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Relationship Between Aerosol Number Size Distribution and Atmospheric Electric Potential Gradient in an Urban Area

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Small ions are created in the atmosphere by ground based radioactive decay and solar and cosmic radiation ionising the air. The ionosphere is maintained at a high potential relative to the Earth due to global thunderstorm activity, a current from the ionosphere transfers charge back to the ground through the weakly ionised atmosphere. A potential gradient (PG) exists between the ionosphere and the ground that can be measured in fair weather using devices such as an electric field mill.

PG is inversely-proportional to the conductivity of the air and therefore to the number of ions of a given electrical mobility; a reduction of air ions will cause an increase of PG. Aerosols in the atmosphere act as a sink of air ions with an attachment rate dependent on aerosol size distribution and ion mobility. These relationships have been used to infer high particulate, and hence pollution, levels in historic datasets of atmospheric PG.

A measurement campaign was undertaken in Manchester, UK for three weeks in July and August where atmospheric PG was measured with an electric field mill (JCI131, JCI Chilworth) on a second floor balcony, aerosol size distribution measured with a scanning mobility particle sizer (SMPS, TSI3936), aerosol concentration measured with a condensation particle counter (CPC, Grimm 5.403) and local meteorological measurements taken on a rooftop measurement site ~200 m away. Field mill and CPC data were taken at 1 s intervals and SMPS data in 2.5 minute cycles. Data were excluded for one hour either side of rainfall as rainclouds and droplets can carry significant charge which would affect PG. A quantity relating to the attachment of ions to aerosol (Ion Sink) was derived from the effective attachment coefficient of the aerosols. Further measurements with the field mill and CPC were taken at the same location in November 2015 when bonfire events would be expected to increase aerosol concentrations.

During the summer measurements, particle number count (PNC) from the CPC and SMPS were very closely correlated. PG was closely related to PNC and the ion sink parameter both with the overall trend, and especially during 'peak' events of high concentration. The data were averaged to a diurnal cycle and the average daily cycle showed variability in PG and PNC consistent with the urban environment including a peak at rush hour and a minimum during the night. Lomb-Scargle periodograms provided the spectral content and daily and weekly peaks were apparent in PG and PNC data. Cross correlation analysis indicates that the best temporal correlation exists between PG and ion sink rate.