ICE SHELF WATER EPISODIC OUTFLOW IN THE ROSS SEA

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Introduction

The deep circulation in the world is driven by dense water formation at high latitudes. The Weddell Sea is thought to be the most important source but the Ross Sea seems to have a crucial relevance in the circulation of the Southern Ocean.
In particular the Ross Sea is the formation site of two important shelf waters which constitute an important fraction of the Antarctic Bottom Water (AABW): the High Salinity Shelf Water (HSSW) characterized by salinity values ranging from 34.75 and 34.85 and the Ice Shelf Water (ISW) characterized by temperature below the surface freezing point.
This dense waters, accumulated on the shallow continental shelves, migrate to the shelf break, and after interacted with the Modified Circumpolar Deep Water (MCDW), spill-over the shelf edge and descend the continental slope with different dynamics (gravity, currents, along slope…….).
The down slope mechanisms are important for ocean-continental shelf exchanges and in particular for the export of organic carbon, suspended material and dissolved gasses such as oxygen, responsible for the ventilation of the deep ocean.
In this work we present some analysis of current meter and hydrographic data collected in the Glomar-Challenger Basin, where downflow phenomena occur (Bergamasco et al., 2002), in the framework of the Italian CLIMA project devoted to study the dynamic of the Ross Sea.

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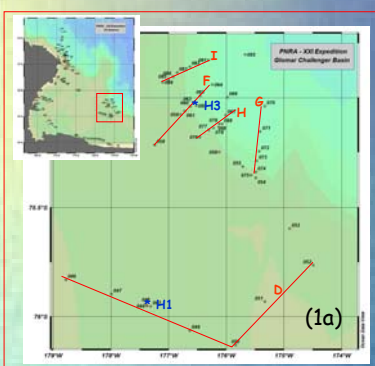

Figure 1
(a) Hydrographic casts and mooring positions in the Glomar-Challenger Basin (Central Ross Sea).
(b) H3 mooring composition on 2005.

The data set

The Italian research vessel ITALICA operated in the Ross Sea from January to February 2006 collecting hydrographic data as well as recovering and re-deploying moorings.
In this work we analyze the hydrographic data (Figure 1a) collected in the Glomar- Challenger Basin shelf break and the time series acquired by mooring H3 [Figure 1a] by means of two current meters (Aanderaa RCM9).
In addition to the standard CTD data, Lowered Acoustic Doppler Current Profiler (LADCP) measurements were performed using two RDI - Workhorse 300 kHz (up and down looking) powered by a lead-acid rechargeable battery packs by Deep Sea Power and Light.

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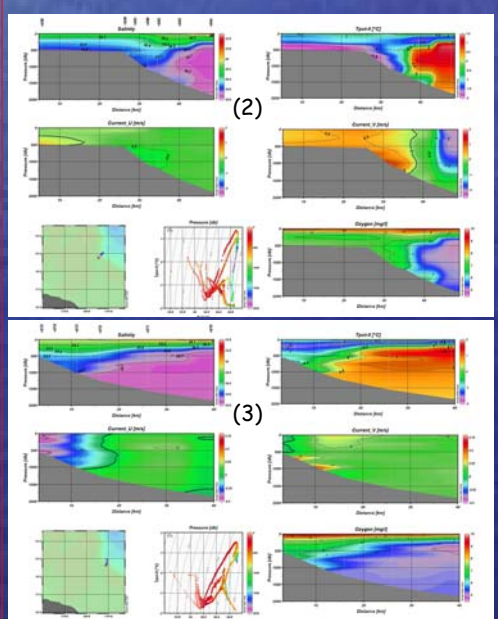

Figure 2 - Vertical section at the Glomar Challenger Trough
Figure 3 - Vertical section eastward of the Glomar Challenger Trough

The Glomar-Challenger outflow

We present the hydrographic results by means of vertical section of Salinity, Potential Temperature, South-North and West-East components (from LADCP), and dissolved oxygen.
The cross-slope section [F, Figure 1a] performed in this area [Figure 2] shows the behavior of the shelf-slope front as the continental margins executes its abrupt turn. Water mass characteristics and the LADCP data indicate that there are significant downslope components of cold shelf water from Glomar-Challenger, showing a very active spill of relatively high salinities, cold and supercold temperatures and remarkably undiluted high oxygen levels. In correspondence of station 60, a core of supercold water appears to follow the bathymetry deeper than 1000 m to northwest with speeds of up to 1.5 m s^{-1}. CLIMA IV mooring "H3" was locate close cast #62 which shows a similar behavior. Moreover at cast #63 (1481 m) a cold, oxygenated and relatively salty layer close to the bottom moves rapidly westward (U = 0.5 m s^{-1}).
An eastern section [G, Figure 1a] crossed the slope just east of the Glomar-Challenger trough [Figure 3]. We found a cold oxygen rich sheet and relatively salty water flowing to the northwest with speeds of about 0.8 m s^{-1} at 1000 m depth (cast #73). The density of such flow appear not be dense enough to finally become Antarctic Bottom Water confirming the key role of the Glomar-Challenger.

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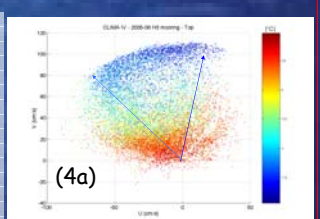
Mooring H3

It was deployed on January 31, 2005 within the CLIMA IV project over the shelf break at 1400 m depth near the date line a 75° S along a possible path followed by the plume of ISW. ISW is a water mass characterized by a potential temperature below the surface freezing point being formed by the melting with the Ross Ice Shelf.
Here we used all available current meter records from the H3 mooring constituted by two Aanderaa RCM 7 (1344 m and 1392 m depth) in order to study downslope events.
The bottom current meter placed (about 8 m from the bottom) measured a mean flow of U = -11.7 cm s^{-1} V = +42.3 cm s^{-1} which roughly matches with the bathymetry orientation as expected. The mean temperature for the arctic range sensor was T = -0.592 °C and T = -0.601 °C for the standard sensor.
The scatter plots of Figure 4 show an evident relationship between the current speed and temperature, in particular the lowest temperature are related with the strong energetic periods while the warm temperature are found during slow flow.
The top current meter placed (about 77 m from the bottom) measured a mean flow of U = -20,7 cm s^{-1} V = +44.2 cm s^{-1} which also roughly matches with the bathymetry orientation. The mean temperature was T = -0.337 °C for the standard sensor.



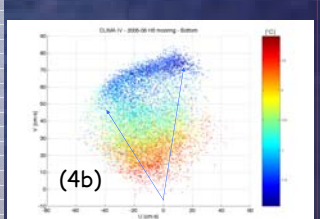


Figure 4 – Scatter plots for the upper (77 m from the bottom, 4a) and deeper (10 m from the bottom, 4b) currentmeters of mooring H3

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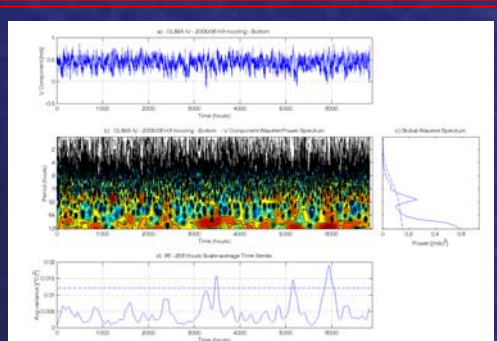
Wavelet analysis

A cross wavelet transform (Grinsted et al., 2004) is used to explore the relationship in time-frequency space for the current time series collected at 8 m over the bottom.
The wavelet techniques is a powerful tool for such studies because it expand time series into time-frequency space and allow to find localized events with intermittent periodicities.
In this first analysis we used the data coming from the bottom currentmeter after filtered using the T-tide routines (Pawlowich et al., 2002) in order to eliminate the variability due to the astronomical forcing.



In figure 5 is reported the wavelet analysis applied to the V component (south-north) which is more representative of downflow phenomena. The time series start on January 31, 2005 and ended 285 days later.
Despite the filtering of the astronomical tides, some picks of energy at about 24 h period are still detectable. Moreover some episodic and energetic events happen with a period of 3÷5 days in several periods of the time series. A more careful analysis will be necessary to understand the origin and the meaning of such periodicities.

Figure 5 – Panel a) shows the analyzed signal (V component, south-north); panel b) shows the wavelet power spectrum; panel c) the global wavelet spectrum; panel d) the 36-256 hours (pass-band) filtered signal.

References

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R.Pawlowicz, B.Beardsley, S.Lentz, 2002 "Classical tidal harmonic analysis including error estimates in MATLAB using T TIDE". Computers & Geosciences 28: 929–937.
A.Grinsted, J.C.Moore, S.Jevrejeva "Application of the cross wavelet transform and wavelet coherence to geophysical time series". Nonlinear Processes in Geophysics, 11: 561–566.