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From Pole to Pole

Last week we visited the geographical North Pole; this week we passed the magnetic South Pole that is currently situated north of Canada at about 84°N. While the first one was celebrated with champagne, a feast and a sunny ice station, the latter was passed quietly during night without much consideration. Nonetheless, this second pole causes considerable headaches and frowning because it disturbs several of our measurements – namely those that depend on compass reading. This includes any kind of velocity measurement that uses direction, such as our remotely operated underwater vehicle “Alfred” with which we observe the underside of the sea ice.

Looking from above, the Arctic packice appears as a large white area that is secondarily structured with leads of open water and ridges of compressed ice. Generally, this white area reflects about 90% of the incoming solar radiation (i.e., sea ice has a fairly high albedo). In contrast, open water reflects only 7% and absorbs most of the sun’s incoming energy.

So what happens with that small part of the insolation that is not reflected by sea ice? How much of it is used to warm or melt snow and ice? How much light reaches the lowest ice layers and the uppermost water levels to be used by organisms as the energy source for photosynthesis? How is the color spectrum of light changing in addition to its total quantity as it moves from the atmosphere to the ocean?

The intensity of light below the ice depends foremost of the amount and properties of the snow, but also from the properties of the sea ice itself. Of course the ice thickness plays a role – particularly now in summer when much of the snow is melted. Consequently, the magnitude and color of the under ice light can vary considerably with the ice’s properties within as little as several meters. Melt ponds and leads act almost as “skylights into the ocean” through the roof of sea-ice.

Although radiation measurements are the backbone for addressing these physical and biological questions about light and ice, so far very few field studies have been conducted. The main reason for this void is that even single point measurements below the ice are much more sophisticated and laborious than surface or open ocean radiometry. Observations covering a significant spatial range are completely absent.

The sea ice physics group wants to fill this gap with their work on board. During each ice station, the group establishes a camp to measure short wave radiation above and below a representative part of the ice flow. Below the ice they use “Alfred” a tethered Remotely Operated Vehicle (ROV). Equipped with light sensors for different colors (spectral radiometers), Alfred is operated through a hole in the ice, often through an open-bottomed melt pond. Two pilots operate the ROV from a nearby tent. They navigate Alfred using video cameras and sonar reflections as they survey the light climate. Two other scientists manage the 300 m long cable entering the melt-pond, and watch out for polar bears. Before and after the dives, numerous additional parameters are measured and samples are



The ROV is lowered into a melt pond. In the background the „operation center“ tent is visible, as well as the tripod holding the reference sensor (Photo: S. Hendricks)



ROV pilots during a mission. Christian (foreground) maneuvers the ROV, Priska (background) controls the sensors and takes notes of the profile. (Photo: M. Nicolaus)



ROV Alfred prior to a dive at the North Pole in front of a refrozen melt pond and multiyear sea ice. (Photo: M. Nicolaus)

taken. Their analysis will finally allow derivation of the relations between ice properties and light transmission.

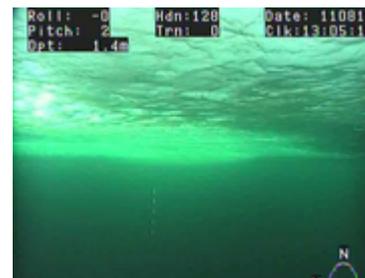
Up until the North Pole, everything was working fine and the first-ever missions in the Arctic brought observations under a multitude of ice types. Normally, the ice physicists operate the ROV at 1.5 to 5 m below the ice, but occasionally they send it down to 50 m depth to find out how fast the light disappears. Alfred has dove below deep pressure ridges, and registered the light conditions below many melt ponds. In addition, the video camera has captured many interesting features of the under-ice world, among them taking an unusual view of the instrumentation lowered by colleagues from other sites of the flow.

Getting closer to the magnetic South Pole, navigation became more and more difficult because it relies on Alfred's magnetic compass. Compasses use the horizontal component of the magnetic field, but near the pole the field lines are oriented more vertically. Alfred, losing more and more its orientation, started swaggering; one could say Alfred became dizzy and in such condition nobody can work properly.

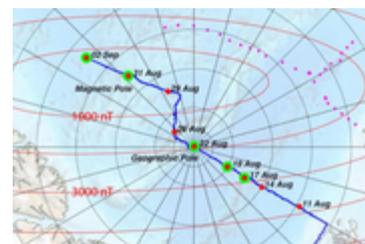
Our sea ice physicists are trying hard to develop alternative strategies to continue sampling light below sea ice close to the pole. Better results emerged on Friday at the southeastern most station in the Canada Basin. There we made a sharp turn, and we are now heading for the Russian drifting station NP38. We plan to visit the Russian station take over material and our polar research colleagues. On our way, we will pass the third pole of our cruise, the "pole of inaccessibility" which is furthest away from any coast.

Best regards from all of us,

Ursula Schauer and Marcel Nicolaus (describing the ROV observations)



Under-water view of the ROV traveling under level sea ice. The light patch in the background indicates a melt pond. The marker is 1 m long, the stripes are 10 cm long. (Photo: AWI Sea ice physics group)



Horizontal intensity of the magnetic field strength (red lines, source: NOAA/NGDC & CIRES, www.ngdc.noaa.gov/geomag/WMM). Red dots: ice stations during TransArc; green circles: ROV missions; pink dots: planned stations; blue line: cruise track of Polarstern. (Graphics: M. Nicolaus)