How wind and water temperature drives sea spray aerosol emissions, based on in situ Eddy Covariance fluxes and compared to laboratory tank experiments

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Dominant physical factors that determine the magnitude of sea spray emissions: 1) Wind speed. 2) Sea ice. 3) Sea surface temperature. The latter is so forth only known from laboratory experiments: Bowyer et al. (1990), Mårtensson et al. (2003), through Hultin et al. (2010) and Zabori et al. (2012a,b,2013), to recent work by Salter et al. (2014; 2015). Our hypothesis is: If sea surface temperature is important for sea spray emissions one should be able to observe its influence *in situ* using direct aerosol eddy covariance fluxes over the ocean.

The AWEP station at Östergarnsholm in the Baltic Sea is operated by Uppsala University since the mid 1990's and includes a 40m CO_2 flux mast. Since 2011 ACEP/Stockholm University operates an aerosol eddy covariance flux system in a 12m tower. The instrumentation includes: Gill Ultrasonic anemometer HS100, Licor 7500, TSI Condensation Particle Counter 3762, Grimm Optical Particle Counter 1.109. sea temperature from satellite and buoy. Eddy covariance fluxes were calculated from wind, temperature, CO_2, H_2O sampled at 20 Hz, and aerosol number concentrations at 1 Hz.

In two recent papers (Salter et al., 2014, 2015), a new sea spray simulation tank was used at ACES to study and parameterize how sea spray production depends on water temperature. For this study similar experiments were made at 6‰ salinity instead of the 35‰ used previously, in order to resample the conditions around Östergarnsholm.

Results and Conclusions

Over the sea, aerosol fluxes were dominated by upward fluxes due to sea spray emissions. Aerosol fluxes, heat and momentum fluxes, surface roughness and other micrometeorological parameters indicates that a wide sector from south-west to east are representative of long fetch sea spray fluxes. Data from this sector is selected for the rest of the data analysis.

As in previous field studies where the eddy covariance method has been used to measure sea spray emissions (Nilsson et al., 2001; Geever et al., 2005) we saw an exponential increase in emissions (upward fluxes) with increasing wind speed. Our new data set is however much larger than previous data sets, covering a wide range of temperatures over several years. This enable us to see that the sea-spray-wind dependency shift also with temperature. Comparing data for temperatures <12°C and >16°C, the lower 90% and upper 10% data range just barely touch. There is clearly a significant difference between sea spray emissions at high and low temperatures. In the brackish water at Östergarnsholm sea spray emissions peak at 4-8°C, see Figure 1, and fall rapidly in magnitude with increasing temperature. This compares well with the laboratory sea spray tank data at a comparable salinity. Experiments at 35‰ (Salter et al., 2014, 2015) suggest that the sea spray emissions over the oceans in general continue to be high towards 0°C.

Our hypothesis has been tested positive. In a world where large parts of the oceans are now in transition towards higher sea surface temperature, this offers a potentially dangerous positive climate change feedback process that may amplify climate change.

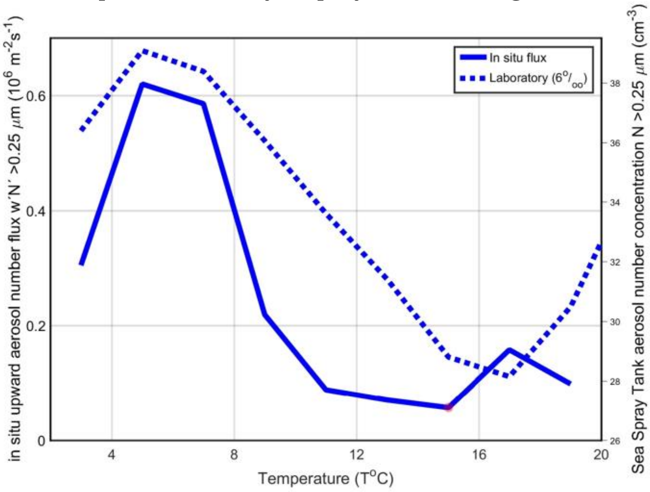

Figure 1. In situ sea spray emission fluxes (full curve) and laboratory sea spray production (dotted curve) as function of water temperature.

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