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Atmospheric Chemistry and Physics Discussions



# *Interactive comment on* "Weekly cycle of $NO_2$ by GOME measurements: A signature of anthropogenic sources" *by* S. Beirle et al.

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**General remark:**

The paper discusses an interesting aspect of the GOME $NO_2$ data set, namely the weekly cycle of tropospheric $NO_2$ for different regions and major cities. To my knowledge this effect has not been discussed in the peer reviewed literature. I am in favour of publication in ACP, after addressing the comments below.

*General*

The paper claims to provide a statistical analysis of weekly cycles of tropospheric $NO_2$ columns. In reality the paper discusses multi-year averages without a detailed discussion of random and systematic errors in the retrieved columns. A few error sources are discussed qualitatively, but I would like to encourage the authors to extend the error



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analysis (see detailed remarks below).

The discussion on the lifetime of $NO_2$ is qualitative, and the interpretation and limitations of the approach should be discussed in more detail.

In the conclusion the authors mention the analysis of the weekly cycle of summer and winter data. This is indeed interesting! Because the authors have the tools to present this analysis, and because this seasonal dependence study is suggested by the authors themselves, an extension of the paper with such an analysis (and an additional figure) would be appropriate.

**Specific remarks and suggestions:**

*Abstract*

"Nitrogen oxides ($NO+NO_2$)" - this suggests the nitrogen oxide family is restricted to NO and $NO_2$ only.

"The presence of a weekly cycle in the measured tropospheric $NO_2$ VCD allows the identification of anthropogenic sources" - This statement suggests that, based on the observed weekly cycle alone, the source contributions can be distinguished. However, such an identification is based on simplified assumptions, such as contributing the weekend reduction effect to traffic. The following statement may be more appropriate: "The presence of a weekly cycle in the measured tropospheric $NO_2$ VCD may help to identify the different anthropogenic source categories"

*Introduction*

The references cited focus on the GOME $NO_2$ work performed in Heidelberg. Additional references to the other groups working on GOME $NO_2$ retrieval would be appropriate in the introduction. For example, a recent paper by Martin et al (2003, JGR in press) discusses emission sources and is very relevant.

"Remote sensing of the troposphere in principle is constrained by clouds". Except



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for clouds and spatial resolution issues, the retrieval is strongly influenced by surface albedo, profile shape and the stratospheric column. It would be useful to reformulate the sentence and also mention these complicating aspects in the introduction.

*Retrieval of tropospheric $NO_2$*

The air-mass factor approach is simple, but well justified in the text. The paper focusses on the ratio between week days and the weekend, and air-mass errors should cancel on average. The discussion of the 35 day period of GOME and the weekly cycle of the cloud cover is nice!

As far as I understand there is no rejection of pixels based on cloud cover. This deserves some discussion: cloudy pixels are not sensitive to the boundary layer, but may for instance contain traces of lightning $NO_2$. This may introduce an offset, which will influence the observed weekly cycle.

*Weekly cycle*

Figure 1: "Metropolises"

The stratospheric reference deserves more discussion: systematic errors made in this quantity are additive, and not multiplicative. This means that such errors influence the observed weekly cycle. Systematic errors may also be different for different regions.

"wind force" -> wind speed

"Nevertheless, there also is a seven day week" (in China)

GOME measures at 10:30 local time. How does this influence the analysis? E.g. there may be regional differences in when the rush hour takes place. The daily cycle of $NO_x$ emissions/concentrations is also of much interest to the topic of the paper. I guess the ratio weekdays/weekend will depend on the satellite local measurement time. The identification of the different anthropogenic sources will then also depend on this observation time.



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The authors mention Essen and Sheffield. Could this be related to cloud cover variability?

As mentioned in the general remarks, what I miss is a discussion of error sources that influence the results, e.g. the variability in cloud cover, stratospheric reference and statistical variability. Figure 3 contains an error bar, but this is not discussed in the text. Is this a realistic error bar?

*Lifetime estimation*

In this section the authors present a simple "average" lifetime estimate. In reality it is difficult to talk about one lifetime: the residence time of nitrogen compounds in the atmosphere depends very much on location (altitude), meteorology (wind, rain) and season (light). Furthermore, the estimation of the lifetime is based on simple assumptions and GOME has been used before for lifetime estimates. Nevertheless, I find this lifetime estimate useful. The authors clearly present the assumptions, but an additional discussion of the interpretation and limitations of the estimate would be useful.

"emitted pollutants remain within the area for at least one day". This is only partly true, and transport from Netherlands/Belgium/France will be substantial.

"analysed in detail": In my opinion a "detailed" analysis will require a model which describe the effects discussed above.

*Conclusions*

"underlining the power of tropospheric trace gas measurements from space": this statement is not so useful at this point.

"This helps to discriminate man-made from natural sources": This claim is not really justified, and the sentence should be reformulated. First, natural emissions are not discussed (the paper focusses on the strong emissions from industrialised countries and cities). Secondly, simplifying assumptions were made concerning the weekly cycle of anthropogenic emission sources (e.g. traffic vs industry).



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Interactive Comment

"allow to deduce the lifetime". This is too strong. Alternative: "allow a rough estimate of the mean lifetime of boundary-layer $NO_x$"

"Further information can be gathered by analysing the weekly cycle of summer and winter data separately, since the role of traffic compared to heating should be different for both cases": I suggest that this analysis is also presented. One additional figure would be appropriate.

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Interactive comment on Atmos. Chem. Phys. Discuss., 3, 3451, 2003.