The CMEMS Mediterranean and Black Sea analysis and forecasting physical systems: description and skill assessment

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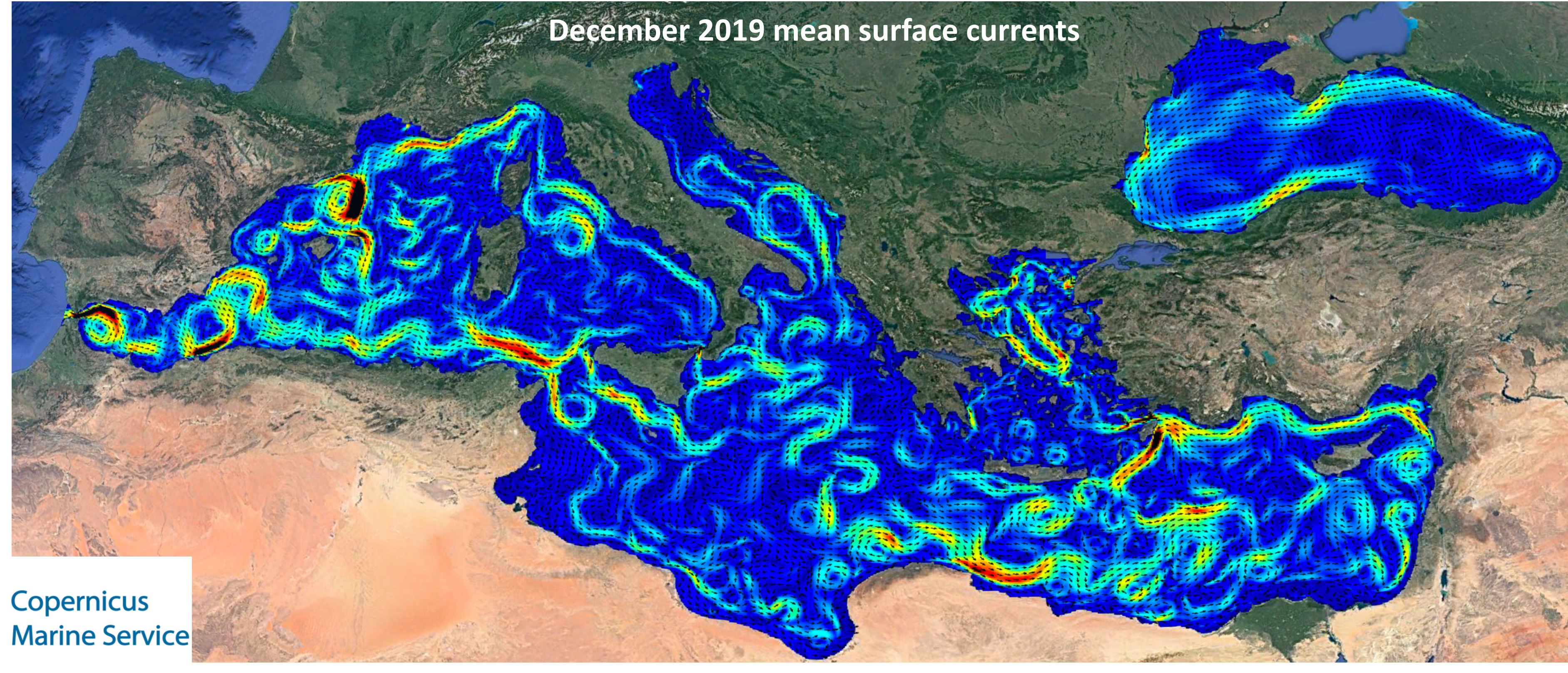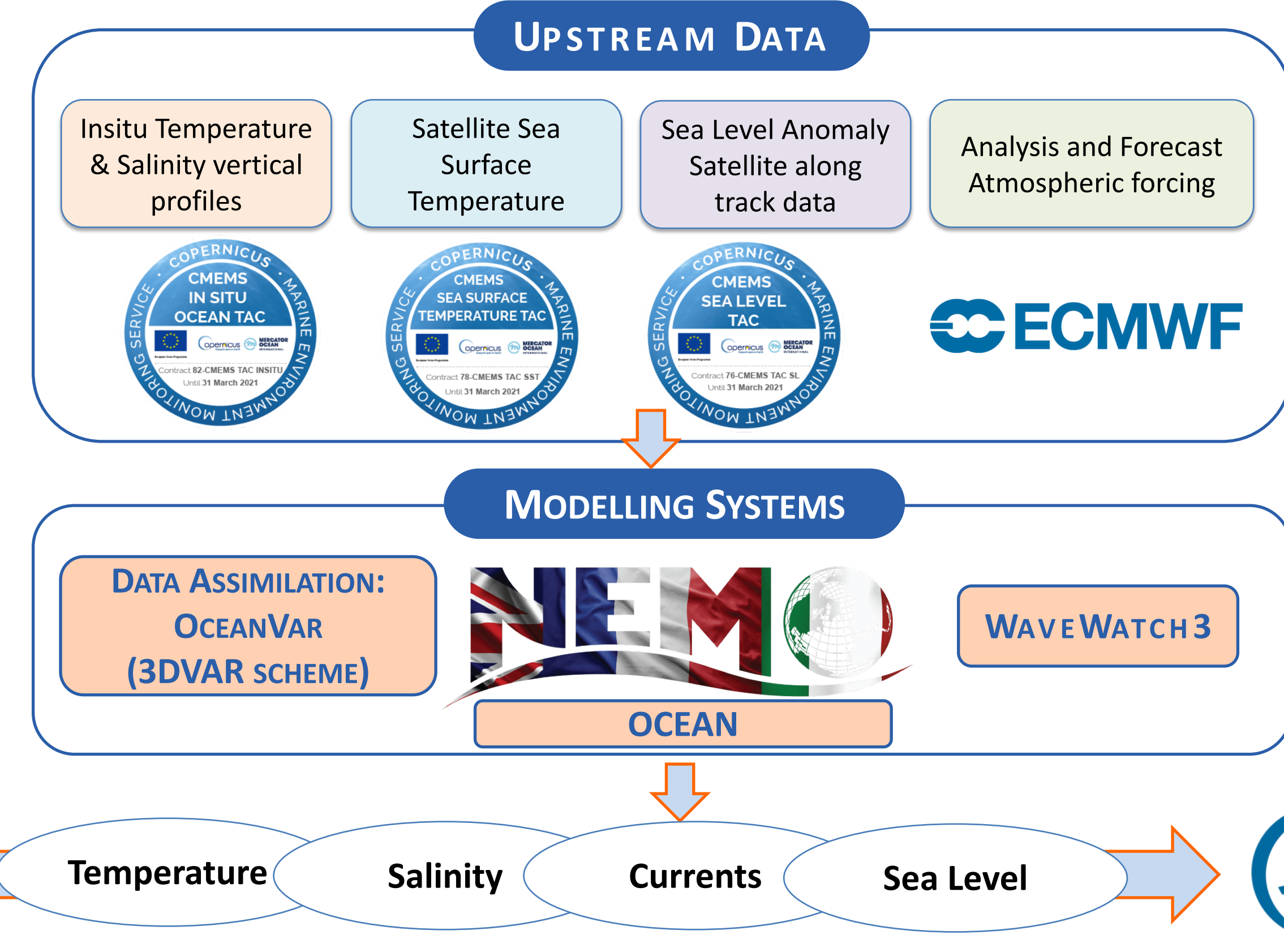(2) CMCC, Euro-Mediterranean Center on Climate Change, Ocean Predictions and Applications, Italy;
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(5) Soa University, Meteorology and Geophysics, Soa, Bulgaria; (6) Istanbul Technical University, Eurasia Institute -> Earth Sciences, Istanbul, Turkey

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**).

All the products are freely available through the CMEMS online Catalogue: http://marine.copernicus.eu/services-portfolio/access-to-products/

UPSTREAM DATA

Insitu Temperature & Salinity vertical profiles

Satellite Sea Surface Temperature

Sea Level Anomaly Satellite along track data

Analysis and Forecast Atmospheric forcing

ECMWF

MODELLING SYSTEMS

DATA ASSIMILATION: OCEANVAR (3DVAR scheme)

NEMO

OCEAN

WAVEWATCH3

Temperature — Salinity — Currents — Sea Level

Copernicus Marine Service

December 2019 mean surface currents

| CONFIGURATION CMEMS PRODUCT NAME	Numerical Model	Model Resolution	Initial Conditions	Lateral Boundary Conditions	Atmospheric Forcing	River inflow	Website description and validation
Mediterranean Sea MEDSEA_ANALYSIS_FORECAST_PHY_006_013	NEMO v3.6 ↓↑ WW3 v3.14	1/24° 141 z levels	WOA Winter climatology	Open lateral boundary conditions in the Atlantic Ocean and Dardanelles Strait	ECMWF @ 1/8° degree resolution & 6hours frequency (hours for the first 3 days of forecasts)	39 rivers climatological inflow	http://medfs.cmcc.it/ http://oceanlab.cmcc.it/mfs-evaluation/
Black Sea BLKSEA_ANALYSIS_FORECAST_PHYS_007_001	NEMO v3.4	1/36° × 1/27° 31 z levels	Simonov & Altman (1991) Jan climatology	Closed lateral boundary conditions in the Bosporus Strait		72 rivers climatological inflow	http://bsfs.cmcc.it/ http://oceanlab.cmcc.it/bsfs-evaluation/

THE MEDITERRANEAN SEA PRODUCT QUALITY

TEMPERATURE RMS MISFITS

SALINITY RMS MISFITS

SEA LEVEL ANOMALY RMS MISFITS
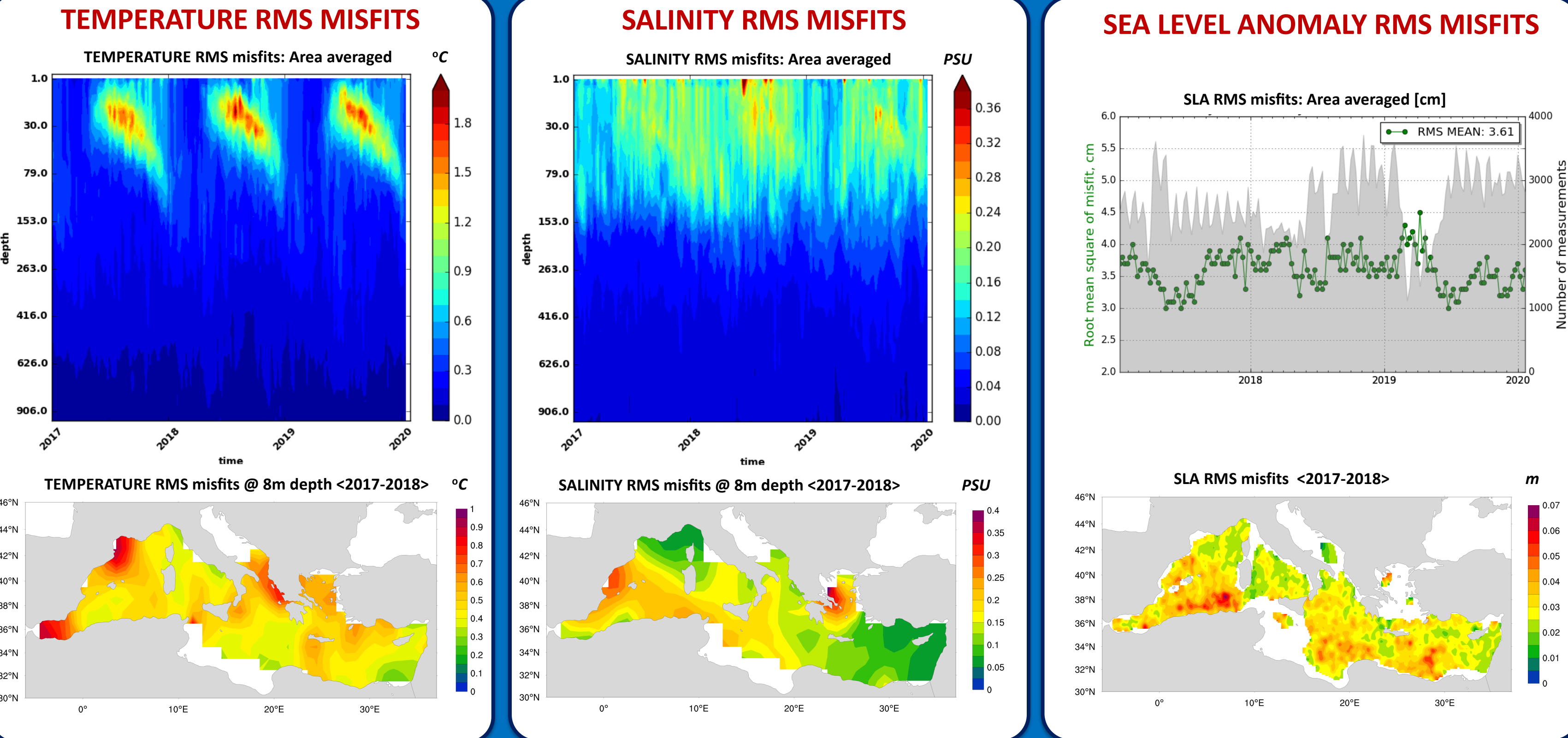
Temperature: Larger error at thermocline during summer/autumn seasons

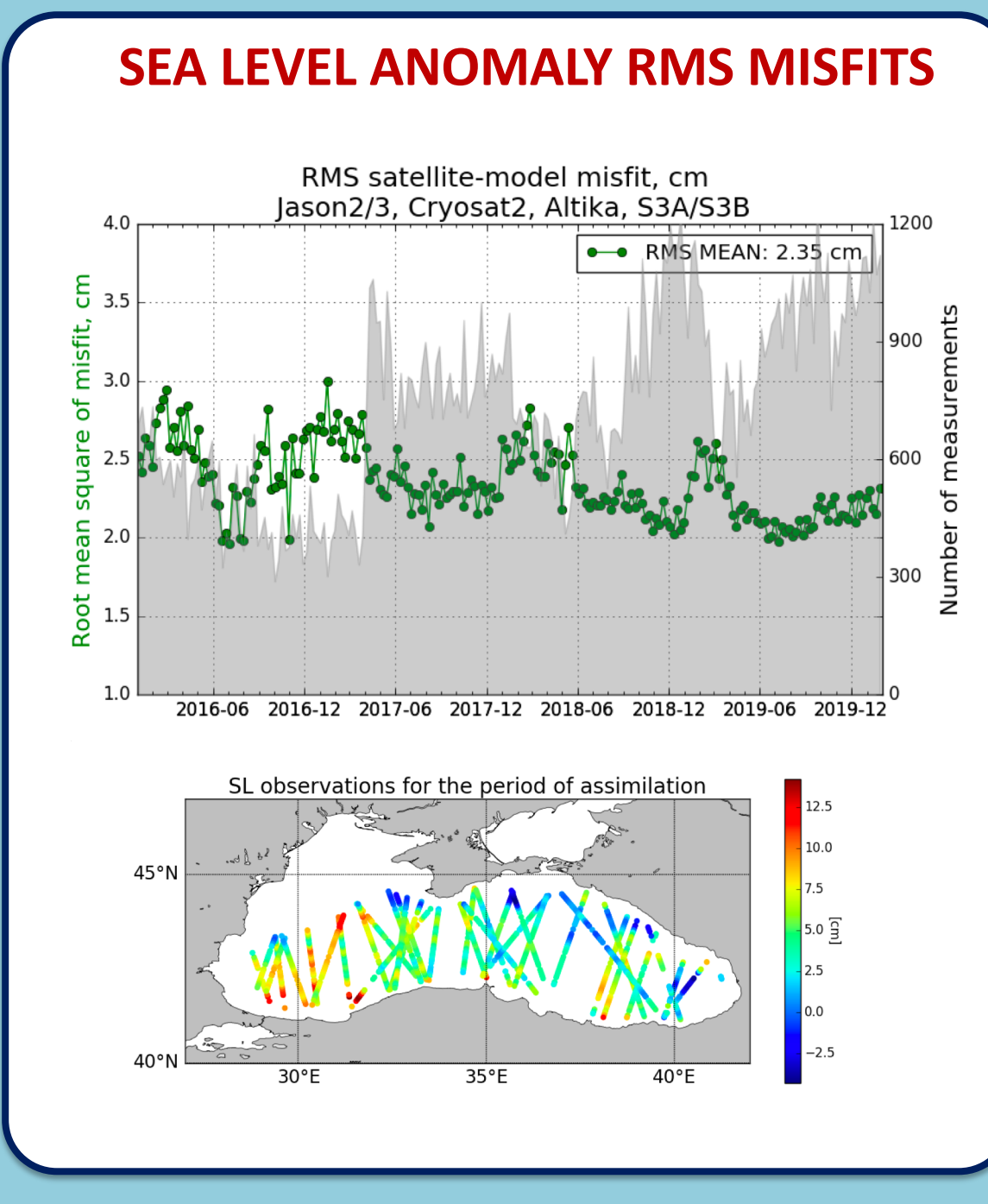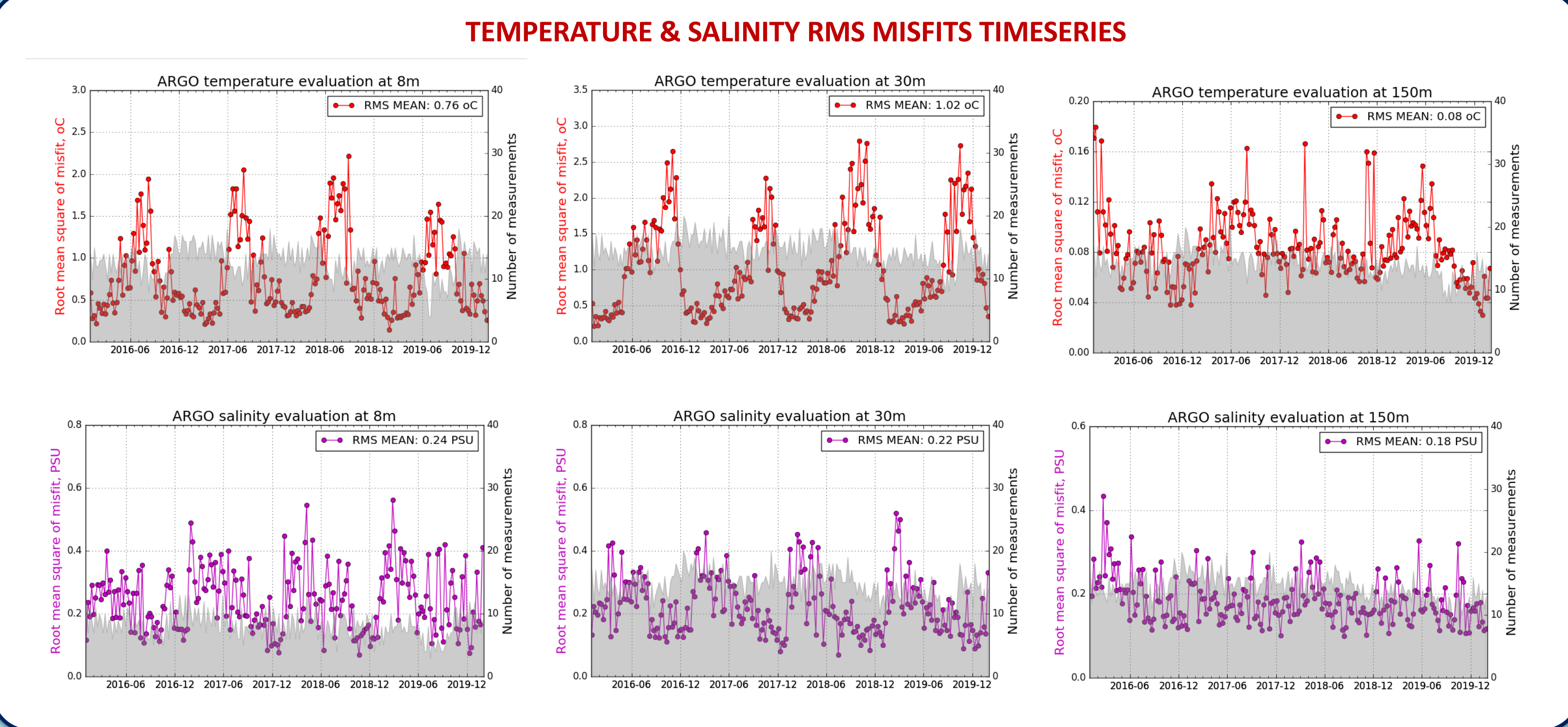**Salinity**: Larger error between 0-150m and at surface in the Western Med & North Aegean Sea

Sea Level Anomaly: Mean error ~3.6 cm; Larger errors in Western and Sothern basins

VENICE "ACQUA ALTA" EXTREME EVENT ON 12 NOV. 2019

On November 12th 2019, the city of Venice in Italy was confronted with an exceptional "Acqua Alta" extreme event with a maximum water level recorded of 187 cm, the highest since the severe flooding event in 1966.

During this event, the Mediterranean Forecasting system, value added with astronomical tides, provided reliable sea level predictions since two days in advance, even with some underestimation (~20% error) mainly caused by the atmospheric forcing fields lack in representing the sudden increase in wind speed.

Predicted Sea Level at a Platform located 15km offshore Venice Lagoon
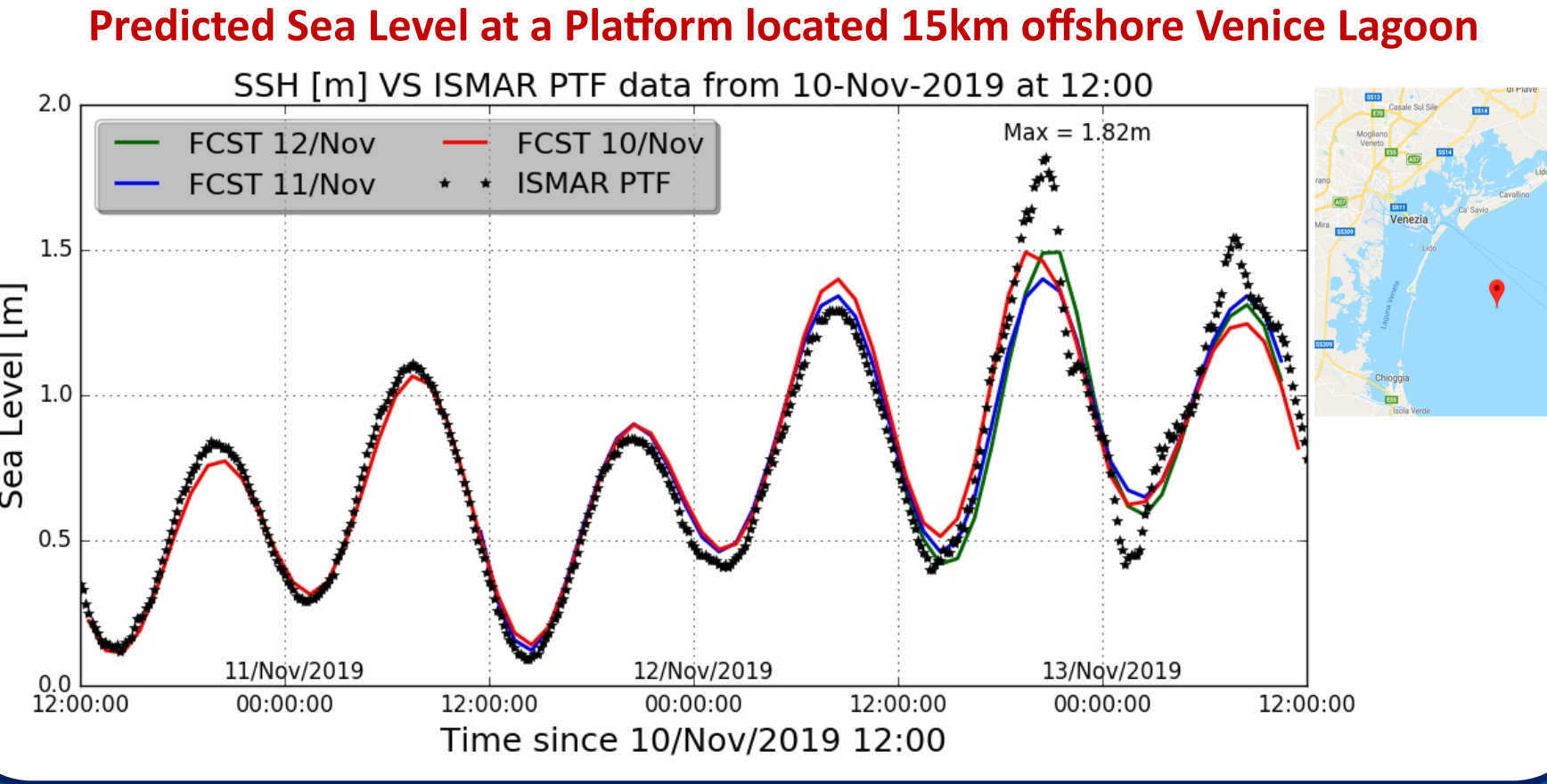
THE BLACK SEA PRODUCT QUALITY

TEMPERATURE & SALINITY RMS MISFITS TIMESERIES

SEA LEVEL ANOMALY RMS MISFITS

Temperature: Higher errors in temperature during summertime (up to 2°C in the upper layer) Mean error for temperature: ~1°C

Salinity: 0.25 PSU of error for salinity in the 0-150 m layer

Sea Level Anomaly: Mean error ~2.4 cm

Scarcity of SL data in the shelf zone, Georgian and Bulgarian region

Fill Gaps and Needs in Observations
Some of the issues of concern and gaps are the following: 1) Lack of real time oceanographic data; 2) Poor geographical coverage; 3) Lack of modern instruments and sensors; 4) Need for homogenization of data management (Palazov et al. 2019)

MEDITERRANEAN SEA MODEL FUTURE UPGRADES

• Include **tides** in the circulation model
• Implementation of estuarine box model (**EBM**) for river-ocean coupling
• Use of **high frequency inter-annual river run off** and river forecasts, where available
• Improvement of the **on-line coupling of NEMO with wave model**
• Improve the **vertical mixing** representation
• **Data assimilation** upgrades and physical parameterization tuning (vertical mixing)

BLACK SEA MODEL FUTURE UPGRADES

• Implement the **Bosporus Strait as open boundary condition** using high resolution ocean fields from unstructured grid model --> **Towards optimal interface Med-BS**
• **Revision of spatial domain:** Increased number of vertical levels up to 121 and new bathymetry
• **ECMWF precipitation** and revision of the processing chain to add products with new temporal frequency
• **Data assimilation** upgrades and **physical parameterization tuning** (vertical mixing, light penetration)