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Atmospheric Chemistry and Physics Discussions



# *Interactive comment on* "Can we explain the trends in European ozone levels?" *by* J. E. Jonson et al.

**J. E. Jonson et al.**

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The manuscript has been revised and new material has been included. Much of the new matial was requested by the referees. Some new material has also been included as we have looked as the manuscript with "fresh eyes".

General comments

Calculated and measured NO2 are shown and descussed separately also for northern Europe and the two eastern European sites. The difference in summer and winter trends are discussed.

At this point we feel that there is no perfect method to account for trends and interannual variability. The Mace Head ajustment is a simple but easy to understand. We have also

tried to use input from global models, but with less sucess. In the paper the Mace Head adjustment and its validity is now explained in some more detail. With the Mace Head ajustment the trend in the mid Atlantic is in line with the trends for the clean sector at Mace Head. The relatively large effect of the Mace Head ajustment in the Alps and Pyrenees is in line with measurements at mountain sites.

More material is included, with new figures and a tables ilustrating the trends for NO2 and ozone in different regions and for all 4 seasons. The likely causes for the different trends are descussed relating them to emission changes and/or changes in background ozone.

Detailed comments referee 3:

Abstract changes as suggested.

P. 5959 line 9

But still not straight foreward.

P 5960, line 1

The emission estimates in Table 1, including those for CO, are based on officially reported data by the countries. (Increased CO emissions in N. America). Emission estimates for CO are however very uncertain, and more so than for NOx and NMVOC.

P 5960, line 3 (ship emissions)

For NOx emissions from ships we have assumed an annual increase of 2.5As an example estimated Nox emissions from the North Sea increase from 506 Gg to 681 Gg in 2002. For comparison reported NOx emissions from the Netherlands decrease from 579 to 406 Gg over the same period. Over the ocean the impact of ship emissions is large, but the effect rapidly vans of as you go inland and hardly affects trends at the measurement sites.

p 5963 line 18 - 20



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We agree that the model calculations do not add to thwe arguments. Therefore the argumentation is moved to an earlier section. Additional text has been included to strengthen the argument.

p5964 line 10-14

Changes in seasonal cycles related to measurements. We think the change in seasonal cycles is an indication that these sites are becomming less controlable by European emissions.

p 5965 end section 5

The main intension of this section is to give an overview of previous model studies. We have also added some additional text:

From the model calculations cited above it seems that the measured increase in background ozone indicated by measurements at Mace Head and mountain tops etc only partially can be explained by emission changes in other continents.

p5966 line 17-28 boundary concentrations

As stated in the paper the Mace Head correction is imposed on the whole (Logan) dataset. Thus also boundaries other than the western boundary is affected by the adjustment. Admittedly this is a crude assumption, but works well because the main bulk of the model domain is in the westerlies. Mace Head has been chosen as it is believed to be representative of a wide sector of inflow to the European continent. We are reluctant to use the trends from sonde sites in general. The lower troposphere over Hohenpeissenberg may also be affected by boundary layer air in summer.

Trends for other species:

Trends in $SO_2$/$SO_4$ and NOx are derived from EPA emissions. Trends for $NH_4$ calculated as 2/3 $SO_2$ + 1/3 NOx.

p5967 section 5.2



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There are a lot more measurements of $NO_2$ available compared to NOx. We have included additional plots with Northern Europe (Norway and Sweden) and Eastern Europe (2 sites).

Inter-annual variability

Commented in the text. Inter annual variability in meteorological fields and sebsequently in the pollutant levels is also descussed in the latest EMEP report available at www.emep.int.

p5967 line 23

Additional text (and 1 figure) added to explain this.

p5968 line 7-10

We have no meteorological input fields for the years 1991 - 1994.

p5968 line 11-13

The main reason why we favour ensembles is that individual sites may be affected by factors such as changes in instrumentation and calibration. Such changes are rarely documented. By using an ensemble such factors will to a large extent cancel out.

p5968 line 18-19

Added text in section 1

p5969 line 3-4

The 2002 base run use year 2002 meteorological fields and Mace Head correction for 2002. Some additional text is added to clearify this. The multiplication with a factor of 2 refers to the sensitivity test with changed lateral boundary concentrations. It seems more robust to use a 10 years average Mace Head correction (1990 - 2000) rather than for a single year (1990). Assuming a near linear increase in the lateral boundary concentration the AvgBC case is roughly representative of boundary concentrations in



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the mid 1990s rather than 1990. In order to compare this to the effects of emission changes between 1990 and 2002 this effect should be multiplied by roughly a factor of 2.

p5969 line 23-27

In the lines just above results for an ensemble of German sites, and one individual German site, are descussed showing a trend for this particular region. We have also included ensembles for northern Europe and Ispra in northern Italy.

p5970 Winter section

The effects of emission changes and changes in lateral boundary concentrations are decussed in more detail in the paper.

section 5.4.5 and 5972 first lines

The discussion here is strengthened.

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Interactive comment on Atmos. Chem. Phys. Discuss., 5, 5957, 2005.