

The new Black Sea Reanalysis System within CMEMS

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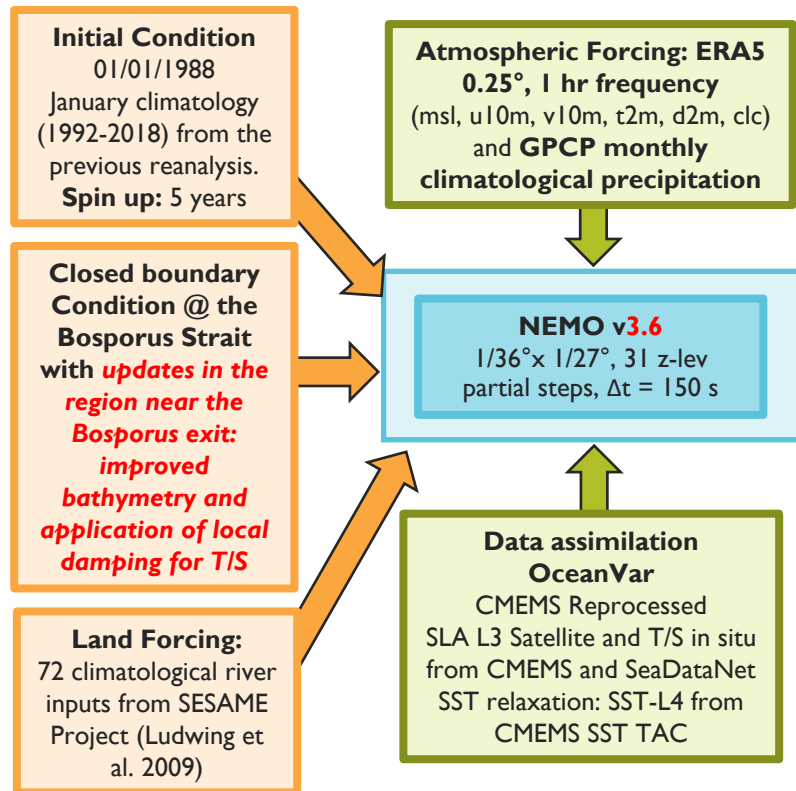
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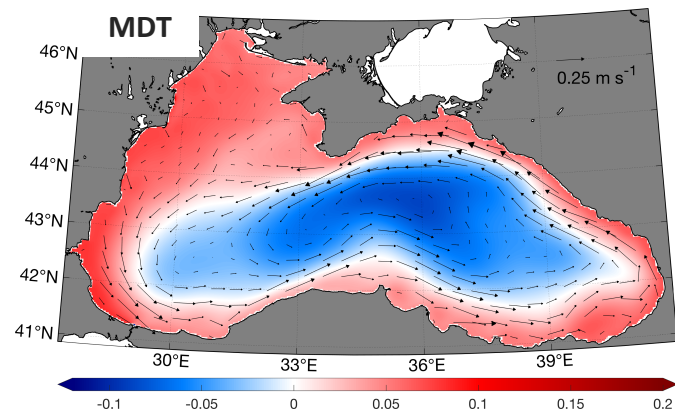
Credits: NASA

MODELLING SYSTEM



Upgrades in the data assimilation scheme (OceanVar):

- New EOFs to estimate the background error covariances (B matrix).
- New observation window: 4-day centered at the analysis time.
- Initialization with incremental analysis update (IAU).
- New model-based MDT to compute the model-equivalent sea level anomaly in data assimilation.

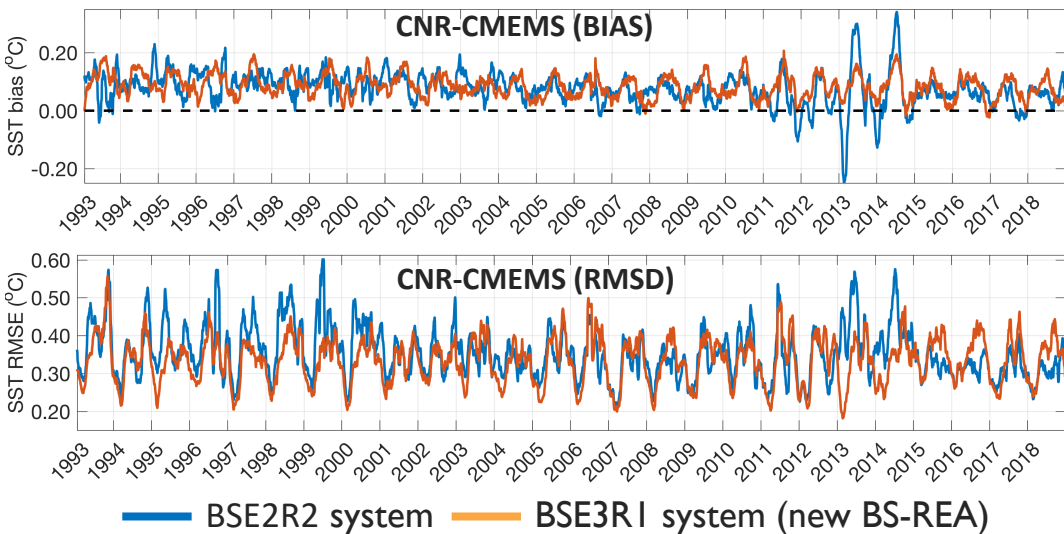
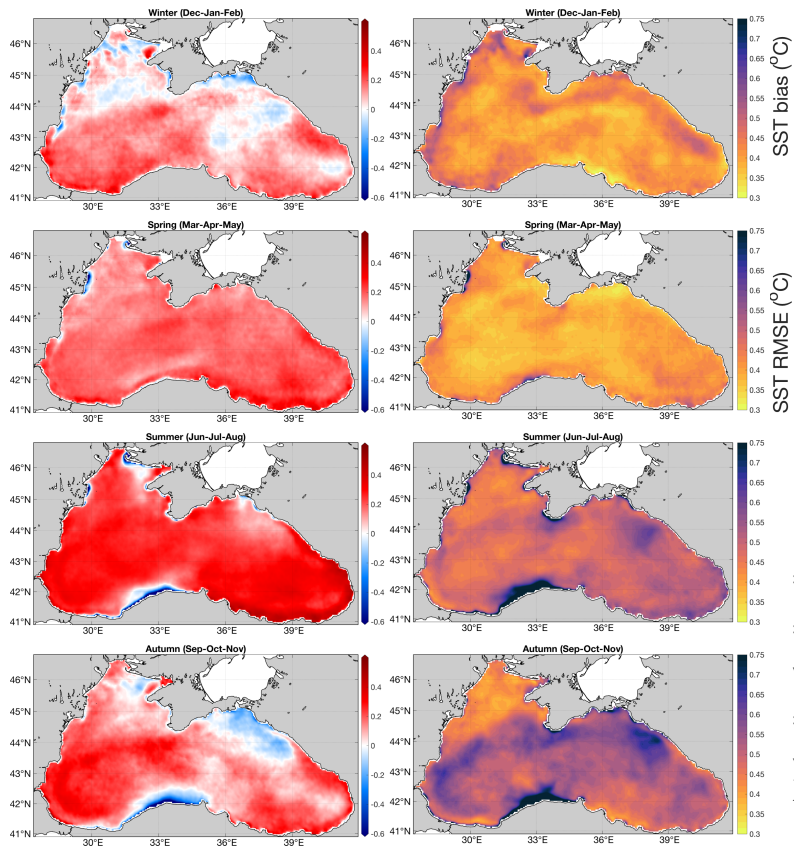


* model-based MDT: time-averaged SSH (1993-2012) from one integration with the assimilation of only T/S *in situ* profiles.

BS - PHY MY system evolution from BSE2R2 to BSE3R1

	<i>BS-REA previous version BSE2R2</i>	<i>BS-REA new version BSE3R1</i>
Temporal Coverage	1992 – Jun 2019	1993 – Dec 2019
Spin up	1990-1992 with data assimilation	1988-1992 with data assimilation
Atmospheric forcing	ERA-Interim (0.75 degrees)	ERA5 (0.25 degrees; 1 h)
EOF	Trivariate (SSH, T and S) Monthly EOFs computed at each grid point	Trivariate (SSH, T and S) Monthly EOFs computed at each grid point estimated from an integration including data assimilation of only T/S profiles
DA frequency	3 days	2 days
Observation window	7 days (including 6 past days)	4-day centered at the analysis time
SSS nudging	EN4-UKMO objective analyses	No
SST assimilation	CNR-CMEMS L4 REP	No
in situ TS assimilation	EN4-UKMO	SeaDataNet and CMEMS NRT in situ TAC
SLA assimilation	CMEMS along-track REP product for the Black Sea	CMEMS along-track REP product for the European seas
Mean Dynamic Topography (MDT)	Model-based	Model-based Time-averaged SSH (1993-2012) from one integration with the assimilation of only in situ T/S
SLA instrumental errors	Vary from 3 to 12 cm according to each satellite	4 cm
Initialization	Direct initialization	Incremental analysis update (IAU)
Recursive filter	Correlation length-scale varies from 7 to 20.85 km (8.5 to 27.14 km) in the meridional (zonal) direction	Correlation length-scale of 20 km
Large Scale Bias Correction	Yes, whole water column	Yes, below 300 m

BS-PHYMY system: SST Validation



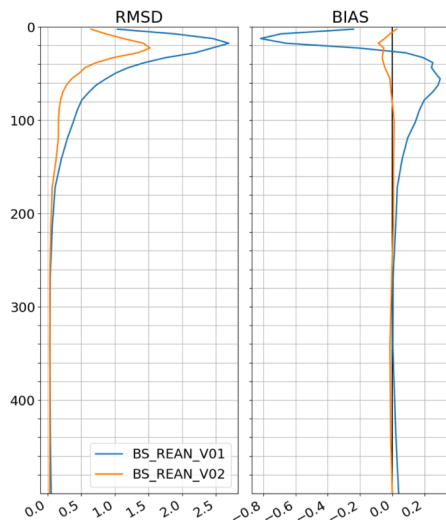
* Both reanalysis versions present a predominance of positive SST bias.

* There is a seasonal cycle with the lowest (highest) values of SST RMSE during the winter (summer).

* The new reanalysis presents lower RMSDs most of the time like during the first years (1993-2000). From 2014, this pattern changes and RMSD values are higher than those from the previous version, mainly during the summer.

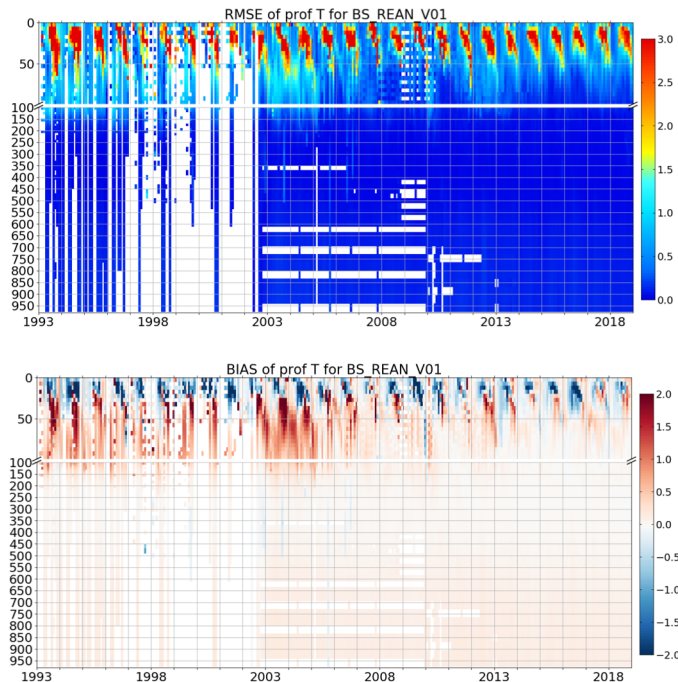
BS-PHY MY system: T/S Validation

T (degC) 1993-2018

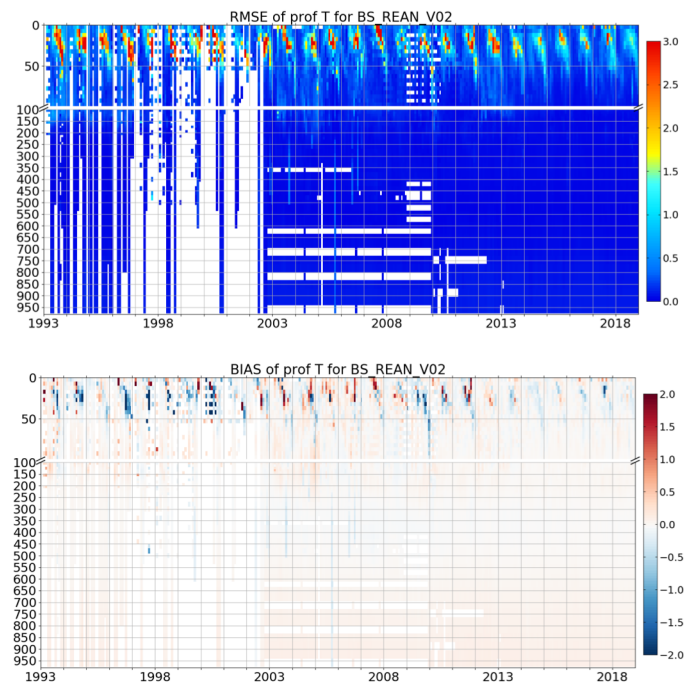


— BSE2R2 — BSE3R I

BSE2R2

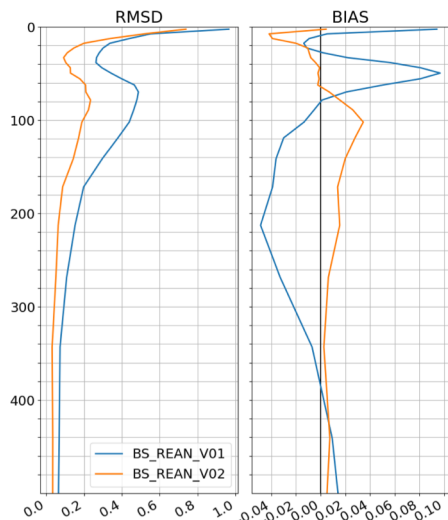


BSE3R I



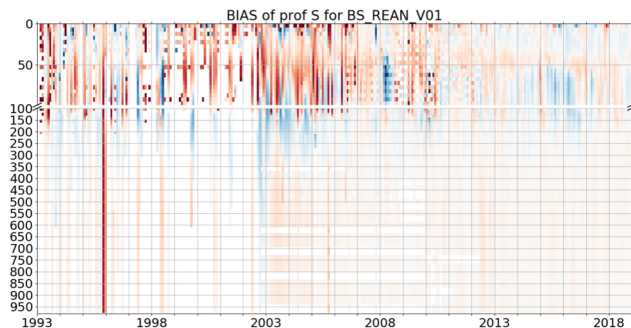
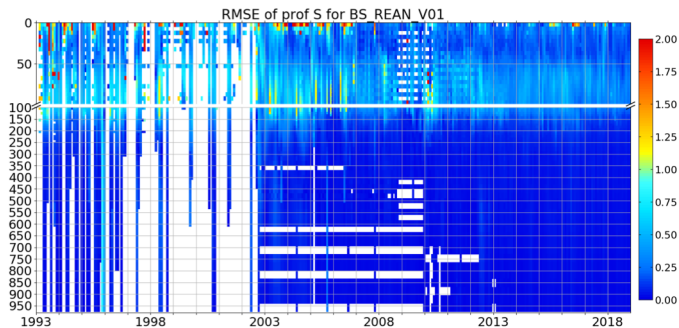
BS-PHY MY system: T/S Validation

S (PSU) 1993-2018

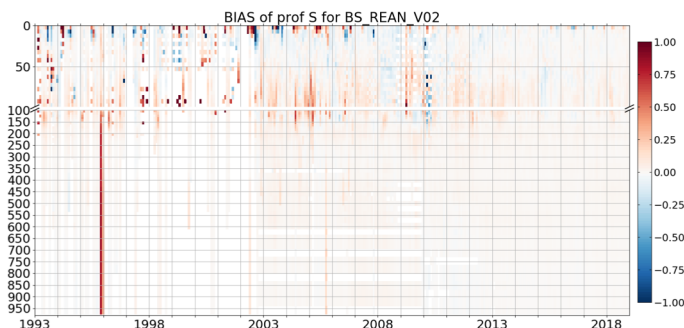
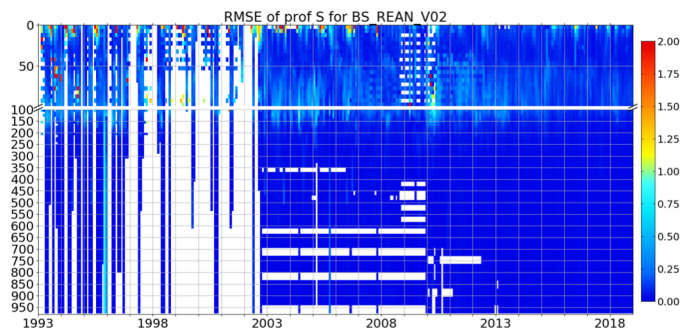


— BSE2R2 — BSE3R1

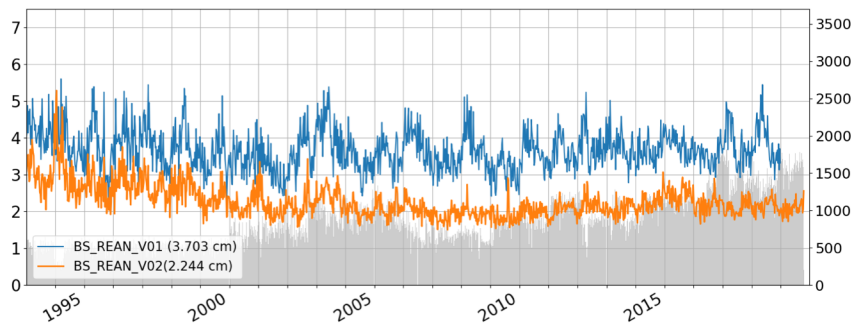
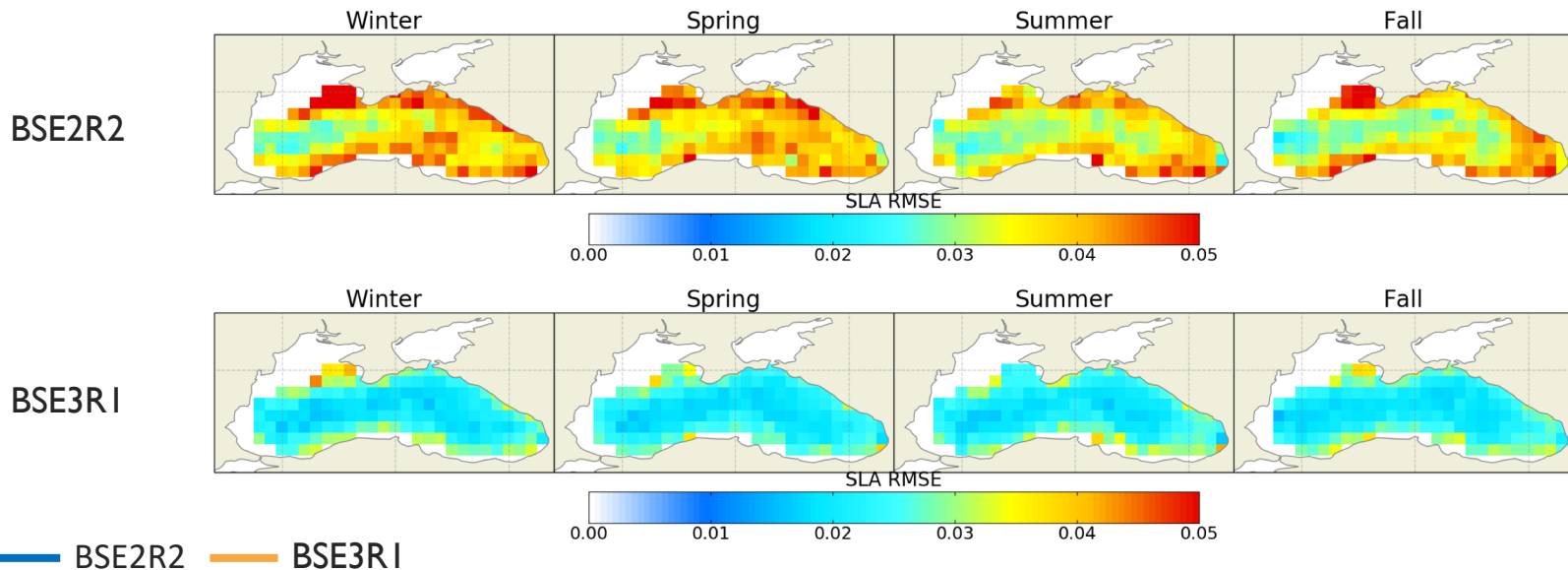
BSE2R2



BSE3R1



BS-PHY MY system: SLA Validation



- Spatial maps of sea level anomaly reveal the largest values of RMSD close to the shelf areas, which are related to the mesoscale activity along the Rim current.
- For example, errors relatively high can be found near the Crimean Peninsula in the Sevastopol eddy region

BS-PHY Product Catalogue

Products are accessible through the CMEMS website <https://marine.copernicus.eu/>



BLKSEA_MULTIYEAR_PHY_007_004

Daily + Monthly mean:
1993-2019

- 2D Sea Surface Height
- 3D Salinity
- 3D Potential Temperature
- 3D Zonal/Meridional currents
- 2D Mixed Layer Depth
- 2D Bottom Temperature

BS-PHY
MY

Black Sea subsurface Temperature anomaly
(1993 – 2018)
Black Sea anomaly map of Sea Surface
Salinity

BS-PHY
OMI

CONCLUSIONS

- The system has produced very accurate estimates which makes it suitable for understanding the BS physical state from the past 28 years (1993-2019), allowing to obtain better climate imprints to the sea, for instance.
- In order to improve the quality of the BS reanalysis, new developments in ocean modelling and data assimilation are still important, and sustaining the BS ocean observing system is crucial.
- Model developments: increased vertical resolution (from 31 to 121 levels), open boundary conditions at the Marmara Sea box, interannual dataset for river discharge at the Danube
- Data assimilation:
 - SST assimilation: previous investigations have indicated the importance of applying special techniques (e.g. SST vertical localization) to vertically translate the model covariances from empirical orthogonal functions to the background covariance matrix in OceanVar;
 - first guess at appropriate time (FGAT);
 - ensemble experiments / Hybrid DA
- Operational implementation of the BS-REA for Interim-mode
- DOIs:
 - Lima, L., Aydogdu, A., Escudier, R., Masina, S., Ciliberti, S. A., Azevedo, D., Peneva, E. L., Causio, S., Cipollone, A., Clementi, E., Cretí, S., Stefanizzi, L., Lecci, R., Palermo, F., Coppini, G., Pinardi, N., & Palazov, A. (2020). Black Sea Physical Reanalysis (CMEMS BS-Currents) (Version 1) [Data set]. Copernicus Monitoring Environment Marine Service (CMEMS). https://doi.org/10.25423/CMCC/BLKSEA_MULTIYEAR_PHY_007_004