The Use of Single Particle Mass Spectrometry to characterize the chemistry of atmospheric particulate and interpret its properties

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Introduction:

Atmospheric particles have a wide range of compositions resulting from their source and their interactions in the atmosphere. Primary particles, such as dust or sea salt, are emitted into the atmosphere as a result of wind generated resuspension. Other primary particles include black carbon, or soot, from incomplete combustion. Once in the atmosphere, particles act as sites for condensation of secondary material, formed from gas phase oxidation of precursor material. Particles can act as sites for cloud formation, either as droplets or ice particles. This may further process the particles. As a result of these complex chemical processes the particles have a wide range of properties that can affect their influence on a wide range of atmospheric phenomena. The optical properties of particles will depend on their chemical mixing state. The effectiveness of particles as sites for cloud droplet formation or as nucleation sites for ice formation is dependent on the chemistry. This in turn influences the transport pathways of the particles through the atmosphere and their removal. Particles are often vectors for transport of key nutrients or pollutants through the Earth System, such as iron transport from land to the ocean through desert dust. Many of these processes are rather poorly understood and predictive capability using state of the art models is often low. There is a need to examine the chemical mixing state of individual particles directly through atmospheric measurement however this is a challenging measurement. Single particle laser ablation mass spectrometry is an approach that can provide mass spectral fingerprints of single particles in the atmosphere and developing these techniques is an important instrument development challenge.

Project Summary:

The University of Manchester have one such instrument, the LAAP-TOF (Laser Ablation of Aerosol Particles Time Of Flight Mass Spectrometer). The instrument is now operational and has recently been deployed in Cape Verde to study the chemical mixing state of dust in the atmosphere. The next stages of its development include improving the sizing capability of the instrument, characterising the mass spectral fingerprints detected and applying advanced data analysis techniques to characterise and cluster the large data sets that are produced by the instrument, and modifying it for installation in the UK research aircraft.

You will learn how to use the LAAP-ToF instrument and conduct a range of tests to characterise its response to a wide range of particle chemistries. Instrument and/or data analysis developments will be investigated and you will be expected to participate in the integration of the instrument into the UK research aircraft, characterise its performance, participate in a number of aircraft missions planned over the sub-tropical Atlantic Ocean and above the Canadian Arctic and analyse the data from one or more these missions. The PhD offers an exciting opportunity to work on a technically challenging advanced mass spectrometer and apply it to study the real-world challenges in the atmosphere from an exciting airborne research platform. The work will involve collaboration with a number of international laboratories.

References

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