

# WHICH PROCESSES CONTROL THE PATHWAYS OF FLOATING PLASTIC ?

## STUDYING PARTICLE TRANSPORT USING PARCELS

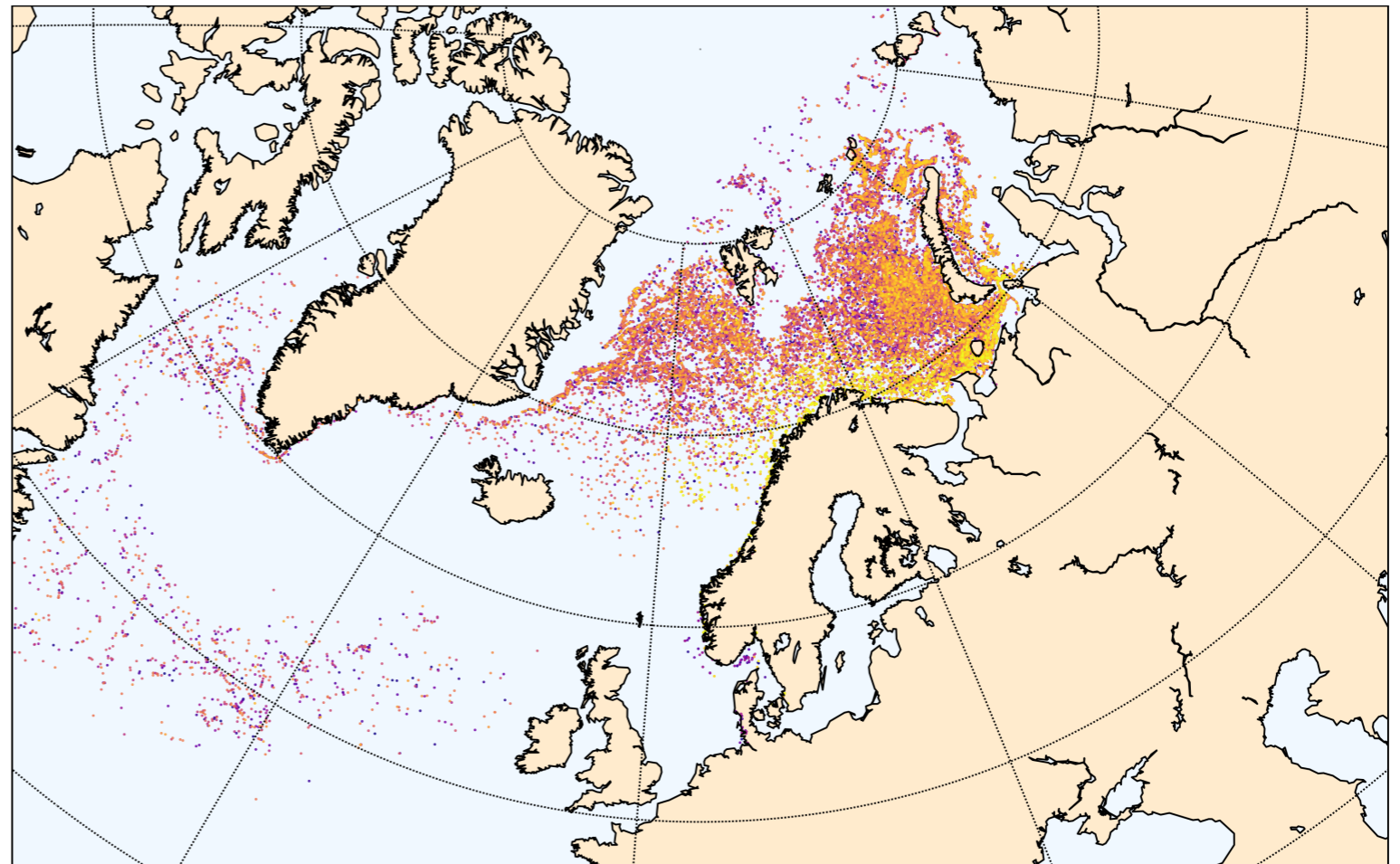
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Utrecht University



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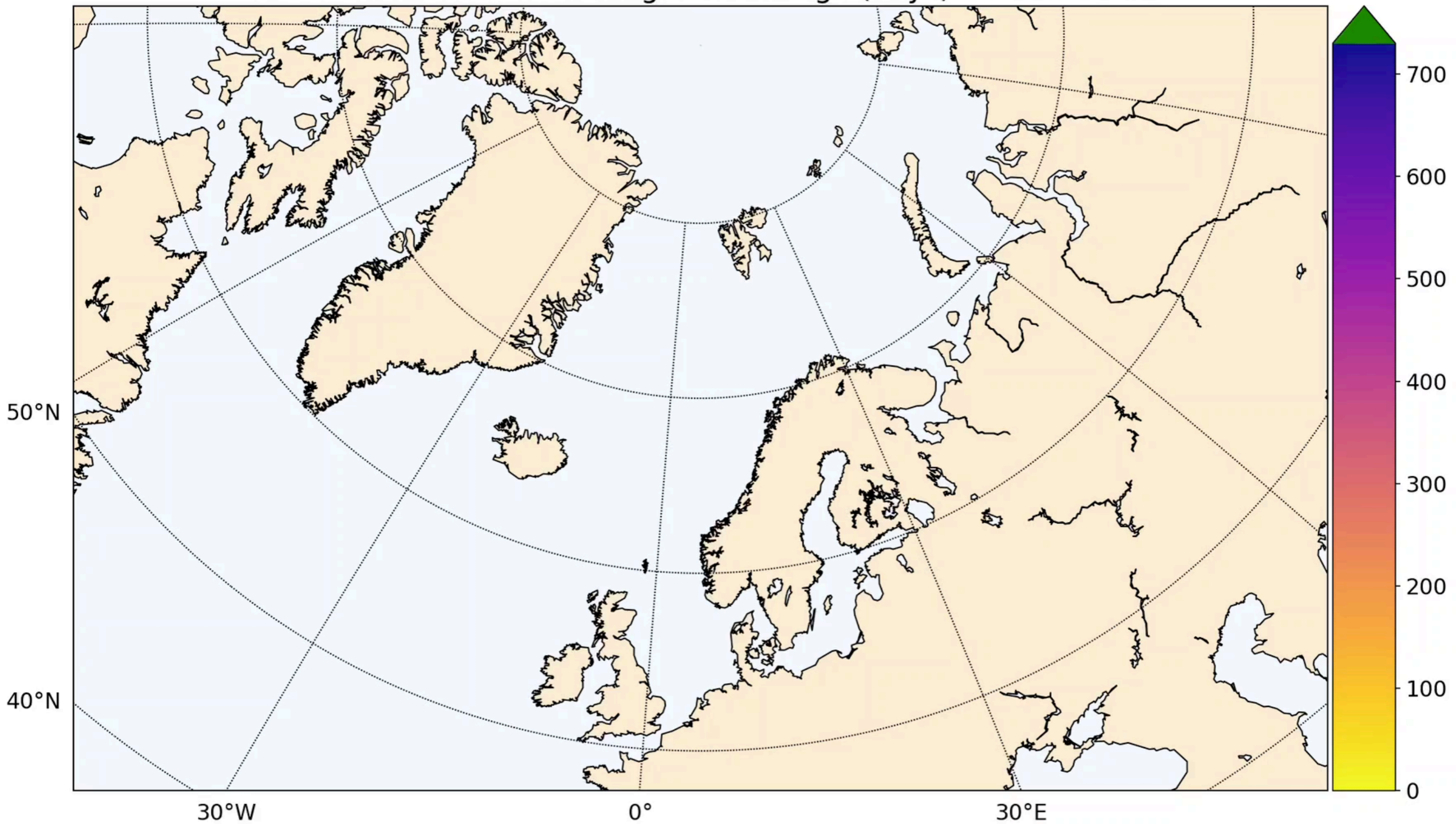
Doppler Oceanography from Space  
Brest - Oct 2018



OceanParcels

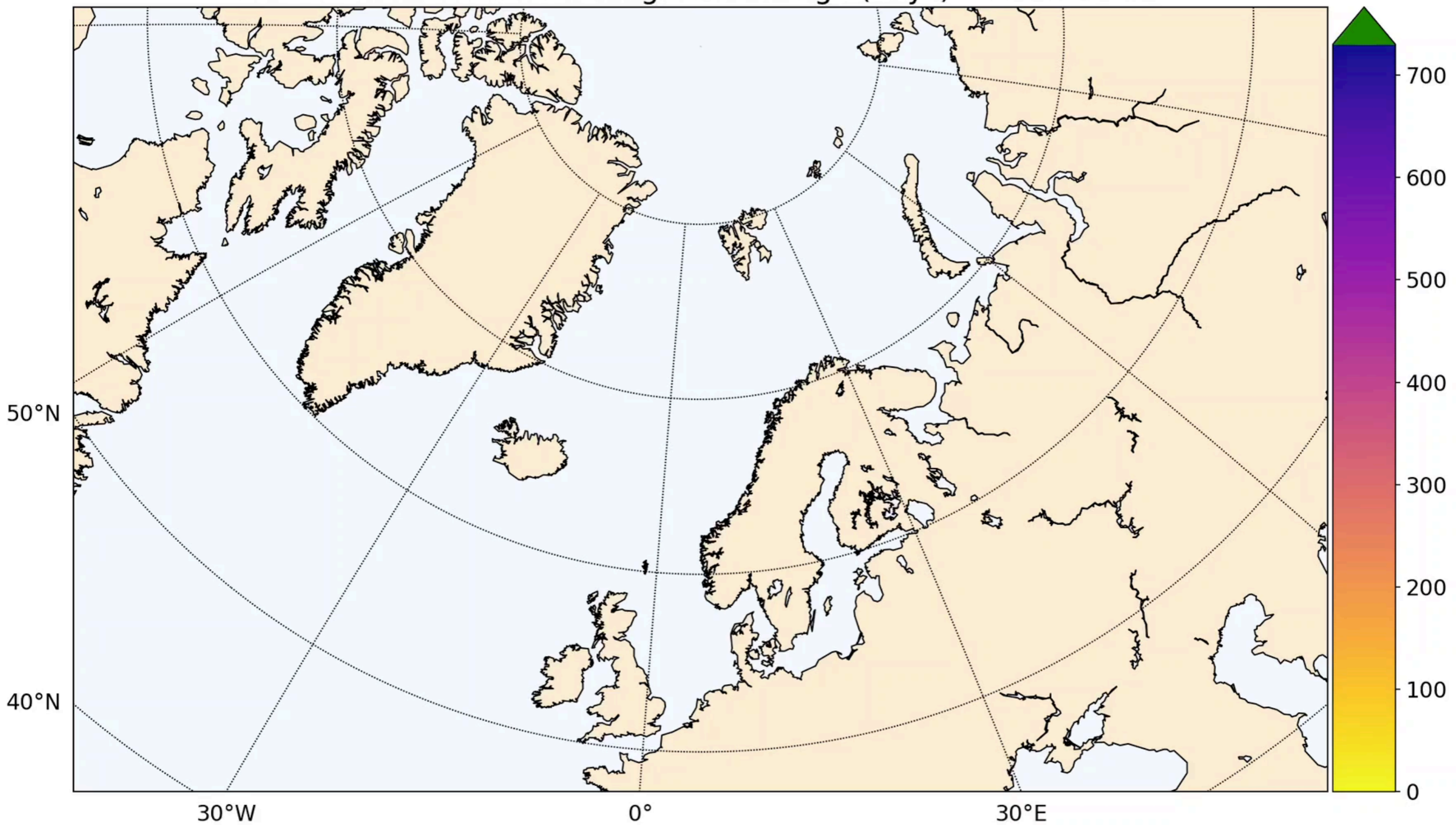
# NORTH SEA FLOATING PLASTIC

NEMO+CMEMS+Unbeaching: Particle age (days) -- 2000-01-02



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# LAGRANGIAN MODELLING

- Matter of perspective:

- Eulerian

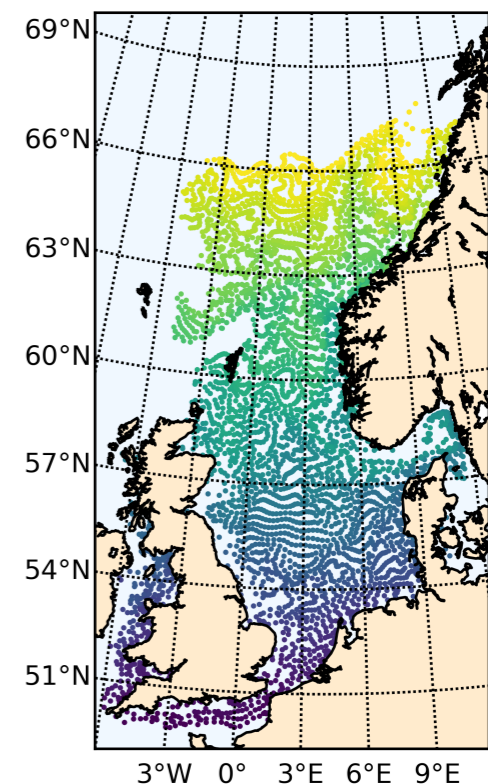
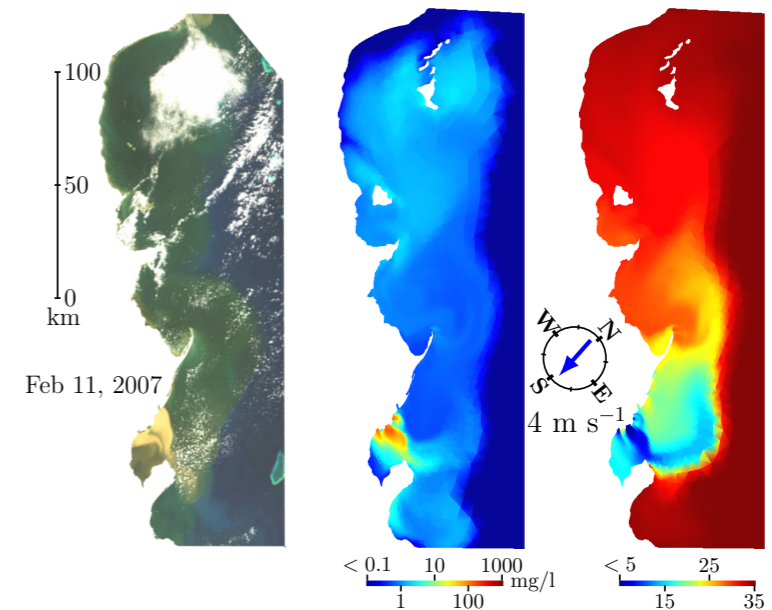
- reference fixed in space

$$\frac{\partial f(\mathbf{x}, t)}{\partial t} + \nabla \cdot (\mathbf{u} f(\mathbf{x}, t)) = F$$

- Lagrangian

- reference attached to material point

$$\frac{\partial f(\mathbf{X}(\mathbf{x}_0, t), t)}{\partial t} = F$$

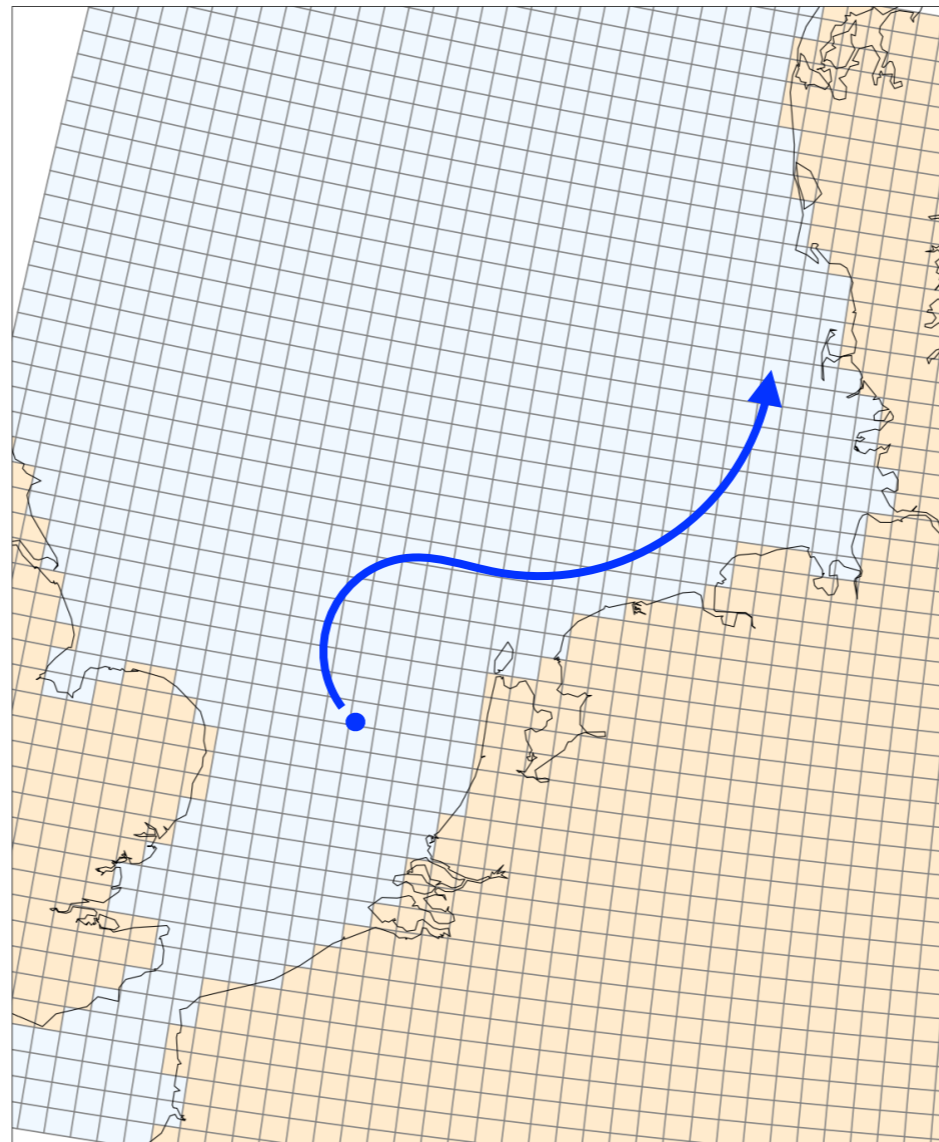


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# WHAT IS PARCELS ?

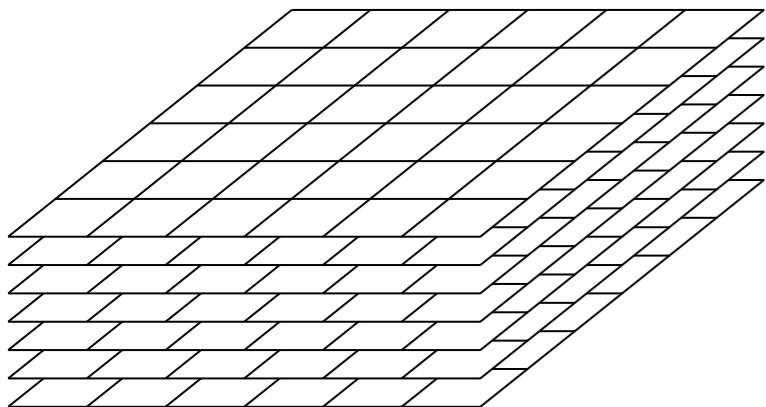
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## Particle dynamics

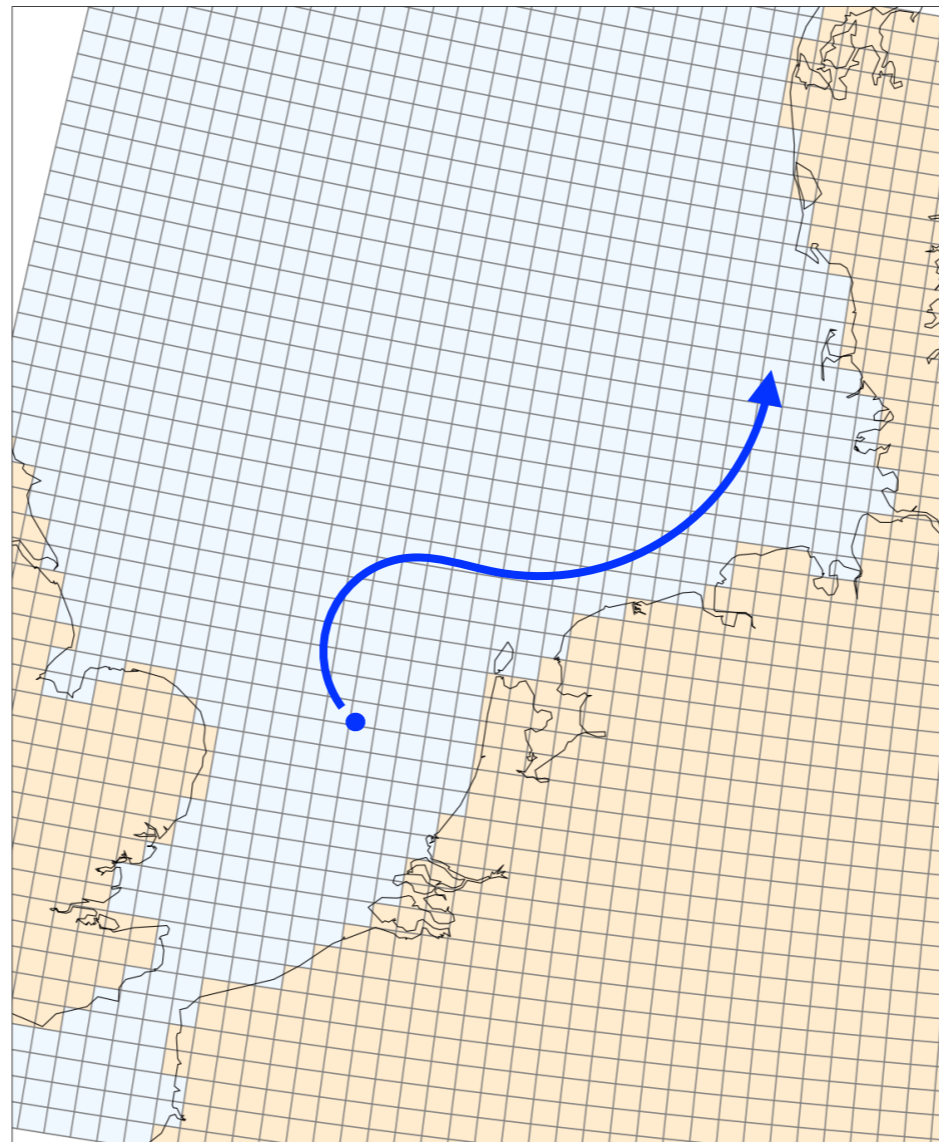


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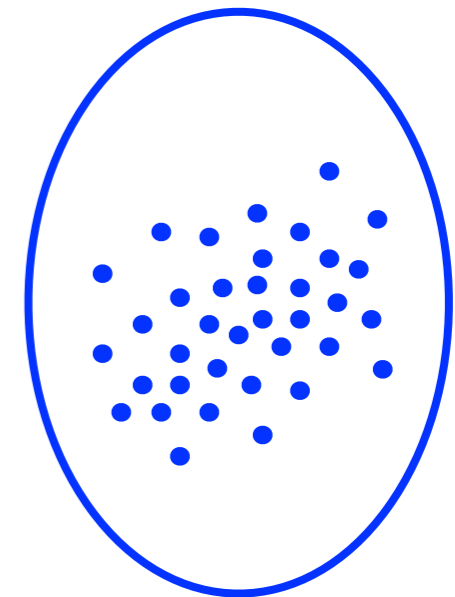
FieldSet



Particle dynamics



ParticleSet



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# PARCELS

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- “Probably A Really Computationally Efficient Lagrangian Simulator”
- A new open-source set of Python classes and methods for building Lagrangian particle models
  - Flexible and customisable API allows rapid model development
    - particle dynamics, data manipulation, etc.
  - High-level abstraction hides complexities from user
    - field sampling, loop scheduling, file I/O, etc.

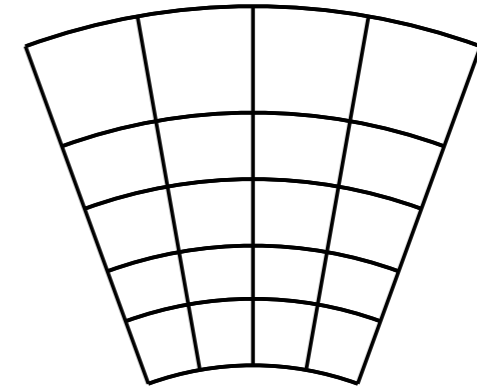
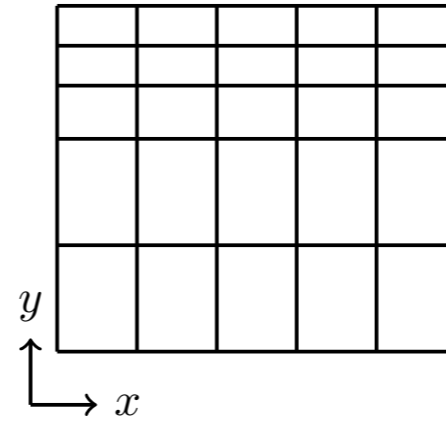


Ocean**Parcels**

# GRID AND SPACE DISCRETISATION

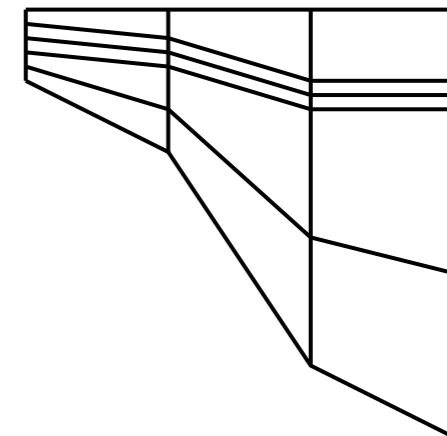
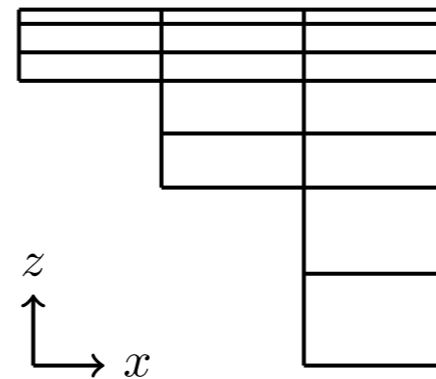
- Horizontal mesh

- Rectilinear
- Curvilinear



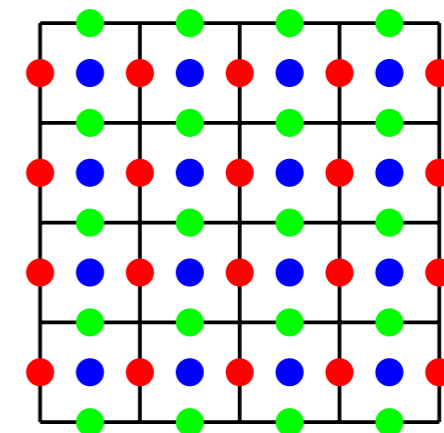
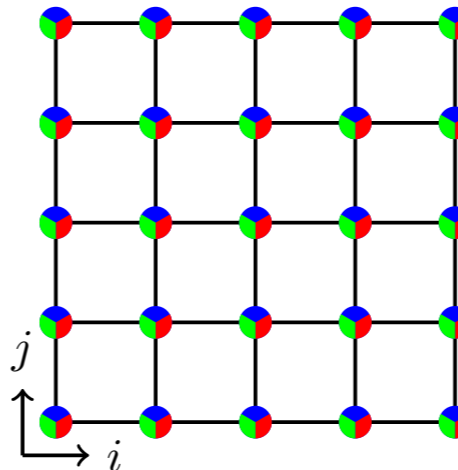
- Vertical mesh

- Z-grid
- S-grid







- Discretisation

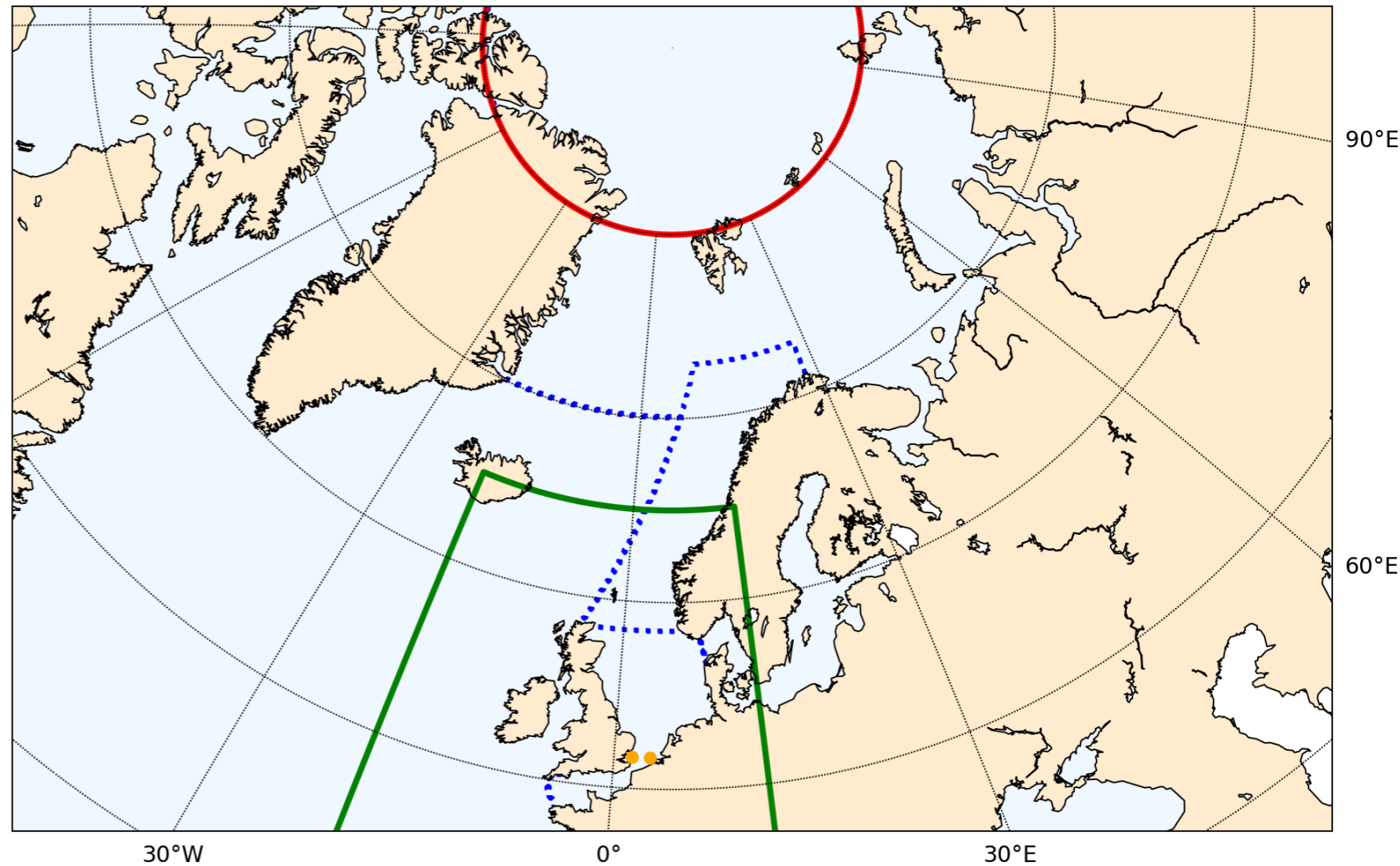
- A-grid
- C-grid





# NORTH SEA PLASTIC TRANSPORT

- NEMO N006
  - density+wind
  - $1/12^\circ$  or  $1/4^\circ$
  - global
- CMEMS
  - density+wind+tides
  - $1/15^\circ \times 1/9^\circ$
  - 
- WWIII - CFSR
  - Stokes or wind
  - $1/2^\circ$
  - 
- Zones 
- Release 

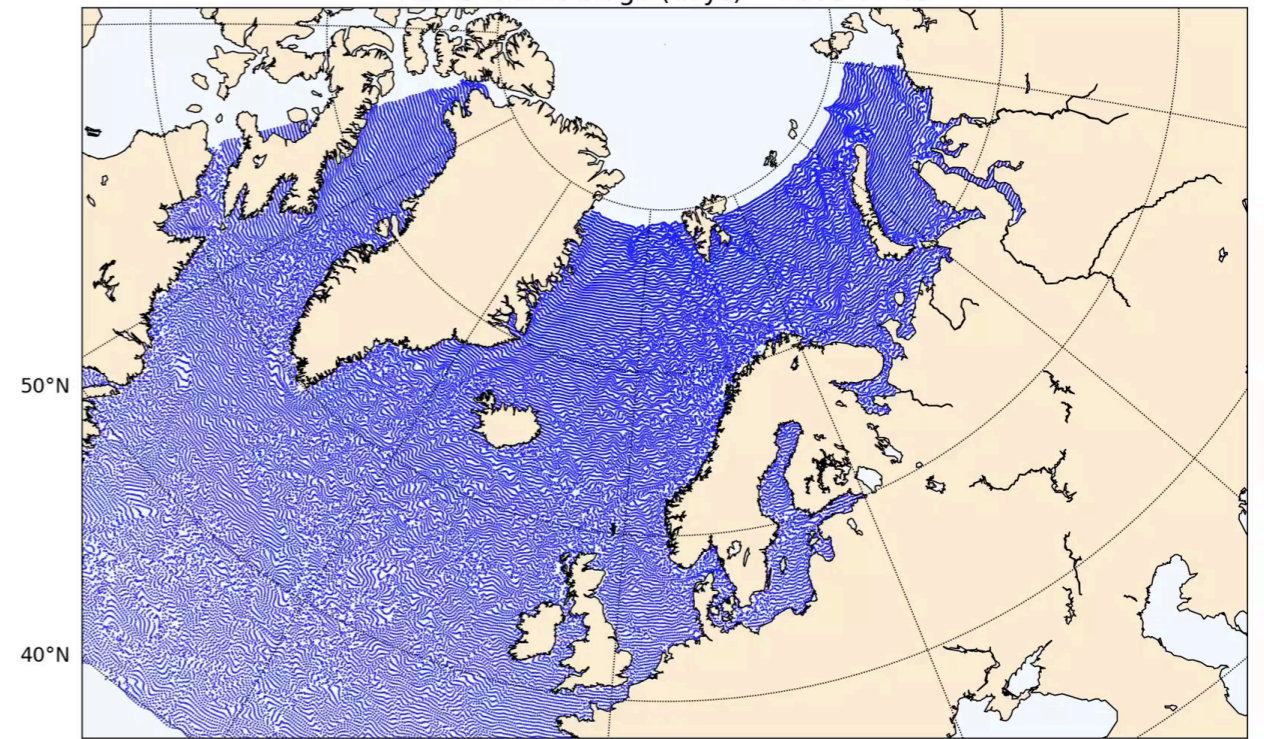


# PLASTIC TRANSPORT SENSITIVITY

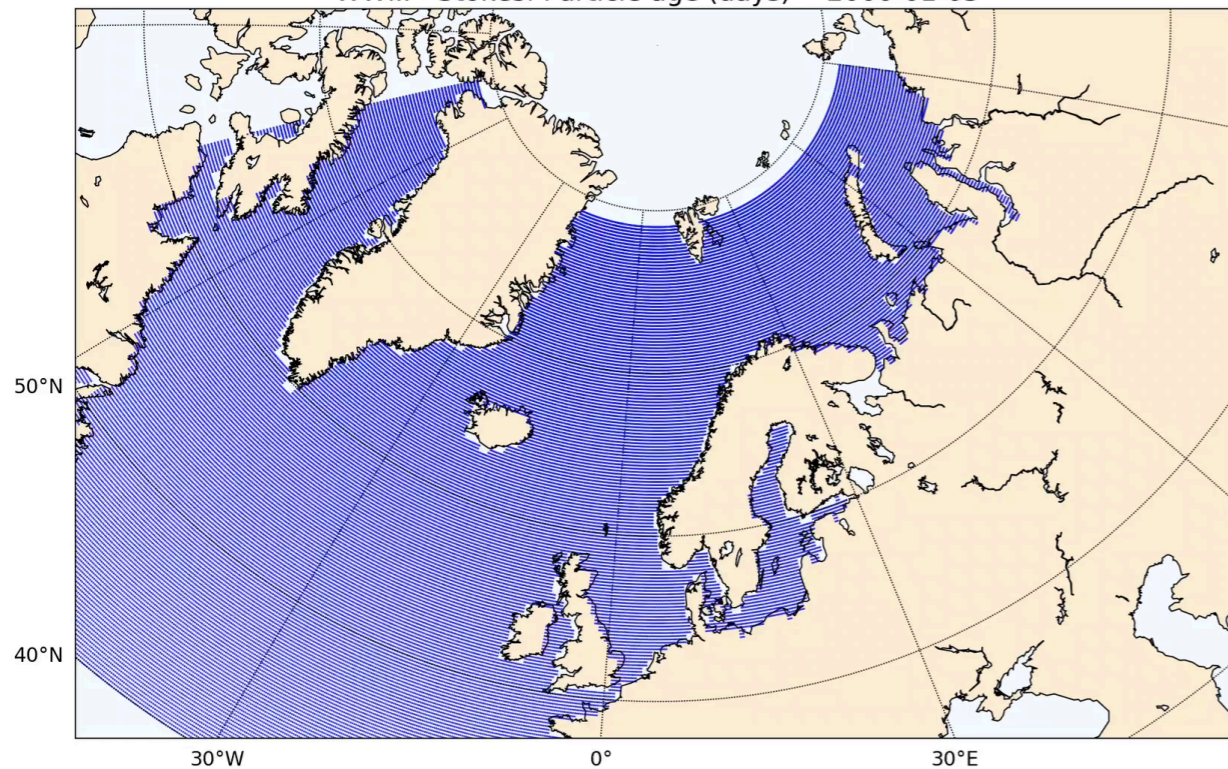
What is the importance of:

- Resolution
- Stokes / wind
- Coastal dyn.
- Diffusion

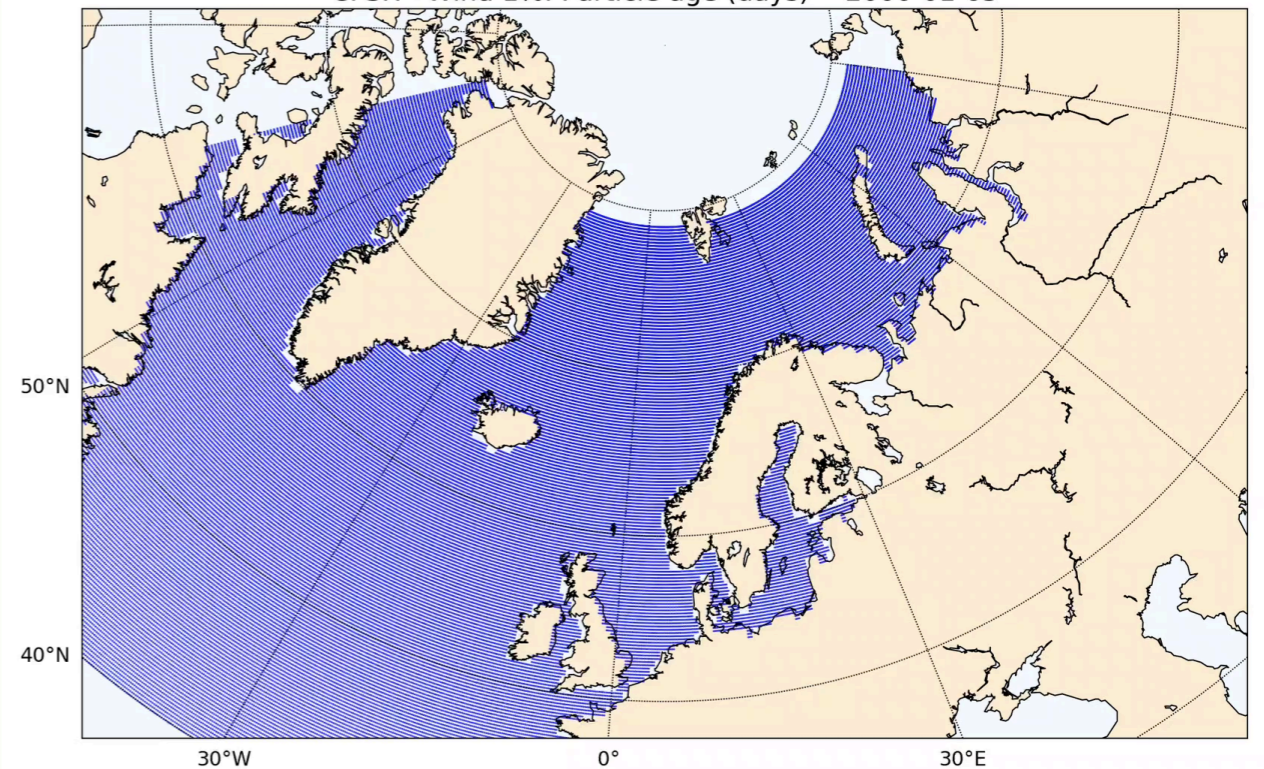
NEMO: Particle age (days) -- 2000-01-05



WWIII - Stokes: Particle age (days) -- 2000-01-05



CFSR - Wind 1%: Particle age (days) -- 2000-01-05

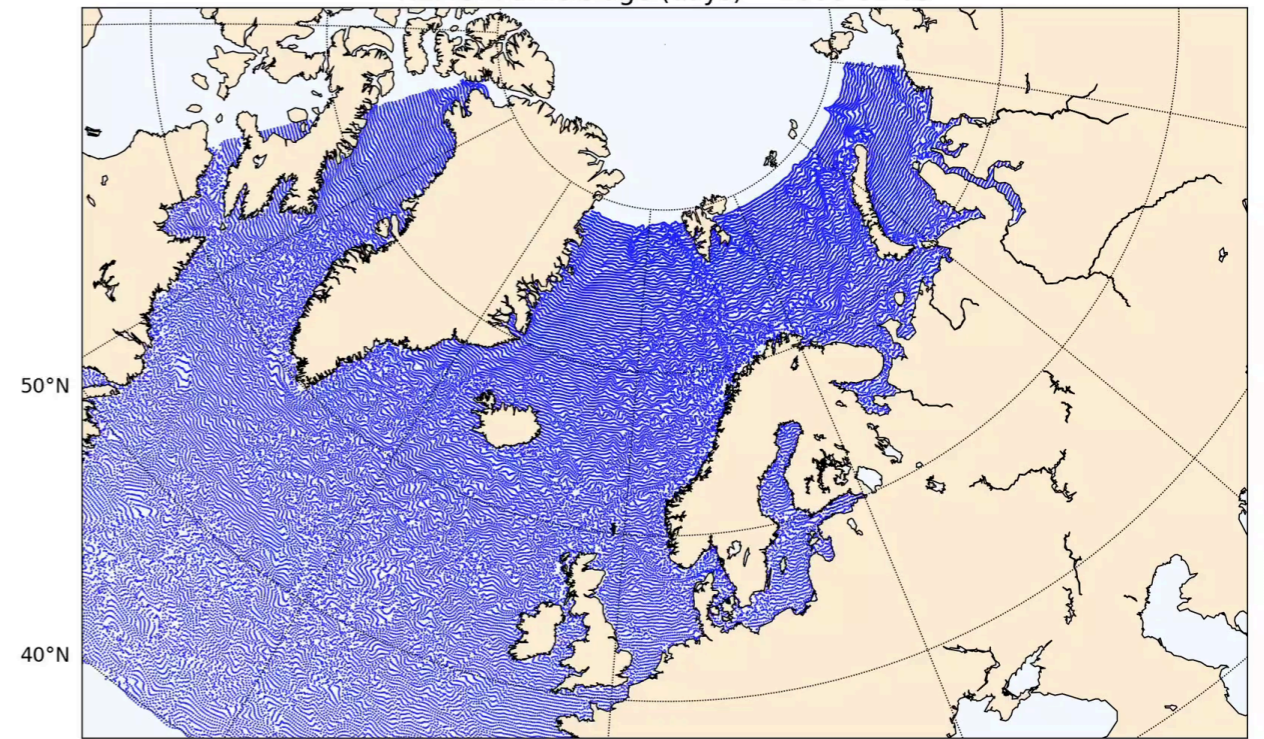


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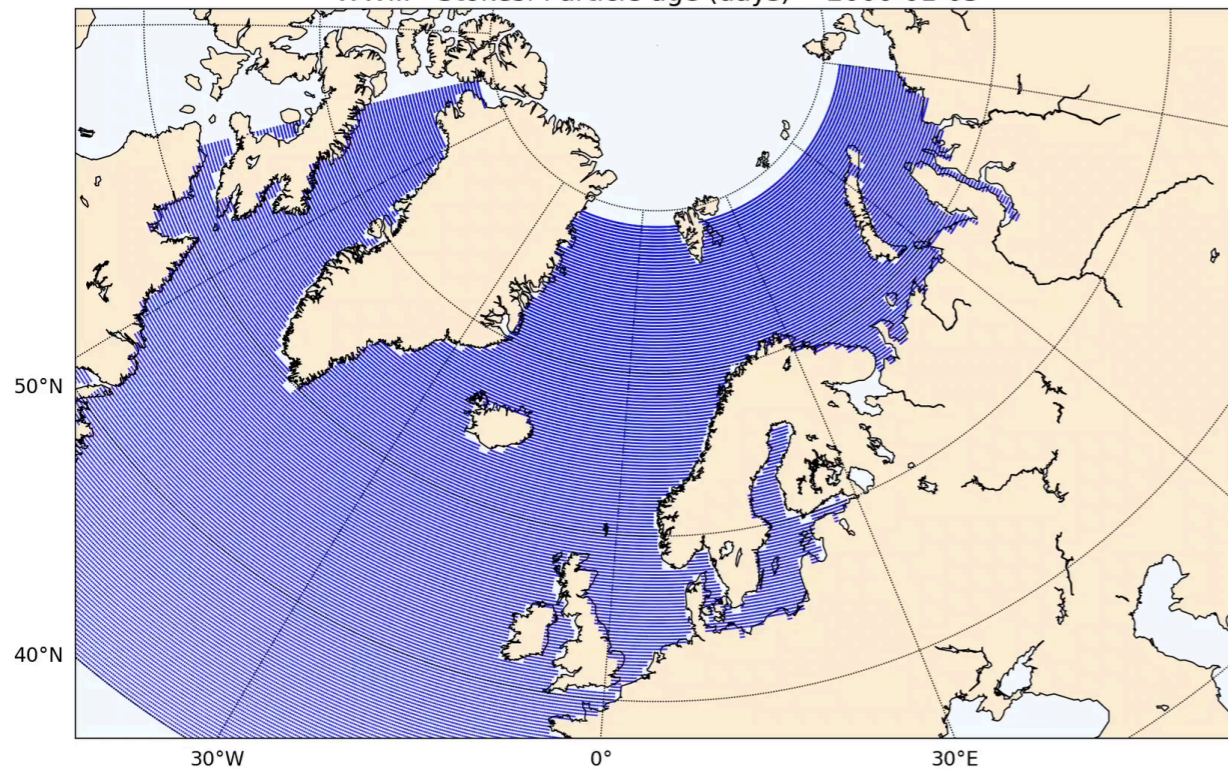
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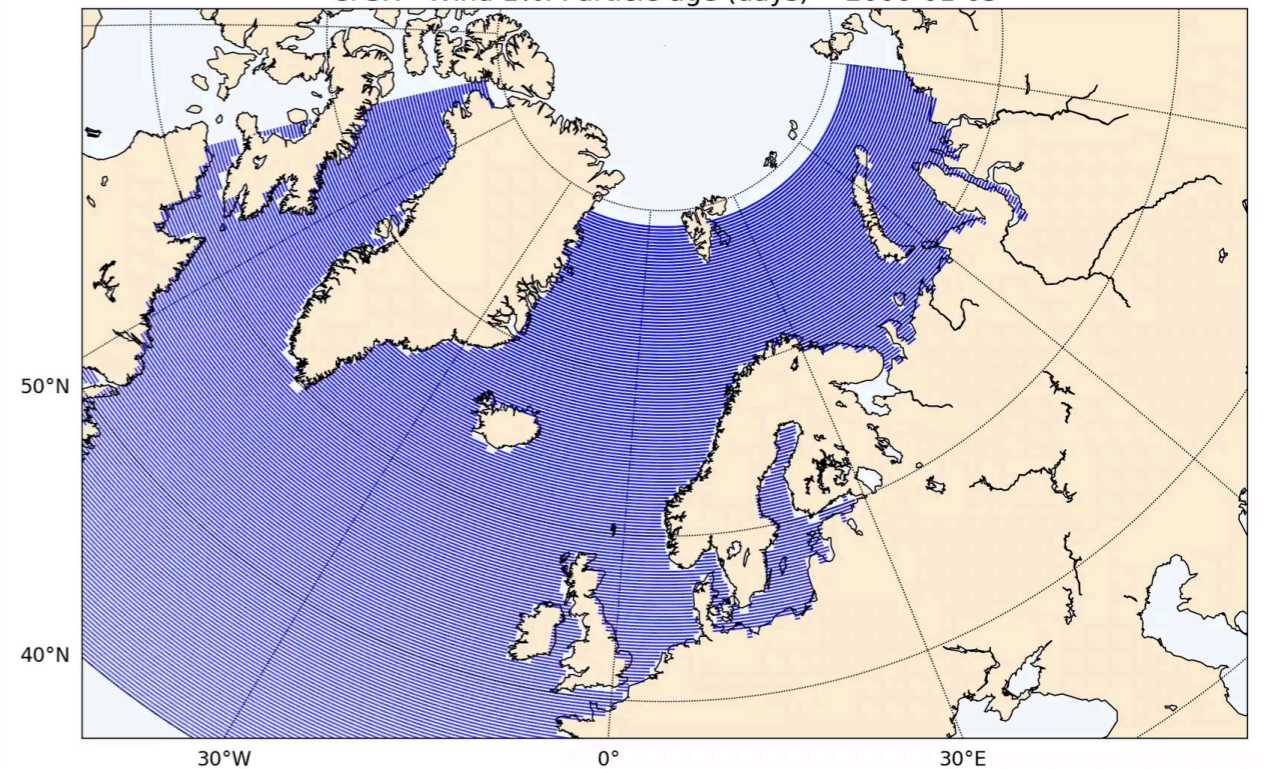
NEMO: Particle age (days) -- 2000-01-05



WWIII - Stokes: Particle age (days) -- 2000-01-05

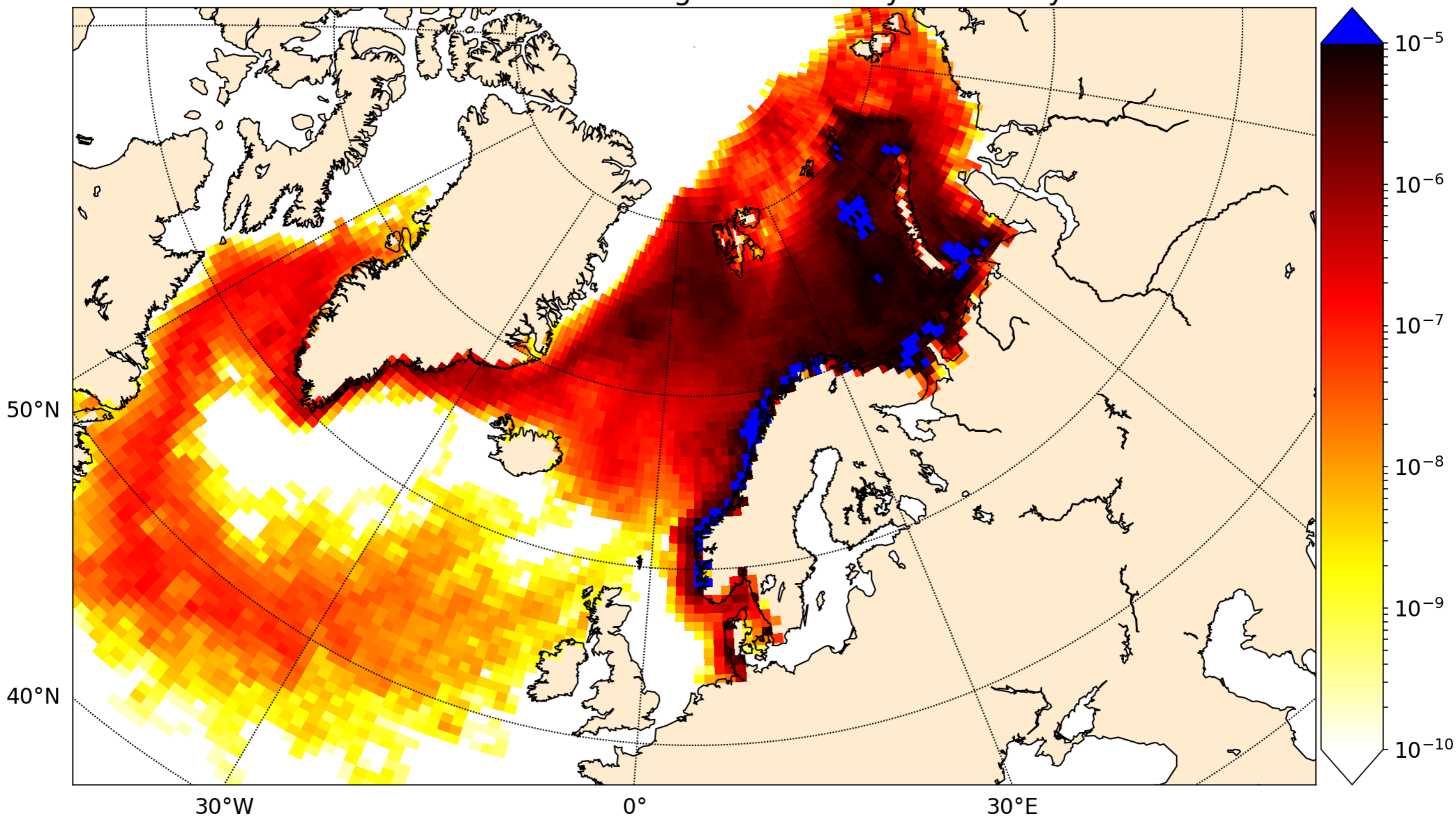


CFSR - Wind 1%: Particle age (days) -- 2000-01-05



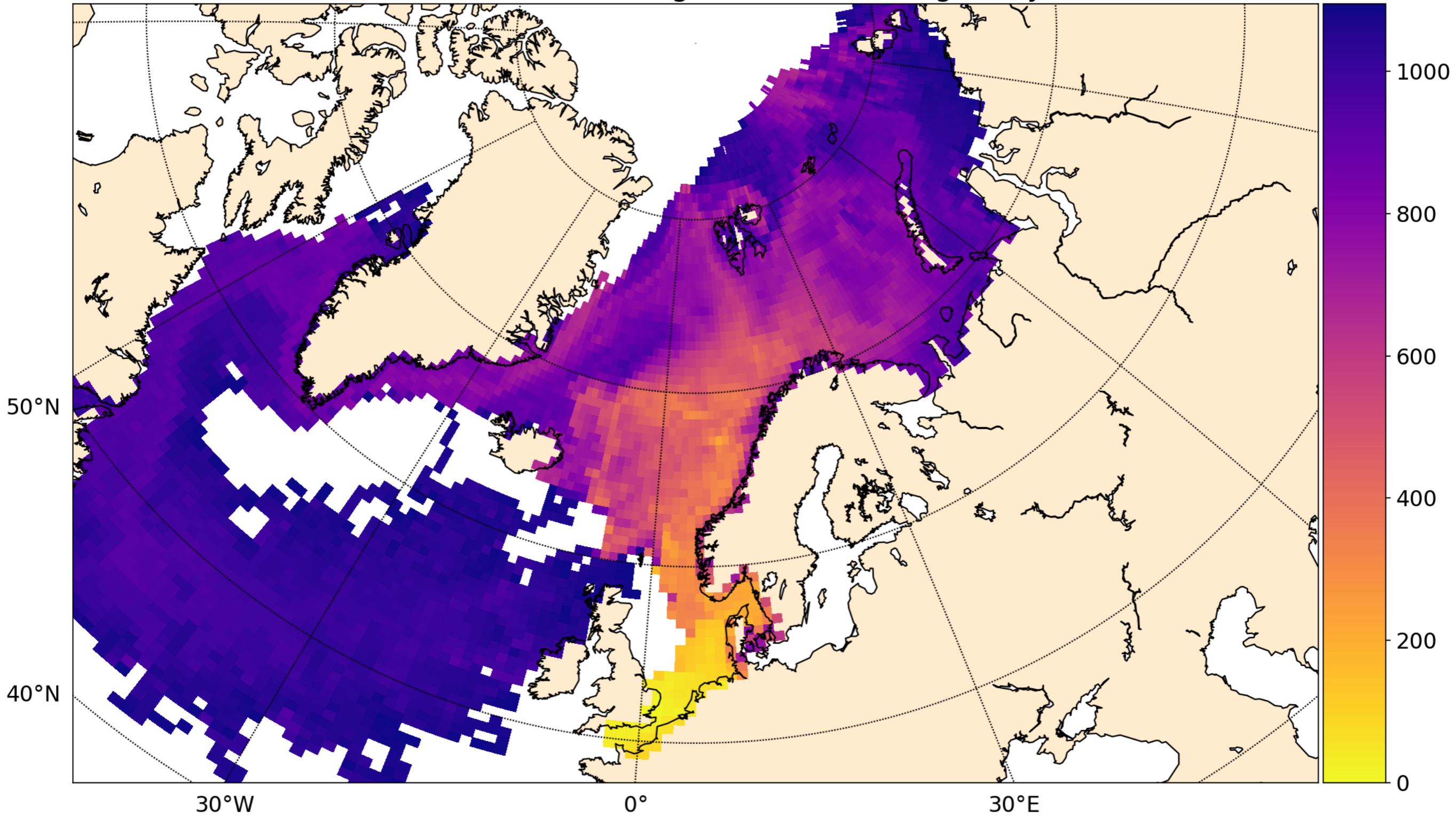
# PLASTIC 3RD YEAR DENSITY

NEMO-0083+Unbeaching: Particle 3rd year density



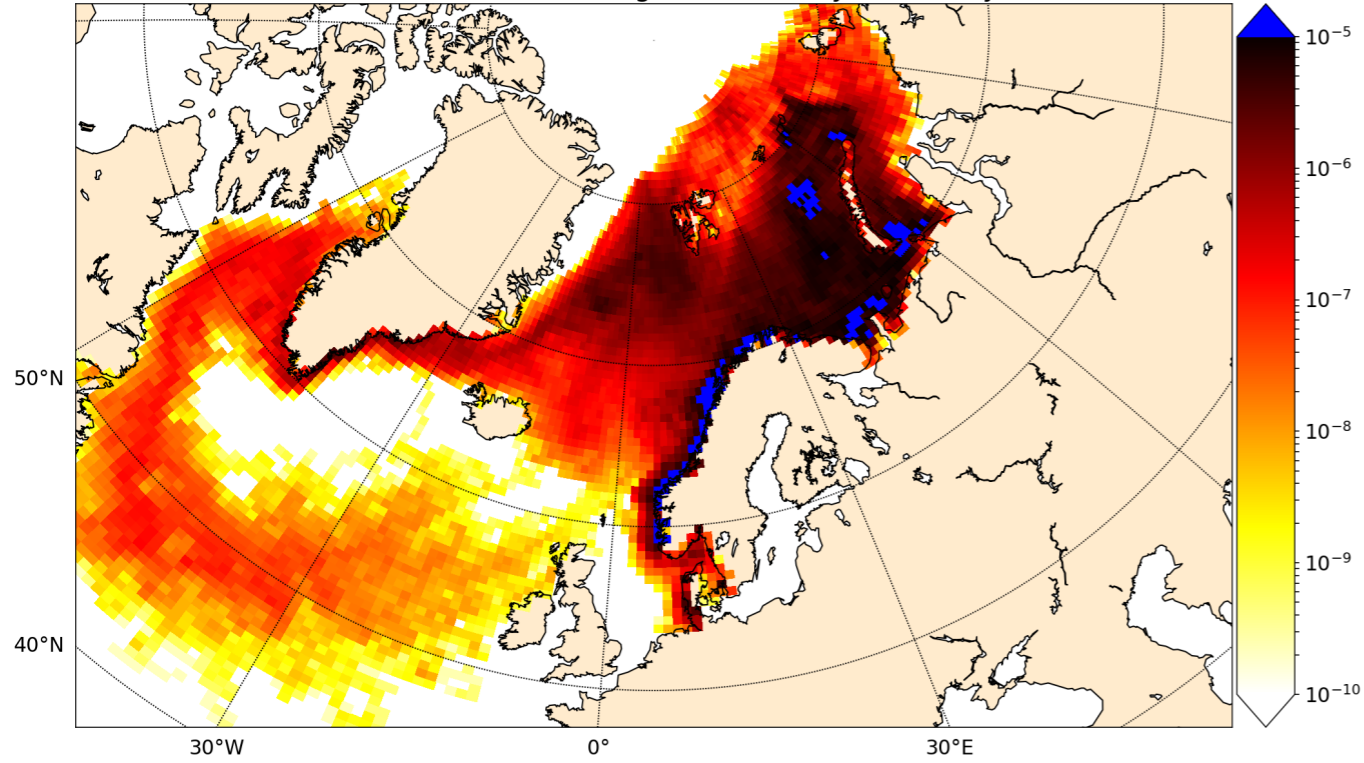
# PLASTIC MEAN AGE

NEMO-0083+Unbeaching: Particle mean age (days)

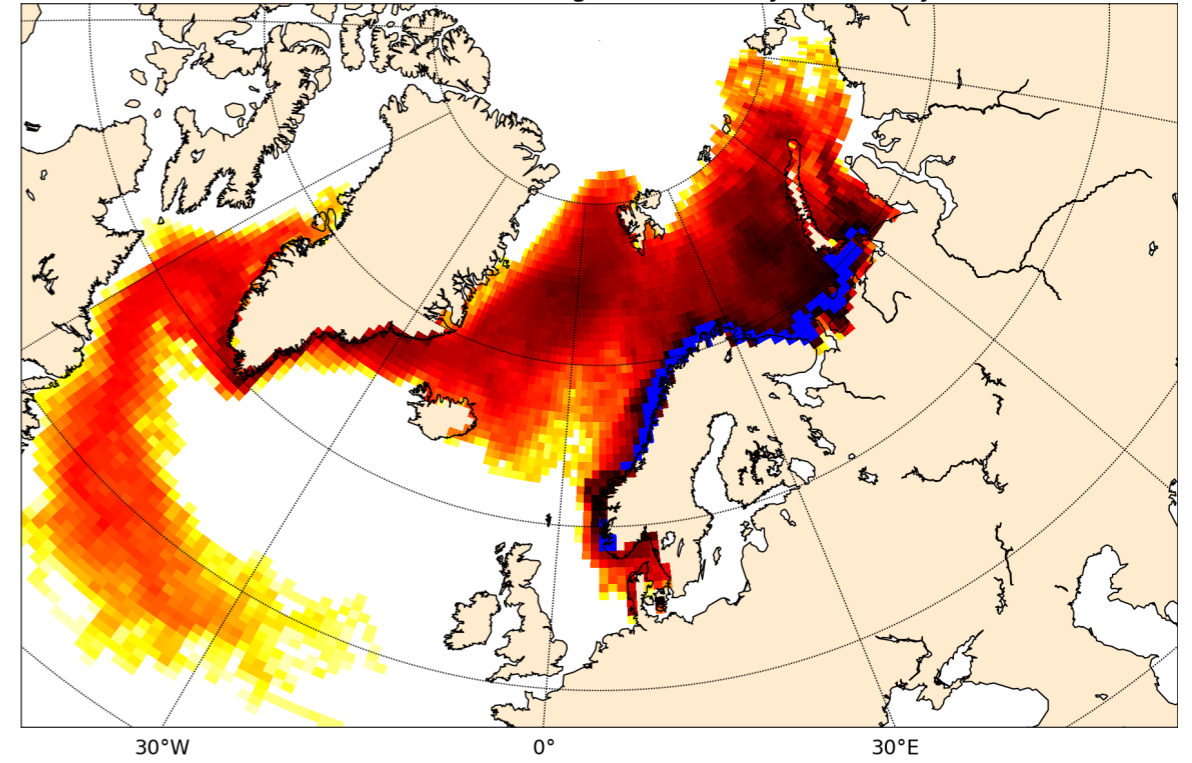


# INTER COMPARISON

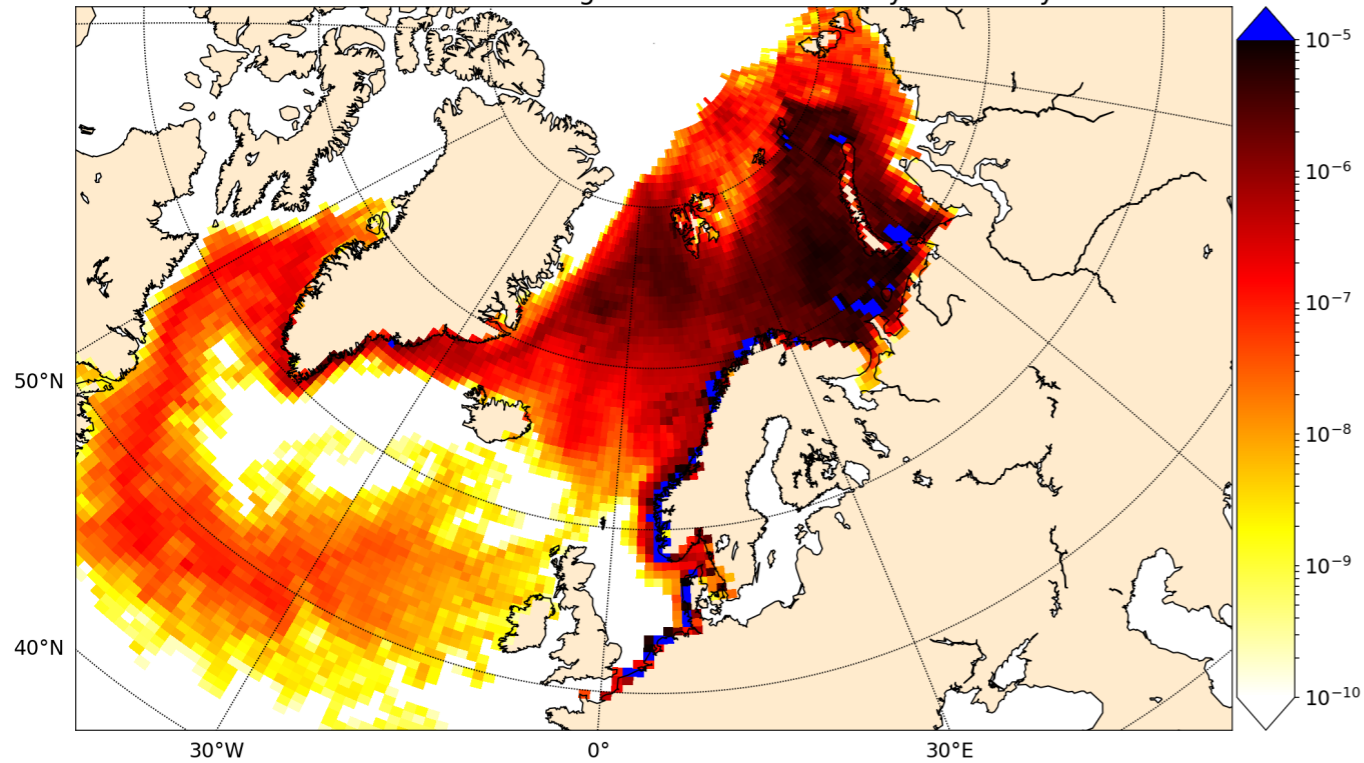
NEMO-0083+Unbeaching: Particle 3rd year density



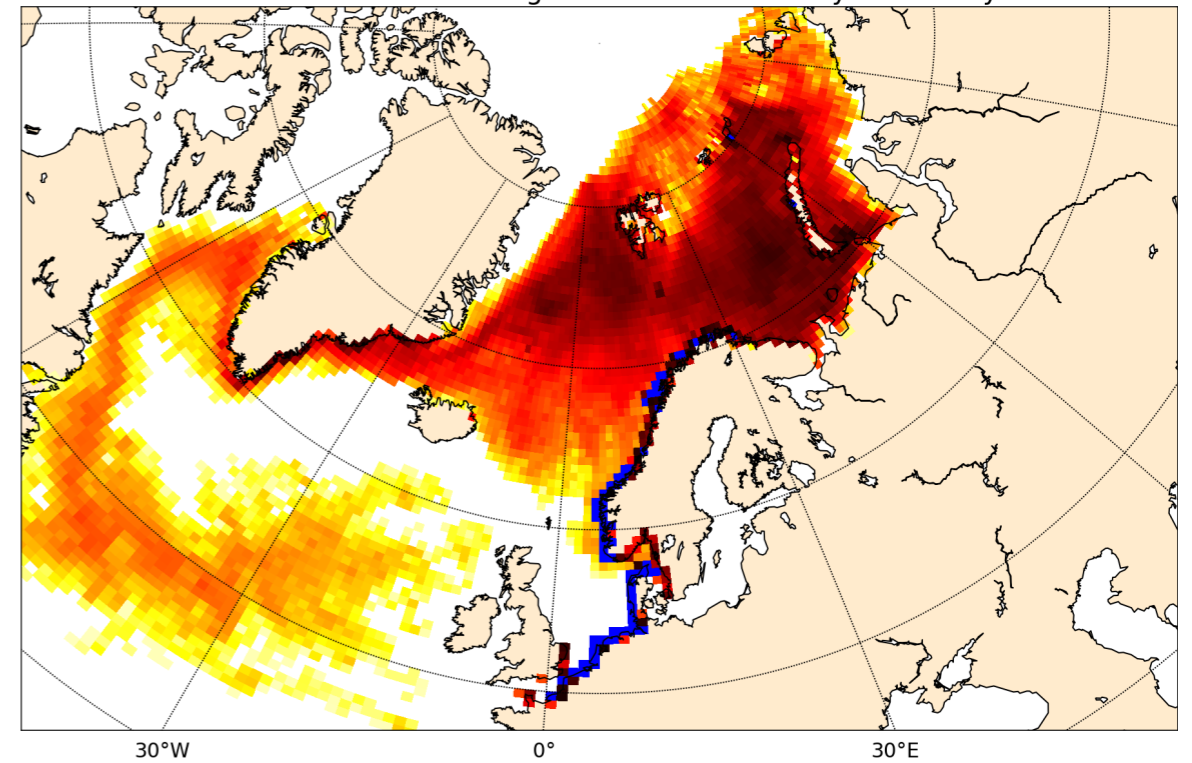
NEMO-025+Unbeaching: Particle 3rd year density



NEMO-0083+Unbeaching+Stokes: Particle 3rd year density

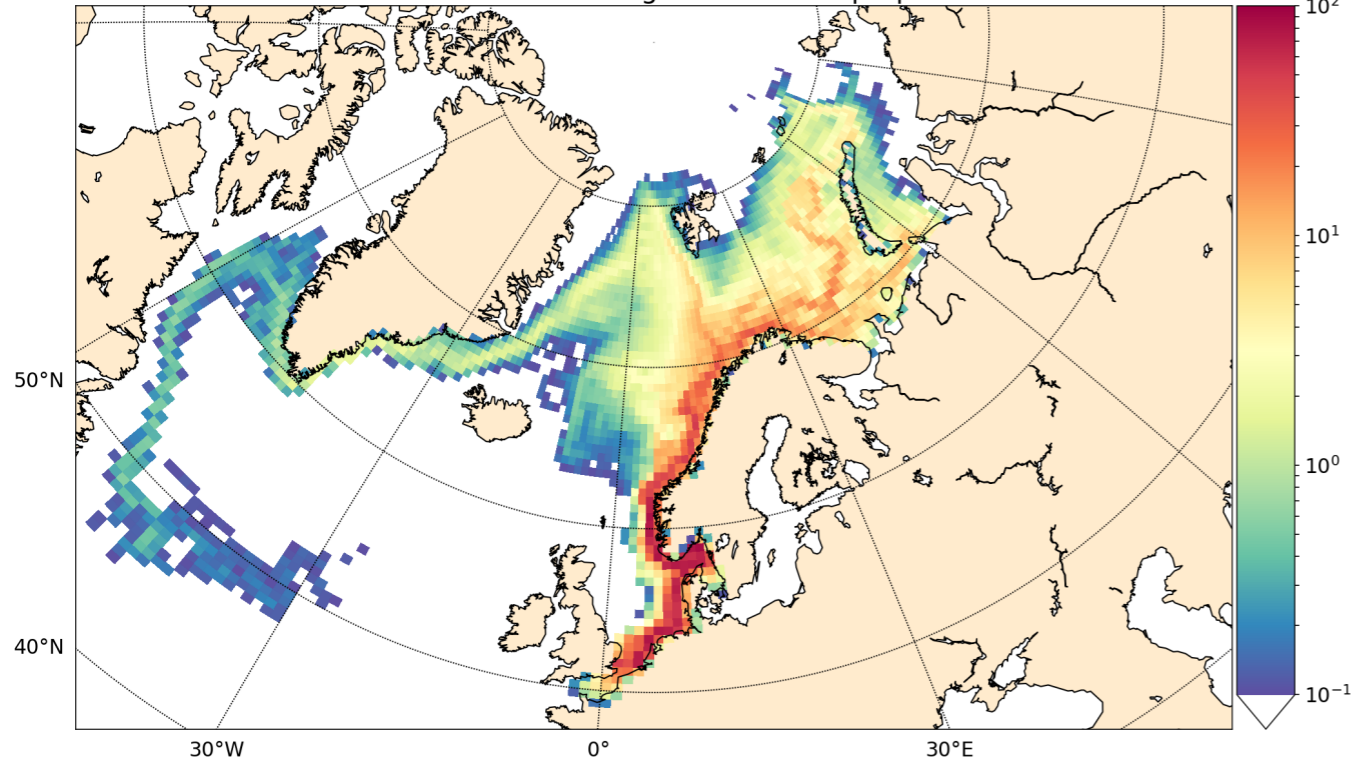


NEMO-0083+Unbeaching+diff1.0: Particle 3rd year density

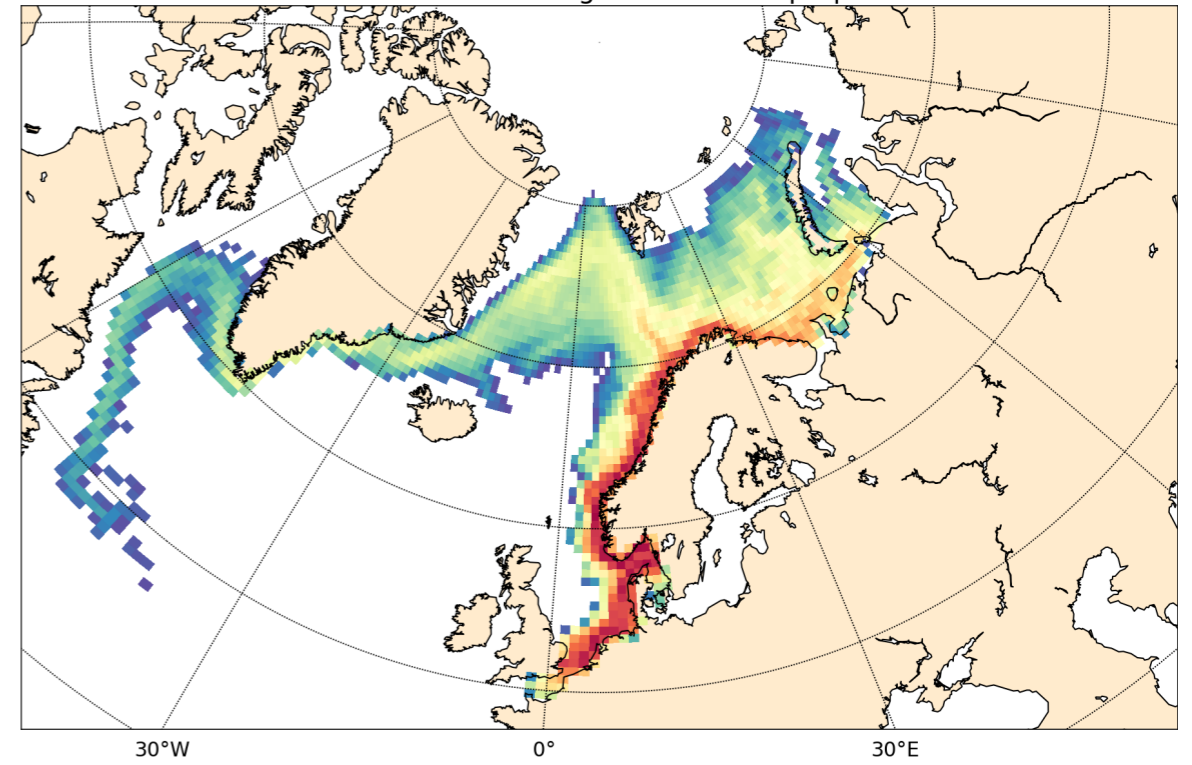


# INTER COMPARISON

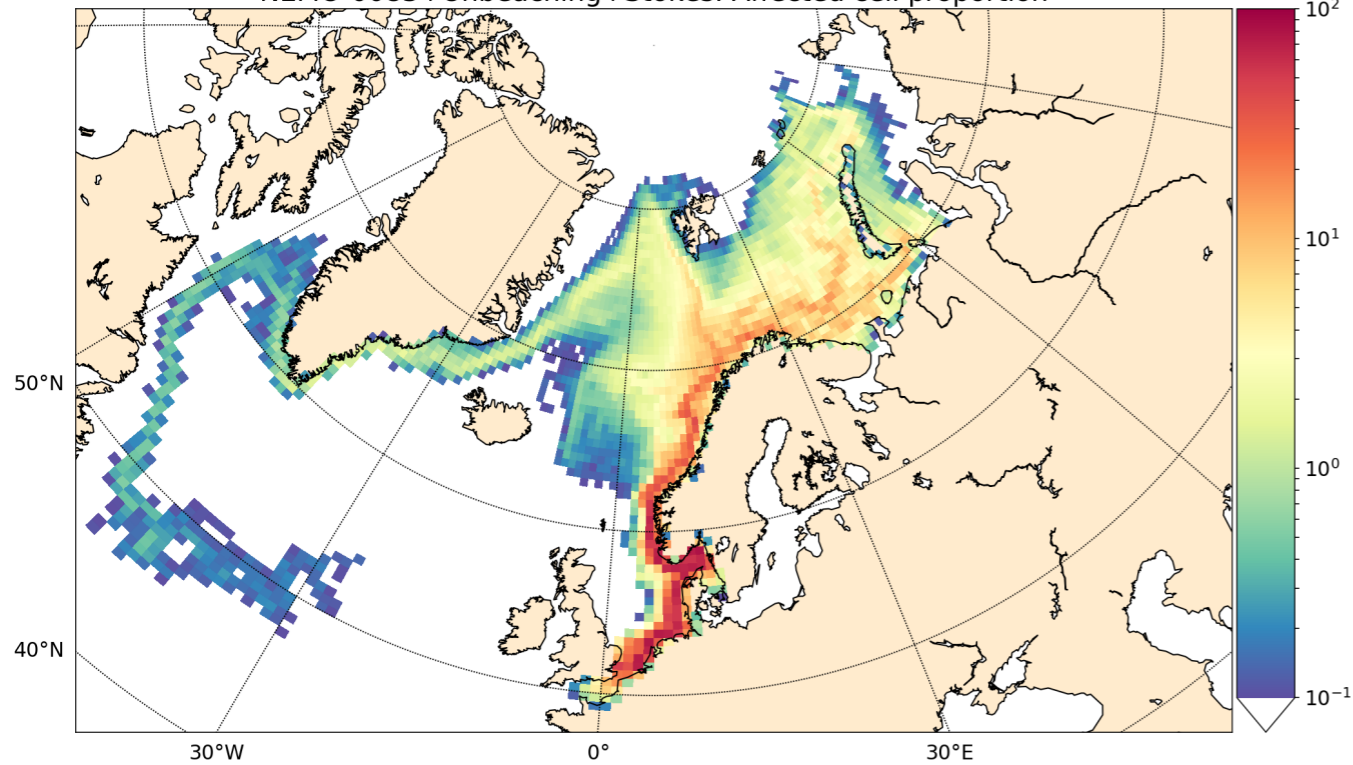
NEMO-0083+Unbeaching: Affected cell proportion



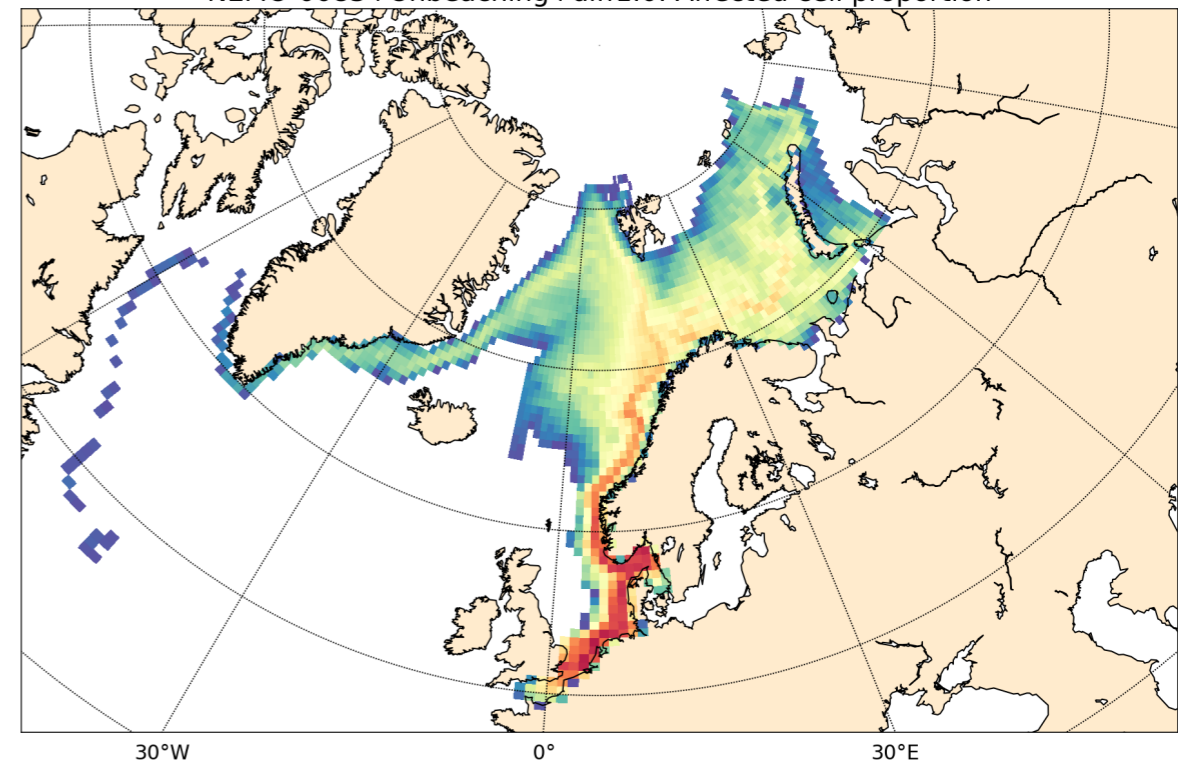
NEMO-025+Unbeaching: Affected cell proportion



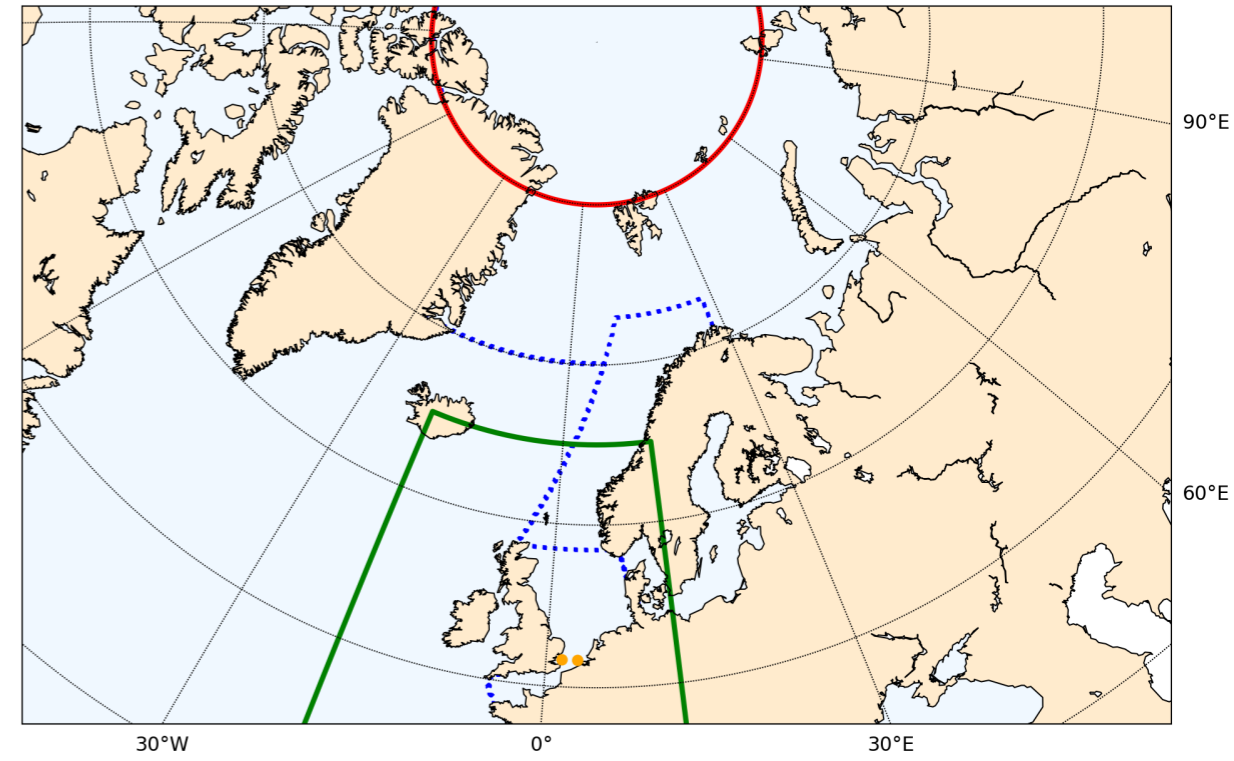
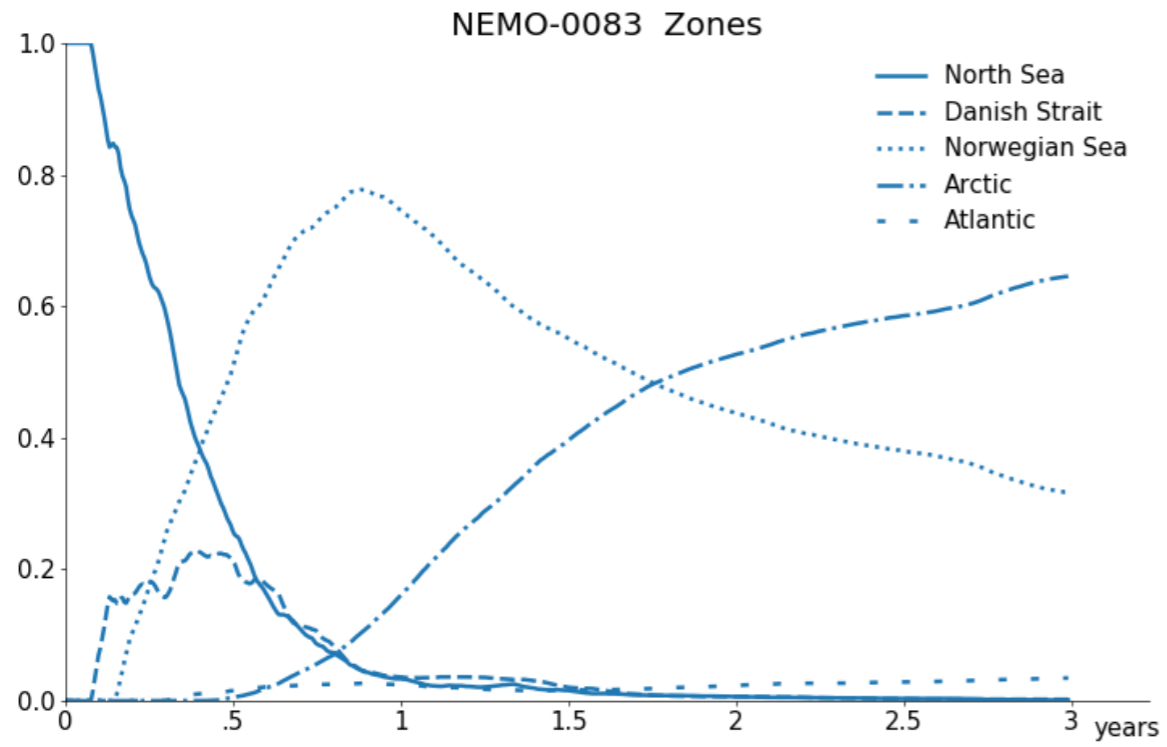
NEMO-0083+Unbeaching+Stokes: Affected cell proportion



NEMO-0083+Unbeaching+diff1.0: Affected cell proportion

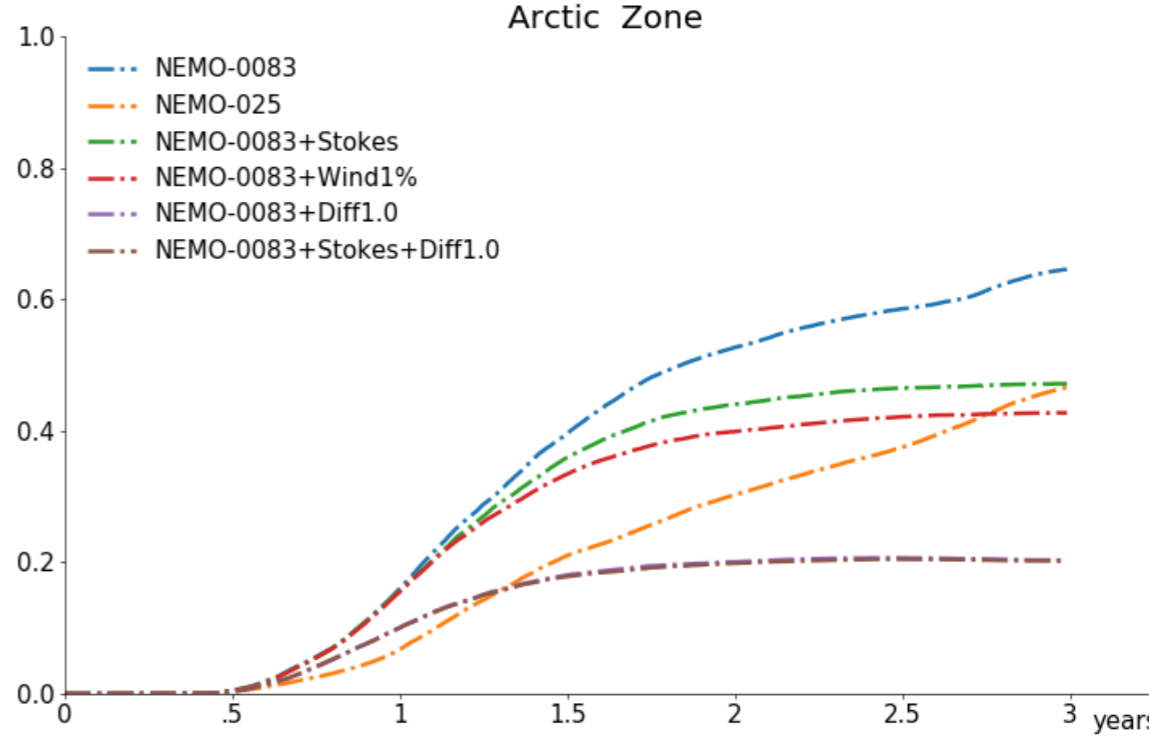
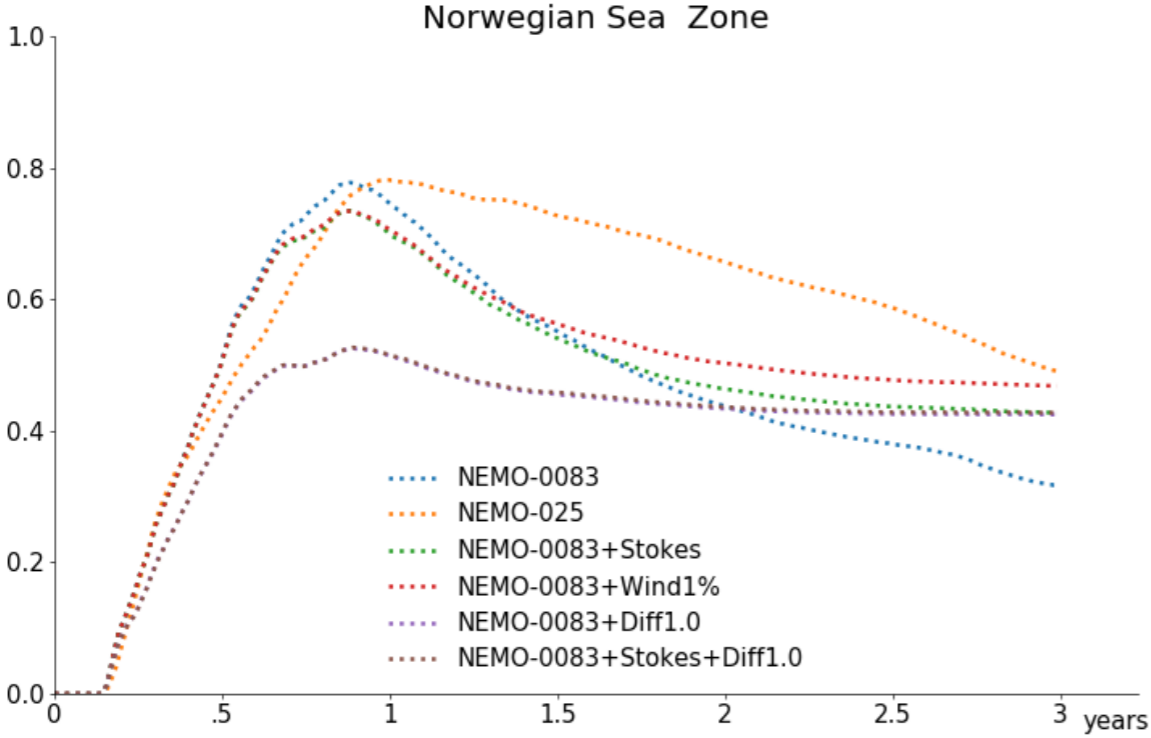
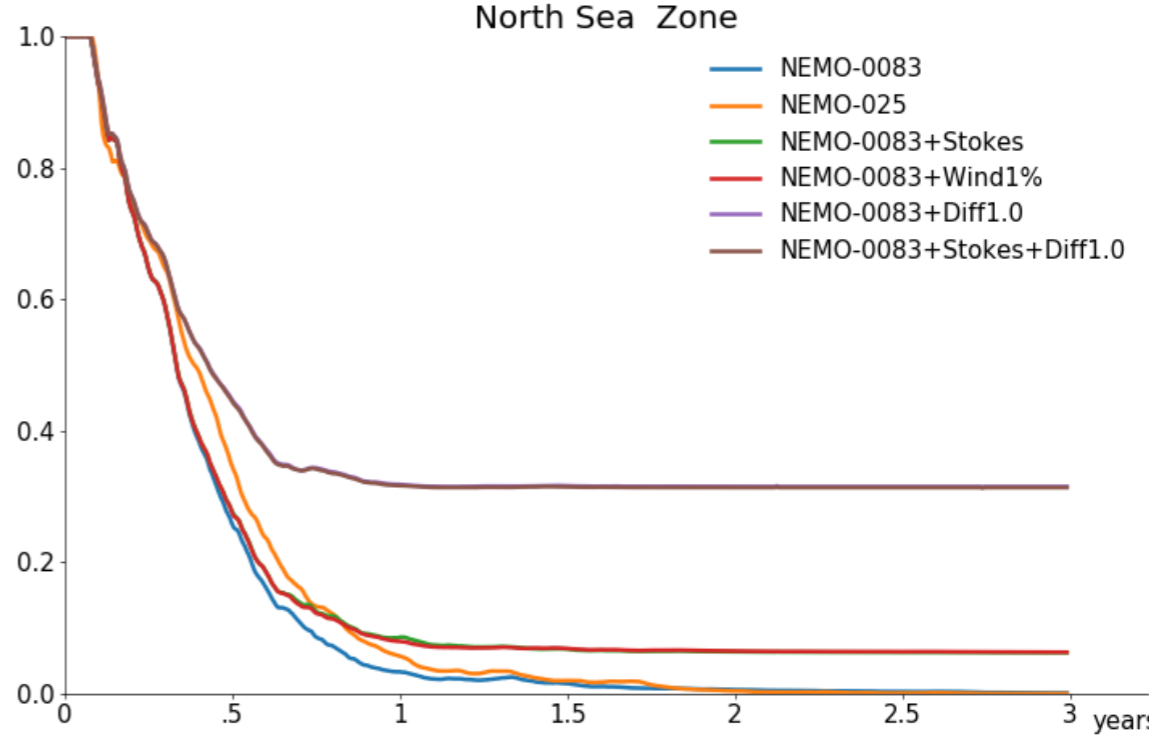
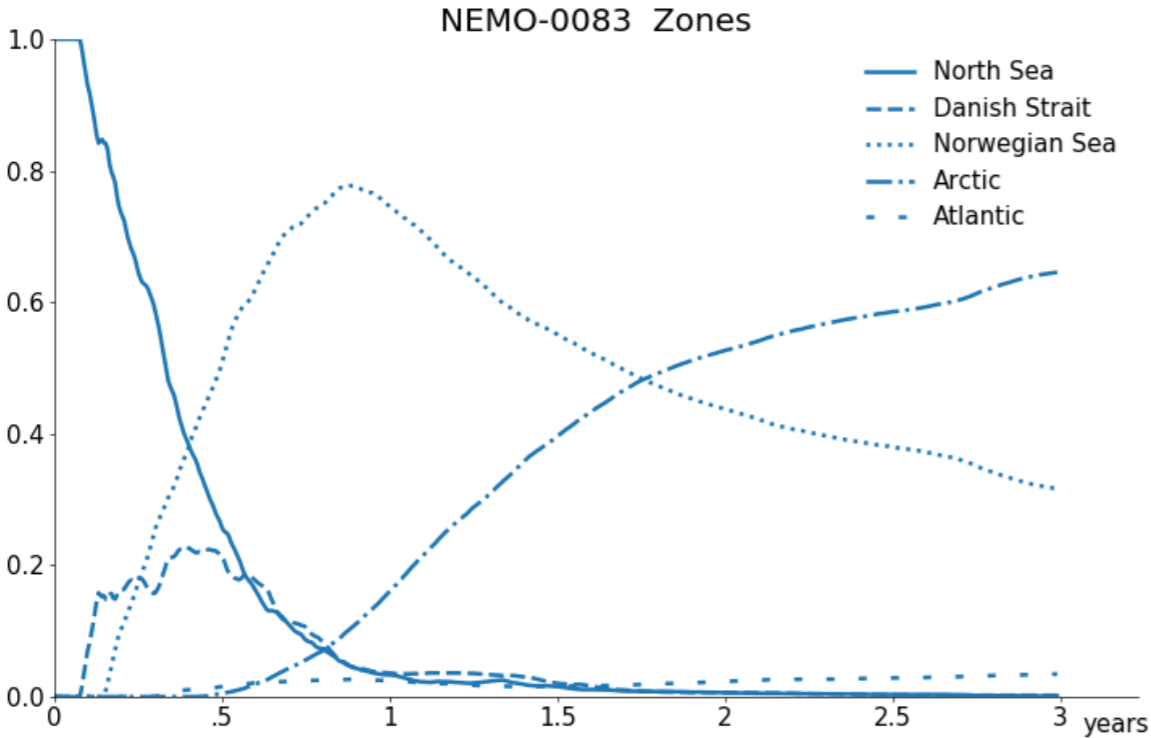


# BUDGET

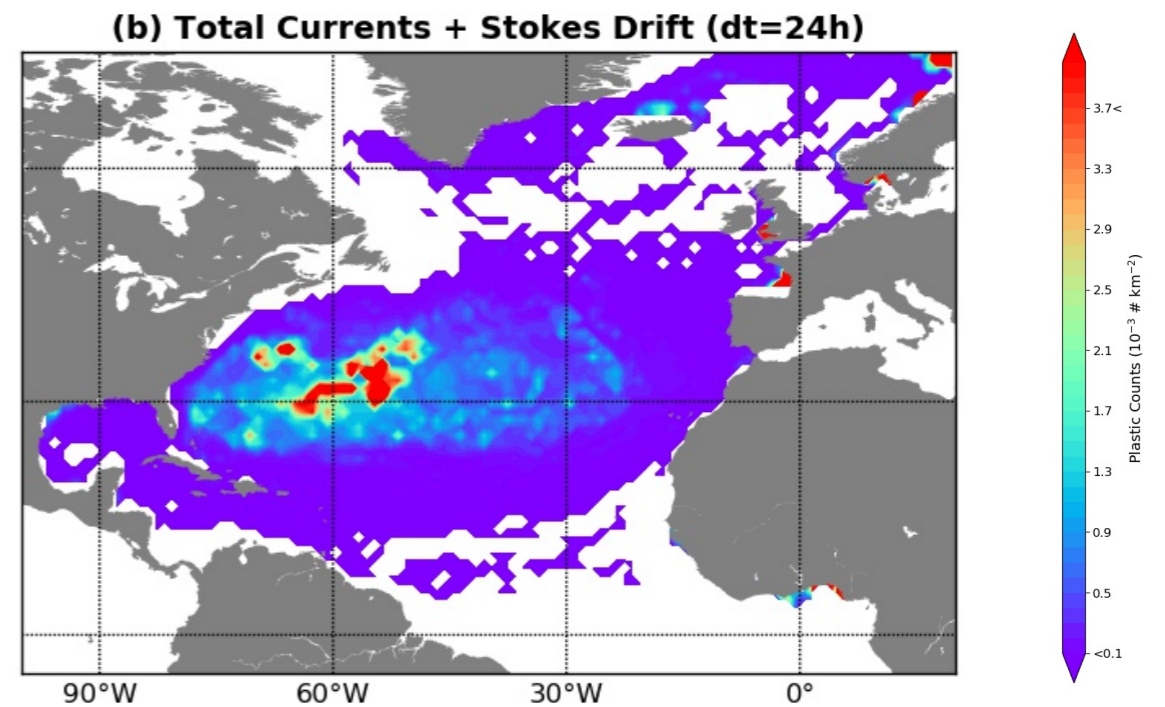
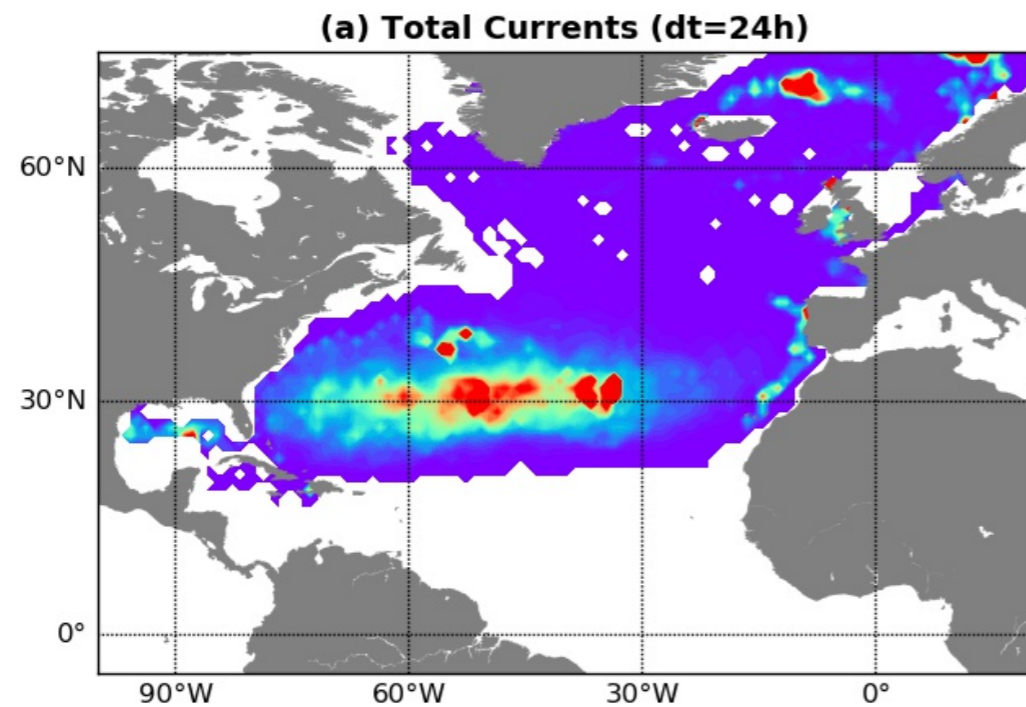
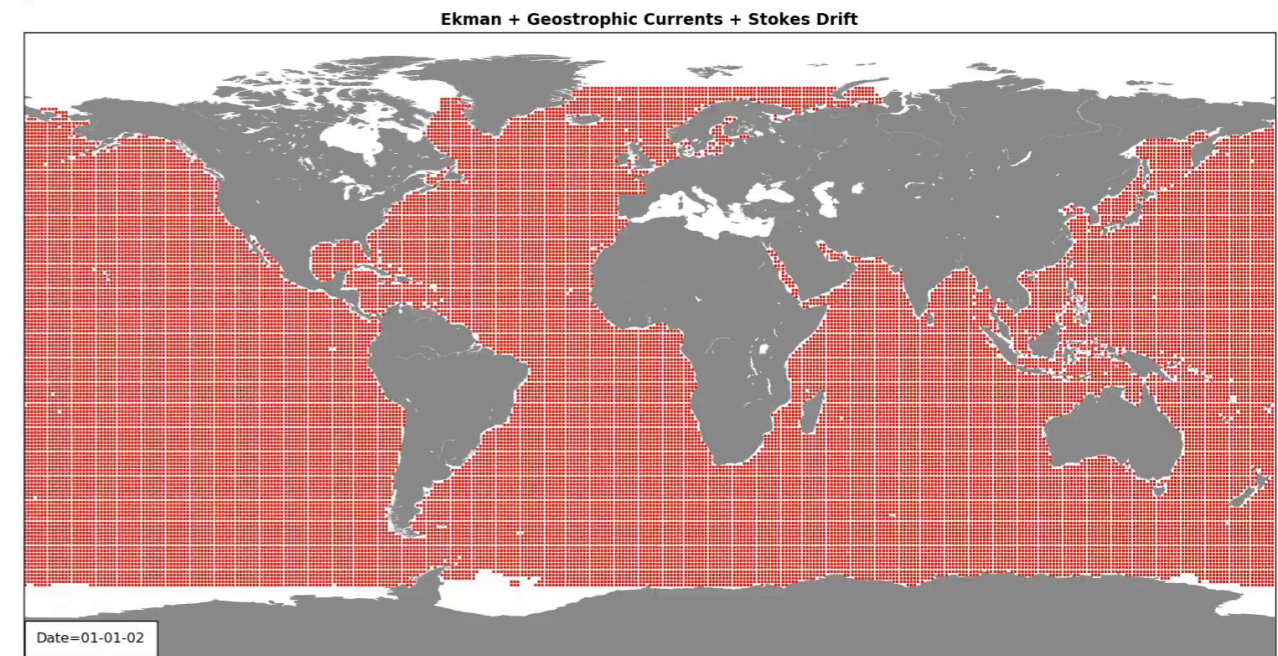
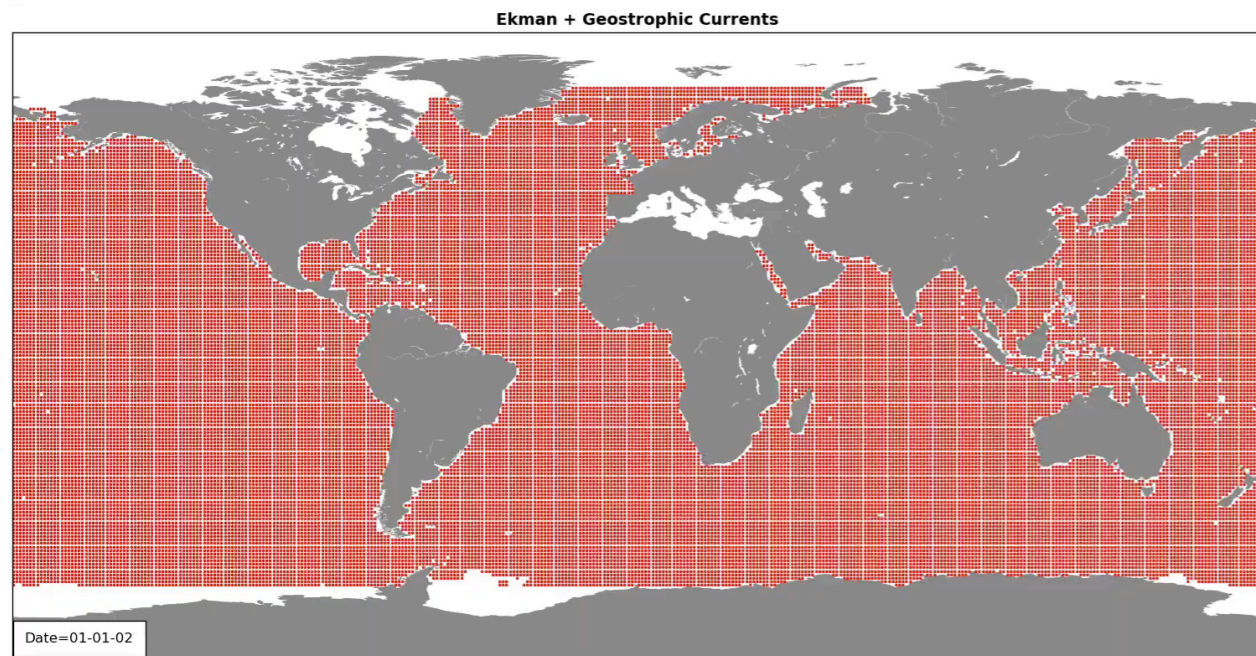




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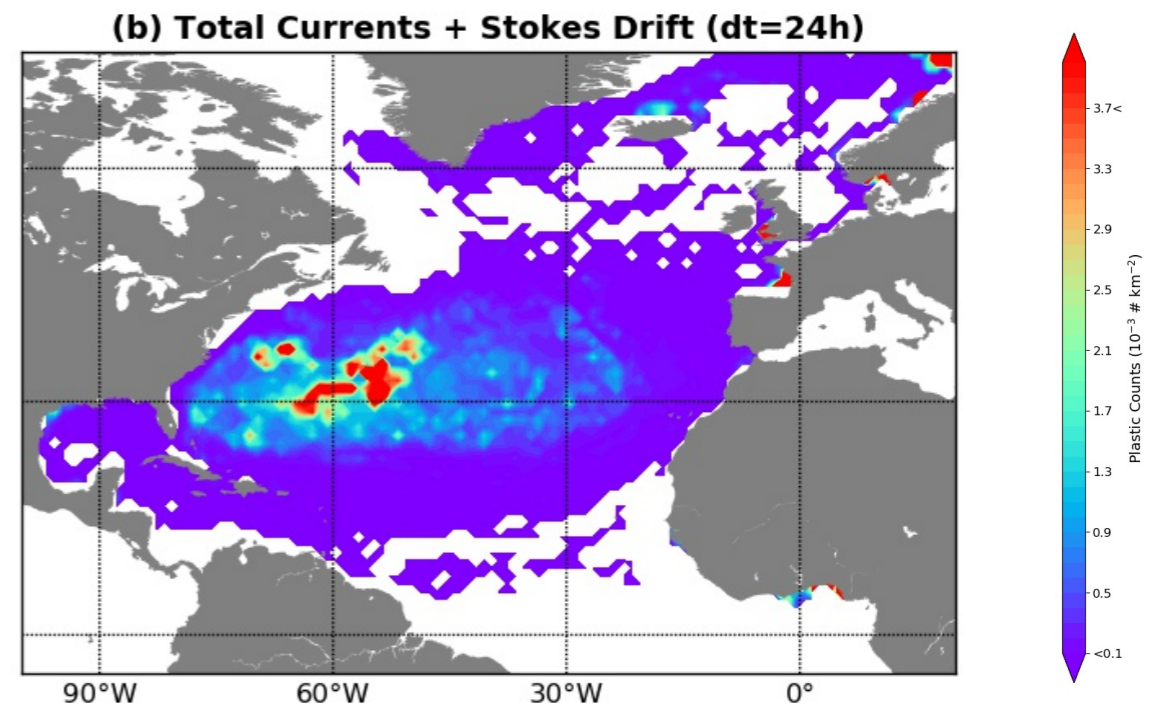
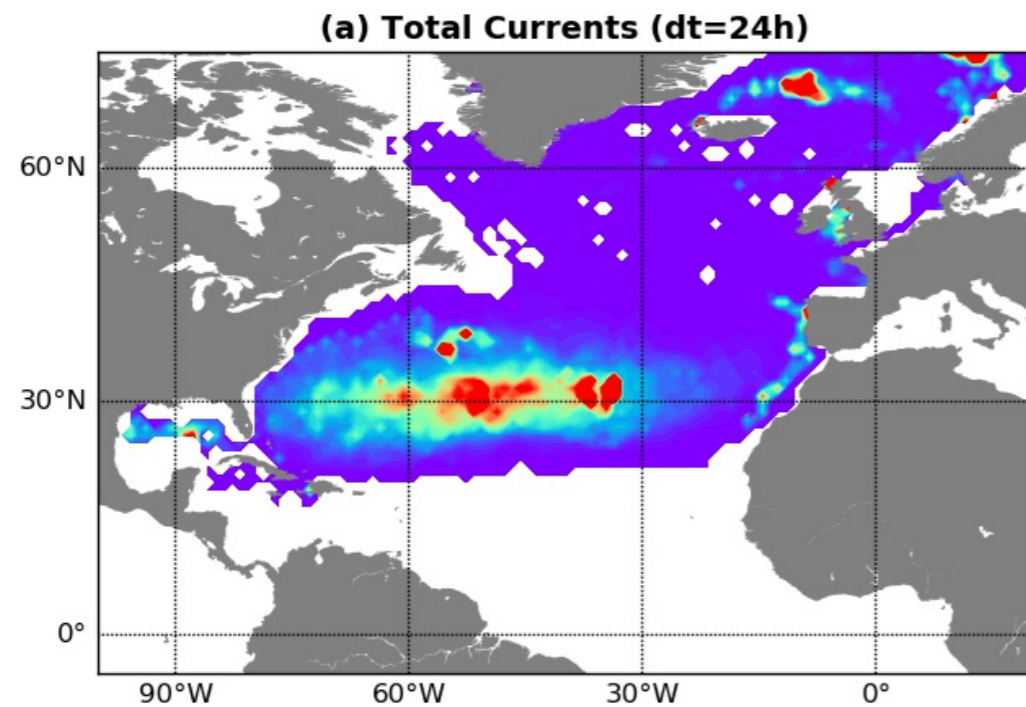
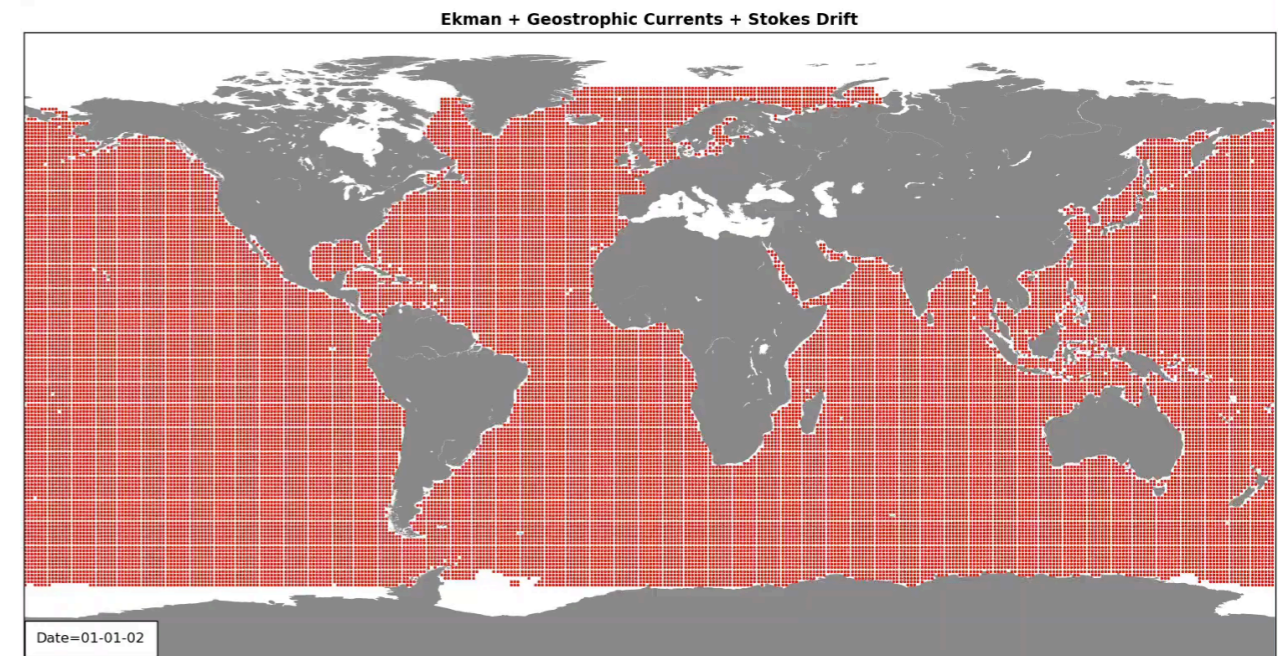
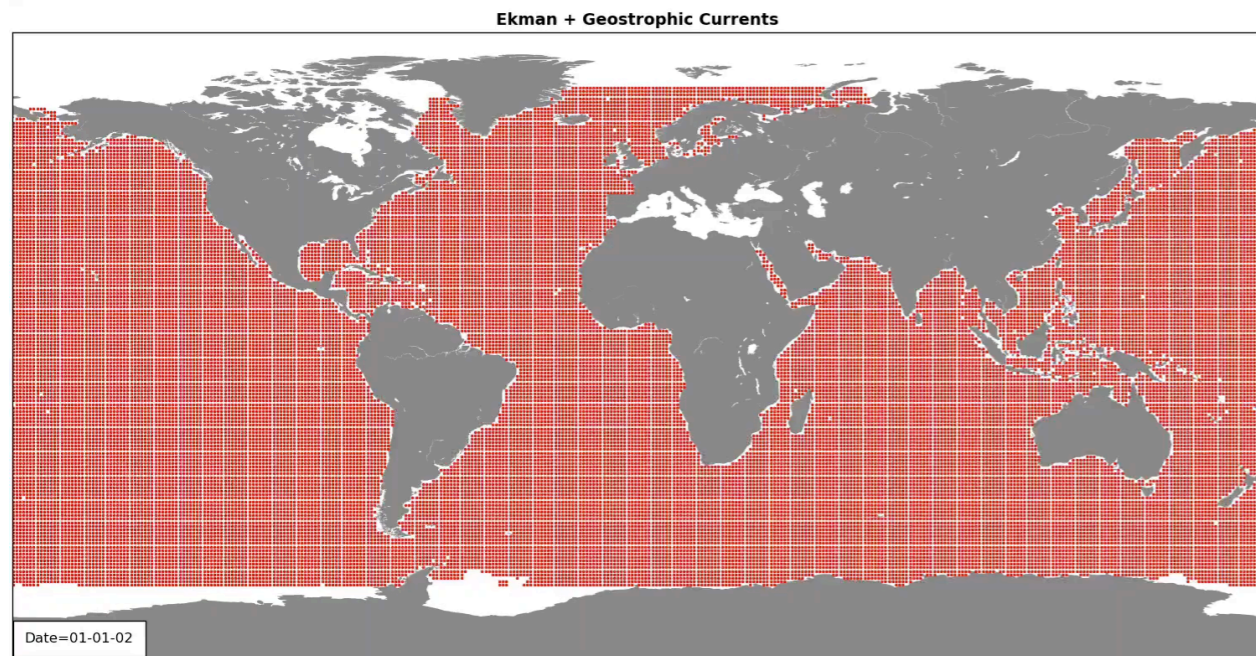


# GLOBAL SURFACE PLASTIC DISTRIBUTION



Onink et al. (2018, submitted)

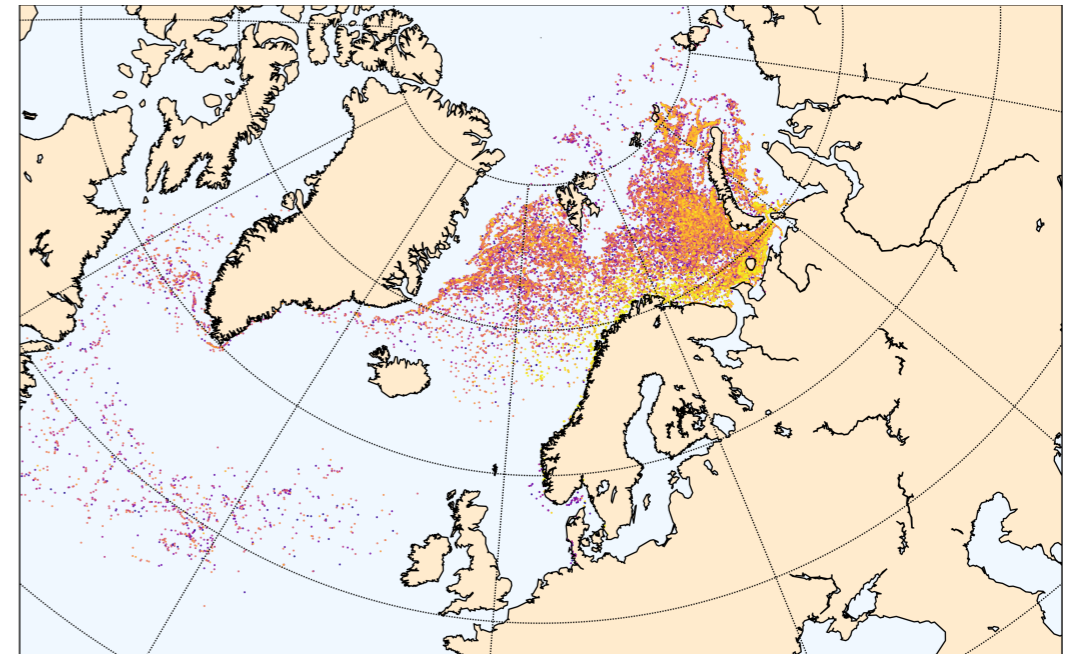
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Onink et al. (2018, submitted)

# CONCLUSION

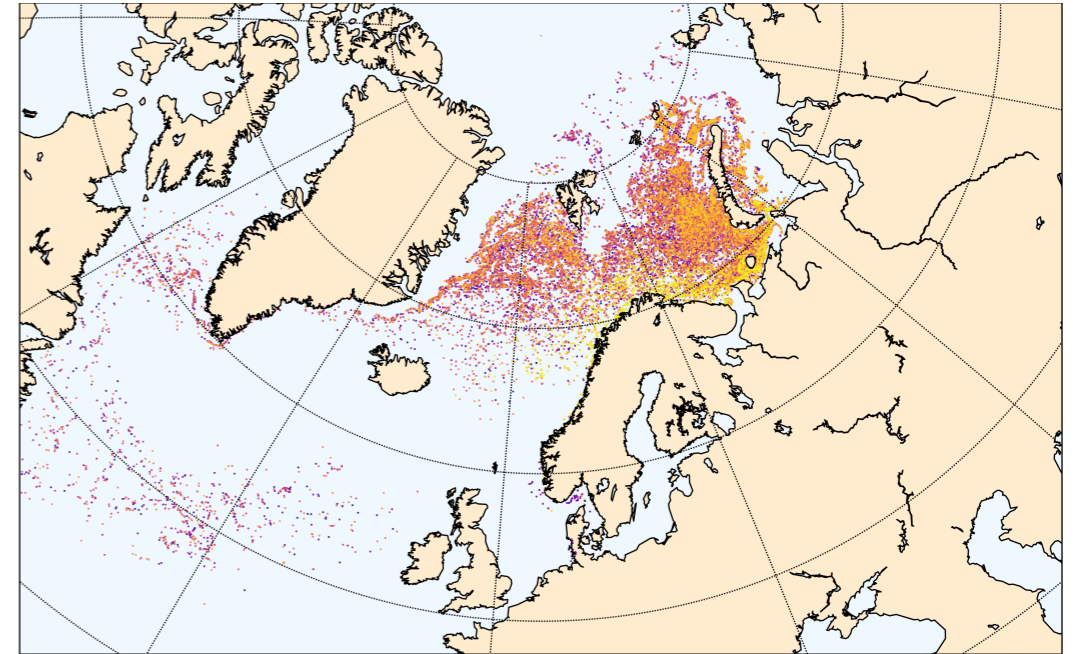
- Processes controlling the pathways of floating plastic:
  - Stokes drift is a major actor in high latitudes and coastal areas
  - Diffusion cannot be ignored. How to parametrise it ?
  - Coastal zones sensitive to resolution
- Parcels:
  - Reads different fields / grids / formats
  - Easy / efficient / customisable



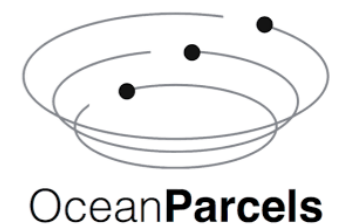
Ocean**Parcels**

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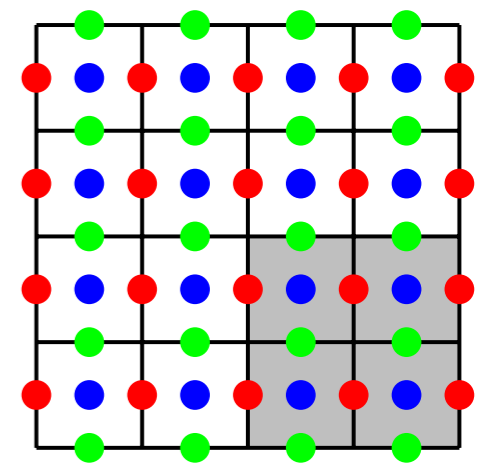
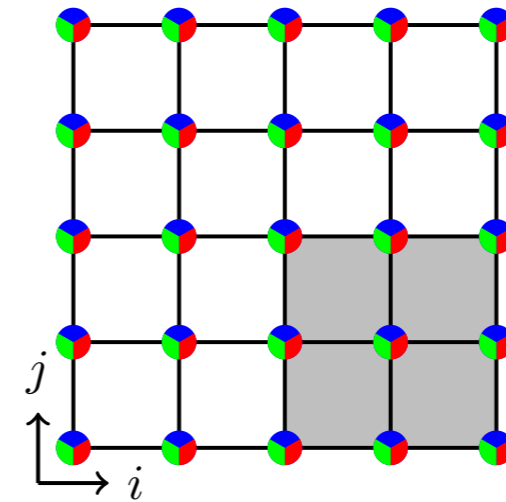
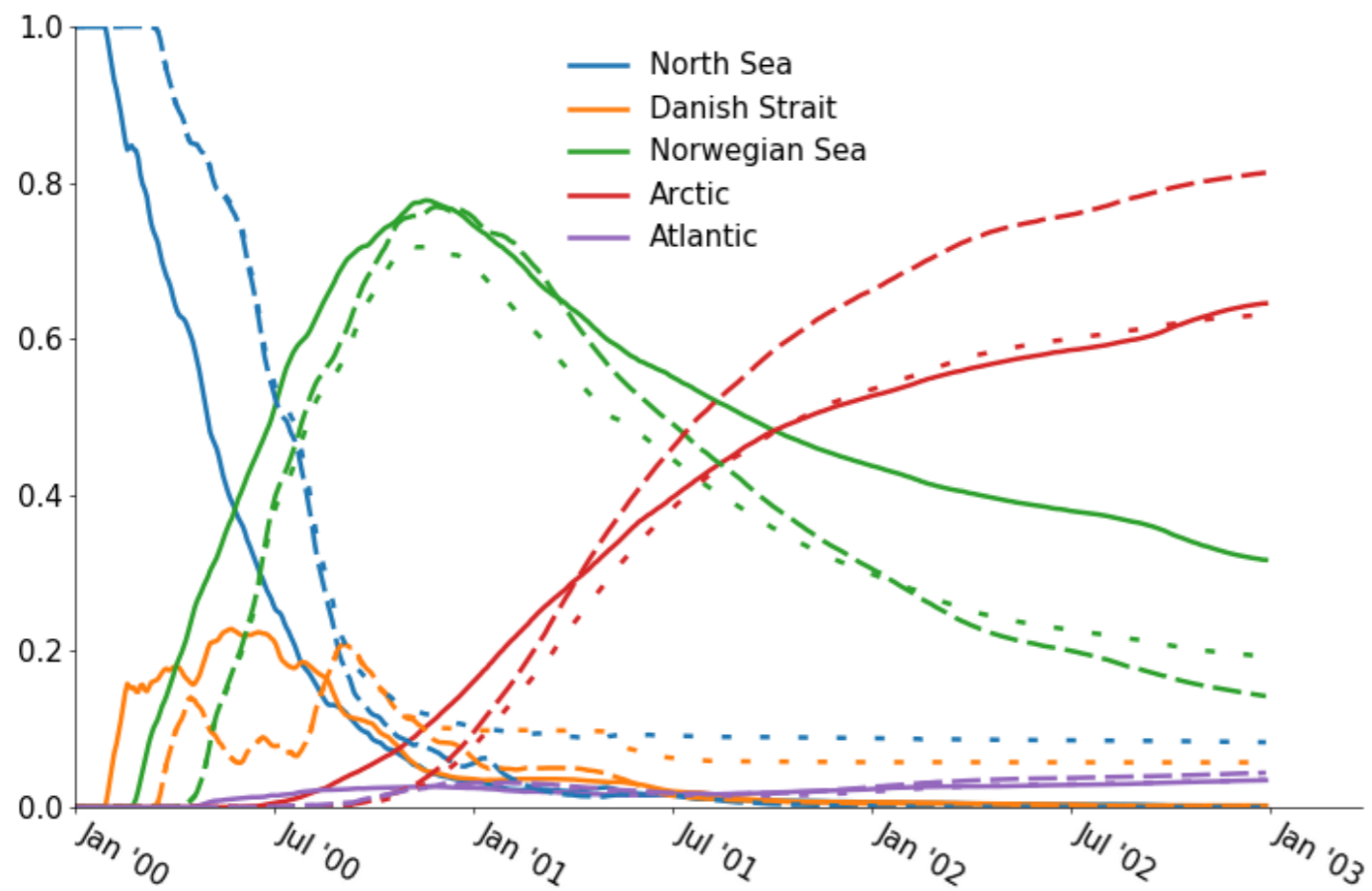


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# UNBEACHING PARAMETRISATION

- NEMO + local unbeaching
- - - NEMO + CMEMS + proximity unbeaching
- ..... NEMO + CMEMS + local unbeaching



# WWV III - STOKES VS WIND

