EPJ Web of Conferences **119**, 06015 (2016) DOI: 10.1051/epjconf/201611906015
ILRC 27

NEAR-RANGE RECEIVER UNIT OF NEXT GENERATION POLLY^{XT} USED WITH KOLDEWAY AEROSOL RAMAN LIDAR IN ARCTIC

Iwona S. Stachlewska[1*], Krzysztof M. Markowicz[1], Christoph Ritter[2], Roland Neuber[2], Birgit Heese[3], Ronny Engelmann[3], Holger Linne[4]

[1]*Institute of Geophysics, Faculty of Physics, University of Warsaw, (IG FUW) Warsaw, Poland, *E-mail: iwona.stachlewska@igf.fuw.edu.pl*

[2]*Alfred-Wegener Institute for Polar and Marine Research (AWI), Potsdam, Germany.*

[3]*Institute for Tropospheric Research (TROPOS), Leipzig, Germany.*

[4]*Max-Planck Institute for Meteorology (MPI), Hamburg, Germany.*

ABSTRACT

The Near-range Aerosol Raman lidar (NARLa) receiver unit, that was designed to enhance the detection range of the NeXT generation Polly^{XT} Aerosol-Depolarization-Raman (ADR) lidar of the University of Warsaw, was employed next the Koldeway Aerosol Raman Lidar (KARL) at the AWI-IPEV German-French station in Arctic during Spring 2015. Here we introduce shortly design of both lidars, the scheme of their installation next to each other, and preliminary results of observations aiming at arctic haze investigation by the lidars and the iCAP a set of particle counter and aethalometer installed under a tethered balloon.

1. INTRODUCTION

Presence of the absorbing aerosols in troposphere causes locally warming effect at the altitude of their occurrence and cooling effect below, at the ground. Measurements have shown that black carbon could be a minor, but due to its absorption, an important component found in arctic haze advection events over Ny-Alesund [1], what has been confirmed by chemical in-situ measurements from Zeppelin station [2].

In the frame of the iAREA project, an arctic field campaign was performed during 26 March to 7 May 2015 at Ny-Alesund, Spitsbergen, Arctic. We aimed at assessing a possibility of profiling absorbing particles during arctic haze event, using a set of a compact particle counter and an aethalometer installed under a tethered balloon, in combination with ground-based observations of a near-range aerosol elastic and Raman lidar signals measured at UV and VIS channels, that completed measurements of an advanced multi-wavelength multi-channel aerosol-raman-depolarization lidar.

The Near-range Aerosol Raman lidar (NARLa), was initially developed for the Radiative Transfer Labolatory (RTLab) of the IG FUW in Warsaw to serve along with the advanced 8-channel (2α + 3β + 2δ + wv) aerosol-depolarization-Raman lidar (ADR lidar) of Polly^{XT}-type, that was developed withinin the SONATA-BIS project in a scientific cooperation with TROPOS in Leipzig [3]. The ADR lidar has a completed overlap at about 600 m, which was not sufficiently low to measure Winter boundary layer structures, that are expected to be often below that altitude over Warsaw [4]. Since our long-term goal at RT Lab is to measure aerosols within the boundary layer and in the free troposphere, to investigate exchange processes between them, we required an additional receiving/detecting unit (possibly independent on the ADR lidar receiving/detecting unit), that could be applied for the near range measurements starting from almost a ground level (NARLa).

The compact design of NARLa and its operation (independent on the ADR lidar), allowed us to use this near-range unit with other lidar systems, for example with the KARL lidar during the arctic field campaign in Spring 2015 on Spitsbergen. Preliminary analysis of the data taken on April 3rd and 7th, 2015 shows that on the first day background aerosol was measured while on the other a possible arctic have event occurred.

 DOI: 10.1051/epjconf/201611906015

2. INSTRUMENTATION

The NARLa is dedicated to near-range detection with a full overlap around 120m above the ground for a configuration with the ADR lidar, and thus it lowers the overlap-affected height range of the overall system of about 480 m and allows to improve the detection within the boundary layer. It and comprises 4 channels (2α + 2β) at 355 and 532 nm. The channels for detection of polarization were not implemented as this unit is normally used with the ADR lidar that collects the polarization signals at both 532 and 355nm channels, and thus provides particle linear depolarization profiles almost down to the ground. The photon counting data acquisition system for the NARLa and the ADR lidar were adopted after the MPI-Hamburg design to provide a small and relatively low-priced data acquisition for scientific lidar measurements characterized by an excellent response to the high dynamic range of lidar data.

The NARLa comprises the Newtonian type telescope of a diameter of 5cm and focal length of 20cm, a fiber core of 0,4 mm resulting in FOV of 2mrad. A fiber-optic scrambler consisting of a ball lens of 2 mm diameter links two fiber patch cables to clean angular distortions. After, the light passes a set of beam splitters and interference filters before the elastic signals are detected at 355 and 532nm, and the Nitrogen Raman channels collect the light at 387 and 607nm (Fig.1). For all channels the Hamamatsu P10721-110 are used in photon counting mode with low overall dead-time of about 2ns at each channel.

Fig.1: The NARLa detector unit consisting of elastic and Raman channels at 355nm and 532nm.

The acquisition is triggered with scattered laser light and obtained with 800 MHz photon counters with 7.5m spatial resolution. The first 256 signal bins are allocated for pre-trigger and signal is obtained up to ~40km.

The operation of NARLa was tested initially in February 2015 in an installation at the ACTRIS-EARLINET Supersite, next to a primary receiver of the MARTHA lidar at TROPOS in Leipzig. Then, at the beginning of March 2015 it was tested in an installation next to the ADR lidar at IG FUW in Warsaw. The installation of NARLa naxt to the KARL at AWI-IPEV station in Ny-Alesund was done from 27 March till 6 May 2015 (Fig.2). In all of the mentioned configurations we used the powerful lasers of the three advanced lidar systems as a source of radiation for NARLa.

Fig.2: Installation of the NARLa receiver/detection unit next to the KARL lidar receiver at Ny-Alesund.

The Koldewey Aerosol Raman Lidar (KARL) [5] is a coaxial (2α + 3β + 2δ + 2wv) Nd:Yag based system with ~10W / color, with 0.6 mrad laser divergence and 70 cm diameter receiving mirror. An aperture stop that is movable in position and diameter allows measurements in the troposphere (overlap range above 700m) and stratosphere. The KARL lidar is member of the NOAA - Network for the Detection of Atmospheric Composition Change (NDACC).

Table 1. Detection channels used by the three lidars ADR, KARL, and NARLa.

Detected Wavelength (nm)	Detection Type	ADR lidar Warsaw Poland	KARL Warsaw Spitsbergen Arctic	NARLa mobile detection module
1064	Elastic total	x	x	
660	Raman H_2O		x	
607	Vibrational Raman N2	x	x	x
532	Elastic total	x		x
532	Elastic cross	x	x	
532	Elastic parallel		x	
407	Raman H_2O	x	x	
387	Vibrational Raman N_2	x	x	x
355	Elastic total	x		x
355	Elastic cross	x	x	
355	Elastic parallel		x	

Additionally, profiling of absorbing particles was performed with the iCAP set, that comprises two in-situ sensors – the AE51 aethalometer and the HandiLaz aerosol particle counter together with the GoPro camera. The iCAP set (Fig.3) was installed on the tethered balloon that can be released to the maximum altitude of ~1600m. During the campaign in Spring 2015 the iCAP measurements were performed up to 5 times a day in favorable weather conditions (not too strong wins speed and not too thick clouds). Duration of a single ascent/profile is of ~30 min.

The quick-looks a vieved online via the website of the polish aerosol observational network Poland AOD (http://www.polandaod.pl).

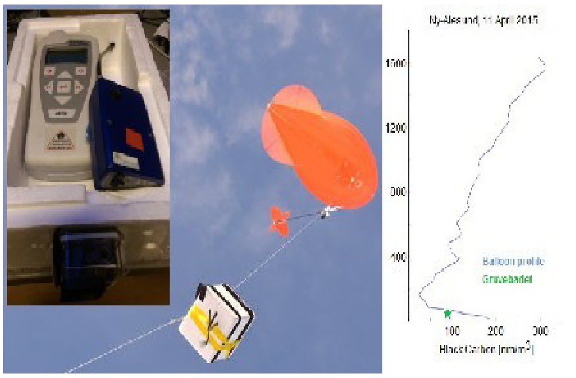

Fig.3: The iCAP set installed on tethered balloon for absorbing particles profiling. On the right an ascent with black carbon measurement taken at Ny-Alesund on 11/04/ 2015 compared with in-situ measurement at Gruvebadet station.

3. RESULTS

The layered structure of troposphere obtained with NARLa receiver at 532nm attenuated backscatter signals on 03/04/2015 and 07/04/2015 is depicted in Fig.4.

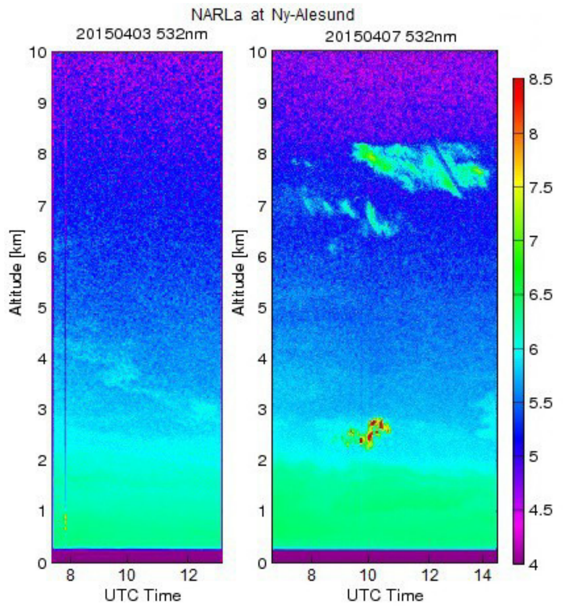

Fig.4: Attenuated backscattering coefficient profiles at 532 nm [1/m/sr] measured by NARLa on 03/04/2015 and 07/04/2015 in Ny-Alesund, Arctic. The signals are available for evaluation in the range between about 300m up to 10km. Quick-looks of the data set are given at http://www.polandaod.pl.

The first day was characterized by clear-sky weather conditions (background aerosol). On the second day the aerosol load in lower troposphere was significantly enhanced (arctic haze) and in the upper atmosphere Cirrus clouds appeared.

A preliminary backscatter coefficient profiles calculated for KARL and NARLa observations at 12 UTC on 03/04/2015 at 355, 532 and 1064nm are compared in Fig.5. All profiles were averaged over 1h (no smoothing was applied and range resolution was kept at 7.5m), prior to applying the Klett's evaluation scheme with lidar ratio of 30sr and calibration value set at 3.75km (NARLa) and 12km (KARL). The agreement of VIS channels (green) is clear but reason for profiles shift at UV channels (blue) need to be further investigated.

As a next step, an evaluation of entire data set of NARLa and KARL obtained during Spring 2015 campaign using the Ansmann evaluation scheme to obtain independently extinction coefficient and lidar ratio profiles will be conducted together with analysis of absorption profiles obtained using the iCAP set.

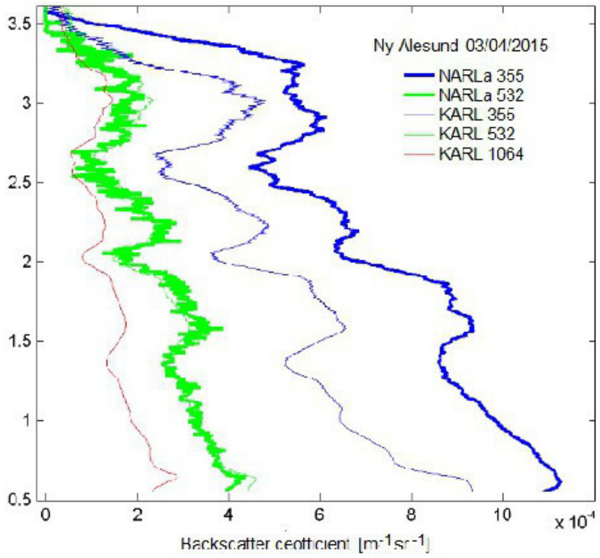

Fig. 2. The backscatter profiles obtained around 12 UTC on 03/04/2015 by NARLa and the KARL receivers in Ny-Alesund, Arctic. The disagreement of the UV profiles still need to be investigated.

4. CONCLUSIONS

The NARLa proved robust and compact enough for easy installation next to the different lidars (MARTHA in Leipzig, ADR in WARSAW, KARL in Ny-Alesund). The latter configuration show that it is capable of performing aerosol measurements even up to 10 km at UV and VIS channels in tough Arctic conditions.

ACKNOWLEDGEMENT

The development of NARLa was conducted in the frame of the SONATA-BIS Project: *Integrated study of climate processes involving absorbing aerosols,* funded by the National Science Centre of Poland (2012/05/E/ST10/01578).

The arctic campaign in 2015 was financed in the frame of the iAREA Project: *Impact of absorbing aerosols on radiative forcing in the European Arctic* funded by the Polish-Norwegian Research Programme (Pol-Nor/196911/38/2013).

REFERENCES

[1] Yamanouchi T., et al. 2005: *Arctic Study of Tropospheric Aerosol and Radiation (ASTAR) 2000: Arctic haze case study*, Tellus 57B, 141–152

[2] Tunved P., et al. 2013: *Arctic aerosol life cycle: linking aerosol size distributions observed between 2000 and 2010 with air mass transport and precipitation at Zeppelin station, Ny-Alesund, Svalbard*, Atmos. Chem. Phys., 13, 3643-3660

[3] Engelmann R., et al. 2015: *EARLINET Raman lidar Polly^{XT}: The NeXT Generation*, Atmos. Meas. Techn. Discuss. (submitted April 2015)

[4] Stachlewska I.S., et al. 2012: *Ceilometer observations of the boundary layer over Warsaw*, Poland, Acta Geophys. 60, 1386-1412, **2012**

[5] Hoffmann A., et al. 2010: A redesigned Raman lidar for cloud and aerosol profiling in the Arctic, iILRC 25, St. Petersburg.