ELSEVIER

Atmospheric Research 80 (2006) 86–103

ATMOSPHERIC RESEARCH

www.elsevier.com/locate/atmos

PBL and dust layer seasonal evolution by lidar and radiosounding measurements over a peninsular site

Ferdinando De Tomasi *, Maria Rita Perrone

Dipartimento di Fisica, Universitá di Lecce, via Arnesano, I-73100 Lecce, Italy

Received 15 December 2004; received in revised form 29 June 2005; accepted 29 June 2005

Abstract

Planetary boundary layer (PBL) and dust layer (DL) height evolution have systematically been investigated during the past 2 years at Lecce, Italy (40.33°N, 18.10°E) using a lidar. These heights are identified as the height at which the first and second measurable minima of the derivative of the lidar signal normalized to the backscatter molecular signal occurs. The PBL and DL heights were lower during the summer than the winter, contrary to what is expected. This behavior can be explained in terms of the suppression of the boundary layer depth growth caused by the advection of marine air. It is shown that PBL and DL heights retrieved by lidar are in good agreement with the ones obtained by radiosounding measurements from a close meteorological station.

Keywords: Lidar; Boundary layer; Climatology; Radiosonde

1. Introduction

Experimental observations of atmospheric layers are particularly important at low altitudes, because of the trapping effects of aerosols, water vapor and pollutants. Air quality is directly connected to the presence of inversion layers, mainly when sources of pollutants are present. The aerosol concentration is generally a maximum within the

* Corresponding author.
E-mail address: Ferdinando.DeTomasi@le.infn.it (F. De Tomasi).

0169-8095/$ - see front matter
doi:10.1016/j.atmosres.2005.06.010

planetary boundary layer (PBL) and climate forcing investigators might benefit from measurements of the PBL height, since aerosols affect radiative transfer processes (Hansen et al., 1997). Detailed experimental observations of PBL heights can also be used as input of meteorological and climatologic models.

The PBL, i.e. the lower layer of the atmosphere that is sensitive to the effect of the Earth's surface, controls the flow of heat and momentum between the surface and the free atmosphere, thus playing a key role in atmospheric circulation (Stull, 1988). Over oceans, the boundary layer depth varies relatively slowly in space and time since the sea surface temperature changes little over a diurnal cycle. On the contrary, over land surfaces in high pressure regions, the boundary layer has a well-defined structure that evolves with the diurnal cycle. The three major components of this structure are the mixed layer, the residual layer, and the stable boundary layer. On initially cloud-free days the mixed layer growth is tied to solar heating of the ground. About half an hour before sunset the thermals cease to form, allowing turbulence to decay in the formerly well-mixed layer. The resulting layer of air is often called residual layer. Then, as the night progresses, the bottom portion of the residual layer is transformed by its contact with the ground into a stable boundary layer (Stull, 1988). However, single layer evolutions and interactions between two close layers are not well known when the horography is complex, ground is not homogeneous and advection processes occur. In coastal sites, the advection of cooler air from the sea (sea breezes) may significantly affect the PBL growth (Stull, 1988; Melas et al., 1995; Martano, 2002).

Different experimental techniques can be used to monitor layer heights within the lower troposphere. Some techniques are based on direct measurements of atmospheric parameters, using meteorological towers, radiosounding or tethered balloons; others are based on remote sensing measurements, performed with SODAR, RADAR, or LIDAR (hereafter referred as lidar). This paper deals with systematic lidar observations of atmospheric layers over a peninsular site, Lecce, Italy (40.33°N, 18.10°E). Lidars operating in the UV and visible spectral regions are sensitive to the elastic backscattering from molecules and aerosols. However, in the interface region between two layers, the vertical variation of the molecule concentration is small, whereas the vertical variation of aerosol concentration is large. Therefore, lidars can be used to follow the time evolution of atmospheric aerosol layers and can also be well suited for long-term monitoring. The investigation of PBL heights at several European sites has been one of the main goals of the European Project EARLINET—European Aerosol Research LIdar NETwork, which ran from May 2000 to November 2002 (Boesenberg et al., 2003). Matthias et al. (2004a) studied the seasonal evolution of PBL heights at 10 EARLINET stations. They show that PBL heights are generally characterized by a seasonal cycle in which maximum heights are found during summer months, as expected. They do note an exception: Lecce shows lower PBL heights during summer months. It is worth mentioning that in that paper, they use PBL height for that height below which most of the aerosol is confined, even if this layer is not in every case a well-mixed layer. Dayan et al. (1996) have also observed lower PBL heights during the summer compared to during the winter in the southeastern part of the Mediterranean Sea. They used radiosonde data in their study. These anomalous results, i.e. low PBL heights in summer, have stimulated the more detailed investigation on the seasonal evolution of the height of lower troposphere layers reported in this paper. We used lidar measurements performed at Lecce and radiosounding measurements performed