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Cosmic ray induced formation of atmospheric aerosol particles and cloud condensation nuclei: new insights from atmospheric trace gas and ion measurements and laboratory investigations of ion induced nucleation

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Cosmic ray induced aerosol formation represents a potentially important physical mechanism which may connect clouds and climate with cosmic rays and solar activity. It involves three major steps: (a) cosmic ray induced formation of atmospheric molecular and atomic ions; (b) clustering of certain atmospheric trace gas molecules X to ions eventually leading to large cluster ions; (c) ion-ion recombination of large cluster ions eventually leading to stable molecular clusters which represent already small aerosol particles which grow further by condensation and coagulation and may eventually grow sufficiently to become cloud condensation nuclei (CCN). The only trace gas X so far detected in the atmosphere is gaseous sulphuric acid (H2SO4) which is formed from the sulphur-bearing precursor gas SO2. We have made new measurements of SO2, gaseous H2SO4, and cluster ions in the remote and relatively unpolluted atmosphere using aircraft-based and ship-based mass spectrometer instruments. We have also made laboratory investigations of sulphuric acid cluster ions and model simulations of ion-induced H2SO4 nucleation. Our work indicates that cosmic ray induced aerosol formation is particularly efficient in the upper troposphere and

that a substantial fraction of newly formed particles may indeed become CCN.