Influence of Future Climate Changes in Europe on Exceeded Ozone Critical Levels

A contribution to subproject GLOREAM

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Summary

Changes in climate variability and extreme weather and climate events in the 20th century, especially in the last two-three decades of the 20th century, have been discussed in many recent scientific publications. Attempts to project the results of such studies in the future have been made under different assumptions. We shall (i) take one of the well-known scenarios predicting changes of the climate in the last 30 years of the 21st century and (ii) investigate the impact of these changes on the future high ozone levels. The results indicate that, although the annual means of the ozone concentrations are rather insensitive to the predicted climate changes, some related quantities are increased considerably.

Introduction

There are many uncertainties related to the climate changes in the future (Houghton et al., 2001). It is nevertheless worthwhile to investigate the impact of possible climatic changes on the pollution levels. Three climatic scenarios are introduced and the third one is used to study the impact of the predicted climatic changes on ozone pollution levels in Europe.

Direct use of the SRES A2 scenario (First Climatic Scenario)

Several scenarios, called SRES, are discussed in (Houghton et al., 2001). We chose to follow the SRES A2 scenario. Resulting from it changes in Europe are shown in Fig. 1. Consider any cell of the grid and assume that this cell is located in a region in Fig. 1 where the increase of the temperature is in the interval *[a,b]*. The temperature at the chosen cell at a time *n* is increased by an amount *a+c(n)*, where *c(n)* is randomly generated in the interval *[0,b-a]*. The mathematical expectation of the increase of the annual mean of the temperature at any cell of the space domain is *(b-a)/2*. Only temperatures are varied in this scenario.

Including information about extreme temperatures (Second Climatic Scenario)

The extreme cases will become even stronger in the future climate; see Table 9.6 on p. 575 in (Houghton et al., 2001). It is expected that: (i) there will be higher maximum temperatures and more hot days in the land areas, (ii) there will be higher minimum temperatures, fewer cold days and fewer frost days in nearly all land areas and (iii) the diurnal temperature range will be reduced over land areas. We increased the temperatures during the night with a factor larger than the factor by which the daytime temperatures were increased. In this way the second and the third requirements are satisfied. The first requirement is satisfied as follows. During the summer periods the daytime temperatures are increased by a larger amount in hot days. All these changes are carried out only over land. Furthermore, the temperatures were varied in such a way that their annual means remained the same, at all cells, as those in the first climatic scenario. We also varied the cloud covers during the summer periods.

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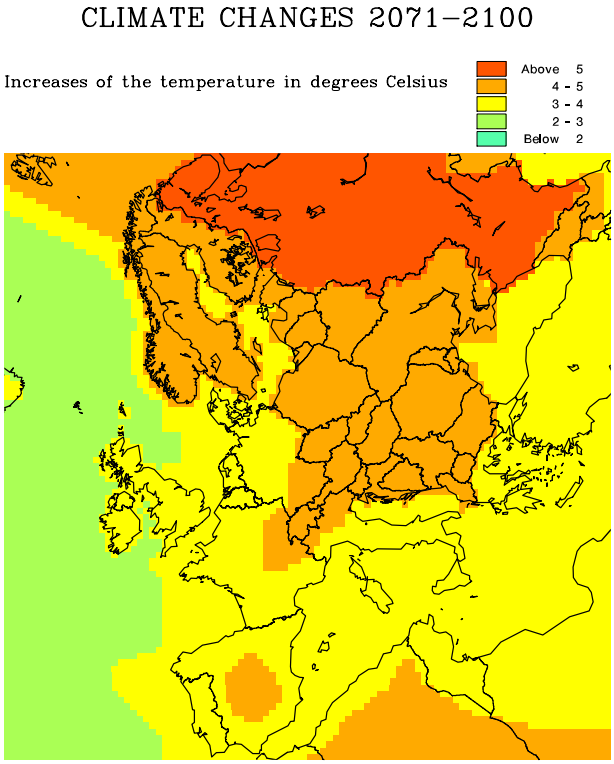

Figure 1.

Including changes in precipitation and humidity (Third Climatic Scenario)

It is also expected, see Table 9.6 on p. 575 in (Houghton et al., 2001), that: (i) there will be more intense precipitation events and (ii) there will be increased summer drying and associated risk of drought. We increased the precipitation events during winter (both over land and over water). During summer, the precipitation events in the continental parts of Europe were reduced. Similar changes in the humidity data were made. The cloud covers during winter were increased, while the same cloud covers as in the second climatic scenario were applied in the third climatic scenario during summer.

Running two air pollution scenarios

The Danish Eulerian Model, DEM (Zlatev, 1995) was run with a Basic Scenario and Scenario Climate 3. The Basic Scenario was run for (1989-1998). When we ran the model for year *N*, we used the EMEP emissions and meteorological data for the same year *N*. Scenario Climate 3 is described in Section 4. It was run for ten hypothetical years. We denote by 1989C the hypothetical year corresponding to year 1989. When we run DEM for year 1989C, we (i) perform the changes described in Section 4 and (ii) use the EMEP 1989 data for the remaining meteorological parameters and for the emissions.

Annual means of ozone concentrations

The comparison of the annual means of the ozone concentrations obtained by the two scenarios from Section 6 shows that the changes are small. Averaged values of the annual means for the whole Denmark were calculated. The differences between the corresponding values of the two scenarios are no greater than 1-2 ppb (see Fig. 2). However, the results for each scenario vary more considerably from one year to another. The differences in the latter case are caused both from differences in meteorological data and emissions.

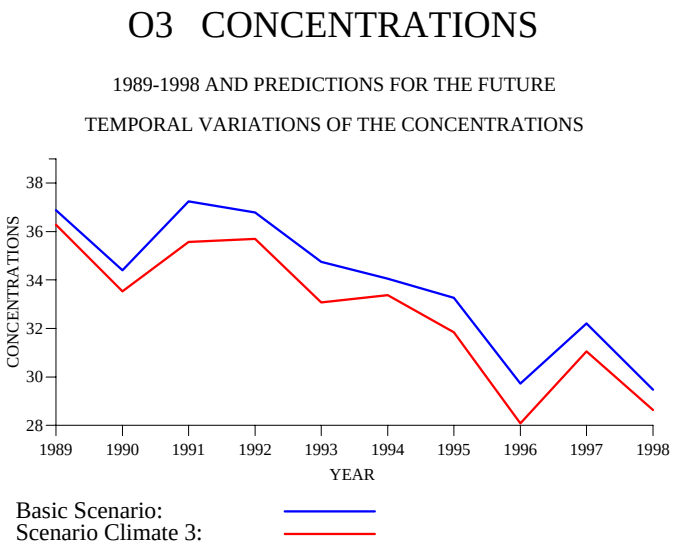

Figure 2.

Changes of high ozone levels

The damaging effects caused by ozone are evaluated not by using directly the ozone concentrations, but by using other quantities that are related to high ozone levels (Zlatev et al., 2001). AOT40 (Accumulated Over Threshold of 40 ppb, over the period May-July when losses of crops are studied), numbers of days in which at least once the 8-hour average ozone concentration is over 60 ppb and averaged daily maxima of ozone concentrations are compared in Fig. 3 – Fig. 5. The Basic Scenario and Scenario Climate 3 are used in the comparison.

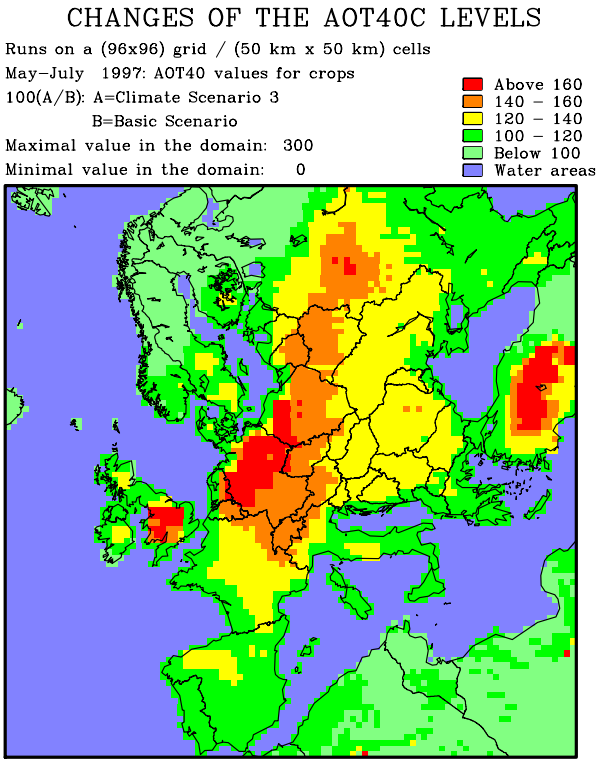

Figure 3.

The results indicate that, while the annual means of the ozone concentrations in Denmark for the Scenario Climate 3 are less than the corresponding values for the Basic Scenario (in Denmark, at least, see Fig. 2), the damaging ozone levels shown in Fig. 3 – Fig. 5 are increased in large areas of Europe. The greater activity of the photochemical reactions in the hotter days during summer when Scenario Climate 3 is used is the possible explanation of this behaviour.

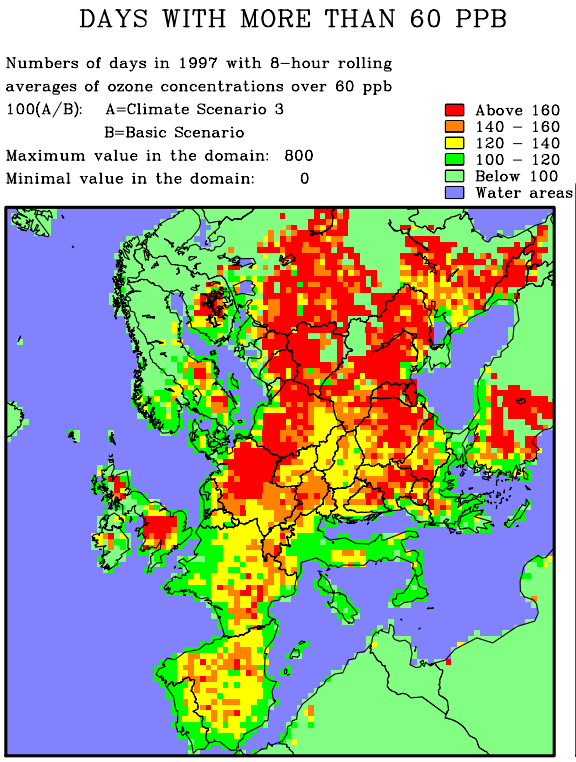

Figure 4.

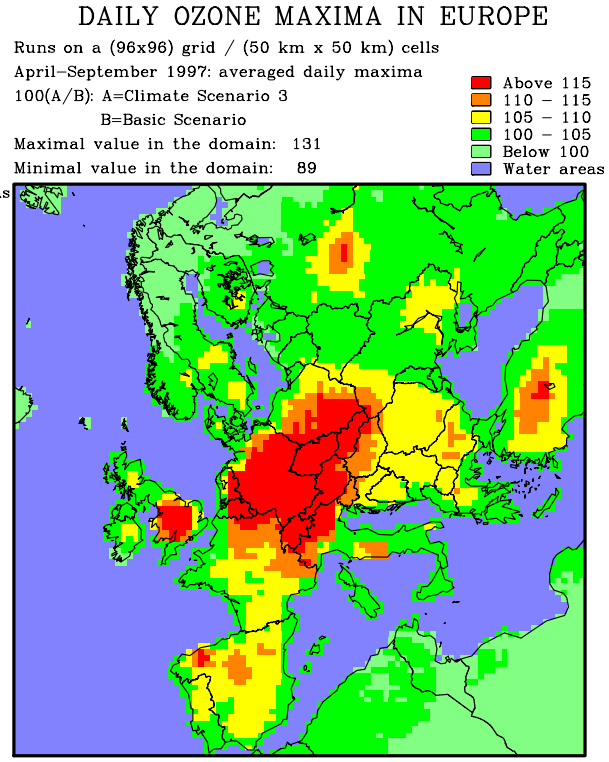

Figure 5.

References

Houghton J. T., Y. Ding, D. J. Griggs, M. Noguer, P. J. van der Linden, X. Dai, K. Maskell and C. A. Johnson, eds., Climate Change 2001: The Scientific Basis, Cambridge University Press, Cambridge-New York-Melbourne-Madrid-Cape Town, 2001.

Zlatev, Z., Computer treatment of large air pollution models, Kluwer Academic Publishers, Dordrecht-Boston-London, 1995.

Zlatev, Z., I. Dimov, Tz. Ostromsky, G. Geernaert, I. Tzvetanov and A. Bastrup-Birk, Calculating Losses of Crops in Denmark Caused by High Ozone Levels, Environmental Modelling and Assessment, Vol. 6 (2001), pp. 35-55.