Reply to comments of reviewer #1 on the manuscript "Tropical tropospheric ozone column retrieval for GOME-2" by P. Valks et al.

We would like to thank the reviewer for his helpful comments and suggestions. In the following, we will reply to them point by point, including the reviewer's text in italic.

Section 4.2, line 15: The very low to near-zero ozone measured by GOME-2 is an important science result that is not really commented much about in the paper. Kley et al. [1996; Science] shows measurements of near-zero ozone in the tropical Pacific mid-upper troposphere associated with deep convective clouds. However, a later paper by Vomel and Diaz [2010; Atmos. Meas. Tech., 495-] attributed the near-zero ozone measured by the sondes as an artifact. Both OMI [Ziemke et al., 2009a] and now GOME-2 independently measure very low to near-zero ozone concentrations in these tropical regions implying that such exceedingly low concentrations are likely not just artifacts of the satellite and sonde measurements.

We agree with the reviewer that the very low ozone measured by GOME-2 in the tropical Pacific is an important science results and deserves more attention in the paper. Extremely low ozone concentrations have not only been measured in the upper troposphere, but also in the marine boundary layer (e.g. Browell et al., 2001). Individual ozone sonde profiles from Samoa (as used in this paper for comparisons with the GOME-2 results) also show very low ozone concentrations (≤ 15 ppbv), especially around February (note that a constant ozone concentration of 15 ppbv between the surface and 200 hPa represents an ozone column of ~10 DU). In addition, Rex et al. (2014) show measurements and model results of very low ozone in the tropical West Pacific. These results, and the OMI measurements from Ziemke et al. (2009a), are consistent with the small tropospheric ozone columns over the Pacific found with the GOME-2 CCD method.

Here it should be noted that the uncertainty in the background current correction results in a detection limit of ECC ozonesonde sensors of around 15 ppbv (see Vomel and Diaz (2010) and Rex et al. (2014)). Therefore, ozonesonde measurements are not optimal for quantitative analyses and comparisons with GOME-2 for situations with very low ozone concentrations (< 15 ppbv).

In the updated paper, we have extended the discussion on the very low ozone measured by GOME-2 (and ozone sondes) in Sections 4-6, and added references to Kley et al. (1996) and Rex et al., 2014.

The authors might mention that mean concentrations of 4-7 ppbv in Figure 4 represent average column abundance of at most about 1 Dobson Unit (based on a 300 hPa mean cloud pressure). Hence, the above-cloud amount in these regions is essentially identical to stratospheric column ozone. This further corroborates from independent GOME-2 measurements the basic hypothesis of Ziemke et al. [1998, 2009a] for deriving stratospheric column ozone in the Pacific from deep convective clouds. It seems that most of the 4-7 ppbv ozone concentrations in Figure 4 originate from the upper levels above about 250 hPa and with essentially near-zero ozone below 250 hPa.

Correct, a mean ozone concentration of 4-7 ppbv inside the deep convective clouds represent an average column abundance < 1 DU (between 350 and 200 hPa). This is already shortly mentioned in Section 4.1, but we have extended the description in the updated manuscript. We agree that these concentrations are extremely low, and that Fig. 4 points to essentially near-zero ozone below 250 hPa. However, the uncertainty in the derived ozone concentrations with the cloud-slicing method is also relatively large in these extreme low ozone situations, as can be seen in Fig. 4.

Our results seem to be consistent with the lidar measurements of Browell et al. (2001), showing ozone concentrations of 7-10 ppbv in convective air masses in the upper troposphere. However, a quantitative validation of these extremely low ozone concentrations is difficult. They are below the detection limit of ozonesonde measurements (see comment above), and other measurements (aircraft, lidar) are sparse. We have added this discussion to the updated manuscript.

Figure 7: It would be useful in Figure 7 to embed mean differences (GOME2 minus sonde, EMAC minus sonde) and standard deviation of the differences with the sondes. Correlation might also be included. Perhaps because this figure is quite congested another Table could be constructed for the statistics rather than being embedded in the figure.
We added the mean differences (GOME-2 minus sonde, EMAC minus sonde) to the ozone sonde comparisons in Figure 7 of the updated paper. In addition, we added the ozone sonde comparisons for the Equatorial Eastern African site Nairobi (1°S, 37ºE), see comment from Reviewer #2. The statistics on the ozone sonde comparisons (Bias, Diff. RMS and correlation coefficients are included in Table 1.

The other reviewer(s) may agree with me that the figure labeling is very small and difficult to read.
The labels of Fig 2, 4, 6 and 7 have been enlarged.