Project AFI 8/17
Synoptic Antarctic Shelf-Slope Interactions

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Location: On board the RRS Ernest Shackleton, Weddell Sea

Field Personnel:

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University of Bergen: Dr. Ilker Fer, Mr. Helge Bryhni, Ms. Kjersti Daae

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Rationale

Freshwater on the Antarctic margin has been shown to affect global climate, at least in climate models. Recent observations suggest that the water on the continental shelf of Antarctica is freshening. This project will study the oceanographic processes on the Antarctic continental shelf and slope, in particular the role of freshwater and interaction between ice and ocean. This is a critical but under-observed region for physical processes affecting global climate. We will deploy for one year a unique moored array measuring ocean temperature, salinity and velocity, and collecting *in situ* water samples. This will provide the first year-round study of the upstream processes influencing the formation of Antarctic Bottom Water and the melting of ice shelves in the Weddell Sea.

Field work

From January 23 to March 8, 2009, we undertook a research cruise (ES033) on the RRS Ernest Shackleton, in the Weddell Sea. We deployed five moorings on the continental slope and shelf between 17 and 19 degrees

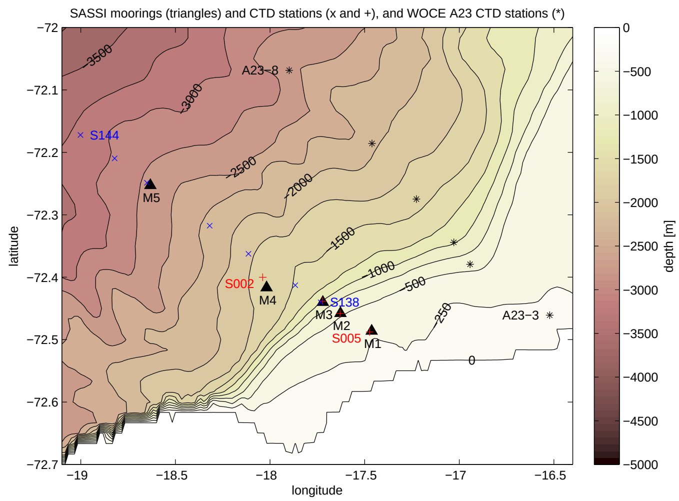

Figure 1: SASSI moorings (M1 to M5, black triangles) and CTD/LADCP stations undertaken during the cruise (red pluses and blue crosses), overlaid on bathymetry from GEBCO1. WOCE A23 CTD stations are also indicated (black stars).

West (Fig. 1), and one Pressure Inverted Echo Sounder (PIES) in the Orkney Passage, east of the South Orkney Islands.

The moorings were planned to be deployed along the WOCE A23 section undertaken in 1995 (stars in Fig. 1), at depths determined from the WOCE A23 observations ([Heywood et al., 1998]) to sample the features of interest. Its location on the Antarctic slope had been chosen for the relatively smooth bathymetry, to avoid complex topographic steering of the currents above the slope (thereafter called slope currents). When arriving on site on January 31, a conglomeration of sea ice prevented us from deploying the moorings as planned. We found another area with relatively smooth bathymetry about 20 km to the west, partially clear of sea ice, but allowing us to install only 3 moorings at the planned depths and a fourth slightly shallower than planned. It was assumed that the main currents were steered by topography and would therefore be located over the same isobaths at the new location. Because we could not know whether the sea ice would clear up during the rest of the cruise, we decided to deploy the four shallowest moorings immediately (M1 to M4 black triangles in Fig. 1), and come back later for the remaining mooring and PIES.

CTD/LADCP (Conductivity-Temperature-Depth / Lowered-Acoustic-Doppler-Current-Profiler) stations (S002 to S005, red pluses in Fig. 1) were taken after each mooring deployment. They revealed that the core of the southwestward slope current was lying over deeper isobaths than during the WOCE A23 section, possibly further offshore than mooring M4 (Fig. 2), prompting the need for a longer CTD/LADCP section before deploying the remaining mooring.

The fifth mooring was deployed on February 24. Sea ice had cleared up, and a CTD/LADCP section (S138 to S144, blue crosses in Fig. 1) was undertaken to determine where to deploy the fifth mooring and the PIES. The core of the southwestward slope current was lying even further offshore than during the first section (Fig. 3). The fifth mooring was deployed in 2600 m, the maximum depth allowed by the available cable length, and near the core of the slope current.

Unfortunately, the PIES was not deployed because of a misleading diagnostic on the instrument. We discovered it was working properly too late to turn back. We deployed it on March 2 as part of the Long Term Monitoring and Survey array in Orkney passage, where its utility in Antarctic regions can be fully trialled.

Preliminary results

Figs. 2 and 3 show the CTD/LADCP sections undertaken on January 31 and February 23-24, respectively.

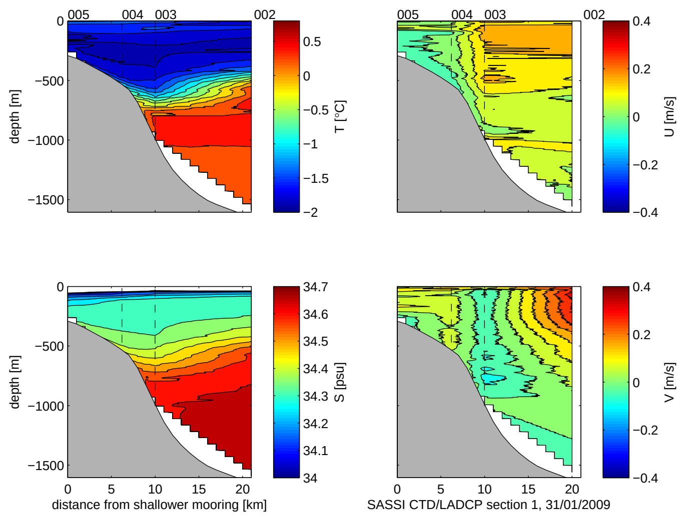

Figure 2: CTD/LADCP section undertaken on January 31, 2009. Temperature (upper left panel) and salinity (lower left panel) are from the secondary CTD sensor during downcast (salinity values have not been calibrated yet). Currents are averaged from the downward-looking and upward-looking LADCPs during downcast and upcast, and have been rotated into along-section (northwestward, upper right panel) and across-section (southwestward, lower right panel) components. The station numbers are indicated on the top x-axes of the top panels. Individual vertical profiles were bi-linearly interpolated on a regular depth by horizontal distance grid.

On the first section (Fig. 2), the maximum across-section current reached 33 cm/s at 70 m depth in 1600-m deep water. However, the core of the slope current may have been located even further offshore. An interesting feature is the northeastward (negative across-section) undercurrent above the steepest part of the continental slope, reaching 8.5 cm/s around 760 m, associated with an onshore uplift of the isohalines and isotherms, well resolved by moorings 2 and 3. This is reminiscent of the undercurrent observed by [Heywood et al., 1998] along the WOCE A23 section at a similar depth.

On the second section (Fig. 3), taken 3 weeks later, the core of the slope current had shifted offshore by about 30 km, reaching 37 cm/s at 45 m depth in 2700-m deep water. Again, a northeastward undercurrent was observed above the steepest part of the continental slope, reaching 13.5 cm/s around 530 m.

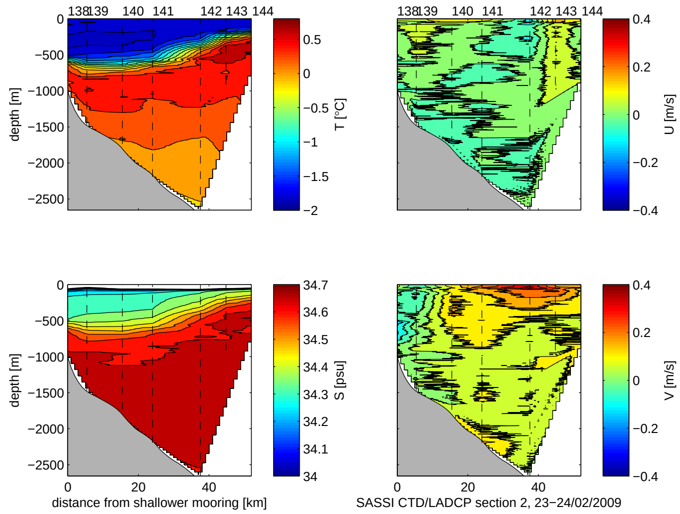

Figure 3: Same as Fig. 2 for CTD/LADCP section undertaken on February 23-24, 2009. Only the downward-looking LADCP was available for currents.

Conclusions

The two CTD/LADCP sections undertaken during cruise ES033 at the SASSI moorings location reveal that the slope current position relative to topography is not fixed. The moorings will help quantify the variability in the slope current position and transport during a full year. The undercurrent discovered by [Heywood et al., 1998] was observed again on both sections, suggesting that it may be a robust feature of the circulation above the continental slope. The associated onshore uplift of isotherms may facilitate flooding of Warm Deep Water onto the continental shelf, with potential impacts on ice-shelf melting and freshening of the water supplying the regions where the components of Antarctic Bottom Water (AABW) are formed in the Weddell Sea. The *in situ* water samples being collected at the two shallowest moorings, combined with the hydrographic and current measurements, will enable us to quantify the freshwater budget for this important area.

Acknowledgments

We thank Ilker Fer for providing the processed CTD and LADCP data, and the scientific field personnel for helping with moorings preparation and deployment and with CTD/LADCP casts. We are grateful to the ship's officers and crew for their hard work, dedication, professionalism and enthusiastic willingness to help. We also appreciate the logistical and planning support from British Antarctic Survey.

References

[Heywood et al., 1998] Heywood, K., R. Locarnini, R. Frew, P. Dennis, and B. King, Transport and water masses of the Antarctic Slope Front system in the eastern Weddell Sea, in *Ocean, Ice, and Atmosphere: Interactions at the Antarctic Continental Margin*, ed Jacobs & Weiss, pp. 203-214, AGU, Washington DC, 1998.