AANDERAA DATA INSTRUMENTS

4 September, 2008

Long-Term Instrument Installations in the Polar Regions

As part of the International Polar Year project BIAC (Bipolar Atlantic Thermohaline Circulation), Aanderaa Data Instrument (AADI) was approached by the Bjerknes Centre for Climate Research in Norway to design and develop an optimal ocean observing system for dense water production on polar shelves. Monitoring the flow of dense water from its formation areas towards the abyss of the world oceans is a key issue for climate research

About BIAC

The objective of BIAC is to study the Arctic and Southern Ocean shelf ventilation processes and determine their impacts on the Bipolar Atlantic Thermohaline Circulation. Because world oceans are ventilated in the polar regions, a striking feature is that most of the water masses are cold (80% below 5ºC). The densest water masses are formed in the Antarctic, and the slightly less dense water masses above are formed either north of the Greenland-Scotland Ridge (GSR) or in the Labrador-Irminger basins, see Fig.1.

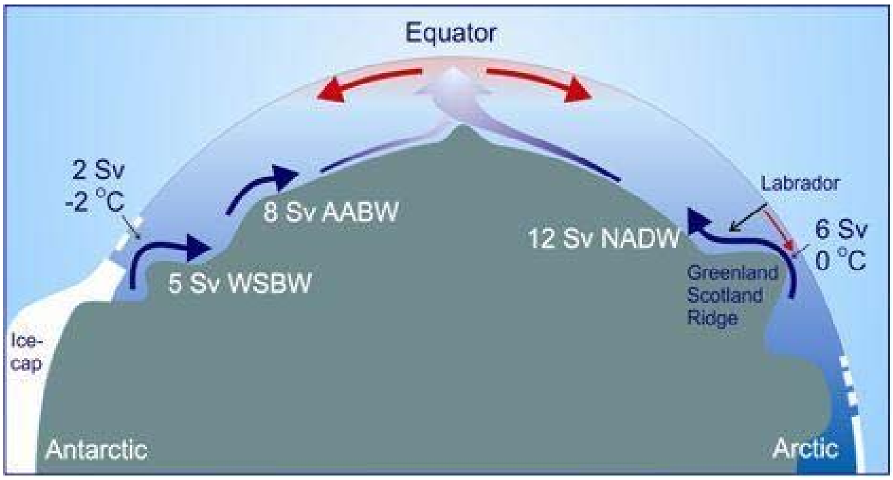

Fig.1 Illustrating the Atlantic Bipolar Thermohaline Circulation

Dense, High Salinity Shelf Water (HSSW) masses form along the Arctic and Antarctic shelves through freezing of sea ice. The High Salinity Shelf Water cascade off the continental shelves is crucial for the global ocean circulation and climate and is a major control on deep water biogeochemistry. As the direct link between the atmosphere and the intermediate and deep oceans, the rate of deep water formation controls the oxygenation of the deep ocean and regulates the response time of the ocean to changing concentrations of CO_2 and other gases in the atmosphere. The large-scale circulation, hydrography, forcing conditions and dominant mixing mechanisms preconditioning the shelf waters for dense water production must be well-understood to obtain accurate estimates of deep water formation. The mixing which occurs during the cascading process leads to irreversible modifications in the water mass properties further downstream from the production sites. These end products are fundamental in determining the carbon and nutrient fluxes to the deep ocean, and for shelf-deep water exchange in general.

The water masses formed on the polar continental shelves contribute to the deepest branches of the global Thermohaline Circulation and fill the abyss. The Antarctic Bottom Water (AABW) is denser than the northern component North Atlantic Deep Water (NADW) for two reasons. Firstly, the sill between the main formation area in the Weddell Sea and the Atlantic is as deep as 3000m, while the deepest connection between Arctic and the Atlantic Ocean is only 800m. Secondly, in the Antarctic there are giant floating ice shelves, below which the water masses become super-cooled (T<-1.9°C) Ice Shelf Water (ISW). The Antarctic Bottom Water resides below the Atlantic Deep Water where the two water masses meet (Fig.1). The production rates of Atlantic Deep Water and North Atlantic Deep Water (NADW) are believed to be respectively about 8 Sv and 12Sv, but even such important quantities are still much disputed. The densest source of North Atlantic Deep Water is now probably found within the Arctic Ocean, where the shelf processes described here are of fundamental importance and thus a key component in the climate system. The role of the last decades' large-scale changes in the hydrographic properties of the North Atlantic-Arctic Mediterranean in the Thermohaline Circulation is not well understood. Although there are indications of a recent slow-down of the deep branch of the Thermohaline Circulation, this is not observed in the compensating northward flow of Atlantic Water via the North Atlantic Current.

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Two key study areas are identified; The **Barents Sea** and the **southern Weddell Sea**, Fig. 2.

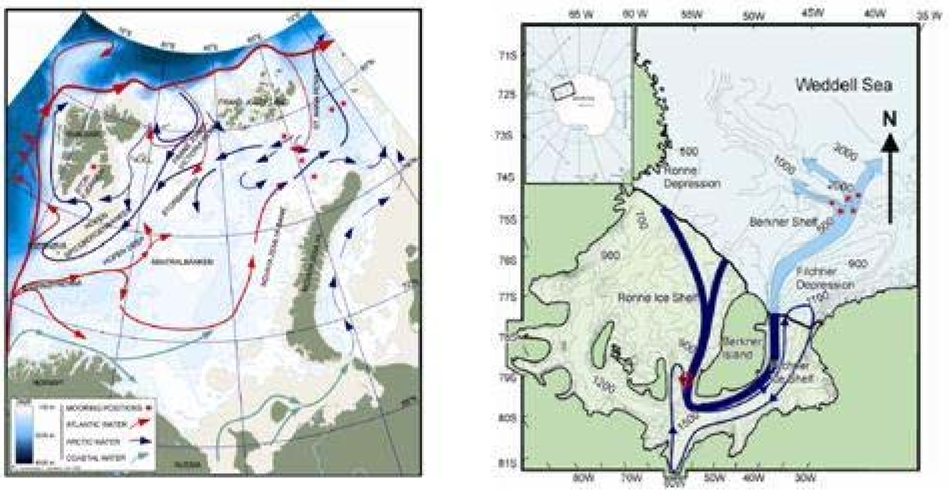

Fig.2. (left) Study areas in the Arctic are focused on Storfjorden and the eastern Barents Sea between Novaja Zemlja and Franz Josef Land including the St. Anna Trough. (right) The main study area in the Weddell Sea is concentrated along the path of the Ice Shelf Water. Approximate mooring positions are indicated by (*). The long term monitoring position on the ice shelf south of Berkner Island is marked by a circle.

In the shallow Barents Sea, warm, saline Atlantic water enters in the west. On its way eastwards to the strait between Franz Josef Land and Novaya Zemlya, the Barents Sea Exit (BSX), the water is effectively cooled. During winter there is vigorous ice formation in the North and East Barents Sea, and our hypothesis is that the around 2Sv of dense water entering the Arctic Ocean via Barents Sea Exit contributes significantly to the Greenland-Scotland Ridge overflow.

In the Weddell Sea, formation of High Salinity Shelf Water takes place on the Ronne shelf. Underneath the floating Filchner-Ronne ice shelf the High Salinity Shelf Water is transformed to Ice Shelf Water. About 2Sv of Ice Shelf Water cascades towards the deep Weddell Sea as a dense bottom plume, and its fate in connection with the formation of the Weddell Sea Bottom Water, and finally Antarctic Bottom Water, are key issues.

AADI plays a significant role in the BIAC study

AADI has had a long lasting cooperation with both the Geophysical Institute at the University of Bergen, and the Bjerknes Centre for Climate Research in Norway. This, in combination with our well-known history of producing reliable and long lasting solutions and products of high quality, are the main reason for being approached by the Institute in 2006. For the BIAC project, AADI was asked to design a sustainable monitoring system for dense water production on the polar shelves.

This observation system, consisting of in-situ stations with self contained instruments supported by ship- and space-borne measurements, will provide accurate time series of mass, heat and salt fluxes at key locations, allowing us to assess the strength of the Bipolar Atlantic Thermohaline Circulation. The stations (moorings) have been constructed with the intention to be serviced at ~5 years intervals. The result is low costs, and the goal is to have the stations operative for several decades. One mooring rig will replace the already existing monitoring station for the Ice Shelf Water overflow in the southern Weddell Sea. One station will be moored near the St. Anna trough, Barents Sea, where the year to year variability in the dense water bottom plume will be monitored. See fig. 3.

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Fig.3 Illustrating the mooring rig system being deployed

The Mooring Rig Systems

Years of field experience has lead Aanderaa Data Instruments to produce products with very low power consumption, minimizing the amount of batteries required. The AADI bottom mooring frames are constructed for measurements of currents and other environmental parameters in the BIAC project. The mooring rig has a titanium frame and is equipped with two autonomous sampling systems, both collecting temperature, conductivity, and dissolved oxygen. In addition, one system has an acoustic current profiler (RDCP 600), and one has a pressure sensor. Both systems will be connected to the same acoustic modem that will handle data transfer to the surface, while data is also stored on SD flash cards – both internally in the instrument itself, as well as inside the modem. This has been done in order to secure that data will not be lost should something unforeseen occur.

The acoustic modem is designed for up to five years of operation, and data can be retrieved from depths down to 1000m by research-vessels or ships of opportunity via acoustic communication. The acoustic modem and the batteries are built into deep sea glass spheres. This is not only a cost-efficient solution, but also a creative and safe solution for the customer. The glass spheres have properties which make them perfectly destined for deep-sea use. It's corrosion resistance, it's lightness, it's chemical, electrical and magnetic inertness and it's optical qualities add up to a valuable combination. See fig.4.

Fig.4 Illustrating the deep sea glass spheres housing batteries and modem

The spears used on the mooring rig system are used both as floats and as instrument housings. Five of the spheres are used for buoyancy to the surface after the acoustic release has been activated, and the other three spheres are used to house the modem as well as the batteries. From the spheres used as housing, there are cables connected to an external transducer sending data to the surface.

Testing and Deployment of the Mooring Rig

The first mooring rig has been tested in Fanafjorden, just outside Bergen, Norway. The BIAC system was deployed at 226 meters depth for one month during this summer. The data transfer test proved that the technology works and high quality data are being transferred. After the one month testing period in the fjords of Norway, the first station is planned transported to the southern Weddell Sea where it will be deployed during the first quarter of 2009.

BIAC will thus investigate relationships between variability in deep-water formation, CO2 uptake rates and large scale natural and anthropogenic climate forcing. AADI is both honoured and proud to be part of this very exciting as well as important project, and we are looking forward to follow closely the new developments and the results which the BIAC project will provide us with. We are confident that our technology and creative solutions will prove themselves in the demanding environment we face in the polar regions, and provide us with data needed to investigate further the effects the Bipolar Atlantic Thermohaline Circulation has on climate change.