20 years of tropical tropospheric ozone columns from nadir retrievals of GOME, SCIAMACHY and GOME-2 using the Convective Clouds Differential technique

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Stratospheric ozone is well known for protecting the surface from harmful ultraviolet solar radiation whereas ozone in the troposphere plays a more complex role. In the lower troposphere ozone can be extremely harmful for human health as it can oxidize biological tissues and causes respiratory problems. Several studies have shown that the tropospheric ozone burden (300±30Tg (IPCC, 2007)) increases by 1-7% per decade in the tropics (Beig and Singh, 2007; Cooper et al., 2014) which makes the need to monitor it on a global scale crucial. Remote sensing from satellites has been proven to be very useful in providing information of tropospheric ozone concentrations over large areas. Tropical tropospheric ozone columns can be retrieved with the Convective Cloud Differential (CCD) technique (Ziemke et al. 1998) using retrieved total ozone columns and cloud parameters from space-borne observations. We have developed a CCD-IUP algorithm which was applied to GOME/ERS- 2 (1995-2003), SCIAMACHY/Envisat (2002-2012), and GOME-2/MetOpA (2007-2012) weighting function DOAS (Coldewey-Egbers et al., 2005, Weber et al., 2005) total ozone data. A unique long-term record of monthly averaged tropical tropospheric ozone columns (20◦S – 20◦N) was created starting in 1996. This dataset has been extensively validated by comparisons with SHADOZ (Thompson et al., 2003) ozonesonde data and limb-nadir Matching (Ebojie et al. 2014) tropospheric ozone data. The comparison with the ozonesondes shows good agreement with respect to range, inter-annual variation, and variance. Biases where found to be within 5 DU and the RMS errors less than 10 DU. This 20-years dataset has been harmonized into one consistent time series, taking into account the three instruments' differences, therefore 3 different scenarios have been tested. The harmonised dataset was later used to determine tropical tropospheric ozone trends and climatological values. The tropical tropospheric ozone trends have been found to differ depending on the harmonisation approach. For the selected harmonisation scenario, the mean tropical tropospheric ozone trends range between ±5 DU/Decade with a mean value of 1.15 ± 1.1 DU/Decade. The influence of 2015 el Niño event has been investigated in a case study using simulations from the ECHAM/Messy Atmospheric Chemisty (EMAC) model. El Niño events are major sources of the tropospheric ozone variability (Ziemke and Chandra,2003) due to changes in the convection pattern and large-scale circulation in the tropical Pacific region. More clouds and rainfall appear in the central and eastern Pacific whereas more dryness over Indonesia and as a result strongest forest fires. These effects caused enhanced tropospheric ozone columns over the Indonesian region (~ 8DU) and reduced over the eastern Pacific (~-10 DU) in September 2015. The comparison with the EMAC model shows a strong disagreement over the Indonesian region which has been further investigated via the precursors (NO_2 and CO) concentrations.