Field:

Earth Science/Geosciences/Environment

Session Topic:

Interaction between Ocean and Atmosphere

Speaker:

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Using the eddy correlation technique to measure open ocean DMS air-sea fluxes

Biological, chemical, and physical processes that occur at the massive extent of the ocean-atmosphere interface have the potential to significantly impact atmospheric trace gas chemistry through air-sea exchange, with important consequences for climate and life on Earth. Two of the most often cited examples of this include ocean uptake of anthropogenic carbon dioxide (CO_2), influencing global climate change, and ocean emissions of dimethylsulfide (DMS).Many studies have investigated surface ocean processes as well as the physical constraints on air-sea flux, with a major goal of predicting air-sea fluxes of trace gases using models (Wanninkhof et al., 2009). However, simple parameterizations of air-sea exchange are proving difficult to obtain and the findings using a variety of techniques are not in agreement. Direct air-sea flux measurements, such as those obtained with the eddy correlation technique (EC), can contribute significantly to our understanding of the physical and chemical constraints on gas exchange. Forward progress with EC has been hindered by its technical difficulty, especially on a moving platform such as a research ship. In recent years, new instrumentation has become available which can be used to perform open ocean eddy correlation measurements of a variety of trace gases, such as CO_2, DMS, ozone, and acetone.

DMS is the most abundant volatile sulfur compound in the ocean and the ocean is the main source of biogenic reduced sulfur to the atmosphere (Simo´, 2001). DMS emitted from the sea surface has been thought to play a dominant role in the formation of remote marine aerosols, which can directly influence atmospheric radiation or indirectly influence atmospheric radiation by forming cloud condensation nuclei (CCN). The precursor of DMS in the surface ocean is dimethylsulfionpropionate (DMSP), a metabolic product of several algae groups. The main DMSP producing algae are coccolithophorids and dinoflagellates. DMSP can either be converted into bacterial or algal biomass or cleaved into DMS and acrylate by a variety of algal or bacterial enzymes (Todd et al., 2009). Because downwelling solar radiation affects algal productivity, the phytoplankton-DMS-CCN cycle was hypothesized by Charlson et al. (1987) as a biogenic regulation of the Earth's climate system (the CLAW hypothesis).

Atmospheric pressure chemical ionization mass spectrometry (AP-CIMS) was used to perform direct air-sea flux measurements of dimethylsulfide (DMS) with the eddy correlation technique. The DMS air-sea concentration difference was also measured in order to derive the gas transfer coefficient (k). The measurements were made aboard three cruises: 1) PHASE-I in the equatorial and northern Pacific Ocean from May-July 2004, 2) Knorr-06 in the southeastern Pacific Ocean in January 2006, 3) Knorr-07 in the north Atlantic in July 2007. The wind speed dependence of the derived k values was examined and compared to that of previous and concurrent DMS, CO_2, and dual tracer measurements. The results from these field campaigns appear to support a linear wind speed dependence of k_{DMS}. The k values from these measurements are in generally good agreement with those from published DMS and dual tracer experiments. However, the agreement between these measurements and published k_{CO2} values is unclear and requires further exploration. Interestingly, measured values of the DMS flux in the intense bloom region of the N. Atlantic were significantly higher than those predicted using current models. This may have implications for the way DMS flux is computed in models and the contribution of DMS air-sea flux to atmospheric sulfur loading in the northern hemisphere.

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Todd, J. D *et al.* The *dddP* gene, encoding a novel enzyme that converts dimethylsulfoniopropionate into dimethyl sulfide, is widespread in ocean metagenomes and marine bacteria and also occurs in some Ascomycete fungi. Environ. Microbiol., **11**, 1376 (2009)
Wanninkhof, R. et al. Advances in quantifying air-sea gas exchange and environmental forcing. Annu. Rev. Mar. Sci. **1**, 213 (2009)