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Relationship between aerosol concentration, relative humidity and atmospheric electric potential gradient in cities

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The vertical atmospheric potential gradient is particularly affected by high aerosol loading in cities as the air's conductivity is reduced through aerosol attachment of free ions. The reduction of ion concentrations decreases the conductivity and, as the air-earth current remains constant, the potential difference increases. Aerosol size distributions can be affected by the relative humidity dependent on the aerosol hygroscopicity, if an aerosol is sufficiently hygroscopic, it will grow as humidity increases. As larger aerosols are, in principle, more prone to effectively scavenge ions, an increase in relative humidity may increase the size of hygroscopic aerosols, decrease ion concentrations and hence increased measured potential gradient. Measurements of atmospheric potential gradient in Lisbon, Portugal, demonstrated an increase in potential gradient associated with increasing relative humidity (in the range 60-90%), mainly for wind directions corresponding to marine air.

A JCI 131 field mill (Chilworth) and Maximet 500 (Gill) weather station were positioned on the roof of the University of Bristol School of Chemistry between May and September 2016. Particle number concentration was determined using a condensation particle counter (TSI 3010) with an upper limit of 10,000 particles cm^{-3}. A dilution system was put in place to increase this range to 14,000 cm^{-3}. The same field mill and weather station were used in Thailand. Measurements at 1 Hz (averaged to 1-minute samples) were taken on the roof of a 6-floor building, approximately 100 m from a busy toll road in Lak Si, northern Bangkok. Aerosol concentrations were taken with a Condensation Particle Counter (Grimm Aerosol Technik) at the same height. The measurement period began on March 8th 2018 after which there were 8 weeks of particle number count data.

In the Bristol measurement between 50% and 80% relative humidity, the median potential gradient increased, but above this it sharply decreases, which may be due to disturbed weather at the highest humidities. Initial analysis of the relationship between relative humidity and potential gradient in Bangkok shows a decrease in median potential gradient as relative humidity increases. This may be due to a large proportion of traffic related aerosol which could be less hygroscopic, but the potential for effects of disturbed weather and traffic to mask hygroscopic effects will be considered.