# Connecting marine productivity to sea-spray via nanoscale biological processes


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Marine aerosol enrichment by biogenic organic matter (OM) has been linked to phytoplankton activity (O'Dowd et al., 2004), thus having a strong seasonal impact on both the Earth's albedo and climate. In addition to a seasonal cycle, sea-spray generation and its enrichment with OM is a very dynamic process producing regular OM plumes over N.E. Atlantic (Ovadnevaite et al., 2011). Plankton-enriched seawater contains a complex mixture of dissolved and particulate organic carbon components (POC and DOC) producing both water soluble and insoluble organic aerosol species (Facchini et al., 2008; Russell et al., 2010).

Reanalysis of long-term observations of North Atlantic marine aerosols and satellite derived measurements show a clear dependence of OM mass-fraction enrichment in sea spray (OMss) on both phytoplankton biomass, determined from Chlorophyll-a (Chl-a) and Net Primary Productivity (NPP) (Figure 1). The correlation coefficient for OMss as a function of Chl-a increased form 0.67 on a daily timescale to 0.85 on a monthly timescale. An even stronger correlation was found as a function of NPP, increasing to 0.93 on a monthly timescale.

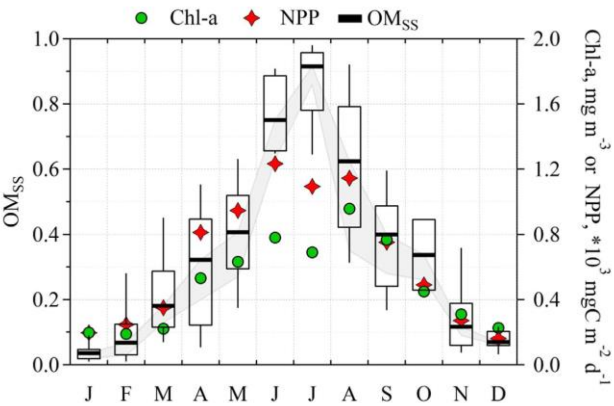


Figure 1. Seasonality of fractional OM in sea spray, chlorophyll-a and net primary production. (O'Dowd et al., 2015)

The long-term observations and data analysis suggested the observed dependence is through the demise of the bloom, driven by nanoscale biological processes (such as viral infections), releasing large quantities of transferable OM comprising cell debris, exudates and other colloidal materials. The importance of phytoplankton bloom development on observed fractional OM in sea spray was first implicated by Rinaldi et al. (2013) who found a significant lag between fractional OM and chlorophyll-a concentration. High time resolution data analysis confirmed the lag clearly pointing at bloom demise based on temporal evolution of correlation matrix. The biogenic OM, through aggregation processes, leads to enrichment in sea-spray, thus demonstrating an important coupling between biologically-driven plankton bloom termination, marine productivity and sea-spray modification with potentially significant climate impacts.

Extensive lab studies were performed during different seasons using cultured phytoplankton species and their symbiotic marine viruses which suggested a convoluted interplay between biological organisms. Physico-chemical properties of produced OM while not an exact replica of ambient aerosol were exhibiting similar features of particle water uptake with potentially crucial climate effects.

The significance of these experiments is that they demonstrated, for the first time, that the OMss bursts occur both in ambient air experiments and laboratory experiments and not only do they reaffirm that OMss contributions can reach 95% submicron mass while simultaneously leading to ambient air OM mass contributions 10-fold higher than other studies reported, but they also show approximately an order of magnitude variability in OMss.


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Facchini, M.C., et al. (2008) *Geophys. Res. Lett.*, 35(17), L17814.

O'Dowd, C.D., et al. (2004) *Nature*, 431, 676-680.

O'Dowd, C.D., et al. (2015) *Scientific Reports, 5, 14883.*

Ovadnevaite, J., et al. (2011) *Geophys. Res. Lett.*, 38(2), L02807.

Rinaldi, M., et al. (2013 *J. Geophys. Res*, 118, 4964-4973.

Russell, L.M., et al. (2010) *P. Natl. Acad. Sci.*, USA 107(15), 6652-6657.