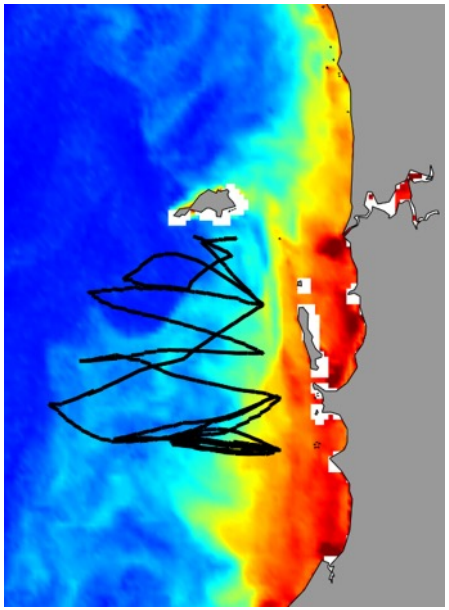
THE UNIVERSITY OF WESTERN AUSTRALIA | Oceans Institute



Mixing and rolling with ocean gliders

Dennis Stanley, Charitha Pattiaratchi, Ivica Janekovic /
Oceans Graduate School and UWA Oceans Institute

Coastal Oceanography

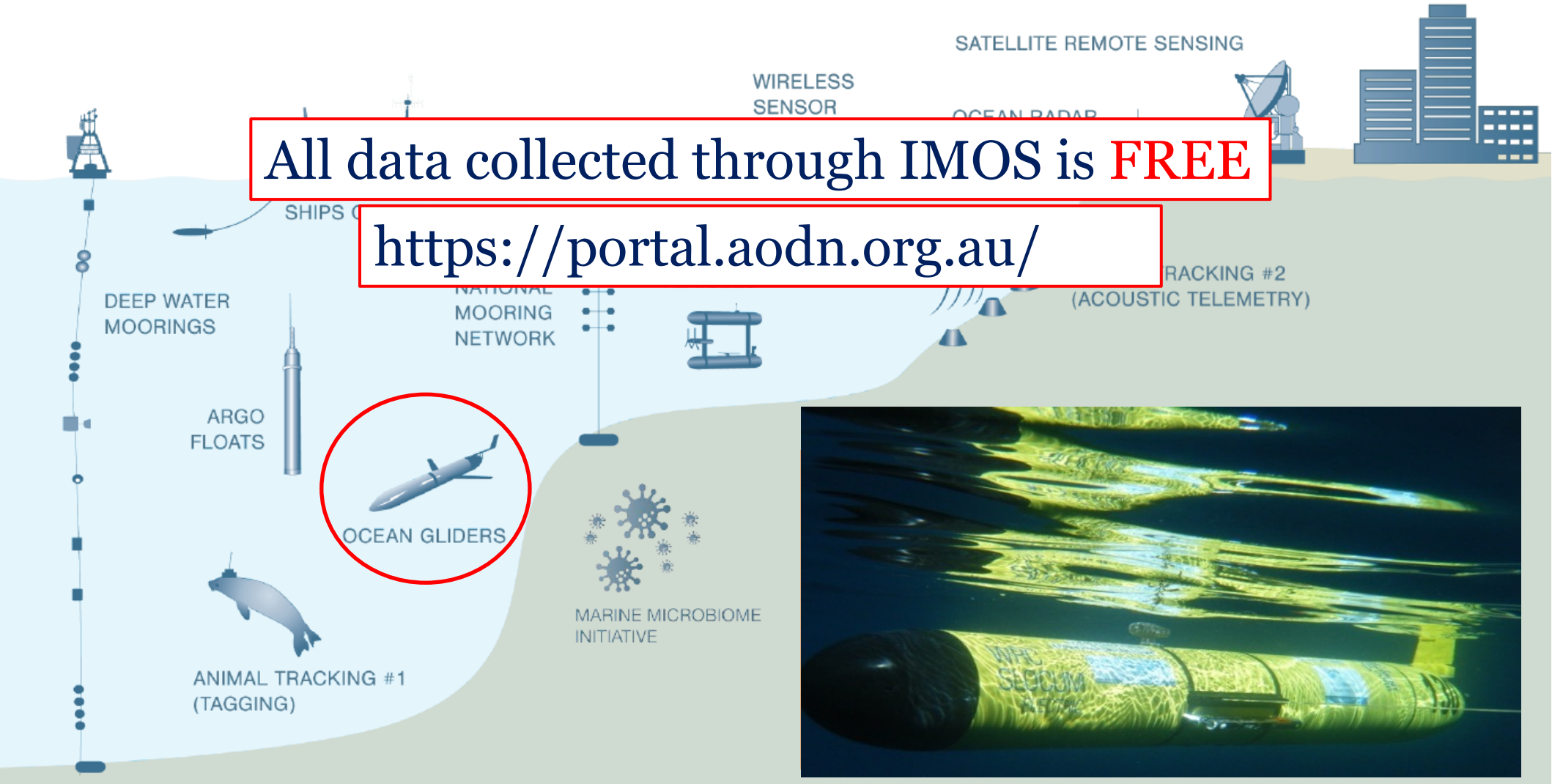
13 / June / 2024

IUGC2024

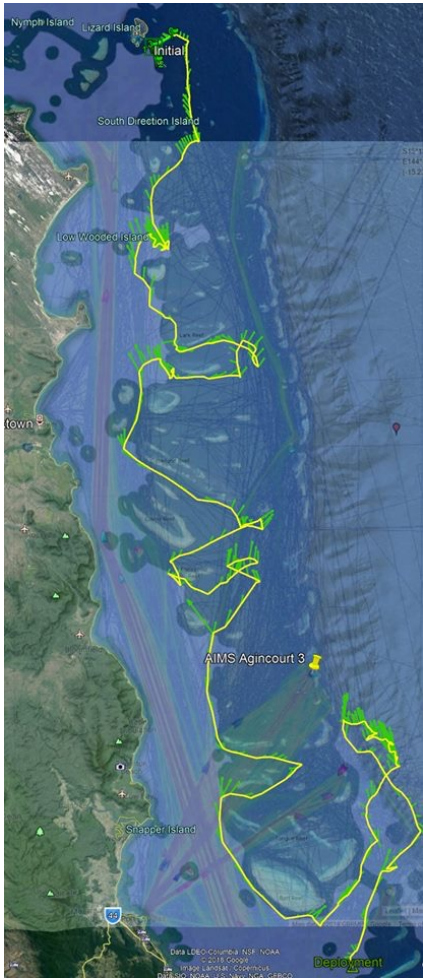
NCRIS National Research Infrastructure for Australia
An Australian Government Initiative

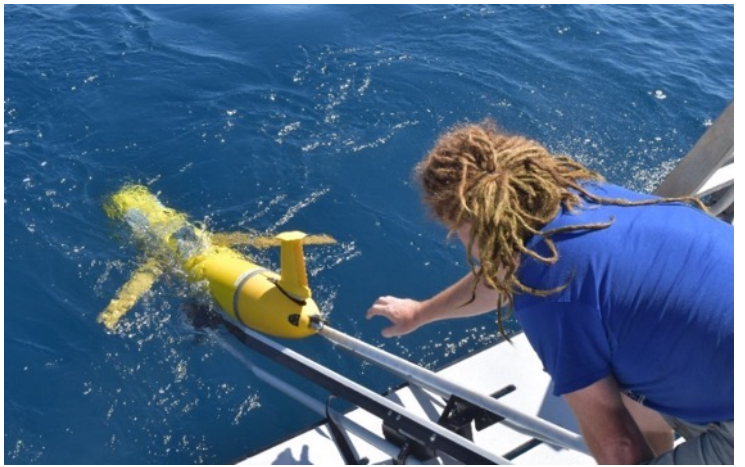
IMOS Integrated Marine Observing System

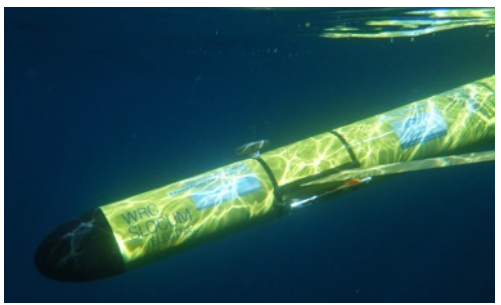
The Integrated Marine Observing System ++ AUSTRALIAN OCEAN DATA NETWORK



Glider deployments







THE UNIVERSITY OF WESTERN AUSTRALIA

2009-2022

8971 glider days (> 24.5 years)

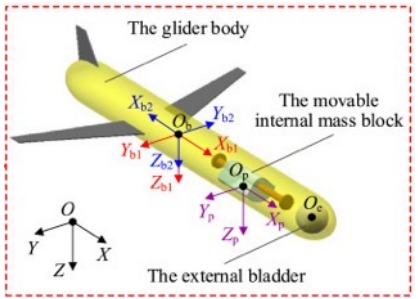
193695 km

Glider data

Ocean Glider data

Engineering data
5 s

Heading
Roll
Pitch
Yaw
'Diagnostics'



Scientific data
2Hz

Temperature
Salinity
Pressure
Fluorescence
DO
Backscatter
CDOM
Irradiance

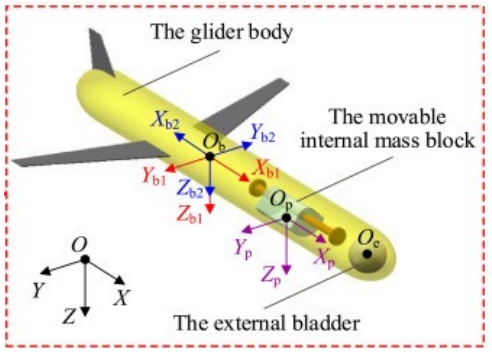
Can we use flight data to resolve "bumpy" flying conditions?

If so, do these observations match up with observed mixing conditions & drivers (stratification, winds and currents)?

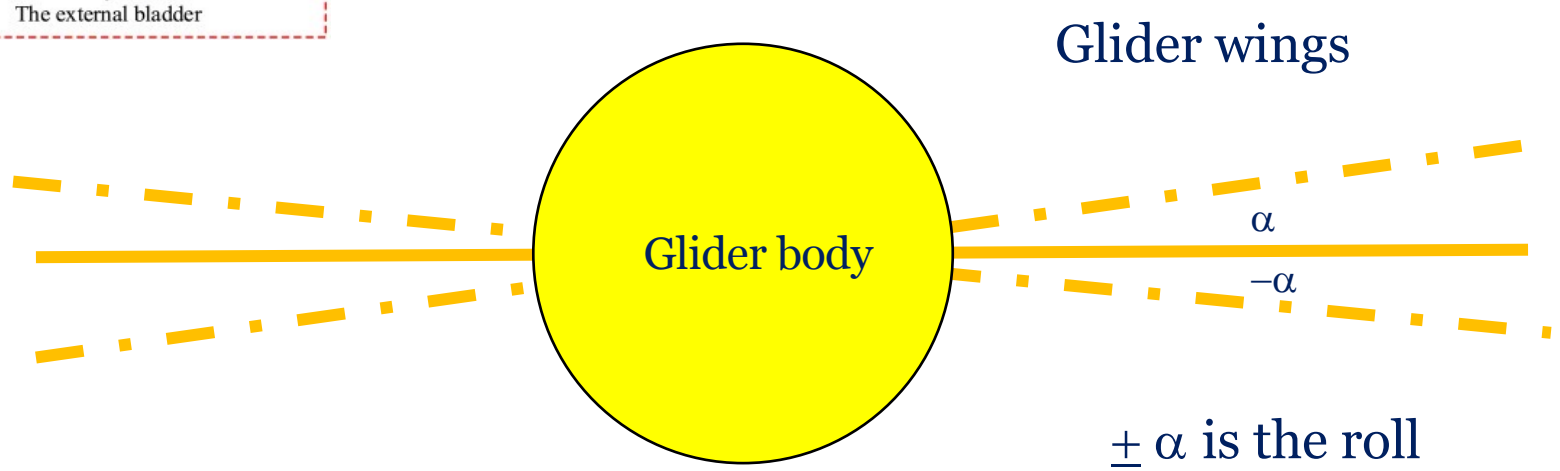
Potential candidates

- Depth rate change
- Heading
- Pitch
- Roll

Glider motion



roll (α) – motion in the Y_{b1}-Y_{b2} plane
pitch (θ) – motion in the X_{b1}-X_{b2} plane



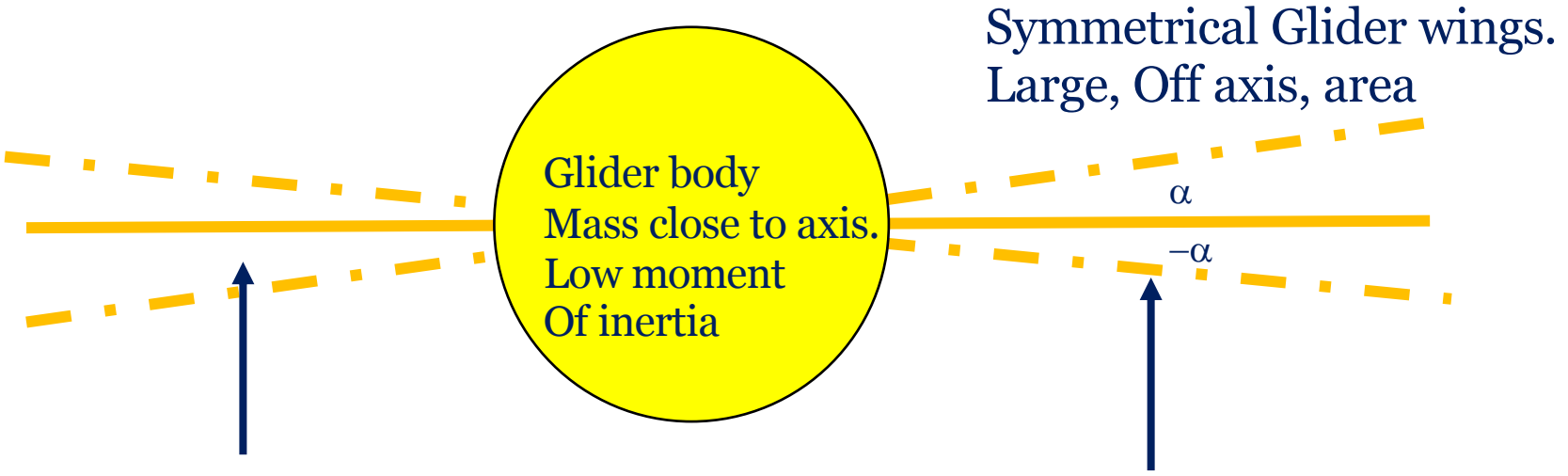
$\pm\,\alpha$ is the roll

$$roll\_rate = \left|\frac{\partial \alpha}{\partial t}\right|$$

We use the roll_rate as a proxy for turbulence/mixing

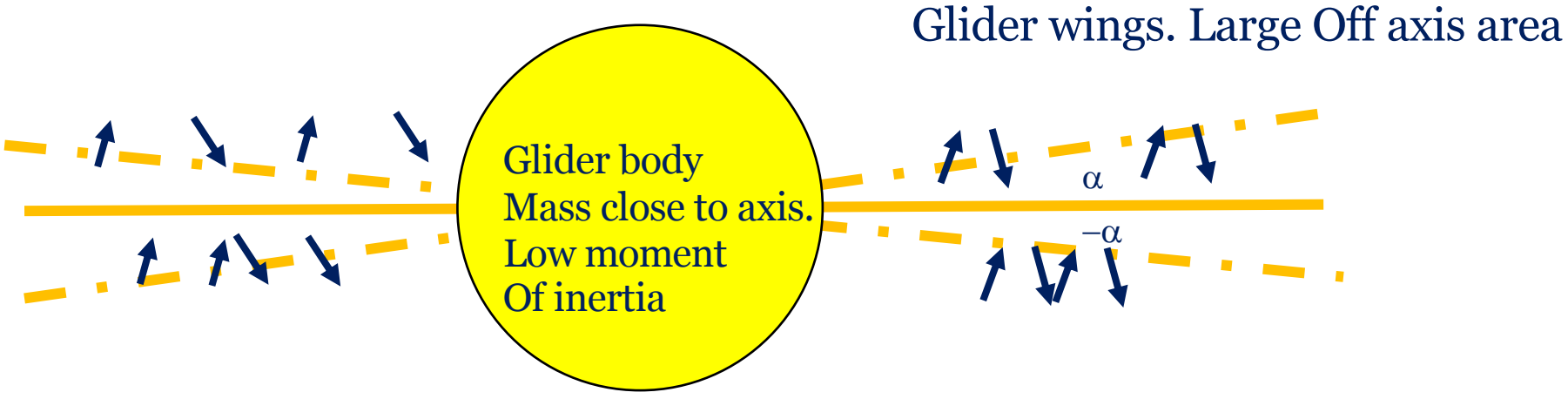
Glider Roll

Large scale processes act equally on both wings so do not produce a roll moment



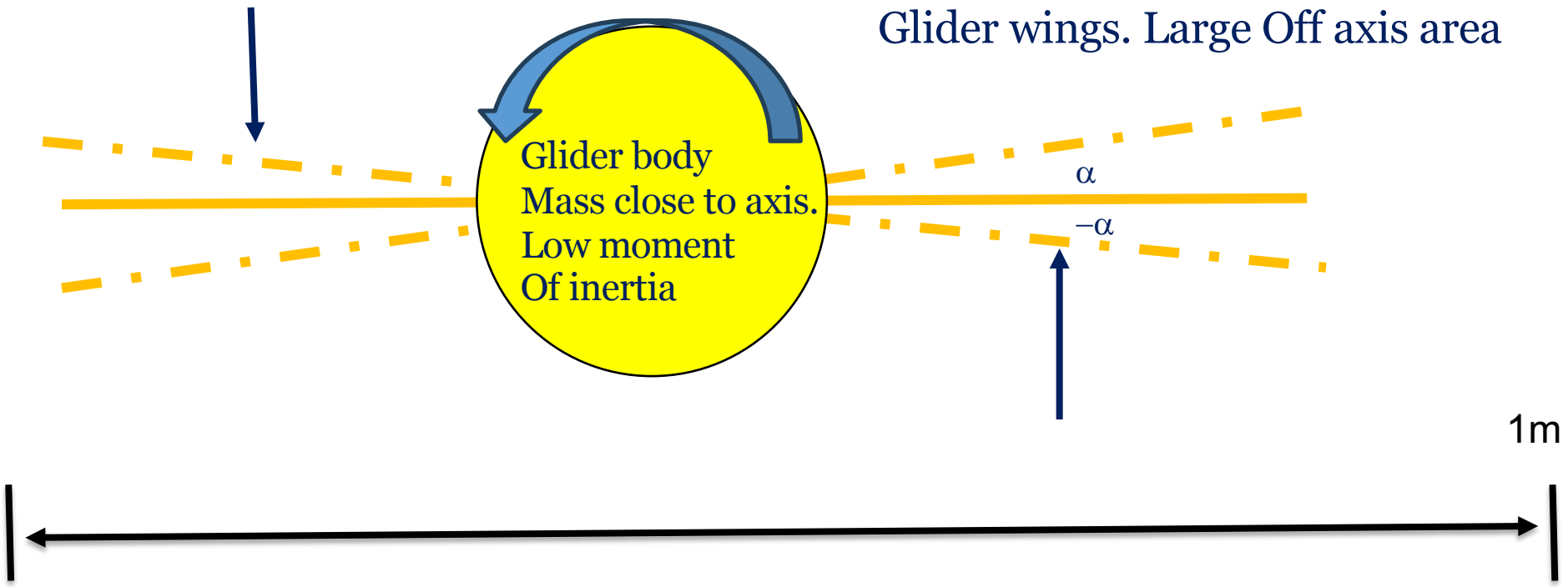
Glider Roll

Very small scale processes distributed across the wing surface balance out so produce no net roll moment

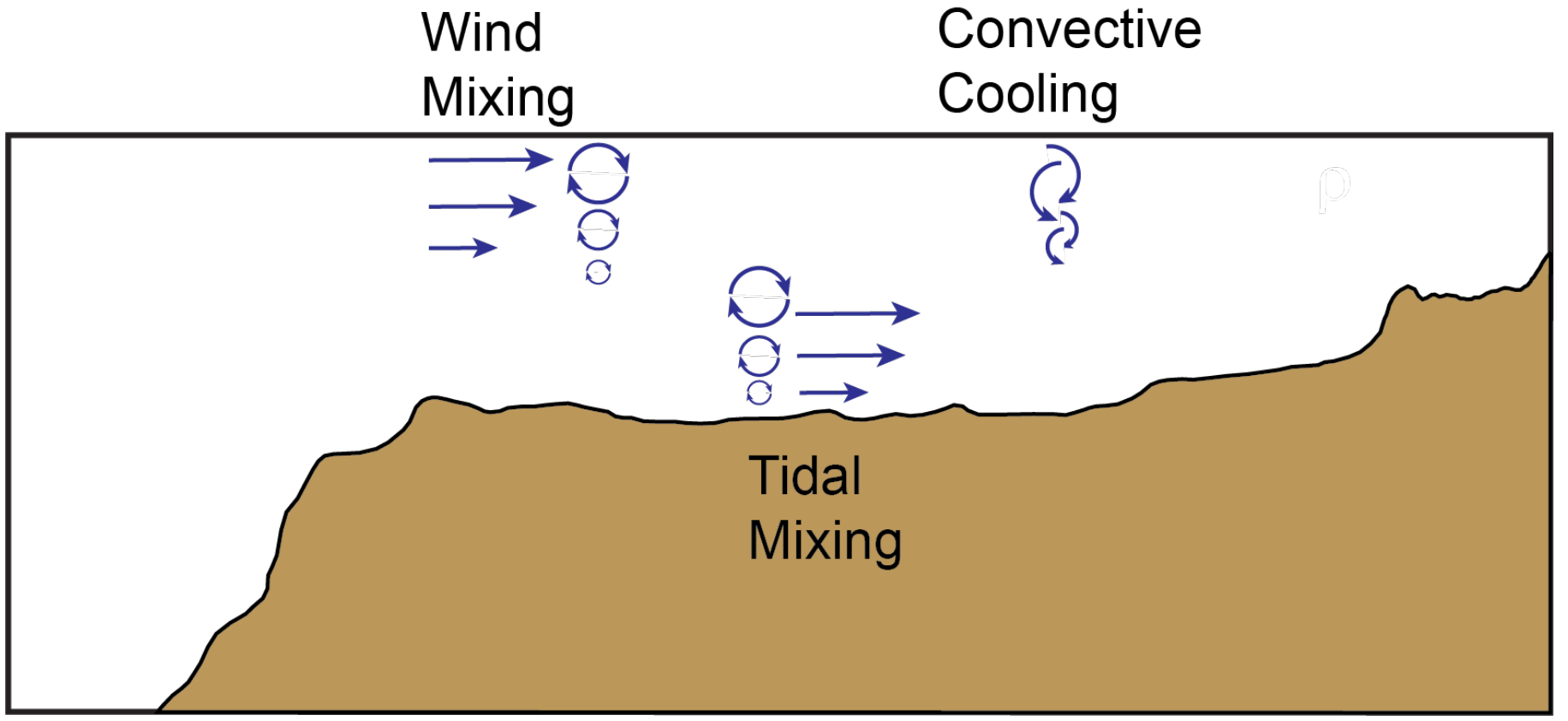


Glider Roll

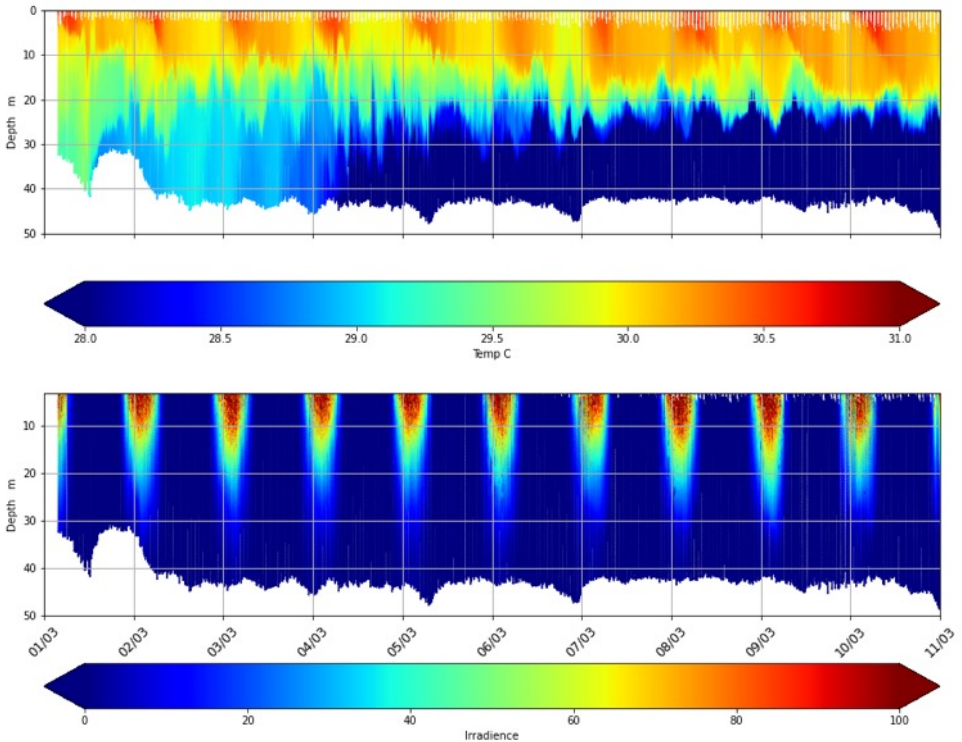
Processes of the scale of the glider wingspan act differently on each wing to produce a net rolling moment & angular movement



Vertical mixing

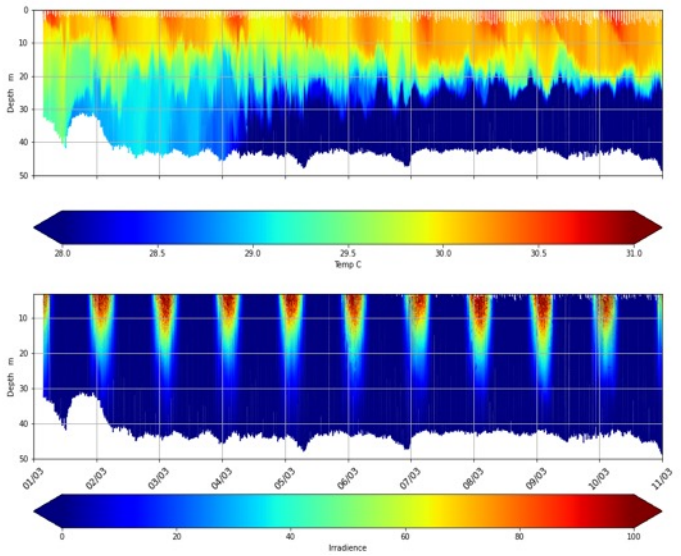


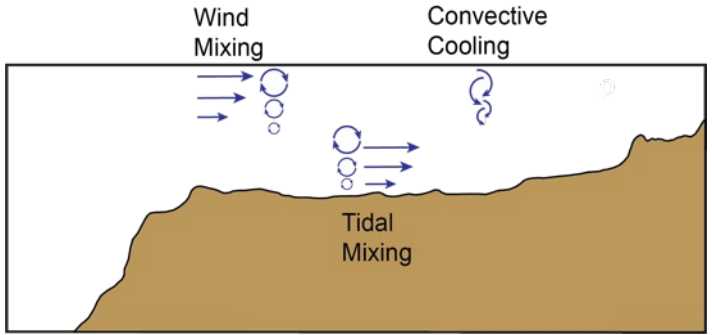
Coral Bleaching on the Great Barrier Reef



- My Science focus is How can glider measurements inform our understanding of the physical conditions that contribute to coral stress during bleaching conditions
- Glider data clearly gives us vertical structure of temperature & irradiance

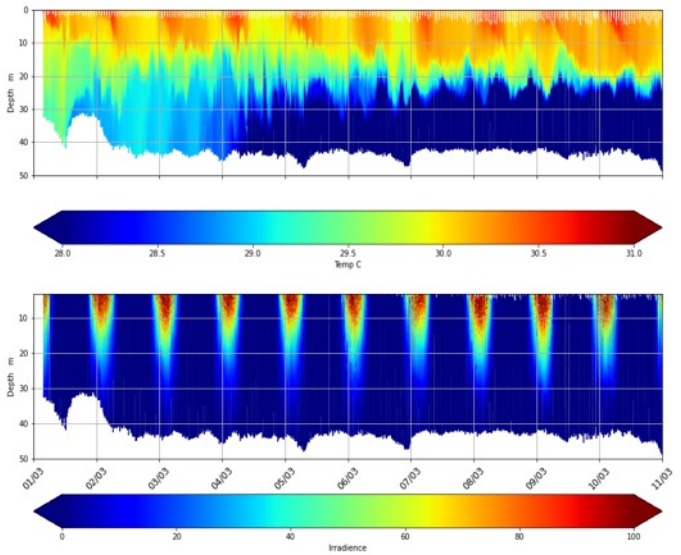
Coral Bleaching on the Great Barrier Reef

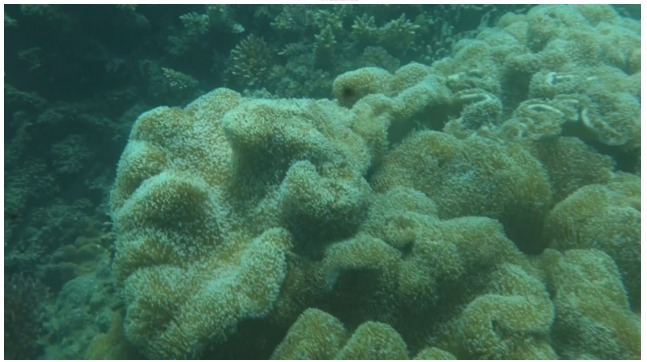




- Glider data clearly gives us vertical structure of temperature & irradiance
- **Flow** is an important parameter that contributes to coral stress. Can we resolve flow from glider data ?
- Most obviously depth average current give us a measure of flow
- But what about smaller scale mixing processes. Can we see evidence of them?

Coral Bleaching on the Great Barrier Reef





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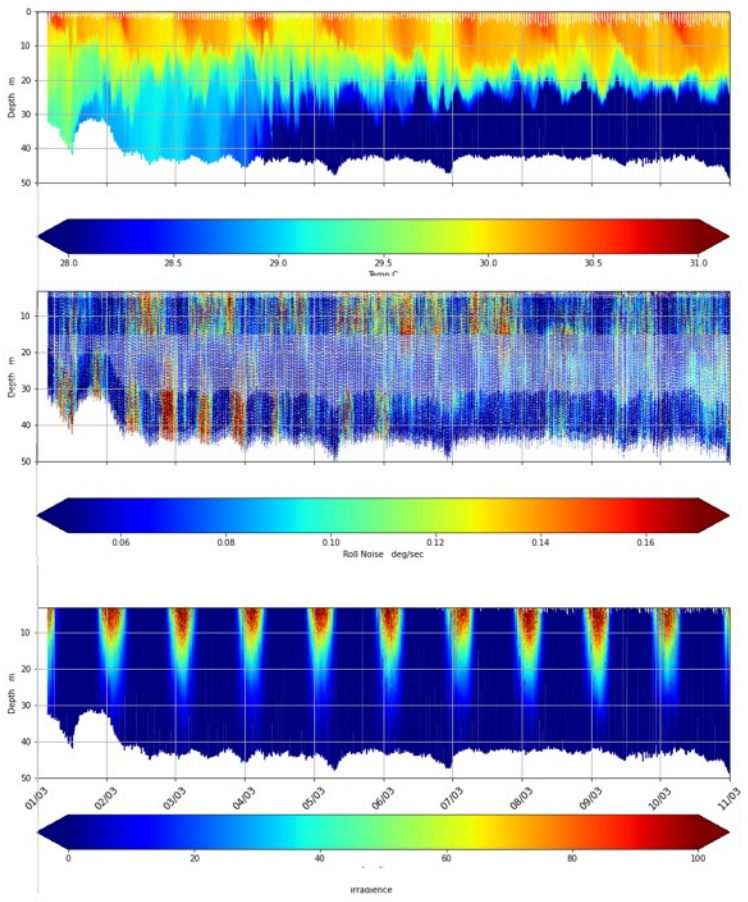
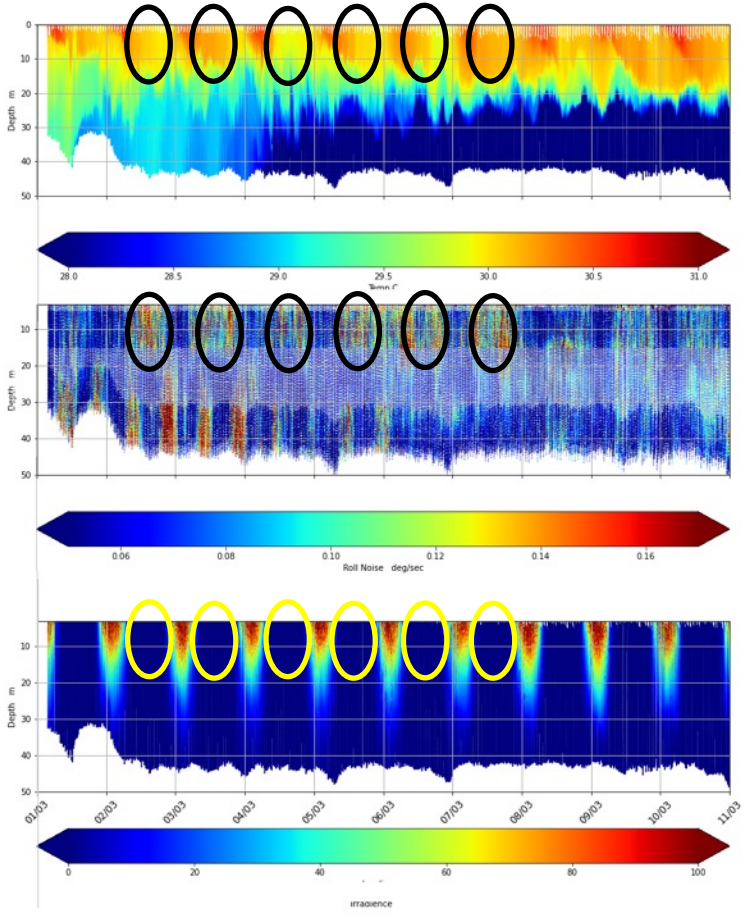


- Low upper ocean roll rate (daily heating and cooling
- The glider experienced higher upper ocean roll-rate at night time
- And near the seabed with tidal mixing
- Surface and benthic Roll Rate petered out in the last 3 days (neap tides, calm winds)
- …Coincident with a period of very strong stratification

Coral Bleaching on the Great Barrier Reef



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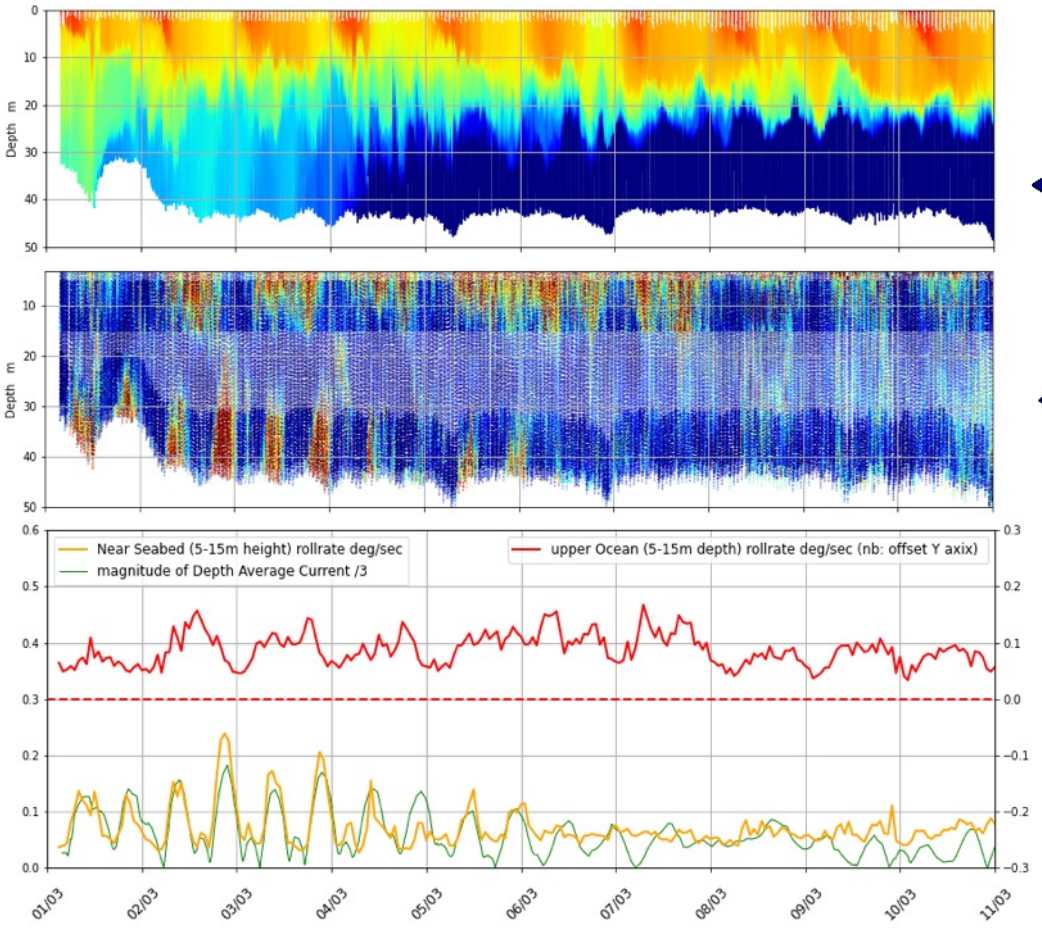
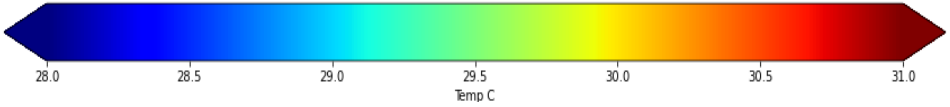
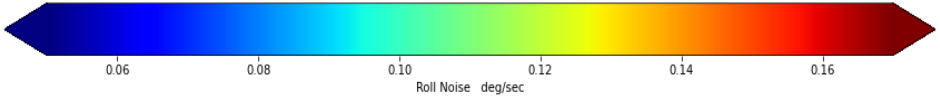


Temperature



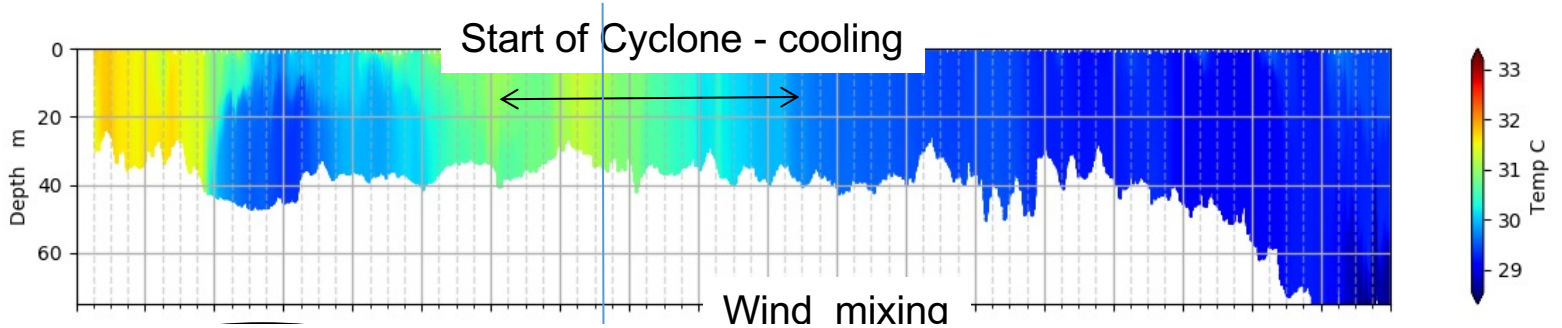
Roll Rate



Near-surface

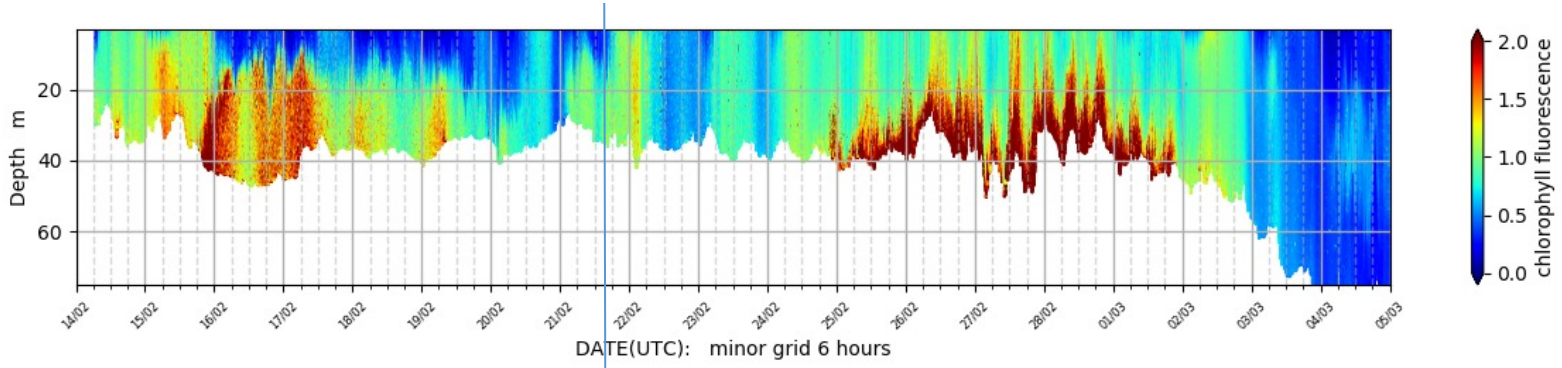
Near-bed

TC Rusty – ocean glider data



Tidal mixing – from bottom upwards

Wind mixing - from surface downwards



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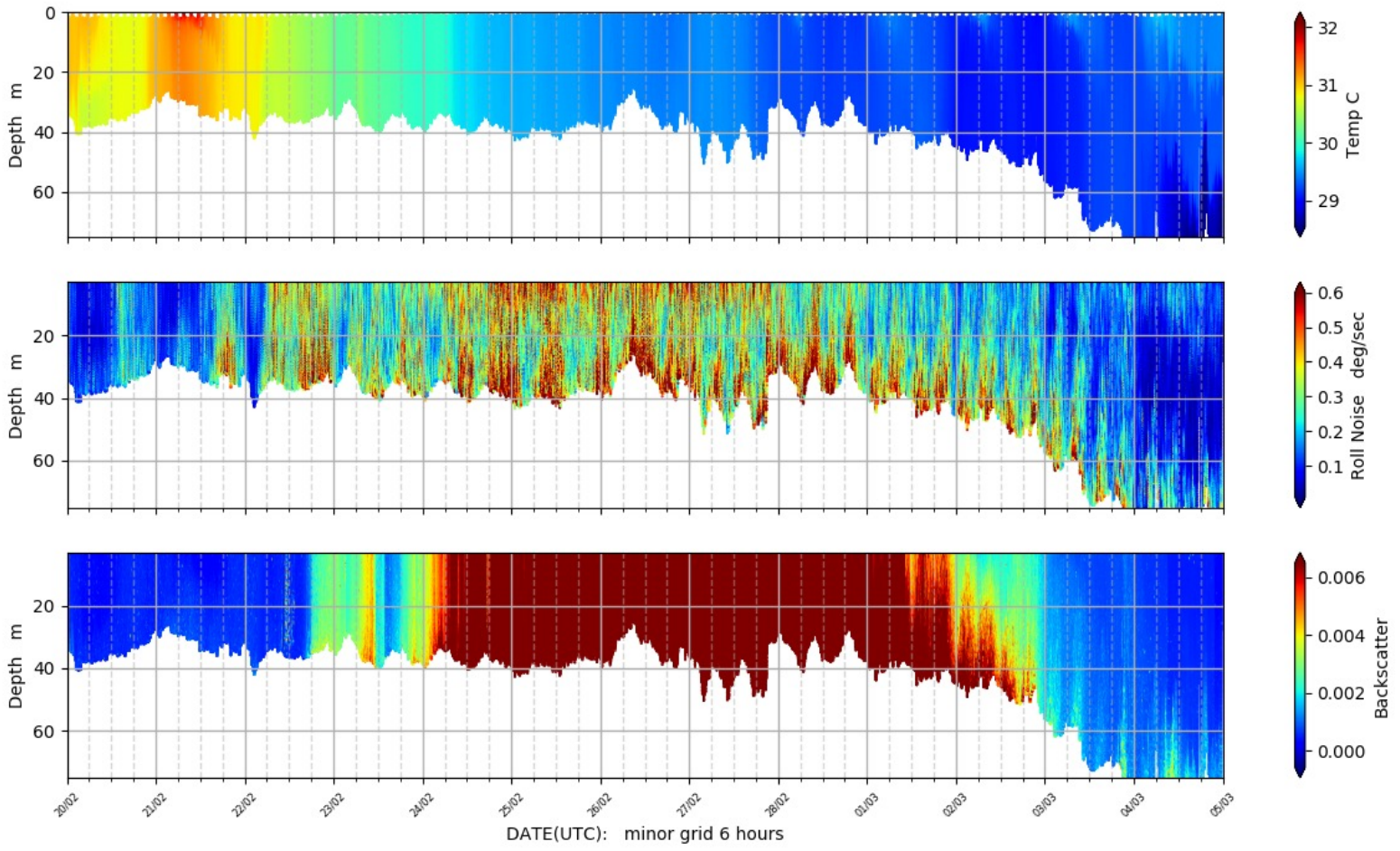

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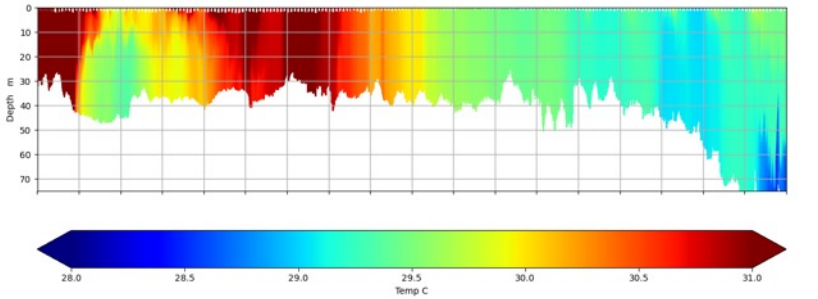
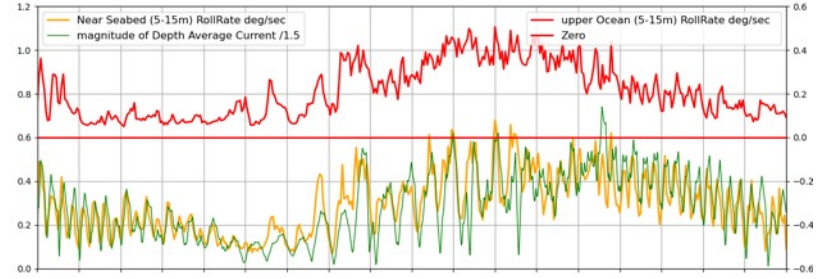
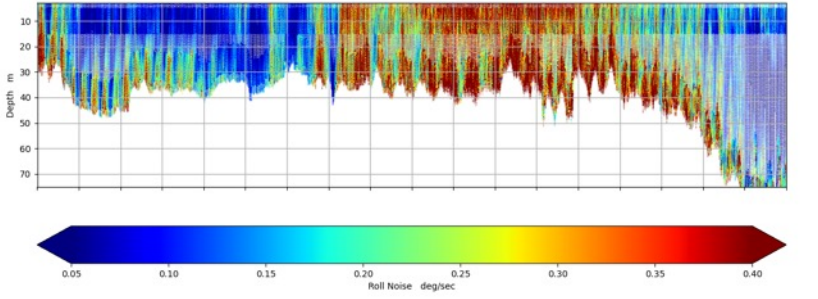
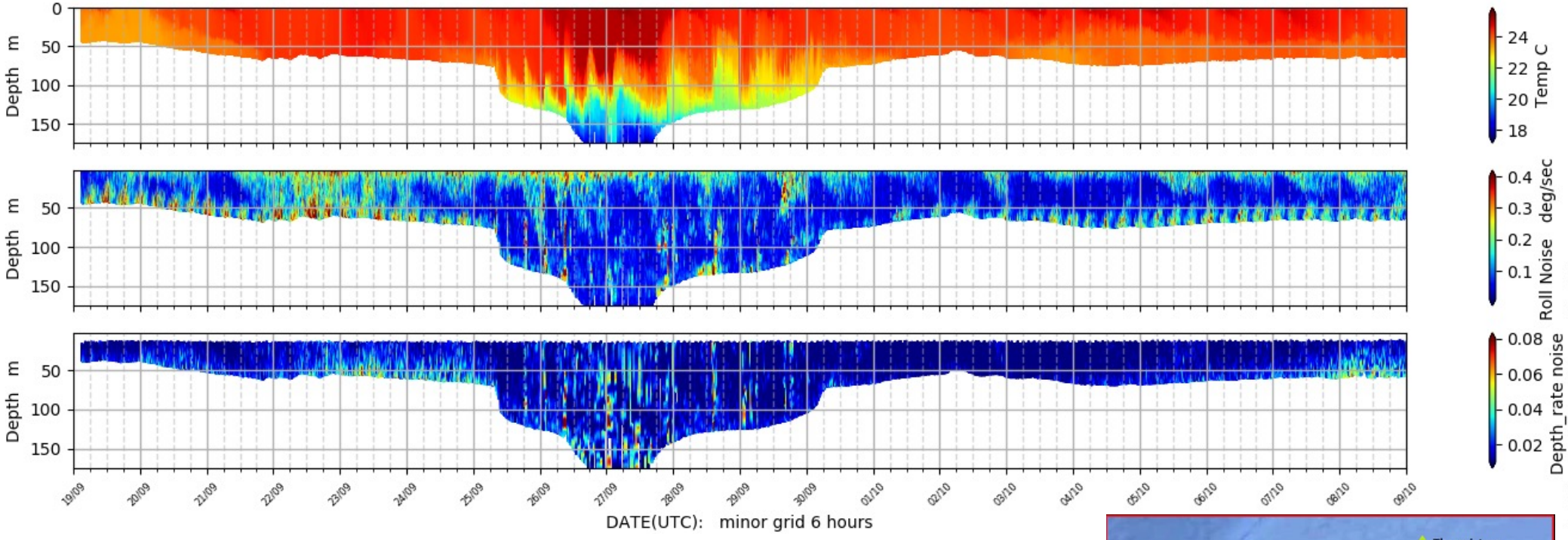
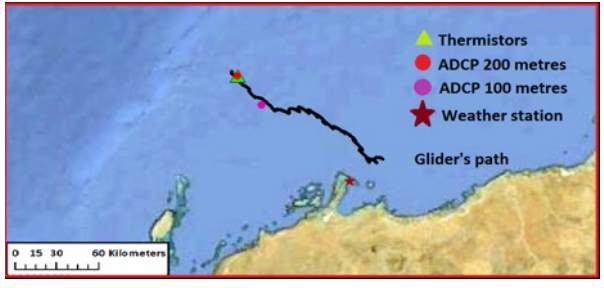




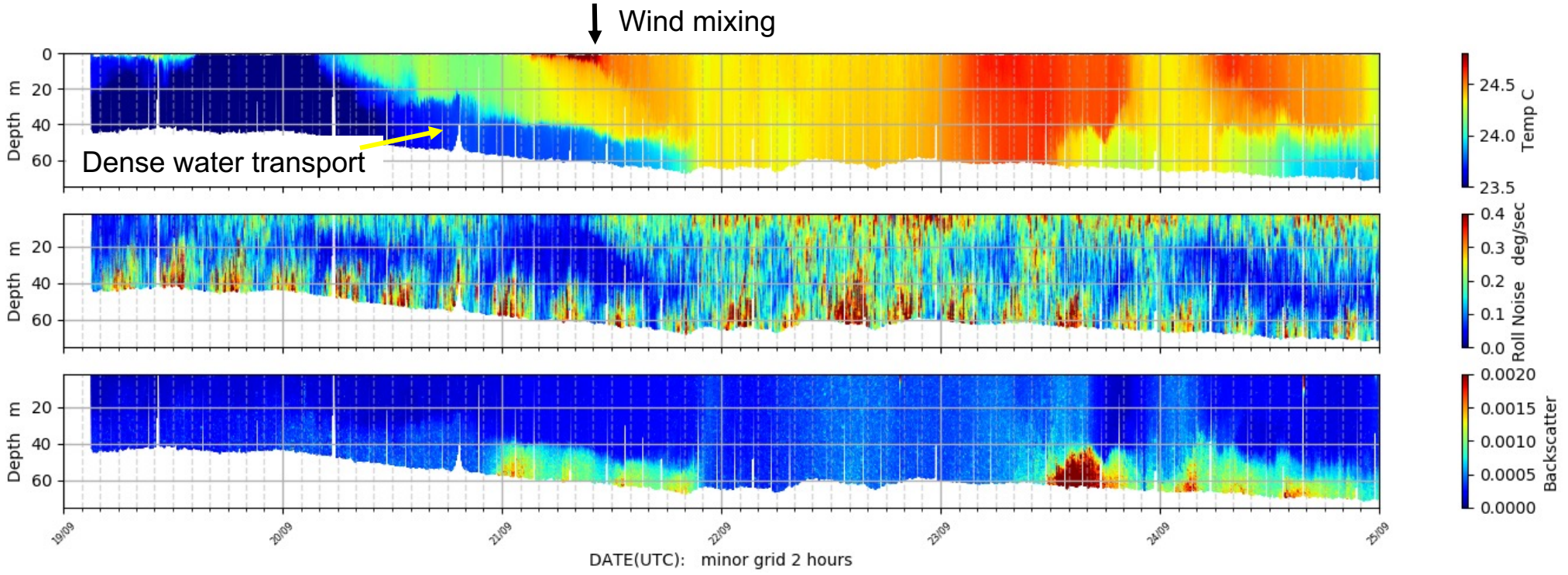


Pilbara

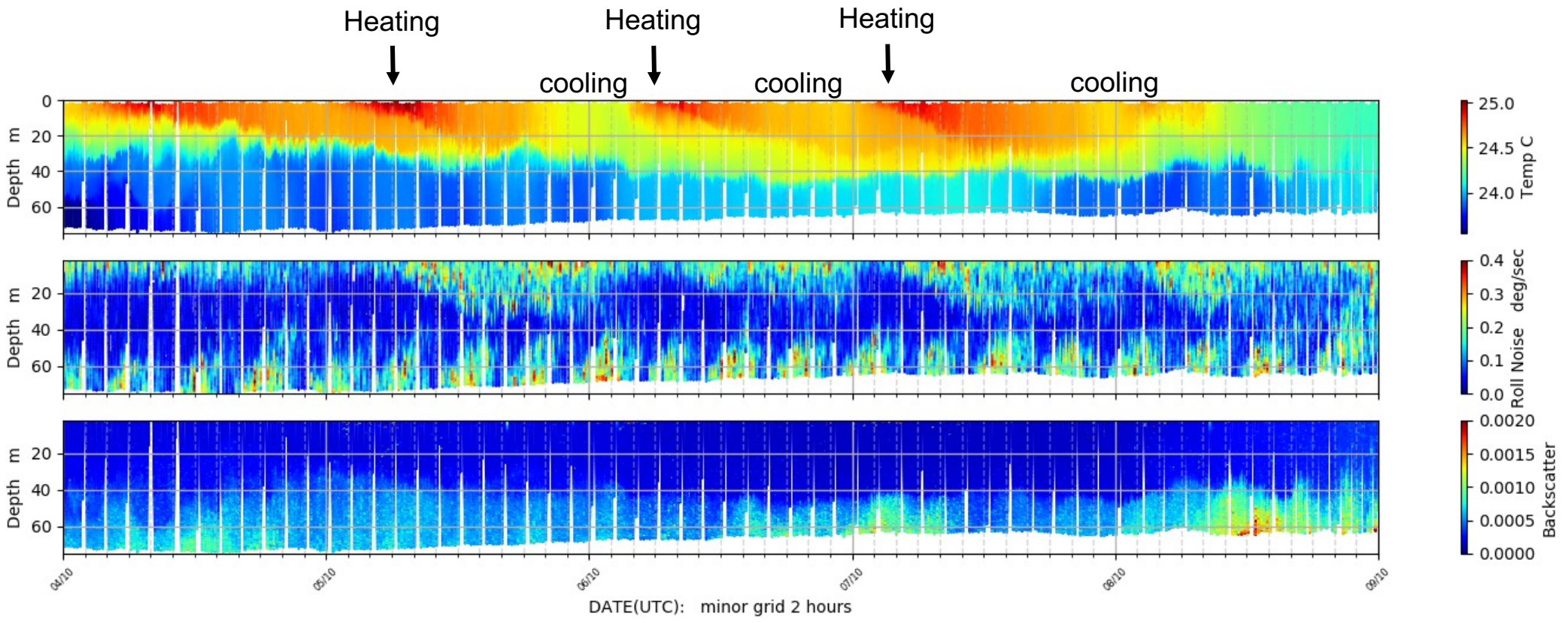

Depth m
0
50
100
150
Temp C
24
22
20
18
Roll Noise deg/sec
0.4
0.3
0.2
0.1
Depth_rate noise
0.08
0.06
0.04
0.02
19/09
20/09
21/09
22/09
23/09
24/09
25/09
26/09
27/09
28/09
29/09
30/09
01/10
02/10
03/10
04/10
05/10
06/10
07/10
08/10
09/10
DATE(UTC): minor grid 6 hours


Thermistors
ADCP 200 metres
ADCP 100 metres
Weather station
Glider's path
0 15 30 60 Kilometers

Pilbara


Wind mixing
Dense water transport
Depth m
0
20
40
60
24.5
24.0
23.5
Temp C
0.4
0.3
0.2
0.1
0.0
Roll Noise deg/sec
0.0020
0.0015
0.0010
0.0005
0.0000
Backscatter
19/09
20/09
21/09
22/09
23/09
24/09
25/09
DATE(UTC): minor grid 2 hours

Pilbara


Heating
Heating
Heating
cooling
cooling
cooling
Depth m
0
20
40
60
25.0
24.5
24.0
Temp C
0.4
0.3
0.2
0.1
0.0
Roll Noise deg/sec
0.0020
0.0015
0.0010
0.0005
0.0000
Backscatter
04/10
05/10
06/10
07/10
08/10
09/10
DATE(UTC): minor grid 2 hours

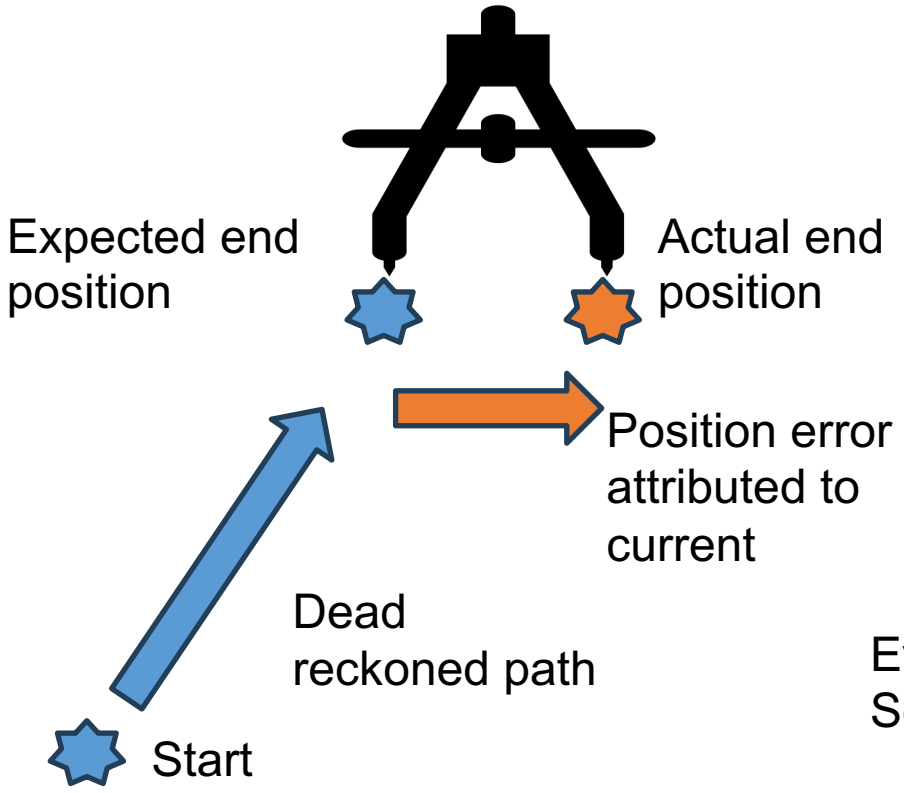
Depth Average current & Roll Rate

What is Depth Average Current ?

What is Roll Rate ?

Spoiler alert they are the same thing!

Depth Average current & Roll Rate

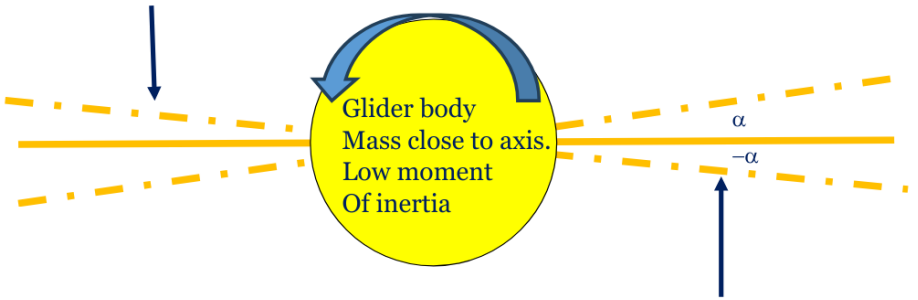


Depth Average Current is

- A deviation from the expected motion of the glider
- Due to an external force.
- That we attribute to the motion of the water through which the glider is traveling

Evaluated every surfacing (hour/hours)
Scale 100s of meters

Depth Average current & Roll Rate



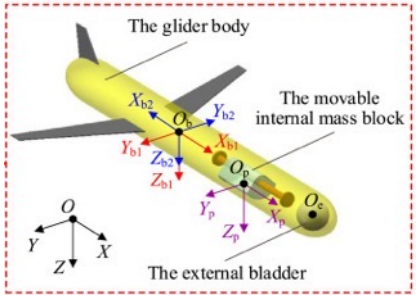
Evaluated every 5s
Scale 0.1 -> 1m

Roll Rate is

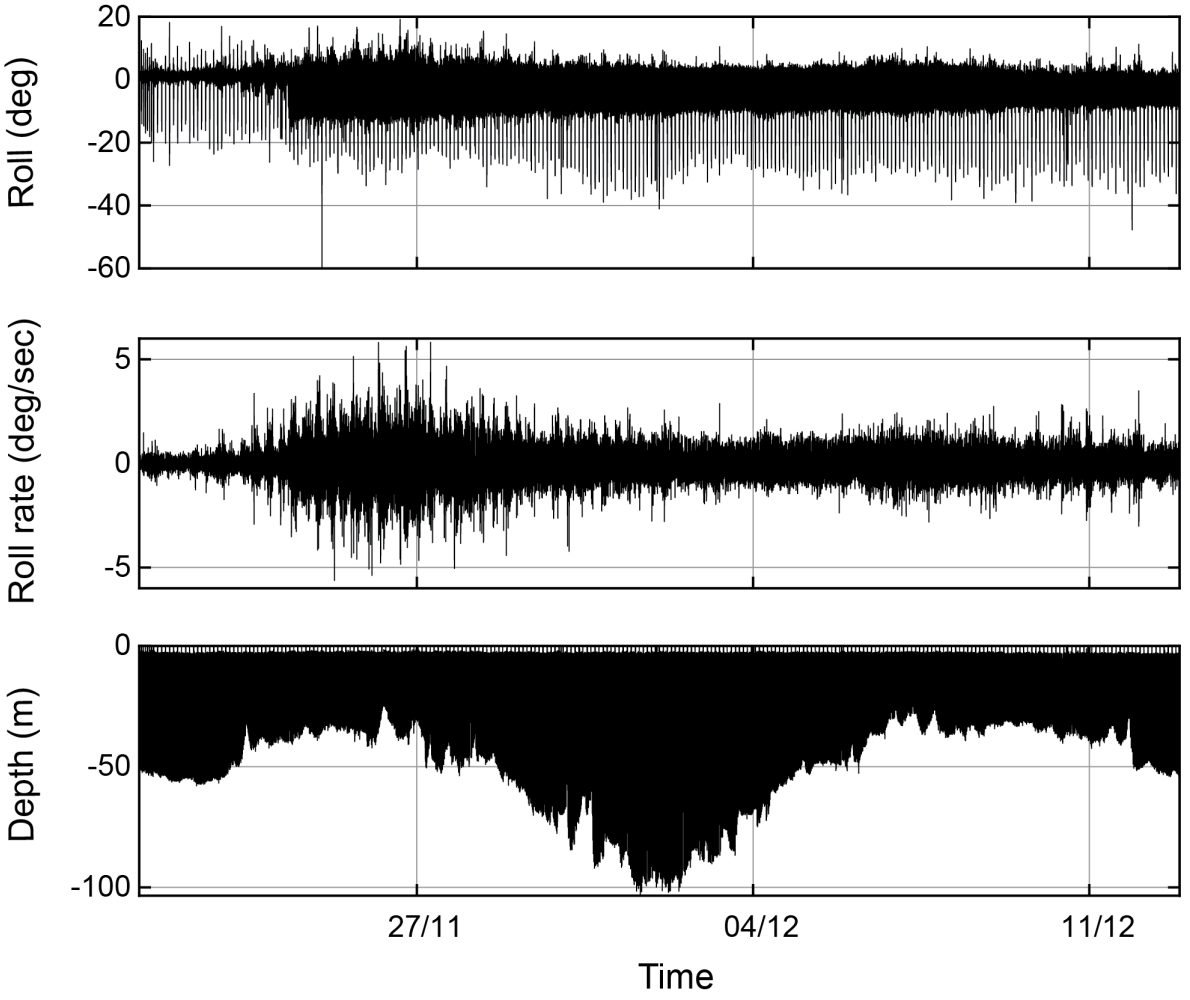
- A deviation from the expected motion of the glider (level flight)
- Due to an external force.
- That we attribute to the motion of the water through which the glider is traveling
- Just an approximately 1000 times smaller and faster scale

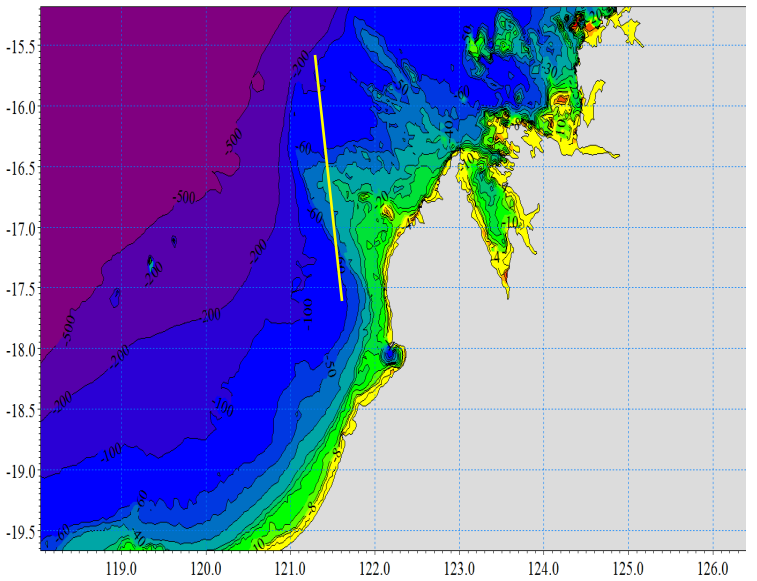
Summary: Welcome to "Roll Rate"

- A new parameter to explore the water column
- Ocean glider roll rate could be used as a proxy for mixing
- Effective in tidal environments and strong wind forcing
- At present qualitative results

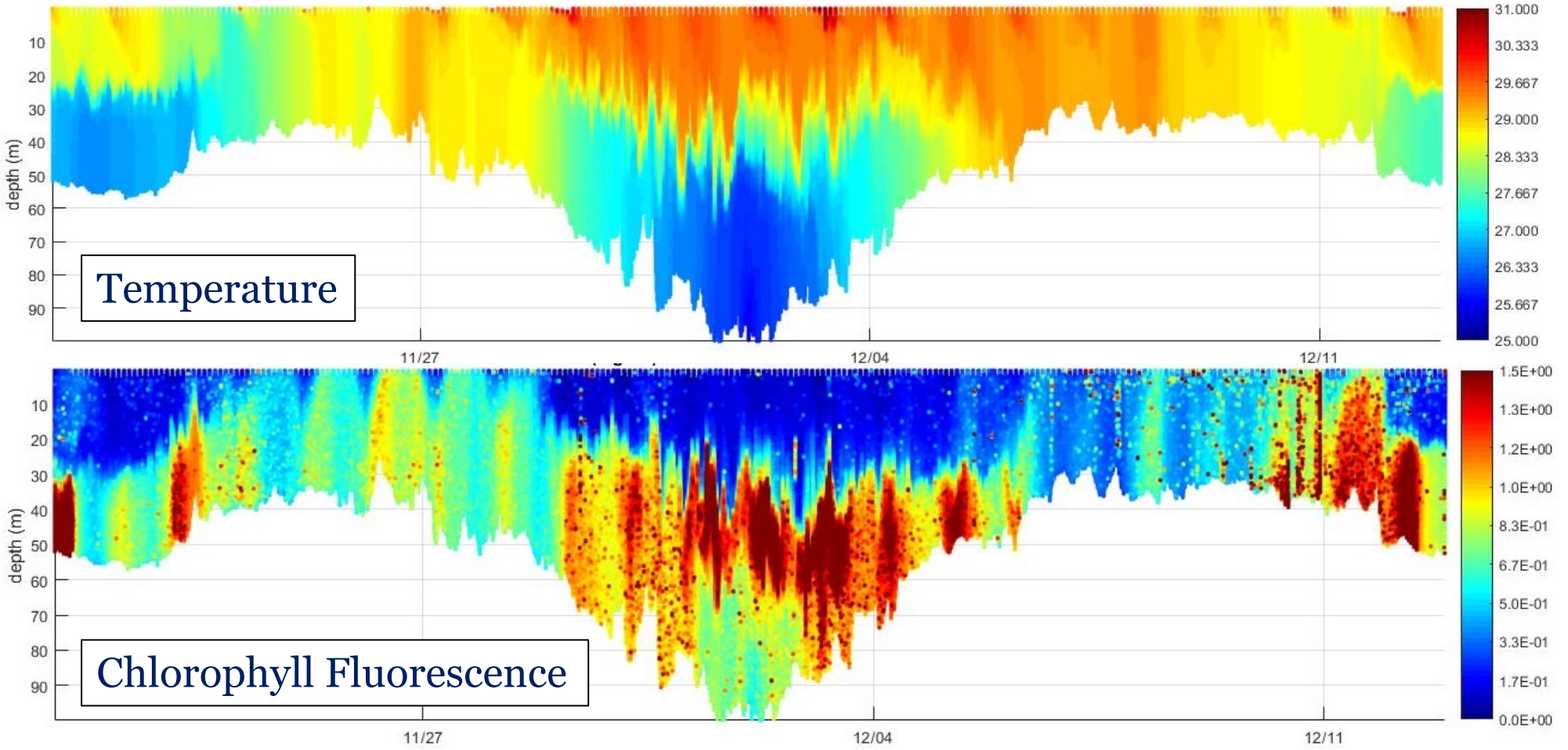


Glider roll parameters: Kimberley

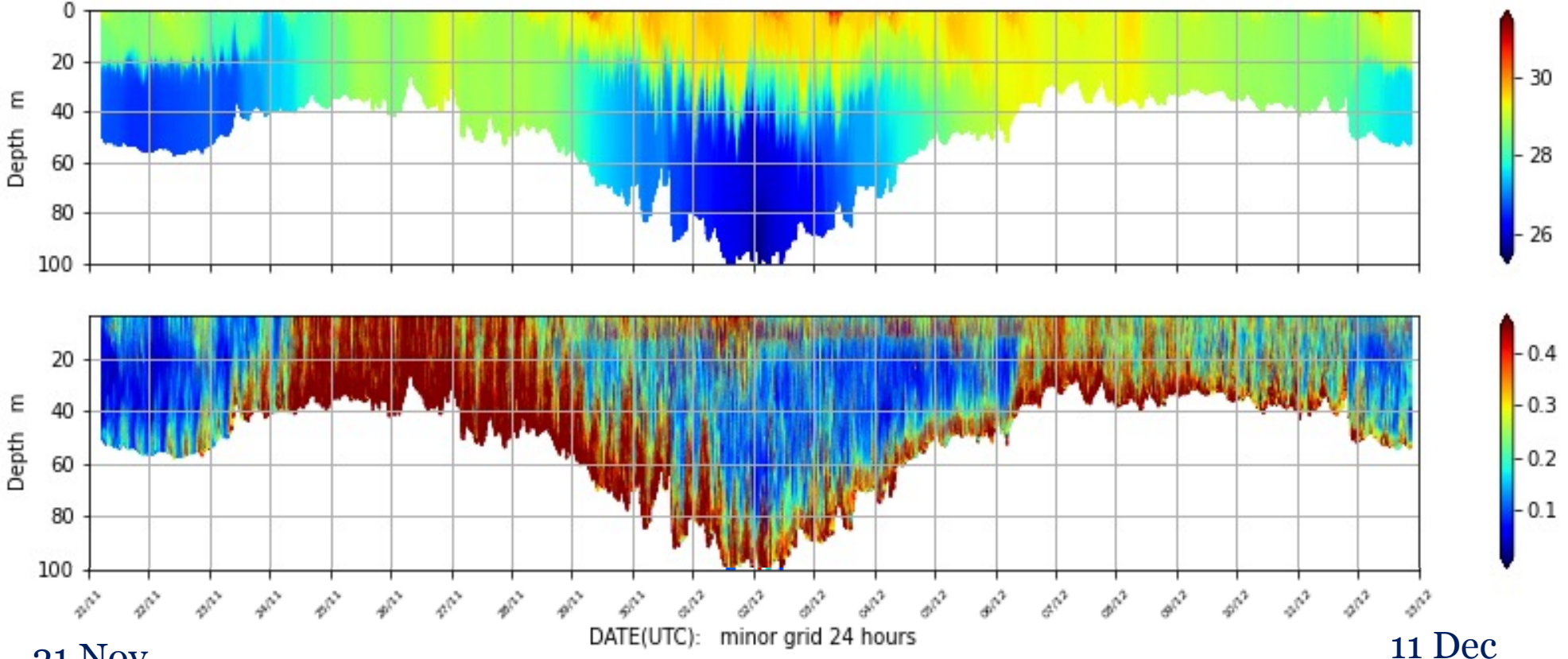




Glider Transect: Kimberley



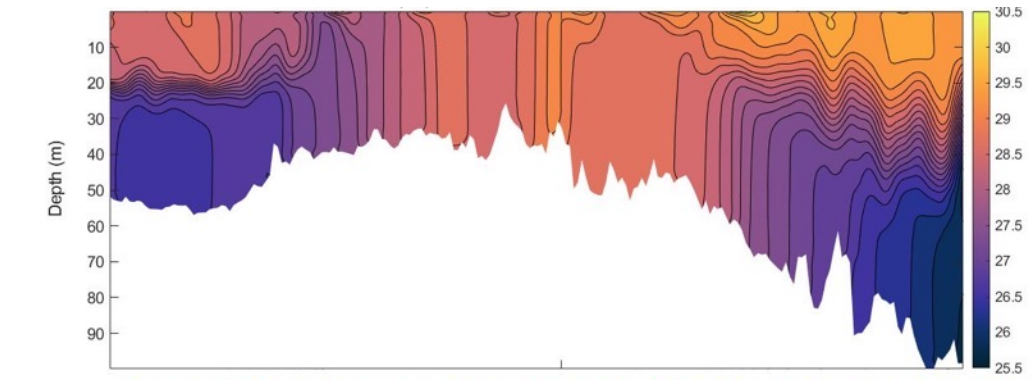
Glider roll parameters: Kimberley



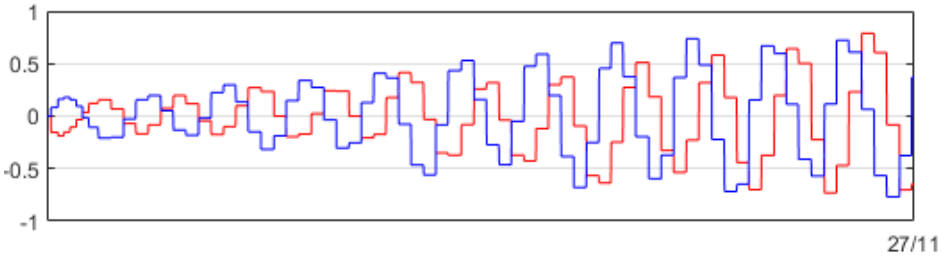
21 Nov

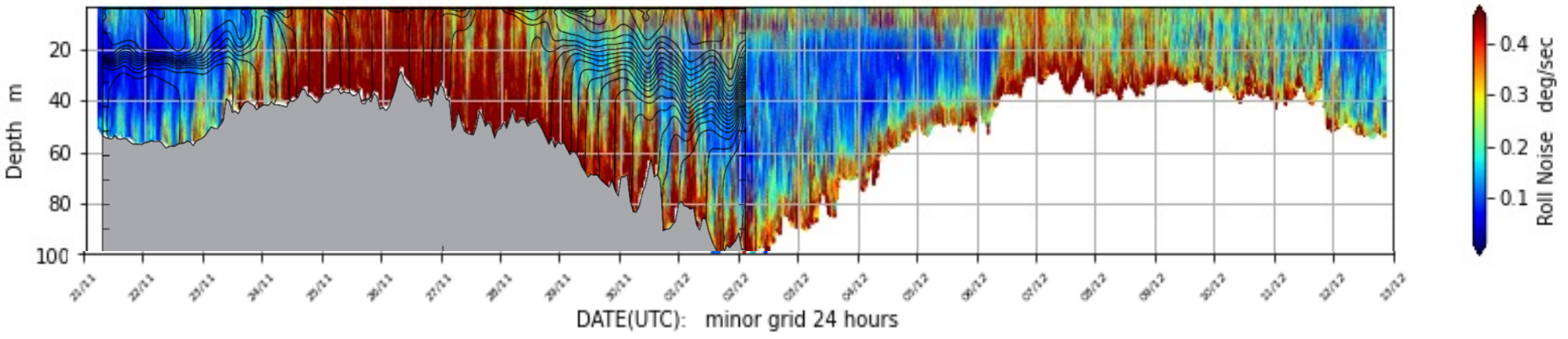
11 Dec

Glider roll parameters: Kimberley

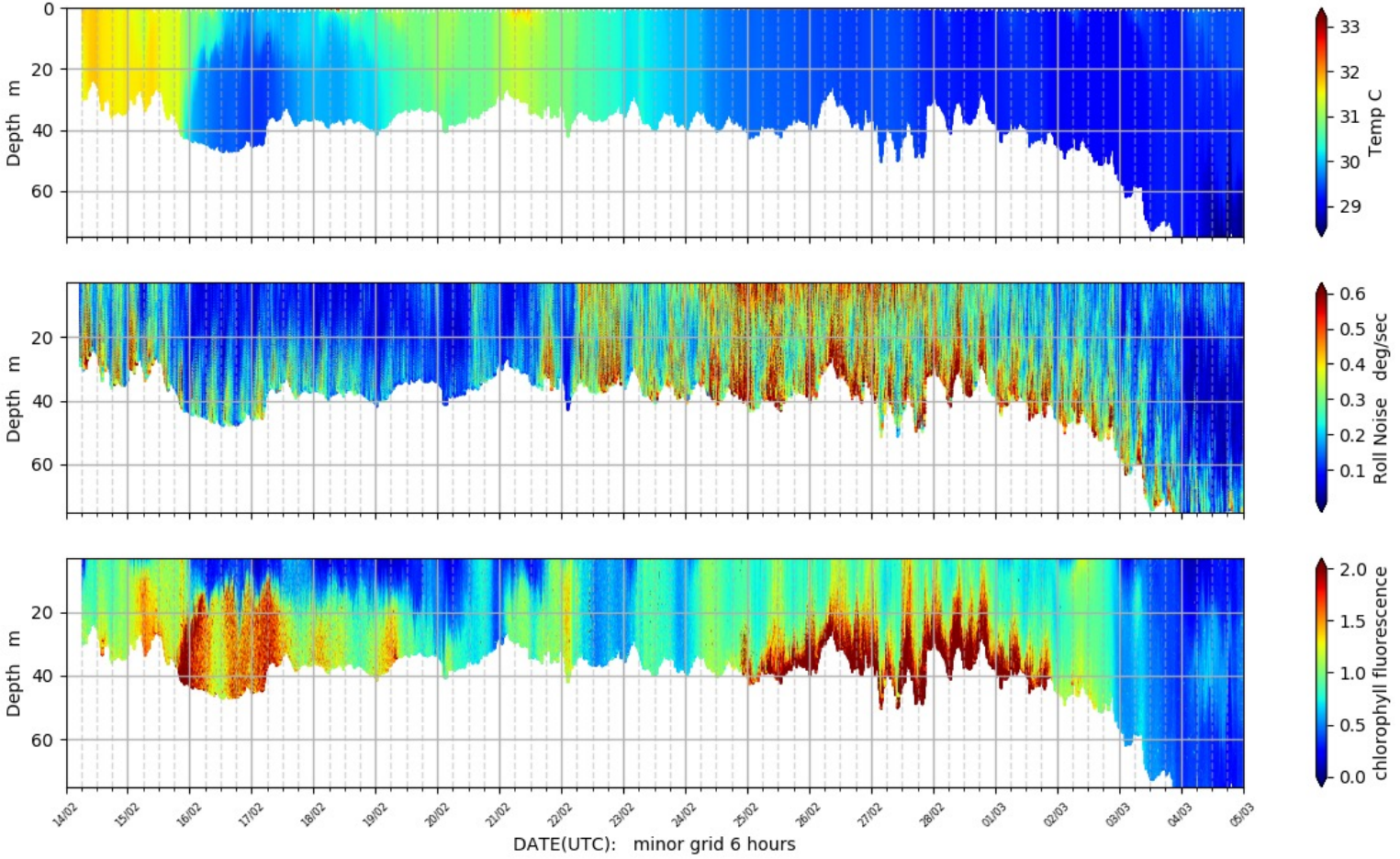


Depth mean currents





TC Rusty – ocean glider data



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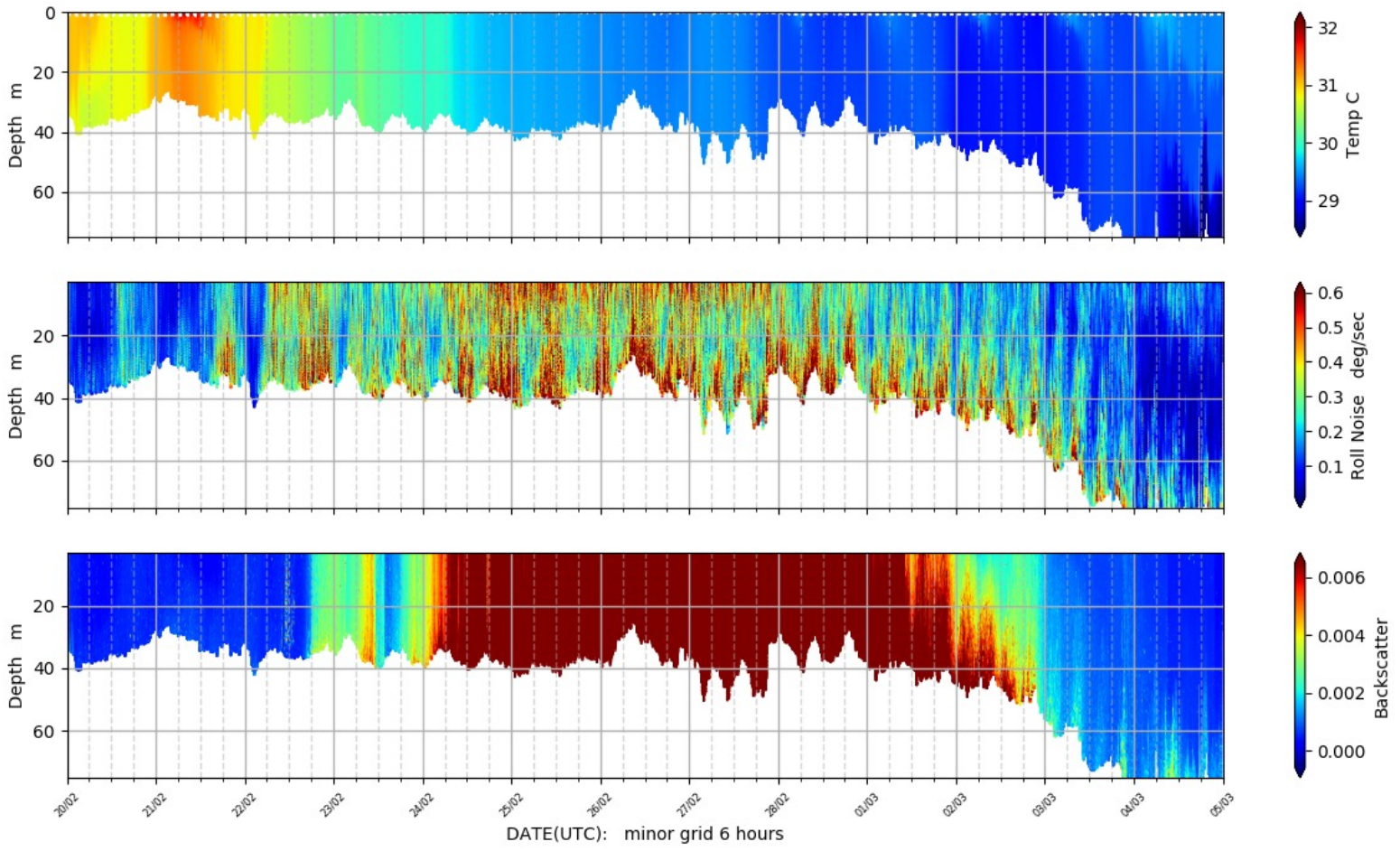
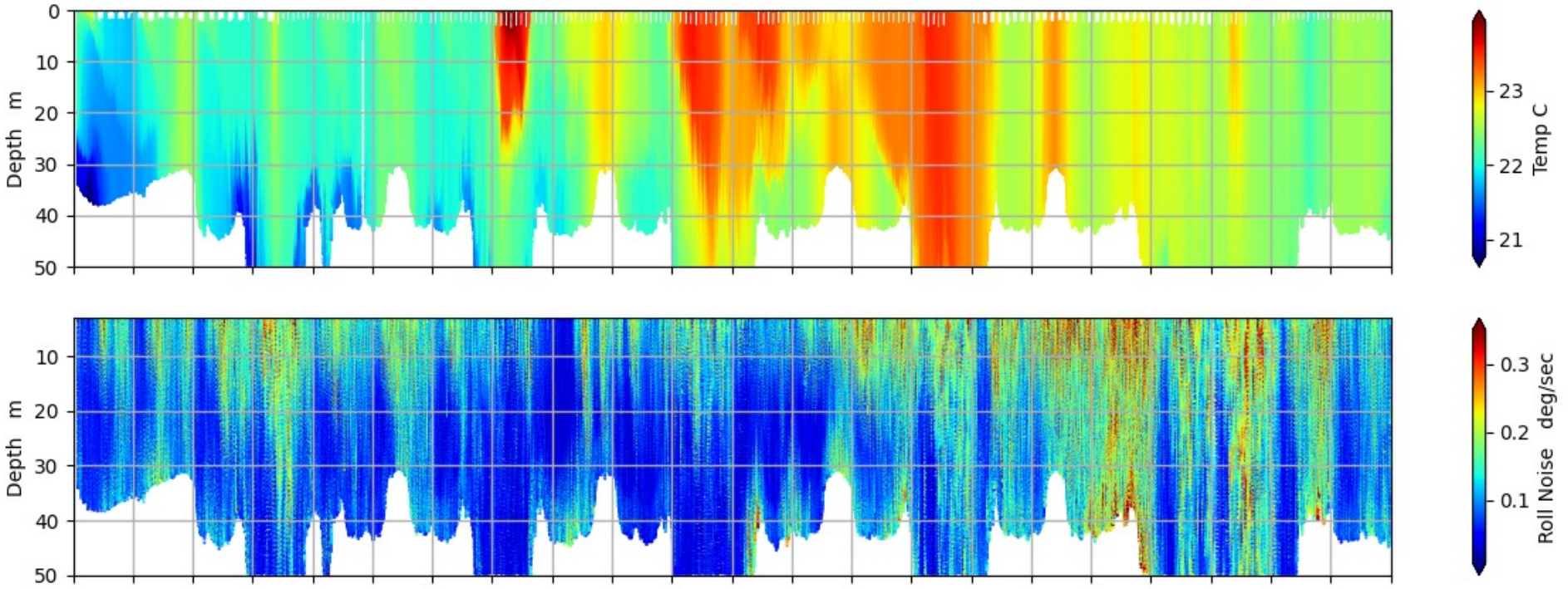
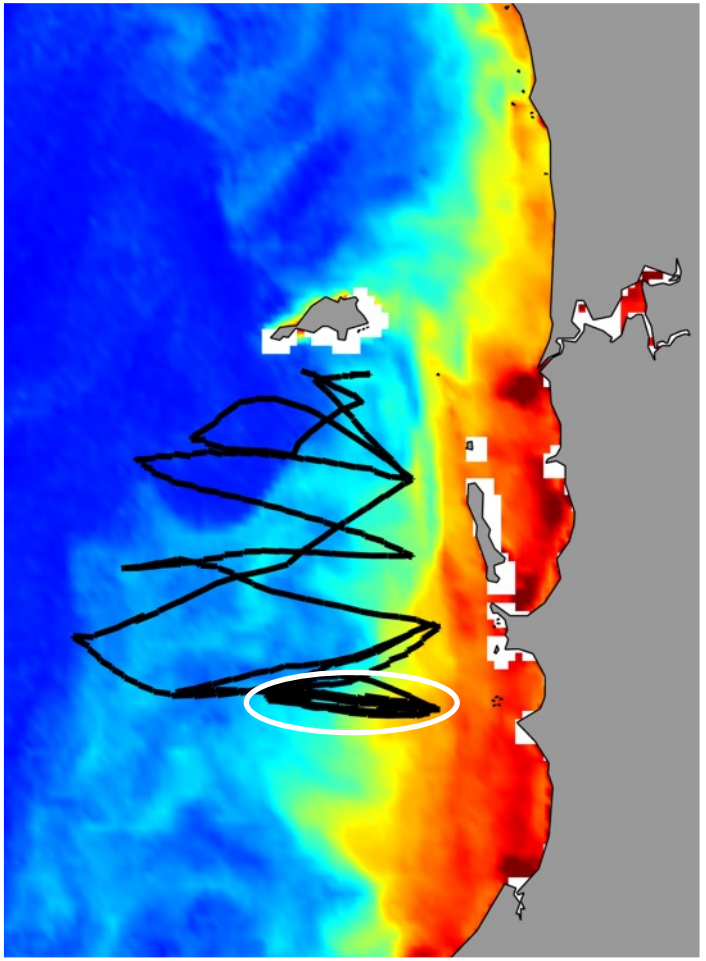
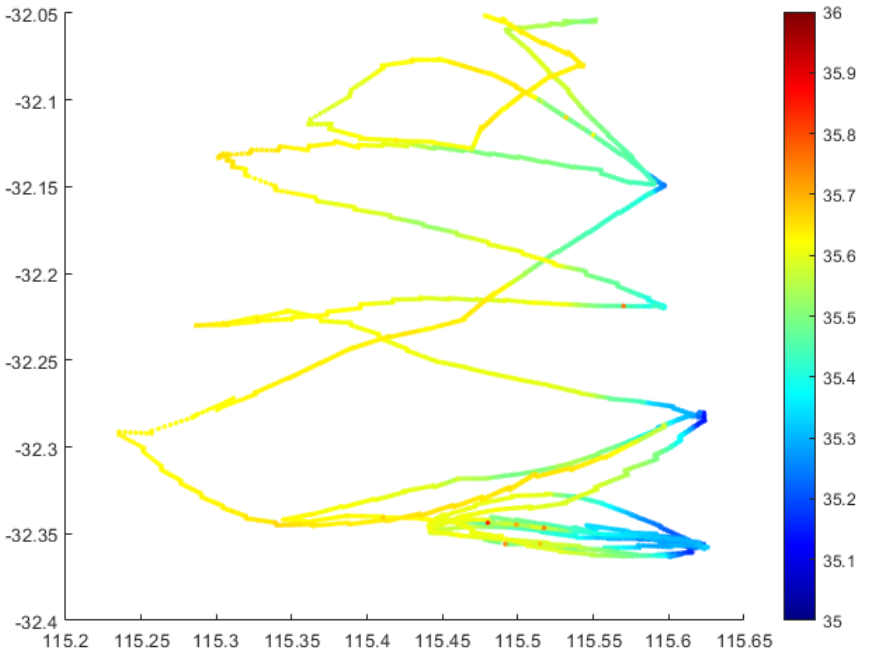


Rottnest shelf: Two Rocks

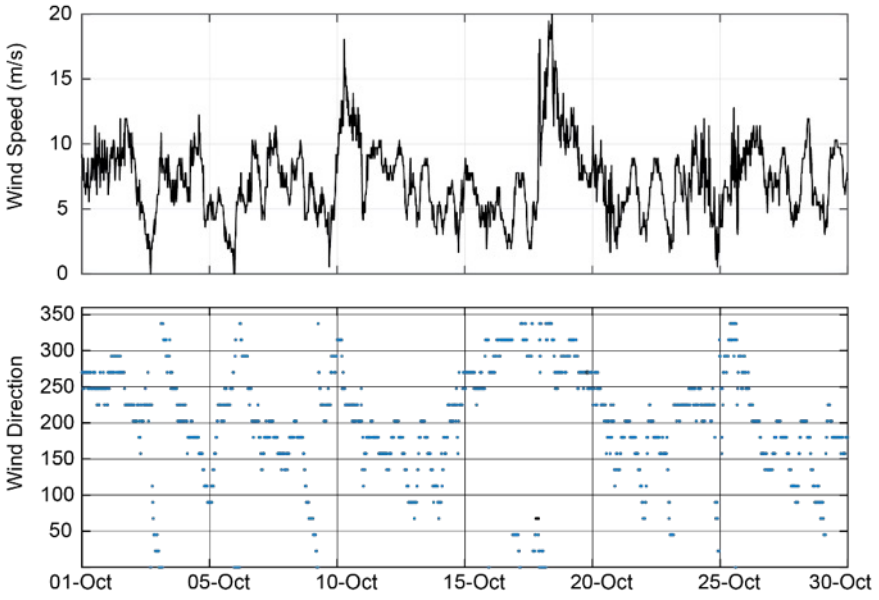


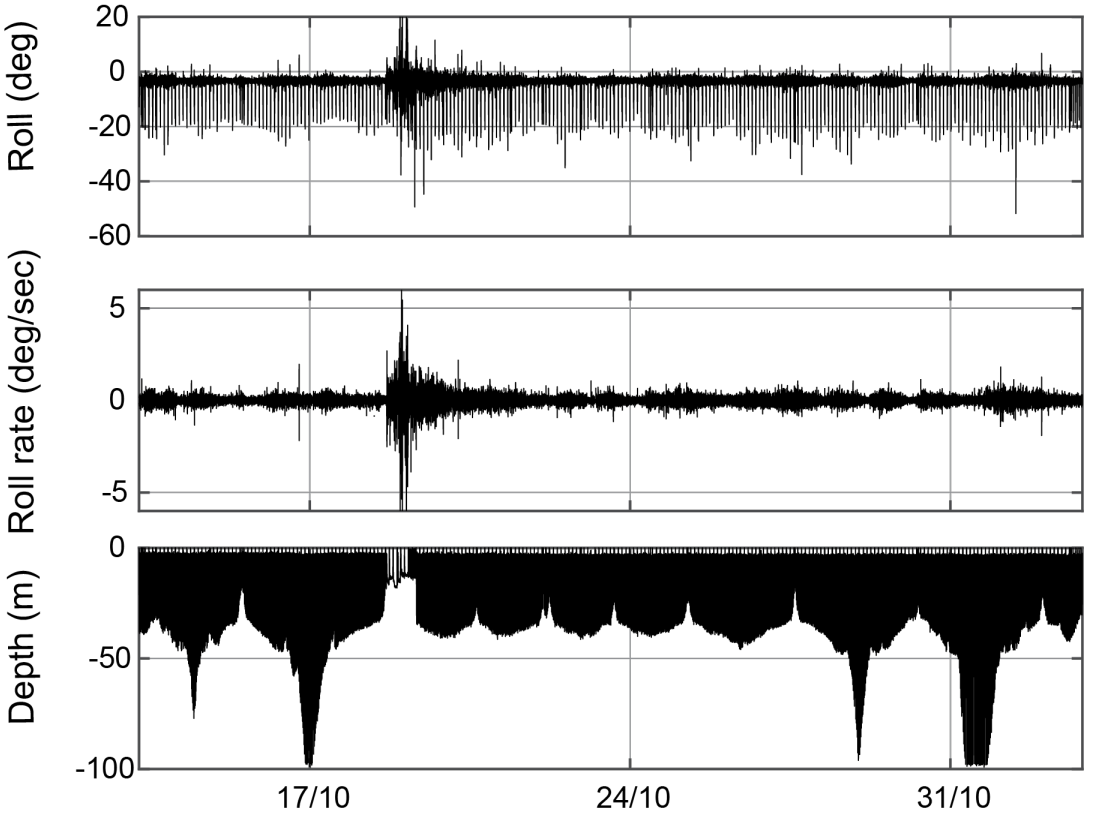
Rottnest shelf



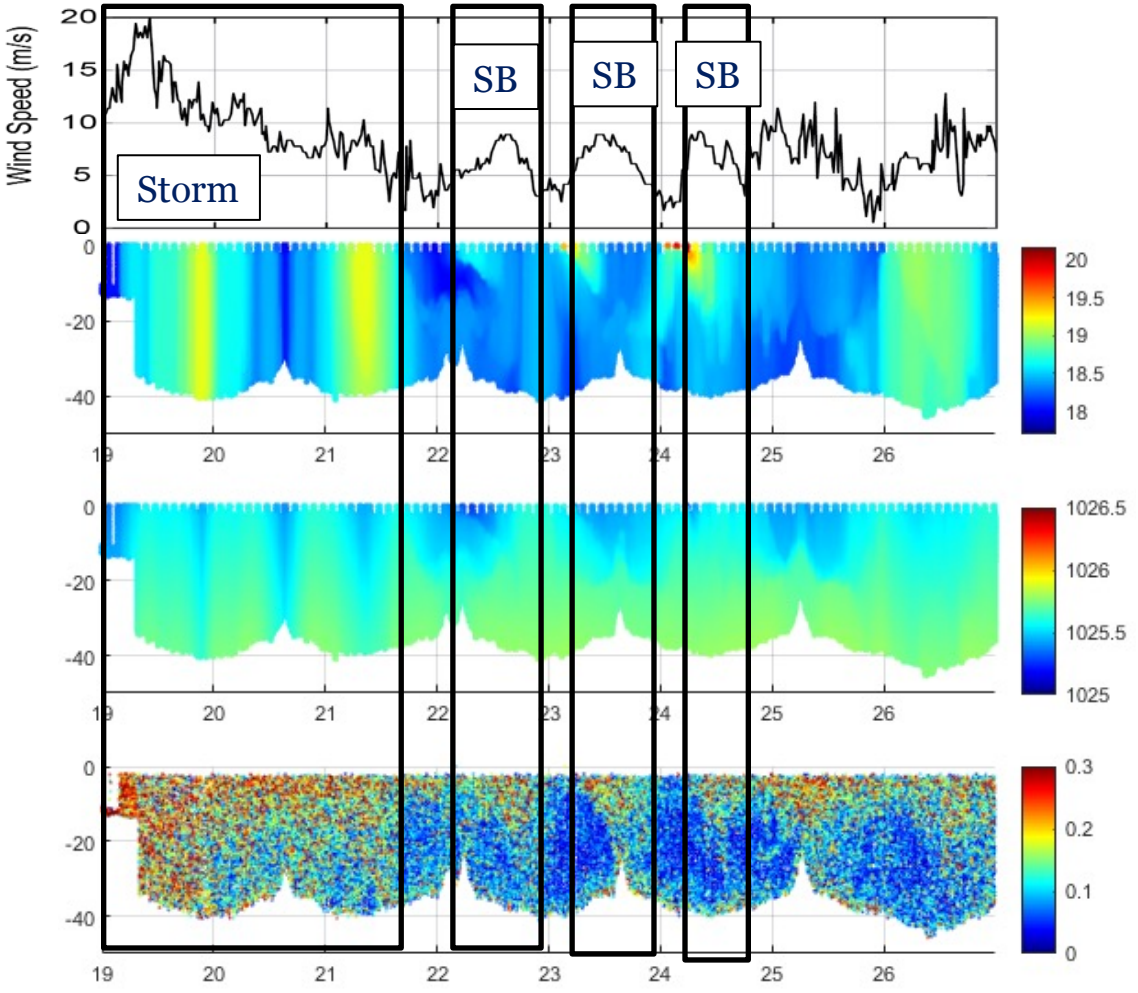


Rottnest shelf

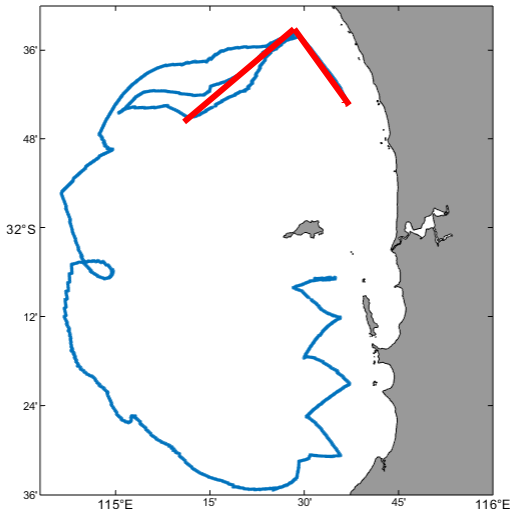


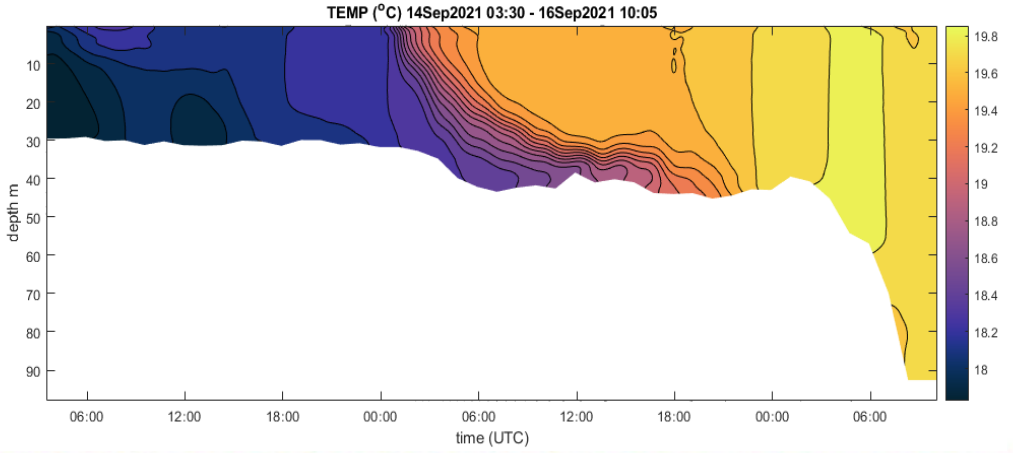


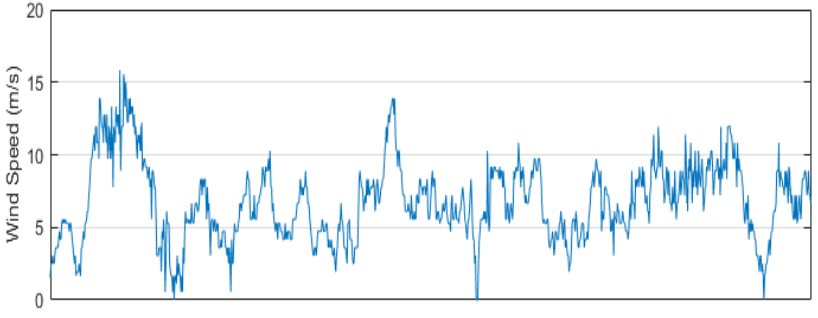
Rottnest shelf

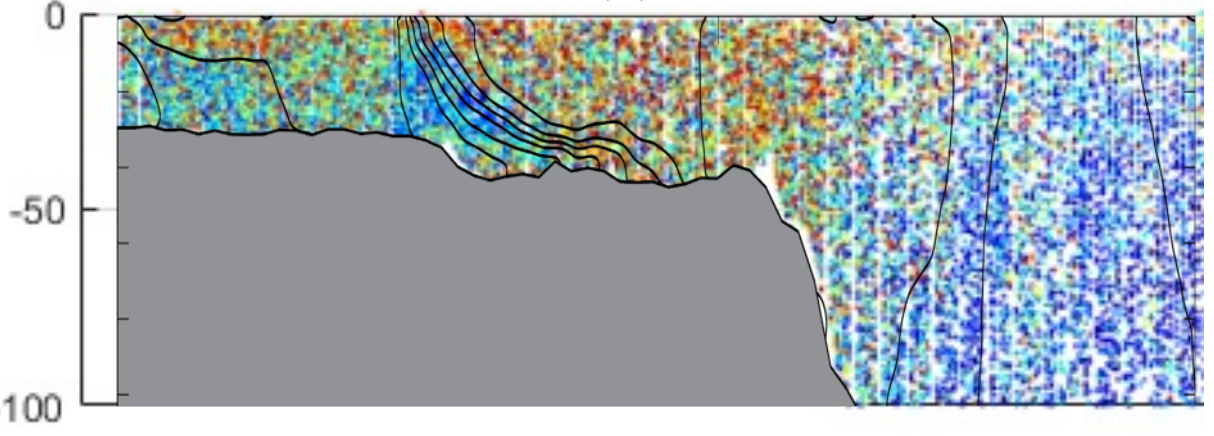


Rottnest shelf

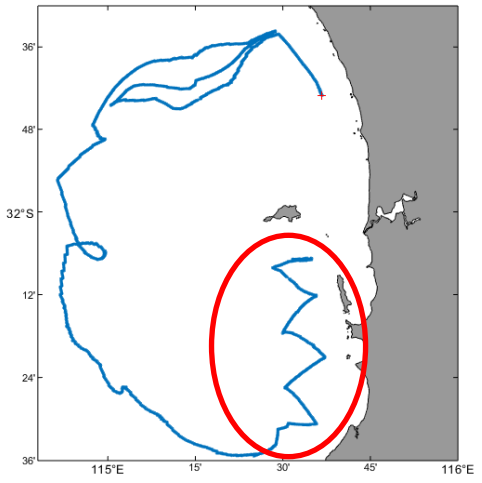


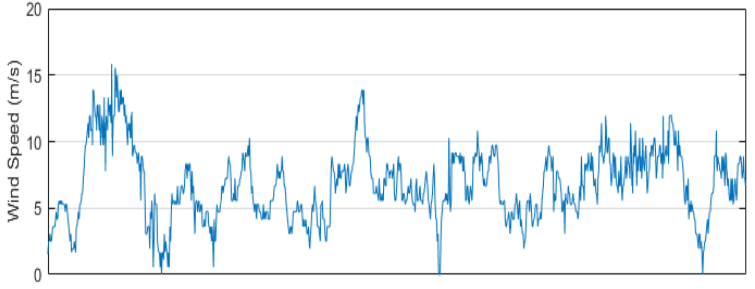


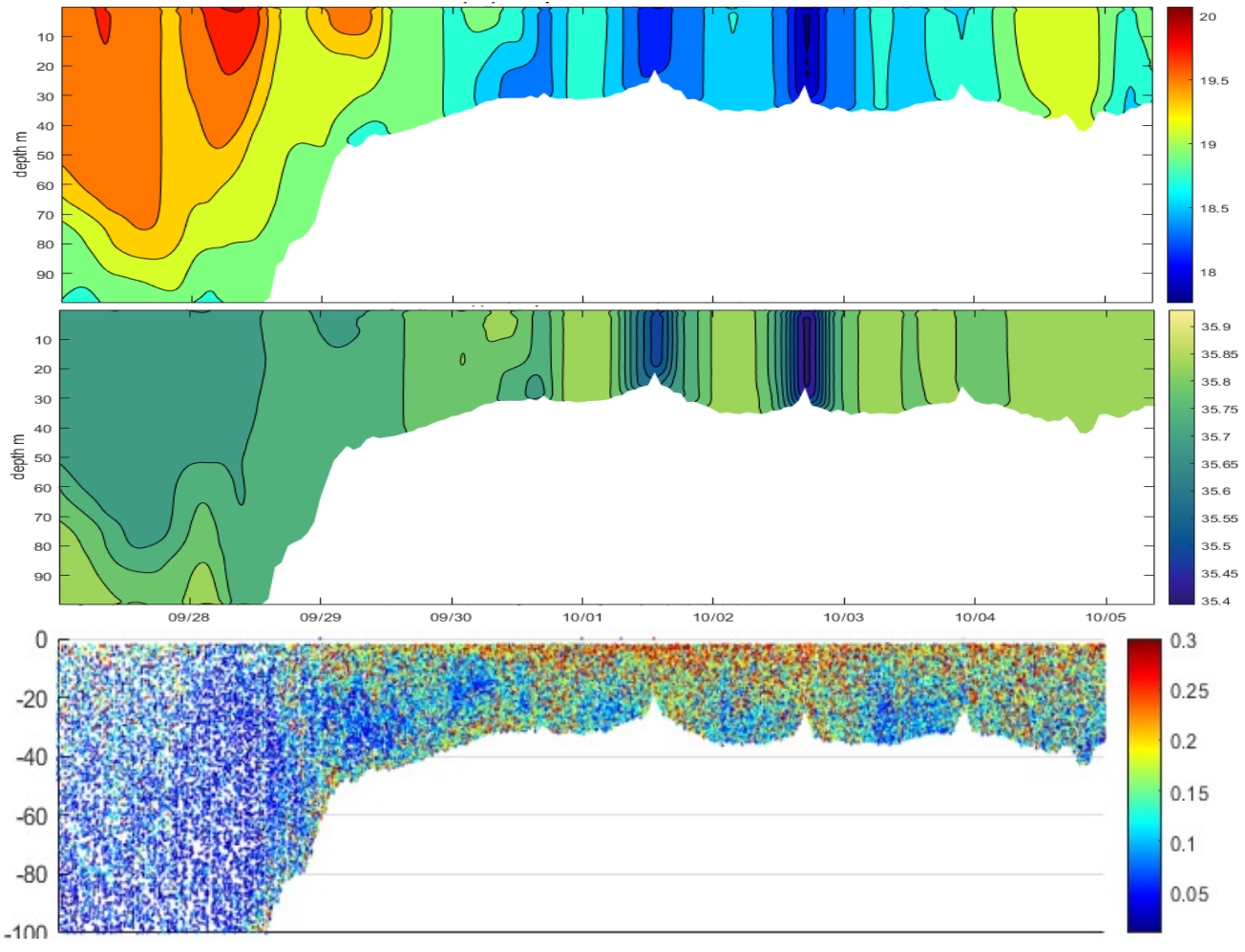




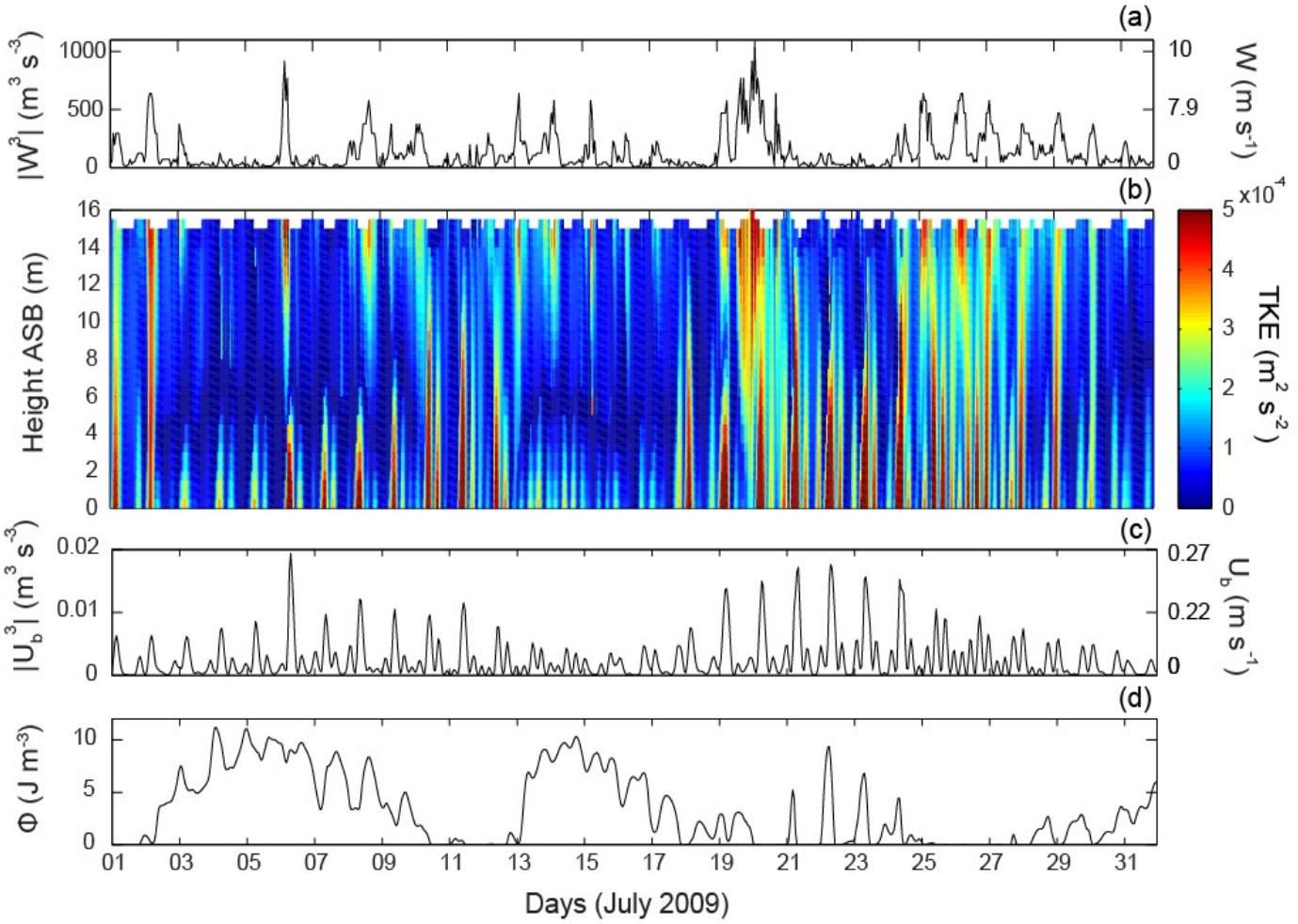
Rottnest shelf







Stratification and Mixing



Hetzel et al., 2015

River outflows