MERCATOR OCEAN INTERNATIONAL

Advancing Ocean Forecasting: Data Assimilation at MOi – Current Practice and Future Outlook

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Mercator Ocean International
General Mission Interest

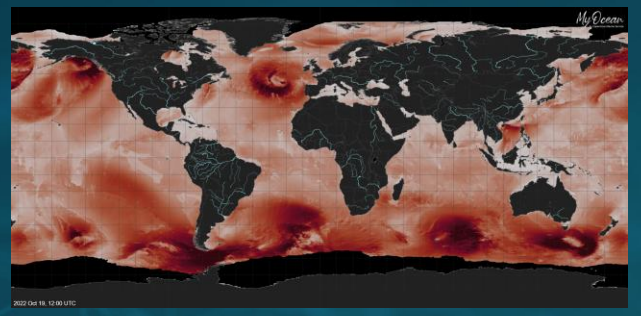
Multinational governance

EU Entrusted Entity

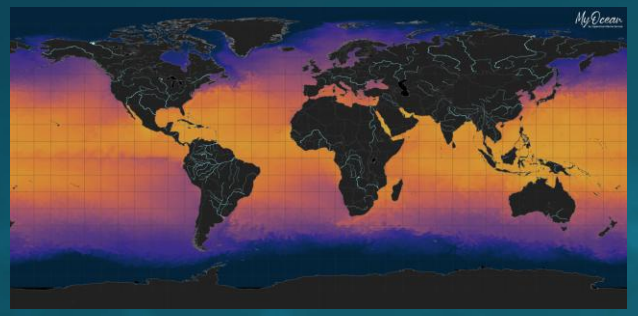
Users' information and products / Brazil

Copernicus Marine Service

- Top products (Last 12 months) -



Global Ocean Physics Analysis and Forecast

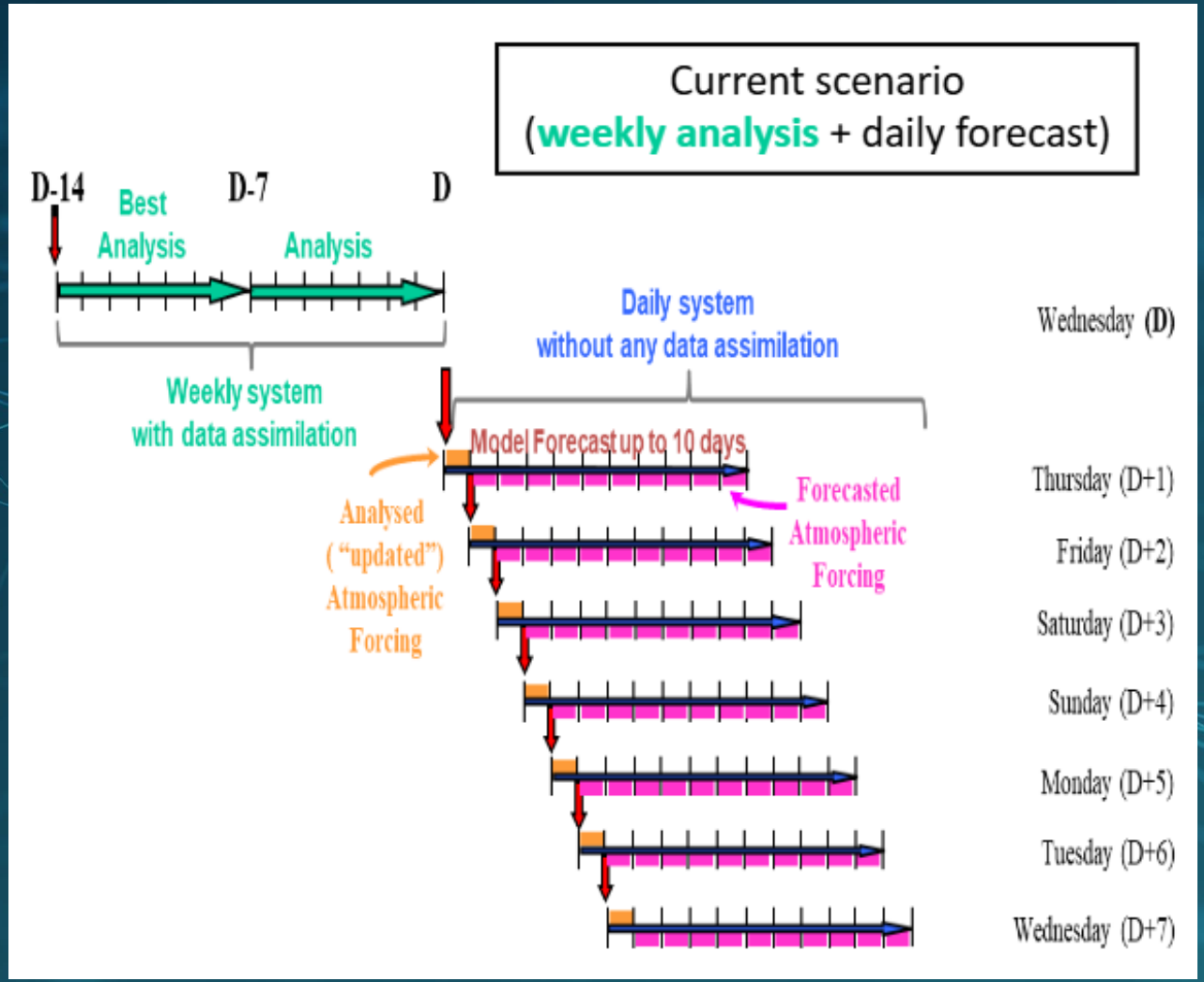


Global Ocean Physics Reanalysis

Data Assimilation and forecasting systems at Mercator Ocean

Physics and Sea-ice

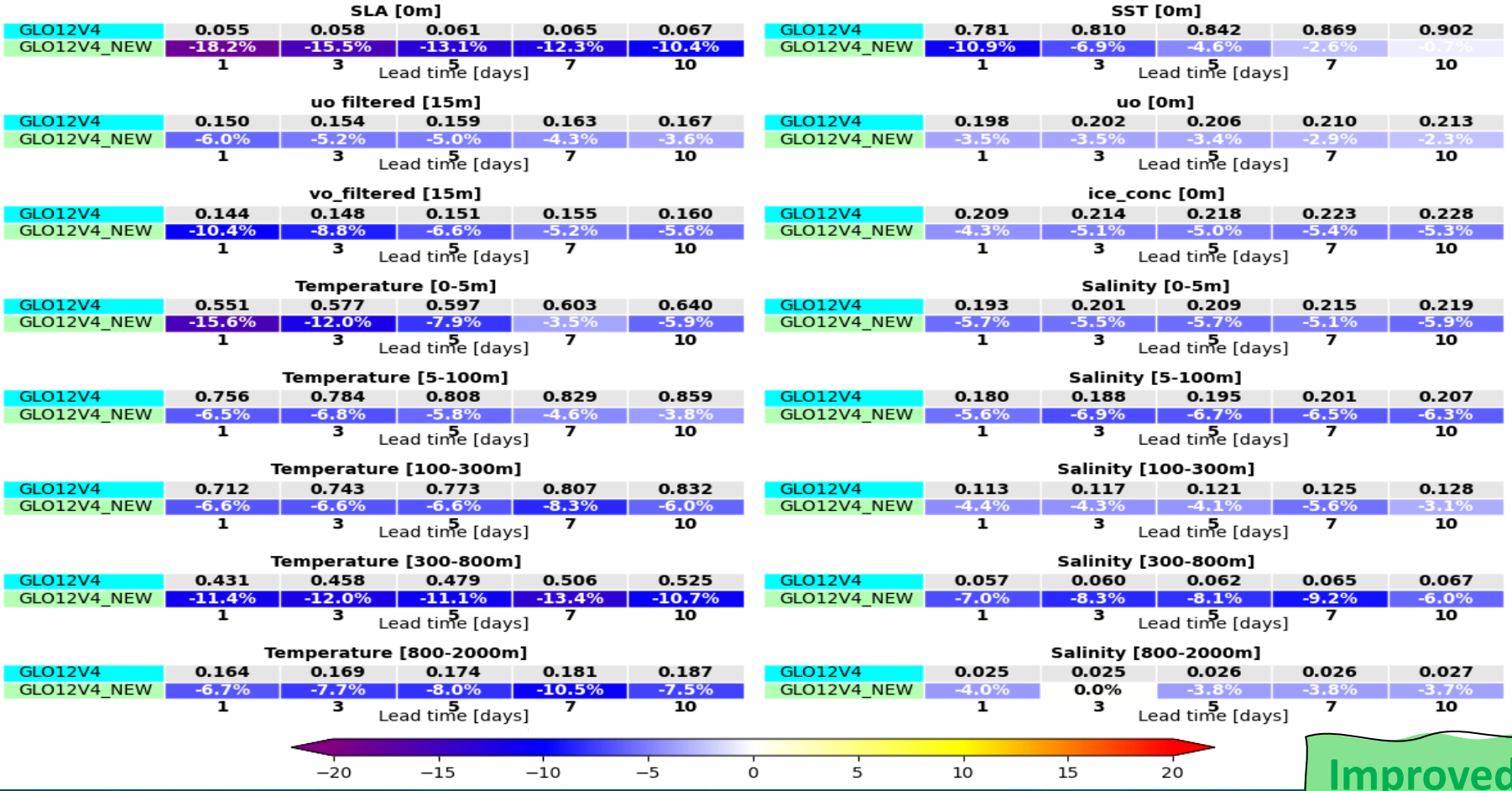
- ✓Global 1/12° coupled to multicategory sea-ice model (Nemo+LIM3)
- ✓7-day DA window for OITKF
- ✓Fully multivariate scheme for ocean physics
- ✓3Dvar bias correction for T/S
- ✓Only sea-ice concentration is corrected by DA
- ✓Assimilates:
  - ✓ AVISO SLA (L3)
  - ✓ ODYSSEA SST (L3S),
  - ✓ CORA T/S in-situ
  - ✓ AMSR sea-ice concentration



Innovations & Future

Daily Analysis (Nov 2026)

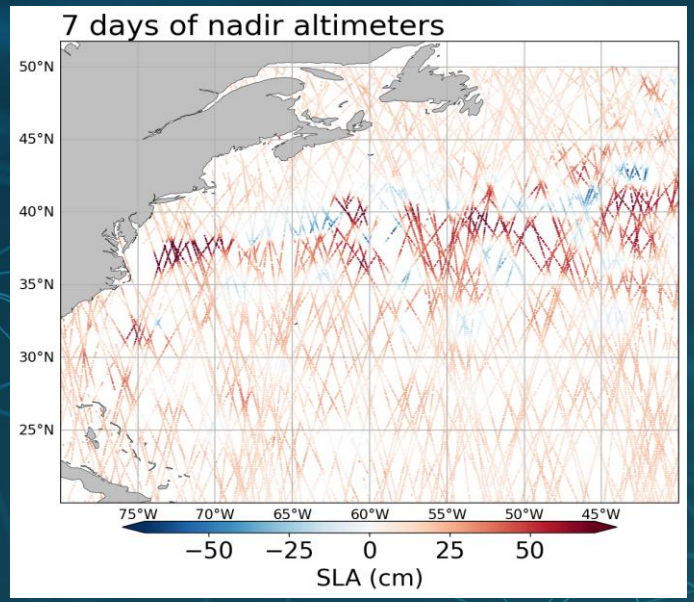
RMSD improvement/degradation (in %): **blue indicates better performance.**
GLO12v4 (current system), GLO12v4_NEW (with daily analysis)

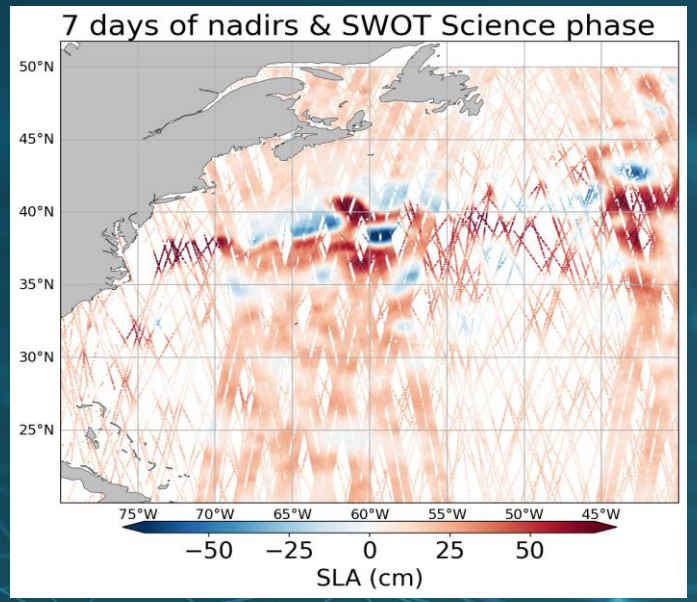


Improved initial state and forecast score for all physical variables.

Assimilation of SWOT data (March 2027)

- ✓ Information on small mesoscale features
- ✓ Reduction of large errors in currents (intensity and direction)
- ✓ Highly informative for building a new MDT
- ✓ Positive impact in BGC forecasts

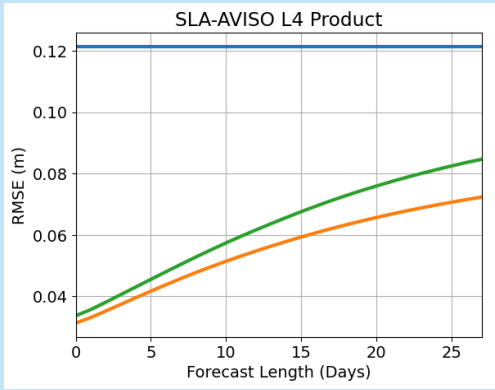


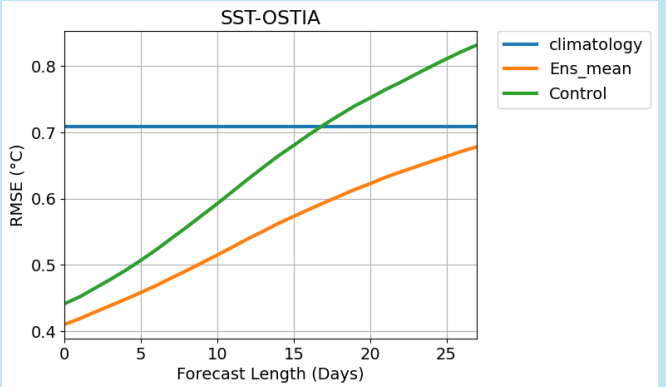


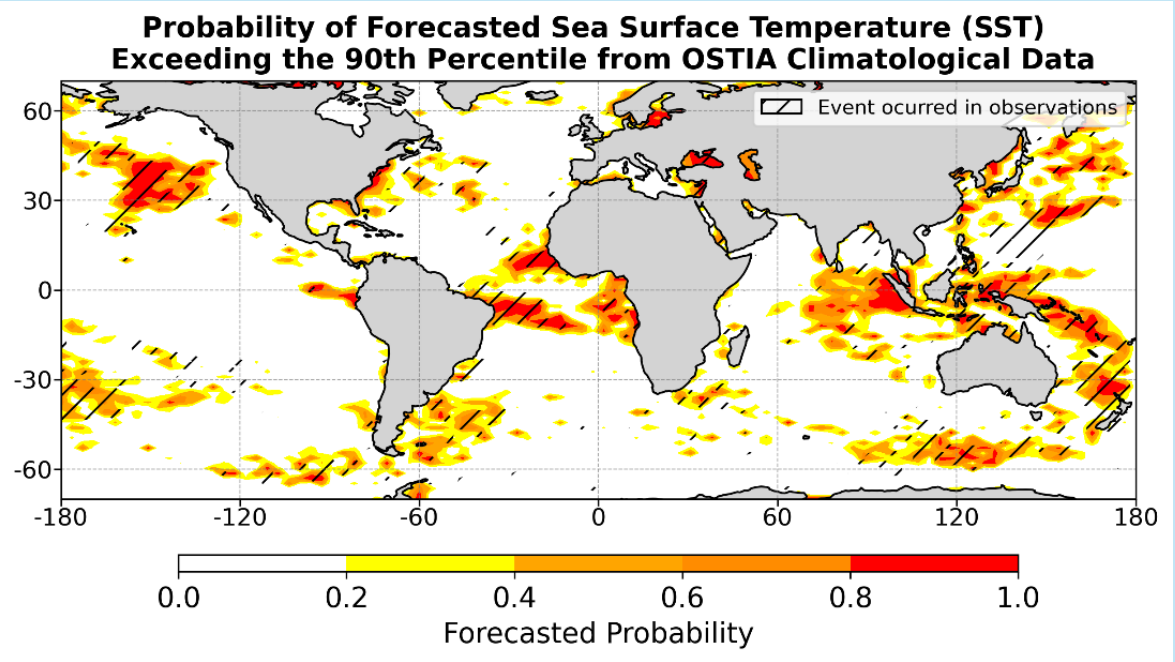
Ensemble System (Nov 2027)

- ✓Eddy permitting (GLO ¼)
- ✓Stochastic representation of model errors
- ✓50 members and one control (not perturbed but assimilating with the ensemble cov.)
- ✓Extended-Range probabilistic forecasts (28 days)

Informative extended range forecasts

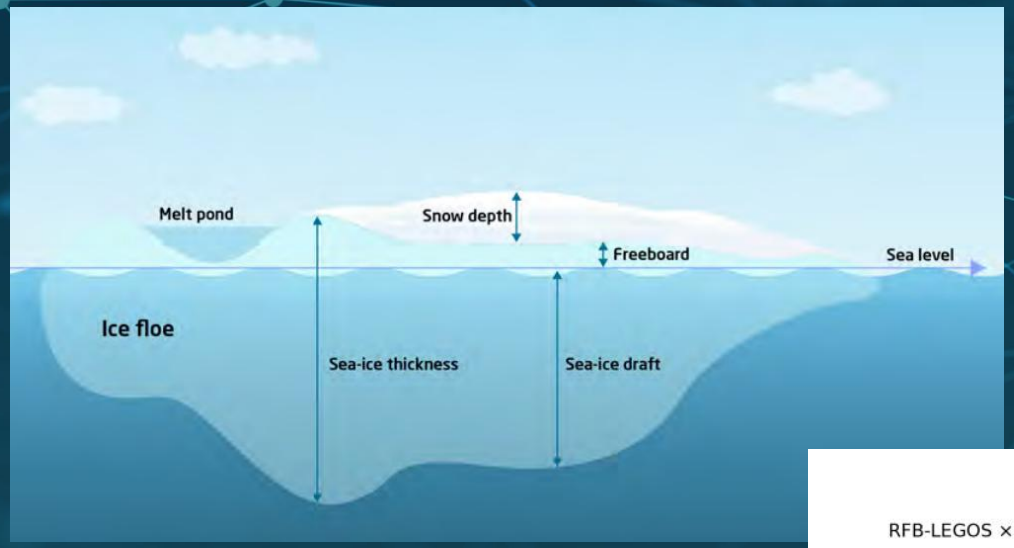




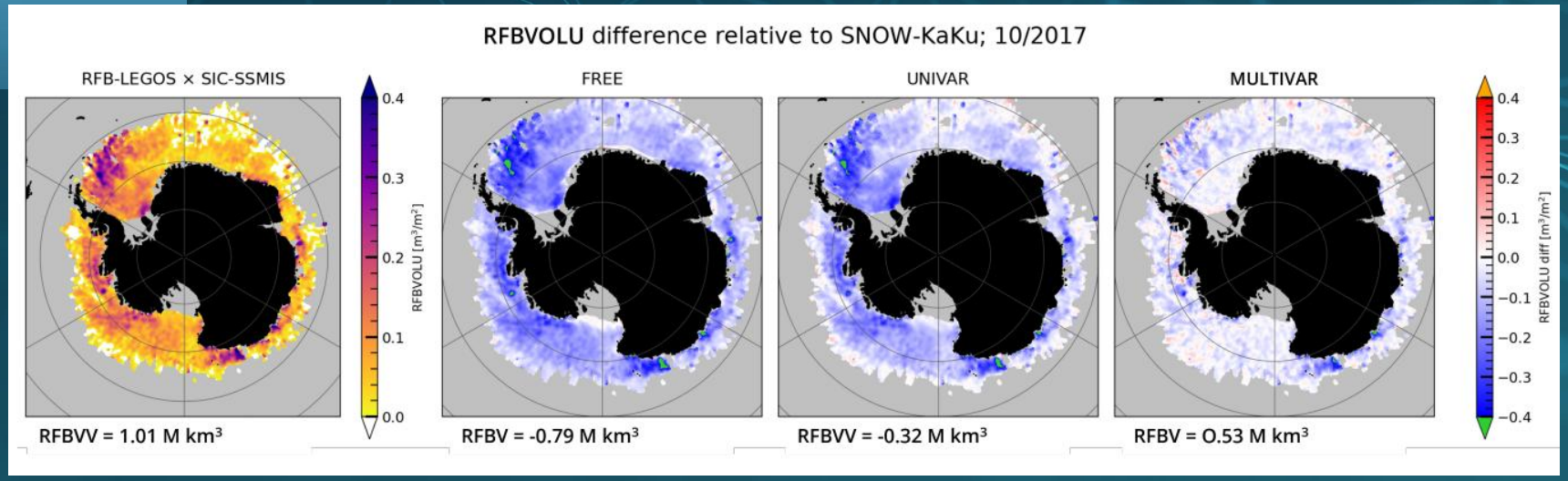


Sea-Ice Innovations (> 2028)

- ✓Joint assimilation of sea-ice concentration and radar freeboard (MULTIVAR)



- ✓Improves bias in sea-ice volume
- ✓Better monitoring of sea-ice vulnerability
- ✓Predicting navigation routes (Arctic)



AI & Hybrid Methods (2026-2030)

- ✓Hybrid CPU/GPU support for ocean models and DA codes
- ✓Hybrid physics/emulators to increase ensemble diversity
- ✓Latent Space data assimilation (Variational autoencoders)
- ✓End-to-End systems (e.g. 4DvarNet, flow matching)

Open Collaboration

- ✓**INPO – Mercator Cooperation:** integrate European and Brazilian scientific, operational, and digital infrastructures, building on capacities from the Copernicus Marine Service, the European DTO framework, and Brazilian operational oceanography systems
- ✓Leverage REMO’s non-public data to validate and improve CMEMS forecasting system accuracy
- ✓Share best practices on observation operators and error covariance parametrization (background + observation)
- ✓Use the new ensemble system to co-develop **hybrid static/dynamic covariance matrices** for advanced analysis

Takeaways

✓**Global and regional DA** – Physics, sea-ice, BGC at 1/4°–1/12°-1/36°

✓**Innovation roadmap** – new obs. → Ensembles → AI/hybrid (2030)

✓**Open collaboration** – Knowledge & code sharing for next-gen DA

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Thank you !
Muito Obrigado !

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