A modeling study to investigate the meteorological factors for inducing high ozone concentration in southern Taiwan

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Introduction

In order to understand the causes for inducing the high ozone concentrations in southern Taiwan (**Fig.1**), the Weather Research Forecasting (WRF) meteorological model and CMAQ air quality modeling were performed to investigate the relationship between the meteorology and high ozone concentrations. In this study, the WRF meteorological modeling is improved significantly with the update of the land use type, aerodynamic roughness length and the terrain height (Cheng et al., 2012). The emission inventory is generated using the Taiwan Emission Data System version 7.0 (TEDS7.0) data.

Through out the whole study episode, the local weather in Taiwan was mostly dominated by a strong synoptic northeasterly monsoonal flow. The preliminary CMAQ simulation results show that the high ozone concentration is induced by the accumulation of the ozone precursors as well as the land sea breeze recirculation flows.

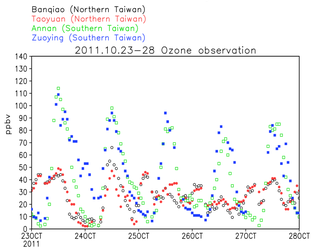

Fig. 1. Ozone observation at 23-28 October, 2011.

Methodology

The mesoscale meteorological simulation using WRF is performed for the area in Taiwan by using the updated LU type, and roughness length (Z0). The updated LU data were reclassified using the 2007 Moderate Resolution Imaging Spectroradiometer (MODIS) satellite image. The new LU data correctly represents Taiwan as mixtures of cropland, urban, and forestlands as well as the other land types (**Fig. 2**). The Z0 is recalculated using the arithmetic mean of the fraction of each LU type and the corresponded Z0 (**Fig. 3**) (Cheng et al., 2012 and Tsai et al., 2005).

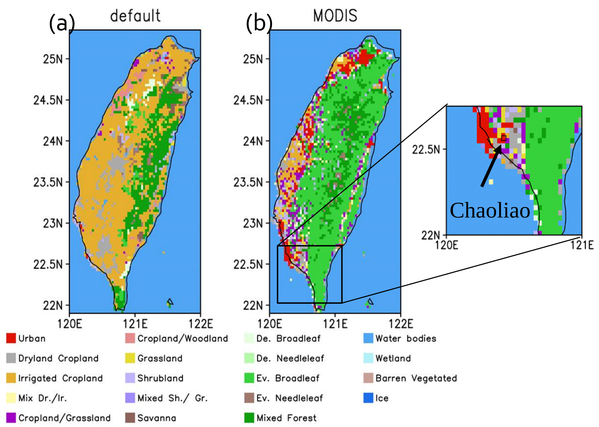

Fig. 2. The distribution of LU from (a) default and (b) MODIS

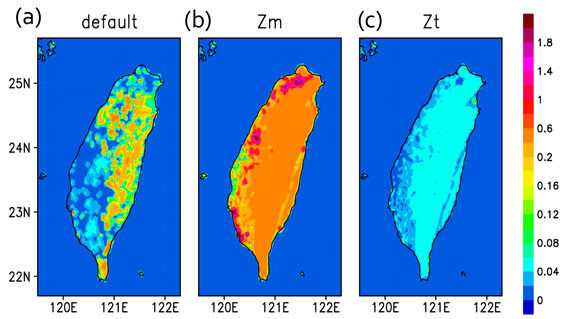

Fig. 3. The distribution of Z0 from (a) default, (b) Zm, and (c) Zt

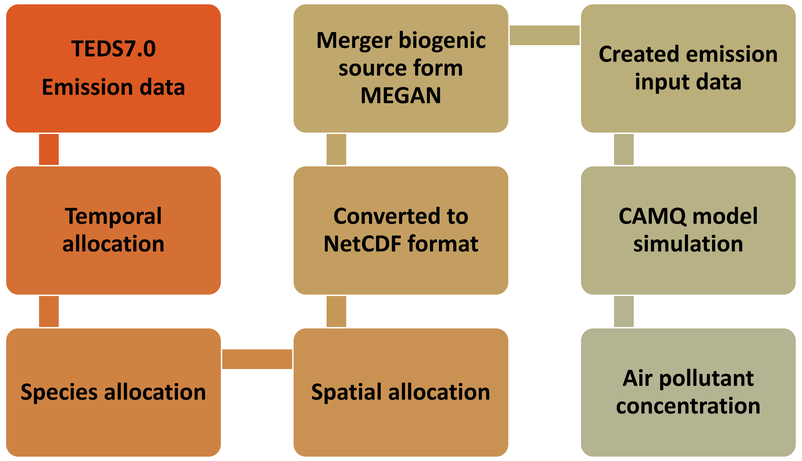

Fig. 4. TEDS7.0 emissions data processing flow chart.

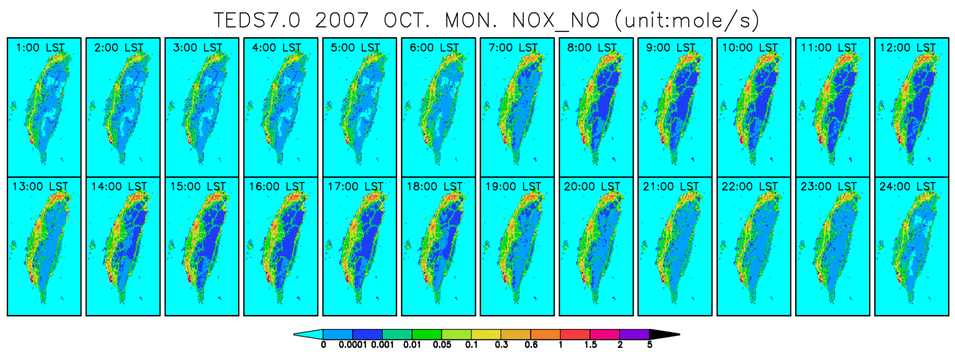

Fig. 5. Nitric oxide (NO) 24 hours emissions in October 2007 Monday in Taiwan.

The TEDS7.0 includes point, line, area and biogenic sources. The processing steps follow the procedures of "temporal allocation", "species allocation" and "spatial allocation" (**Fig. 4**).

Fig. 5 shows diurnal distribution of nitric oxide hourly emissions. Apparently high emissions are observed in several urban areas such as Taipei, Taichung and Kaohsiung city. This pattern also occur in other species.

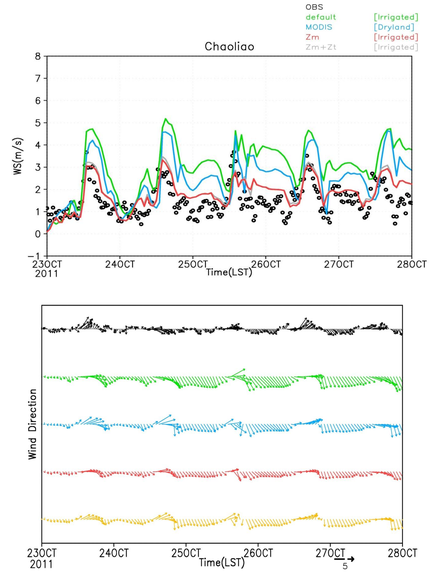

Fig. 6. Time series comparison of wind speed from observation and simulations at Chaoliao site. (Black circle: observation, green line: default, blue line: MODIS, red line: Zm, grey line: Zm+Zt)

Fig. 7. Time series comparison of wind direction (bottom panel) from observations (black), WRF-default (green), WRF-MODIS (blue), WRF-Zm (red) and WRF-MODIS+Zm (yellow).

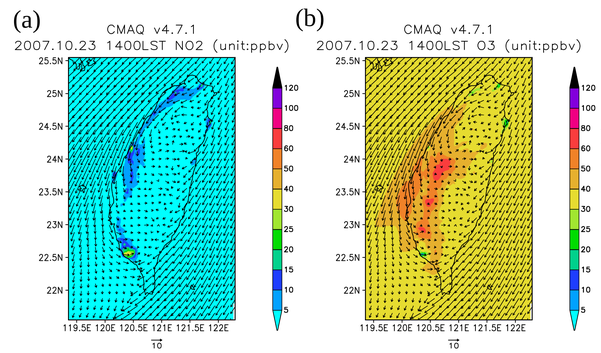

Fig. 8. NO_2 and ozone concentration on 23 October, 2011. (a) 1600LST NO_2 (b) 1600LST O_3.

Results, discussions and future work

On 23 Oct 2011, the strong northeasterly wind were prevailing through out the Taiwan; however. the local circulation was dominated by the land-sea breeze flow in southern Taiwan (**Fig. 6 and 7**). **Fig. 8** shows the simulated NO_2 and O_3 at 1600 LST 23 Oct 2011.

The preliminary CMAQ simulation result shows underestimation of the O_3 that could be related to too low emission input or too high mixing layer depth.

We are still working on the evaluation of the accuracy of the emission inputs as well as the meteorological parameters.

References

Cheng, F.-Y.*, Lin, C.-F., Tsai, J.-L., Tsuang, B.-J., 2012. The impact of aerodynamic roughness length in mesoscale meteorological simulations in Taiwan. Journal of Geophysical Research. Submitted.

Tsai, J.-L., and B.-J. Tsuang (2005), Aerodynamic roughness over an urban area and over two farmlands in a populated area as determined by wind profiles and surface energy flux measurements, Agric. For. Meteor., 132, 154–170.