Determination of quartz concentration in mineral dust from measurements of quartz Raman scattering with lidar at two wavelength

Ina Mattis[1], **Detlef Müller**[2], **Dong-Ho Shin**[2], **Youngmin Noh**[2], **Boyan Tatarov**[3], **Taejin Choi**[4], **and Namyi Chae**[4]

[1]*Leibniz Institute for Tropospheric Research, Permoser Str. 15, 04318 Leipzig, Germany, ina@tropos.de*
[2]*Atmospheric Remote Sensing Laboratory, Department of Environmental Science and Engineering, Gwangju Institute of Science and Technology (GIST), 261 Cheomdan-Gwagiro (Oryong-dong), Buk-Gu, Gwangju 500-712, Republic of Korea*
[3]*National Institute for Environmental Studies, 16-2 Onogawa, Tsukuba, Ibaraki, 305-8506, Japan*
[4]*Korea Polar Research Institute (KOPRI) SongDo Techno Park, 7-50 Songdo-Dong, Yeonsu-Gu, Incheon, Republic of Korea*

ABSTRACT

The multi-wavelength Raman lidar of the Gwangju Institute for Science and Technology was equipped with two Raman channels at 360 and 546 nm for the measurement of quartz concentration in mineral dust layers. We have proofed that the new channels are functional. The measurement example of March 31, 2009 is presented in more detail.

First measurements with the new channels have been performed during the Asian dust season from March to May 2009. We detected Asian dust in the polluted boundary layer with plumes of dust in the free troposphere.

1. INTRODUCTION

In East Asia layers of mineral dust are often immersed in layers of anthropogenic pollution. Under such circumstances it is very difficult to separate between the two aerosol components with lidar remote sensing. In 2005 it was proposed to use the Raman method for measurements of quartz concentrations in mineral dust layers (1). In this study laser light was emitted at 532 nm and the quartz channel detected inelastically backscattered light at 546 nm. This wavelength shift is due to Raman scattering at quartz grains.

In our study we use the multi-wavelength Raman lidar of the Gwangju Institute of Science and Technology (GIST), Republic of Korea (35.10N, 126.53E). This instrument allows us to infer vertical profiles of backscatter coefficients at 355, 532, and 1064 nm, extinction profiles at 355 and 532 nm as well as volume-depolarization ratio profiles at 532 nm. In Spring 2009 this lidar was equipped with two additional Raman channels at 360 and 546 nm for the measurement of quartz concentration in mineral dust layers.

2. INSTRUMENTATION

From measurements with the GIST multi-wavelength Raman lidar (MWL) we obtain vertical profiles of backscatter coefficients at 355, 532, and 1064 nm, extinction profiles at 355 and 532 nm as well as depolarization ratio profiles at 532 nm. The lidar system and data analysis are described by (2). In Spring 2009 this lidar was equipped with two additional Raman channels at 360 and 546 nm. These channels detect Raman scattering at quartz grains. Figure 1 illustrates the receiver box of the MWL. The data of the quartz channels and of the regular channels of the MWL have been recorded alternately because the data acquisition unit had not enough acquisition channels.

The Korean Polar Research Institute (KOPRI) operated a depolarization lidar (DPL) in spring 2009. This backscatter lidar provides profiles of volume depolarization ratio and extinction coefficients at 532 nm. The data of this lidar can be used to link the different different measurement periods of MWL.

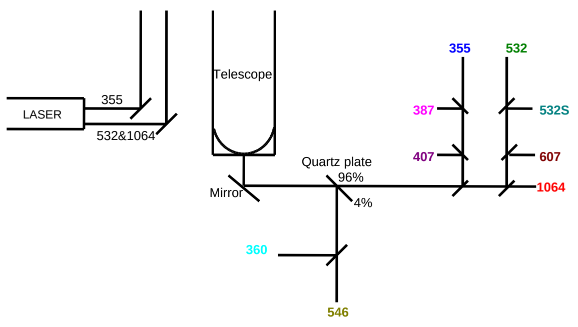

Figure 1. Schematic of the GIST Multi-wavelengths Raman lidar.

3. OBSERVATIONS

The measurements with the two quartz Raman channels started in March 2009. They covered the complete dust season and lasted until end of May 2009. There were about 15 measurement days with dust layers in the atmosphere.

Figures 2 and 3 present the measurement of March 31, 2009 as an example. There was a dust layer with enhanced volume depolarization ratios close to the ground. The top height of the dust layer increased during the night from 1 km to 2 km. From 12 to 13 UTC we observed midlevel clouds around 4-5 km height and around 14:30 UTC some low clouds occured. Simulations with the dust transport model DREAM (3) also indicate a moderate dust load over Korea during this measurement (see Fig. 4).

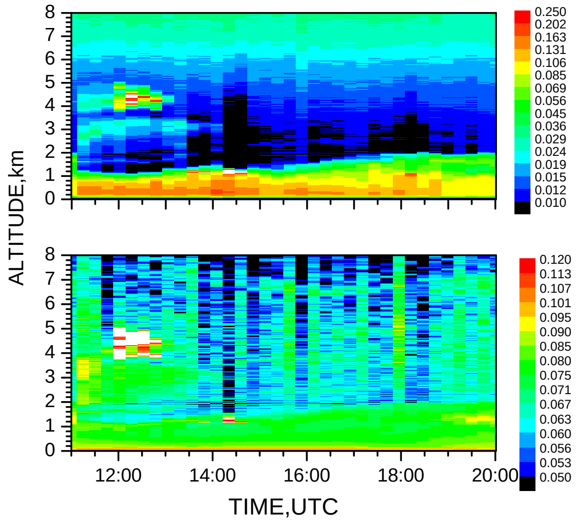

Figure 2. Time series of the observation of March 31, 2009 over Gwangju, Korea. The top panel shows the extinction coefficient in km^{-1}*. The bottom panel indicates the linear volume depolarization ratio. The data have been obtained with the depolarization lidar of KOPRI.*

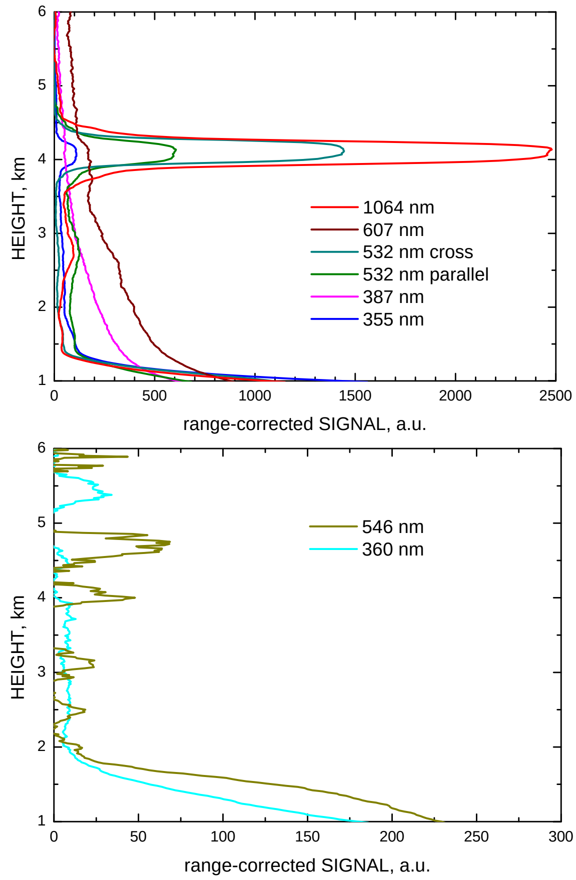

Figure 3. Range corrected signals. Top: regular MWL signals measured at March 31, 2009 from 10:30 to 11:30 UTC. Bottom: Raman quartz signals at 360 and 546 nm measured with MWL at March 31, 2009 from 14:27 to 17:27 UTC.

Figure 3 illustrates the vetical structure of the atmosphere over Gwangju in terms of range-corrected signals. The regular MWL signals show the top height of the planetary boundary layer at 1.2 km height, a dust layer between 2 and 3 km and a cloud around 4 km height. Both quartz Raman signals are detectable within the dust lowest layer up to 1.5 km height. The second dust layer up to 4 km is visible only in the 360-nm signal. The 546-nm signal is too noisy in this upper height range.

4. SUMMARY AND OUTLOOK

The analysis of the Raman quartz measurements at Gwangju will be continued. The combined data set of MWL signals and DPL signals will be used to calculate profiles of the backscatter coefficients at 355, 532, and 1064 nm, of extinction coefficients at 355 and 532 nm as well as a profile of the volume depolarization ratio at 532 nm. Quartz concentrations will be estimated. We will use cloud measurements to check the Raman signals for cross talk with the elastic signals.

The 360-nm channel is now mounted to the multi-wavelength Raman lidar of the Leibniz Institute for Tropospheric Research, Leipzig, Germany. We wait for plumes of Saharan dust that often occur in early summer and late fall over Central Europe. From those observation we may compare properties of Asian dust and Sahara dust.

REFERENCES

[1] B. Tatarov and N. Sugimoto, “Estimation of quartz concentration in the tropospheric mineral aerosols using combined Raman and high-spectral-resolution lidars,” Opt. Lett. **30**, 3407–3409 (2005).

[2] Y. M. Noh, D. Müller, D. H. Shin, J. S. Jung, K. H. Lee, Z. Li, and Y. J. Kim, “Integrated monitoring of severe haze event using multi-wavelength Raman

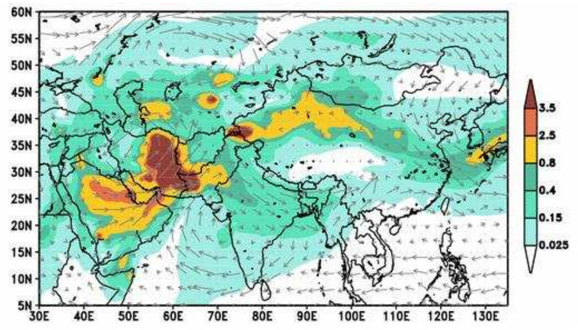

Figure 4. Simulation with the DREAM model: optical depth of mineral dust at 500 nm on March 31, 2009, 12 UTC.

lidar, satellite, and in-situ measurement in Gwangju, Korea," Atmos. Env. **43**, 879–888 (2009).

[3] C. Pérez García-Pando, "`http://www.bsc.es/projects/earthscience/DREAM/`," Web page (2007).