(22-240328-A) **Global Ground-based Tropospheric Ozone Measurements: Reference Trends (2000-2022) from the TOAR-II/HEGIFTOM Project**

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Tropospheric ozone trends among various models and satellites diverge widely, the former due to different emission and dynamical parameterizations, the latter due to varying spectral techniques or algorithms. Ground-based (GB) observations are required to verify models and satellites but GB network data themselves can display station biases and discontinuities over time. The TOAR-II Working Group, HEGIFTOM (Harmonization and Evaluation of Ground-based Instruments for Free-Tropospheric Ozone Measurements) used uniform procedures to "homogenize" data from 5 network instrument types: ozonesondes, IAGOS profiles, FTIR, Lidar, Dobson Umkehr. The data are at: https://hegiftom.meteo.be/datasets. Amounts and uncertainties for tropospheric ozone (nominally "total" column, surface to 300 hPa), free (FT) and lower (LT) tropospheric columns were calculated for each GB network over ~25 years. We report trends for the period 2000 to 2022 from the HEGIFTOM data based on Quantile Regression (QR) and Multiple Linear Regression (MLR) methods. The key findings: (1) For both statistical methods, pole-to-pole and across the full longitude range of observations, medians for all trends fall within +3 ppbv/decade to -3 ppbv/decade; (2) There are comparable numbers of negative and positive trends, i.e., a "zonal" mean tropospheric trend is meaningless. (3) Ozone over SE Asia and a few tropical stations exhibit the greatest increases but even in the tropics there are stations with negative trends. (4) Trends in total ozone may be greater or smaller than FT ozone, depending on whether pollution over a site is more concentrated near the surface or in the FT. In summary, the HEGIFTOM analyses show that multi-instrument, high-quality, harmonized data provide robust trends (2000-2022) across statistical methods: within ±3 ppbv ozone/decade for the surface to 300 hPa column. The remarkably comprehensive HEGIFTOM dataset provides clear constraints for TOAR II global models and evolving tropospheric ozone satellite products for the 2000-2022 period.
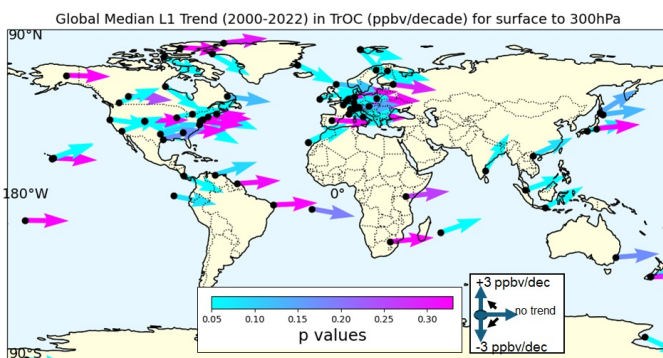
Figure 1. Map of QR 50th percentile trends (arrow directions are in ppbv/decade over 2000-2022) column-averaged tropospheric ozone, surface to 300 hPa, for L1 (all individual readings) from 1-3 instrument types at each site. Colors represent p-values. Key insert: increasing ozone (upward arrow), decreasing (downward) or no trend (to right).
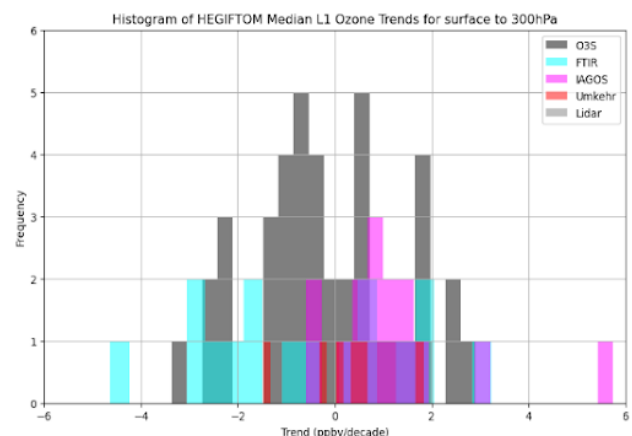

Figure 2.

A histogram of ozone trends based on the analyses in Fig. 1, illustrating the range of QR trends from HEGIFTOM tropospheric ozone columns (surface to 300 hPa) for the 5 instrument types included.