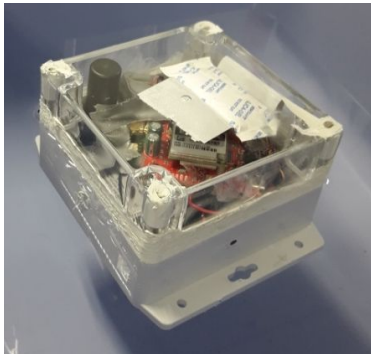
Small Friendly Wavebuoy & OpenMetBuoy

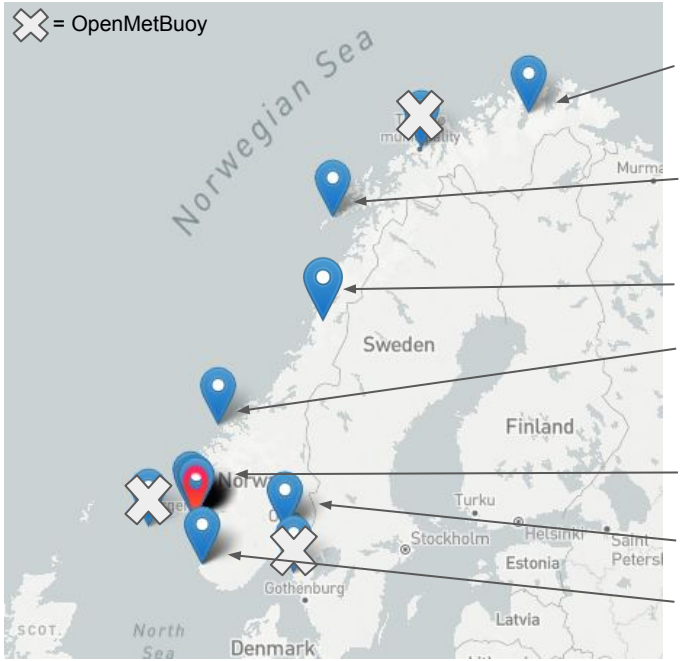


Gaute Hope & Jean Rabault Førland
gauteh@met.no / 2022

Motivation

- Most incidents happen near the shore and inside fjords
- Many measurement positions are better than having a few fixed moorings
- Drifters are needed for trajectory modeling
- Lightweight, drifting, wave-buoys can be used for surf-measurements
- Higher bandwidth enables us to transmit timeseries of high frequency measurements, hopefully this means that we can start looking at breaking waves
- Low-cost and self-built enables us to have many units, and customize for our need.

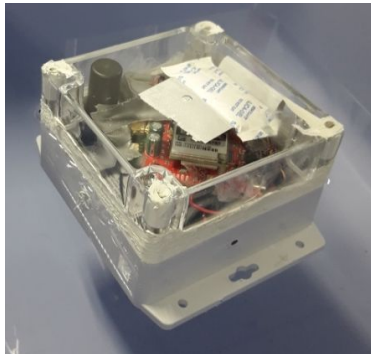
https://github.com/gauteh/sfy



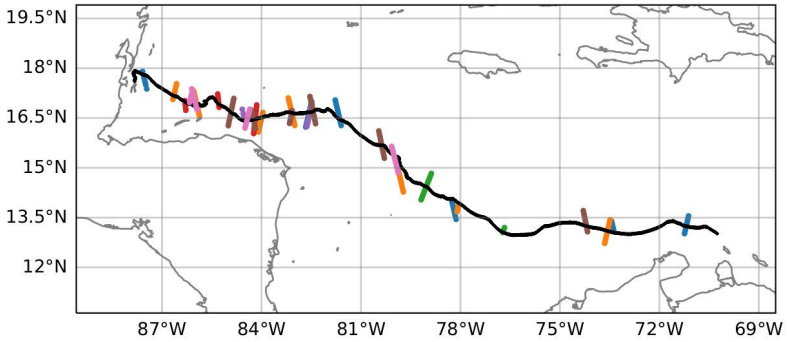
https://wavebug.met.no (token: wipeout)

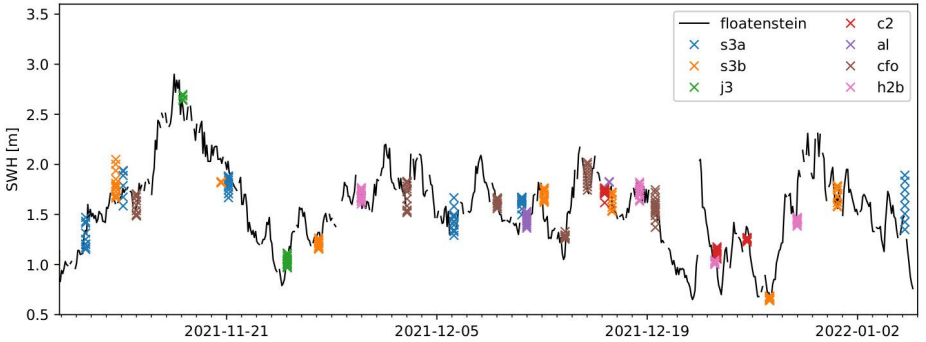
- Sample rate: **52 Hz sampling rate**, filtered (FIR) and downsampled from *208 Hz input to AHRS algorithm*.
- Telemetry: Full time-series through **cellular network**, GSM, LTE.
- Georeference and time: GPS/GNSS
- On-board storage: SD-card
- Cost of parts: **About 2000 NOK / 250 USD.**

OpenMetBuoy / Floatenstein

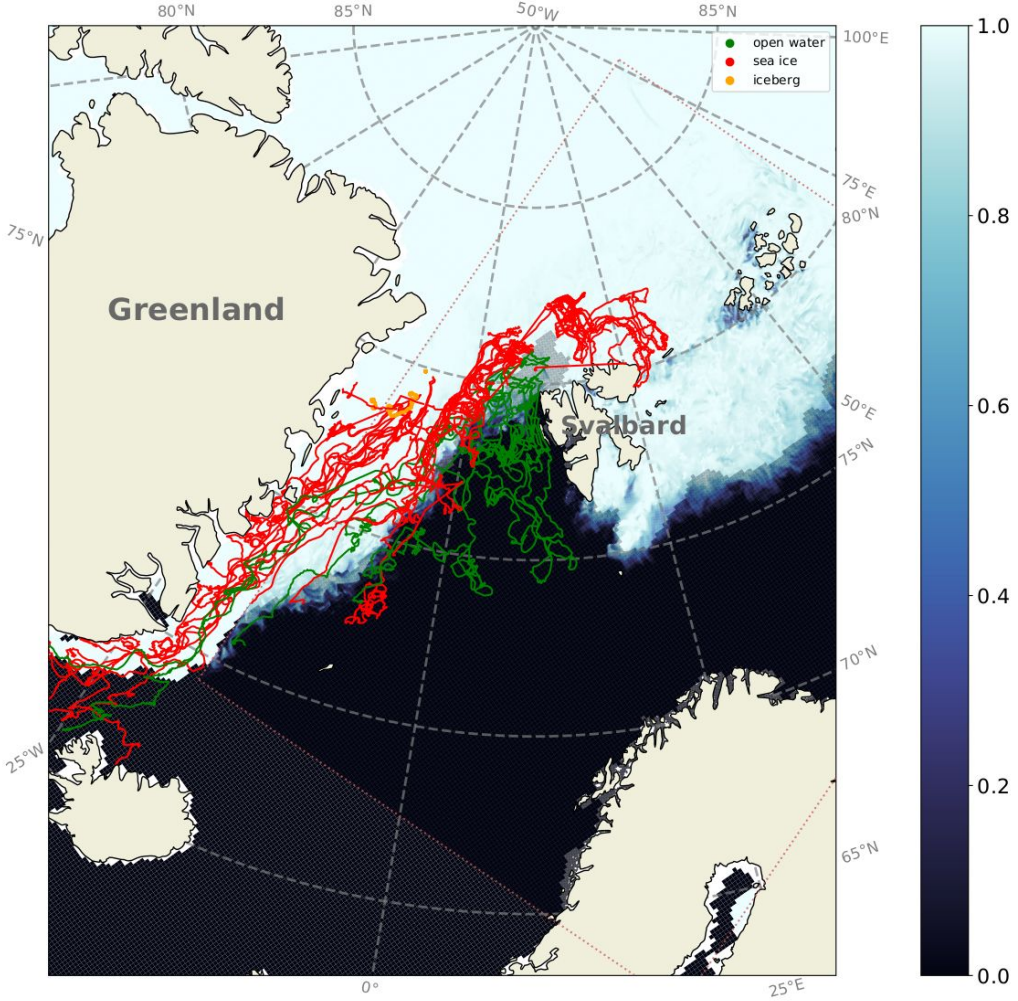


- total cost of the parts: 562USD (Nov. 2021 price).
- typical assembly time: around 1-1.5hr per buoy when producing a small series efficiently.
- cost of the iridium communications: 42USD / month if using only GPS, up to 108USD / month v using GPS and high frequency wave measurements (Nov. 2021 price).
- battery autonomy: i) 4.6 months using 2 Li D-cells, with GPS and wave measurements activate Over 1 year using 2 Li D-cells and GPS tracking only. iii) Battery life scales linearly with the nur D-cells included in the instrument.
- typical detection threshold for waves in ice: 0.5cm at 16s period, even better detection thresho obtained at higher frequency due to using an IMU to perform the measurements.





J. Rabault


80°N
85°N
50°W
85°N
100°E
75°E
80°N
50°E
75°N
70°N
65°N
25°W
0°
25°E
75°N
open water
sea ice
iceberg
Greenland
Svalbard
1.0
0.8
0.6
0.4
0.2
0.0

J. Rabault

OpenMetBuoy: deployments

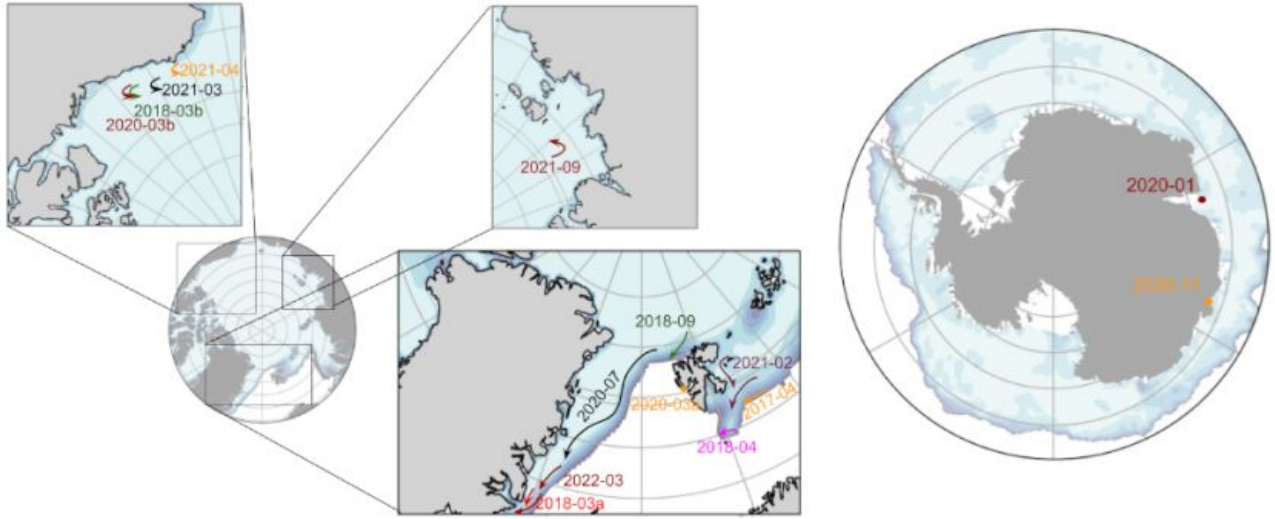


Figure 2. Overview of the deployments present in the dataset. The SIC map show the averaged SIC over the local winter month in the Arctic and Antarctic.

A dataset of direct observations of sea ice drift and waves in ice
J. Rabault et. al.
2022

OpenMetBuoy: data archives

https://github.com/jerabaul29/data_release_sea_ice_drift_waves_in_ice_marginal_ice_zone_2022/tree/master/Data/2022_March_East_Greenland/Instruments_V_2021a

```
❯ ncdump -h data_drift_waves_Greenland_2022_seals_cruise.nc
netcdf data_drift_waves_Greenland_2022_seals_cruise {
dimensions:
        trajectory = 2 ;
        observation = 3356 ;
        len_of_name = 16 ;
        frequency = 55 ;
variables:
        float frequency(frequency) ;
                frequency:long_name = "frequency bins of the spectra" ;
                frequency:units = "s-1" ;
        char trajectory_id(trajectory, len_of_name) ;
                trajectory_id:standard_name = "platform_id" ;
                trajectory_id:long_name = "platform name" ;
        char message_kind(trajectory, observation) ;
                message_kind:long_name = "whether the current [trajectory, observation]
contains GPS [kind G], or Waves [kind W], or None [kind N, in case of failed transmission]
data." ;
        double time(trajectory, observation) ;
```

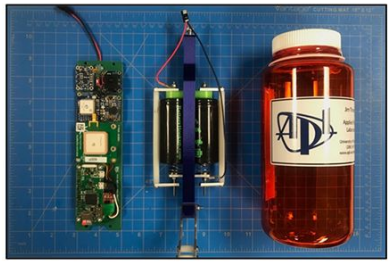
microSWIFTs (Applied Physics Laboratory, UW, Seattle)

MICROSWIFT EXPENDABLE WAVE BUOY

Applied Physics Laboratory
University of Washington
1013 NE 40th St, Seattle WA 98105

Specifications

Enclosure	**1 L Naglene bottle**
Dimensions	9.2 cm (3.6 in) diameter, 21.4 cm (8.4 in) length
Weight	0.9 Kg (2.0 lbs)
Batteries	Rechargeable $LiFePO_4$, 2 cells at 19.2 Wh and 141 g each
Telemetry	Satellite (Iridium SBD)
Connectivity	WiFi
Processor	Raspberry Pi Zero
GPS	GlobalTop FGPMMOPA6H
IMU	FXOS8700CQ (9 dof)
Water temperature	Adafruit TMP36
On-board storage	microSD card
Onboard software	Python, https://github.com/alexdeklerk/microSWIFT
Sampling rates	4 Hz (GPS), 12 Hz (IMU)
Air drop parachute	61 cm (24 in) diameter with 63.5 (25 in) bridle
Endurance	2 days

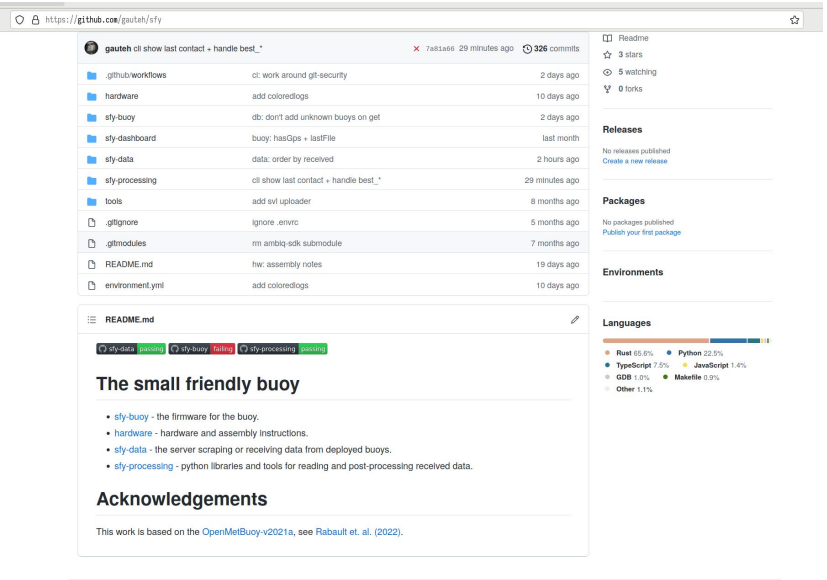


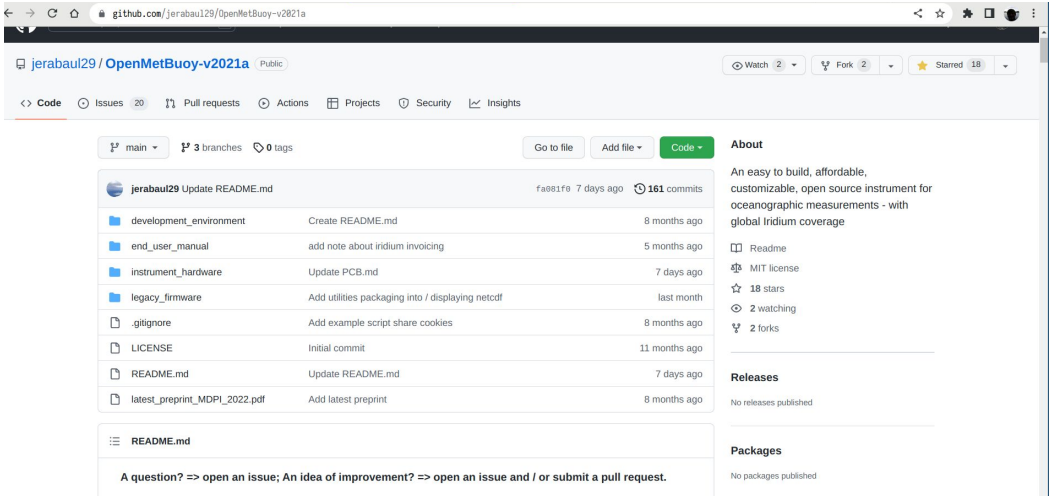
Hourly telemetry products and accuracy

Position (lat, lon)	**± 5 m**
Significant wave height, Hs	± 0.1 m
Peak wave period, Tp	± 1 s
Dominant wave direction, Dp	± 15 deg
Scalar wave energy spectrum, E(f)	± 10^{-2} m^2/Hz, 0.05 < f < 0.5 Hz
Directional moments of the spectrum (a1,a2,b1,b2)	± 0.1, 0.05 < f < 0.5 Hz

Public server for telemetry products (data tab): http://www.apl.uw.edu/SWIFT
Live map for active buoys (rolling 3 hr window): http://swiftserver.apl.washington.edu/map/
GitHub repository for fetching telemetry and post-processing (inc. raw wave displacements): https://github.com/jthomson-apluw/SWIFT-codes

Open source: hardware and software





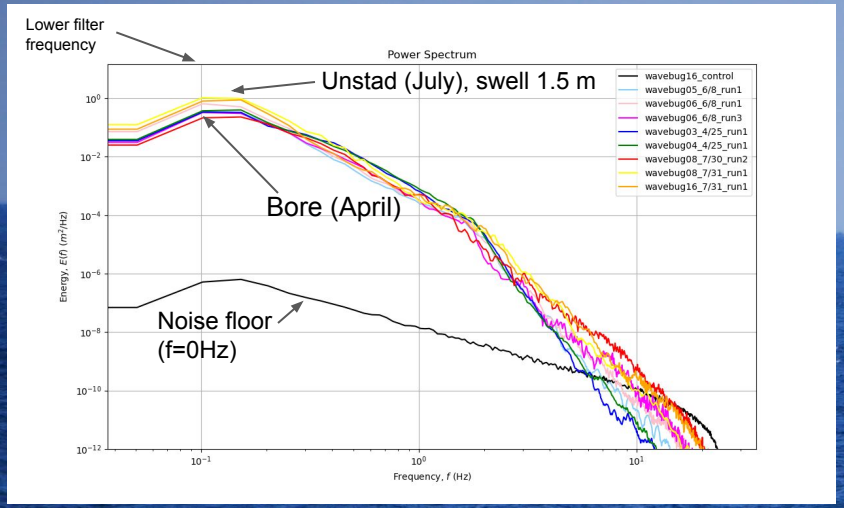


Photo: Torunn Irene Seldal

Borestranda (April 2022)

https://www.youtube.com/watch?v=iUGFtYr9HlY

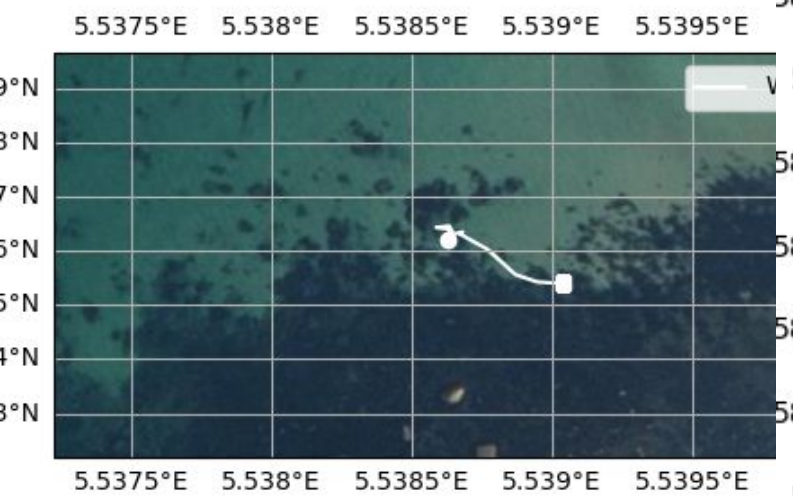
Video by: Torunn Irene Seldal

Borestranda II

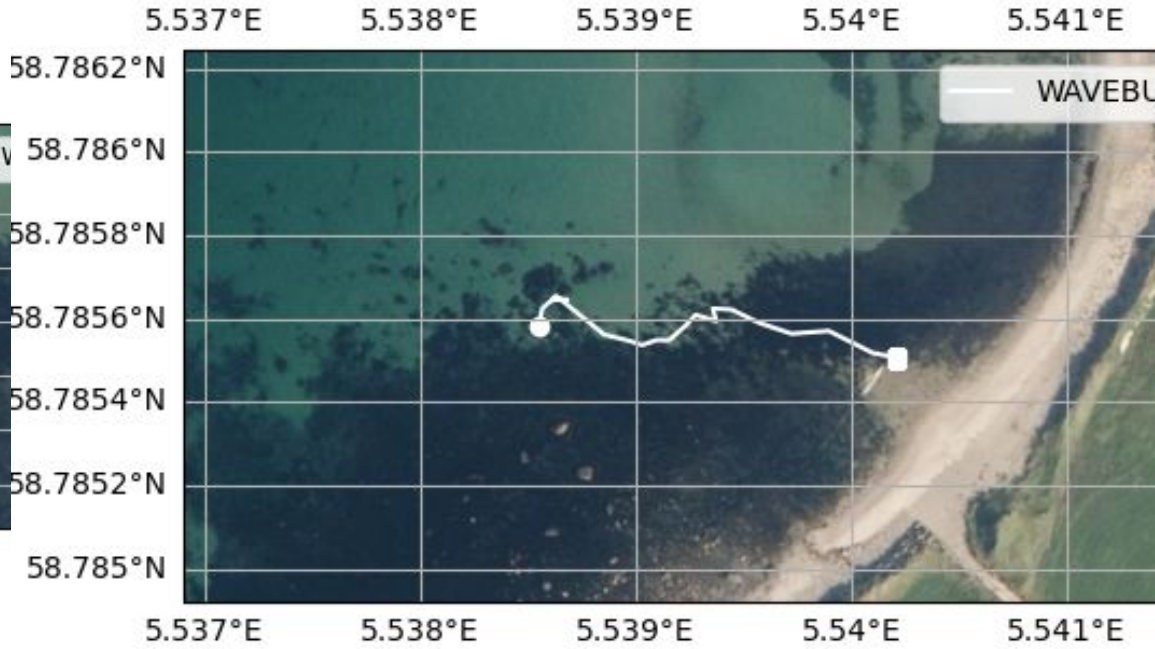
Photo: Torunn Irene Seldal

Fuglingen – Bore

Bøye 6

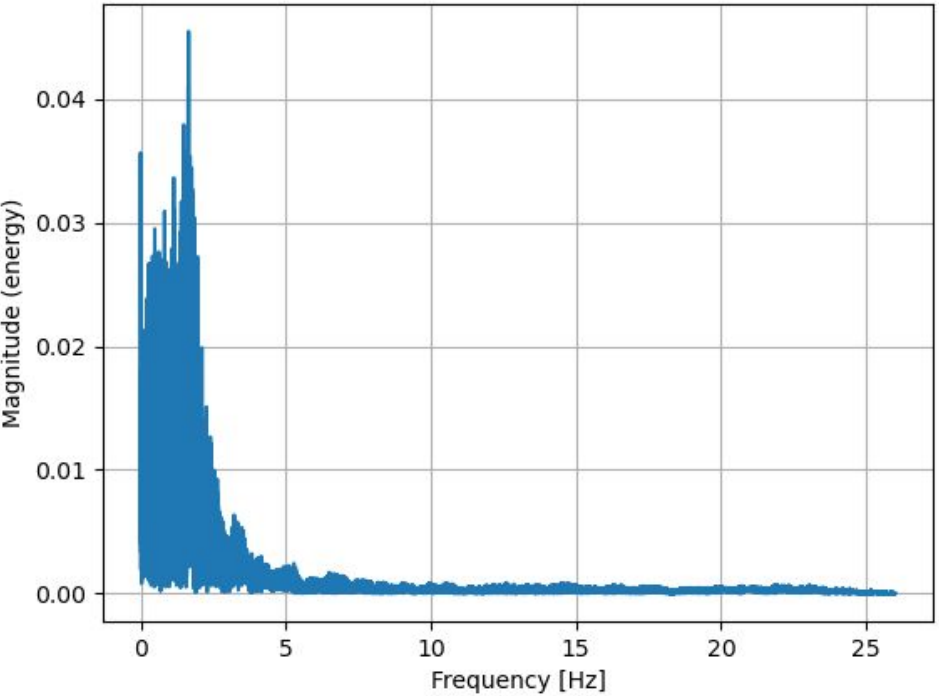


Bøye 5

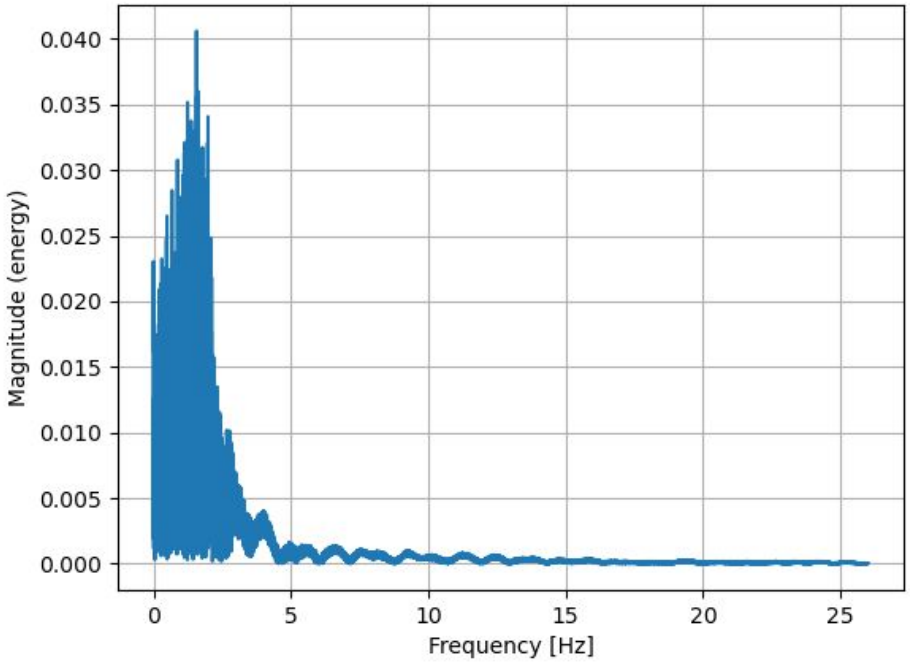


Spektrum

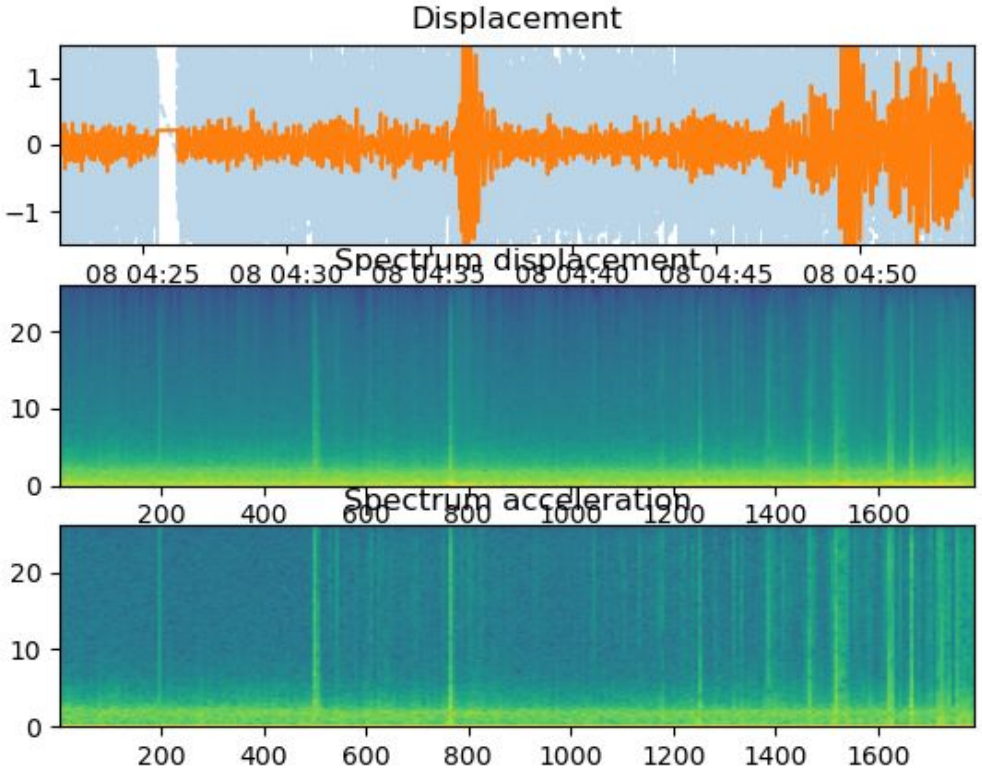
Bøye 6



Bøye 5



Bøye 6


Displacement
1
0
−1
08 04:25
08 04:30
08 04:35
08 04:40
08 04:45
08 04:50
Spectrum displacement
20
10
0
200
400
600
800
1000
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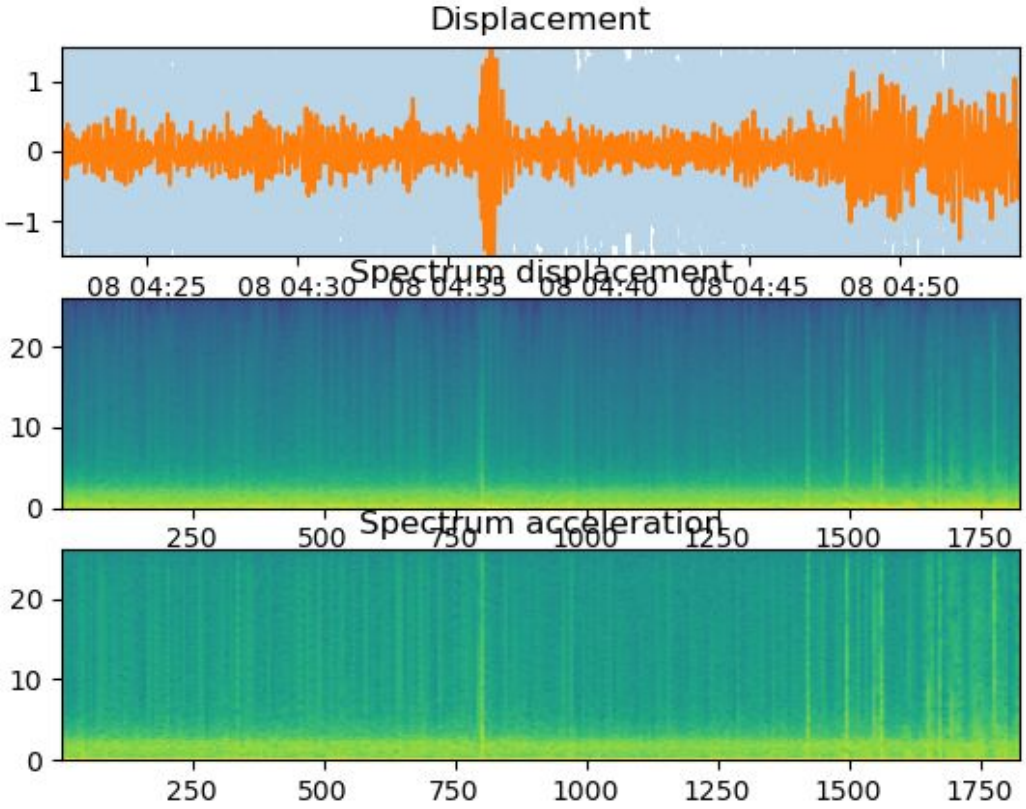
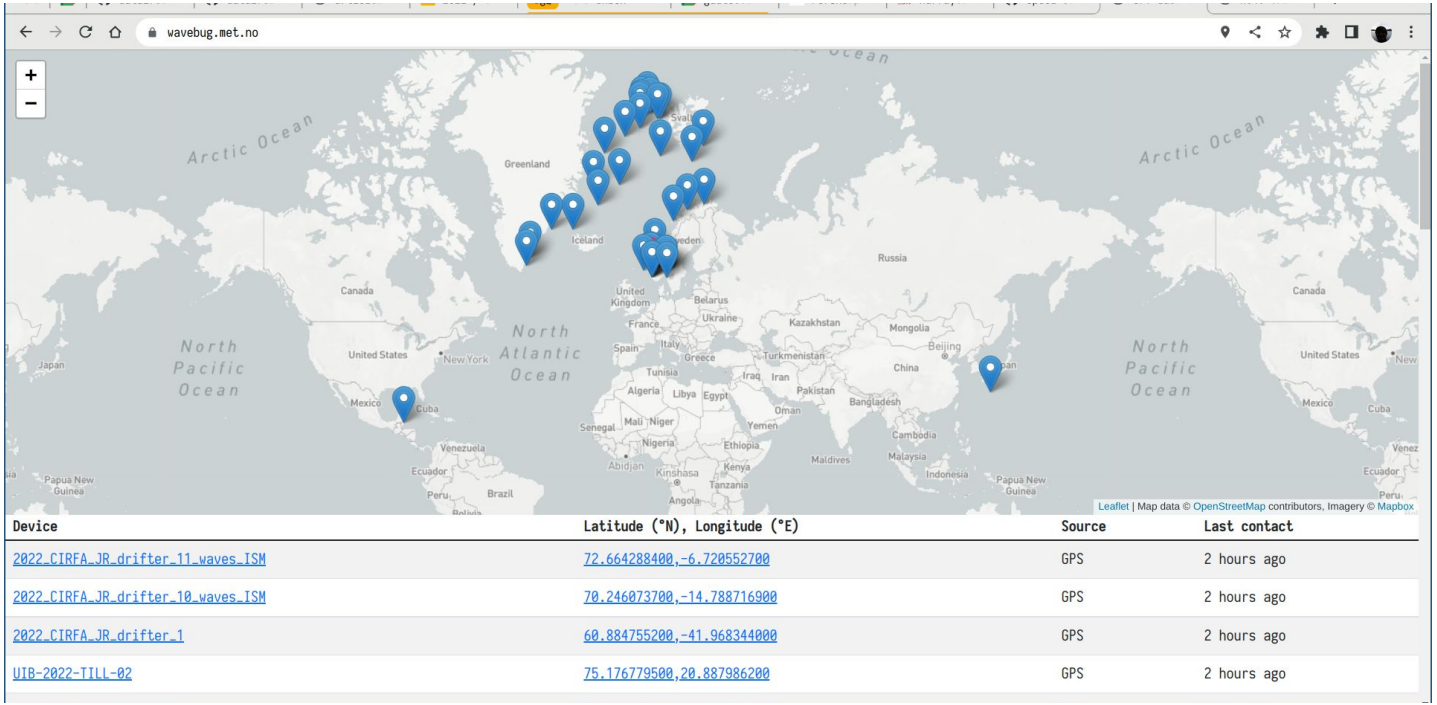
1600
Spectrum accleration
20
10
0
200
400
600
800
1000
1200
1400
1600

Bøye 5


Displacement
1
0
−1
08 04:25
08 04:30
08 04:35
08 04:40
08 04:45
08 04:50
Spectrum displacement
20
10
0
Spectrum acceleration
20
10
0
250
500
750
1000
1250
1500
1750

Dashboard and data hub



Device	Latitude (°N), Longitude (°E)	Source	Last contact
2022_CIRFA_JR_drifter_11_waves_ISM	72.664288400,-6.720552700	GPS	2 hours ago
2022_CIRFA_JR_drifter_10_waves_ISM	70.246073700,-14.788716900	GPS	2 hours ago
2022_CIRFA_JR_drifter_1	60.884755200,-41.968344000	GPS	2 hours ago
UIB-2022-TILL-02	75.176779500,20.887986200	GPS	2 hours ago

https://wavebug.met.no/ (token: wipeout)

Data pipeline

Iridium:

1) Buoy -> Iridium SBS to provider (Rockblock)
2) Provider -> Email / HTTP-Post / HTTP-api
3) Store in DB (sqlite) (data-hub)
4) Accessible through API
5) Process to CF compatible NetCDF files

Cellular:

1) Buoy -> Cellular provider (event)
2) Provider -> HTTP post to data-hub
3) Store in DB (sqlite) (data-hub)
4) Accessible though API
5) Process to CF compatible NetCDF files

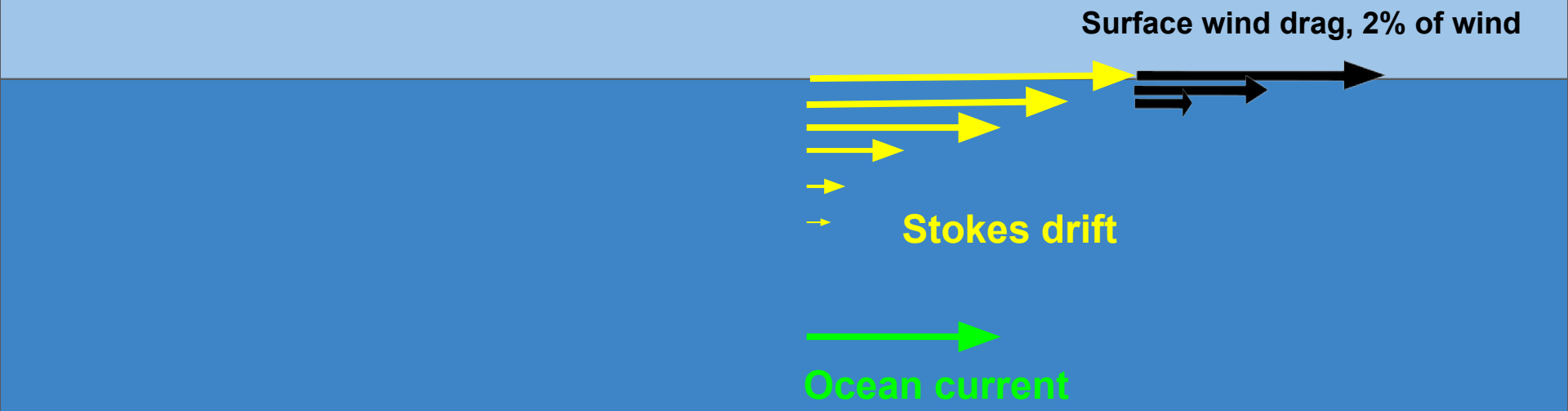
tools: https://github.com/OceanGlidersCommunity

trajectory data: https://cfconventions.org/Data/cf-conventions/cf-conventions-1.7/build/aphs04.html

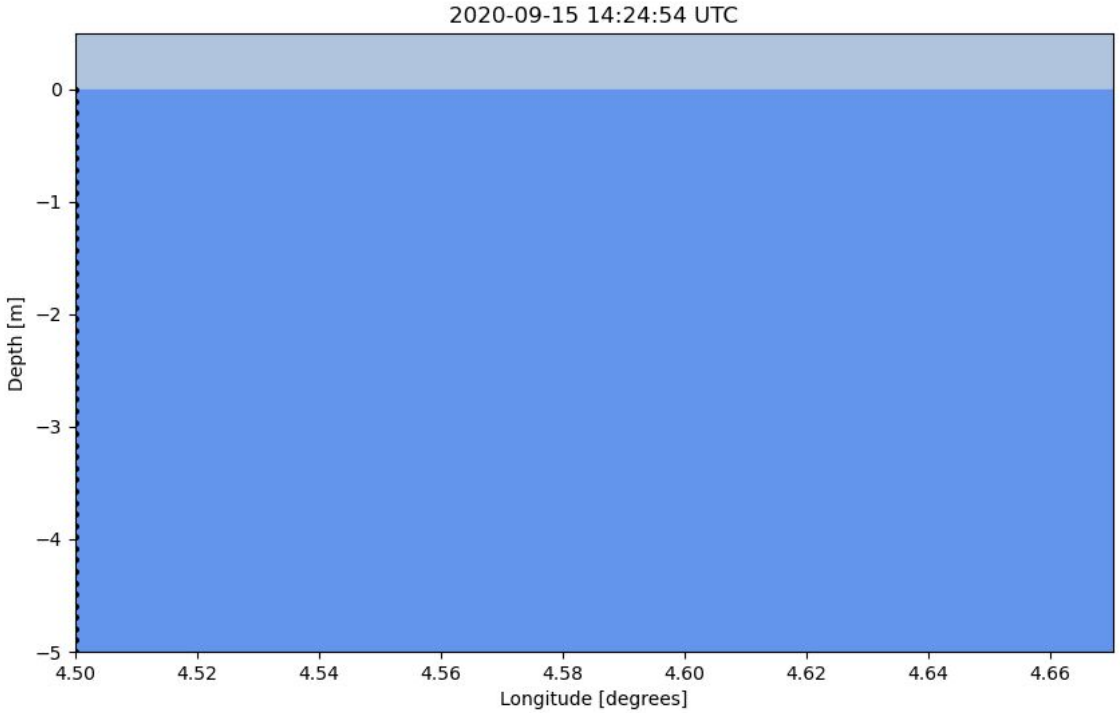
$ sfydata axl ts bug18 --tx-start 2022-09-20 --tx-end 2022-09-21 --start 2022-09-20T09:15:00 --end 2022-09-20T10:15:00 --file bug18.nc

Effect of drifter drogues

Horizontal drift



Vertical drift profile



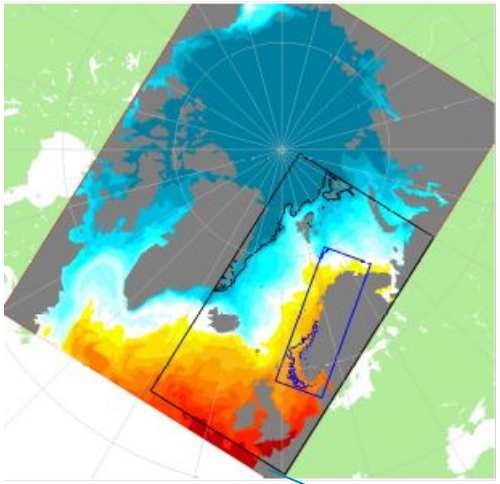
OpenDrift

Knut-Frode Dagestad, Gaute Hope

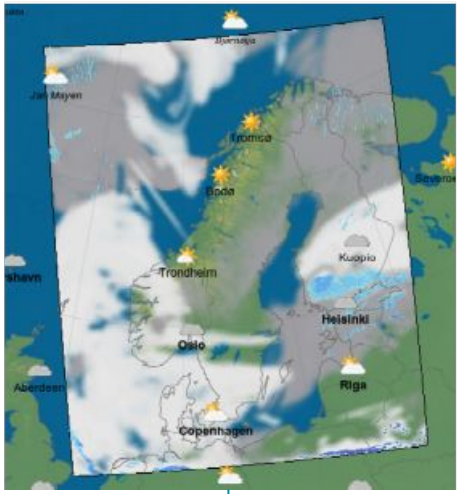
Norwegian
Meteorological
Institute

Offline and online trajectory models

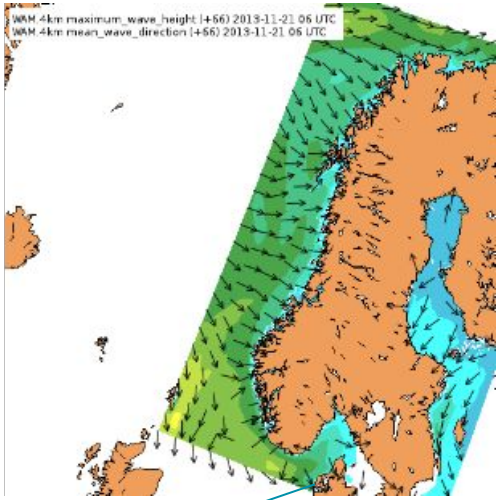
Ocean model



Atmospheric model



Wave model



Offline trajectory model

http://opendrift.github.io

opendrift.github.io

OpenDrift

Search docs

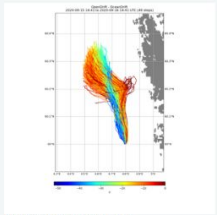
- Introduction to OpenDrift
- History
- Installing OpenDrift
- Tutorial
- Theory
- How to choose which model to use
- How to write a new module
- Gallery
- Oil types
- Interaction with coastline
- Graphical User Interface
- Publications
- API Reference

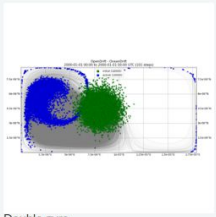
» Introduction to OpenDrift — View page source

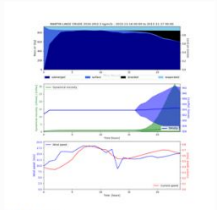
Introduction to OpenDrift

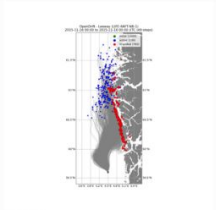
OpenDrift is a software package for modeling the trajectories and fate of objects or substances drifting in the ocean, or even in the atmosphere.

OpenDrift is open source (available on GitHub), and is programmed in Python. As the software is very generic, it is rather a "framework" than a "trajectory model" in the traditional sense. Trajectory models for specific purposes (e.g. `oil drift`, `search and rescue`, `larvae drift` etc) may reuse all common functionality from the `core model`, and need only implement a Python Class describing the purpose-specific processes (physics/biology etc). See Specifications and background requirements and Data model for more detailed information.


Drift at different depths


Double gyre


Oil budget


Leeway

Some key features of OpenDrift are:

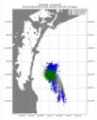

Wind blow model

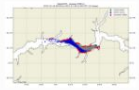
Grid

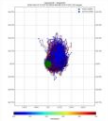
Show dominating source

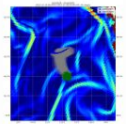

Advection schemes

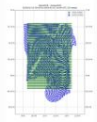
Vietnam

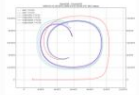

SHYFEM: Using model input from unstructured grid


Fjord

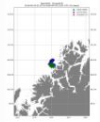

Ship drift

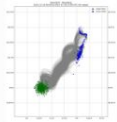

LCS Norkyst

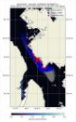

Reader boundary

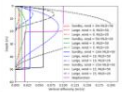

Double gyre, advection

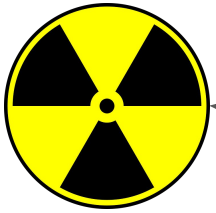

Plotting map


FVCOM: Using model input from unstructured grid

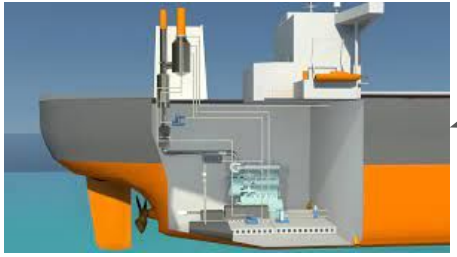

Ice berg (openberg) deterministic

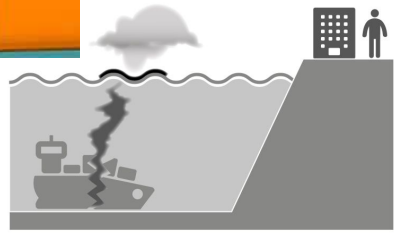

Oil in ice


Vertical diffusivity



OpenDrift





Meteorologisk institutt

Naming convention (CF) allows ANY model to be used with ANY reader

www.cfconventions.org

```
class Leeway(OpenDriftSimulation):

    required_variables =
        ['x_wind', 'y_wind',
         'x_sea_water_velocity',
         'y_sea_water_velocity',
         'land_binary_mask']

…
```

```
$ ncdump -h
https://thredds.met.no/thredds/dodsC/sea/norkyst800m/1h/aggregate_be
….
        float Uwind(time, Y, X) ;
                Uwind:long_name = "surface u-wind component" ;
                Uwind:units = "meter second-1" ;
                Uwind:time = "ocean_time" ;
                Uwind:grid = "grid" ;
                Uwind:location = "face" ;
                Uwind:field = "u-wind, scalar, series" ;
                Uwind:_FillValue = 1.e+37f ;
                Uwind:standard_name = "x_wind" ;
                Uwind:coordinates = "lon lat" ;
                Uwind:grid_mapping = "projection_stere" ;

….
```