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Gas transfer under high wind and its dependence on wave breaking and sea state

Sophia Brumer (1), Christopher Zappa (1), Christopher Fairall (2), Byron Blomquist (3), Ian Brooks (4), and Mingxi Yang (5)

(1) Lamont-Doherty Earth Observatory of Columbia University, New York, NY, United States, (2) NOAA/ESRL, Physical Sciences Division, Boulder, CO, United States , (3) Department of Oceanography, University of Hawaii, Honolulu, HI, United States , (4) University of Leeds, Leeds, United Kingdom , (5) Plymouth Marine Laboratory, Plymouth, 4United Kingdom

Quantifying greenhouse gas fluxes on regional and global scales relies on parameterizations of the gas transfer velocity K. To first order, K is dictated by wind speed (U) and is typically parameterized as a non-linear functions of U. There is however a large spread in K predicted by the traditional parameterizations at high wind speed. This is because a large variety of environmental forcing and processes (Wind, Currents, Rain, Waves, Breaking, Surfactants, Fetch) actually influence K and wind speed alone cannot capture the variability of air-water gas exchange.

At high wind speed especially, breaking waves become a key factor to take into account when estimating gas fluxes. The High Wind Gas exchange Study (HiWinGS) presents the unique opportunity to gain new insights on this poorly understood aspects of air-sea interaction under high winds. The HiWinGS cruise took place in the North Atlantic during October and November 2013. Wind speeds exceeded 15 m s^{-1} 25% of the time, including 48 hrs with U10 > 20 m s^{-1}. Continuous measurements of turbulent fluxes of heat, momentum, and gas (CO_2, DMS, acetone and methanol) were taken from the bow of the R/V Knorr. The wave field was sampled by a wave rider buoy and breaking events were tracked in visible imagery was acquired from the port and starboard side of the flying bridge during daylight hours at 20Hz.

Taking advantage of the range of physical forcing and wave conditions sampled during HiWinGS, we test existing parameterizations and explore ways of better constraining K based on whitecap coverage, sea state and breaking statistics contrasting pure windseas to swell dominated periods. We distinguish between windseas and swell based on a separation algorithm applied to directional wave spectra for mixed seas, system alignment is considered when interpreting results.

The four gases sampled during HiWinGS ranged from being mostly waterside controlled to almost entirely airside controlled. While bubble-mediated transfer appears to be small for moderately soluble gases like DMS, the importance of wave breaking turbulence transport has yet to be determined for all gases regardless of their solubility. This will be addressed by correlating measured K to estimates of active whitecap fraction (WA) and turbulent kinetic energy dissipation rate (ϵ). WA and ϵ are estimated from moments of the breaking crest length distribution derived from the imagery, focusing on young seas, when it is likely that large-scale breaking waves (i.e., whitecapping) will dominate the ϵ.