Remote Sensing of the Environment using Laser Radar Techniques

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1 Introduction


Laser radar monitoring of the environment is an application of time-resolved laser spectroscopy. Differential optical absorption as well as laser-induced fluorescence can be used for this type of remote sensing. Apart from providing range-resolved data, the use of an active illumination source provides a more accurate assessment than if just the ambient passive radiation is employed. However, by necessity a limited monitoring range is imposed by the use of an artificial source.

An overview of atmospheric pollution monitoring and vegetation status assessment using laser radar techniques will be given with illustrations from work at the Lund Institute of Technology. We will start with monitoring of industrial and urban air pollution and will continue with measurements of geophysical gas emissions. Applications of fluorescence lidar to vegetation and water are then discussed and, finally, an outlook for the future is given.

2 Monitoring of Urban and Industrial Air Pollutants

The differential absorption lidar (dial) technique (see e.g. Svanberg 1994 for a review) provides three-dimensional mapping of gas distributions in the atmosphere. Pulses from a tuneable laser are transmitted into the atmosphere and photons, elastically back-scattered from aerosols and major constituents, are collected by an optical telescope giving rise to an electrical transient after detection in a photomultiplier tube. An example of a lidar curve for a range up to 4.5 km obtained with a vertically aimed lidar system (Wallinder et al. 1996) is given in Fig. 1. An excimer laser transmitter was used, providing
pulses at 317 nm after stimulated Raman conversion of 248 nm KrF radiation. Since the laser beam is transmitted from a point displaced by about 0.3 m from the receiving telescope axis, the signal starts at a low value and reaches a maximum when the transmission and receiving fields of view overlap. Then a $1/R^2$ fall-off is observed, reflecting the normal illumination law. At a distance of about 2.1 km the increased backscatter from a dual-layered cloud can be seen. In the $\times 100$ magnification the optical attenuation by the cloud reducing the backscattered radiation from above the cloud can also be seen. While the relative distribution of aerosol particles can be displayed by a curve such as the one shown in Fig. 1, molecular concentration measurements require the recording of curves at two closely spaced laser wavelengths.

![Lidar signal obtained in vertical sounding using an excimer lidar. Initially the signal displays a gradual increase as the transmitted beam and the telescope fields of view start to overlap. Then a fall-off, basically with a $1/R^2$ dependence, follows. An increased back-scatter from thin clouds at a height of about 2 km is observed.](image)

One is chosen corresponding to a strong absorption of the gas under study while the other one, off-resonance, is used for reference purposes. By dividing the "on"-resonance curve by the "off"-resonance curve the influence of aerosols is eliminated and the range resolved gas concentration is calculated.