

A two-year time series of current velocity from moored buoys in a Western Norwegian fjord system



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The coast of Møre, Western Norway

- Deep fjords
- Narrow continental shelf
- Norway's southernmost bird cliff
- Important spawning grounds for several fish species
- Maritime industry
- Aquaculture

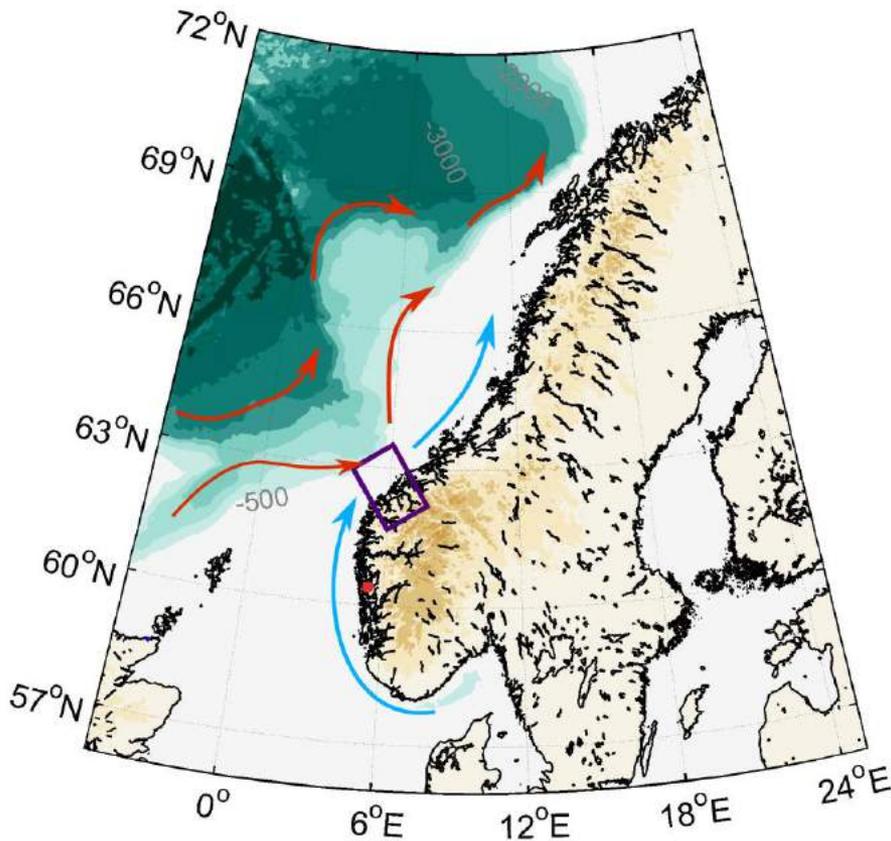


Photo: Arild Hareide

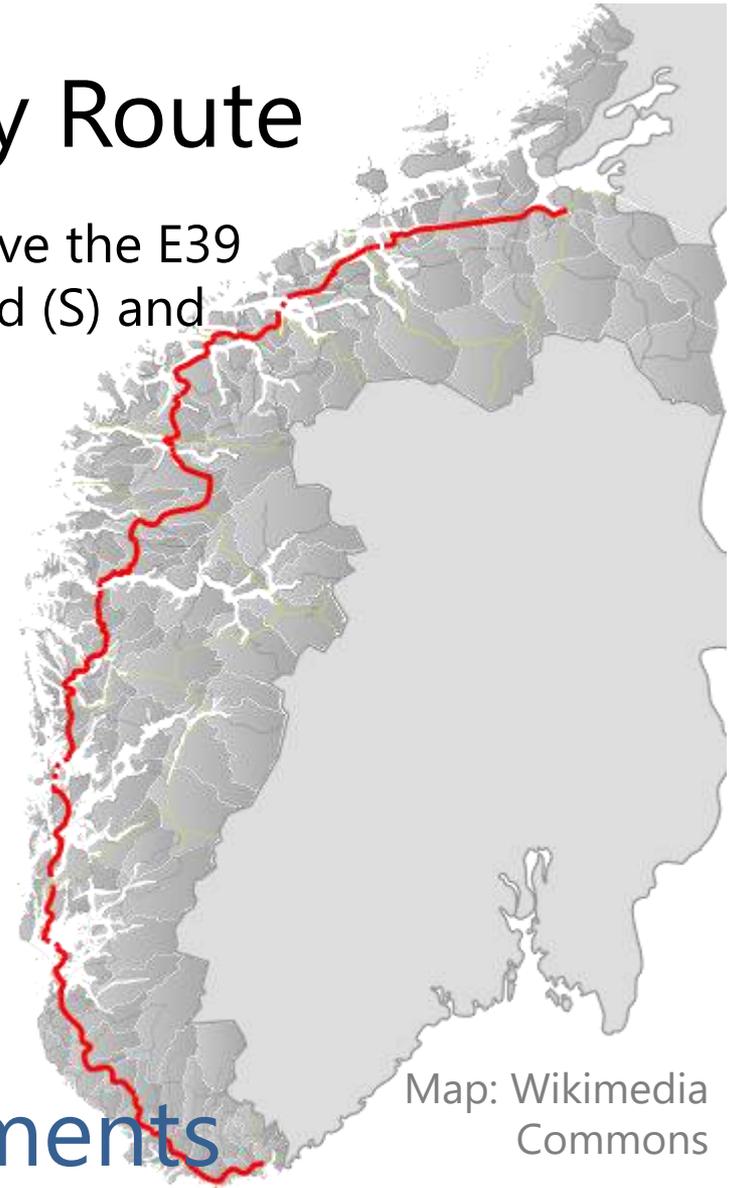
The E39 Coastal Highway Route

The *Storting** has a long-term goal to improve the E39 Coastal Highway Route between Kristiansand (S) and Trondheim (N).

- Today: 1100 km route, 7 ferries, ca 21 h. travel time
- Aim: cut travel time by half
- **Replace ferries by bridges** and tunnels
- Estimated cost ca NOK 340 billion**
- Related research: 50 PhDs on fjord crossings, social impacts, sustainable infrastructure etc.



Environmental measurements



Map: Wikimedia Commons

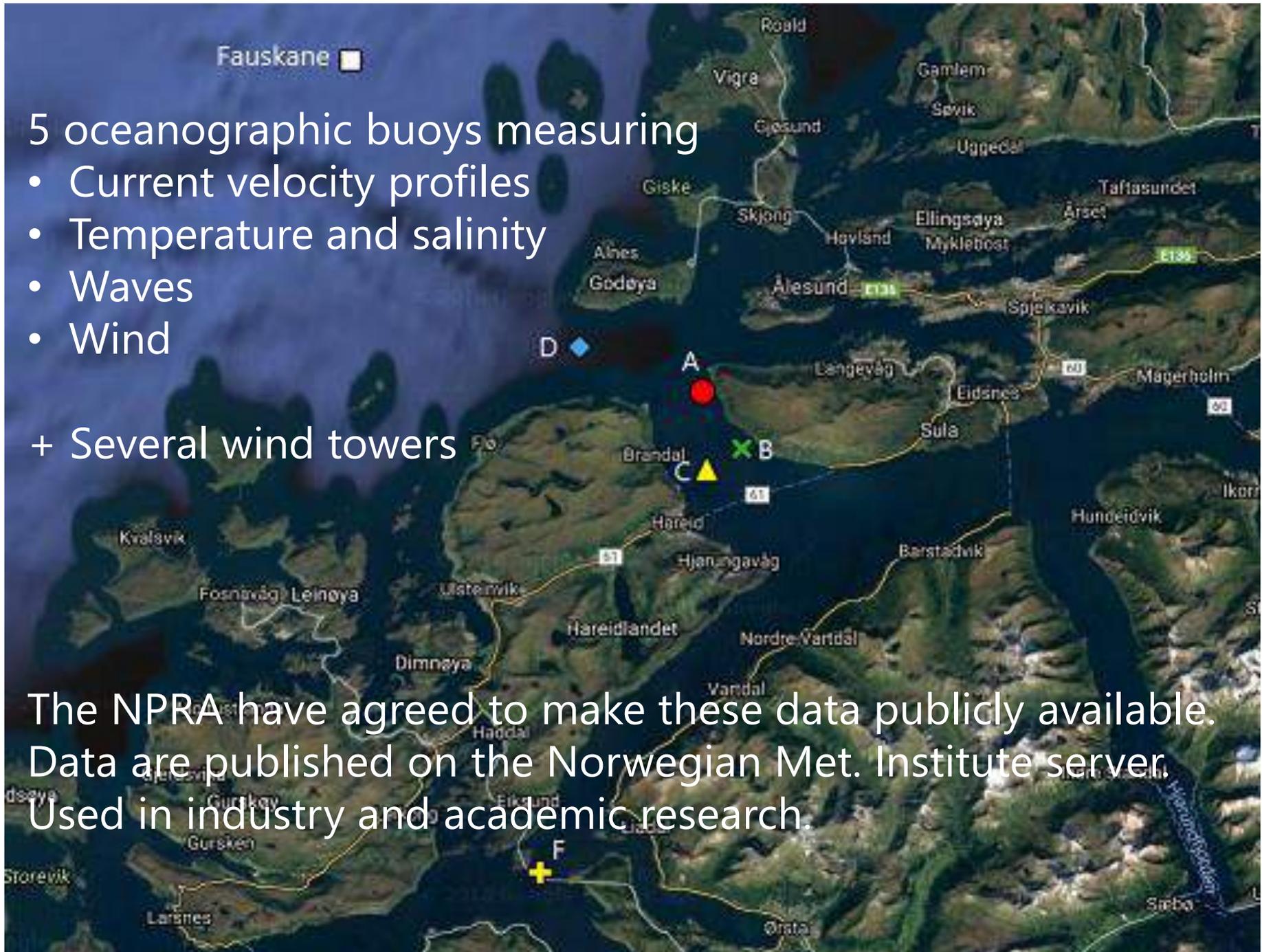
**Big Thing* – the Norwegian Parliament **35 billion euro only

5 oceanographic buoys measuring

- Current velocity profiles
- Temperature and salinity
- Waves
- Wind

+ Several wind towers

The NPRA have agreed to make these data publicly available. Data are published on the Norwegian Met. Institute server. Used in industry and academic research.



Innovative ship speed and power optimization by the aid of sea current predictions (InnoCurrent)

- Better understanding of effects of environmental conditions on ship speed and fuel consumption
- Validation of the current prediction model NorKyst800
- Validation of new Doppler-based ship speed log



Bilde: Nor Lines

Rolls-Royce Marine AS

Nortek AS

FjordShipping/NorLines

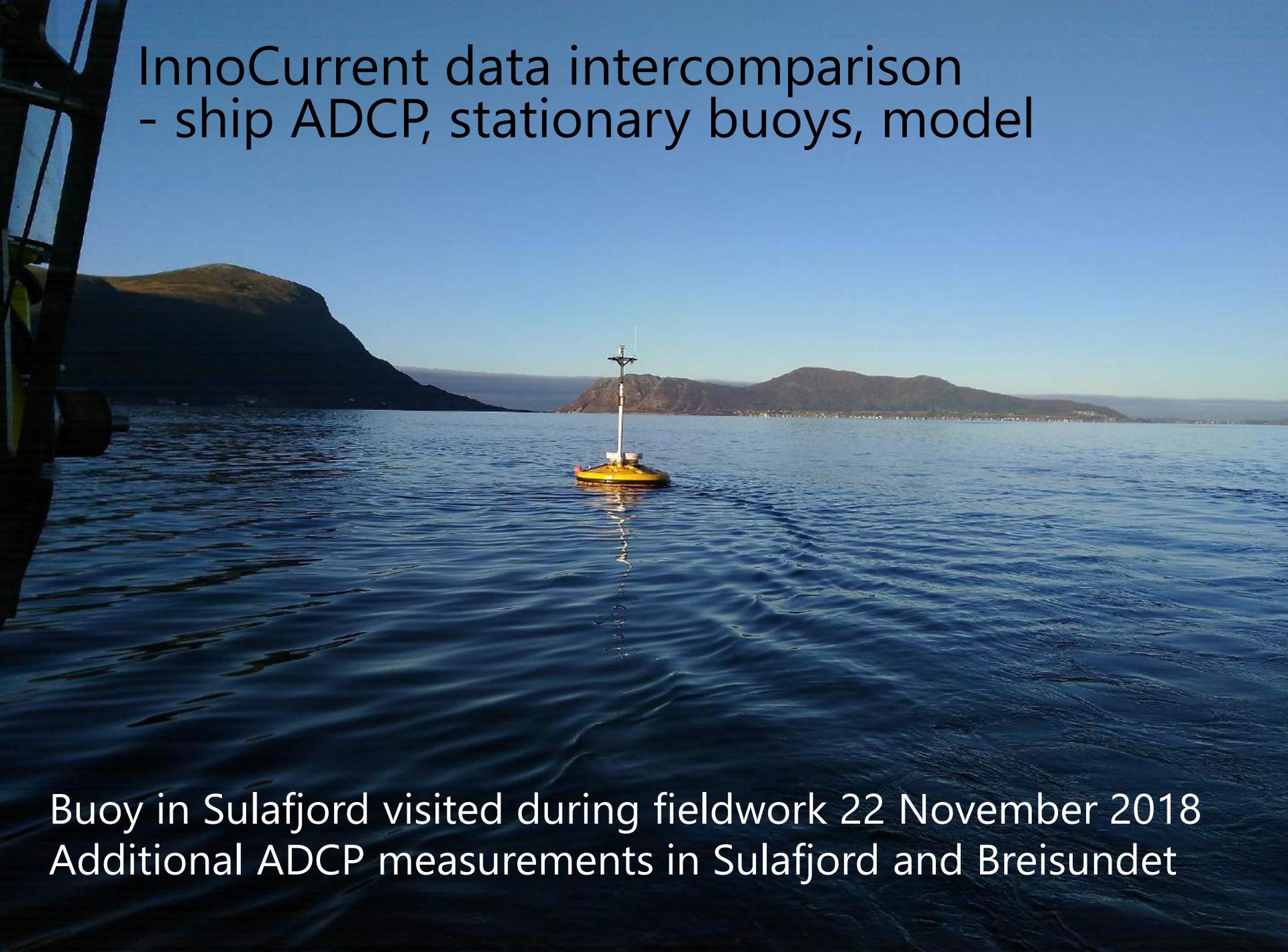
NTNU

Norw. Meteorological Institute

Institute of Marine Research

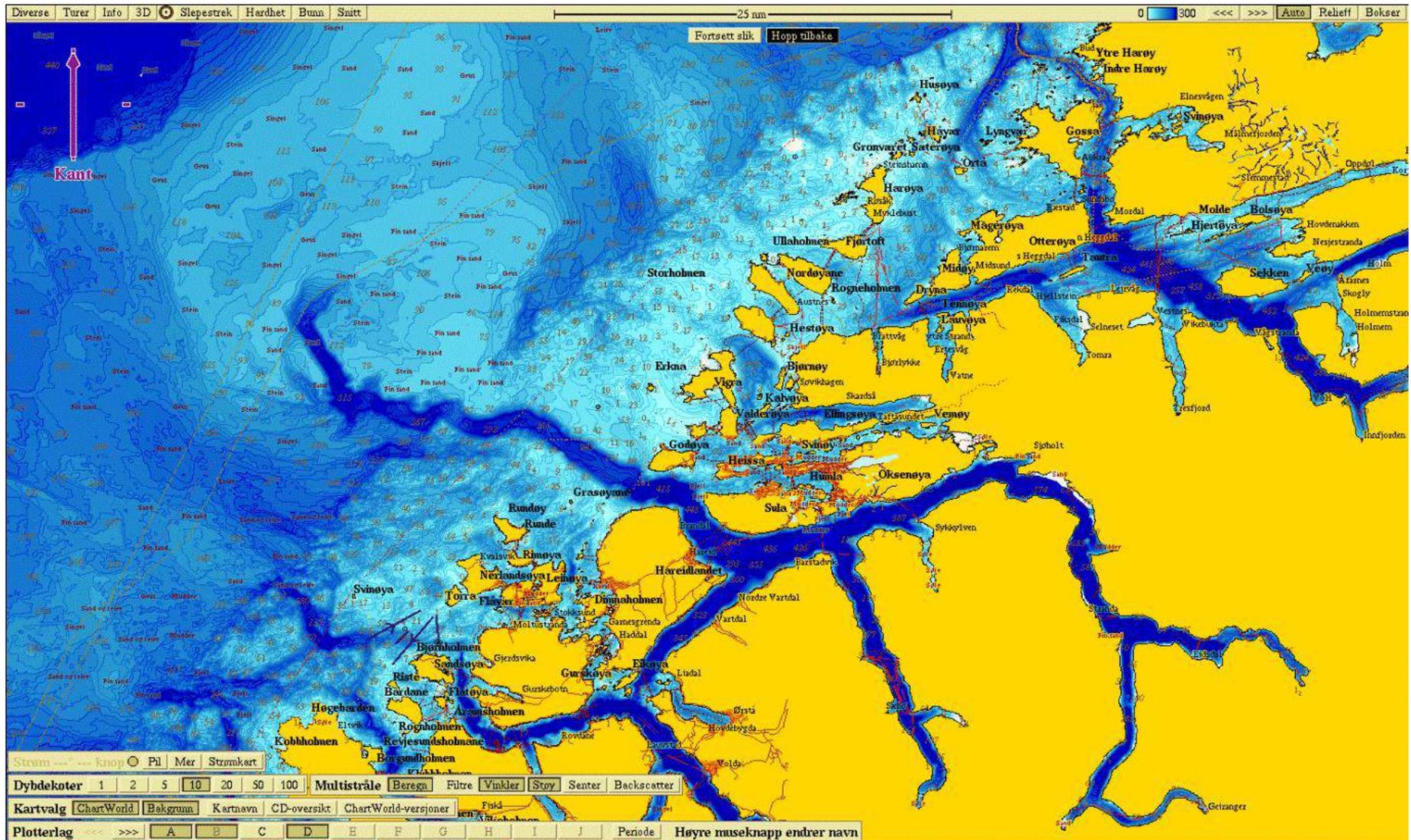
Runde Environmental Centre

InnoCurrent data intercomparison - ship ADCP, stationary buoys, model



Buoy in Sulafjord visited during fieldwork 22 November 2018
Additional ADCP measurements in Sulafjord and Breisundet

Also an opportunity to improve our understanding of our local, complex fjord system

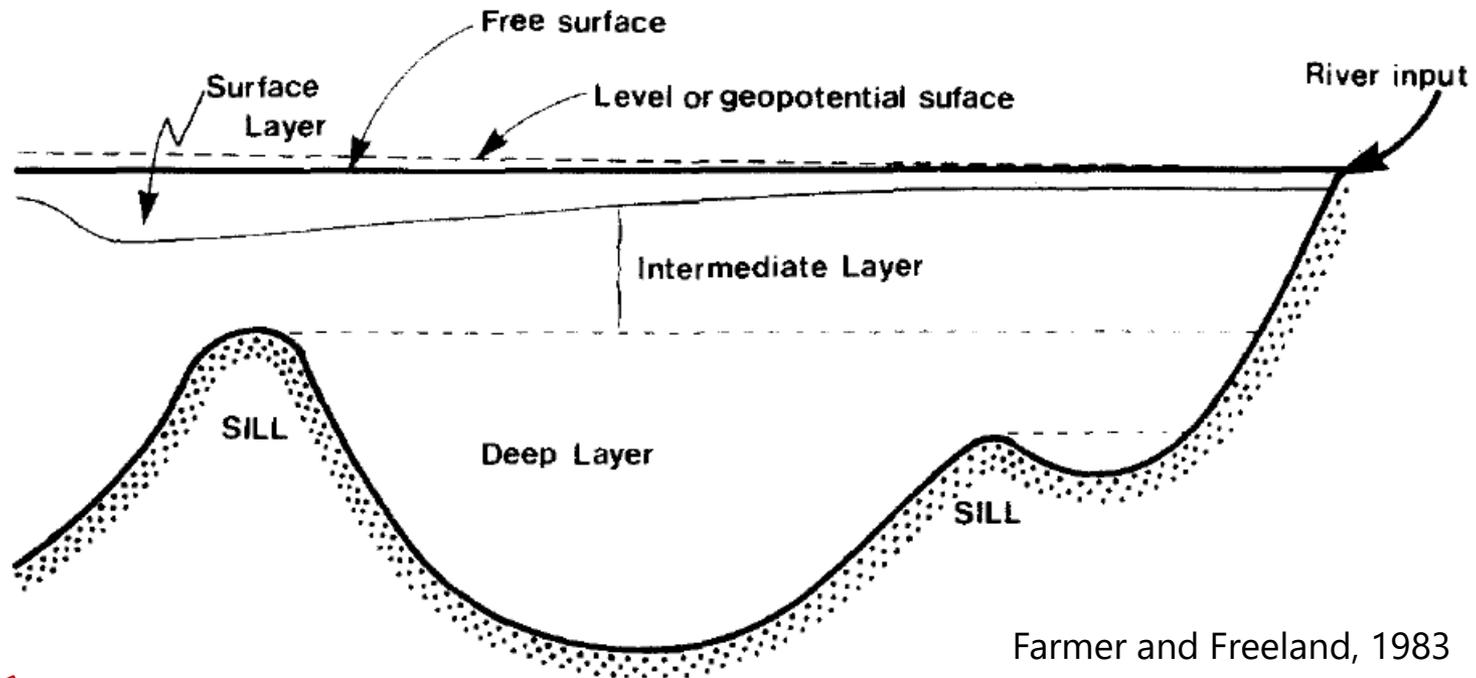


Fjord circulation

Long-term residual circulation: outward flow of **low-salinity surface water**,

Balanced by **inflow of coastal water in the intermediate layer**

Circulation influenced by **tides**, **wind**, and changes in the density structure of the coastal waters outside.

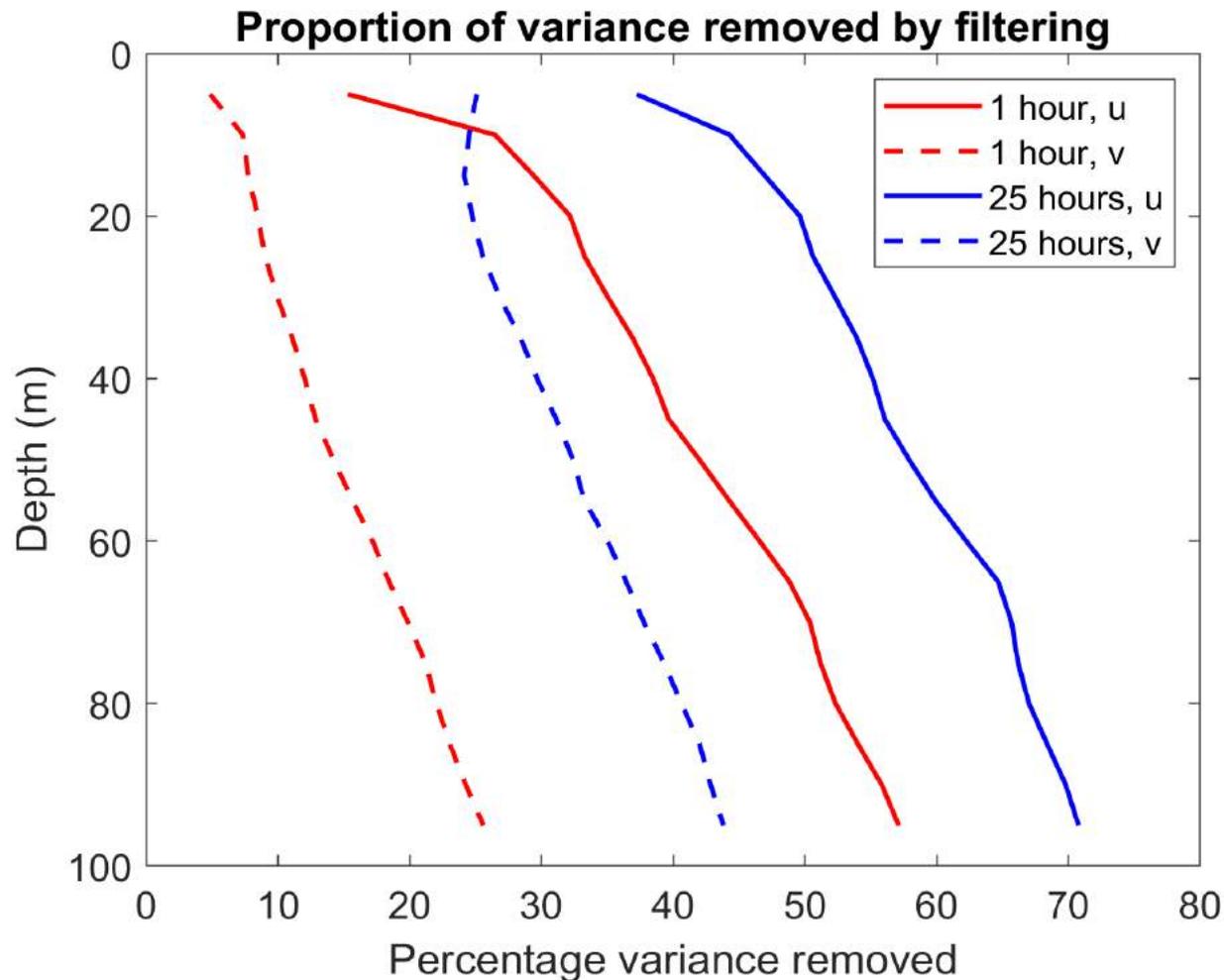


BUT:

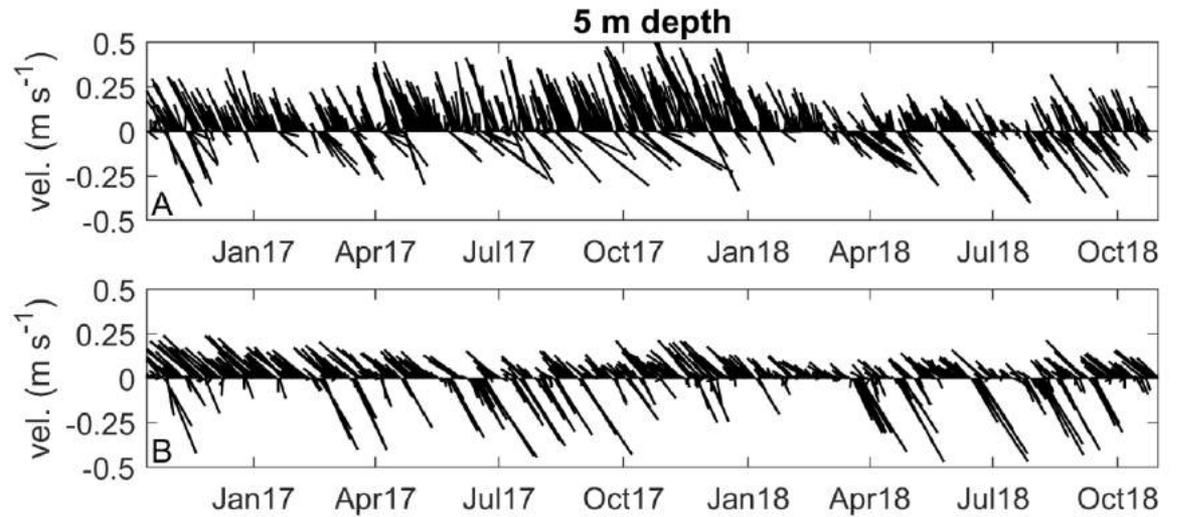
“...no two fjords are truly alike.” Inall and Gillibrand, 2010.

Current velocity time series

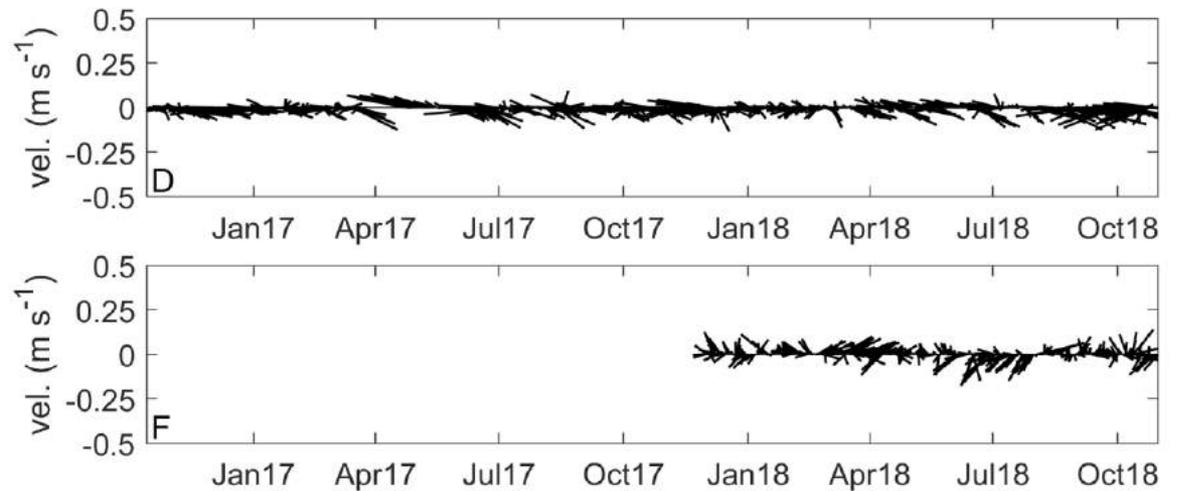
Short-term variability



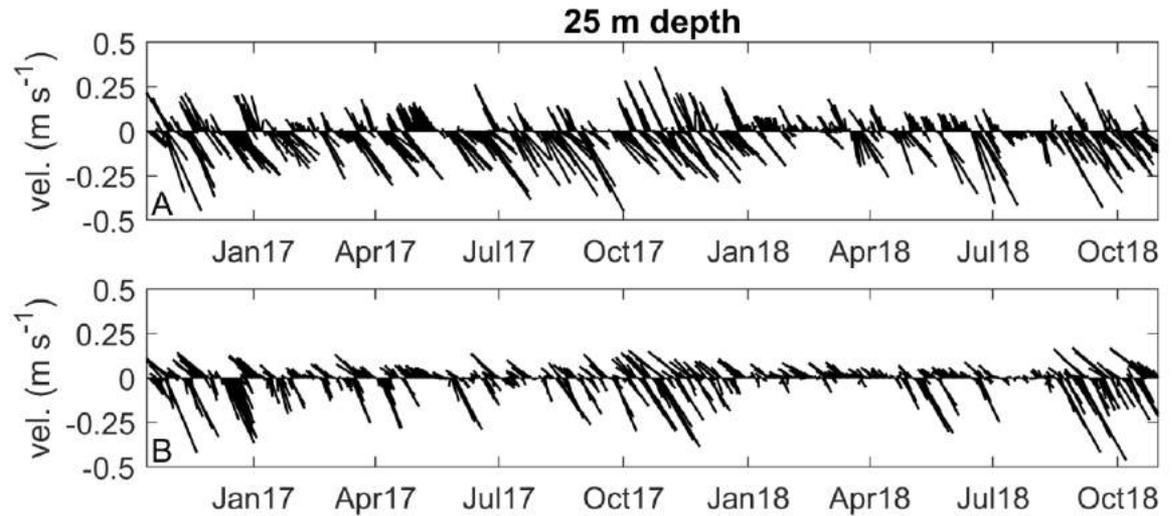
Current velocity vectors



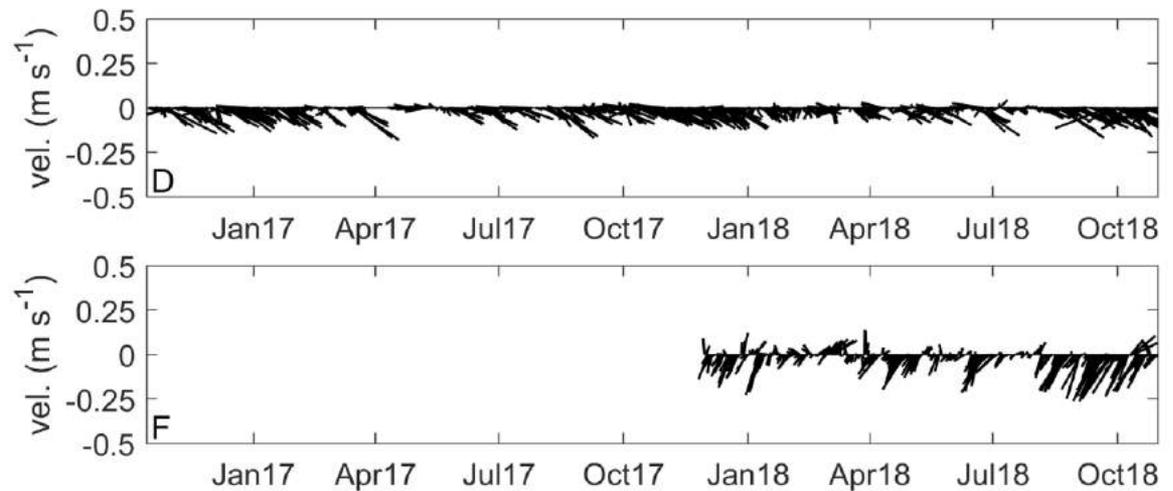
Low-pass filtered with 3.5 day cut-off
Subsampled daily



Current velocity vectors



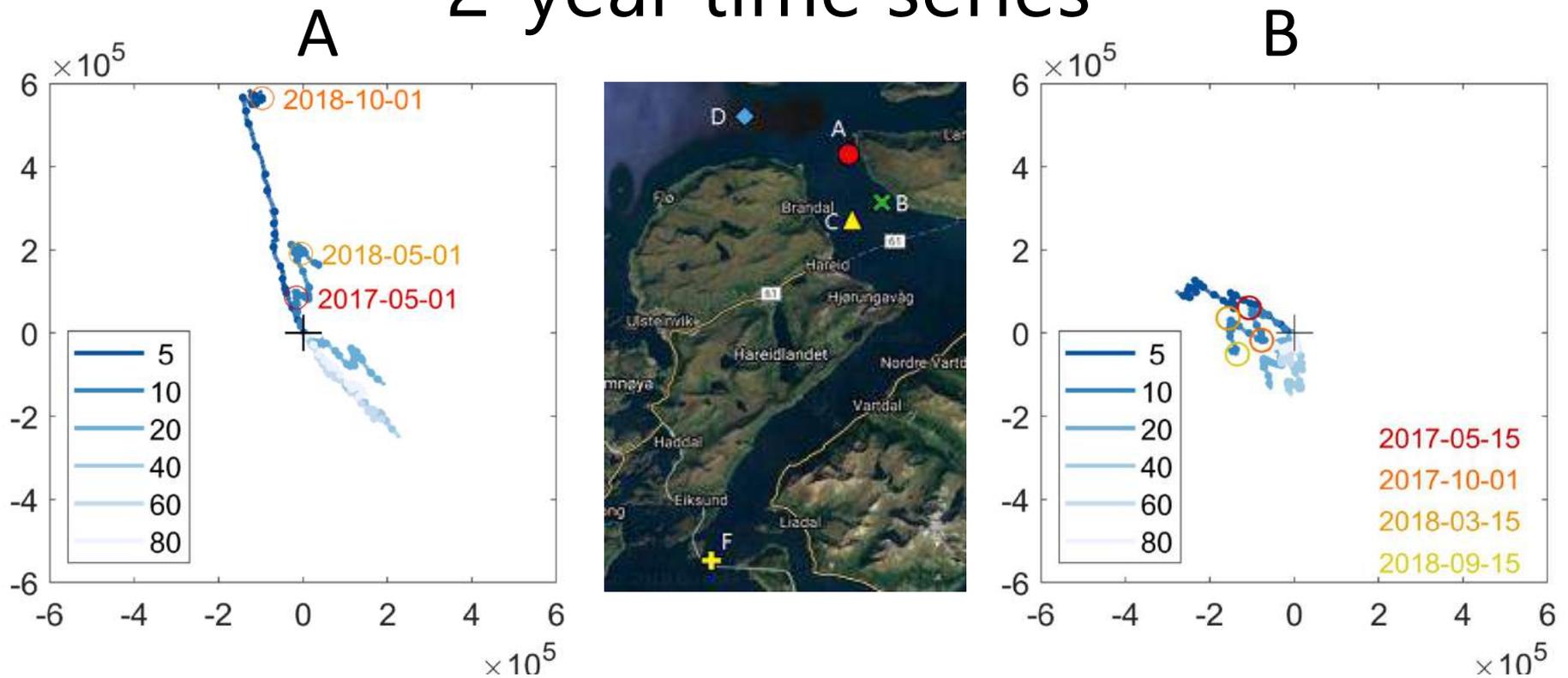
Low-pass filtered with 3.5 day cut-off
Subsampled daily



Progressive vector plot

Cumulative sum of velocity x sample interval – suggests particle trajectory

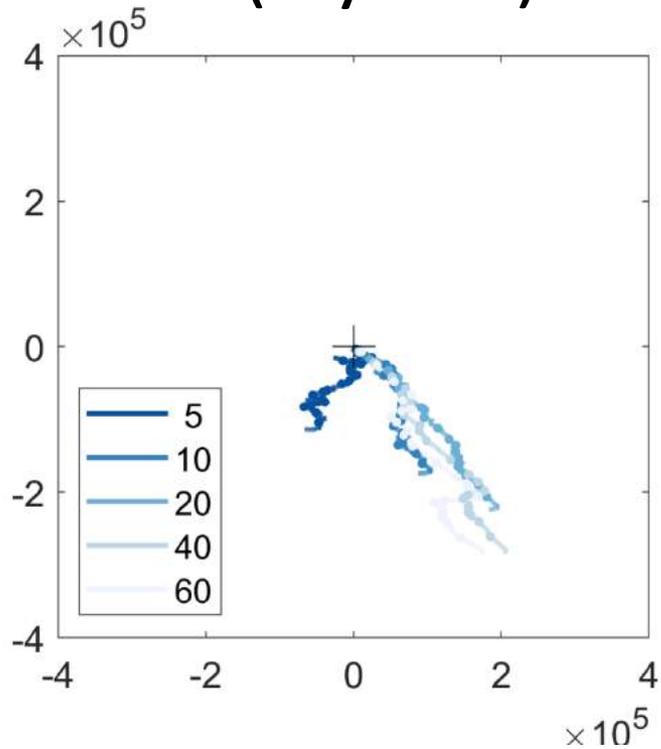
2-year time series



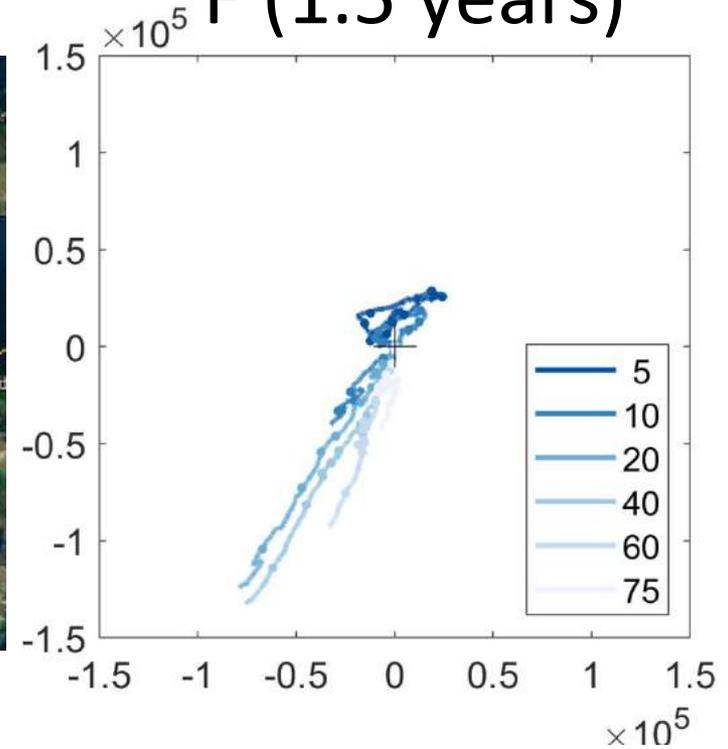
Progressive vector plot

Cumulative sum of velocity x sample interval – suggests particle trajectory

D (2 years)

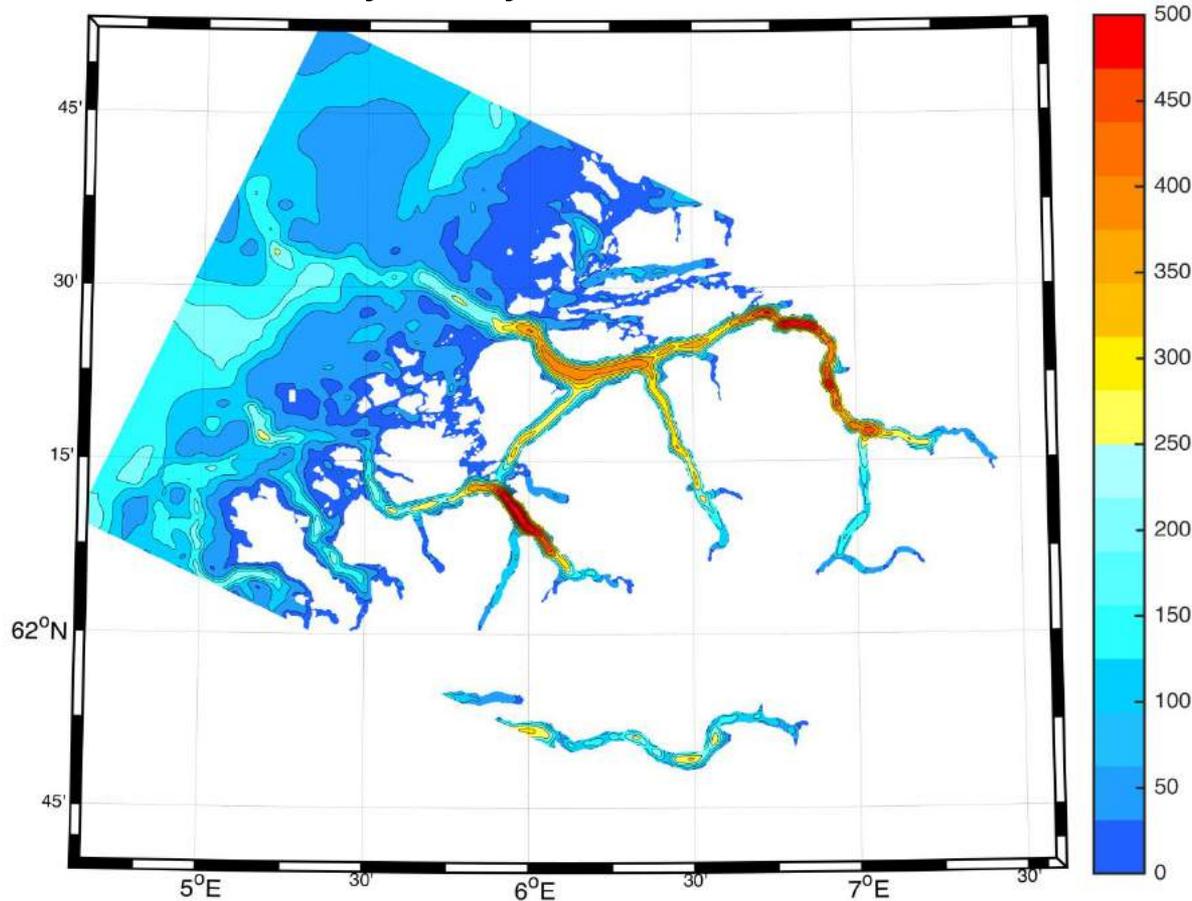


F (1.5 years)



Model – buoy data comparison

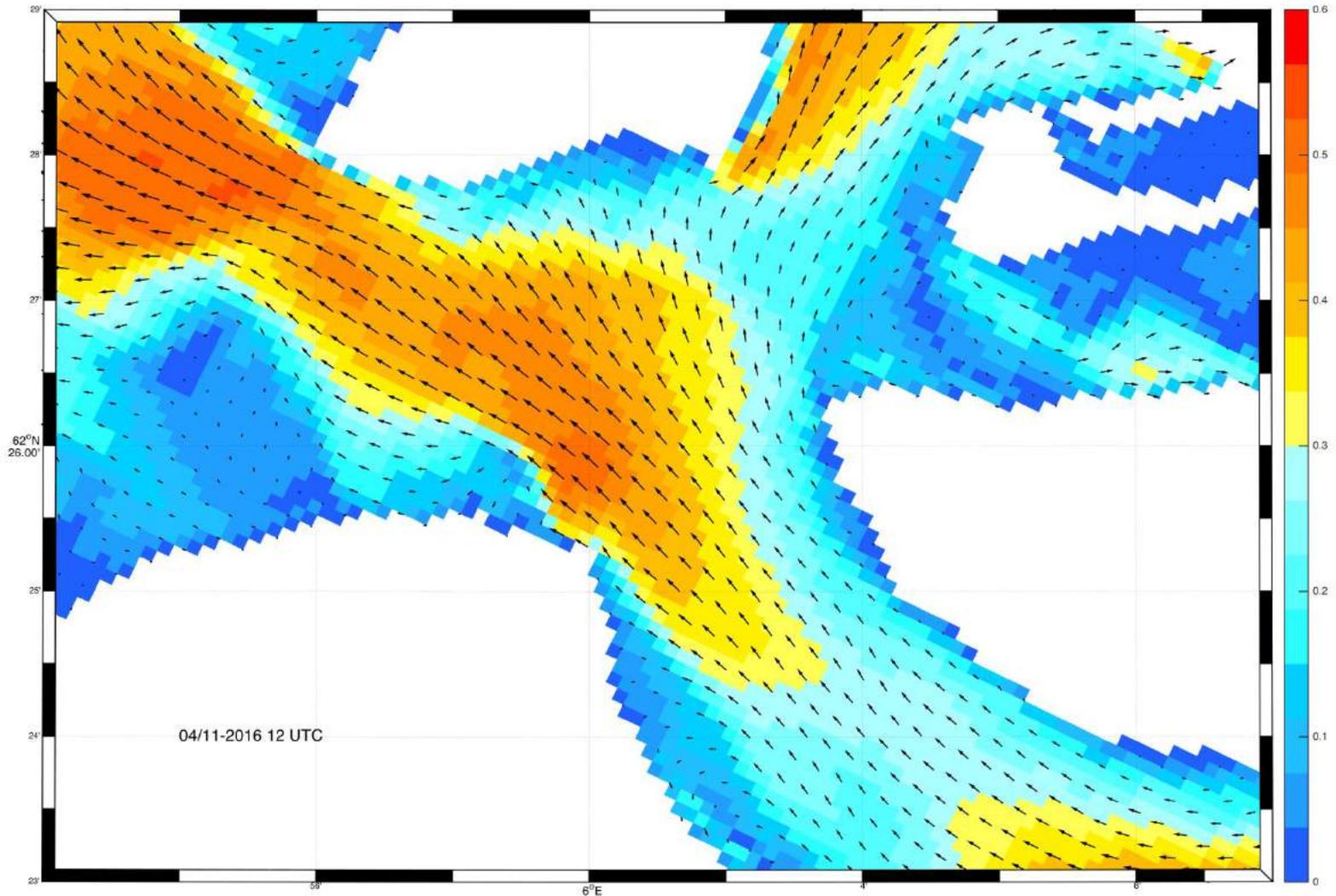
Model bathymetry (m)



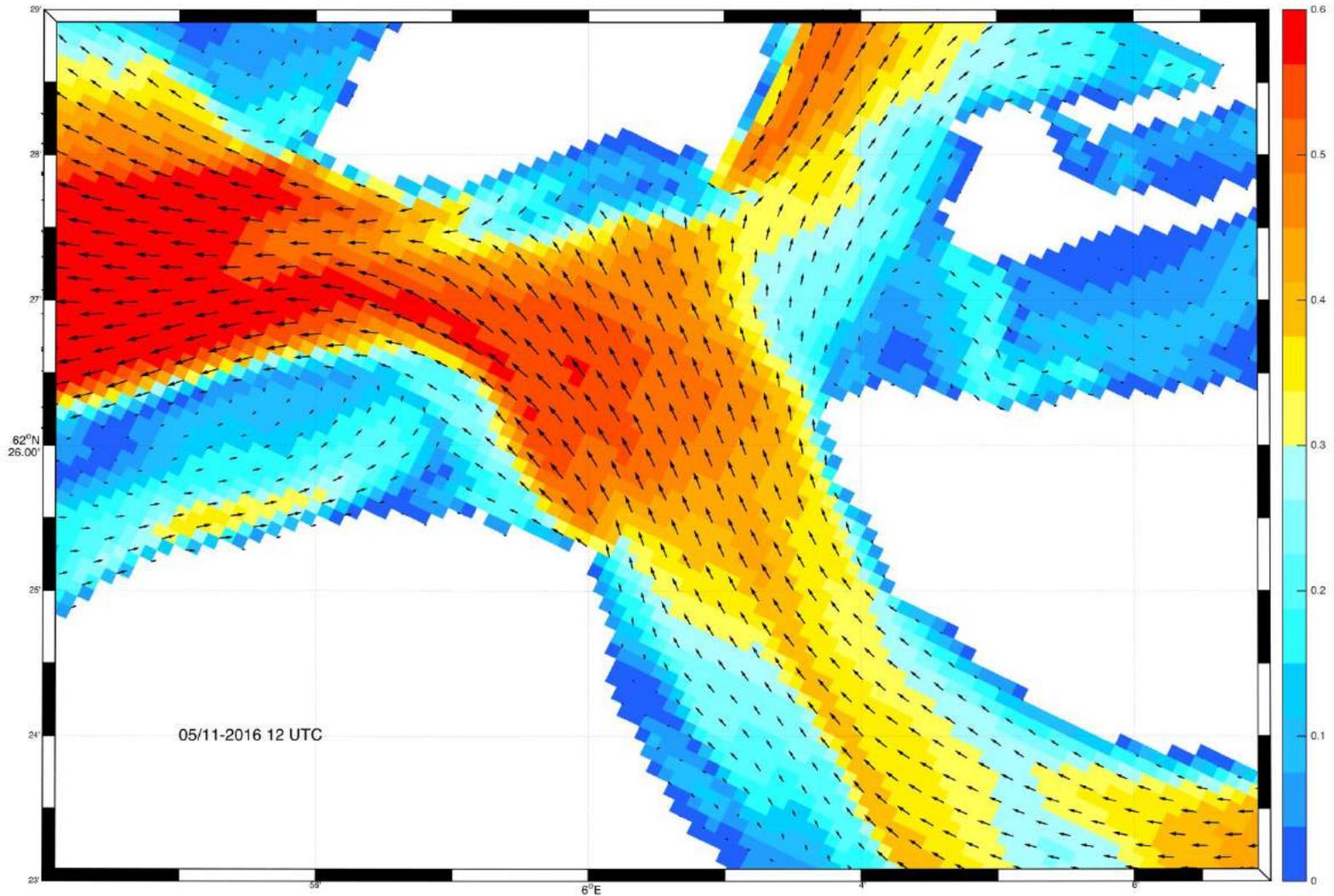
NorFjords160
160 m resolution
Results for 2016

Model results provided by Jon Albretsen, Institute of Marine Research

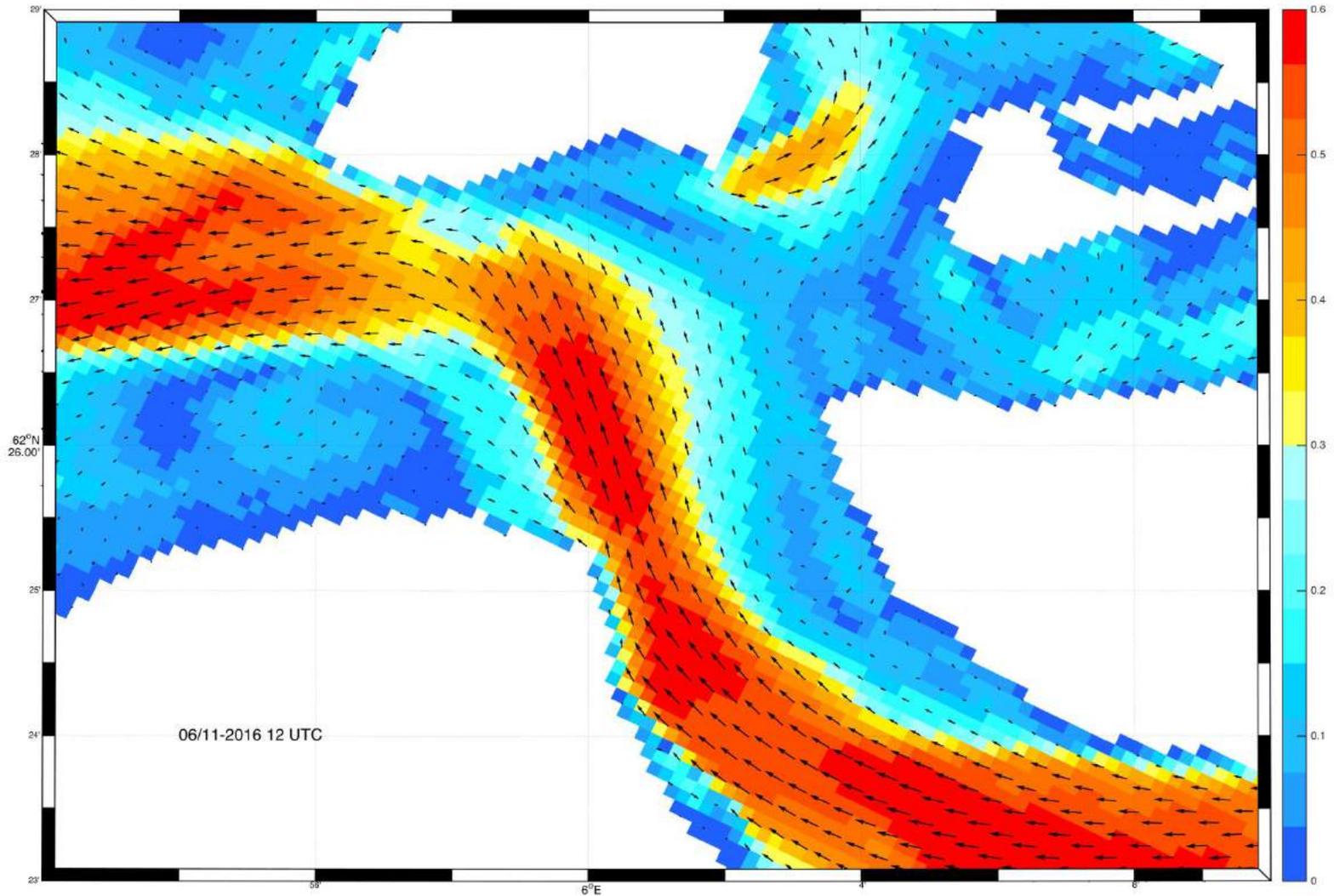
Example: model surface current vectors, 2016-11-04, 12 UTC



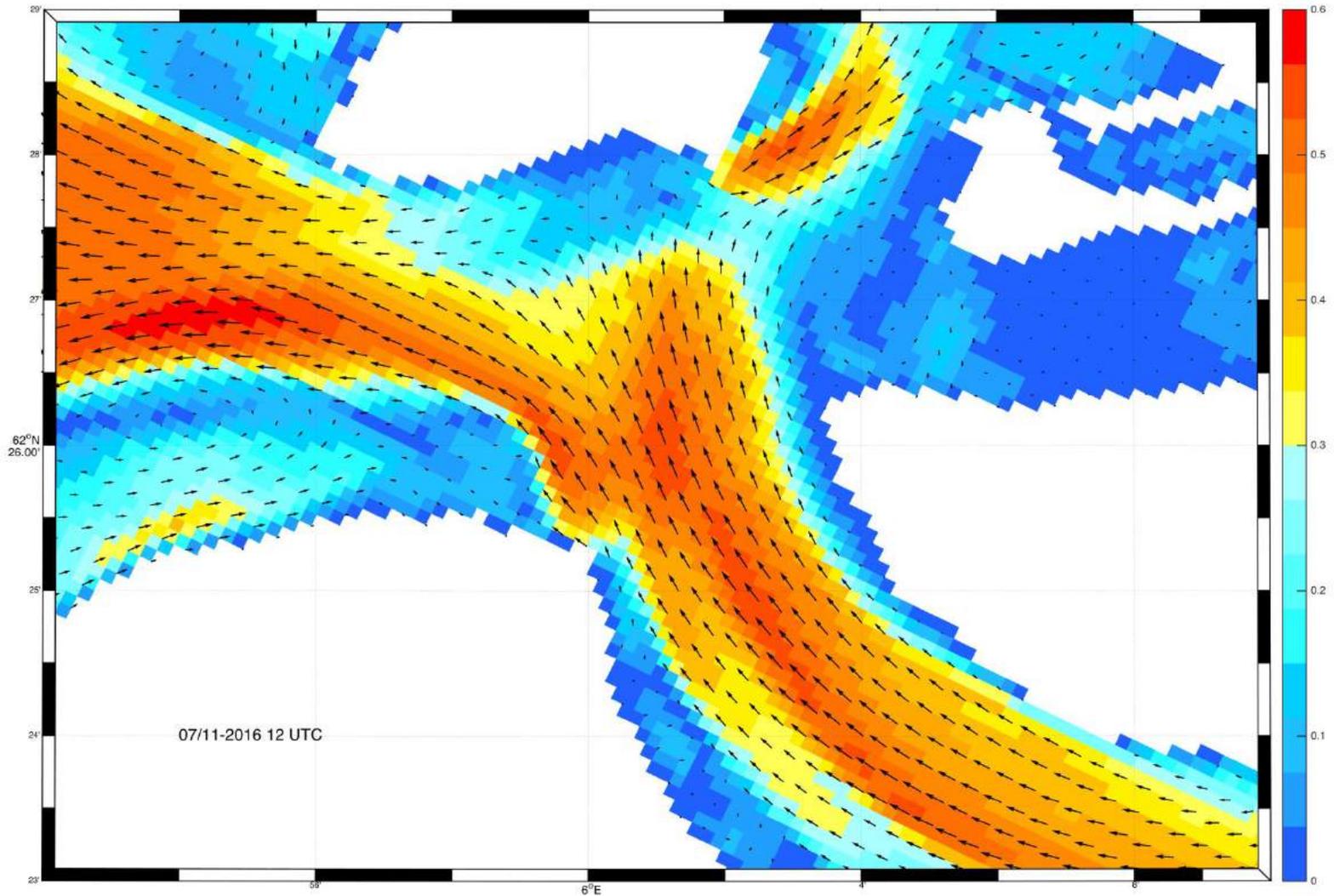
Example: model surface current vectors, 2016-11-05, 12 UTC



Example: model surface current vectors, 2016-11-06, 12 UTC



Example: model surface current vectors, 2016-11-07, 12 UTC



Current velocity observations

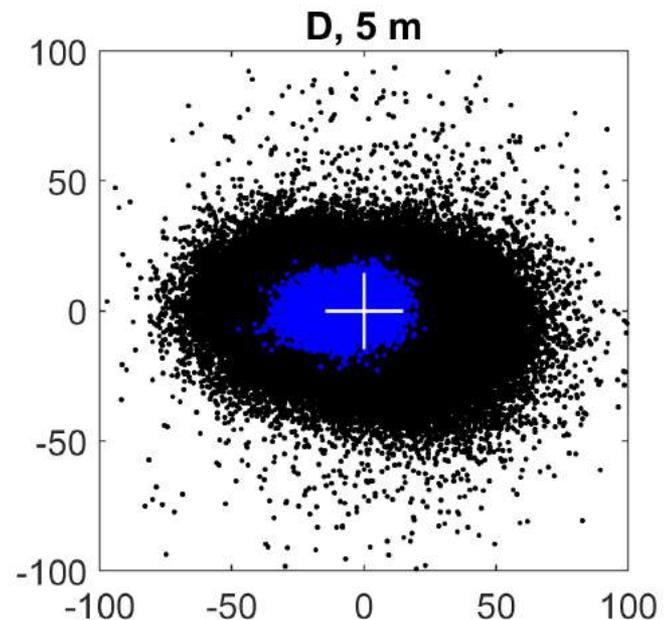
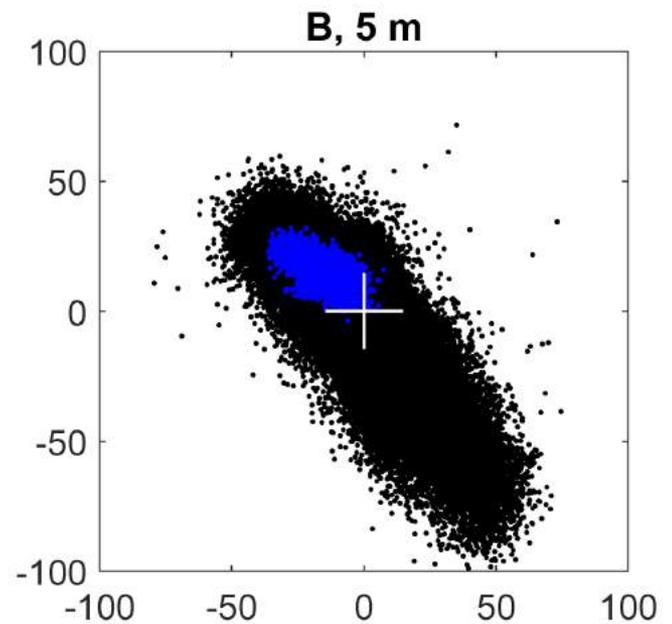
Scatter plots of observed u , v velocity (cm/s)

Black: all data from 2 year buoy time series at original 1 minute time resolution

Blue: only the 2016-11-04 – 2016-11-07 period for comparison with model vector plots

Flow at B, inside fjord, is strongly aligned with topography

At D, current direction is more variable

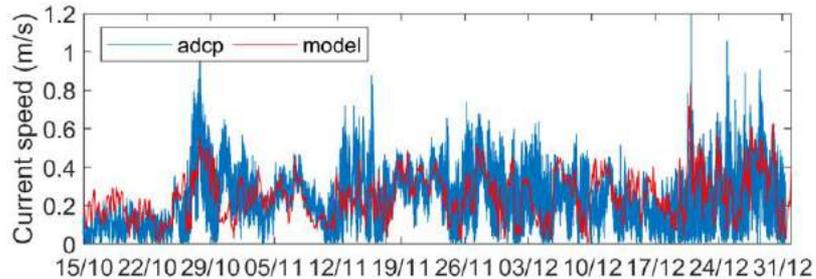
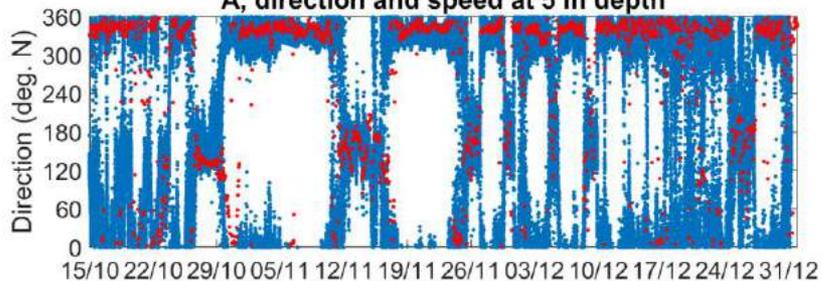


Model – buoy comparison

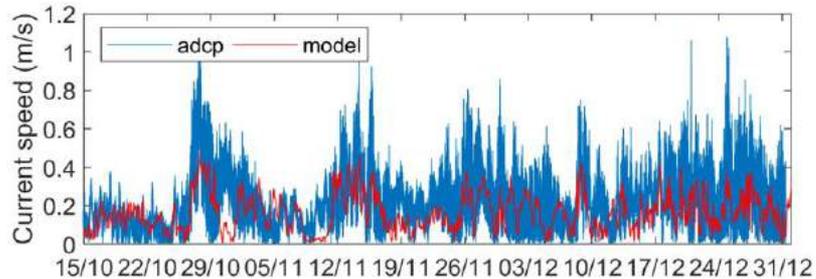
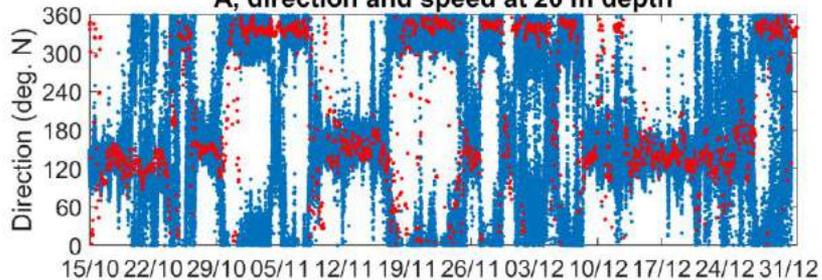
Buoy A, Sulafjord



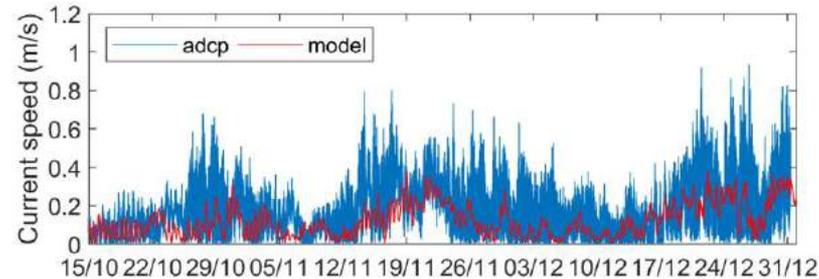
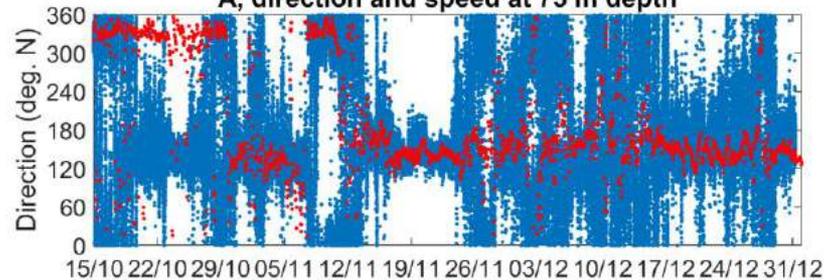
A, direction and speed at 5 m depth



A, direction and speed at 20 m depth



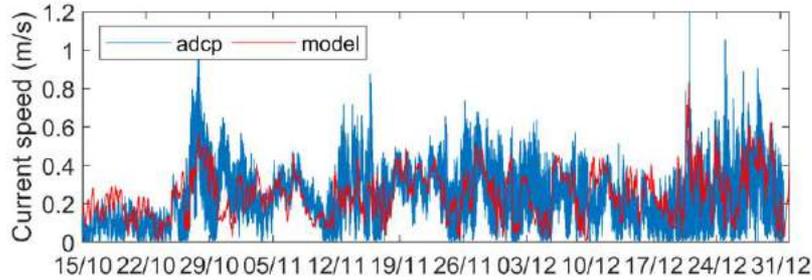
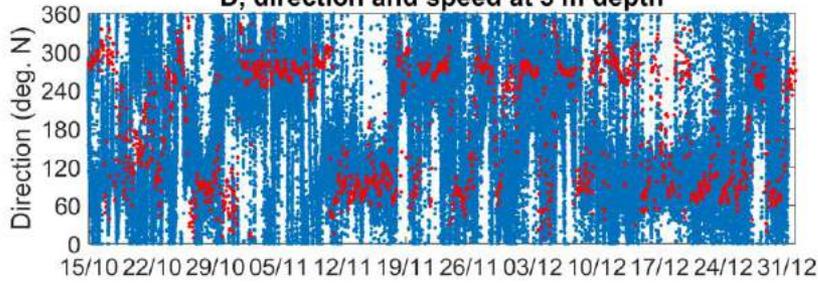
A, direction and speed at 75 m depth



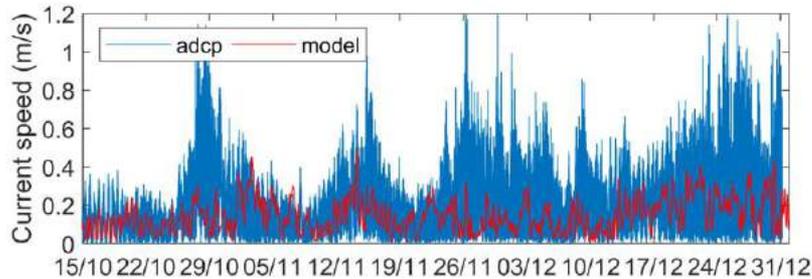
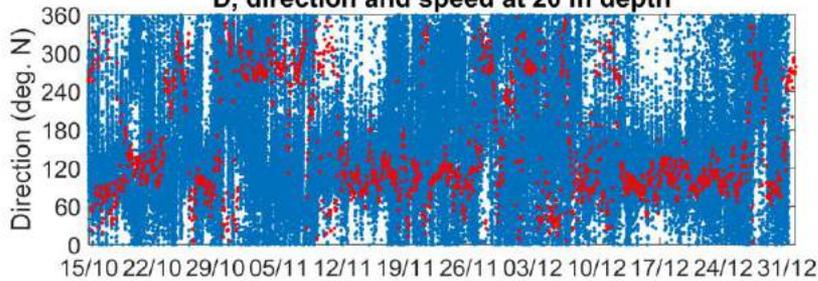
Model – buoy comparison



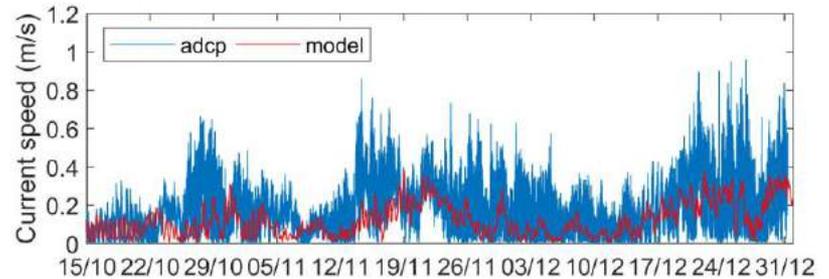
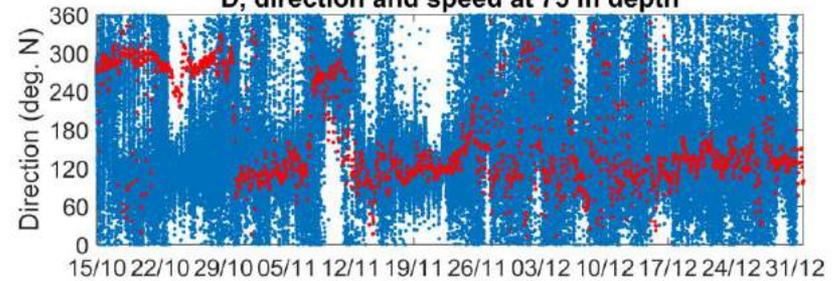
D, direction and speed at 5 m depth



D, direction and speed at 20 m depth



D, direction and speed at 75 m depth



Our concept: opportunistic data use

Work to get more data (publicly and privately funded) made available for research.



Collaborate on sharing, formatting, processing, quality control.

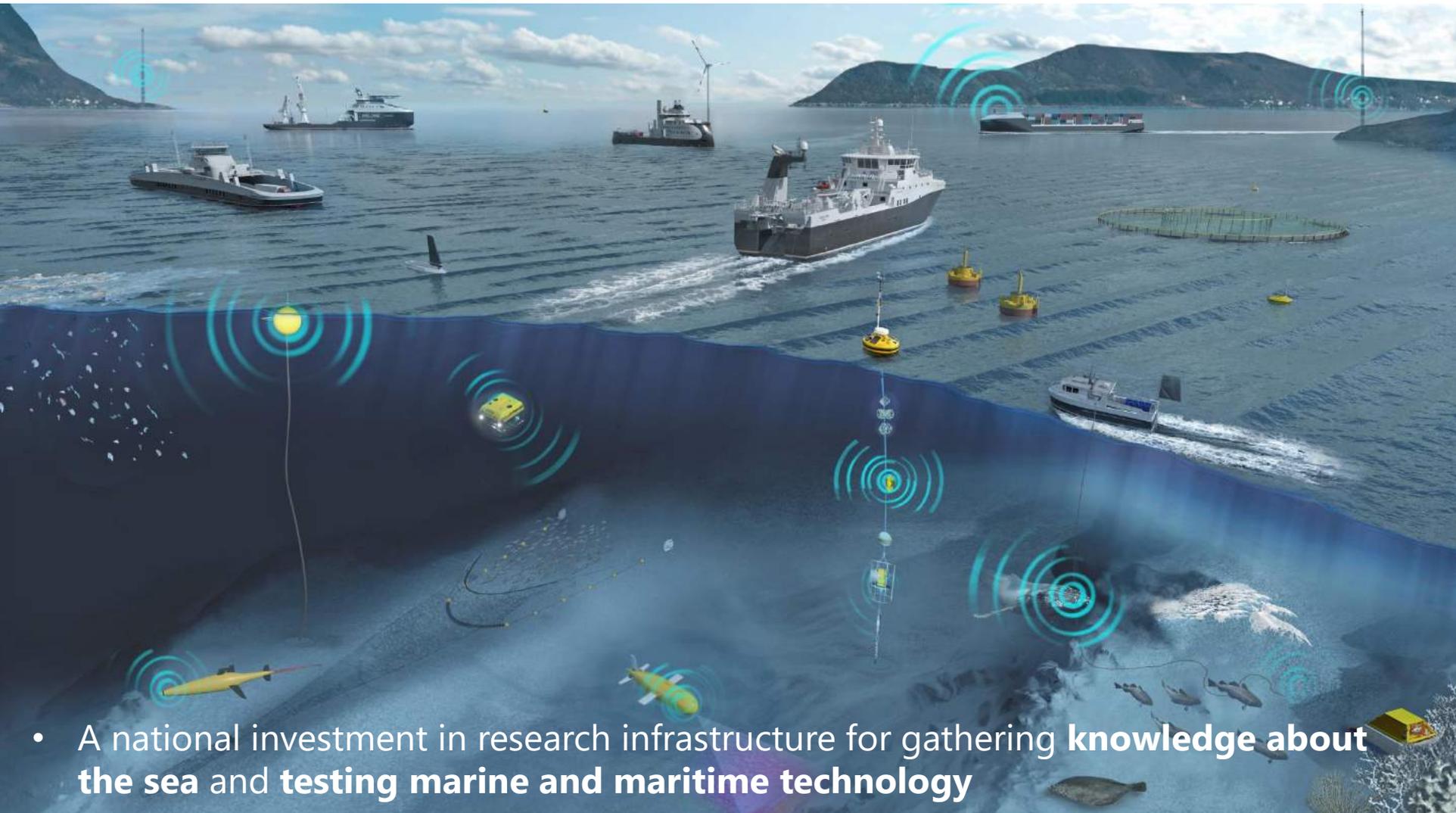
Be prepared to dig.

- Data collected on behalf of the NPRA will be used for **model validation**
- Improve control of **marine autonomous vehicles** by incorporating available (externally collected) environmental variables?
- Area designated for testing autonomous ships
- Ferry autocrossing, autodocking?
- Various AUVs and USVs deployed during fieldwork in 2017*
- Runde Environmental Centre work with underwater gliders → coastal?

*see e.g. Fossum et al., 2018, (re-)submitted manuscript 😊

Fun fact: Several seminal fjord oceanography papers (Stigebrandt, 1980s) stemmed from an aquaculture environmental impact assessment for the Møre & Romsdal County Council.

Møre Ocean Lab

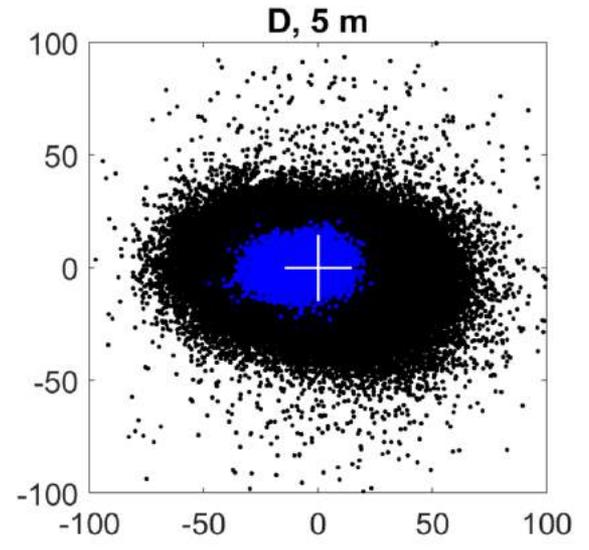
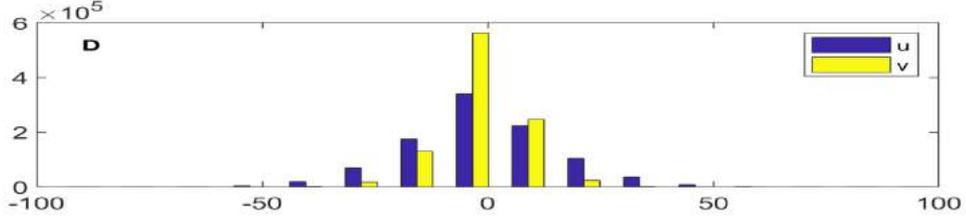
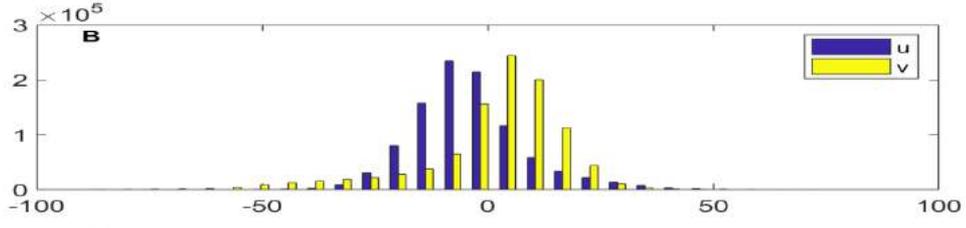
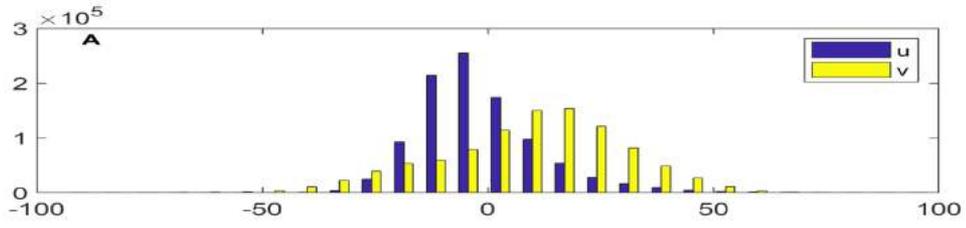
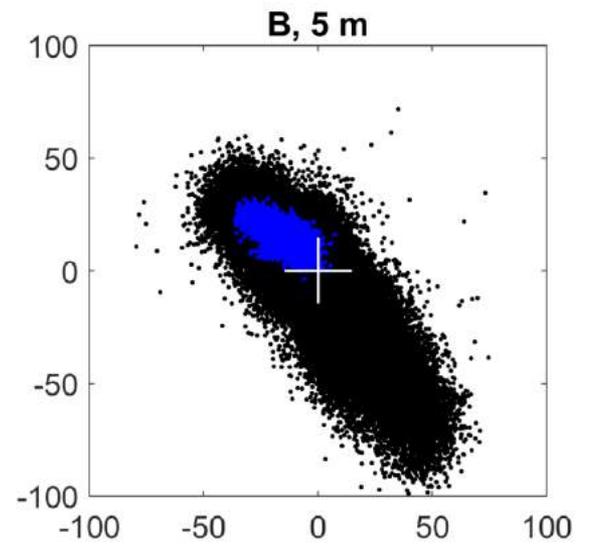
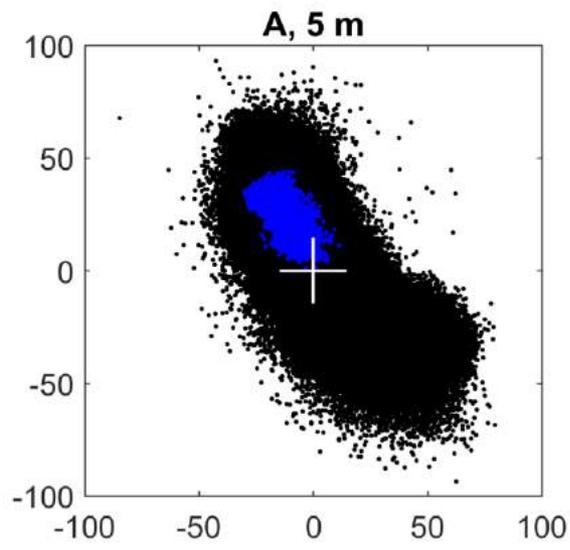


- A national investment in research infrastructure for gathering **knowledge about the sea** and **testing marine and maritime technology**
- A complete, miniature 'ocean space' where the **ocean meets the fjords**
- Already one of the most **well-instrumented** areas along the Norwegian coast

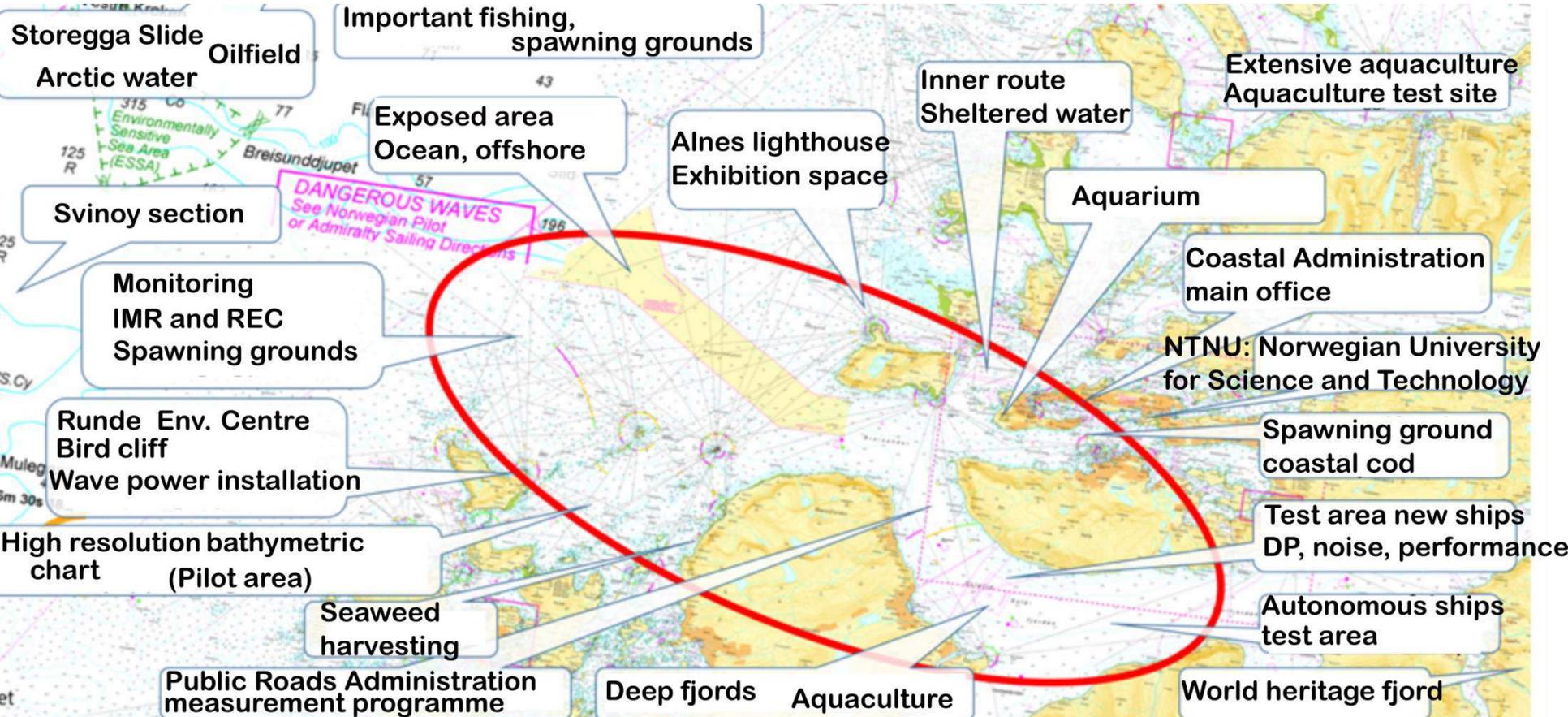


Thank you!

«Extra material»



«Extra material»



Ship design, Shipyards
Maritime technology

Cold water corals

Plastic litter hotspot

Trawl testing

Testing scientific equipment
(plankton nets)