Observational Constraints on Concentration and Production of Sea-spray Aerosol Particles

Ernie R. Lewis       Stephen E. Schwartz
elewis@bnl.gov       ses@bnl.gov
Atmospheric Sciences Division
Brookhaven National Laboratory
Upton, NY 11973-5000

MOTIVATION
Current estimates of the size-dependent production flux of sea-spray aerosol particles vary over several orders of magnitude and some seem too high to be realistic. Can observations can constrain these estimates?

SEA-SALT MASS CONCENTRATION
Sea-spray mass consists mainly of sea salt. Dry sea-salt mass concentrations in the marine boundary layer (from filter measurements of sodium concentration) range from 10-50 $\mu$g m$^{-3}$.

AEROSOL OPTICAL DEPTH
The main contribution to extinction of visible radiation over the ocean is from sea-salt aerosol particles which due to their size have values of extinction coefficient $Q_{sp}$ near 2.

Typical values of AOT in the marine atmosphere relatively free of anthropogenic influences range from 0.05-0.1.

These values include contributions from tropospheric aerosols besides sea spray and from stratospheric aerosols.

These values limit the column burden (vertical integral) of sea-salt aerosol surface-area concentration.

For typical marine boundary layer (MBL) height of 0.5 km with uniform RH of 80%, this range of values limits the number of sea-salt particles with $r_{80}$ greater than a given value.

$N(r_{80} > 1 \mu m) < 10-50$ cm$^{-3}$
$N(r_{80} > 3 \mu m) < 0.3-1.5$ cm$^{-3}$
$N(r_{80} > 5 \mu m) < 0.08-0.4$ cm$^{-3}$

These bounds are less stringent than those for mass concentrations, and this approach also provides little constraint on the number concentration or production flux of sea-spray particles with $r_{80} < 1 \mu m$.

NUMBER CONCENTRATION
Marine aerosol number concentrations of particles with $r_{80} > 0.01 \mu m$ under conditions of minimal anthropogenic influence typically range from 200-500 cm$^{-3}$ and are dominated by smaller particles ($r_{80} < 1 \mu m$).

These values, together with estimates of removal rates, bound the total sea-spray production flux. The dominant removal mechanism for particles of these sizes is precipitation. Assumptions of ~3 days (time between precipitation events) for particle lifetimes and a 0.5 km MBL height yield a maximum increase in the number concentration of 70-170 cm$^{-3}$ day$^{-1}$.

Some recent estimates are much greater!

CONCLUSIONS
Measurements of number concentration and estimates of particle lifetime weakly constrain the number production flux of sea-spray aerosol. Further progress requires measurements of individual particle composition to determine the fraction of marine aerosol particles that are primary.

Lewis & Schwartz *, 2004

* Assessment based on large collection of data for sea-salt aerosol particles.