Exchanges Across Antarctic and Arctic Circumpolar Shelf Break Fronts: Similarities, Differences and Impacts

Submitted for Consideration as an IPY Program by iAnZone, a SCOR-Affiliated Organization

The Scientific Issue

The Antarctic continent and the central basin of the Arctic Ocean are each surrounded by well defined frontal systems that coincide roughly with the continental shelf breaks and mark the boundaries between shelf-conditioned waters and the deep basins. The fronts vary in configuration from that of a simple sloping system separating shelf and slope waters to, for much of the Antarctic, a more complex system that has a V-shaped cross section normal to the bathymetry. Both polar frontal systems become indistinguishable, in places, from coastal currents or slope-trapped boundary flows. Both have been hypothesized to play significant roles in the formation and modification of dense waters that contribute to deep and bottom waters, and both likely play significant roles in the distribution of the freshwater fractions that impact in turn the vertical oceanic heat fluxes and the sea ice cover.

Though the Antarctic and Arctic circumpolar fronts share many physical characteristics and probably strongly impact their respective adjacent deep basins, there are also major differences. The Antarctic frontal system bounds a continent to the south and is open to the north, whereas the Arctic system is bounded to the south and opens into a basin to the north. The Antarctic shelves have depths of 400-500 m, while the Arctic shelves are nearly an order of magnitude shallower. Mean and tidal currents associated with the Antarctic shelves are generally more energetic than those in the Arctic, although this is not particularly well documented.

Despite considerable historical interest and a strong belief that these high latitude frontal systems play significant roles with respect to the global ocean climate, they are not well documented or quantitatively understood. Much of our current information is based on highly nonsynoptic data obtained from different regions during different years under the auspices of projects having differing goals. We have few observations adequate to assess the dynamics or seasonality of the frontal systems, or their interannual variability.

A Proposal, and Some Objectives

Significant advances in our understanding of these two great frontal systems and of their roles in the global ocean climate system will require an effort that can only be undertaken through a concentrated and well organized multinational program. A program of this magnitude would be well suited to the International Polar Year. Indeed, it would require an international committment in terms of funds and manpower that could probably only be obtained under the auspices of such a project. We advocate a bi-polar approach, and the iAnZone organization proposes to develop, jointly with an interested Arctic group, a study of the Antarctic and Arctic circumpolar fronts. Such an effort might include the following objectives:

- Dynamical understanding of coastal currents and associated slope fronts and their links to deep ocean overturning;
- Quantification of freshwater transports, including interannual fluctuations, around both polar basins;
- Determination of the sources and maintenance mechanisms for low salinity fractions;
- Assessment of the roles of circumpolar transports of heat (on and near the continental shelves) in melting sea ice and, in the Antarctic, melting ice shelves;

- Assessment of the roles of sea ice and ice shelves in determining transports, pathways and stratification of coastal and slope currents;
- Understanding the regional origins and decays of fronts, for example, the major frontal discontinuity off the West Antarctic Peninsula;
- Assessment of the degree to which shelf-break currents are adequately represented in models; and
- Determination of the quantitative importance, to coupled climate models, of these boundary current systems.

Possible Approaches

The methods and technologies needed for a study like that envisaged here exist and are readily available. Much of the requisite new field data might be obtained during routine transits with little additional effort. The global scale ocean climate models exist and undergo continual adjustment and refinement. At a minimum, repeat observations of such routine and easily-measured ocean variables as temperature, conductivity and vertical current profiles should be obtained along routes that are routinely transitted either for their scientific value or en route to resupply permanent shore facilities. Moorings can be deployed in regions of high interest, and both subsurface and ice-mounted surface drifter can be deployed to yield information on currents, ice motions, and weather patterns. Drifter results are especially informative in evaluating results from numerical model predictions that involve ocean-ice interactions. Many such models exist at present. Perturbation studies might be used to assess the impacts on the ocean of varying ice cover. The possibilities here are virtually endless.

Some Logistical Issues

A breakdown of program component according to region will be essential, since no single group can be expected to cover such large regions. Much can be done through active coordination of existing programs and of preparation of proposals for new work. Ongoing or firmly planned projects that could make strong initial contributions include:

- The NSF-funded AnSlope study of impacts of the Ross Sea shelf break front on deep water egress;
- Ongoing work by various parties on the Weddell-Scotia Confluence region;
- The NSF-funded program for study of the Arctic Freshwater Cycle, a contributor to ASOF (the Arctic-Subarctic Ocean Flux project);
- Ongoing efforts, primarily at the University of Washington and funded by ONR and NSF, to describe the Arctic Ocean circumpolar frontal system;
- The planned ISPOL winter drifting station along the western Weddell Sea boundary;
- Ongoing potential for repeat data collection along established oceanographic transects, such as that across the Weddell Sea, and along Antarctic station resupply routes.

Initial Planning

The iAnZone organization is prepared to take on the initial organization of an effort such as outlined above. Ultimately, however, many other organizations would become involved and would probably include the CLIVAR Southern Ocean Panel, IPAB (for Antarctic buoys) and IABP (for Arctic buoys), AsPECT, ASOF, SEARCH, the Arctic Ocean Sciences Board, and the Polar Research Board. Planning efforts would be initiated upon approval of the program. An initial workshop relative to an Antarctic frontal study is planned by iAnZone for autumn 2004, and this would provide a suitable venue for initiating planning of a bipolar effort.