Aerosol sounding with LOAC at the EGU 2013 General Assembly

Remember the orange ballon flying outside the Austria Center Vienna during this year's General Assembly? It was part of an experiment to measure aerosol concentration and determine air quality at the conference. Experiment-leader Jean-Baptiste Renard reports on the results here.

Measuring the concentration and mass of aerosols in the lower atmosphere is of primary importance. Their presence in the ambient air can have direct effect on human health as these pollutant particles can enter the body's airways and interfere with gas exchange in the lungs. Further, their interactions with solar radiation and clouds are likely to affect the climate and, in some occasions of very high concentrations in altitude, they can affect air traffic security.

Due to the large variety of aerosol sources, both of natural and man-made origins, and their relatively short lifetime in the atmosphere, the concentration, nature and size of the particles experience significant variability. To understand and predict aerosol impacts, it is important to develop observation and monitoring systems allowing their characterisation. To determine the size and distribution of aerosols, researchers often use optical particle counters, which work by detecting the light scattered by the suspended particles.

LOAC at the EGU General Assembly

At the EGU 2013 General Assembly, which took place in Vienna in April this year, we conducted aerosol measurements under a tethered balloon using a new kind of light aerosols counter (Fig. 1, left). The instrument, called LOAC (Light Optical Aerosols Counter), weighs 1 kg and can determine the concentration of particles in 19 size classes, with diameters from 0.3 to 50 µm. It can also inform on the main nature of the detected aerosols: carbon (such as soot), mineral (such as microscopic sands) and liquid (droplets).

We flew LOAC under a 6 m^3 tethered balloon operated by the Austrian Meteorological Office, with maximum altitudes in the 110–220 m range (Fig. 1, right). On 9 April 2013, we conducted the fights during the morning coffee break (~10:30), lunch time (~13:00) and afternoon coffee break (~15:30) while on 11 April 2013, only one flight was conducted, during the morning coffee break (~10:30). For each 30-minute session of measurements, the LOAC performed two ascents and two descents. For comparison, we also conducted indoor measurements in the main hall of the conference centre during the 10 April afternoon (15:30–16:30).

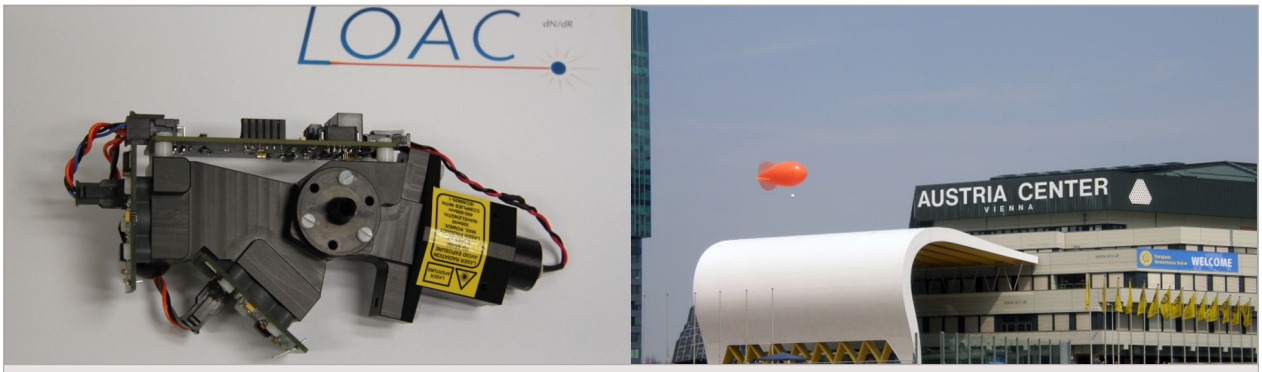

Figure 1. Left: LOAC optical chamber and electronics. Right: LOAC balloon deployment at the EGU 2013 – the aerosol counter is in the small white box under the balloon. (Credit: F. Dulac)

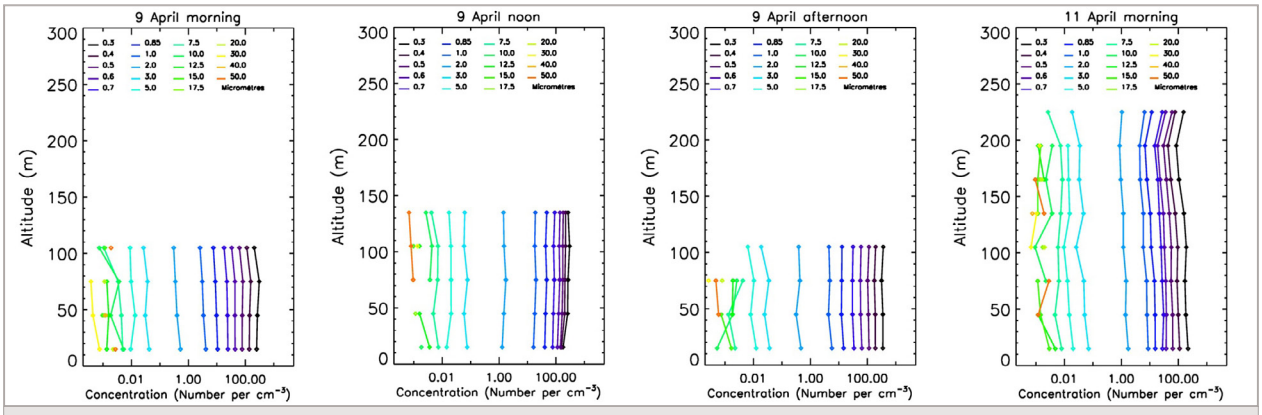

Figure 2. Vertical distributions of 19 size classes for the four LOAC flights

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Aerosol concentrations at the conference

Figure 2 presents the evolution with altitude of the concentration for 19 size classes obtained during the four outdoor flights. The concentration of particles greater than ~3 µm decreases with altitude because they are more massive than the smallest ones. This effect, shown in Fig. 3 for two different altitudes during the 11 April morning flight, induces changes in the size distribution.

The smallest aerosols exhibit significant variation of concentration with altitude, probably due to air masses of different origins. The size distribution of these aerosols also changes with time due to different processes in the aerosol formation and transport during the day.

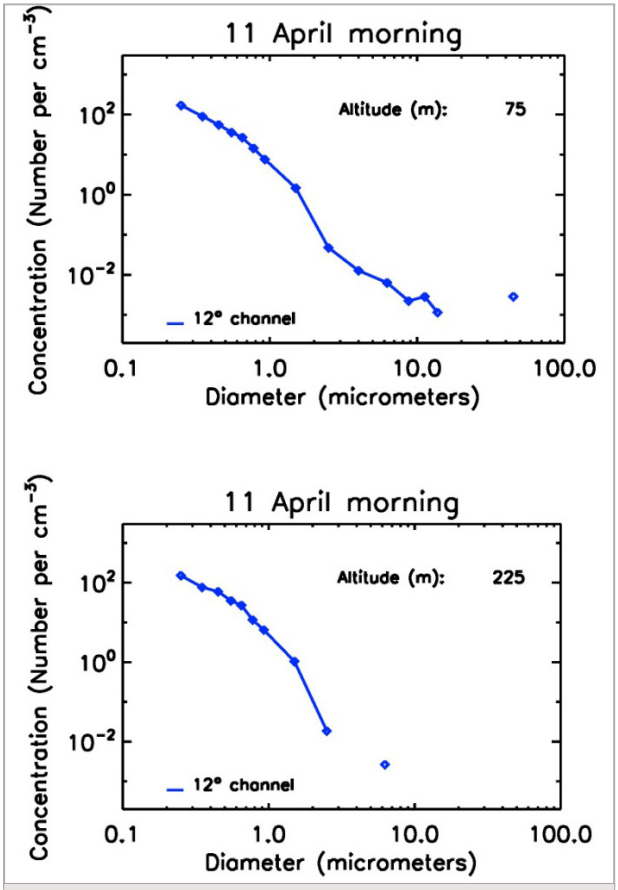

Figure 3. Size distribution at two different altitudes for the 11 April morning flight (12° channel refer to the scattering angle measurements used by LOAC for the counting)

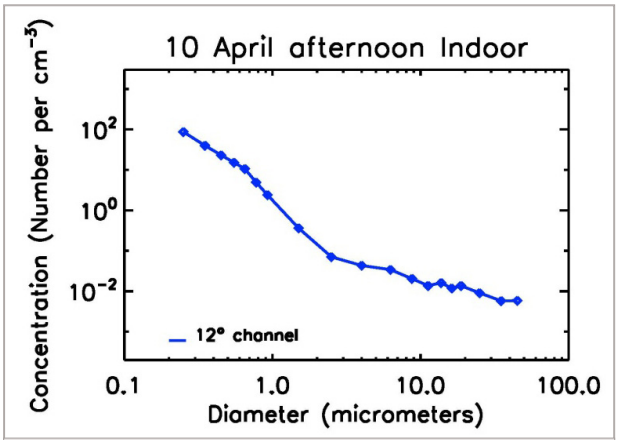

Figure 4. Indoor measurements during the 10 April afternoon coffee break

The measurements indicate various natures of particles depending on the altitude and time of measurements. During the 9 April morning flight, LOAC detected only mineral particles. At lunch time, carbon particles and large mineral particles were present at all altitudes. Then, in the afternoon, the particles were mineral for altitudes below 100 m and carbon above. On 11 April, mineral and carbon particles were present from the ground up to 150 m. Above 175 m, only carbon particles were detected, as expected for urban pollution. The presence of mineral particles below 150 m could be due to building works going on in the towers close to the conference centre. Thus, at the EGU 2013 General Assembly, mineral particles dominated the ambient air, which is unusual since carbon particles are expected to be the main population of urban aerosols.

To compare the outdoor air quality with that indoors, we present in Fig. 4 the size distribution for the aerosol measurements we conducted indoors on 10 April. The concentration of the largest particles was about five times higher than in the outdoor air, with the nature of particles being mineral and carbon. Such measurements show that the indoor air was more polluted than outside in terms of total aerosol mass, as expected since many human activities and movements were present. From the LOAC counting, it is possible to provide a rough estimation of the total mass of particles per cubic metre, assuming a mean density of 2 g/cm^3 for the particles. During peak activity, the concentration of particles smaller than 10 µm surpassed 50 µg/m^3, which is the limit daily-average value defined by EU air quality standards.

LOAC's uses

In conclusion, the flights conducted with LOAC under a tethered balloon allowed us to determine the vertical evolution of pollution particles up to an altitude of 200 m, and to point out an evolution of the nature of aerosols with altitude. These kinds of measurements can help distinguish between local sources and averaged ambient air above cities. Similar measurements are now conducted routinely with LOAC from the Observatoire Atmosphérique Generali touristic balloon in Paris, up to an altitude of 300 m.

LOAC is also involved in several campaigns, such as ChArMEx (studies of tropospheric pollution in the Mediterranean Sea) and AEROWAVE (studies of variability of aerosols atmospheric content up to the stratosphere) with flights under different types of balloons.

Jean-Baptiste Renard
Senior scientist at LPC2E–CNRS and Orléans University in France, on behalf of the LOAC team and collaborations

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