Miniature, low-cost optical particle counters

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Abstract

A range of miniature, low-cost optical particle counters for characterizing atmospheric particles has been developed. They are intended for use with disposable balloon-borne radiosondes, dropsondes or in dense ground-based sensor networks. Versions exist that are suitable for determining the size distributions and number concentrations of cloud particles or atmospheric aerosols such as mineral dust or volcanic ash.

1 Introduction

Routine meteorological data is obtained by profiling the atmosphere using disposable "radiosondes", thousands of which are launched daily on meteorological balloons. These give temperature, pressure, humidity and wind speed. Additional measurements are obtained from so-called "dropsondes", released from research aircraft. However, a crucial property not yet measured for lack of suitable equipment is the size and concentration of atmospheric particulates: cloud particles and aerosols. Instead, indirect, measurements are employed, relying on remote sensing, to meet the demands from not only weather forecasting, but many other areas such as climate research, air quality monitoring, civil contingencies etc. In addition, research aircraft can be used *in situ*, but airborne measurements are expensive. Moreover, aircraft use is restricted to near-horizontal profiling, which is a limitation, as cloud properties are driven by processes taking place in the vertical direction. Therefore, vertical profiling with sondes, either upwards or downwards, is often preferable. There are also many instances when aircraft cannot be used for *in situ* measurements, ranging from common occurrences, such as vigorous storm systems, to the unusual but far-reaching events, such as volcanic eruptions.

The Centre for Atmospheric and Instrumentation Research at the University of Hertfordshire specializes in the development of light-scattering instruments for the characterization of aerosols and cloud particles. In the last few years a range of miniature particle counters for characterizing atmospheric particles has been developed. They are intended for use together with systems such as disposable balloon-borne radiosondes, aircraft dropsondes or in dense ground-based sensor networks. Versions exist that are suitable for determining the size distributions and number concentrations of particles with different size ranges. They have been used for vertical profiling of atmospheric aerosols such as mineral dust, volcanic ash, as well as clouds, and for ground based air-quality monitoring [5,6].

2 Selected results

An early counter was developed in 2009 for profiling atmospheric mineral dust. It was designed for attaching to a standard Vaisala RS92 radiosonde and launching on a small meteorological balloon. It provided a size distribution in five bins and could also be interfaced to an electric charge sensor to detect aerosol charging [1-3]. In 2010 this counter was used to profile ash layers from the Eyjafjallajökull eruption [4]. A number of these units are currently held by the UK Met Office for use in the event of further volcanic ash episodes.

A disadvantage of conventional optical particle counters that draw ambient air in through a narrow inlet is that they can become blocked, which is almost inevitable during measurements in the presence of supercooled cloud droplets, for example. Therefore, a different counter version was developed, which can have more open-path geometry, as the sensing zone is defined optically rather than being delimited by the flow system. This counter is currently used in a network of about 50 multi-parameter sensor stations for air quality monitoring around Heathrow airport, and for fog characterization. These counters size particles into bins in the range from 0.35 to 17 µm [5,6]. The counter has now been adapted for use with radiosondes or dropsondes. The dropsonde version has been successfully tested by launching it from research aircraft together with the so-called *KITsonde*, developed at the Karlsruhe Institute of Technology, which determines standard meteorological parameters and GPS position for transmission back to the aircraft [7].

3 Conclusion

Low cost optical particle counters can be used in conjunction with meteorological radiosondes or dropsondes to obtain vertical profiles of the size distributions and concentrations of atmospheric aerosols and cloud particles on a routine basis. They also allow measurements where research aircraft cannot fly safely, as was demonstrated during the Eyjafjallajökull volcanic eruption. Open-path particle counters are especially valuable, as they permit measurements in the presence of liquid water.

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