P2-32 Simulation of Multiple Scattering Effects in Planned Measurements with the MDS-Lidar (ELISE)

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1 Introduction

The National Space Development Agency of Japan (NASDA) is currently developing a lidar system for spaceborne measurements. The lidar (called Experimental Lidar In Space Equipment or ELISE for short) is planned to be launched on NASDA's Mission Demonstration Satellite II (MDS-2) in year 2002. Its goals are (a) to demonstrate the applicability of the lidar's key components for long-term operation in space and (b) to provide observation data with nearly global coverage over a period of one year. The collected data will help to achieve further insight in regional and seasonal variations of the atmosphere. The observations are mainly aimed at detecting boundaries of optically thin cloud and aerosol layers, estimating their optical thickness and investigating multi-layered cloud systems.

One of the key problems of the inversion of space lidar measurements is the proper handling of multiple scattering effects. Due to the large distance between the lidar system and the atmospheric object to be observed multiple scattering can be expected to influence the backscatter signal significantly. Hence, estimating multiple scattering intensities for different atmospheric conditions is a necessary prerequisite for the signal inversion.

We present simulations to estimate the influence of multiple scattering on observations of the Planetary Boundary Layer (PBL) when using ELISE's shorter wavelength at 527nm.

2 Simulations

Aerosol mixtures in the PBL are highly variable, depending both on the meteorological con-

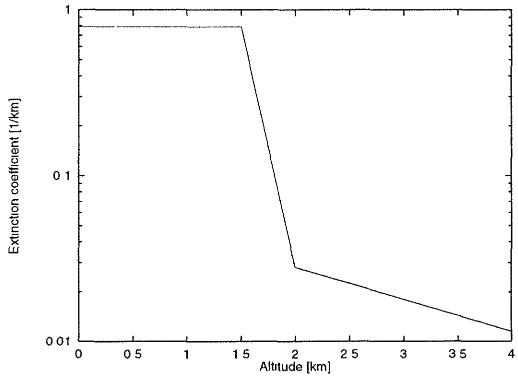

Figure 1: Assumed extinction profile at ELISE's shorter wavelength (527nm) for a visibility of 5km.

ditions (e.g. relative humidity and wind direction) and on the location. A reasonable way to reduce the number of mixtures to be considered is to make use of an aerosol classifications. For our study we selected eight different aerosol types from the OPAC data set Heßet al. (1998) covering a wide range of mixtures both of maritime and continental origin. The atmospheric model we used consisted of a well-mixed PBL below 1.5km (i.e. constant aerosol extinction coefficient but relative humidity increasing with altitude), the free troposphere above 2km with a moderate exponential decrease of extinction and an intermediate layer between 1.5 and 2km with a strong exponential decrease of the aerosol extinction coefficient, as shown in Fig 1.. We used ELISE's system parameter as given by Sasano (1998).

The lidar signals were simulated with a Monte Carlo model (Kerscher et al. 1995) which both calculates the total backscatter intensity and the

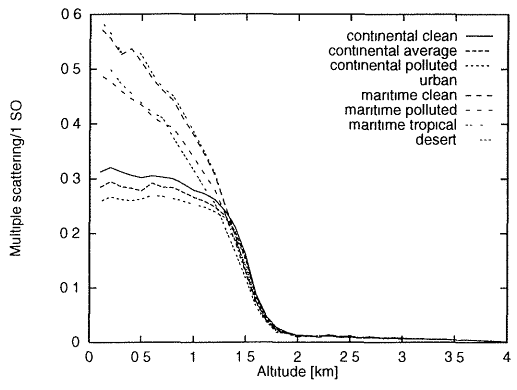

Figure 2: Ratio of multiple to single scattering intensities for different aerosol mixtures assuming the extinction profile described in the text.

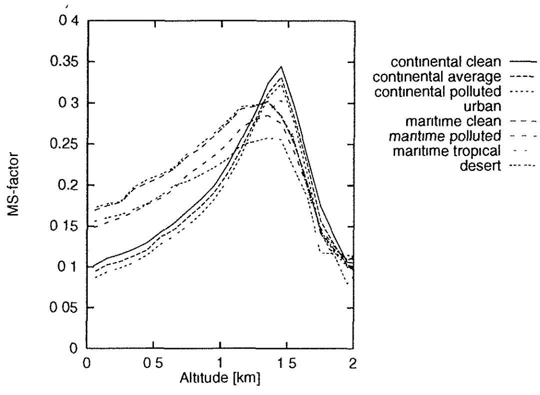

Figure 3: Multiple scattering factor for the same cases as in Fig. 2.

intensities of individual scattering orders. To estimate the influence of multiple scattering on the actual inversion we followed the approach by Kunkel and Weinman (1976), i.e. we assumed that the multiple scattering lidar equation can be approximated by

$$P(R) = \frac{C}{R^2}\beta(R)\exp\left(-2\int_0^R [1 - F(r)]\sigma(r)dr\right)$$

with $P(R)$ the detected signal from range R, C a constant, β and σ the backscatter and extinction coefficients, respectively. F is called multiple scattering factor.

Fig. 2 shows the ratio of multiple to single scattering intensities for all eight considered aerosol mixtures. In all cases the same extinction profile assumed with a visibility at ground of 5km. The simulations reveal that two groups of aerosol mixtures can be distinguished. Aerosols of continental origin (without deserts) yield relatively low multiple scattering intensities while more multiple scattering can be expected from maritime and desert aerosols. The reason is the greater number of large particles in the latter aerosol mixtures which leads to a stronger forward scattering intensity.

Similar to the ratio of multiple to single scattering also the multiple scattering factor F shows a clear distinction between both groups (Fig 3). For continental aerosols (without desert) F reaches a pronounced maximum at the top of thc PBL and then decreses strongly with increasing penetration depth (i. e. with decreasing altitude). The other mixtures show in principle the same functional dependence, however, both the maximum and the decrease of F are clearly less pronounced. Note that for continental mixtures F is larger at the top of the PBL though the ratio of multiple to single scattering is approximately the same for all aerosol mixtures. This shows clearly that F depends strongly on the aerosols' phase function and hence on their size distribution.

3 Conclusions

It is well known that the extinction coefficient influences the importance of multiple scattering in the backscatter signal. Our simulations show that even for aerosol layers it is additionally affected by the aerosol mixture in the case of space lidar measurements.

REFERENCES

Heß, M., Koepke, P., Schult, I., 1998, Bull. Am. Met. Soc. 79, 831–844

Kerscher, M., Krichbaumer, W., Oppel, U. G., Noormohammadian, M., 1995, Opt. Rev. 2, 304–307

Kunkel, K., Weinman, J., 1976, J. Atmos. Sci. 33, 1772–1780

Sasano, Y.: 1998, In: *Proceedings of the 19th ILRC, Hampton, USA*, pp. 949–953

Tatsumi, K., Imai, T., Kawamura, Y. et al.: 1998, In: *Proceedings of the First Workshop on Mission Demonstration Satellite Lidar, Hakone, Japan*, pp. 16–28