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Regional chemical weather forecast over the central Japan: The effects of diffusion and mixing parameterization on local meteorology and chemical transport

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The regional-scale air quality forecast (AQF) system has been developed based on two chemical transport models (CTM): the global CTM CHASER (CHemical Atmospheric general circulation model for Study of atmospheric Environment and Radiative forcing), and the regional CTM WRF (Weather Research and Forecasting)/Chem. The AQF system predicts the regional distribution of ozone (O_3) and its precursors, including carbon monoxide (CO), nitrogen oxides (NOx), and non-methane hydrocarbons (NMHCs) over the central Japan for 15 hours four times daily.

Hindcast experiments without chemical module during the period of June-July in 2005 and 2006 can reproduce observed features of land-sea breeze with correlation coefficients of 0.9 and 0.7 for surface temperature and winds, respectively. However, the timing of change from sea breeze to land breeze in the Tokyo bay are not well simulated, related to cold bias at night time as well as coarse resolution of terrain. To reproduce the return flow of air pollution by land-breeze, cold bias is thought to be a key issue.Two non-local PBL schemes (Yonsei University and Medium Range Forecast) show deeper PBL height and stronger sea-breeze related with warmer surface temperature, compared to those from observation and local PBL scheme (Mellor-Yamada-Janjic).

An experiment with chemical module for July-August in 2005, when ozone episodes more than 120 ppbv frequently occur, can simulate ozone variation from surface and Differential Absorption Lidar (DIAL) observation, and exhibits three types of enhancement: 1) layered enhancement at altitudes between 1 and 2 km, 2) vertically-homogeneous enhancement up to 2 km, and 3) layered enhancement at altitudes between 2 and 6 km. By switching chemical lateral boundaries, ozone plumes below 2 km and between 2 and 6 km are found to attribute to pollutants from the Tokyo metropolitan region and the western lateral boundary, respectively. This result emphasizes that the vertical mixing between local and trans-boundary pollutants is of importance in determining the surface ozone level over the central Japan in RCWF. Experiments changing PBL schemes indicate that the effect of trans-boundary pollutants on the surface ozone depends on the PBL height and the strength of LSB resulting from the choice of the PBL scheme.