Dear Editor,

With regard to the manuscript:

MS-NR: acp-2012-201
Title: Analysis of stratospheric NO2 trends above Jungfraujoch using ground-based UV-visible, FTIR, and satellite nadir observations

Author(s): F. Hendrick, et al.

Please find below the replies to Referee T. Blumenstock's comments.

Sincerely yours,

F. Hendrick (**franch@oma.be**)

Referee T. Blumenstock

First, we would like to thank T. Blumenstock for his helpful comments.

General comments:

The authors present a trend study of NO2. The study is based on consolidated long term data sets from ground-based measurements. Furthermore, satellite data from different sensors are merged after validation with ground-based data set from SAOZ. The derived trends are consistent among the various data sets. The trends are discussed in the context of trends of other species. This topic, quantification and understanding trends of atmospheric constituents is an important scientific issue. The subject is fully appropriate for publication in ACP. I recommend publication after minor revisions.

Specific comments:

Chapter 2.1: While for FTIR and satellite data an error estimate is given, it is missing for SAOZ observations.

We don't agree with this comment. On pages 12363 (lines 27-28) and 12364 (lines 1-2), we give an error estimate on the SAOZ NO2 columns based on the total retrieval errors (sum of smoothing error, retrieval noise, and forward model parameter error). The smoothing and retrieval noise errors are random while the forward model parameter error can have both random and systematic components. Moreover, in response to Anonymous Referee #1's comment on the impact of the temperature dependence of the NO2 cross sections on SAOZ observations, we have estimated the systematic uncertainty related to this

parameter (maximum 4% in summer). By adding all uncertainties in Gaussian quadrature, the total uncertainty on the SAOZ NO2 columns is about 9%, which is not significantly different from the 8% given in the paper.

In Chapter 4.1 the formula by Weatherhead et al. 1998 is given which allows one to calculate the length of the data set needed to derive a statistically significant trend. Did you calculate this and how does this value compare to the time series used (see also comment to chapter 4.2).

We have done this calculation and we obtained the following values: 16 years for both SAOZ and FTIR over the 1990-2009 period and 22, 16, 14, and 17 over the 1996-2009 period for satellites, SAOZ at satellite SZA, FTIR, and SAOZ at FTIR SZA, respectively. So, for the 1990-2009 period, the length of the data set needed to derive a statistically significant trend is smaller than the length of both FTIR and SAOZ time-series used (19 years), confirming the significance of the estimated trend values. For the 1996-2009 period, the length of the data set needed to derive a statistically significant trend is larger than the length of the time-series used, except for FTIR observations. The 22-year period obtained for the satellite time-series explains why the trend is not significant at the 95% confidence level. For the corresponding SAOZ time-series, the estimated lengths of data sets needed to obtain a statistically significant trend are slightly larger than the 14 years of the 1996-2009 period. This could explain the tB values close to 2 obtained for these two time-series, meaning that we are at the limit of the 95% confidence level significance.

Chapter 4.2: Maybe, you can add tB values as defined by formula (5) in Tab. 1 to show directly which trend is significant within the 95% confidence level.

In the revised manuscript, we have added the tB values in Table 1.

To calculate tB sigmaB is used which presumably has been calculated according to formula 4 (Weatherhead et al., 1998). How did you estimate the autocorrelation of the data set? Did you use the same data set or an independent one (e.g. from model data)?

We calculated the correlation of the noise among successive measurements as suggested in Weatherhead et al. (1998), so no independent data set is used. In practice, we applied the IDL function a_correlate with a lag of 1 to the data set. Details on this IDL function can be found at http://idlastro.gsfc.nasa.gov/idl_html_help/A_CORRELATE.html.

While trends derived from SAOZ and FTIR time series are significant on the 95% confidence level, the trend from satellite data is not. In other words, the period of the time series of satellite data is still too short for a significant (95% conf.) trend detection. Using formula 4 (Weatherhead et al.,

1998) you might calculate the length of the data set needed to derive a statistically significant trend.

See above our reply to the comment related to Chapter 4.1.

Typos/minor corrections:

p. 12362: considered => considered as

We think that adding ‘as’ is not necessary.

p. 12371:
- N2 Oof => N2O of
- N2 Otrends => N2O trends

Corrected.

Reference:

Weatherhead, E. C., et al.: Factors affecting the detection of trends: Statistical considerations and applications to environmental data, J. Geophys. Res., 103, 17,149-17,161, 1998