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An observational and numerical study of daytime boundary layer heights over mountainous terrain

S.F.J. De Wekker

National Center for Atmospheric Research

Daytime boundary layer heights over mountainous terrain have not been investigated well despite their importance for transport of air pollutants across mountain ranges. In recent years, the development of remote sensors, in particular the downlooking lidar, has facilitated the investigation of boundary layer heights. Lidar measurements provide vertical profiles of aerosol backscatter and gradients in backscatter are used to detect the height of an aerosol-laden layer. Studies over flat terrain have shown that there is a good correspondence between this aerosol layer height and boundary layer height. The current study focuses on the relationship between aerosol layer heights and boundary layer heights in mountainous terrain. During the STAAARTE '97 field study, a downlooking lidar was carried aboard an aircraft that flew over the European Alps around the Jungfraujoch (3580m; Switzerland) on 30 July 1997. This was a fair weather day with weak synoptic flow. Aerosol layer height behaviour is investigated using these data and it is found that the aerosol layer does not follow topography. Unfortunately, few observations of the thermodynamic structure of the atmosphere are available for this day. Thus, to investigate the observed behaviour in more detail, the numerical mesoscale model CSU-RAMS and a particle dispersion model were used. The three-dimensional simulations use two-way interactive, nested grids, with the innermost grid having a grid size of 1 km. The simulations are initialized with gridded pressure data from NCEP model analyses and validated with available observations. Model output is used to determine boundary layer heights. Results indicate that over mountainous terrain, the assumption that aerosol layer height equal convective boundary layer height may not be valid most of the time; significant aerosol concentrations are often found above the top of the convective boundary layer. Based on the findings, the traditional concept of a boundary layer height is revisited for mountainous terrain. Mechanisms that cause aerosols to be transported to regions above the top of the convective boundary layer are investigated. Implications of a difference between aerosol- and boundary layer heights for the transport of air pollutants over mountainous terrain are also discussed.