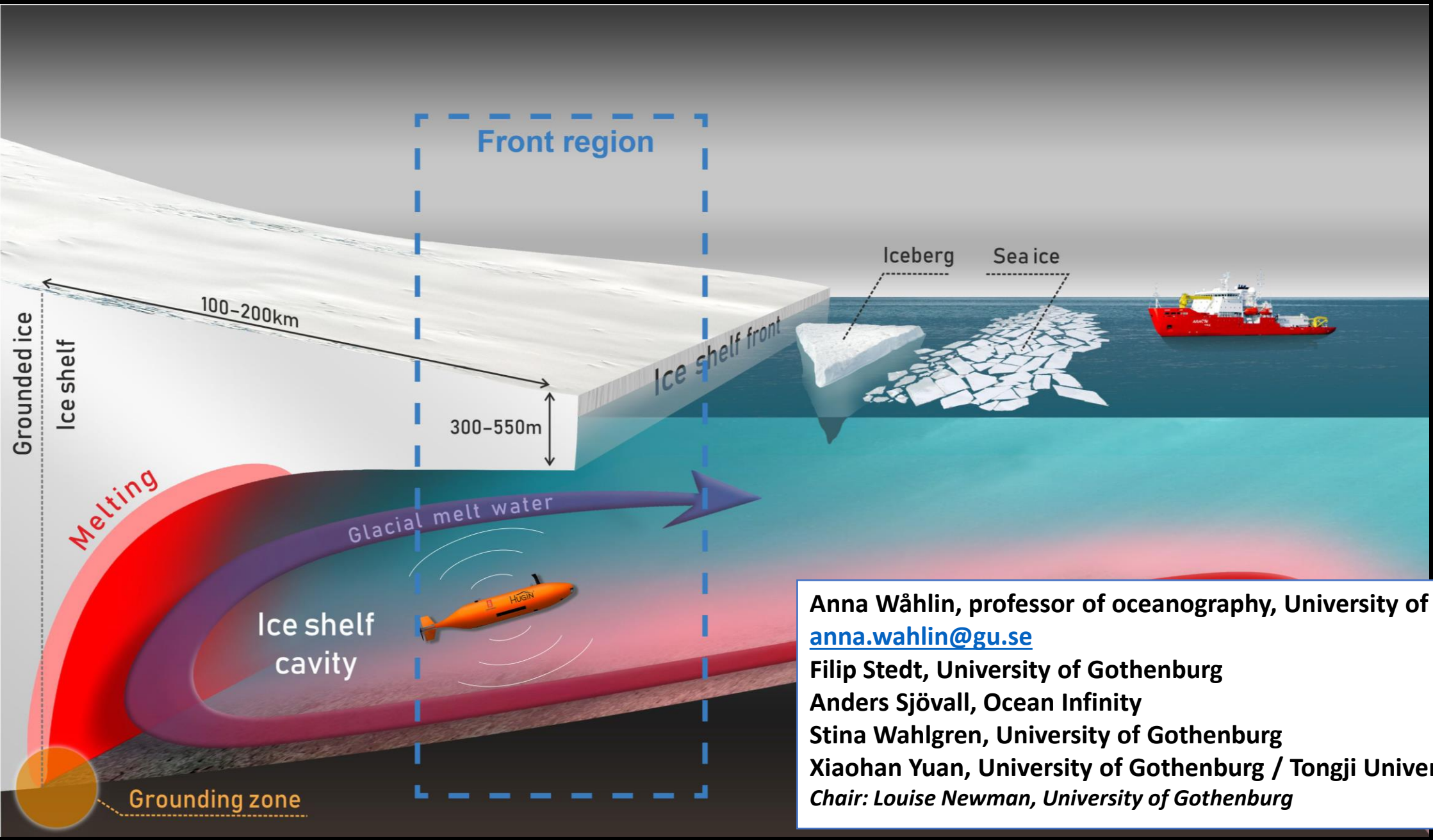
Pushing the limits – an AUV below the Antarctic ice



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Filip Stedt, University of Gothenburg
Anders Sjövall, Ocean Infinity
Stina Wahlgren, University of Gothenburg
Xiaohan Yuan, University of Gothenburg / Tongji University Shanghai
Chair: Louise Newman, University of Gothenburg

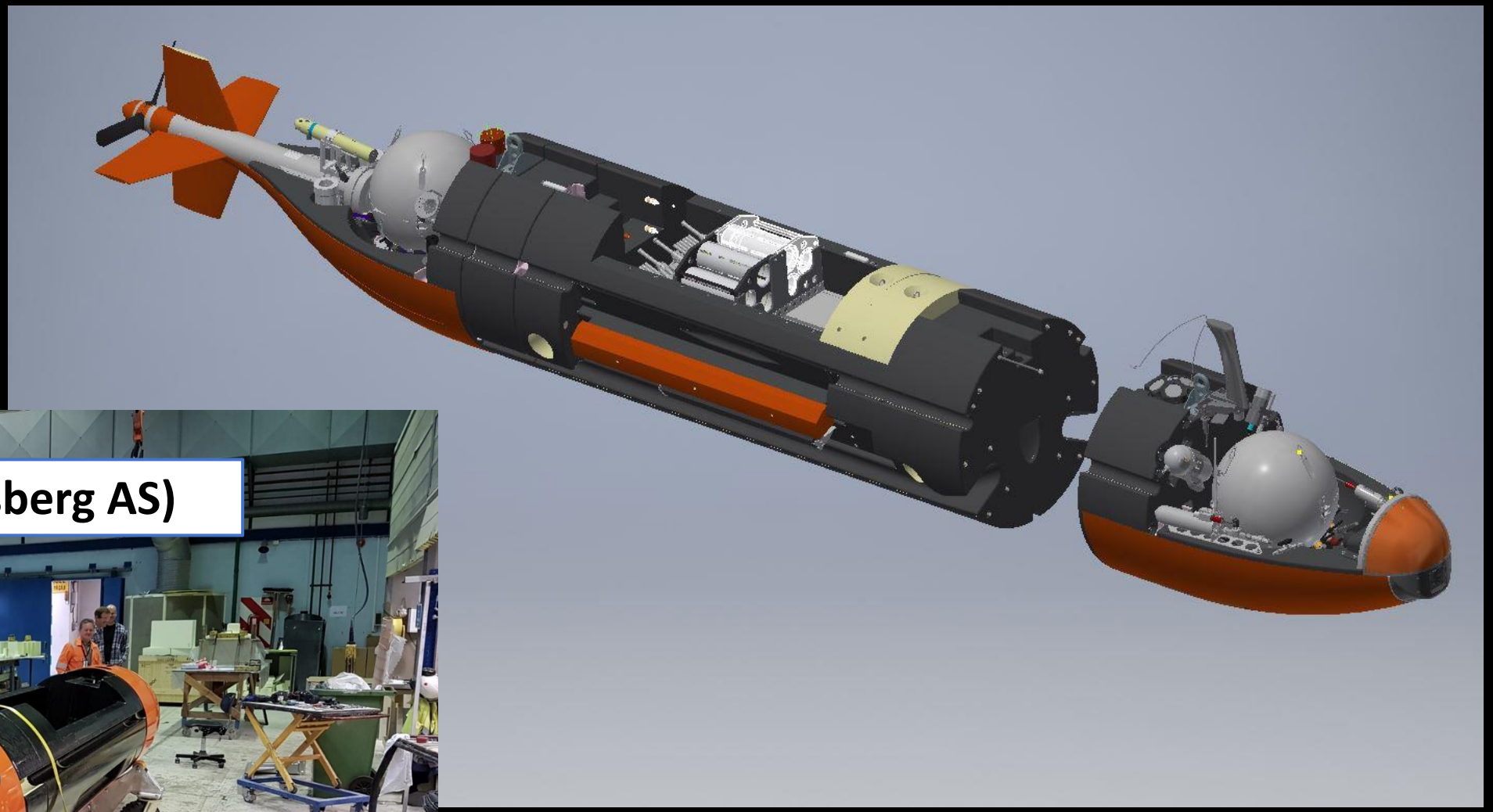
AUV ’*Ran*’

A Kongsberg Hugin 3000 m Autonomous Underwater Vehicle

Dimensions	Depth rating and range	Power supply	Endurance
Length: approx. **6.5 m** Diameter: 875 mm Weight: 1850 kg	3000 m 300 km	4 (max 6) rechargeable and swappable Lithium Polymer batteries	36 hours

Funded by Knut & Alice Wallenberg Foundation

https://www.gu.se/en/skagerak/new-rv-skagerak/autonomous-underwater-vehicle

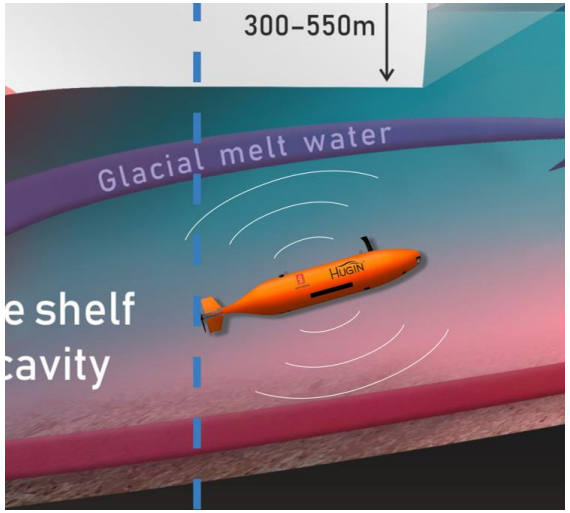


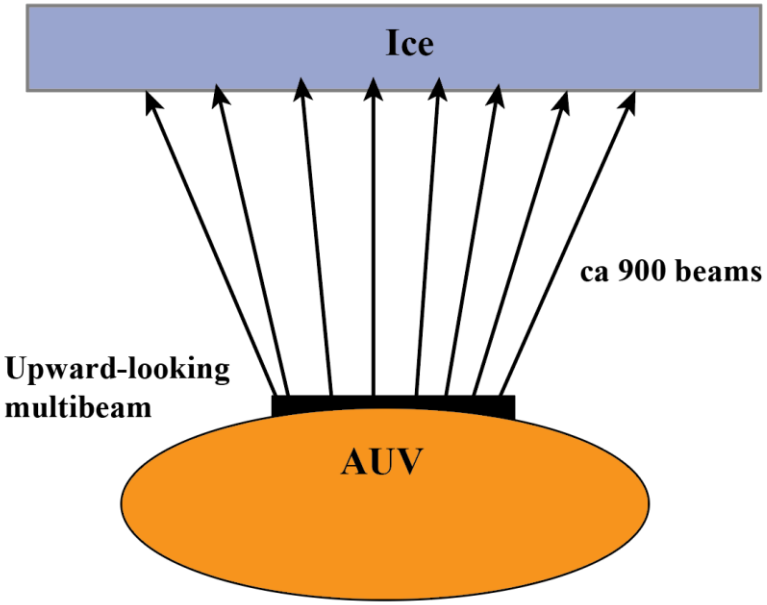
Horten Norge (Kongsberg AS)

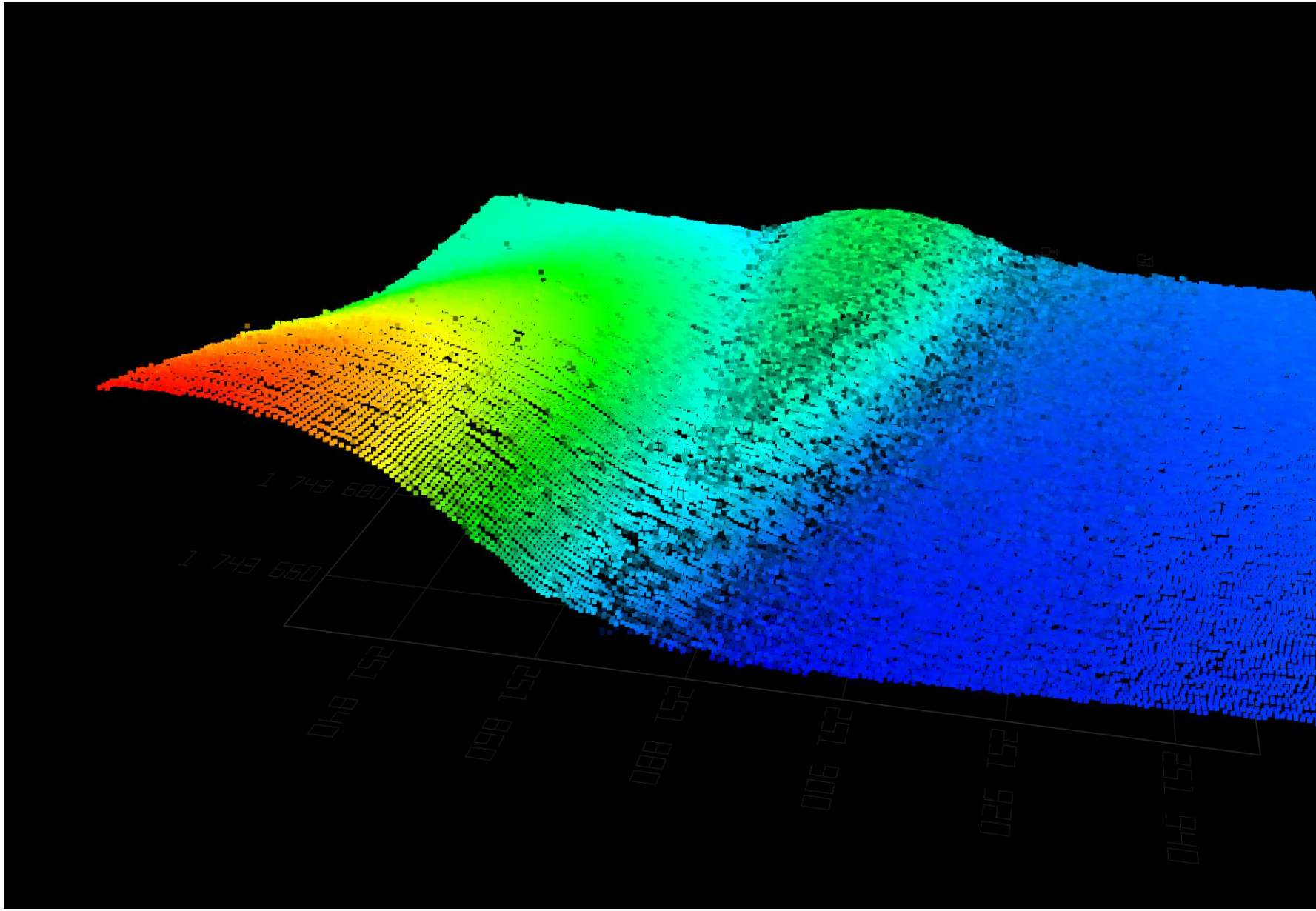
2-6 knot speed
Very good navigation

37 sensors – upward- and downward-looking multibeam, SeaBird T, S & O2, Nitrate and CO2, water sampling

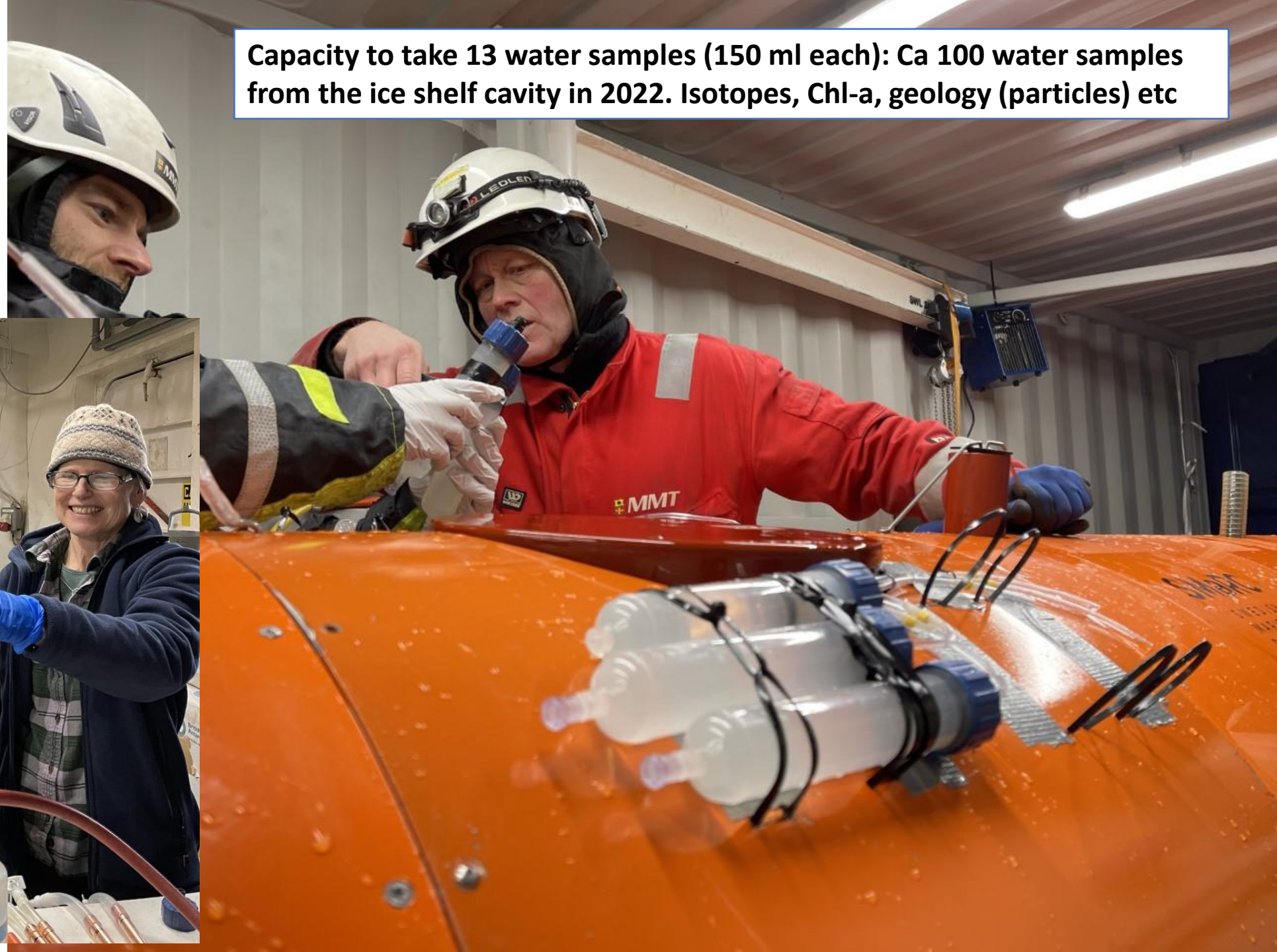
Upward-looking multibeam: Kongsberg EM2040 CX





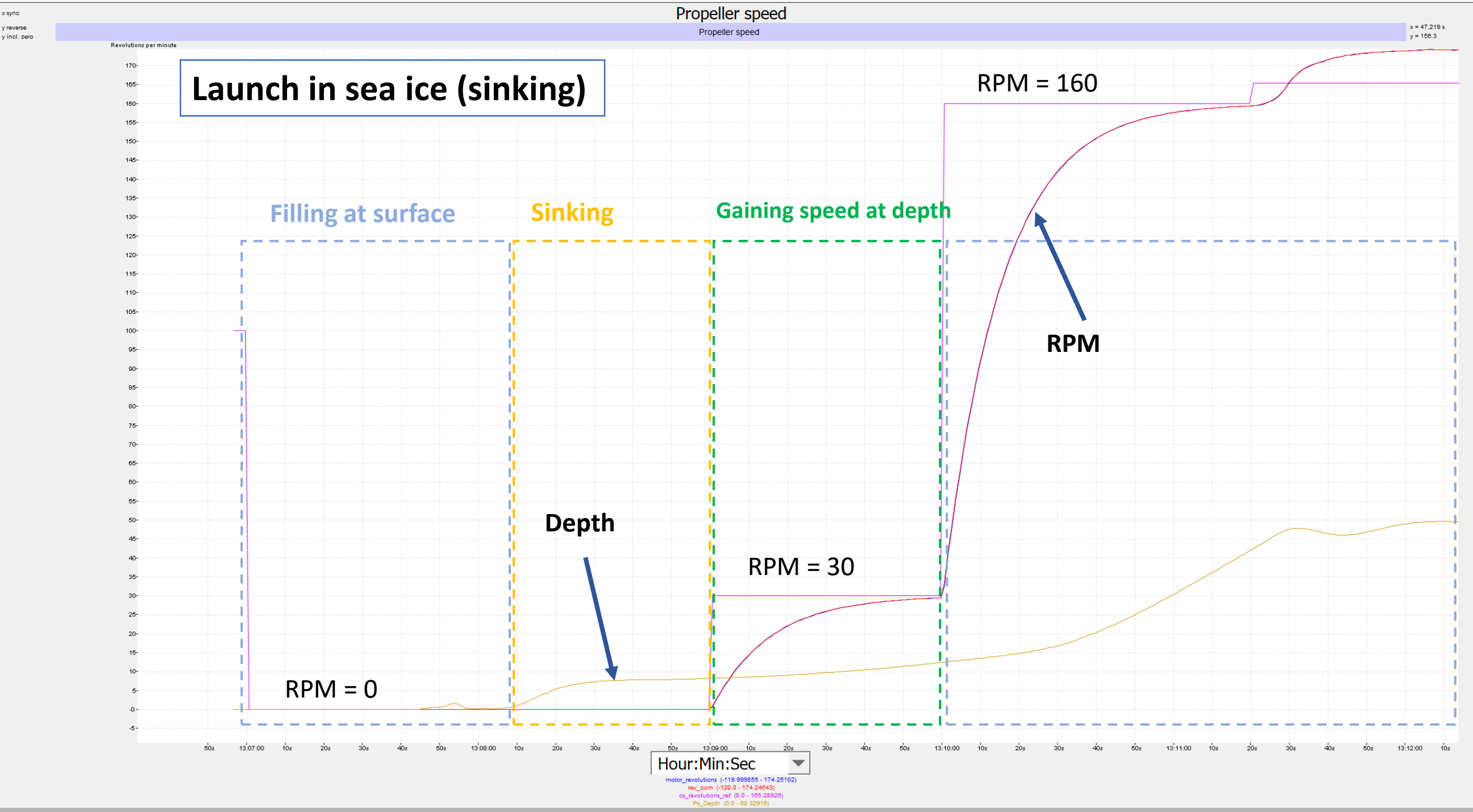


Capacity to take 13 water samples (150 ml each): Ca 100 water samples from the ice shelf cavity in 2022. Isotopes, Chl-a, geology (particles) etc



AUV + all equipment comes in one 40-foot container and one 10 foot container

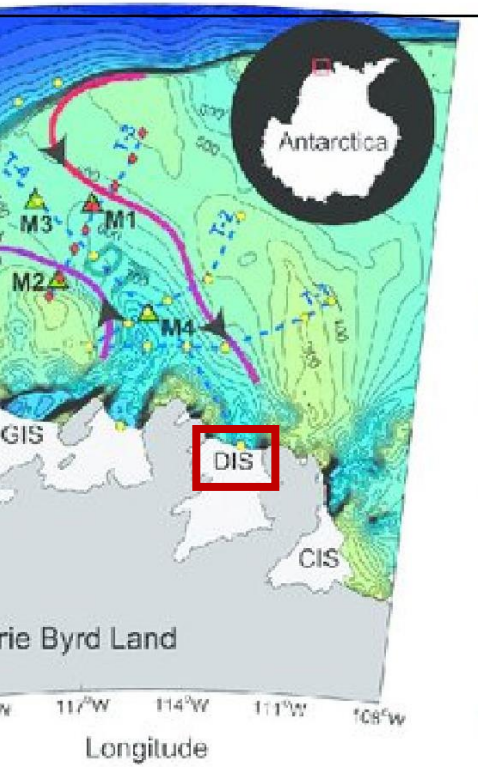
Launch and recovery

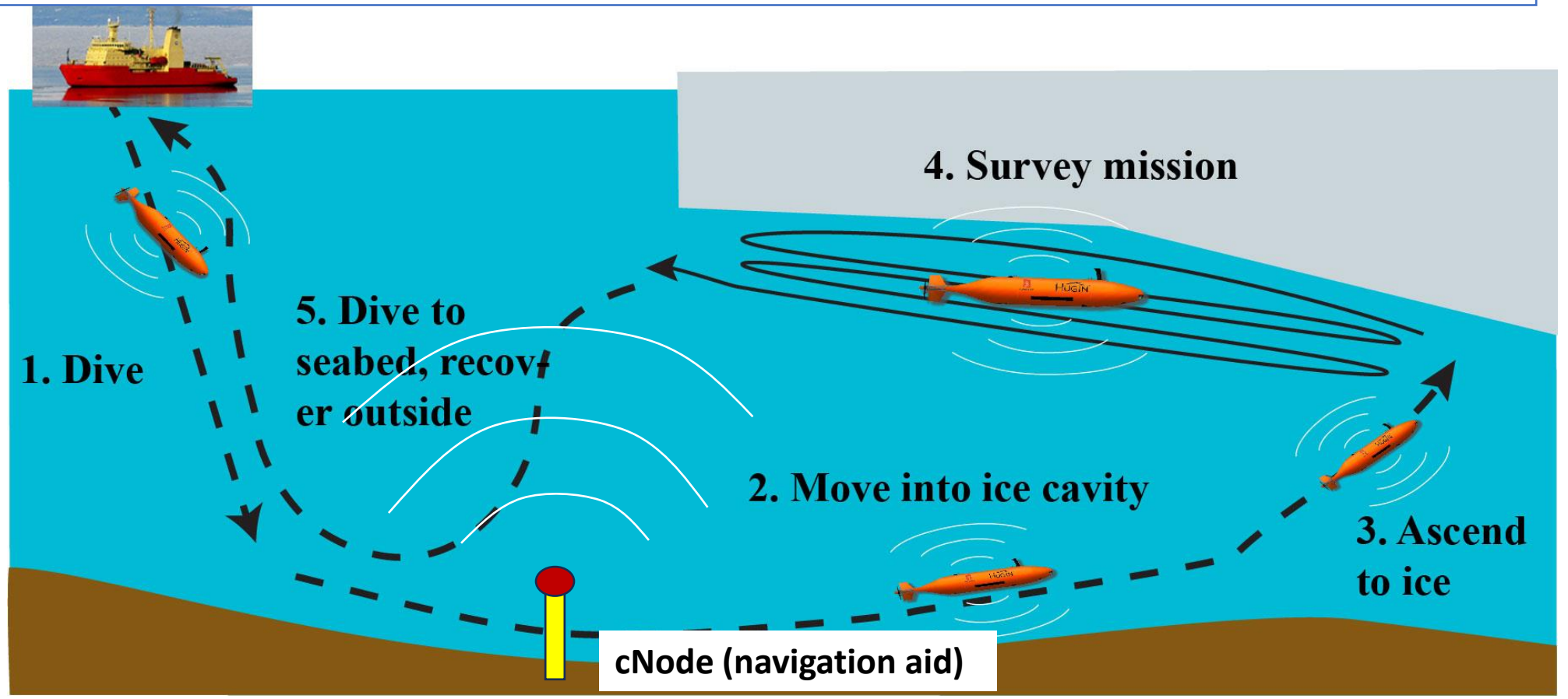

Propeller speed
Propeller speed
x = 47,219 s
y = 156.3
x sync
y reverse
y incl. zero
Revolutions per minute
Launch in sea ice (sinking)
RPM = 160
Filling at surface
Sinking
Gaining speed at depth
RPM
Depth
RPM = 30
RPM = 0
Hour:Min:Sec
motor_revolutions (-119.999855 - 174.25102)
rev_com (-120.0 - 174.24643)
cs_revolutions_ref (0.0 - 165.28926)
Ps_Depth (0.0 - 50.32916)


Recovery in sea ice
SKAGERAK
Vetenskapsrådet

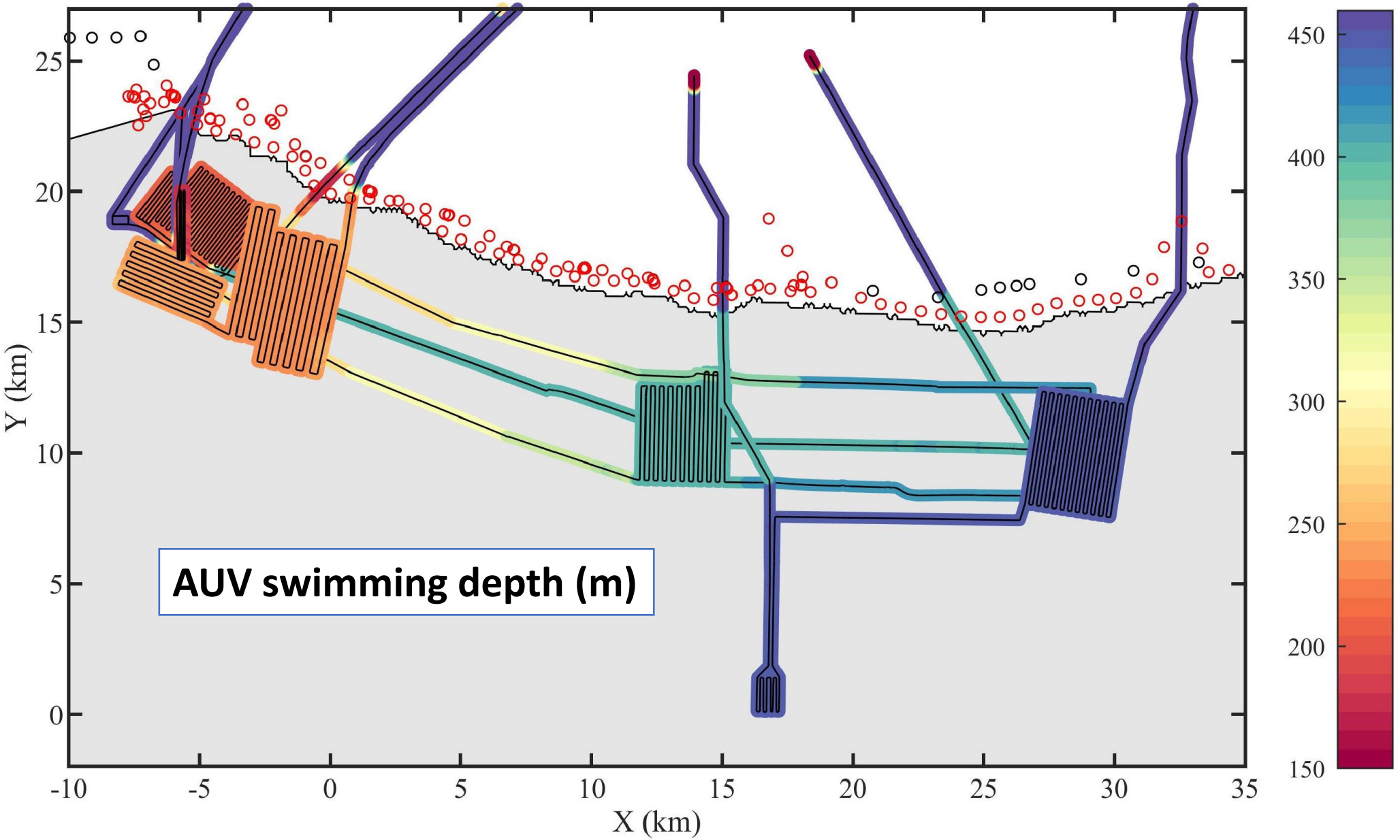
Jan – March 2022: 14 missions in Amundsen Sea (West Antarctica) from NB Palmer
Launch in safe, icefree place, dive down to seabed, swim into the cavity, swim up to ice, perform ice survey, then dive down to seabed and swim northwards for 1 h

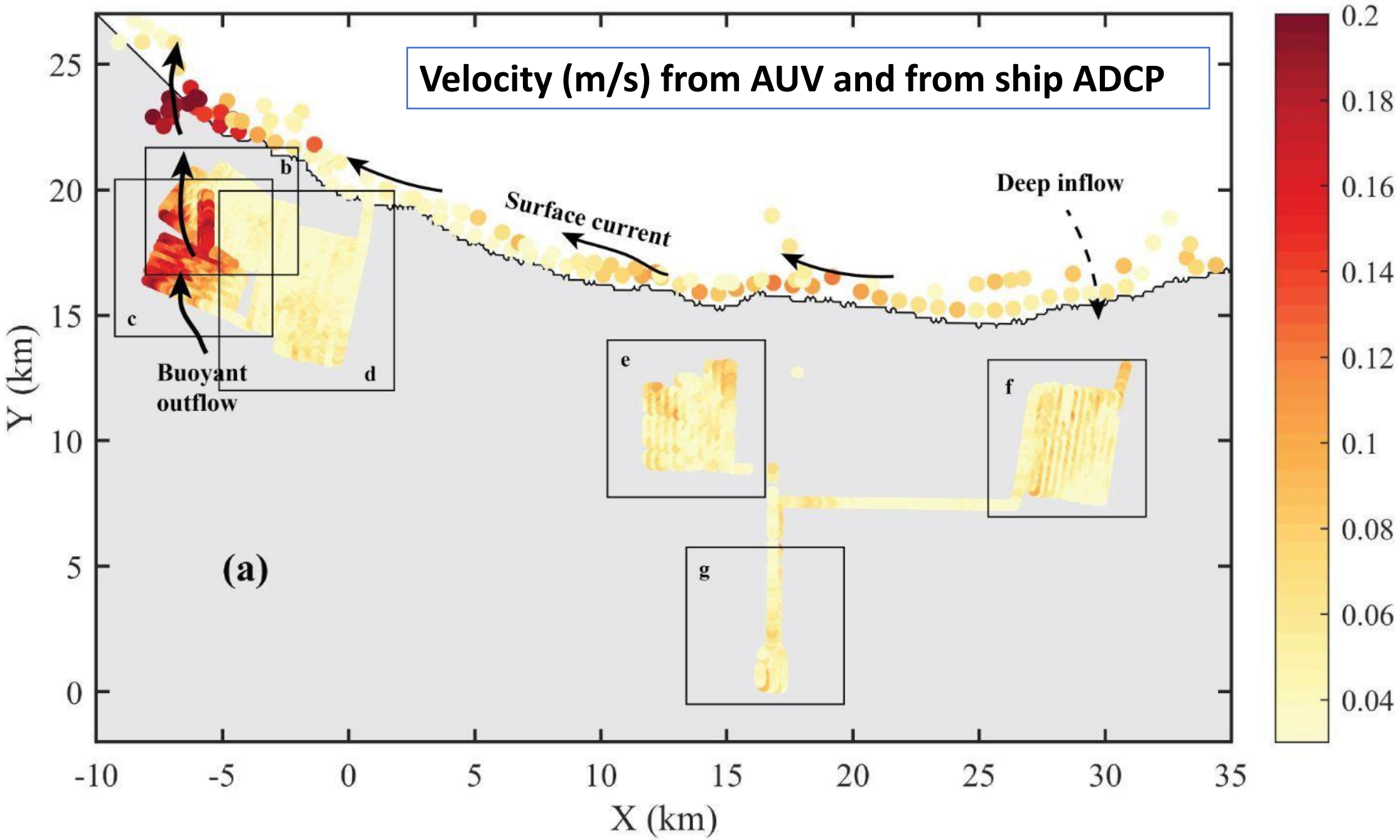
1732 km distance traveled (1075 km under ice)
Data sets: High resolution (1 dm) maps of ice base, high resolution (<5 dm) maps of seabed, T, S and O_2, CO_2, nitrate, Fl, turbidity, about 100 water samples (150 ml each), and current velocity

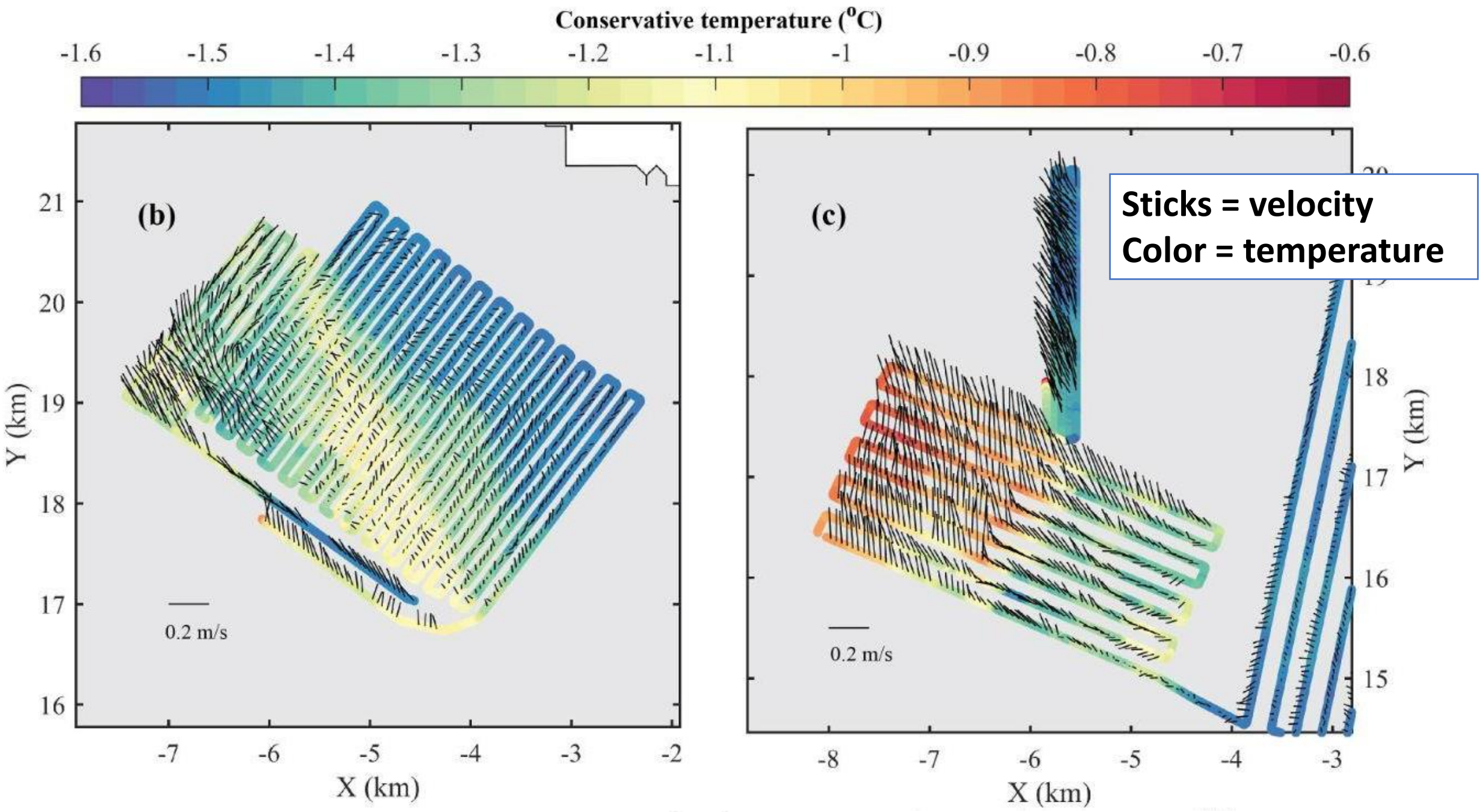




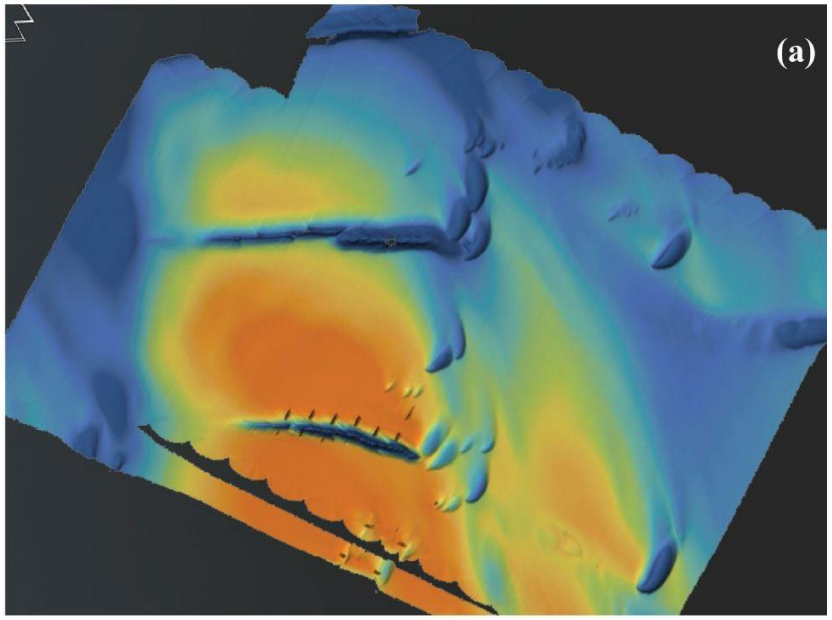
Dotson ice shelf: 6 high resolution maps of the ice base (swimming 20 – 80 m below the ice)



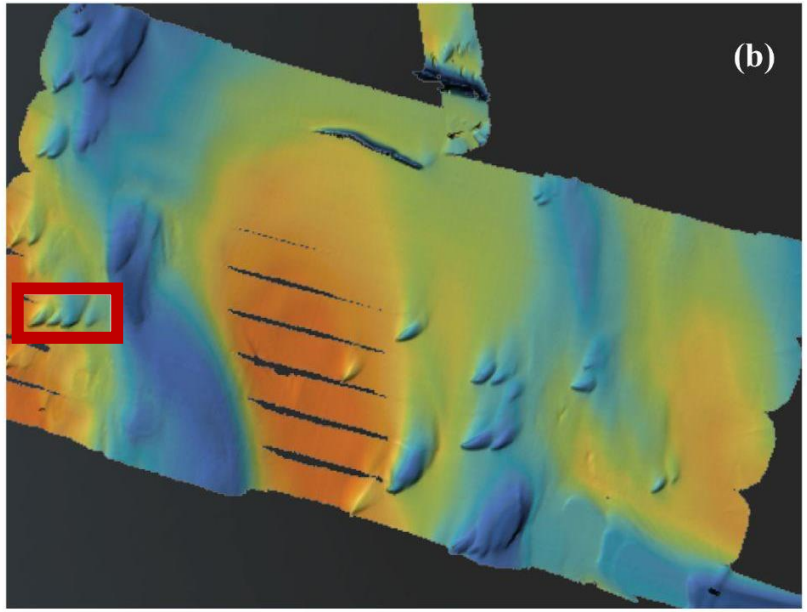

Velocity (m/s) from AUV and from ship ADCP
Surface current
Deep inflow
Buoyant outflow
b
c
d
e
f
g
(a)
Y (km)
X (km)
25
20
15
10
5
0
-10
-5
0
5
10
15
20
25
30
35
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04

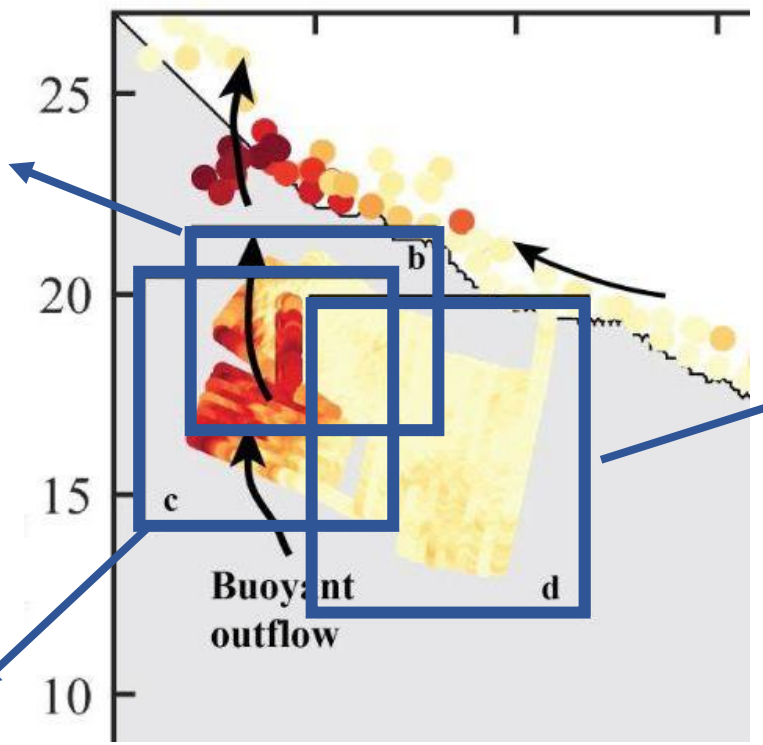

Conservative temperature (°C)
-1.6
-1.5
-1.4
-1.3
-1.2
-1.1
-1
-0.9
-0.8
-0.7
-0.6
(b)
(c)
0.2 m/s
0.2 m/s
Y (km)
X (km)
Sticks = velocity
Color = temperature

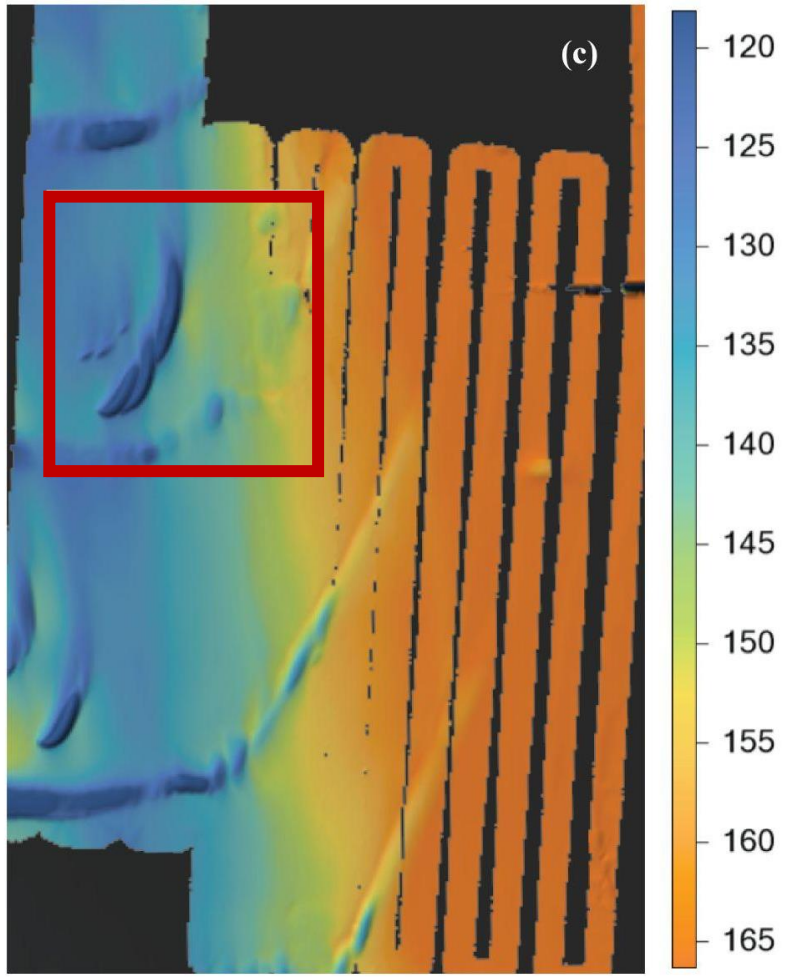
Maps of the ice base in the western (outflow) region: Ice erosion plus enigmatic teardrop-shaped features, 10 m deep and 20 – 300 m long

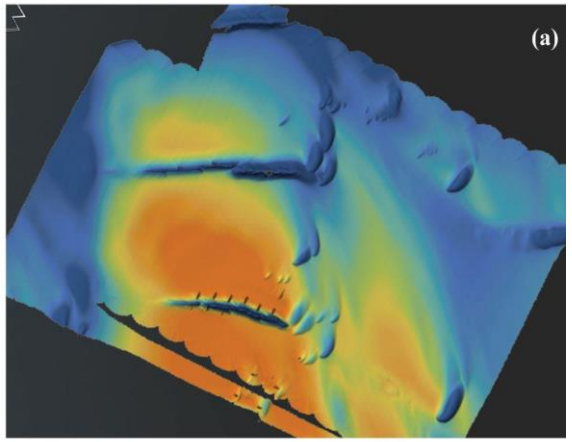


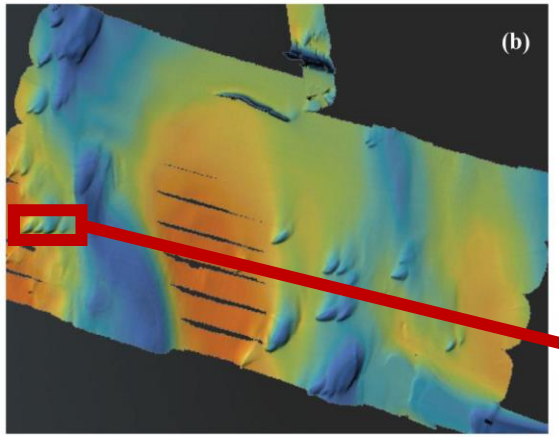
4 km

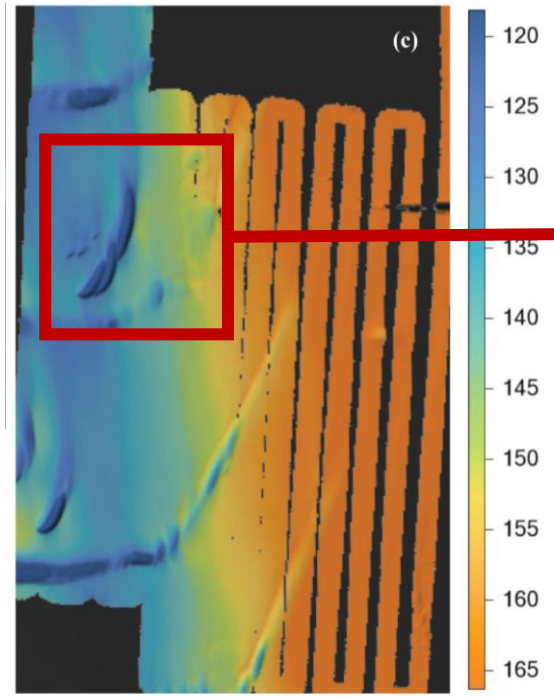


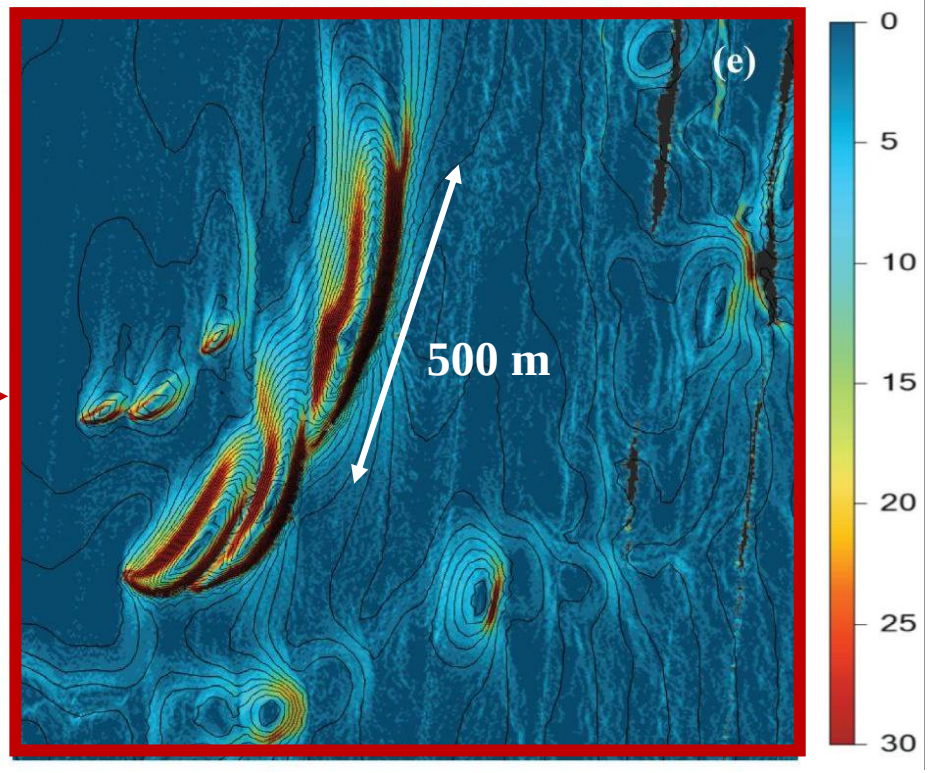


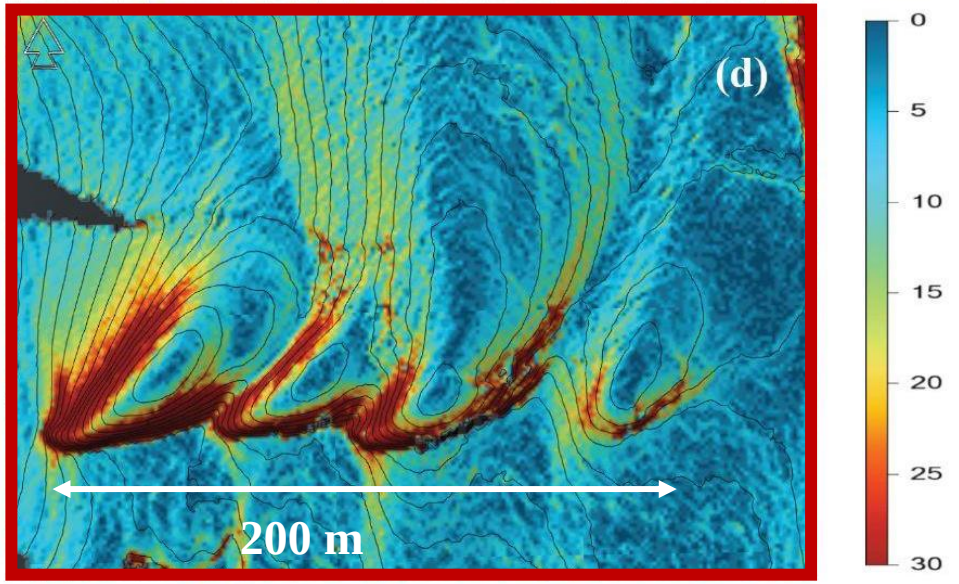



(a)

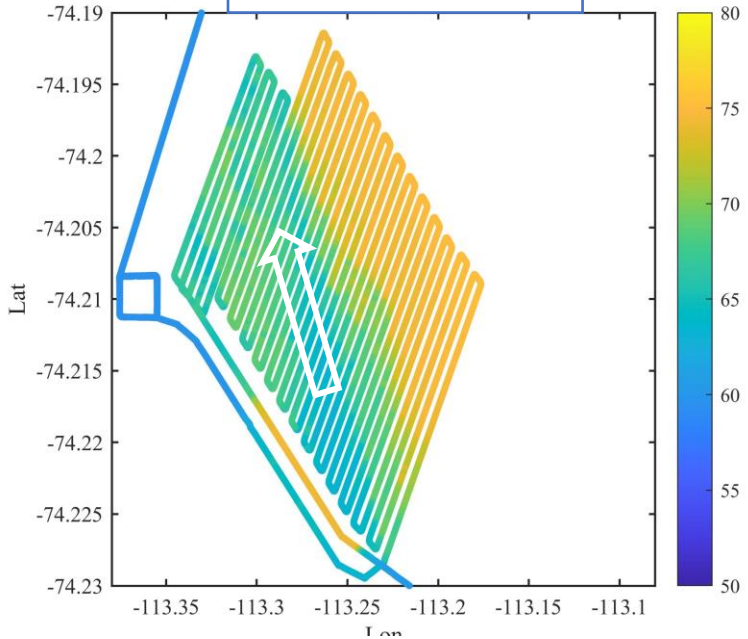

(b)


(c)
120
125
130
135
140
145
150
155
160
165

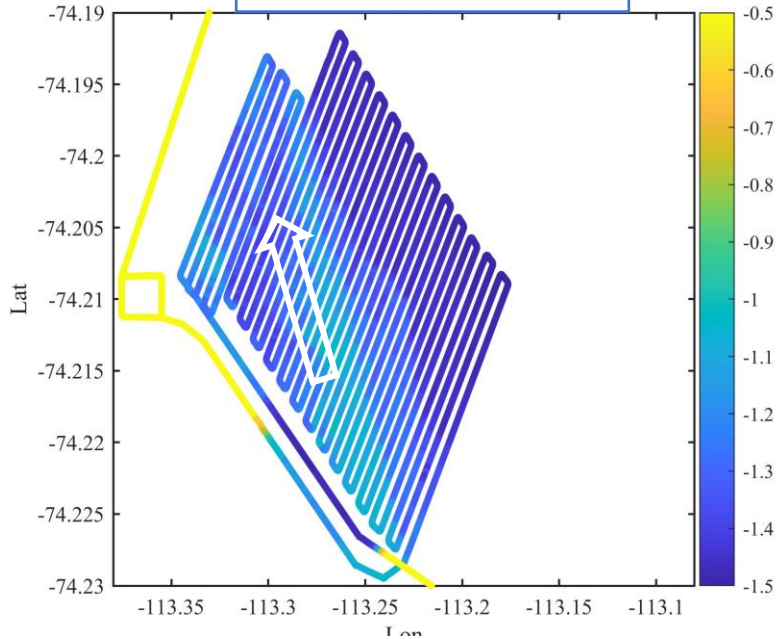

(e)
500 m
0
5
10
15
20
25
30


(d)
200 m
0
5
10
15
20
25
30

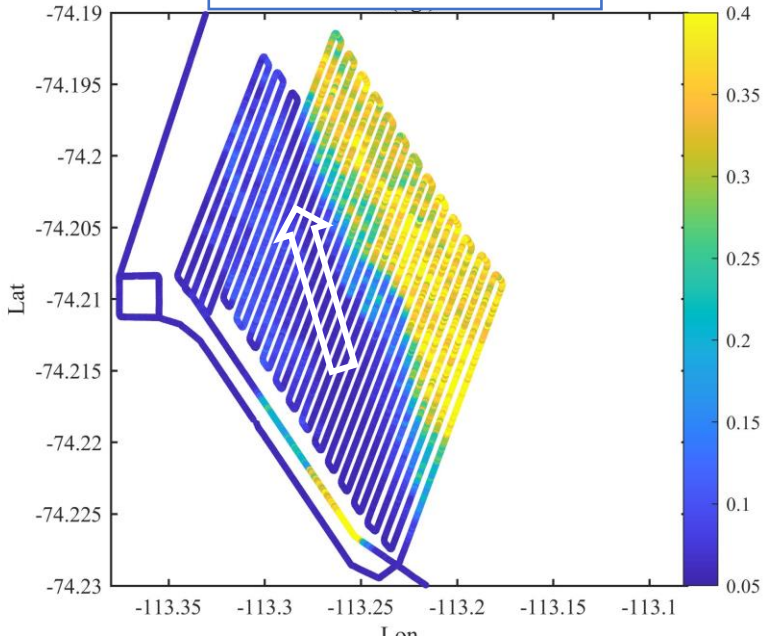
DO (sat %)

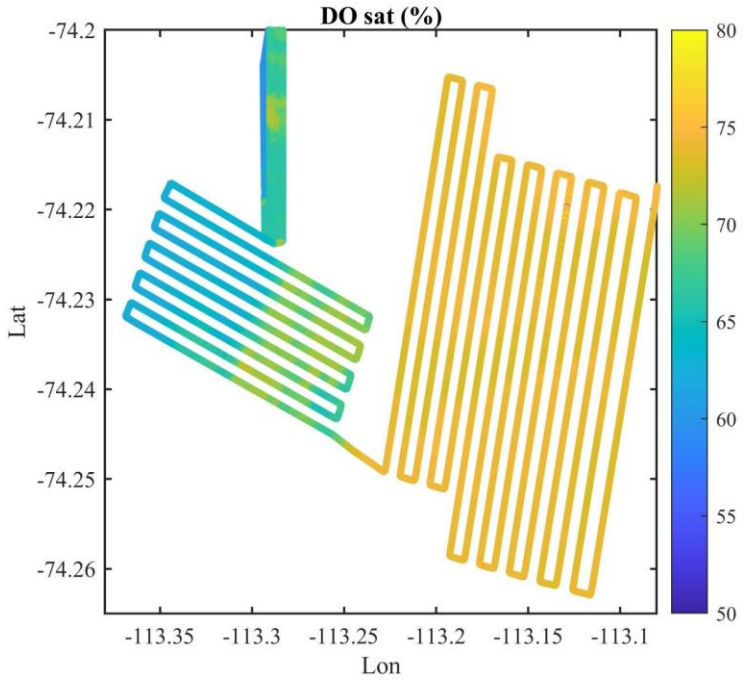


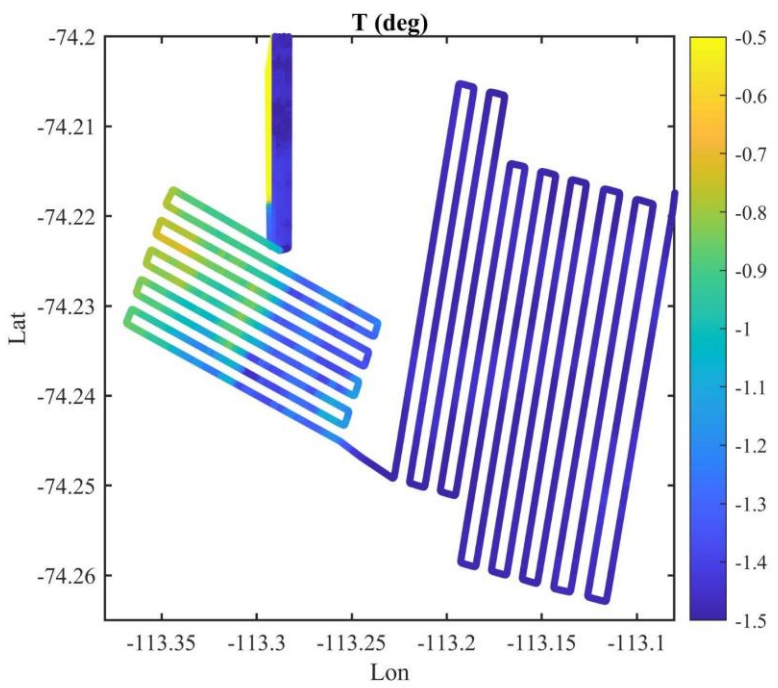
T (deg)

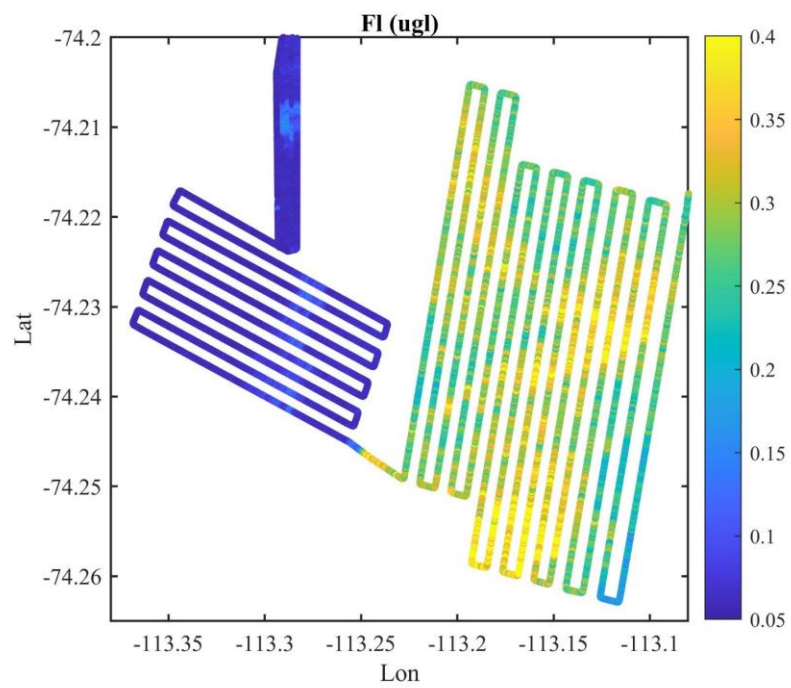


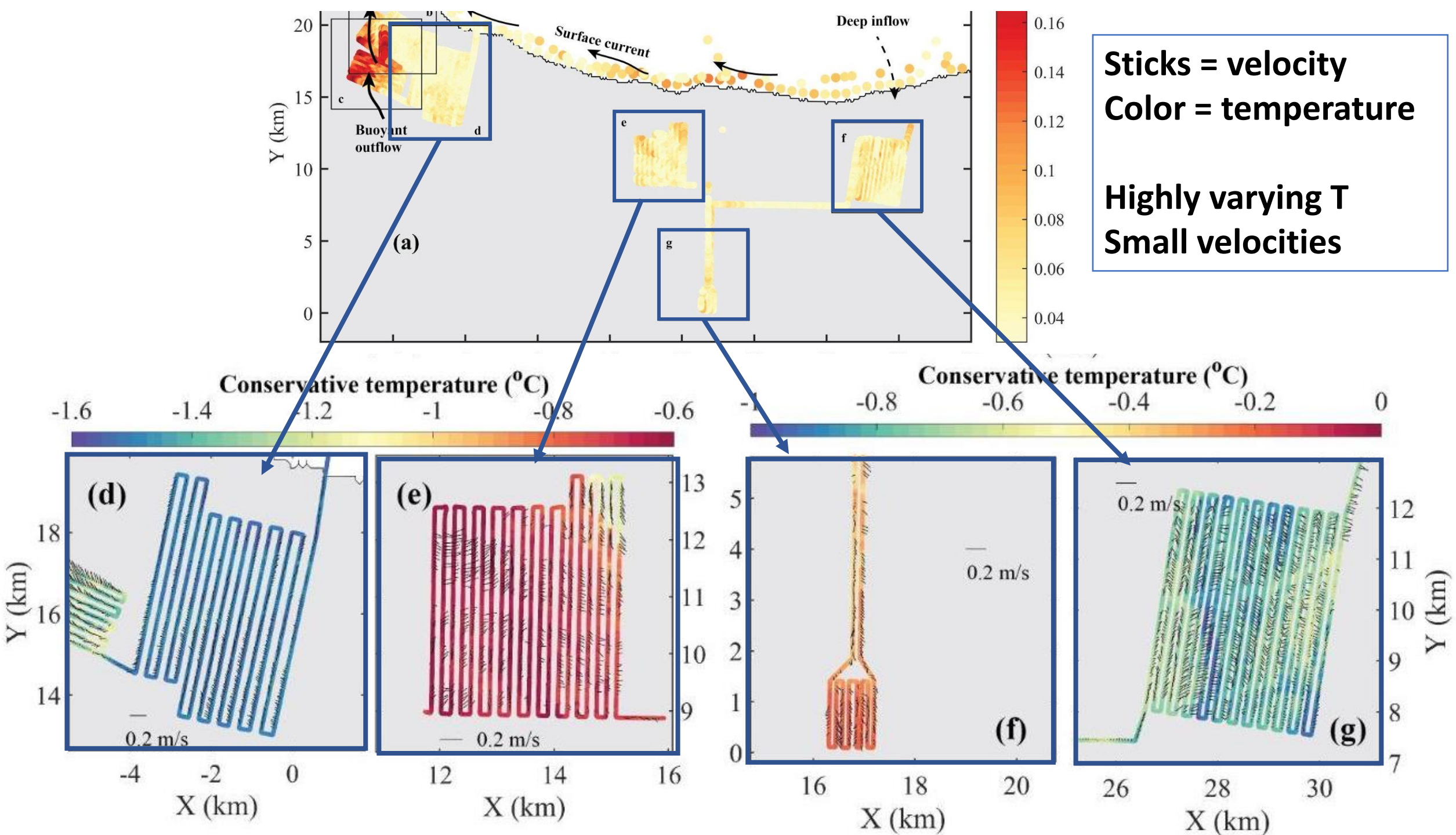
Fl (ug/l)







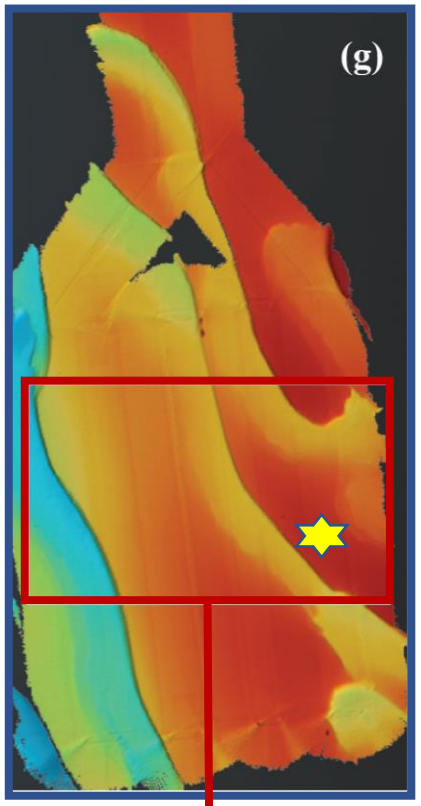


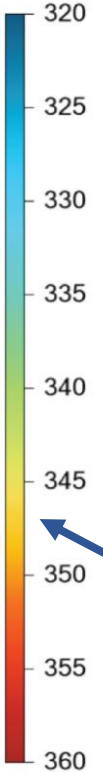


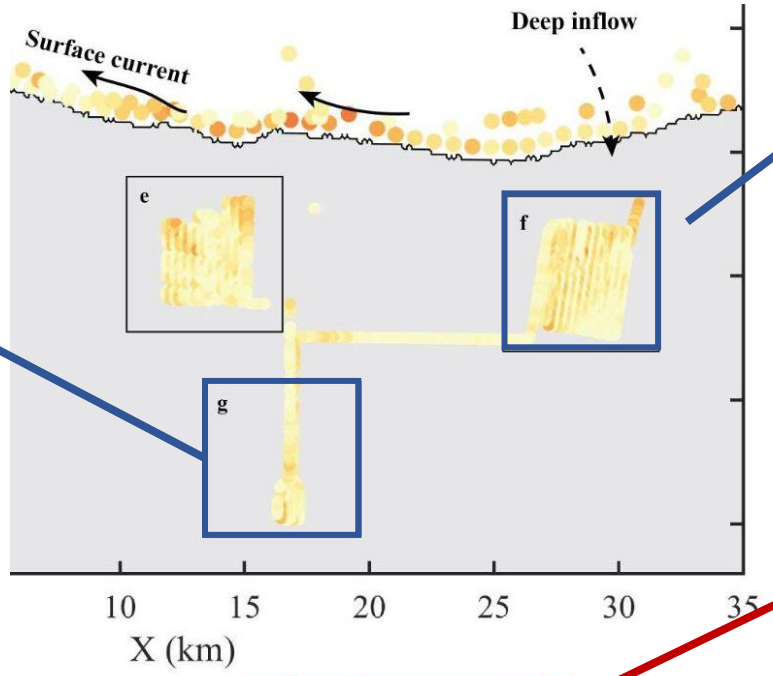
Sticks = velocity
Color = temperature

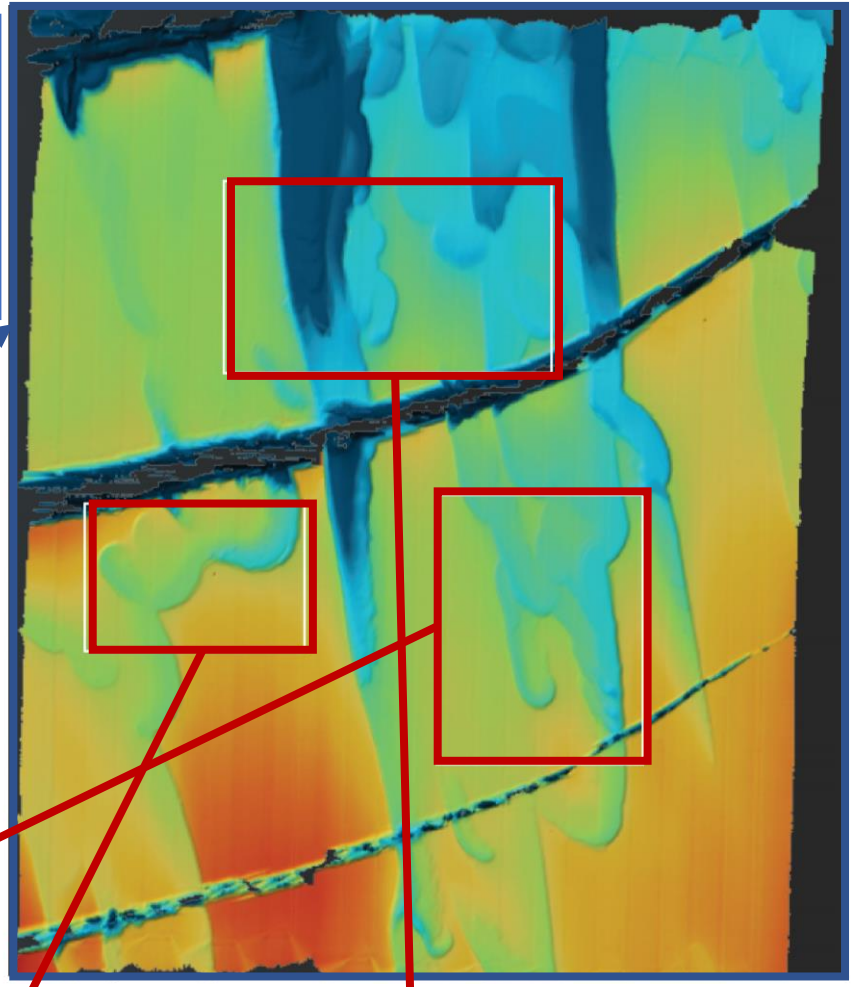
Highly varying T
Small velocities

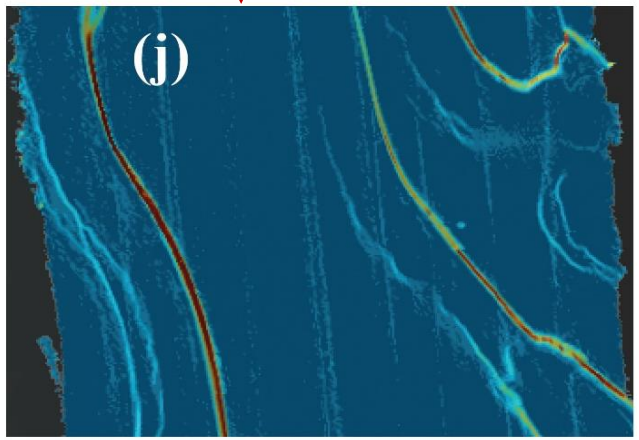
Eastern side and inner cavity: Terraces and steps in several layers (2 – 20 m high)
Swirly shaped structures
Water flowing?

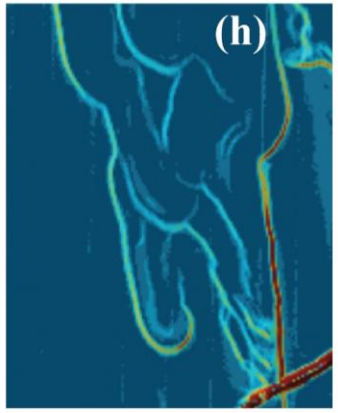


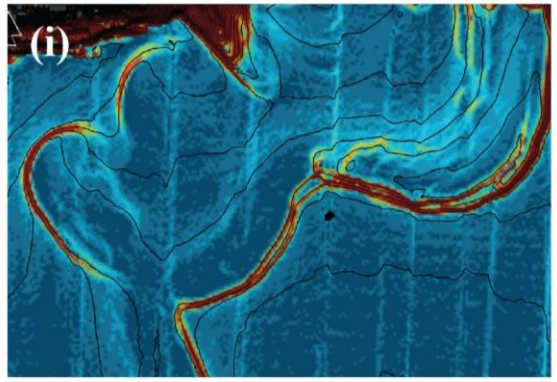


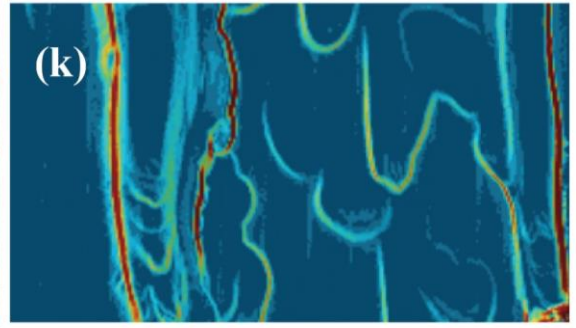


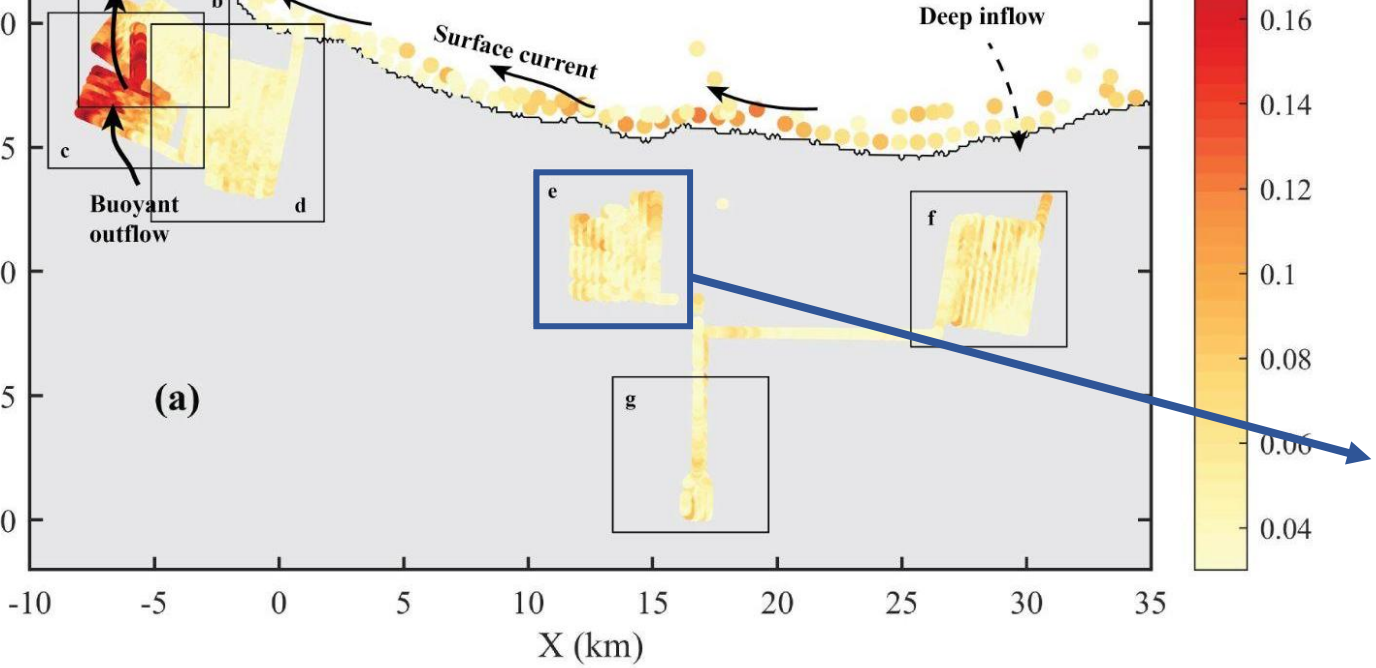


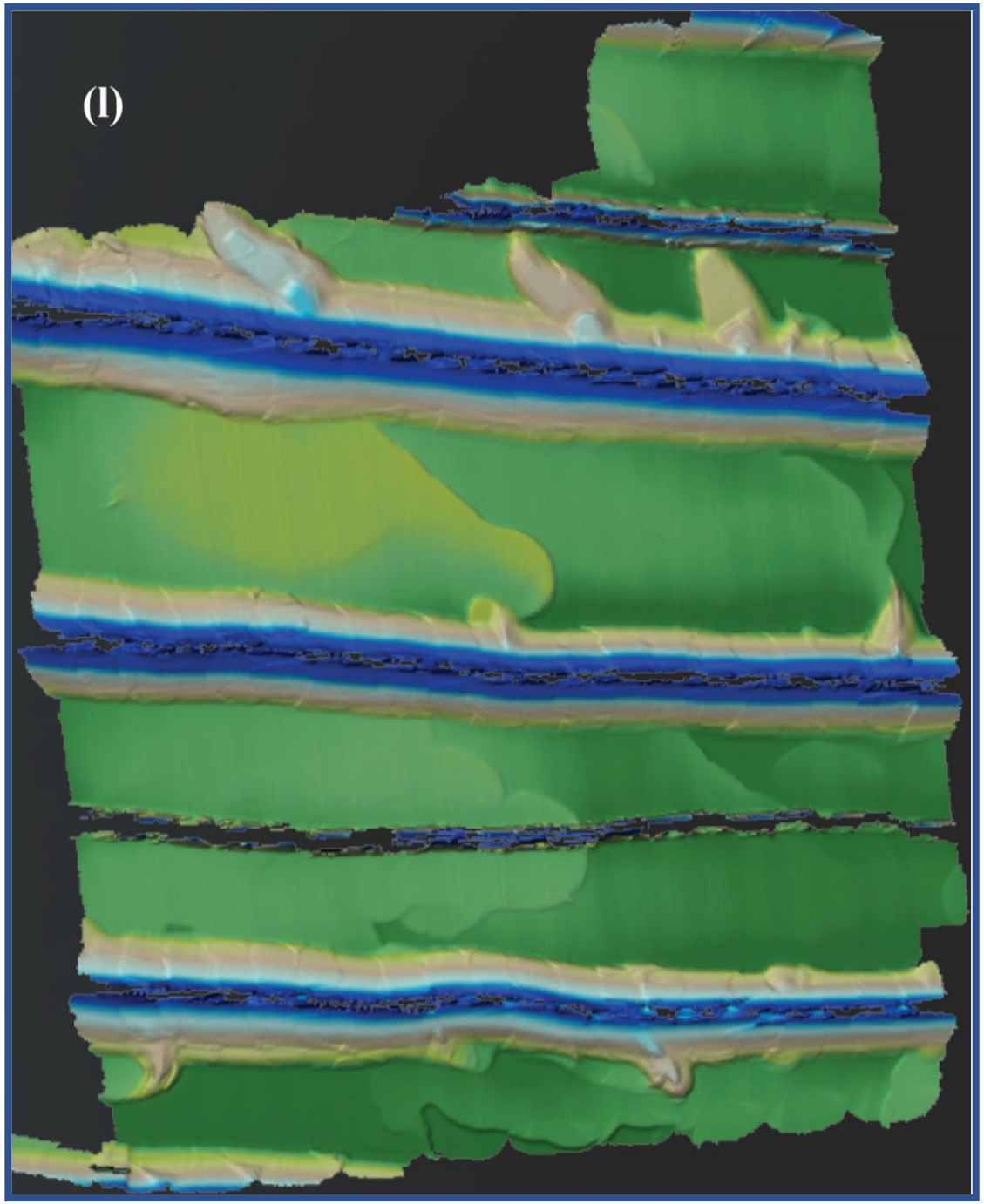












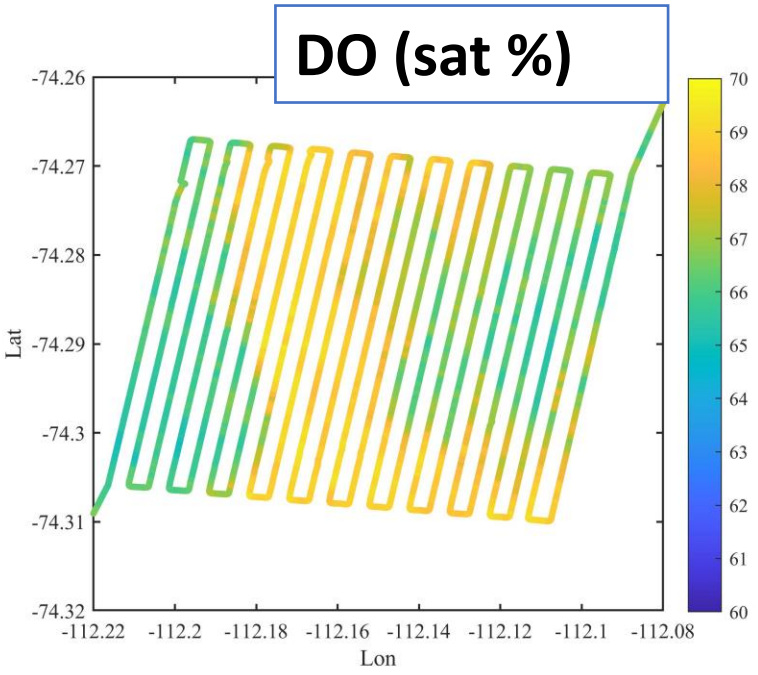
Center region:

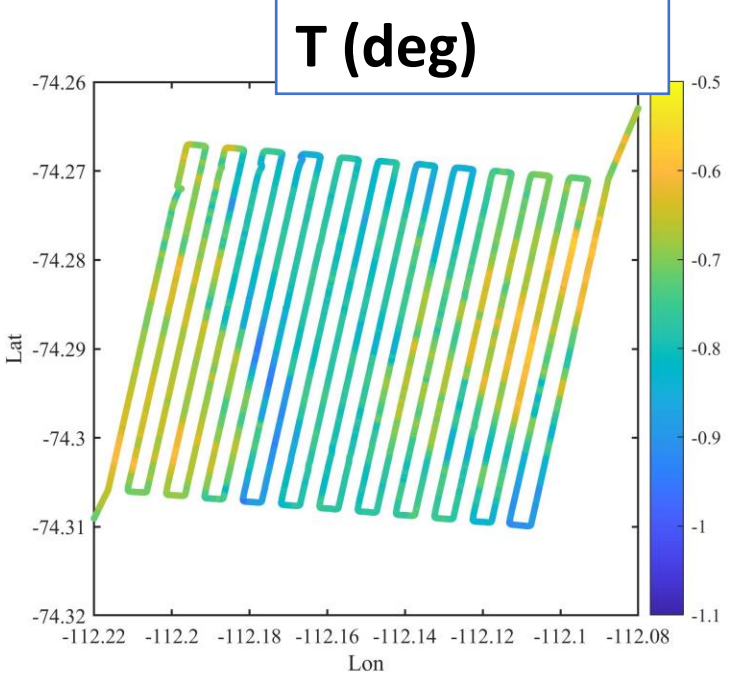
Fractures, up to 500 m wide at base – also visible at surface (full thickness fractures)

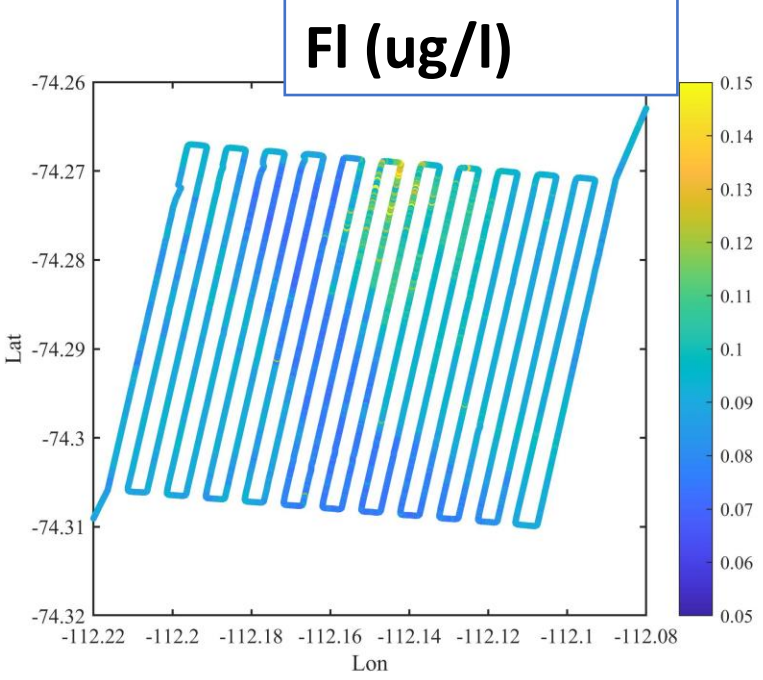
Enhanced melting at the base of fractures

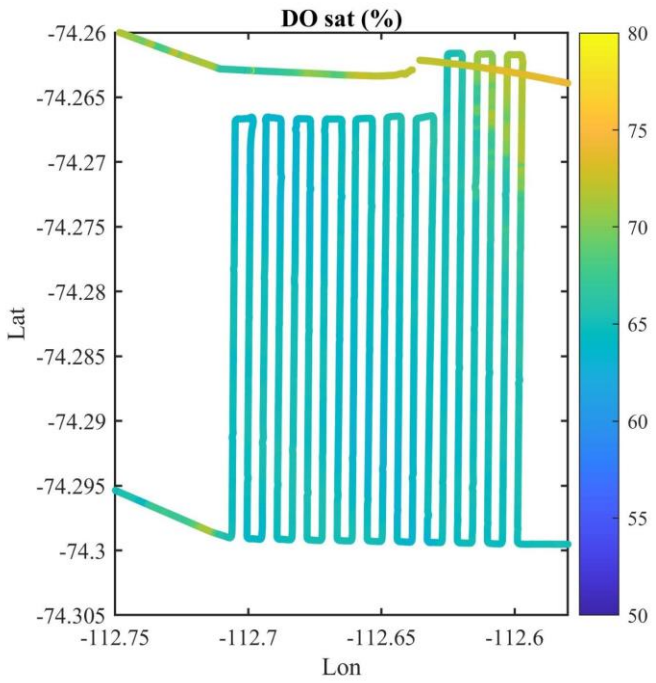
Terraces

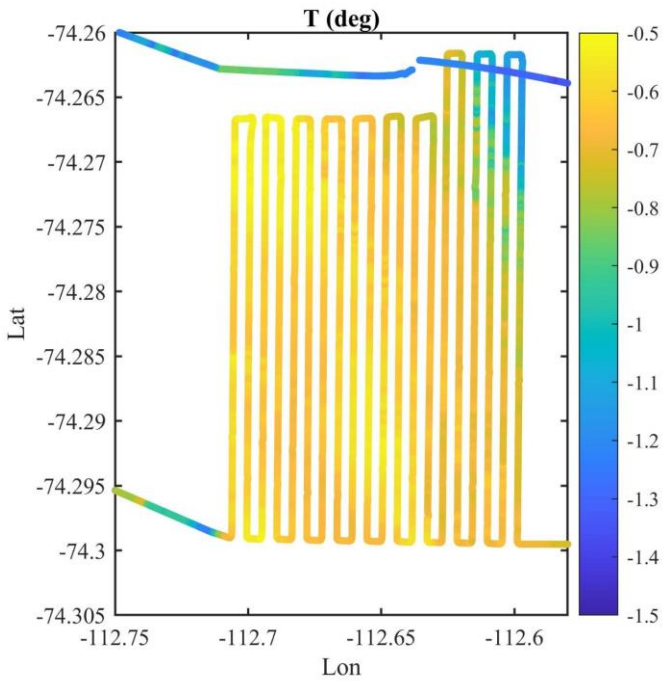
New and old fractures

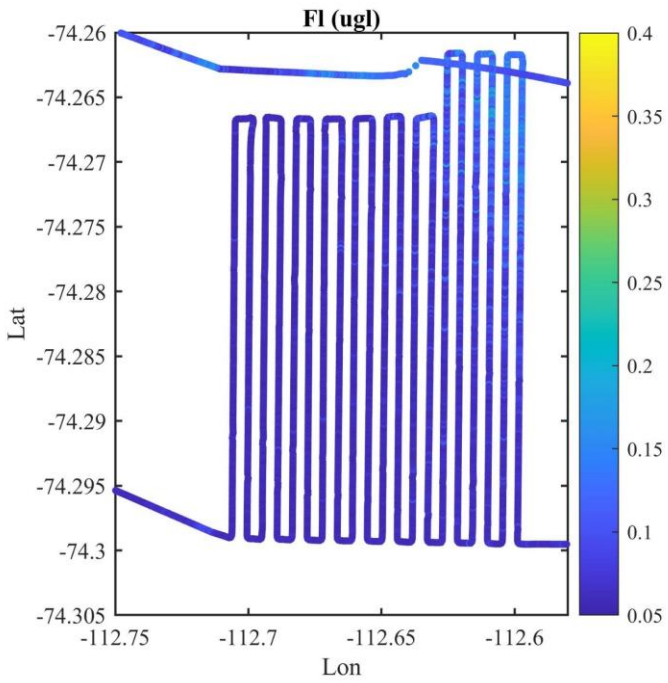

DO (sat %)
Lat
Lon


T (deg)
Lat
Lon


Fl (ug/l)
Lat
Lon


DO sat (%)
Lat
Lon

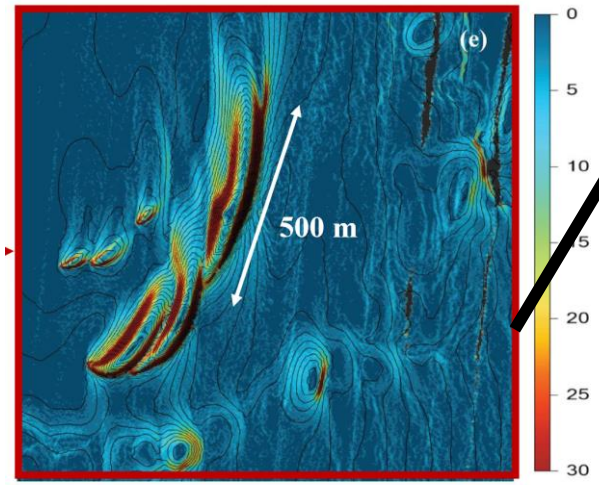

T (deg)
Lat
Lon

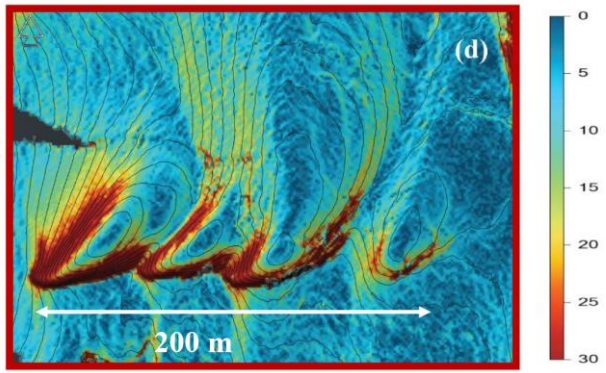

Fl (ugl)
Lat
Lon

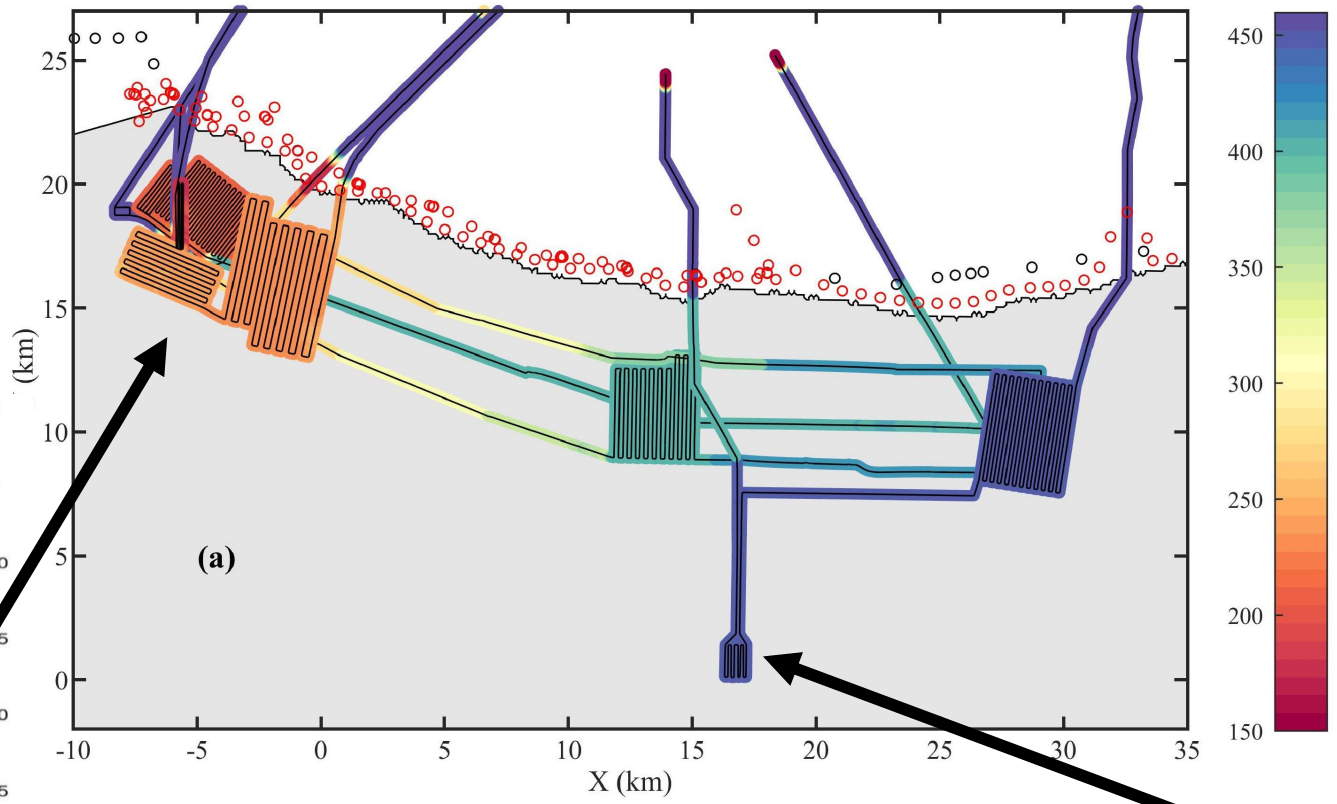
KOREA-SWEDEN-US-UK, Antarctic work 2024 - 2030

- **Field work from RVIB Araon: Investigating ice shelf cavities in the Amundsen Sea with Ran in 2023/2024 and 2025/2026**
- **Already funded: Swedish Research Council (2022 – 2032) and EU H2020 (2023-2027)**
- **Funding secured for AUV dayrate, staff, travel and other expenses (for Swedish and Korean collaborators**

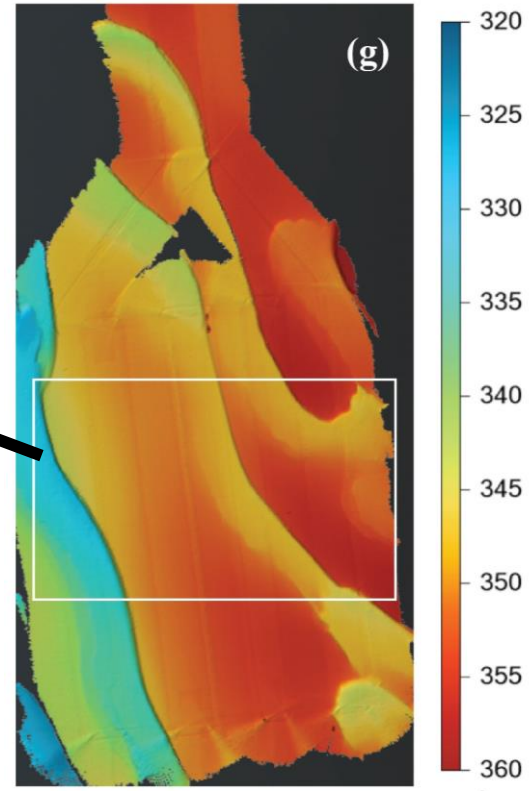
Opportunity to revisit Dotson:



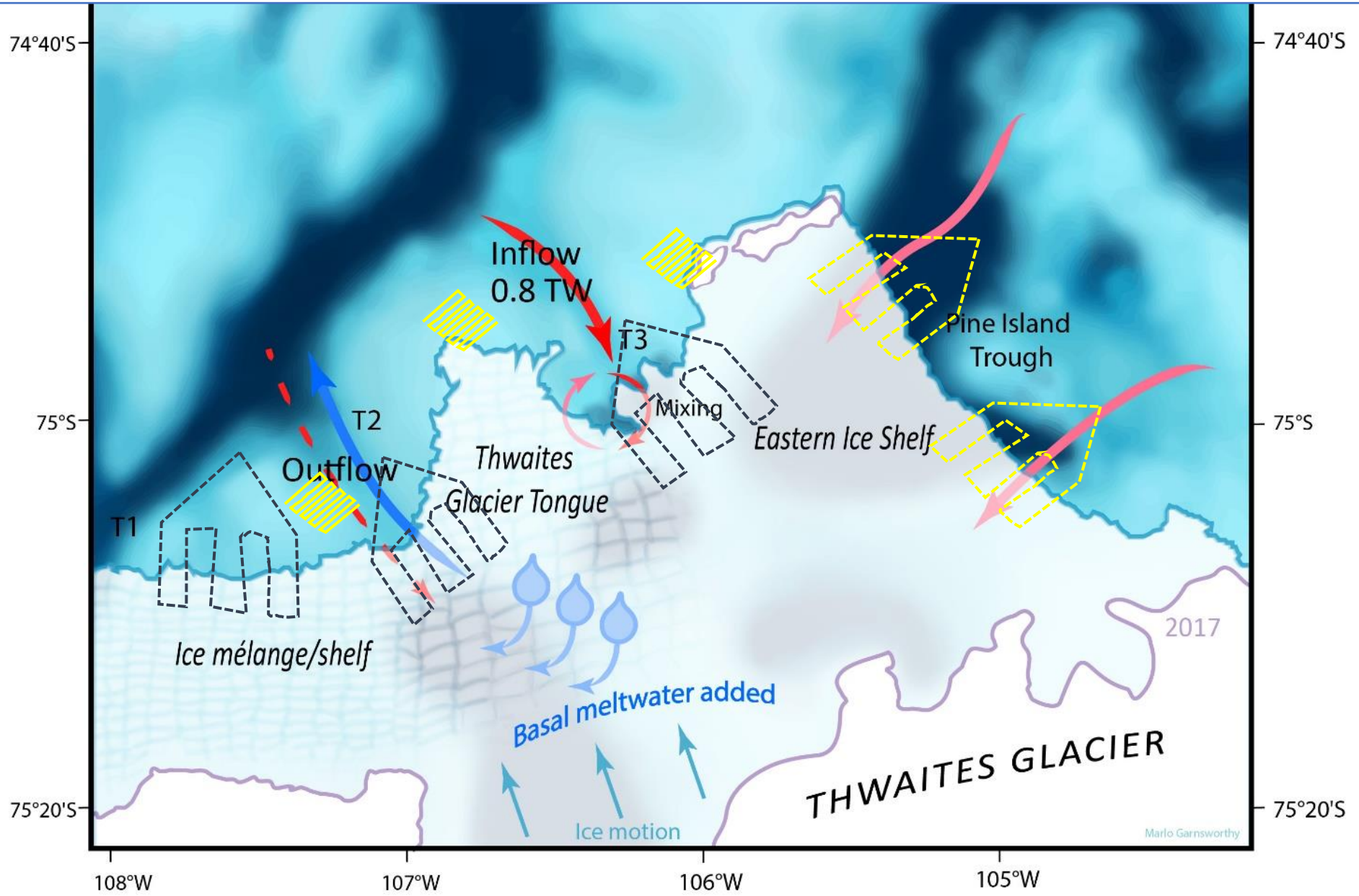




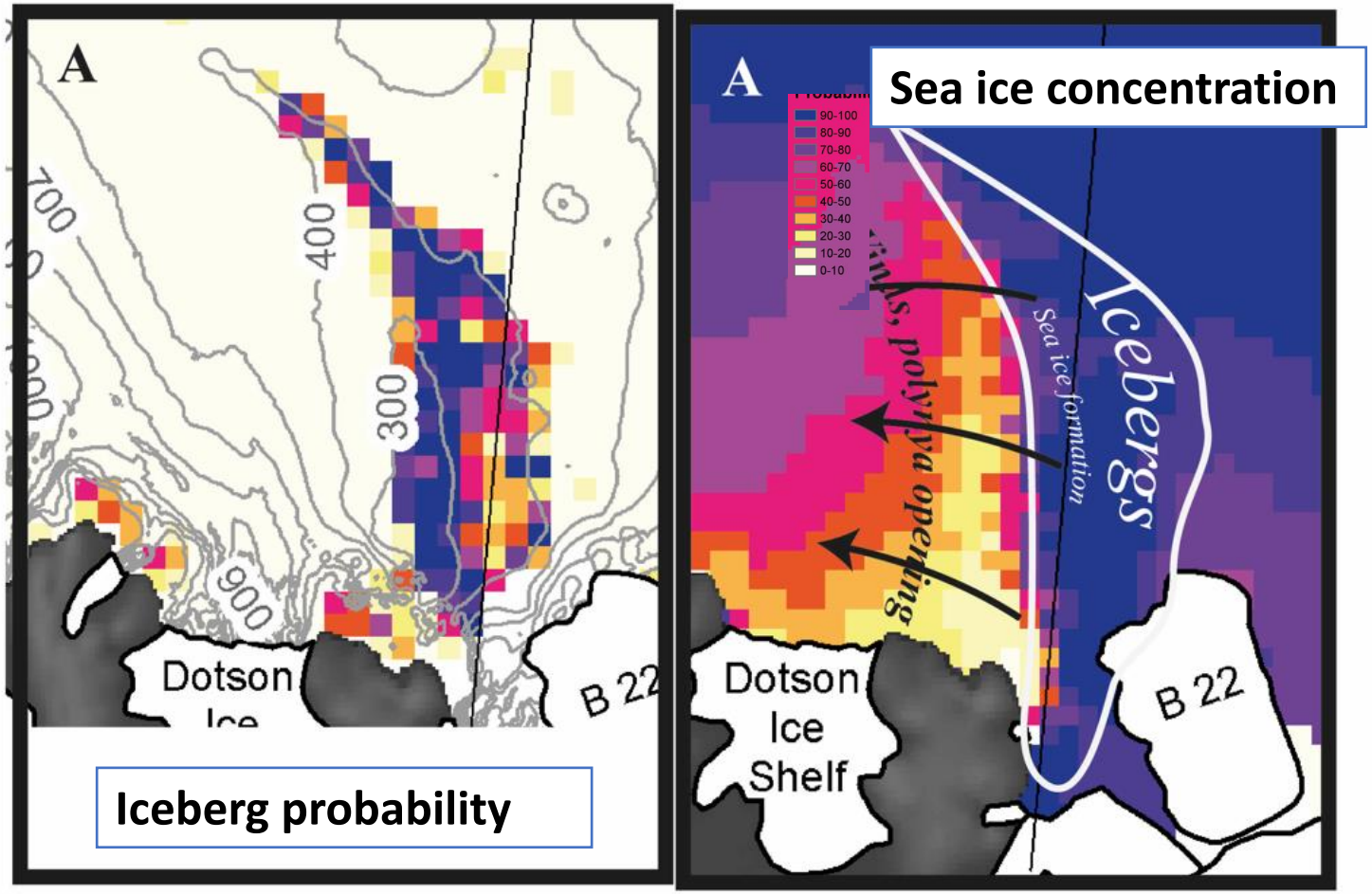
Have they moved?
Disappeared or new ones appeared?
Complementary data (turbulence + high resolution ice surface



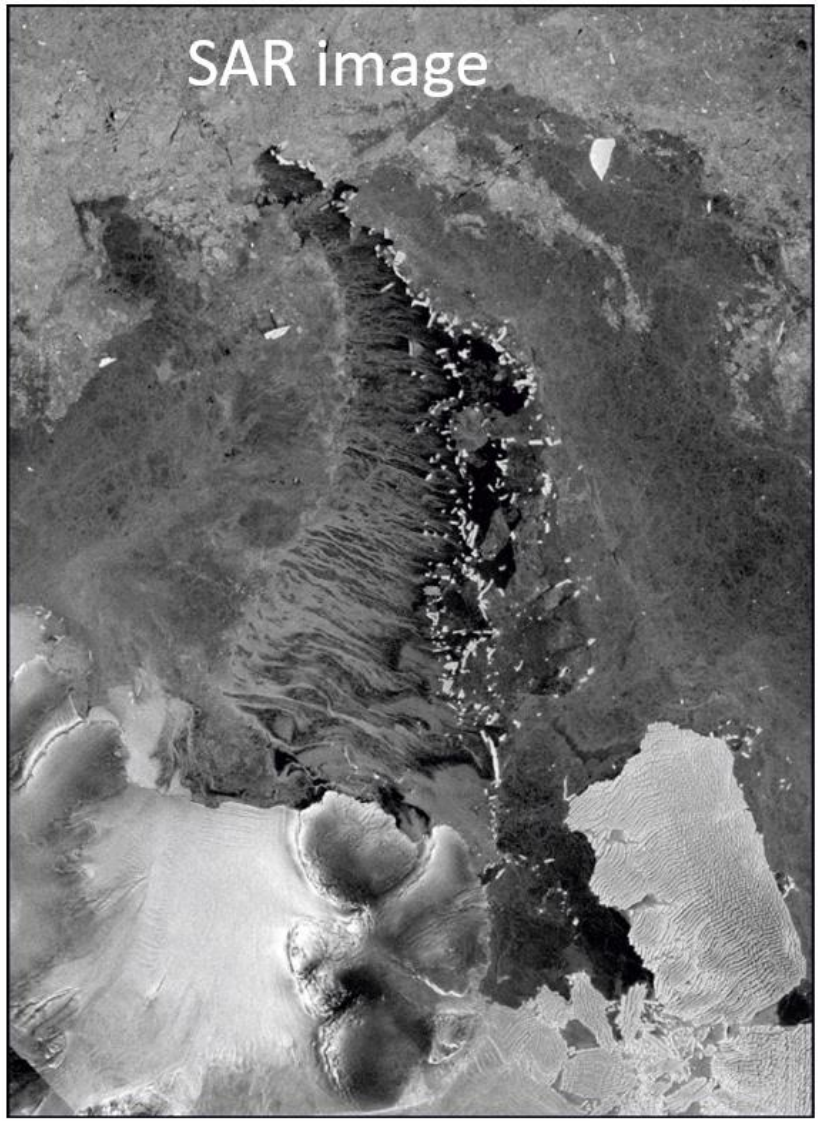
Thwaites ('Doomsday glacier'): Repeat plan from Dotson, focusing on front regions and former grounding zones / pinning points



Bear ridge: An inaccessible ice factory

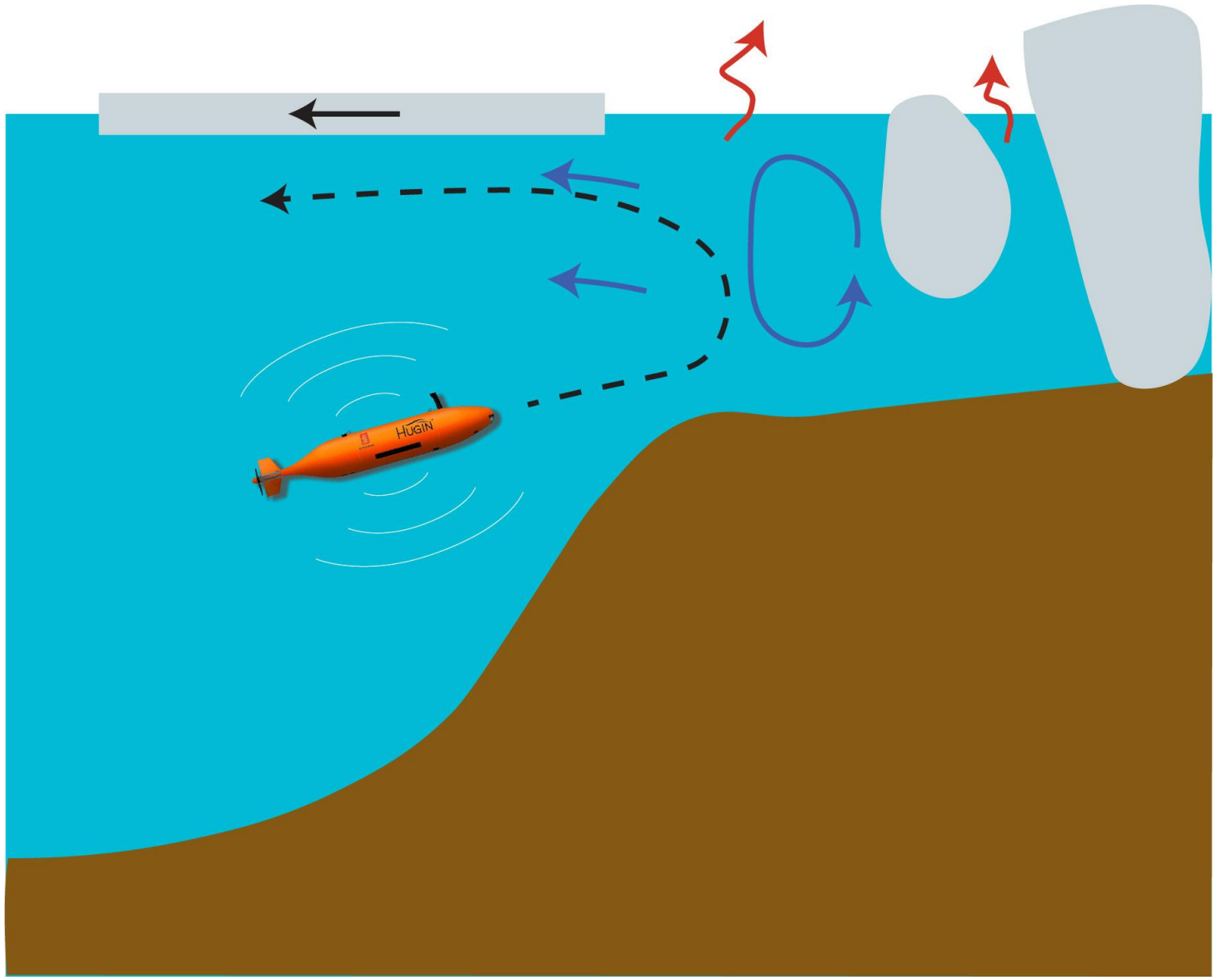


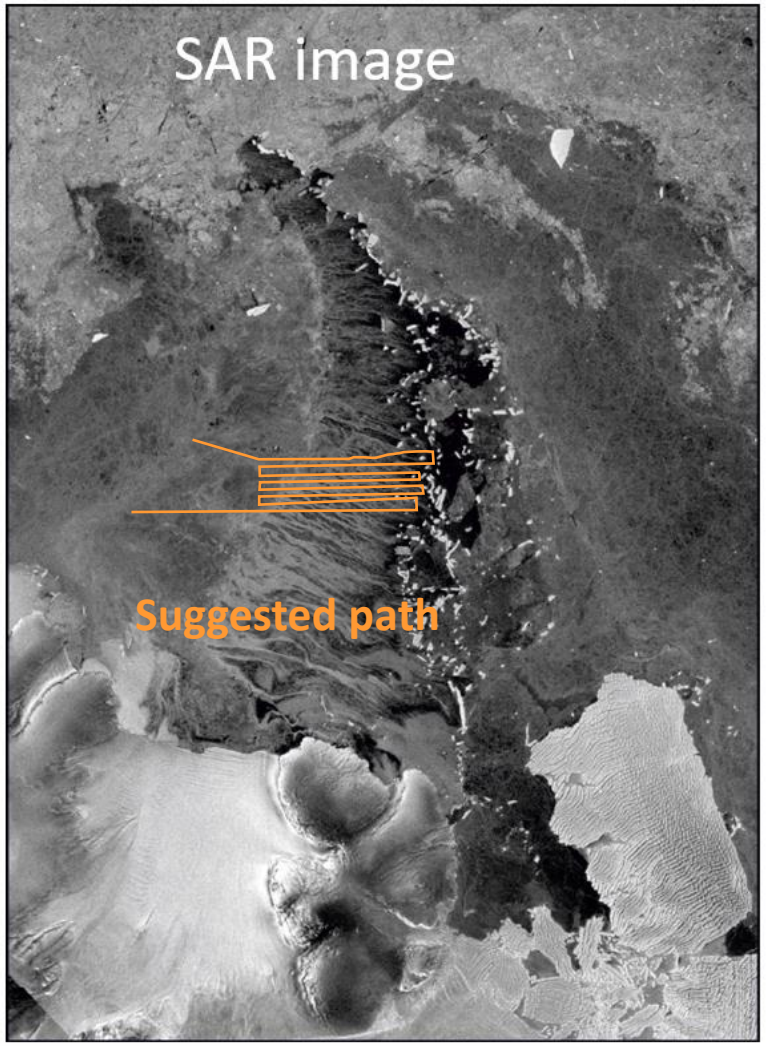
Iceberg probability



Mazur, A. 2017: Detection and characteristics of icebergs in the Amundsen Sea, Antarctica. Ph. D. thesis, University of Gdansk

Bear ridge: An inaccessible ice factory





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