Ocean Predict

SYMPOSIUM OP'24

In partnership with unesco Intergovernmental Oceanographic Commission

2021 2030 United Nations Decade of Ocean Science for Sustainable Development

High Resolution Operational Forecasts of Ocean Surface Currents for Optimal Ship Routing

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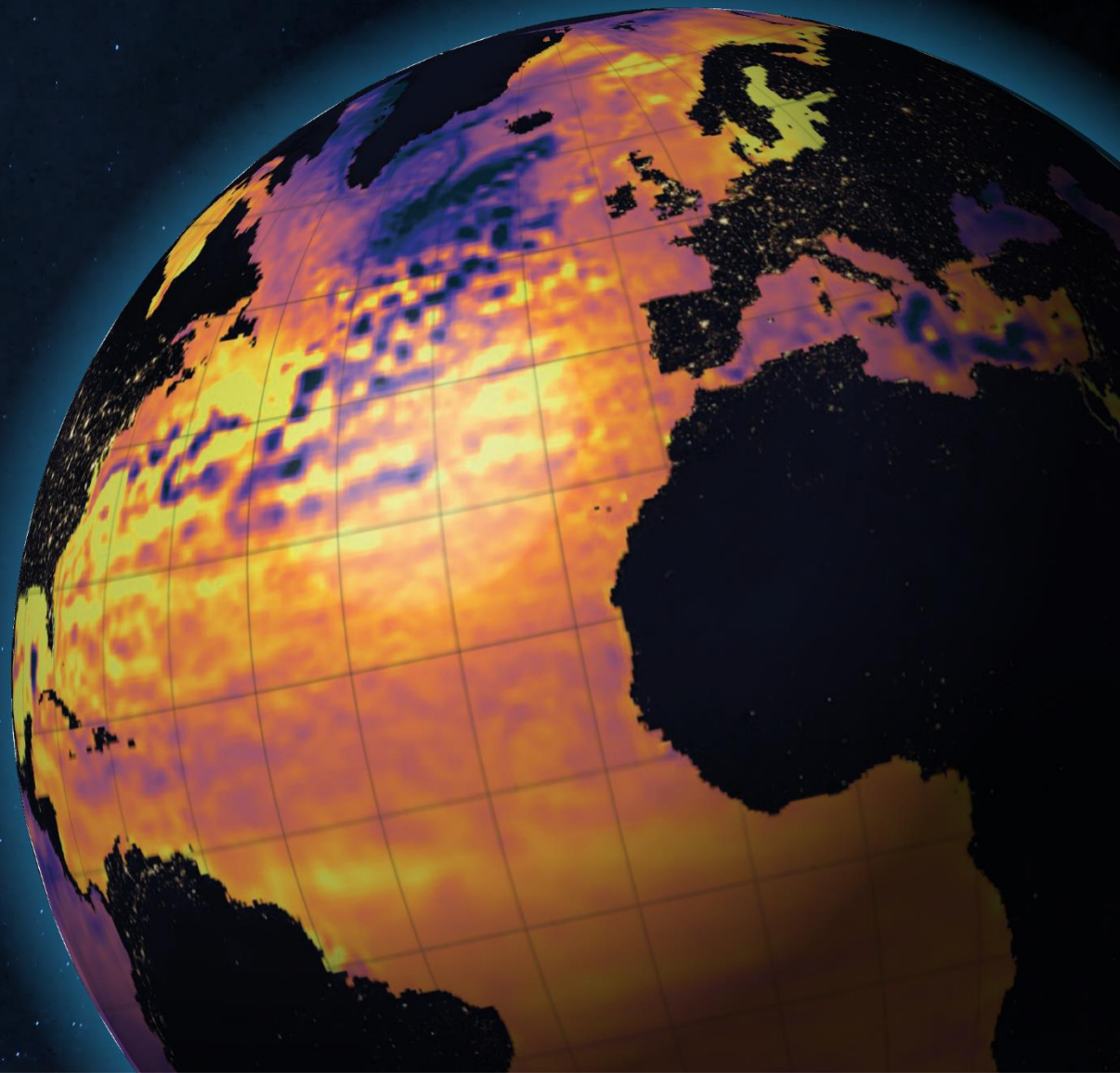
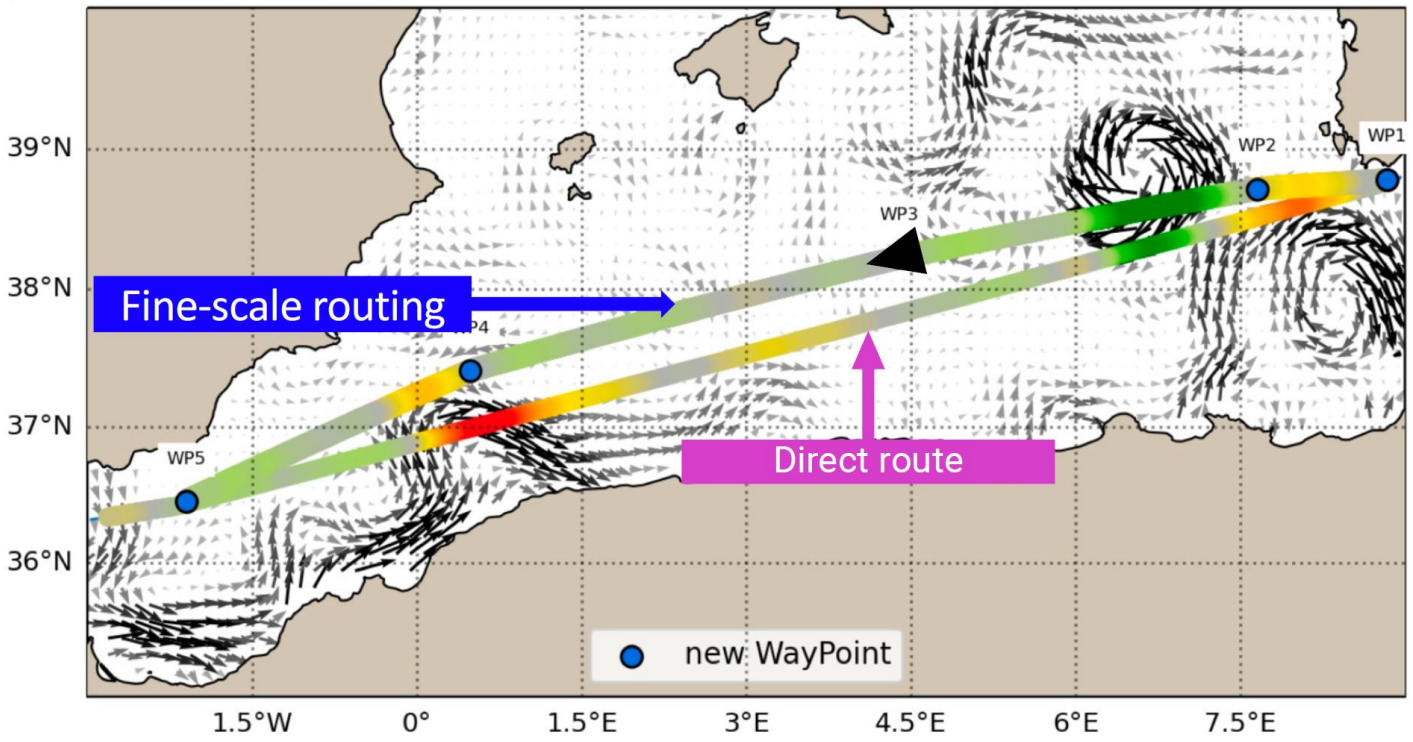
With Pierre Garcia, Amélie Pesnec, Hannah Bull and Théo Archambault

www.amphitrite.fr



Fine-Scale Ship Routing



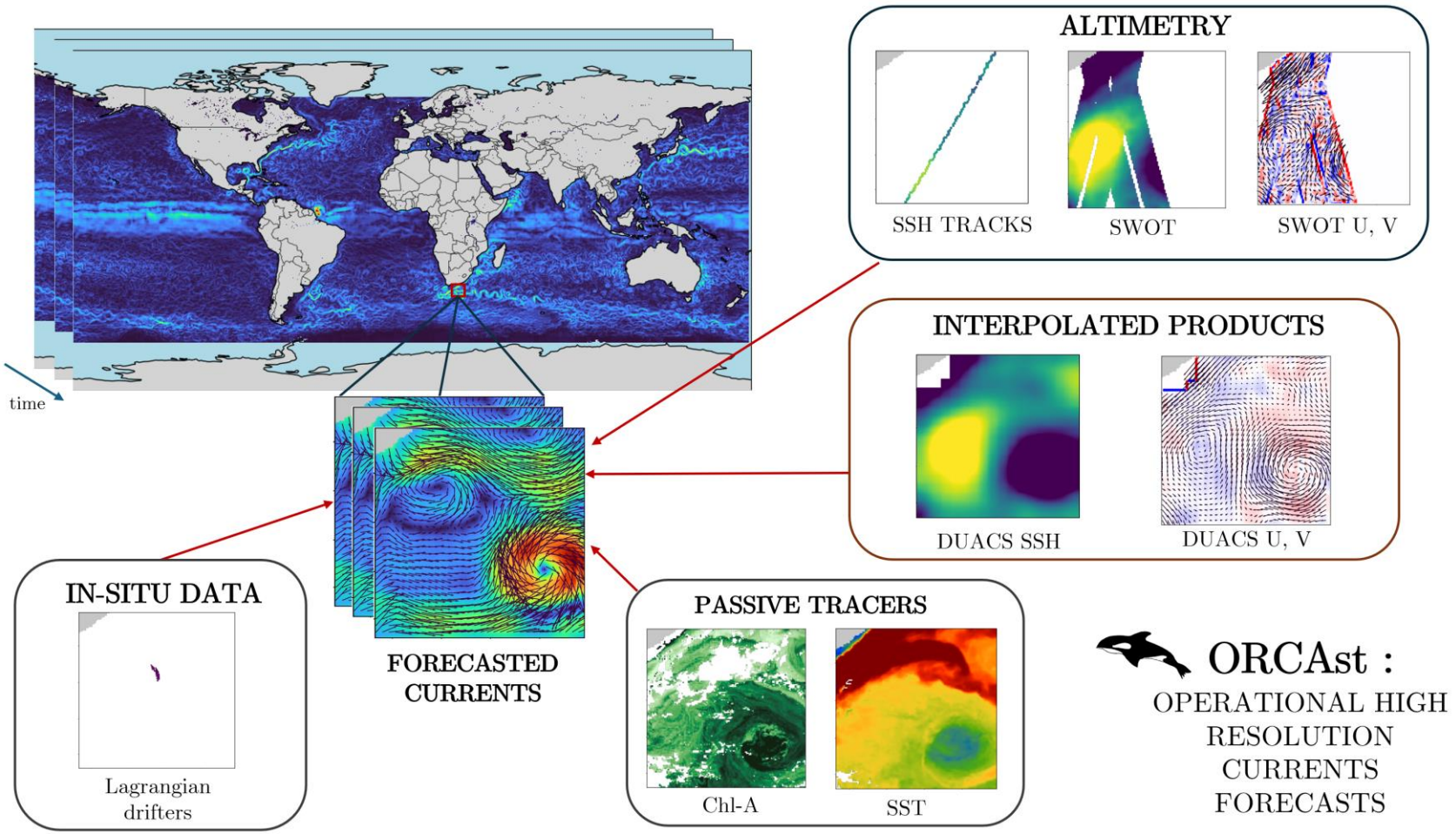
Route Optimisation : A tool for ships to reduce their Carbon Intensity Index

Accurate positionning of ships to avoid adverse currents and take advantage of favorable ones

Need for high-resolution ocean surface currents maps

The Ocean Bulletin : https://bulletin.amphitrite.fr/

Our Forecasting Model



Architecture

INPUTS

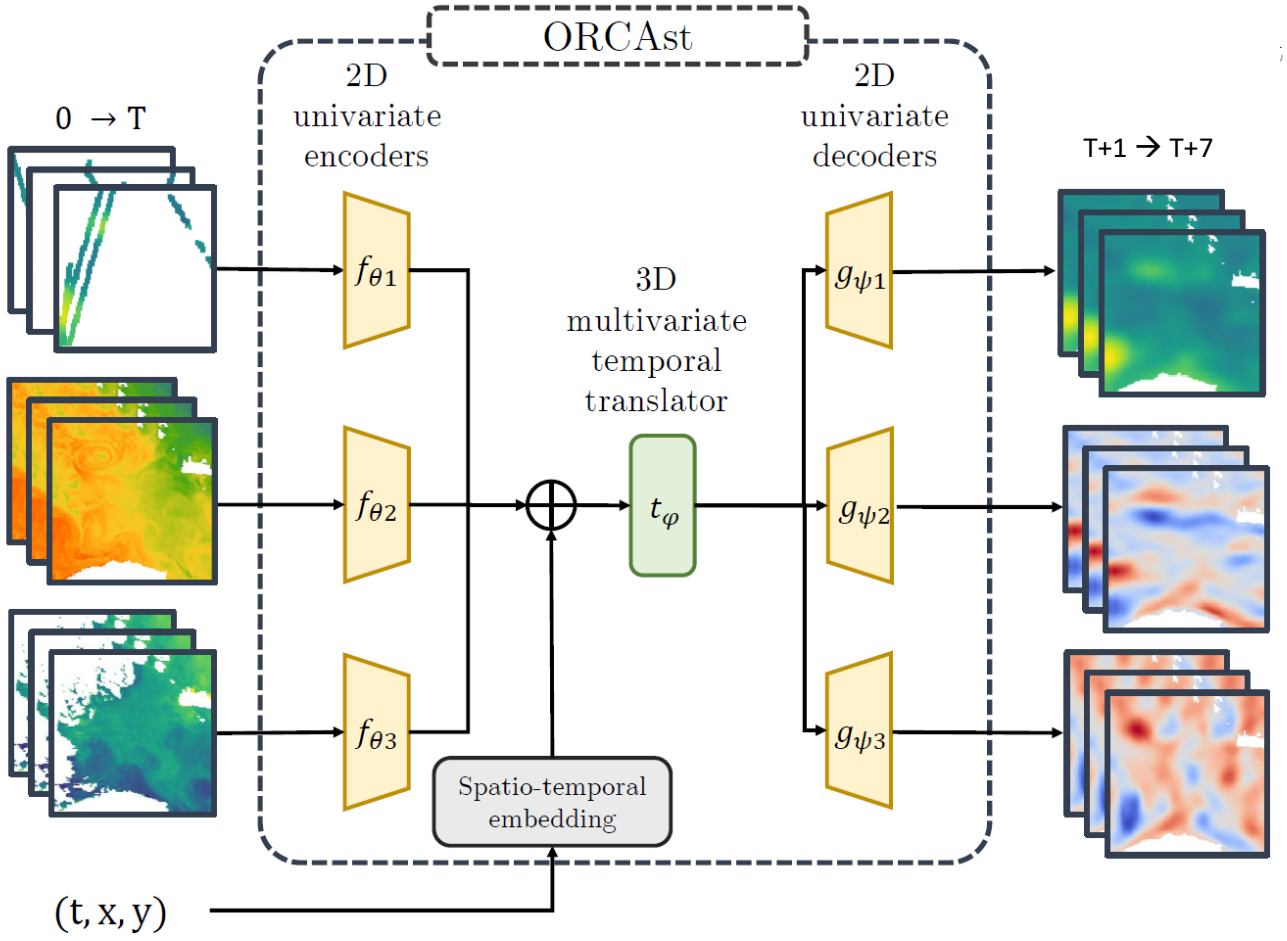
11 days

NADIR SSH

SST L3

Chl-A

SATELLITE DATA



OUTPUTS

7 days

SSH

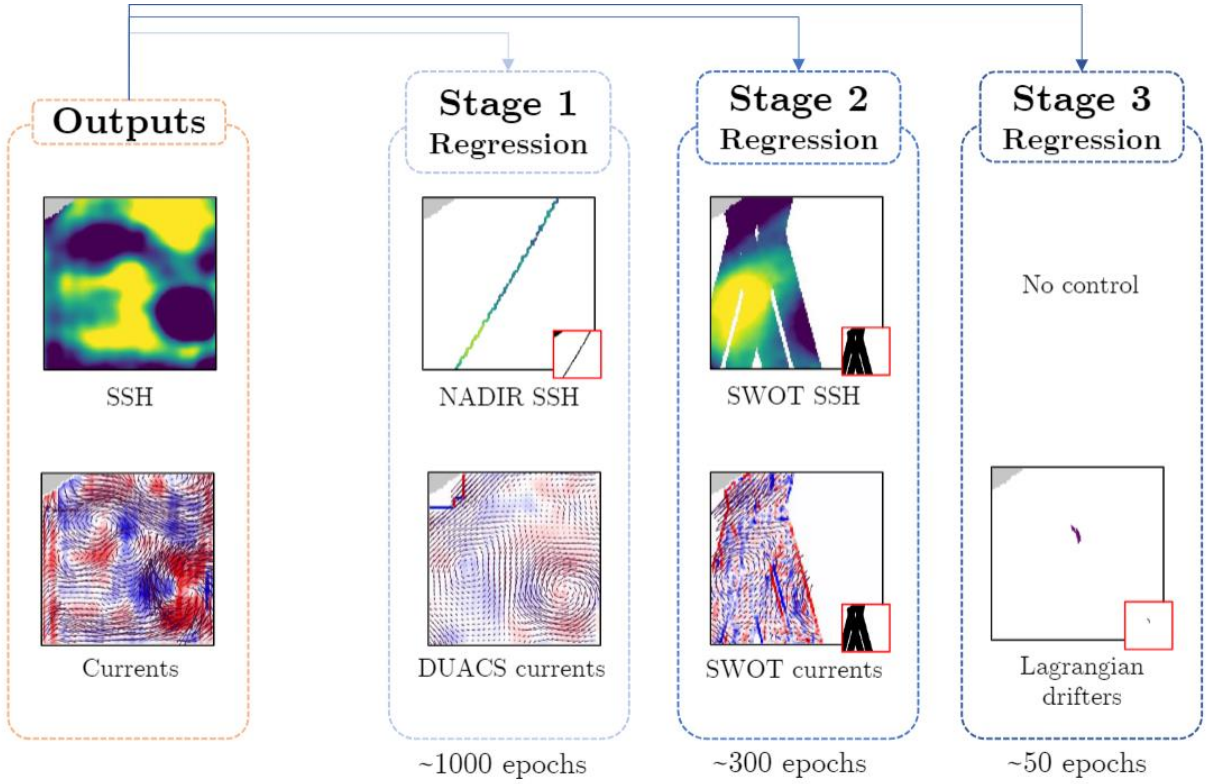
U

V

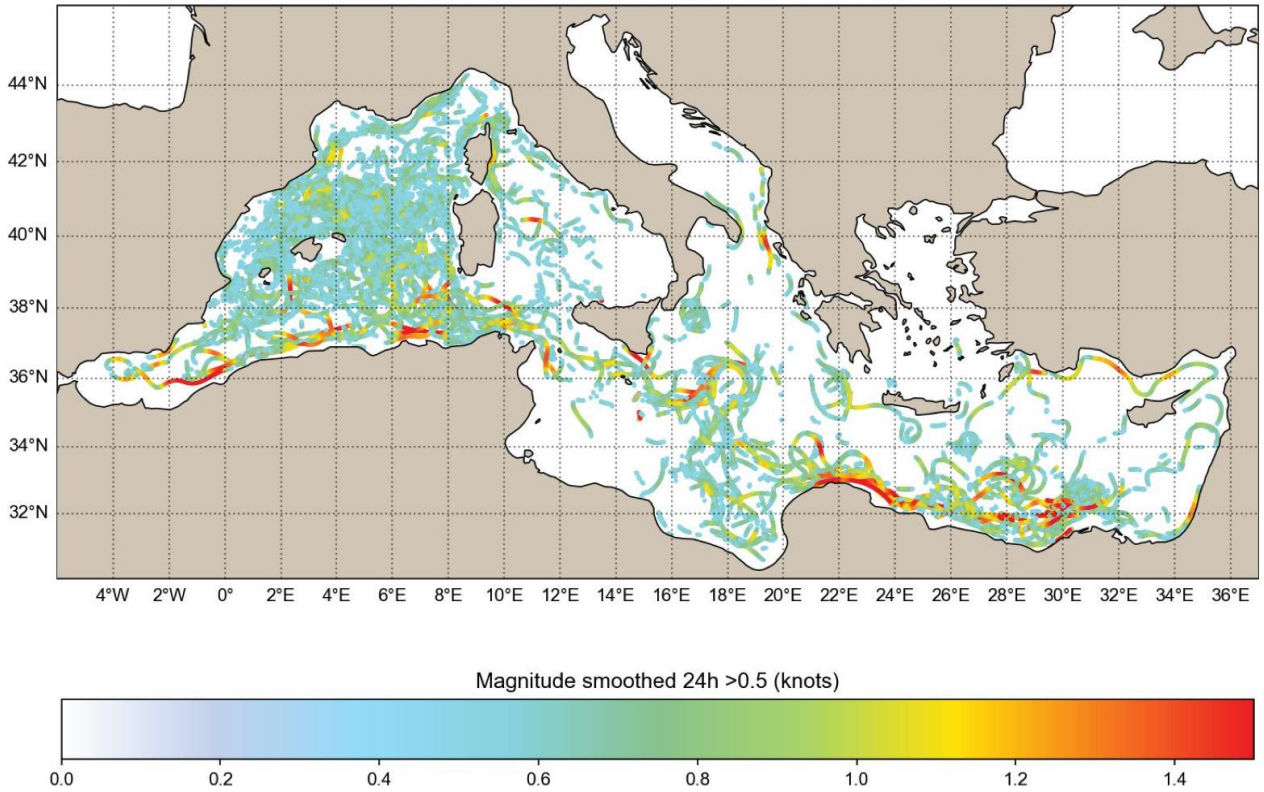
SURFACE CURRENTS 1/30°

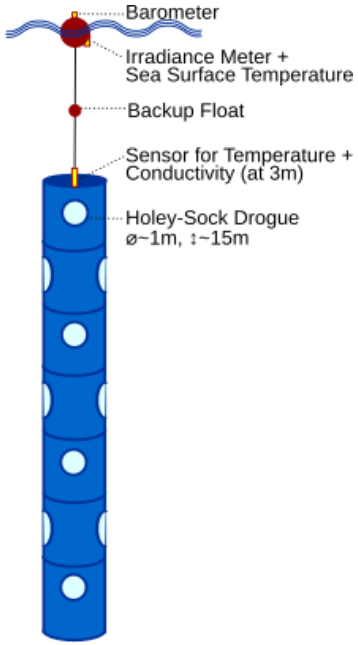
Training by region in 3 stages

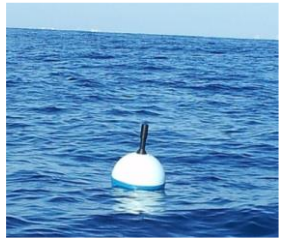
Multi-stage training strategy → Amelie's presentation, Session 5.1 : ***Integrating SWOT data into a deep learning model for real-time high-resolution prediction of ocean surface currents***



Evaluation strategy: Lagrangian drifters





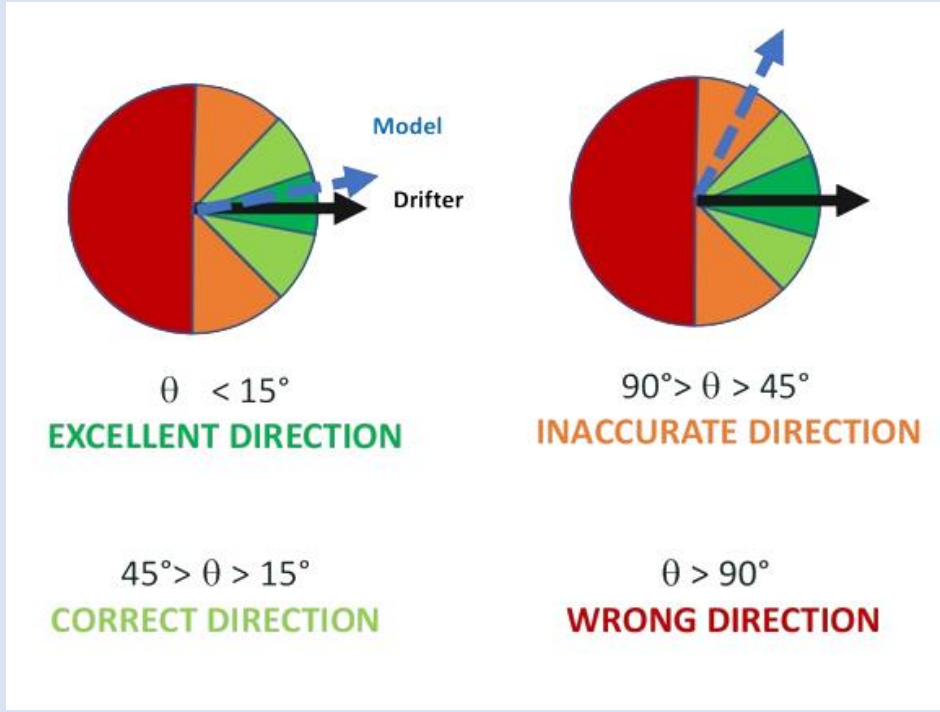


Mediteranean Sea : 93k Surface Drifter Measurements in 2020-2022

Evaluation strategy : Metrics

DIRECTION ACCURACY

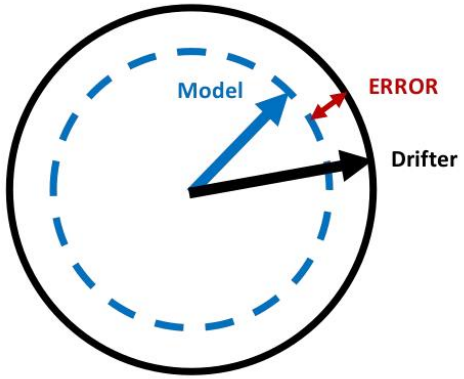
$$\theta = \frac{180}{\pi} \cos^{-1}\left(\frac{\hat{w} \cdot w_{\text{drifter}}}{\|\hat{w}\| \|w_{\text{drifter}}\|}\right) \in [0;180]$$



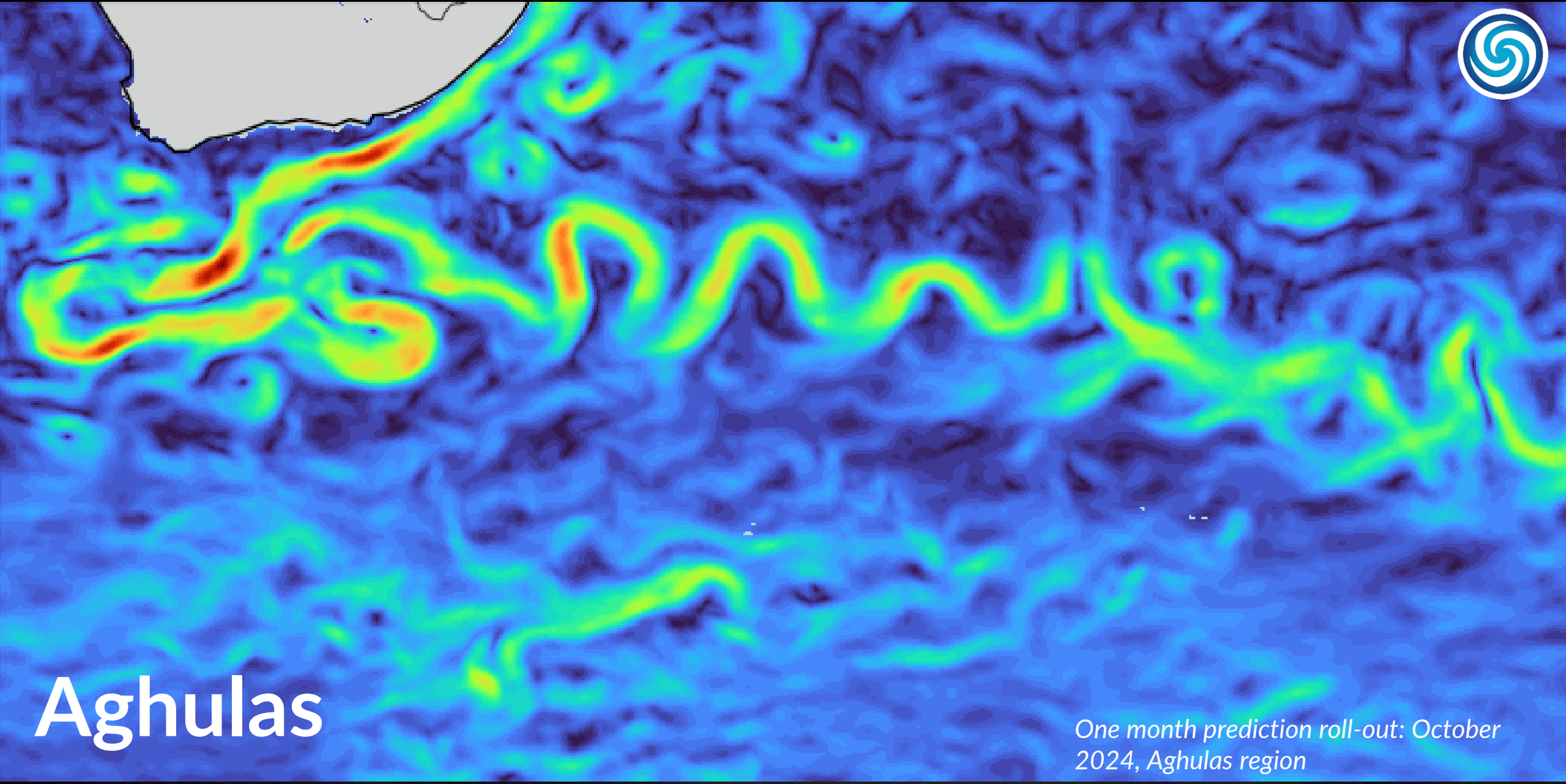
Evaluation strategy : Metrics

MAGNITUDE ACCURACY

$$\Delta M = \left| \|\hat{w}\| - \|w_{\text{drifter}}\| \right| \in \mathbb{R}$$



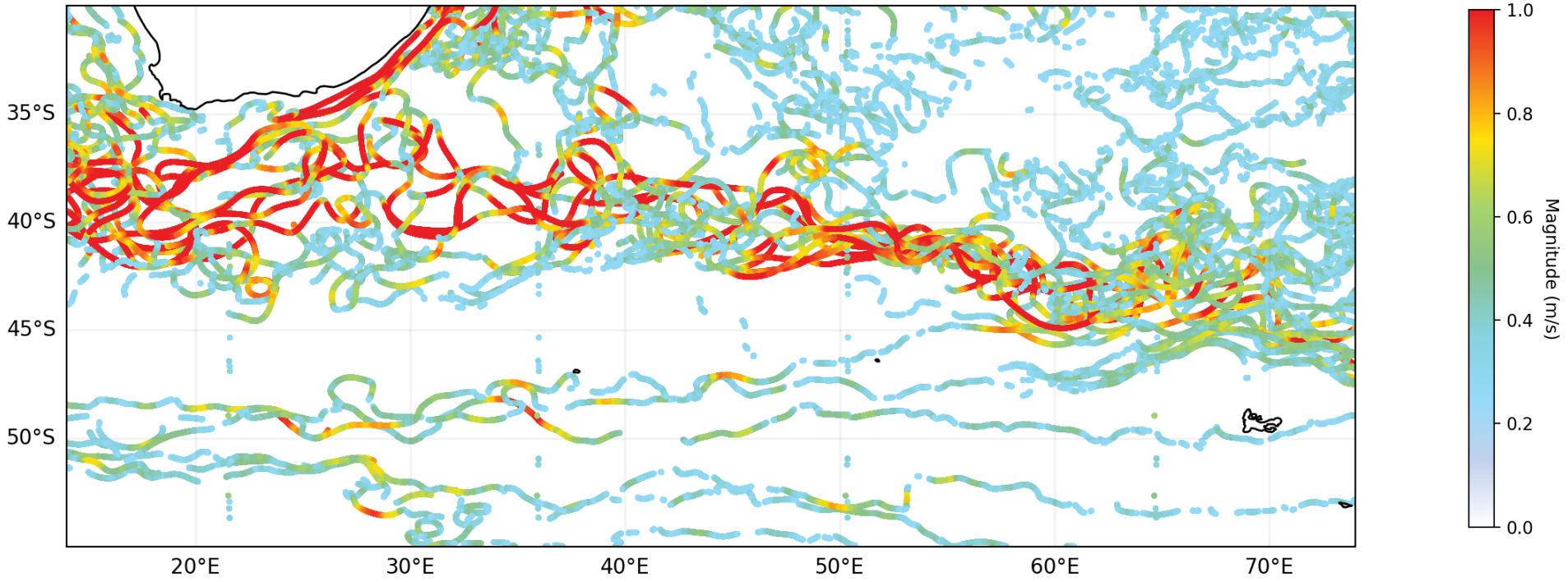
	ΔM (cm/s)
Excellent	[0,5]
Correct	[5,15]
Inaccurate	[15, 25]
Wrong	>25



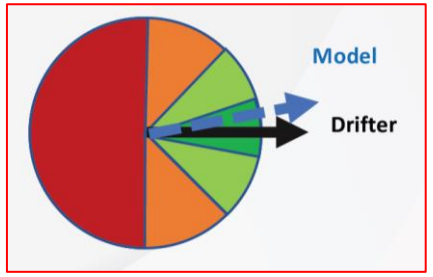
Aghulas

One month prediction roll-out: October 2024, Aghulas region

Distribution of drifters used for evaluation:
between 01/01/2023 and 31/12/2023,
with magnitude filter 0.25 m/s.

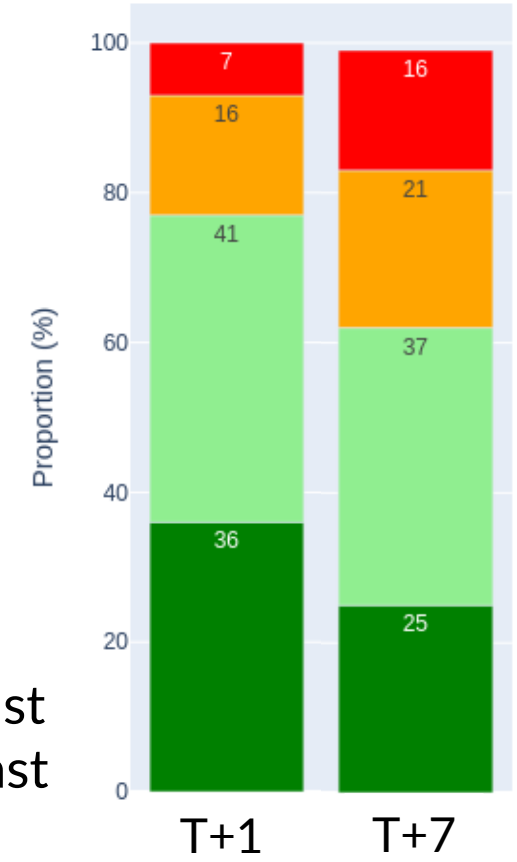


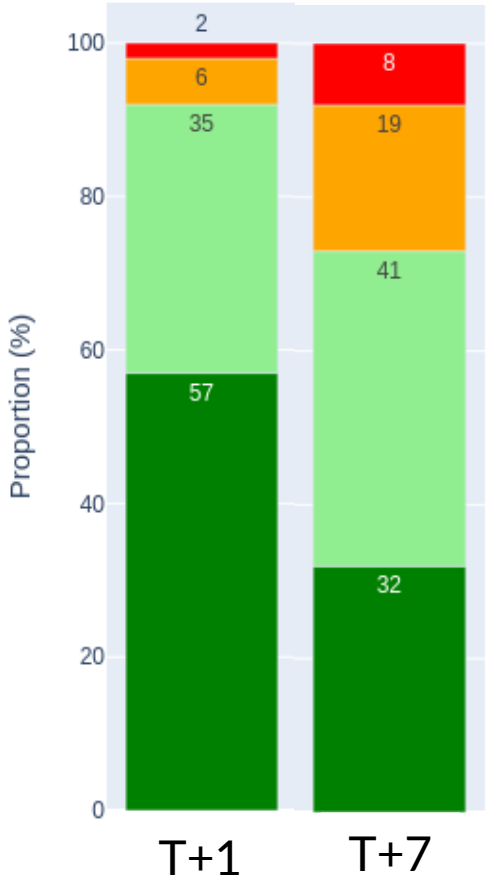
Average magnitude : 0.5 m/s.
Total number of measurements used for comparison : 93186



Angle Error

Improvements on direction accuracy

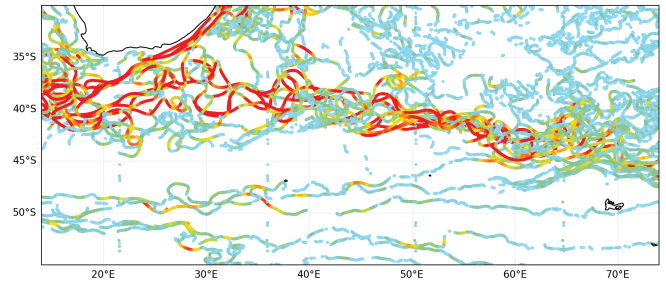


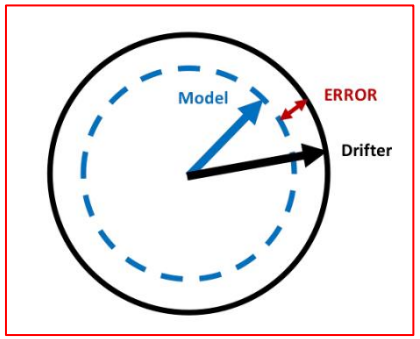


Between 0° and 15°
Between 15° and 45°
Between 45° and 90°
Above 90°

T+1: 1st day of forecast
T+7: 7th day of forecast

Evaluation datapoints

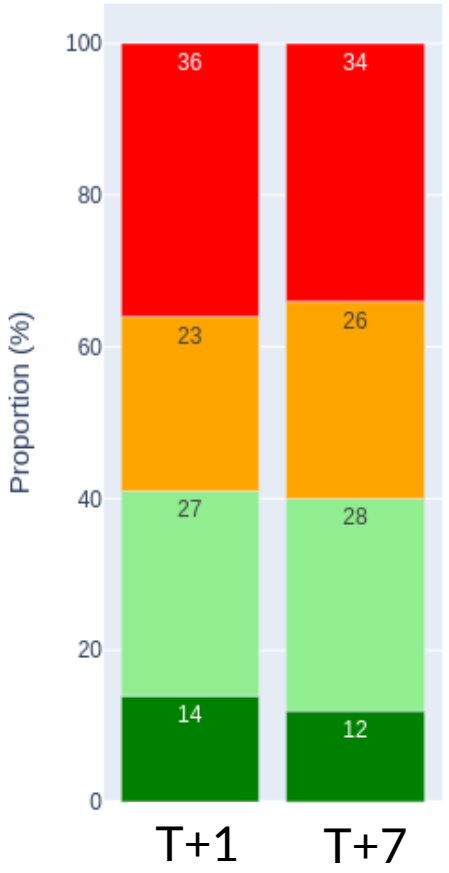




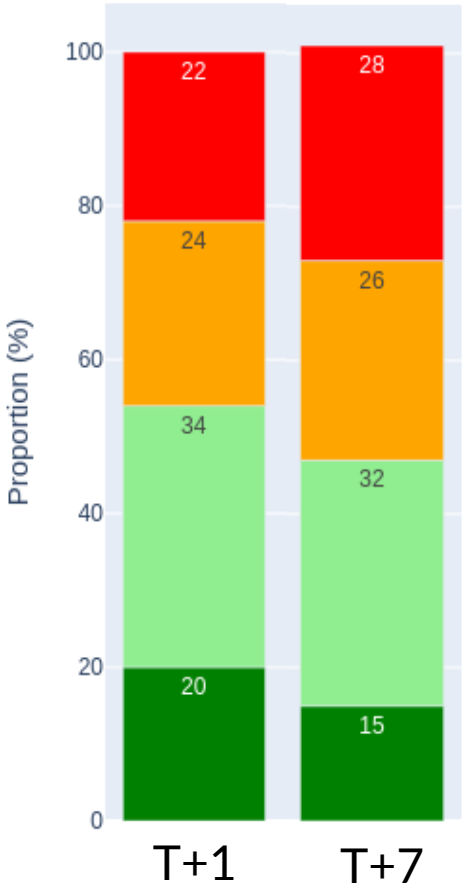
Magnitude Error

Improvements on magnitude accuracy

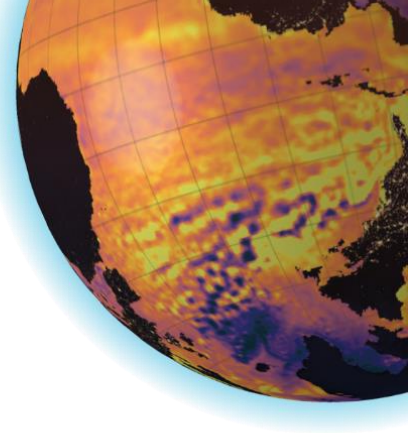
T+1: 1st day of forecast
T+7: 7th day of forecast

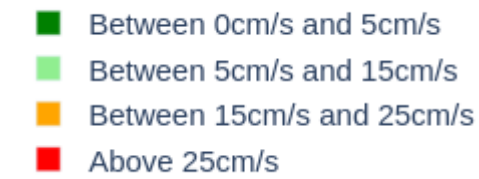


MERCATOR OCEAN INTERNATIONAL

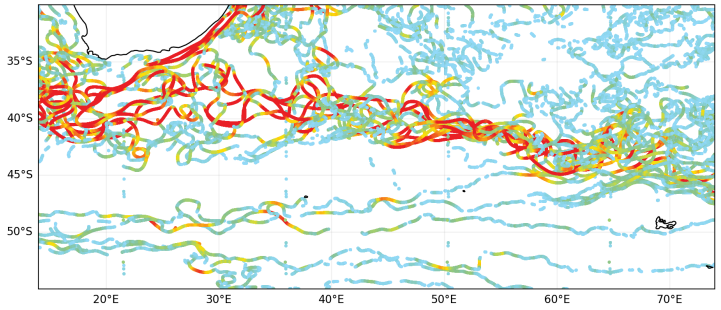


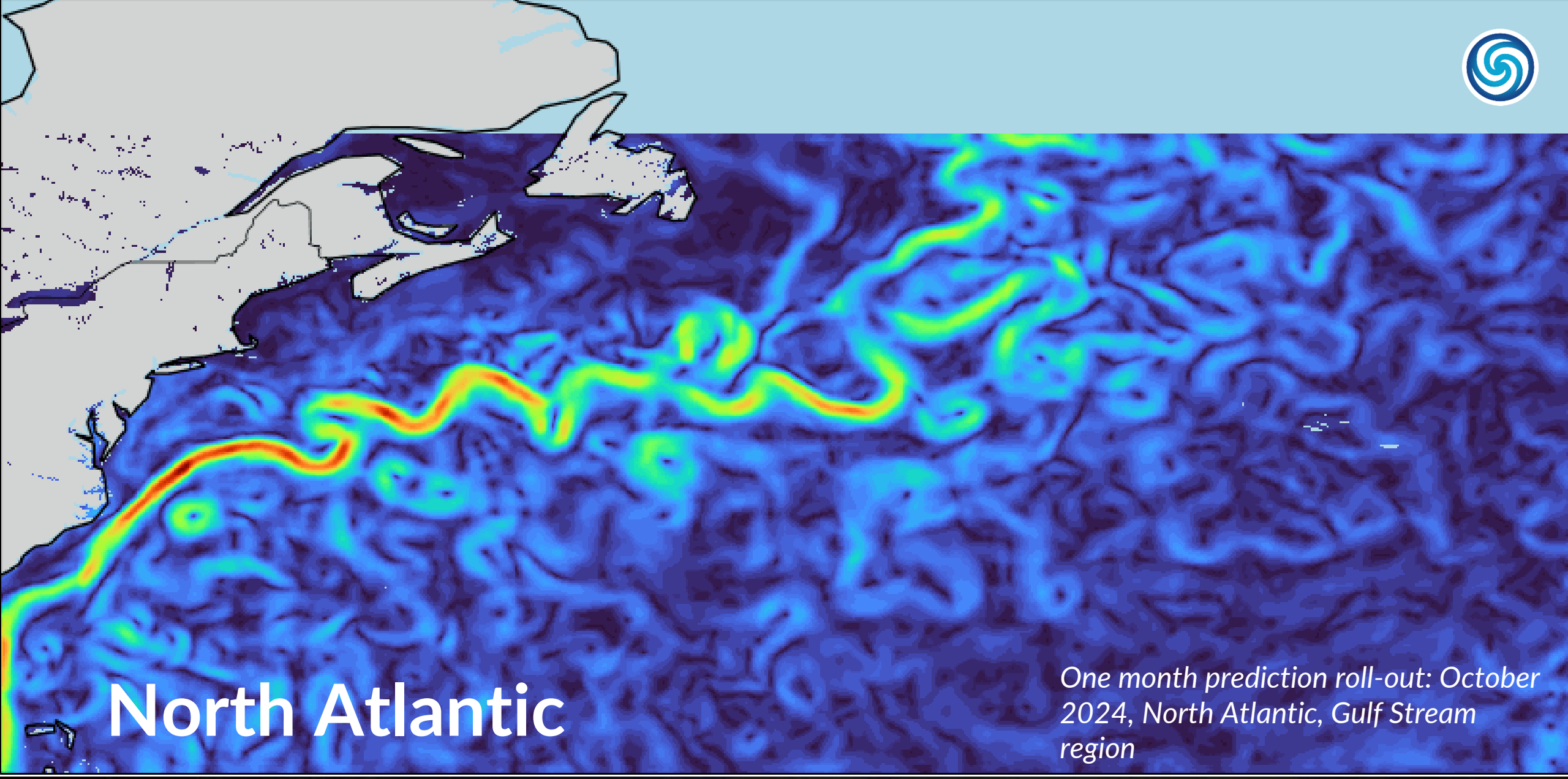
ORCAst





Evaluation datapoints

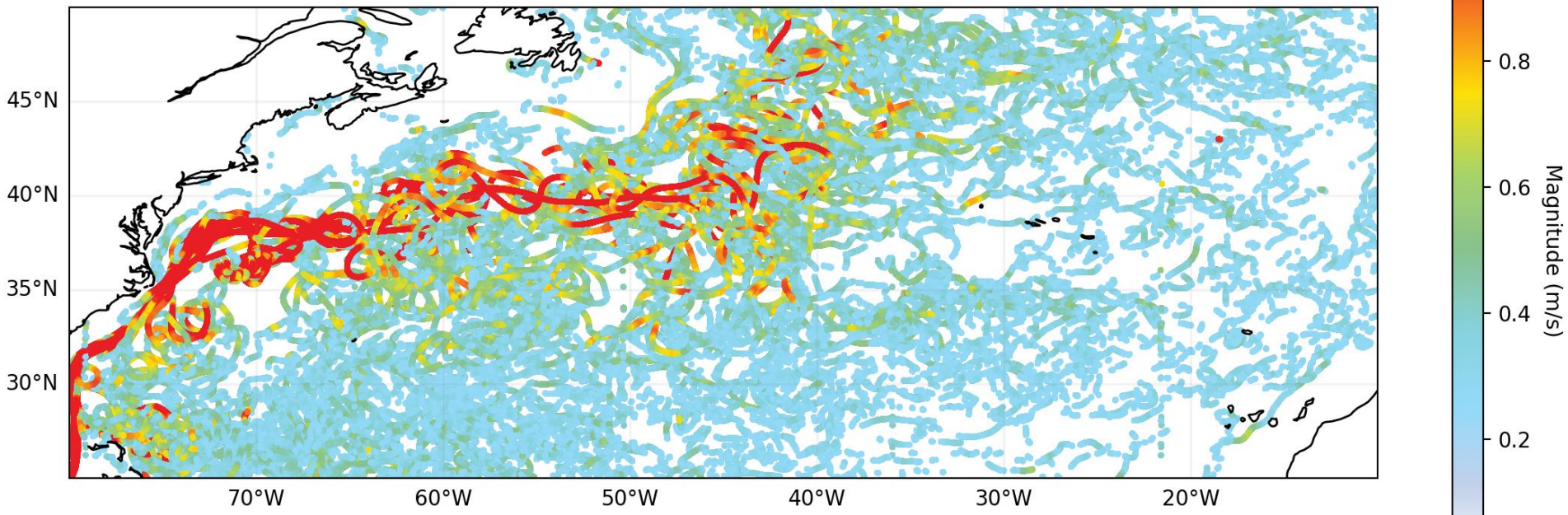




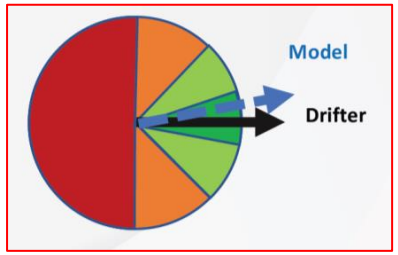
North Atlantic

One month prediction roll-out: October 2024, North Atlantic, Gulf Stream region

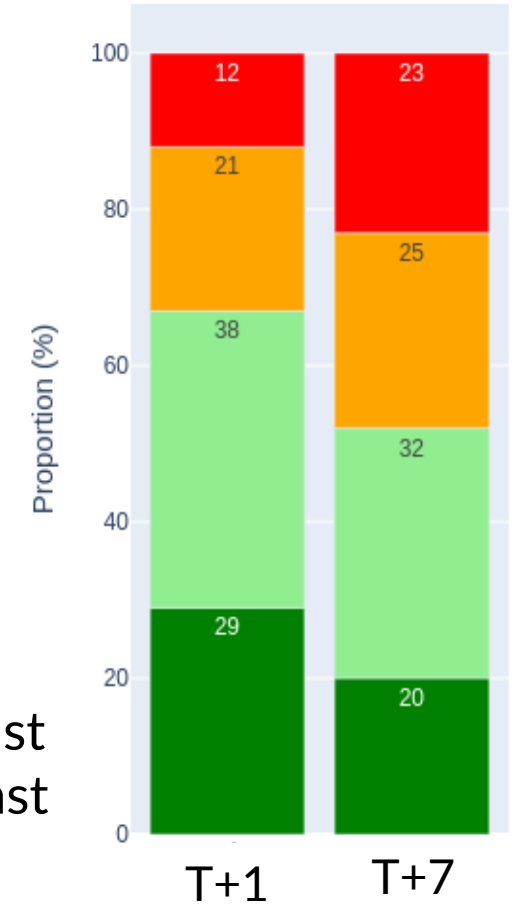
Distribution of drifters used for evaluation:
between 01/01/2023 and 31/12/2023,
with magnitude filter 0.25 m/s.

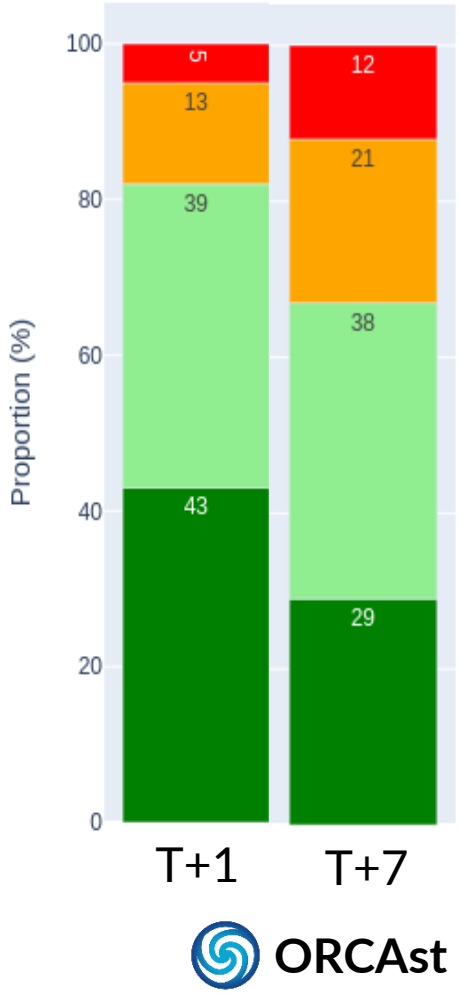


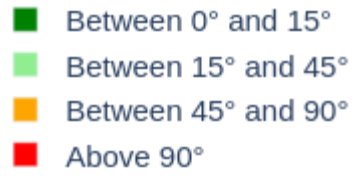
Average magnitude : 0.41 m/s.
Total number of measurements used for comparison : 271,104



Angle Error



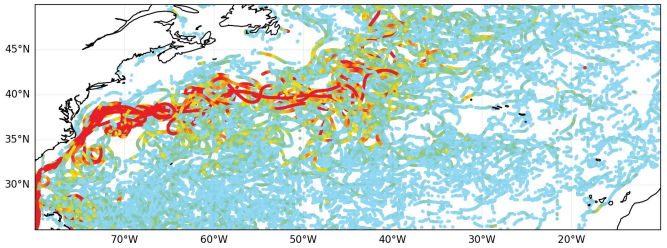


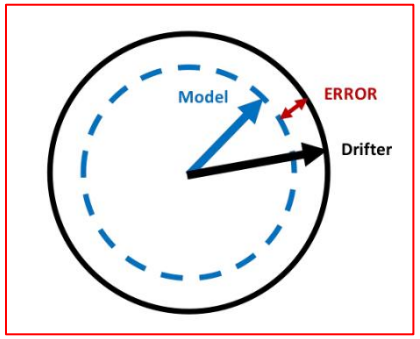


Improvements on direction accuracy

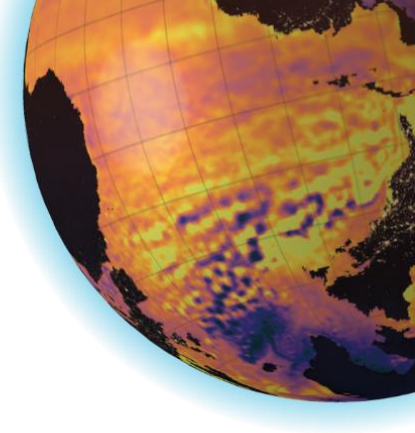
T+1: 1st day of forecast
T+7: 7th day of forecast

Evaluation datapoints

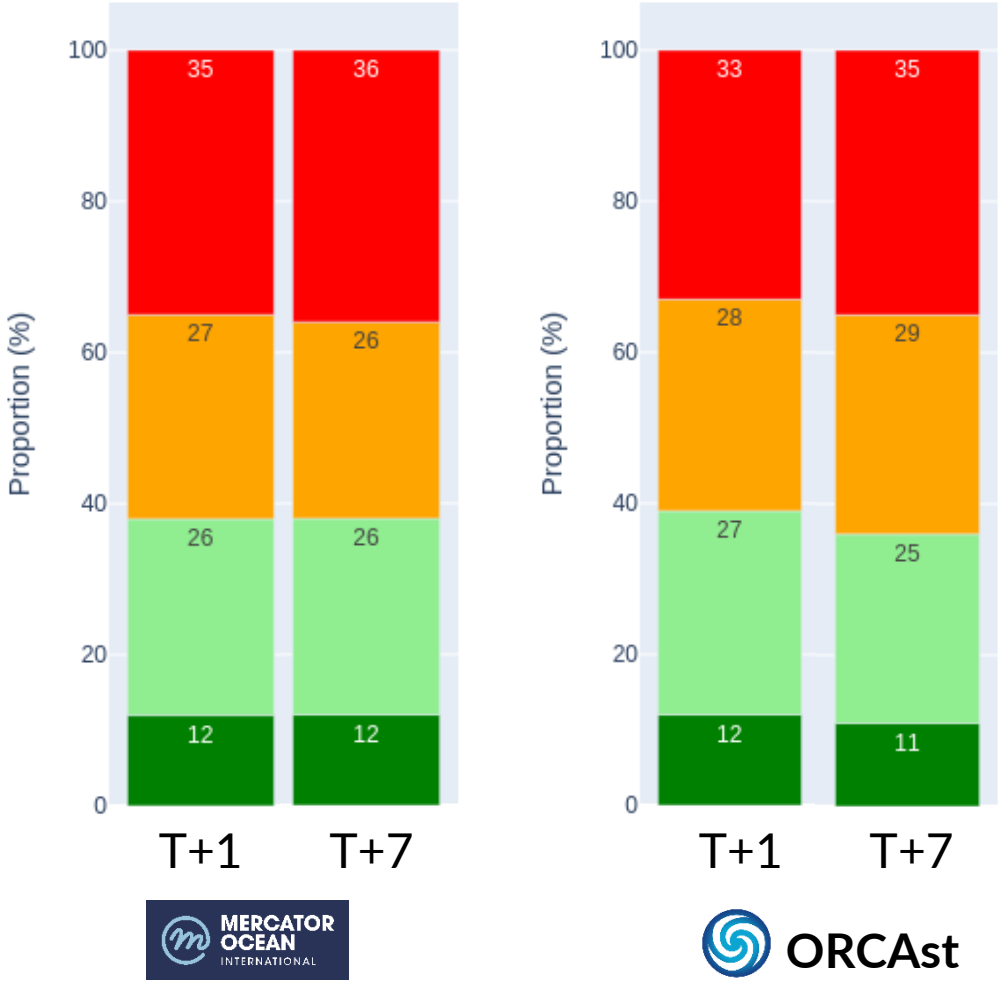


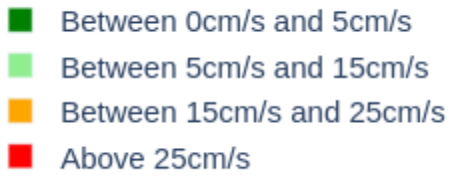


Magnitude Error



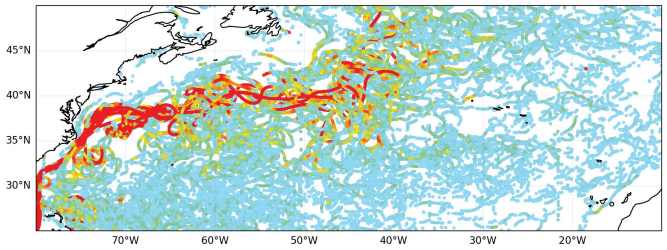
No significant difference in performance

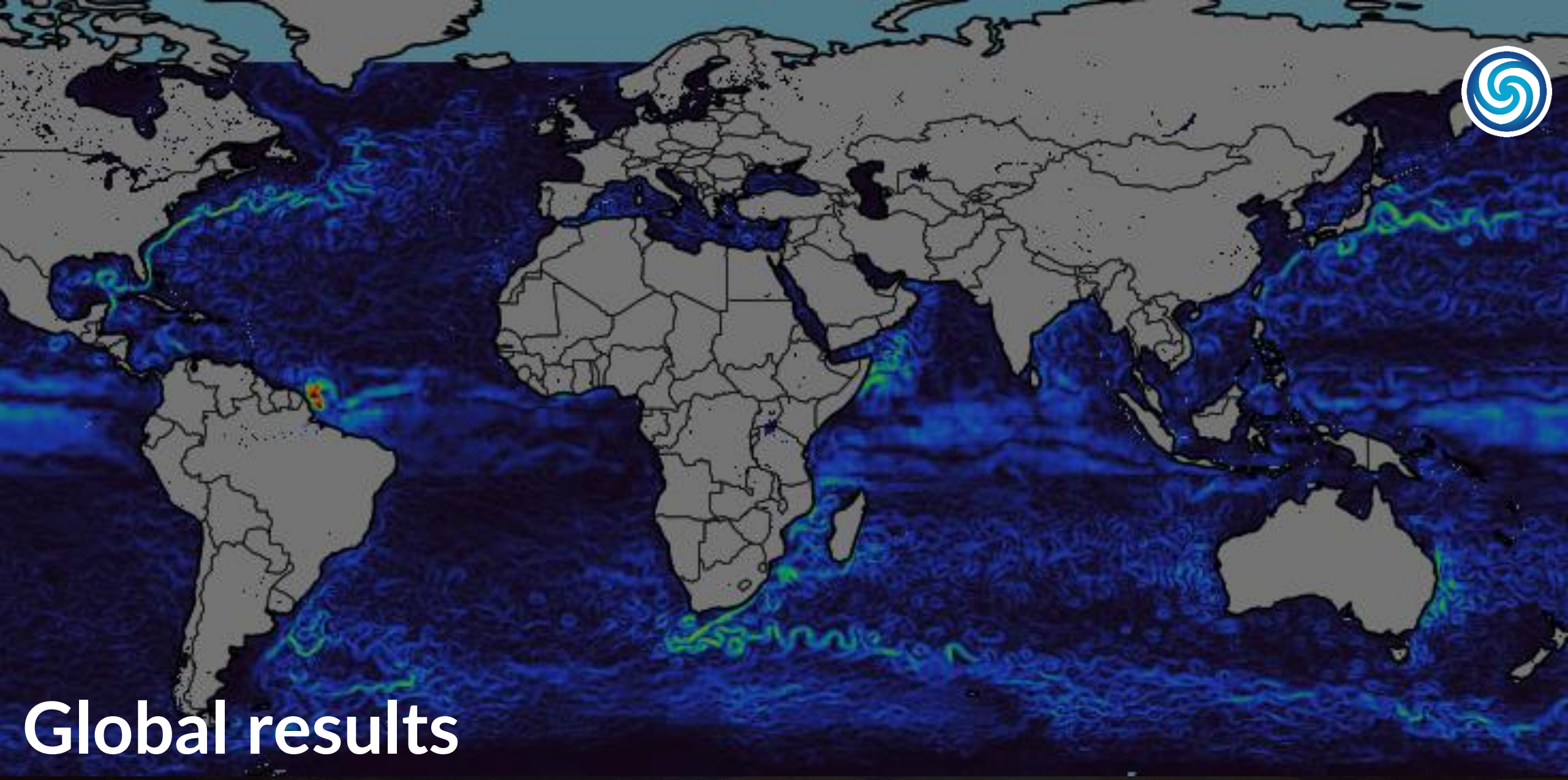




T+1: 1st day of forecast
T+7: 7th day of forecast

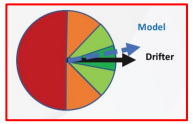
Evaluation datapoints

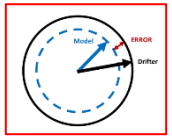




Global results

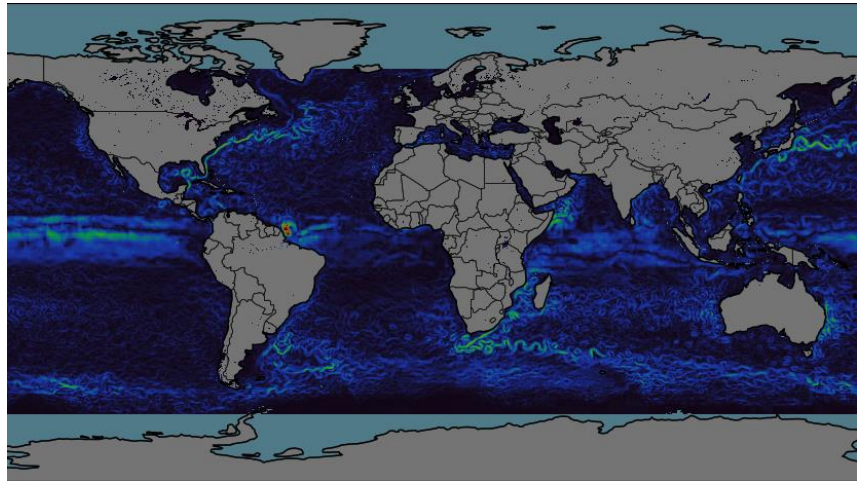
Global results





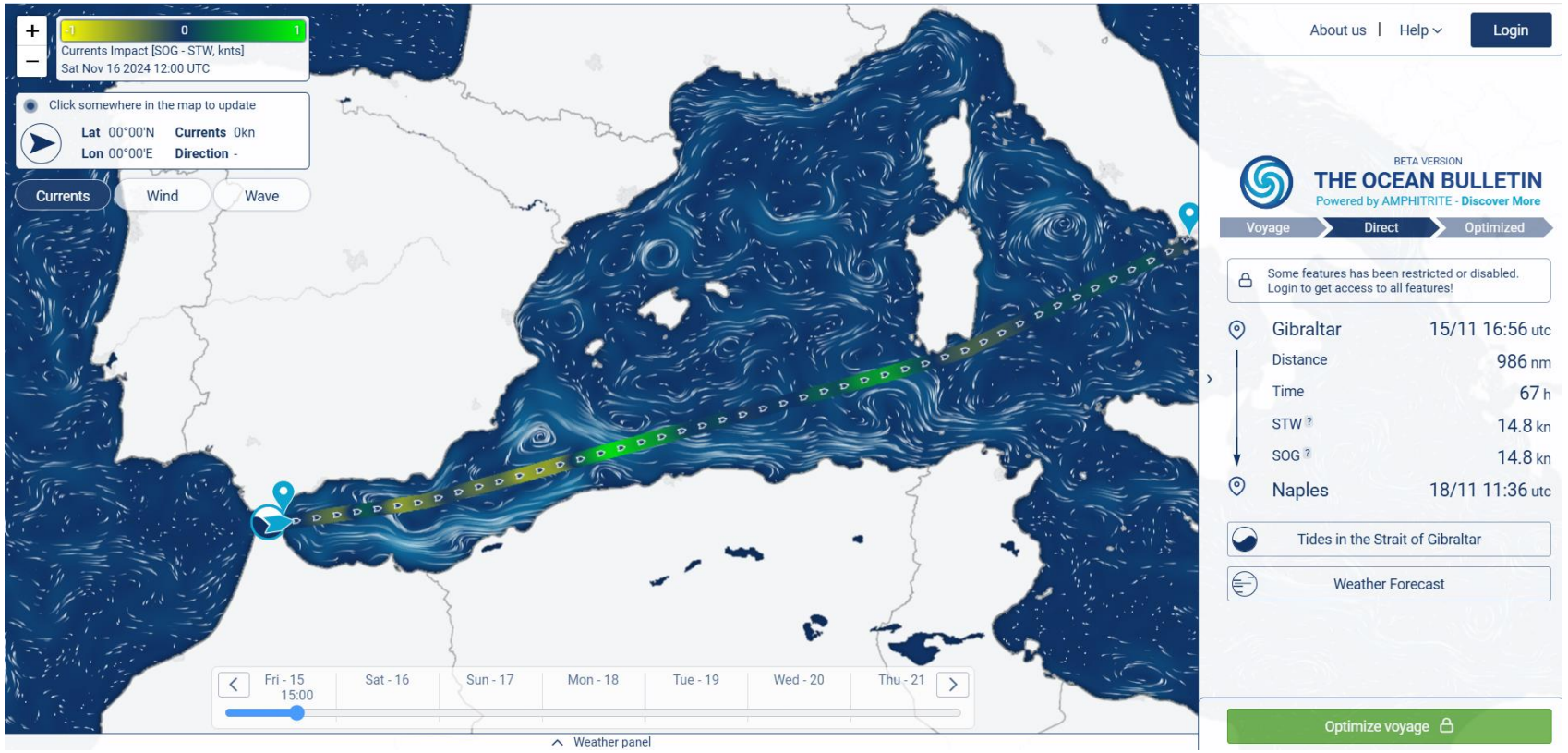
	Method	Correct direction		Correct magnitude	
		T+1 (%)	T+7 (%)	T+1 (%)	T+7 (%)
AVISO-DUACS	Optimal interpolation *Delayed Time (6 days)*	78	-	69	-
NEUROST (2024) [1]	AI *Delayed Time (15 days)*	83	-	72	-
Mercator Forecast	Numerical Assimilated Model *Operational*	70	56	68	68
ORCAst	AI *Operational*	**85**	**70**	**77**	**69**

ORCAst global forecast



[1] Martin, S. A., Manucharyan, G. E., & Klein, P. (2024). Deep learning improves global satellite observations of ocean eddy dynamics. *Geophysical Research Letters*, 51, e2024GL110059. https://doi.org/10.1029/2024GL110059

Thanks! Any questions?



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AMPHITRITE OCEAN DATA INTELLIGENCE

Ocean Predict

SYMPOSIUM OP'24

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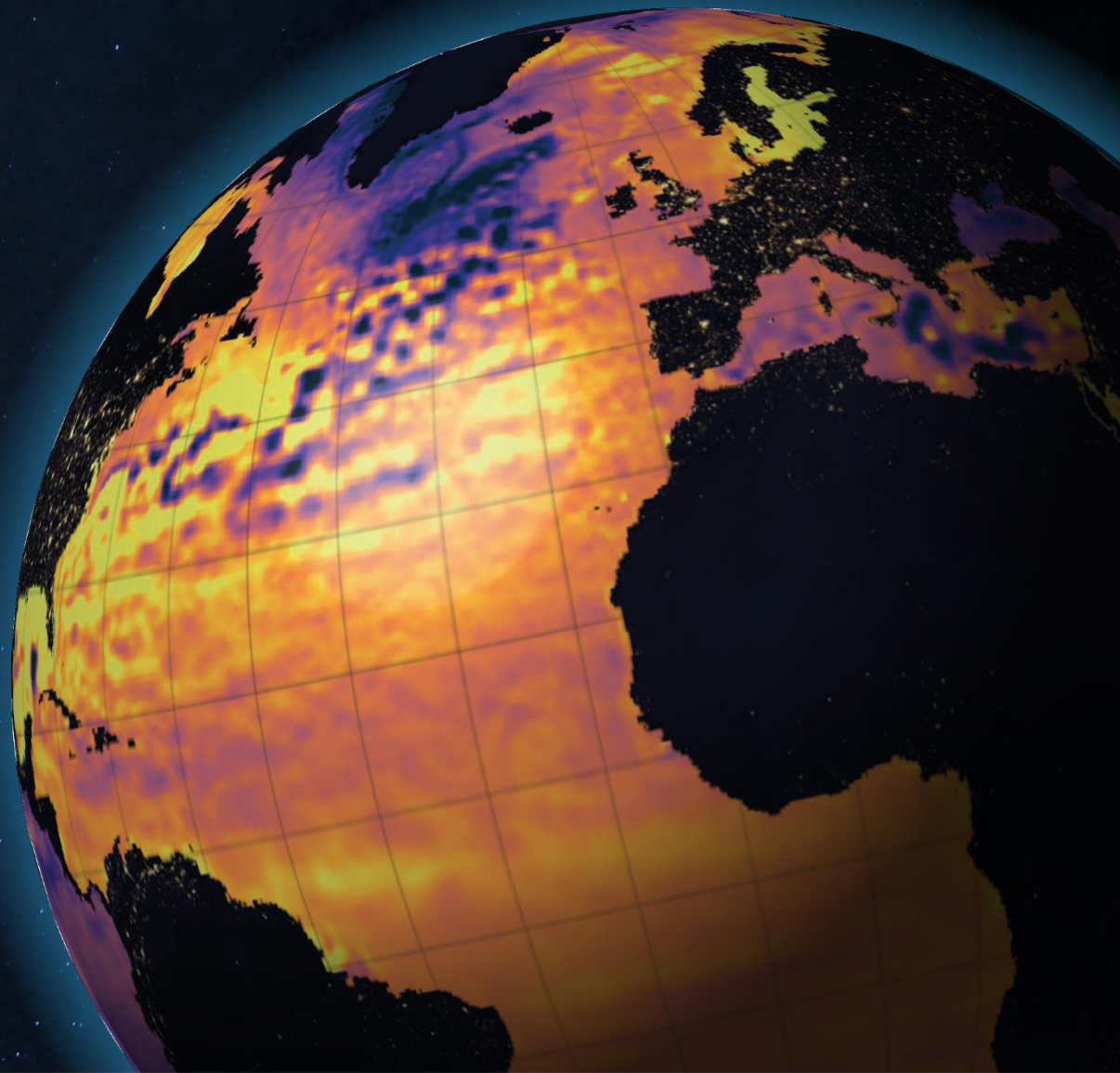
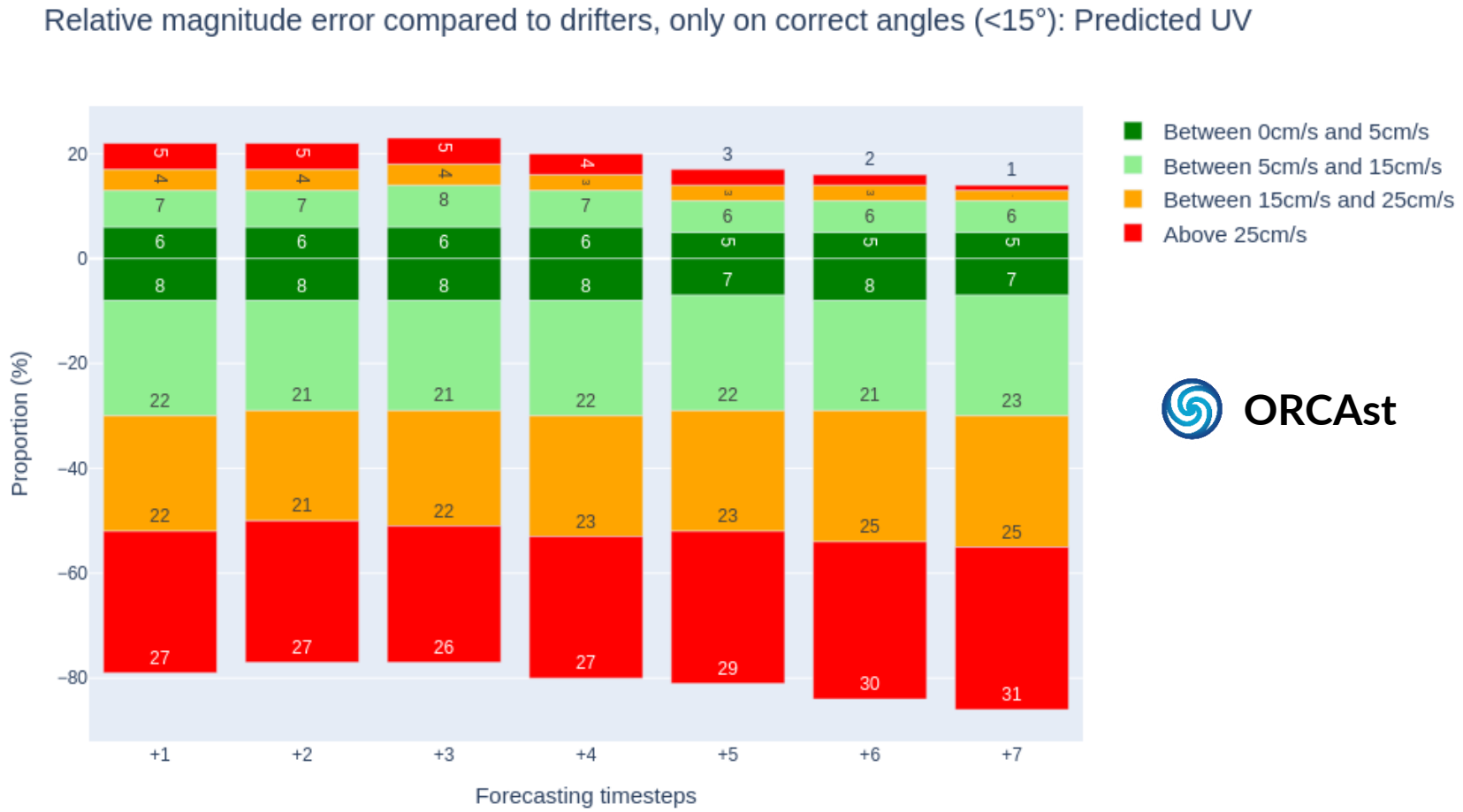
2021 2030 United Nations Decade of Ocean Science for Sustainable Development

Appendix

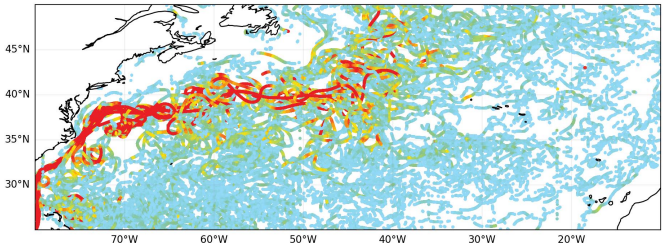


North Atlantic

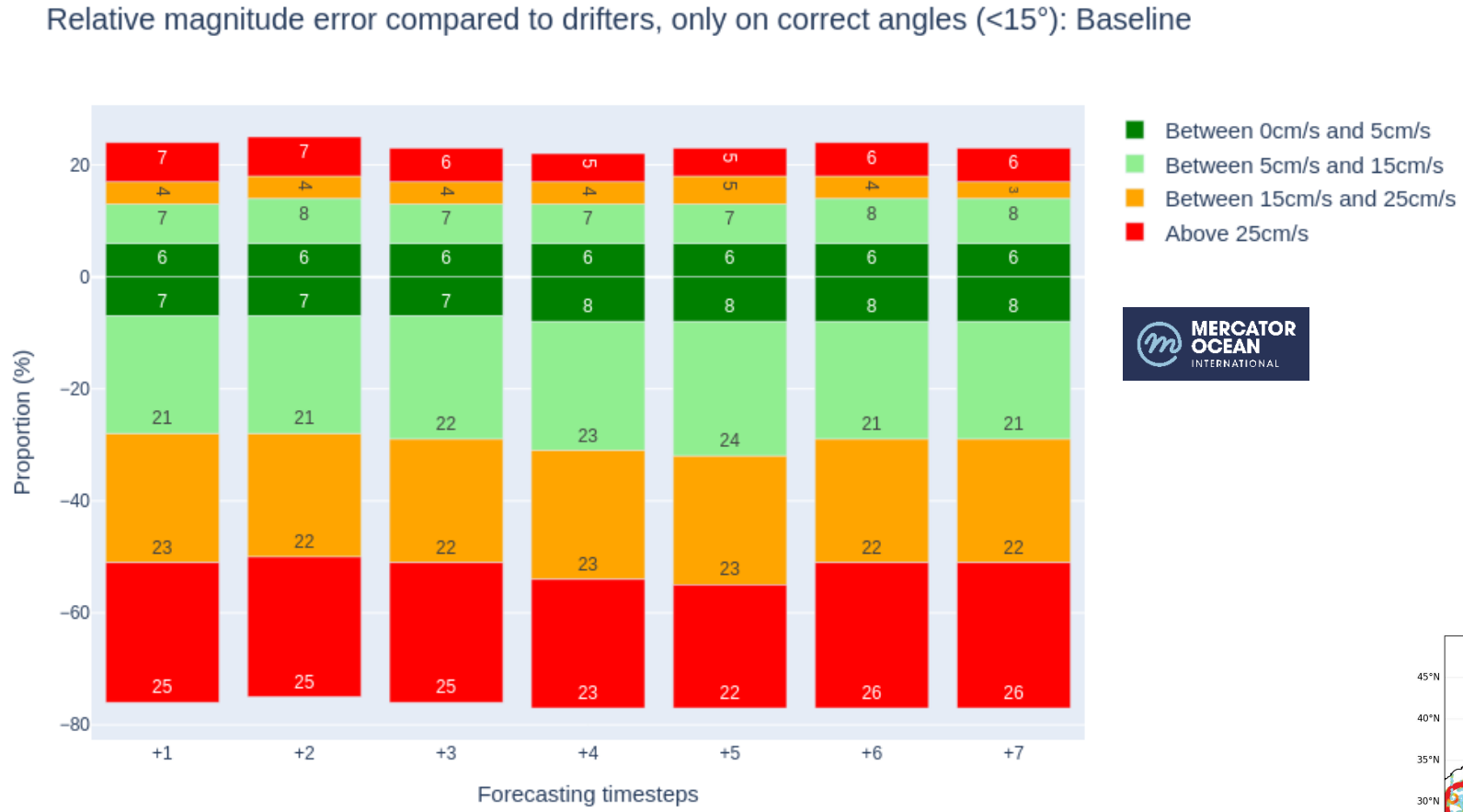


ORCAst

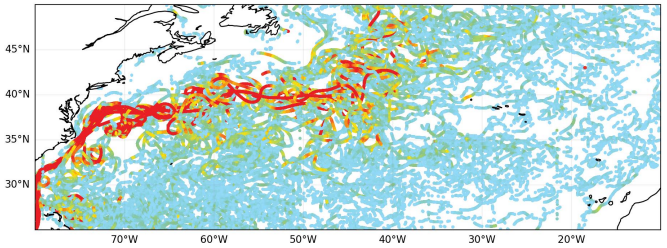
Evaluation datapoints



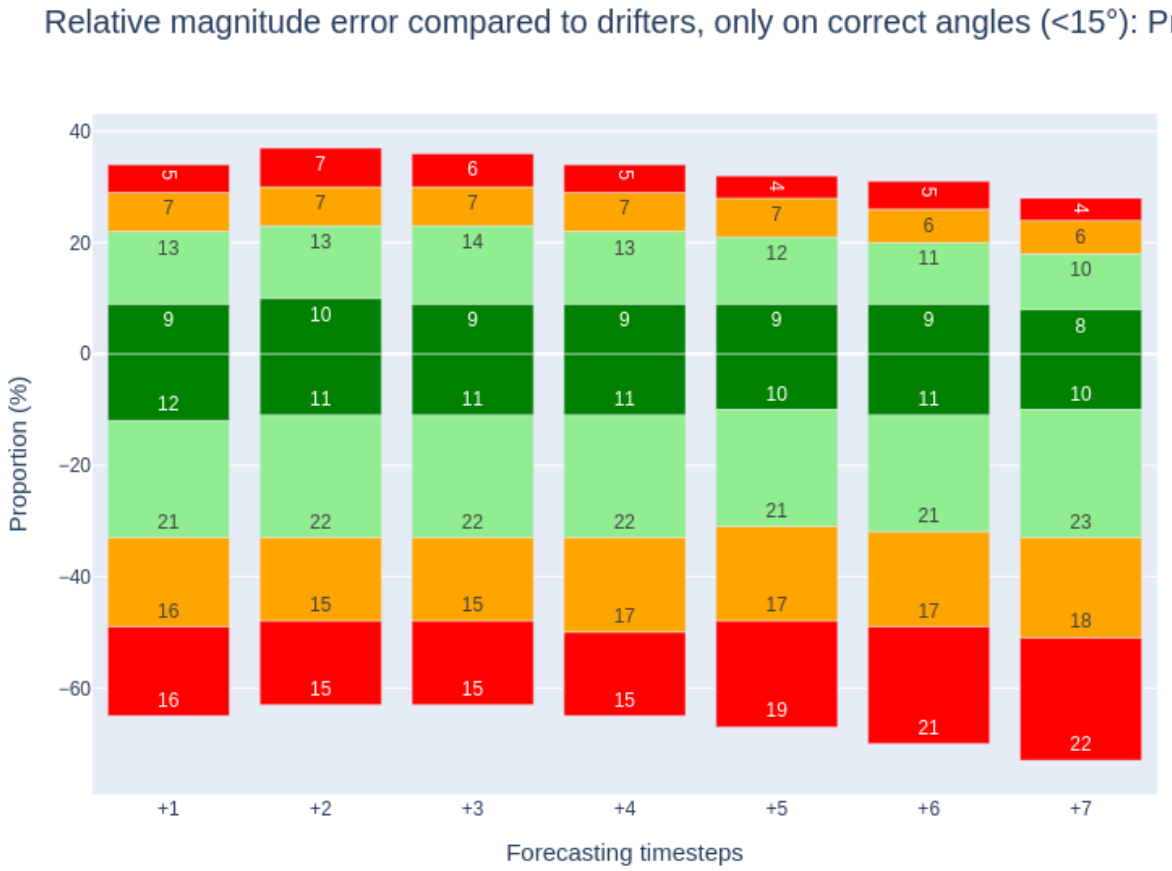
North Atlantic



Evaluation datapoints

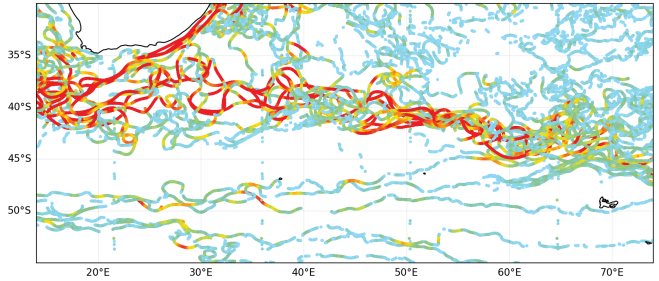


Aghulas

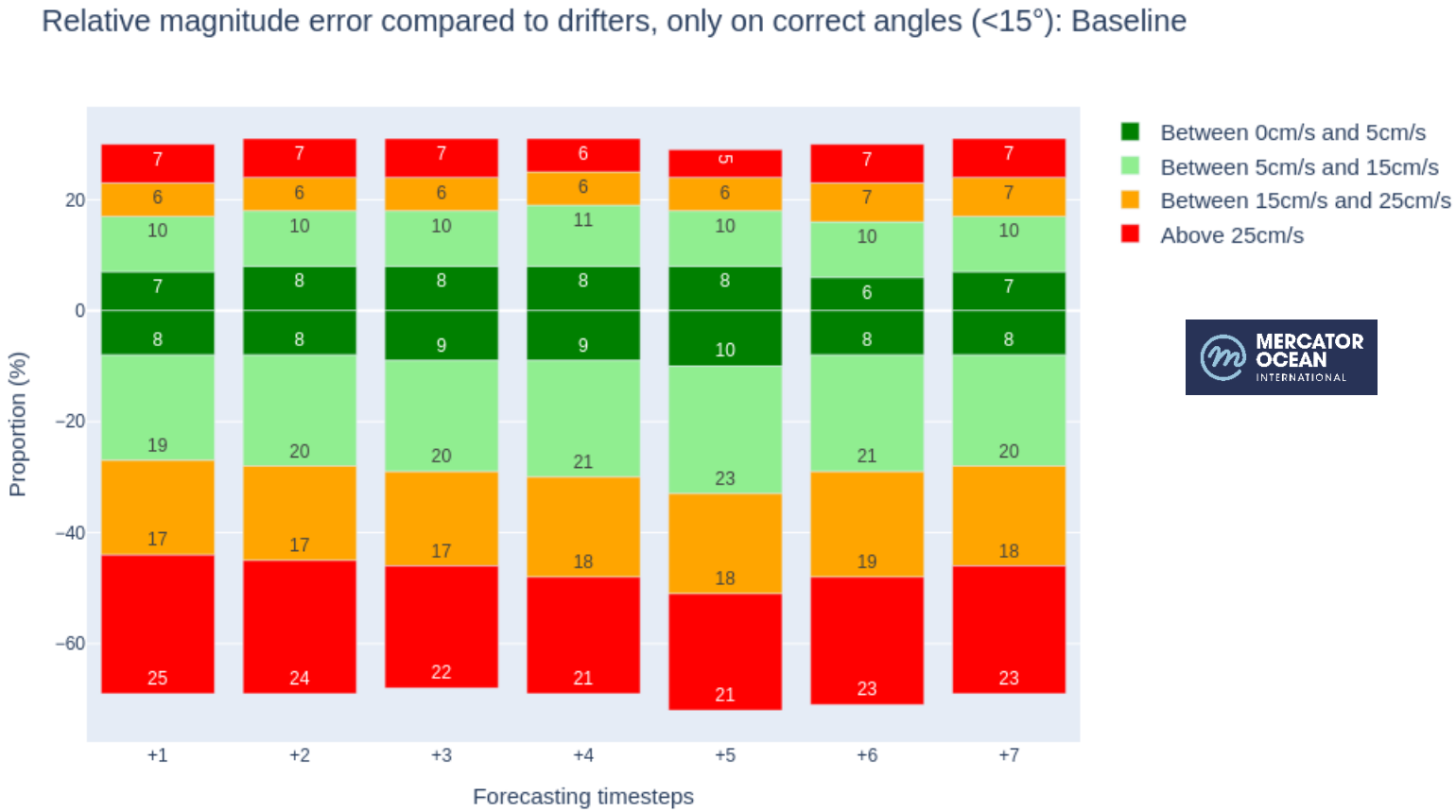


ORCAst

Evaluation datapoints



Aghulas



Evaluation datapoints