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Umkehr ozone profiles in Thessaloniki and comparison with MLS overpasses

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Regular Umkehr measurements have been carried out in Thessaloniki, Greece (40.634° N, 22.956° E, 60 m altitude) since 1993. Afternoon measurements were performed with a single monochromator Brewer spectrophotometer, type MKII. In this study, we present analysis of Umkehr ozone profiles covering a 12-year period (2004 – 2015). The re-evaluated Umkehr retrievals are processed with the modified O_3BUmkehr processing (V3.2) that accounts for the stray light contribution in the Umkehr measurements. Umkehr profiles are compared with profiles from the Microwave Limb Sounder (MLS) instrument aboard the NASA's Aura spacecraft. The Thessaloniki station overpass data (24 hours, within a radius of 1000 Km) are used for comparisons. In addition, the MLS profiles have been smoothed with the Umkehr averaging kernels to reduce differences between Umkehr and MLS retrievals due to the Umkehr vertical resolution limitation ($\sim$ 5-10 km). The overall agreement is quite satisfactory ($\pm$10%), with the highest variability observed in the lower stratosphere (layers 2 and 3, between $\sim$10 and 20 km). The best agreement is found for layers 4 and 5 (between $\sim$20 and 30 km), where the bulk of the ozone absorption occurs. Furthermore, we examine the dependence of the difference between the Umkehr retrievals and the MLS profiles from various factors, such as the distance of the MLS overpass to the ground station, the quality of the retrieved Umkehr profiles expressed as the root mean squared error of the residuals (RMSE) and the measured TOC from the Brewer direct sun measurements. Finally, we investigate some of the parameters that affect the Umkehr retrievals, including the out of band stray-light and the temperature dependence of the ozone absorption coefficients. While the ozone effective temperature that is used to correct the temperature dependence of the ozone absorption coefficients has a minor effect, the effect of the stray-light is quite significant (between -14 and 8%, depending on the layer), which is in agreement with earlier studies (Petropavlovskikh et al, 2011).