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The Freshwater Balance in the Arctic

A Report from the NATO Advanced Research Workshop on
The Freshwater Budget of the Arctic Ocean
Tallinn, Estonia, April 27 to May 1, 1998

The Advanced Research Workshop (ARW) was an interdisciplinary workshop with some 50 senior researchers present from the fields of meteorology, hydrology, oceanography, cryology, climatology and modeling. The freshwater flow into the Arctic Ocean, its variation, distribution and the processes it drives has important implications to the regional and global climate. Not only is the Arctic estimated to be an important contributor to climatic processes, but models suggest it to be the region where global warming will be first detected and where the effects of global warming will be most intense. Social and economic impacts of a warmer Arctic Ocean will be highly significant to northerners. The results of the ARW will be the subject of a reference publication to be available soon, covering the present knowledge of the subject.

The Arctic Ocean Sciences Board originated the concept of a Symposium on the Freshwater Balance of the Arctic Ocean and applied successfully to the NATO Science Committee for funds. In addition to the funds from NATO, the workshop was also sponsored by SCOR, through a contribution from the USA National Science Foundation and supported by the ACSYS Project Office. The ARW was managed and co-chaired by Dr. E. L. Lewis and Dr. I. Shiklomonov.

This newsletter represents an informal report from the Past Chairman of the AOSB on Arctic Ocean priorities. It is not an official version of the outcome of the meeting.

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Atmospheric Conditions

There are significant changes in the major atmospheric patterns affecting the distribution and flow of moisture into and out of the Arctic basin. The N/S Atlantic Oscillation and the position of the Aleutian High was seen to have significant effects on the atmospheric flows over the polar region and consequent changes in the ice and ocean flows.

Priorities

1. The root causes of these system changes and the downstream impacts need to be studied
2. The coupled ocean/ice/atmosphere processes need to be better understood.
3. The estimates of precipitation and evaporation over the Arctic Ocean need to be improved

Freshwater Influx

The Arctic Ocean receives its freshwater inflow from the inputs of direct atmospheric precipitation and from run-off from catchment areas draining into the Arctic basin . The catchment area is larger than the ocean area and the Arctic Ocean receives about 10% of the total global run-off. In addition, as the Arctic warms, there is a potential contribution from glacier meltback and from a melting of permafrost. Records from the major rivers, which contribute a large percentage of the total influx, are relatively good over the last fifty years. Input over that time is remarkably stable (±10%), although the distribution among the rivers varies. On the other hand, the precipitation and evaporation rates over the ocean is poorly known as is the present glacial input and the total run-off from smaller rivers. Little data are available on permafrost melting, although this may become a significant contributor as warming trends continue. The paleo-records of river flows may shed some light on the variability and periodicity of changes in the past. Although the present regime seems relatively stable, more significant changes in the distant past may indicate possible other stable regimes.

Priorities

1. To add the Canadian data to the present river input bilateral USA/Russian data base.
2. To maintain and improve the rawinsonde data network in the polar region.
3. To obtain information on glacial and permafrost contributions.
4. To obtain paleo-records of river flows.
5. To collect data on the discharge of the numerous small rivers not presently accounted for.

Ocean Water and Sea-Ice

Surface seawater enters the Arctic Ocean through the Bering Strait and exits through the Canadian Archipelago. A major two-way exchange of seawater occurs between the Arctic Ocean and the North Atlantic between Greenland and Norway. In terms of freshwater flow, the relative salinity of the incoming and exiting waters contribute to the overall balance of the Arctic Ocean. Of these, the North Atlantic flow is the largest, is the most studied, and continues to be relatively well instrumented. However, recirculation at the entrance to the Arctic Ocean makes confident estimates difficult for both the net flows of the seawater and the freshwater component the seawater carries. Flow through the Canadian Archipelago has been less studied but is thought to be significant, especially for surface flows where most of the freshwater exchange occurs. To date, coupled hemispheric models have not incorporated this flow and some models continue to omit both the Bering Strait and the Canadian Archipelago as sites of water exchange. Inflow through the Bering Strait is due to a dynamic head between the North Pacific and North Atlantic waters which could be affected by the barometric pressure variation. It is much smaller than the Atlantic exchange but provides an important source of fresh water (the Pacific is fresher than the Atlantic) and hence has important consequences both for the stratification of the Arctic waters and for basin to basin differences within the Arctic Ocean.

The formation and melting of sea-ice in the Arctic basin does not directly contribute to the net freshwater budget but is a seasonal process that alternatively extracts and then adds freshwater to the system. However, when the salt rejected by the ice is convected deep into the water, or when the ice melting occurs in a different location from ice formation, stratification is produced. The seasonal pulse of freshwater from melting ice can affect the ocean processes controlling the outflow from the Arctic basin and freshwater budgets can be affected either from meltwater or from sea-ice transport. Therefore, the extent of sea-ice cover and the processes involved in sea-ice melting and formation are important factors in the overall freshwater balance.

Priorities

1. To study the shelf processes in the formation of sea-ice and of dense bottom water, including the importance of polynyas and leads.
2. To study the outflow of freshwater and ice through the Canadian Archipelago.
3. To use computer models to study the impact of a diminution or cut-off of the inflow of Pacific water.
4. To continue the present monitoring of the North Atlantic ocean inflow and outflow, including the export of ice.

Conclusions

The discussions at the Workshop indicated that in both the atmosphere and the ocean, episodic events are important to the freshwater balance of the Arctic. Therefore, the processes involved - whether atmospheric cyclonic disturbances bringing in large quantities of moisture into the system or the formation of deep ocean water - need to be better understood before the longer term changes can be appreciated. In terms of how the Arctic Ocean and its freshwater budget might be impacted by global change or indeed how the Arctic processes themselves contribute to the global situation, there are two issues which need understanding but have hitherto been neglected: 1.Coupling between the seasonal cycles (e.g. run-off vs. ice formation) and 2.Points of bifurcation (e.g. freshwater input from the Laptev entering the Canadian Basin or the Eurasian Basin; freshwater leaving the Canadian Archipelago vs. Fram Strait). The Arctic Ocean basin is still a data-sparse area and existing monitoring programs need to be protected. More extensive and continuous networks also need to be established. Finally, models are becoming available with finer resolution and these can be used not only for forecasting longer term trends, but also to shed light on the processes involved in the freshwater balance and to eventually replace some of the physical data networks through assimilation techniques.

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