Field Measurements of Aerosol Production from Whitecaps in the Open Ocean
by Norris et al.

The purpose of this paper is to estimate aerosol fluxes per unit area of whitecap using measurements of near-surface aerosol concentration and bubble spectra. The study was carried out in the North Atlantic Ocean as part of two cruises during the SEASAW project. The cruises occurred during the periods 7 November to 2 December 2006, and 21 March to 12 April 2008. A compact Lightweight Aerosol Spectrometer Probe (CLASP) attached to a small buoy with an inlet 1 m above the surface was deployed during each cruise. CLASP provides a 16-channel size spectrum at ambient relative humidity, covering the size range $0.12 < R_{amb} < 9.25$ μm at a sample rate of 10 Hz. Size spectra were adjusted to 80% relative humidity for sea-salt. Measurements of bubble size spectra in the range 13-620 μm was done by a video-based measuring system, mounted underside the buoy at 0.4 m below the surface. An accelerometer allowed the movement of the buoy over the waves to be determined, along with estimates of individual wave heights. Finally, two Nikon Coolpix 8800 digital SLR cameras were installed on the port side of the bridge, with images taken every 30 s during daylight hours to estimate the whitecap fraction of breaking waves at the surface. The authors compare their mean bubble spectra with laboratory studies at different water temperatures, three open ocean studies, and two surf zone studies.

The authors have given a good summary of their experiment and present valuable results. Conclusions of this paper contribute to the current field of marine aerosol production, and therefore I would like to see paper published. However, the manuscript requires significant restructuring and clarifications.

One of the main findings of the paper is that the aerosol production flux per unit area of whitecap derived from mean particle spectra increases with the wind speed for particles with R_{80} below approximately 1–2 μm, while there is no clear relationship between the production flux of larger particles and wind speed. Paper also shows that production flux for larger particles decreased more rapidly with bubble size compared to production flux of the earlier studies. To explain these differences the authors name multiple different factors, often without clear rational. For example, when talking about the effect of bubbles the logic does not seem to work. Fig. 4 shows much higher concentration for the lab generated and surf zone bubbles compared to the open ocean. The differences are particularly pronounced for bubbles with diameter larger than 200 μm. Now, considering that "jet droplets, between about 1 and 10 μm radius, are produced by the smallest (< 200 μm diameter) bubbles (Blanchard, 1983)," shouldn't there be *lower* production flux of film drops for the open ocean measurements? Is that due to normalization by whitecaps? The effect of measurement height? (as noticed in the paper the majority of the field measurements of sea spray particle number concentrations have been made between 5–25 m above the surface, compared to 1 m used in the current study.) Could the entire notation of large bubbles producing sub-micron sized film drops while small bubbles producing super-micron sized jet drops be flawed? If this is the case, which may very well be true, I would recommend authors to remove the discussion of the bubble spectra.

The discussion for the potential dependence of sub-micron in situ flux estimates with wind history is also confusing. Were there corresponding differences (i.e., with increasing, decreasing and steady wind speeds) in the bubble spectra recorded? Can change in the bubble spectra or variability in whitecap coverage support these source flux estimates?

Specific comments:

Please include the mean aerosol spectra for each buoy deployment. The knowledge of number of particles in each CLASP channel size is important for interpretation of the production flux data.

Pg. 3366. While Horst and Weil (1992) model formulation defines flux footprint, I believe concentration footprint should be used in the manuscript. Compared to flux footprint, concentration footprint can be 10–100 times further upwind (Ceburnis et al. 2008; Vesala et al., 2008).

Pg. 3370. Please explain how the production flux was derived, include references.

Pg. 3390. Please correct the legend in Figure 6.

References:

Ceburnis, D., O'Dowd, C. D., Jennings, G. S., Facchini, M. C., Emblico, L., Decesari, S., Fuzzi, S., and Sakalys, J.: Marine aerosol chemistry gradients: elucidating primary and secondary processes and fluxes, Geophys. Res. Lett., 35, L07804, doi:10.1029/2008GL033462, 2008.

Vesala, T., Kljun, N., Rannik, Ü., Rinne, J., Sogachev, A., Markkanen, T., Sabelfeld, K., Foken, T., and Leclerc, M. Y.: Flux and concentration footprint modelling: State of the art, Environ. Pollut., 152(3), 653–666, 2008.