

Finding The Monk

How to Predict Where the Ocean Takes a Float

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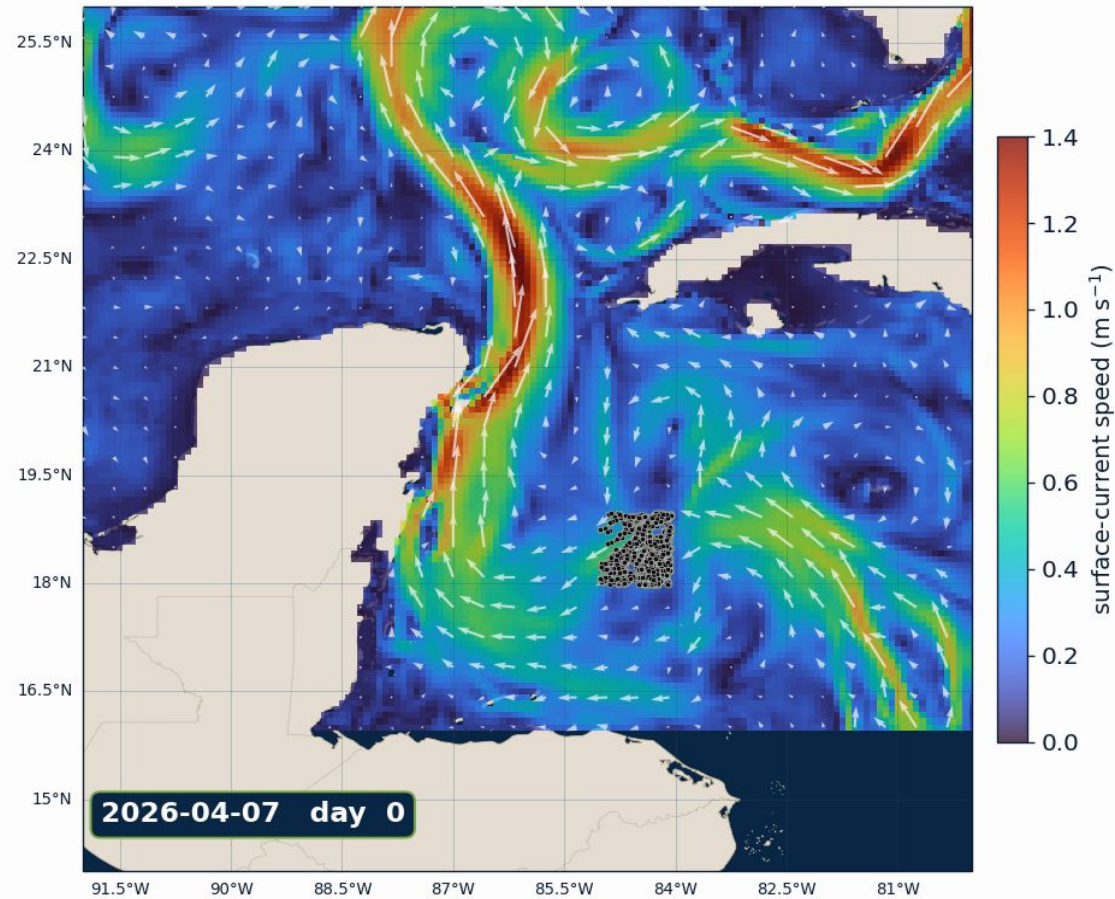
[linkedin.com/in/jose-echevarria-aquab1t](https://www.linkedin.com/in/jose-echevarria-aquab1t)

Seatrec webinar - August 18 2026

Background

Pelagic Sargassum drift simulation seeded from satellite detections (Sentinel-2)

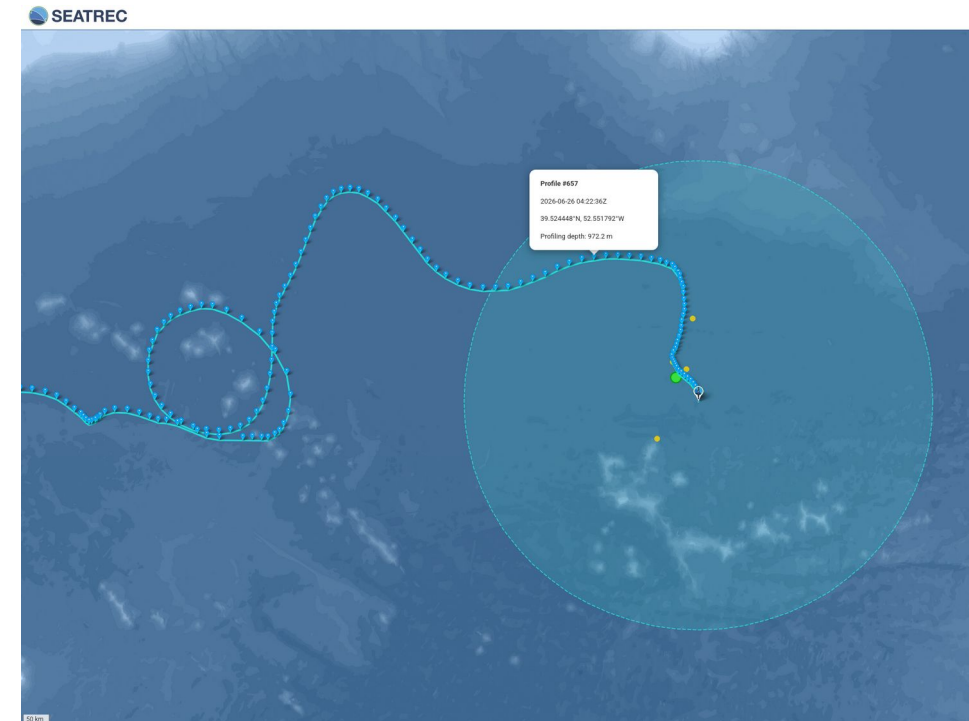
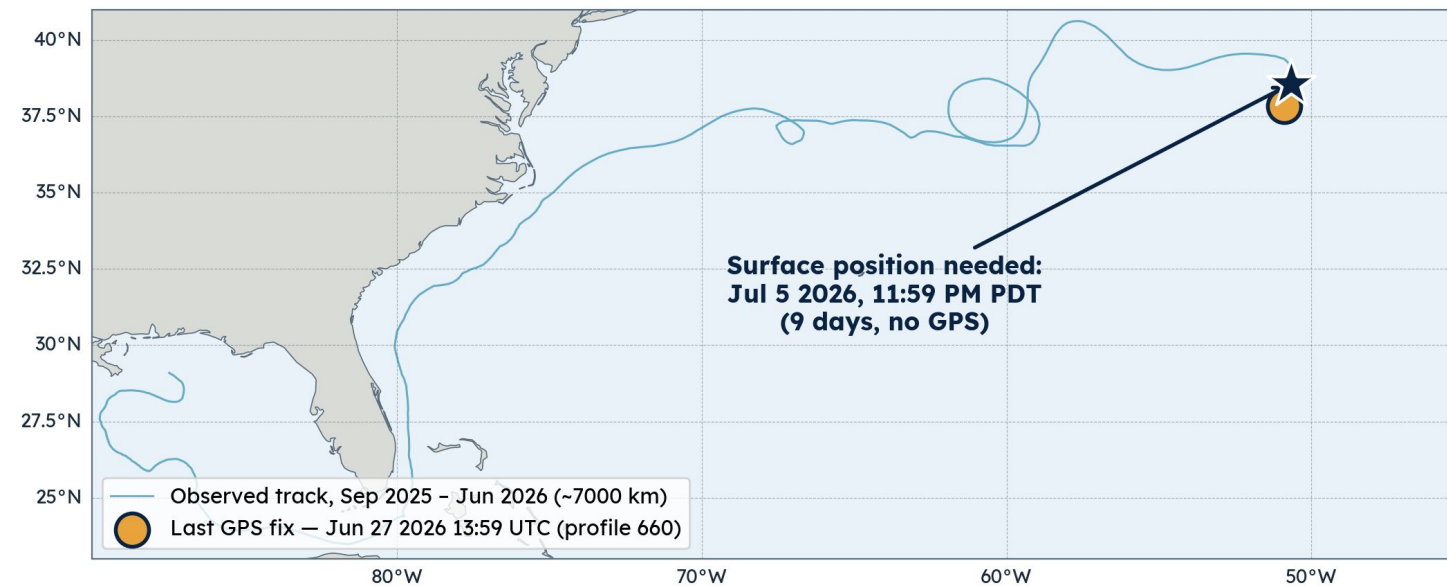
Sargassum riding the surface currents — Sentinel-2 2026-04-07



Sentinel-2 Sargassum detection 2026-04-07 drifting on the CMEMS surface-current field (OpenDrift + ML)

The Challenge

9-day forecast from the last GPS fix into mesoscale chaos



Seatrec Contest Mission:

Target: Where will float iF00008 surface on July 5, 2026 at 11:59 PM PDT?

Last fix: Jun 27 13:59 UTC
Horizon: ~9 days forecast (no GPS)
Regime: Gulf Stream meanders & eddy chaos

The Data: CMEMS Operational Mercator Currents

Copernicus GLOBAL_ANALYSISFORECAST_PHY_001_024 (1/12° ~9 km, 50 levels)

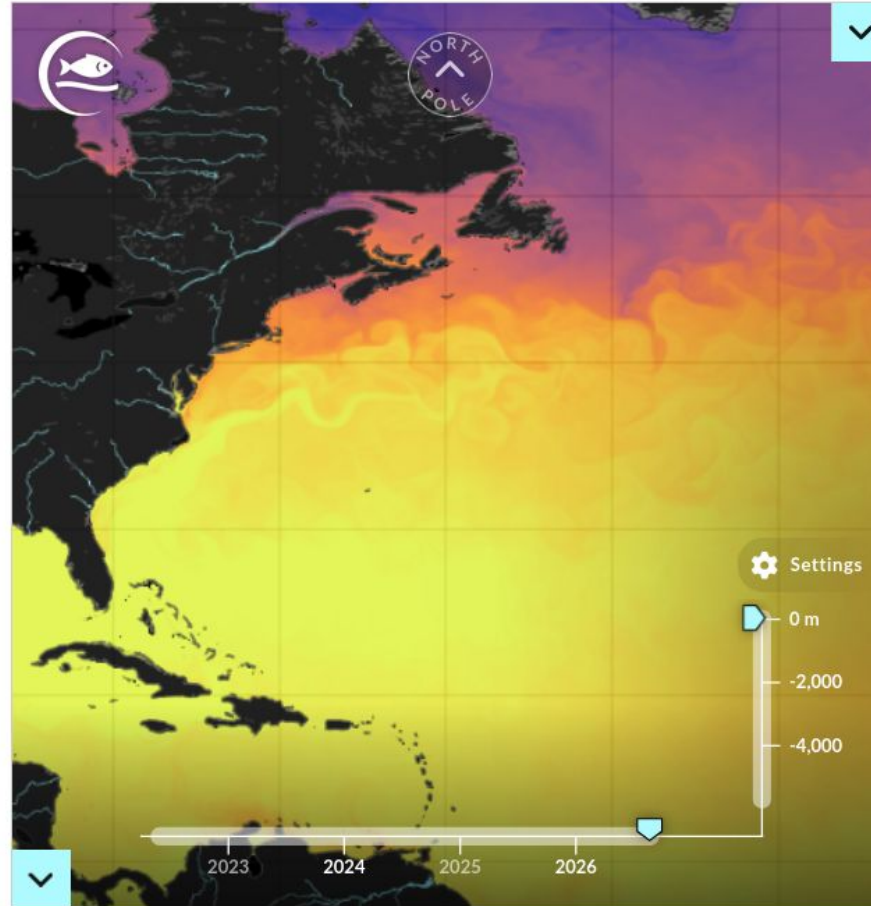
Overview

The Operational Mercator global ocean analysis and forecast system at 1/12 degree is providing 10 days of 3D global ocean forecasts updated daily. The time series is aggregated in time in order to reach a two full year's time series sliding window.

This product includes daily and monthly mean files of temperature, salinity, currents, sea level, mixed layer depth and ice parameters from the top to the bottom over the global ocean. It also includes hourly mean surface fields for sea level height, temperature and currents. The global ocean output files are displayed with a 1/12 degree horizontal resolution with regular longitude/latitude equirectangular projection.

50 vertical levels are ranging from 0 to 5500 meters.

This product also delivers a special dataset for surface current which also includes wave and tidal drift called SMOC (Surface merged Ocean Current).



Explore in MyOcean Pro

Mercator GLO12 Cube:

Grid: 1/12° (~9 km), global
Cadence: 1-hourly snapshots
Coverage: Sep 2025 -> Jul 2026
Total: 4.0 GB (merged file)

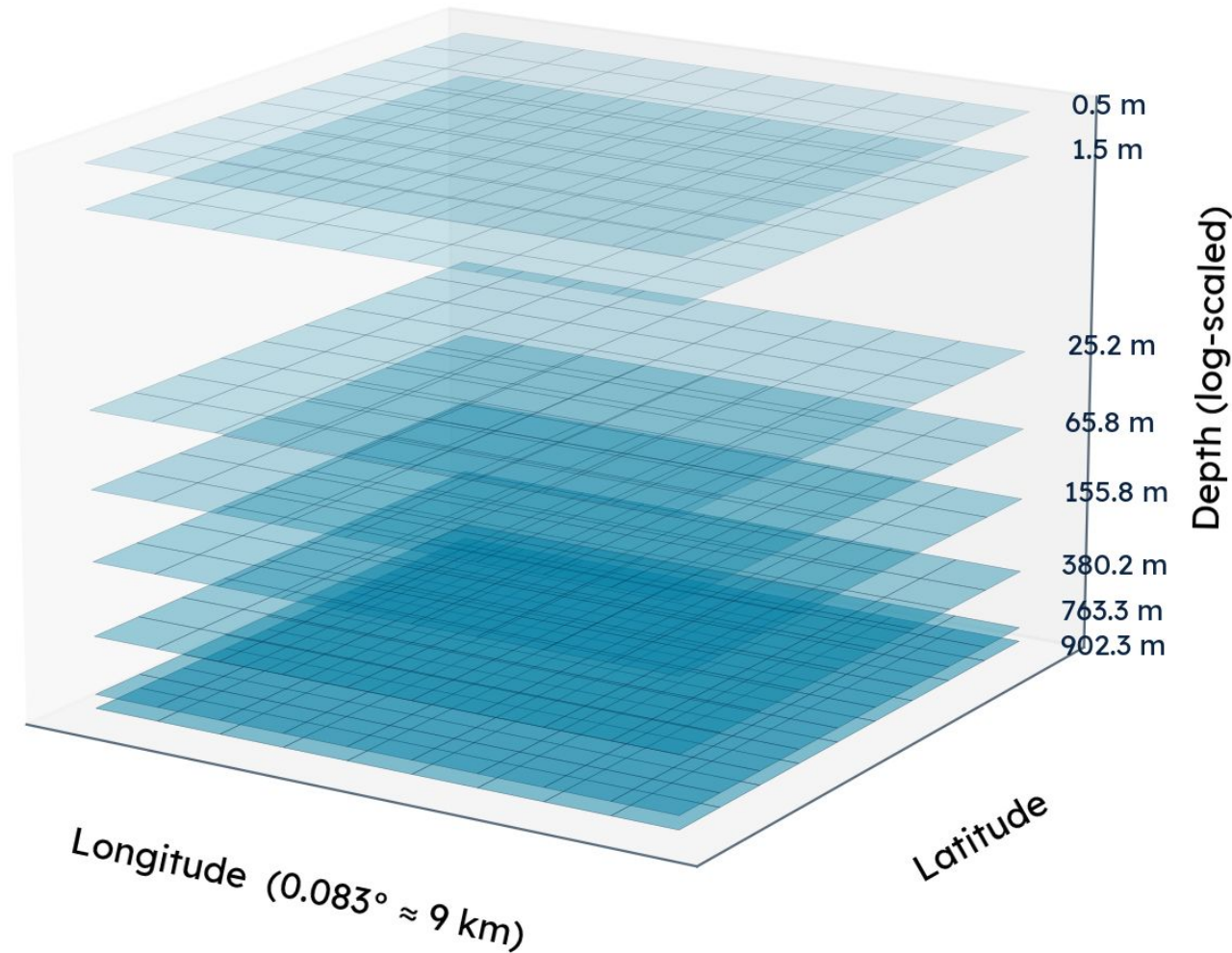
8 selected depth levels (m):
[0.49, 1.54, 25.2, 65.8,
155.9, 380.2, 763.3, 902.3]

Why 8 depths? The 902 m cell captures deep parking flow (~961 m mean).

Stokes drift tested, discarded (float below wave base ~98% time).

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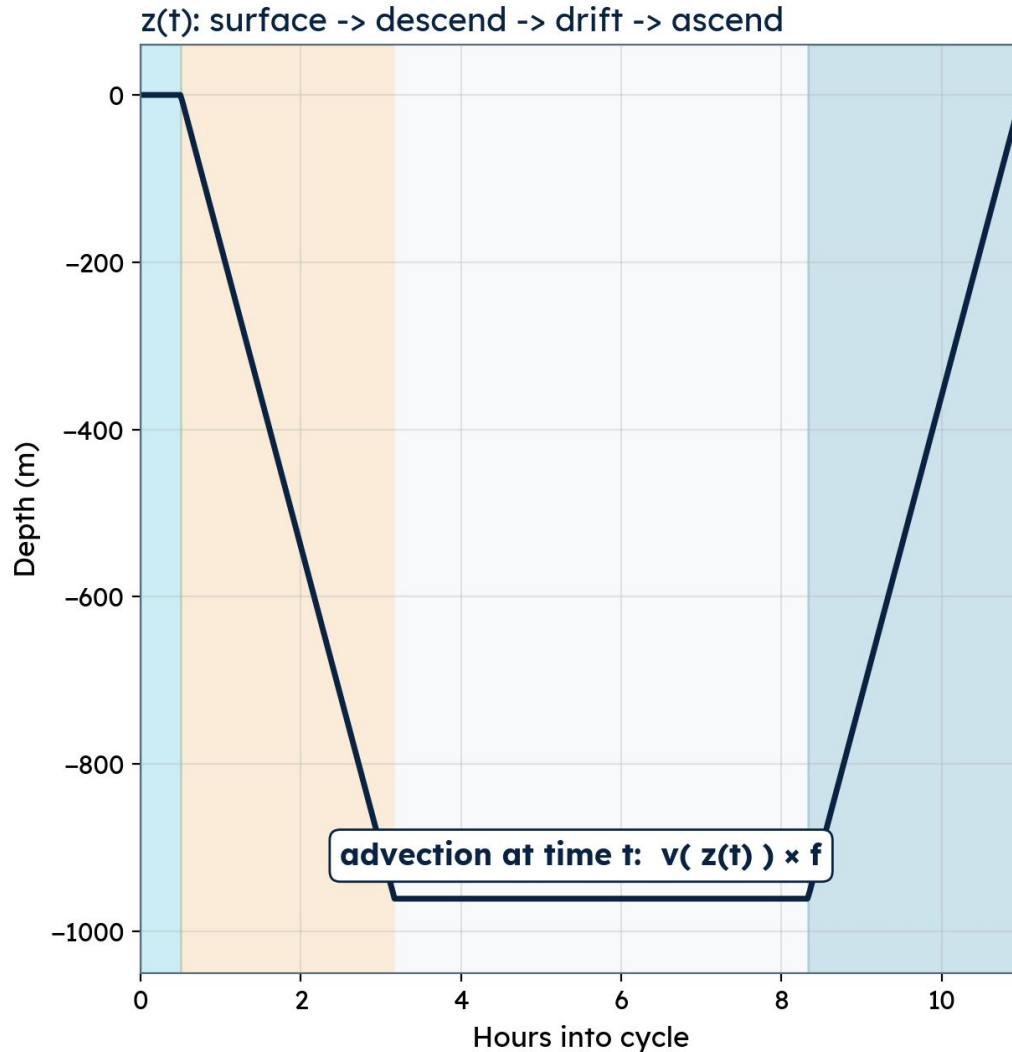
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Meet The Monk

infiniTE thermal-harvesting profiling float iF00008



Specs at a glance:

Type: infinITE thermal-harvesting profiling float

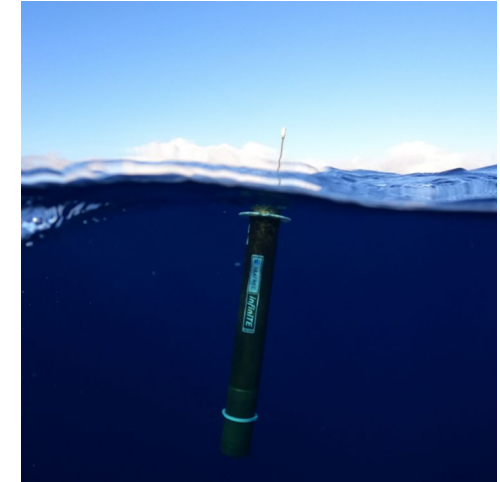
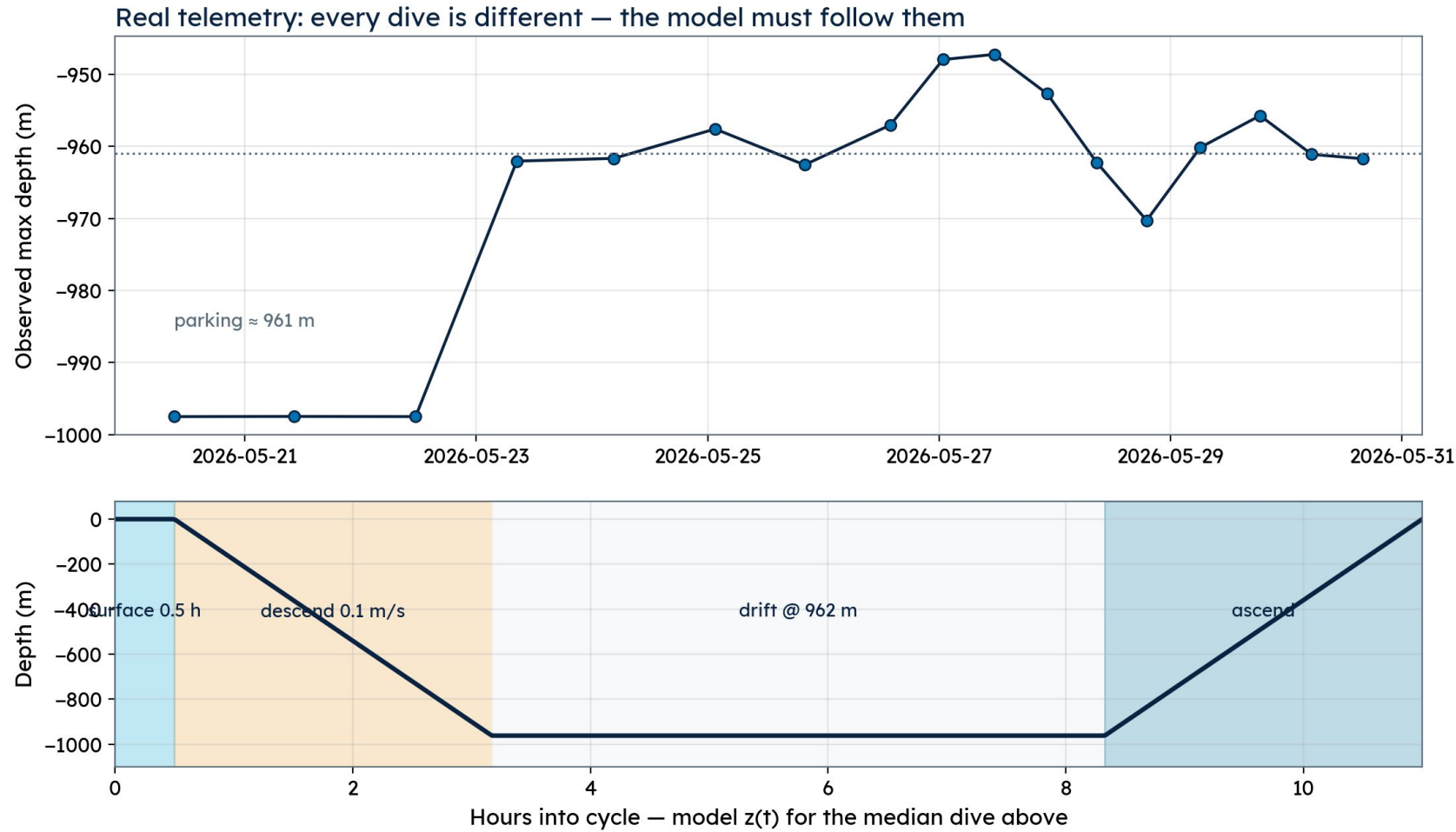
Record: 284 days (Sep '25 - Jun '26)
Track: ~7000 horizontal km
Cycle: surfaces ~every 11 h
Parking: ~961 m (mean 777, max 998)
Speed: 0.1 m/s descend / ascend

Six things must be right:

1. Mean current (Gulf Stream ~100 km/day)
2. Mesoscale eddies (rings pinching off)
3. Meanders (baroclinic instability)
4. Vertical shear (different at depth)
5. Chaotic dynamics (small errors grow)

The Modeling Idea

A profiling float spends ~98% of its life below the wave base



Every ~11 h the float samples 3 current regimes:

1. Mixed layer / surface jets (Gulf Stream)
2. Thermocline shear
3. Parking depth (~961 m, weak flow)

Holding particle at ONE depth samples the **WRONG** current.

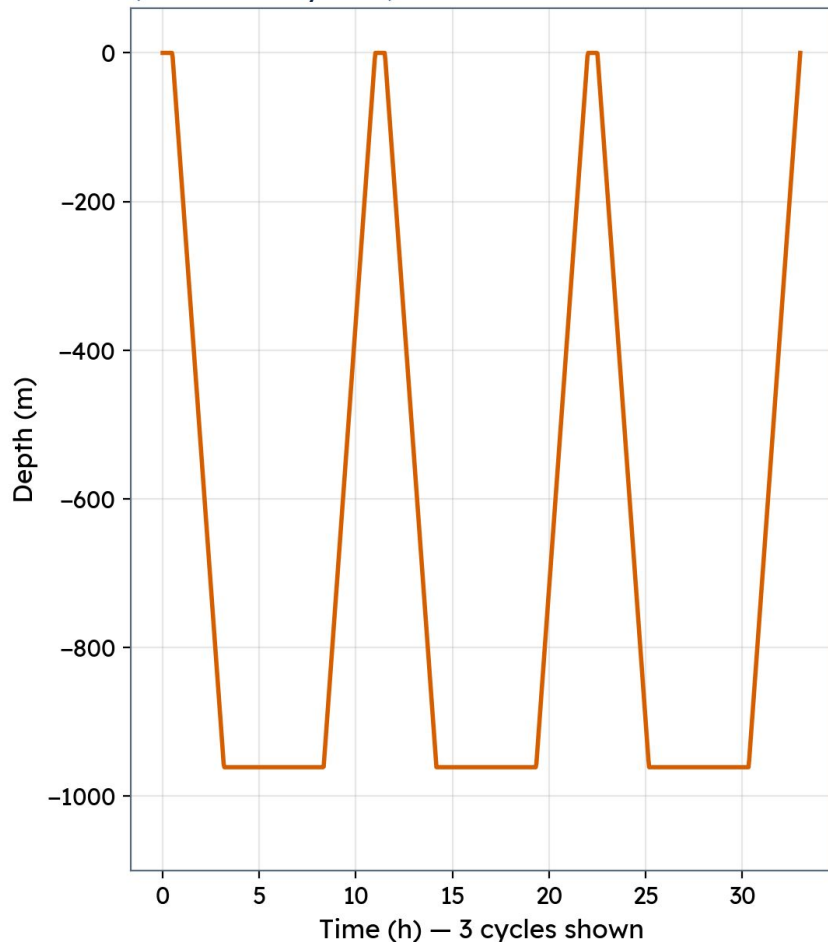
Model the dive, not just the drift.

Two Lagrangian Frameworks

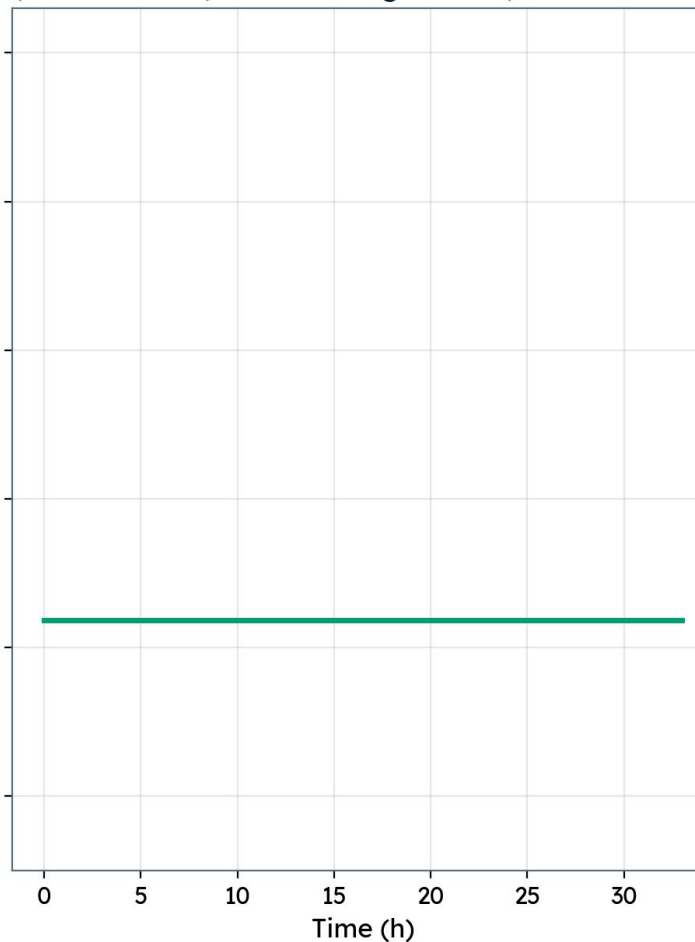
OpenDrift (custom physics) vs OceanParcels (depth-clamped)

Same currents, same float — only the depth model differs

OpenDrift — custom per-particle $z(t)$
(follows every dive)



OceanParcels (v1 config) — constant depth
(held at 763 m, nearest old grid level)



OpenDrift:

- Native Python Lagrangian tool
- Full freedom to specify $z(t)$ via dynamic particle classes

OceanParcels:

- Industry-standard ocean framework
- Used for constant-depth baseline (763 m grid level)

Key takeaway:

The performance gap is NOT the code; it is whether the physics follows $z(t)$ or holds the float at a single depth.

Validation: Reinit-Window Hindcasting & Skill Formulation

Rolling scheme; canonical Liu & Weisberg (2011) skill score

2.7. Validation Metric

The Liu–Weisberg (2011) skill score [31]:

$$SS = 1 - \frac{\sum_{i=1}^N d_i}{\sum_{i=1}^N L_i}, \quad (8)$$

where d_i is the great-circle separation between simulated and observed positions at step i , and L_i is the great-circle distance from the drifter's *first* observed position to its observed position at step i (straight-line displacement from origin, a variant of the original arc-length denominator of Liu & Weisberg 2011 [31]). $SS \geq 0.65$ defines a “skillful” prediction; $SS \leq 0$ indicates a model worse than simple persistence.

Liu & Weisberg (2011) Score:

$$SS = 1 - (d_sep / RMS_obs)$$

Numerator (mean separation):

$$d_sep = (1/K) \sum_k d_hav(x_obs(k), x_sim(k))$$

Denominator (obs centroid spread):

$$RMS_obs = \sqrt{[(1/K) \sum_k d_hav^2(x_obs(k), x_c)]}$$

where $x_c = (\text{mean_lat}, \text{mean_lon})$

Properties:

- $SS = 1.0 \rightarrow$ Perfect match
- $SS = 0.0 \rightarrow$ Equal to static centroid
- $SS < 0.0 \rightarrow$ Worse than centroid

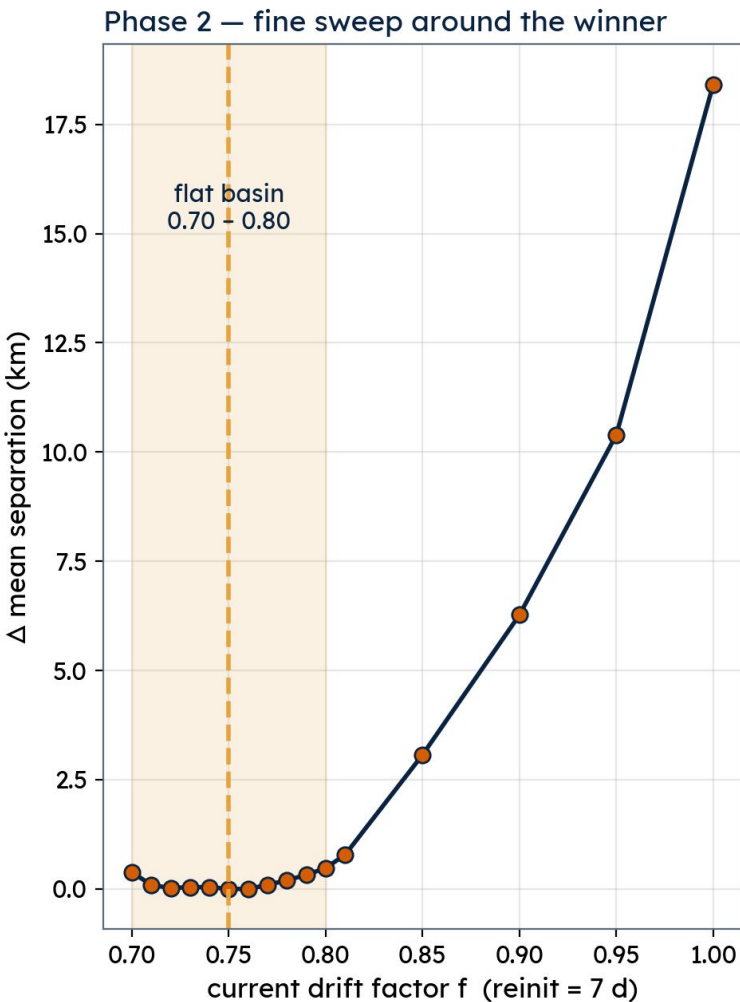
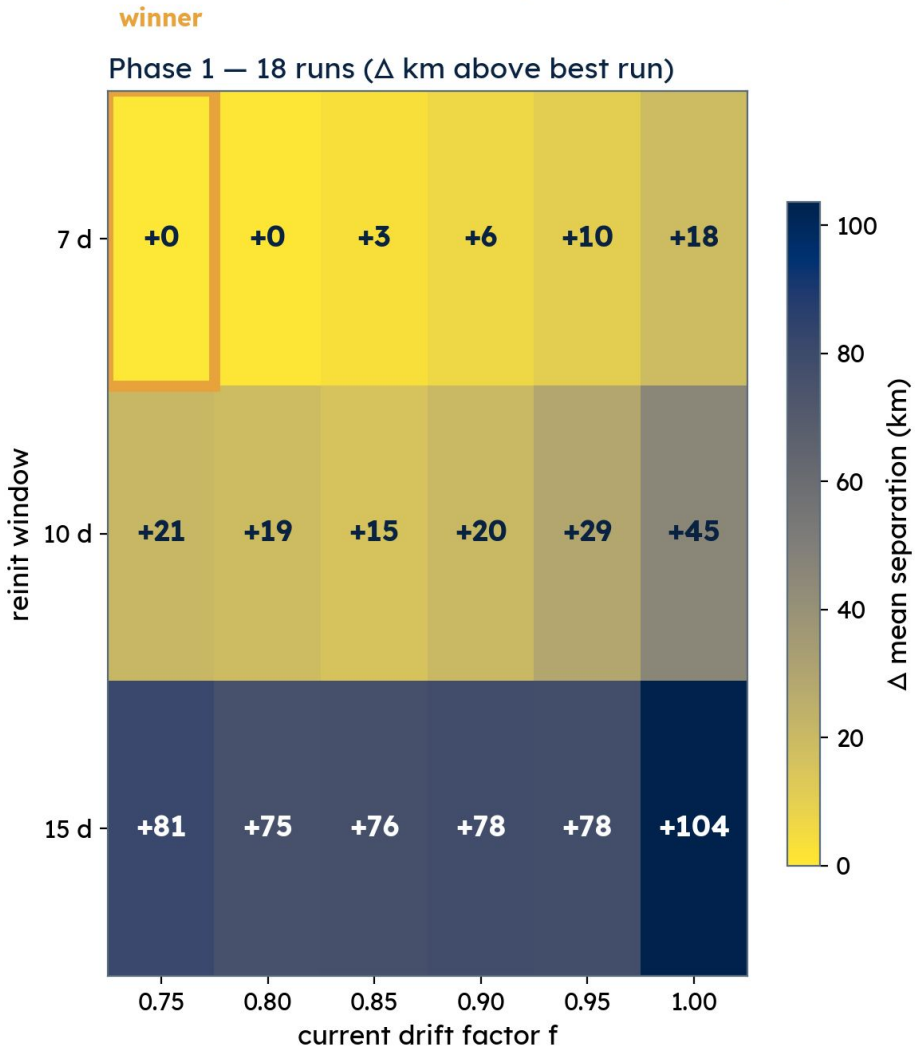
Reinit Cadence:

41 rolling 7d windows | 19 15d windows

The Optimization: 2-Phase Grid Search

28 combinations across factor x reinit x parking grid

28 combinations, ~60 min of compute: reinit window dominates; $f = 0.75$ wins



Three knobs:

1. Reinit window N (days)
2. Current drift factor f (slip of the float in the water)
3. Parking-depth grid (data choice)

Phase 1:

6 factors x 3 reinit windows = 18
[0.75, 0.80, ..., 1.00] x [7, 10, 15 days]

Phase 2:

fine factor sweep near winner
10 more combinations

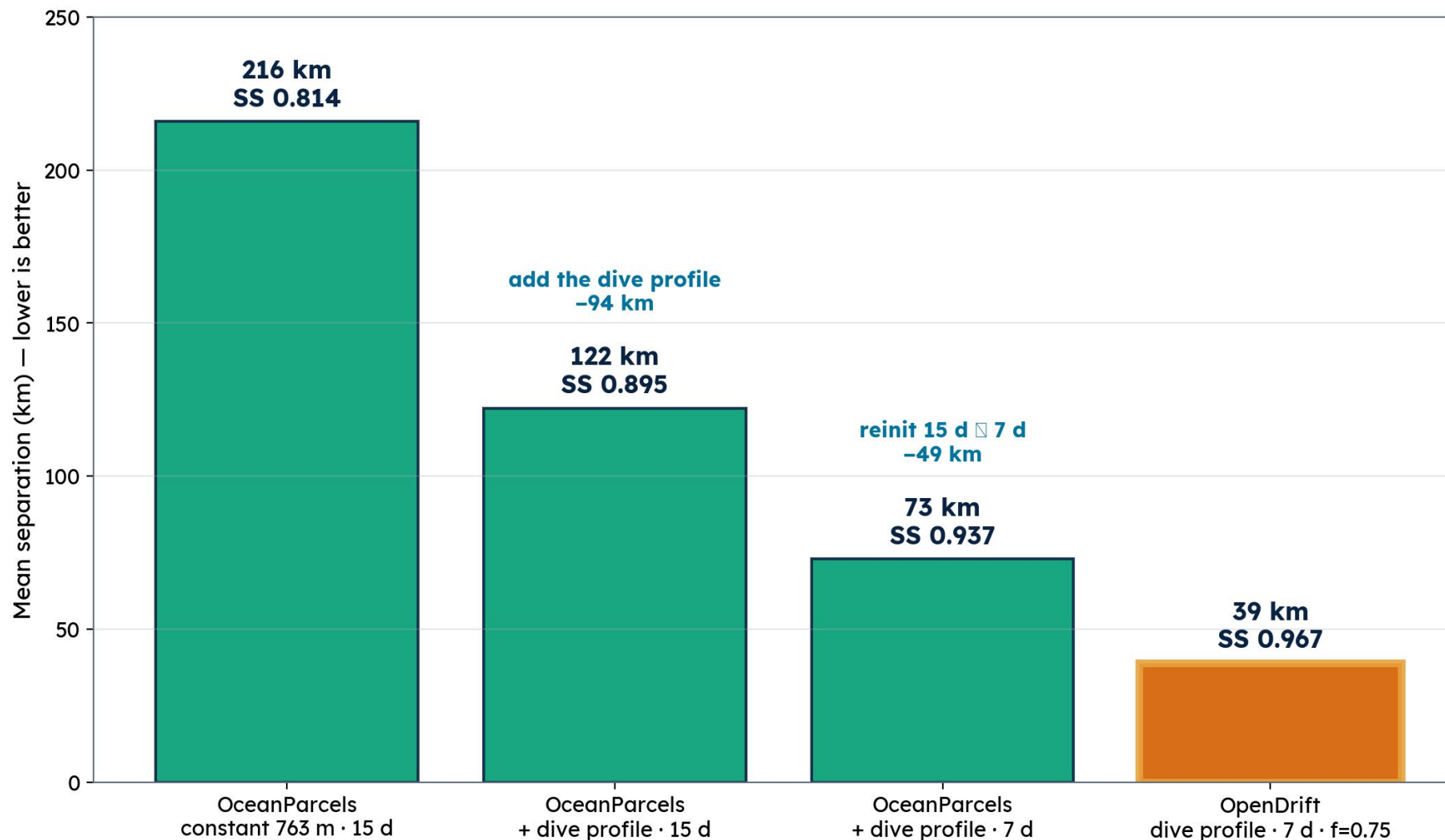
Total: 28 combinations

Winner: 7-day reinit, $f=0.75$
(yellow box in the figure)

Search surface from the original June-2026 scan (shown as Δ km above the best run). Post-audit canonical optimum at 7 d, $f = 0.75$: 39.0 km, SS 0.967.

The Gap Was the Dive Profile

Same currents, same float - only the depth model differs



Mean separation (canonical LW SS):

OP, constant 763 m, 15 d
215.9 km (SS 0.814)

OP + dive profile, 15 d
122.3 km (SS 0.895)

OP + dive profile, 7 d
72.9 km (SS 0.937)

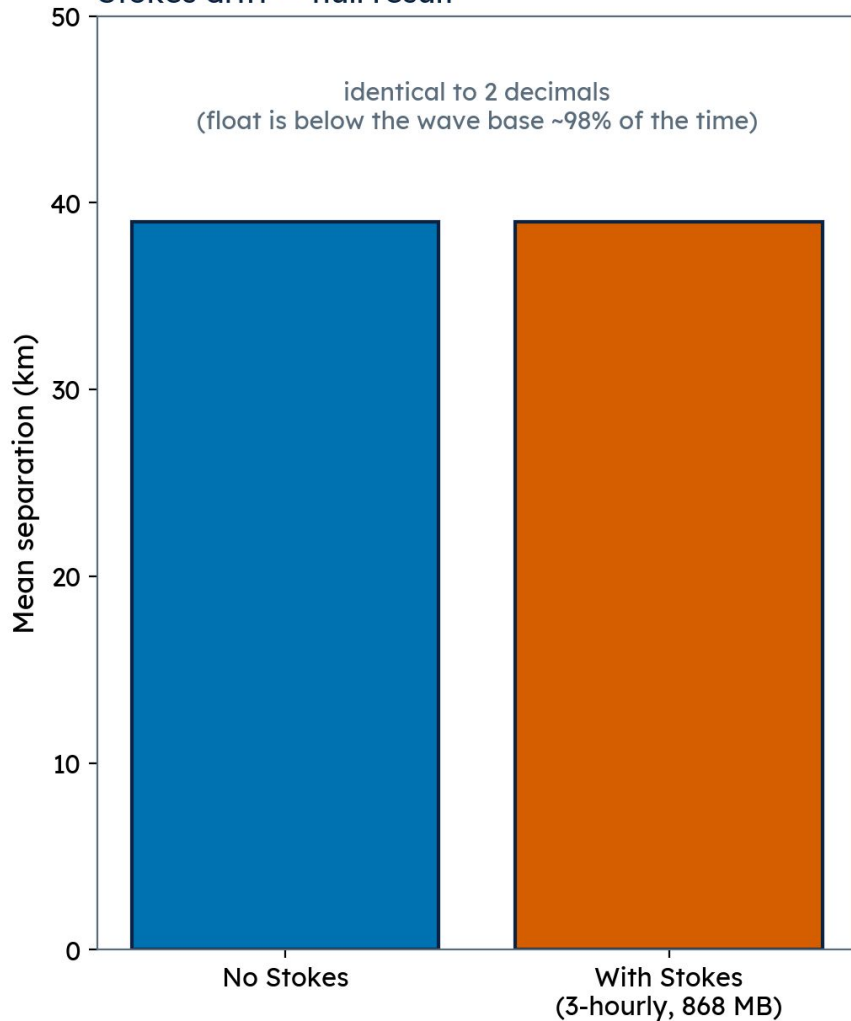
OD, dive profile, 15 d
92.2 km (SS 0.921)

OpenDrift, dive profile, 7 d, f=0.75
39.0 km (SS 0.967) (**winner**)

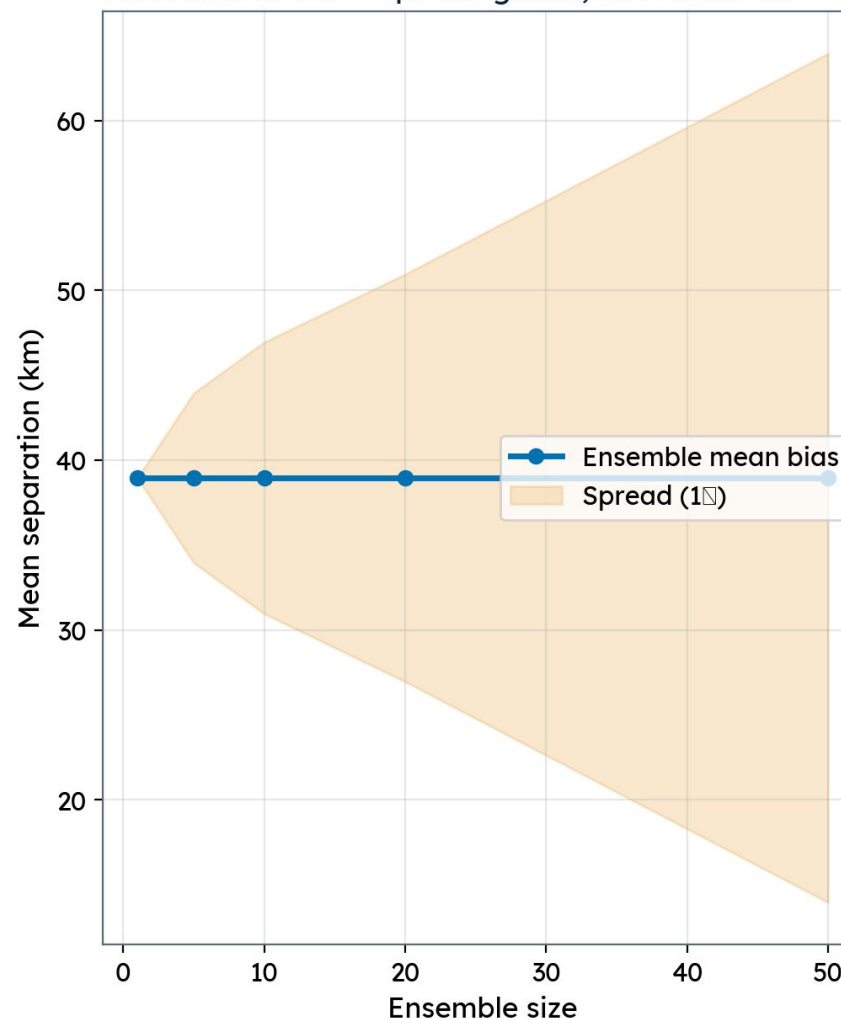
Two Things That Did Not Help

Stokes drift and ML velocity correction

Stokes drift — null result



Ensemble at 7 d — spread grows, bias does not



Stokes drift (surface-wave velocity):

- 3-hourly CMEMS, added to advection
- Result: no improvement
- Float below wave base > 98% of time
- Stokes decays exponentially w/ depth

Ensemble mean at 7-day timescale:

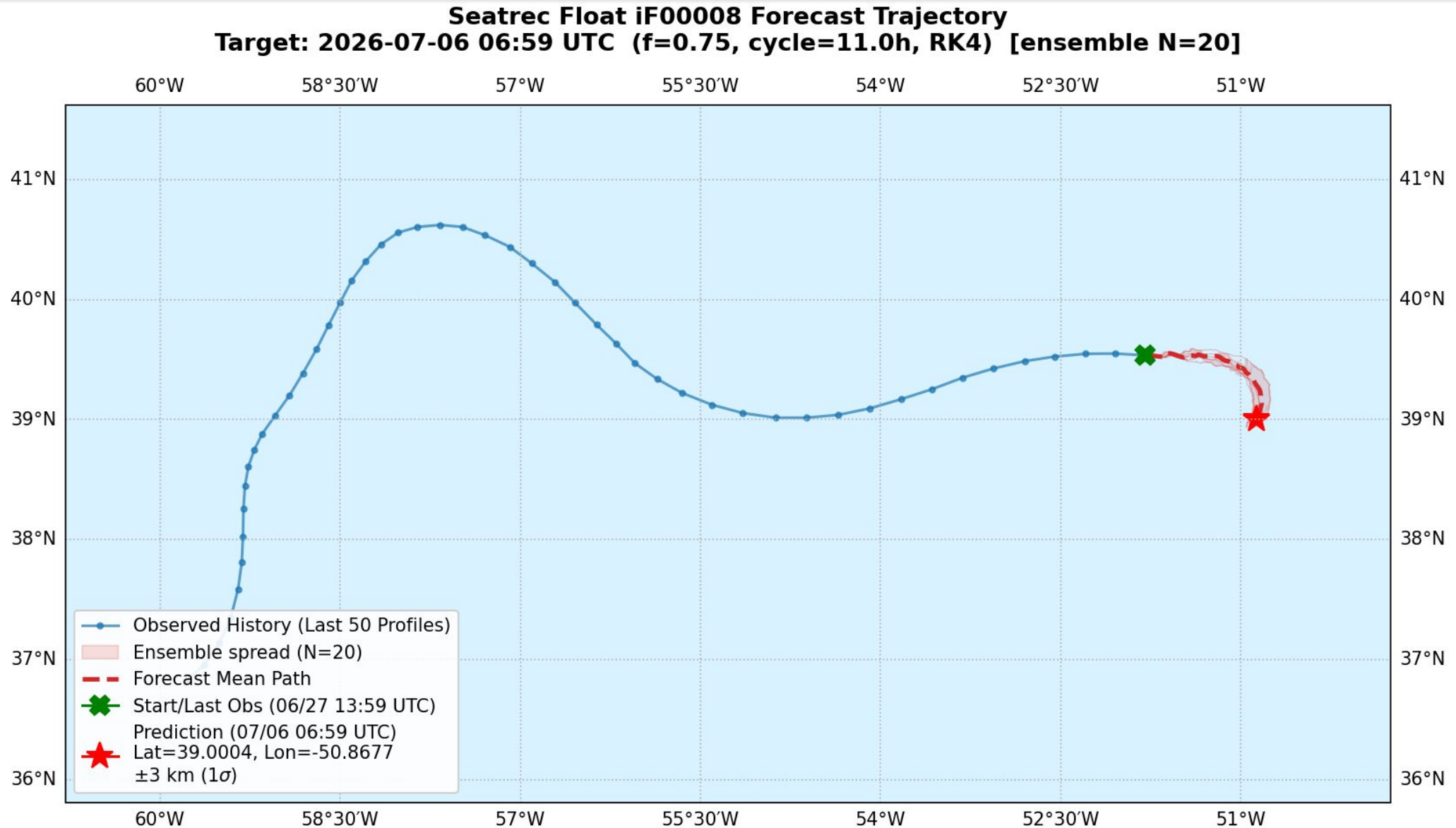
- 20 particles, 10 m²/s diffusivity
- Mean bias unchanged (same forcing)
- Spread grows, but spread is not error

ML velocity correction:

- displacement samples from 1 float
- Far too few to separate bias from overfitting. Abandoned.

The Final Forecast (52 km)

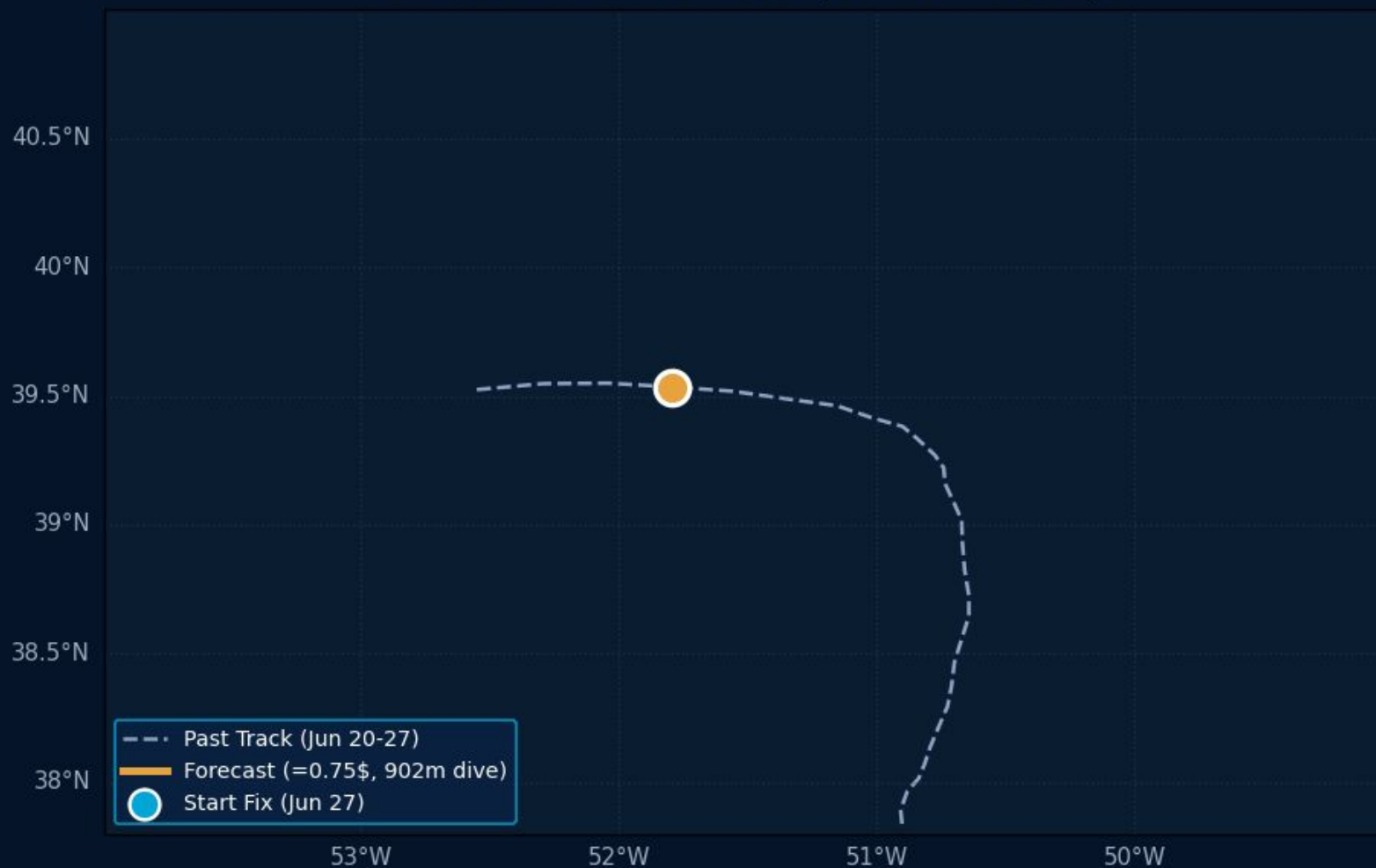
Advection through 902-m CMECS currents, 20-particle ensemble for uncertainty



The Final Forecast: Evolution & Simulation (Jul 5 2026)

Advected through 902-m CMECS currents, 20-particle ensemble for uncertainty

Winning Forecast Evolution vs CMECS Currents at Parking Depth (902 m)
Valid: 2026-06-27 12:00 UTC | Horizon: -0.1 days



Validated config:
7-day reinit, $f=0.75$, RK4
1-hour timestep
8 depths (902 m parking)
No Stokes drift

Initialized at last fix:
Jun 27 13:59 UTC
39.535 N, 51.797 W (prof 660)

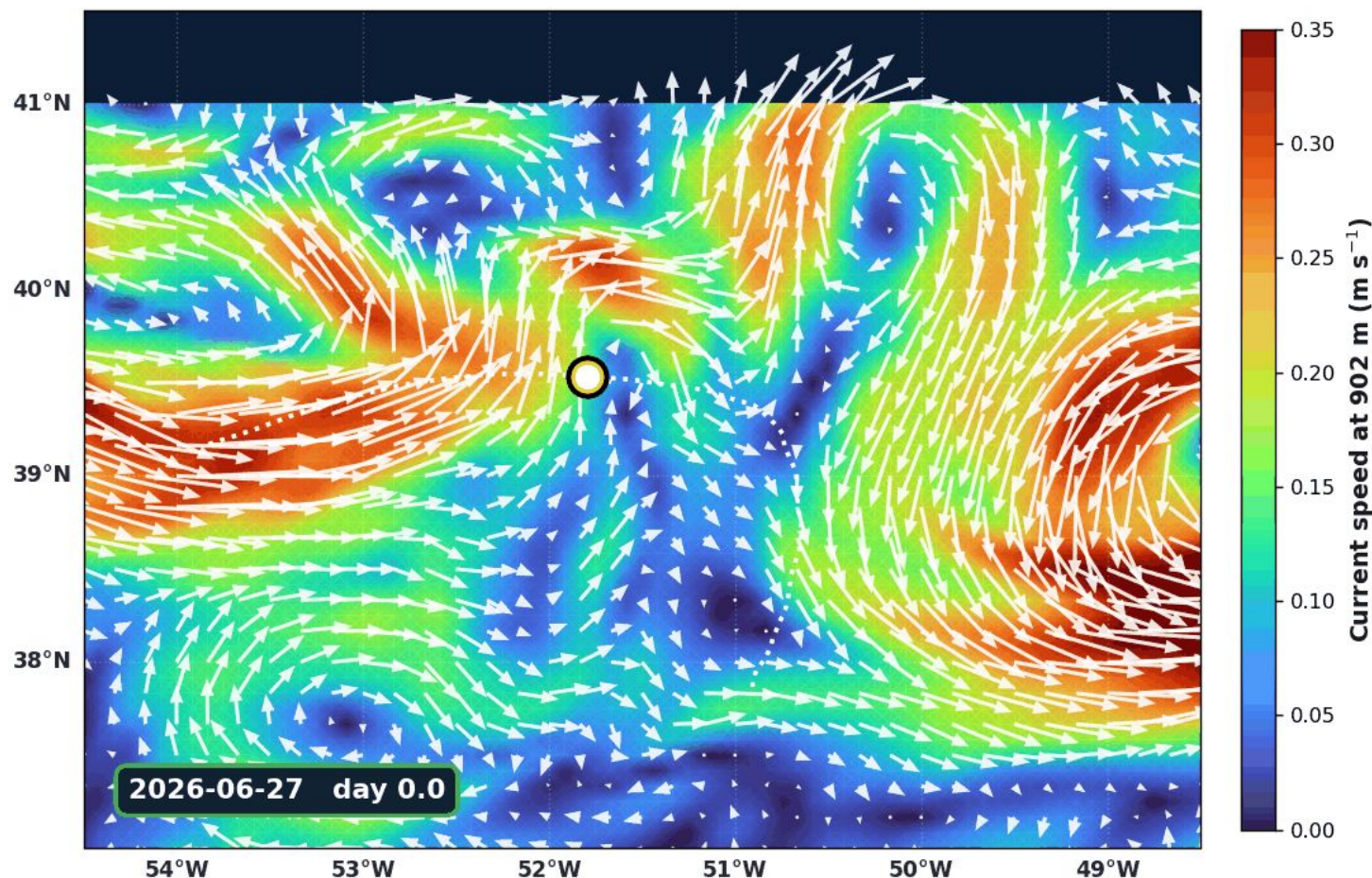
9-day forward dead reckoning

20-particle ensemble:
0.01 deg offset + $10 \text{ m}^2/\text{s}$
diffusivity (spread $\pm 3.1 \text{ km}$)

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Advected through 902-m CMEMS currents; 20-particle ensemble for uncertainty

The Monk Float Drift vs Deep Currents (902 m) — 2026-06-27



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The Monk (iF00008) 9-day winning forecast advecting through CMEMS Mercator GLO12 902 m layer

Three small ideas done carefully

1

Model the dive,
not just the drift

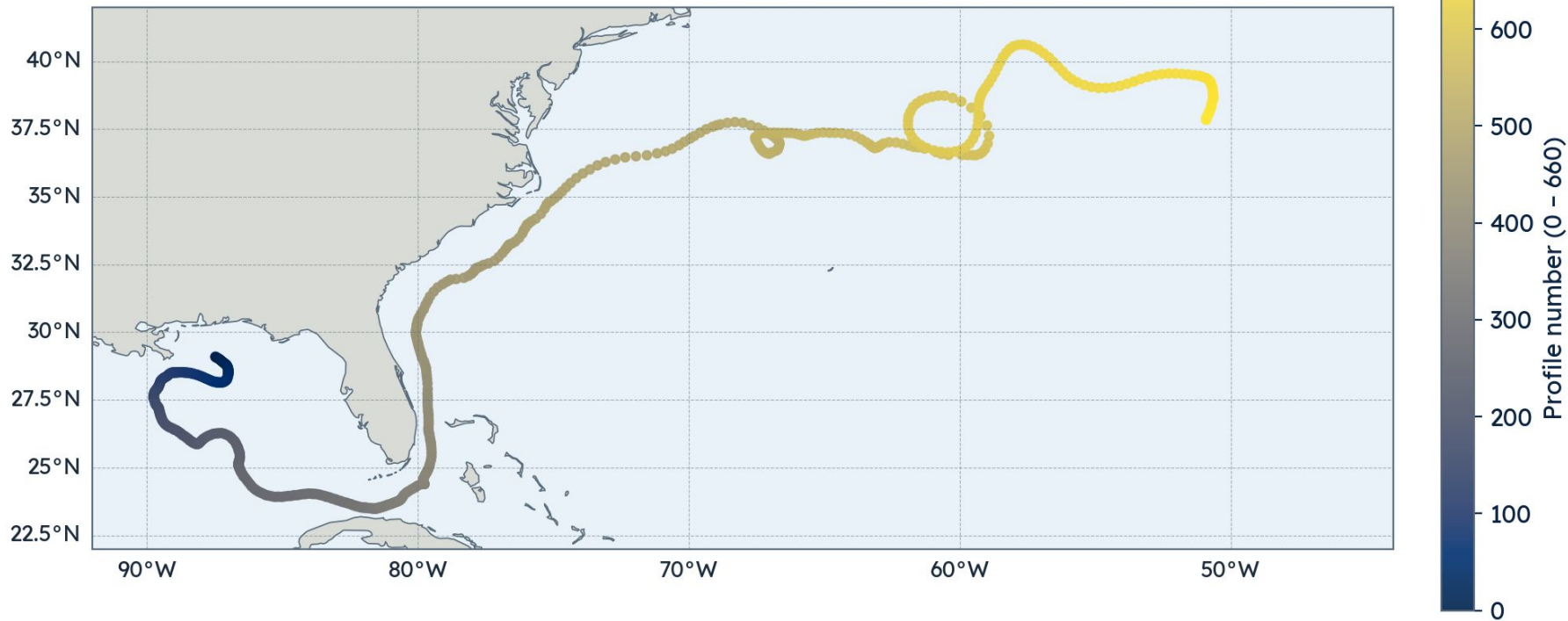
2

Short reinit windows
prevent error growth

3

Trustworthy metrics

The Monk's Complete 284-day Trajectory (Sep 2025 - Jun 2026)



Thanks

Seatrec (organizers + challenge)

Knut-Frode Dagestad (up next)
OpenDrift co-developer, Part-2
winner - MET Norway

Co-entrants

Q&A welcome

Thank you!