THESIS FOR DEGREE OF DOCTOR OF PHILOSOPHY

Lidar Studies of Tropospheric Aerosols and Clouds

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Abstract

An improved description of aerosol and cloud processes is a prerequisite for successful prediction of future climate change. The climate on Earth is controlled by the radiation budget, *i.e.* the relation between the radiation going into and out from the atmosphere. Aerosols are said to have two main effects on the climate. The direct effect refers to cooling and warming by reflection of incoming solar radiation and absorption of outgoing thermal radiation, respectively. The indirect effect concerns the ability of aerosols to influence cloud formation and to change the optical and physical properties of clouds. Clouds normally occupy at least 50% of the sky on a global scale. The presence of clouds greatly increases the portion of the solar radiation reflected back to space, but on the other hand clouds may absorb outgoing thermal radiation from Earth and in the same way as a greenhouse gas partly counteract the cooling effect. The Intergovernmental Panel on Climate Change has identified clouds as the key uncertainty in predicting climate change: "The single largest uncertainty in determining the climate sensitivity to either natural or anthropogenic changes is clouds and their effects on radiation and their role in the hydrological cycle".

The overall aim of the present thesis is to contribute to an increased understanding of climate effects as well as air quality issues related to aerosol and clouds. The radiative properties of clouds are determined by the microphysics, *i.e.* refractive index, shape, and size distribution. In this thesis the construction and development of a bistatic lidar set-up for polarisation measurements throughout the troposphere is described and the results obtained with this system are presented. From the measurements of optically thin or mildly opaque high latitude clouds substantial depolarisation was observed. Ray tracing calculations for hexagonal ice columns were able to produce all the experimental values if a suitable degree of surface roughness was introduced. The results show that it is important to account for non-spherical shapes for the assessment of the radiative impact of Arctic ice clouds, and that the bistatic lidar technique may provide a useful complementary technique to be used together with existing lidar setups.

Lidar measurements were also conducted with the aim to study particulate air pollution in Göteborg. The limited insolation in wintertime sometimes resulted in near neutral boundary layer conditions and inefficient ventilation during the day. Considerable variation in the rate of rising polluted air subsequent to inversion layer break-up was observed, ranging from 200 to 800 m/h. Recently formed particles were observed around midday subsequent to surface layer ventilation. The boundary layer dynamics are concluded to have a strong impact on the properties of the urban aerosol and to a large extent determine the severity of the wintertime urban air pollution episodes to human health.

Keywords: *lidar, bistatic lidar, troposphere, aerosols, clouds, cirrus, ice particles, polarisation, particle shape, CABLE, urban air quality, temperature inversion, dispersion, GÖTE*

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