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During the past week the research programme has led us from the dense interior pack ice back to the sea ice margin, where we conducted a final oceanographic section between Joinville Island and Elephant Island. During our cruise, in addition to the traditional oceanographic measurements tracers in the seawater have been measured and our atmospheric chemists have investigated the gas exchange between sea ice and the atmosphere with various methods.

By measuring CFCs and the noble gases helium and neon we are literally tracing the deep ocean currents. In seawater these gases are dissolved in trace amounts only, which makes their sampling and measurement a great challenge. They are distributed within the spreading water masses of the inner ocean like a dye that allows us to trace the pathways of these deep-water masses back to their sources. For instance, helium and neon are trapped in tiny gas bubbles in the Antarctic ice sheet, which spreads towards the ocean under its own weight. When the floating glaciers or ice shelves are melted from below by saline seawater as a result dense water is formed and sinks to depth renewing the bottom water. The trapped gases are dissolved completely due to the enhanced hydrostatic pressure underneath the several hundred metres thick ice shelves. Thus, the strongly enhanced concentrations of helium and neon can be used as a fingerprint of this special type of bottom water, even if sampled far from its source.

The atmospheric concentrations of CFCs – known as green house gases or ozone destroyers in the upper atmosphere – have increased steadily since 1950. Concentrations have now reached a plateau or are slightly decreasing due to the Montreal Protocol. The still increasing concentrations in the ocean interior can be used as a kind of clock, inferring the time how long the analyzed water mass was on its way from the ocean surface, where it was loaded with atmospheric CFCs, to the place of observation elsewhere in the inner ocean.

The gas exchange between atmosphere and ocean is strongly affected by the presence of sea ice. Fragile crystals, so-called frost flowers, are generated on newly formed sea ice at low air temperatures. Due to the migration of sea salt into the crystals the frost flowers can contain high concentrations of salt, reaching values much higher than in the ocean water. Some of the sea salt components can be transformed by chemical and physical processes into reactive halogens such as chlorine or bromine, which can react with atmospheric trace compounds like ozone or mercury. As a consequence, in springtime, the ozone and mercury concentrations remain negligible for periods of several days. During these periods the mercury is transformed into different species, which can be deposited as toxic compounds on snow and ice. Are the frost flowers really the source of the halogens?

We are trying to answer this question and elucidate the underlying processes using several methods. Frost flowers were collected whenever possible to investigate the different sea salt components. Moreover, the concentrations of the concerned atmospheric trace compounds ozone, mercury, and reactive halogens were continuously monitored on board. Measurements of the same compounds using the helicopters will be used to study the spatial distribution of the various chemicals in the atmosphere. Using additional remote sensing data of the sea ice extent we want to examine the connection between atmospheric processes and the occurrence of frost flowers.

Greetings from the snow showers at the ice edge on behalf of all participants of this cruise,

Yours Peter Lemke
Polarstern, 60°30'S, 52°22'W