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

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MOTIVATION

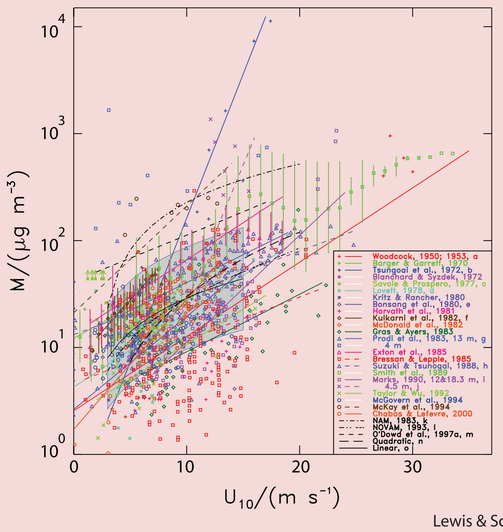
Current estimates of the size-dependent production flux of sea-spray aerosol particles vary over several orders of magnitude and some seem too high to be realistic.

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 $\mu g\ m^{-3}$.



Lewis & Schwartz, 2004

Such values restrict the number concentration of sea-salt particles with r_{80} (the radius at 80% RH) greater than a given value.

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

This approach provides virtually no constraint on the number concentration or production flux of sea-spray particles with $r_{80} < 1\ \mu m$, although it might be of interest to considerations of giant CCN.

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.

$$N(r_{80} > 1\ \mu m) < 15\text{-}30\ cm^{-3}$$
$$N(r_{80} > 3\ \mu m) < 1.5\text{-}3\ cm^{-3}$$
$$N(r_{80} > 5\ \mu m) < 0.5\text{-}1\ cm^{-3}$$

Greater MBL heights and the expected increase in RH with height would decrease these upper bounds.

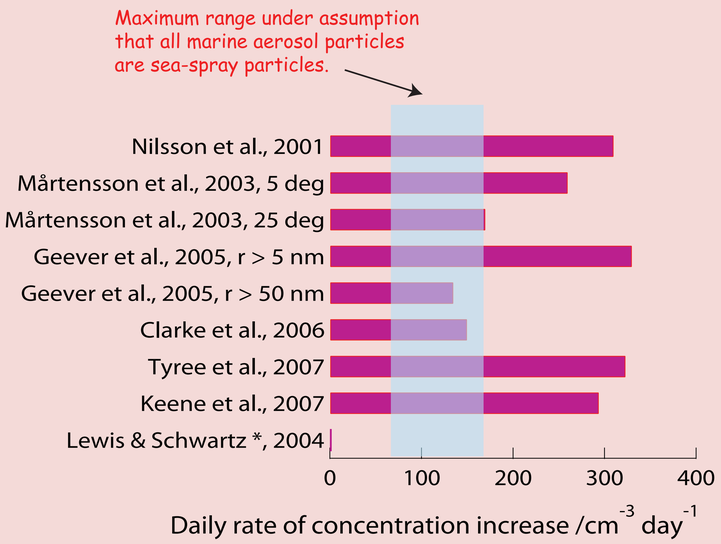
These bounds are less stringent than those for mass concentrations, and this approach also provides little constraint on the number concentration or production flux of sea-spray particles with $r_{80} < 1\ \mu m$.

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!



* Assessment based on large collection of data for **sea-salt** aerosol particles. Lewis, E. R., & S. E. Schwartz, Sea Spray Aerosol Production: Mechanisms, Methods, Measurements and Models - A Critical Review, American Geophysical Union, 2004.

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.