MER-EP

(Marine Environment Reanalyses – Evaluation Project)

SynObs workshop 23-25/08/2026



Outlines

MER-EP: project presentation

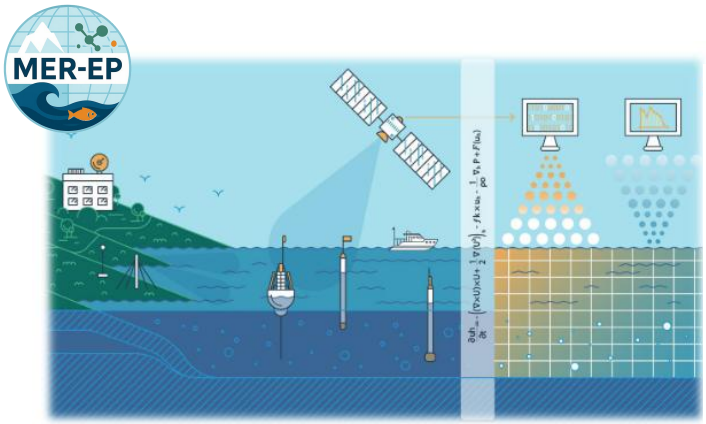
MER-EP: short overview of progress of some use cases

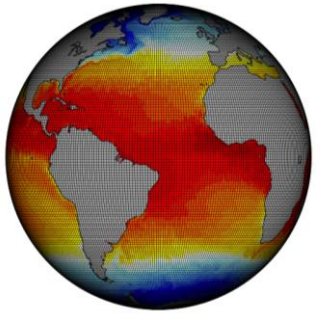
Links between MER-EP and SynObs

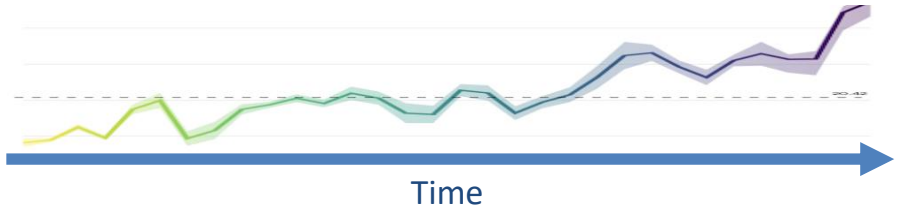
Ocean reanalyses

Reconstruction 3D of ocean state over last decades by using a combinason (DA) of osberved data (insitu & sattelite) and numerical models.

! Main difference with objective analysis: numerical models to fill the non-observed areas and propose a solution dynamicaly consistant with physics !







Various ocean reanalysis:

- Physical ocean, sea ice, BGC and higher trophic levels
- Coupling between components
- Global or regional domain

=> Numerical models and ocean observations are mandatory

History of ocean reanalyses intercomparison

2006… CLIVAR/GSOP workshop

2010… Firsts Ocean Reanalyses Intercomparison Projects: ORA-IP, EOS COST, GSOP

2020… The Ocean Monitoring Indicators (OMIs) : an ORA-IP heritage

2023 The Ocean Reanalyses Workshop of the Copernicus Marine Service

2025-2029 A new intercomparison exercise: **MER-EP**



MER-EP: an User Oriented Evaluation

MER-EP :

An international initiative to evaluate marine environment reanalyses to better use their potential for ocean and climate monitoring and prediction

By sharing “best practices” derived from the studies and use cases:

- **Guidelines** on how to use reanalyses
  - for monitoring the state of the ocean
  - for training AI forecasting models
  - as environmental forcing for ecosystem models
  - …
- **Methods and tools** to handle the data (Copernicus Marine Service EDITO)

MER-EP as a UN decade project

- **A project endorsed under the ForeSea and DITTO programmes of the United Nations Decade**

- **An international collaboration framework** with no direct funding, in kind contributions from international partners

- PIs: Drévillon Marie & Bourdallé-Badie Romain (MOi); Yang Chunxue (CNR)

- Programs which support MER-EP initiative:

MER-EP: a collaborative effort



Consiglio Nazionale delle Ricerche

JAMSTEC

MERCATOR OCEAN INTERNATIONAL

ACRI ST

cmcc Centro Euro-Mediterraneo sui Cambiamenti Climatici

Copernicus Marine Service

ECMWF

Met Office

Massachusetts Institute of Technology

CLS COLLECTE LOCALISATION SATELLITES

NERSC NANSENSENTERET

magellium artal group

universität wien

LIÈGE université

UNIVERSITY OF MARYLAND 18 56

Environment Canada

OGS

Australian Government Bureau of Meteorology

hcmr ΕΛΚΕΘΕ

METEO FRANCE

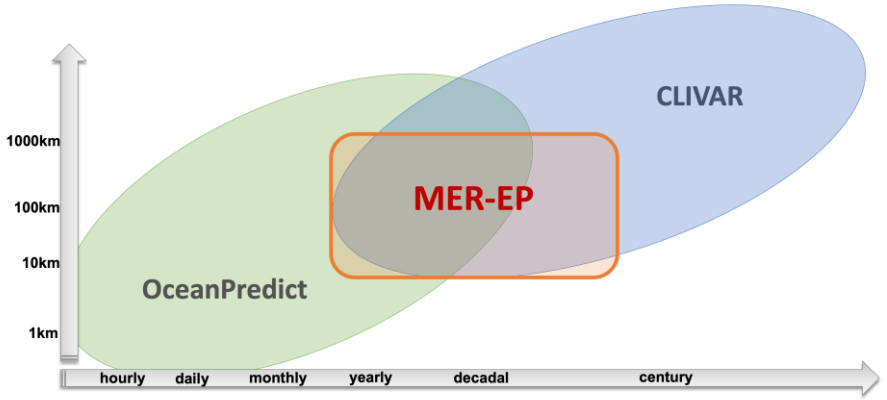
IRD Institut de Recherche pour le Développement FRANCE

CSIRO

University of Reading

MER-EP: area of studies

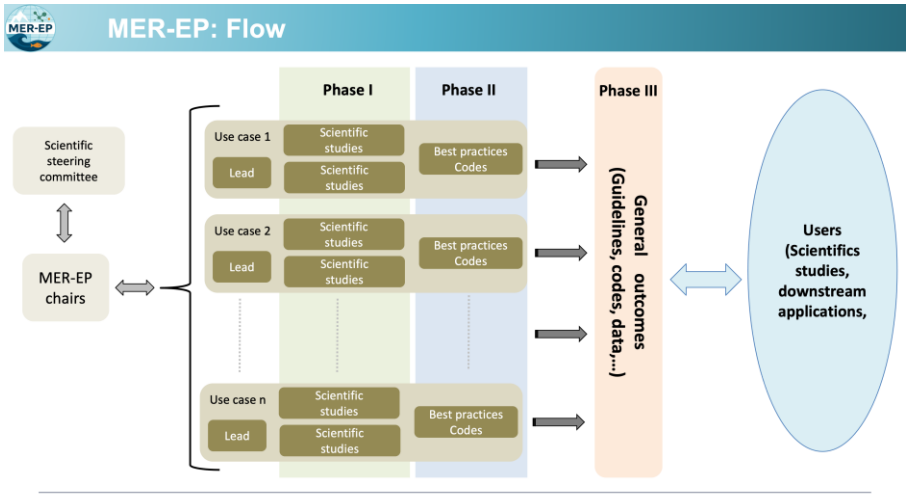
- MER-EP at the frontier between OceanPredict and CLIVAR actions
- From global to regional approaches
  - Regional estimates could be compared to global reanalyses on common area for OMI
  - Regional rea. could propose studies on local specificities
- From monthly to decadal time scales
- Physical ocean (temperature/salinity/dynamic/wave), sea ice (concentration/thickness, velocity, snow,..), marine ecosystem (Chlorophyl, O2,… low and high trophic levels)



MER-EP areas of studies

MER-EP: flow

- People/institutes interested to join this international effort are **still welcome**.
- Table of existing “use cases” available online
- scientific steering committee to supervise MER-EP
- How MER-EP will proceed for each use cases:
  - Groups of institutes addressing a use case.List data needed (a maximum of worldwide products should be considerate **not only own product**)
  - Specific validation studies performed and **published** Data/code sharing (EDITO, cloud facilities,…)
  - Working on downstream applications using reanalysis or recommendations for best practices. Exchange on how to better address user requirements



Scientific steering committee

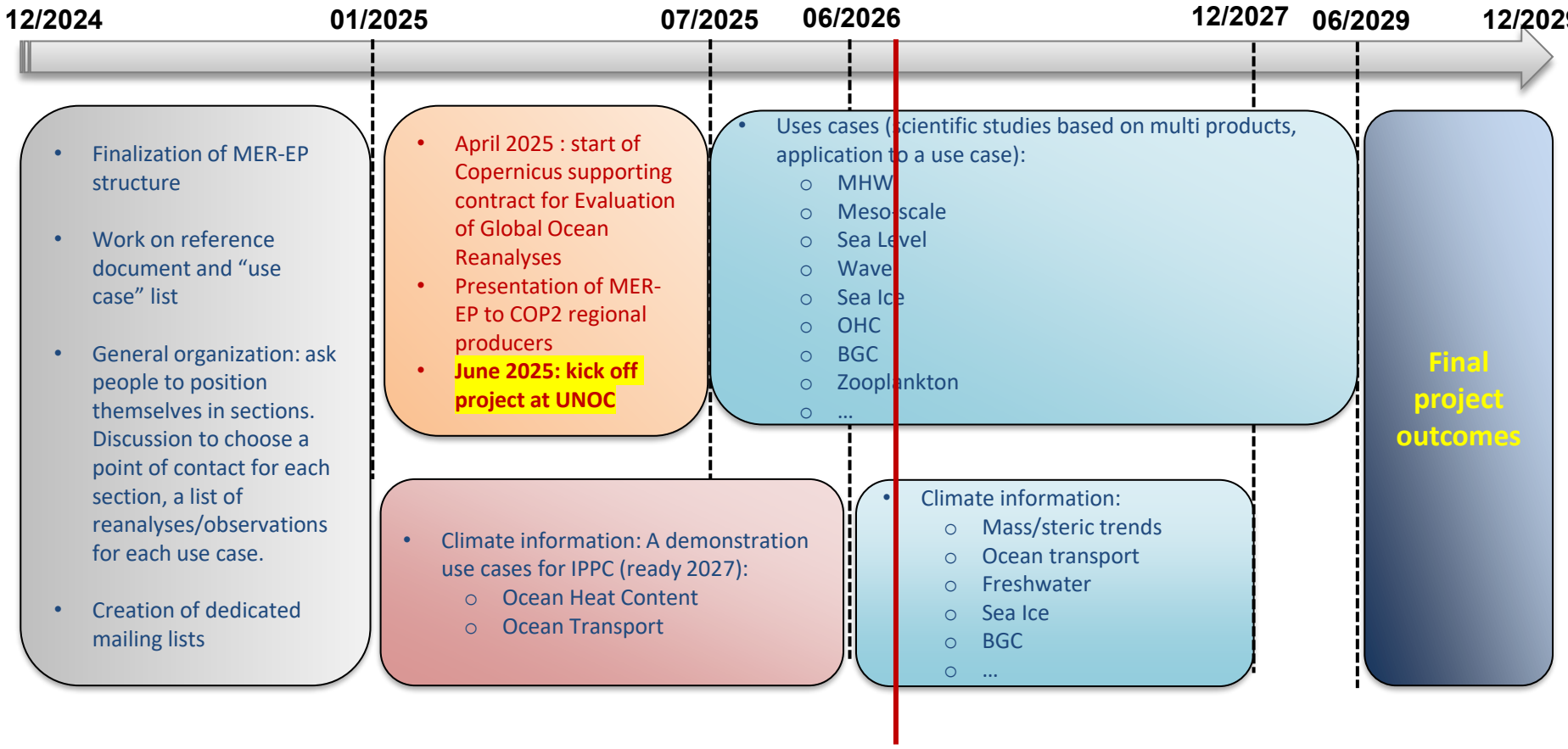
Scientific Steering committee:

- Composed of individuals with strong experience and a high scientific level. Ensures diversity in expertise, as well as geographical and human representation.
- Role:
  - Monitors the progress and evolution of use cases.
  - Provides advice on possible directions and future developments.
  - Identifies potential needs of related projects or initiatives.
  - Contributes to summarizing and formulating guidance.

Surname	First name	Affiliation (Project)
Bourdallé-Badie	**Romain**	**MOi/France (MER-EP PI)**
Drévillon	**Marie**	**MOi/France (MER-EP PI)**
Yang	**Chunxue**	**CNR/Italia (MER-EP PI)**
Forget	Gaël	MIT/USA
Fujii	Yosuke	MRI-JMA/Japan
Martin	Matthew	MetOffice/UK
Oke	Peter	CISRO/Australia
Magdalena	Balmaseda	ECMWF, U. Reading/ UK
Gokhan	Danabasoglu	NCAR/USA
Samuelsen	Annette	NERSC/Norway
Cheng	Lijing	IAP/China

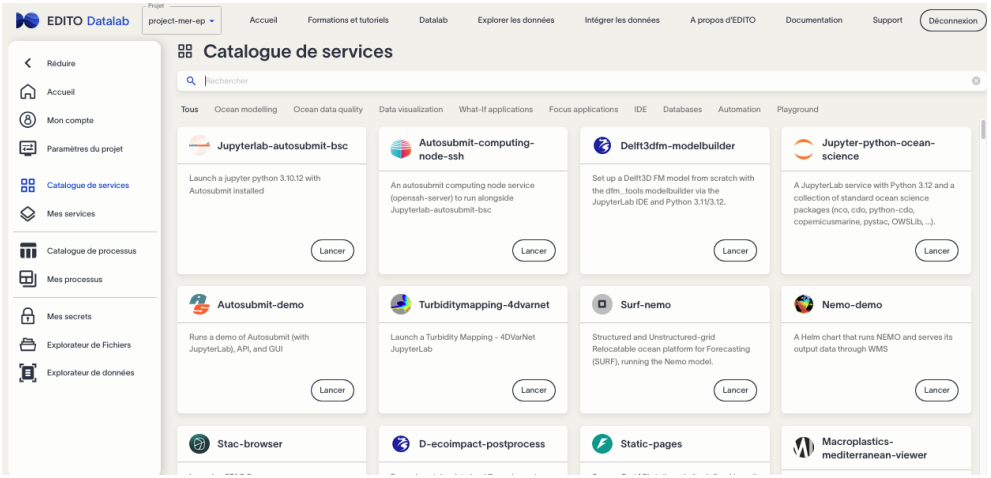
MER-EP Scientific steering committee (August 2026)

Schedule


12/2024
01/2025
07/2025
06/2026
12/2027
06/2029
12/2029
Finalization of MER-EP structure
Work on reference document and "use case" list
General organization: ask people to position themselves in sections. Discussion to choose a point of contact for each section, a list of reanalyses/observations for each use case.
Creation of dedicated mailing lists
April 2025 : start of Copernicus supporting contract for Evaluation of Global Ocean Reanalyses
Presentation of MER-EP to COP2 regional producers
June 2025: kick off project at UNOC
Uses cases (scientific studies based on multi products, application to a use case):
MHW
Meso-scale
Sea Level
Wave
Sea Ice
OHC
BGC
Zooplankton
...
Final project outcomes
Climate information: A demonstration use cases for IPPC (ready 2027):
Ocean Heat Content
Ocean Transport
Climate information:
Mass/steric trends
Ocean transport
Freshwater
Sea Ice
BGC
...

Sharing data & code: EDITO & Git

- EDITO:
  - “mer-ep” project has been created on EDITO (EDITO datalab)
  - Each user can request an account associated with this project.
  - All Copernicus Marine data are available.
  - Access to data on the **native grid** and **non-Copernicus data** is currently under development/investigation.



EDITO dataLab

- GitHub:
  - Dedicated repository just created
  - First accounts delivered only on mer-ep participants (on request)

Possible link to CMIP exercise

- **Reference material:** Current diagnostics and datasets available in the CMIP Rapid Evaluation Framework.
- **MER-EP goal:** Propose new diagnostics and/or reference datasets.
- **Timeline:** Submission in 2026; associated publication accepted before March 2027.
- **Candidate variables:** OHC (Ocean Heat Content) and ocean transports.
- **Dataset proposal:** To be submitted to the Obs4MIPs Steering Panel (datasets to be defined).
  Preparation: Use CMOR or produce CMOR-like datasets following ODS2.6 standards.

Diagnostic collections including reference datasets

The CMIP Model Benchmarking Task Team, through consultation with the CMIP modelling community, have collected a set of informative diagnostic collections for five different climate model themes. for CMIP Assessment Fast Track model evaluation



Oceans & Sea ice - 6 diagnostic collections, 6 reference datasets

	Diagnostics	Reference datasets
1.1	Antarctic annual mean, Arctic September rate of sea ice area (SIA) loss per degree warming (dSIA / dGMST)	OSI SAF/CCI, HadCRUT
1.2	Atlantic meridional overturning circulation (AMOC)	RAPID-v2023-1
1.3	El Niño Southern Oscillation (ENSO) diagnostics (lifecycle, seasonality, amplitude, teleconnections)	CMAP-V1902, TropFlux-1-0, AVISO-1-0, ERA-5, GPCP-SG-2-3, HadISST-1-1
1.4	Sea surface temperature (SST) bias, Sea surface salinity (SSS) bias	WOA2023
1.5	Ocean heat content (OHC)	MGOHCTA-WOA09
1.6	Antarctic & Arctic sea ice area seasonal cycle	OSISAF-V3

Progress of some use cases

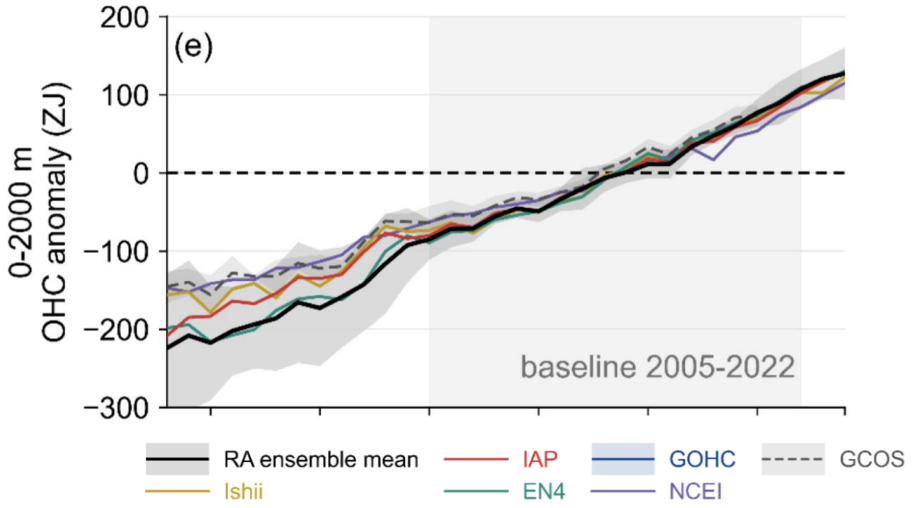
Example of use cases: OHC (Zhang et al. in prepa.)

Table 1 Overview of the different objective analysis and reanalysis products used in MER-EP

Product	Institution	Configuration	Resolution	Max. Latitude	Year used	Assimilation method	Reference
Objective Analysis products							
IAPv4	IAP/CAS		1°; 119 levels to 6000 m	90° N	1993-2024	EnOI-DE	Cheng et al. (2024)
EN4	Met Office Hadley Centre		1°; 42 levels to 5350 m	90° N	1993-2024	OI	Good et al. (2013)
Ishii	MRI/JMA		1°; 26 levels to 2000 m;	90° N	1993-2024	3DVAR OA	Ishii et al. (2017)
NCEI	NOAA		1°; 26 levels to 2000 m	90° N	1993-2024	Barnes OA	Levitus et al. (2012)
GOHC	Mercator Ocean		time series only	90° N	1993-2024		Miniere et al. (2026)
GCOS	Mercator Ocean		time series only	60° N	1993-2022		von Schuckmann et al. (2023)
Reanalysis products							
GloSea5	UK Met Office	NEMO3.4	1/4°; 75 levels to 5902 m	90° N	1993-2020	NEMOVAR DA	MacLachlan et al. (2015)
GLORYS4v2	Mercator Ocean	NEMO3.1	1/4°; 75 levels to 5902 m	90° N	1993-2023	SAM multiv. DA	Lellouche et al. (2013)
ESTOC	JAMSTEC	MOM3	1°; 46 levels to 5525 m	79.5° N	1993-2022	Adjoint 4DVAR	Osafune et al. (2015)
C-GLORSv8	CMCC	NEMO4.2	1/4°; 75 levels to 5902 m	90° N	1993-2023	OceanVar 3DVAR-FGAT	Selivanova et al. (2026)
BRAN2023	CSIRO	OFAM3	1/10°; 51 levels to 4509 m	75° N	1993-2023	BODAS EnOI	Chamberlain et al. (2021)
C-GLORSv7	CMCC	NEMO3.4	1/4°; 75 levels to 5902 m	90° N	1993-2024	OceanVar 3DVAR-FGAT	Storto et al. (2016)
ECCO-Cube92	MIT	MITgcm	1/4°; 50 levels to 5906 m	90° N	1993-2024	LS-4D OSE	Menemenlis et al. (2008)
GLORYS12v1	MOI	NEMO3.1	1/12°; 50 levels to 5728 m	90° N	1993-2024	SAM2 ROKF/3DVAR	Lellouche et al. (2021)
GLORYS2v4	MOI	NEMO3.1	1/4°; 75 levels to 5902 m	90° N	1993-2024	SAM2-SEEK	Lellouche et al. (2013)
SODA3	University of Maryland	MOM5	1/4°; 50 levels to 5395 m	90° N	1993-2024	SeqDA	Carton et al. (2018)
CIGAR1	CNR-ISMAR	NEMO4	1°; 75 levels to 5902 m	90° N	1993-2024	3DVAR + LSBC	Storto and Yang (2024)
CIGAR025	CNR-ISMAR	NEMO4	1/4°; 75 levels to 5902 m	90° N	1993-2024	3DVAR + LSBC	Storto and Yang (2024)
ORAS5	ECMWF	NEMO3.4	1/4°; 75 levels to 5902 m	90° N	1993-2024	NEMOVAR 3DVAR-FGAT	Zuo et al. (2019)
GODAS	NOAA	MOM.v3	1/3°; 40 levels to 4478 m	64.5° N	1993-2024	3DVAR	Huang et al., (2008)

- A large amount of data was intercompared over the 1993–2022 period
- RAs and OAs ensemble means are nearly identical.
- Uncertainty is reduced after 2005

OHC trend over 1993-2024

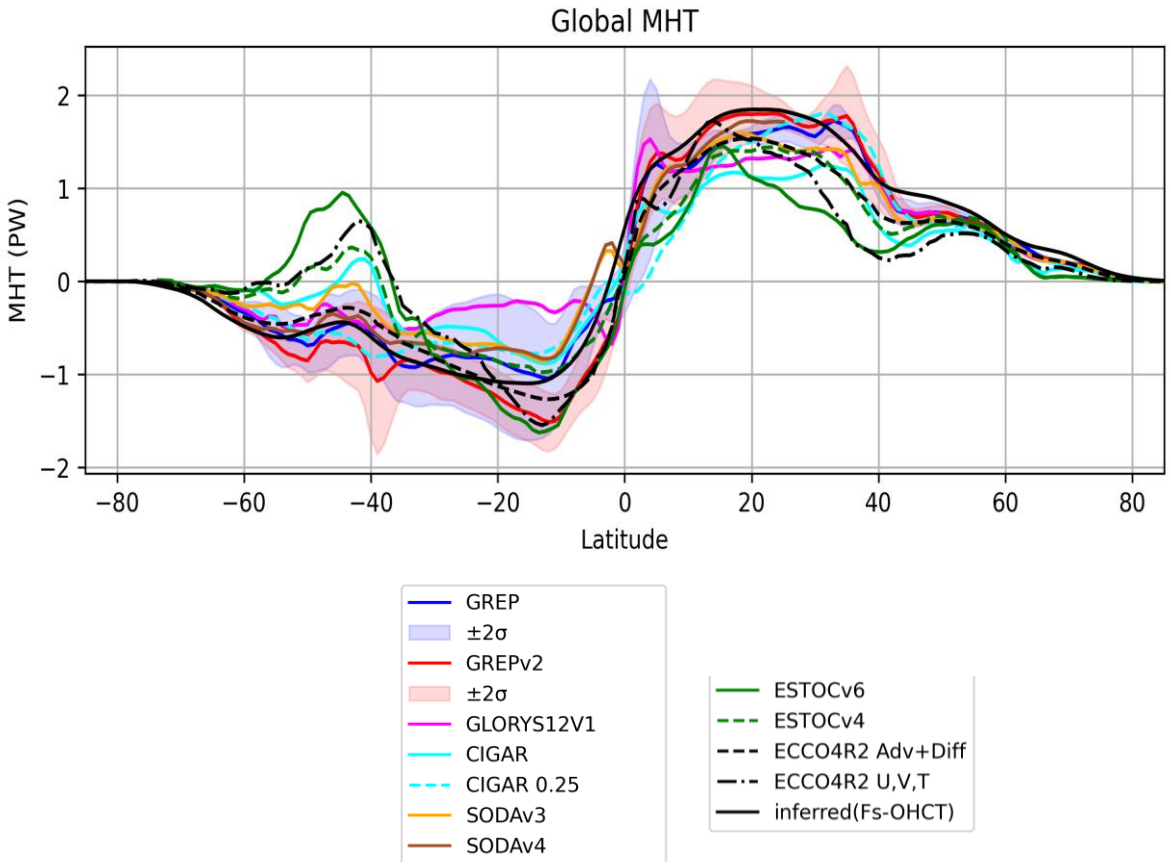


=> What is the impact of observation network pre and during Argo period?

Example of use cases: Ocean Heat Transport (Winkelbauer et al. in prep.)

- Multi-product intercomparison and comparison with indirect estimates
- Large-scale structure of MHT ok in most products but…
- Substantial spread across some products!
- Comparison with **inferred** MHT from the energy budget

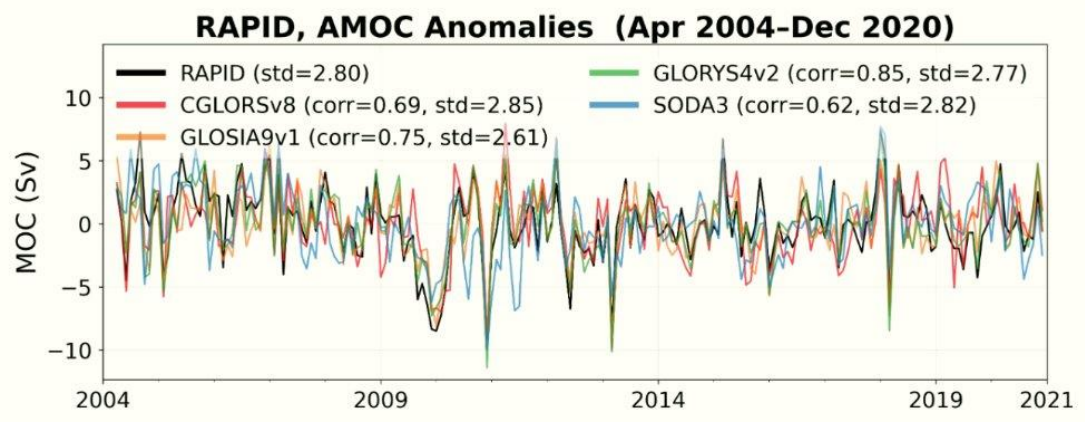
  - **OHCT**: ocean reanalysis, IAPv4, RFROM, MOHeaCAN
  - **Fs** (inferred): ERA5, JRA3Q, MERRA2
  - **MET**: GIOMAS, ocean reanalysis

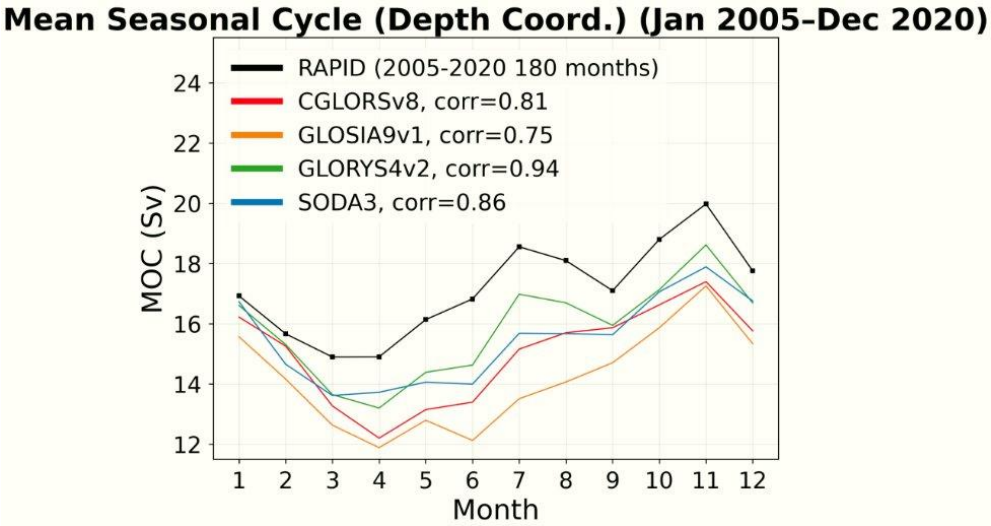


=> What is the sensitivity of the solution to observation network?

Example of use cases: AMOC

- AMOC of future reanalysis products compare to AMOC estimation of RAPID data
- Generally good AMOC variability both seasonally and at lower and higher frequencies
- In future addition of more reanalysis: disentangle impact of model, data assimilation, assimilated data, forcing



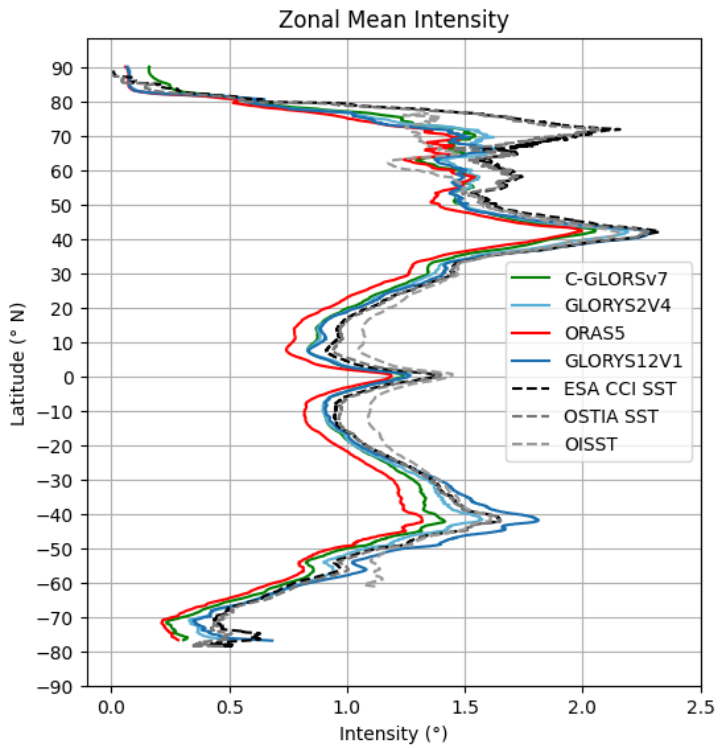


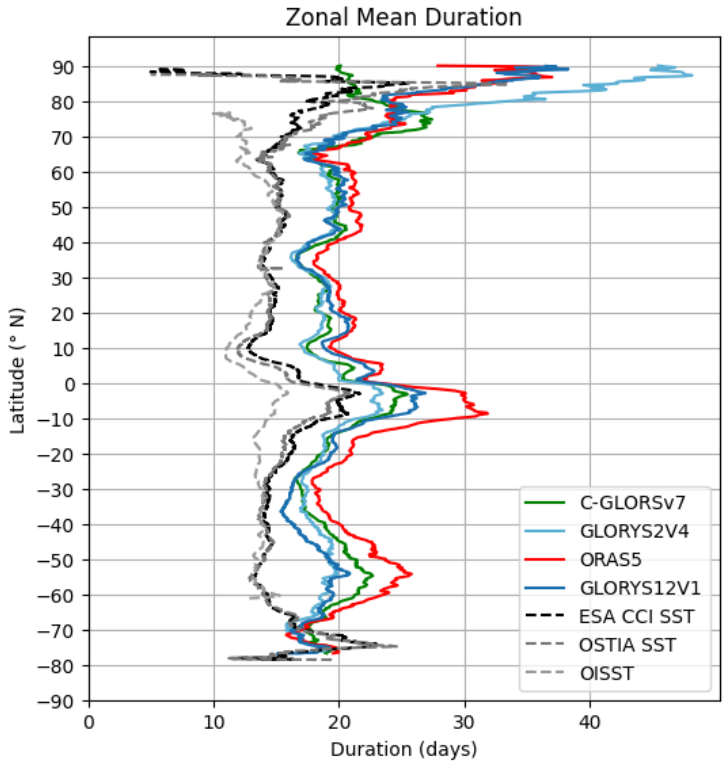
=> To what extent is the AMOC constrained by in situ observations?

Example of use cases: Marine Heat Wave

"Biases" in Surface MHW Characteristics

- Reanalyses MHW less intense but longer compare to observations
- Highlight regions with greatest issues in representations: polar regions, WBCs (not shown)



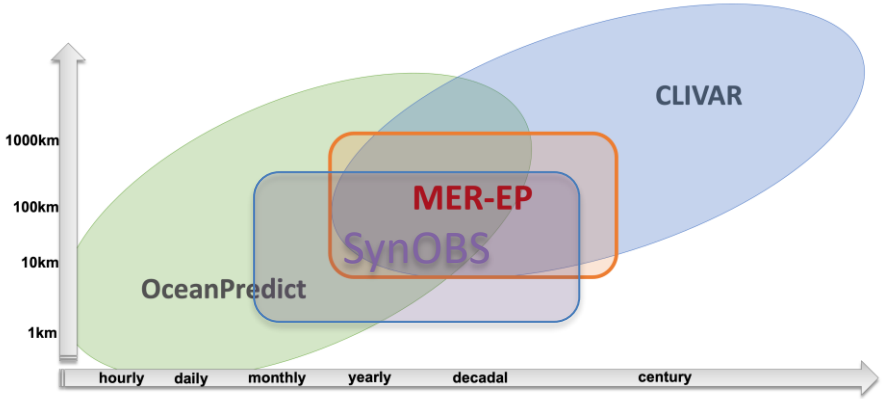


=> Impact of the ratio noise/signal in SST observation ? Are the reanalysis too smooth?

Links between MER-EP and SynObs

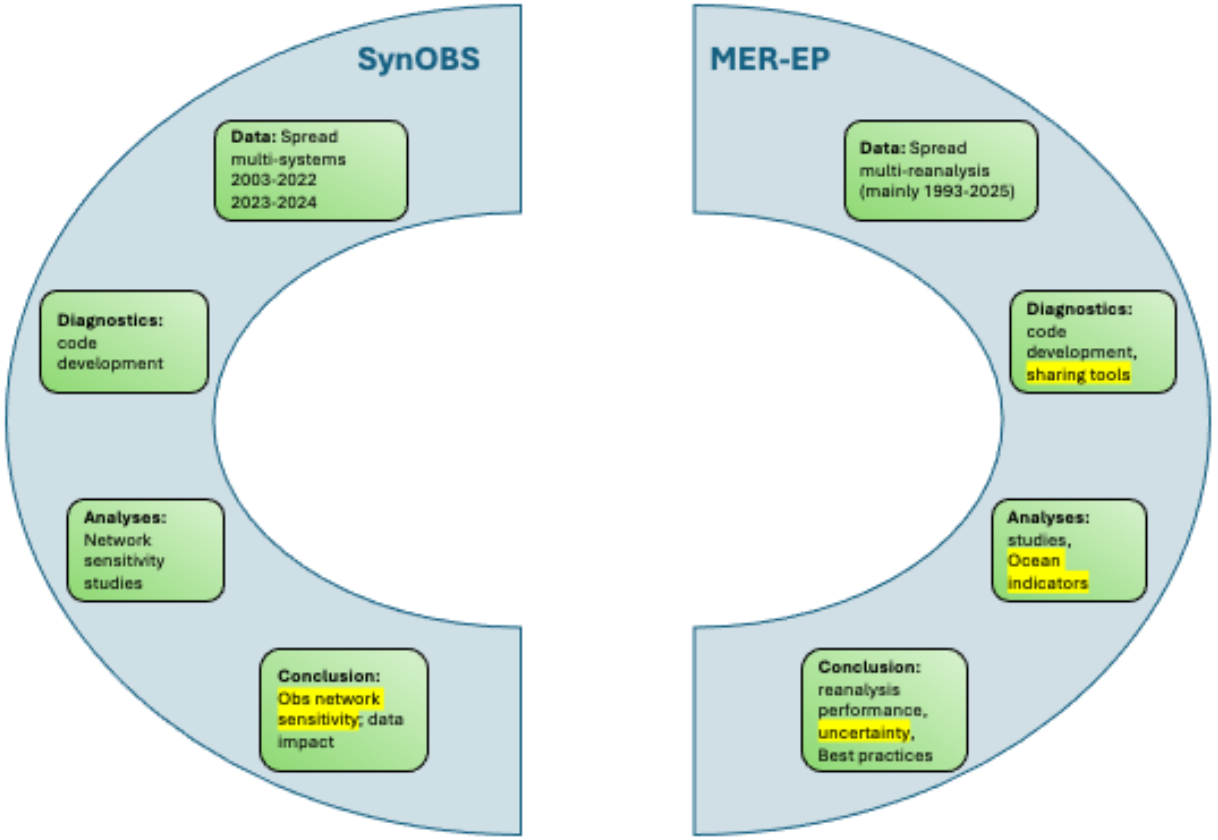
Link with SynObs?

- Strong overlap between the scientific scope of SynOBS and MER-EP
- Both projects bridge OceanPredict and CLIVAR
- SynOBS has a stronger operational focus, while sharing similar temporal and spatial scales with MER-EP



MER-EP & SynOBS areas of studies

Link with SynObs?



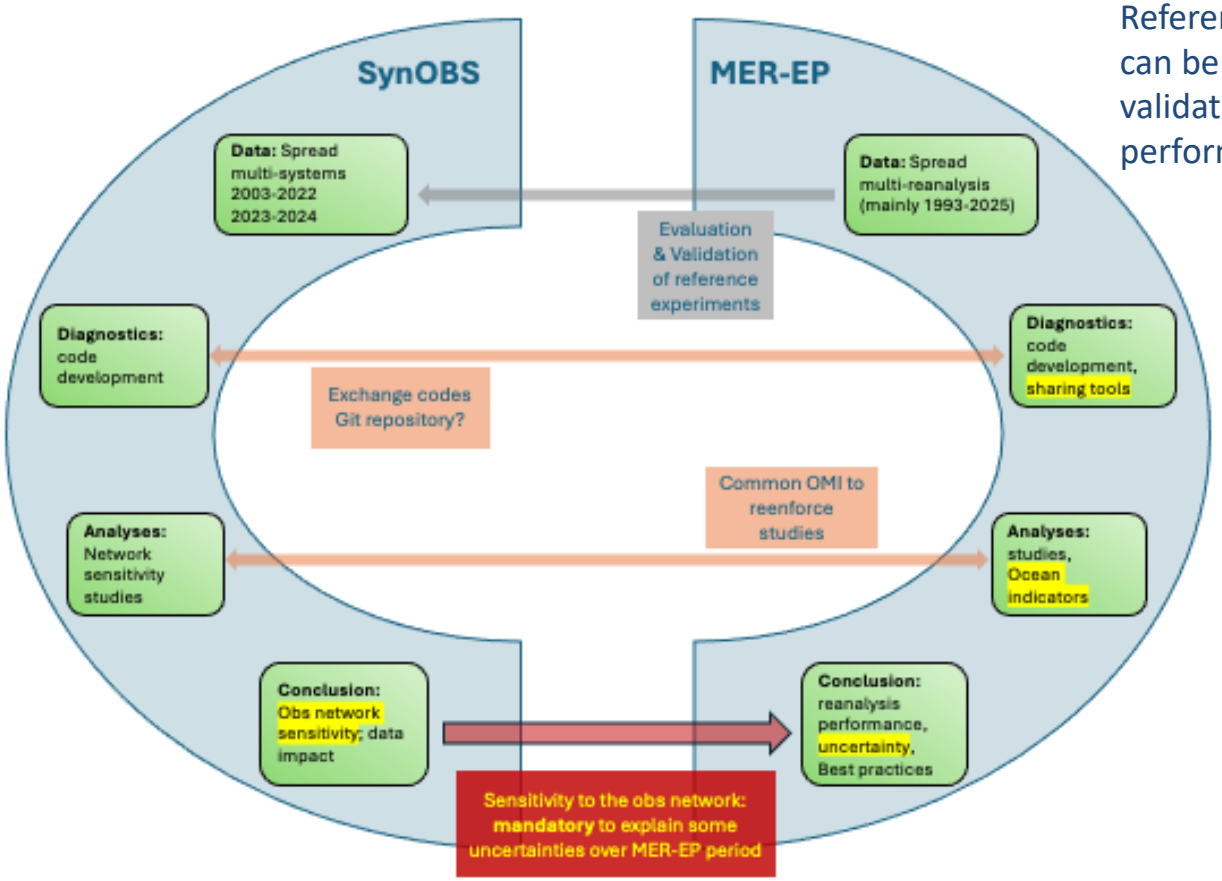
Strong similarities in data products, workflows, and evaluation metrics

Link with SynObs?

Reference data base can be used for validation and/or performed statistics

Codes available on EDITO/Git: could be exchange/shared

Comon metrics definition

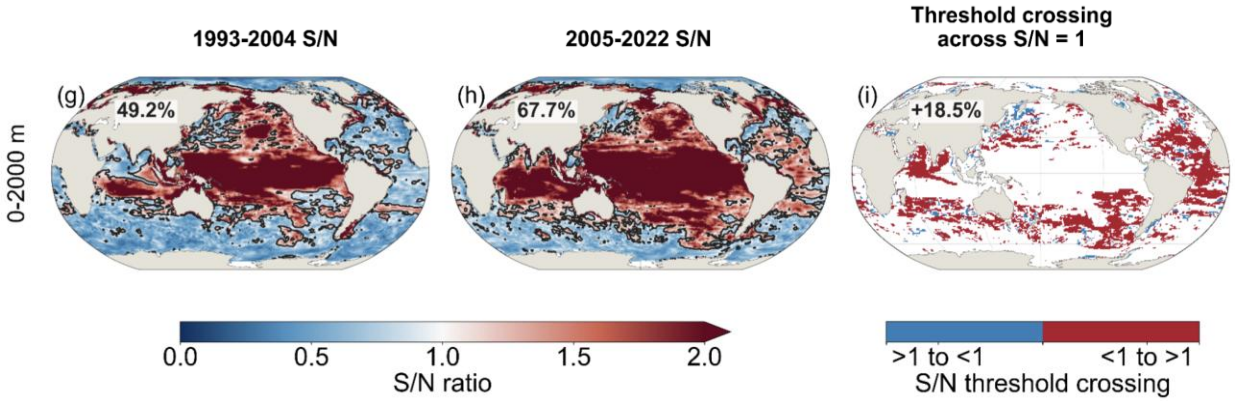


SynOBS findings can help explain MER-EP spreads and uncertainties

Link with SynObs: a concrete example

- Comparison of the OHC signal-to-noise ratio in the 0–2000 m layer for two periods: 1993–2004 and 2005–2022
- Signal increases over the recent period in many regions (up to +20%)
- Direct link with the in situ observing network?

OHC Ratio signal/noise (Zhang et al. In prepa.)



=> If SynOBS experiments without Argo produce similar results, their findings can help explain MER-EP spread and uncertainties.

Conclusions

MER-EP

- **MER-EP was launched one year ago.**
- The project continues to grow, with an increasing number of participants and ocean reanalyses involved.
- First results are emerging across several use cases, showing that the project is now fully underway.
- **First scientific publications** are in preparation (OHC, OHT, eddies, ...).

✓ A general meeting is planned for **April 2027** in Rome, Italy.

✓ A dedicated **special issue** on ocean reanalyses is opened in Ocean Sciences Journal, including:

- product description papers from producers,
- intercomparison and methodological studies,
- downstream applications based on ocean reanalyses.

MER-EP & SynOBS

- MER-EP and SynOBS can naturally share data, codes, and evaluation metrics.
- In one side: MER-EP can provide an indirect assessment of SynOBS's reference simulations.
- In other side: **SynOBS can help MER-EP better understand and explain uncertainties in ocean reanalyses.**

  => MER-EP can be viewed as a user of SynOBS outcomes.
- **Practical aspects**
  - Joint meetings (remote or in person) would help strengthen collaboration and foster exchanges?
  - A natural connection already exists (Dr. Fuji, Dr Balmaseda)

Thanks you

