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Impact of nucleation on global CCN

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Abstract. Cloud condensation nuclei (CCN) are derived from particles emitted directly into the atmosphere (primary emissions) or from the growth of nanometer-sized particles nucleated in the atmosphere. It is important to separate these two sources because they respond in different ways to gas and particle emission control strategies and environmental changes. Here, we use a global aerosol microphysics model to quantify the contribution of primary and nucleated particles to global CCN. The model considers primary emissions of sea spray, sulfate and carbonaceous particles, and nucleation processes appropriate for the free troposphere and boundary layer. We estimate that 45% of global low-level cloud CCN at 0.2% supersaturation are secondary aerosol derived from nucleation (ranging between 31–49% taking into account uncertainties in primary emissions and nucleation rates), with the remainder from primary emissions. The model suggests that 35% of CCN (0.2%) in global low-level clouds were created in the free and upper troposphere. In the marine boundary layer 55% of CCN (0.2%) are from nucleation, with 45% entrained from the free troposphere and 10% nucleated directly in the boundary layer. Combinations of model runs show that primary and nucleated CCN are non-linearly coupled. In particular, boundary layer nucleated CCN are strongly suppressed by both primary emissions and entrainment of particles nucleated in the free troposphere. Elimination of all primary emissions reduces global CCN (0.2%) by only 20% and elimination of upper tropospheric nucleation reduces CCN (0.2%) by only 12% because of the increased contribution from boundary layer nucleation.

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