A novel measurement of optical extinction by atmospheric aerosol

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Introduction:

Aerosol particles scatter incoming solar radiation back to space and in doing so reduce shortwave radiation at the surface. Regionally, this effect may be substantial and play a very significant role in the atmospheric radiation balance. Prediction of these effects remains a challenge for global and regional models, whose predictions are usually tested by comparison with satellite measurements and long term surface based remote sensing observations of the atmospheric column. However, there are multiple assumptions in both of these approaches and neither measures the underlying state of the aerosol rather the turbidity of the atmosphere. As a result, they cannot assess how representative a model's representation of the aerosol is of the real atmospheric state. To link these together aircraft are used to measure the aerosol properties in situ. However, aerosol particles have water associated with them and so change in size and refractive index as the humidity in the atmosphere changes. Currently, the physical and chemical properties of aerosol are measured in situ inside the aircraft under dry conditions and this is related to the ambient through calculations of the equilibrium water content based on composition and size. Recent findings of co-condensation and other assumptions make this a rather uncertain step and as a result is a weakness when linking in situ measurements to radiative properties of the column. A measurement of extinction under ambient humidity conditions would provide a direct link between the in situ detailed aerosol property measurements and those of the column conditions and would allow models of regional aerosol to be thoroughly tested.

Project Summary:

This project is to design, build and test an instrument for measuring the extinction of aerosol particles in the real atmosphere under ambient humidity conditions with a view to future development and installation on research aircraft. Cavity attenuated phase shift has been used to measure atmospheric light extinction by aerosol particles previously and a commercial device is currently being operated at Manchester. However, this instrument uses an enclosed optical path and an inlet and pump to draw the aerosol through the measurement chamber. The modification of this technology to an open path will allow the measurement of extinction under ambient conditions. The project will involve a major design phase to achieve the desired operational performance, construction and testing. The Centre for Atmospheric Science has extensive calibration facilities and a large aerosol chamber which will enable performance characterization to be carried out. It is anticipated that multiple iterations of the design may be necessary before ground based field testing. If time permits an aircraft deployment may be possible in the final stages of the PhD.

References

Massoli, P., Kebabian, P. L., Onasch, T. B., Hills, F. B., and Freedman, A.: Aerosol Light Extinction Measurements by Cavity Attenuated Phase Shift (CAPS) Spectroscopy: Laboratory Validation and Field Deployment of a Compact Aerosol Particle Extinction Monitor, Aerosol Sci. Technol., 44, 428–435, doi:10.1080/02786821003716599, 2010.

Haywood, J.M., Francis, P.N., Glew, M.D., Dubovik, O., and Holben, B.N, Comparison of aerosol size distributions, radiative properties, and optical depths determined by aircraft observations and Sun photometers during SAFARI-2000. Journal of Geophysical Research, 108(D13), 8471, doi:10.1029/2002JD002250, 2003a.

Johnson, B.T., Christopher, S., Haywood, J.M., Osborne,S.R., McFarlane, S., Hsu, C., Salustro, C., and Kahn R., Measurements of aerosol properties from aircraft, satellite and ground-based remote sensing: A case-study from the Dust and Biomass-burning Experiment (DABEX), QUARTERLY JOURNAL OF THE ROYAL METEOROLOGICAL SOCIETY Q. J. R. Meteorol. Soc. 135: 922–934 (2009), DOI: 10.1002/qj.420