Long-term Oceanographic Mooring Measurements in Arctic Regions

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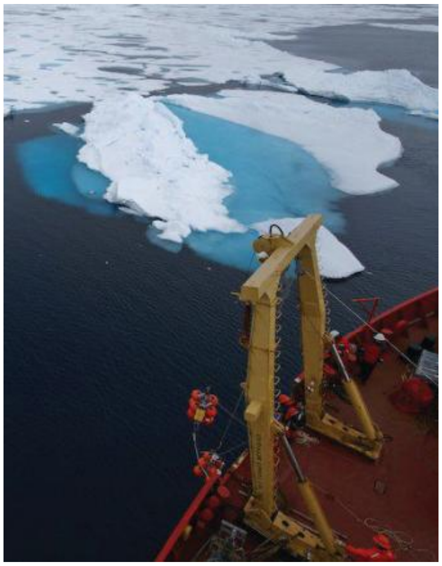

Figure 1: Deployment of an Arctic oceanographic mooring in the Beaufort Sea of the Arctic Ocean (Photo Credit: M. Fortier, ArcticNet)

The need for studies of the oceanography and sea ice of the Arctic Ocean and its adjoining seas has greatly increased over recent decades, driven by the rapid transition underway in this region. Better understandings of Arctic oceanography and sea ice are required to address present deficiencies in our knowledge of the Arctic Climate System which is important far beyond the Arctic. Measurement programs in support of these scientific studies as well as for economic development activities and the usage of the Arctic marine areas by its indigenous peoples, requires oceanographic and sea ice measurement campaigns in this remote and challenging environment which has received little attention by comparison to other marine areas of the world.

Based on our experience with Arctic oceanographic and sea ice studies spanning more than 40 years, we present some of the best practices that we and others have developed to conduct successful measurement programs. Arctic oceanographic studies are hampered by the remoteness of the region, lack of infrastructure, brief open-water season and the frigid working conditions which occur even during the times of reduced sea ice cover. As a result, the logistics costs for ocean research greatly increase and the ship-based methods to deploy, and especially to recover the moorings, are more demanding from those of other areas. Modified procedures are required especially when sea ice is present (Figure 1).

Instrument Power Considerations under Restricted Access for Long Periods

Instruments on subsurface moorings are typically required to operate for a year between servicing, which can then be extended to two or more years if heavy sea ice presence precludes recovery when the ship returns. These working conditions require instruments that offer robust and reliable data collection over long time periods. Purpose-built instruments developed for Arctic regions address these requirements by offering reduced power consumption and/or increased power capacity from their battery systems. Examples of such instruments include the Ice Profiling Sonar™ (IPS) developed by ASL Environmental Sciences Inc. and the Canadian Institute of Ocean Sciences. An IPS can operate remotely over periods of 1-3 years and provide continuous, very accurate measurements of the underwater ice thickness and ocean waves directly above the instrument at sampling rates of 0.5 – 4 seconds. These instruments are programmed to sample at different sampling rates for different times of the year, e.g. at fast sampling rates during the brief periods of low ice concentrations when surface waves are present and at lower sampling rates in winter under conditions of slow-moving highly concentrated sea ice.

Another adaptation to address power issues is the provision of additional power capacity. This can be done through the use of extended or external battery systems. An alternative approach is to use higher energy density battery systems such as lithium primary cells but this approach can be hampered if the instruments and batteries need to be shipped by aircraft, due to shipping restrictions on lithium power systems.

Operation of Compass Sensors in Reduced Geomagnetic Fields

Magnetic compasses in current meters depend on the horizontal component of the earth's magnetic field to determine directions. At the equator the magnetic field is largely in the horizontal plane and a magnetic compass works well. At higher latitudes, the earth's magnetic field dips downward, until at the magnetic north pole the horizontal component is negligible (Figure 2). As a result, the directional accuracy of these instruments is degraded in Arctic regions, especially in the western Arctic where the magnetic north pole is presently located.

Compass accuracy is improved in Arctic Regions by calibrating locally

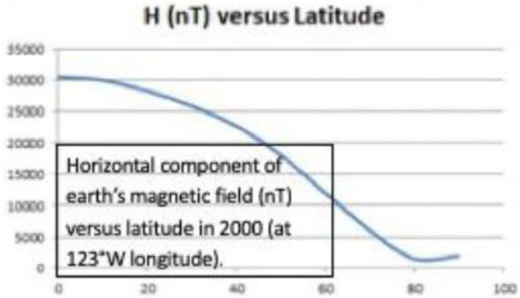

Figure 2: A map of the changing location of the magnetic north pole, along with the horizontal component of the earth's magnetic field along the 123rd west meridion showing the large reduction in the Beaufort Sea by at least a factor of 5 from the values in temperate latitudes.

rather than at facilities where they are manufactured or maintained. The calibration must be conducted away from any magnetic influences such as ships, metal pilings, concrete pads containing rebar, buried metal or other magnetized materials. Usually a coastal location is selected near the study region (Figure 3). Battery packs can become magnetized during their manufacture and subsequently during shipment. Ideally, these battery packs are magnetically degaussed prior to installation. ASL technicians test the magnetic signature of each battery pack after degaussing and only low signature batteries are used. During the deployment, use of non-magnetic mooring frame components such as aluminum and type 316 stainless steel is prudent.

By using the measures described above combined with post-processing methods, current meters can provide accurate directions to within about 5° or better at locations where the horizontal component of the earth's magnetic field is above 3,000 nanotesla (nT). Without these mitigation measures, the directional measurements would be much less accurate and seriously degrade the value of the measured ocean currents and ice velocities.

Reduction in Acoustic Backscattering Levels through the Arctic Winter

Another issue for accurate acoustic oceanographic measurements is the marked reduction in natural acoustic backscatter levels within the water column during the Arctic winter under the presence of sea ice and snow cover at the surface. These conditions result in a reduction of zooplankton which reduces the acoustic backscatter levels which ADCP instruments require. The net effect is to reduce the range over which acoustic Doppler-current measurements can be achieved, by as much as 30 percent or more. Awareness of this limitation is required in preparing the measurement plan for year-long Arctic measurement campaigns through either changing the settings used for the ADCP instrument or changing the locations of the instruments on the mooring to avoid data gaps in the ocean current profiles.

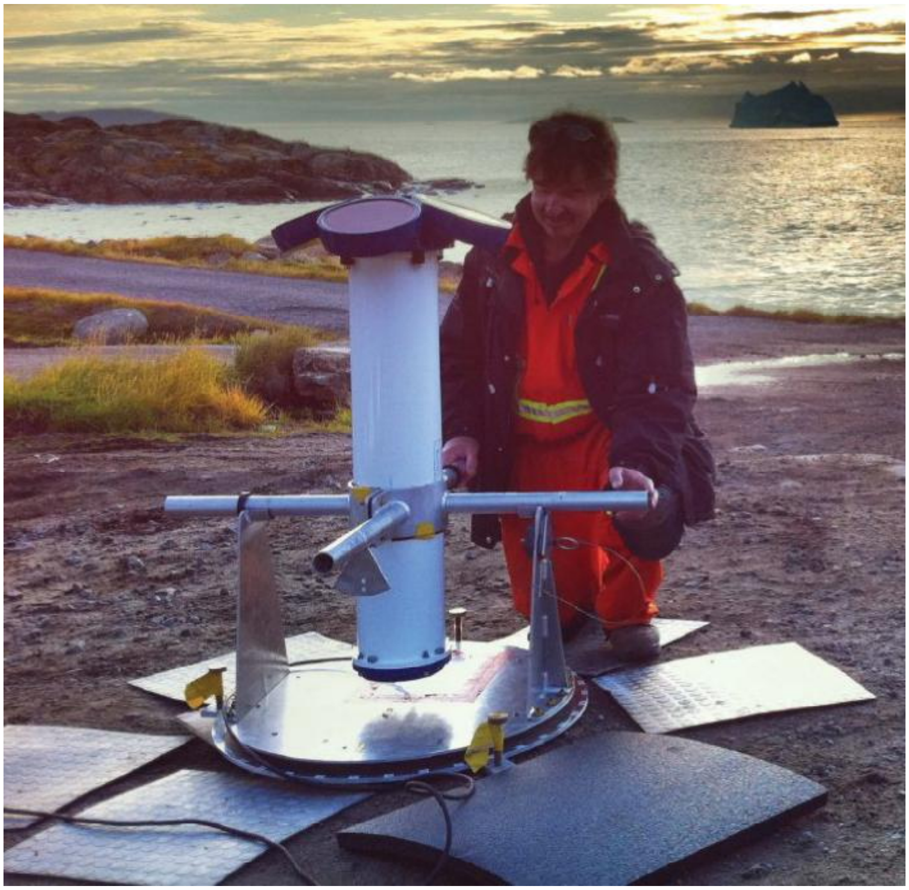

Figure 3: Operation of a non-magnetic calibration system used for the compass calibration of a Long Ranger Acoustic Doppler Current Profiler (ADCP) in west Greenland off Baffin Bay.