Ozone Production in Global Tropospheric Models: Quantifying Errors due to Grid Resolution

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1. Introduction
Ozone production in global chemical models is dependent on model resolution because ozone chemistry is inherently nonlinear, the timescales for chemical production are short, and precursors are artificially distributed over the spatial scale of the model grid. Here we examine the sensitivity of ozone, its precursors, and its production to resolution by running a global chemical transport model at four different resolutions: T21 (5.6° × 5.6°), T42 (2.8° × 2.8°), T63 (1.9° × 1.9°) and T106 (1.1° × 1.1°) under the same conditions and then by quantifying the errors in regional and global budgets.

2. Model Studies
We use the FRAGC/UJH CTM [Wild and Prather, 2000] to study the global impacts of model resolution and consider East Asia to provide a regional focus. Measurements from the NASA TRACE-P campaign in Spring 2001 allow a detailed assessment of model performance.

3. Global O$_3$ Production

| Table 2. Global O$_3$ Budgets for March/April 2001 |
|-----------------|-----------------|-----------------|-----------------|
|                  | T21             | T42             | T63             | T106            |
| O$_3$ Production | 2090            | 2210            | 2250            | 2300            |
| Net Chemical Production | 2000            | 1760            | 1670            | 1730            |
| Deposition (Gg/day) | 2090            | 2210            | 2250            | 2300            |
| Oxidative Lifetimes (years) | 8.06            | 8.32            | 8.44            | 8.57            |

4. Regional O$_3$ Production

| Table 3. Comparison of Boundary O$_3$ Emissions over East Asia |
|-----------------|-----------------|-----------------|-----------------|
|                  | T21             | T42             | T63             |
| O$_3$ Production | 2000            | 1760            | 1670            |
| Oxidative Lifetimes (years) | 8.06            | 8.32            | 8.44            |

5. Quantifying Resolution Errors

Quantify the errors due to resolution ($\varepsilon$) by deriving values for the limit of infinite resolution ($T_\infty$) based on the convergence T42-T63-T106, and assume that the absolute error is proportional to some power ($n$) of the grid size ($h$), i.e., $\varepsilon = h^n$ (Richardson extrapolation).

| Table 3. Convergence and Resolution Errors in Ozone Budgets |
|-----------------|-----------------|-----------------|-----------------|
|                  | T21             | T42             | T63             | T106            |
| O$_3$ Production | 2000            | 1760            | 1670            | 1730            |
| Oxidative Lifetimes (years) | 8.06            | 8.32            | 8.44            | 8.57            |

6. Conclusions

1. Boundary layer O$_3$ production is less at higher resolution emissions less smeared, production lower, precursor export greater; agreement with aircraft/sonde measurements better at higher resolution.
2. Global O$_3$ production is less affected by resolution chemical changes buffered by changes in deposition and distribution and by poorer representation of stratos-trop exchange at T21.
3. Demonstrate convergence with increasing resolution geometric convergence occurring for T42-T63-T106 sequence.
4. Large errors in regional O$_3$ production still present at T106 for East Asian industrial sources regional production is overestimated by 27% at T21, 13% at T42, 9% at T63, and 5% at T106.

References