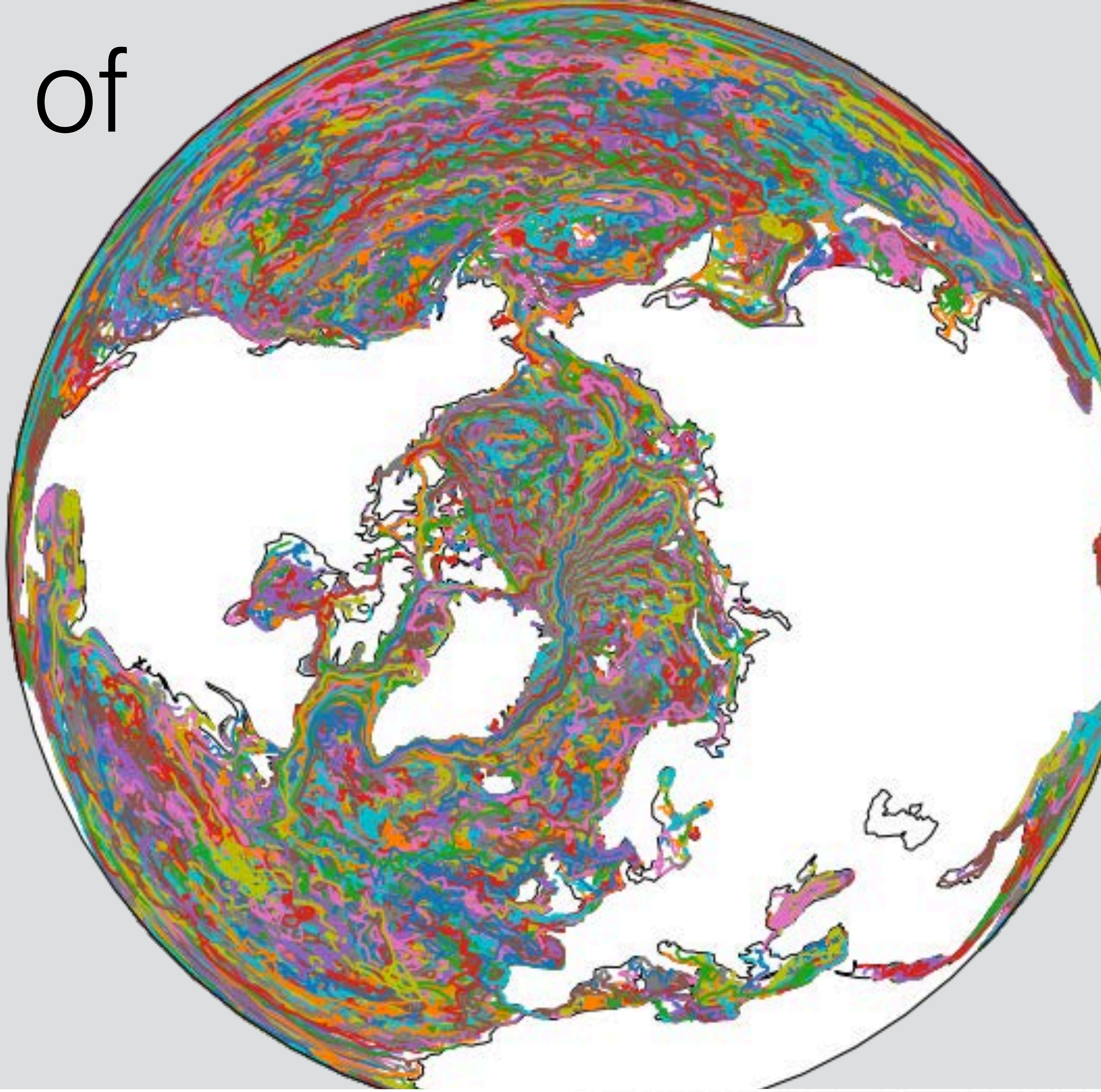
Simulating the transport of floating marine litter across scales



Erik van Sebille
and the topios.org and oceanparcels.org teams

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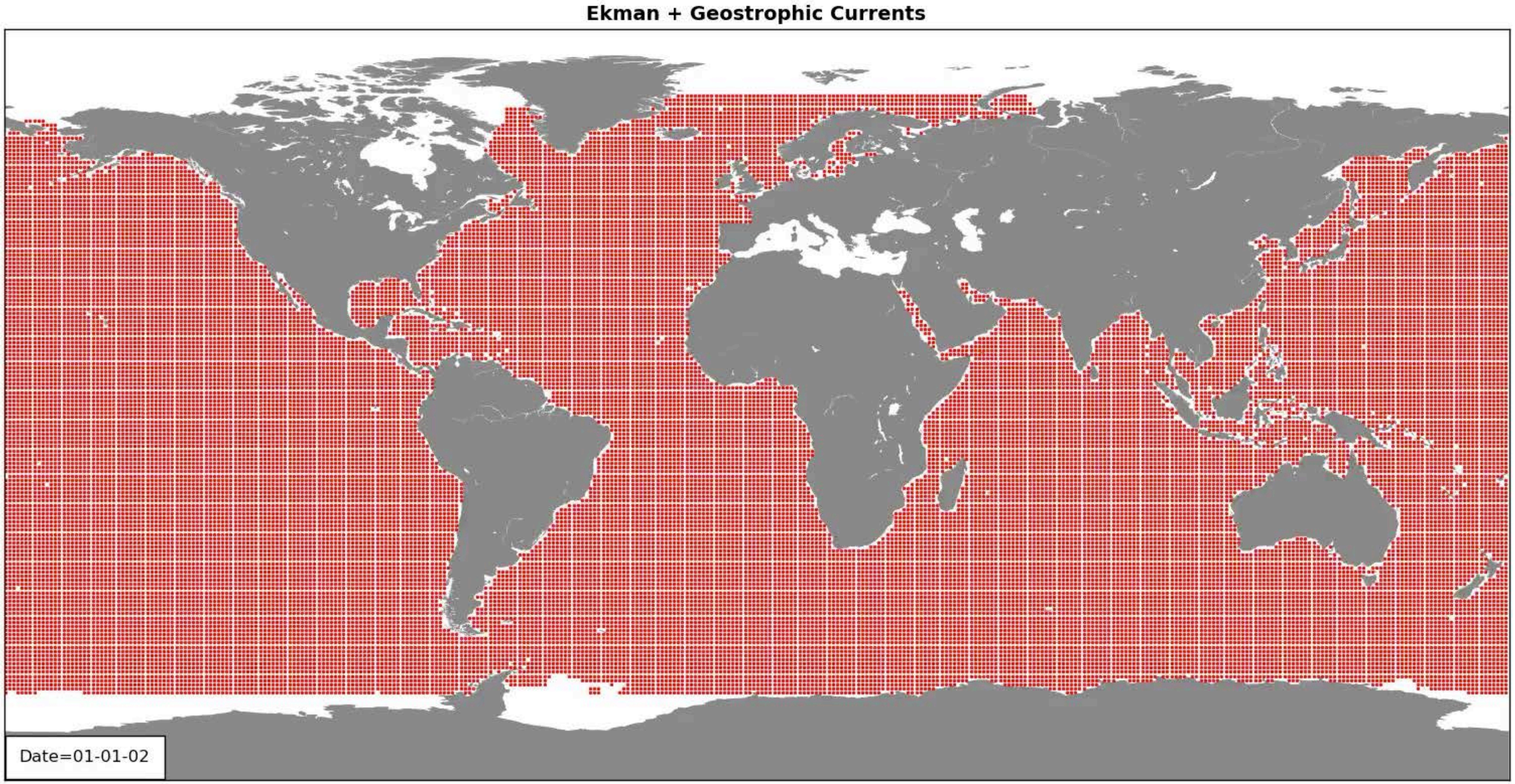
Simulating surface transport on a global scale with GlobCurrent



Onink, Wichmann, Delandmeter & Van Sebille (2019) *Journal of Geophysical Research*

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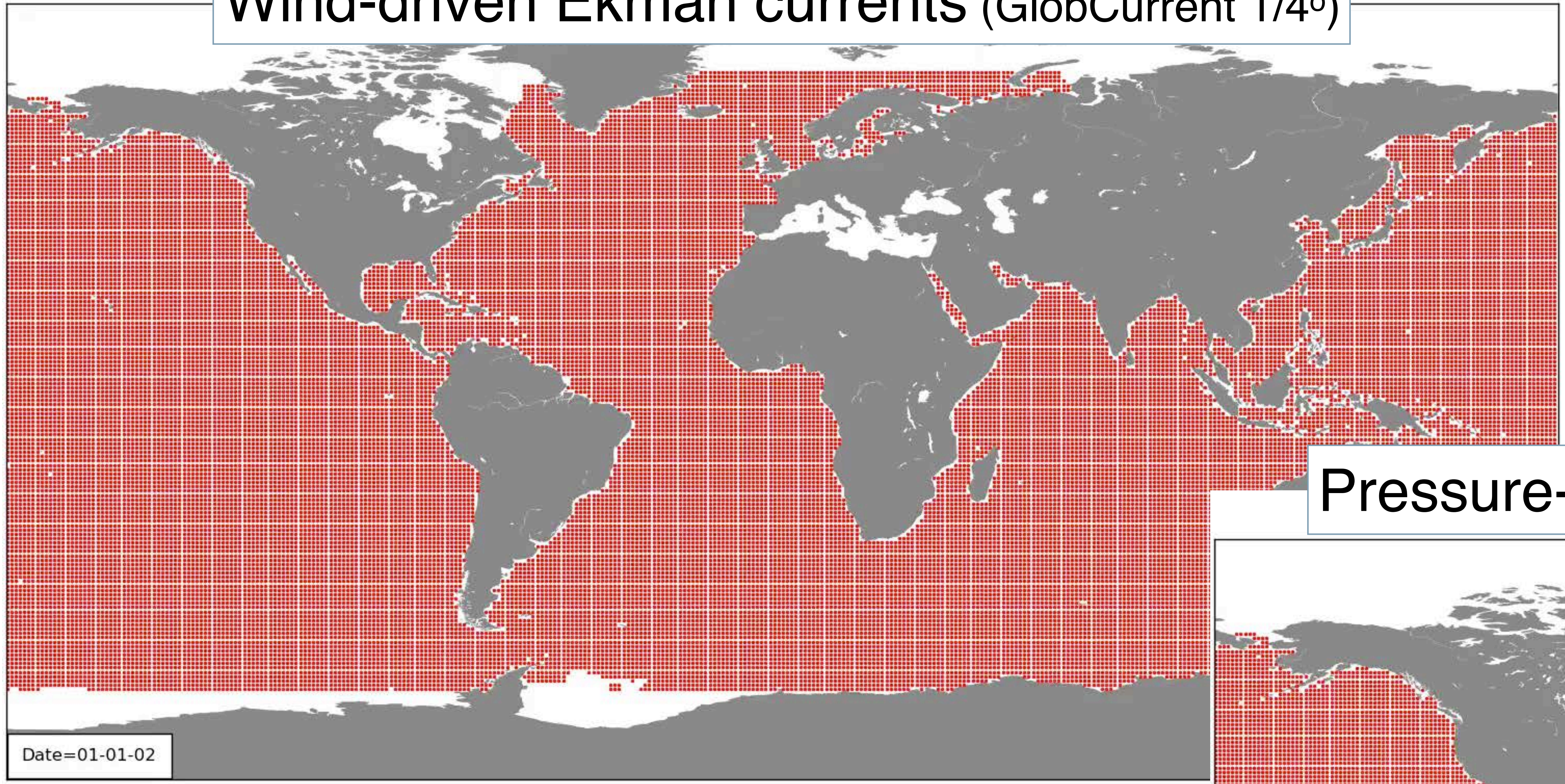
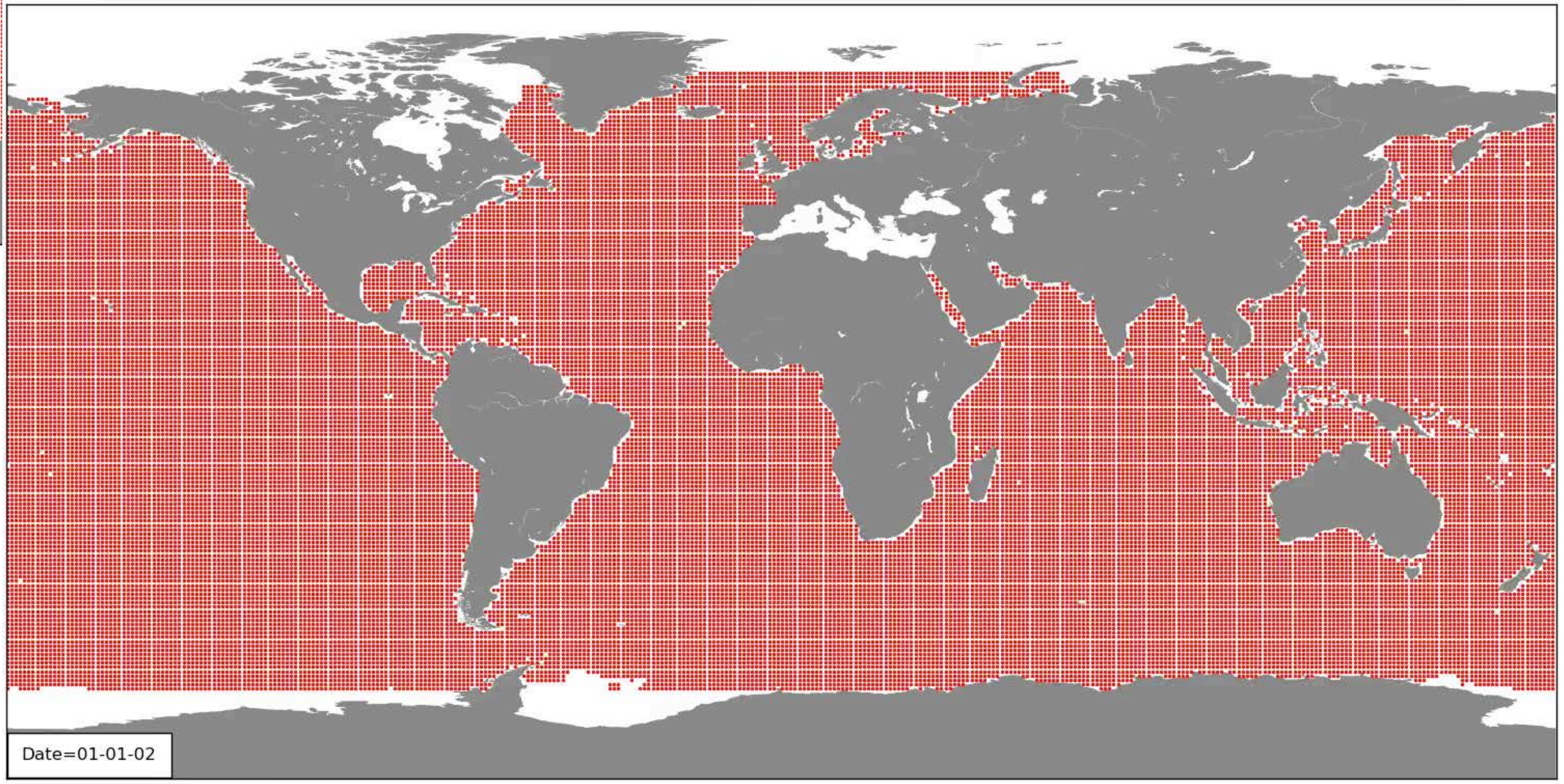
Separating the effects of Ekman and geostrophy

Wind-driven Ekman currents (GlobCurrent 1/4°)

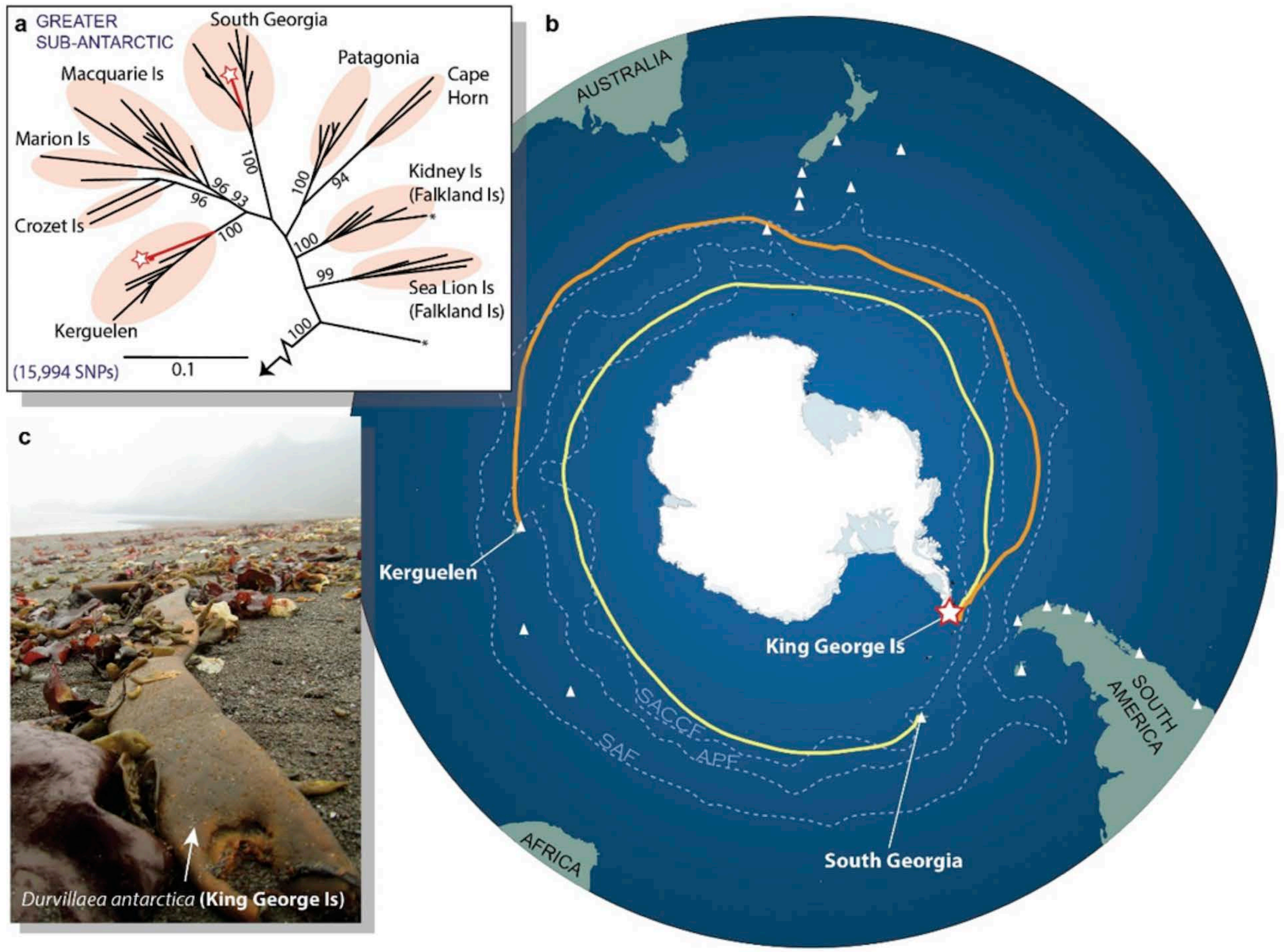


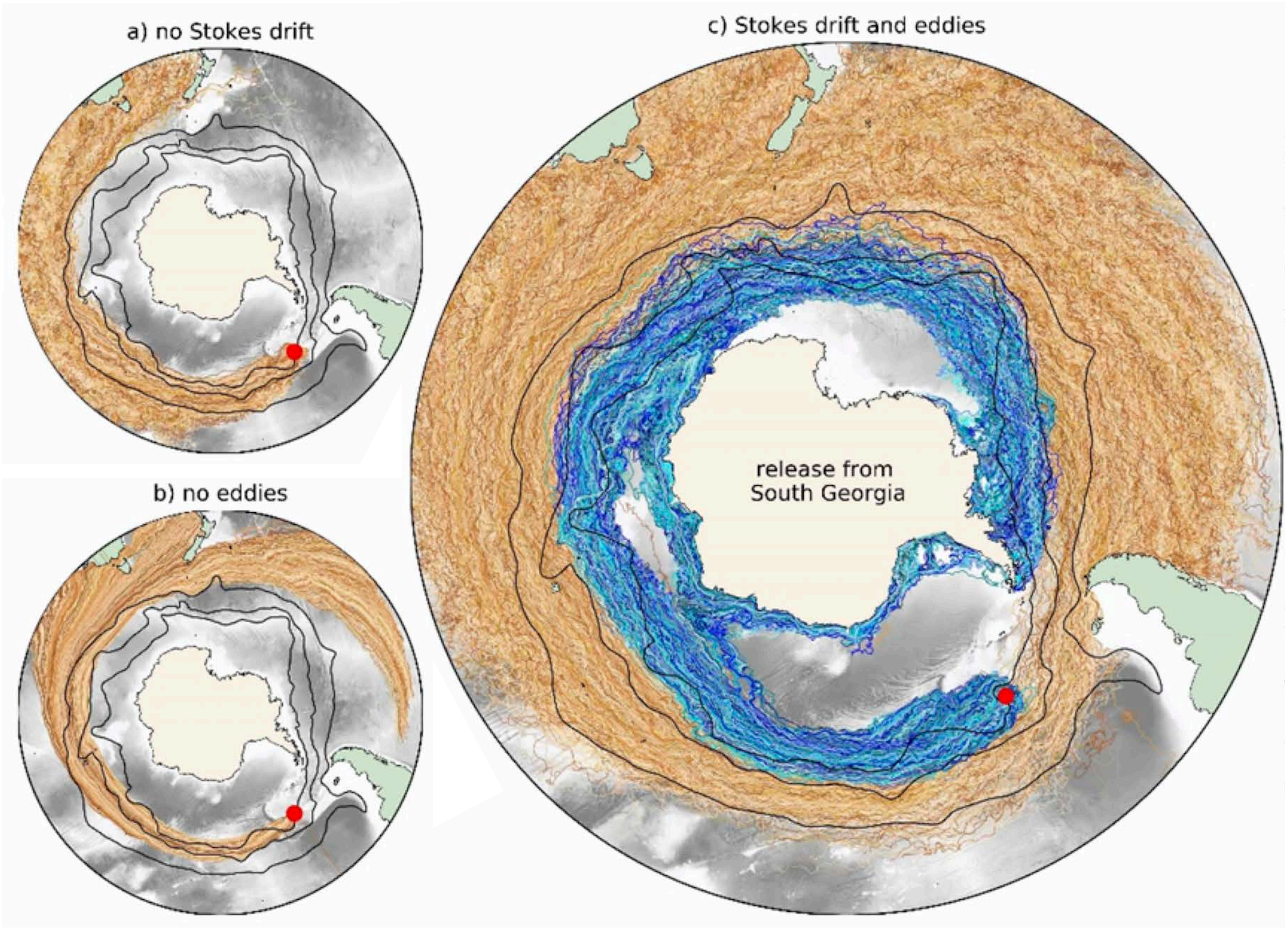
Pressure-driven geostrophic currents (GlobCurrent 1/4°)



Onink, Wichmann, Delandmeter & Van Sebille (2019) *Journal of Geophysical Research*

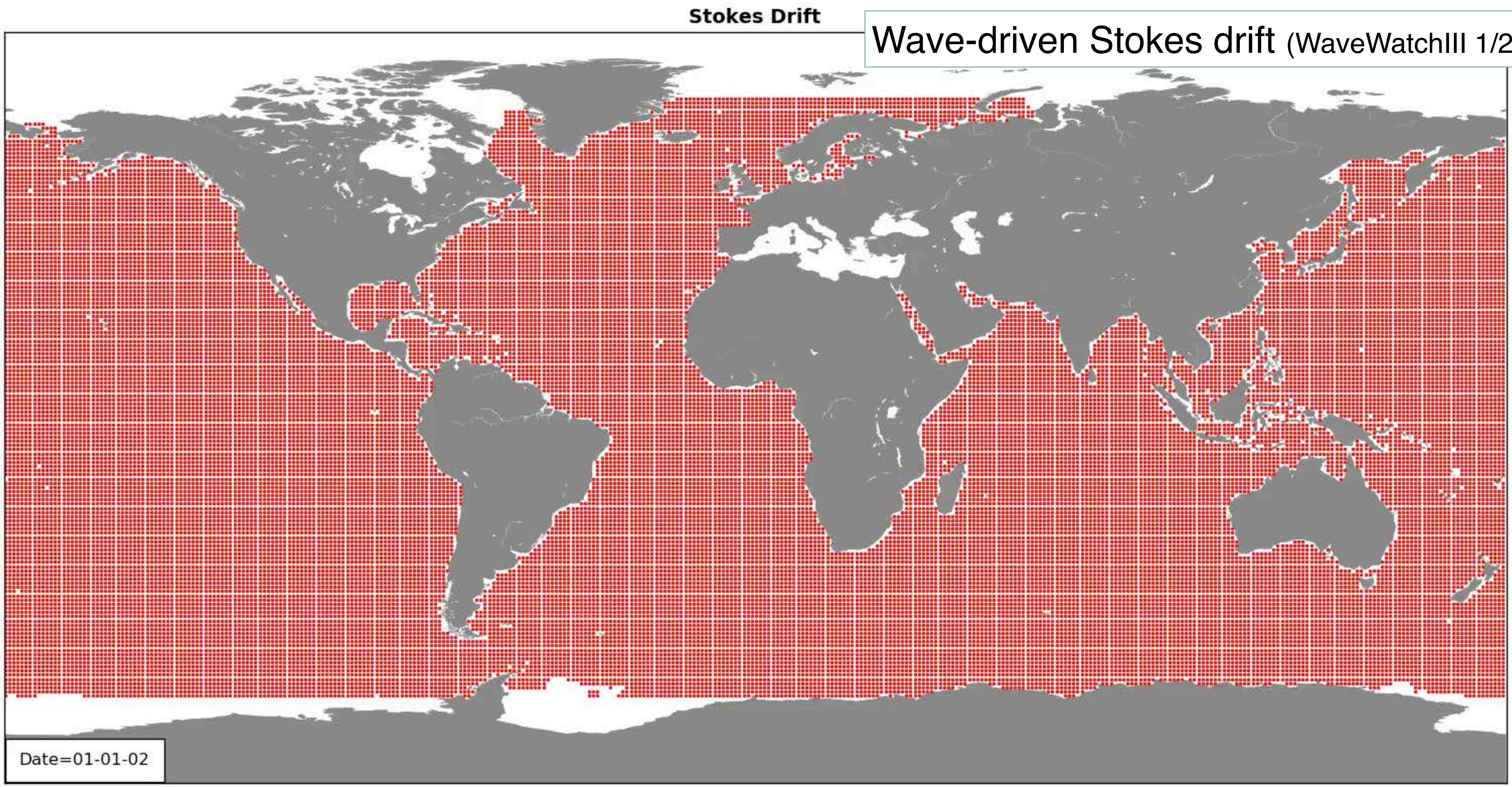
The effect of Stokes drift in transporting floating items southward





Fraser, Morrison, Hogg, Macaya, Van Sebille, Ryan, Padovan, Jack, Valdivia & Waters (2018) *Nature Climate Change*

The effects of waves via Stokes drift

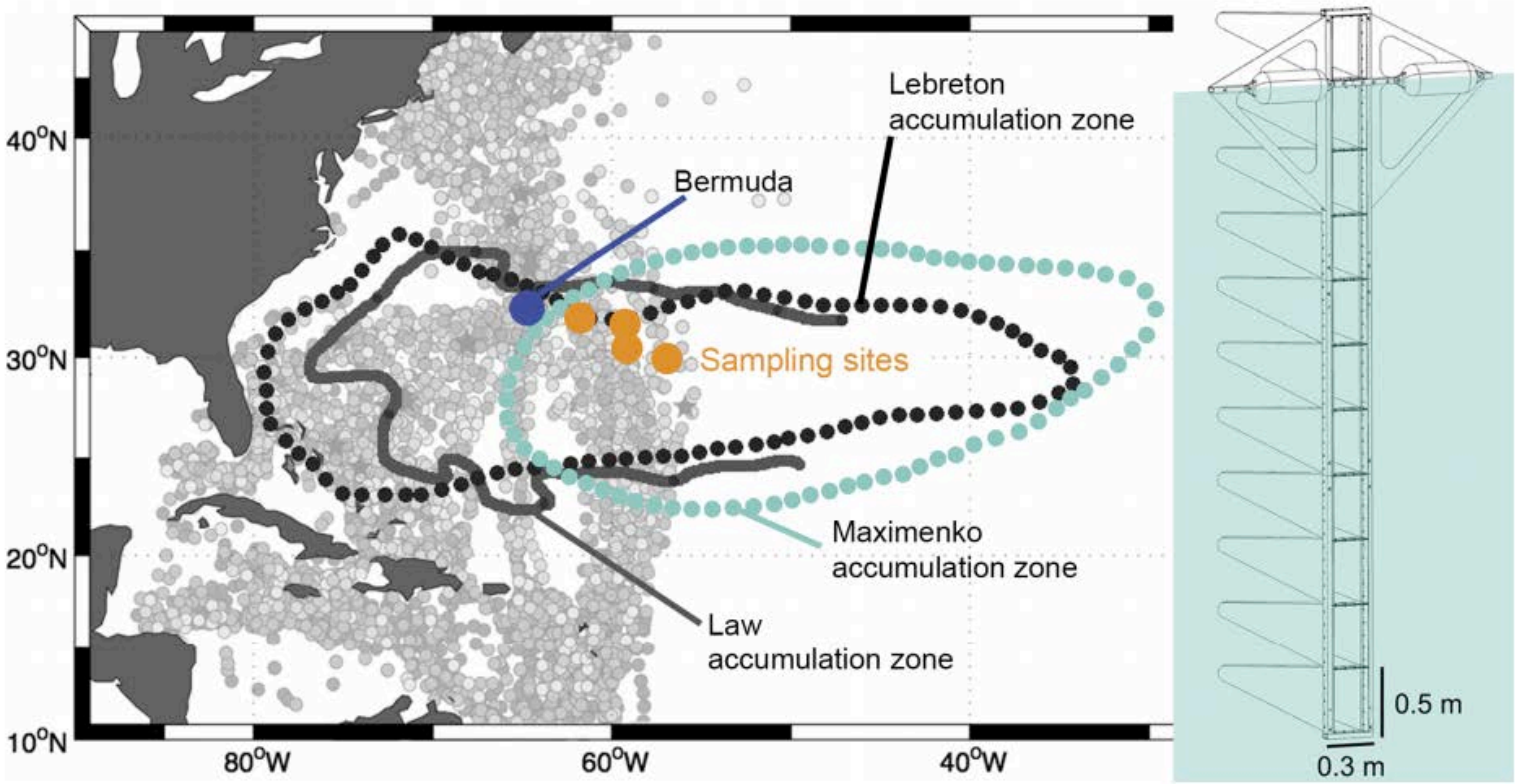


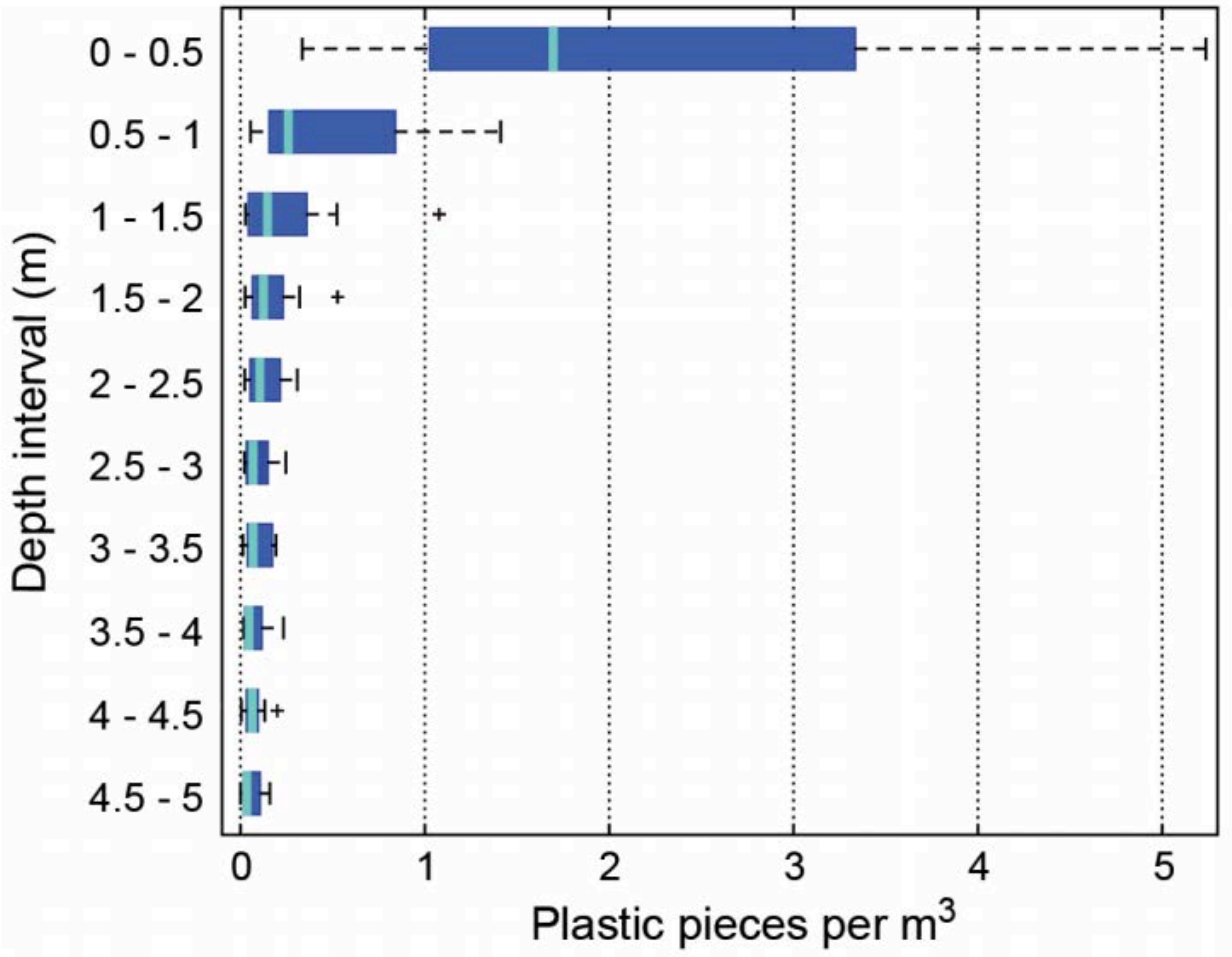
Wave-driven Stokes drift (WaveWatchIII 1/2°)

Onink, Wichmann, Delandmeter & Van Sebille (2019) *Journal of Geophysical Research*

OceanParcels.org

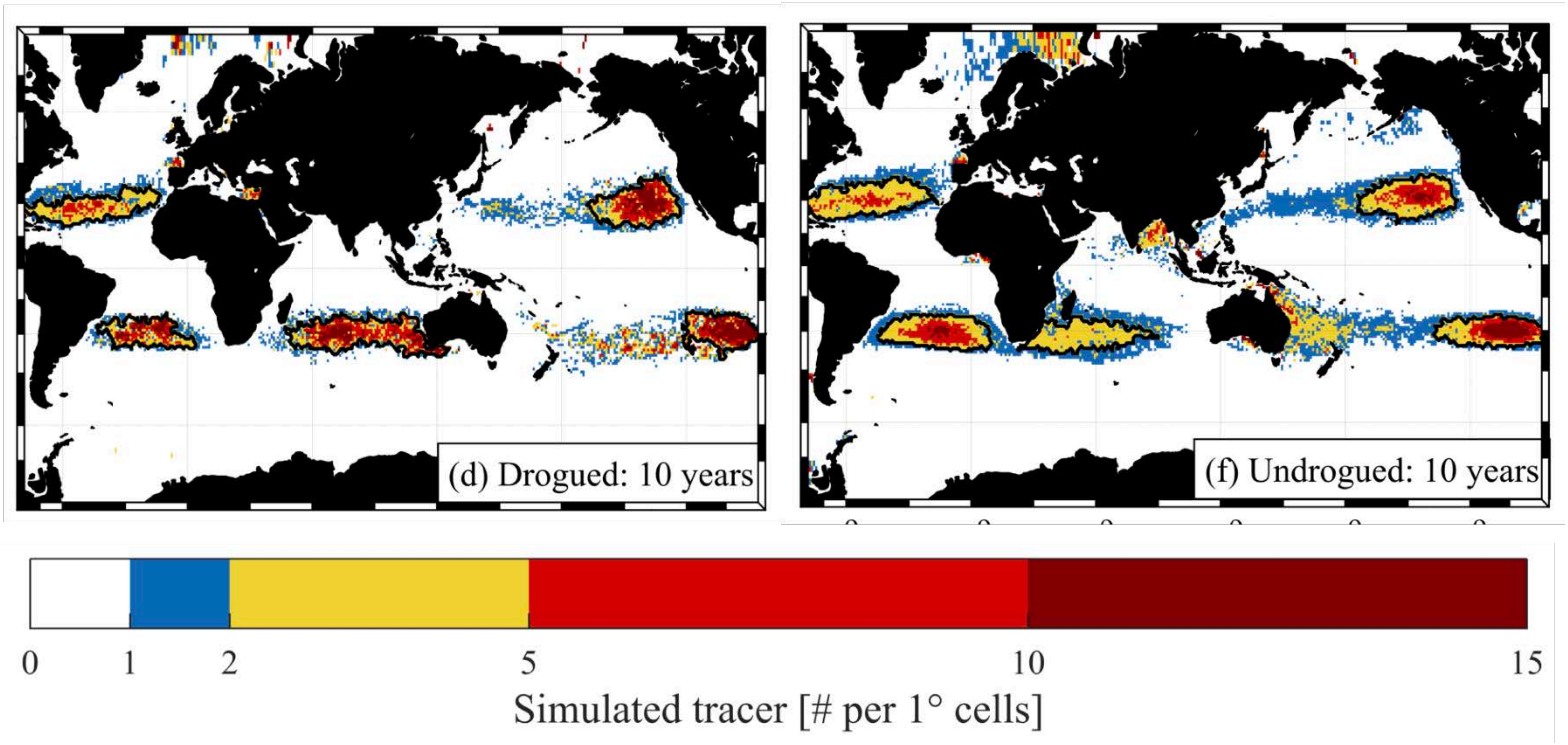
The depth distribution of plastic





Reisser, Slat, Noble, Du Plessis, App, Proietti, De Sonneville, Becker & Pattriaratchi (2015) *Biogeosciences*

Transition matrices from drogued vs undrogued drifters

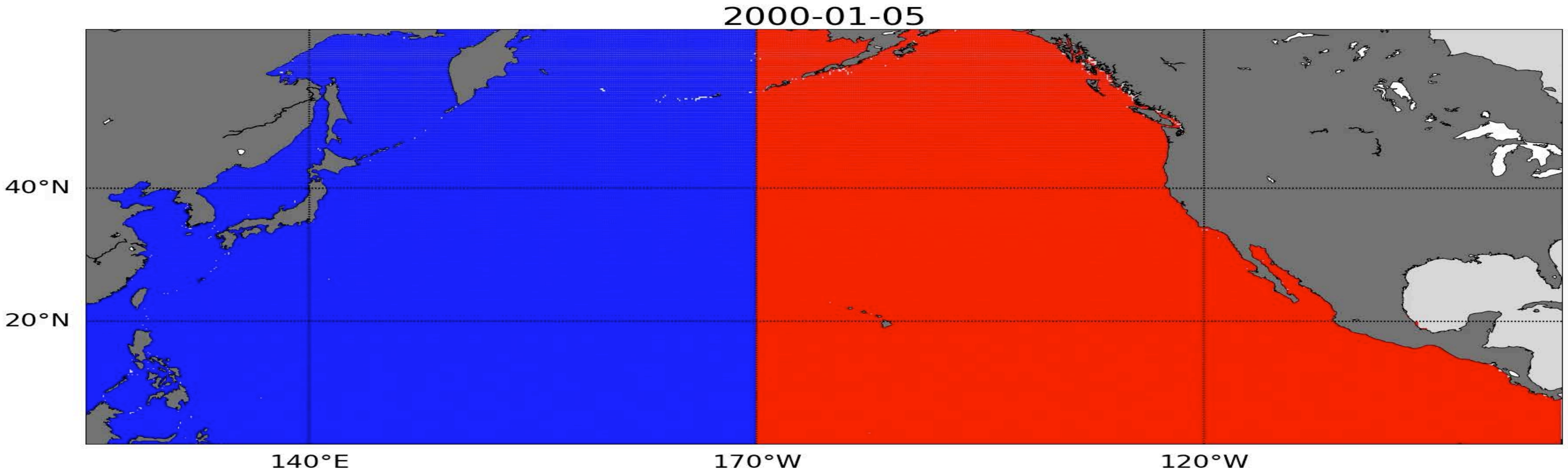


Van der Mheen, Pattiaratchi & Van Sebille (2019) *Journal of Geophysical Research*

The effect of large-scale vertical shear

Wichmann, Delandmeter & Van Sebille (2019) *Journal of Geophysical Research*

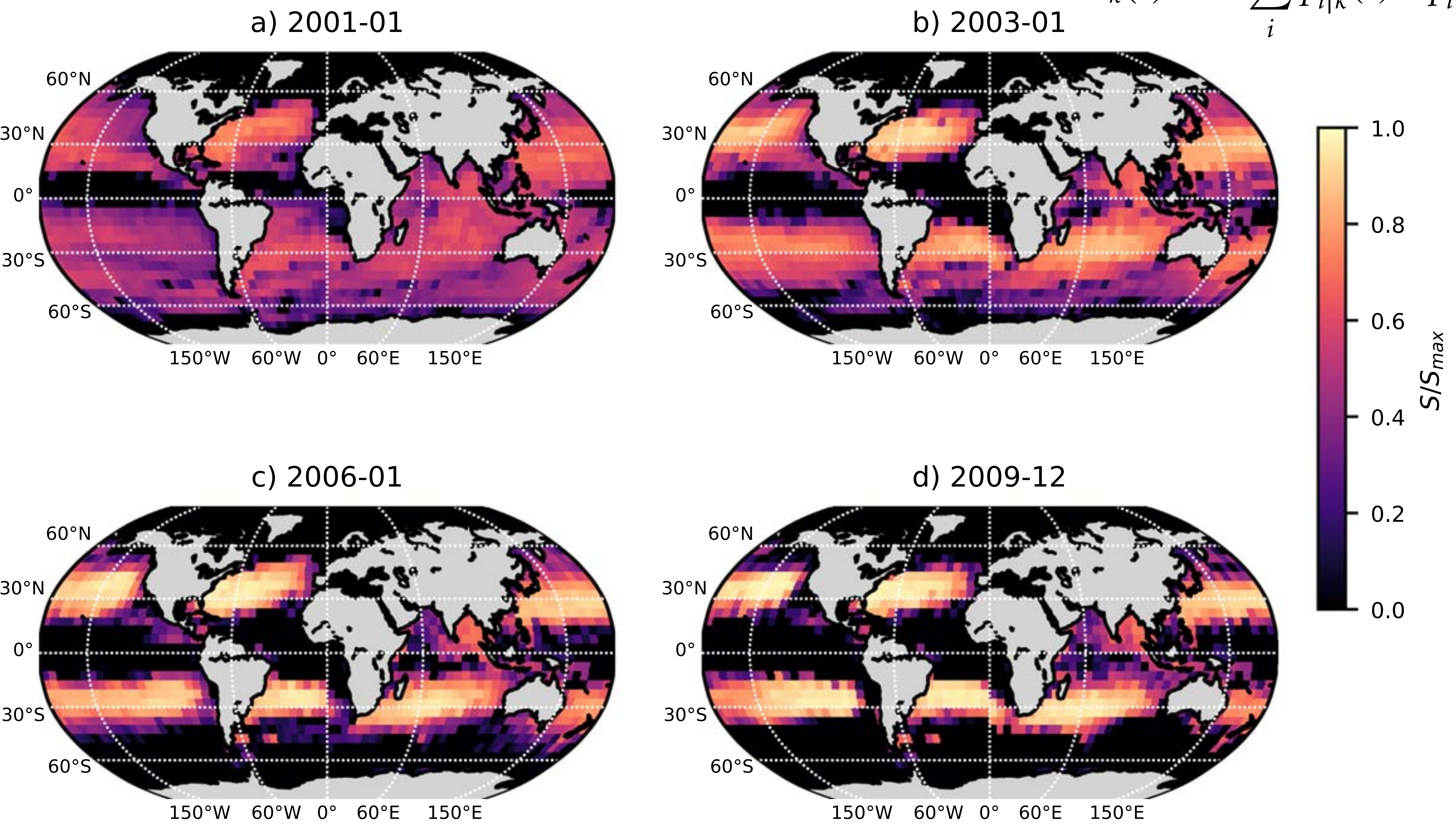
So how important are the initial conditions?



Wichmann, Delandmeter, Dijkstra & Van Sebille (2019) *Environmental Research Communications*

Quantifying mixing entropy

$$S_k(t) = -\sum_i p_{i|k}(t) \ln p_{i|k}(t), \quad p_{i|k}(t) = \frac{\rho_{i,k}(t)}{\sum_i \rho_{i,k}(t)}$$



Wichmann, Delandmeter, Dijkstra & Van Sebille (2019) *Environmental Research Communications*

frontiers in Marine Science

REVIEW
published: 28 August 2019
doi: 10.3389/fmars.2019.00447

OPEN ACCESS

Edited by:
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Specialty section:
This article was submitted to Ocean Observation, a section of the journal Frontiers in Marine Science

Toward the Integrated Marine Debris Observing System

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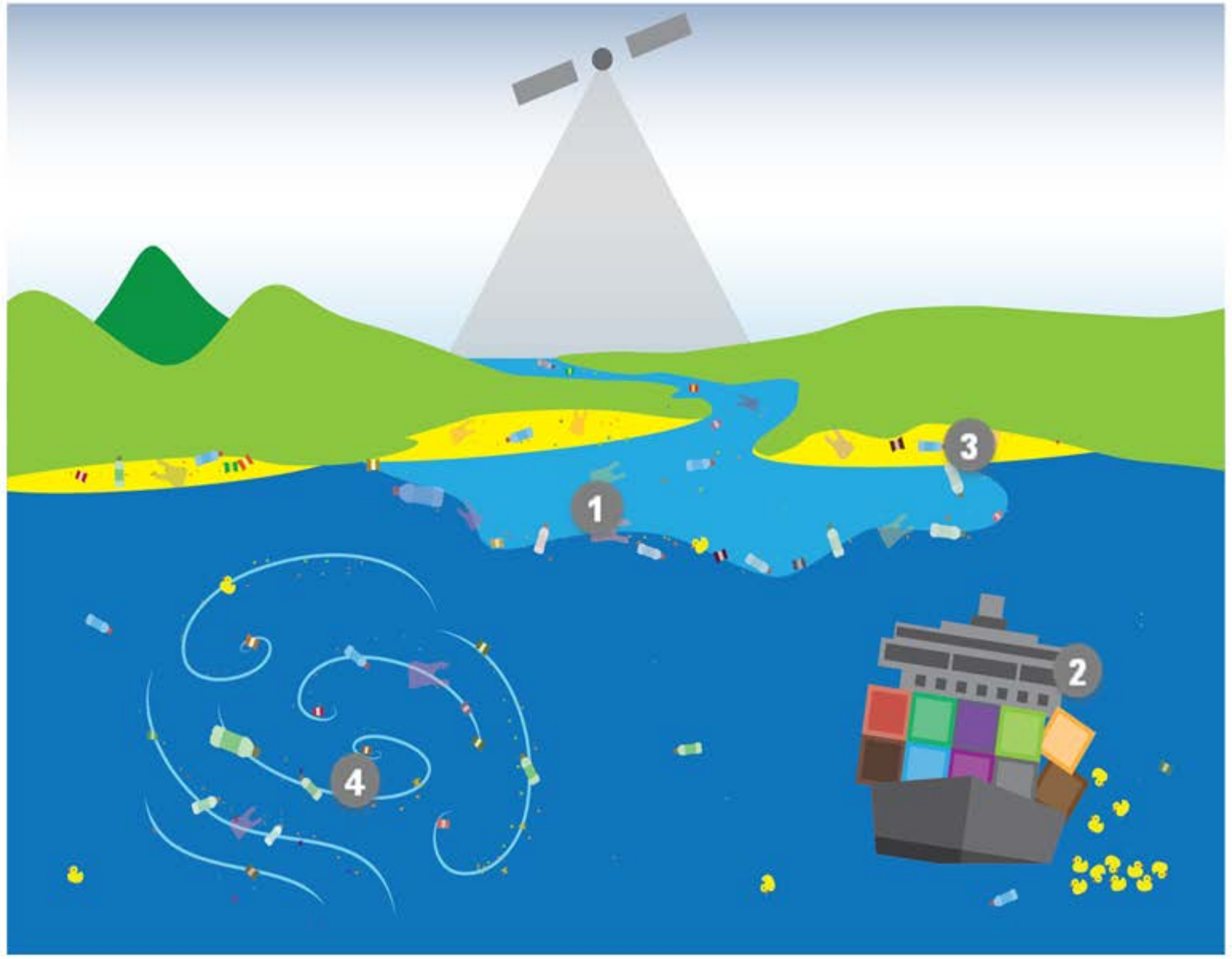
Mapping of plastic with Earth Observation?

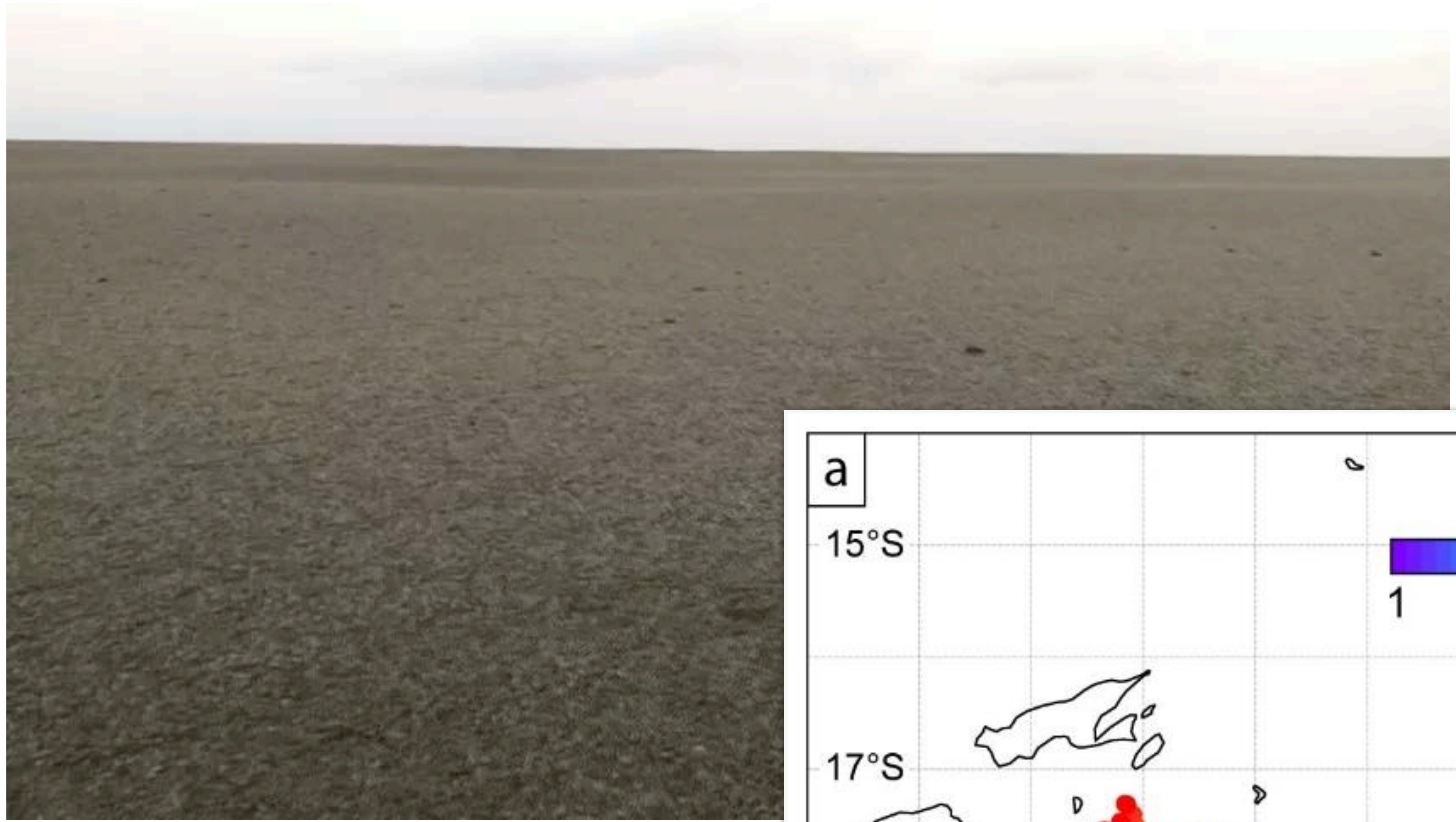
Marine process	Spatial	
	Spatial Extent(max)	**Required Spatial Resolution of observations**
River discharge	100 Km	30 m (G) 500 m (T)
Spill	100 Km	1 m (G) 50 m (T)
Shoreline accumulation	1000 km	1 m (G) 5 m (T)
Submesoscale convergence filaments	10 km	30 m (G) 100 m (T)

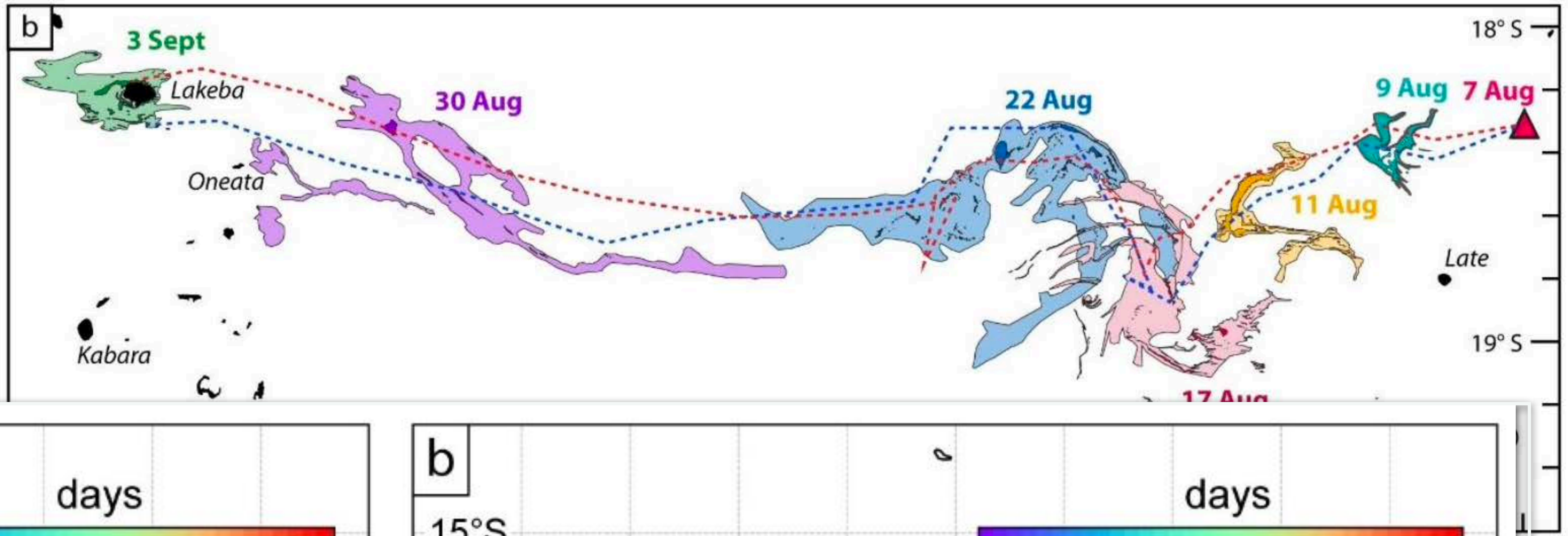
Marine process	Temporal	
	Lifetime of process (max)	**Required frequency of observations**
River discharge	1 month	3 h (T)
Spill	1 month	2 h (T)
Shoreline accumulation	10 year	12 h (G) 5 d (T)
Submesoscale convergence filaments	1 month	1 d (T)

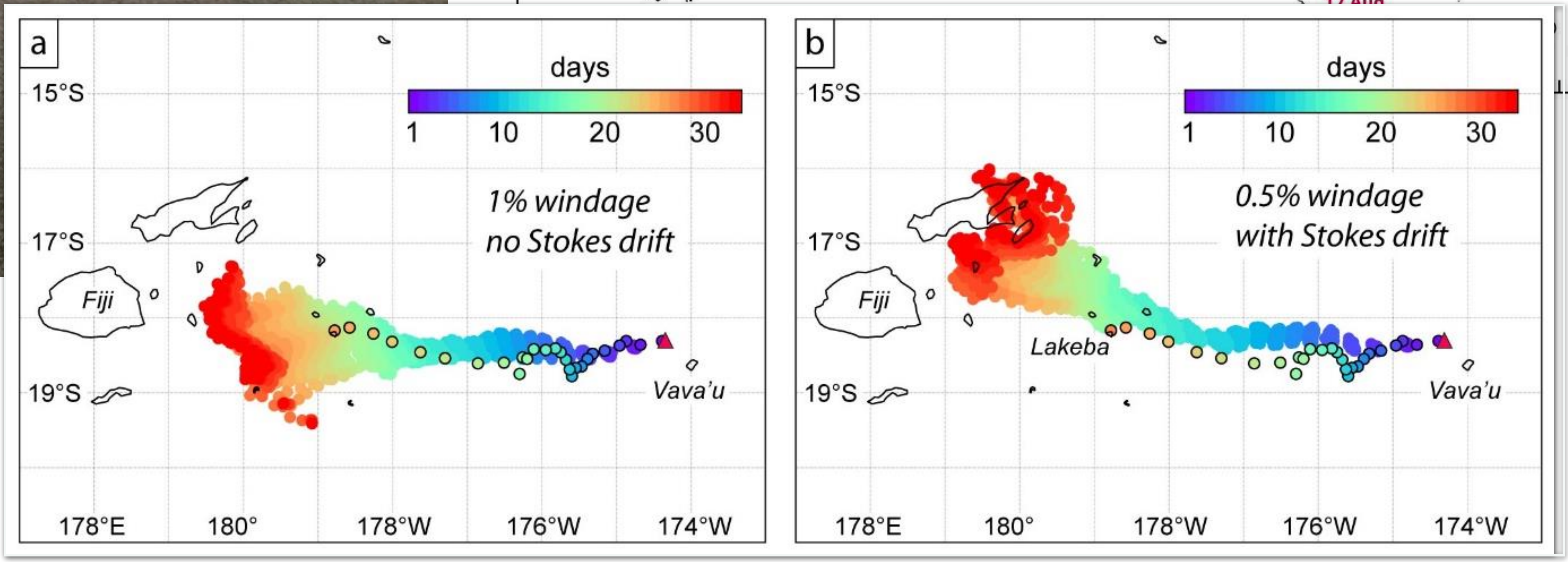


Martinez-Vicente, Clark, Corradi, Aliani, Arias, Bochow, Bonnery, Cole, Cozar, Donnelly, Echevarria, Galgani, Garaba, Goddijn-Murphy, Lebreton, Leslie, Lindeque, Maximenko, Martin-Lauzer, Moller, Murphy, Palombi, Raimondi, Reisser, Romero, Simis, Sterckx, Thompson, Topouzelis, Van Sebille, Veiga & Vethaak (2019) Remote Sensing

Tracking pumice to validate surface flow








```
fset_wind.U.set_scaling_factor(withwind)
fset_wind.V.set_scaling_factor(withwind)

fieldset = FieldSet(U=fset_currents.U + fset_stokes.U + fset_wind.U,
                    V=fset_currents.V + fset_stokes.V + fset_wind.V)
```

Jutzeler, Marsh, Van Sebille, Mital, Carey, Fauria, Manga & McPhie (2020) *Geophysical Research Letters*

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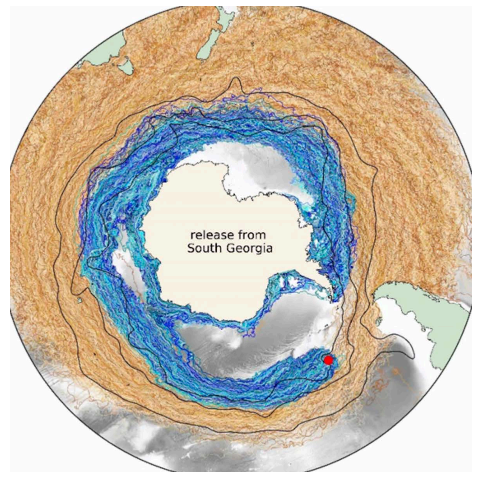
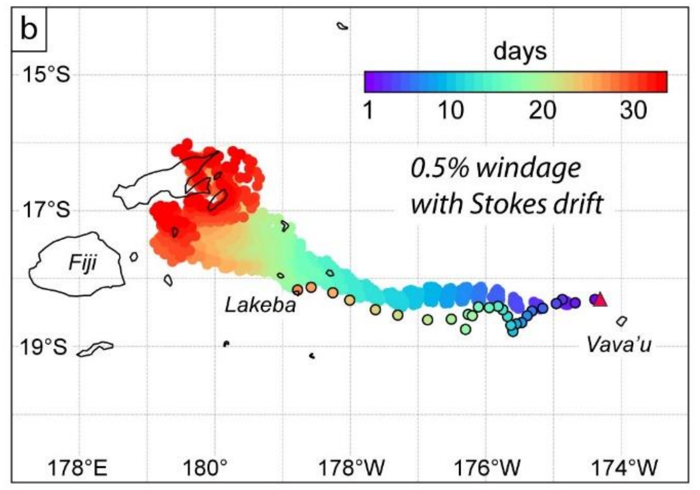
Conclusions

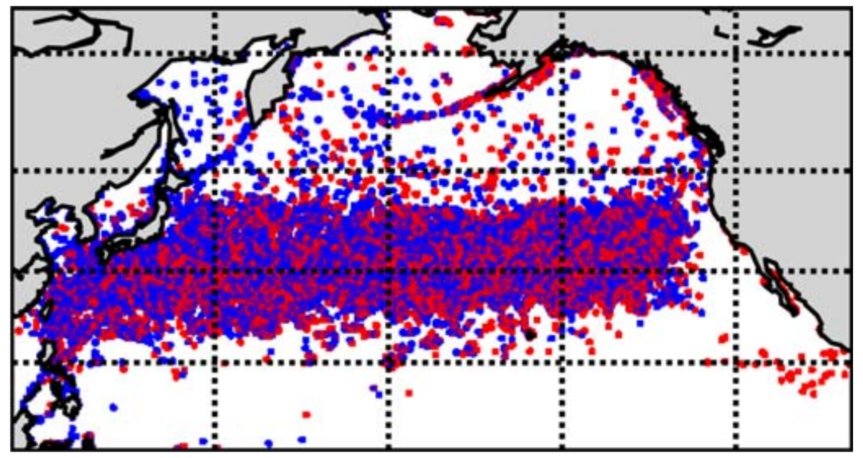
Geostrophy, Stokes and Ekman are all important for the transport of floating material



Events like the Tonga eruption provide unique opportunity to validate transport models

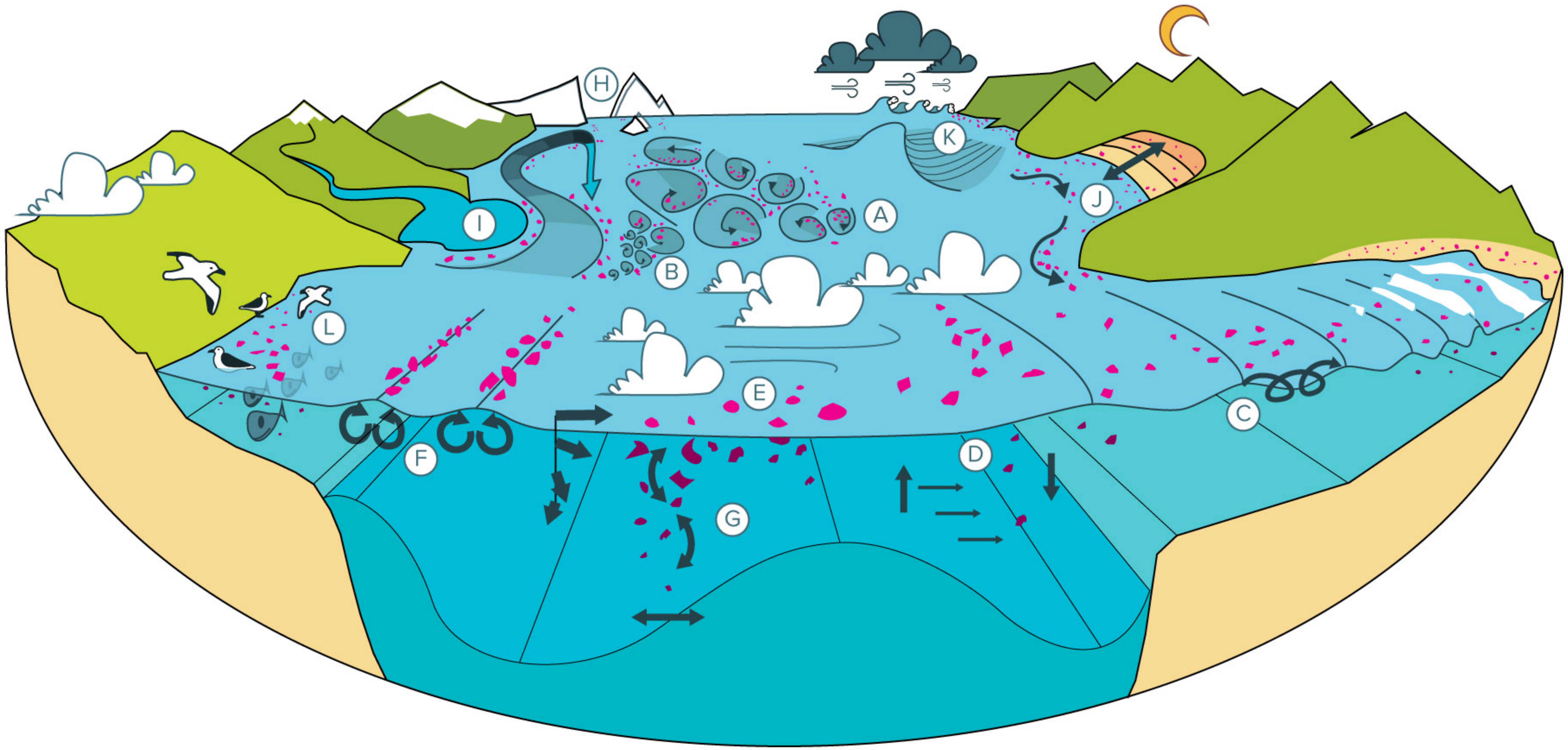


However, not on timescales of much more than a few years



Utrecht University SCOR SURF SARA EPSRC Engineering and Physical Sciences Research Council Galapagos Conservation Trust esa NWO erc European Research Council Established by the European Commission

The physical oceanography of the transport of floating marine debris



PHYSICAL PROCESSES

A Large-scale open ocean processes
B Submesoscale open ocean processes
C Open ocean Stokes drift
D Internal tides
E Direct wind transport (windage)
F Langmuir circulation
G Vertical mixing
H Ice formation, melting and drift
I River plumes and coastal fronts
J Coastal currents, surface waves and beaching
K Extreme events
L *Transport by biology*

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Van Sebille, Aliani, Law, Maximenko, Alsina, Bagaev, Bergmann, Chapron, Chubarenko, Cózar, Delandmeter, Egger, Fox-Kemper, Garaba, Goddijn-Murphy, Hardesty, Hoffman, Isobe, Jongedijk, Kaandorp, Khatmullina, Koelmans, Kukulka, Laufkötter, Lebreton, Lobelle, Maes, Martinez-Vicente, Morales Maqueda, Poulain-Zarcos, Rodríguez, Ryan, Shank, Shim, Suaria, Thiel, van den Bremer and Wichmann (2020) *Environmental Research Letters*