The influence of ion-induced nucleation on atmospheric aerosols based on data from the CERN CLOUD experiment

E.M. Dunne[1], K.S. Carslaw[1], J. Almeida[2], and the CLOUD collaboration[2]

[1]School of Earth and Environment, University of Leeds, Leeds, LS2 9JT, UK
[2]CERN, Geneva, Switzerland
Keywords: aerosol modelling, ion-induced nucleation.
Presenting author email: E.Dunne@leeds.ac.uk

A range of observations support a connection between cosmic ray intensity and the Earth's climate, on time-scales from days (Pudovkin and Veretenenko, 1995) to centuries (Eichler *et al*, 2010) to millennia (Bond *et al*, 2001). Away from the surface, ion concentrations are controlled by cosmic-ray induced ionization. One likely candidate for the mechanism connecting cosmic rays and the climate is the ion-induced nucleation of aerosol.

Because ions stabilise sub-critical nuclei, ion-induced nucleation is likely to dominate as a nucleation pathway in remote regions with low concentrations of precursor vapours. When determining the impact of this phenomenon on the climate, a global aerosol microphysics model is a vital tool due to its inclusion of the various processes which affect particle growth and deposition.

The CERN CLOUD experiment is designed to accurately measure both ion-induced and neutral nucleation rates in unprecedented detail (Kirkby *et al*, 2011). The experiment has found that the presence of both ions and ammonia enhance nucleation rates beyond the binary neutral, but that inorganic precursor vapours are not sufficient to reproduce atmospheric observations of new particle formation events.

Using the GLOMAP aerosol microphysics model, we quantify the contribution of ion-induced nucleation to global aerosol based on new results from the CLOUD experiment at CERN. We will present the results of the implementation within a global model of the first parametrization of ion-induced nucleation based on experimental observations rather than theoretical predictions. This parametrization is the result of work in the ternary H_2SO_4-NH_3-H_2O system by the CLOUD collaboration at CERN.

The ternary and ion-induced nucleation parametrization causes a non-negligible increase in CN (diameter > 3 nm) and CCN (diameter > 70 nm) at the surface when compared with a simulation which uses a binary neutral nucleation mechanism.

We would like to thank CERN for supporting CLOUD with important technical resources, and for providing a particle beam from the CERN Proton Synchrotron. This research has received funding from the EC's Seventh Framework Programme under grant agreement no. 215072 (Marie Curie Initial Training Network "CLOUD-ITN"), from the German Federal Ministry of Education and Research (project no. 01LK0902A), from the Swiss National Science Foundation, and from the Academy of Finland Center of Excellence program (project no. 1118615).

Bond, G.C., B. Kromer *et al* (2001) *Persistent solar influence on North Atlantic climate during the Holocene*. Science 294:2130–2136

Eichler, A., S. Olivier *et al* (2009) *Temperature response in the Altai region lags solar forcing*. Geophysical Research Letters

Kirkby et al. (2011) *Role of sulphuric acid, ammonia and galactic cosmic rays in atmospheric aerosol nucleation.* Nature

Pudovkin, M.I., Veretenenko, S.V. (1995) *Cloudiness decreases associated with Forbush decreases of galactic cosmic rays.* Journal of Atmospheric and Terrestrial Physics