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Centro Euro-Mediterraneo
sui Cambiamenti Climatici

Global Ocean Forecasting System at 1/16

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IV-TT seminar - July 15, 2026

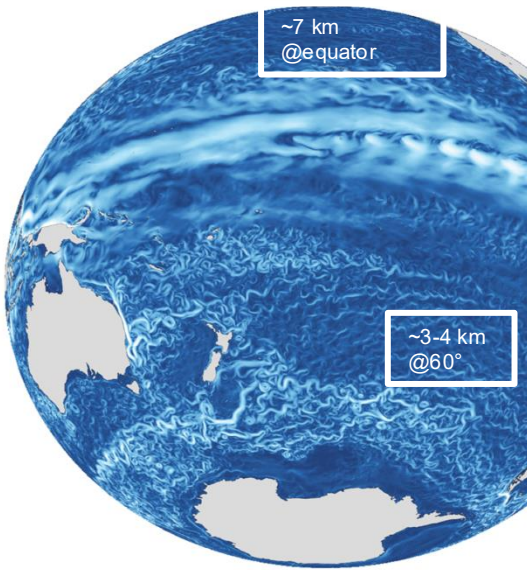
Overview of the system

Forecast model (**NEMOv3.4-LIM2**)

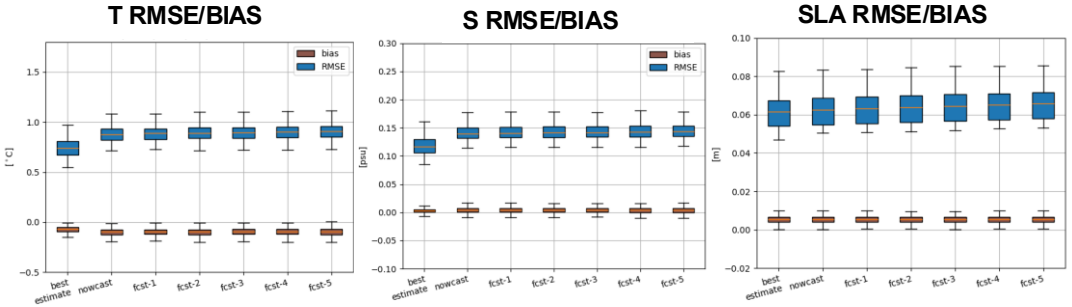
- **GRID**: GLOB16 (Iovino et al 2016)
- **Res**: 6.9km at the equator, increasing poleward to ~2km
- **Atm Forcings**: NOAA analysis/forecast
- **Nudging** : Heat and Freshwater correction and SIC
- **LBC**: free slip
- **Forecast**: From +0h to +144h
- **Update frequency**: Daily via initialization through IAU

Assimilation system (**OceanVar**)

- GRID: **Same of the model**
- 3DVAR + overlapping cost function (Cipollone et al 2021)
- Data ingested :**T/S profiles** and **SLA** from NRT CMEMS products, **SST** from Metop-B/AVHRR and GCOM-W/AMRS-2 (placed on the first model level)



2025 Statistics from GODAE/OceanPredict dataset



GOFS16 review

Masina et al 2026, under review GMD:
https://doi.org/10.5194/egusphere-2026-887

Comparison against other models:

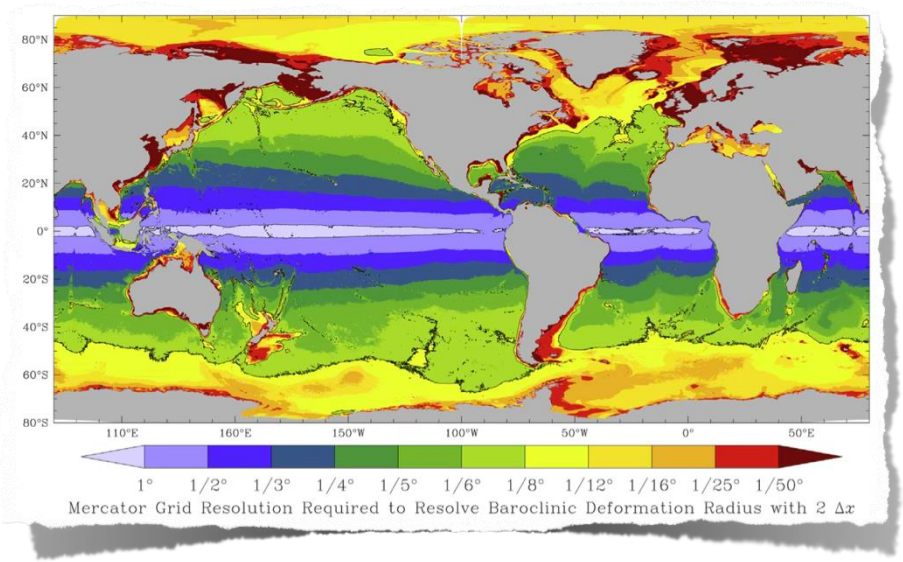
Smith et al 2026, under review BAMS

Two words on the resolution…

Some scientific info

- Most of the ocean basin is resolved expect for polar regions and shelves

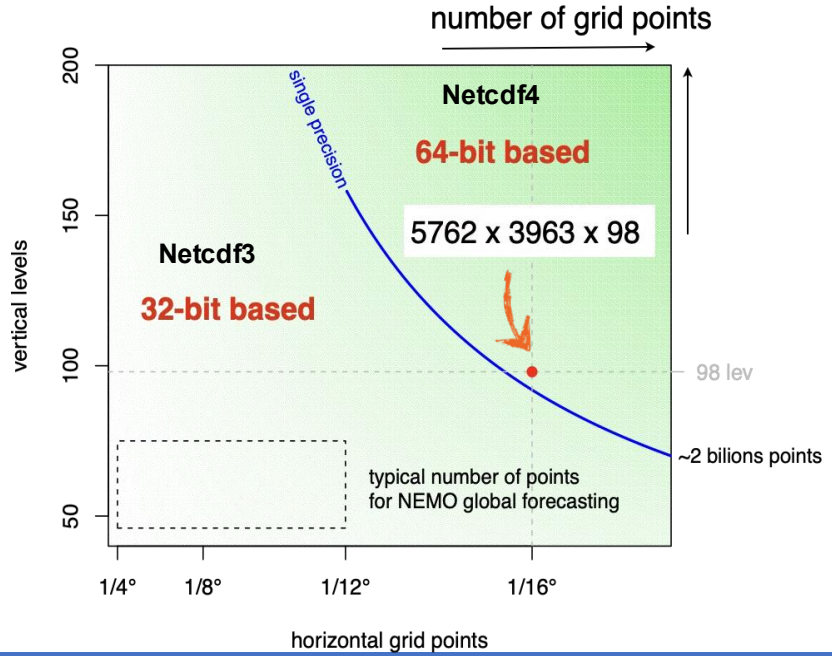
Deformation radius



(Hallberg, 2013)

Other technical ones

- 1TB of outputs produced **every day** that are compressed/ transformed and stored (~46TB/year)
- The grid is too big for a classic netcdf3



Two words on the DA

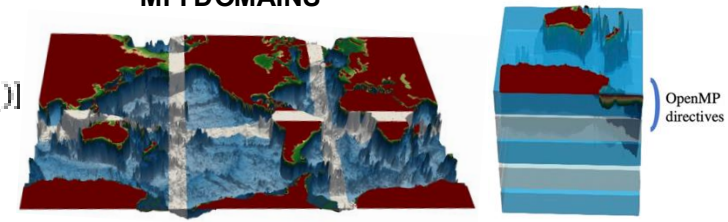
3Dvar with overlapping cost function (Cipollone et al, 2021)

$$J(\mathbf{v}) = \frac{1}{2}\mathbf{v}^{\mathrm{T}}\mathbf{I}\mathbf{v} + \frac{1}{2}(\mathbf{H}\mathbf{V}\mathbf{v} - \mathbf{d})^{\mathrm{T}}\mathbf{R}^{-1}(\mathbf{H}\mathbf{V}\mathbf{v} - \mathbf{d}) + \frac{1}{2}\sum_{j\in\text{Neighbor of }1}[\mathbf{v}_1(\cap_{1j}) - \mathbf{v}_j(\cap_{j1})]\mathbf{Q}_{1j}^{-1}[\mathbf{v}_1(\cap_{1j}) - \mathbf{v}_j(\cap_{j1})]$$

Standard cost function for each region

penalize solutions that diverge in the overlapping areas

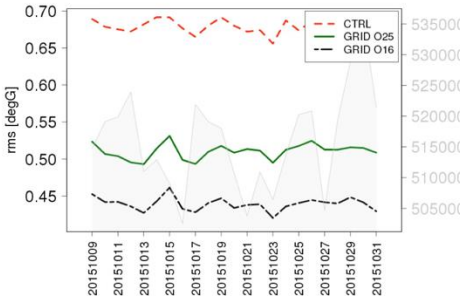
MPI DOMAINS



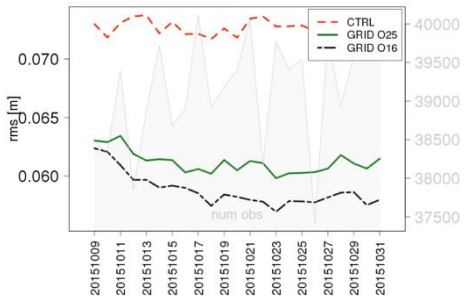
GLOB16 grid used at DA level

GLOB16 Improves the skill-score for dense observations (SST,SLA) when compared to low-res grids (model kept at 1/16), no impact on insitu

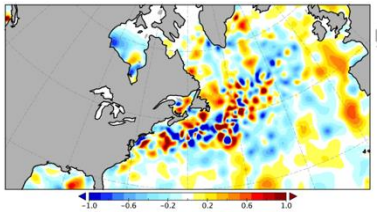
SST RMSE



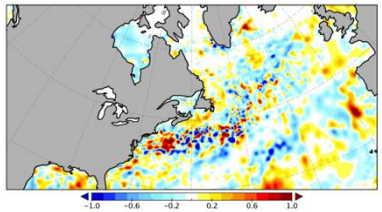
SLA RMSE



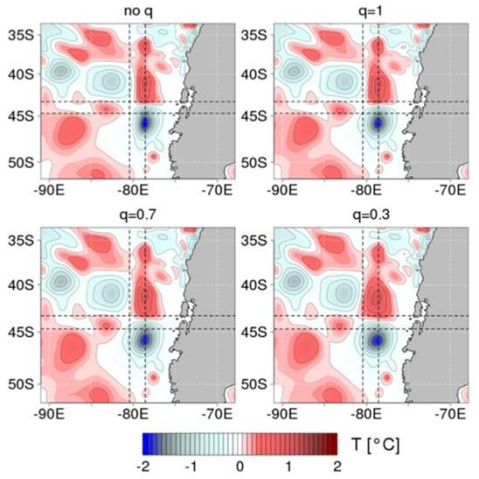
ORCA025



GLOB16



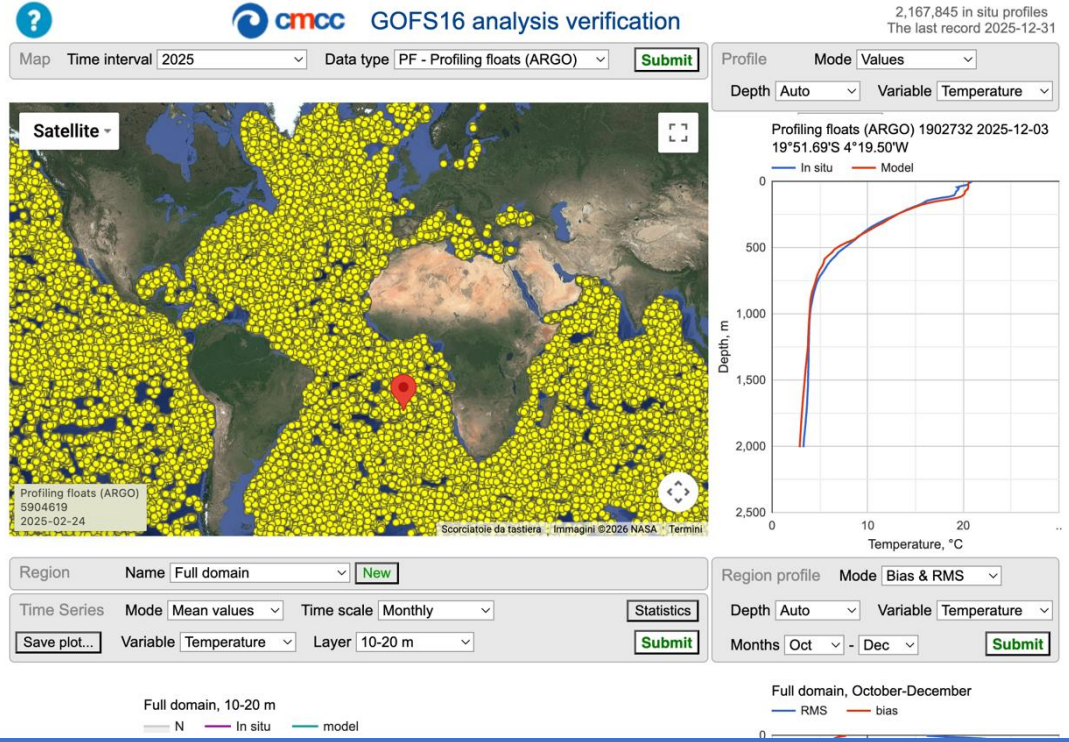
T INCREMENTS



Overview of the system

Evaluation of GOFS16 analysis field against **multiple insitu** profiles is available from the website

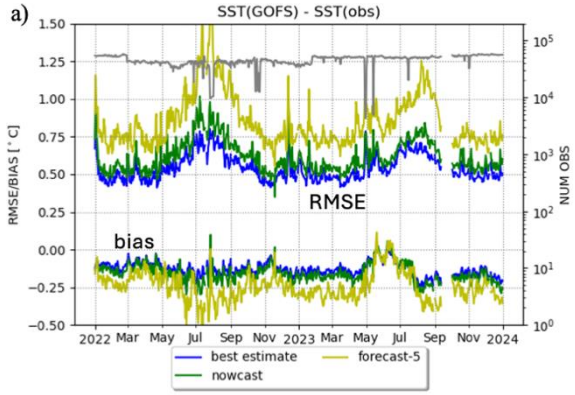
https://evalid-dev.cmcc-opa.eu/evaluation/gofs/

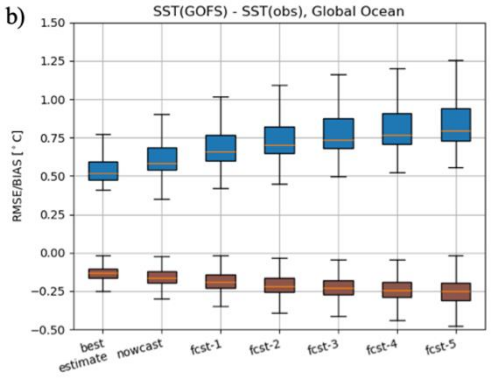


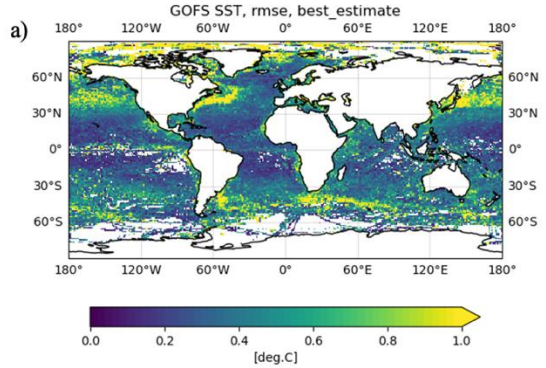
Evaluation on SST skill scores

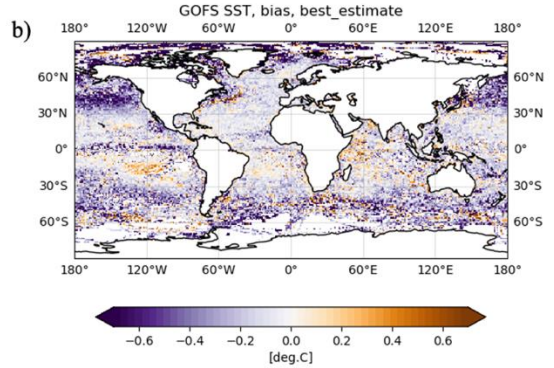
SST scores against drifter SST via GODAE/OceanPredict (independent)

- SST obs are placed at the first model level
- SST RMSE is seasonally dependent coming from the drifter spatial distribution
- RMSE gradually increases by 50% from nowcast to 5° day of forecast
- A global cold bias persists and degrade with forecst day
- Spatially the error is generally low. It is saturated by the **cold bias** expecially in the Nord Pacific





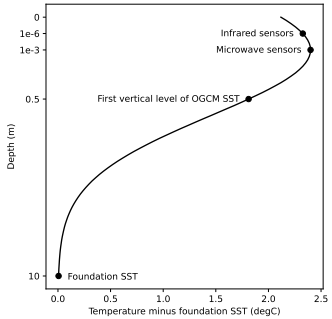




Next on SST

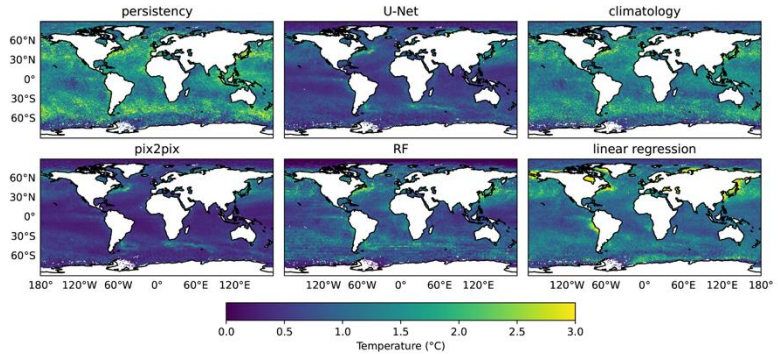
- Development on new operator based on CNN (Broccoli & Cipollone, 2025)

Typical T profile in first 10m



Different operators were tested: (climatology, linear regression, random forest, CNN, etc)

RSME w.r.t. ground truth

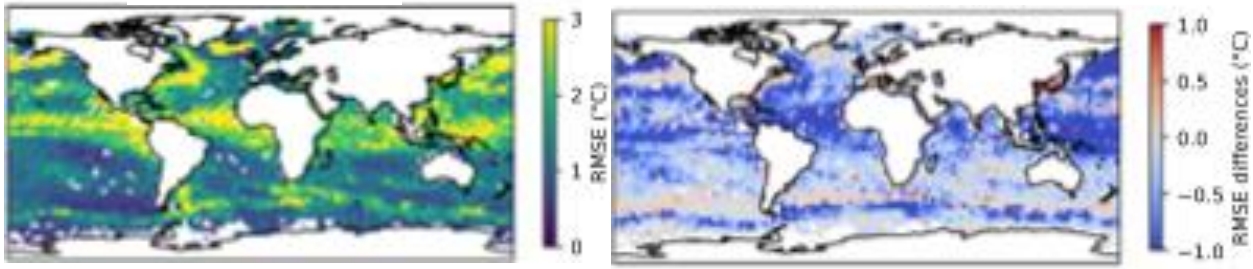


- Assimilative twin experiments (1-year-long) of diurnal SST subskin observations ***only*** at 1/4

- ML-assisted SST obs operator improves the RMSE by 20% in a experiments with SST assim only
- The improvement reduces to 9-10% if insitu data are assimilated contemporary

DIRECT EXP RMSE

ML-assisted EXP RMSE – DIRECT EXP RMSE



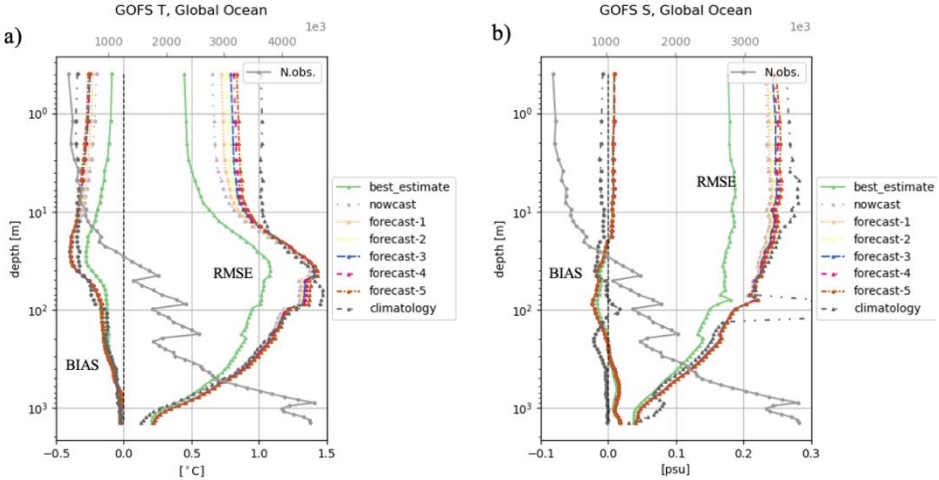
RMSE against *in situ* observations for the first 100m of depth

Other statistics

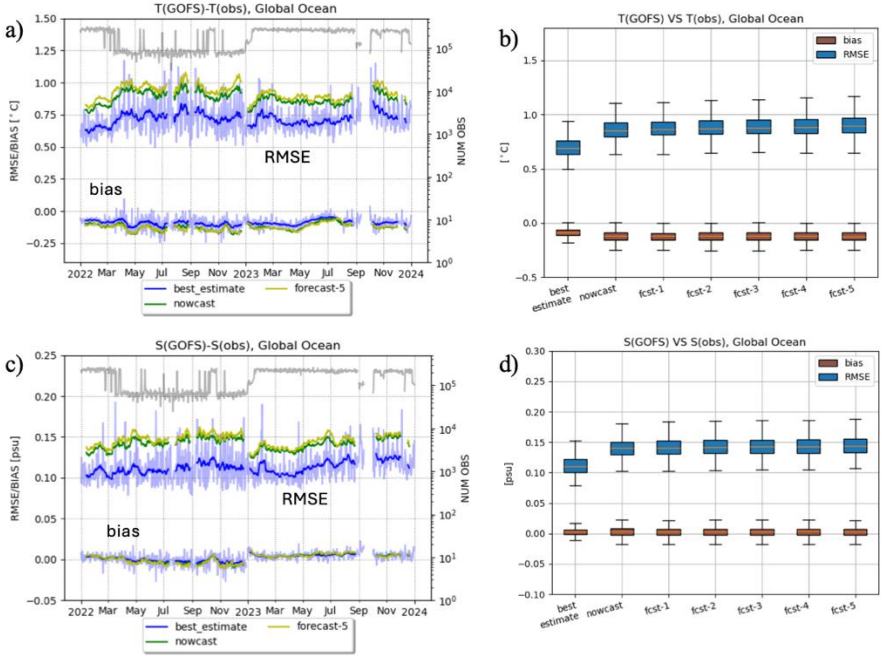
Summary of 2022-2023 statistics (Masina et al, 2026)

- Evolution of T and S RMSE is pretty stable.
- Need to improve the error of T and S at depth (>1000m)

Vertical RMSE/BIAS as function of the day of forecast



T and S RMSE/BIAS evolution

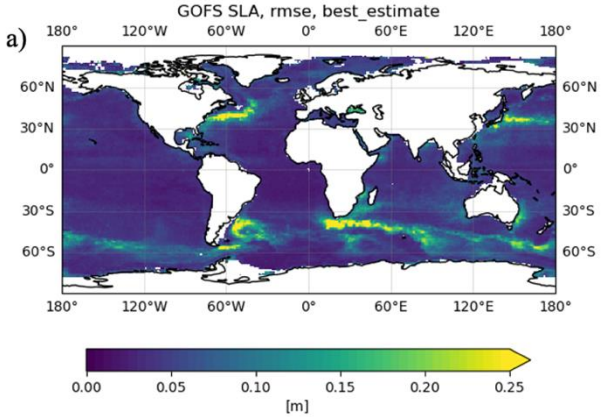


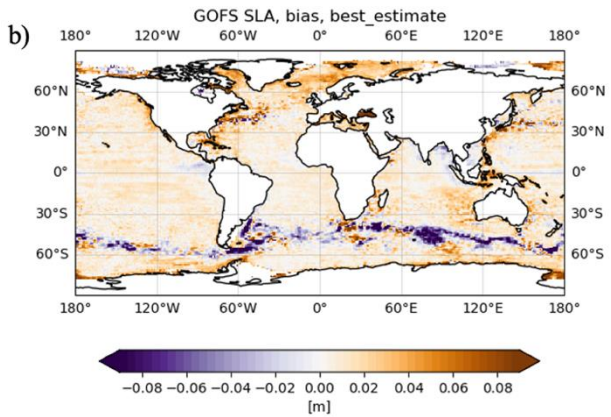
Obs with clim RMSE > 1 psu for salinity has been removed

Other statistics

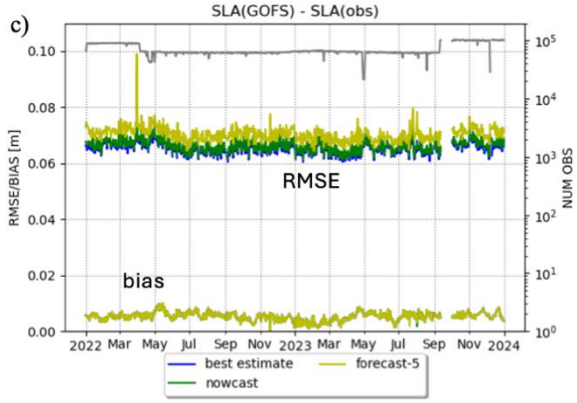
Summary of 2022-2023 statistics (Masina et al, 2026)

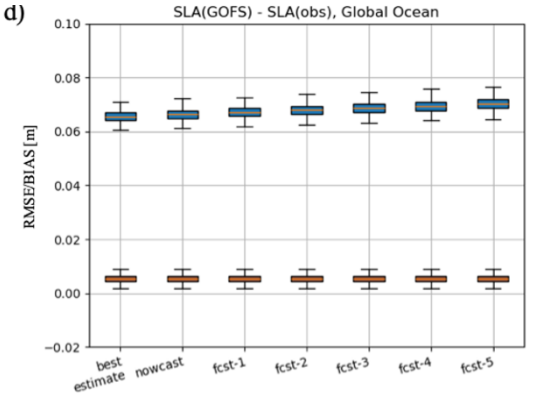
- Evolution of SLA RMSE is pretty stable.
- Presence of small bias globally, regionally it can be high (see ACC)





SLA RMSE/BIAS evolution





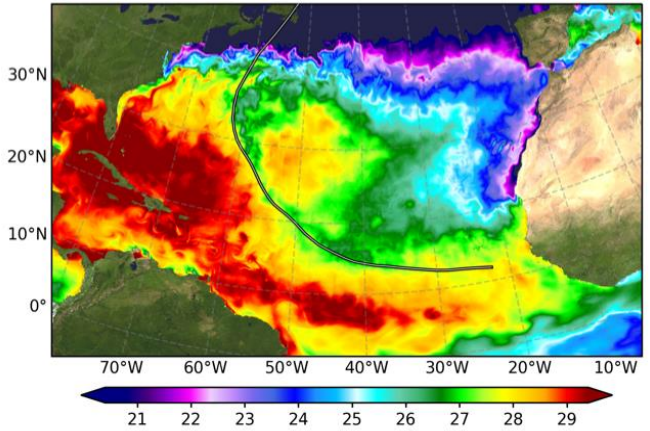
Extreme event

Representation of Tropical Cyclone Larry

- For relatively-weak TCs (≤Category 3), the subsurface water tends to cool with air–sea heat exchange and upwelling prevailing on mixing and downwelling that in turn tend to generate subsurface warm anomalies (Zhang et al 2021).

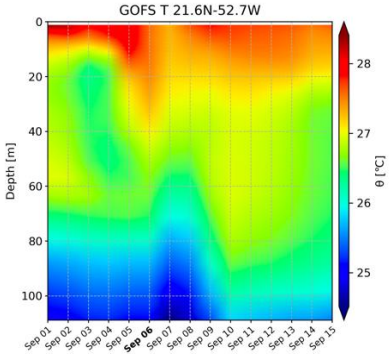
- TC Larry became a major Category 3 hurricane early on September 4th 2021 (at 15.2ºN and 42.7ºW) and stays the same category for several days

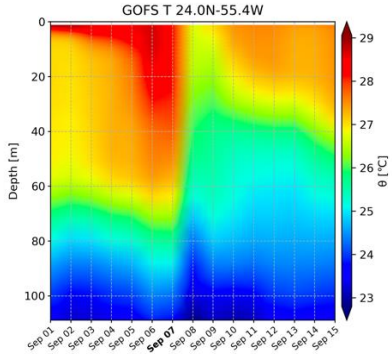
- GOFS16 show severe upwelling of cold thermocline water during and after Larry passes over the specific location. Water masses deeper than ~100m rise up towards the sea surface with temperature lower than the pre-hurricane conditions.

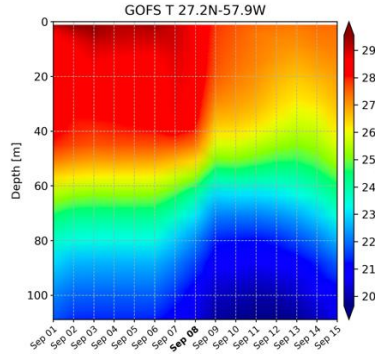


Larry track position (31 Aug – 11 Sept 2021) from NOAA and GOFS16 sst analysis in 10th Sept

Hovmöller diagrams of daily GOFS16 between Sept 1 and Sept 15 (at 12pm UTC) in three selected Larry positions. The bold date on the x-axis indicates which day Larry passes at that locations.



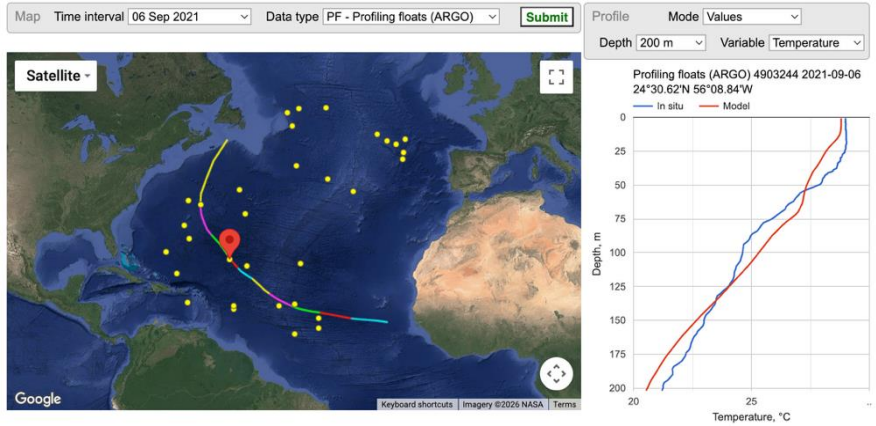




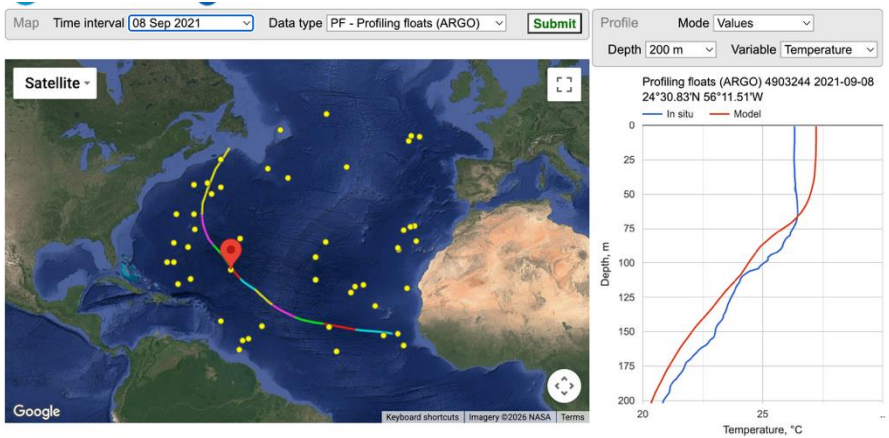
Extreme event

Representation of Tropical Cyclone Larry

- Comparison against Argo **before** the passage (6-09-2021)



- Comparison against Argo **after** the passage (8-09-2021)



Thank you!!