Global and Mediterranean Operational Forecasting systems @ CMCC - Italy

**OPOS-WG**

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Centro Euro-Mediterraneo
sui Cambiamenti Climatici

Global system – GOFS16

- Hydrodynamic Model (**NEMOv3.6-LIM2**)
  - ➢ Resolution: ORCA grid at 1/16, 98 vertical level
  - ➢ Heat and Freshwater correction on-line
  - ➢ SIC nudging
  - ➢ Daily initialization through Incremental An. Update (IAU)
- Assimilation system (**OceanVar**)
  - ➢ Resolution: ORCA grid at 1/16, 98 vertical level
  - ➢ 3DVAR for T/S, SST and SLA

Website with latest bulletin

https://gofs.cmcc.it/

~7 km @equator

~3-4 km @60°
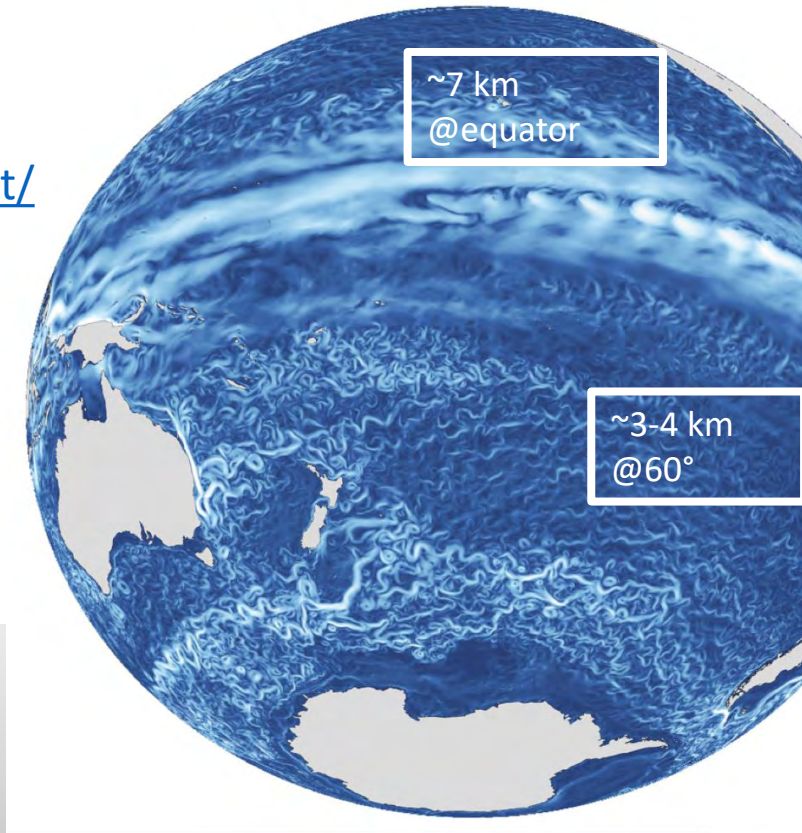
Scheme of assimilation cycle
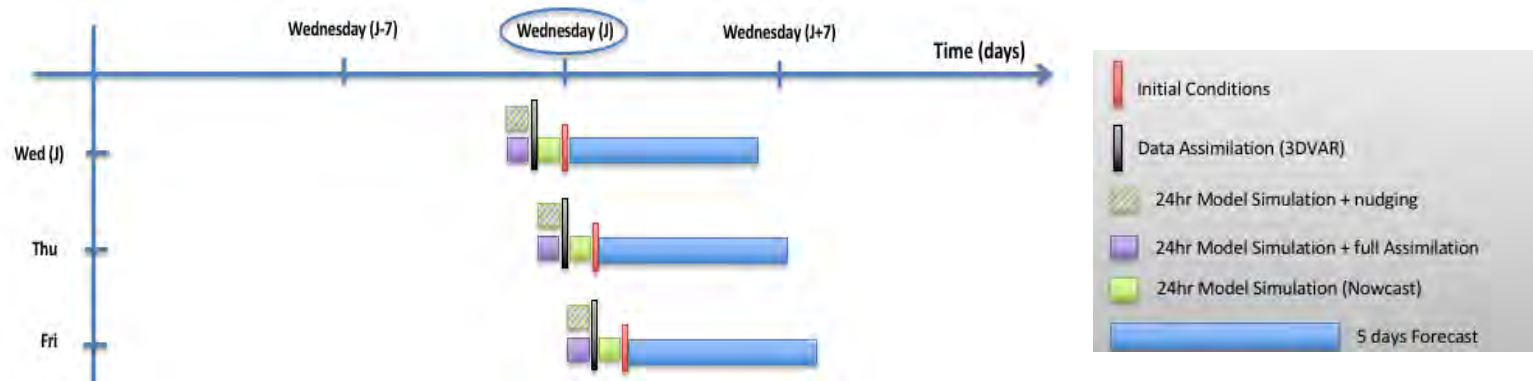
Next advances in the system

- Update of the ocean and sea-ice model
- Inclusion of a longer analysis (weekly basis)
- New atmospheric forcing (NCEP 1/4 deg -> ECMWF 1/10 deg)

- New scheme for DA parallelization
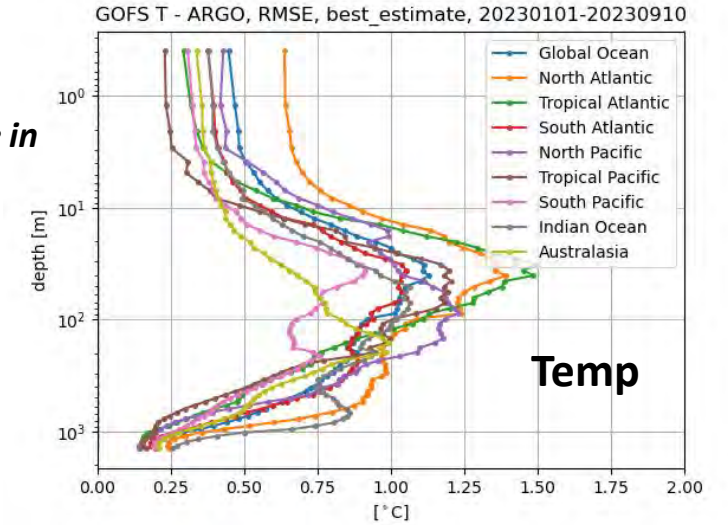- New SST operator based on ML

GODAE/OceanPredict intercomparison

- Using the GODAE/OceanPredict collected data, a validation against in-situ T/S, satellite SLA and drifter SST is performed and disseminated via the common ftp
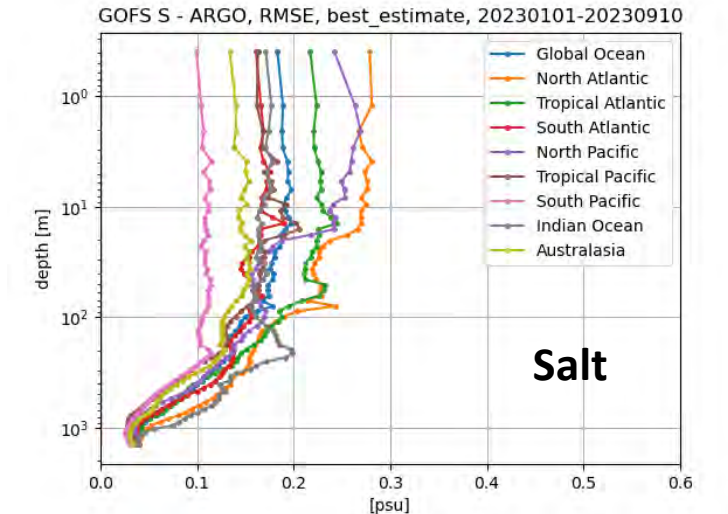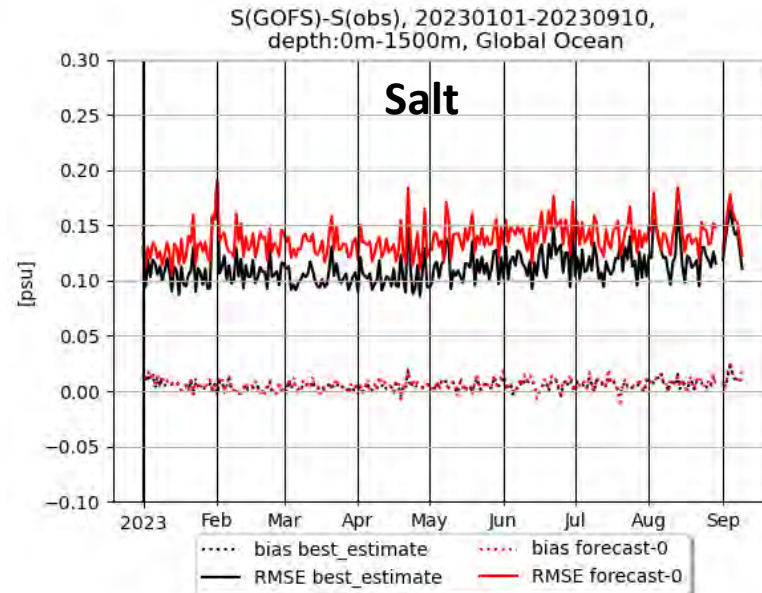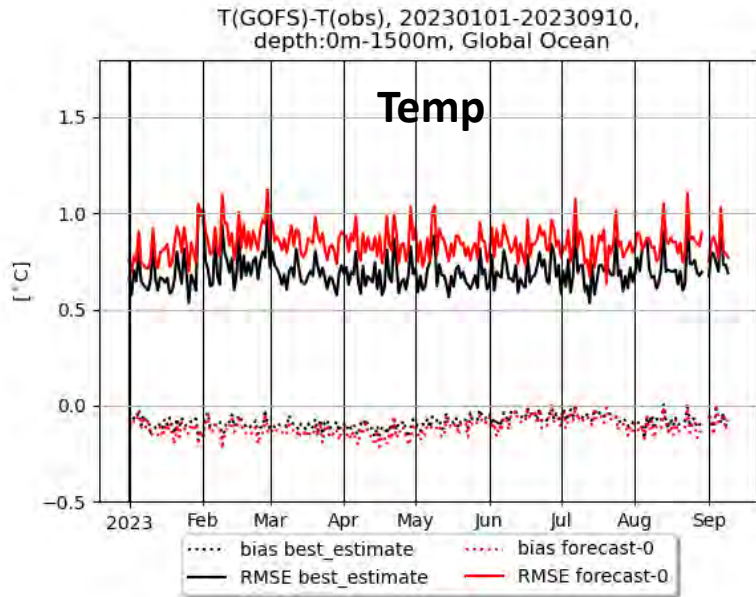
Summary of 2023 statistics

- The present error for T and S is about 0.6 deg a and 0.1 psu integrated over the water column for the best estimate and 0.75 degC and 0.14 psu for the first day of forecast

Vertical RMSE profile in different regions


2023 Timeseries for T and S

GODAE/OceanPredict intercomparison

- Using the GODAE/OceanPredict collected data, a validation against insitu T/S, satellite SLA and drifter SST is performed and disseminated via the common ftp
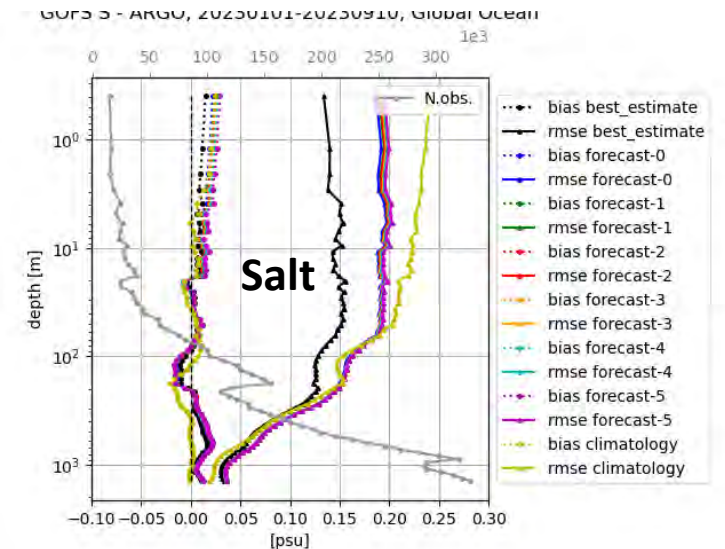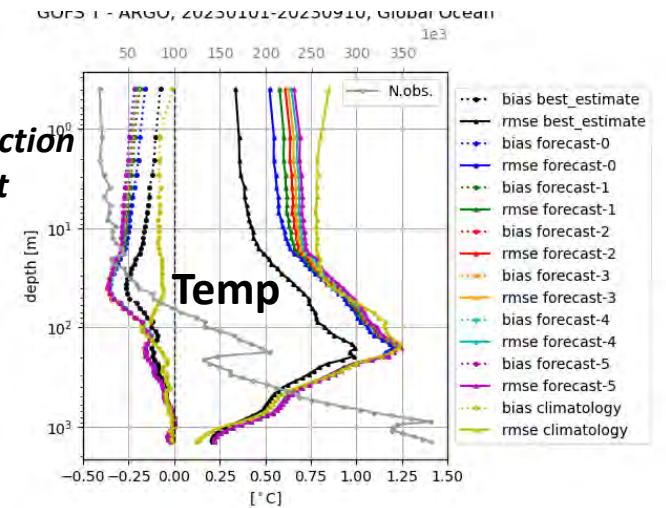
Summary of 2023 statistics

- Evolution of T and S RMSE is pretty stable with the increasing forecasts lead time
- Need to improve the error of T and S at depth (>1000m)
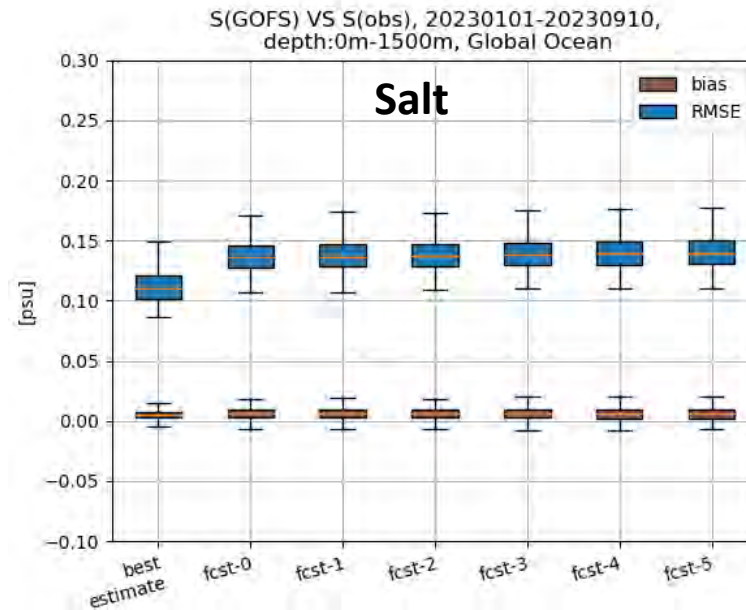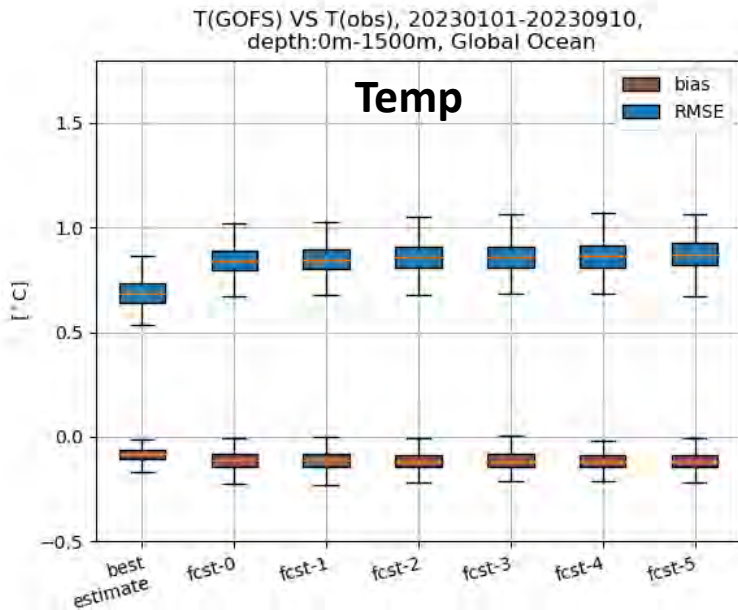
Vertical RMSE as function of the day of forecast

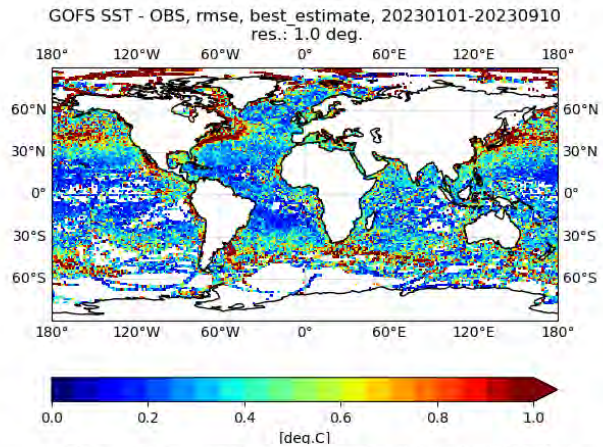*RMSE evolution with the day of forecast*
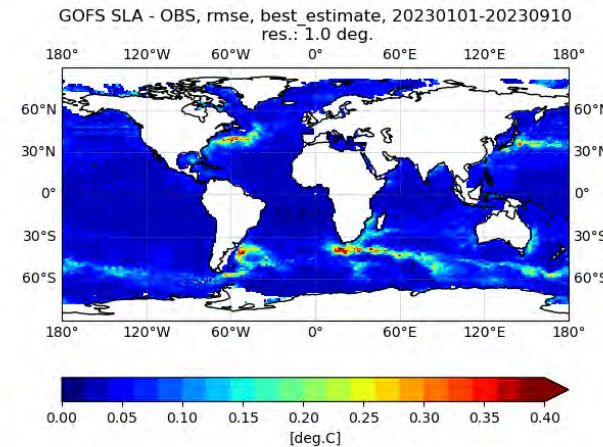
GODAE/OceanPredict intercomparison

Surface SST and SLA validation, a negative bias is present in the SST (model is colder than drifters' observation)
A new SST observation operator is under development to reduce the bias.

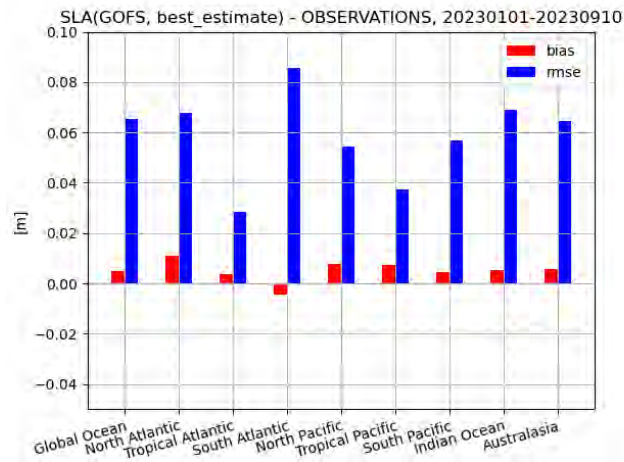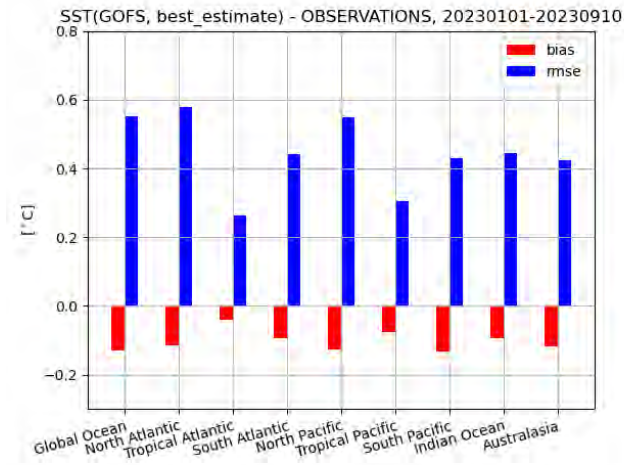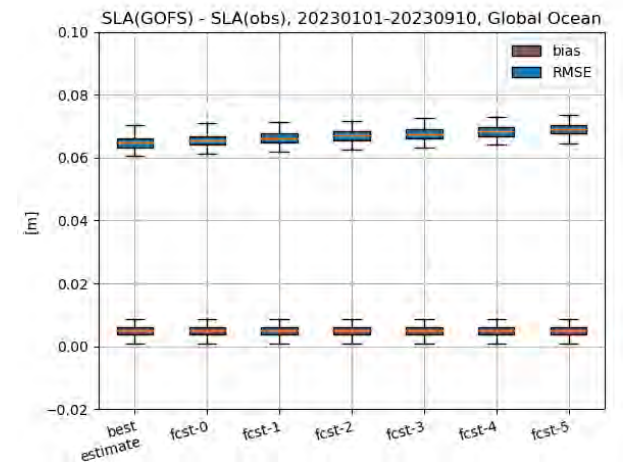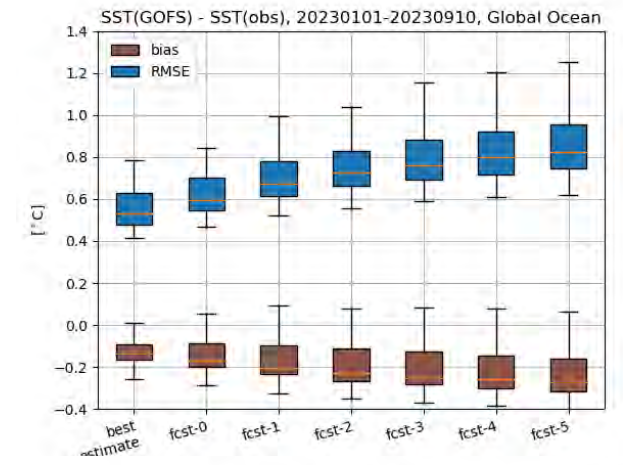

Spatial RMSE for the best estimate

Basin RMSE and BIAS

BIAS/RMSE evolution with the day of forecast

SST

SLA

Representation of Tropical Cyclone Larry

- TC Larry became a major Category 3 hurricane early on September 4th 2021 (at 15.2ºN and 42.7ºW). The water masses deeper than ~100m rise up towards the sea surface with temperature lower than the pre-hurricane conditions
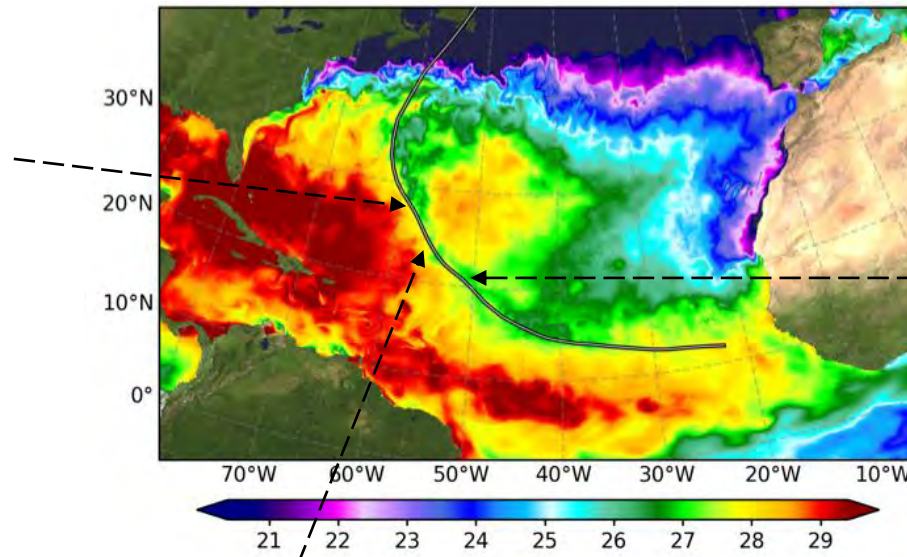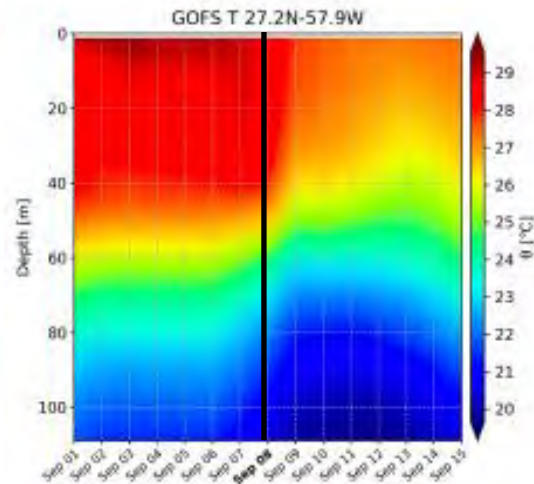
Larry track position (31 Aug – 11 Sept 2021) from NOAA and GOFS16 SST analysis on 10th Sept 2021
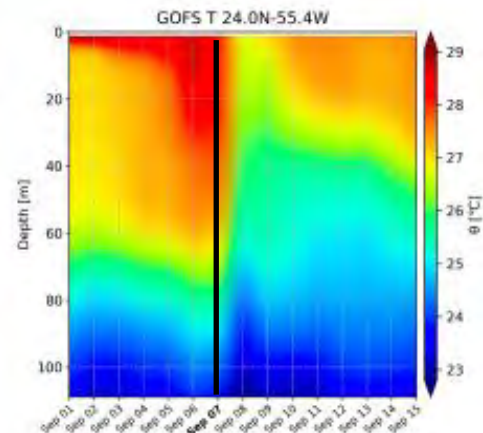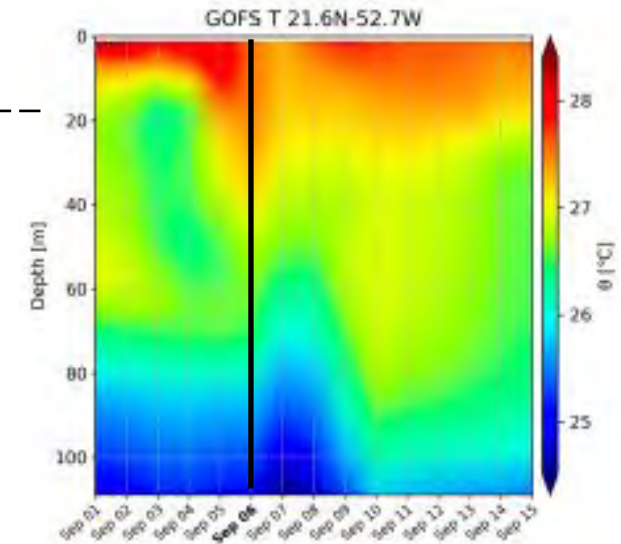
Hovmöller diagrams of daily GOFS16 between Sept 1 and Sept 15 (at 12pm UTC) 2021 in three selected points along Larry's path. The old line indicates which day Larry passed on that location.

Mediterranean system – MedFS EAS7 (Copernicus)

- Model (**NEMOv3.6 - WW3v3.14**)
  - Resolution: 1/24, 141 vertical level
  - Tides (8 components)
  - Heat flux correction with Sat. SST
  - Daily Direct initialization
- Assimilation system (**OceanVar**)
  - Resolution: 1/24, 141 vertical level
  - 3DVAR for T/S, and SLA

From Dec 2023

Mediterranean system – MedFS EAS8 (Copernicus)

- Model (**NEMOv4.2 - WW3v6.07**)
  - Resolution: 1/24, 141 vertical level
  - Tides (8 components)
  - Heat correction with Sat. SST
  - Daily Direct initialization
- Assimilation system (**OceanVar**)
  - Resolution: 1/24, 141 vertical level
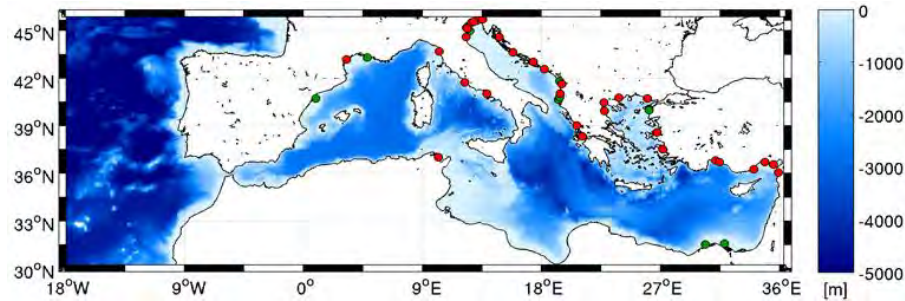 - 3DVAR for T/S, and SLA

+ new EOFs + assim Atlantic + updated QC

Website with latest bulletin   https://medfs.cmcc.it/

ECMWF atmospheric fields:

Spatial resolution: 1/10°
Temporal resolution:
Forecasts: 1hr – 3hrs – 6 hrs
Analysis: 6 hours time resolution

Land river runoff:
Surface boundary condition for **39** major rivers with annual mean discharge > 50 m^3/s using climatological monthly mean values
Po river daily observations

Lateral Boundary conditions:
Atlantic: Daily NRT analyses and forecasts from Copernicus Global Forecasting System (GLO-MFC) @ 1/12, 50 vert lev.
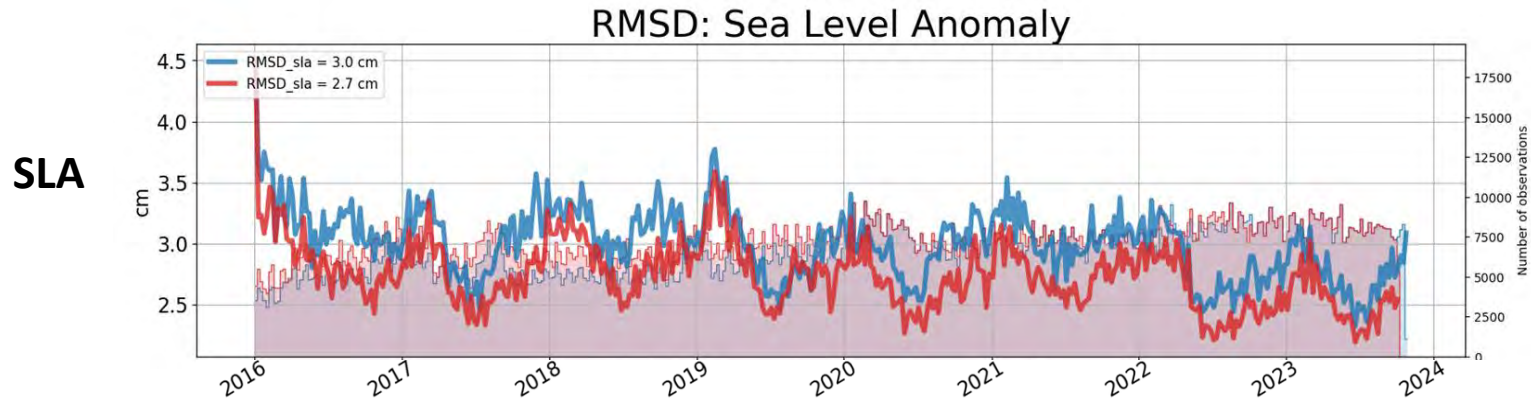**Dardanelles:** box model (Maderich et al. 2015) daily clim. + Temperature from GLO-MFC
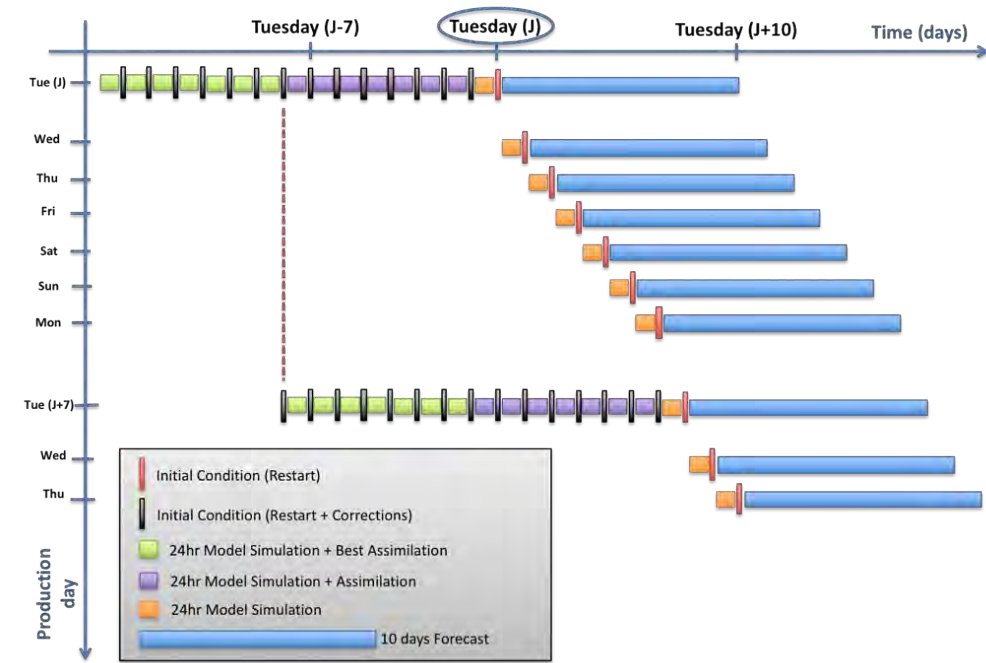
T & S Model Skill wrt in-situ observations
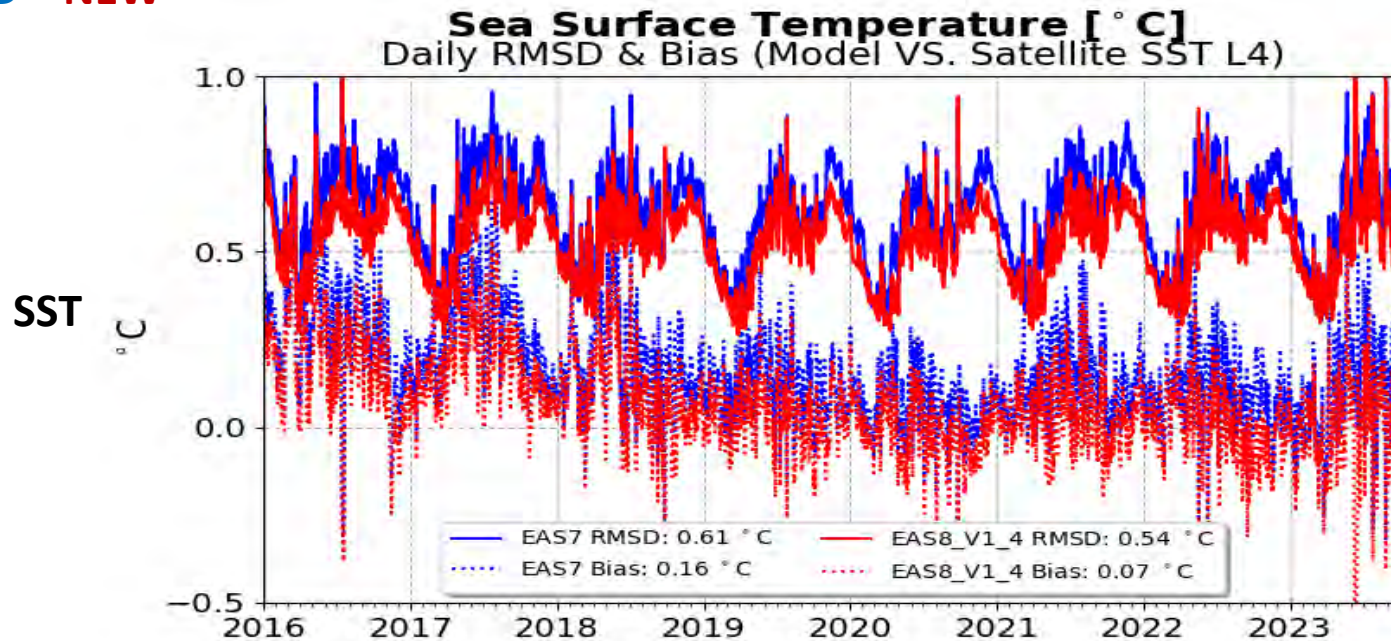
Temperature

Salinity
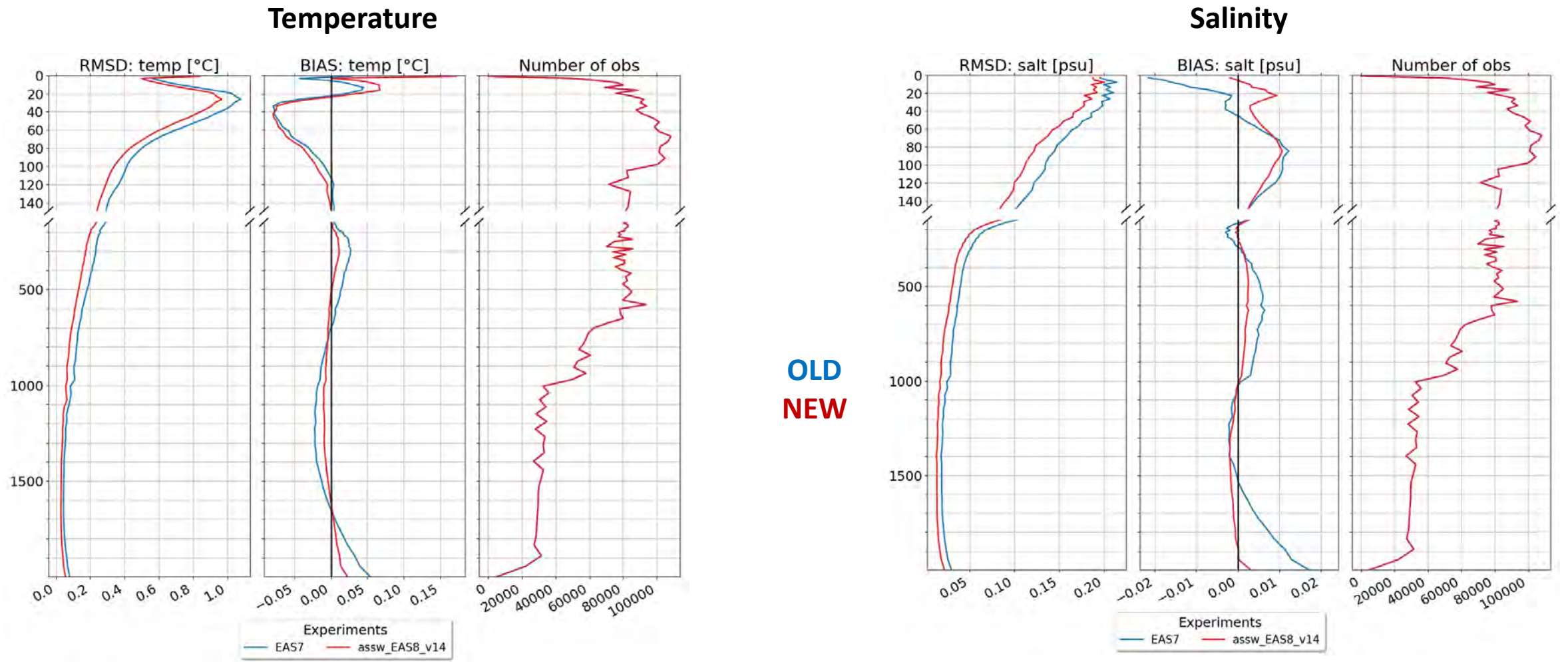
OLD
NEW

New version: Overall decrease of the model error
at all depth and bias especially al larger depths

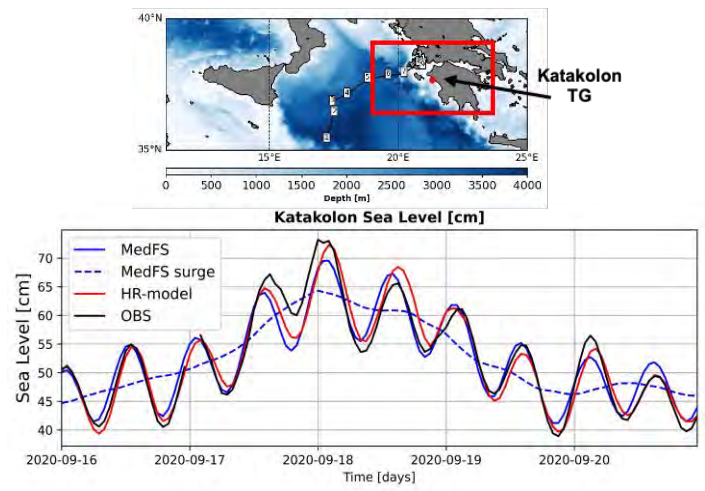## SLA & SST Model Skill wrt satellite observations

RMSD: Sea Level Anomaly

SLA

OLD   NEW

SST

Sea Surface Temperature [°C]
Daily RMSD & Bias (Model VS. Satellite SST L4)

**New version**: SLA and SST errors decrease of ~10%

MedFS Forecasting Extreme Events

Medicane Ianos
September 2020

- MedFS **correctly reproduced Medicane Ianos path & SST decrease** (not shown)
- **Model SSH** in agreement with Katakolon TG Underestimation ~ 4 cm at peak
  → *Clementi et al. 2021 in OSR6*
- **MedFS used to force high res**. (3km to 100m) **unstructured grid model** (red box) → reduced error at peak
  Contribution from I. Federico (CMCC)

SST & Marine Heat Waves
Summer 2022
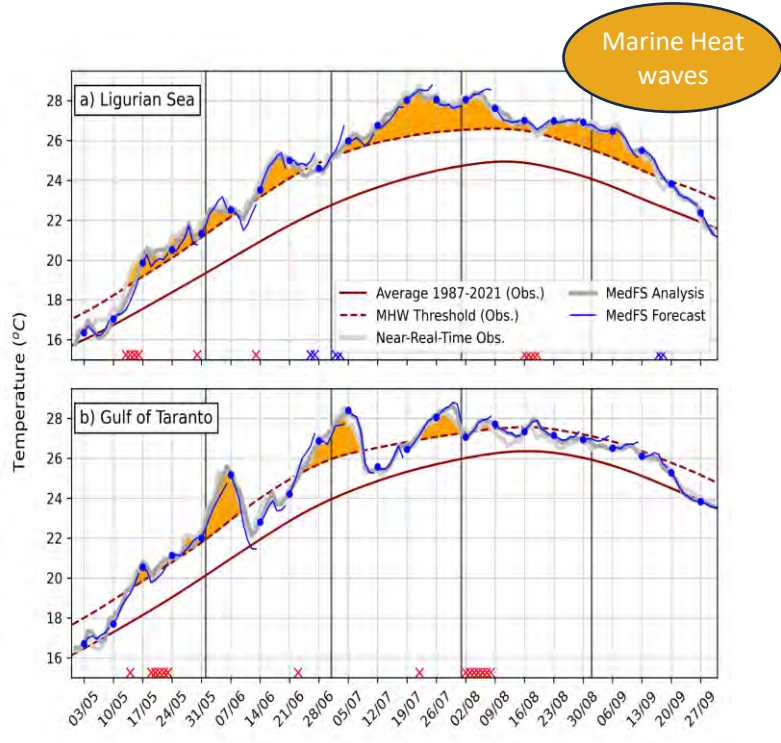
MedFS **predicting Marine Heat waves**
Mc Adam et al. 2023, Submitted in ORS8

Venice Acqua Alta
November 2022

https://medfs.cmcc.it/
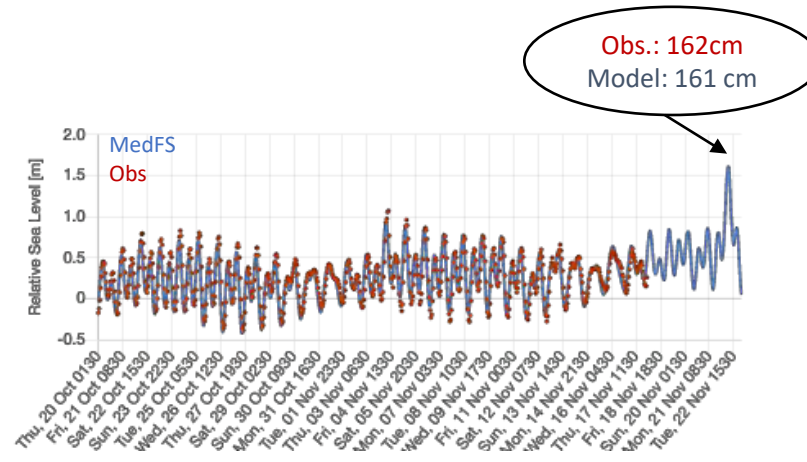
MedFS **predicting Acqua Alta events** in Venice with 3 days in advance

- The **CMCC Global** and **Mediterranean Sea operational systems** are **constantly ameliorated** to improve the forecast accuracy

- The systems are **validated** before delivering an updated version and continuously **monitored** during operations

- **Validation assessment is performed** by comparing model daily analysis and forecast fields with respect to satellite and in-situ observations

    - **Global**: intercomparison within Ocean Predict IV-TT

    - **Mediterranean**: operational validation produced within Copernicus Marine Service

- Both systems produce accurate data to represent and forecast **extreme events**

Thanks