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Article

Supplementary Information (SI) Impact of Urbanization on the Predictions of Urban Meteorology and Air Pollutants over Four Major North American Cities

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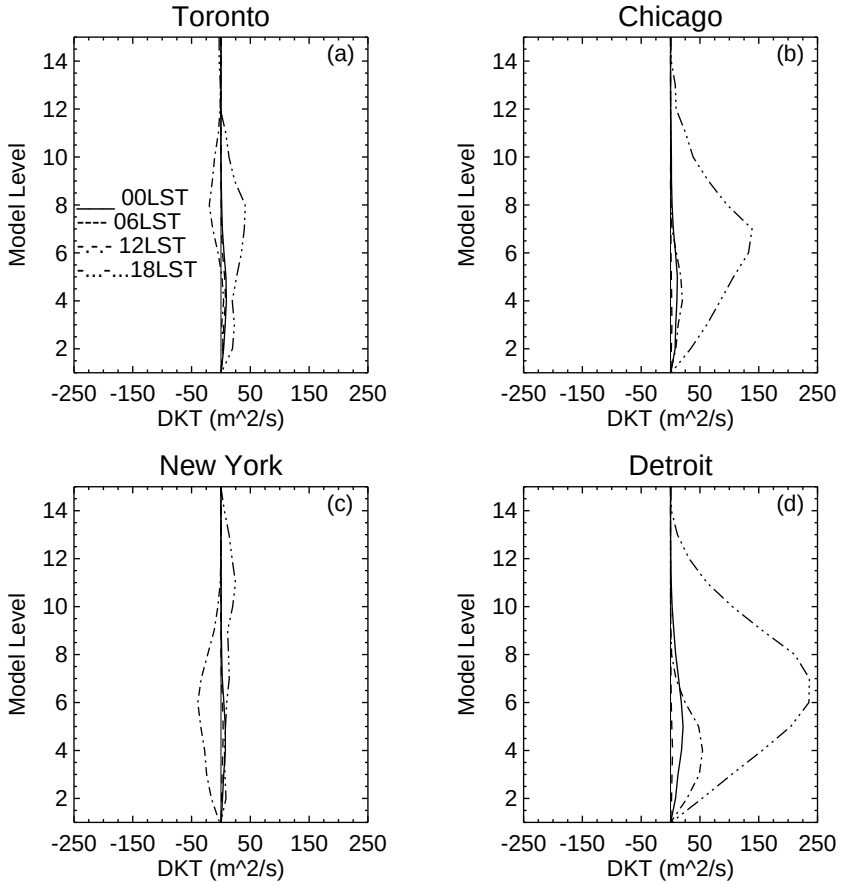

Figure S1. Vertical profiles of the monthly mean diffusion coefficient differences between the TEB and non-TEB simulations over July at 0 6, 12, 18 hour (local time) in the downtown areas of Toronto (**a**), Chicago (**b**), New York City (**c**), and Detroit (**d**). The heights of the first and the 14th level over the Toronto urban center are about 24 m and 2766 m, respectively.

Section S1: Vertical profiles of the impact on diffusivity

The impact of urbanization on vertical diffusivity is not limited to the levels near the surface. The positive differences in July can reach maximum at the eighth model level (900 m) over Chicago, Detroit and Toronto and even higher over New York City at 18:00 PM (Fig.S1). The magnitude of the impact at this level is more than 150 m^2/s over Detroit and Chicago and less than 50 m^2/s over Toronto and New York City. Around noontime, the TEB scheme provides negative differences between the first and tenth levels over New York city and between the sixth and tenth levels over Toronto. In January the impacts are all positive, and the largest enhancement (70 m^2/s) appears at 18:00 PM at the sixth level over Toronto and New York City (not shown). Because the diffusion coefficient is determined by TKE and stability function, the vertical variation of the diffusion coefficient differences are due to the vertical variations of the TKE and temperature differences under the influence of change of surface momentum and heat flux as well as the reference diffusivity (of the non-TEB simulations).

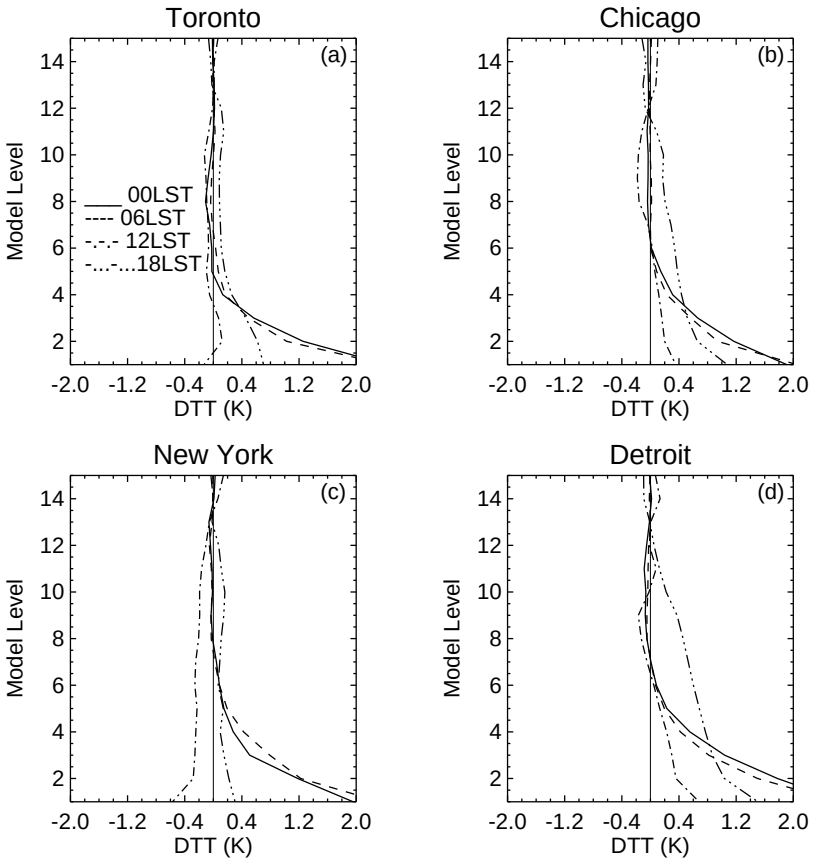

Figure S2. Vertical profiles of the monthly mean temperature differences between the TEB and non-TEB simulations over July at 0 6, 12, 18 hour (local time) in the downtown areas of Toronto (**a**), Chicago (**b**), New York City (**c**), and Detroit (**d**). The heights of the first and the 14th level over the Toronto urban center are about 24 m and 2766 m, respectively.

Section S2: Vertical profiles of impact on temperature

The impact of urbanization on temperature is not limited to the lowest model level, and it can reach higher levels. Figure S2 shows that in summer the impact decreases as height increases, and can reach the sixth model level (from below) which is about 600 m from ground and higher at 6:00 PM. In winter, the impact at noontime and 18:00 PM can reach as high as the 12th model level (from below) which is about 1800 m (not shown).

Section S3: P-O statistics of $PM_{2.5}$

P-O statistics show that $PM_{2.5}$ is over predicted in both TEB and non-TEB simulations over all the areas except the suburban area (Fig.S3). 20%-30% improvement on biases by TEB effects can be seen over these areas. TEB effects also lead apparent improvement on RMSDs over downtown and industrial areas, and small improvements over uptown and Lakeshore areas. Again, there is virtually no difference in correlation coefficients between the TEB and non-TEB simulations.

The diurnal variation of $PM_{2.5}$ biases and RMSD of TEB and non-TEB simulations are shown in Fig. S4. It can be seen from the figure that both TEB and non-TEB simulations produce strong positive biases over the downtown, uptown and industrial areas between 6:00 AM to 11:00 AM, and big positive biases over lakeshore and suburban areas between 7:00 AM and 10:00AM. The TEB scheme leads to big bias reduction between 8:00 PM to 8:00 AM over the downtown and industrial areas, and

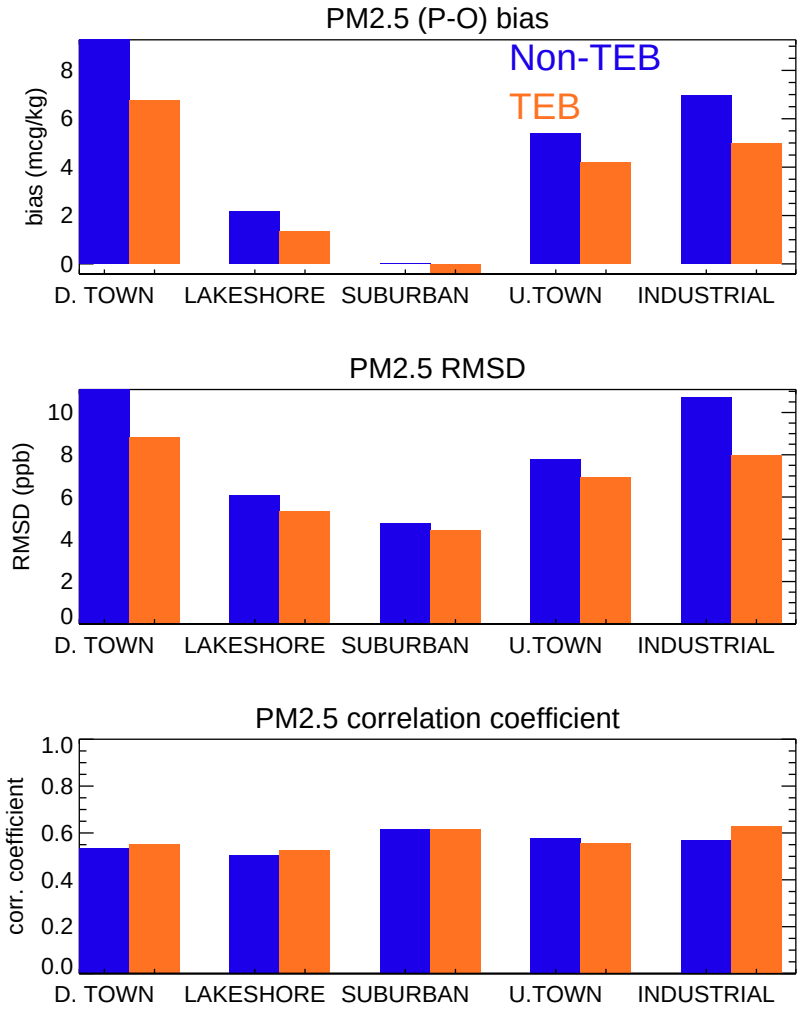

Figure S3. Monthly mean and hourly mean $PM_{2.5}$ P-O biases, RMS, and correlation coefficients of simulations of TEB (orange) and non-TEB (blue).

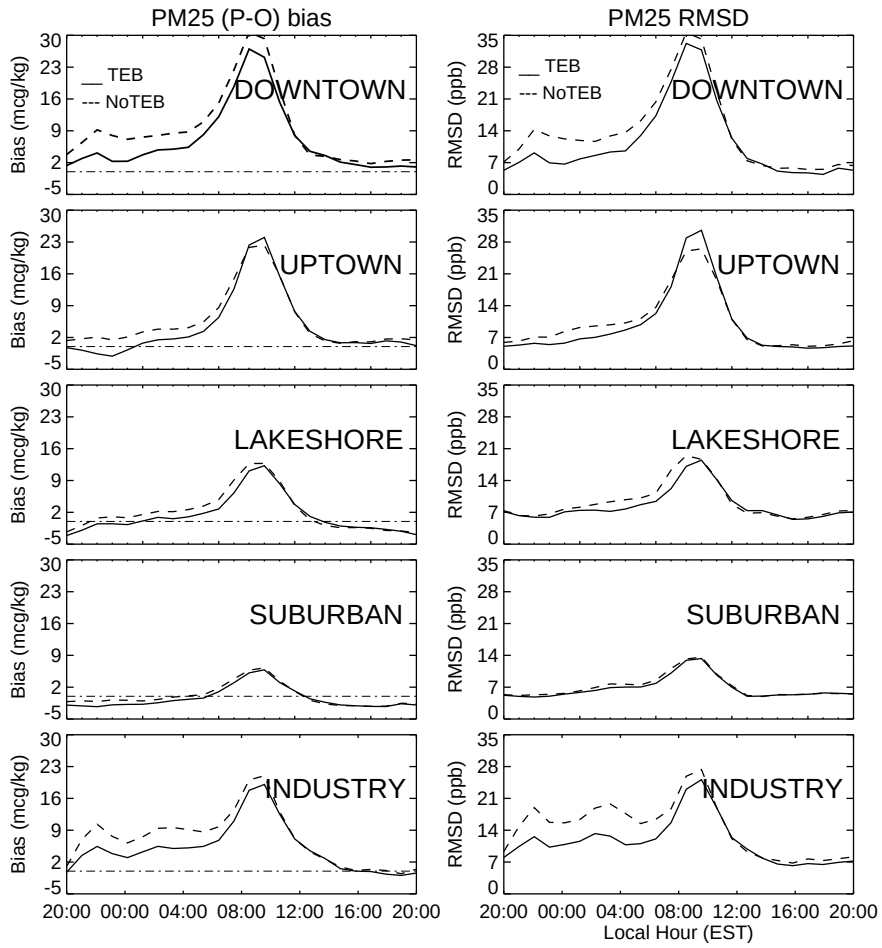

Figure S4. Monthly mean diurnal variation of $PM_{2.5}$ (P-O) biases (left panel) and RMSD (right panel) for TEB (solid lines) and non-TEB (dashed lines) simulations in five areas in the GTA.

noticeable improvement between 0:00 AM to 8:00 AM over uptown and lakeshore areas. RMSD is also greatly improved by the TEB scheme between 8:00 PM to 8:00 AM over downtown and industrial areas. Improvement can be also seen over lakeshore and suburban areas between 0:00 AM to 8:00 AM. The correlation coefficient is improved by the TEB scheme only over the downtown area between 2:00 PM to 6:00 AM (not shown).