Comparison of surface ozone at European sites with a global model

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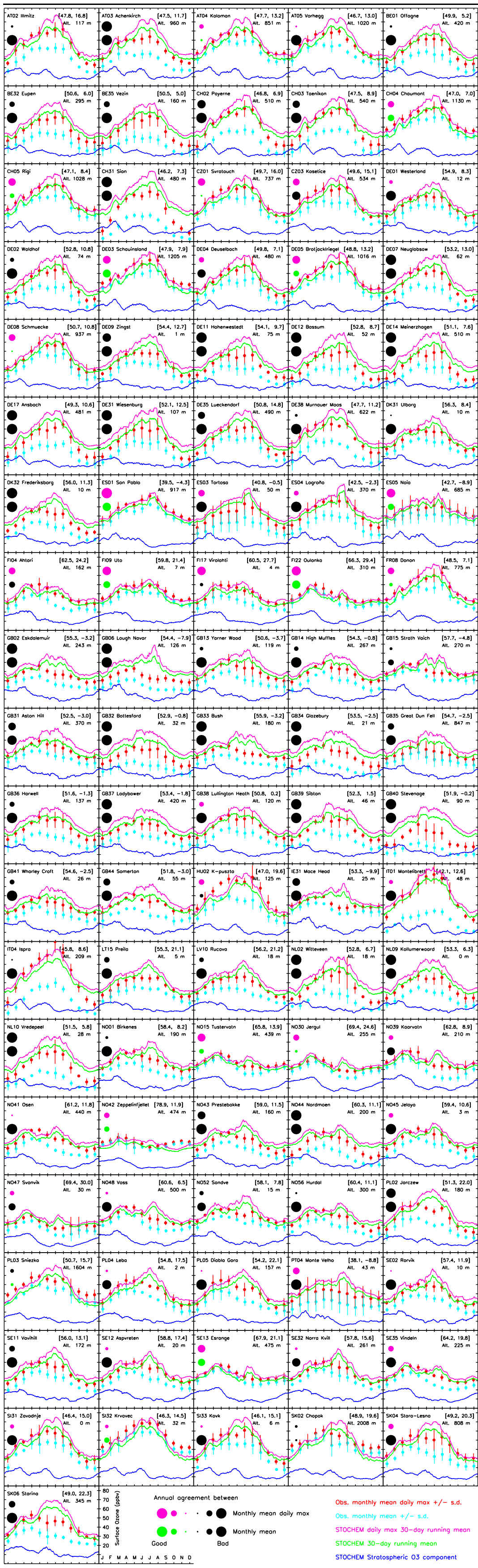

Introduction

Surface ozone measurements from the European EMEP/TOR2 network (Hjellbrekke and Solberg, 1999) provide a major source of data for model validation. Ozone observations from 96 stations gathered during the 1990s are compared here with results from the global model STOCHEM. Comparisons with monthly mean data are made, using: (1) data at all times of day; and (2) daily maximum values. Nighttime surface O_3, especially during winter, is more difficult to model due to the formation of shallow surface boundary layers. Under these conditions, rapid O_3 depletion occurs through dry deposition, and, close to emissions sources, through NO_x titration. Shallow boundary layers are unlikely to be resolved in global models. These problems are more likely at specific sites, at particular times of day, and only during some seasons. By careful site and time selection, data can be useful for model validation, and to show the limitations of modelling.

Global model: STOCHEM

STOCHEM is a global Lagrangian tropospheric chemistry model (Collins *et al.*, 2000), coupled 3-hourly to the Hadley Centre climate model. The version used here has 50,000 air parcels, producing output on a $5° \times 5°$ grid with 22 vertical levels, of c.100 hPa thickness (c.1 km) near the surface. The model has a detailed chemical scheme with 70 species, including 13 emitted hydrocarbons. Emissions from EDGARv2.0 (Olivier *et al.*, 1996) are specified on the $5° \times 5°$ grid. Ozone relaxes towards a sratospheric climatology above the tropopause. Results are from the last 12 months of a 16 month run.

Ozone from the lowest model layer was interpolated to each station's location using the four surrounding values at 6-hourly intervals. Annual cycles of 30-day running means using all data (green lines) and daily maximum data (pink lines) are plotted. Surface O_3 originating in the stratosphere is shown in blue.

Ozone data

Ozone data is from the EMEP database (`www.nilu.no/projects/ccc/emepdata.html`), and is from all stations reporting more than 3 years of data over the period 1990-99. Monthly means and standard deviations (bars) are plotted for all times (light blue) and daily maxima (red).

Model-data comparisons

Two dots on each plot represent a quantitative measure of agreement between the model and observations for daily maxima data (upper dot: pink/black), and all times data (lower dot: green/black). Monthly RMS deviations of the model from the observations beyond one standard deviation are averaged over all months for each station. Deviations in the range 0-3 ppbv are denoted with coloured dots, with larger dots indicating better agreement. Deviations of 3-6 ppbv (and over) are shown by black dots; larger dots indicate bigger discrepancies.

Maps of these dots for the daily maxima are shown in the third row of the panel below; the 4 adjacent plots show equivalent seasonal maps. The model is better at predicting daily maxima than daily mean values. The upper maps show annual and seasonal observed (top row) and modelled (second row) daily maximum O_3. The fourth row shows the level of agreement plotted in altitude- diurnal range space.

The model typically slightly overestimates maximum surface ozone, particularly in summer, and at polluted sites at low altitude (e.g. GB, NL). Observed diurnal variation is generally larger than modelled. Low nighttime values significantly reduce daily mean O_3 values, particularly at polluted sites (e.g. IT01, CH31, NL10). Daytime non-summer values are quite well modelled, with the exception of a few very polluted sites (CH31, DE14, GB34, GB40, NL10). At these sites, the model overestimates O_3, probably because much of the oxidant ($O_x = O_3 + NO_2$) is present as NO_2, due to local peaks in NO_x emissions that are spread out in the coarse resolution model. The model overestimates O_3 most strongly in summer, and this may be because the coarse resolution overmixes the emissions, rather than preserving small scale plume structures. In N. Scandinavia, the model simulates well the spring peak in O_3 (e.g. NO48, SE35). These modelled peaks have a clear stratospheric component, but a spurious summer peak, 'leaking' from central Europe, again reflecting coarse model resolution.

References

Collins WJ *et al.* (2000) Q. J. R. Meteorol. Soc., 126, 1925-1952.
Hjellbrekke AG & S Solberg (2000) EMEP/CCC-Report 1/2001, NILU.
Olivier JGJ *et al.* (1996) RIVM Report 771060 002, Bilthoven.

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