Variability modes of Umkehr vertical ozone profiles at Marambio, Antarctica

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The B199 MkIII Brewer spectrophotometer provides Umkehr vertical ozone observations at the Marambio Base, Antarctica, since 2010. This study focuses on Umkehr ozone profiles over the ozone-hole period (September–November), 2010–2017. Three versions of Umkehr profiles were analyzed: UMK1 uses a-priori profiles (APP) based on the standard climatology by McPeters et al. (2007), and an increased sigma value of 0.1, which allows for a better estimation of minimal ozone values. UMK2 applies a sigma value of 0.4 and it is based on depleted APP estimated from layer 1–7 ECC ozone soundings at the Marambio Base during the ozone-hole period. For the upper Umkehr layers (8–16), the standard climatology (McPeters et al., 2007) is used. The final, UMKC (combined) version, combines UMK1 and UMK2 profiles according to the position of the station outside/inside the polar vortex, respectively (Čížková et al., 2018).

All versions of the vertical ozone profiles were processed by the Principal Component Analysis (PCA). For UMK1, PCA detected 3 modes of variability, which explained 38, 31, and 14 % of variability, respectively. The first mode was connected mainly with the ozone variability in 40–65 km, which indicated large relative changes of ozone amount in the upper stratosphere. The second mode was related to the ozone variability in 10–25 km, and clearly described ozone depletion. The third mode was linked mainly to the ozone variability in 30–35 km, and its scores usually showed a decreasing trend, which (together with negative loadings) indicated increasing ozone amounts in this layer during the season. For UMK2, 4 relevant modes were found, explaining 41, 25, 12, and 10 % of variability, respectively. Modes 1 a 2 were very similar to the corresponding modes of UMK1. The 3rd mode was linked to the layer between 20 and 25 km, while the 4th mode stayed connected mainly to the variability in 30–35 km, and it was similar to the 3rd mode of UMK1. Therefore, UMK2 is more sensitive to the ozone variability in lower stratosphere, because it contained more relevant PCA variability modes. In UMKC, 4 relevant modes were found, explaining 38, 29, 12, and 10 % of variability, respectively. The individual modes were similar to UMK2; only modes 3 and 4 were swapped. The comparison of explained variability between UMK2 and UMKC versions indicated a better ability of UMKC to capture the ozone variability especially in 10–35 km.

The results indicate that at the stations near the edge of Southern Polar Vortex, the application of more types of APP (one for “non-depleted” situations and another for “depleted” ones) may have a significant influence on the ability of Umkehr measurements to detect ozone variability in this region.

Key words: Brewer spectrophotometer, Marambio Base, Umkehr ozone profile, apriori profile, ozone hole

References

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