

High-Resolution MM5 Simulations with Refined Land Use Categories for Hong Kong

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1. Introduction

Accurate numerical modelling of the atmosphere over Hong Kong is always difficult because of the urban land-sea contrast and the complex terrain of the territory. New land use categories with refined physical parameters, such as roughness length, thermal inertia and so on, are incorporated into the PSU/NCAR Mesoscale Model (MM5) v3.4 to perform high-resolution numerical simulations over Hong Kong and its vicinity during an episode associated with record-high concentrations of nitrogen dioxide (NO_2) and respirable suspended particulates (RSP) *locally* affecting the western part of Hong Kong.

2. Model Configuration

MM5 is run for four one-way nested domains with grid spacing of 40.5, 13.5, 4.5 and 1.5 km. All these domains have same vertical structure with 26 unequally spaced sigma levels, 10 of which are below 1 km. Hourly observational data of surface wind speed and direction at five different stations are assimilated on the 4.5 km and 1.5 km grids. Figure 1 shows the inner two modelling domains and the location of the five observation stations where “obs nudging” is applied. The simulations are run for a 2-day period, beginning at 0000 UTC 28 December 1999 when the episode started to affect the territory.

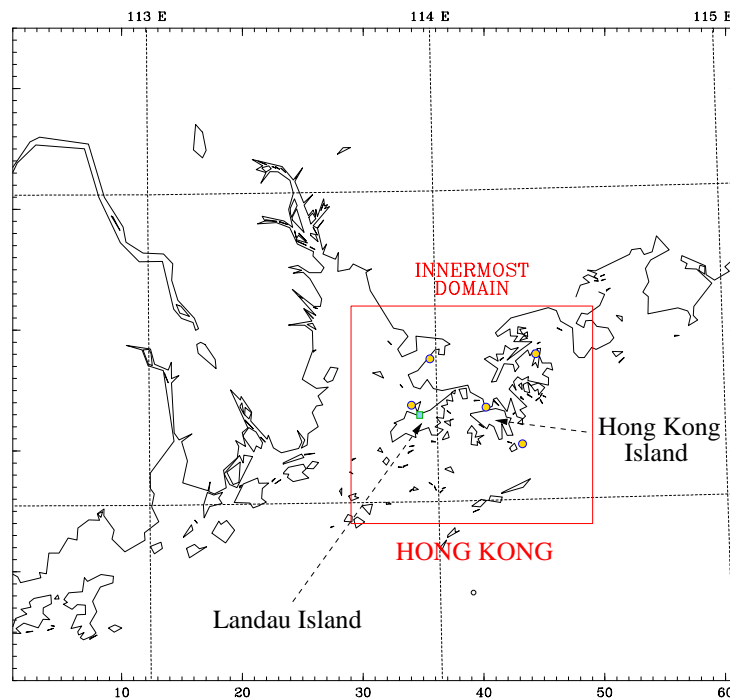


FIG. 1. The inner two domains: 4.5 km and 1.5 km grids. Yellow dots indicate the position of the observation stations which provide hourly surface wind data for obs nudging. The green square is one of the sites in the western part of Hong Kong, where high concentrations of NO_2 and RSP were recorded during 28-30 December 1999.

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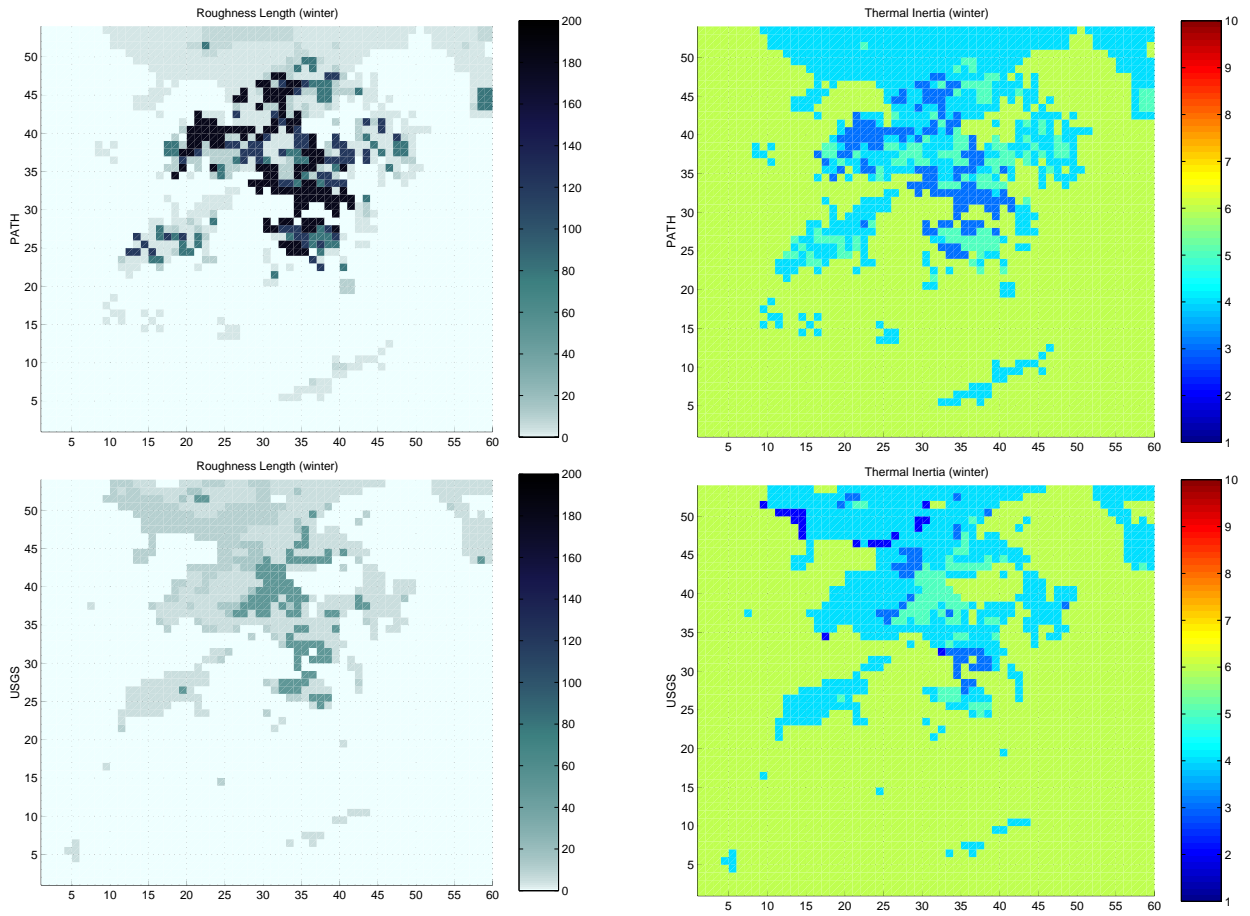


FIG. 2. Roughness length and thermal inertia in the 1.5 km grid derived from PATH and USGS.

2. New land use categories

The new land use categories are adopted from the PATH (Pollutants in the Atmosphere and their Transport over Hongkong) project, tailor-made by the Hong Kong Environmental Protection Department for the territory's air quality modelling. The spatial distributions of roughness length and thermal inertia derived from the PATH project and the USGS data are plotted in figure 2. In the PATH project, the values of physical parameters are carefully tuned based on accumulated experience of numerical air modelling of Hong Kong and on some empirical measurements. Figure 2 illustrates that PATH uses considerably larger roughness length and moderately smaller thermal inertia for most area of Hong Kong, compared with USGS data.

3. Results and Conclusion

With the introduction of PATH land use categories, MM5 simulations show that a convergent zone emerges in the western part of Hong Kong near Landau Island (see figures 1 and 3), approximately during the peri-

ods when maximum concentrations of NO_2 and RSP were reported by the observation station indicated by the green square in figure 1 (the observational data of the concentrations of NO_2 and RSP are not included in this abstract). Recirculation within the convergent zone traps the pollutants whose concentration rapidly increases until the convergent zone breaks down. It is believed that the airborne pollutants NO_2 and RSP were produced by hill fires happened in the southeastern provinces of China and subsequently transport to Hong Kong.

A comparable numerical simulation is also carried out using standard 25-category USGS land use categories. The result is exhibited in figure 4. In this experiment, neither convergent zone nor other flow features that may contribute to the unusual local surge of pollutant concentrations is observed. This suggests that the use of refined land use parameters is very important for numerical modelling of air pollution events over Hong Kong.

Streamlines of Horizontal Wind Init: 0000 UTC Tue 28 Dec 99
 Fcst: 10.00 Valid: 1000 UTC Tue 28 Dec 99 (1800 LST Tue 28 Dec 99)
 Horizontal wind speed at height = 0.10 km
 Terrain height AMSL
 Horizontal wind streamlines at height = 0.10 km

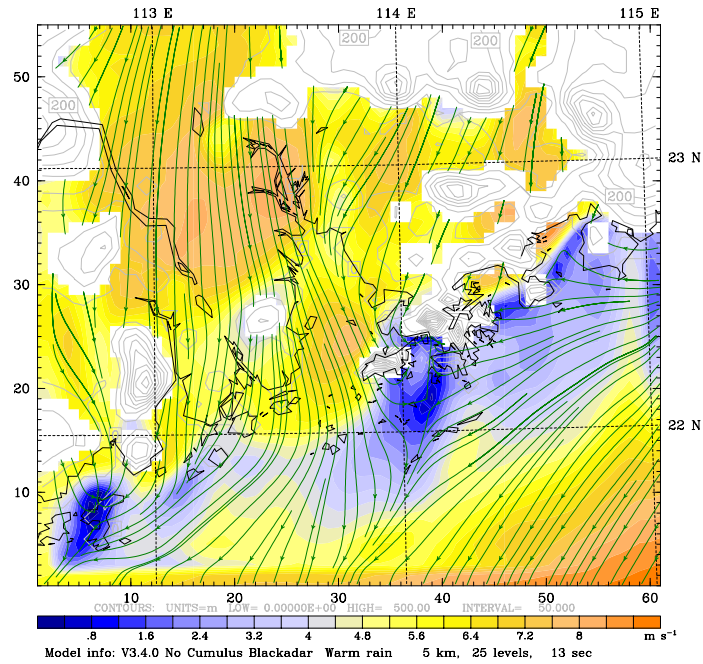


FIG. 3. MM5 simulation using PATH land use categories. The horizontal streamlines at an elevation 100 m above sea level are plotted from the 4.5 km grid.

Streamlines of Horizontal Wind Init: 0000 UTC Tue 28 Dec 99
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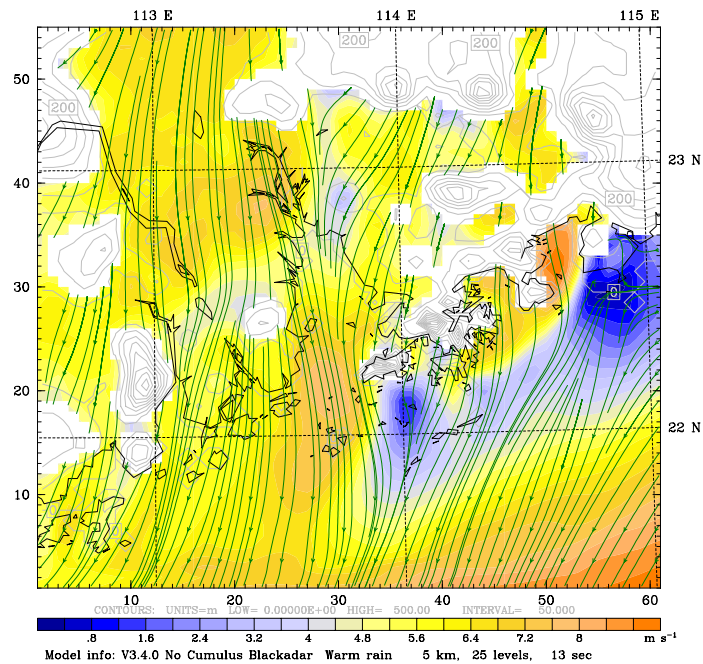


FIG. 4. MM5 simulation using standard USGS land use categories. The horizontal streamlines at an elevation 100 m above sea level are plotted from the 4.5 km grid.