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Measurements and Mesoscale Modeling of Autumnal Vertical Ozone Profiles in Southern Taiwan

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ABSTRACT

Vertical measurements of ozone were made using a tethered balloon at the Linyuan site in Kaohsiung County, southern Taiwan. Ozone was monitored at altitudes of 0, 100, 300, 500, and 1000 m from November 23 to 25 in 2005. The potential temperature profiles revealed a stable atmosphere during the study period, largely because of the dominance of the high-pressure system and nocturnal radiation cooling close to the surface. The mixing height was low (50 - 300 m), particularly in the late night and early morning. The surface ozone concentrations that were predicted using TAPM (The Air Pollution Model) were high (33.7 - 119 ppbv) in the daytime (10:00 - 16:00) and were low (10 - 40 ppbv) at other times; the predictions of which were consistent with the observations. The simulated surface ozone concentrations reveal that costal lands typically had higher ozone concentrations than those inland, because most industrial parks are located in or close to the boundaries of Kaohsiung City. Both measurements and simulations indicate that daytime ozone concentrations decreased quickly with increasing height at altitudes below 300 m; while nighttime ozone concentrations were lower at low altitudes (50 to 300 m) than at higher altitudes, partly because of dry deposition and titration of surface ozone by the near-surface nitrogen oxides (NO_x) and partly because of the existence of the residual layer above the stable nocturnal boundary layer. The simulations show a good correlation between the maximum daytime surface ozone concentration and average nighttime ozone concentration above the nocturnal boundary layer.

Key words: Ozone, Tethered balloon, Vertical mixing, Atmospheric modeling, TAPM

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1. INTRODUCTION

Ground-level ozone (O_3) is a secondary pollutant, primarily generated from its nitrogen oxides (NO_x = NO + NO_2) and NMHC (non-methane hydrocarbons) precursors in photochemical reactions in sunlight. Although most primary pollutants are emitted in the course of local human activities, high ozone events are also related to the long-range transport of pollutants and meteorological conditions (NRC 1991; Ludwig et al. 1995; Sillman 1999; Blanchard 2000; Russell and Dennis 2000; Trainer et al. 2000).

The transport processes of airborne pollutants include the horizontal advection and vertical (downward or upward) movements that are related to small- to large-scale atmospheric motions, meteorological conditions and topography. Vertical measurements suggest that high ozone concentrations aloft during the night may cause pollution events in the following days by downward mixing as the ground heats up and a convective boundary layer develops in the daytime, particularly when a high-pressure system is in the area (Kleinman et al. 1994; Neu et al. 1994; Zhang and Rao 1999; Aneja et al. 2000; Chen et al. 2002; Lin et al. 2004). Unlike the surface measurements of air pollutants, high-altitude measurements are costly and difficult to make. A transport and photochemical model is therefore useful

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