# Testing the Influence of the Biogenic Emissions on High Ozone Levels in Denmark and in Europe

A contribution to subproject GLOREAM

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**Summary**

It is well known that the uncertainties in the determination of the biogenic emissions are very large (some authors claim that these emissions are under-estimated in certain areas up to ten times). A long series of runs with different biogenic emissions was performed. The results obtained in this study show clearly that the biogenic emissions must be taken into account when control strategies are developed for reducing the anthropogenic emissions in order either to reduce some high pollution levels to prescribed critical levels or to keep them under the critical levels.

**Creating an European data base of biogenic emissions**

Consider an arbitrary area within the space domain of consideration (this area could be a grid-square, a country, a group of countries or a whole continent). In our particular study the space domain is the whole of Europe with parts of Asia, Africa and the Atlantic Ocean. Consider also $M$ vegetation categories (as, for example, forests, crops, etc.). Then the VOC emissions in the selected area emitted from the selected vegetation category $j$, $j = 1,2,\ldots,M$, can be described in the following generic form containing a product of three terms in its right-hand-side. This form for representing the biogenic emissions is similar to that discussed in (Simpson et al., 1995):

$$(1) \qquad E_j = \sum_{i=1}^{N} PORTION_i \, TEMPFACT_{ij} \, EMISFACT_{ij}, \qquad j = 1,2,...,M,$$

where (1) $E_j$ is the VOC emission, which is emitted in the area under consideration from vegetation category $j$ during a time-period of $N$ hours, (2) $PORTION_i$ is the portion of the area selected, which is covered by the vegetation category chosen at hour $i$ (it should be mentioned that very often this factor is assumed to be a constant), (3) $TEMPFACT_{ij}$ is a factor dependent on the temperature, which is used to transform the standardised emission $EMISFACT_{ij}$ from vegetation category $j$ (see below) to the actual emission at hour $i$ for the vegetation category chosen, (4) $EMISFACT_{ij}$ is the emission from vegetation category $j$, which is emitted at hour $i$, standardised for temperature of $30^0 C$.

From the section about uncertainties, Section 4 in (Simpson et al., 1995), it becomes clear that the major uncertainties are caused by the lack of knowledge for the values of the important third factor, $EMISFACT_{ij}$. The main aim in this study is

- **to show the impact of the uncertainties in the determination of $EMISFACT_{ij}$ on the ozone pollution levels**.

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## Temporal variations of the biogenic emissions

The major part of the biogenic VOC emissions is coming from the forest areas. During the last 5-10 years, however, more and more scientists are proposing to take into account also biogenic emissions from other kinds of vegetation (these emissions will be called here biogenic emissions from crops only in order to use a shorter name). The temporal variation of the 1995 VOC emissions emitted in the space domain on the Danish Eulerian Model (Zlatev, 1995) are shown in Table 1.

**Table 1.** Temporal variations of the biogenic emissions from forests and from crops. The units are Ktonnes per area per year.

| **Month** | **Forests** | **In percent** | **Crops** | **In percent** |
|---|---|---|---|---|
| January | 265 | 2.3 % | 0.606 | 0.38 % |
| February | 260 | 2.3 % | 0.716 | 0.45 % |
| March | 327 | 2.8 % | 1.150 | 0.72 % |
| April | 605 | 5.2 % | 4.450 | 2.80 % |
| May | 1411 | 12.3 % | 20.800 | 13.10 % |
| June | 2130 | 18.5 % | 38.200 | 24.00 % |
| July | 2341 | 20.3 % | 43.900 | 27.60 % |
| August | 1989 | 17.3 % | 32.100 | 20.20 % |
| September | 1015 | 8.8 % | 11.300 | 7.10 % |
| October | 658 | 5.7 % | 3.800 | 2.40 % |
| November | 295 | 2.6 % | 1.130 | 0.71 % |
| December | 217 | 1.9 % | 0.672 | 0.42 % |
| **1995** | **11513** | | **159.00** | |

The biogenic emissions during the period from April to September (including here both April and September) are much greater than the biogenic emissions for the remaining months. This is especially true for the biogenic emissions from crops. The actual values of the emissions in the period from April to September are: (a) 9491 Ktonnes for the biogenic emissions from forests (i.e. 82.4%), (b) 150.75 Ktonnes for the biogenic emissions from crops (i.e. 94.8%).

## Scenarios for biogenic emissions

Three scenarios for the biogenic emissions in Europe are used in this study: (a) Normal Biogenic Emissions, (b) High Biogenic Emissions and (c) Low Biogenic Emissions.

## Scenarios for the anthropogenic emissions

Eight scenarios for variation of the anthropogenic emissions have been considered: (1) Basic Scenario (the results are computed by using the actual EMEP emissions for 1995), (2) Scenario 2010 (using predicted 2010 emissions), (3) Central Scenario H1 (as Scenario 2010, but the emissions of the 15 EU countries are further reduced), (4) Maximum Feasible Reduction (MFR) Scenario according to Amman et al., 1999), (5) Scenario Basic-1 (the $NO_x$ anthropogenic emissions are as in Scenario 2010, the others as in the Basic Scenario), (6) Scenario Basic-2 (the *VOC* anthropogenic emissions are as in Scenario 2010, the others as in the Basic Scenario), (7) Scenario 2010-1 (the $NO_x$ anthropogenic emissions are as in MFR Scenario, the others as in the Scenario 2010), (8) Scenario 2010-2 (the *VOC* anthropogenic emissions are as in MFR Scenario, the others as in the Scenario 2010). The anthropogenic

emission scenarios were run with the three scenarios for the biogenic emissions (NORMAL, HIGH and LOW). The total number of scenarios is 24. Each of them was run for the 12 months of 1995. The total number of runs was 288. This is a very comprehensive computational task. It was possible to resolve this task only because a highly efficient code was prepared and run on high-speed parallel computers. The total amount of data produced in these runs is several Gbytes. Only a few percent of these data were used until now.

**Ozone levels in Europe for different biogenic emission scenarios**

Results concerning exceedance of AOT40 values in Europe are given in the four plots in Figure 1.

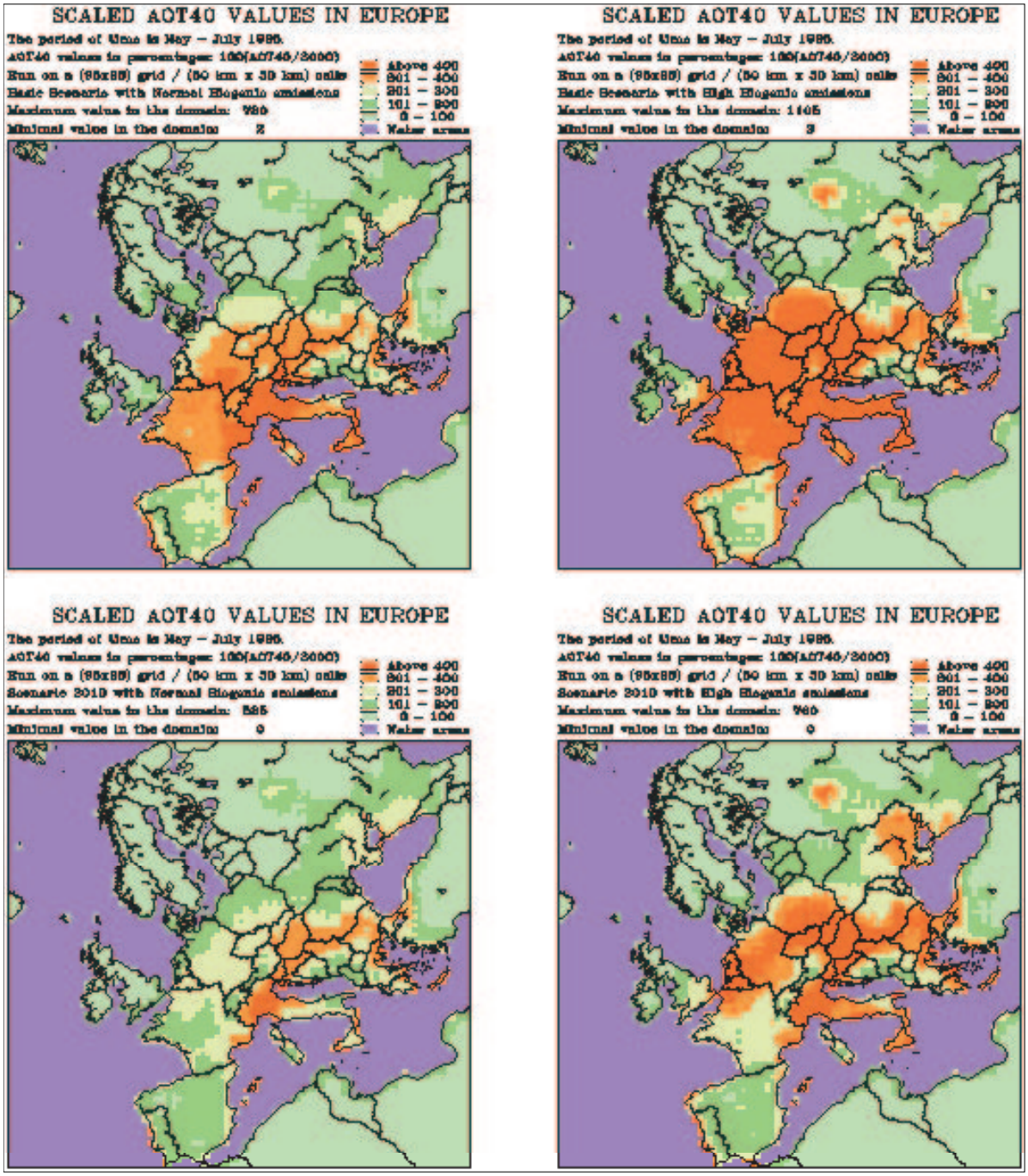


**Figure 1.**

The two upper plots are for the scenario with basic anthropogenic emissions, while the two lower plots are for the scenario with 2010 anthropogenic emissions. The two plots on the left-hand-side are for the normal biogenic emissions, while the two plots on the right-hand-side are for the high biogenic emissions. The transition from the 1995 anthropogenic emissions to the 2010 anthropogenic emissions results in reductions of the highly polluted areas in Europe (both when the normal and the high biogenic emissions are used; compare the upper plots with the lower ones). The transition from the normal biogenic emissions to the high biogenic emissions results in increasing the size of the highly polluted areas in Europe both when the 1995 and 2010 anthropogenic emissions are used; compare the plots in the left-hand-side with the plots in the right-hand-side). In some areas in Europe, the highly polluted parts are bigger in the case where the 2010 anthropogenic emissions are used with high biogenic emissions (the plot in the lower right-hand-side corner) than the highly polluted parts in the case where the 1995 anthropogenic emissions are used with normal biogenic emissions (the plot in the upper left-hand-side part).

These three conclusions have been confirmed by many other results. The above four plots are quite sufficient to illustrate the fact that the biogenic emissions should be included when the sensitivity of some pollution levels to reduction of anthropogenic emissions is studied.

**Discussion of the results obtained by using biogenic emissions scenarios**

The fact that the anthropogenic emissions in Europe (not only the anthropogenic VOC emissions) have been reduced considerably during the last decade shows clearly that the relative part of the biogenic emissions is in general increasing. At the same time, the uncertainties in the evaluation of the biogenic emissions are very big. The great uncertainties in the evaluation of the amount of the biogenic emissions cause bigger and bigger difficulties in the evaluation of different scenarios and in decision making. The considerable reduction of the anthropogenic emissions in Europe and, thus, the increase of the importance of the biogenic emissions are the major sources of these difficulties. Therefore, it is necessary to study more carefully the impact of the biogenic emissions on the pollution levels in Europe under different scenarios with inventories for the anthropogenic emissions, which are closer to the actual anthropogenic emissions.

## References


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