

Responses to Anonymous Referee #2

For clarity we repeat the reviewer comments in normal font, followed by our responses in *blue italic font*.

The manuscript presents trends in tropospheric NO₂ over large urban agglomerations. The authors used a fit of SCIAMACHY NO₂ columns to a statistical model with a linear trend and seasonal component to derive the trend. The main innovations of the work are that the scope both in number and location of the urban agglomerations has been expanded, and a comparison of the NO₂ trend was made to population growth estimates. The manuscript is well written and concise, and presents results that would be useful to the atmospheric science community. Therefore it deserves to be published.

We thank the reviewer for the overall positive assessment.

However, the manuscript would benefit from an expanded and more detailed discussion of the current literature on global and regional NO₂ trends, and some explanation for the results regarding the relationship between NO₂ trend and population growth. In Section 3.3, I think it is important to show examples of the fit to the NO₂ time series, and to include some discussion on the quality of the fit and how this could effect the trend calculations.

We significantly expanded the background section in order to discuss more of the relevant current literature, including all papers specifically recommended by the reviewer, and several more (see the more detailed comments below). Based on the reviewer's recommendation we further expanded the discussion of the results between NO₂ trends and population growth taking into account recent published studies such as Lamsal et al. 2013. In Section 3.3 we followed the advice of the reviewer and included an additional Figure (Figure 2 in the revised paper) giving an example of the fit to the NO₂ time series, as shown for the example of Baghdad, Iraq. We further included a comprehensive discussion of this Figure and added material discussing the quality of the fit and its potential effect on trend calculations.

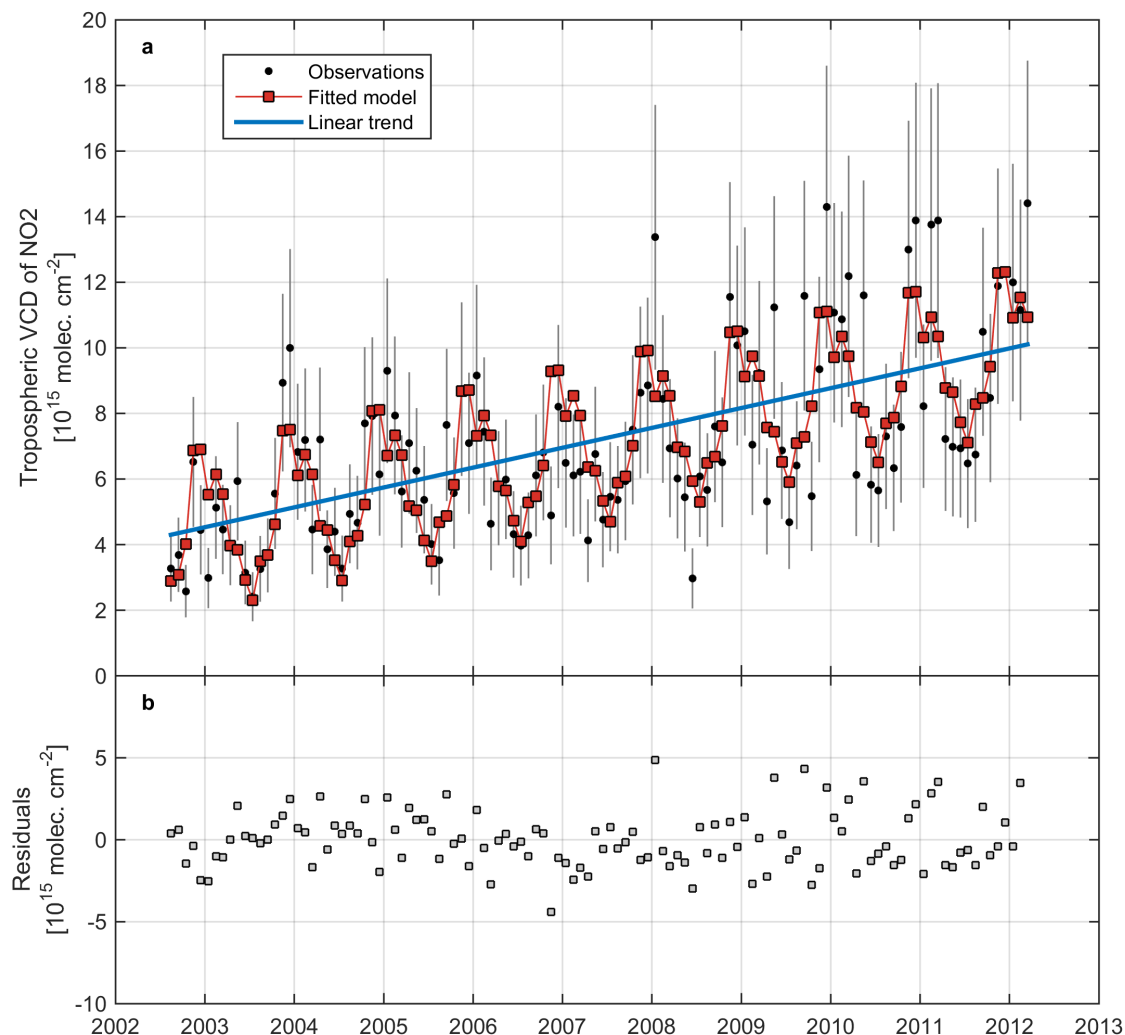


Figure 1: Additional Figure added in Section 3.3 to show an example of the model fit to the NO₂ time series

Below are some specific comments:

Page 24313 Line 16-25: The writer states that in the context of the MACC chemical weather forecasting framework the purpose of the work is to test whether SCIAMACHY observations could be useful for estimating trends. It's not clear how chemical weather forecasting and NO₂ trends from SCIAMACHY are related. SCIAMACHY stopped reporting data in 2012, therefore no new data could be available for forecasting purposes. Some explanation of this should be made here.

The reviewer is correct that SCIAMACHY is no longer operational. However, we see this study as contributing toward preparation for the upcoming Copernicus satellite instruments related to atmospheric composition. Future Copernicus satellites such as Sentinel-5p, Sentinel-5, and Sentinel-4 will carry on the existing NO₂ record provided by SCIAMACHY, OMI, and GOME-2. The methodology and results obtained for a predecessor instrument will be applicable and relevant for the Copernicus-funded successor instruments. Furthermore, there is a strong link between trends in satellite-based

NO2 columns and changes in NOx emissions, which in turn have an important effect on the quality of the results provided by the Copernicus Atmospheric Monitoring Service (CAMS). We also address this point in the response to Reviewer 1.

To clarify these points, and to highlight the relevance of our study for Copernicus more clearly, we have revised this section and added additional material in the introduction.

Page 24314 Line 15: In this section, references to the following recent papers on satellite-based NO2 trends are missing: Zhou et al., Atmospheric Environment (2012). Castellanos and Boersma, Scientific Reports (2012). Curier et al., Remote Sensing of the Environment (2014). In fact, it may be useful to include a table or a simple figure illustrating the findings of past studies, of which at this point there are many.

Thank you for this comment. Not including these references was an oversight and we now add them in this section and include a short summary for each of them. We took this opportunity to significantly expand the background section and we now cite and briefly summarize/discuss many other additional relevant publications, including Meena et al. (2012), Hayn et al. (2009), Sitnov (2011), Guerreiro (2014), World Health Organization (2013), Martin (2008), Duncan et al. (2014), Ionov (2010), Liu and Zhu (2013), and Burrows et al (2011).

Page 24316 Line 25: The correct reference for the slant column assimilation in TM4, and calculation of stratospheric contribution to the NO2 total column is: Dirksen et al. Journal of Geophysical Research (2011).

We thank the reviewer for pointing this out. Dirksen et al (2011) has now been included in the manuscript, both for the assimilation in TM4 and the troposphere/stratosphere separation.

Page 24319 Line 16-18: Here a reference to Figure 1 should be given.

A reference to Figure 1 has been included here in the revised manuscript.

Figure 2: The sites with zero trend (white colored markers) are very difficult to distinguish. Perhaps change the color of the markers or the color of the background to make these points more apparent.

Based on the reviewer's comment we modified this Figure as follows:

- a) We changed the figure to have a different background color for both land and ocean areas so that the markers with low trend magnitudes are more easily distinguishable.*
- b) We slightly increased the size of the markers.*

Page 24325: The correlations between population growth and NO₂ trend for the different regions are very interesting and deserve more discussion. What are the differences between the regions that could drive these distinct clusters? Is it technology? Emissions trends? Trends in regional climate? Measurement artifact? Lamsal et al. Environmental Science and Technology (2013) recently published a similar analysis. How do the results from this work compare?

We significantly expanded this section to discuss in more detail some of the potential drivers of the observed patterns in NO₂ trends versus population growth. We also put these results into context by referring to the recent study of Lamsal et al. (2013) on the relationship between NO₂ and population density.