THE CENTRAL IRMINGER SEA OBSERVATORY

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1. INTRODUCTION

Deep water formation is a key process for the global overturning circulation. The Irminger Sea is one of the few deep water formation areas in the North Atlantic. Here, deep water formation has found to be intermittent in time and space depending on local and large scale oceanic and atmospheric conditions. Scientific interest is in understanding what controls the convection activity in the Irminger Sea and if and how the convection contributes to the “Labrador Sea Water” density range formed further southwest, in the Labrador Sea and which is a major contributor to the North Atlantic Deep Water formation. In addition it is the interplay between physical, biological and chemical processes which is also of great scientific interest as the Irminger Sea is one of the few open ocean regions where surface nitrate concentrations never get depleted. It was for this reasons that the CIS observatory was established in 2002 and designed to allow observing physical, biological, and chemical processes in a deep water formation region.

Environmental conditions in deep water formation areas are often exceptional harsh and in particular measurements at or near the surface require specific observatory design. Our design efforts for the Irminger Sea observatory and selected scientific highlights will be described in the following.

2. OBSERVATORY DESIGN AND LOGISTICS ACHIEVEMENTS

The backbone of the observatory since 2005 is a single steel wire mooring which hosts all instrumentation as well as the surface telemetry buoy. Before 2005 two moorings have been installed at the site, one subsurface mooring with an ADCP, a sediment trap as well as some deep current meters, and one surface mooring with T/C/P recorder (Microcats) and a surface telemetry system. The merge of the two moorings into a single one was for cost and logistic reasons.

The instrumentation installed at the mooring is distributed as such that deep convection events down to a depth of 1500m can be monitored (see Figure 1). At a depth of nominal 40m, which is assumed to be within the mixed layer even during the summer months, a dedicated biogeochemical sensor frame is installed. The frame, with an overall length of 2.5m, was designed and build at IFM-GEOMAR from a 32” Floatation technology buoy and a cage made out of 1.4539 submarine steel. A variety of instrumentation can be mounted on a central rod using custom made Delrin clamps. So far SAMI pCO2 sensor, NAS 2/3X Nitrate sensor, Wetalbs FLNTUSB Chlorophyll/Fluoresesnce, Optode oxygen logger, MicroCat, and inductive coupler have been mounted to the frame. All instruments that are installed at the observatory record data autonomously while for most instruments a real-time data communication ,via inductive connectors (based on SeaBird IMM), has been installed.

The telemetry system is designed using ARGOS DCS. Particular harsh environmental conditions required a special surface telemetry mooring design and we decided to use a lightweight (40kg) and small (17”) design. No meteorological sensors are installed at the surface buoy. This is for space and energy reasons and to avoid damage of the sensors during periods of intermittent mooring knock-down, associated with the passage of eddies. The knock-down events can move instrumentation to several hundred meters below their nominal depth. The mooring wire is about 240m longer than the water depth (2780m) and there is a slack connection between biogeochemcial sensor frame and the surface telemetry buoy. This constructions allows the telemetry buoy to easily move in all directions but without putting too much drag on the subsurface part of the mooring. To avoid distort in the wire, e.g. from period changes in ocean currents, up to 4 swivels are installed in the upper 1000m. These swivels are conductive to allow for the inductive data transfer.

Real time data is received via ARGOS at the EuroSITES Data Assembly Centre (DAC) at NOC, Southampton, UK. Automatic plausibility checks are done and associated flags are allocated. Time series plots are automatically prepared and posted (http://www.eurosites.info/cis/data.php). The data is also copied to an FTP site at NOC Southampton and automatically retrieved from the global data assembly centre (GDAC) Coriolis, Brest, France. Coriolis manages the further distribution of the data (e.g. as an OceanSITES site). The delayed mode data is typically quality controlled within one year after recovery of the instrumentation and again provided in draft OceanSITES CF format and made public available via DAC and GDAC.

3. SELECTED SCIENTIFIC ACHIEVEMENTS

3.1. Physical forcing and deep convection

In understanding the controlling processes on deep convection in the Irminger Sea specific attention was given to processes in the near surface layer and in particular to the role of freshwater fluxes. At the mooring site convection never exceed 600m since 2002 (Figure 1) while deepest convection took place in the winter month of 2008 and 2009. These deeper convection events are associated with comparably high salinity in the mixed layer confirming the results from an earlier study which found that buoyancy fluxes through heat loss would have been sufficient in some years to drive convection to greater depth than those observed. Low salinity water typically enters the region at the end of the summer when heat loss starts to drive overturning.

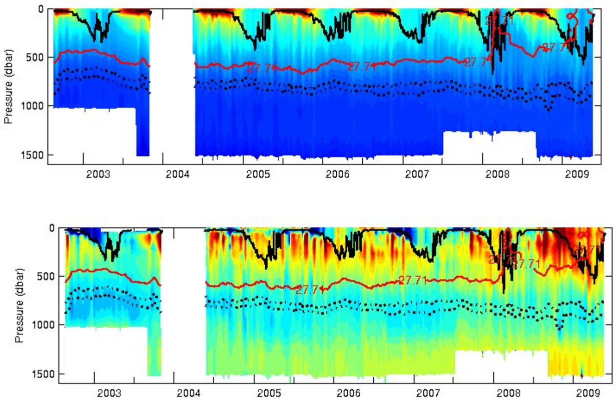

Figure 1: temporal evolution of the upper layer temperature (upper panel) and salinity (lower panel) at the Central Irminger Sea observatory site. The thick black line gives is an estimate of the mixed layer depth, the broken line the depth of the Upper Labrador Sea Water density range, the red line indicates the density of locally ventilated Irminger Sea Water (sigma Theat = 27.71 kg/m³). White areas indicate "no data". Note the increase in mixed layer salinity in 2008 and 2009 and associated deeper convection.

3.2. Nitrate concentration in the mixed layer

Surface waters in the subpolar gyre are over large parts not depleted in nitrate which is also true for the CIS site Nitrate time series from the CIS observatory obtained at nominal 40m depth (Figure 2) show a pronounced seasonal cycle with highest concentrations by the end of the winter season associated with the entrainment of nitrate rich waters from below. Of specific interest is the interannual variability in winter time nitrate concentrations. This variability shows a good correlation with temperature variability at 10m depth and this suggests that overturning intensity, hence upwelling, is an important process in controlling the surface nitrate concentration.

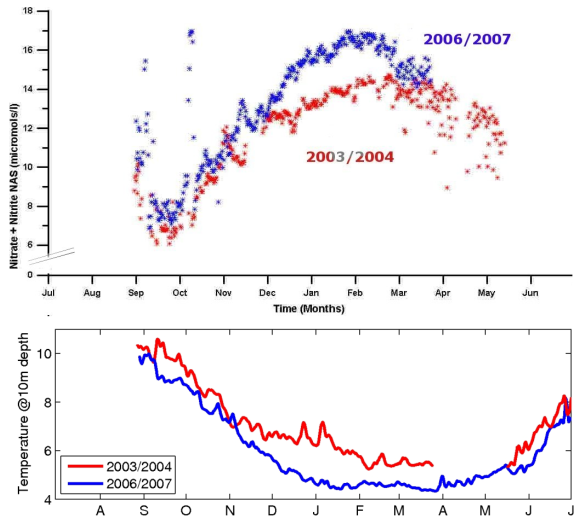

Figure 2: Temporal evolution of the mixed layer nitrate concentration (upper panel) for the years 2003/2004 (red) and 2006/2007 (blue). Note the difference in surface nitrate during the winter month. Scale starts with 8µmol/l. The temperature at 10m depth (lower panel) also indicates the difference in convection activity – warmer water, less intense convection and lower nitrate values in 2003/2004 and the contrary for 2006/2007.

4. FUTURE PERSPECTIVE

In the past decade the Irminger Sea has attracted several groups from the US, Netherlands, Germany to set up long term observatories. Nevertheless the CIS observatory is the only one that reaches up to the surface and concentrates on biogeochemcial/physical interaction. In addition it is the only observatory with real-time data access.

The Ocean Observatories Initiative (OOI) of theOcean Leadership will install one of their global nodes in the Irminger Sea. Installation is planned for summer 2014. This installation comprises a total of four moorings: one surface mooring with a full suite of meteorological sensors, one moored profiler mooring, and two subsurface moorings. This node is planned to be operational over two