UNIVERSITY OF OSLO

Creating a circulation model for the Oslo fjord – A step-by-step guide

Lars Willas Dreyer

Basilisk User Meeting 2025

July 8, 2025

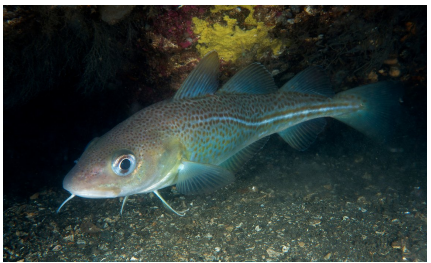
The Oslofjord

Fjord enviroments in Norway are struggling

Oslofjorden lider

Møt Oslofjordens ene torsk

dagbladet.no



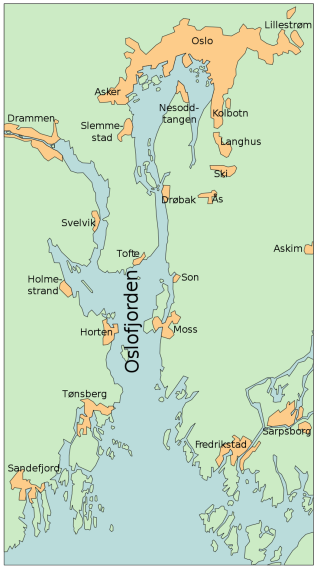
Inst. Marine Research

The Oslofjord

Fjord enviroments in Norway are strug-gling

Important factors

1. Emissions from populated areas
2. Migratory species due to global warming
3. Small, narrow geometries hinders healthy circulation



Wikipedia

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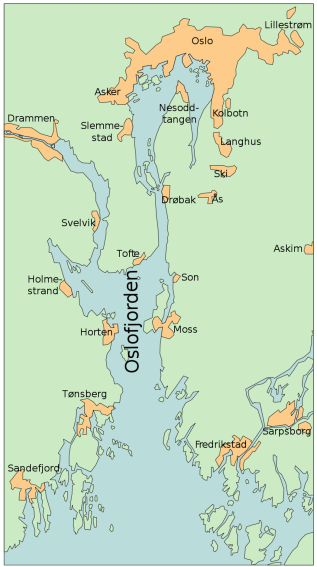

Wikipedia

A rough outline

The talk will be split into two parts:

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1) What is our model, and how did we build it?

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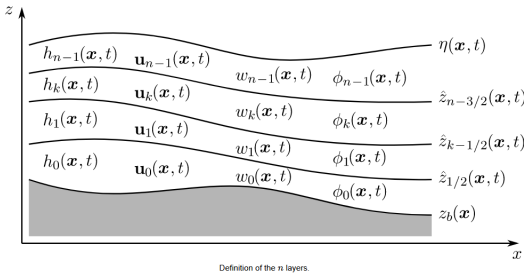
1) What is our model, and how did we build it?
2) How do we validate the model?

Making a model

Fjords are long and shallow.
Multilayer shallow water suitable.



Definition of the n layers.

Making a model

Fjords are long and shallow.
Multilayer shallow water suitable.

Several examples on `basilisk.fr` to lend inspiration

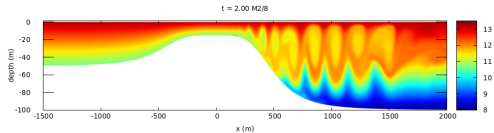


Figure: Lee wave example from the basilisk webpage

Making a model

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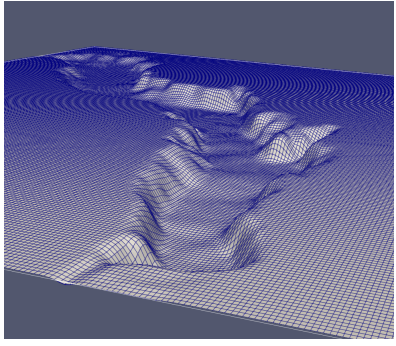
Bottom topography, river flux and tidal data publicly available.



Boundary conditions

- Theoretical models for rivers

River model

$$u = \frac{u^*}{\kappa} \log\left(\frac{z}{z_o}\right), \tag{1}$$

u^* friction velocity, κ von Karman constant, z/z_o height over bottom roughness.

Boundary conditions

- Theoretical models for rivers as inspiration

River model

$$u = U\frac{z_b - z}{z_b}, \tag{1}$$

With U set to ensure correct flux

Boundary conditions

- Theoretical models for rivers as inspiration
- Tidal forcing on outlet, but should also facilitate ”free outflow”

Tidal model

$$\nabla u = \alpha_1 (u - u_{\text{tide}}) \quad (1)$$

Difficulty flowing out proportional to speed difference,

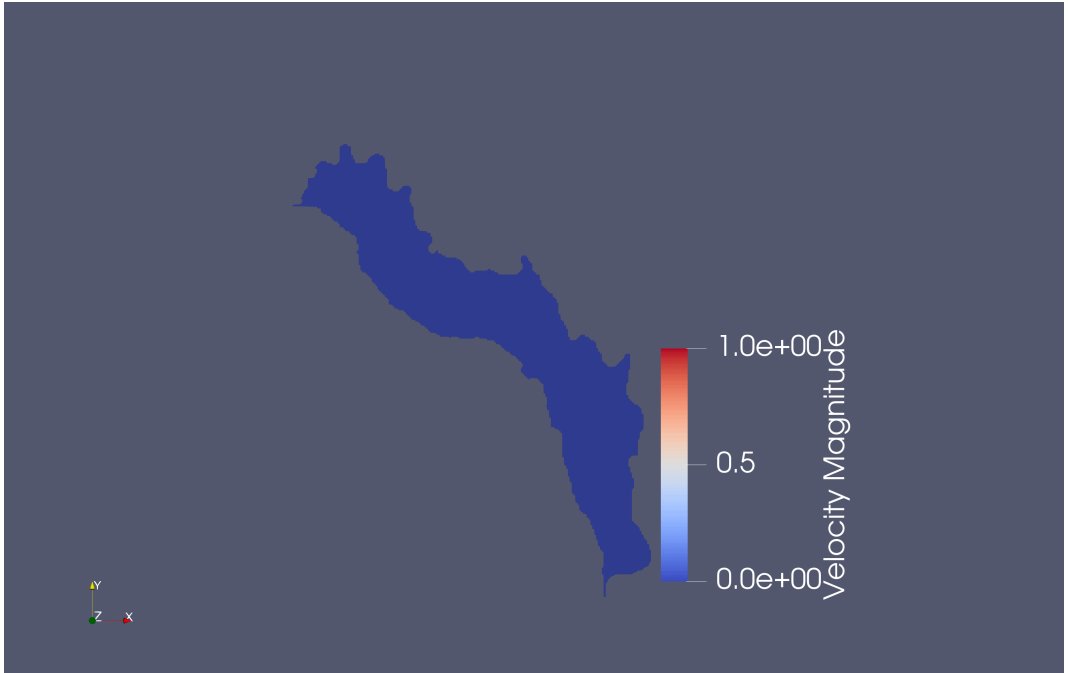
Boundary conditions

- Theoretical models for rivers as inspiration
- Tidal forcing on outlet, but should also facilitate ”free outflow”

Tidal model

$$\nabla u = \alpha_1 (u - u_{\text{tide}}) \quad (1)$$

Difficulty flowing out proportional to speed difference, although we use radiation rather than Neumann.


1.0e+00
0.5
0.0e+00
Velocity Magnitude
Y
Z
X

The strange edge cases

- Fjord bottom topography is steep

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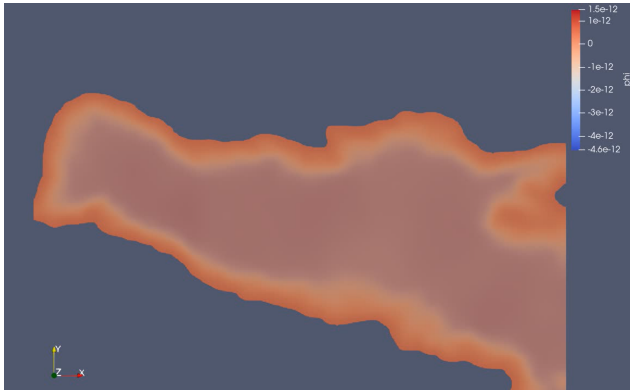
- Instabilities in non-hydrostatic pressure.



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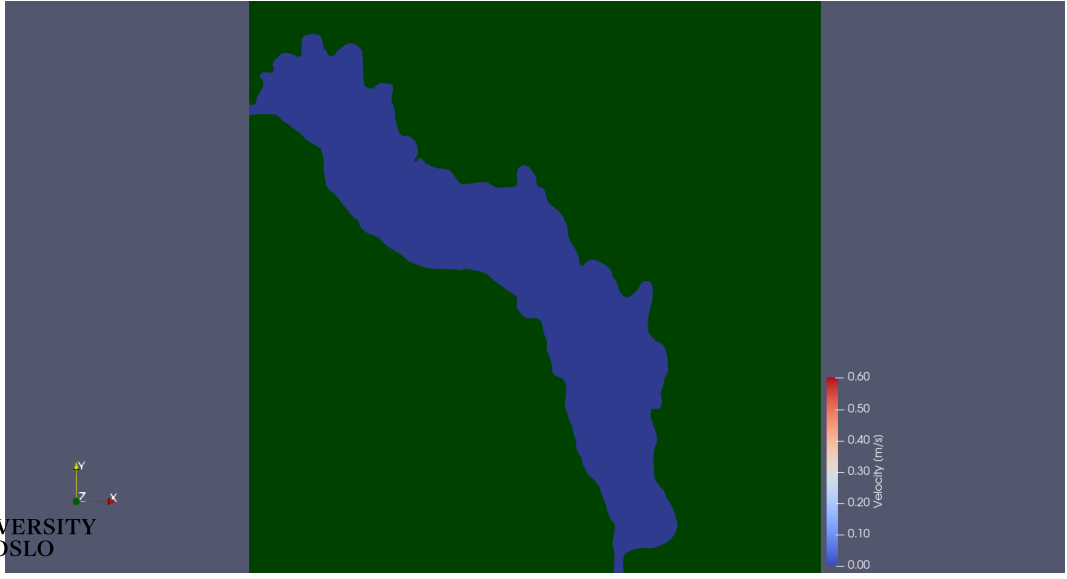
The strange edge cases

- Fjord bottom topography is steep
- Instabilities in non-hydrostatic pressure.
- Somewhat mitigated by lowering the CFL number.
- Or pretending the world is hydrostatic and nice.

Current version of the framework



Validation I - Operational models

- Huge resources are being spent on operational models

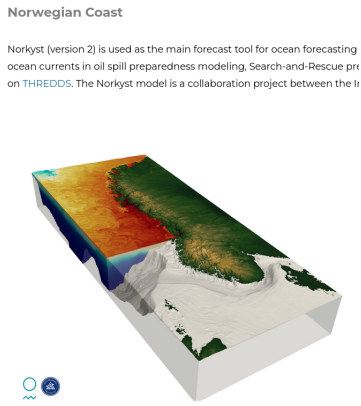


Figure: `ocean.met.no/models`

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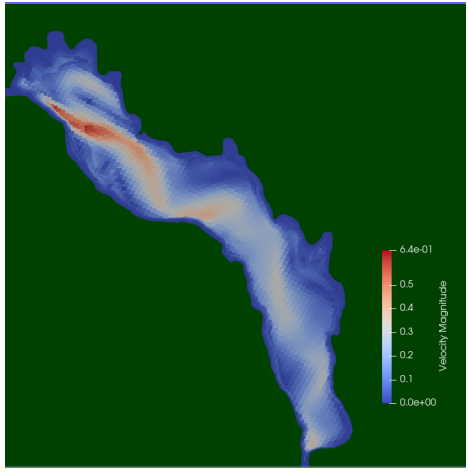
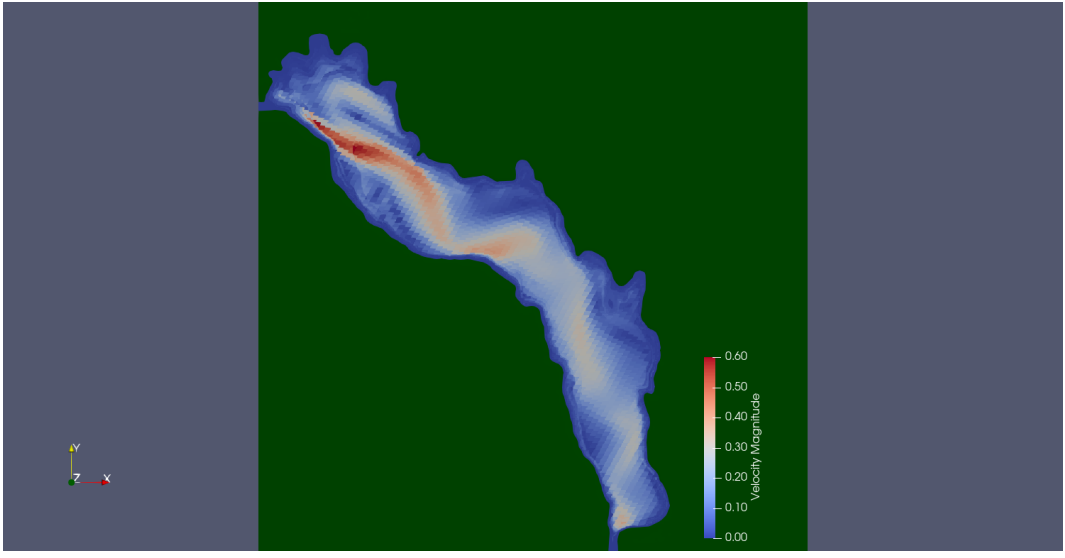


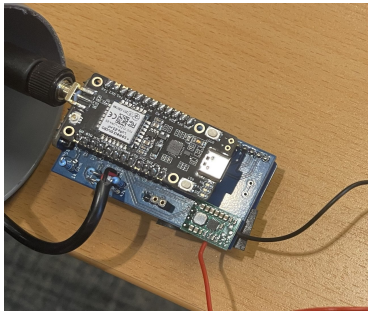
Validation I - Operational models

- Huge resources are being spent on operational models
- Can easily be interpolated into Basilisk
- Although making it work as a succesful initial condition still requires more work.


Y
Z
X
0.60
0.50
0.40
0.30
0.20
0.10
0.00
Velocity Magnitude

Validation II - In-situ measurements

We have made a (~100 €) drifter with
GPS + Thermometer



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Range gives good coverage of the area

Figure: Covering zones of 5 base stations

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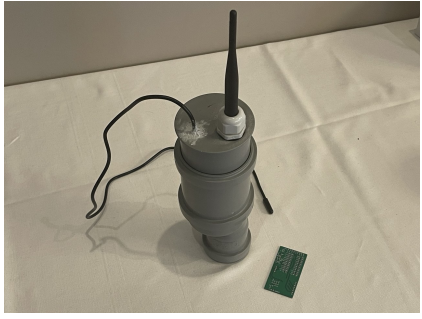

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Compare against particle movements using inertial particles.

Concluding remarks

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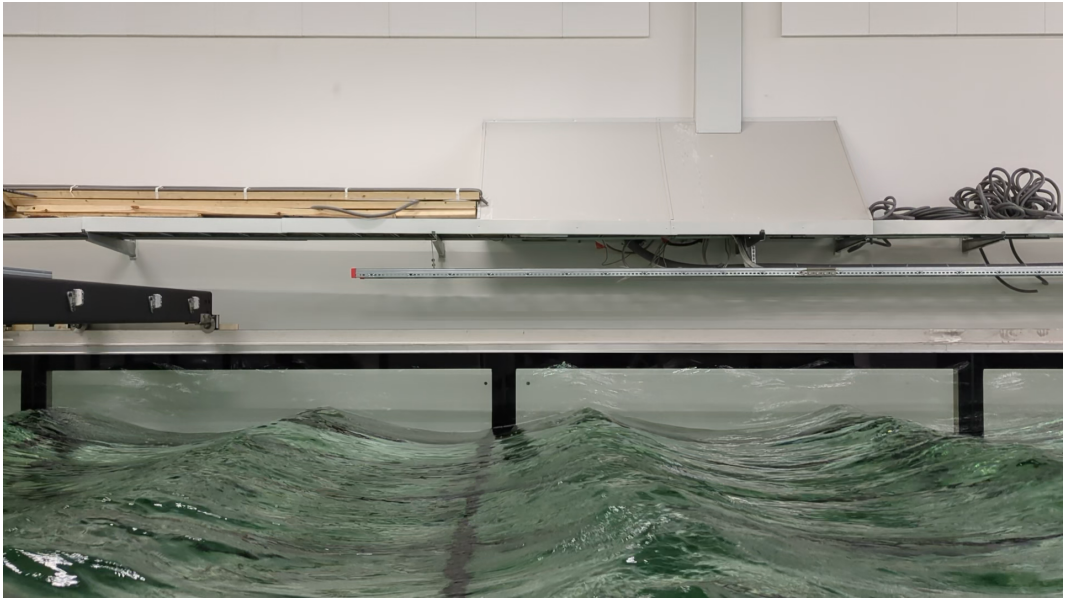
Slartbartifast's reward

"Look at me, I design coastlines. I got an award for Norway. Where's the sense in that?"
- Slartbartifast to Arthur Dent, Hitchhiker's Guide to the Galaxy

Thanks to

- Atle Jensen
- Jean Rabault
- Andrea Pferscher
- Riccardo Sieve
- Øystein Lande
- Stephané Popinet
- Antoon van Hooft
- Einar Broch Johnsen
- Kai-Håkon Christensen



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