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Evaluation of the miniaturized particle counter LOAC for the survey of stratospheric aerosols with meteorological balloons

1Laboratoire de Physique et Chimie de l’Environnement et de l’Espace, CNRS, University of Orleans, France / 2Institute of Space and Atmospheric Studies, University of Saskatchewan, Saskatoon, Canada / 3Science Systems and Applications Inc., Hampton, USA / 4NASA Langley Research Center, NASA / 5Universities Space Research Association, Grenoble, MD, USA / 6NASA Goddard Space Flight Center, Greenbelt, MD, USA / 7LATMOS, CNRS, University of Versailles St Quentin, Guyancourt, France / 8LISCE-CJEP/PL, University of Paris Saclay, CEA Saclay 701, Gil-saint-vent, France

Damién VIGNELLES1, Gwenael BERTHET1, Jean-Baptiste RENARD1, Landon RIEGER2, Adam BOURASSA2, Jean-Paul VERNIER2,4, Ghassan TAHA2,4, Sergei KHYAKIN3, Fabrice JEGOU1, François DULAC3, Thibaut LURTON3,Vincent DUVERGER3, Benoit COUTE1

* Summary *

The study of the stratospheric aerosols is important to our understanding of the terrestrial radiative budget. Aerosols play also an important role on heterogeneous chemistry in stratosphere. Our current comprehension of the different types of stratospheric particles and their spatial and temporal distribution is incomplete.

In the present study, we try to show that measuring particle concentrations by the means of a new balloon-borne miniaturized particle counter, the LOAC, may allow us to determine the local variability in stratospheric aerosols in the size range 0.1-1000 µm in diameter. In that respect, the PhD thesis sum up here consists of a first phase of a more accurate characterisation of the LOAC’s performance under balloon-borne measurement. A second phase consists of comparative analysis of stratospheric aerosol content based on a LOAC data obtained during a continuous campaign of balloon launches in France, and along some occasional flights abroad under particular circumstances (volcanic eruption, Iceland, Réunion Island, monsoon (India)). Thus we show that the LOAC has a detection limit that restricts the measurement of submicronic particles in volcanic Quiescent periods for concentration lower than 1 particles per cm3. Compared to lidar data (LIDARs, CALIOP, and outputs from WACCM-CARMA model) over the France reveal that LOAC data are more dispersed around other dataset until 25 km in altitude where the LOAC results remain converge to the detection limit.

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LOAC (Light Optical Aerosol Counter) – under meteorological balloon

Light miniature particle counter rose through the atmosphere clining to meteorological balloon

- Complete payload : 1 kg (LOAC + pump less than 360 g)
- 3 W electrical consumption
- Concentrations over 19 size classes (0.2 – 1000 µm)
- Typology (main optical nature of aerosols) – 5 classes
- 120 LOAC have been built since 2013
- 10 stratospheric flights and some volcanic eruptions

Results of balloon-borne experiments:

In the period between June 2013 to August 2016, 94 profiles have been made with LOAC from several launching bases in France (Fig. 6).

Averaged flight frequency of 2 flights per month, this innovative dataset represents an important step to study the variations of the stratospheric aerosol content.

In the lower stratosphere (18-24 km) aerosol concentrations are consistent with each other. Above 27 km, OMPS, OHP, and CALIOP give lower extinctions than CALIOP, LOAC, and WACCM. CALIOP gives higher extinctions in middle stratosphere: a combination of two reasons can be suggested in order to explain this phenomenon. Firstly the LOAC’s detection limit is not removed here (Fig. 9, and 10) which is approximately the mean extinction at 35 km. Secondly, retrievals from other lidar and ground-based lidars are based on various assumptions: pure sulfate aerosols, invariable size distributions in order to derive extinction, and no extinction from aerosols above certain levels.

To retrieve 100% of the LOAC data averaged over a 3 year period need further investigations.

In the synthetic temperature profiles, the lidar OHP data reveal that the local temperature variation during flight causes this lower reproducibility. Others comparative flights are under preparations at this time. The LOAC’s performances appear to be limited by the low detection limit and the low representativeness in flight conditions. Low pressure and low temperature are without influence on flow rate and laser power.

The compared LOAC flights indicate a reproducibility lower than the one established in the laboratory. We assumed that the internal temperature variation during flight causes this lower reproducibility. Others comparative flights are under preparations at this time.

Comparative results with other datasets

Comparative results with others datasets allow to determine a new profile (Fig. 7 & blue dotted line) vs. the one of the balloon-borne measurement of the aerosol size distribution from an island’s flood based on the CNES balloon-borne model (Fig. 9) and the CNES balloon-borne model (Fig. 10).

In conclusion, the well-documented balloon-borne model (Fig. 10) reveals a low reproducibility in flight in the same area. This reproducibility lower than the one determined in laboratory must be investigated in order to further discuss these results. New version more accurate and lighter of LOAC are in development.