Aerosol vertical profiles in the Arctic

Mauro Mazzola[1], Maurizio Busetto[1], Luca Ferrero[2], Angelo P. Viola[3], David Cappelletti[1,4]

[1]National Research Council, Institute of Atmospheric Sciences and Climate (CNR-ISAC), Via Gobetti 101, 40129 Bologna, Italy, m.mazzola@isac.cnr.it;
[2]POLARIS Research Center, DISAT, University of Milano-Bicocca, 20126 Milano, Italy;
[3]National Research Council, Institute of Atmospheric Sciences and Climate (CNR-ISAC), Via Fosso del Cavaliere 100, 00133 Roma, Italy;
[4]Department of Chemistry, Biology and Biotechnologies, University of Perugia, 06123 Perugia, Italy;

Abstract

A novel airborne gondola has been developed to profile the Arctic boundary layer exploiting a tethered balloon system. A number of aerosol instrumentation have been customized and deployed in the gondola for three campaigns conducted in Ny-Ålesund in September 2014 and April-May 2015 and 2016. The performances of the instrumental setup have been characterized and a total of more than one hundred vertical profiles have been recorded during the campaigns. The tethered balloon systems demonstrates the capability of successfully lifting up to 15 kg of scientific payload, featuring a power autonomy of about 3 hours of continuous measurements with 1 battery. We demonstrates for the first time on a tethered balloon the capability of measuring at the same time aerosol light scattering and absorption coefficients and size distribution, which is very promising for deducing the aerosol optical properties as a function of height along the probed atmospheric column.

Introduction

Primary objective of this activity is to contribute datasets to build a climatology of the lower troposphere composition in terms of aerosol particles in the Kongsfjorden area. This is achieved by means of a scientific payload that can be lifted up to about 1000 m by a tethered balloon. The work is motivated and reinforced by the presence of permanent measurement stations in the area. Further more specificobjectives are the detection of long-range transport events and the study of aerosol mixing processes from the surface to the troposphere. Previous experiments where performed recently using other payloads (Moroni et al., 2015, 2016; Ferrero et al., 2016) which paved the way for the substantial improvements of the newinstrumental setup.

Method

The instrumental gondola AGAP (Atmospheric Gondola for Aerosol Profiling) has been designed and realized in Italy during summer 2014. The mechanical part has been manufactured in Perugia by assembling aluminium parts cut with a precision laser techniques. The electronics and the instruments assembling has been realized at ISAC-CNR in Bologna. The aerosol instrumentations have been provided by both the Perugia and the ISAC-CNR laboratories from independent funding and previous projects. It includes a Radiance Research nephelometer M903, an AethLabs micro aethalometermodel AE51, an OPC produced by FAI instruments and an ozone monitor 2B Technologies, besides meteorological sensors (Figure 1).

Three measurements campaigns were performed with this setup: the first during fall (8-29 September 2014) while the other two during spring (7 April-8 May 2015 and 3-28 April 2016). Thirty-five profiles were obtained during the first campaign, 43 during the second and 40 during the third one. Aerosol profile measurements were carried out from outside the Gruvebadet laboratory, where many in-situ aerosol observations and sampling are continuously carried out (Giardi et al., 2016), by means of a helium-filled tethered balloon. In the present campaigns we exploited an 8 m long, 50 m^3balloon produced by Aeronord Aerostati (Figure 2). The balloon, the Kevlar rope and

the riggings weight a total of 20 kg , leaving approximately 15 kgfor lifting safely the instrumental payload. An electric winch controls the balloon ascent/descent rate which is typically set at 30 m min^{-1}. The temporal resolution of the measurements varies between 1 sfor aerosol scattering coefficient and meteorological parameters, 6 sfor the size distribution, 10 sfor ozone concentration and 1 minute for BC . This determines the vertical resolution of the experiments which is 0.5 m for aerosol scattering coefficient and meteorological parameters, 3 mfor the aerosol size distribution, 5 mfor ozone concentration and 30 mfor the BC concentration.

Results

The maximum height reached during each flight depended on atmospheric conditions; for the majority of the profiles, the maximum height was between 600 and 800 m a.g.l.. The highest altitude reached was 1350 m a.g.l. on the 20 May 2016.

The temperature inside the gondola was usually between 5 and 10 °Chigher than the external atmospheric temperature and rarely went below -5 °Cduring the spring campaigns. The experiments accounted different measurement procedures: (i)the balloon continuously up and down in order to provide profiles of the aerosol properties along the vertical, and (ii) measuring at a fixed height, defined on the basis of previous observed profiles.

In order to further lighten the payload and make the balloon-gondola system more manoeuvrable, the ozone monitor was removed after the first launches of the first campaign and was not adopted at all during the second campaign.

A total of more than100 profiles were obtained, allowing the definition of typical situations for these two seasons, as well as to identify specific episodes. Preliminary results have been already published (Mazzola et al., 2016).

The activities of AGAP will be continued in the Arctic during next years, while an international campaign is scheduled in Germany for winter 2016/2017.

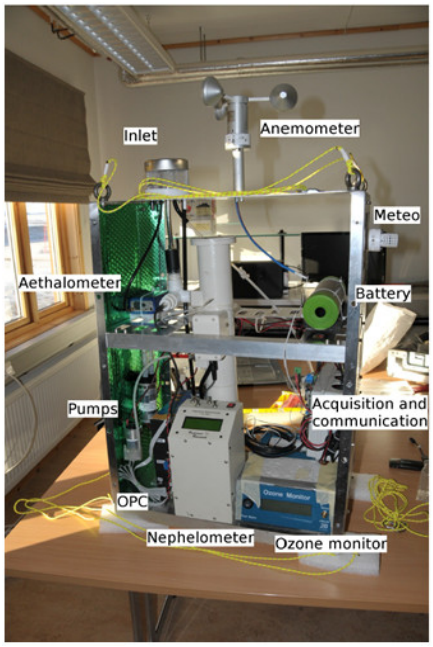

Figure 1: *The AGAP with details of the aerosols instrumentations.*

Figure 2: *The which-AGAP-tethered balloon system in operation in front of the Gruvebadet laboratory.*

References

B. Moroni, S. Becagli, E. Bolzacchini, et al., “Vertical Profiles and Chemical Properties of Aerosol Particles upon Ny-Ålesund (Svalbard Islands),” Advances in Meteorology, vol. 2015, Article ID 292081, 11 pages, 2015. doi:10.1155/2015/292081

Moroni, B., Cappelletti, D., Ferrero, L. et al. Rend. Fis. Acc. Lincei (2016). doi:10.1007/s12210-016-0533-7

Ferrero, L., Cappelletti, D., Busetto, M., Mazzola, M., Lupi, A., Lanconelli, C., Becagli, S., Traversi, R., Caiazzo, L., Giardi, F., Moroni, B., Crocchianti, S., Fierz, M., Mocnik, G., Sangiori, G., Perrone, M. G., Maturilli, M., Vitale, V., Udisti, R., and Bolzacchini, E.: Vertical profiles of aerosol and black carbon in the Arctic: a seasonal phenomenology along two years (2011–2012) of field campaign, Atmos. Chem. Phys. Discuss., doi:10.5194/acp-2016-171, in review, 2016.

Giardi, F., Becagli, S., Traversi, R. et al. Rend.Fis. Acc. Lincei (2016). doi:10.1007/s12210-016-0529-3

Mazzola, M., Busetto, M., Ferrero, L. et al. Rend.Fis. Acc. Lincei (2016). doi:10.1007/s12210-016-0514-x