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Atmospheric Measurement Techniques Discussions

Interactive comment on "Esrange lidar's new pure rotational-Raman channel for measurement of temperature and aerosol extinction in the troposphere and lower stratosphere" *by* P. Achtert et al.

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We thank referee 1 for the review. Below we respond to the questions/comments raised by the referee #1:

Referee:

This manuscript describes the implementation and performance of the rotational Raman channels of the lidar system at Esrange, Sweden, in the Arctic. The technical information which is given is concise. Measurement examples illustrate important applications. The manuscript is well written. My recommendation is to accept the manuscript for publication after minor modifications, see below.

The approach of how the rotational Raman signals are extracted is unique and very interesting: First they are collected with three telescopes then, second, separated depending on their polarization, third, guided by optical fibers to a first bench ("Main Rayleigh Bench") and separated from the elastic signals, forth, both polarization directions are combined and guided by fibers to a second bench ("Rotational Raman bench") and, finally, separated in a low-J and high-J rotational Raman channel. I think, the description of this approach should be extended at least a little bit to explain the motivations to the reader. What are the advantages (simultaneous analysis of polarization and rotational Raman channels), why do you use three telescopes (more cost efficient?), what is the optical efficiency of this approach for all channels, : : :?

Response: Thanks for the comment. We changed the paragraph on page 6459 to: "The Esrange lidar uses three Newtonian telescopes with individual mirror diameters of 50.8 cm and a focal length of 254.0 cm. The backscattered light collected by each telescope is collected into one focal box where it is separated according to wavelength and state of polarization (for more information, see Blum et al. [2005]). From there optical fibers are used to guide the light to the detector. The use of three individual telescopes increases the flexibility of the lidar. In standard configuration, identical focal boxes (separating 532 nm parallel, 532 nm perpendicular, and 608 nm) are used for all three telescopes. In this way, the total signal is maximized and allows for measurements of atmospheric signals that cover 7 to 8 orders of magnitude. It is also possible to attach different focal boxes optimized for different wavelengths to the individual telescopes. In January/February 1999 the focal box of one of the telescopes was optimized for receiving rotational-Raman signals (Behrendt et al. [2000b]). However, this approach of altering only one focal box affects the overall signal strength."

Referee: Title: I suggest changing the title to "Pure rotational-Raman channels of the

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Esrange lidar for temperature and particle extinction measurements in the troposphere and lower stratosphere" or similar – one needs two rotational Raman channels and the authors discuss cloud and not aerosol measurements.

Response: Thanks for the comment. We agree and changed the title to: "Pure rotational-Raman channels of the Esrange lidar for temperature and particle extinction measurements in the troposphere and lower stratosphere."

Referee: Esrange is the abbreviation for European Space and Sounding Rocket Range. This should be explained somewhere.

Response: Esrange nowadays is a Swedish facility. The European abbreviation is no longer used.

Referee: Page 6456, line 7: : : :resolution is: : :

Response: We changed that.

Referee: Page 6456, line 22: : : :capable of measuring: : :

Response: We changed that.

Referee: Page 6457, line 6: To my best knowledge, nobody has achieved reliable temperature measurements with the DIAL technique yet – even in the boundary layer. Or can you give references? I suggest rewriting this paragraph and putting focus on mature techniques. The rotational Raman technique is the technique of choice for lidar temperature measurements from the ground up to about 30 km because in these heights the extinction of aerosol and cloud is substantial compared with molecular extinction.

Response: Thanks for the comment. We removed the respective statement and changed the paragraph to: "A variety of techniques can be applied to obtain temperature profiles from lidar measurements. Each of these techniques covers a certain height range: rotational-Raman and high-spectral-resolution lidar (from the ground to the upper stratosphere), vibrational-Raman lidar (from the upper troposphere and lower stratosphere), the integration technique (from the middle stratosphere up to the mesopause), and the resonance-fluorescence technique (from the mesopause region to the lower thermosphere)."

Referee: Page 6459, line 18: : : :diameters: : :

Response: We changed that.

Referee: Page 6459, line 19: The backscattered light collected by each telescope: : :

Response: We changed that.

Referee: Page 6460, line 3: : : :used tentatively for receiving rotational Raman signals: : : I think, the correct reference is Behrendt et al. 2000b, see below.

Response: Thanks for the comment. We changed the citation to Behrendt at al. 2000b.

Referee: Page 6460, line 4: Here you could explain why it is beneficial to combine both polarizations for the rotational Raman channels, namely, because the rotational Raman signals show a depolarization of 75%.

Response: Thanks for the comment. We added the information on page 4 and changed the paragraph to: "In the new setup presented here a reflection from the interference filters in both parallel and perpendicular optical branches is used to extract rotational-Raman signals from the combined light detected with all three telescopes (Figure 1a). Note that the rotational-Raman lines show a depolarization of 75% for linearly polarized incident light. The approach of combining both parallel and perpendicular optical branches maximizes the detected rotational-Raman signal and furthermore improves the separation of the rotational-Raman scattering from the total elastic backscatter signal."

Referee: Page 6461, line 16: Better references for this statement are Behrendt 2000 and/or Behrendt 2005.

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Response: We included the reference Behrendt 2005.

Referee: Page 6461, line 23: Better references for this statement are Behrendt 2000 and Behrendt et al. 2000a.

Response: We refer to Behrendt 2005 since it provides a thorough summary of the rotational-Raman technique and provides suggestions for further reading. We changed the reference in line 140 to Behrendt (2005) and references therein. We did not cite Dr. Behrendts PhD thesis since it is written in German.

Referee: Page 6465, line 11: To avoid misunderstanding with the term “integration technique”, I suggest writing “: : :collected over: : :”

Response: We changed that.

Referee: Page 6474, figure 2: What is your laser wavelength?

Response: We added the following sentence to the caption: "The CWL of the laser is 532.13 nm."

Referee: Page 6477, figure 5a: Please explain where these data are coming from (measurements of Esrange lidar following the PSC categorization of (: : :) Is there any “ice” present in this case? If not, omit “ice” in the legend. Figures 4, 5, and 6: Delete the texts above the plots; add this information to the figure caption where appropriate.

Response: Thanks for comment: We changed the caption accordingly and deleted the text above the plots. The caption now starts with: "PSC classification of a measurement with the Esrange lidar between 19:48 and 01:23 UT on 6 February 201."

References: Behrendt, A.: "Fernmessung atmosphärischer Temperaturprofile in Wolken mit Rotations-Raman-Lidar (Remote Sensing of Atmospheric Temperature Profiles in Clouds by Use of Rotational Raman Lidar)", Doktorarbeit, Universität Hamburg, 2000. http://ediss.sub.uni-hamburg.de/volltexte/2000/255/ Behrendt, A.; J. Reichardt, A. Dörnbrack, and C. Weitkamp, 2000a: Leewave PSCs in Northern Scandinavia between 22 and 26 January, 1998: Lidar Measurements of Temperature and Optical Particle Properties above Esrange and Mesoscale Model Analyses. In: G. Amanatidis, J. Pyle (Eds.), Stratospheric ozone 1999, Air Pollution Research Report 73, European Commission, ISBN 92-827-5672-6, p.149 - 152. Behrendt, A.; J. Reichardt, J. Siebert, K.-H. Fricke, and C. Weitkamp, 2000b: Tropospheric and Stratospheric Temperature Measurements by Lidar above Esrange in January and February 1999. In: G. Amanatidis, J. Pyle (Eds.), Stratospheric ozone 1999, Air Pollution Research Report 73, European Commission, ISBN 92-827-5672-6, p.153-156.

Interactive comment on Atmos. Meas. Tech. Discuss., 5, 6455, 2012.