Geophysical Research Abstracts
Vol. 12, EGU2010-10661, 2010
EGU General Assembly 2010

Nucleation in an ultra low ionization environment

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Atmospheric ions can enhance the nucleation of aerosols, as has been established by experiments, observation, and theory. In the clean marine atmosphere ionization is mainly caused by cosmic rays which in turn are controlled by the activity of the Sun, thus providing a potential link between solar activity and climate. In order to understand the effect ions may have on the formation of cloud condensation nuclei and thus the Earth's radiation budget the overall contribution of ion induced nucleation to the global production of secondary aerosols must be determined. One issue with determining this contribution is that several mechanisms for nucleation exist and it can be difficult to determine the relative importance of the various mechanisms in a given nucleation event when both ion induced and electrically neutral nucleation mechanisms are at work at the same time.

We have carried out nucleation experiments in the Boulby Underground Laboratory, located 1100 meters below ground, thus reducing the flux of ionizing cosmic radiation by six orders of magnitude. Similarly we have reduced the gamma background by shielding the experiment in lead and copper. Finally we have used air stored for several weeks and passed through an active charcoal filter in order to reduce the Radon concentration. In this way we have been able to make nucleation experiments with very low ionizing background, meaning that we can rule out ion induced nucleation as a contributing mechanism.

Our experimental setup is a 50 L electropolished stainless steel reactor at near atmospheric conditions. The chamber contains clean air with the addition of water vapour, ozone, and sulphur dioxide. Using UV lights at 254 nm ozone is photolyzed, leading to the production of sulphuric acid and thus aerosols. An 18 MBq Caesium-137 gamma ray source with various amounts of lead in front allows us to alter the ionization in our chamber. By making series of nucleation bursts with varying amounts of ionizing radiation we then gauge the relative importance of ion induced nucleation in the events. This set of experiments is, to our knowledge, the first of its kind.