IRS2012-153
International Radiation Symposium 2012
Dahlem Cube, Berlin, Germany, 06 – 10 August 2012

Model studies on the Retrieval of Aerosol properties beneath Cirrus-Clouds for a Spaceborne Lidar

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A vulnerability of spaceborne lidar measurements is the signal attenuation by clouds which leads to strong limitation of usable aerosol data. Under this point of view sensitivity studies have been done to test the lately developed Monte-carlo based Exact Lidar Retrieval Algorithm (ARLEM). ARLEM is an iterative numerical retrieval algorithm based on non-linear estimation theory. ARLEM is the first lidar retrieval algorithm which considers multiple scattering effects not only approximately in the lidar signal. Also new is the idea to retrieve optical properties instead of the usually retrieved backscatter coefficient and lidar ratio from the lidar measurement signal. The main focus in the sensitivity studies was to determine the possibility to retrieve aerosol concentrations beneath thin cirrus clouds with a space-borne High Spectral Resolution Lidar (HSRL). Therefore different simulation scenarios were designed for day- and night-time conditions. Lidar simulations were performed with a lidar simulator which is based on the Monte-carlo code for physically correct tracing of photons in cloudy atmosphere (MYSTIC). To generate a near realistic lidar signal photonic noise and background noise were added to the signal. Instrumental efficiency and cross-talk were also considered in the simulations. These simulated lidar measurement signals formed the basis of the investigations. The sensitivity study shows that it is possible to retrieve aerosol mass concentrations beneath cirrus clouds with an optical depth smaller than one. In these cases and for Aerosol Optical Depth (AOD) higher than 0.5 the relative error in the retrieved total aerosol mass concentrations was smaller than 15%. The error in the resulting AOD is for the same cases smaller than 5%. The accuracy of the retrieval is limited by the signal-to-noise ratio which depends mainly on the strength of the received signal. A possibility to improve the signal-to-noise ratio is a longer averaging time but it has to be considered that this will lead to a loss of information. The results further shows that the used Tikhonov-regularization is not the appropriate choice for the applied inversion method. Since it is not possible to define an optimal regularization parameter which fits to the whole measurement profile.