



Meningsfullt med
Matematisk,
Modellering,
av
Mikroplast,
i vårt
Marine
Miljø?

Motivasjon og
Metoder

Team for modelleringsaktiviteten



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Matematisk Institutt



$$\frac{\partial DU}{\partial x} + \frac{\partial DV}{\partial y} + \frac{\partial \omega}{\partial \sigma} + \frac{\partial \eta}{\partial t} = 0$$

$$\frac{\partial UD}{\partial t} + \frac{\partial U^2 D}{\partial x} + \frac{\partial UVD}{\partial y} + \frac{\partial U\omega}{\partial \sigma} - fVD + gD \frac{\partial \eta}{\partial x} + \frac{gD^2}{\rho_o} \int_{\sigma}^{\sigma'} \left[\frac{\partial \rho'}{\partial x} - \frac{\sigma'}{D} \frac{\partial D}{\partial x} \frac{\partial \rho'}{\partial \sigma'} \right] d\sigma' = \frac{\partial}{\partial \sigma} \left[\frac{K_M}{D} \frac{\partial U}{\partial \sigma} \right] + F_x$$

$$\frac{\partial VD}{\partial t} + \frac{\partial UVD}{\partial x} + \frac{\partial V^2 D}{\partial y} + \frac{\partial V\omega}{\partial \sigma} + fUD + gD \frac{\partial \eta}{\partial y} + \frac{gD^2}{\rho_o} \int_{\sigma}^{\sigma'} \left[\frac{\partial \rho'}{\partial y} - \frac{\sigma'}{D} \frac{\partial D}{\partial y} \frac{\partial \rho'}{\partial \sigma'} \right] d\sigma' = \frac{\partial}{\partial \sigma} \left[\frac{K_M}{D} \frac{\partial V}{\partial \sigma} \right] + F_y$$

$$\frac{\partial TD}{\partial t} + \frac{\partial TUD}{\partial x} + \frac{\partial TVD}{\partial y} + \frac{\partial T\omega}{\partial \sigma} = \frac{\partial}{\partial \sigma} \left[\frac{K_H}{D} \frac{\partial T}{\partial \sigma} \right] + F_T - \frac{\partial R}{\partial z}$$

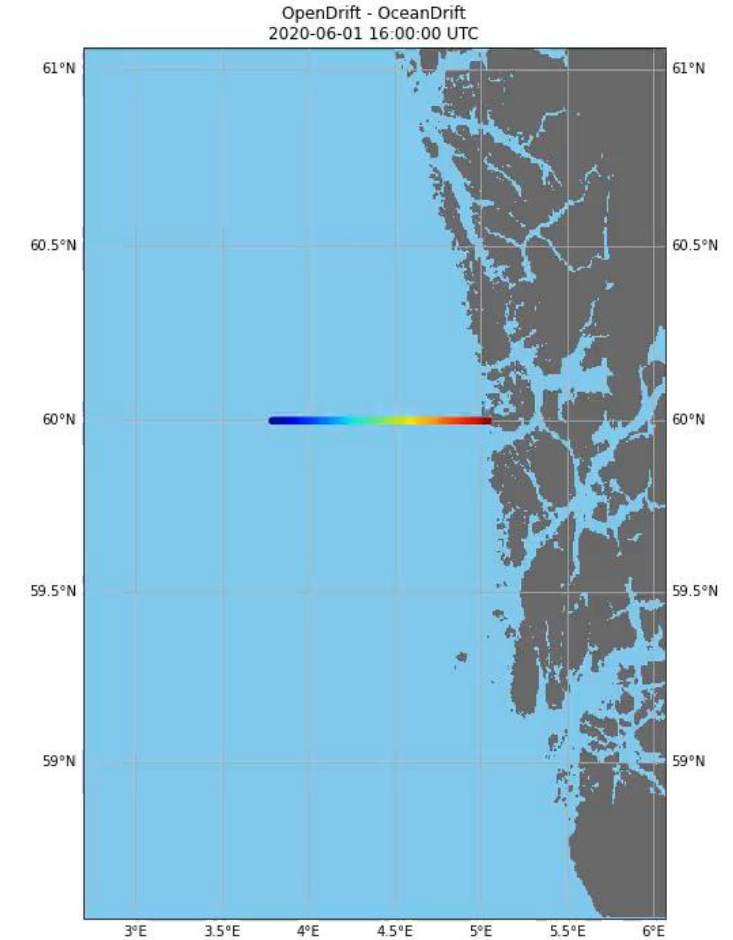
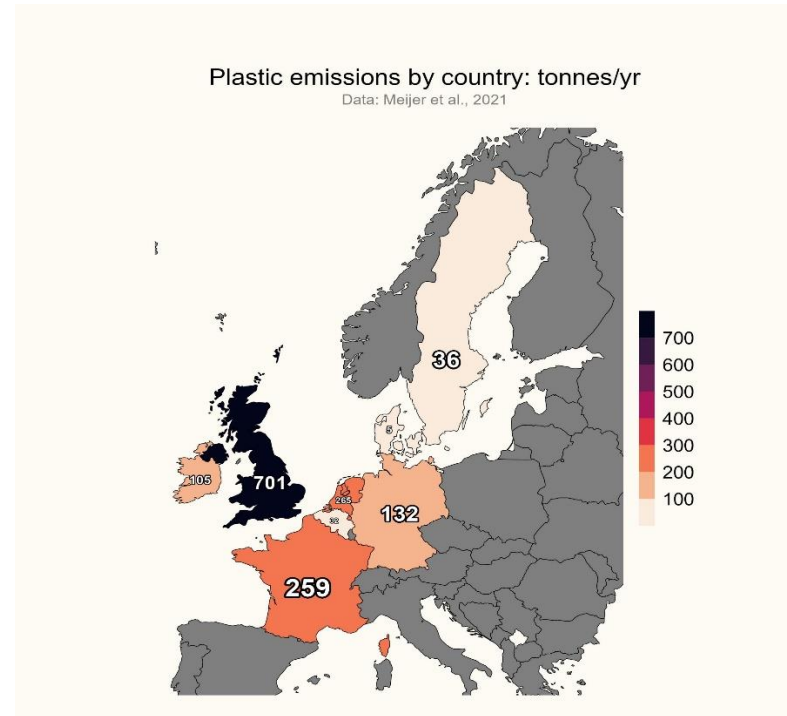
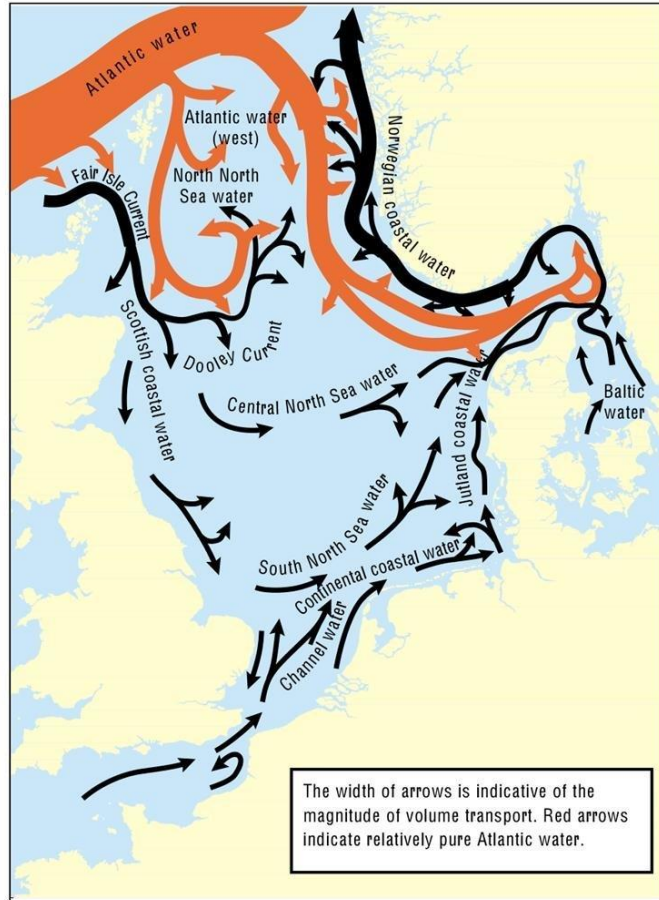
$$\frac{\partial SD}{\partial t} + \frac{\partial SUD}{\partial x} + \frac{\partial SVD}{\partial y} + \frac{\partial S\omega}{\partial \sigma} = \frac{\partial}{\partial \sigma} \left[\frac{K_H}{D} \frac{\partial S}{\partial \sigma} \right] + F_S$$

$$\frac{\partial q^2 D}{\partial t} + \frac{\partial Uq^2 D}{\partial x} + \frac{\partial Vq^2 D}{\partial y} + \frac{\partial \omega q^2}{\partial \sigma} = \frac{\partial}{\partial \sigma} \left[\frac{K_q}{D} \frac{\partial q^2}{\partial \sigma} \right] + \frac{2K_M}{D} \left[\left(\frac{\partial U}{\partial \sigma} \right)^2 + \left(\frac{\partial V}{\partial \sigma} \right)^2 \right] + \frac{2g}{\rho_o} K_H \frac{\partial \tilde{\rho}}{\partial \sigma} - \frac{2Dq^3}{B_1 \ell} + F_q$$

$$\frac{\partial q^2 \ell D}{\partial t} + \frac{\partial Uq^2 \ell D}{\partial x} + \frac{\partial Vq^2 \ell D}{\partial y} + \frac{\partial \omega q^2 \ell}{\partial \sigma} = \frac{\partial}{\partial \sigma} \left[\frac{K_q}{D} \frac{\partial q^2 \ell}{\partial \sigma} \right] + E_1 \ell \left(\frac{K_M}{D} \left[\left(\frac{\partial U}{\partial \sigma} \right)^2 + \left(\frac{\partial V}{\partial \sigma} \right)^2 \right] + E_3 \frac{g}{\rho_o} K_H \frac{\partial \tilde{\rho}}{\partial \sigma} \right) - \frac{Dq^3}{B_1} \tilde{W} + F_\ell$$

Spredning over landegrenser

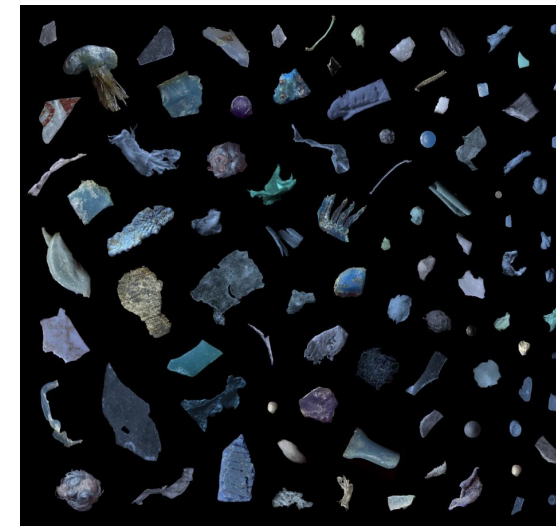
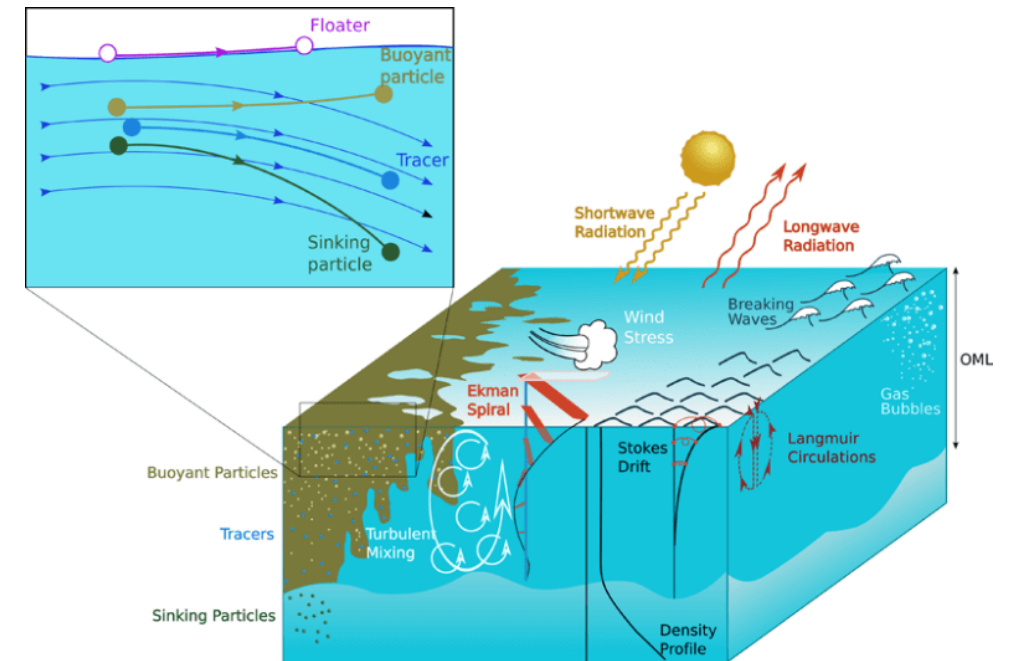
(Strømfelt fra operasjonelle
havsirkulasjonsmodeller)



Utfordringer

- I tillegg til “vanlige” utfordringer med strømmodeller:
 - Turbulens, interaksjon med partikler
 - Hvordan skape statistisk representative eksperiment (ensembles)
- Partikkelmodeller
 - Synkerater
 - Form, størrelse, tetthet, sammensetning
 - Begroing
 - Sedimentering og resuspensjon.
 - Opptak i biologiske organismer
- Tilgjengelighet av data
 - Spesielt viktig for validering
 - Strømforhold på mange skalaer
 - Fordeling av størrelse, form, tetthet.

Byfjorden blinket seg ut som en testcase



Motivasjon:

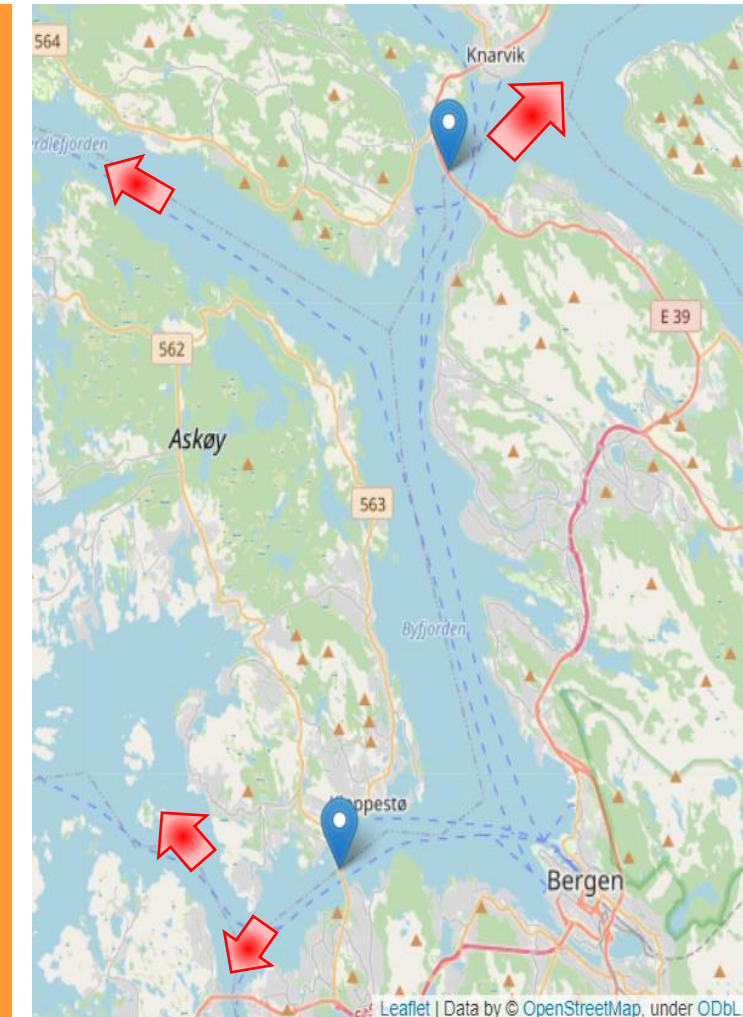
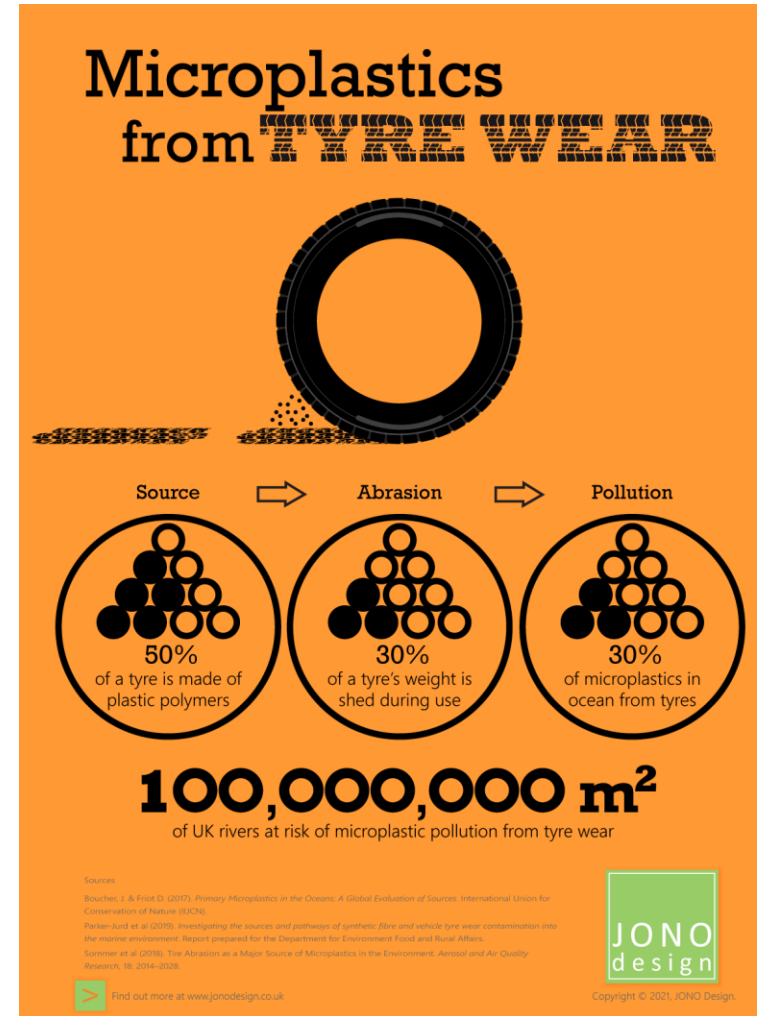
- Studere plastproblemet med matematiske modeller – er de en meningsfull komplementering av målinger?
- Kan modeller bidra til å redusere toktkostnader?

Hva gjør vi?

- Rammeverk for partikkeltransport
- Fokusområde: Byfjorden i Bergen
- Kilder: TRWP (dekk og vei)

Mål:

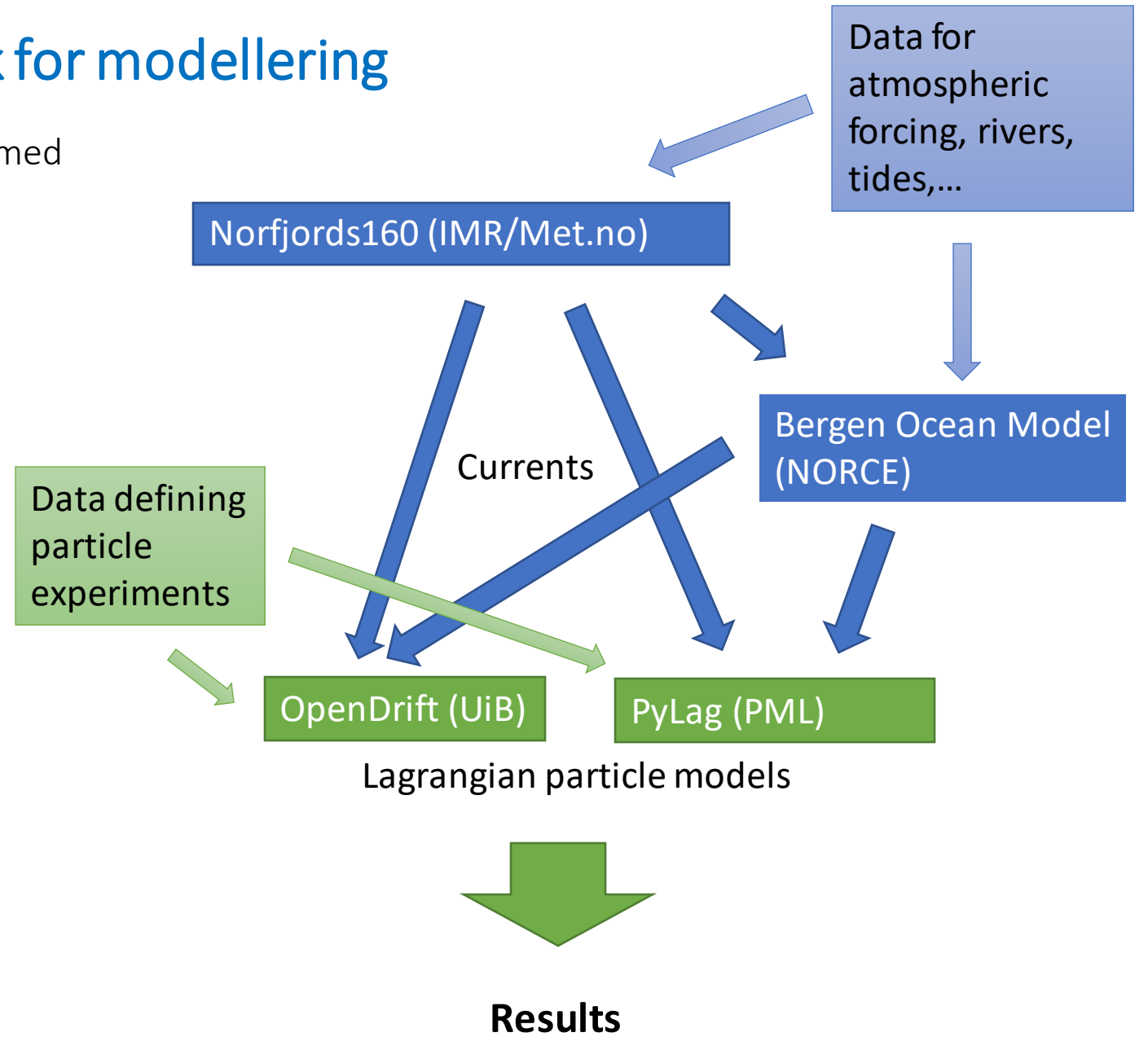
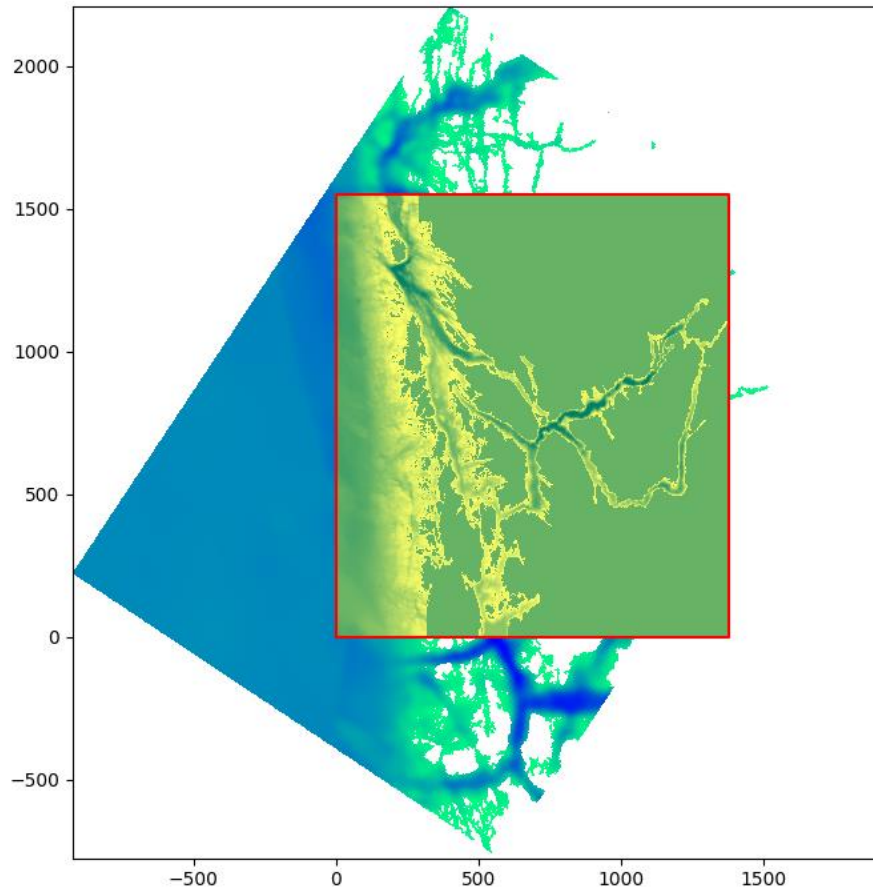
- Studere transport og spredning av TRWP
- Gradienter
- Belyse hvor partikler kommer fra og hvor de ender opp
- Effekten av TRWP kornstørrelse



*Jono Design: Microplastics from Tyre Wear Infographic: Accessed on 11 Nov 2022

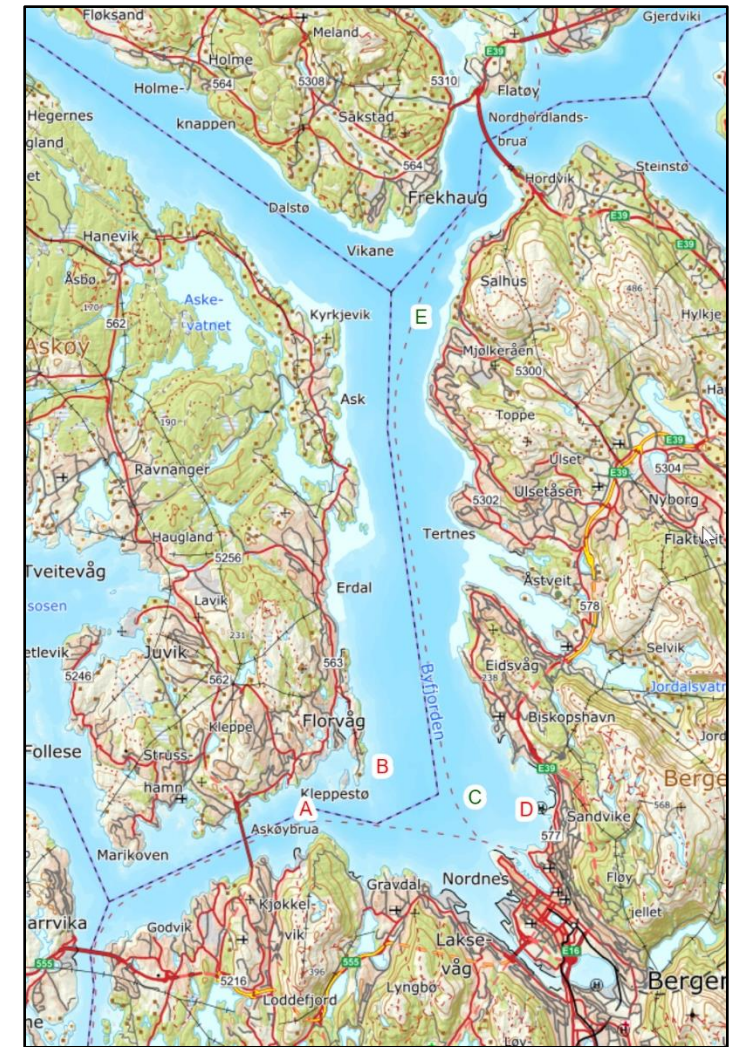
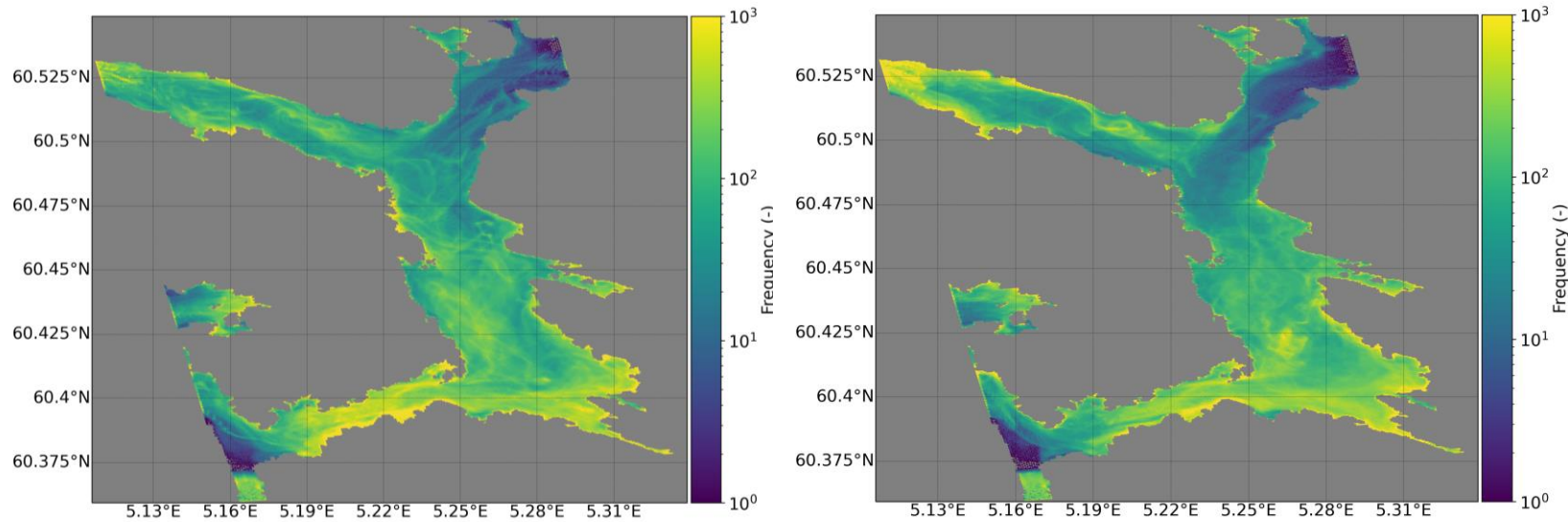
Rammeverk for modellering

4 ulike modeller i tandem gir oss et rikere sett med opsjoner for å utforske ideer.



A first shot at sampling advice

Example experiment: model dispersion of initially uniform distribution of particles over two+ weeks. Starting time 1 week apart. Map of frequency of particle visits in each “cell”.

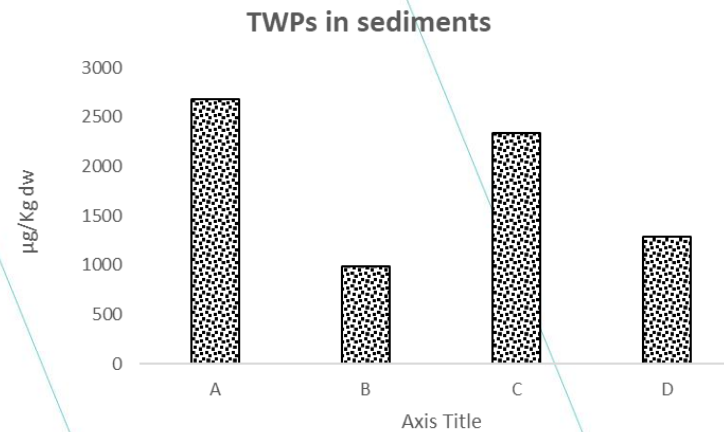
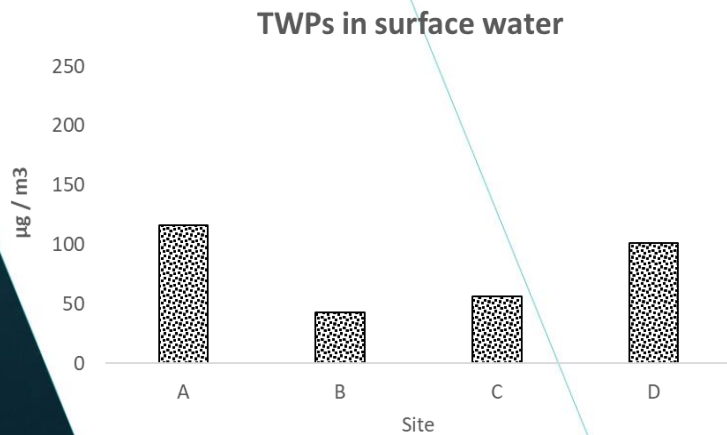
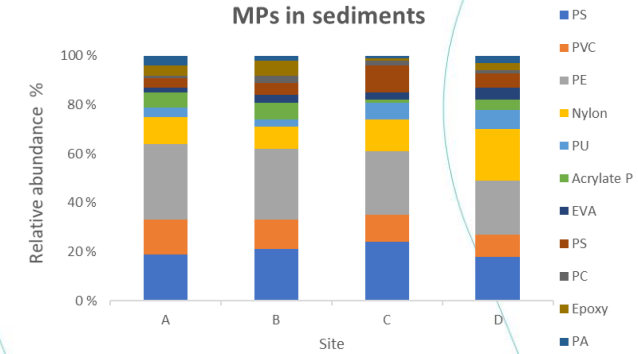
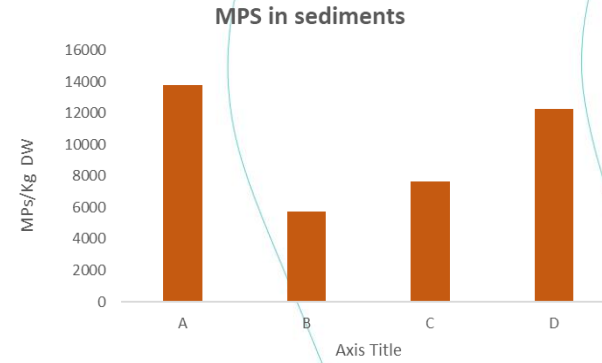
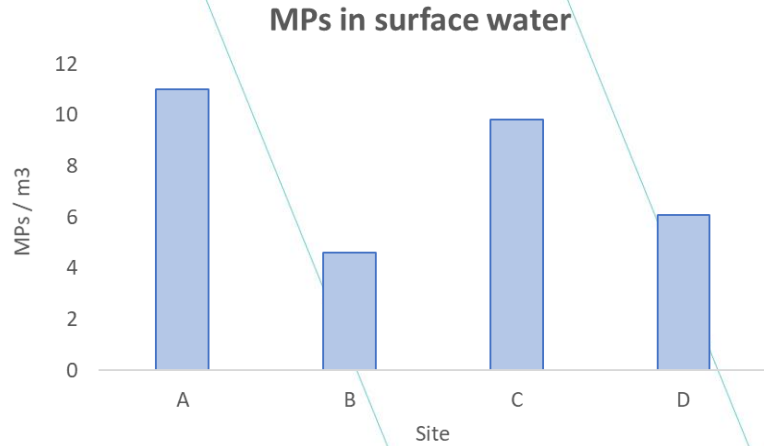


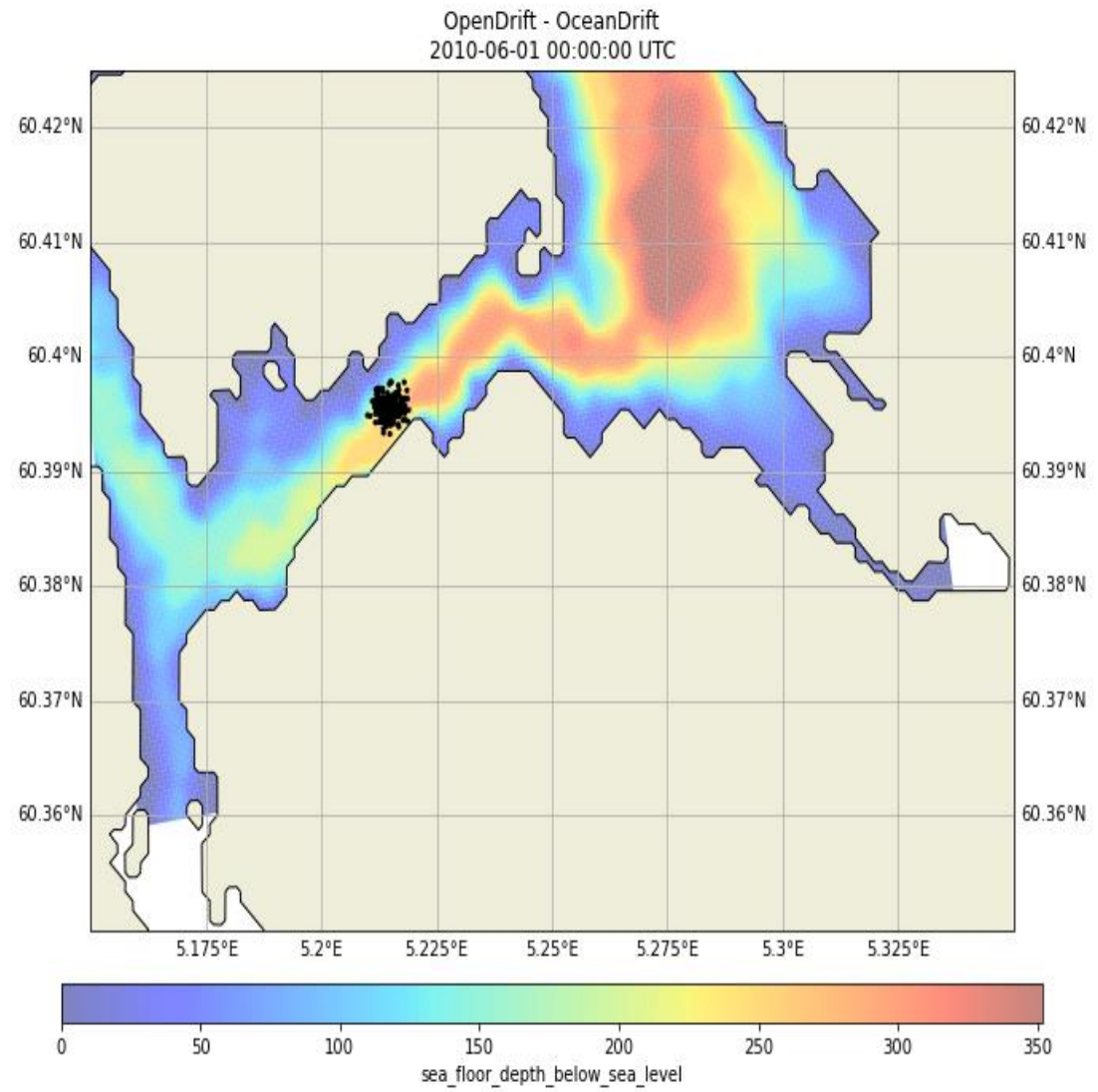
Modeling so far didn't pinpoint stable, strong hotspots, but...

- some areas were indicated to have more particles, A and D, and sometimes B.
- and some less: C & E

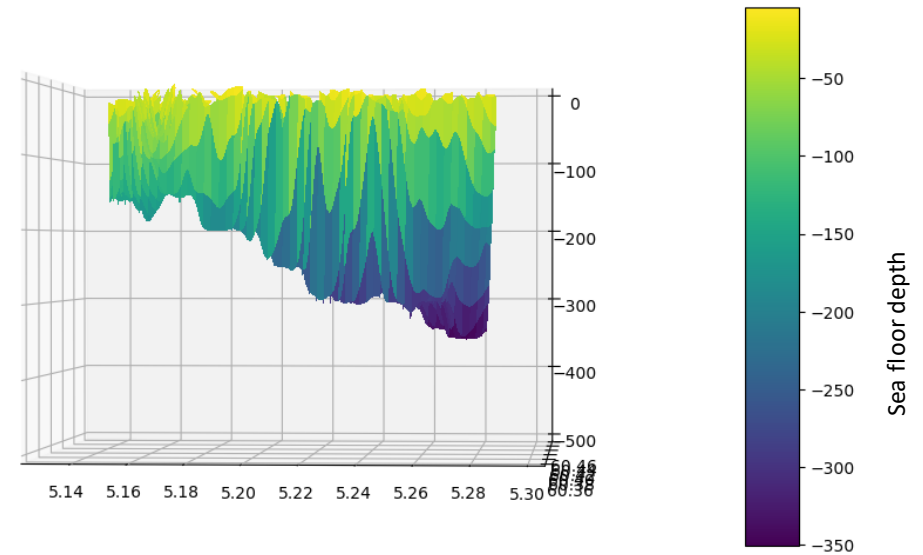
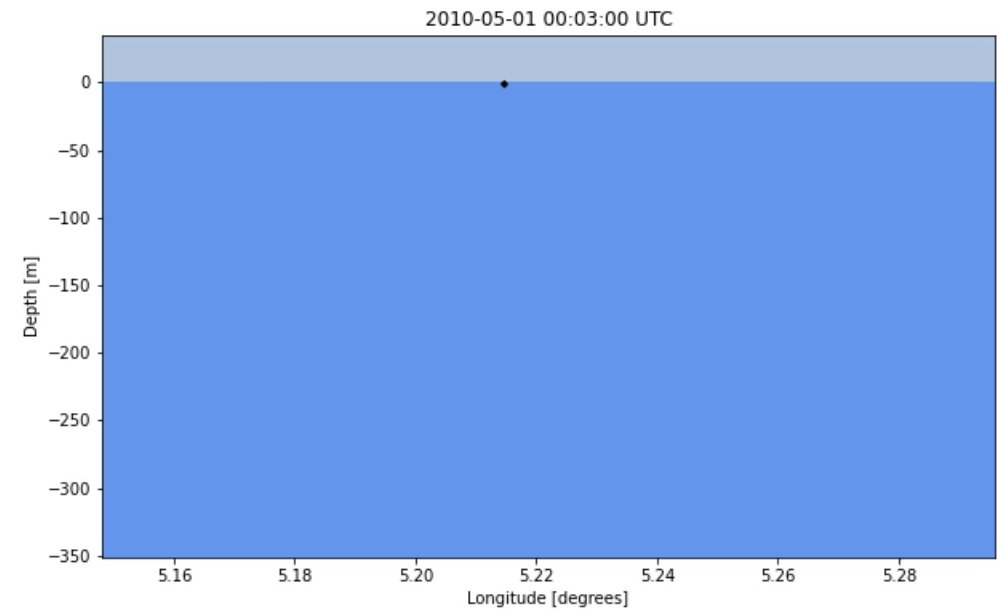
Outcomes of the preliminary field observations

Sampling activity - October 2021

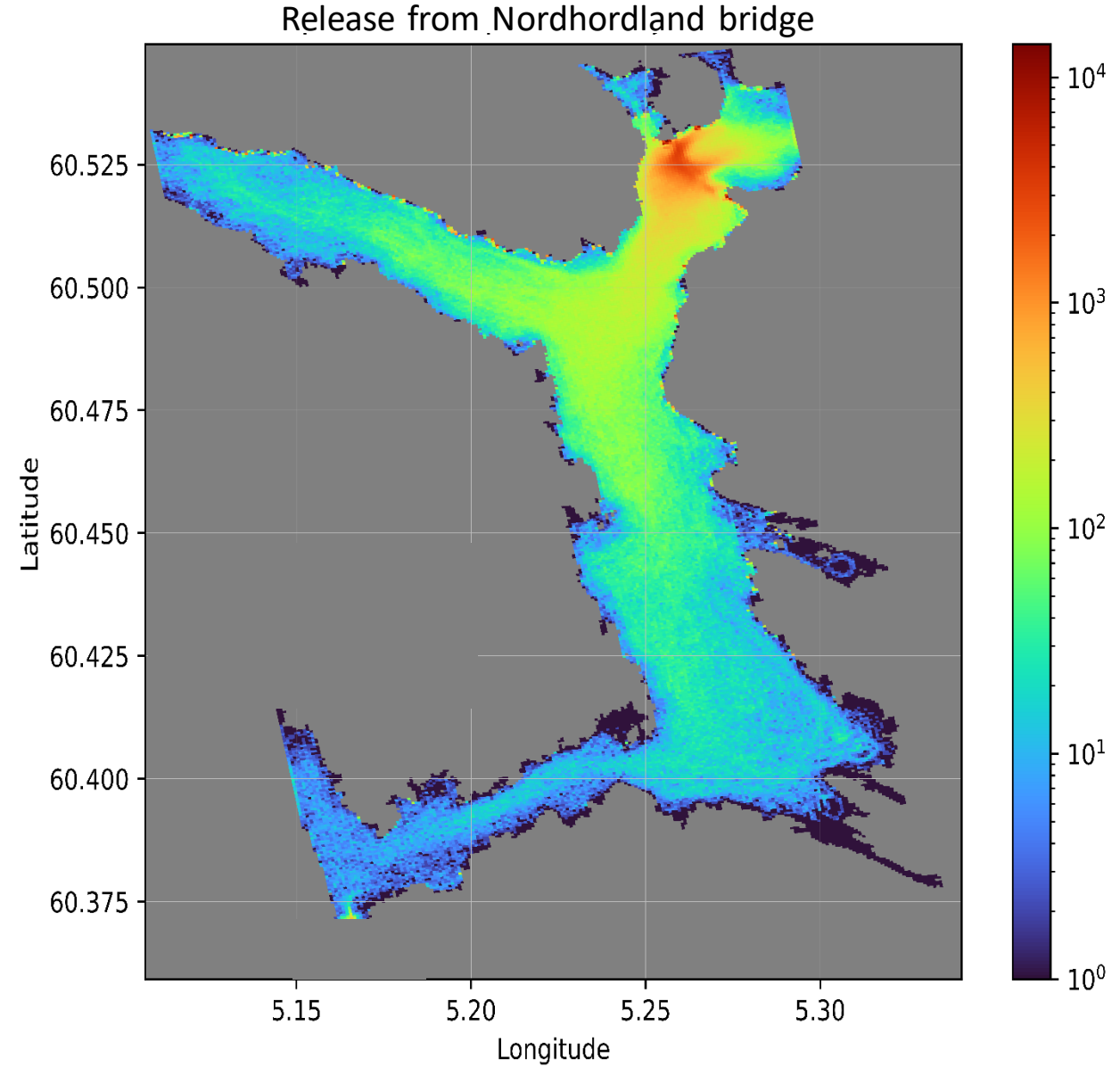




Sedimentation pattern across the fjord

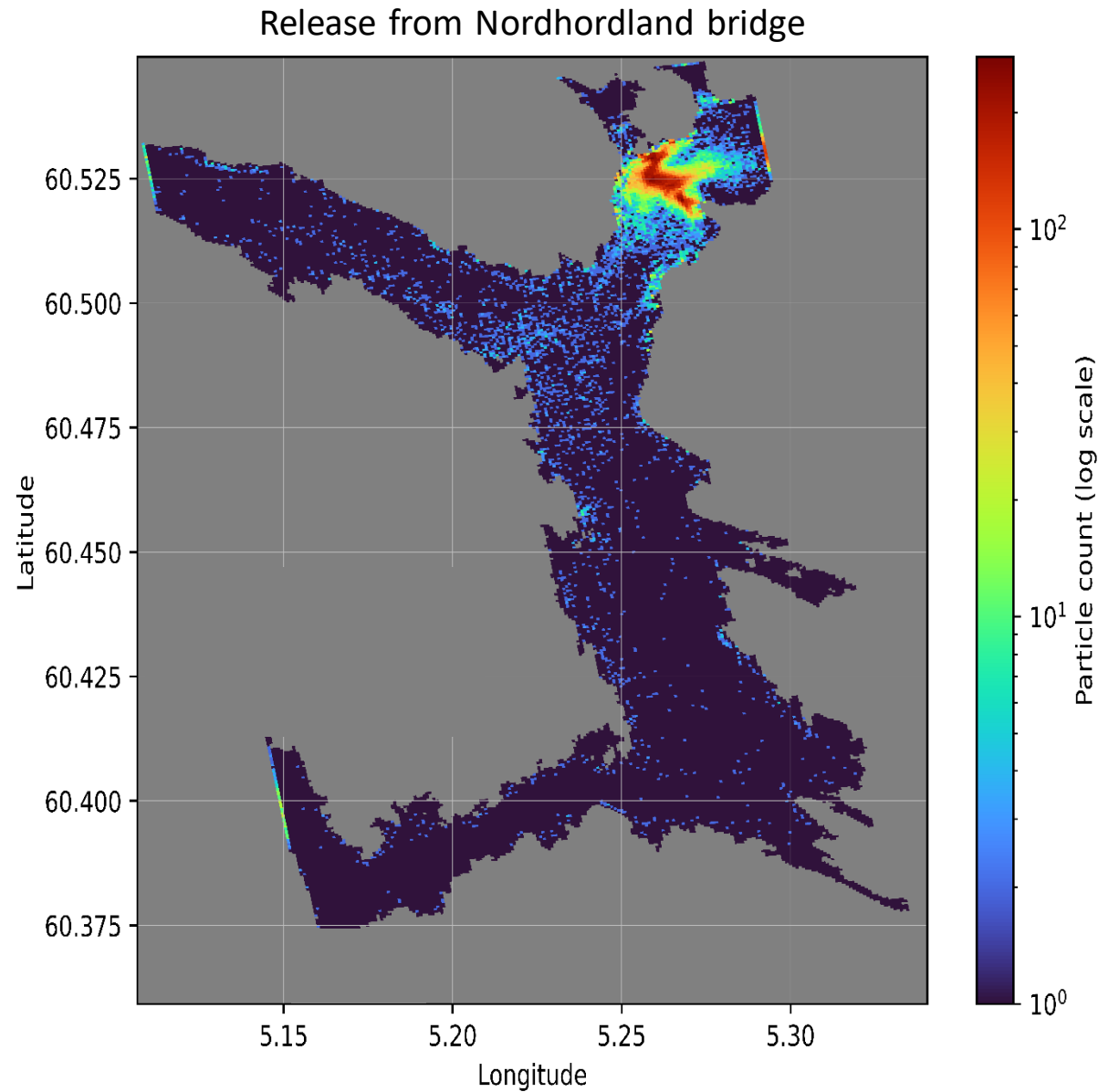


Bathymetry of Byfjorden along the longitude

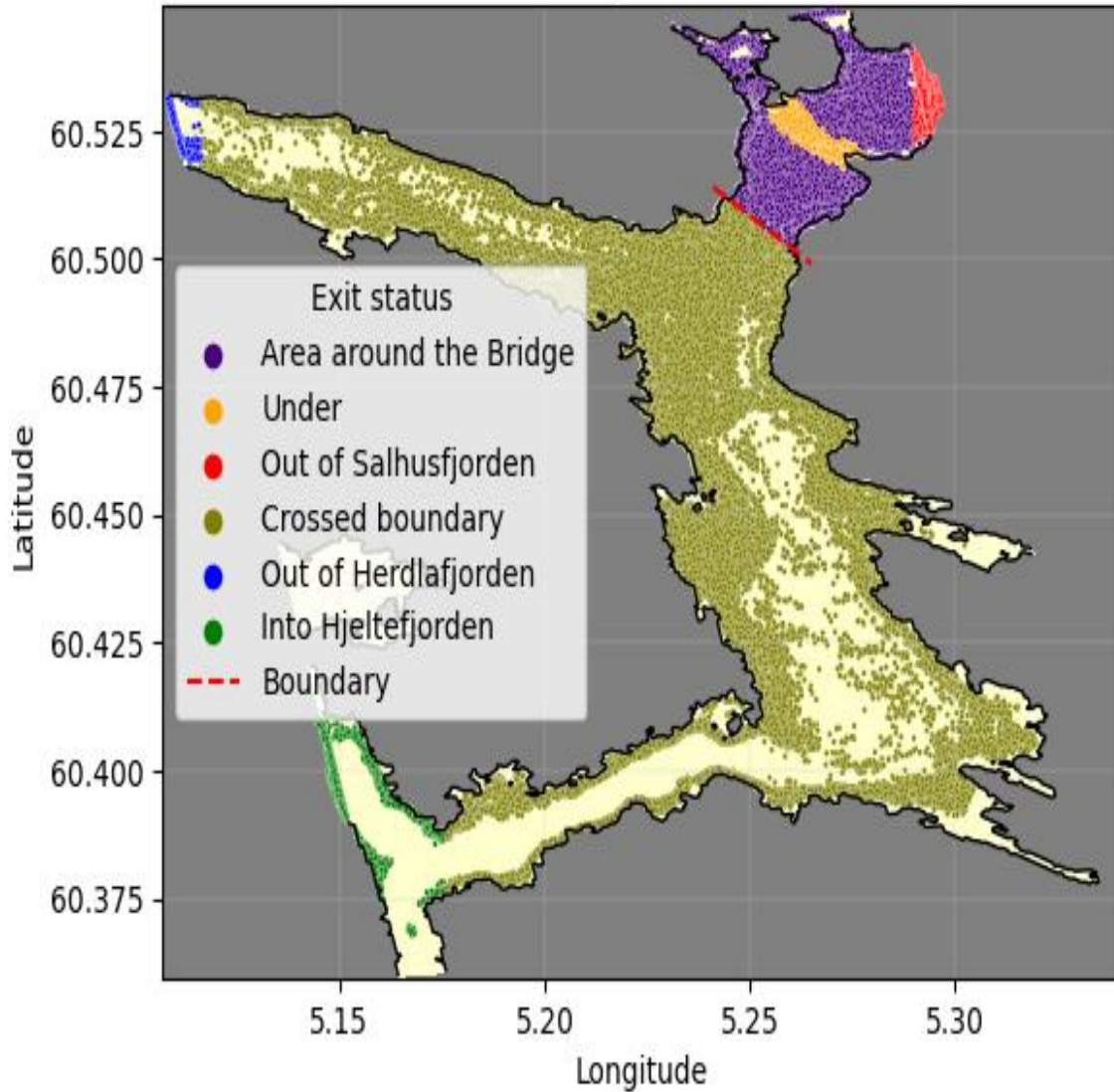


Eksempel på sedimentering TRWP ulike størrelser sluppet fra Nordhordalandsbroen

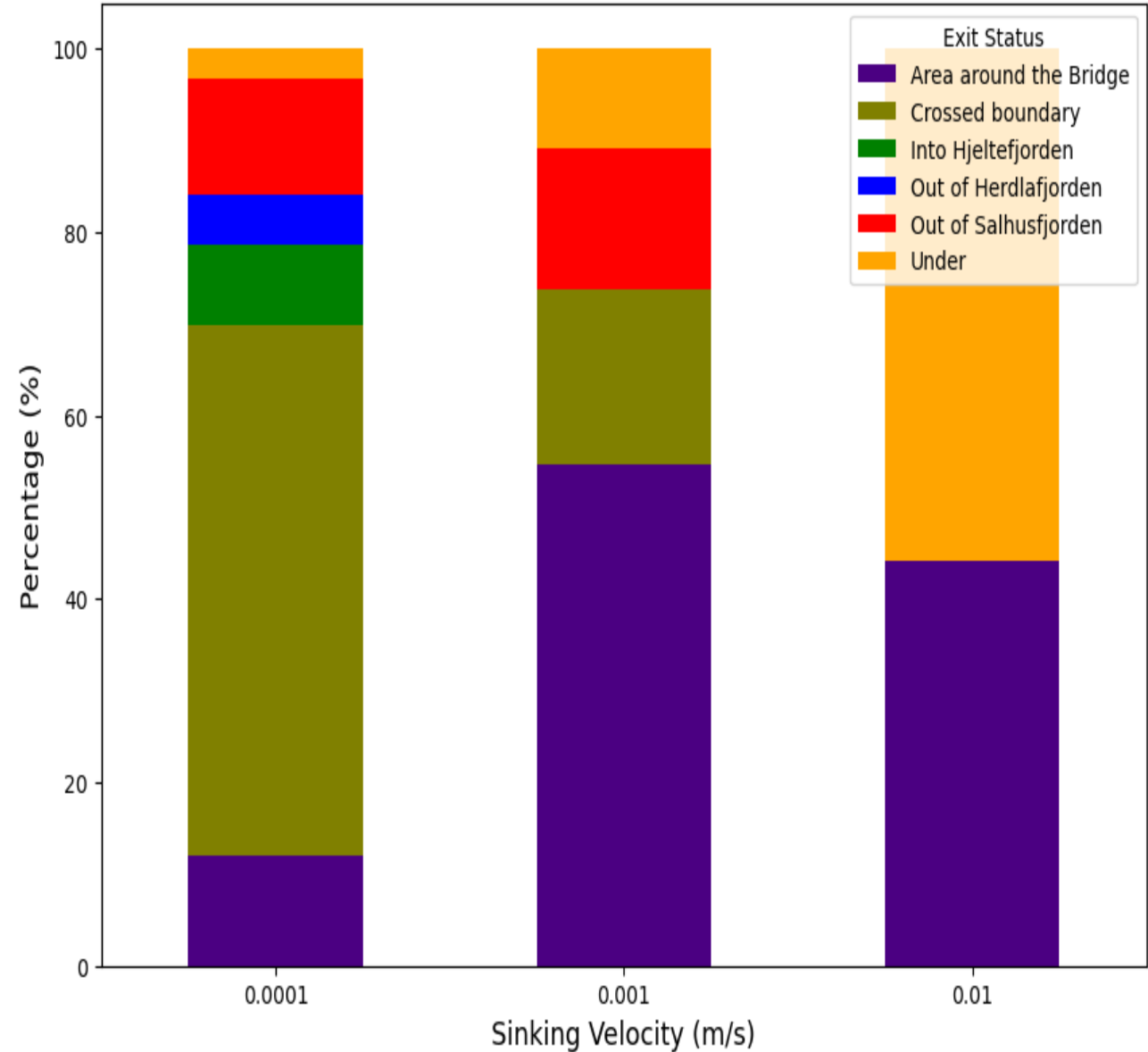
Tetthet
1700 – 2300 kg/m³
Størrelse
6 - 350 mikrometer



Particle End Locations by Exit status: Nordhordland

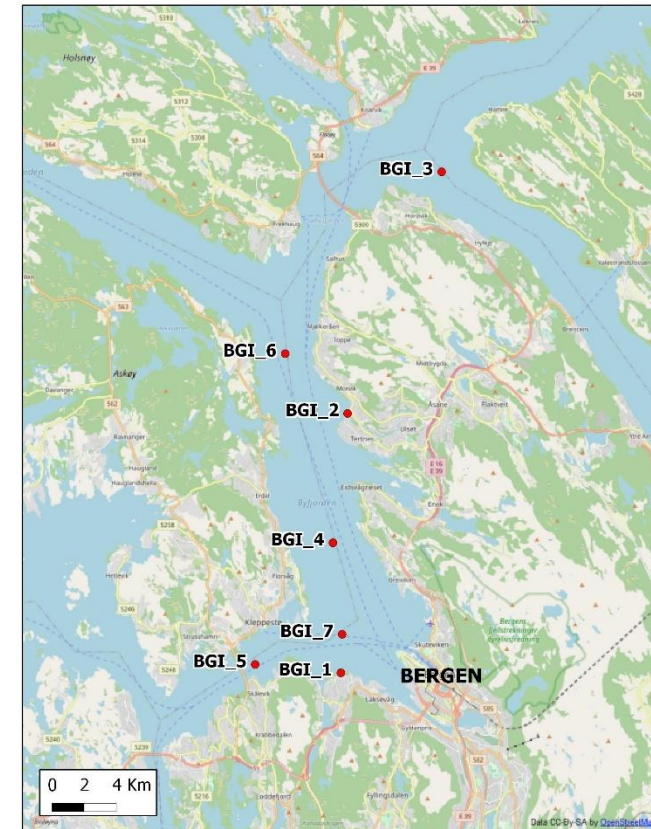


Percentage of Particles by Exit Status for Different Sinking Velocities: Nordhordland



Feltaktivitet – neste steg

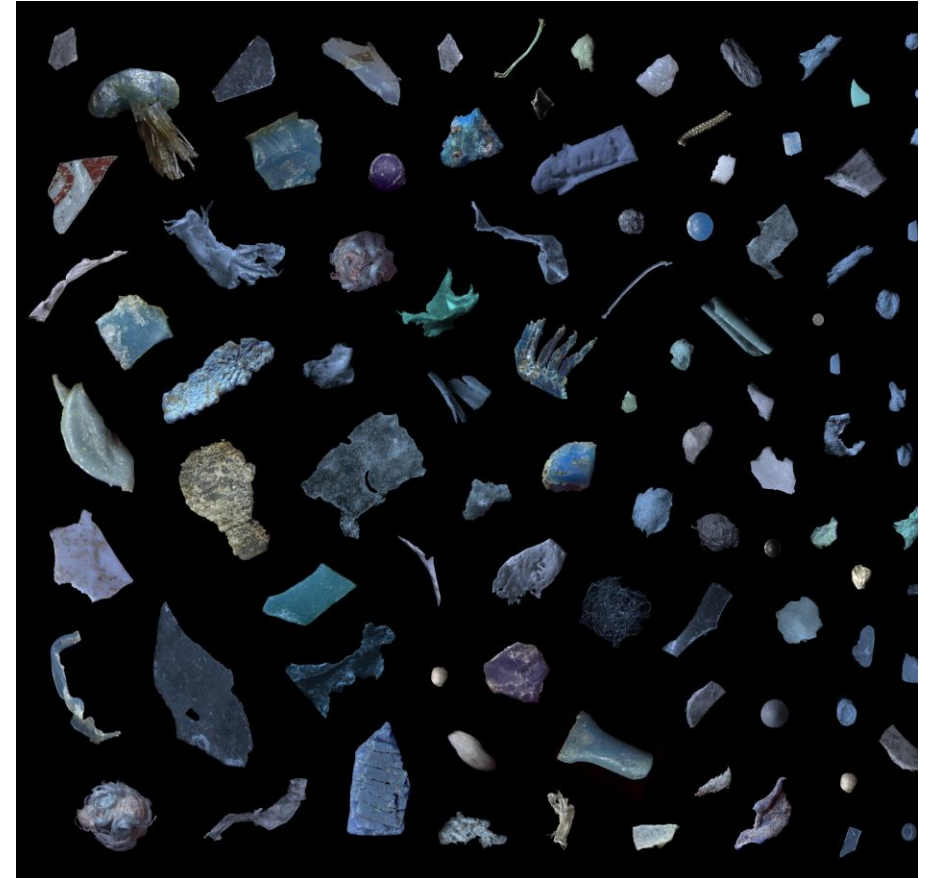
10 model-wise selected sampling sites. Campaign June 2022, analysis still ongoing, almost done.



Finner vi de samme spredningstrekk i målingene som modellen?

Konklusjoner/planer

- Byfjorden er et interessant område å studere plastspredning i – mye data
- Vi har tendens til “skill” i modellene våre
- Arbeider med publisering
- Ønsker på sikt å anvende rammeverket i andre områder



Thank you!

Acknowledgements



Partners

