Geophysical Research Abstracts, Vol. 9, 08314, 2007
SRef-ID: 1607-7962/gra/EGU2007-A-08314

The contribution of nucleation events to global cloud condensation nuclei concentrations

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Nucleation events are regularly observed around the world in locations spanning the sub-Arctic through boreal forests to urban and industrial regions. However, the contribution of these events to regional and global cloud condensation nuclei (CCN) concentrations is unknown. We study this contribution by including a new nucleation mechanism in the global aerosol microphysics model GLOMAP. The mechanism is based on observations at two continental sites in Europe; one in the boreal forest in Finland and one in sub-urban Germany. Rate of formation of molecular clusters is equal to the sulfuric acid concentration to the power one multiplied by an empirical nucleation coefficient A. Modelled particle formation and growth rates agree well with observations made at both sites. Over remote continental regions nucleation events sustain summertime CCN concentrations (at 0.2% supersaturation) 25-60% higher than with binary homogeneous nucleation and primary emissions of sea salt and anthropogenic carbonaceous particles. Over polluted continental regions nucleation events lead to a smaller enhancement of 10-30%. The sensitivity of CCN production to uncertainty in the nucleation coefficient A is small; prediction of CCN enhancement over central Europe changes from 12 to 17% for a two order of magnitude increase in A. The contribution of nucleation events to CCN concentrations is much less during springtime despite the larger number of particle formation events observed and modelled. This is due to slower particle growth through condensation and cloud processing during spring. Overall, these results demonstrate that boundary layer nucleation is a significant source of CCN.