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Temporal variability of the Circumpolar Deep Water inflow onto the Ross Sea continental shelf

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ABSTRACT

The intrusion of Circumpolar Deep Water (CDW) is the primary source of heat, salt and nutrients onto Antarctica's continental shelves and plays a major role in the shelf physical and biological processes.

Different studies have analyzed the processes responsible for the transport of CDW across the Ross Sea shelf break, but until now, there are no continuous observations that investigate the timing of the intrusions. Also, few works have focused on the effect of the tides that control these intrusions.

In the Ross Sea, the CDW intrudes onto the shelf in several locations, but mostly along the troughs.

We use hydrographic observations and a mooring placed on the outer shelf in the middle of the Drygalski Trough in order to characterize the spatial and temporal variability of CDW inflow onto the shelf. Our data span from 2004 to the beginning of 2014.

In the Drygalski Trough, the CDW enters as a 150 m thick layer between 250 and 400 m, and moves upward towards the south. At the mooring location, about 50 km from the shelf break, two main CDW cores can be observed: one on the east side of the trough spreading along the west slope of Mawson Bank from about 200 m to the bottom and the other one in the central-west side from 200 m to about 350 m depth.

A signature of this lighter and relatively warm water is detected by the instruments on the mooring at bottom of the Drygalski Trough. High frequency periodic CDW intrusion at the bottom of the trough is related to the diurnal and spring/neap tidal cycles.

At lower frequency, a seasonal variability of the CDW intrusion is noticed. A strong inflow of CDW is observed every year at the end of December, while the CDW inflow is at its seasonal minimum during the beginning of the austral fall. In addition an interannual variability is also evident. A change of the CDW intrusion before and after 2010 is observed.

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1. Introduction

The exchanges of water between the open ocean and the continental shelves around Antarctica play a key role in the global ocean circulation, biogeochemical cycling of carbon and nutrients and the mass balance of the ice sheets.

Cold and dense shelf water leaves the continental shelf in some locations (such as the Ross Sea), ventilating the abyssal oceans and participating in Antarctic Bottom Water (AABW) formation. AABW is a key component in the global thermohaline circulation (Orsi et al., 1999; Orsi and Bullister, 2002; Jacobs, 2004; Johnson, 2008).

Meanwhile, the Circumpolar Deep Water (CDW), a relatively warm and salty, low oxygenated and rich in nutrients water mass, intrudes over the shelf. The inflow of this warm water onto the Antarctic

continental shelves has a great influence on the heat, salt and nutrient budget of the coastal ocean and is a potential heat source for the ice shelf basal melt (Rignot and Jacobs, 2002; Pritchard et al., 2012). In addition, the intrusion of CDW has also an important role in AABW formation (Foster and Carmack, 1976; Nicholls et al., 2009; Whitworth and Orsi, 2006; Budillon et al., 2011).

Because of the characteristics of the bottom topography, the Western Ross Sea is believed to be a preferable site for CDW onshore intrusions (Dinniman et al., 2003; Klinck and Dinniman, 2010). In particular, they observed that CDW intrudes onto the shelf at sites where the bottom topography changes direction relative to the slope flow.

CDW enters over the shelf near the shelf break and mixes with the Antarctic Slope Front (ASF), a strong, variable boundary between open sea and shelf waters (Jacobs and Giulivi, 2010), characterized by a cold, fresh, V-shaped westward current (Gill, 1973).

The mixing of CDW with the Antarctic slope current and the shelf waters over the slope and outer shelf forms a different water mass

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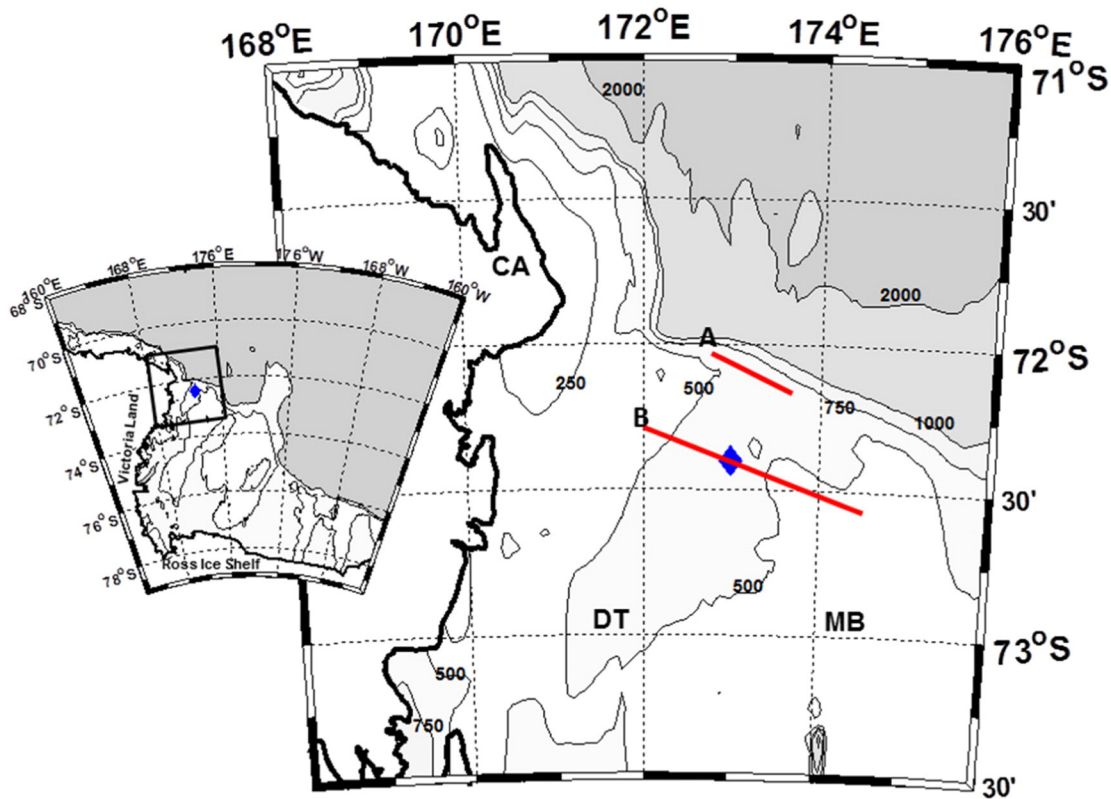


Fig. 1. Map of the western Ross Sea with bottom topography in meters. The transects A and B discussed in the text are shown by the red lines. The blue diamond indicates the mooring position. Locations of geographic features discussed in the text are also indicated: Cape Adare (CA), Drygalski Trough (DT) and Mawson Bank (MB). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

found on the continental shelf defined as modified Circumpolar Deep Water (mCDW).

The most energetic processes that help the intrusion of CDW over the shelf and contribute to the formation of mCDW through mixing are the tides (Whitworth and Orsi, 2006; Padman et al., 2009). The tidal currents in the Ross Sea are predominantly diurnal and essentially barotropic (Robertson, 2005; Muench et al., 2009; Padman et al., 2009). At the shelf break, the tidal currents are associated principally with

diurnal topographically trapped waves (Robertson, 2005; Padman et al., 2009).

Different studies have focused their attention on the inflow of the CDW onto the Ross Sea continental shelf (Budillon et al., 2003; Dinniman et al., 2003; Klinck and Dinniman, 2010; Dinniman et al., 2011; Kohut et al., 2013), but there are no works (using both observational and model data) that we know of that have investigated the seasonal and interannual variability of this inflow.

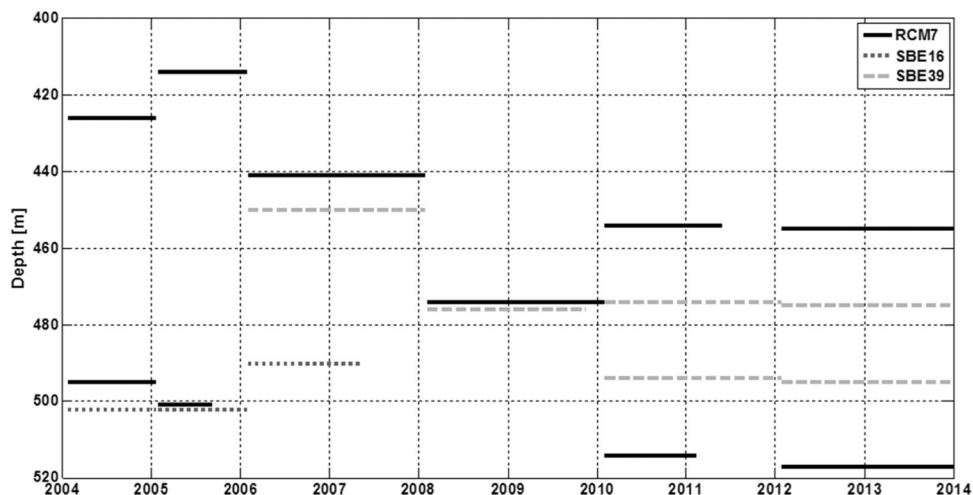


Fig. 2. Operation periods for the mooring deployed in the middle of the Drygalski Trough discussed in the text. The different gray lines indicate the instrument type (see legend, upper right).

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