

Changes in circulation, water mass distribution and ice shelf basal melting in the Ross Sea due to the presence of large icebergs

Karen M. Assmann, David M. Holland

The southwestern Ross Sea is the formation site for the densest shelf waters on the Antarctic continental shelf due to its persistent and well-developed polynyas. High Salinity Shelf Water (HSSW) is formed in the Ross Sea Polynya north of Ross Island (Jacobs & Comiso 1989) and further north along the Victoria Land coast in the Terra Nova Bay polynya (Picco et al. 1999). The Ross Sea continental shelf is generally ice-free during summer (Gloersen 1992). This has made it the primary site for observation of the oceanic shelf processes and lead to one of the longest and most detailed observation records in the Antarctic marginal seas.

In March 2000 the iceberg B-15 broke off the eastern Ross Ice Shelf. Its largest fragment B-15A (approx. 37 x 124 km) grounded north of Ross Island in January 2001 alongside iceberg C-16 (approx. 18 x 48 km) which had grounded there 2 months earlier. Since then these icebergs have remained in their position. In the subsequent years the area of the Ross Sea polynya has been significantly reduced, with B-15A and C-16 blocking the sea ice drift in the steady southerly winds out of the McMurdo Sound region. This anomalously large summer sea ice cover and the increase of fast ice along the Victoria Land coast may have been enhanced by the presence of further fragments of B-15 and of C-19 in the western Ross Sea.

The icebergs' impact on the summer sea-ice cover and the resulting reduction of the seasonal phytoplankton bloom are relatively well-documented through the use of satellite remote sensing (Arrigo et al. 2002). The effect of its presence on the ocean is less clear. Jacobs et al. (2002) identified a decrease in HSSW salinities over the last four decades in the available data base. While this appears to originate in the inflowing water masses to the continental shelf, the smaller Ross Sea polynya area and the reduced brine release during sea-ice formation may have enhanced this negative trend. This could possibly lead to a shift of the main formation site for HSSW in the western Ross Sea to the Terra Nova Bay polynya further north and to changes in the shelf circulation.

The main inflows to the Ross Ice Shelf (RIS) cavity are located in McMurdo Sound and east of Ross Island (Locarnini 1994, Assmann et al. 2003). The circulation in both of the areas is probably affected by the presence of the large icebergs north of Ross Island. This may lead to a change in the cavity circulation and basal mass flux from the ice shelf. It may also affect, in future years, the Ice Shelf Water (ISW) outflow in the central Ross Sea.

We use a sub-ice shelf-ocean model coupled to a sea ice model is used to investigate the effect of these large icebergs on the ice-ocean system in the southwestern Ross Sea. The ocean component is a modified version of the Miami Isopycnic Coordinate Ocean Model (MICOM) (Holland & Jenkins 2001). The formulation of the sub-ice shelf-ocean interaction follows Holland & Jenkins (1999). We use a dynamic-thermodynamic sea-ice model with an elastic-viscous plastic rheology (Hunke & Dukowicz 1997). The model domain extends from 85°S to 65°S and from 160°E to 130°W, i.e., it covers the RIS cavity, the continental shelf, and a sizeable portion of the deep ocean basin. A resolution of 0.6° zonally and 0.6°cos (latitude) meridionally corresponds to approximately 13 km at the RIS front and thus sufficient to resolve local processes in the McMurdo Sound region. NCEP reanalyses are used as atmospheric forcing data. The years 1991 to 2000 serve as a 10-year spin-up period. This is followed by one model experiment that includes the icebergs north of Ross Island and a control experiment which does not. We will present preliminary results from these model simulations and draw first conclusions from their comparison.

References

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