Lidar Observations in Ny-Ålesund:
Previous achievements and aims for the future

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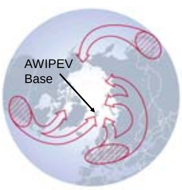
Lidar Measurements



Lidar (Light Detection and Ranging) is an active, optical remote sensing technology that allows measurements of scattered light from the atmosphere to find height-resolved information of air masses.

Currently, at the AWIPEV Arctic Research Base two lidar systems are operational: one for measurements in the troposphere (460m – 17km for aerosol and water vapour) and the other for the stratosphere (8 – 40km for PSC, ozone & temperature profiles). As both systems use the same Nd:YAG laser they cannot operate simultaneously.

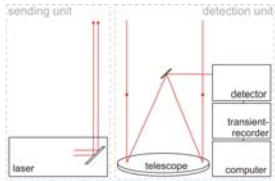


Fig. 1. Schematic setup of a lidar system

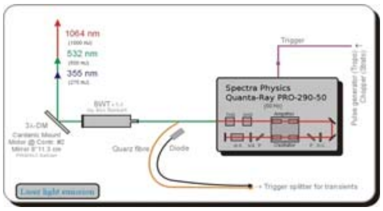
Therefore the tropospheric lidar systems, called Koldewey Aerosol Raman Lidar (**KARL**) will be redesigned this winter. In the current configuration only the backscatter and extinction in the visible wavelengths is evaluable at low altitudes, which makes a comparison with measurements from the Zeppelin station difficult.

The new lidar will bring some useful improvements: all 3 colours will be evaluable between 300m and 35km altitude and an evaluation of non-spherical particles (clouds) will become possible.

Current Setup of KARL

An overview of the sending and detection units in the current setup of the Koldewey Aerosol Raman Lidar is given.

Fig. 2. Emission - The light source of KARL is a pulsed Nd:YAG-Laser, emitting light pulses in 1064 nm, 532 nm und 355 nm at a frequency of 50 Hz. The beam's divergence is reduced to 0.5 mrad using an achromatic beam widening telescope, before the beam is redirected to the vertical.



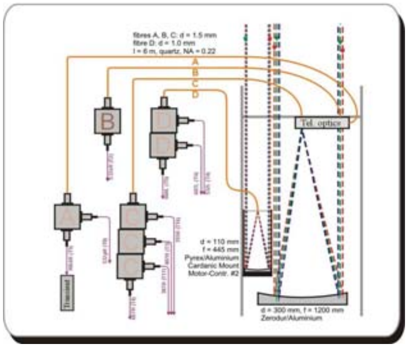


Fig. 3. Detection - The back-scattered light is collected using two parabolic telescope mirrors.

The far field (1.6 – 17 km) telescope mirror has a width of 30 cm and a focal length of 1.20 m. Behind the fixed 1 mm iris in the focus the light is divided into different wavelengths and polarization directions. Behind 3 quartz fibres the elastic wavelengths of 532 nm (plus depolarization channel 532p), 1064 nm and 355 nm and the Raman wavelengths 387 nm, 407 nm und 607 nm are detected by photomultipliers.

The 10.4 cm near field telescope (460 – 2500 m) only detects the wavelengths 532 nm, 607 nm and 660 nm.

Observations

In the current configuration of **KARL** the derivation of a size distribution and a refractive index for spherical aerosol is challenging but possible under daylight conditions up to 6km altitude. This is sufficient for analyzing **Arctic Haze** as presented here. 3 backscatter and 2 extinction values are used as input.

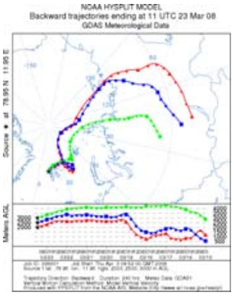


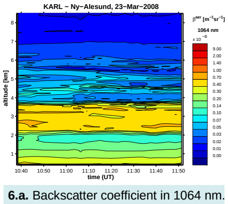
Fig. 4. Backward trajectories, calculated with the NOAA HYSPLIT Model indicate air masses coming from Russia.

As an example, preliminary data from measurements on the 23rd of March, 2008 are presented.

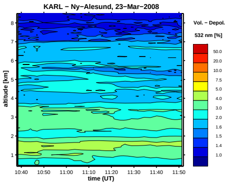
Around noon, a very stable layer with increased backscatter coefficient in all three elastic wavelengths could be detected between 2.3 and 3.7 km altitude (see fig. 6a). The scattering particles have a very small volume depolarization of about 3% (fig. 6b) which indicates almost spherical particles. Therefore, Mie scattering theory can be used to calculate a particle size distribution and a refractive index.

The result of this calculation is given in (fig.5). High quality lidar data are needed for this kind of retrieval.

Fig. 4 shows the backward calculated air trajectories. Assuming the layer came from Russia, it might consist of aged aerosol particles. Further investigations are under way.



6.a. Backscatter coefficient in 1064 nm.



6.b. Volume depolarization in 532 nm.

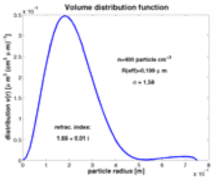


Fig. 6. A layer between 2.3 and 3.7 km with increased backscatter occurs (this can also be seen in 532 nm and 355 nm).
The volume depolarization of approximately 3% indicates spherical particles.

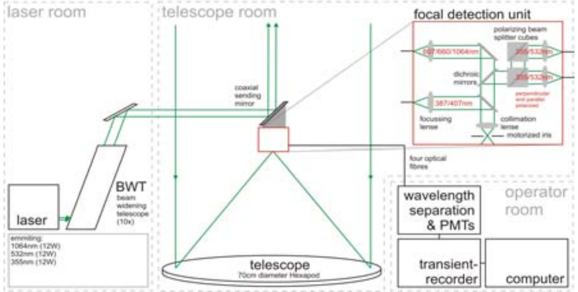
Fig. 5. Volume distribution function of the aerosol case at 11 UT and 2.8km altitude. The index of refraction and the parameters of a hypothetical log-normal distribution are given.

Scientific Aims

By redesigning the lidar system we want to:

1. **Combine the stratospheric and the tropospheric system** and facilitate the operation.
   This will allow longer observation time during the seasons and give a more representative view of aerosol and cloud occurrences, as well as their interaction.
2. Construct a system that is **easy to adjust and to operate**.
3. Improve the **signal quality of the weak Raman shifted lines**. This will improve the determination of the extinction coefficient and the water vapor content.
4. Reduce the overlap altitude to allow direct **comparisons with the Zeppelin station** in 475 m altitude for all wavelenghts. The overlap altitude is the minimum measurement height.
   The combination of in situ and remote sensing instruments will, hopefully, improve our understanding of the role of aerosol in the Arctic climate.
5. Implement an **additional depolarization channel** for the estimation of the sphericity of the particles as well as all Raman channels over the whole altitude range.

Setup of the redesigned System



- Tenfold widening of the laser beam reduces the beam divergence to 0.2 mrad
  →measurements in higher altitudes, better S/N

- Usage of only one telescope for the whole altitude range
- Coaxial setup reduces overlap altitude
- Usage of a bigger telescope mirror for improved Raman signals
- Covered beam lines reduce stray light

- Standardization of the PMT system
- Changeover to Ethernet communication
- Realization of extensive electronic control

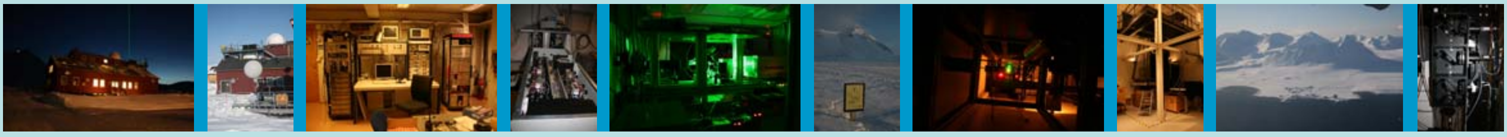
- Adapted field of view using a motorized iris aperture increases altitude range,
- Large iris reduces overlap altitude
- Measurement of three backscatter coefficients, two extinction coefficients and two depolarization channels allow estimating particle size distribution and refractive index

Time Schedule

Currently
- Building the new modules, e.g. focal detection unit or BWT

Fall 2008
- Implementing the new modules at the AWIPEV research station

2009
- Adaptation of control software for automatic measurements with variable field of view



AWIPEV meeting, 8. – 10. Oct. 2008, Bremen, Germany

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