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Response of Cloud Condensation Nuclei (> 50 nm) to changes in ion-nucleation

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The role of ionization in the formation of clouds and aerosols has been investigated for many years. In recent years clear experimental evidence has also been produced showing that ionization can promote the nucleation of small aerosols (1-3 nm) at atmospheric conditions (Svensmark et al 2007, Kirkby et al 2011).

The experiments initially showed that an increase in ionization leads to an increase in the formation of ultrafine aerosols (~3 nm), but in the real atmosphere such small particles have to grow by coagulation and intake of condensable gases to become cloud condensation nuclei (CCN) (> 50 nm) in order to have an effect on clouds.

Theoretical doubts about the likelihood of such particle growth into CCN have arisen from consideration of (1) the competition between the additional ultra-fine aerosols for the limited supply of condensable gases leading to a slower growth and (2) the larger losses of the additional particles during the longer growth-time to larger particles by coagulation and by other loss mechanisms. Numerical studies using the current knowledge of aerosol dynamics predict that variations in the count of ultra-fine aerosols will lead only to an insignificant change in the count of CCN (Pierce and Adams 2009). It is even suggested that an increased production of ultra-fine particles as a result of GCR ionization leads to a reduction in the CCN count.

In order to study the growth of aerosols to CCN sizes, measurements were performed in an 8 m³ reaction chamber made from electro-polished stainless steel. One side was fitted with a Teflon foil to allow ultraviolet light (253.7 nm) to illuminate the chamber, which was continuously flushed with dry purified air. Variable concentrations of water vapor, ozone, and sulfur dioxide could be added to the chamber, where the pressure was held a few Pa above atmospheric pressure, and the temperature at around 296 K. UV-lamps initiated photochemistry producing sulfuric acid. Ions were produced in the chamber by the naturally occurring GCR and by background radiation from radon, and the ionization could be enhanced with two Cs-137 gamma sources (30 MBq), mounted on each side of the chamber.

The evolution of the aerosols, following a nucleation event induced by the gamma sources was measured and aerosol growth up to 68 nm was followed for up to two days.

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