IUGC2024
The International Underwater Glider Conference, 10-14 June 2024, Gothenburg, Sweden

OGS

Glider observations of cyclonic cones in the Antarctic and Mediterranean Sea: formation mechanism and deep impact on the circulation

Annunziata Pirro, Daniela Flocco, Riccardo Martellucci, Milena Menna, Silvina Julieta Logarzo, Angela Garzia, Naomi Krauzig, Pasquale Castagno Pierpaolo Falco, Enrico Zambianchi, Elena Mauri

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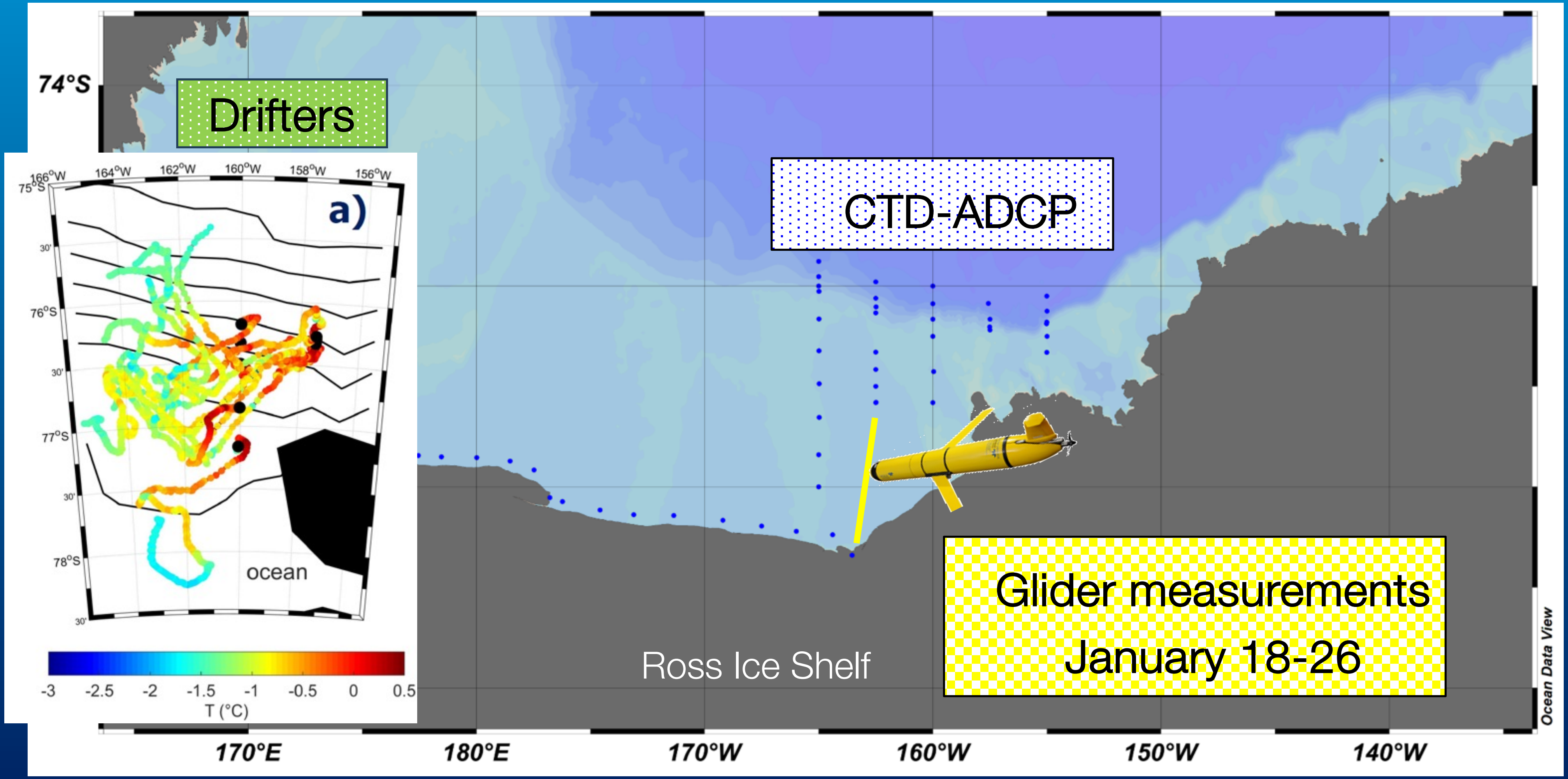
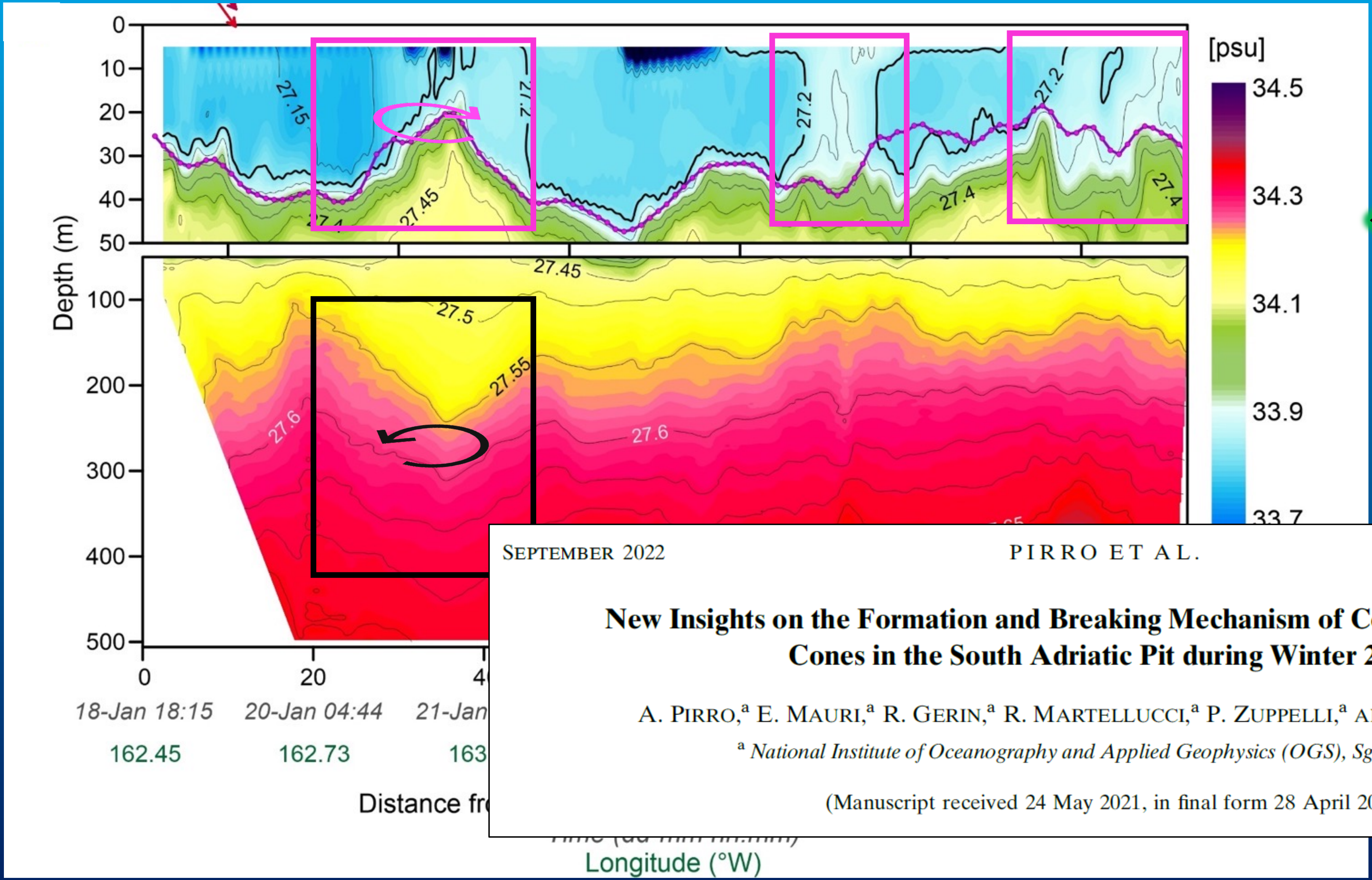
ESTRO Project 2020



Motivation



go back to 2022

SEPTEMBER 2022 PIRRO ET AL. 2049

New Insights on the Formation and Breaking Mechanism of Convective Cyclonic Cones in the South Adriatic Pit during Winter 2018

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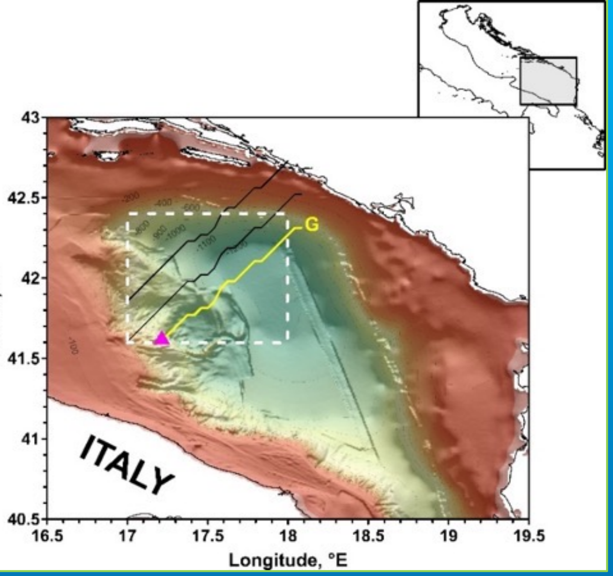
(Manuscript received 24 May 2021, in final form 28 April 2022)

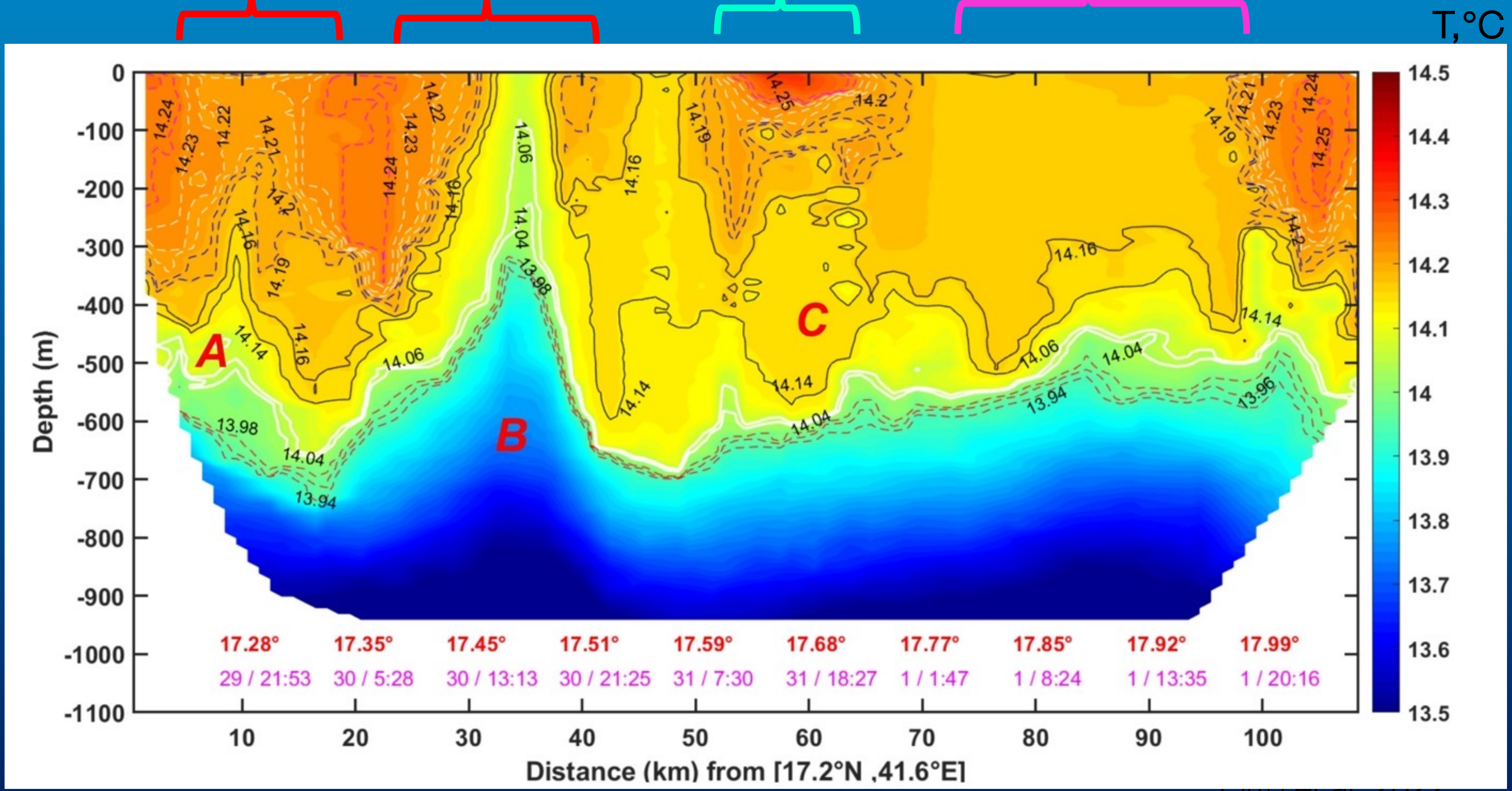
OGS perform yearly glider campaigns to study ocean convection in the South Adriatic



A & B formed

C forming

D & E will form



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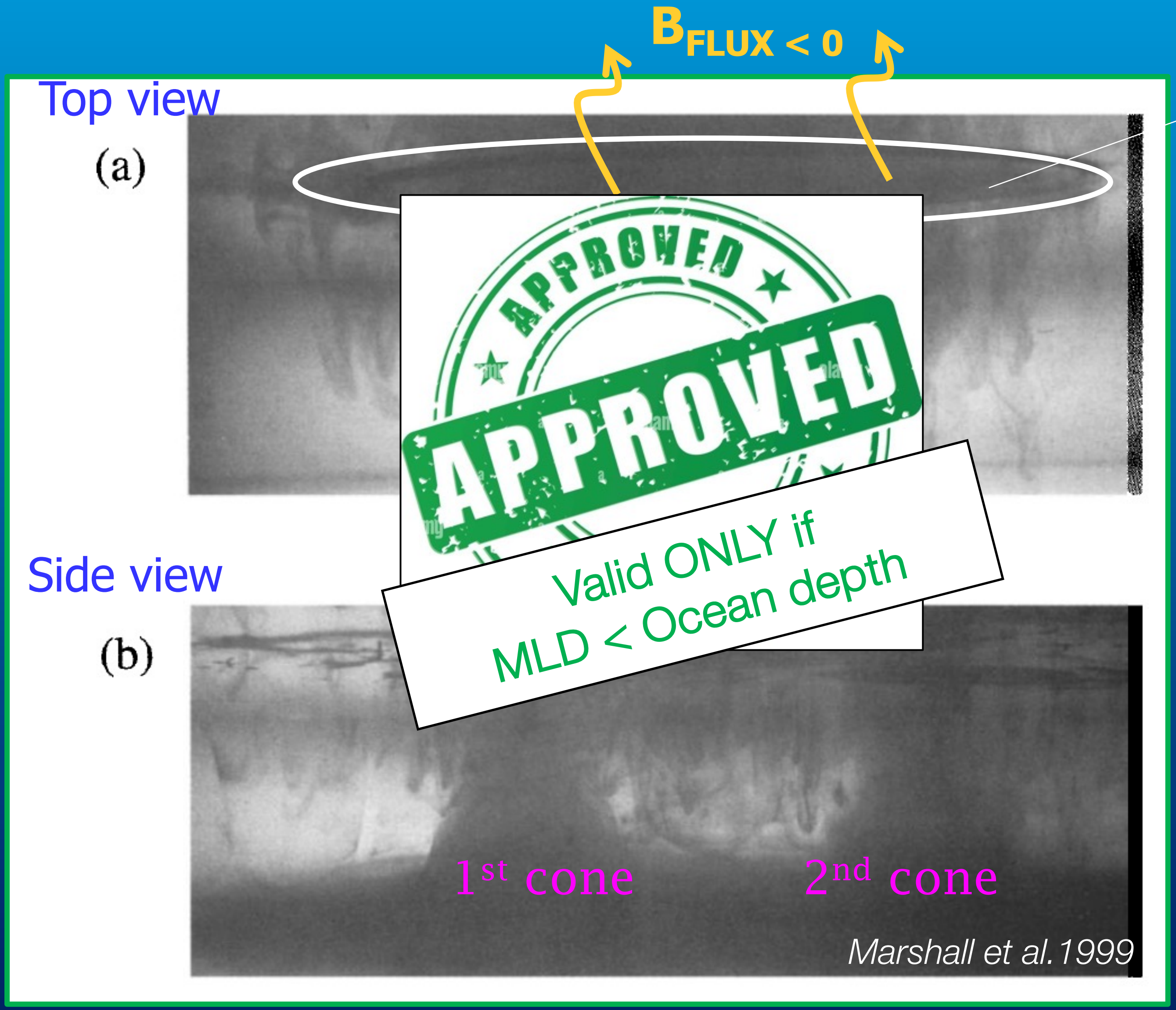
Unconfined laboratory experiment in a rotating tank

John Marshall helped to understand the physical processes



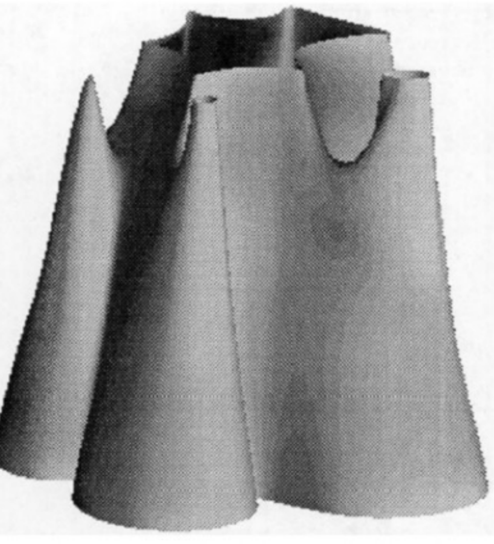
A disc of colored ice floating on the surface of a homogeneous fluid simulates the MIXING phase during the winter season

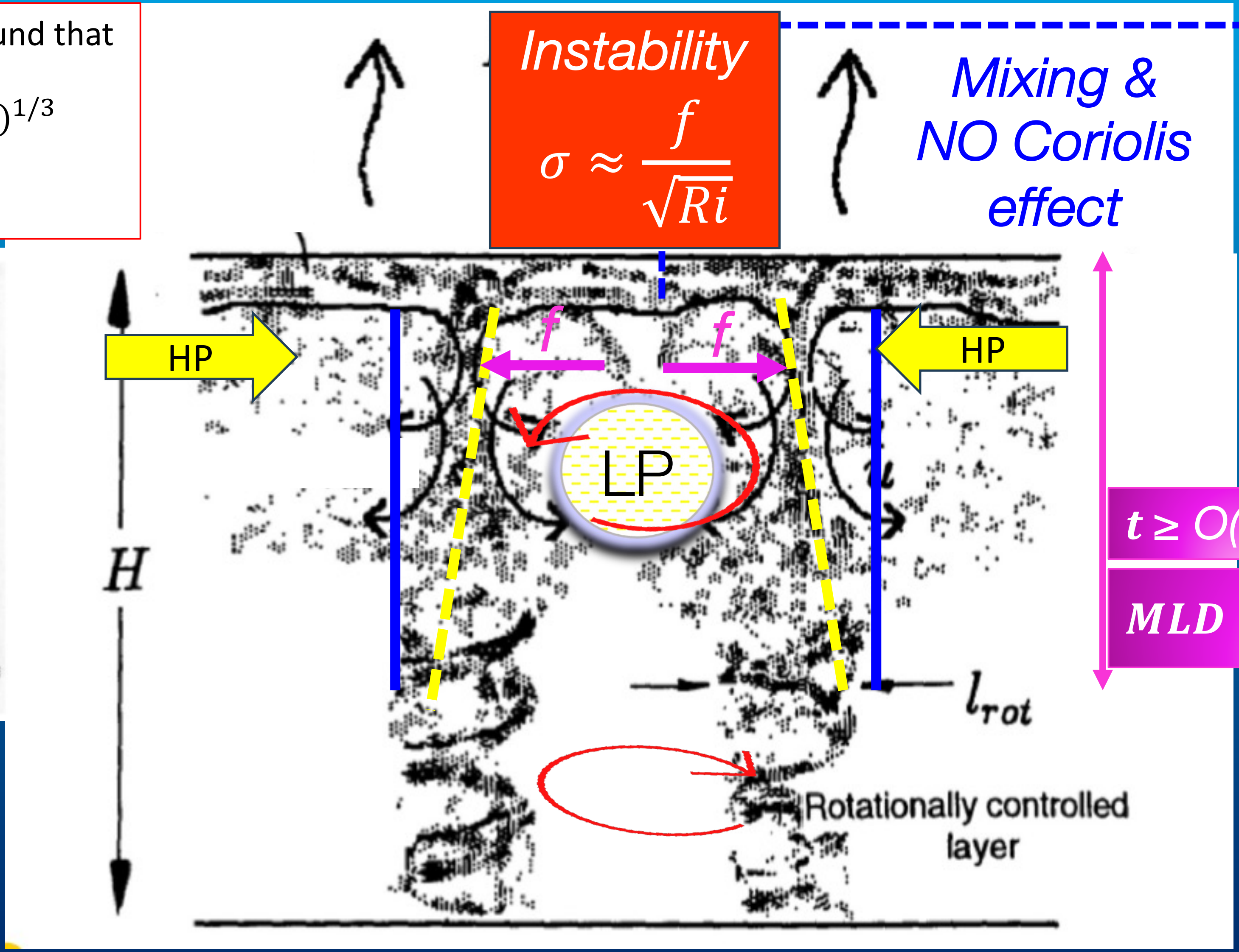
- The melting of the ice generates buoyancy loss
- Formation of small convective cells: plumes
- By the time the ice was melted the cold fluid had broken in cyclonic eddies with conical shape: cones!!

Schematic representation of the mixing phase

Experimentally has been found that

$$D_{cone} \sim L\rho \sim \frac{\left(B_0^{1/4} f^{1/2}\right)^{1/2}}{f} \left(\frac{r}{H}\right)^{1/3}$$





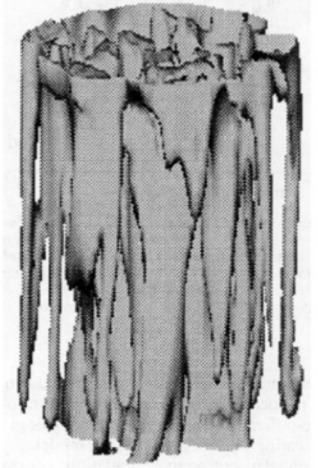
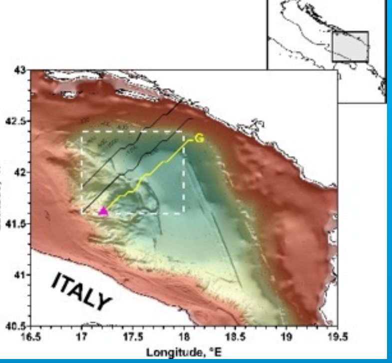


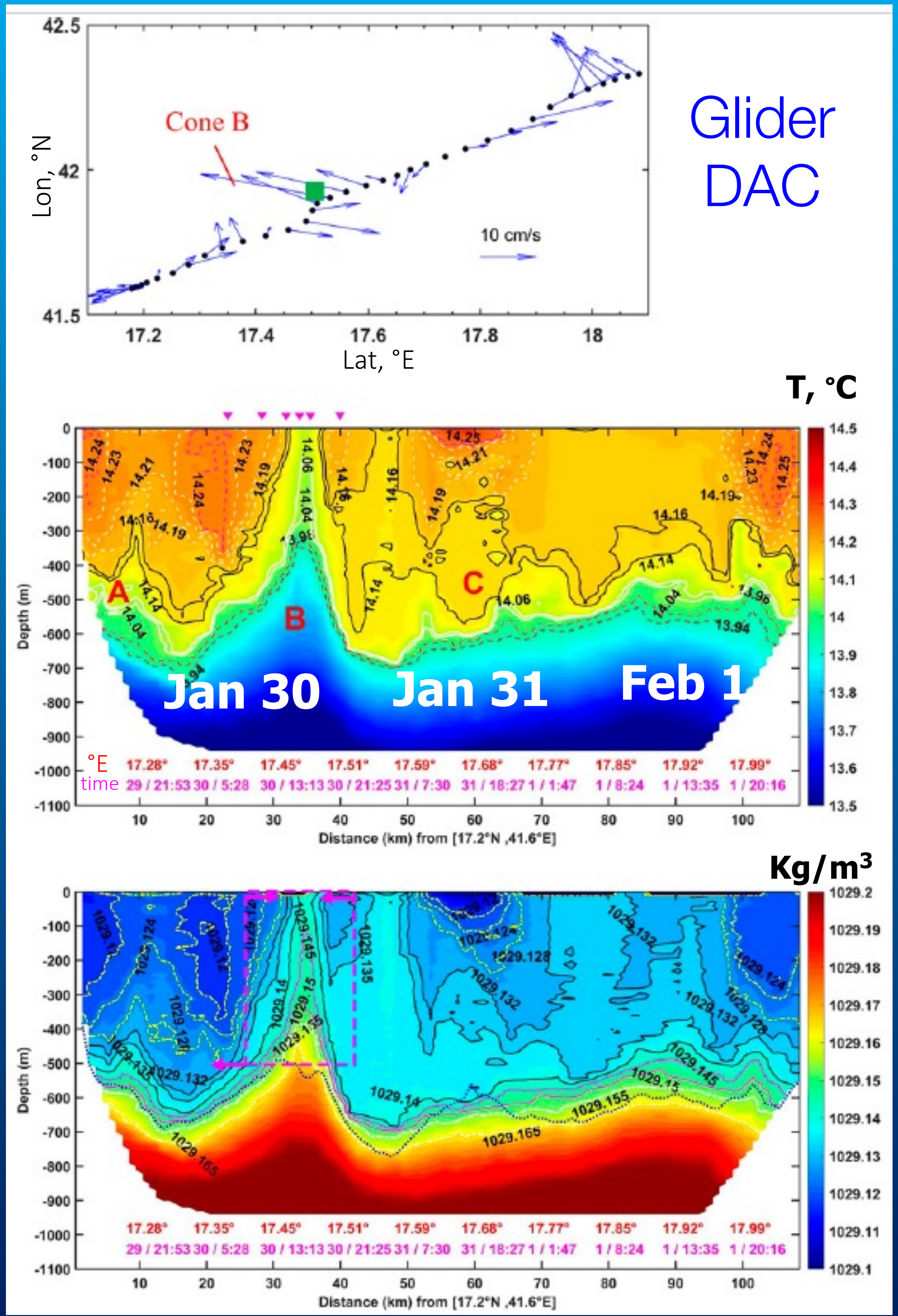
FIG. 5. An isothermal surface from the reference experiment at the end of day 2 capturing the 3D form of the population of sinking plumes.

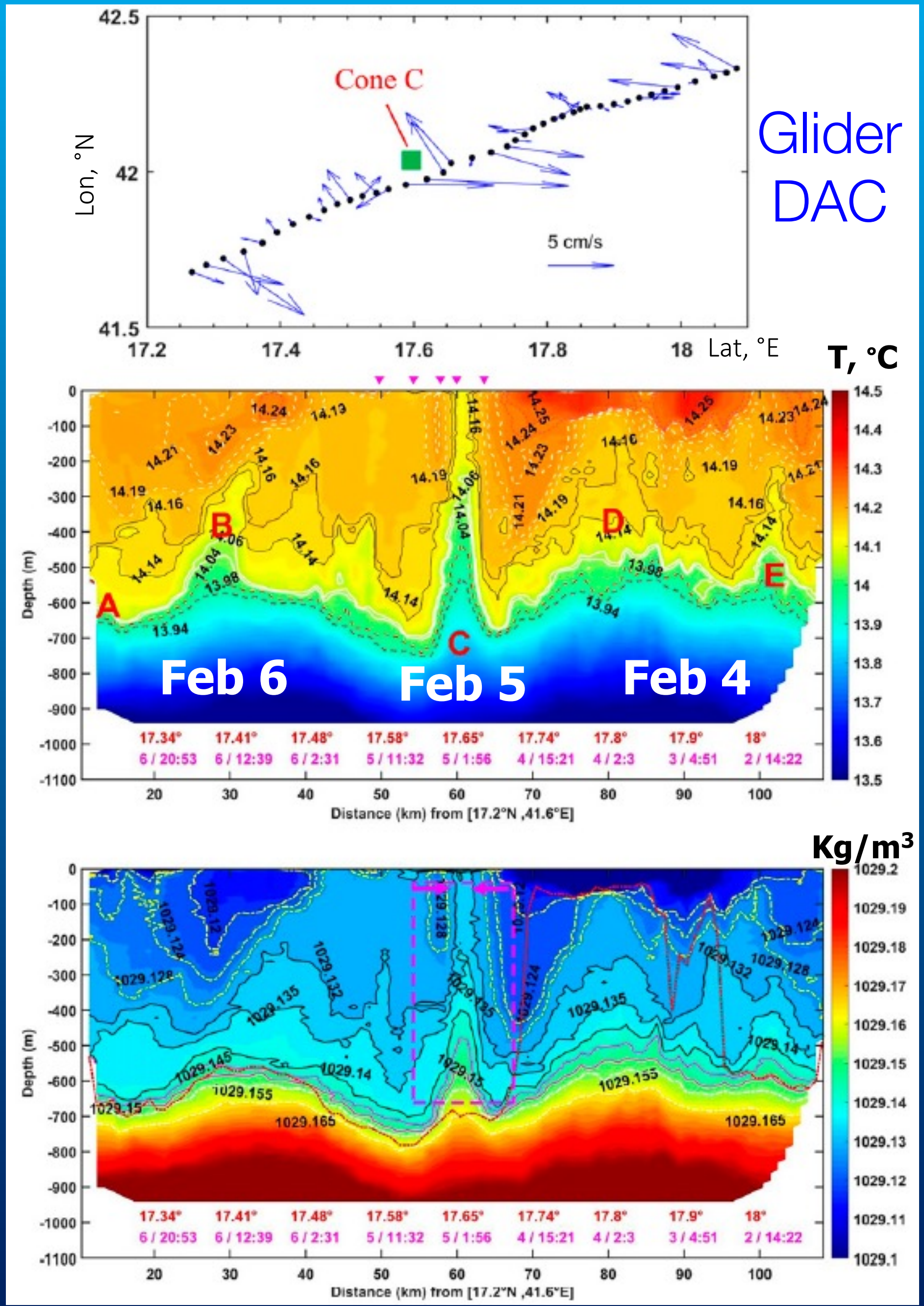
JM 1993



Bari-Dubvronik

Dubvronik-Bari





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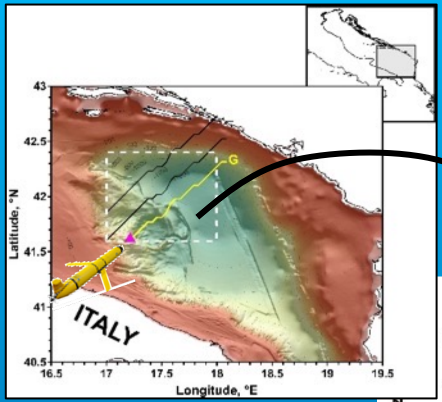
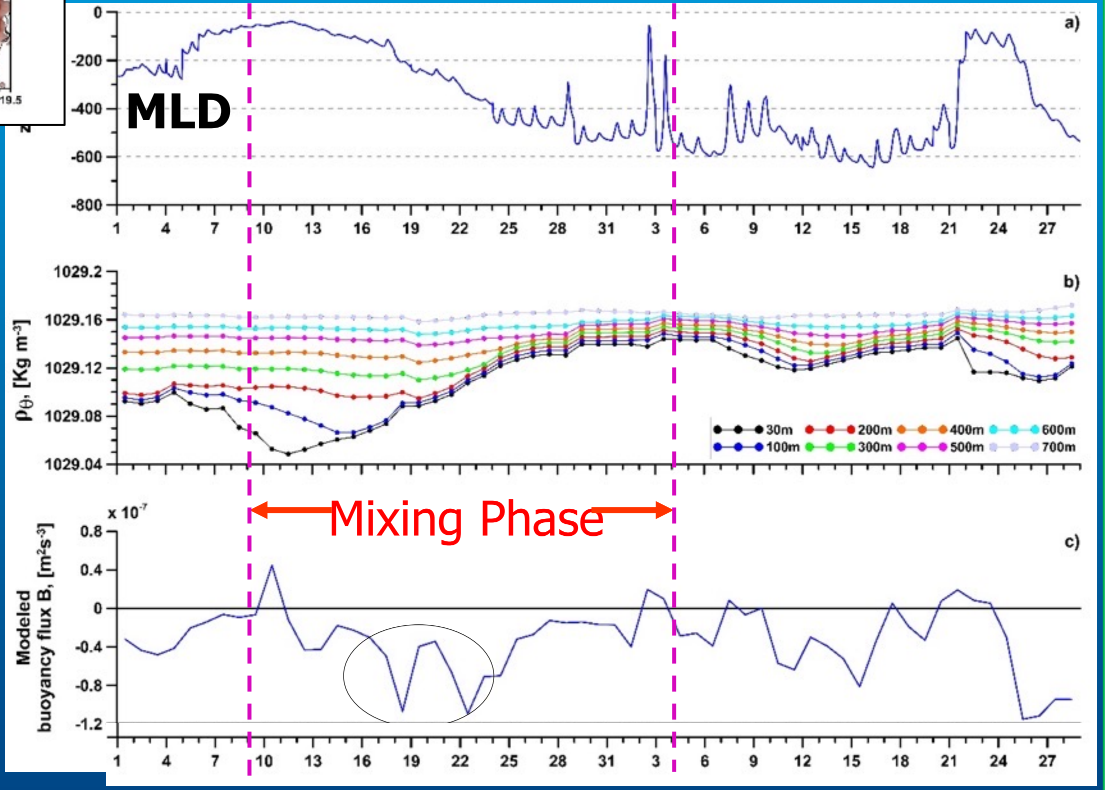
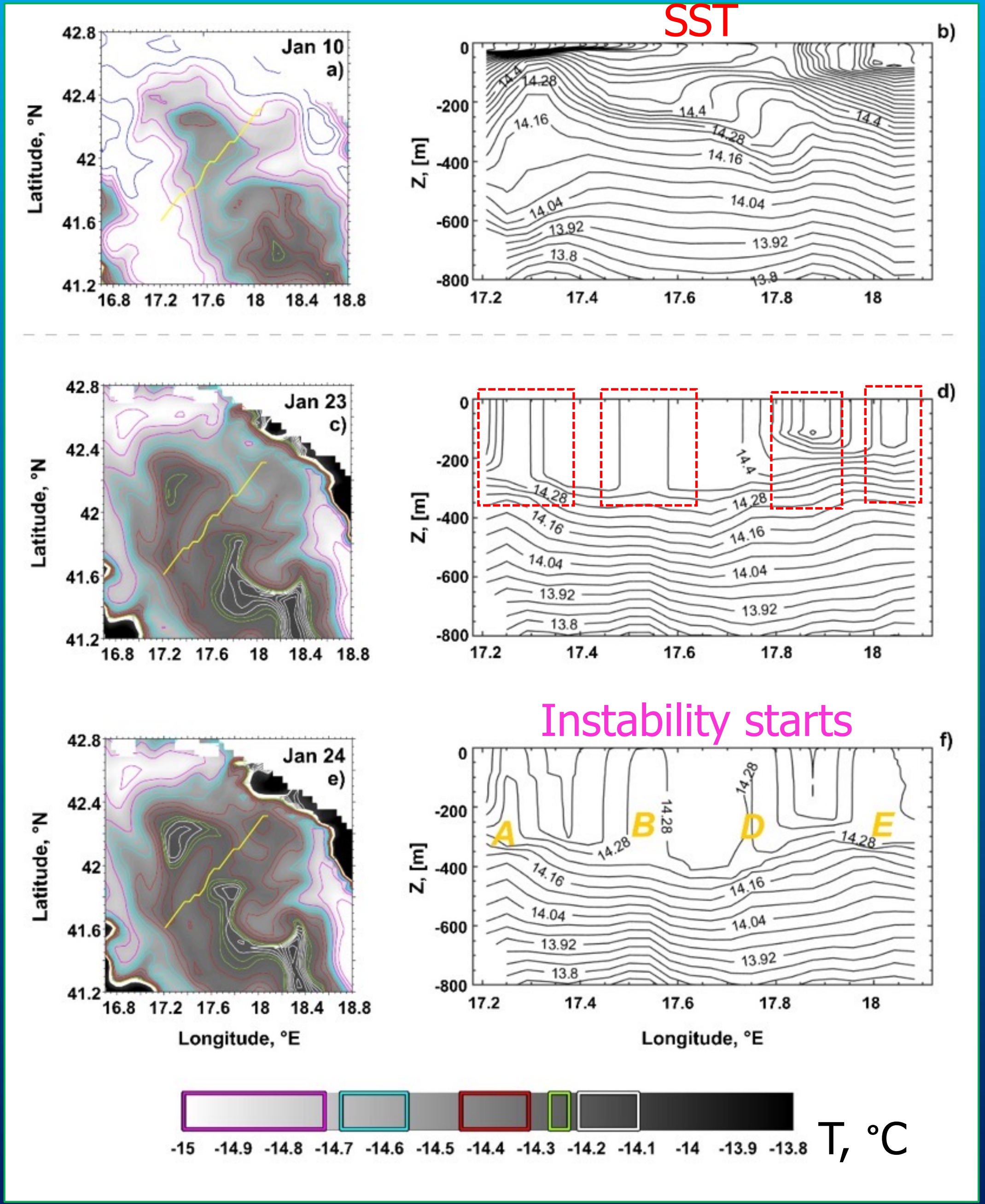
Reanalysis products





Days of January – February 2018



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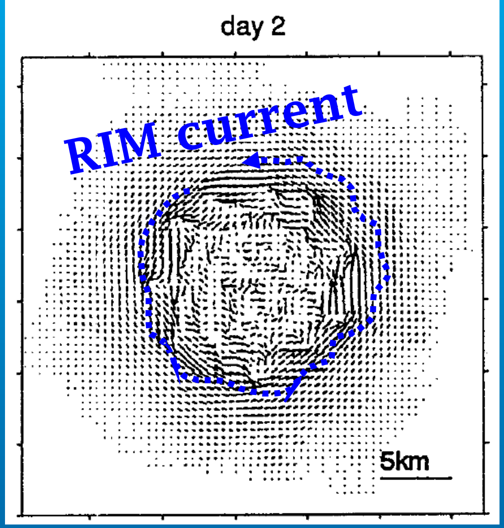
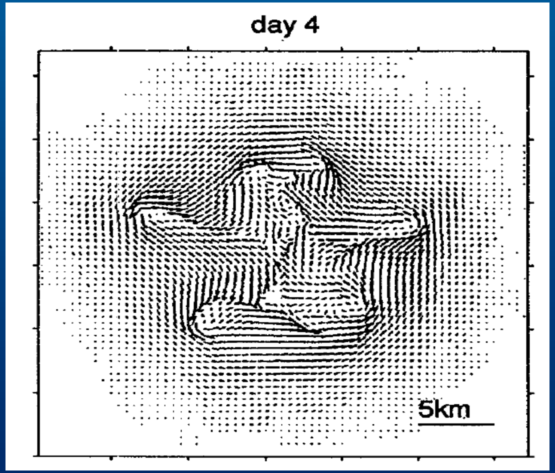
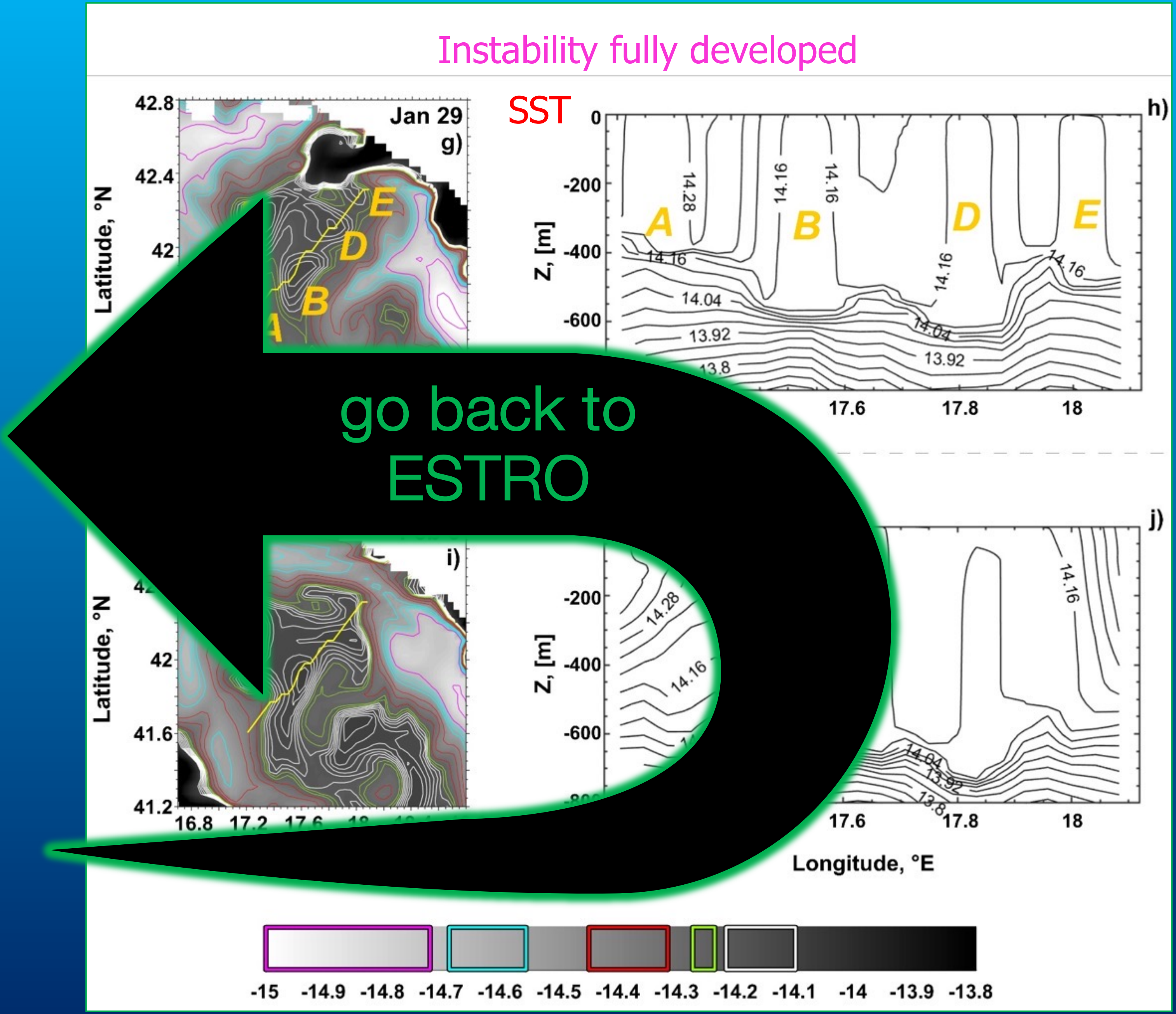


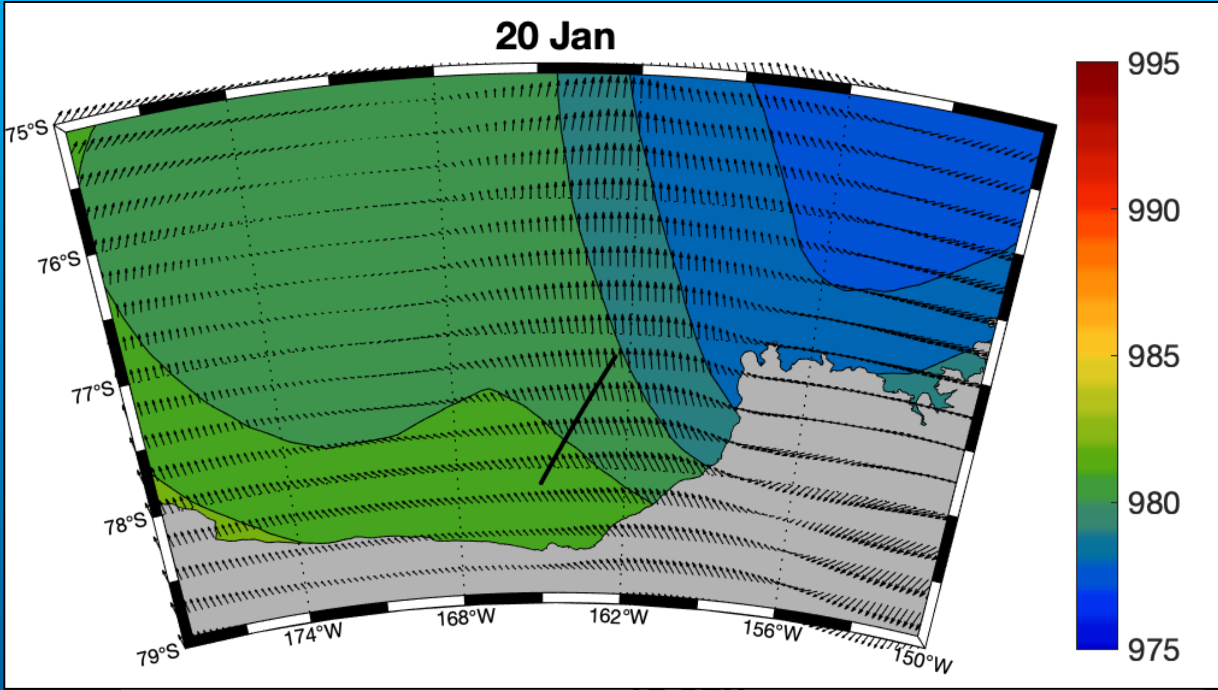
Losing the shape

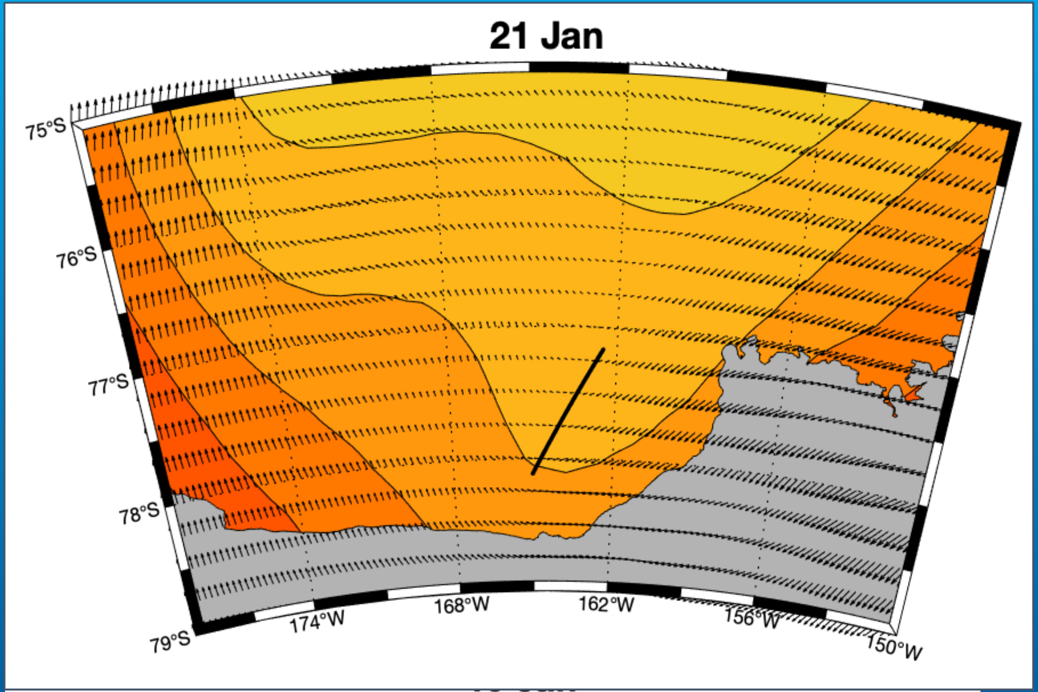


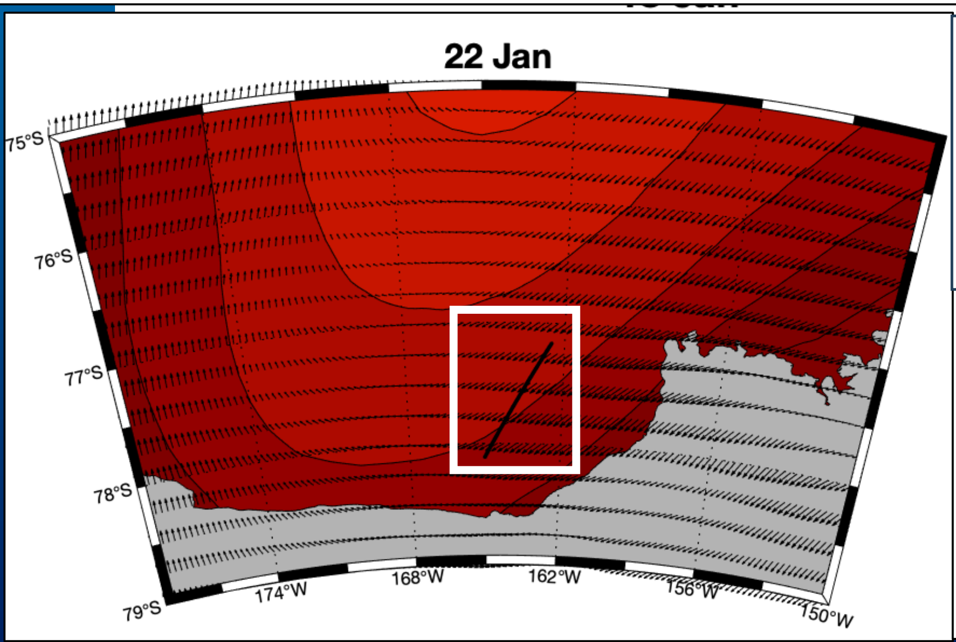
JM 1993



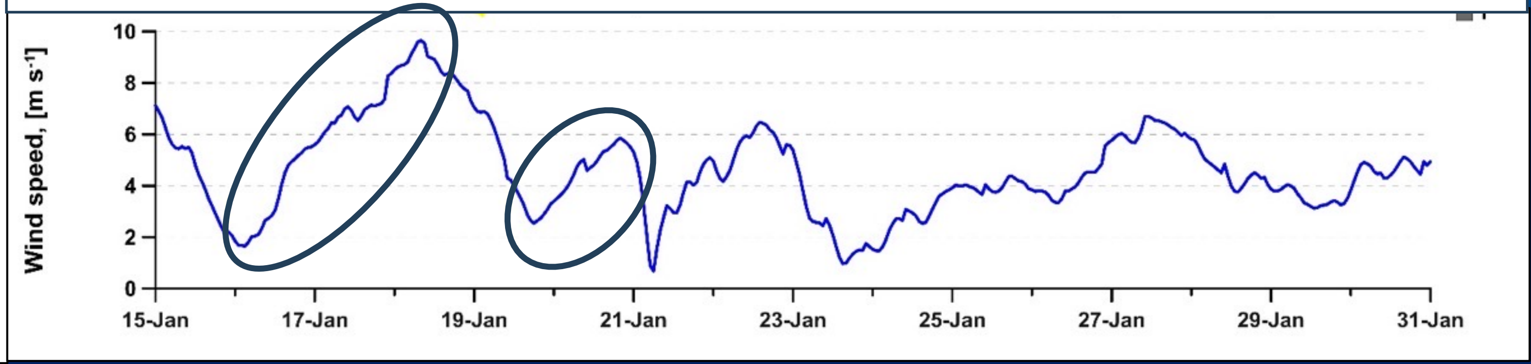
ESTRO Mean Sea Level pressure

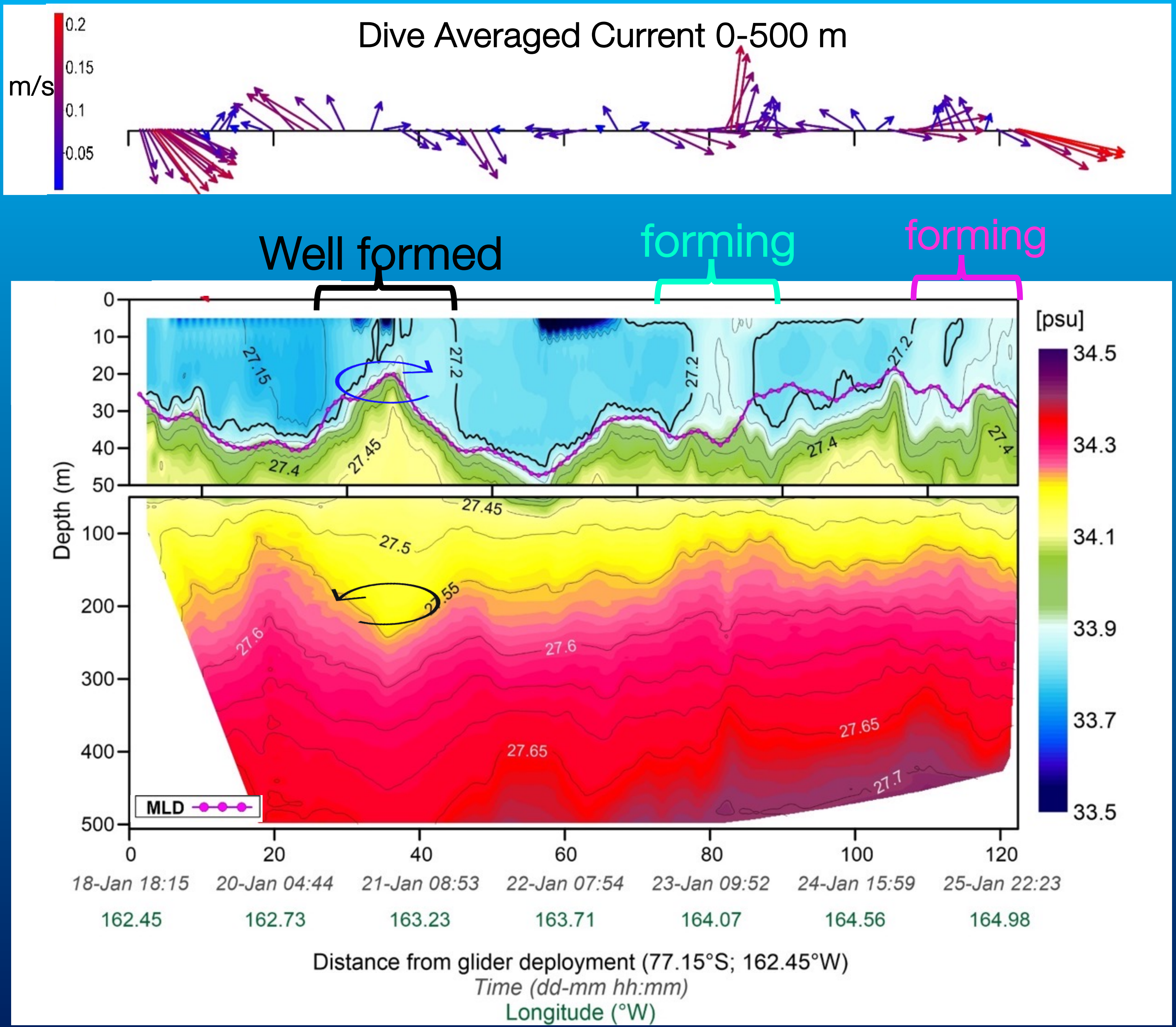






Wind speed averaged





January 16

wind increases

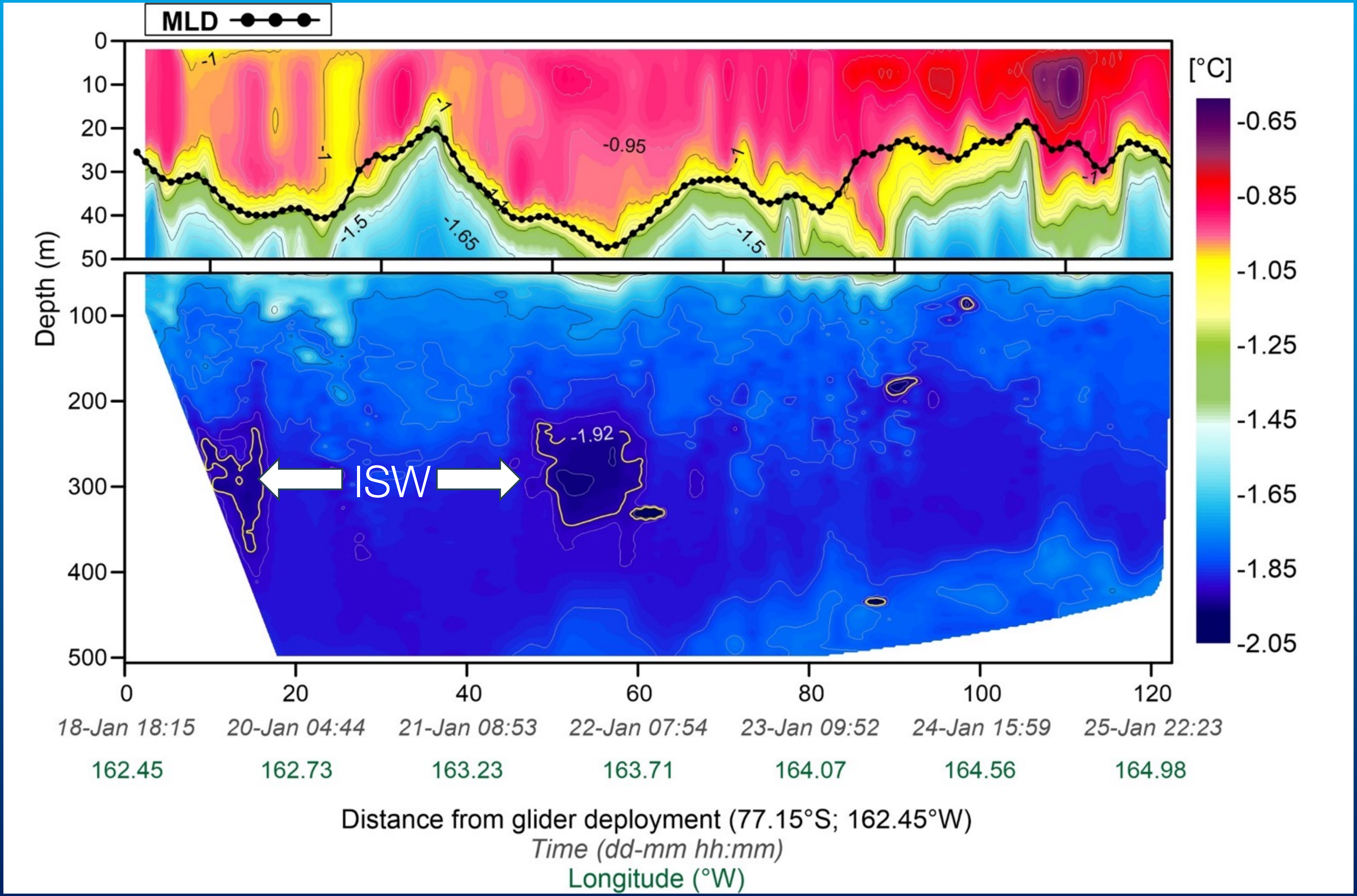
t = O(2π/f) ~12 hr

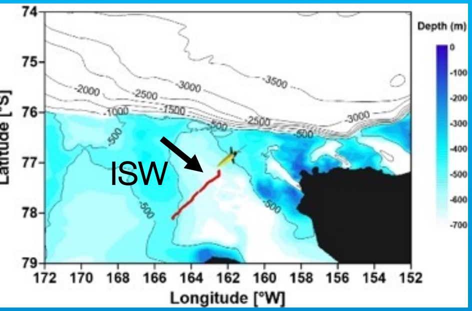
Coriolis acts

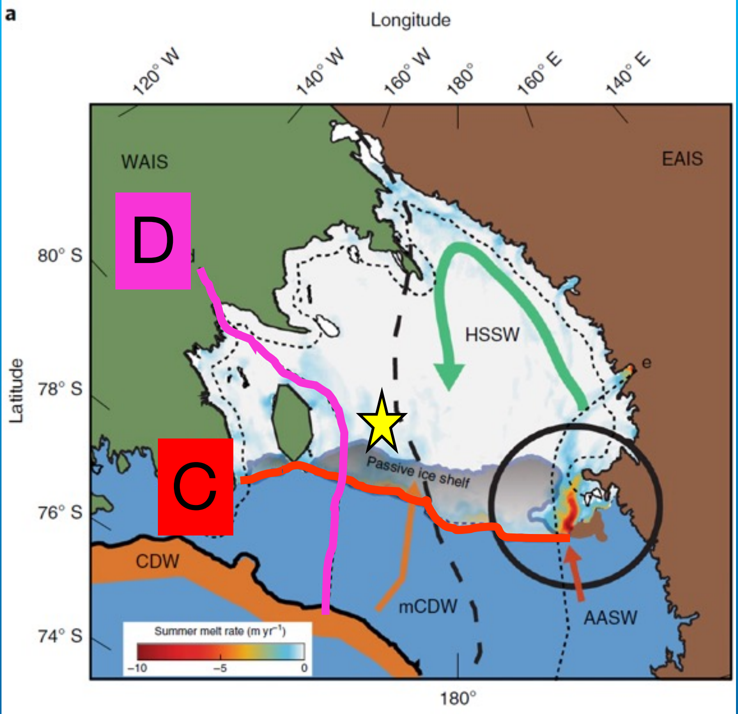
$$\sigma \approx \frac{f}{\sqrt{Ri}} < 1 \text{ day}$$

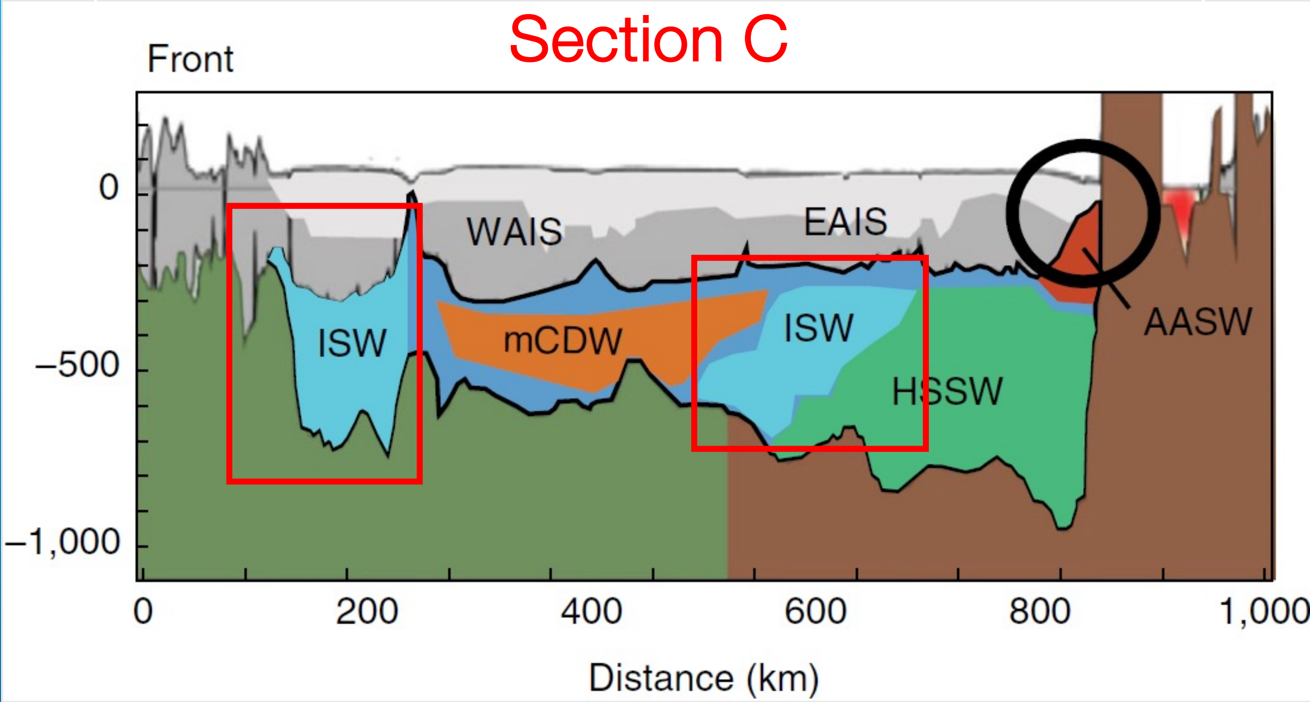
Instability starts

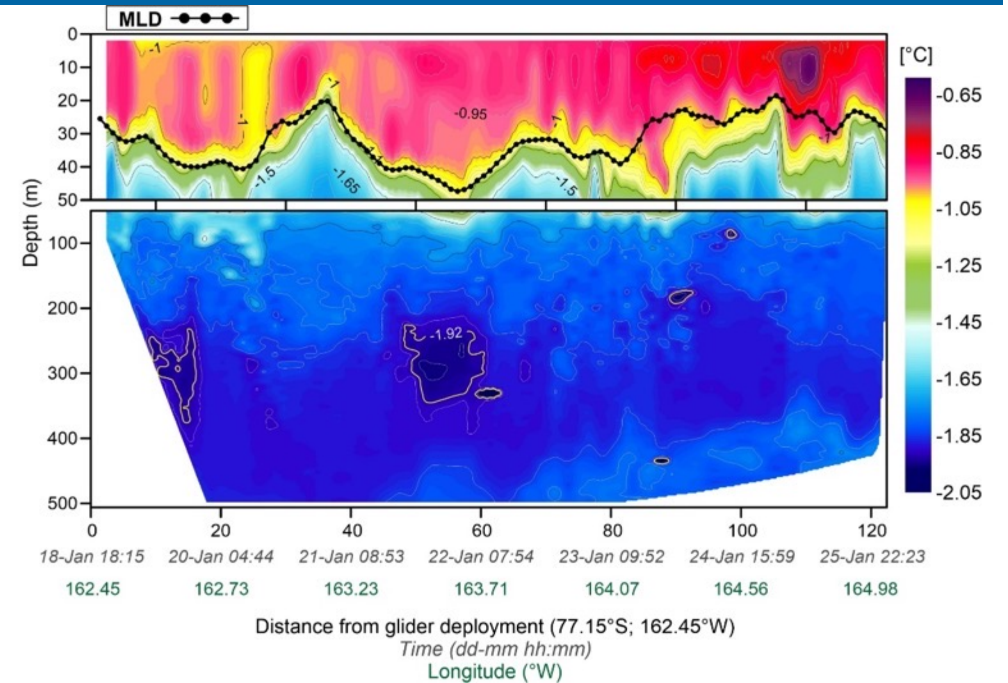
Potential Temperature

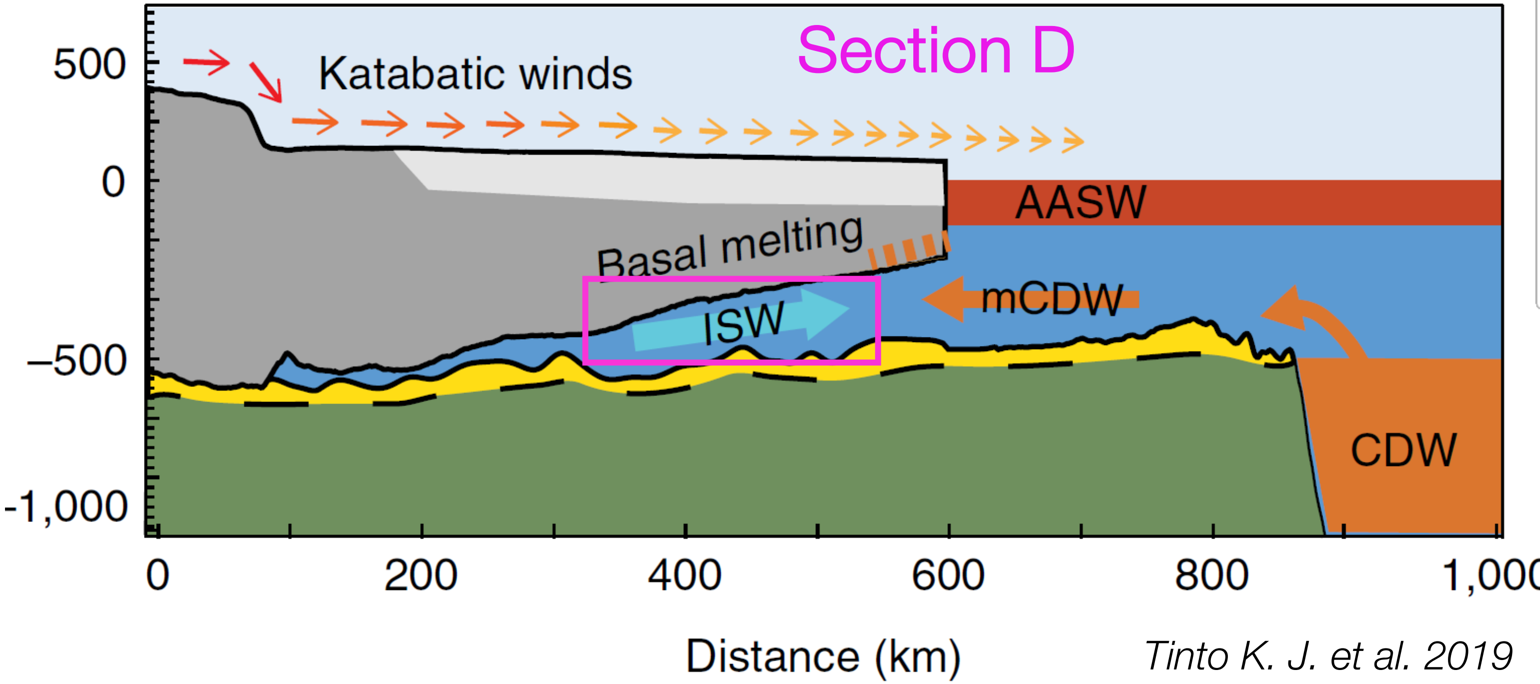






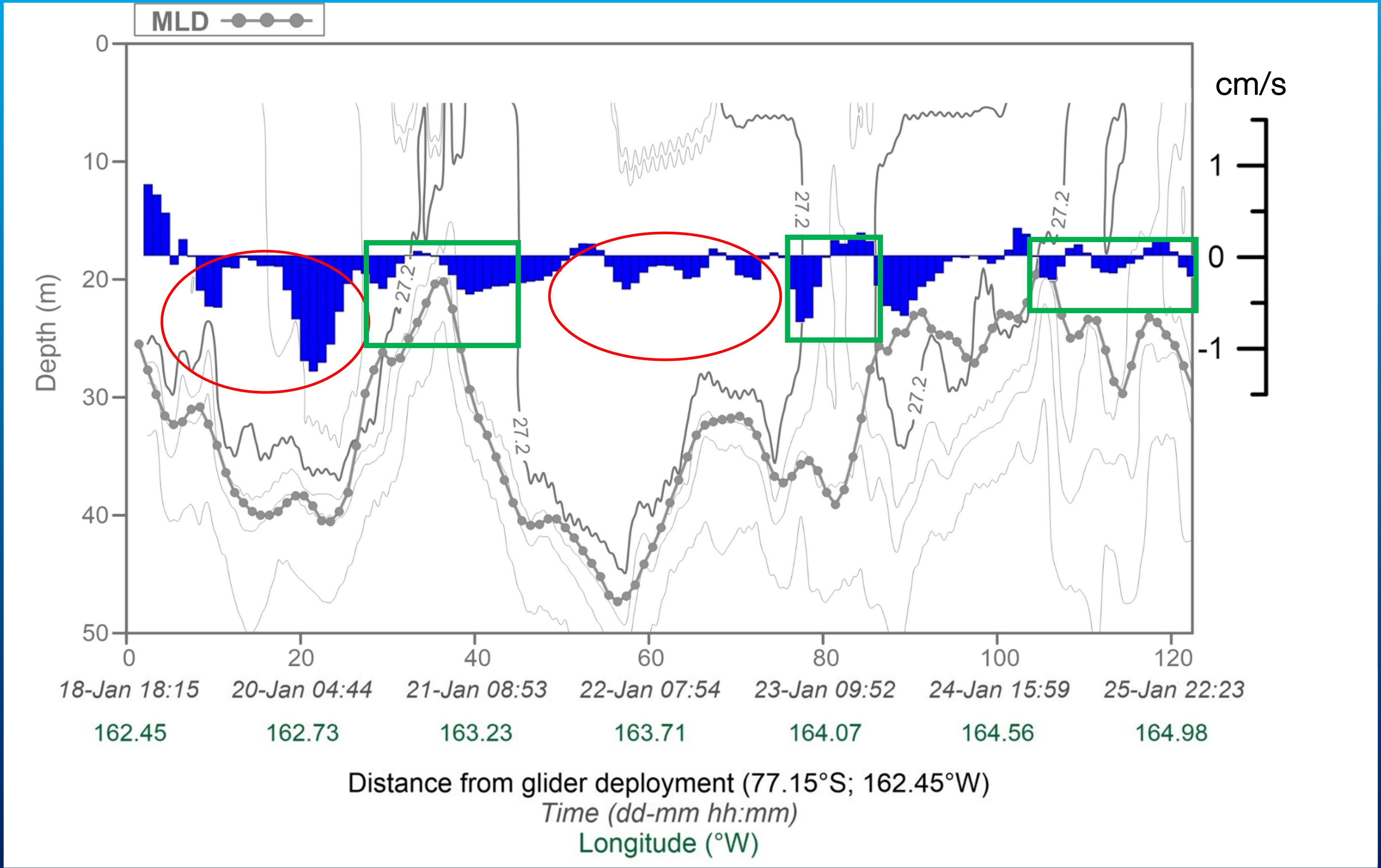




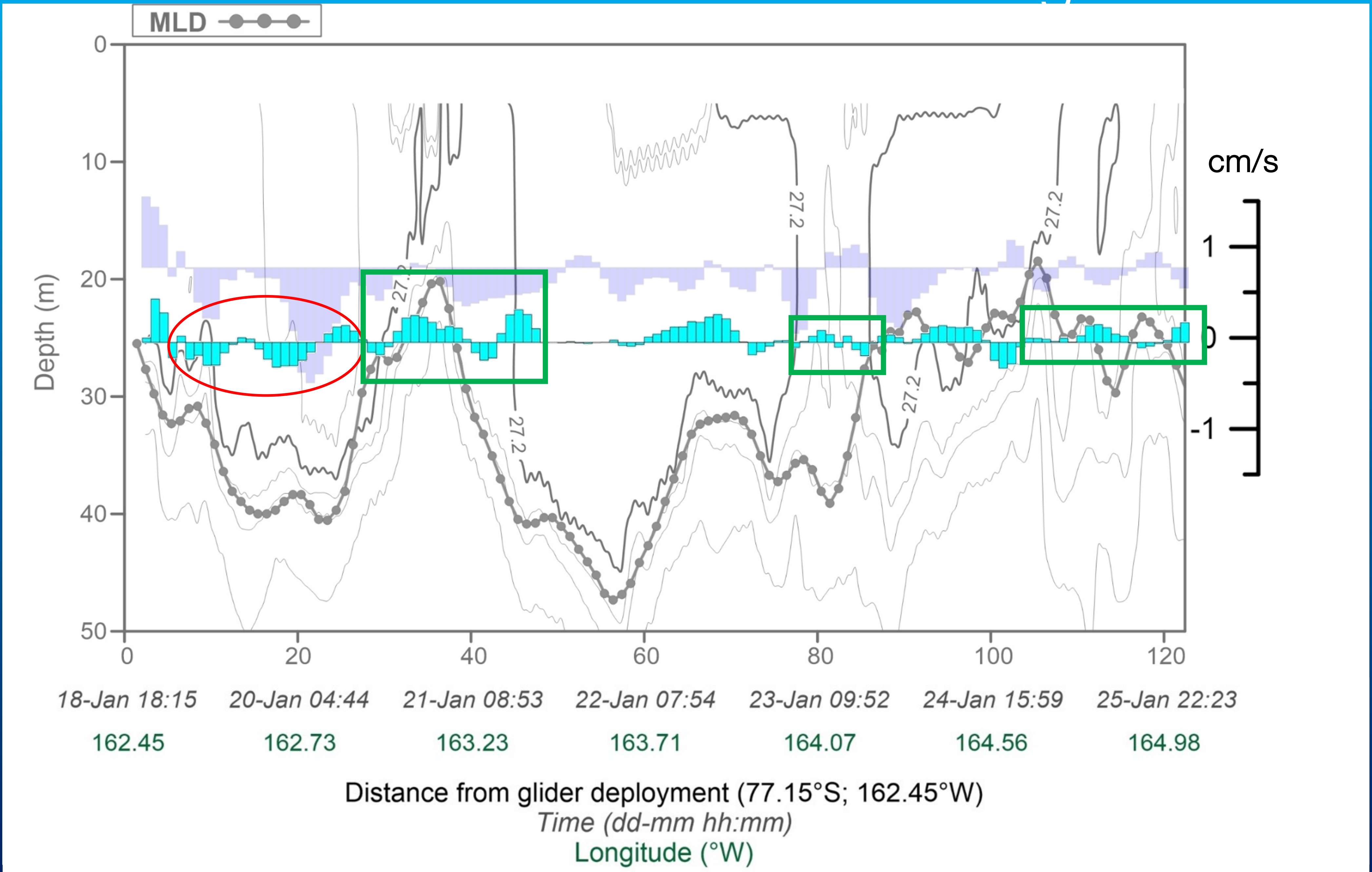


Tinto K. J. et al. 2019

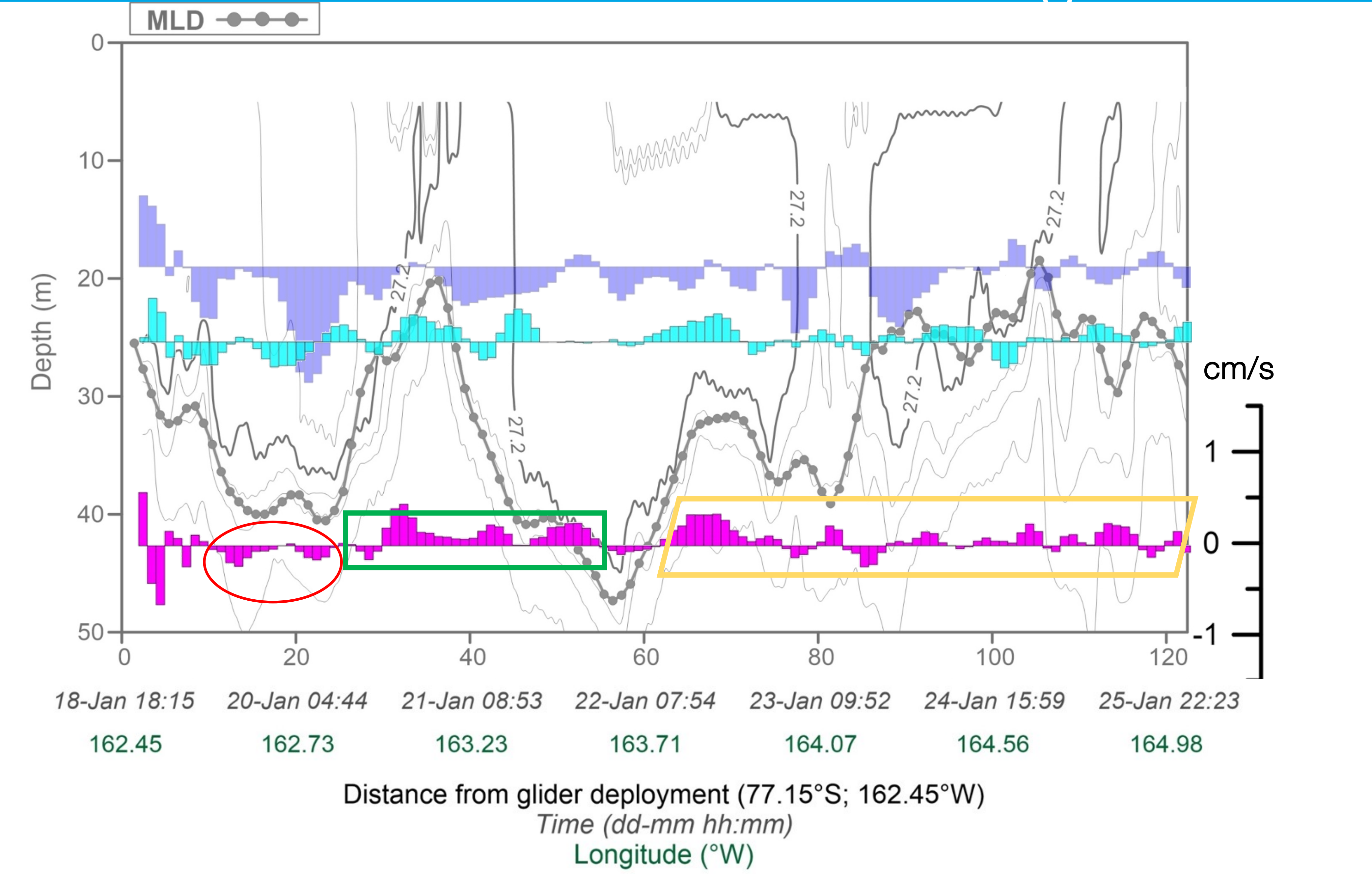
W velocities calculated from the glider



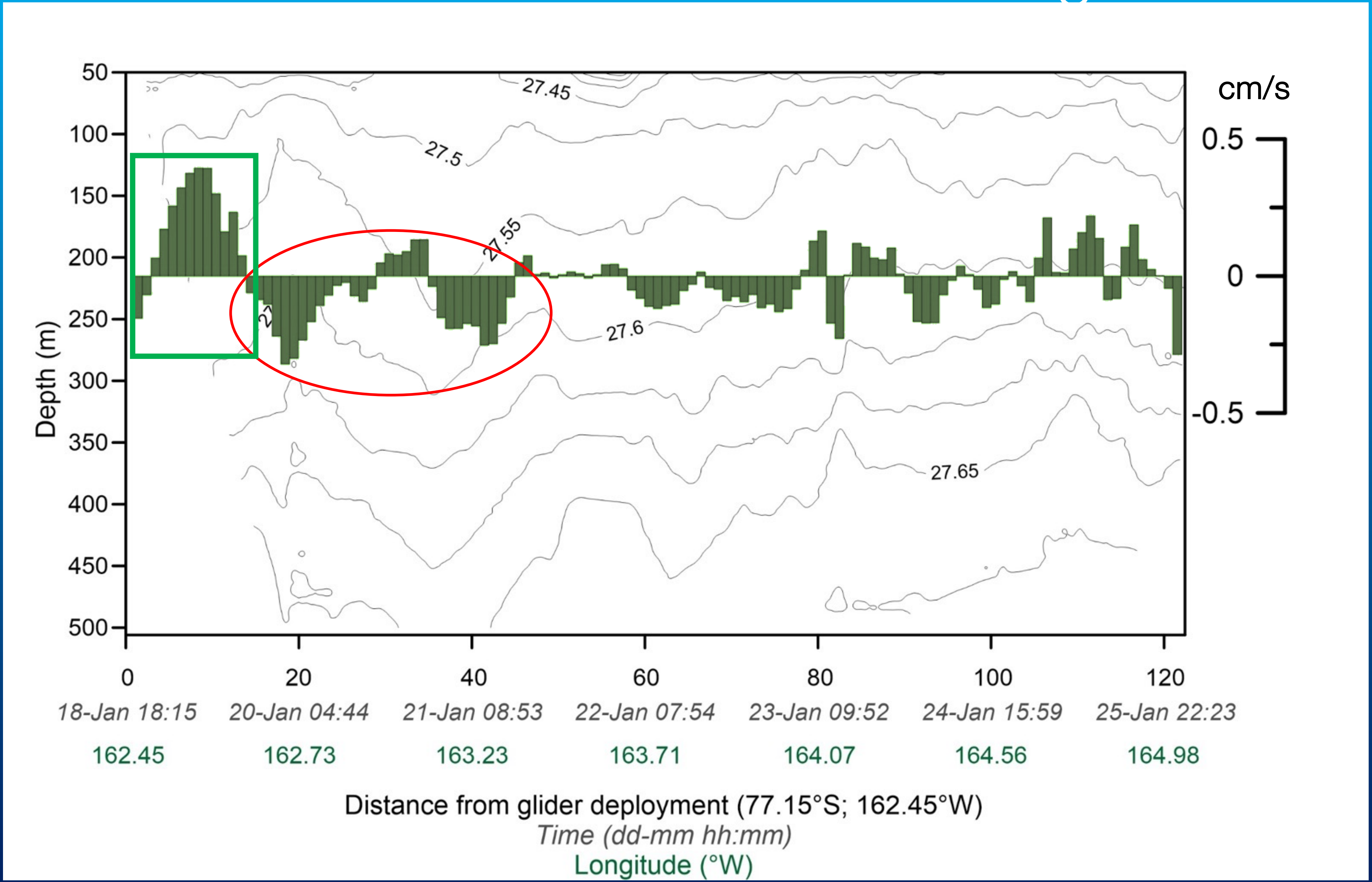
W velocities calculated from the glider



W velocities calculated from the glider



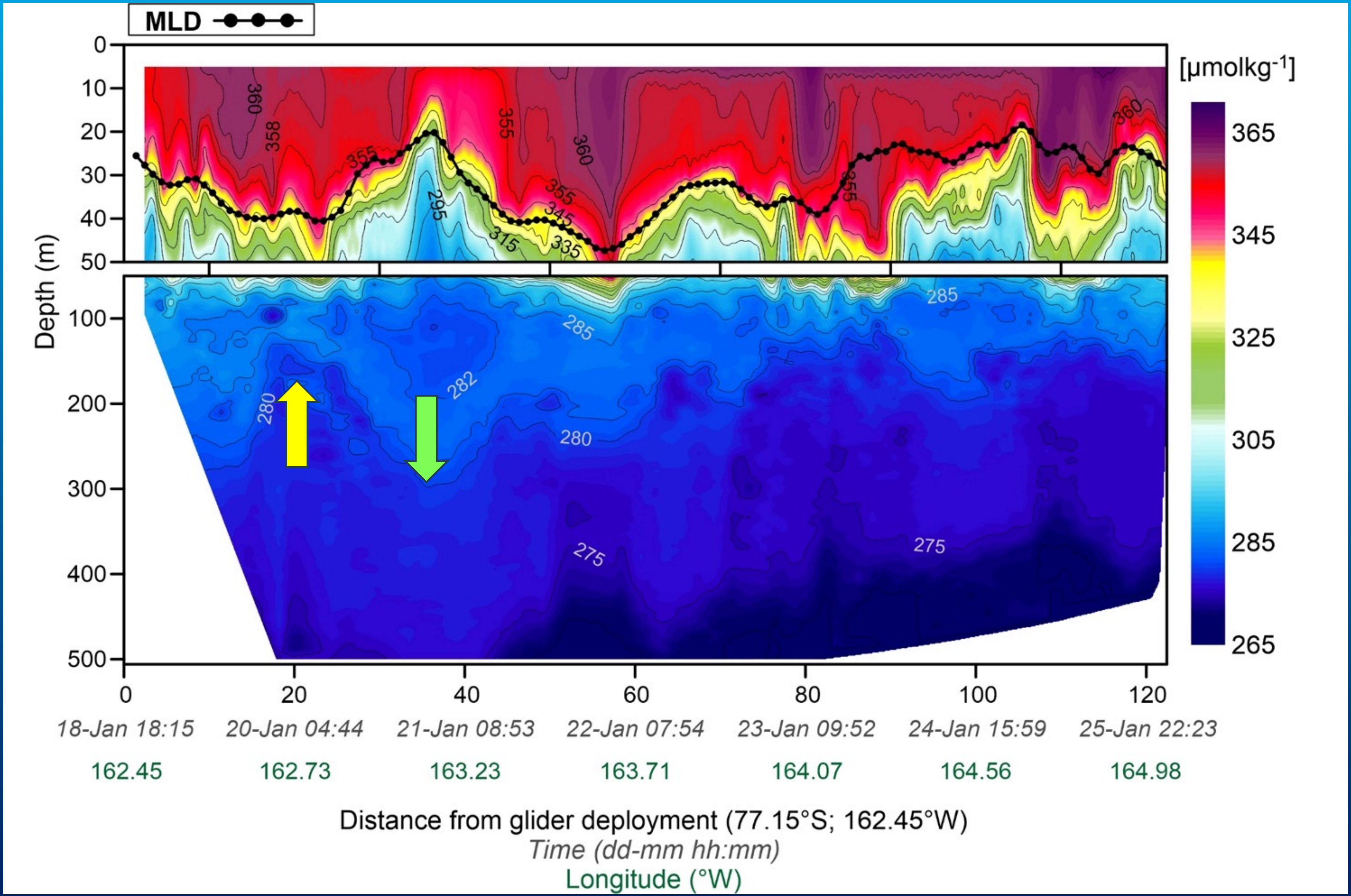
W velocities calculated from the glider



Conclusions

- Following a strong wind event, three cyclonic features develop in the upper ~ 50m and are similar to the ones observed in the South Adriatic
- The first structure is clearly a cyclonic cone with an anticyclonic mode in the layer 50-400m
- The W velocities at different depths confirm the dynamics of these cones
- The deep downwelling associated to the cones may impact the water masses dynamics

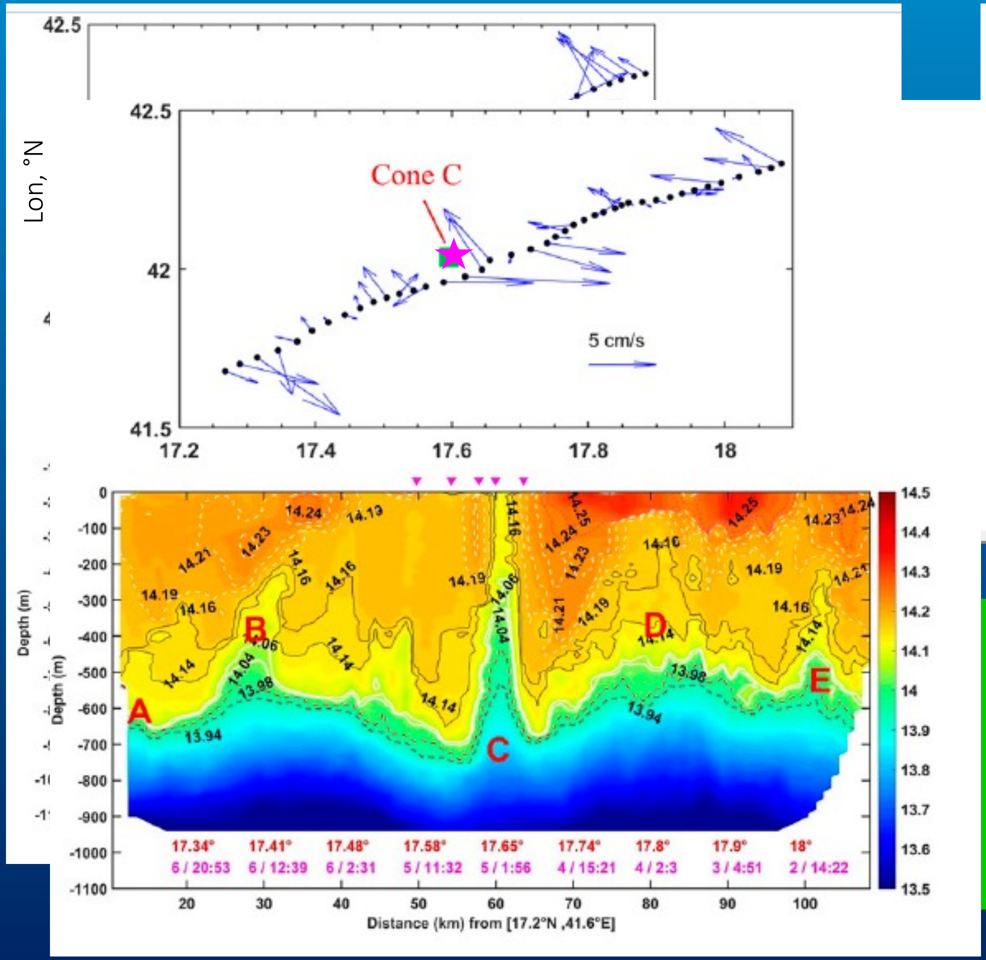
Oxygen

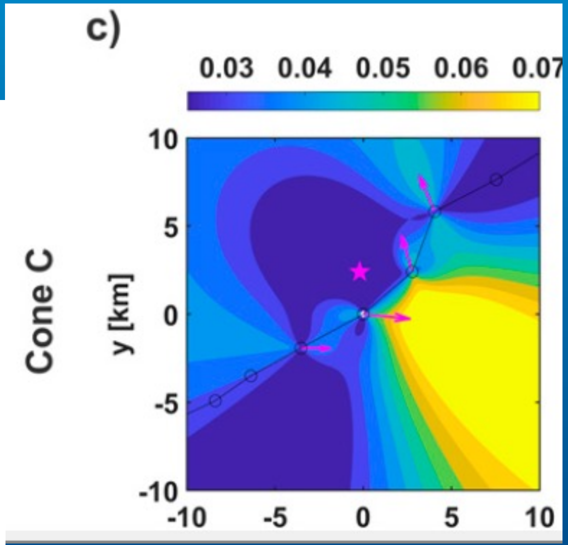


MLD
Depth (m)
[μmolkg-1]
365
345
325
305
285
265
0
10
20
30
40
50
100
200
300
400
500
0
20
40
60
80
100
120
18-Jan 18:15
20-Jan 04:44
21-Jan 08:53
22-Jan 07:54
23-Jan 09:52
24-Jan 15:59
25-Jan 22:23
162.45
162.73
163.23
163.71
164.07
164.56
164.98
Distance from glider deployment (77.15°S; 162.45°W)
Time (dd-mm hh:mm)
Longitude (°W)

Cost function center detection

$$g(x,y) = \frac{1}{n}\sum_{i=1}^{n}\left[v_i \frac{r_i(x,y)}{\|r_i(x,y)\|}\right]^2$$





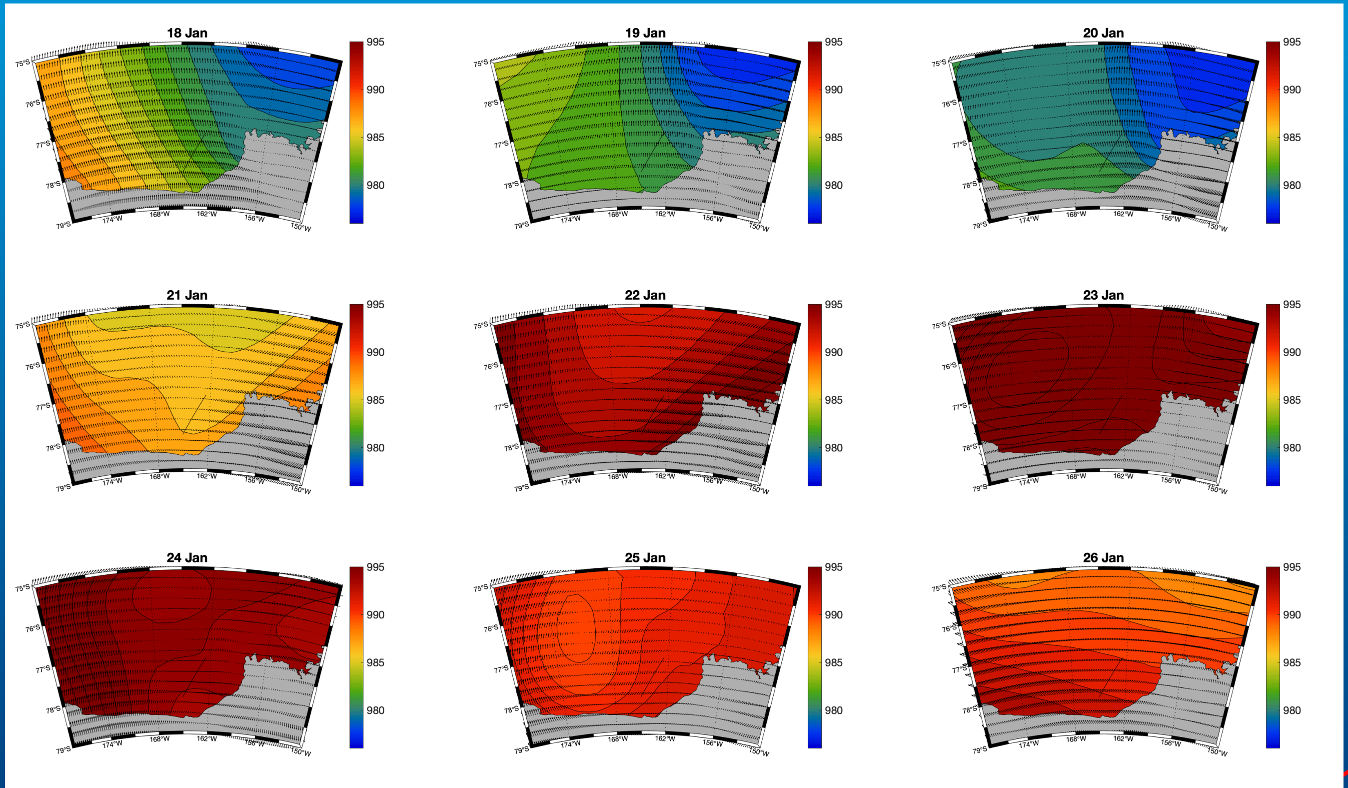
D_{cone}C (theory)~ 10 km

D_{cone}C (cost func)~ 11 km

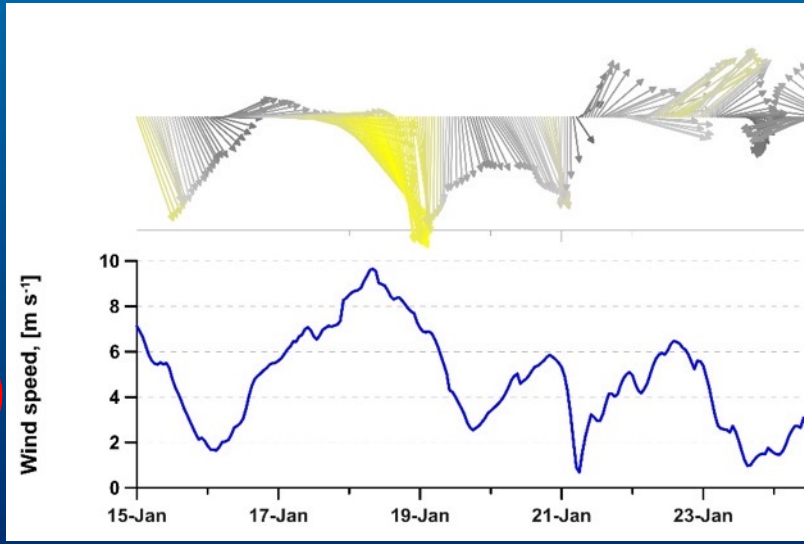
D_{cone}C (observ) ~ 10 km

Pirro et al. 2022

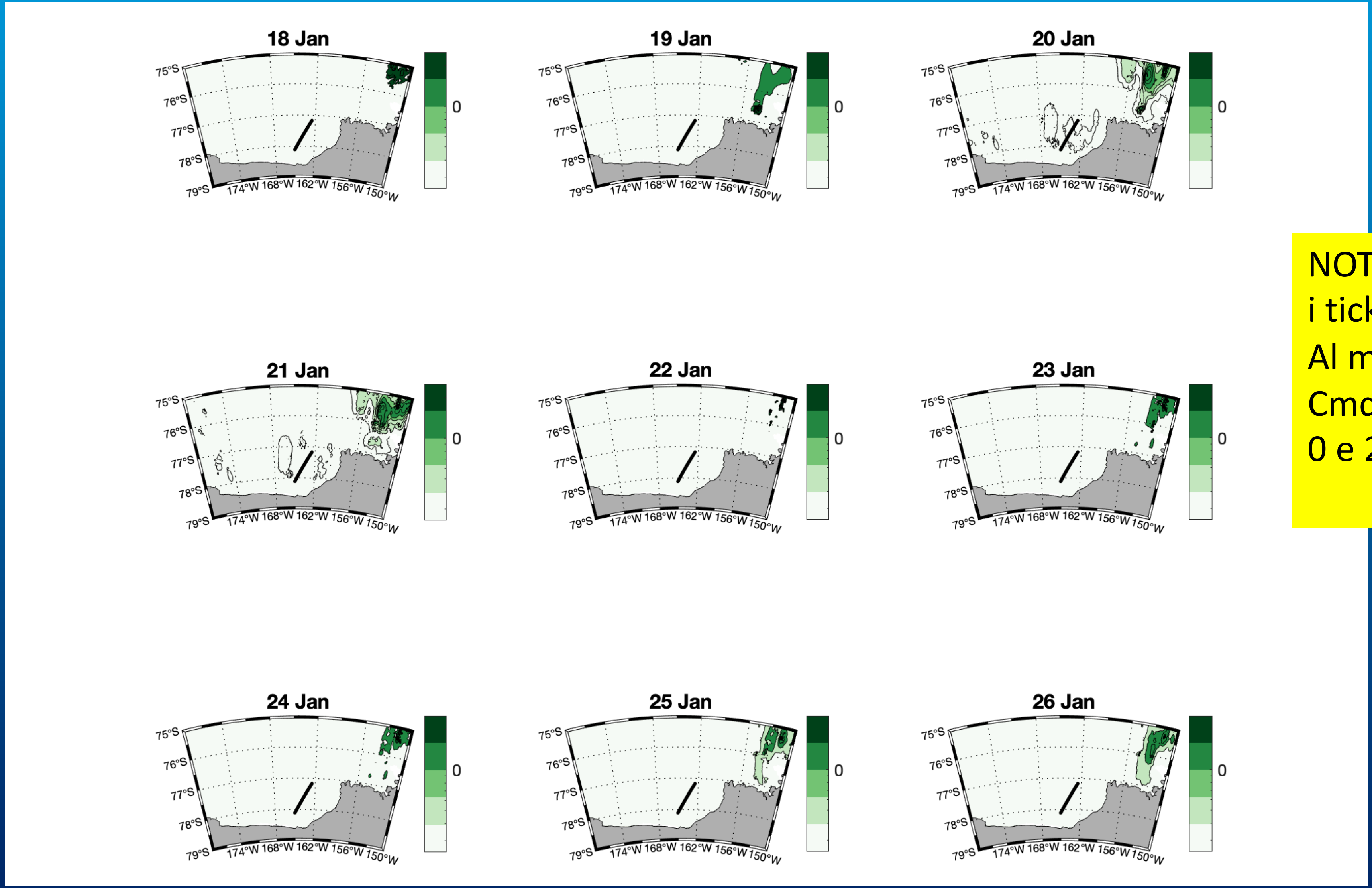
Mean Sea Level pressure



77° - 78.25° S
162° - 165.5° W

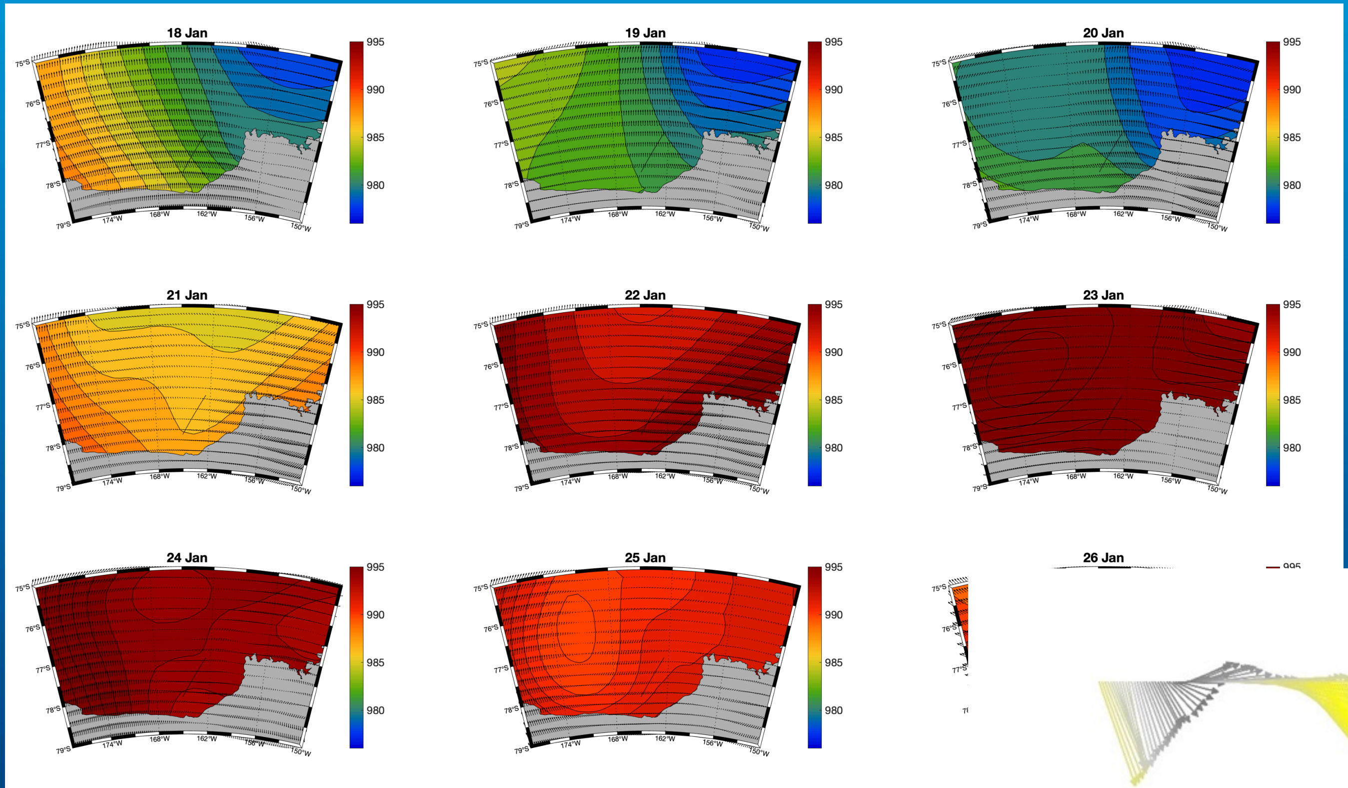


Chlorophill A



NOTE: sto impazzendo cor
i ticks che non funzionano
Al max li metto a mano.
Cmq questi sono valori fra
0 e 2.5 CHL (mg/m^3)

Mean Sea Level pressure



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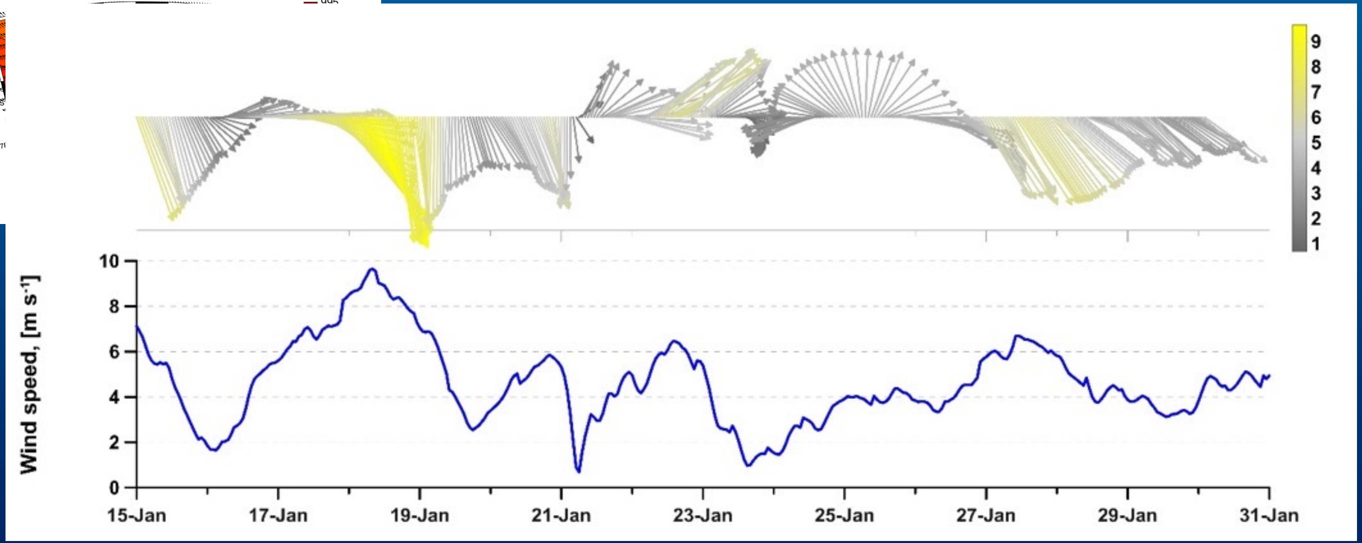
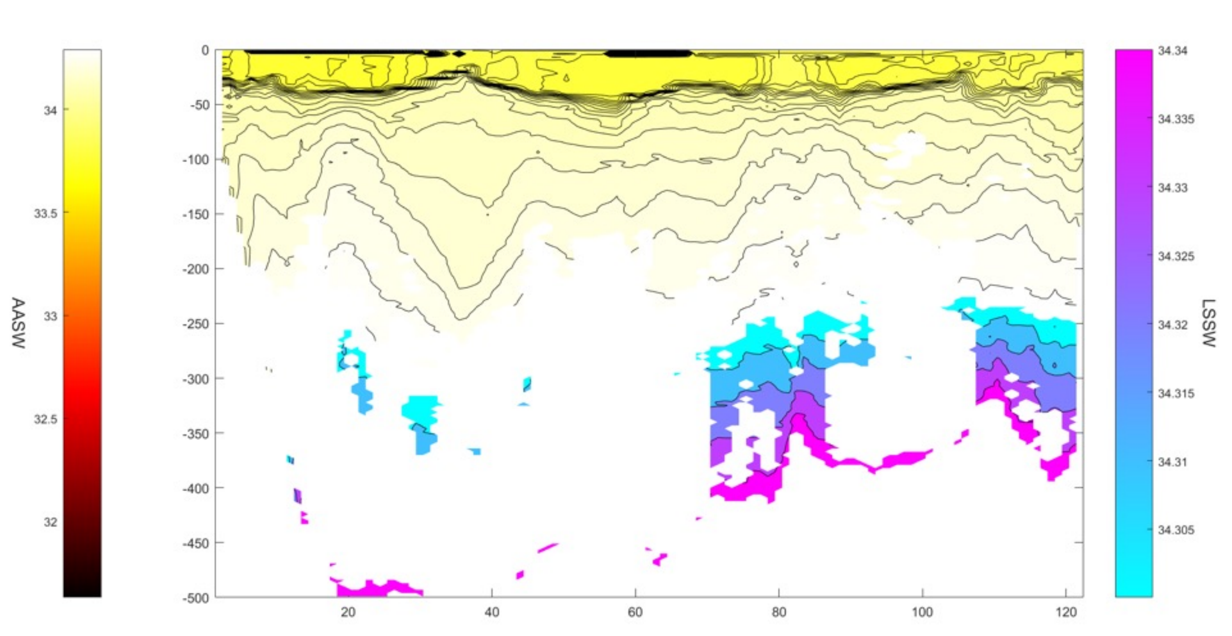
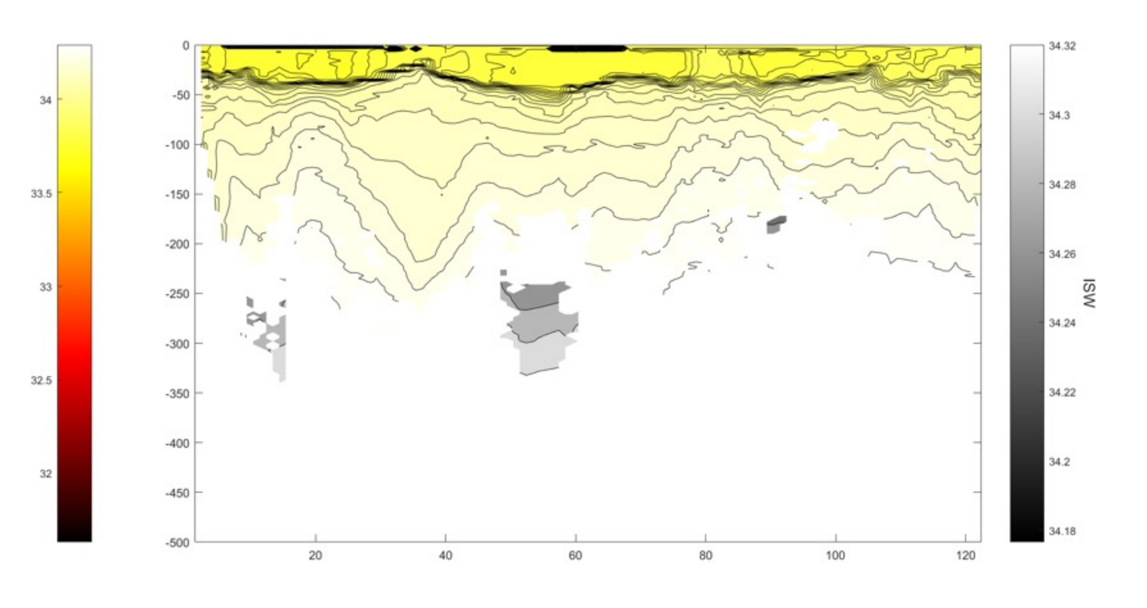
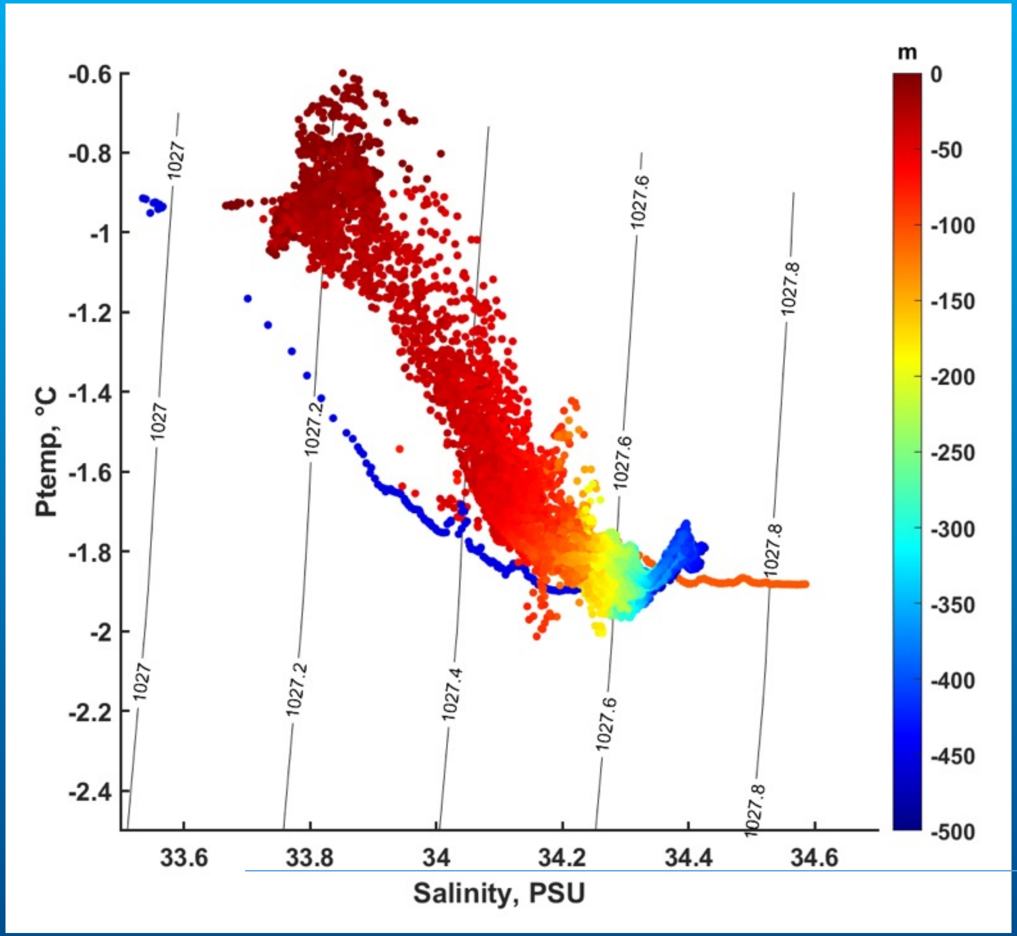


Water masses

Bisogna cambiare il minimo della AASW

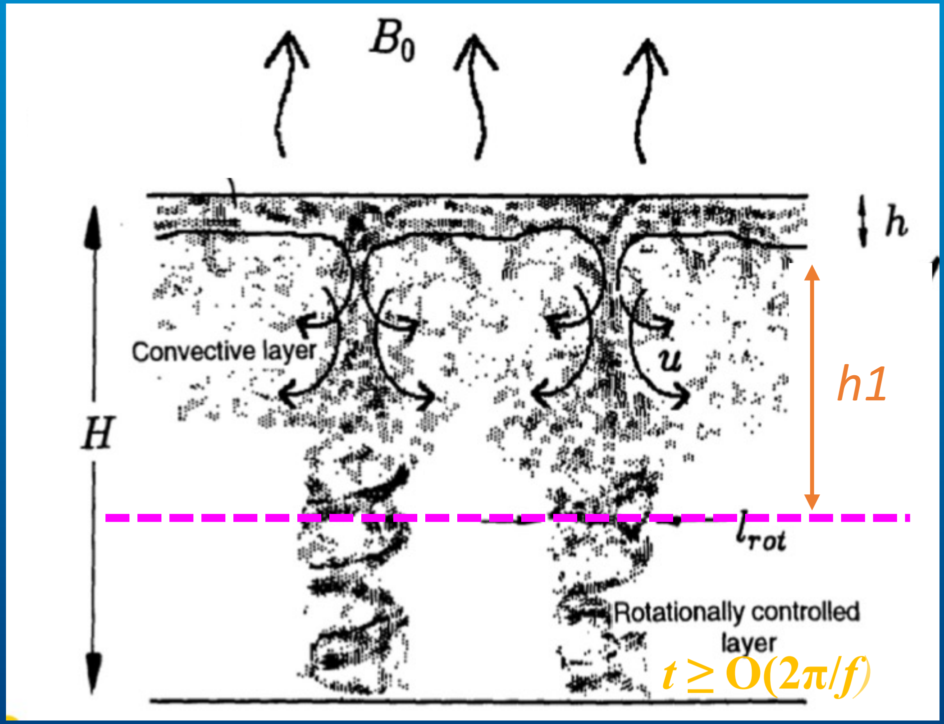





m
0
-50
-100
-150
-200
-250
-300
-350
-400
-450
-500
-0.6
-0.8
-1
-1.2
-1.4
-1.6
-1.8
-2
-2.2
-2.4
Ptemp, °C
33.6
33.8
34
34.2
34.4
34.6
Salinity, PSU
1027
1027.2
1027.4
1027.6
1027.8

Schematic representation of the mixing phase

Convective process



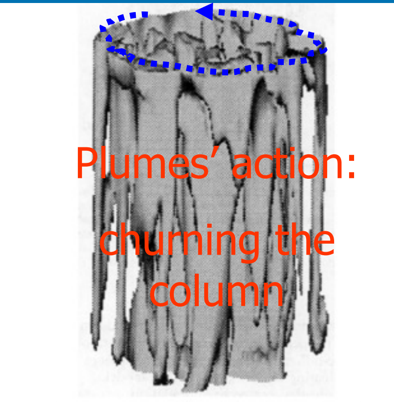
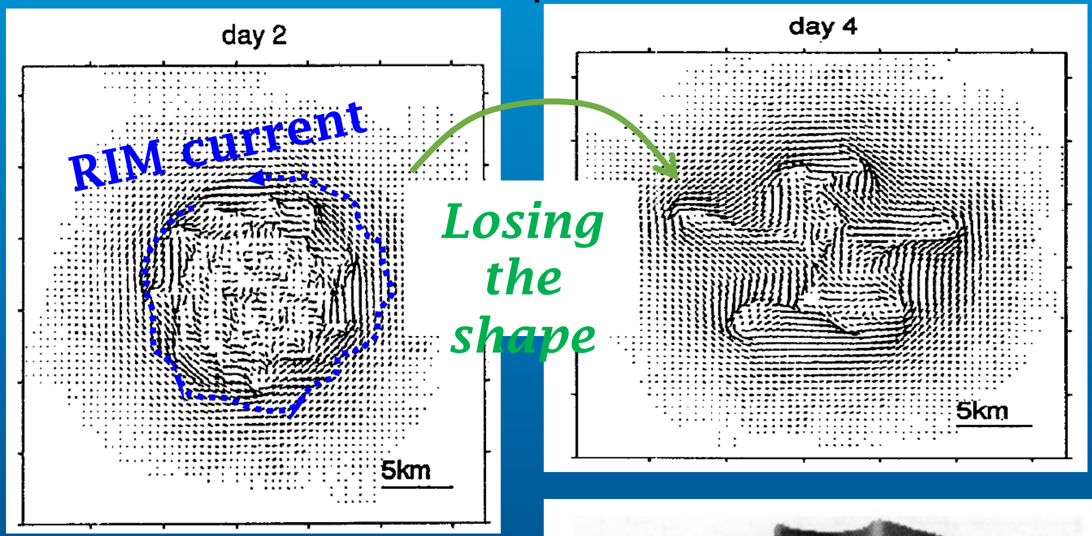


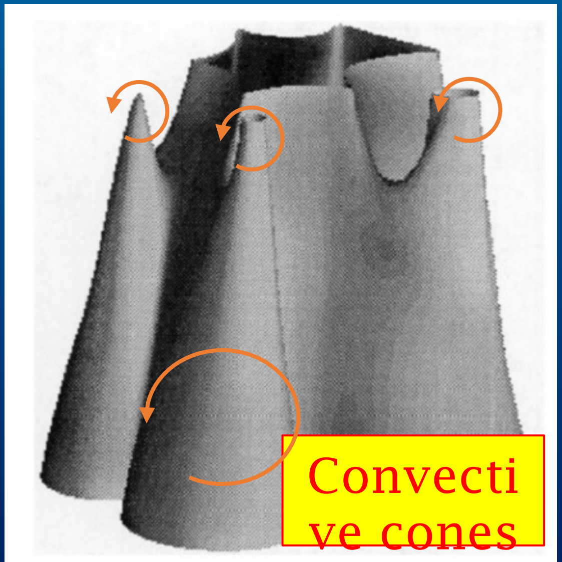
FIG. 5. An isothermal surface from the reference experiment at the end of day 2 capturing the 3D form of the population of sinking plumes.

$$h1 = L_{ro} = \sqrt{\left(\frac{2B_0\,t}{N^2}\right)}$$

Baroclinic process

Surface top view simulation





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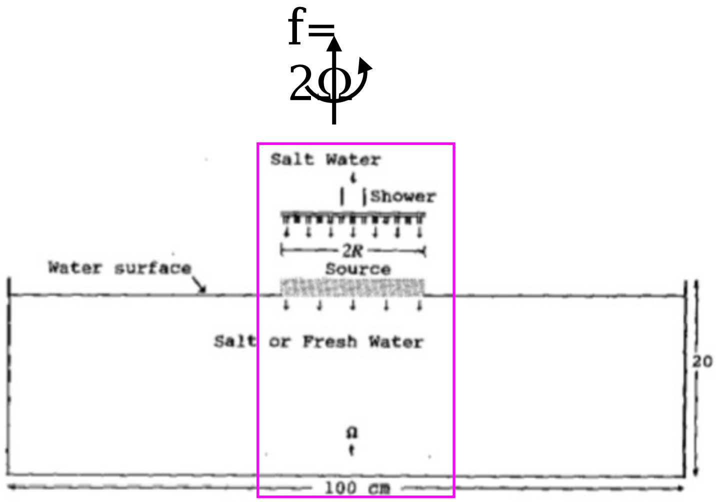
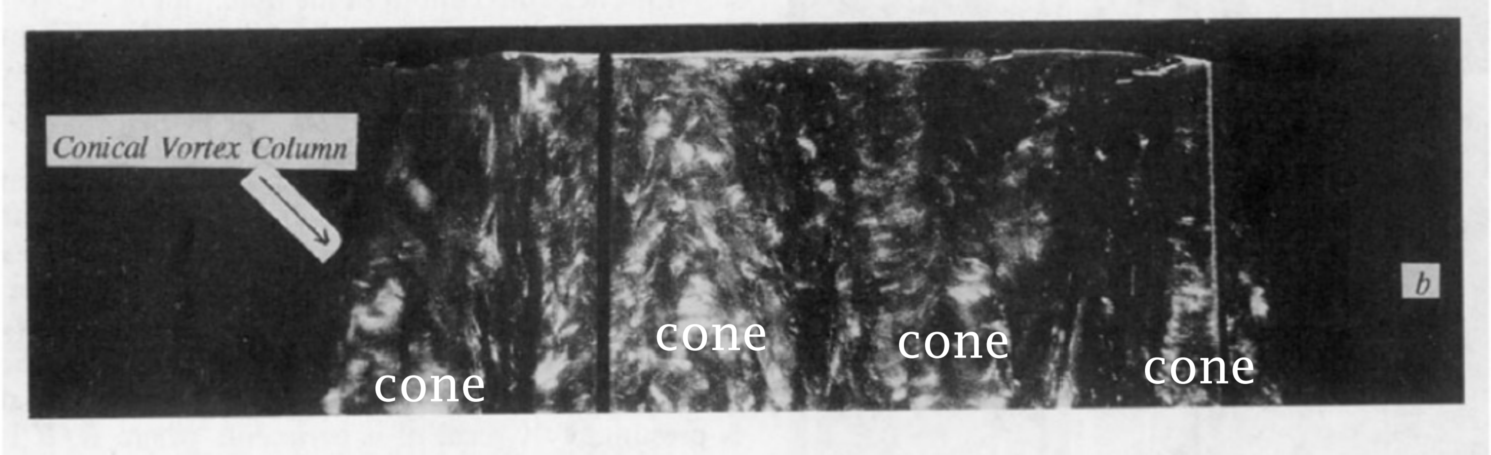
JM 1993



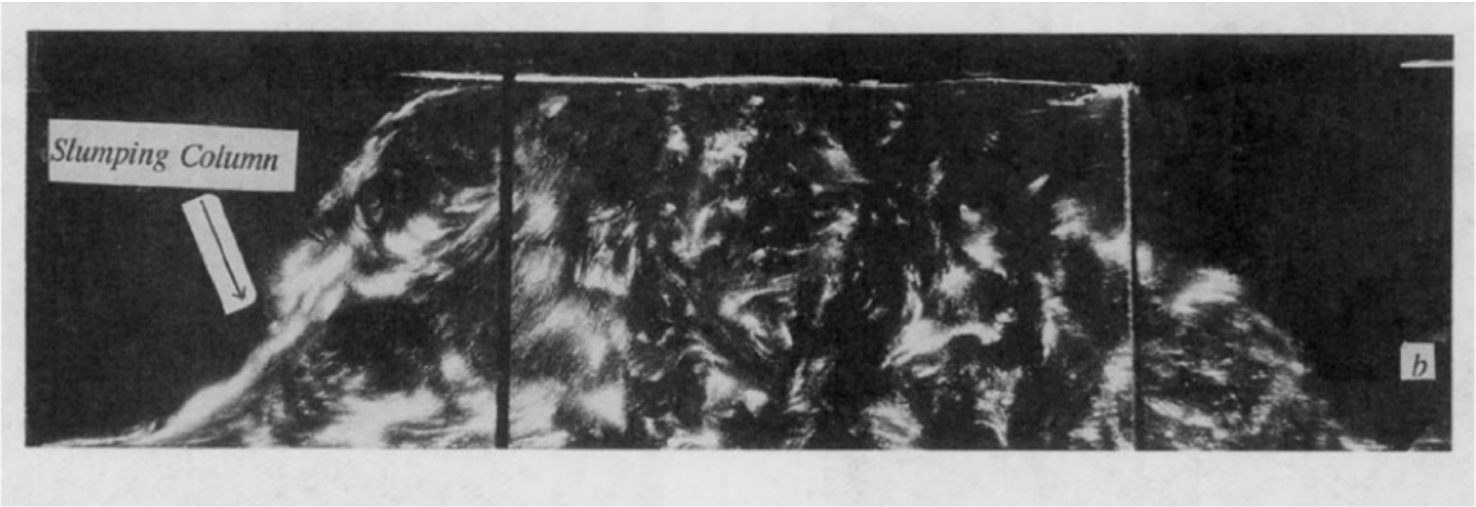
Formation of multiple CONES

h1 < H



Formation of ONE big truncated cone

h1 ≥ H



Maxworthy et al.,1994