THE UNIVERSITY OF WESTERN AUSTRALIA

Coastal Oceanography

School of Civil, Environmental and Mining Engineering

Occurrence of Dense Shelf Water Cascades around Australia using ocean gliders

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Introduction

- Dense Shelf Water Cascades (DSWC) are gravity currents that form in coastal waters due to cross shelf density gradients.
- Density gradients are generated by a decrease in temperature through cooling and/or an increase in salinity from evaporation (Fig. 1).
- DSWC have been documented in six different locations around Australia where gliders have been deployed.
- The formation of DSWC is controlled by turbulent vertical mixing (wind and tidal mixing).

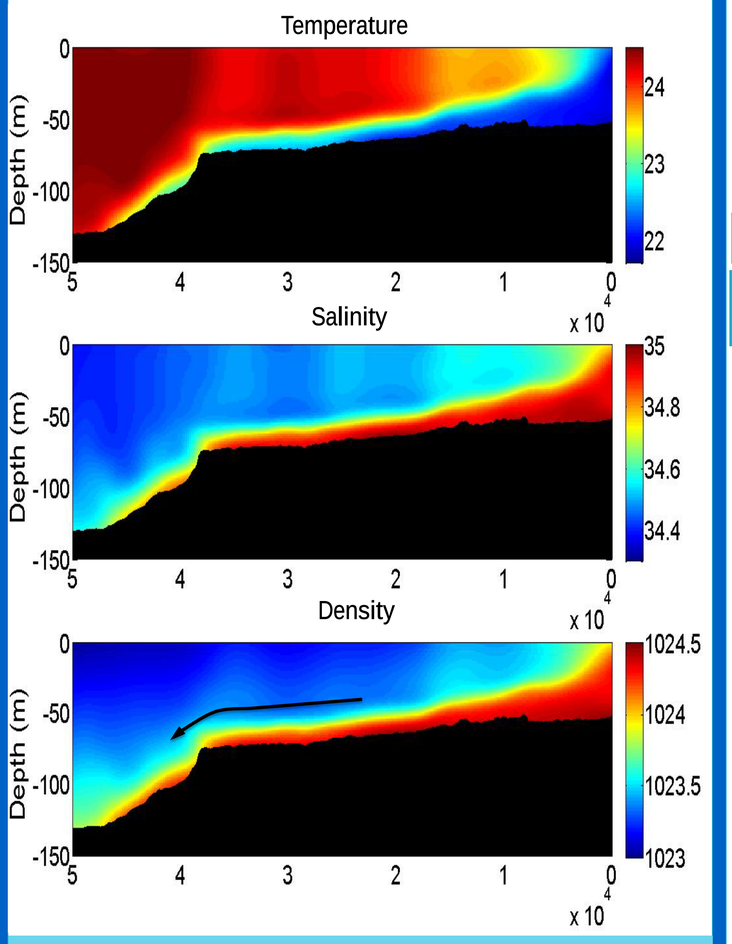

Figure 1: Cross shelf profile of DSWC as measured by a Slocum ocean glider on the Pilbara Coast during June 2012

How do we measure DSWC? : Ocean Glider

- Small in size, efficient, high temporal and spatial resolution, extended deployments, economical (Fig. 2)
- Use buoyancy control and wings to provide horizontal motion
- Measure temperature, salinity, density and other parameters (e.g. fluorescence)

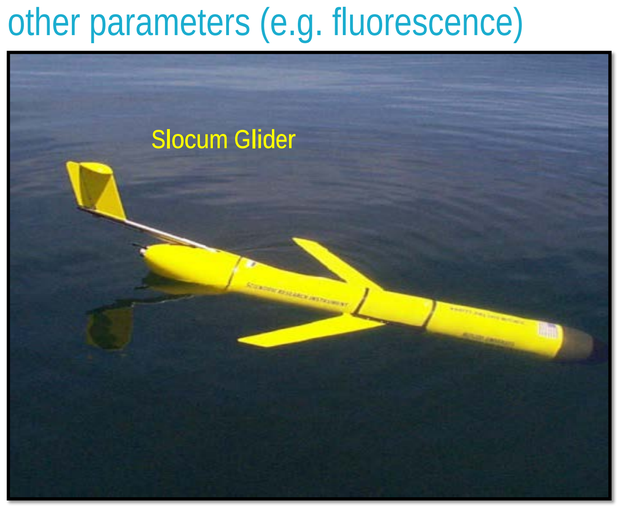

Figure 2: Slocum glider floating at the water surface

Documentation of DSWC

Preliminary analysis from 90 ocean glider mission from six contrasting regions has allowed us to confirm the existence of DSWC around Australia (Fig. 3).

Occurrence of DSWC around Australia

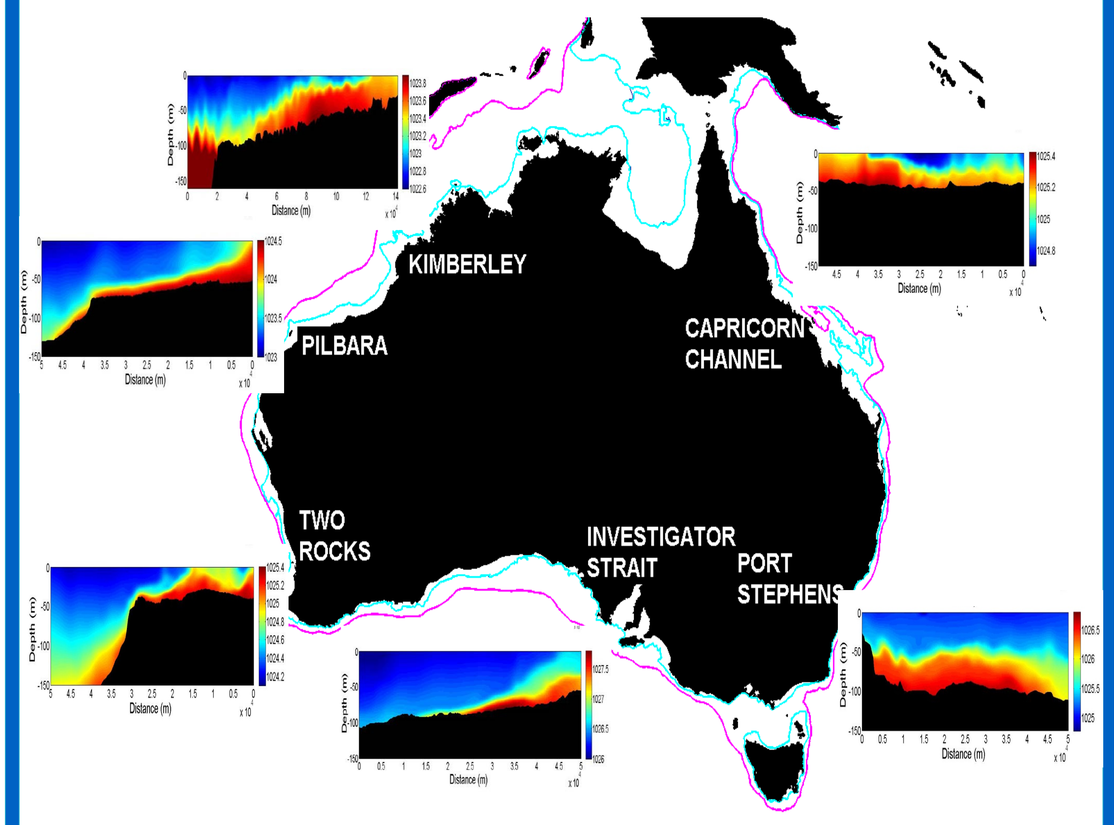

Figure 3: Observations of DSWC around Australia

Driving force: Cross shelf density gradients

- In winter, positive density gradients (colder, denser water near the coast) drive DSWC (Fig 4)
- In summer, gradients can be negative with warmer, less dense water near the coast (no DSWC) at some locations

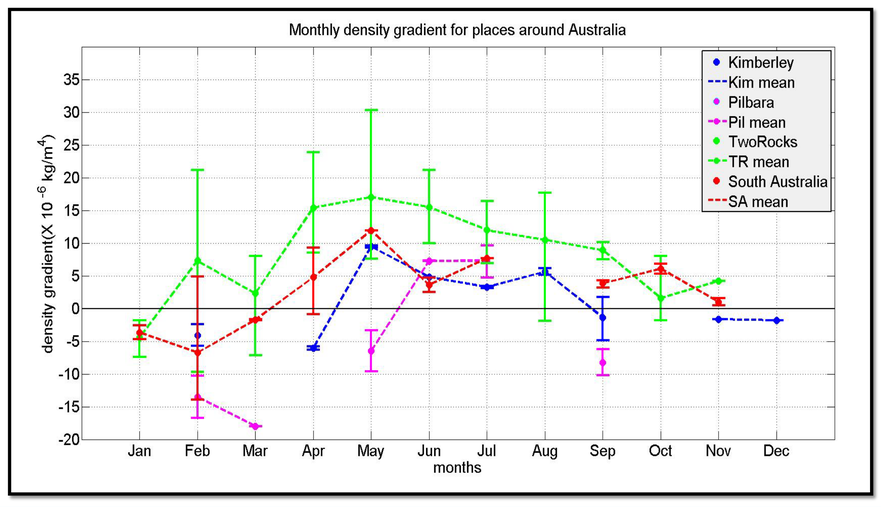

Figure 4: Seasonal viability of horizontal density gradients calculated from glider data

Control of DSWC

- Wind mixing and tidal mixing control the formation of DSWC and the relative importance of these factors varies around Australia (Fig. 5)
- Under low wind and tidal mixing conditions, the water column stratifies and dense water flows offshore along the sea bed; whereas high vertical mixing inhibits stratification and the offshore transport of water (Fig. 6)

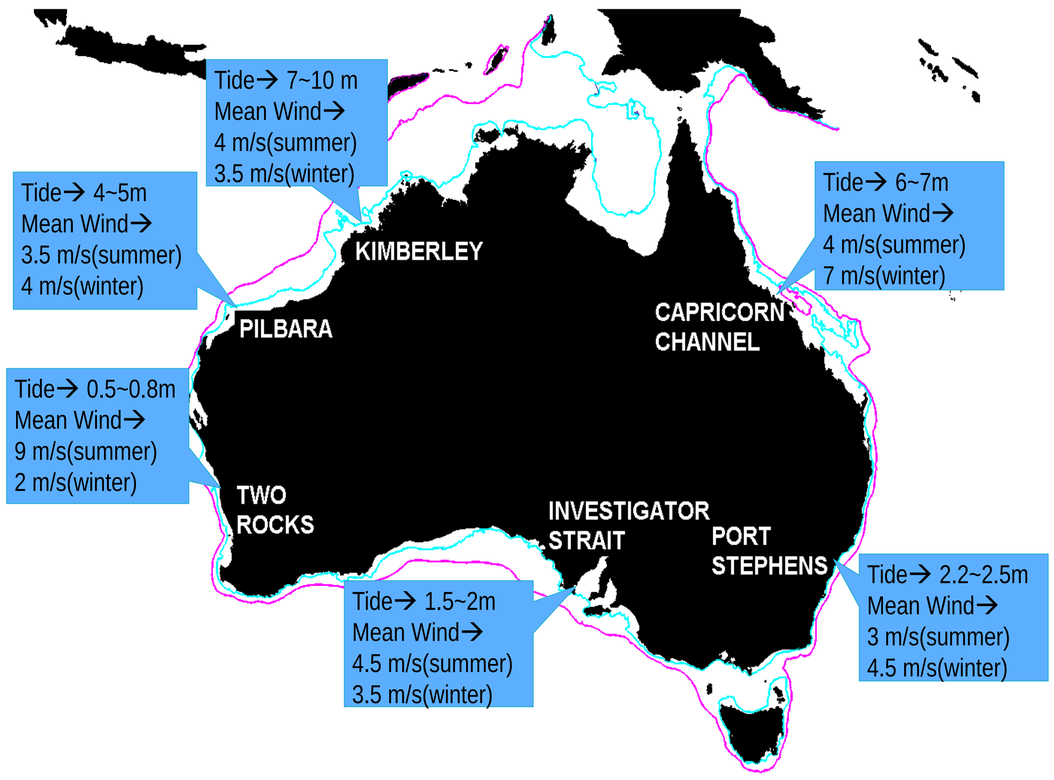

Figure 5: Tidal range and mean wind speed (in summer and winter) around Australia

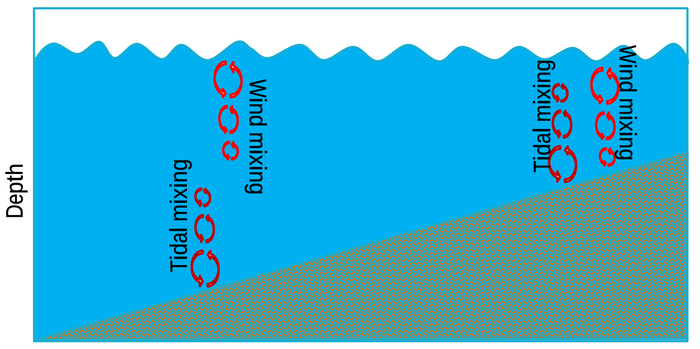

Figure 6: Tidal currents over sea bed or wind stress on surface create turbulent mixing and inhibit DSWC

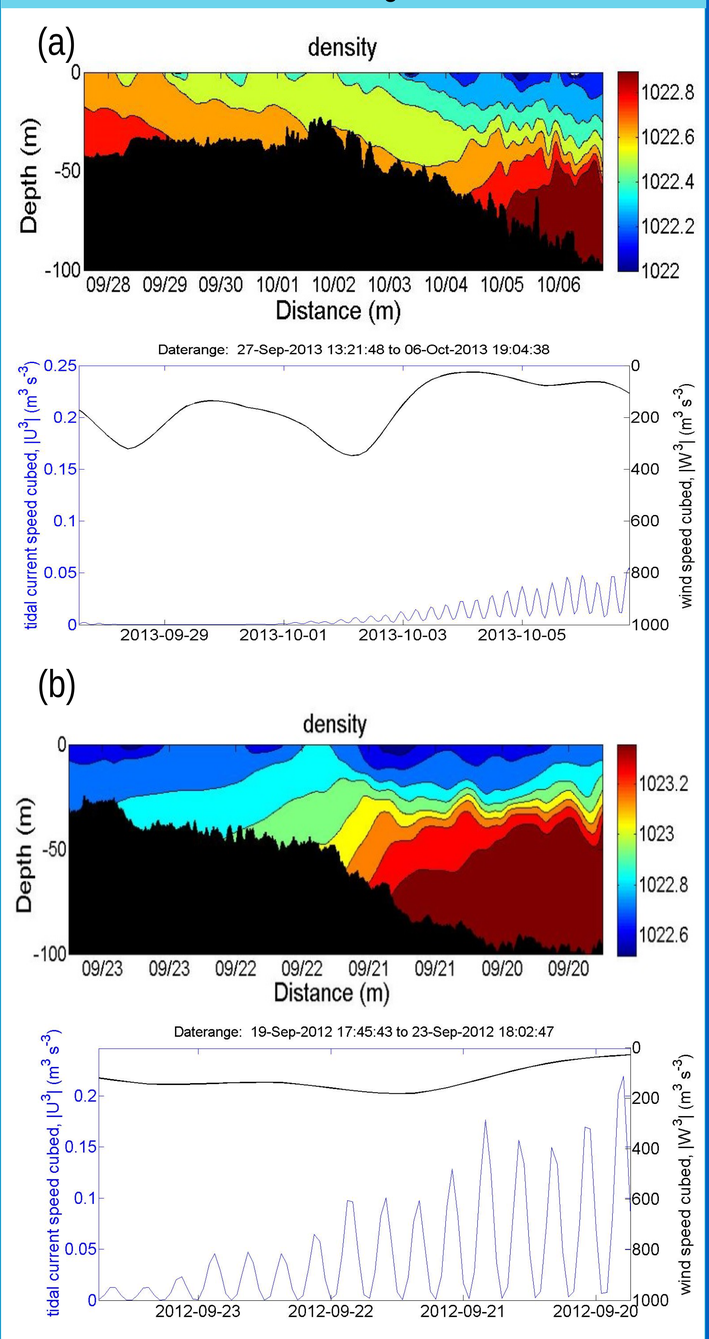

Figure 7: Wind and Tide effects on DSWC; (a) presence of DSWC due to neap tide on Kimberley Coast during September 2013; (b) no DSWC formation due to spring tide on Kimberley Coast during September 2012.

Conclusions

- The formation of DSWC depends on the balance between the cross shelf density gradient ($d\rho/dx$) and vertical mixing
- $d\rho/dx$ > mixing ⟹ *DSWC*
- Mixing > $d\rho/dx$ ⟹ No *DSWC*
- Around Australia during winter the cross shelf density gradient dominates over mixing much of the time
- As a result DSWC can occur in all Australian coastal waters, even where the tidal range exceeds 10 m
- DSWC generally occur during neap tides and weak winds (Fig. 7)

Acknowledgements

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