Lagrangian drift of *Sargassum* and oil spills

Laura Gómez Navarro[1], Erik van Sebille[1], Joey Richardson[1], Clement Ubelmann[2], Duarte Soares[3] and Pierre Daniel[4]

[1]Utrecht University, [2]DATLAS, [3]ITOPF, [4]MeteoFrance

World Ocean Circulation User Consultation Meeting

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ESA-ESRIN, Frascati, Italy

Overview

Case studies

Sargassum

Case 1

Miron *et al.* (2020) drifters (TATL, 2018)

(region extended)

Case 2

Satellite images where *Sargassum* mats identified (TATL, May 2019)

Oil spills

Case 1

Golden Trader (NATL, Sep. 2011)

Case 2

Sanchi (Kuroshio region, Jan. 2018)

(Extra region)

Lagrangian simulator

OceanParcels framework

(www.OceanParcels.org)

- The Parcels code (**P**robably **A** **R**eally **C**omputationally **E**fficient **L**agrangian **S**imulator):

→ set of Python classes and methods to create customisable particle tracking simulations using velocities from for example outputs from Ocean Circulation models.

- Version 2.2.2 (Delandmeter & van Sebille, 2019; (https://github.com/OceanParcels/parcels/releases)

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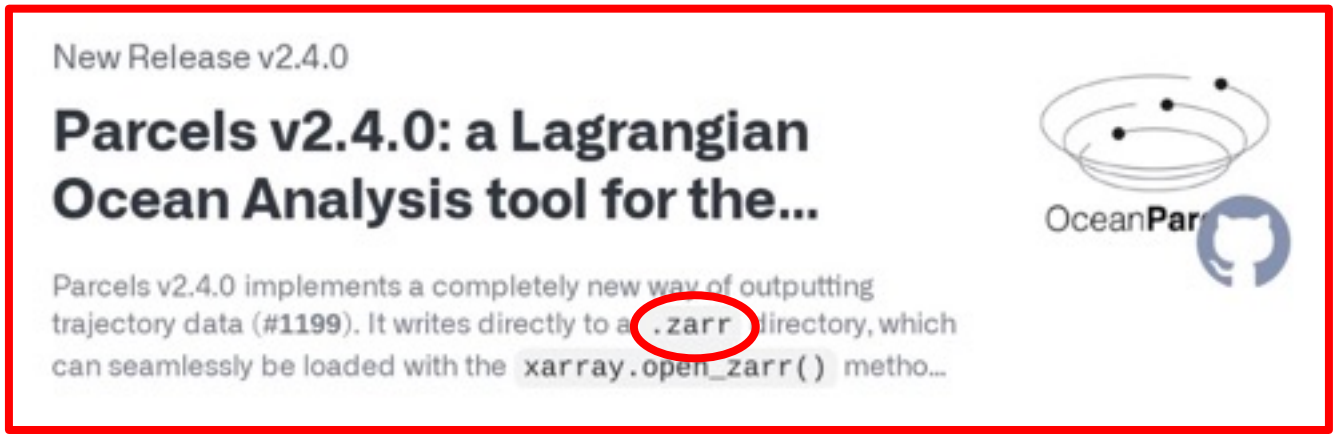


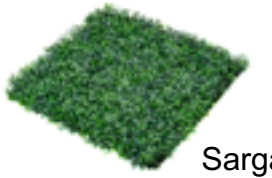
- Version 2.2.2 (Delandmeter & van Sebille, 2019; (https://github.com/OceanParcels/parcels/releases)

Case 1: *Sargassum* drifters

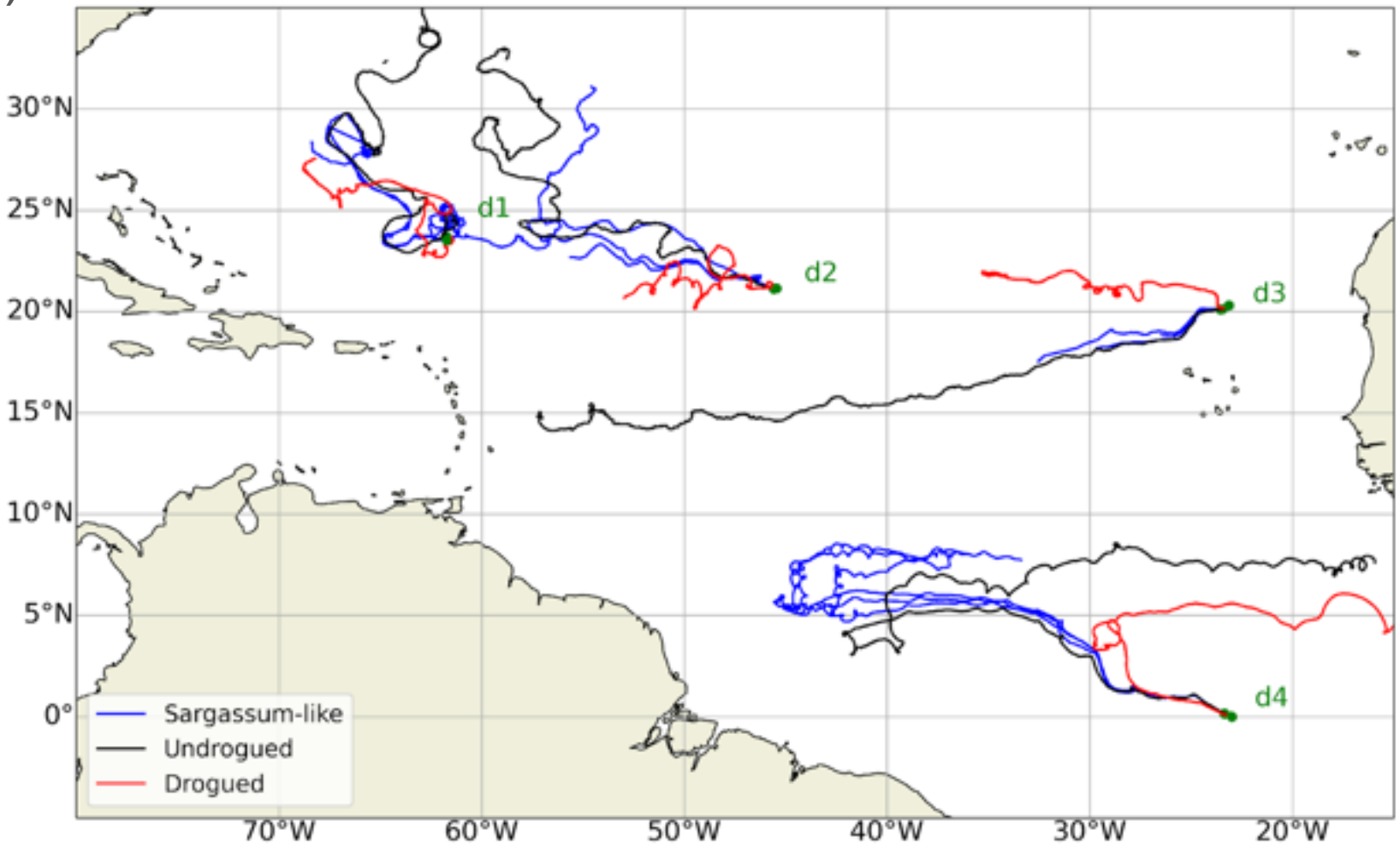
Based on Miron *et al*. (2020) field study

Types of drifters:

- 0: svp without drogue
- 1: sargassum-like mats
- 2: small sphere
- 3: square
- 4: cube
- 5: large sphere
- 6: svp



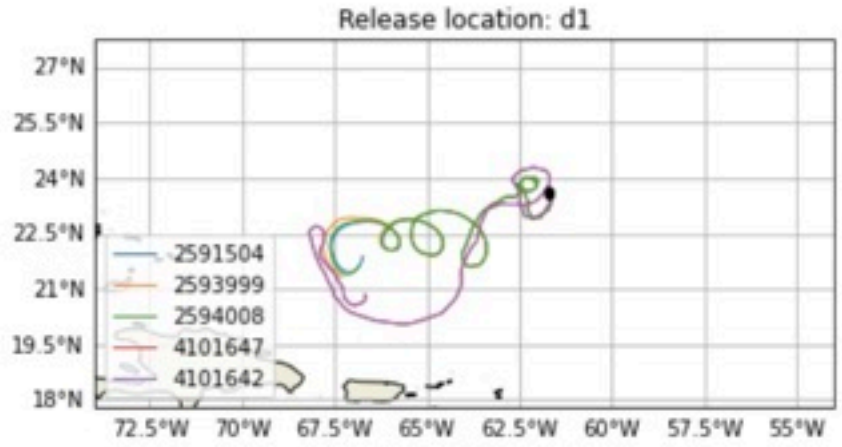
Sargassum-like drifter (Miron *et al (2020)*)

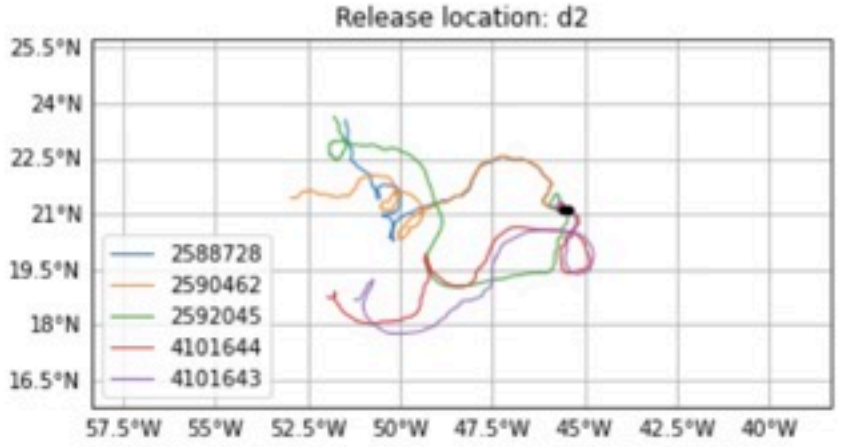


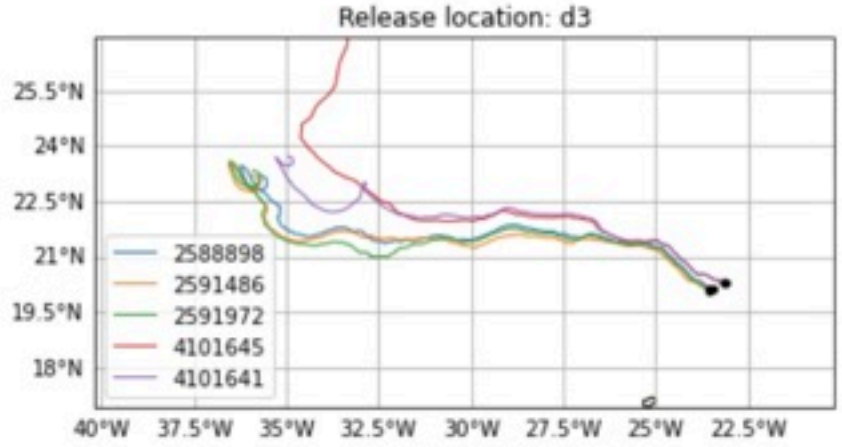
Case 1: *Sargassum* drifters

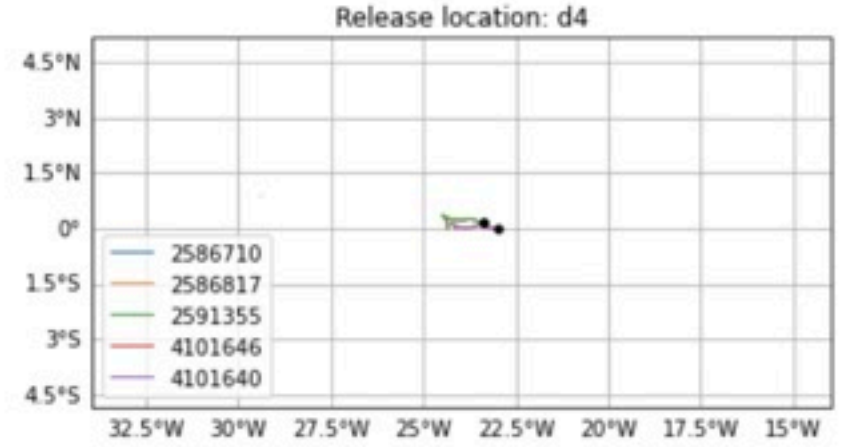
Simulated drifters

(advected only with WOC current data)









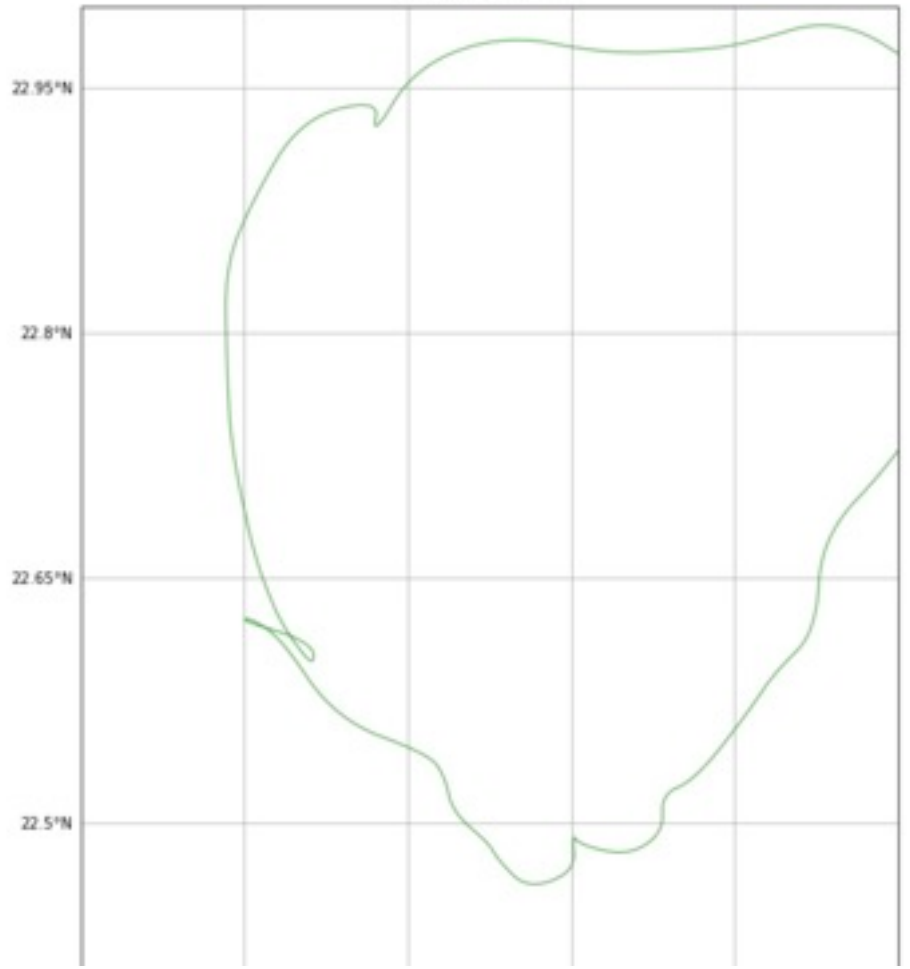
Case 1: *Sargassum* drifters

Location d2

Case 1: *Sargassum* drifters

Location d2

Eddy + inertial oscillations

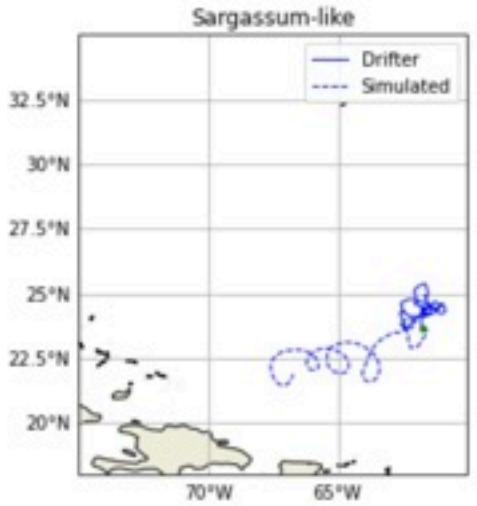


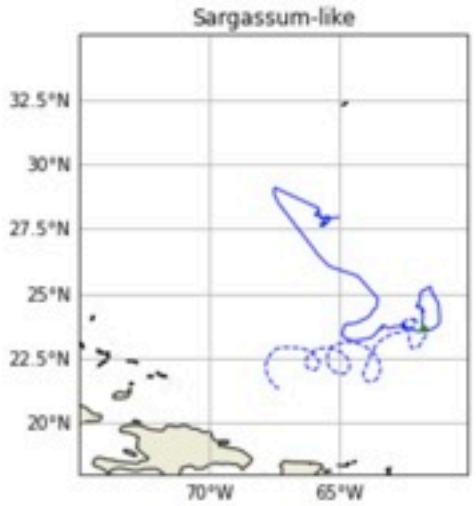
Case 1: *Sargassum* drifters

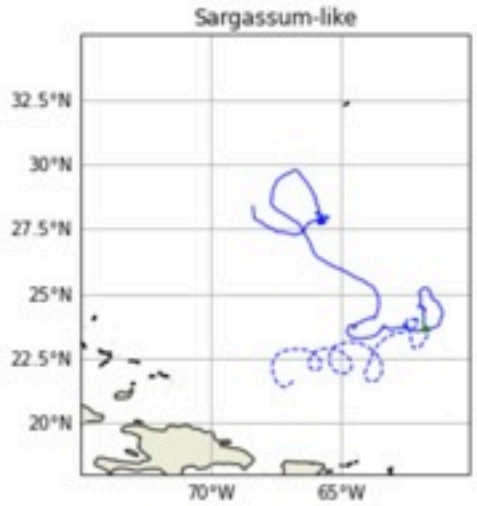
Comparison with real drifters

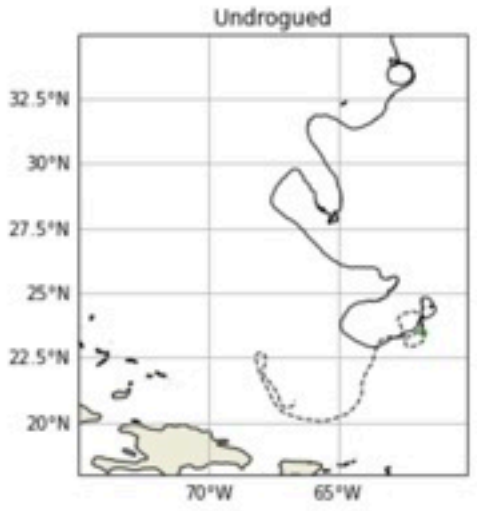
- Location d1

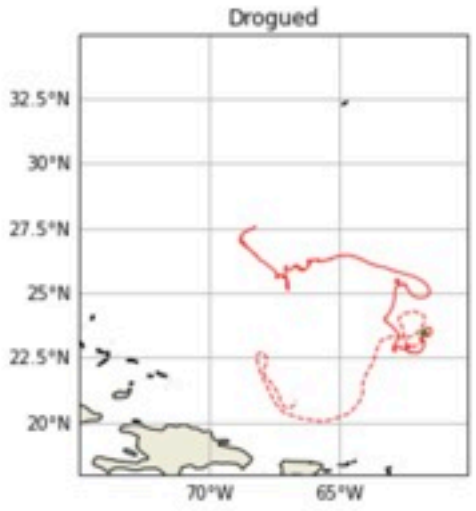
→ Impact of eddy representation







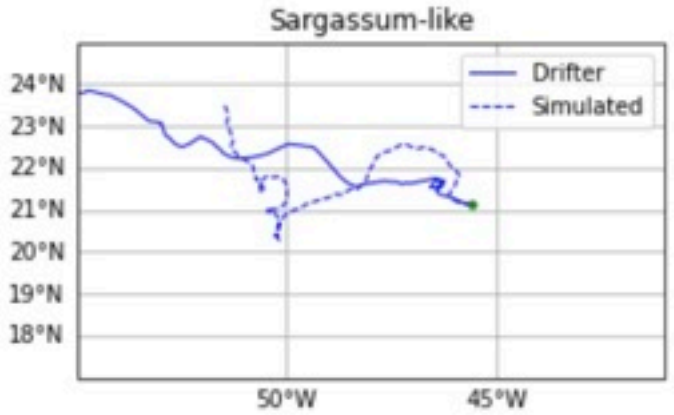


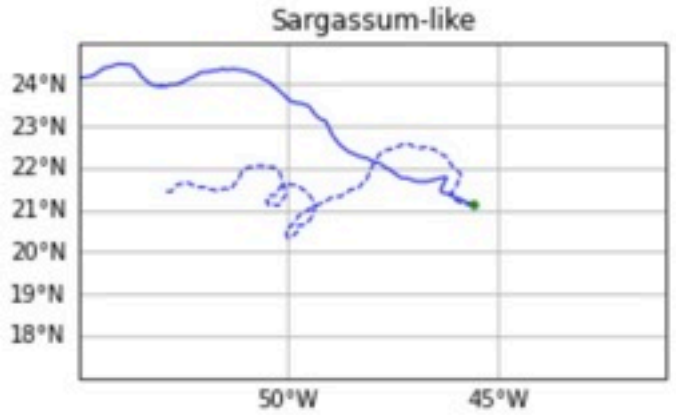


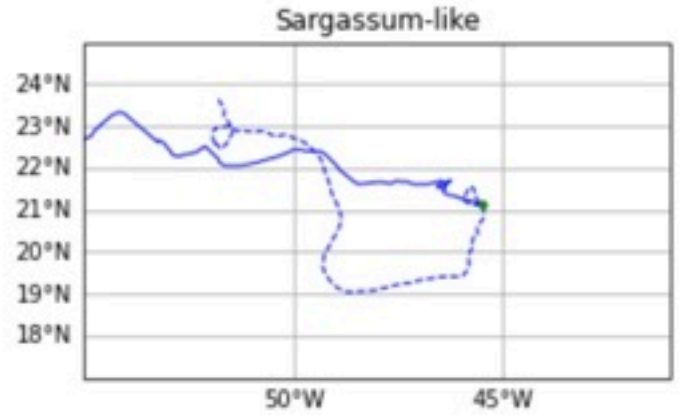
Case 1: *Sargassum* drifters

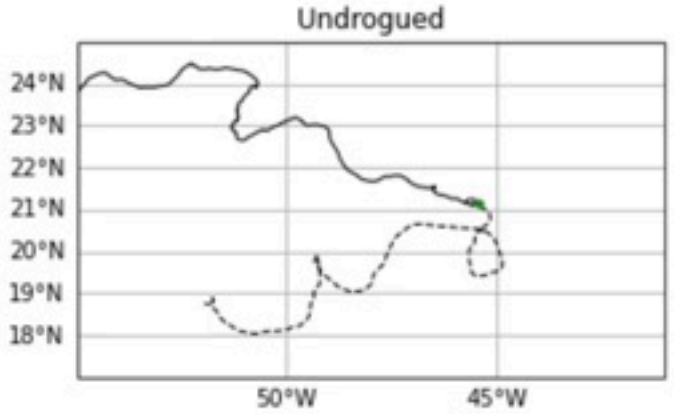
Comparison with real drifters

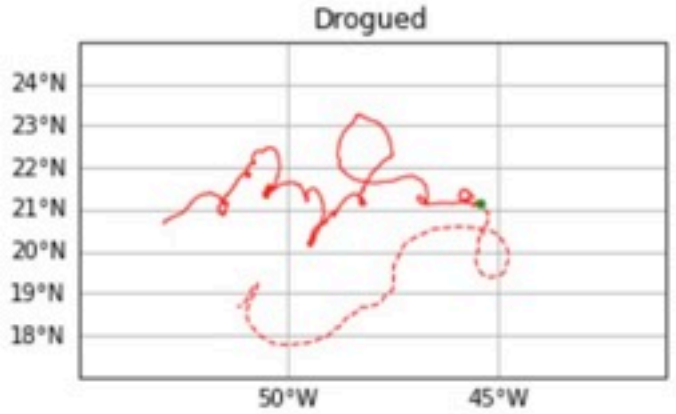
- Location d2











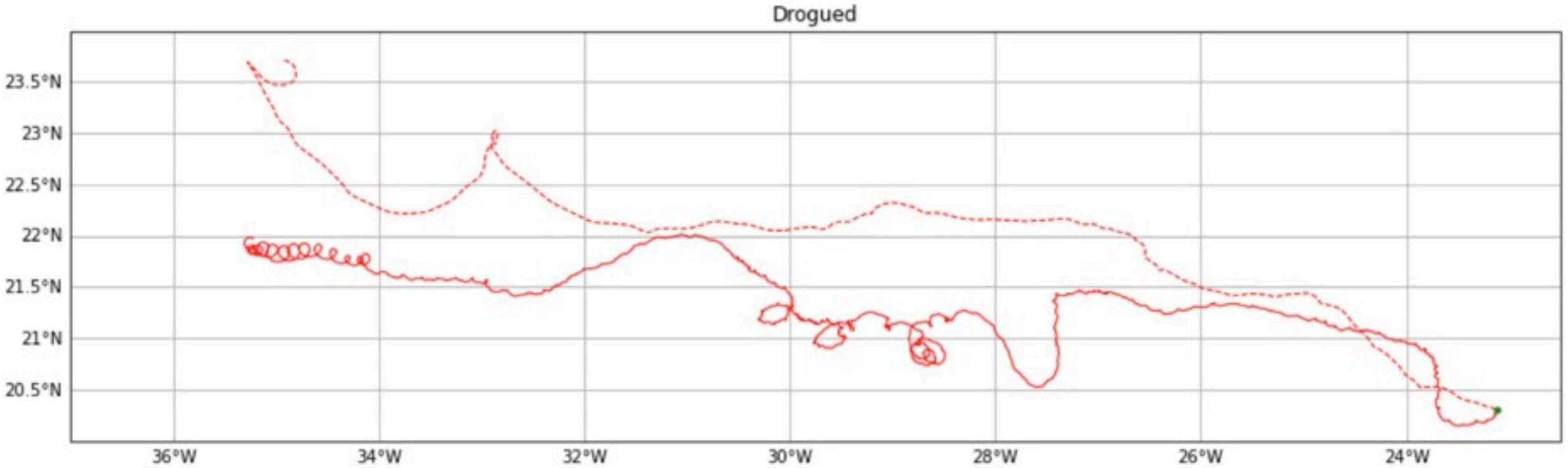
→ Westward trajectories

→ Inertial osc. start to be resolved

Case 1: *Sargassum* drifters

Comparison with real drifters

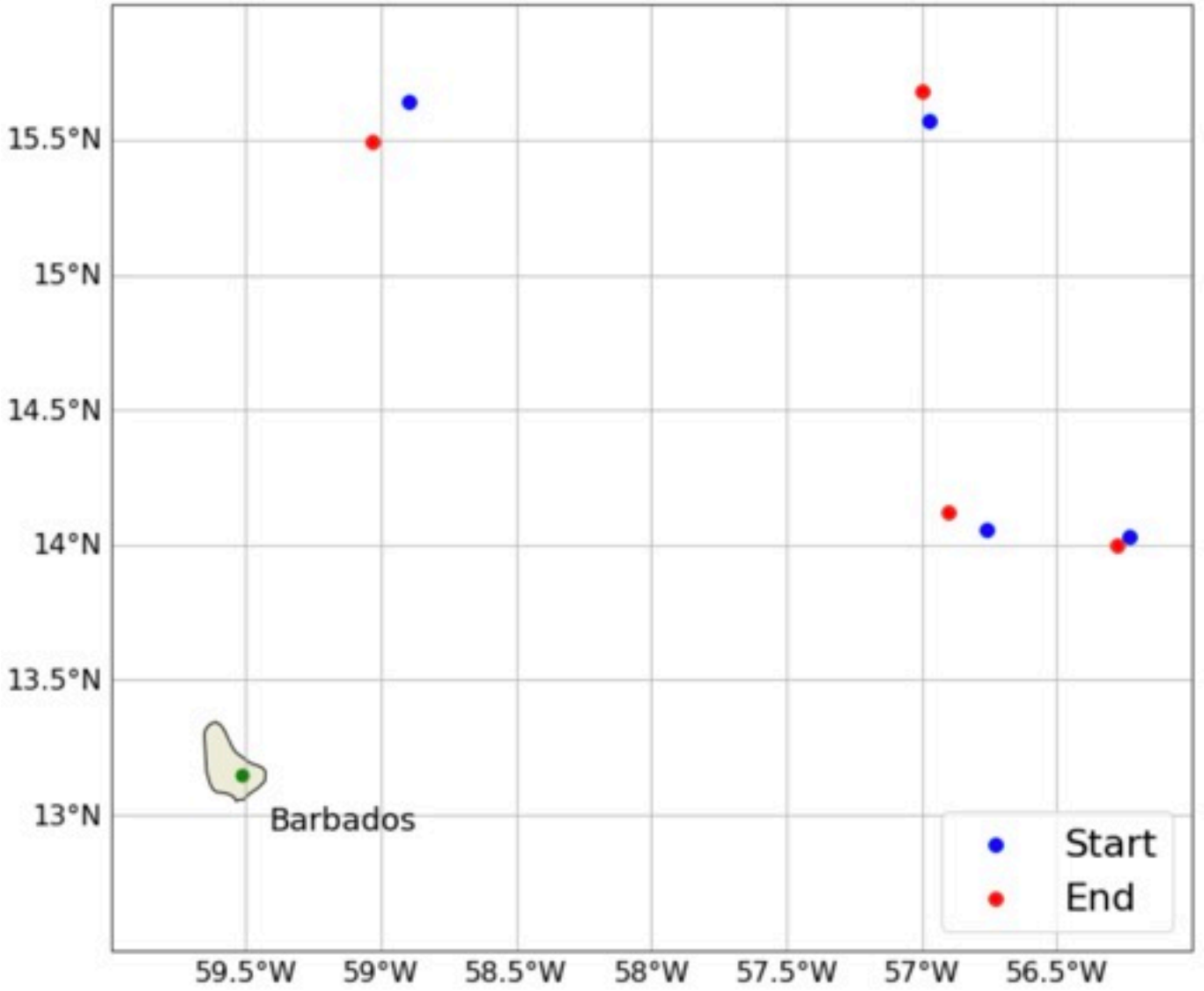
- Location d3



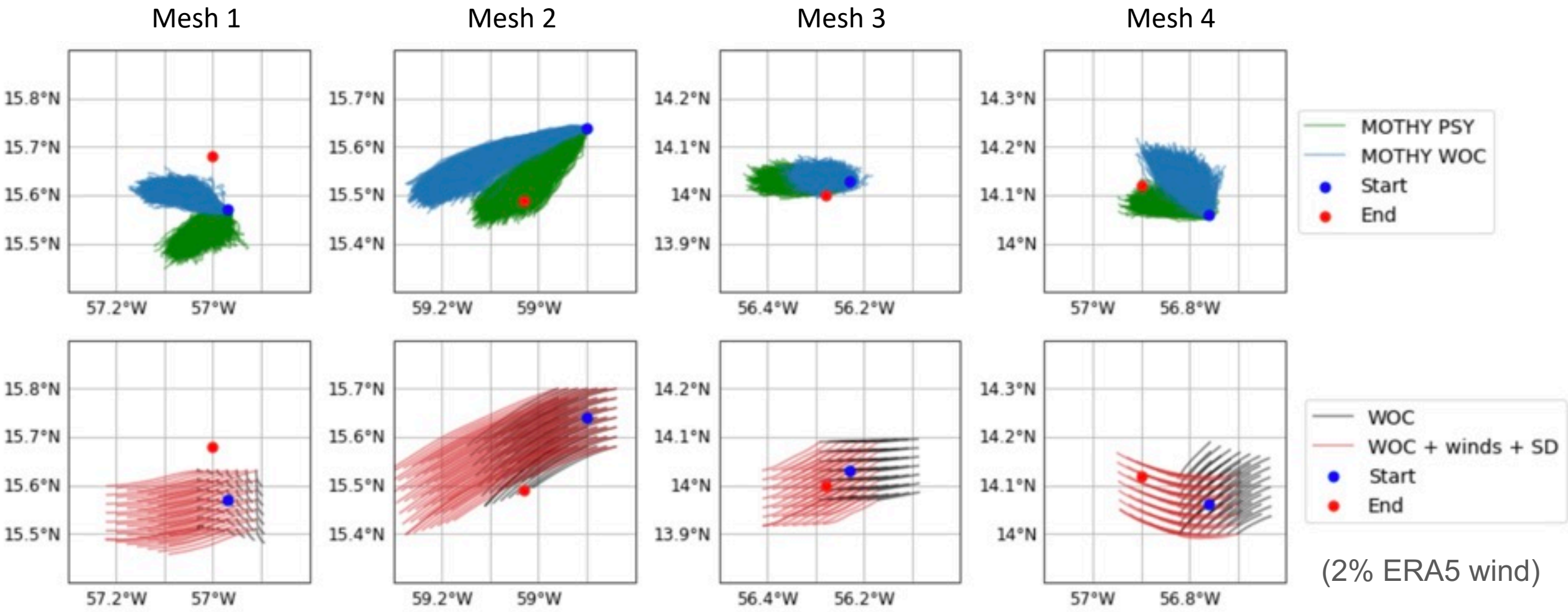
Case 2: *Sargassum* satellite images

Sargassum mats detected in satellite images by MeteoFrance and location followed for 24 hours

→ During May 2019



Case 2: *Sargassum* satellite images



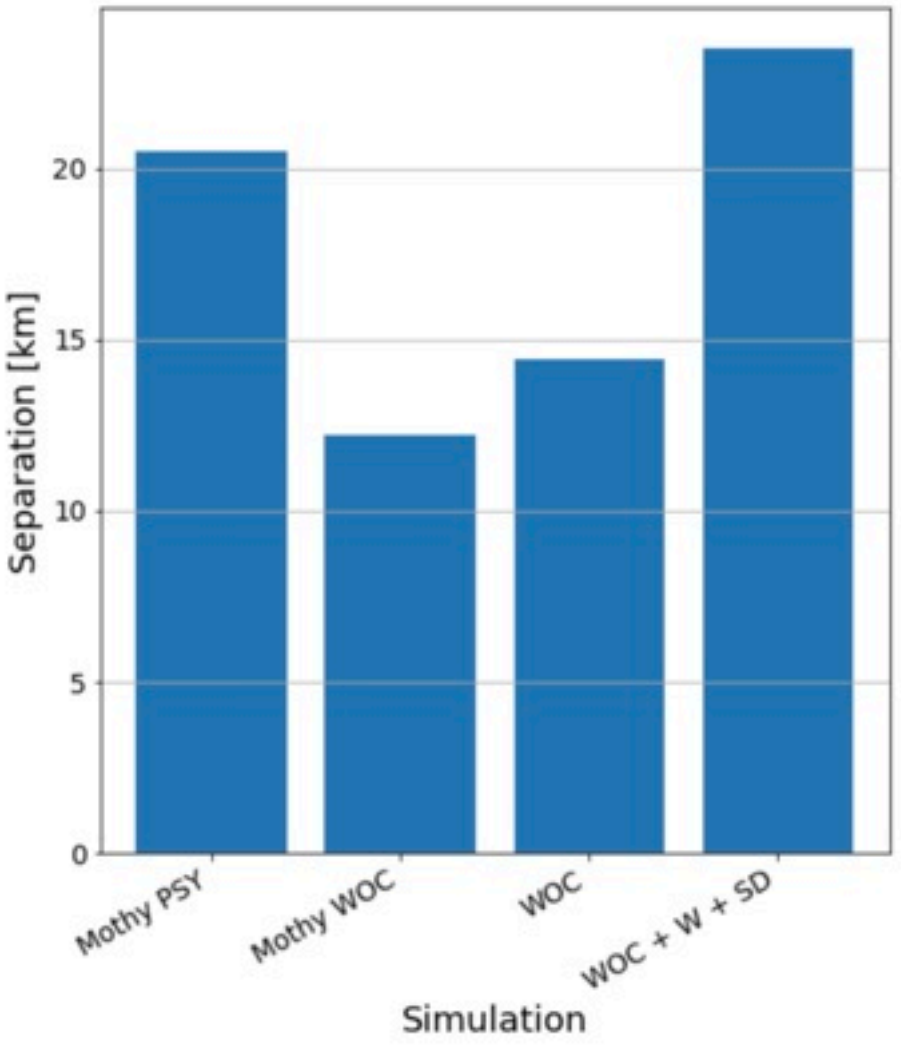
(2% ERA5 wind)

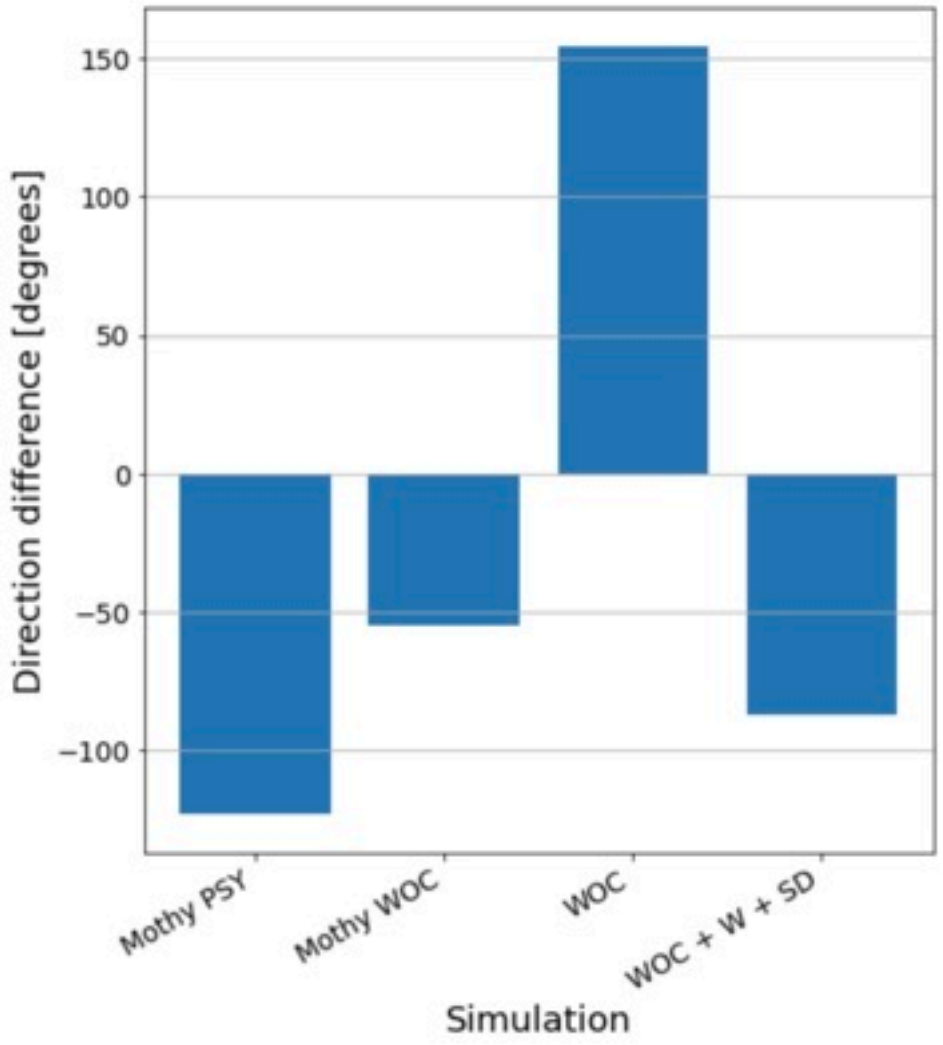
Case 2: *Sargassum* satellite images

- Mesh 1

Sep: MOTHY WOC

Angle: MOTHY WOC





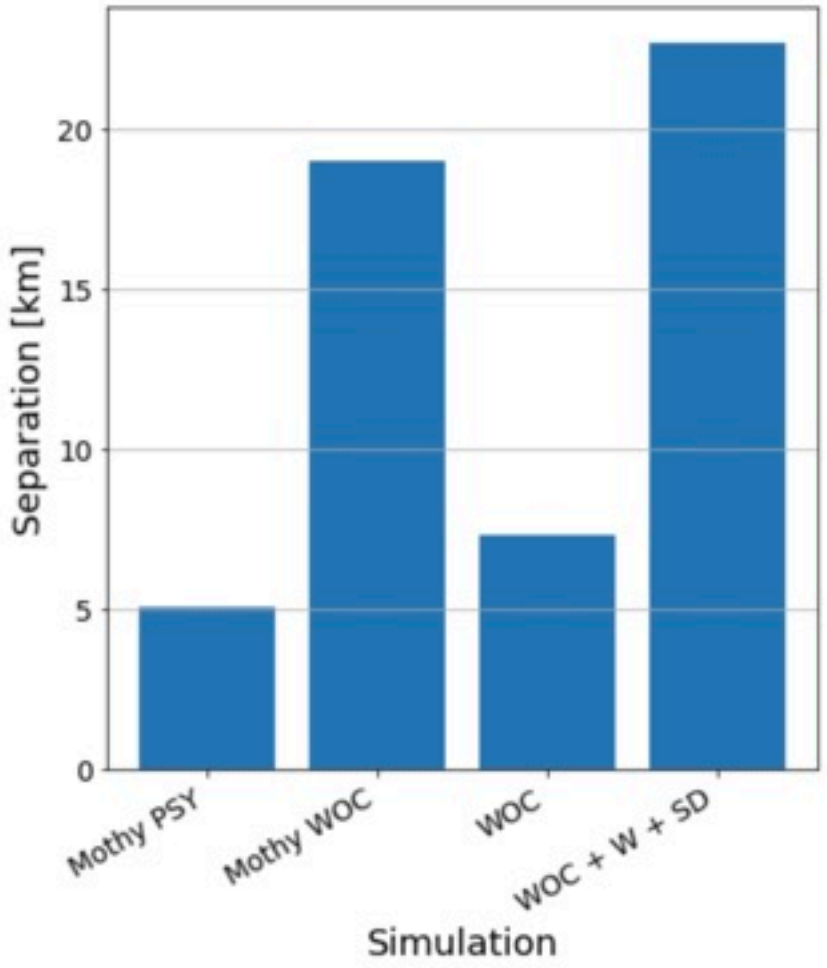
Case 2: *Sargassum* satellite images

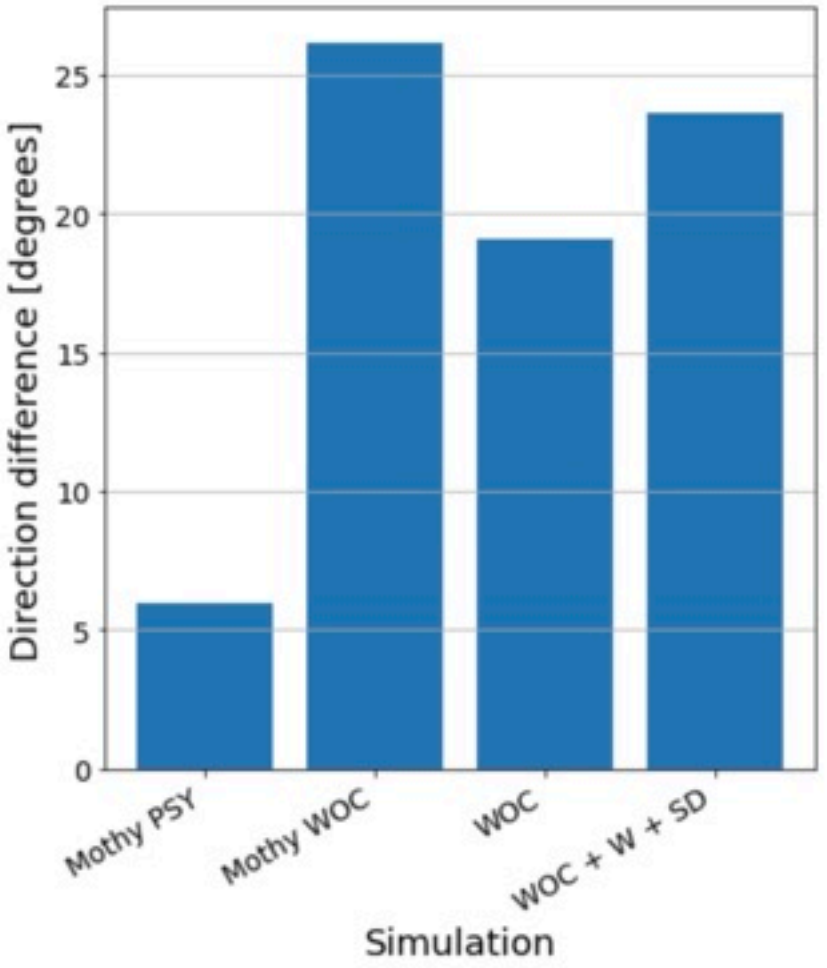
- Mesh 2

Sep: MOTHY PSY

Angle: MOTHY PSY

→ In general all work well here (<30 values)





Case 2: *Sargassum* satellite images

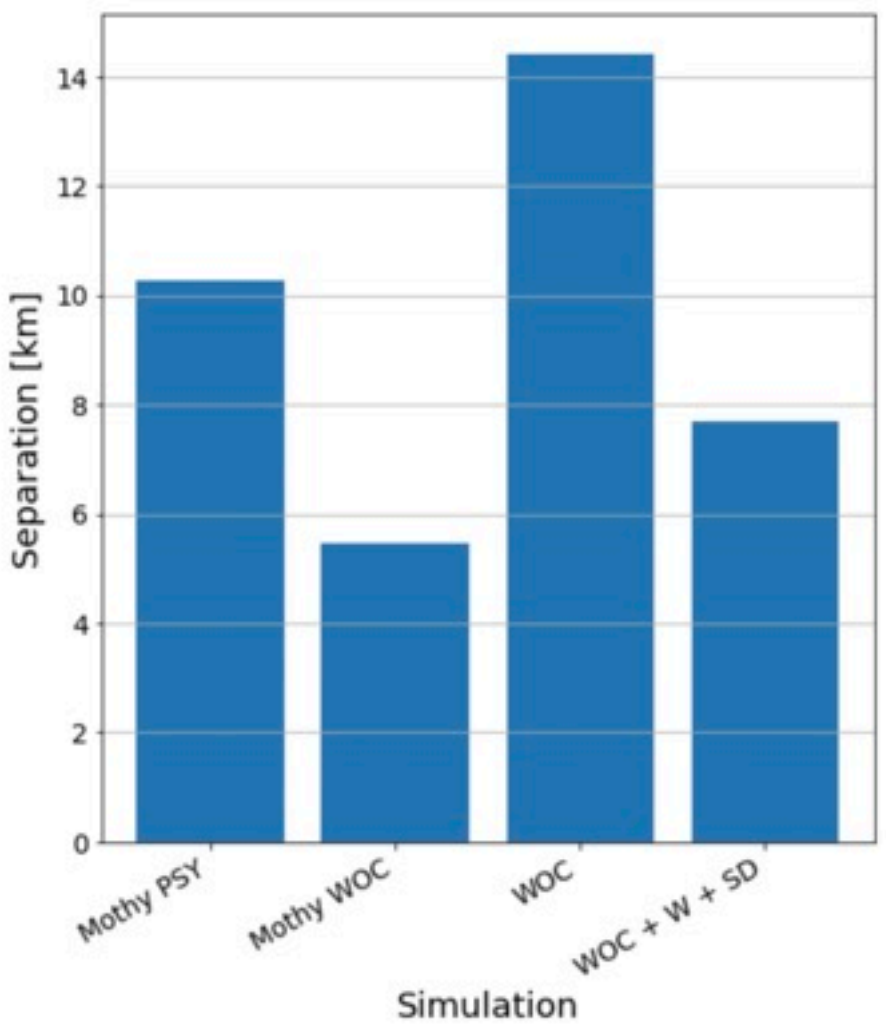
- Mesh 3

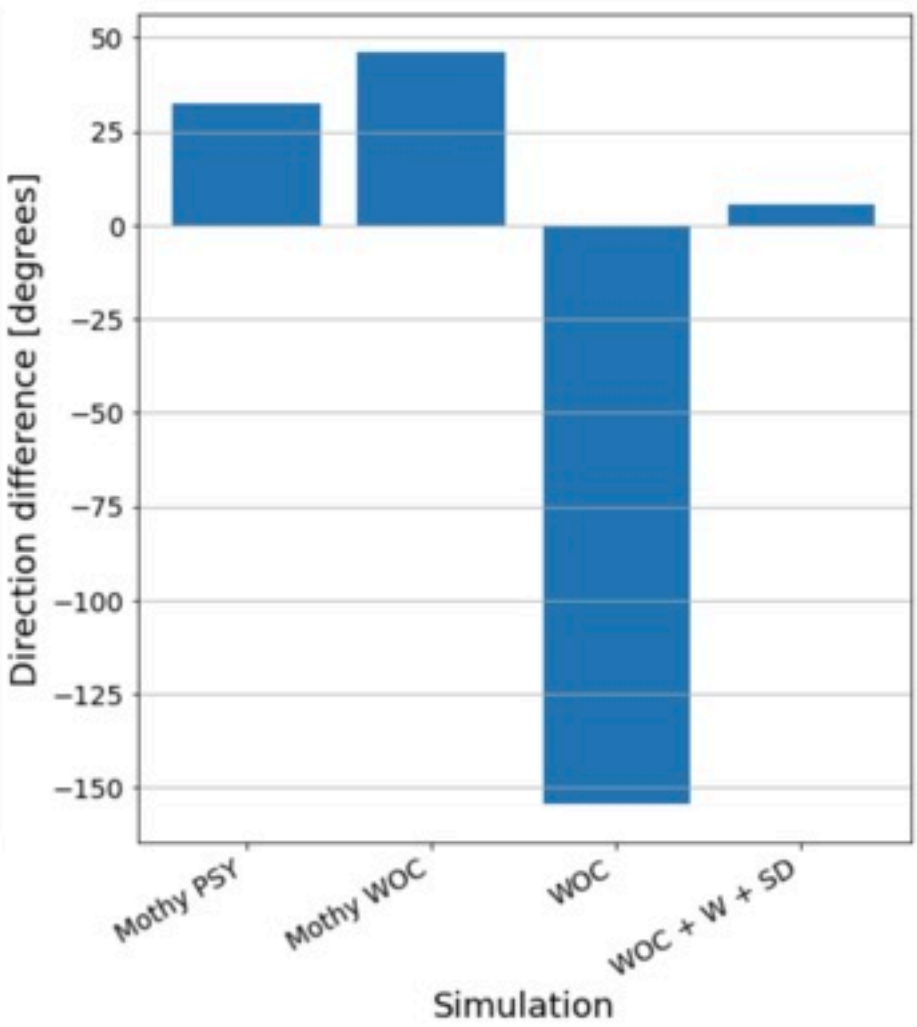
Sep: MOTHY WOC

Angle: WOC + W. + SD

→Best:

WOC + W. + SD (just a bit too far!)



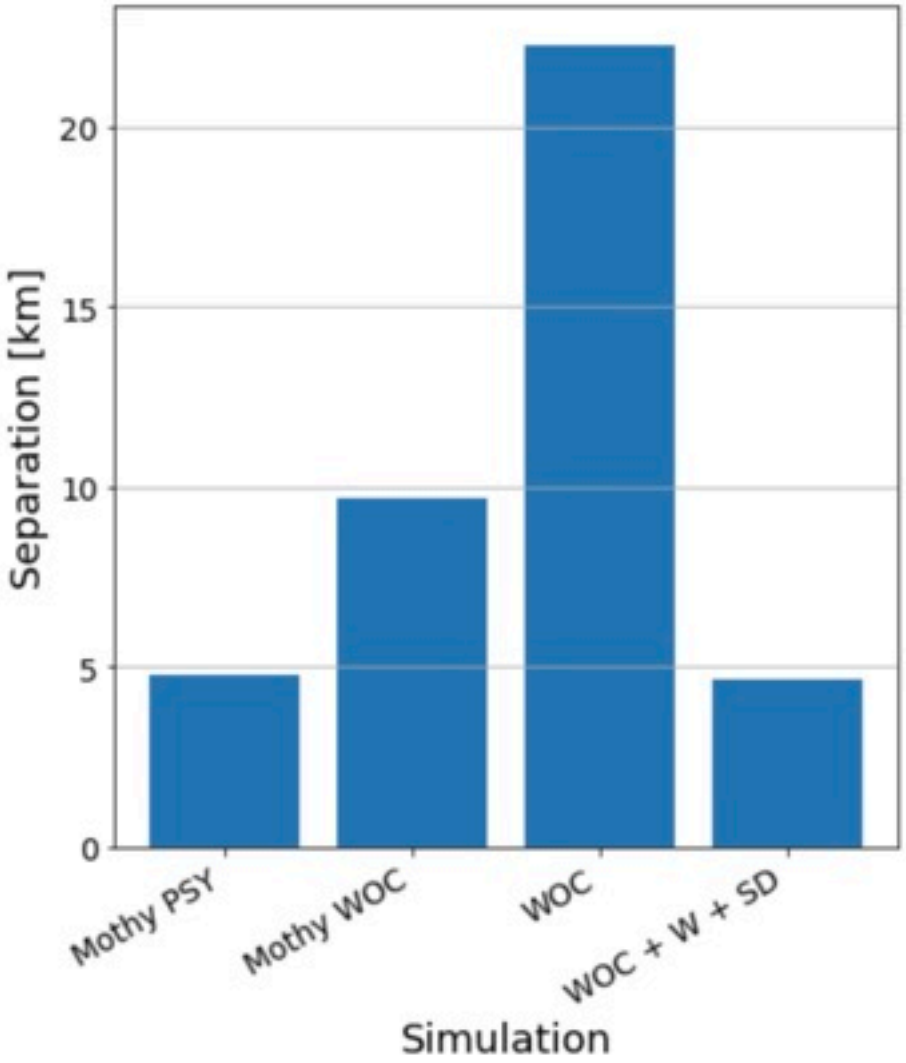


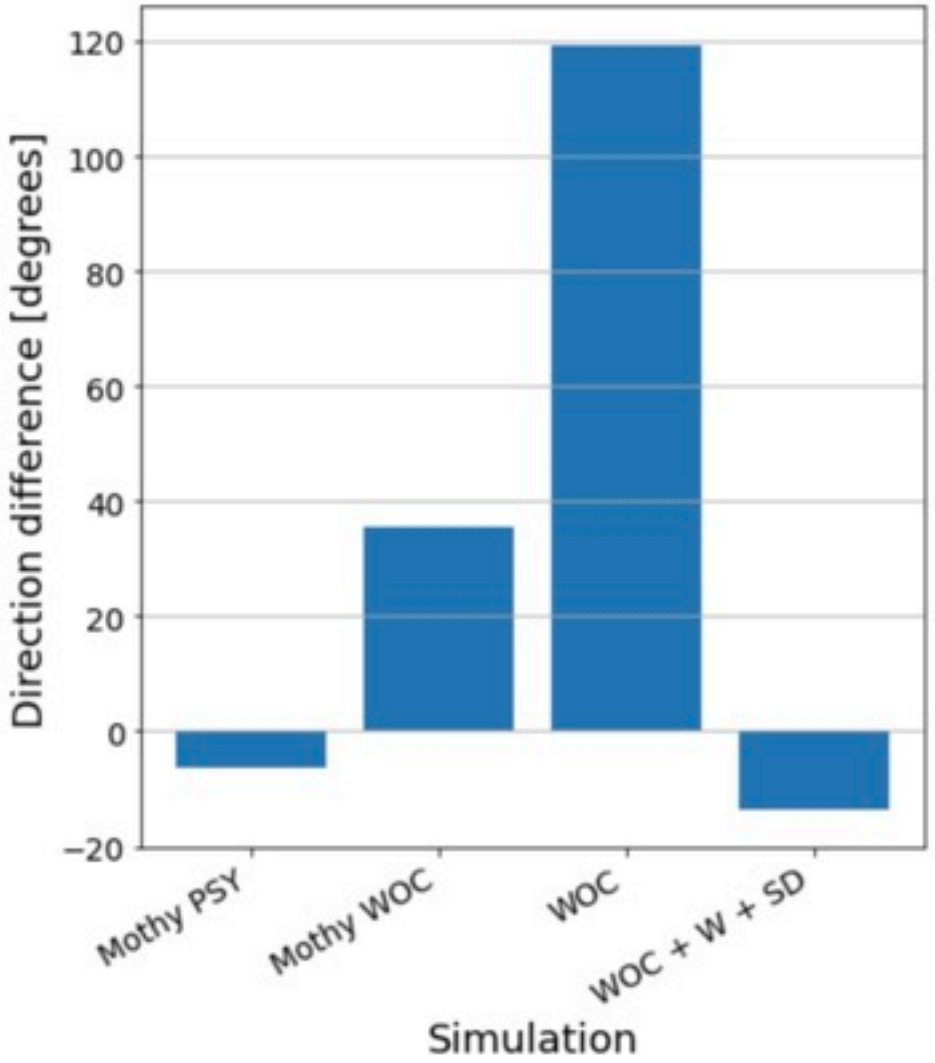
Case 2: *Sargassum* satellite images

- Mesh 4

Sep: WOC + W + SD

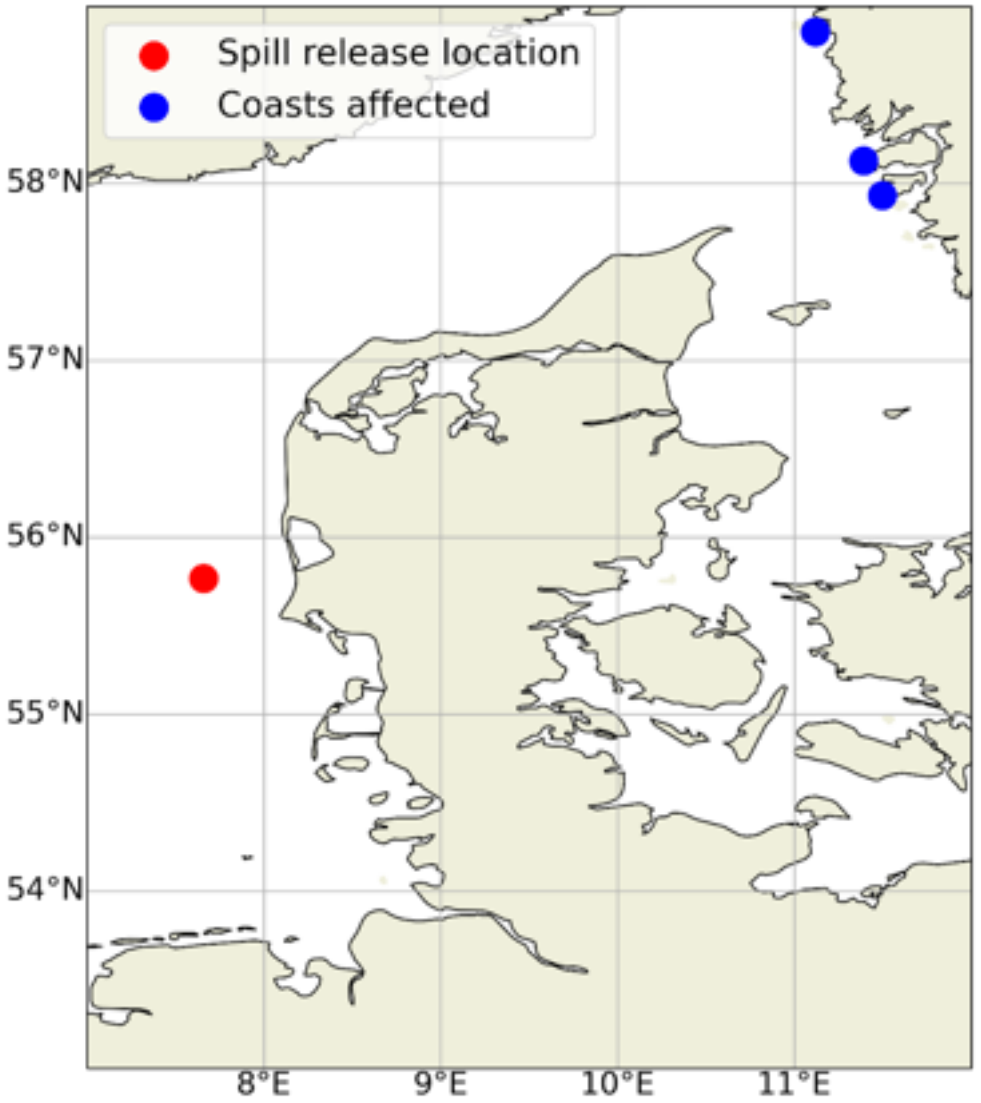
Angle: MOTHY PSY





Case 1: Golden Trader oil spill

- Incident occurred on 10/09/2011, west coast of Denmark, ~40km SW of Ringkobing Fjord.
- Collision with a fishing vessel.
- Substance spilt was bunker fuel (IFO), Swedish coast impacted. (Swedish island Tjörn and to the north)



Case 1: Golden Trader oil spill

Landing days

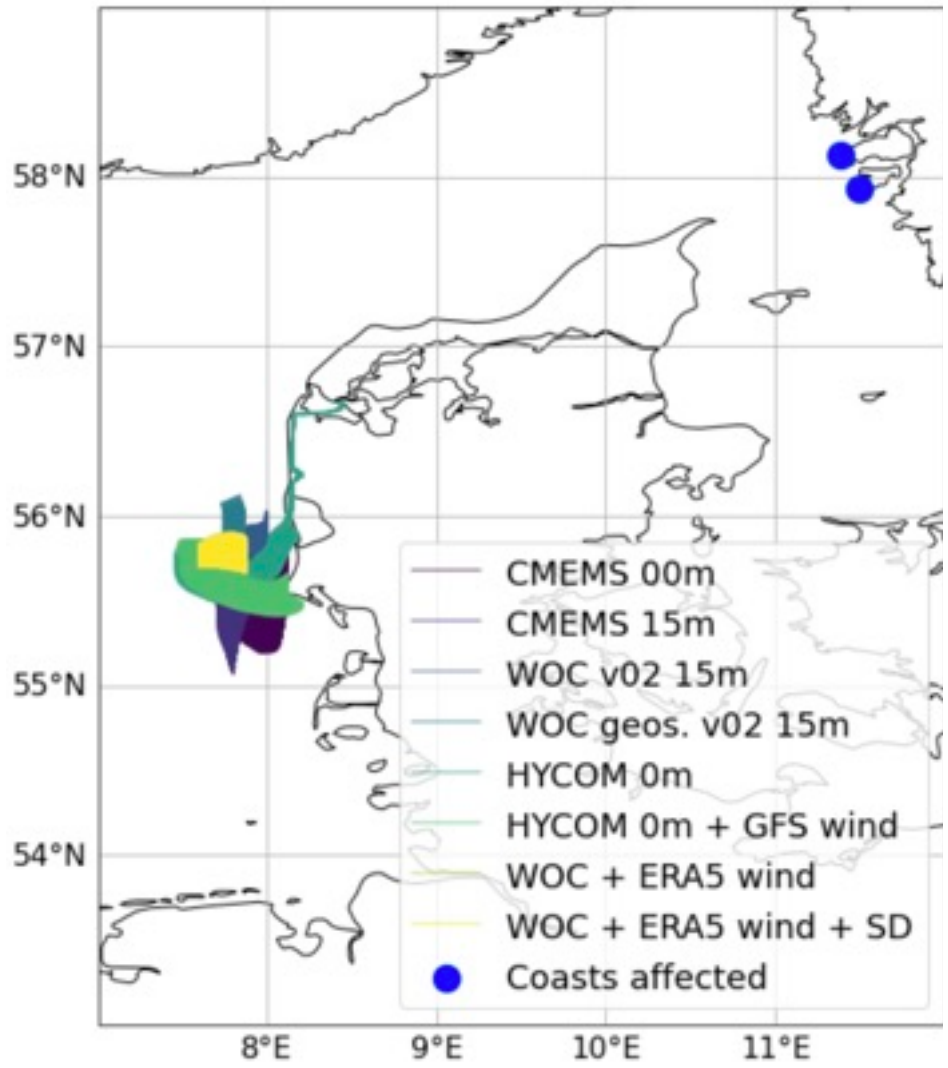
Left: first landing (16/09/11)

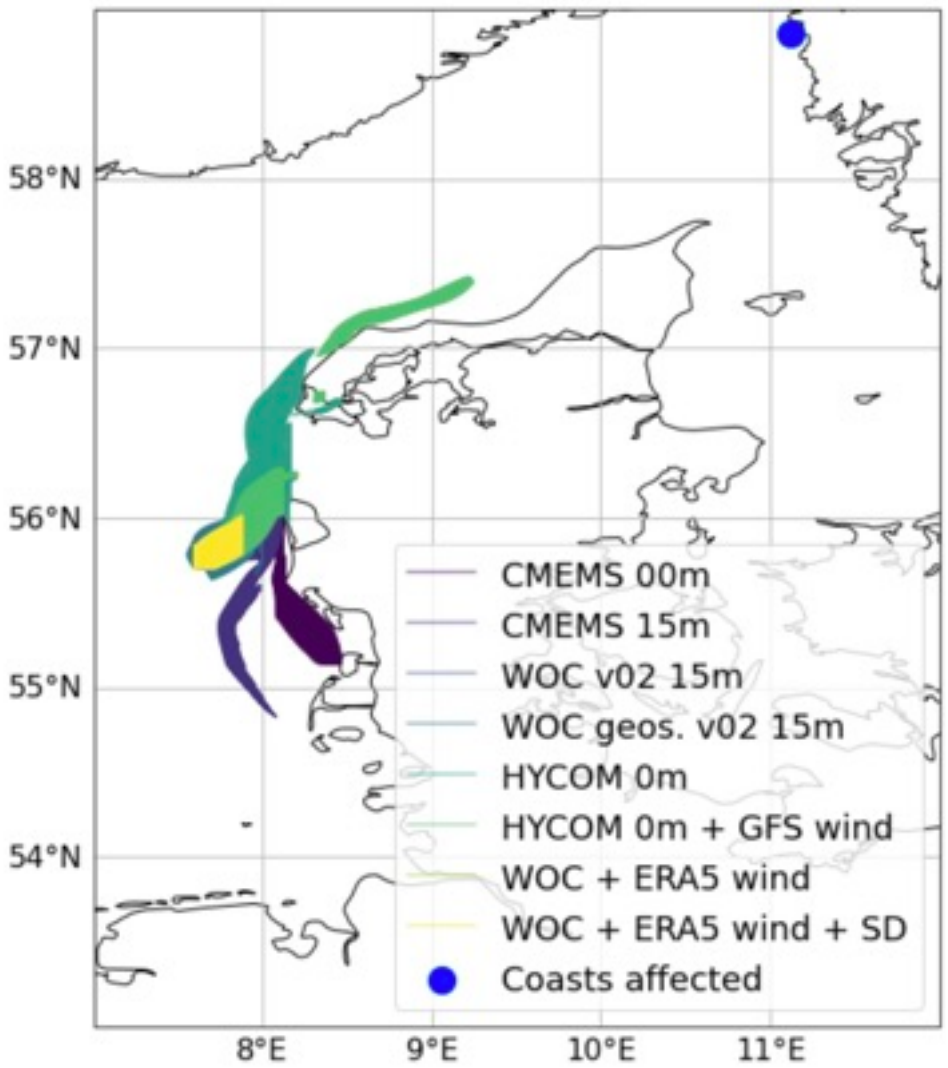
Right: second landing (21/09/11)

→Coastal currents missing

→Case were wind makes things worse!

→CMEMS southward





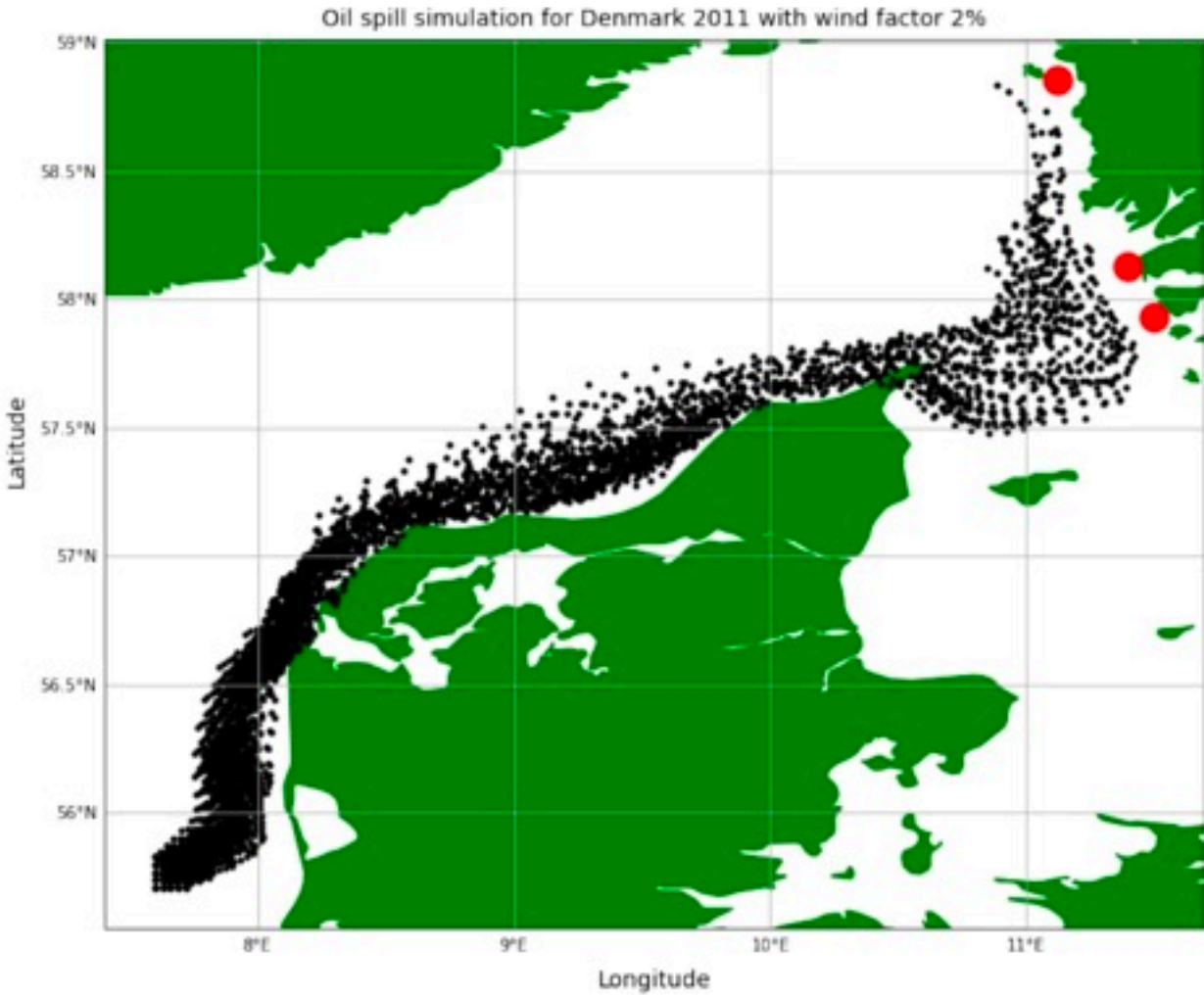
Case 1: Golden Trader oil spill

Results from Joey Richardson's MSc project

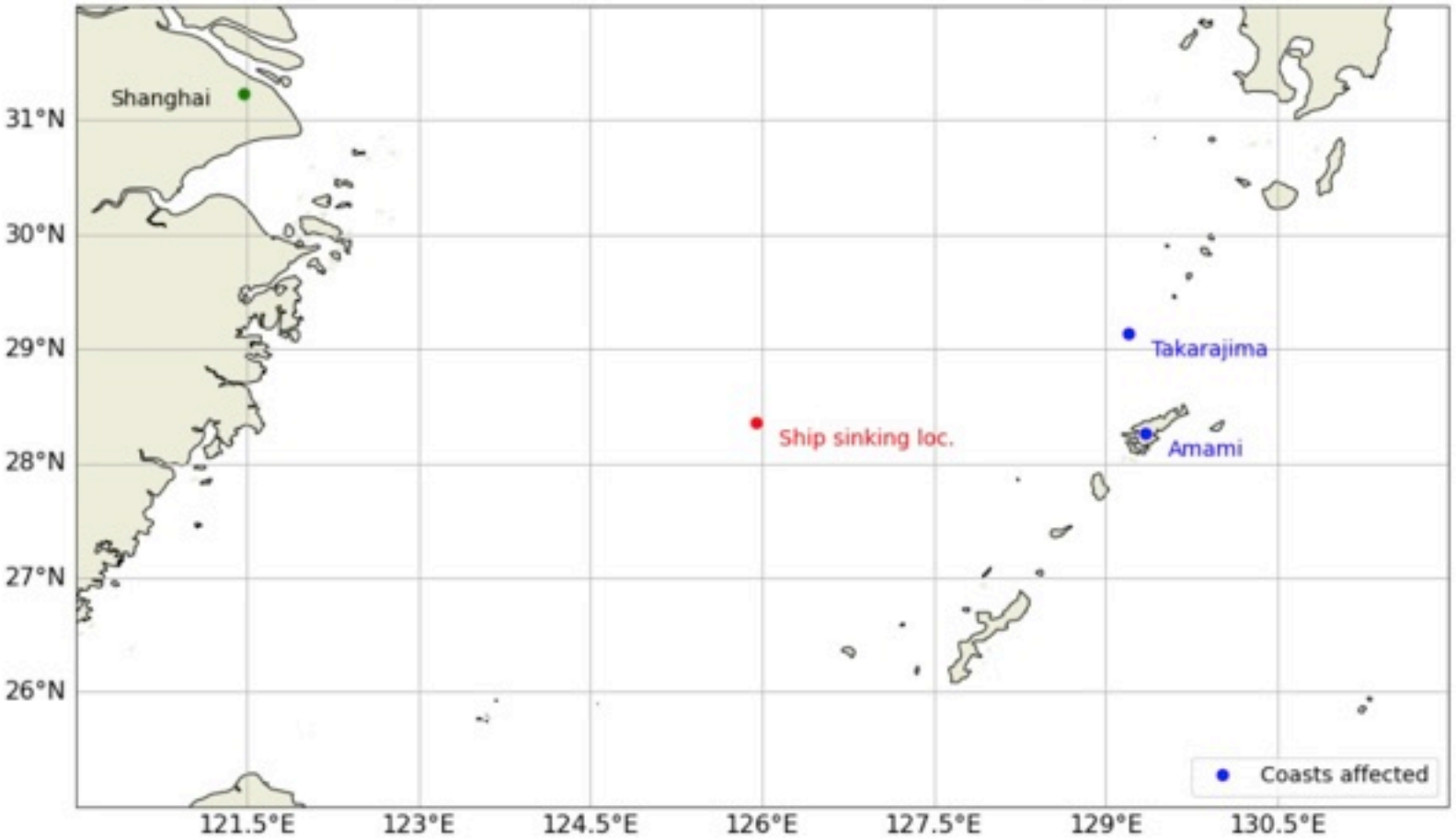
- Advected with
  - Currents: MOi (1/12˚, daily)

([NEMO Global 1/12° Analysis & Forecast](#))

  - Winds: ERA5 (31km, hourly)
    - 2% windage
- Simulation length: 14 days
- Weathering processes
  - Evaporation
  - Emulsification
  - Spreading



Case 2: Sanchi oil spill

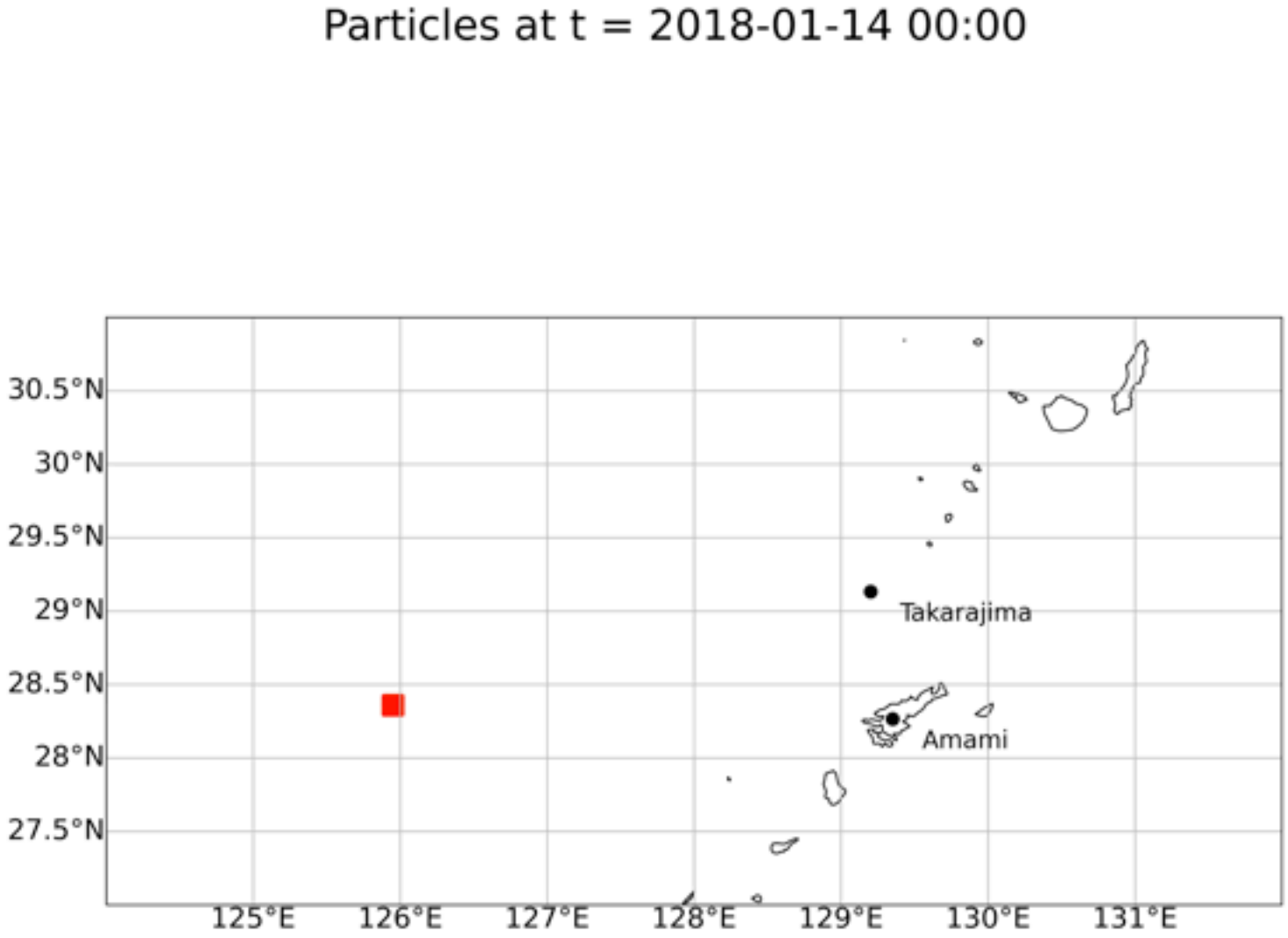


- Incident occurred on 14/01/2018, at East China Sea.
- Collision of oil tanker (Sanchi) with a cargo ship.
- HFO was spilled and affected several islands (Takarajima on ~28/01/2018 and Amami ~01/02/2018).

Case 2: Sanchi oil spill

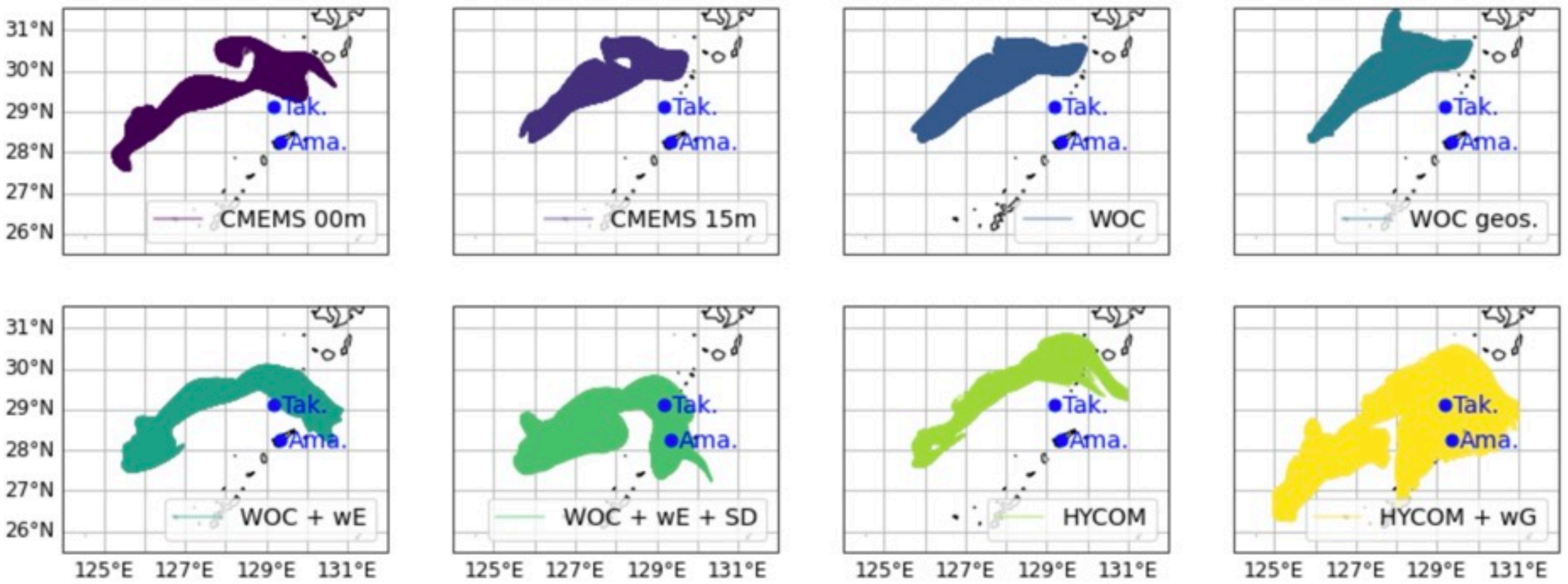
Simulation characteristics

- Advected with:
  - WOC currents
  - ERA5 winds (2%)
  - WOC Stokes drift
- Continuous release for first 10 days
- Mesh of particles released around sinking location



Case 2: Sanchi oil spill

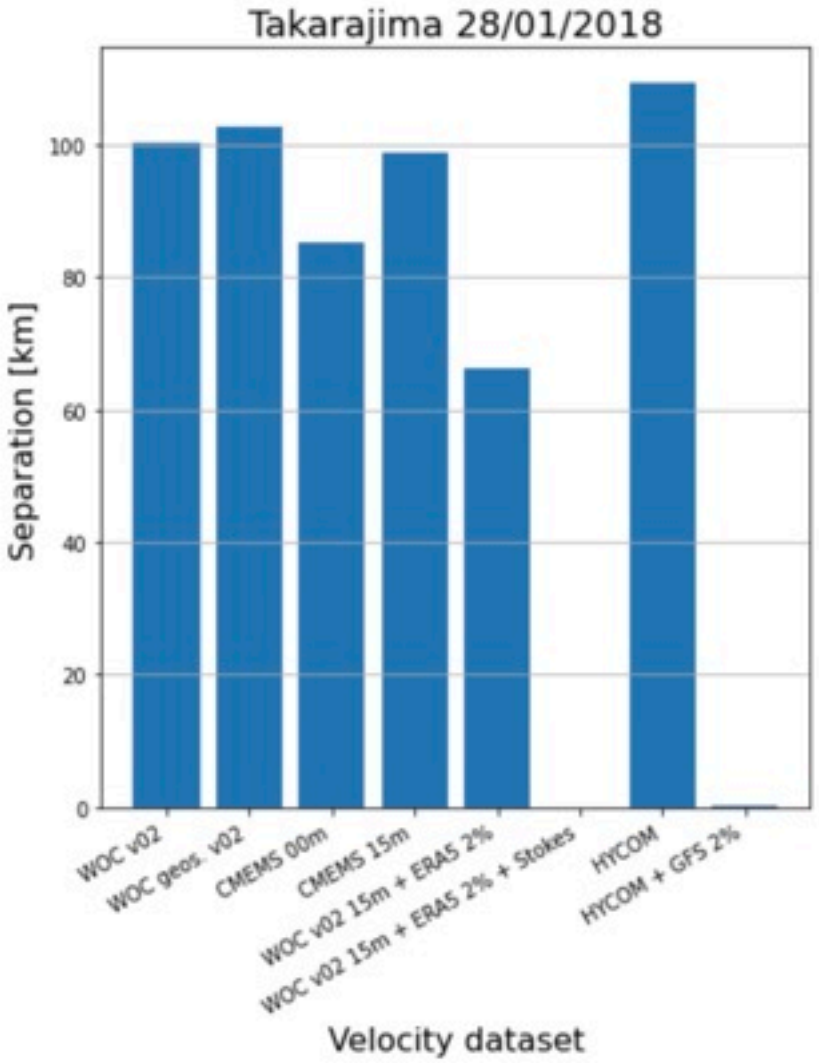
Simulation outputs (full trajectories)

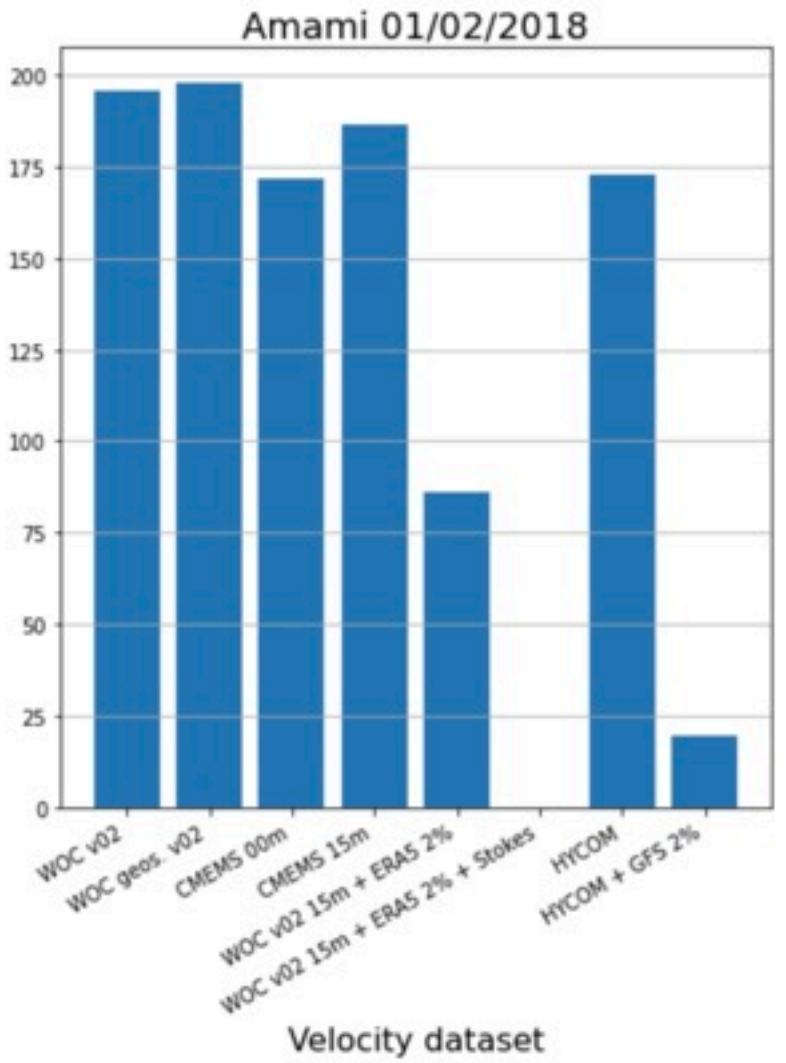


Case 2: Sanchi oil spill

Distance to landings

→ Best results from:
WOC currents + 2%
ERA5 wind + WOC
Stokes drift





Conclusions

Sargassum

- Case 1: Improvement with inertial oscillations → impact of small-scale features on long trajectories still present (as expected)

- Case 2: Very short trajectories → some better simulated with WOC

Oil spills

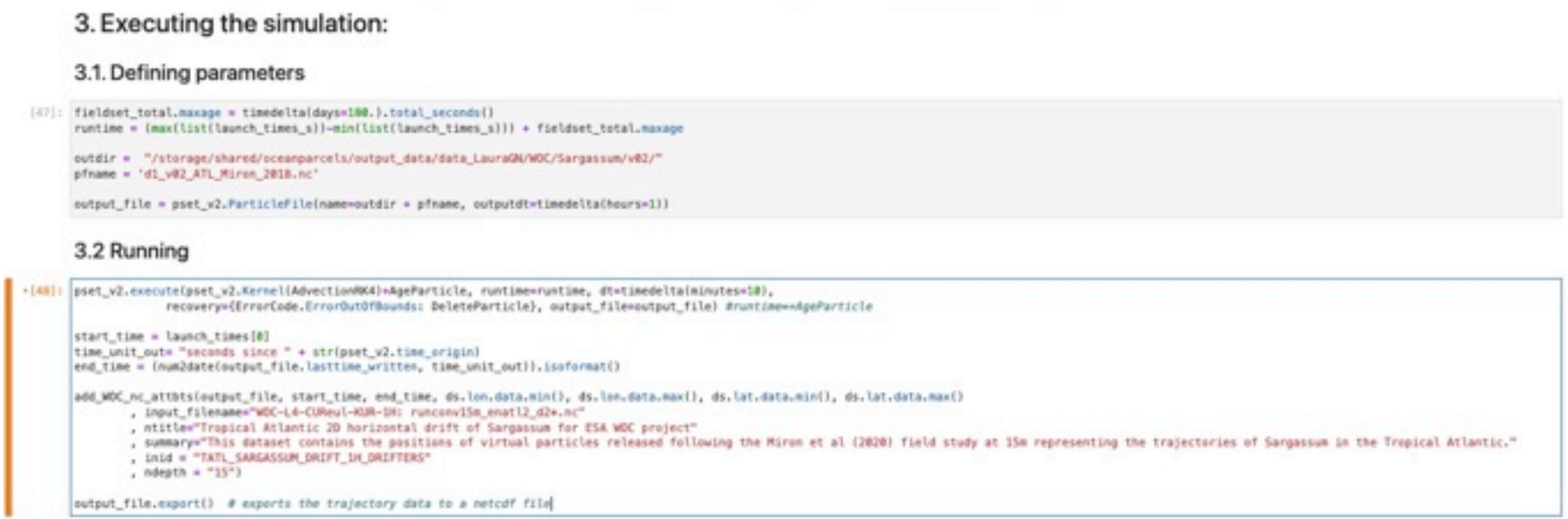
- Case 1: To coastal to properly simulate it

- Case 2: WOC data with wind drift and Stokes drift provides very good results!

Perspectives

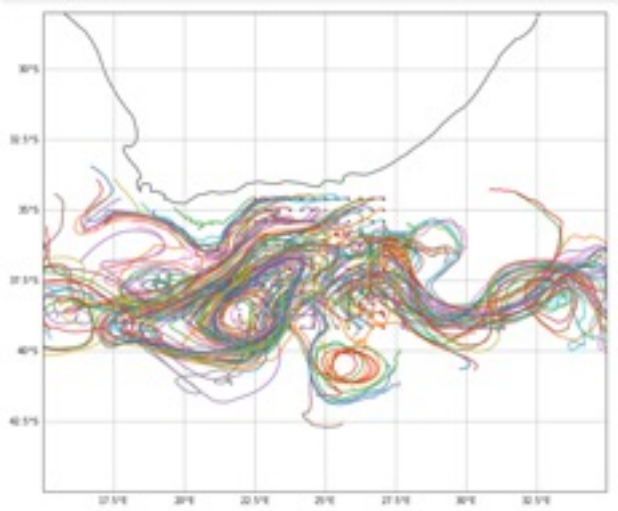
On-going

- Test with **ERA* wind** product
- New ***Sargassum* case** around Puerto Rico based on data from Putman *et al* (2020)
- **Algorithm** for *Sargassum* and oil spill simulations with OceanParcels
  → jupyter notebook example with different processes available



Perspectives

- Gathering of **more data** → greater availability of satellite images? More *in situ* data?
- Explore more cases in the **open Ocean** e.g. oil spill near the Açores Islands
- Better satellite-derived products **nearshore** → new satellite missions e.g. SWOT? SAR?
- Put together **Lagrangian diagnostics toolbox**! Started with Siren Rühs, the Parcels team, Mike Hart-Davis, others?



Main challenges

- **Availability of data** for validation
- Representation of **small-scale structures** e.g. submesoscale eddies
- Resolving trajectories **nearshore** → for landing/beaching predictions or backtracking applications
- Application to **forecasts** of *Sargassum* and oil spills (near real time)

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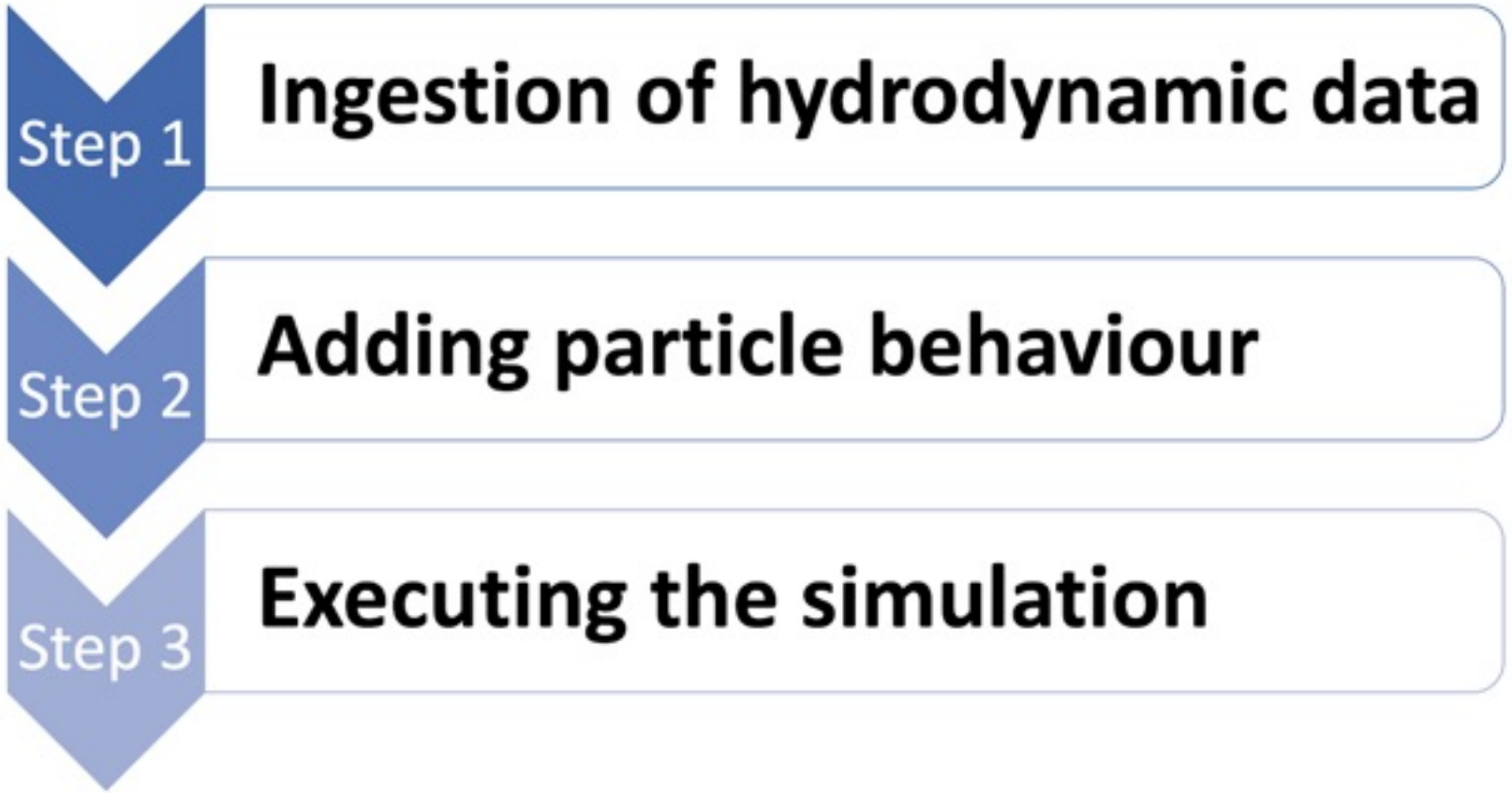
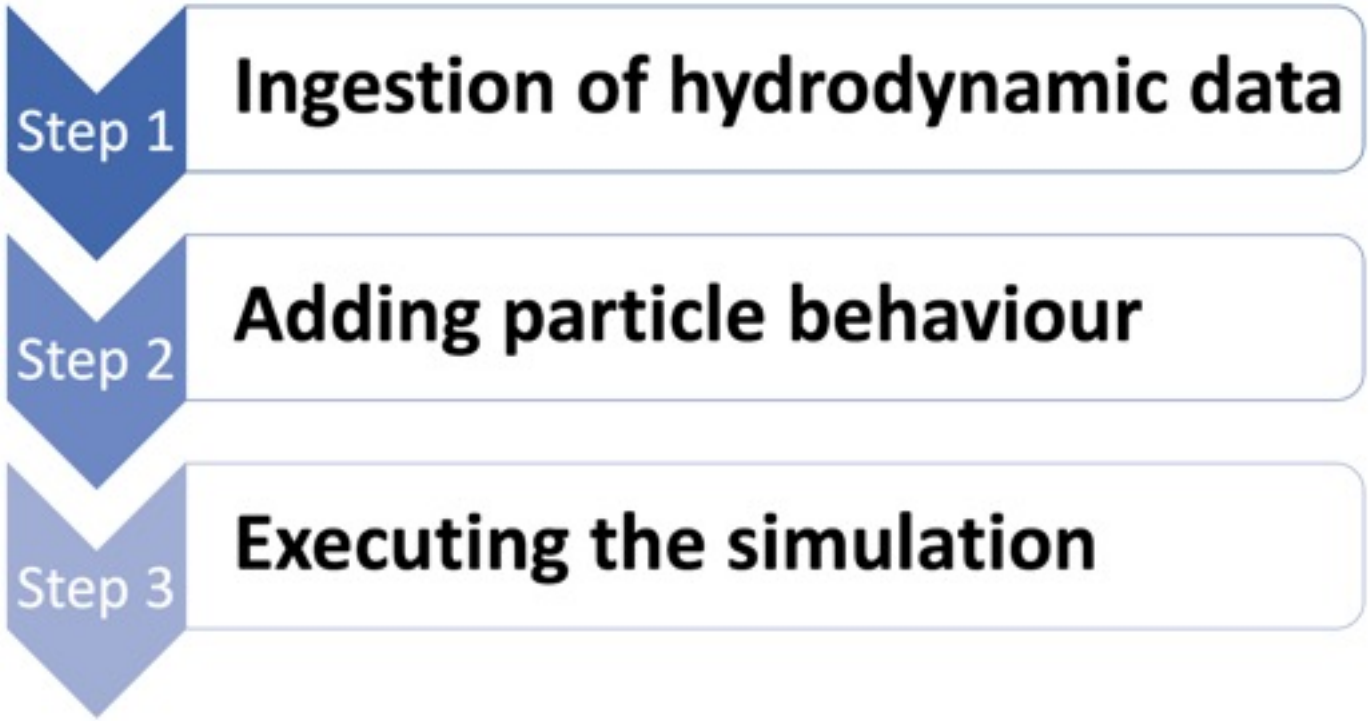
l.gomeznavarro@uu.nl

Steps



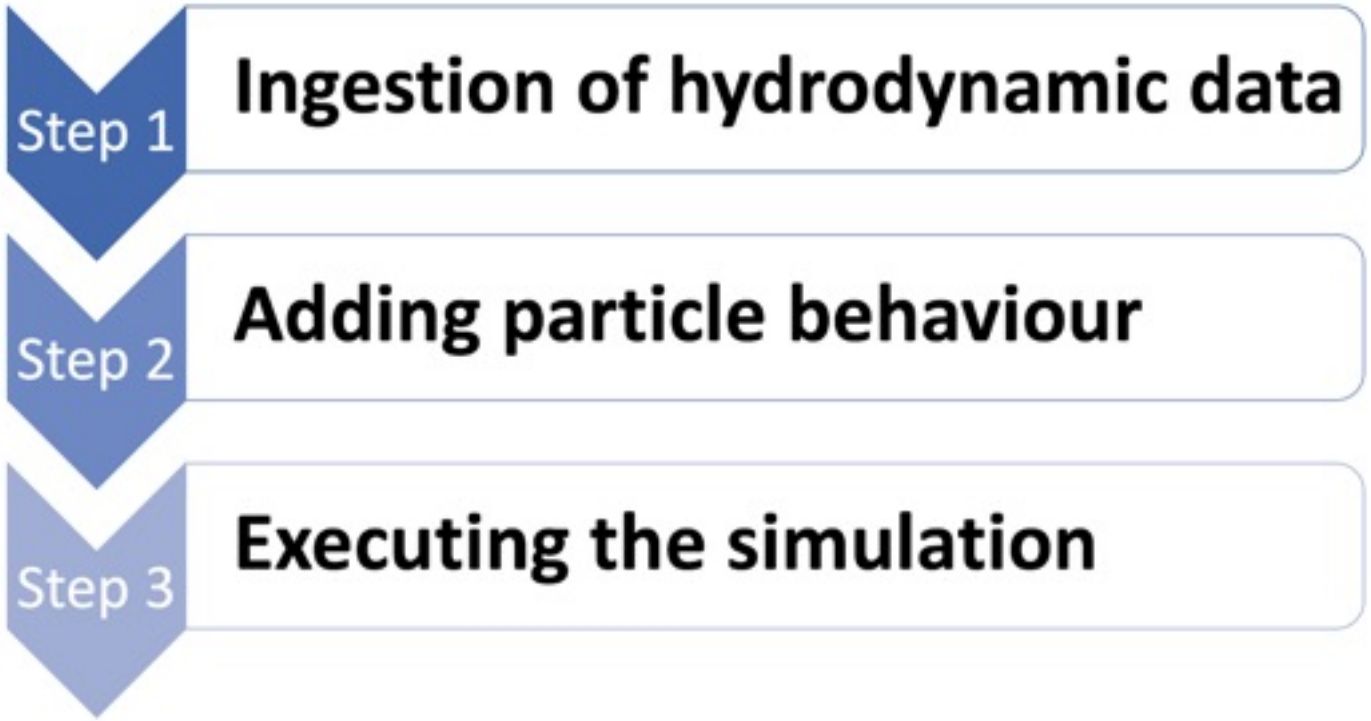
Steps



1)

- Software uses the velocity fields to advect particles and simulate their trajectories.
- The velocity fields used are a combination of satellite and drifter data.
- Tropical and North Atlantic regions during 2018 and 2011, respectively.
- The data has a spatial resolution of 1/5°, an hourly temporal resolution and is available at depths of 0 and 15m.

Steps



2)

- Velocity fields include geostrophic currents, inertial oscillations, Ekman and Stokes as a total component.
- First version: we assume particles follow the total velocity (no specific particle behaviour kernels)

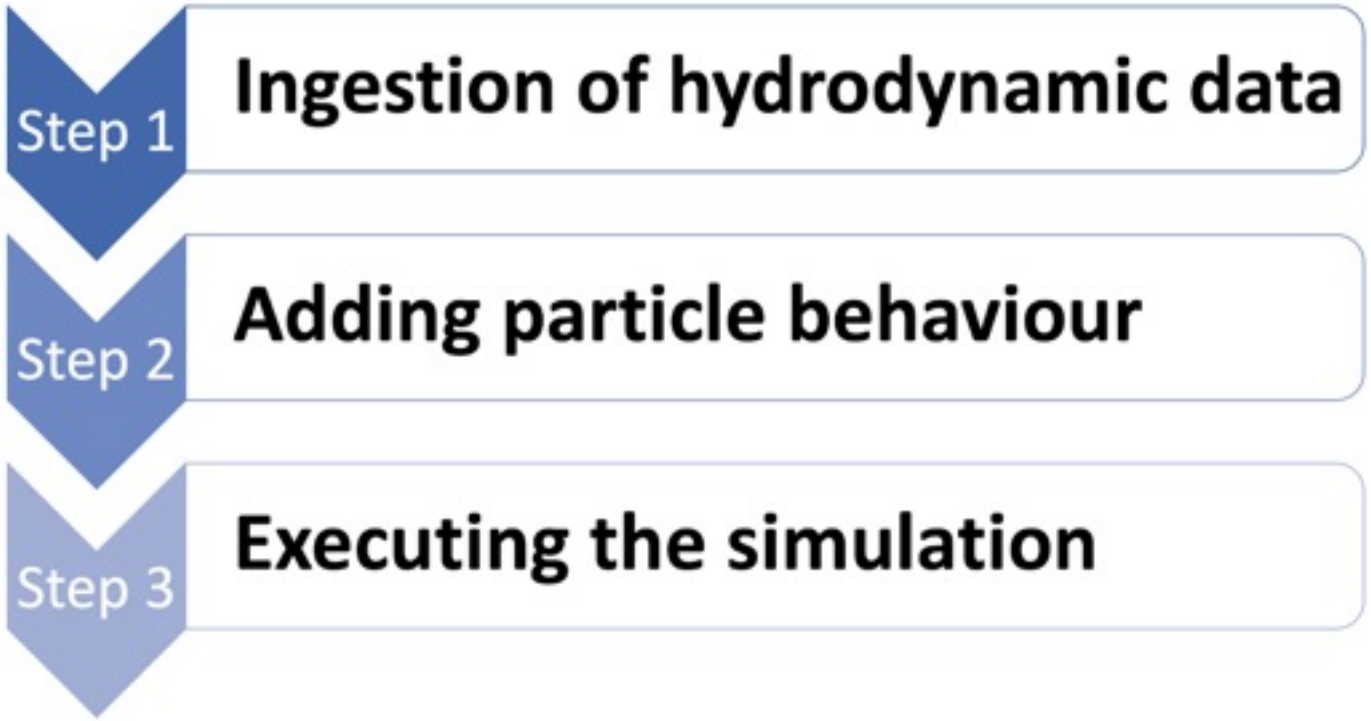
→ first analyses to identify **where/how** improvements needed

- Main kernel: **horizontal advection** (4^{th} order Runge-Kutta)
- Other kernels:

  - Delete particles outside domain

  - Age of particles (drifter-like) release

Steps



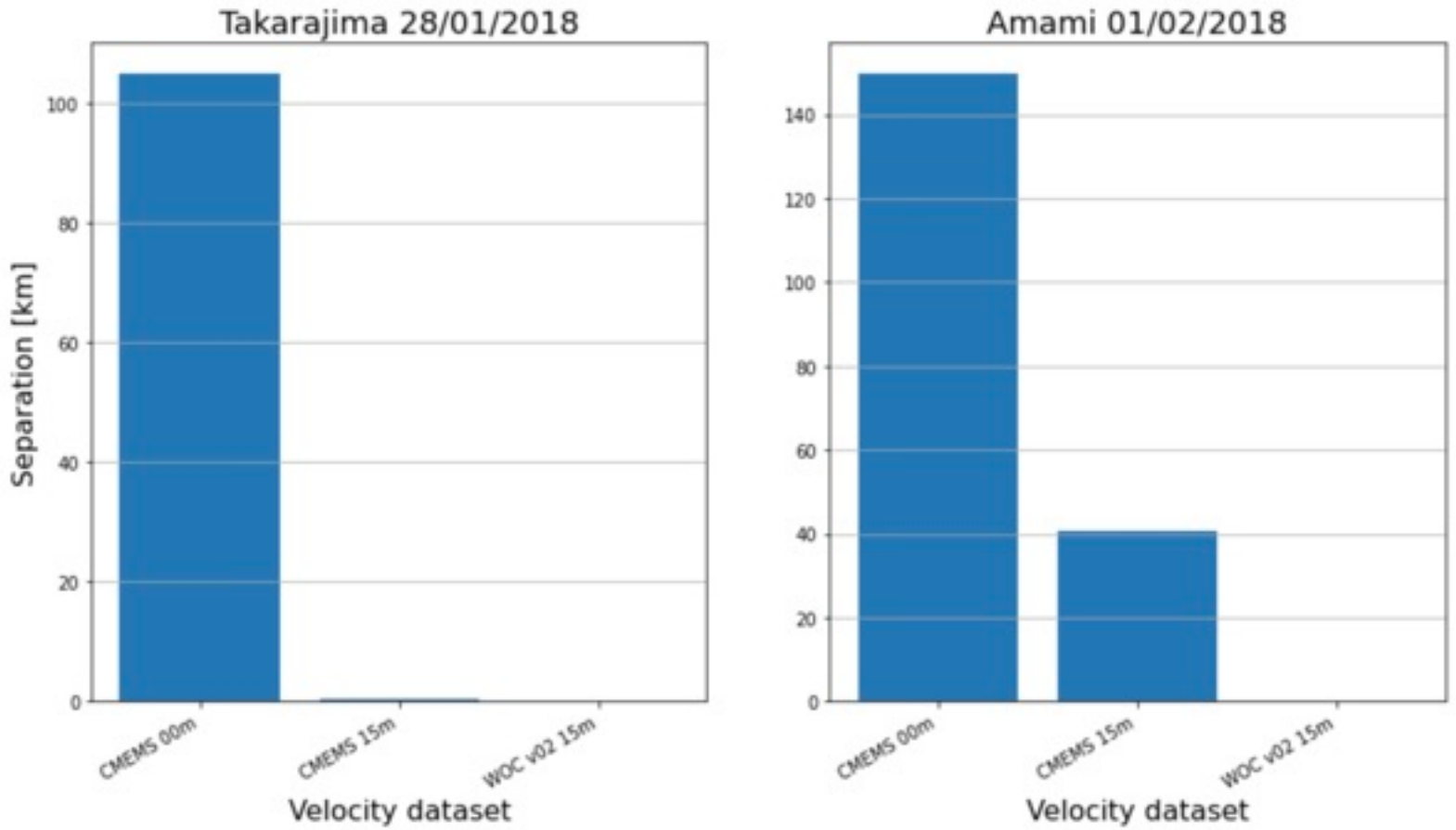
3)

- Run parameters
- Timestep: 10 minutes (small enough no grid cells skipped)
- Repeat dt : 3 hours (cont. oil spill)
- Output timestep: 1 hour
- Integration time : 180 and 14 days (Sargassum and oil spills)

- Adding formatting to netCDF (e.g. project-required attributes)

Additional material

Sanchi comparison with CMEMS with winds and Stokes



Additional material

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Case 1: Golden Trader oil spill

<u>Simulation characteristics:</u>

- Dfd
- Df
- D
- **ANIMATION**

Case 1: Golden Trader oil spill

Comp with the other datasets!

- **add in my presentation that for golden trader noaa data —> The winds make the trajectories worse here!**