The Mediterranean Sea analysis and forecasting physical system for the Copernicus Marine Service: description and skill assessment

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The Mediterranean Analysis and Forecasting Physical System, Med-Currents, developed in the framework of the Copernicus Marine Service (CMEMS), is a numerical ocean prediction system that operationally produces the analysis of the current ocean state as well as daily updates of the following 10 days forecast of the main physical parameters for the Mediterranean Sea. The system is continuously upgraded following users requirements.

OBJECTIVES

Present the new CMEMS Med-Currents system including (a) an upgraded SST nudging and (b) Dardanelles Strait implemented as a Lateral Open Boundary condition.
Show the product quality assessment performed in order to provide the skill of the system.

1. Med-PHY ANALYSIS AND FORECAST PHYSICAL SYSTEM DESCRIPTION

Atmospheric Forcings

ECMWF 1/8° forecast/analysis fields time resolution: 3/6 hrs:
mean sea level pressure (MSLP) , cloud cover, 2m relative humidity, 2m air temperature, 10m zonal and meridional wind components, Precipitation

Assimilated Observations

Along track satellite SLA
from CMEMS SL-TAC, for all available satellites:
Jason 2/2N/3, Cryosat2, Saral/AltiKa, Sentinel3

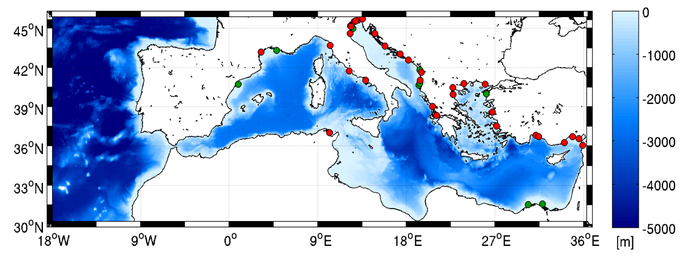
Vertical profiles of T and S
from CMEMS InSitu TAC:
Argo, XBT

NEMO v3.6 + WW3

Circulation-Wave modeling system
2-way hourly coupling (Clementi et al., 2017)
1/24° hor. res
141 vert. levels

Data Assimilation: 3DVar

Satellite and InSitu observations are jointly assimilated using a 3DVAR assimilation scheme with a daily assimilation cycle.
Non-solar heat flux correction is achieved through satellite SST (L4) nudging.



Initial Conditions from WOA winter climatologies to initialize the system on Jan/2016
Boundary conditions (1) in the Atlantic**:** daily analyses/forecasts from GLO-MFC @ 1/12° **(2)** in the Dardanelles Strait: daily GLO-MFC AN/FCST (1/12°res.) & Maderich et al., 2015.
Land river runoff: 39 river inputs: Q > 50m^3/s climatological data from PERSEUS dataset

MEDSEA_ANALYSIS_FORECAS TPHY_006_013

@ CMEMS catalogue:
http://marine.copernicus.eu

Hourly, Daily & Monthly averages

- Temperature (3D)
- Salinity (3D)
- Currents (3D)
- SSH (2D)
- Mixed Layer Depth (2D)
- Bottom Temperature (2D)

2. LATEST MODELING SYSTEM UPGRADES

The Med-MFC Physical modeling system has been recently upgraded by including 2 new model developments consisting in:

- **Upgrade of nudging toward observed SST** (correction of incoming solar heat fluxes):

$$Q_{corrected} = Q_{forc} + \frac{dQdSST}{\rho C_p}(SST_{model} - SST_{observation})$$

- **Dardanelles Strait implemented as a Lateral Open Boundary Condition** in order to better represent the tracers and water transport at the strait and improve the model skill especially in the North Aegean Sea area.

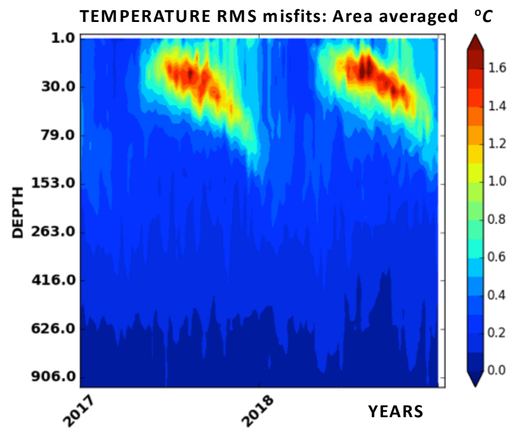
	EAS3 (old)	EAS4 (new)
SST nudging	Nudging to satellite SST data is applied at each time step over the whole day $dQdSST = -40\ Wm^{-2}K^{-1}$	Nudging to satellite SST data is applied close to midnight (observation time) $dQdSST = -110\ Wm^{-2}K^{-1}$
Dardanelles Strait	Surface boundary condition achieved through a river-like parameterization using volume flux and salinity monthly climatological values (Kourafalou and Barbopoulos, 2003)	Lateral open boundary condition using Currents and Salinity fields from Maderich et al., (2015) and Temperature and Sea Level from GLO-MFC Analysis and Forecast product (1/12° horizontal resolution)

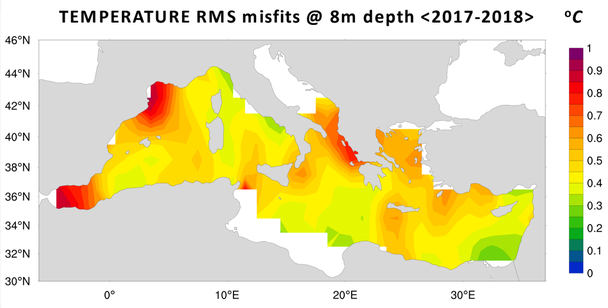
3. FUTURE UPGRADES

- Implementation of an estuarine box model (EBM) for river-ocean coupling
- Use of high frequency inter-annual river runoff and river forecasts, where available
- Include tides
- Use a different vertical mixing scheme
- Improvement of DA to account for Tides, new vertical mixing
- Improvement of the on-line coupling of NEMO with wave model (e.g. enhanced mixing due to waves)
- Ingestion of Sentinel-6 altimetry data

4. SKILL ASSESSMENT

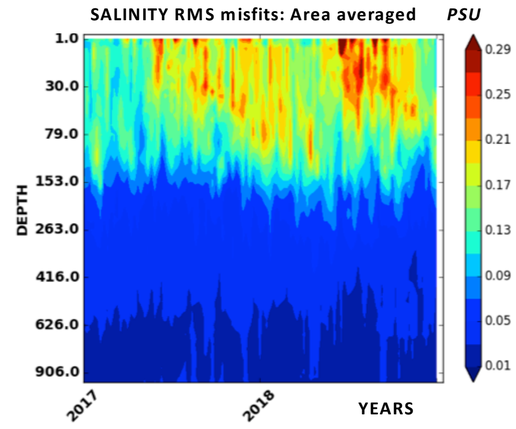
TEMPERATURE RMS MISFITS

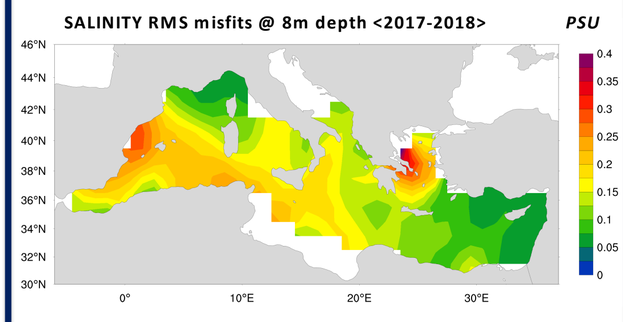




Larger error at thermocline during summer/autumn period

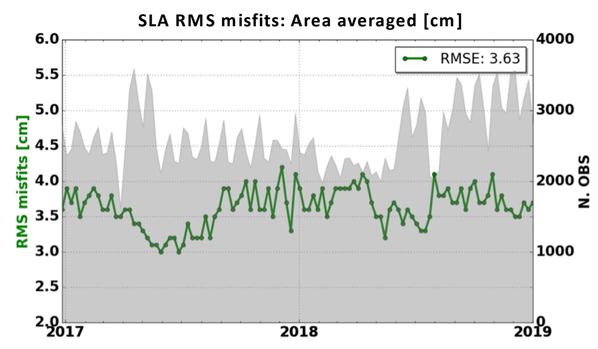
SALINITY RMS MISFITS

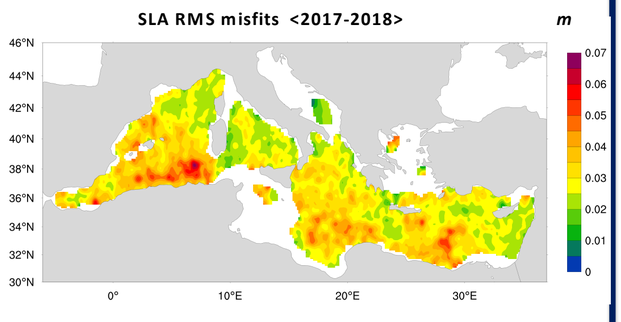




Larger error between 0-150m;
in the Western Med & North Aegean Sea

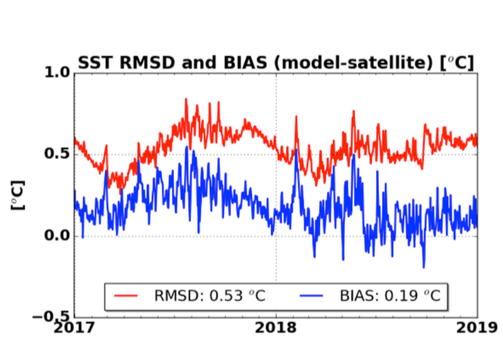
SEA LEVEL ANOMALY RMS MISFITS

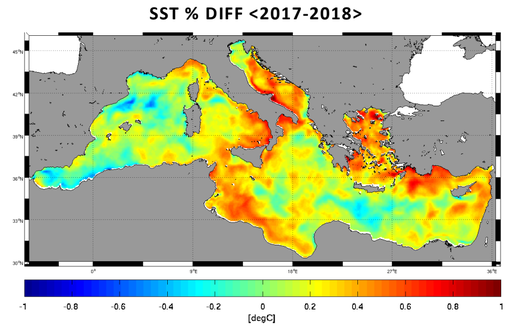




Average SLA error ~3.6 cm
Larger error Western and Sothern basins

SST RMSD & BIAS





Positive Bias (~0.2°C) in the whole basin with maximum difference ~5%

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