

International Verification Methods Workshop Online (2020-IVMW-O)

The Mediterranean, Black and Marmara Seas analysis and forecasting physical systems: validation methodology and quality assessment

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The Copernicus Marine Service and the Med-BS scientific challenges

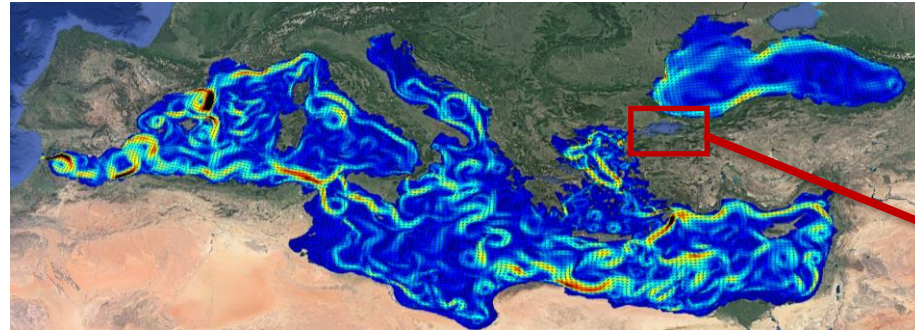
- The Mediterranean (**MED-MFC**) and Black Sea (**BS-MFC**) Monitoring and Forecasting Centers are part of the Copernicus Marine Environment and Monitoring Service (**CMEMS**) and provide regular and systematic information on the time-evolving Mediterranean and Black Sea ocean state
- The **numerical ocean prediction modelling systems operationally produce**: reanalysis, analyses and short term forecasts of the main physical parameters for the entire Mediterranean Sea (**MED-PHY**) and for the Black Sea (**BS-PHY**)
- **Connection among the 2 regional seas is guaranteed through the Marmara Sea**: a major R&D action is to implement an Optimal Interface to provide operational lateral open boundary conditions to the Mediterranean Sea through the Dardanelles Strait and to the Black Sea through the Bosphorus Strait
- The **validation of the modelling system and the estimate of the accuracy of model products** are key issues to ensure reliable information to the users and the downstream services

CMEMS <https://marine.copernicus.eu/>



The Modelling systems

CMEMS Mediterranean & Black Seas Operational Systems



ECMWF IFS 12.5km @3-6h

MED - PHY

NEMO v3.4 ↔ WW3 v3.14
1/24°, 141 z-leve

Data Assimilation 3DVAR
OceanVAR

BS - PHY

NEMO v3.4
1/36°x 1/27°, 31 z-leve

Data Assimilation 3DVAR
OceanVAR

SST

SLA

INS
T-S

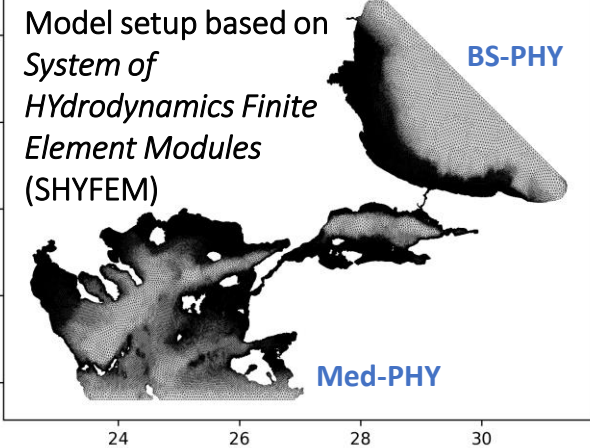
LOBC:
Open In
Atlantic &
Dardanelles

39 **river**
inputs
monthly
clim

LOBC:
Closed at
the
Bosphorus

72 **river**
inputs
monthly
clim

Marmara Sea
Connector



Model setup based on
System of
Hydrodynamics Finite
Element Modules
(SHYFEM)

BS-PHY

Med-PHY

Resolution: ~ 50 meter resolution
in the Turkish Straits, 93 levels

Lateral boundary conditions from
CMEMS Med-PHY and BS-PHY
systems

Surface boundary conditions from
ECMWF IFS 12.5km @3-6h

Model simulation: 2016-2019

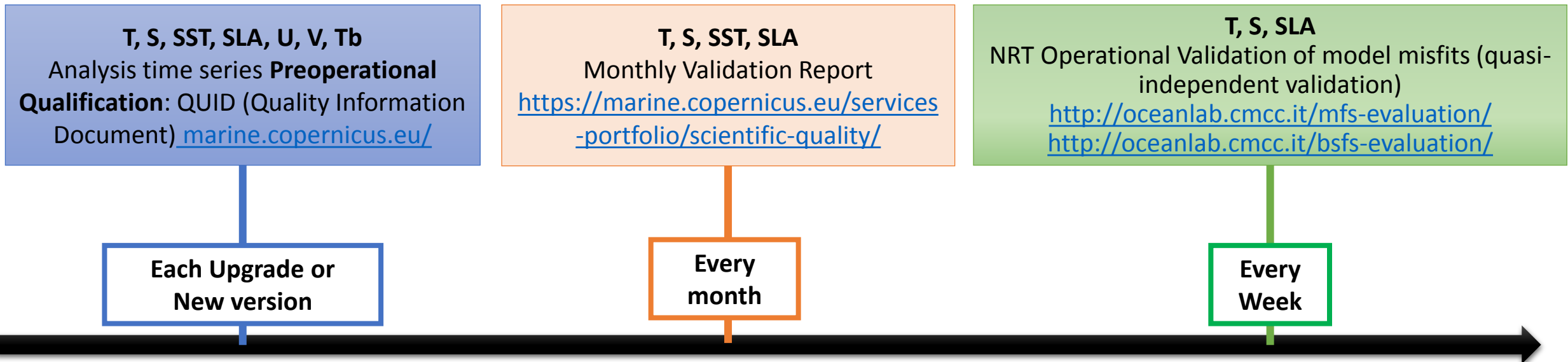
The product quality and validation framework

Product quality activities are regularly performed by means of both **pre-operational** qualification and **near real time operational validation** procedures

Pre-operational qualification activities

focus on testing the quality improvements of a new or upgraded modelling system and rely on past simulation and historical observations

NRT operational validation activities provide a routinely and on-line skill assessment of the model analysis and forecast and rely on the NRT available observations



Pre-Operational Qualification

Estimated Accuracy Numbers (EANs): mean and the RMS of the difference between the model and in-situ / satellite reference observations for:

- Temperature
- Salinity
- Sea Surface Temperature (SST)
- Sea Level Anomaly (SLA)

Black Sea example →

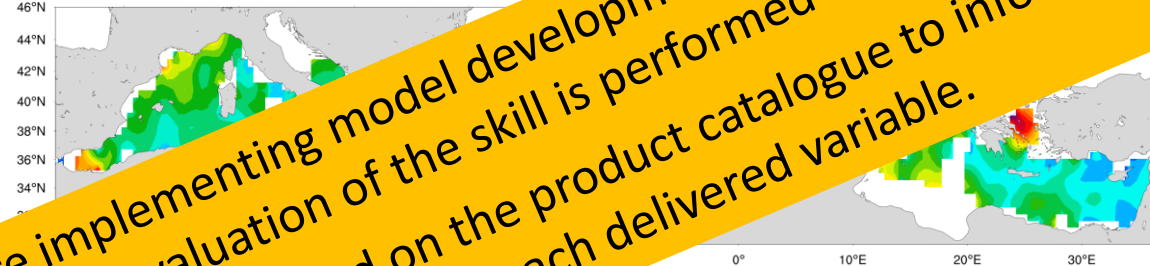
T prod - T ref [°C]		V2.2 system		V3 system		S prod - S ref [PSU]		V2.2 system		V3 system		SLA prod - SLA ref [m]		V2.2 system		V3 system	
Layer (m)	Mean T-CLASS4-EAN- MEAN_LAYER	RMS T-CLASS4-EAN- RMS_LAYER	Mean T-CLASS4-EAN- MEAN_LAYER	RMS T-CLASS4-EAN- RMS_LAYER	Layer (m)	Mean T-CLASS4-EAN- MEAN_LAYER	RMS T-CLASS4-EAN- RMS_LAYER	Mean T-CLASS4-EAN- MEAN_LAYER	RMS T-CLASS4-EAN- RMS_LAYER	Mean T-CLASS4-EAN- MEAN_LAYER	RMS T-CLASS4-EAN- RMS_LAYER	Mean SST-CLASS4- EAN- MEAN_BASIN	RMS SST-CLASS4- EAN- RMS_BASIN	Mean SL-CLASS4-EAN- MEAN_BASIN	RMS SL-CLASS4-EAN- RMS_BASIN		
2-5	0.05	0.55	0.05	0.54	2-5	0.05	0.54	0.05	0.54	-0.01	0.28	-0.01	0.27				
5-10	0.34	0.95	0.26	0.90	5-10	0.31	0.91	0.30	0.91								
10-20	0.21	1.26	0.20	0.95	10-20	0.19	1.20	0.19	1.20								
20-30	-0.18	1.18	0.10	1.12	20-30	-0.16	1.12	-0.16	1.12								
30-50	-0.22	0.90	-0.17	0.90	30-50	-0.20	0.88	-0.20	0.88								
50-75	-0.14	0.57	-0.13	0.56	50-75	-0.13	0.56	-0.13	0.56								
75-100	-0.09	0.30	-0.07	0.28	75-100	-0.09	0.28	-0.09	0.28								
100-200	-0.06	0.14	-0.06	0.14	100-200	-0.06	0.14	-0.06	0.14								
200-500	-0.02	0.05	-0.02	0.045	200-500	-0.02	0.045	-0.02	0.045								
500-1000	-0.07	0.08	-0.07	0.08	500-1000	-0.07	0.08	-0.07	0.08								

Maps of mean RMS Errors:

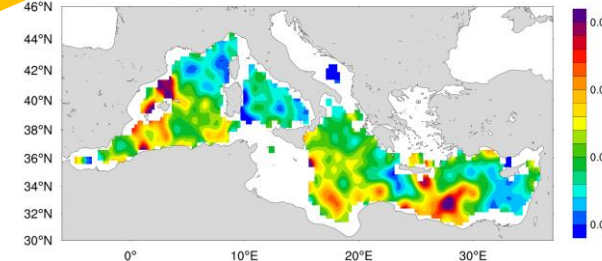
- Temperature
- Salinity
- Sea Level Anomaly

Mediterranean Sea example

Temperature @ 8m [°C]



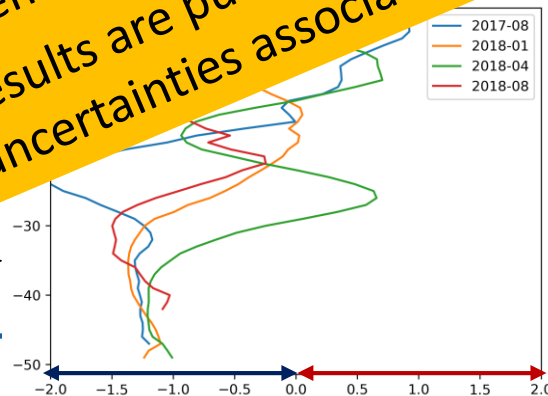
Sea Level Anomaly [m]



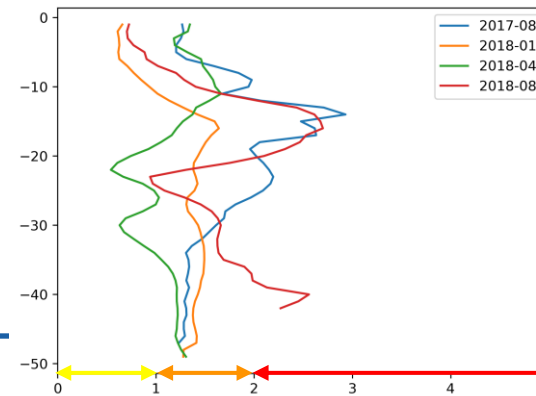
Vertical Mean Errors and Bias

- Temperature
- Salinity

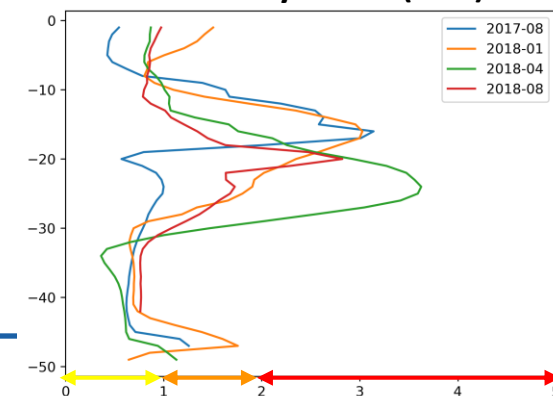
Marmara Sea example →



Temperature RMSE [°C]



Salinity RMSE (PSU)



Before implementing model developments in a new operational system, an extensive evaluation of the skill is performed to assess the product improvements. Results are published on the product catalogue to inform users on the quality and uncertainties associate to each delivered variable.

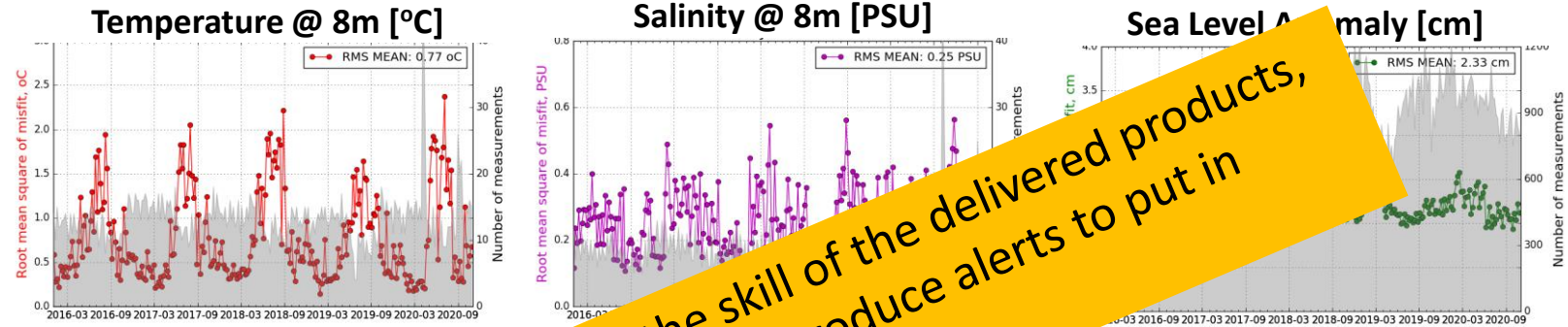
Pre-Operational Qualification & NRT Operational Validation

RMS of misfits: model – obs at the time and location of the observation, before the observation is assimilated

- Temperature
- Salinity
- Sea Level Anomaly (SLA)

Black Sea example

<http://oceanlab.cmcc.it/bsfs-evaluation/>

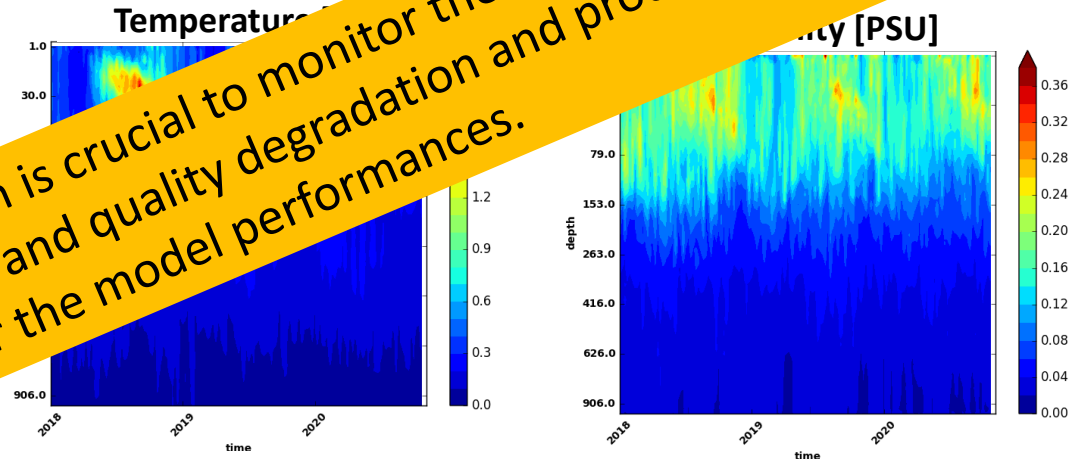


Hovmoller depth-time error diagrams:

- Temperature
- Salinity

Mediterranean Sea example

<http://oceanlab.cmcc.it/mfs-evaluation/>

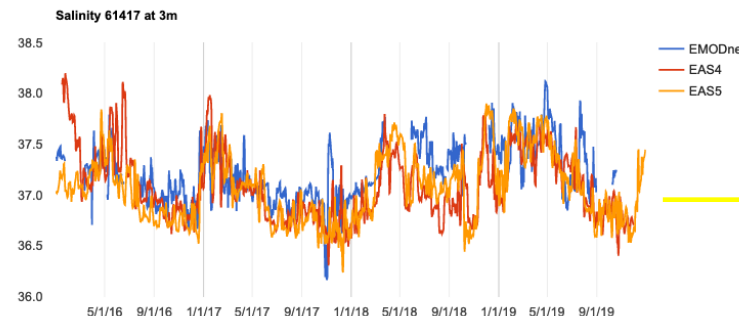


Independent Validation wrt to

- Temperature
- Salinity
- Sea Level

Mediterranean Sea example

<http://evalid.cmcc.it/evaluation/calval/>



NRT operational validation is crucial to monitor the skill of the delivered products, to detect possible issues and quality degradation and produce alerts to put in place actions to recover the model performances.



Monthly Operational Validation

RMSD and Bias of analysis and several forecast days:

- Temperature
- Salinity
- Sea Surface Temperature (SST)
- Sea Level Anomaly (SLA)

Mediterranean Sea example →

<https://marine.copernicus.eu/services-portfolio/scientific-quality/>

Long term quality assessment

The long term operational quality changes associated to the modelling systems evolution can provide a clear view of the quality evolution of the products according to improvements, increased resolution,...

Mediterranean Sea example →

A set of standardised metrics are used to monitor the forecast skill and to assess system evolutions i.e. physical processes

