Abstract: Trace gas fluxes in the polar seas: The importance of direct observations and improved measurement methods. Barry Huebert, Byron Blomquist, Mingxi Yang, University of Hawaii, Department of Oceanography.

There is reason to believe the air-sea flux of trace gases in the polar oceans may exert a significant influence on global climate:

1) Polar oceans are thought to provide a significant long term sink of atmospheric carbon dioxide through deep convection, but the net magnitude of this sink depends on the complex interactions of annual cycles in biological productivity and the weather patterns driving ocean cooling and surface mixing (Miller, 1999). Modeling the carbon budget requires an understanding of all these factors, including the dependence of gas exchange on wind speed and sea state under often extreme conditions.

2) Dimethylsulfide (DMS) is the most significant source of sulfate aerosol in the Southern Ocean, thus the magnitude and seasonal variability in DMS flux is an important factor influencing the formation and optical properties of clouds in this region. It is apparent from recent field studies that the transfer velocity of DMS may be significantly less than that of CO2 and other lower solubility gases under conditions of high winds and colder temperatures (Blomquist 2006, Huebert 2004). This may decrease the magnitude of Southern Ocean contributions to modeled global aerosol fields (Elliot 2009).

3) Gas exchange through sea-ice may be a significant contribution to net annual flux of CO2 and DMS in polar oceans (Semiletov 2004). Significant variability in the saturation levels of these gases in sea-ice pore brines has been reported (Delille 2007) but direct flux measurements have not been attempted. Modeling gas fluxes over sea-ice requires a detailed understanding of the biological dynamics during the Spring thaw and an accurate parameterization of gas transfer at the ice surface.

Measurements of the DMS air-sea flux have been reported from several recent field programs using recently developed mass spectrometric instruments (e.g. Blomquist 2010, Marandino 2007). We observe a linear relationship between u* and k for intermediate wind speeds (Huebert 2010), but an apparent roll off in k with higher winds (unpublished Southern Ocean GASEX data). Competing or complimentary theories describing high wind gas transfer may be advanced to explain the DMS observations (e.g. Soloviev 1994, Vlahos 2009) but this remains the issue of greatest uncertainty. Direct observations under high wind / low SST conditions typical of polar oceans will provide the greatest contribution to advancing models.

CO2 flux and transfer velocity have been reported from several programs over the last decade (e.g. McGillis 2001a, 2004) but the method is currently limited to regions of large CO2 supersaturation or depletion, and there are measurement challenges relating to motion artifacts and moisture interference (e..g. McGillis 2001b). A new generation of fast CO2 sensors based on cavity ring-down spectroscopy may improve CO2 measurement capabilities significantly and are currently under evaluation. We hope to deploy the most current version of this instrument on cruises this year.

Trace gas solubility plays and important role in determining gas transfer mediated by breaking waves and bubbles at high wind speeds. Considerable progress in understanding the physical mechanisms of gas transfer under these conditions can be realized by simultaneous flux measurements of gases with widely differing solubility. In this respect, CO2 and DMS are ideal candidates for field observation programs. Inclusion of direct CO2 and DMS flux measurements should be an important component of field programs focused on high wind and sea ice environments. Exploratory measurements of other gases with widely differing solubility, such a carbon monoxide and acetone, would further improve our ability to refine and validate physical gas exchange models.

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