Development of an Autonomous Buoy for Year-Round Measurement of O_3, CO_2, and BrO over the Arctic Ocean

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Introduction:

To date there have been many measurements of bromine monoxide (BrO) radical, ozone (O_3) and CO_2 over coastal Arctic land masses but very few over the ocean and sea ice, and certainly none for extended periods of time. Since sea salt is a source of bromine and sea ice is no longer considered a cap for sea-air exchange, measurements over the sea ice are of potentially extreme importance.

The goal of our research is to measure O_3, BrO, CO_2, and various meteorological parameters over Arctic sea ice for periods on the order of a year without human intervention. We have designed, tested, and recently deployed in sea ice an autonomous, self-powered, satellite-communicating O-Buoy capable of continuous measurements. Eventually multiple O-Buoys will form an Arctic network, providing an understanding of the atmospheric processes involved.

Project Overview:

An aluminum buoy hull was constructed at the U.S. Army Cold Regions Research and Engineering Laboratories (CRREL-NH). The O-Buoy has a specialized 2B 205 ozone monitor, a specialized Li-COR CO_2 sensor, a DOAS for measuring the BrO radical, an Iridium satellite communication system, a central computer to control all instrumentation and communication hardware as well as track power consumption/battery pack power stores and battery packs (lithium-ion and lead acid packs) to get through the winter. Solar panels are outside of the O-Buoy to charge the lead acid batteries and run the instrumentation during the summer. All instrumentation was cold tested individually and as one unit for a period of 8 weeks at CRREL, to ensure the O-Buoy's hardware would not fail at temperatures < 0ºC. The O-Buoy was deployed in sea ice in Elson Lagoon off Barrow, Alaska in February-May 2009. All tests were successful. All communication and software updates with the buoy were conducted via Iridium. The buoy was deployed on multi-year sea-ice in the Beaufort Sea in October 2009 for year round measurements.

Publications:

Knepp, T. N., J. Bottenheim, M. Carlsen, D. Carlson, D. Donohoue, G. Friederich, P. A. Matrai, S. Netcheva, D. K. Perovich, R. Santini, P. B. Shepson, W. Simpson, R. Stehle, T. Valentic, C. Williams, and P. J. Wyss. 2010. Development of an autonomous sea ice tethered buoy for the study of ocean-atmosphere-sea ice-snow pack interactions: the O-buoy. *Atmos. Meas. Tech*., 3, 249-210.

Carlson, D., Donohoue, D., Platt, U., and Simpson, W. R. 2010. A low power automated MAX-DOAS instrument for the Arctic and other remote unmanned locations. *Atmos. Meas. Tech. Discuss*., 2, 2347-2375, 2009.

Acknowledgements:

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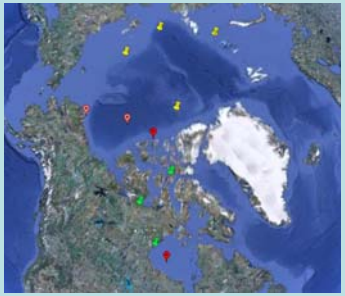
Locations:

Fig 1: Location of currently funded (**red**, NSF, Canada IPY), proposed (**green**, NASA; **yellow**, NSF) O-Buoys.



Instrumentation/Housing:

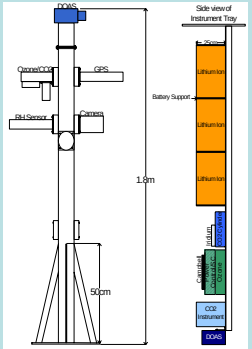


Fig 2: (A) Schematic representation of the mast and instrument arrangement in the hull. (B) Photo of the buoy deployed in Beaufort sea ice. (C) Installation in Elson Lagoon and Beaufort Sea.

Installation:

Buoy Data:

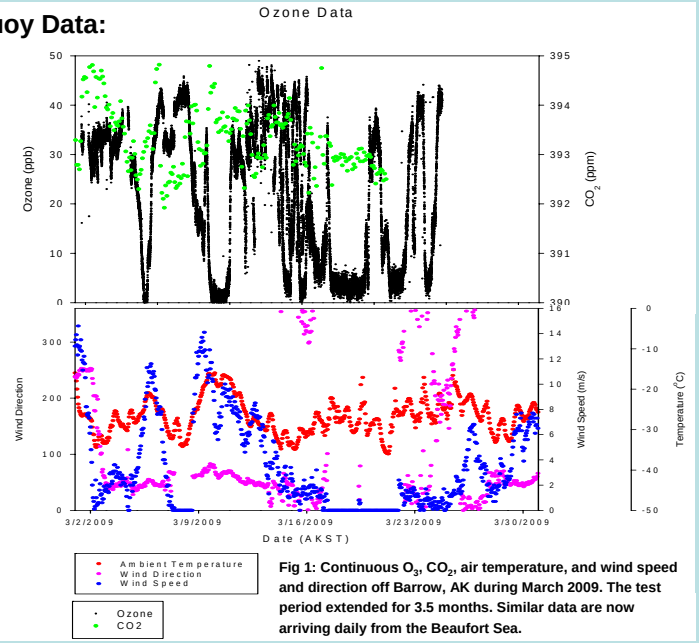


Fig 1: Continuous O_3, CO_2, air temperature, and wind speed and direction off Barrow, AK during March 2009. The test period extended for 3.5 months. Similar data are now arriving daily from the Beaufort Sea.

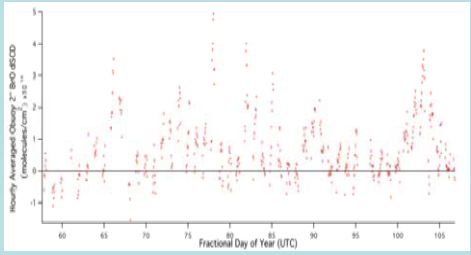


Fig 2: Hourly averaged BrO differential slant column densities at 2 degree elevation angle as a function of the day of year in 2009. In the next stage of analysis, we will convert these data to vertical column densities of BrO (for comparison with satellite observations) and concentrations (for understanding chemistry).

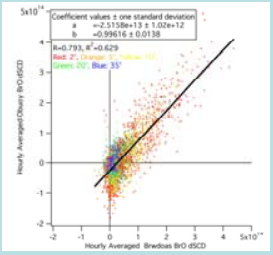


Fig 3: Correlation between BrO observations from the O-Buoy MAXDOAS and a resident MAXDOAS system in Barrow. The O-Buoy MAXDOAS gets data comparable to the Barrow system. In other work, the Barrow MAXDOAS system has validated satellite BrO data. Therefore, the O-Buoys will be able to validate the satellite observations at previously inaccessible locations.

O-Buoy website:
http://www.bigelow.org/index.php/research/facilities/srs_laboratories/patty_matrai_laboratory/research/o_buoy_/