# Domain expansion and nudging method of JMA's Local Chemical Transport Model

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## 1. Introduction

JMA introduced a regional Chemical Transport Model (NHM-Chem; Kajino et al. 2019; 20-km resolution) to support air quality forecasting for smog information in March 2015, and added a local CTM (ASUCA-Chem; Kajino et al. 2022; 5-km resolution) for more detailed forecasting in March 2021 with assimilation of in-situ surface ozone observation data starting in June 2022. The calculation domain of the local CTM was also expanded in February 2023 for effective issuance of operational smog information (Figure 1), and its ozone boundary conditions were changed to JMA's global CTM from the regional CTM. The model after domain expansion is referred to as the local CTM here to distinguish it from the regional CTM. The local domains differ.

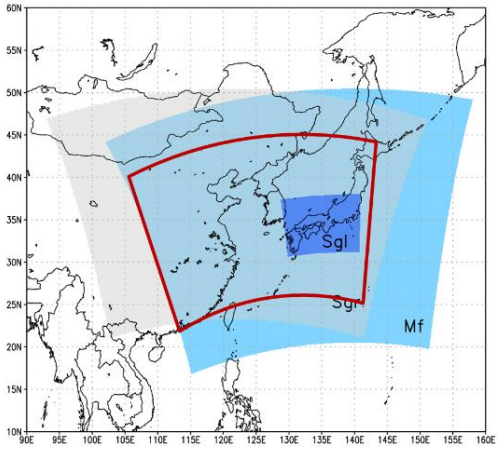


Figure.1 Calculation domains for JMA's MSM (light blue), regional CTM (grey), previous CTM (blue) and new local CTM (red)

## 2. Model and data assimilation

Output from the JMA Meso-Scale Model (MSM) is used for local CTM meteorological fields, and simplification is applied in forecasting of surface photochemical oxidants to reduce computational costs. The horizontal resolution is 5 × 5 km in Lambert coordinates, and the vertical resolution has 19 levels in terrain-following coordinates from the ground surface to 10 km above sea level.

The local CTM operationally runs over 51 hours with an initial time of 12 UTC once a day, assimilating surface ozone concentration data (AEROS: Atmospheric Environmental Regional Observation System in Japan) during the first 6 hours. Nudging is applied for data assimilation as with the regional CTM (JMA 2023).

## 3. Experiment

Forecasts from the new local CTM with data assimilation and the expanded domain were tested (Sgl-TEST) and compared with operational forecasts from the regional CTM (Sgr-CNTL) and the previous version of the local CTM (Sgl-CNTL). The comparison periods were 1 April – 15 June 2022 and 16 June – 30 September 2022 in consideration of the timing of data assimilation into Sgl-CNTL on 15 June 2022.

Figure 2 shows an event involving high surface ozone concentration when smog information was issued. Sgl-TEST and Sgl-CNTL show quantitatively consistent distribution to AEROS and more precise distribution than Sgr-CNTL.

The root mean square error (RMSE) of Sgl-TEST in spring was generally smaller than those of Sgr-CNTL and Sgl-CNTL (Figure 3), showing the effects of data assimilation for the lead time of 6 hours and until morning during the forecast period. In regard to the high ozone concentration that often occurs in coastal metropolitan areas and then moves inland during daytime in summer, Sgl-TEST and Sgl-CNTL tended to overestimate surface ozone concentration in inland areas, and related RMSEs were generally higher than those of Sgr-CNTL. Sgl-TEST forecasted surface ozone better than Sgr-CNTL for nighttime periods and in coastal areas (not shown).

## 4. Summary

JMA originally had two CTMs with different resolutions

and domains for photochemical smog bulletins. New data assimilation and domain expansion for the higher-resolution CTM optimized forecast skill for surface ozone concentration. As a result, the lower-resolution CTM was replaced with the higher-resolution version in February 2023.

**References**


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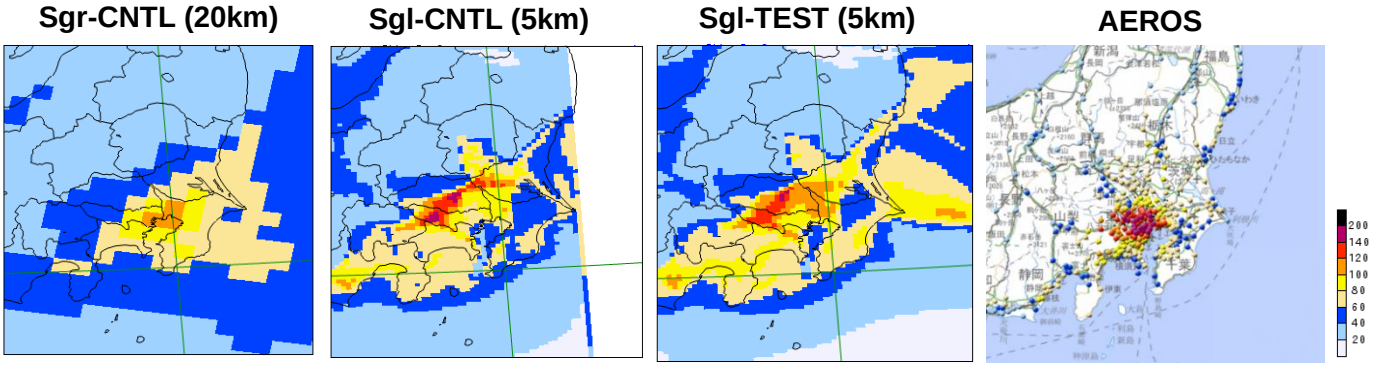


Figure.2 Surface ozone concentration at 15:00 JST (lead time: 18 hrs) on June 30 2022. AEROS data are mapped under GSI Tiles at https://maps.gsi.go.jp/development/ichiran.html.

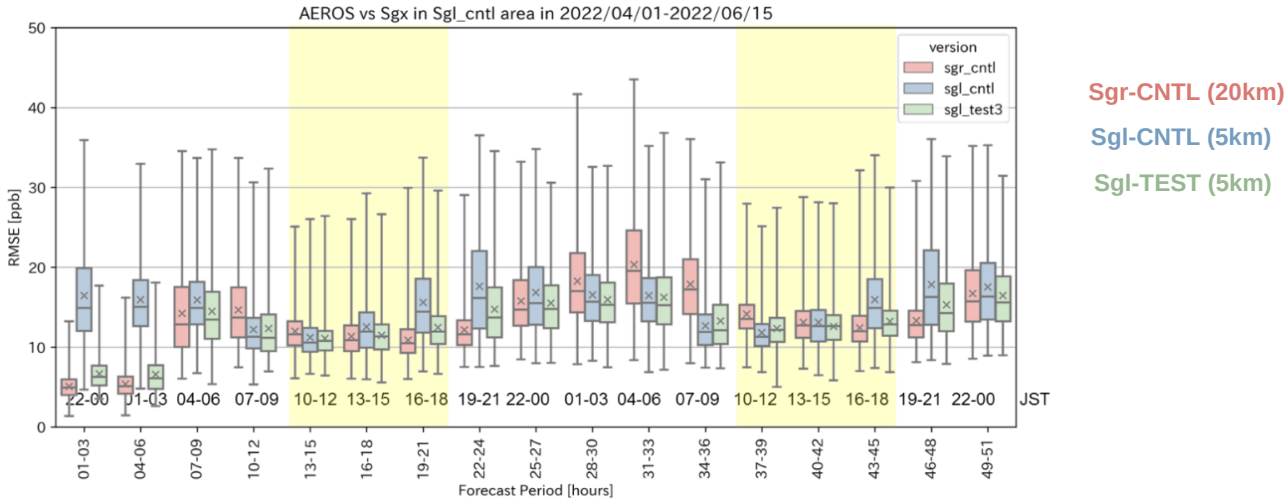


Figure.3 RMSEs of spring surface ozone forecasts from Sgr-CNTL (red), Sgl-CNTL (blue) and Sgl-TEST (green). Horizontal axis: lead time; yellow shading: daytime hours; whiskers: 0th and 100th percentile; boxes 25th – 75th percentiles; bars: 50th percentile; x: mean