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OBSERVATIONAL CONSTRAINTS ON CONCENTRATION AND PRODUCTION OF SEA-SPRAY AEROSOL

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ABSTRACT

The fraction of marine aerosol that is comprised of sea-spray aerosol (SSA) varies greatly and is often highly uncertain. The size-dependent production flux is likewise highly uncertain, by a multiplicative factor of times/divided by 5 or more under given conditions. Concentrations of SSA may be constrained by readily measured quantities, and as the vast majority of SSA, by mass and by number, remains in the marine boundary layer (MBL), with negligible amounts detrained to the free troposphere, these observations, together with estimates of removal rates, make it possible to constrain the production flux. Typical measured values of sea salt mass concentration, which is dominated by the largest particles, ranges from 10 to50 μg m^{-3}, from which the upper bound on the number concentration of SSA particles with r_{80} (radius at 80% relative humidity RH) greater than 1 μm is 10 to 50 cm^{-3}, respectively, and of particles with $r_{80} > 3$ μm, 0.3 to 1.5 cm^{-3}. Measurements of aerosol optical thickness (AOT) provide a constraint on the column burden of the concentration of surface area, as particles that provide the dominant contribution to extinction of visible radiation are sufficiently large that the extinction efficiency is near 2. Measured AOT in the marine atmosphere relatively free of anthropogenic influences, which includes contributions from stratospheric aerosols and tropospheric aerosols other than SSA, is typically 0.05 to 0.1. For typical marine boundary layer height of 0.5 km with uniform RH 80%, the upper bound on the column-average number concentration of SSA particles with $r_{80} > 1$ μm is thus 15 to 30 cm^{-3}, and for particles with $r_{80} > 3$ μm, 2 to 3 cm^{-3}; the expected increase in RH with increasing height would decrease these upper bounds, as would a greater MBL height. Measurements of total aerosol number concentration, which is dominated by smaller particles, provide an upper bound on the number concentration of SSA particles, as these measurements include other marine aerosols such as exogenous continental aerosols and particles produced by nucleation. Total aerosol number concentration reported under conditions of minimal anthropogenic perturbation typically ranges from 200 to 500 cm^{-3}. As the dominant factor in determining the lifetimes of these particles is removal by precipitation, with typical lifetime ~3 days, nearly independent of size for particles with 0.01 μm < r_{80} < 3 μm, an upper bound on the SSA number production flux can also be estimated. For these conditions, with the assumption of a 0.5 km marine boundary layer height, this upper limit would be 4 to 10 × 10^5 m^{-2} s^{-1}, near the low end of current estimates of SSA production flux.