration methods to generate L3 DUACS SWOT products.
2. Task 2: Prepare the assimilation of SWOT data into high resolution ocean models and assess the impact of SWOT data on representation and prediction of mesoscale/submesocale ocean dynamics.
3. Task 3: Characterization of tidal signals, balanced/non-balanced signals in a 1/36° global model.
4. **Task 4: Analysis of first data from the SWOT mission during its fast-sampling phase and contribution to the SWOT Cal/Val phase.**
5. **Task 5: Assimilation of SWOT data during its fast sampling and its 21-day phases.**

Tasks 1 and 2 are almost completed. Task 3 is ongoing. Global simulation at 1/36° with and without tides produced. Analyses are ongoing.

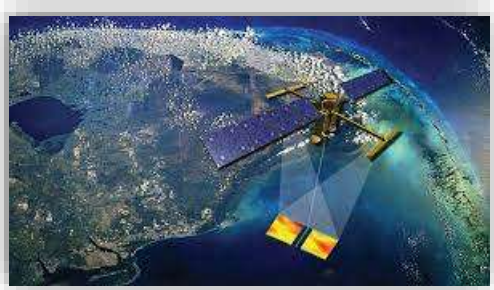
Task 4 started in September 2023 and Task 5 just started in November 2023 and will continue in 2024 and 2025. Near real time demonstration planned in Spring 2024. Integration of SWOT in operational systems (MOi and Copernicus Marine) in 2025.

Assessing the impact of future observations
Observing System Simulation Experiments

Impact of the future SWOT mission on the 1/12° Mercator Ocean global ocean analysis and forecasting system (Benkiran et al., 2021; Tchonang et al., 2021)



Sea level error (in cm^2) for mesoscale structures at wavelengths < 200 km. **Adding SWOT (OSSE3) in addition to 3 nadir altimeters (OSSE1) reduces errors up to 40 % outside tropical areas**.



ORIGINAL RESEARCH article

Assessing the Impact of the Assimilation of SWOT Observations in a Global High-Resolution Analysis and Forecasting System Part 1: Methods

ORIGINAL RESEARCH article

Assessing the Impact of the Assimilation of SWOT Observations in a Global High-Resolution Analysis and Forecasting System – Part 2: Results

SWOT in Copernicus Marine Service / plans

SWOT data in Copernicus Marine => Sea Level Thematic Assembly Center (TAC) (DUACS) and Modelling and Forecasting Centers (MFCs) (global and regional).

SWOT demo data products target in DUACS - (L3 products) (end of 2023)

SWOT demo model (global forecasts) products Mercator Ocean – Spring 2024

SWOT data (Karin) integrated in the operational Copernicus Marine service portfolio

Observation products (Sea Level TAC) – 2024 (demo) - 2025

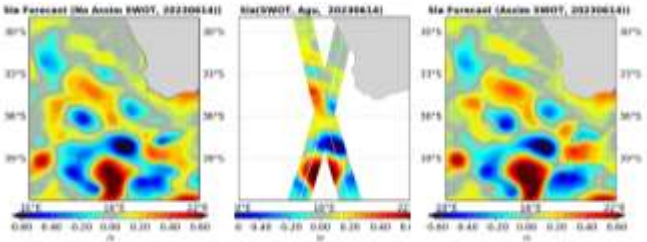
Model products (MFCs) – end of 2025.

Initial results – 1 day phase

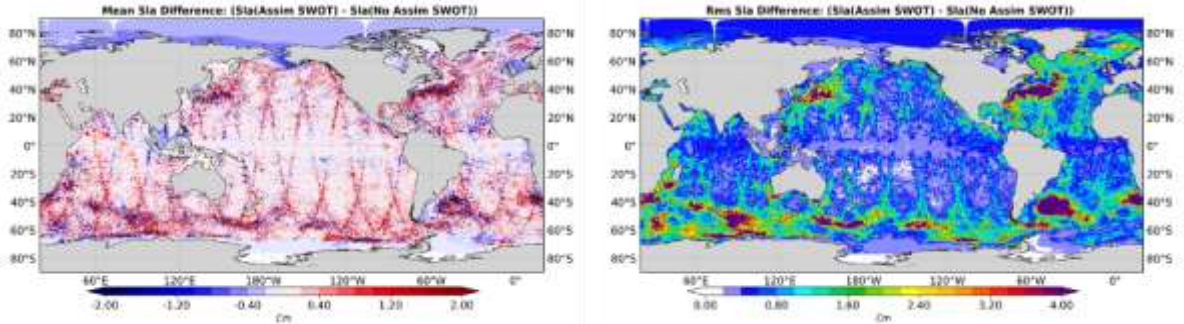
Impact of the SWOT 1-Day phase data on the 1/12° Mercator Ocean global ocean analysis and forecasting system

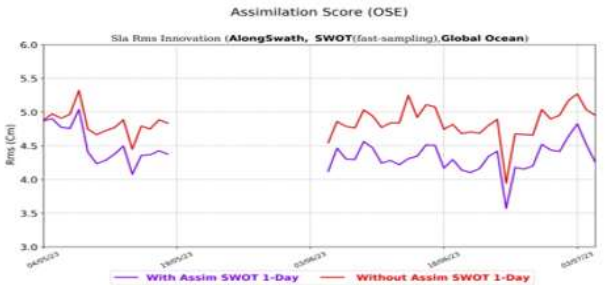
OSE1 : SST (ODYSSEA,1/10), Temperature and Salinity profiles and SLA from altimeters (c2n, h2b, j3n, s3a, s3b, s6a_hr, SWOT(1-Day, **not assimilated**),Saral/altika **(not assimilated for validation)**)

OSE2 : SST (ODYSSEA,1/10), Temperature and Salinity profiles (and SLA from altimeters (c2n, h2b, j3n, s3a, s3b, s6a_hr, SWOT(1-Day **assimilated**), Saral/altika **(not assimilated for validation)**)



SLA Difference : Sla (**with** Assim SWOT) – Sla (**Without Assim** SWOT), May and June 2023



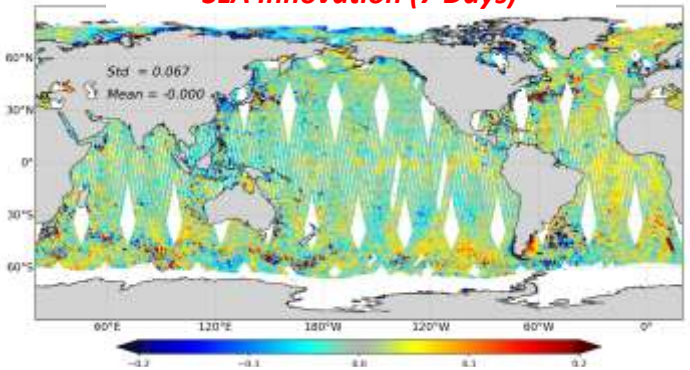


The model propagates information (from 1-day SWOT) both under the swaths and outside the swaths

Initial results – 21 Day phase

Impact of SWOT 21-day phase data on the 1/12° Mercator Ocean global forecasting system

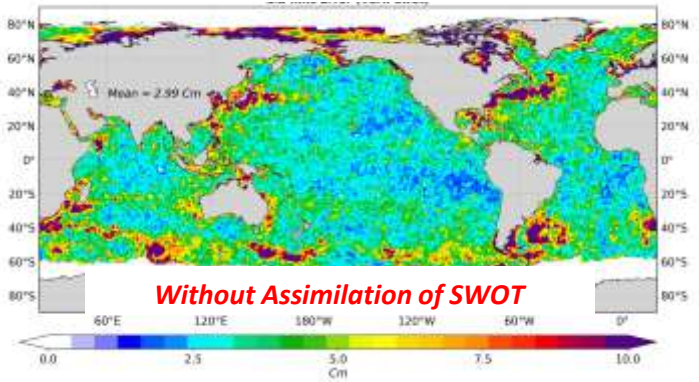
SLA Innovation (7 Days)



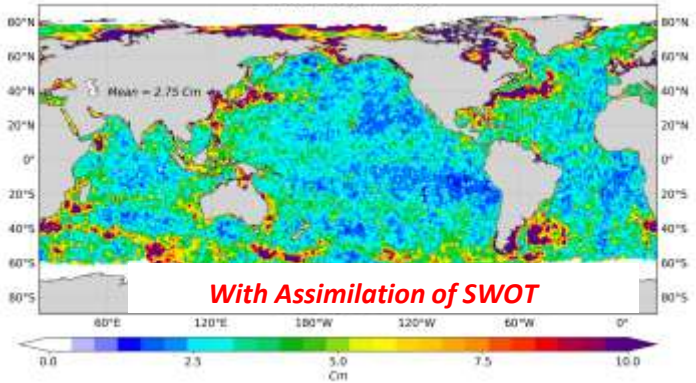
OSE: global Copernicus Marine/MOi forecasting system with and without SWOT data over 1 month (all other conventional altimeter assimilated, SST + in-situ)

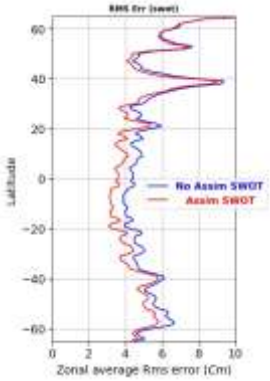
These very first results show already a promising improvement of the quality of ocean forecasts (gain : 15%).

SLA Rms Error (1 month)



SLA Rms Error (1 month)





Summary

- Copernicus Marine Service: a long term EU capability for ocean monitoring and forecasting. A successful integration of SWOT data in Copernicus Marine Service will allow demonstrating its usefulness and impact for a wide range of ocean applications.
- Preparatory works (CLS, MOi) have been carried out in partnership with CNES
- Demonstration of the impact of SWOT for the MOi and Copernicus Marine on going. Very positive preliminary results. Use of L3 CNES products (developed as part the of DESMOS-2 project).
- Near real time demonstration planned in Spring 2024. Operational implementation in the Copernicus Marine portfolio to follow (2025+).