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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Global and zonal tropospheric ozone variations from 2003–2011 as seen by SCIAMACHY" *by* F. Ebojie et al.

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Author comment on "Global and zonal tropospheric ozone variations from 2003 - 2011 as seen by SCIAMACHY" by F. Ebojie et al. Atmos. Chem. Phys. Discuss., 15, C7515–C7516, 2015.

Response to anonymous reviewer #1 and editor

We thank the reviewer for this review and highly appreciate the comments and suggestions. Please find below a response to the comments. âĂİ

Anonymous reviewer and editor (Comments to Author): This descriptive paper investigates tropospheric ozone trends from 2003 to 2011. It uses a data set generated by limb-nadir matching observations. The key figures 7 and 8 highlight regions of sig-

nificant trends, which the paper tries to explain (tries to motivate why the trend might occur). Generally the paper is well written and illustrated. Sometimes it is hard to understand why figures have been chosen. Figures 3 to 6 are fairly underused (or not really necessary), but I have no objections keeping them in.

Reply: We thank the anonymous reviewer for the encouraging comments. Figures 3 to 6 help us to understand and quantify the contributions of the residual and the individual regression terms to our analysis. In addition, we included a subtitle "3.4 Quasi-biennial oscillation and El Niño-Southern Oscillation response to changes in tropospheric ozone column" and added figures 7-9 to explain the response of the proxies to TOC changes. We also added the following statement to our abstract "In addition, the response of El Niño-Southern Oscillation and quasi-biennial oscillation to changes in TOC for the period 2003–2011 was investigated. The result shows extensive regions of significant ENSO responses to changes in TOC and significant QBO response to TOC changes over some regions."

However, I would like to see a more critical assessment of significance in the conclusions section. Currently the conclusions read like a theory of everything, but it would be nice to have a better idea why some areas of compact correlations are used and others ignored (e.g. west of -90 longitude n figures 7 and 8), and why the authors believe that trends over such a short period might not be decadal variability.

Reply: Thank you for this, we have added two regions west of -90 in our analysis. We have also added statements as follows. "Furthermore, long-range ozone transport within the troposphere is modulated by interannual to decadal climate variability (e.g., Lin et al., 2014; Ziemke et al., 2015)."

"The observed TOC changes might have been influenced by changes in transport of pollution, anthropogenic O3 precursor emissions and dynamical phenomena including ENSO, the North Atlantic Oscillation/Northern Annular Mode (NAO/NAM), Southern Annular Mode (SAM) in the extra-tropics, Pacific North American (PNA), Pacific

Decadal Oscillation (PDO), Atlantic Multi-Decadal Oscillation (AMO), etc. (e.g., Handorf and Dethloff, 2009; Lin et al., 2014; Ziemke et al., 2015). The climate pat- terns associated with the modes may exhibit, structural, spatial, index or no change (e.g., Compo and Sardeshmukh, 2010; Bulic and Kucharski, 2012). During El Niño events, the ITCZ is farther south and closer to the equator, while during La Niña, it is farther north and away from the equator (e.g., Hastenrath, 1977; Schneider et al., 2014). These alter the strength of the tropical cyclones over the Pacific and Indian Oceans, thus influencing TOC changes. Close to the branches of the ITCZ in the Indian and Pacific ocean, and possibly close to the ITCZ in other regions, we observe significant linear trends for the analysis period 2003 to 2011. Generally air masses are different on the different sides of the ITCZ. Thus, they have different amounts of tropospheric O3 . Our explanation of the observed lin- ear trends is that the positions of the oceanic branches of the ITCZ, and perhaps also the ITCZ, have been changing (e.g., Hastenrath, 1977; Pike, 1971; Xie and Philander, 1994; Moxim and Levy II, 2000; Schneider et al., 2014). This may be induced from oscillations of the position of the ITCZ, produced by natural phenomena, or possibly an early warning of anthropogenic induced changes (e.g., Hastenrath, 1977; Xie and Tanimoto, 1998; Xie and Philander, 1994; Chang et al., 1997; Schneider et al., 2014). In general, changes of the position of the ITCZ, in addition to that simply expected seasonally, their origins and consequences for the production and removal of tropospheric O3 and other pollutants require careful assessment in the future. Longer time series of data and more research are required to identify unambiguously the origin of these trends." I am happy for the paper to be published in ACP, with a small (self-)critical addition to the conclusions section.

Reply: Thank you for this, we modified the conclusion and added some statements as follows.

"It should be noted that a final attribution of the variability and trends observed in specific regions to the different underlying processes is not possible based on the analysis alone as presented in this paper. This task requires in addition dedicated model sim-

ulations that will allow us to separate the different relevant processes. The value of the study lies more in the presentation of experimental results on global and regional tropospheric ozone columns to be used as a benchmark for model simulations."

We also added the following statement "tropospheric O3 . Investigation of the response of El Niño-Southern Oscillation and quasi-biennial oscillation to changes in TOC for the period 2003–2011 shows extensive regions of significant ENSO responses to changes in TOC and significant QBO response to changes in TOC over some regions."

Please also note the supplement to this comment:
http://www.atmos-chem-phys-discuss.net/15/C10471/2015/acpd-15-C10471-2015-supplement.zip

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Interactive comment on Atmos. Chem. Phys. Discuss., 15, 24085, 2015.