EVALUATION OF OZONE CONCENTRATIONS AT RESIDENCE LAYER IN THE SOUTHERN TAIWAN BY CMAQ

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Abstract

Significant diurnal variations were observed for the ozone concentrations at surface monitoring site; the peak ozone concentrations are generally at noon to 2 pm and the nighttime concentrations are generally less than 10 ppb. However, the ozone concentrations at 600 m to 1000 m, which is the residence layer, are generally greater than 50 ppb at nighttime. The variations of ozone concentrations at the residence layer are determined by the sea-land breeze, the NO titration and surface temperature inversion at night, and the plume from major stationary sources. Extended field campaign for vertical profile of ozone concentrations and meteorological conditions were conducted during 13 to 19/12/2002 and 1 to 4/5/2003 (Lin et al., 2004). Models-3/CMAQ was used to simulate the variations of vertical profile for ozone concentrations. In order to simulate the vertical profile of ozone concentrations, finer resolutions in vertical direction was used in this study.

The meteorological conditions were simulated with MM5 with four layers of nested grids and the finest grid size was 3 km by 3 km over the whole island. Therefore, all the emissions in Taiwan were included in the simulation for the finest grid size. The Taiwan emission datum system, which was compiled by Taiwan EPA, was used as the basis for emission data.

The spatial distributions for the simulated ground ozone concentrations were shown in Figure 1 for the 13 to 15, December. The spatial distributions of simulated ground ozone concentrations were consistent with the observed results. That is, the greater concentrations were in southwestern Taiwan on the 12th, the hot spot was then shifted to the central Taiwan with greater polluted area on the 13th, and the high ozone concentrations were then at the southern and northern Taiwan on the 15th. However, the ground ozone concentrations in the 15th were less than the observed results as shown in Figure 2 for the time series plots of simulated and observed ground ozone concentrations. Therefore, the simulated ground ozone concentrations

were in good agreement with the observed data, except for those on the 15th. The time series plots for simulated and observed NOx concentrations were also shown in Figure 3 for comparison. The temporal variations for both were the same and the simulated nocturnal NOx concentrations were generally less than the observed data due to the temperature inversion near ground.

The temporal variations of vertical profiles for simulated ozone concentrations were shown in Figure 4. High ozone concentrations greater than 40 ppbv were found at 800 m or higher locations in the early morning, although the ground ozone concentrations were less than 10 ppbv. This greater ozone concentrations at high elevation were consistent with those observed in the residence layer. The ground ozone concentrations were then increased to about 75 ppbv due to the photochemical reactions at the early afternoon and the vertical profiles were uniform within the mixing layer. However, at the early evening, the ground ozone concentrations were decreased to about 30 ppbv due to its dry deposition and NO titration and those at elevation greater than 1000 m were still greater than 50 ppbv. Therefore, the nocturnal ozone residence layer was formed within the mixing layer by photochemical reaction and it was transported upward during the afternoon.

The ground ozone concentrations simulated by using Models-3/CMAQ were generally in good agreement with the observed results in southern Taiwan. Nocturnal ozone residence layer was also found in the simulated vertical concentrations profiles and the results were consistent with those observed. The ozone in nocturnal residence layer was from the daytime photochemical reaction within the mixing layer.

Lin C.-H., Y.-L. Wu, C.-H. Lai, P.-H. Lin, H.-C. Lai, and P.-L. Lin (2004) "Experimental investigation of ozone accumulation overnight during a wintertime ozone episode in south Taiwan," Atmos. Environ., 38: 4267-4278.

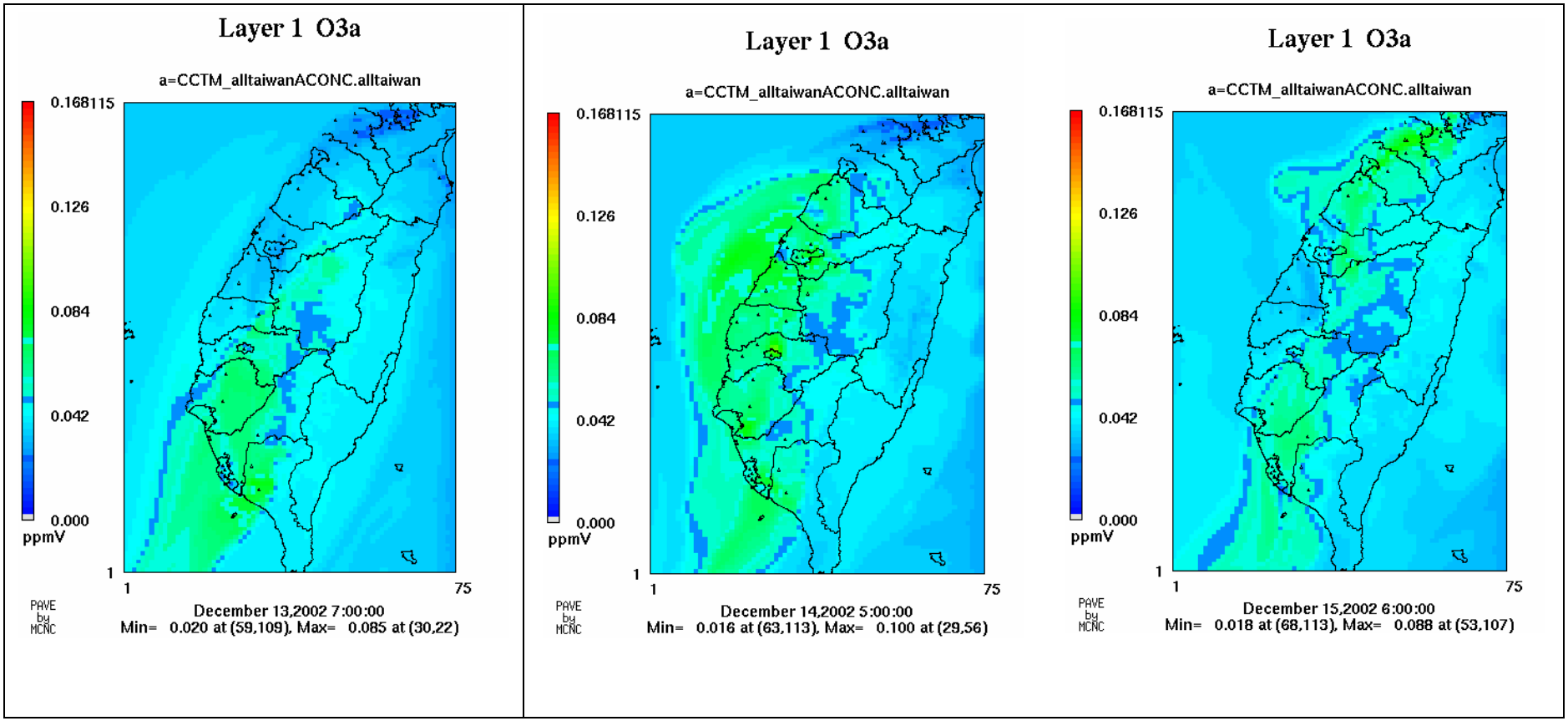

Figure 1. Spatial distributions of simulated ozone concentrations at ground layer.

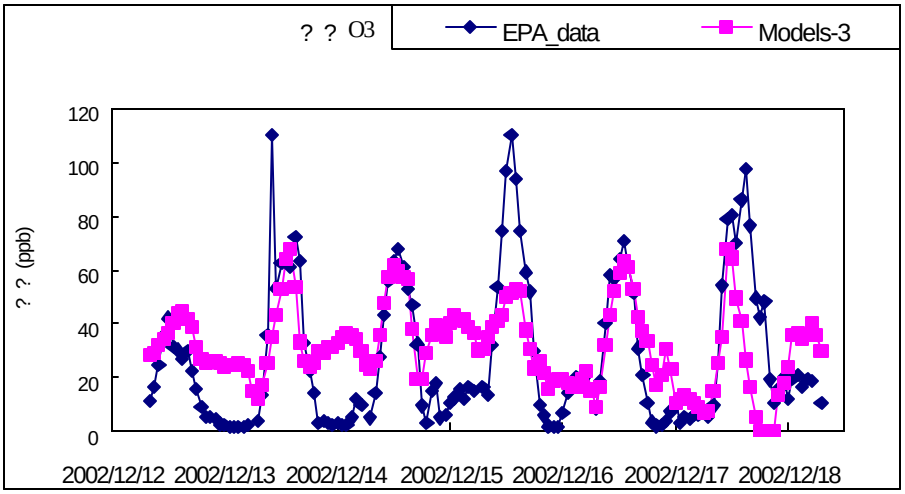

Figure 2. Comparisons between simulated and observed ozone concentrations.

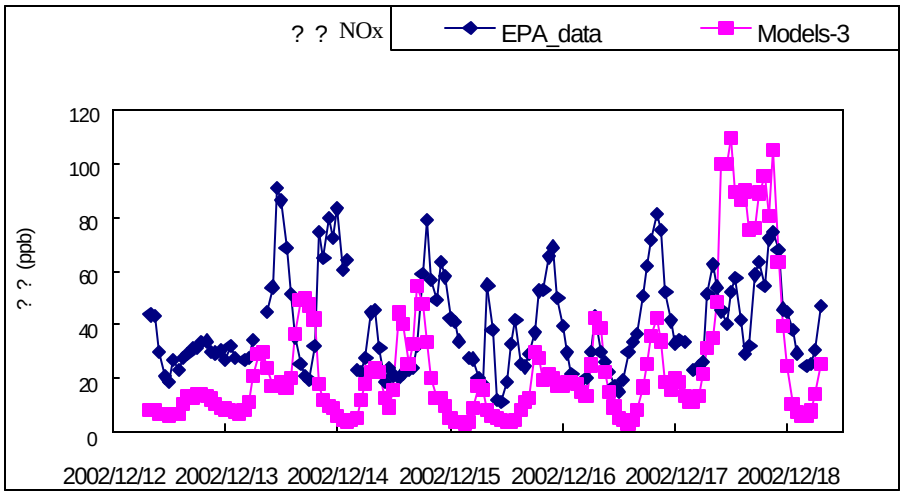

Figure 3. Comparisons between simulated and observed NOx concentrations.

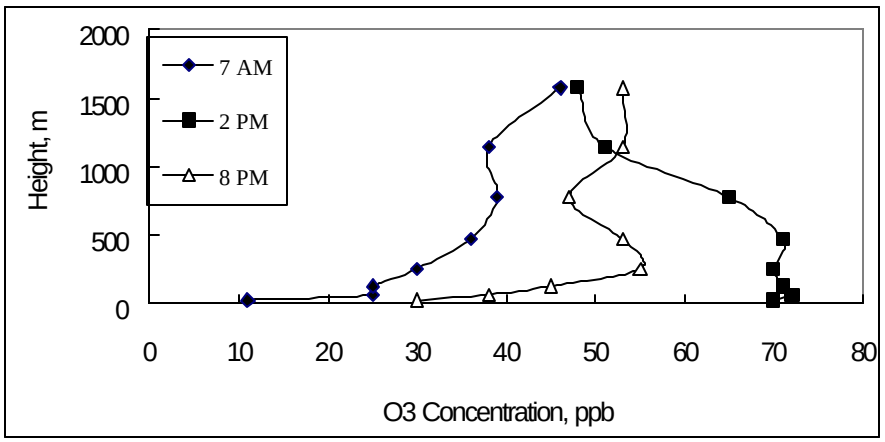

Figure 4. Temporal variations of simulated vertical profiles of ozone concentrations.