Research Grant – Successful Submission

Dr Helen Smith – Postdoctoral Research Associate – Awarded £5000

In-situ profiling of the aerosol particle size distribution with disposable optical sensors

1. Aim of the Project

Build and deploy optical particle counters as part of a low-cost balloon borne sounding system for atmospheric profiling of particle size distributions with co-located sun photometer and lidar measurements. Airborne measurements of atmospheric particles are often limited to observations with tethered balloons and research aircraft. A newly developed disposable optical particle counter that is attached to a standard meteorological sonde will be tested.

Previous versions of the optical particle counter have been used in ground based studies for monitoring air quality, as dropsondes for measuring mineral dust and volcanic ash clouds over Europe and as balloon-borne sounding systems to measure the mineral dust in the Saharan air layer in the African outflow regime. The deployment as an addition to a standard meteorological sounding has the potential to provide low-cost airborne measurements of the particle size distribution as an alternative to aircraft campaigns.

2. Programme of Work

This grant will be used to fund the building and operation of several Universal Cloud and Aerosol Sounding System (UCASS) instruments. This probe is a wide-angle light scattering device designed for the counting and sizing of atmospheric particulates in the size range from 0.4 to 17µm. The device is an open geometry system, designed to be used in an external air flow (i.e. dropped from aircraft, launched on balloons or flown on UAVs). The use of the UCASS as an upsonde/dropsonde system allows the aerosol distribution to profiled vertically, whereas measurements from research aircraft are restricted to near-horizontal profiling. These vertical profiles are particularly valuable in atmospheric modelling and for the validation of remote sensing retrievals.

For this project, the probes will be launched as part of balloon-borne sounding systems in tantem with a standard meteorological sonde (a GRAW DFM-09). The complete sounding system will therefore measure profiles of the particle size distribution at ambient conditions, in addition to temperature, pressure and humidity.

The sondes will be launched from the University of Hertfordshire's Bayfordbury Observatory. The observatory provides complementary measurements with ground based particle counters, sun photometer and lidar. The remote-sensing observations with sun photometer (giving a column-integrated aerosol size distribution) and lidar (giving the position of particles in the atmospheric column) will be used to assess the performance of the UCASS probe.

The purpose of this project is the compare the particle size distributions measured with UCASS to the ones derived from the sun photometer observations. This requires stable conditions with respect to aerosol loading in the atmospheric column, as a height-resolved measurement (UCASS) will be compared with a result from column-integrated observations (sun photometer). The lidar will give us insight into the vertical distribution of the particles in the atmosphere. Particularly good conditions for such a comparison are usually found during long-range transport events of, e.g., biomass-burning smoke or mineral dust, which are observed quite frequently at Bayfordbury observatory.

The proposed time line is as follows:

- time to build 5 to 10 sondes: 1 month
- deployment will depend on atmospheric aerosol conditions within a time window of 2 months
- analysis of sonde measurements is not time consuming as particle size spectra are available virtually instantaneously
- further analysis and quality assurance: 1 month

3. Potential Applications

The data collected by the UCASS probes have the potential to provide an affordable alternative to airborne measurements with research aircraft. They can be used for climatological studies, to validate microphysical products of remote-sensing retrievals, or for assimilation into chemical transport, weather, or climate models. UCASS can also be incorporated as a dropsonde system during aircraft based measurements or with routine balloon-borne soundings for regular measurement of profiles of the particle size distribution.

The work proposed here will be conducted in house by members of the University of Hertfordshire, although we hope to make use of the resultant data to demonstrate the capabilities of the UCASS to foster collaborations in upcoming field based measurement campaigns.

The data will be used for further testing and validation of UCASS measurement capabilities. Demonstrating the potential of UCASS' capabilities to the research community opens the route to participation in future campaigns, and potentially, to routine balloon-borne soundings of atmospheric particle size distributions.

The duration of this project will be 4 months.