

To: Prof Chris Rapley (Chair), Dr Robin Bell (Vice-Chair), ICSU IPY Planning Group

Re: Southern Ocean activities in the International Polar Year

The joint Southern Ocean panel of the Climate Variability and Predictability (CLIVAR) and Climate and the Cryosphere (CliC) programs discussed the International Polar Year at our meeting in September 2003. The panel strongly supported the idea of an IPY and endorsed the three themes and overall goals expressed in your open letter of 3 September 2003.

The group took the opportunity to canvas ideas for research activities to be carried out during the IPY. There was consensus that the role of the high latitude oceans in the global water cycle had sufficient scope and significance to make it an appropriate focus for the IPY. We understand the Arctic Ocean Sciences Board has also proposed such an initiative.

A draft goal for the proposed polar water balance project is to quantify the high-latitude contributions to the global water cycle, to determine the sensitivity of the polar water cycle to climate change and variability, and to identify the impact of changes in the high latitude water cycle on the rest of the globe. Here we consider the water balance to include the atmosphere (eg precipitation, evaporation and circulation), the cryosphere (eg sea ice and glacial ice), and the hydrosphere (eg ocean circulation and stratification, river run-off).

A focus on the role of the high latitude oceans in the global water cycle satisfies all of the criteria identified as high priority by the IPY Planning Group:

- The high latitude water balance is of global significance. Global climate is sensitive to changes in ocean circulation and heat transport resulting from changes in freshwater input.
- The polar regions are likely to provide early indicators of climate change. Climate models predict the Arctic will experience greater rates of warming than any other region of the Earth. The stratification of the Southern Ocean is delicately poised and sensitive to changes in the freshwater balance.
- Due to the nonlinear dependence of water vapour pressure on temperature, an increase in vigour of the hydrological cycle is one of the most robust projections of likely climate change. Limited observations suggest changes in the global water cycle may already be apparent in changes in ocean stratification.
- The water cycle is crucial to both polar regions.
- Such a program addresses all three overarching themes of the IPY: Exploration of New Frontiers, Understanding Change at the Poles, and Decoding Polar Processes
- Key uncertainties of the high latitude water balance are of such a scale that a coordinated multi-disciplinary, multi-national effort is required to address them, and so a major initiative like the IPY is essential.
- Innovative technologies are required to observe key components of the polar water balance (eg under-ice profiling and cost-effective ice thickness measurements), fueling development of an observing system that will provide a foundation for future decades of polar studies. Many of the required tools are now

under development; the IPY will provide the impetus to ensure they are brought from prototype to operational status in a timely manner.

- A focus on the high latitude water cycle will capture the interest of the public and convey the message that the polar regions play a crucial role in the Earth system. Questions like “Will the sea ice disappear, and what will happen when it goes?” provide an effective way to engage the community (and the funding agencies they support).

The time is right for a concerted effort to quantify the contributions to the high latitude water cycle and their sensitivity to change. Recent developments in technology, simulation and understanding make it now feasible to quantify the key processes involved in the polar water balance, to determine the response of the ocean to changes in freshwater forcing, and to forecast the response of the global system to changes in the water cycle at both poles.

The program will require an enhanced observation period over a full annual cycle in both polar regions. Observations of the atmosphere, ocean and cryosphere are needed. The observing system must observe variables such as the atmospheric circulation (winds, storms, evaporation, precipitation, moisture flux); the horizontal and vertical circulation of the ocean, including exchange between high and low latitude; sea ice extent, thickness and distribution; and the contribution of glacial ice to the high latitude water balance. Models will play a central role in integrating sparse observations, testing hypotheses, aiding the interpretation of observed changes and projecting future change.

While the design of the experiment requires further consultation and hard thought, the panel believes an enhanced observing system adequate to address key uncertainties in the polar water cycle is likely to include the following elements in the Southern Ocean:

- It is critical that a capacity to routinely observe the ice-covered seas is developed. Sub-ice measurement systems are likely to include a mix of moored, drifting and sea ice-based instruments, with a heavy dependence on autonomous systems. Acoustic methods are likely to play a prominent role in tracking instruments and data transmission.
- During the IPY a concerted effort should be made to quantify sea ice volume for the first time. This will require circumpolar measurements of ice thickness from gliders and AUVs, ships, moorings, drifters, and air-borne sensors, complemented by remote sensing.
- We need to be able to monitor the seasonally-varying stratification in both the open ocean and sea ice zone. Profiling floats, with acoustic tracking under the ice, are likely to play a key role.
- High quality hydrographic sections are needed to quantify transports of heat and freshwater, to estimate changes in stratification and storage of heat and freshwater from previous surveys, and to provide a baseline for assessment of future change.
- Existing numerical weather prediction models, and the flux products derived from re-analyses of these models, still have large errors and biases in high latitudes. A focused effort of enhanced atmospheric observations should be made during the IPY, both to test present models and to examine the extent to which assimilation of additional observations can improve the models. These observations should include an enhanced ice drifter array measuring atmospheric pressure, additional

automatic weather stations on the continent, more rawinsondes, and improved meteorological measurements from ships.

- We need to quantify the present input of freshwater from ice shelves and icebergs, and develop models capable of predicting changes in the melt of glacial ice in the future.

The panel, and the Southern Ocean community we represent, is excited by the prospects of the IPY. We believe the IPY provides an unprecedented opportunity to make a serious attempt to understand the role of the oceans in the high latitude water cycle, and that such a study would have far-reaching and long-lasting implications. We look forward to working with your group and others to develop an inspirational science program for the IPY.

Sincerely yours,

Dr Steve Rintoul and Dr Eberhard Fahrback (co-chairs), on behalf of the CLIVAR-CliC Southern Ocean panel.

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