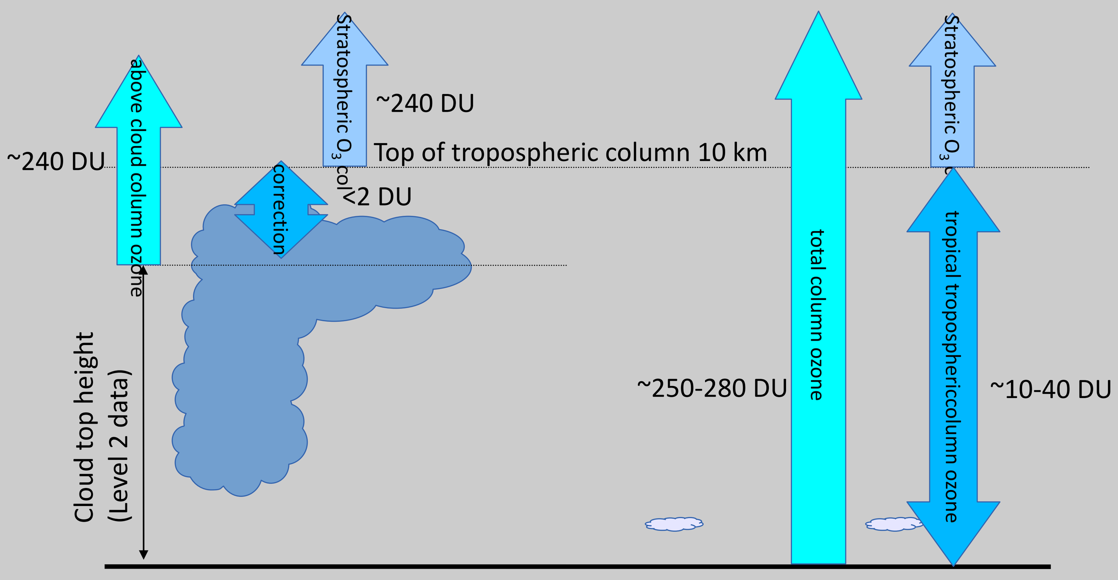
Tropospheric ozone column data records based on total columns from GOME, SCIAMACHY, GOME-2, OMI and TROPOMI using CCD algorithm or in combination with BASCOE/MLS

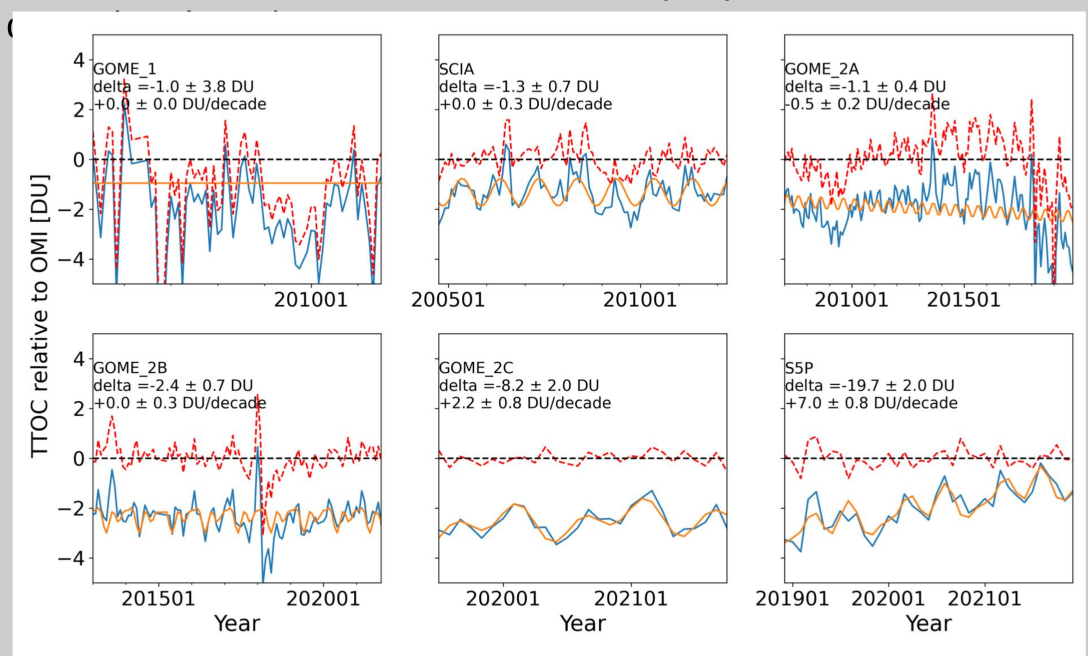
Klaus-Peter Heue[1,2], Fabian Romahn[1], Melanie Coldewey-Egbers[1], Diego Loyola[1], Christophe Lerot[3], Quentin Errera[3], Simon Chabrillat[3], Jae Hwan Kim[4]

1) DLR Oberpfaffenhofen, 2) TUM München, 3) BIRA-IASB Bruxelles, 4) Busan National University, Busan

CCD method

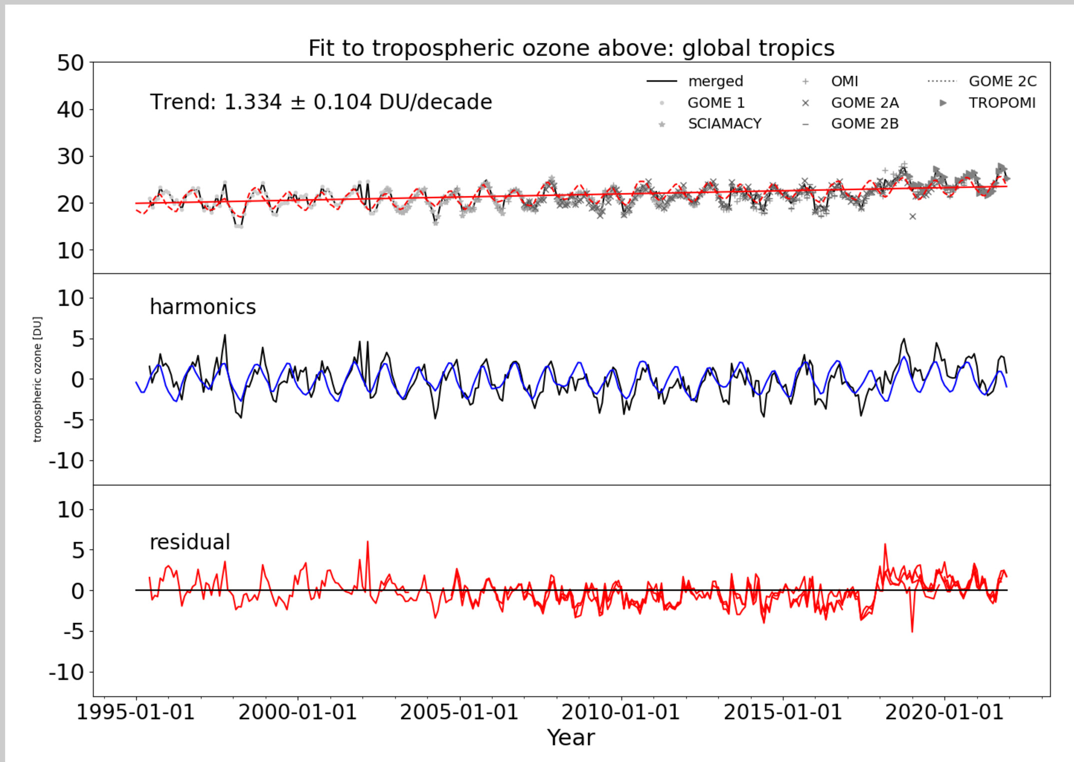


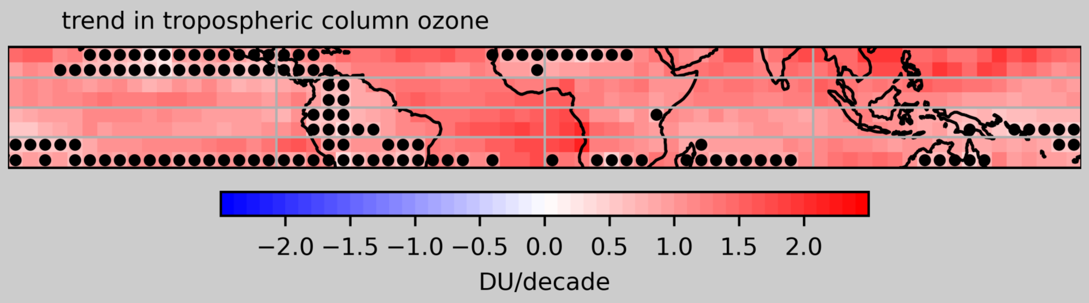
The above cloud ozone column is used to estimate the stratospheric ozone column, By adding or subtracting a correction term the above cloud column ozone is harmonized for the different cloud altitudes.
The corrected above cloud column is averaged for several latitude band and for 70°E to 170° W. Finally this stratospheric column is subtracted from cloud free total columns. By using a reference area and subtracting a constant stratospheric column we assume the stratospheric ozone column to be constant in time and latitude. This assumption is roughly (~5% standard deviation) full-filled in the tropics and hence limits the algorithm to 20°South to 20° North.
This algorithm has been applied to the the total column column data from GOME, SCIAMACHY, OMI, the GOME-2 series and TROPOMI. For TROPOMI the tropospheric column is an



The Tropospheric ozone columns from the different sensor show a mean bias relative to each other as well as a drift and deviations in the annual cycle. Because of its long-term stability **OMI** is a good choice for the reference instrument.
Therefore we fitted respective corrections of all other instruments relative to OMI an added the difference to the mean.

The merged data set can be used to estimate a mean tropical trend as well as local or seasonal trends. In the tropics ozone increased by 1.3 ± 0.1 DU/decade since 1995. Compared to our previous studies e.g. Heue et al. 2016 the trend is larger but to up to now we used SCIAMACHY as reference.



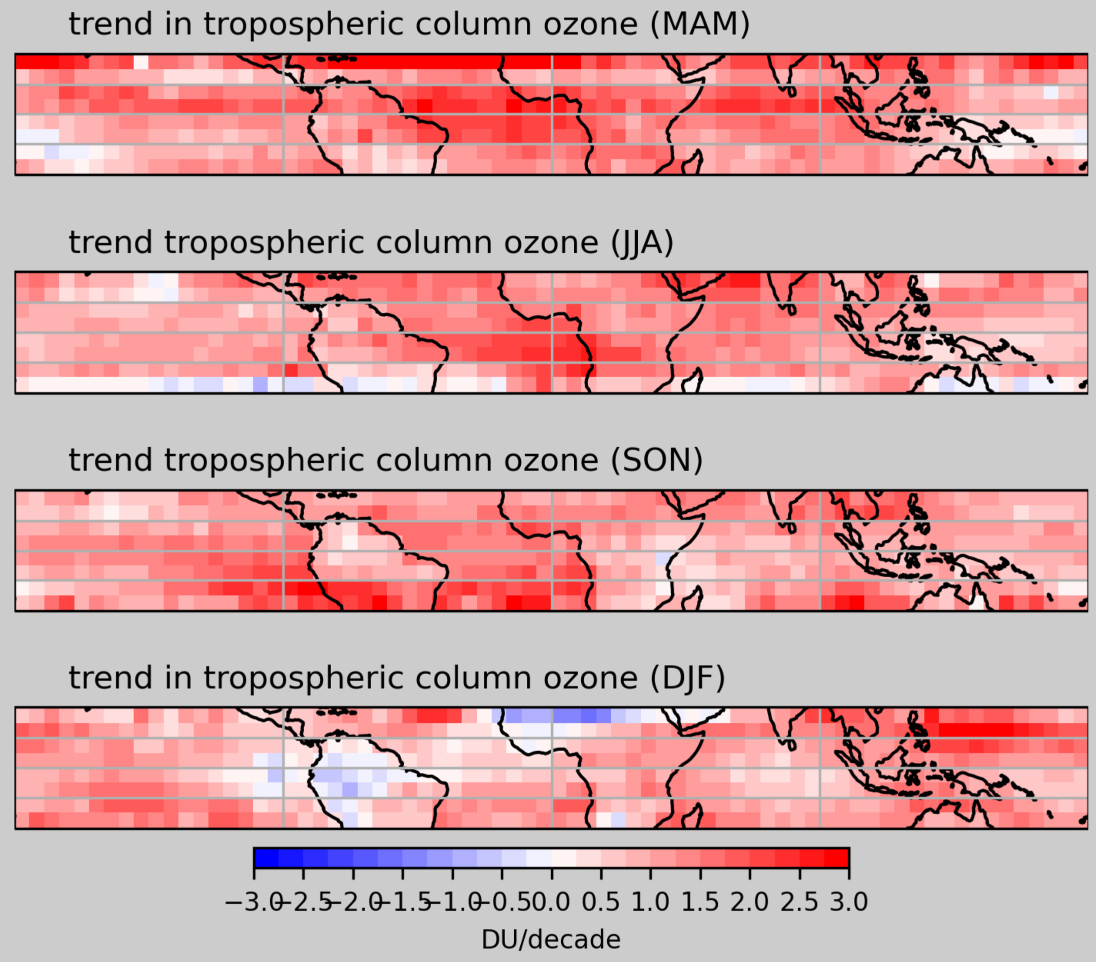


For the local trends we averaged the TTOC to 5°x5° before the fitting. The map above shows the local trends, they vary between 0.2 and 2.1 DU/decade. No decreasing trends is observed throughout the tropics. The increase is strongest over African Atlantic coast 2.1 DU/decade, and smallest over the Pacific. Thereby the amplitude of the wave-one-pattern increases.
The dots indicate insignificant trends (slope < 3 slope error).

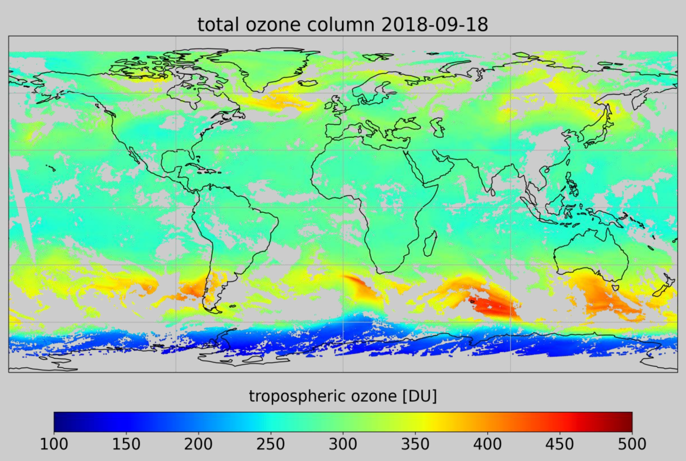
Depending on the season the tropospheric ozone increases faster or slower. The mean trend per season is listed in the table below.

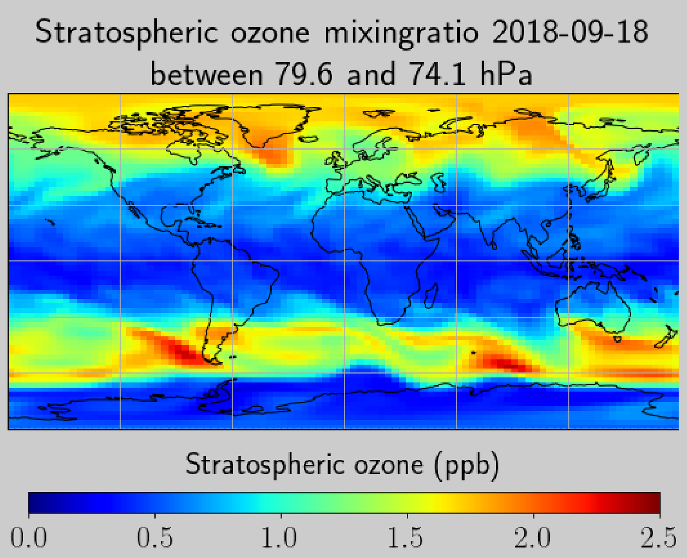
	Mean trend	Trend uncertainty
MAM	0.51	0.65
JJA	0.38	0.70
SON	0.85	0.77
DJF	0.41	0.71

For the seasonal trends fits only ¼ of the total monthly mean data is available per season, hence the uncertainty is higher than for the global mean trend. Because of the high uncertainty no reliable or unreliable data are marked in the trends world map.



S5P-BASCOE

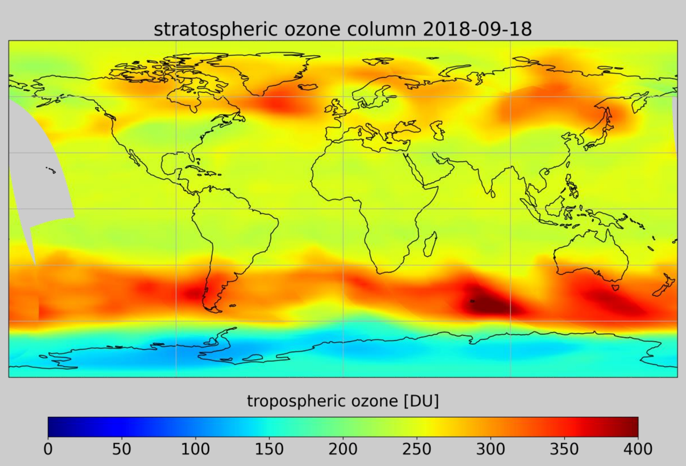


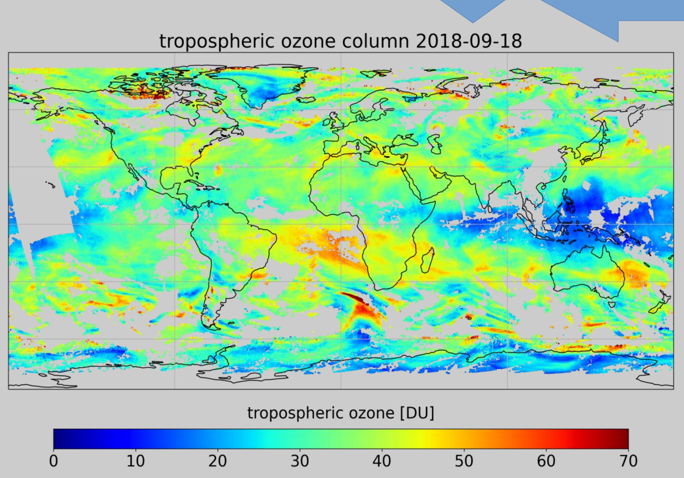


BASCOE assimilated MLS ozone profile integrated above tropopause and interpolated to TROPOMI pixel

TROPOMI total column ozone cloud free (cf<0.2)

Subtract stratospheric from total Column



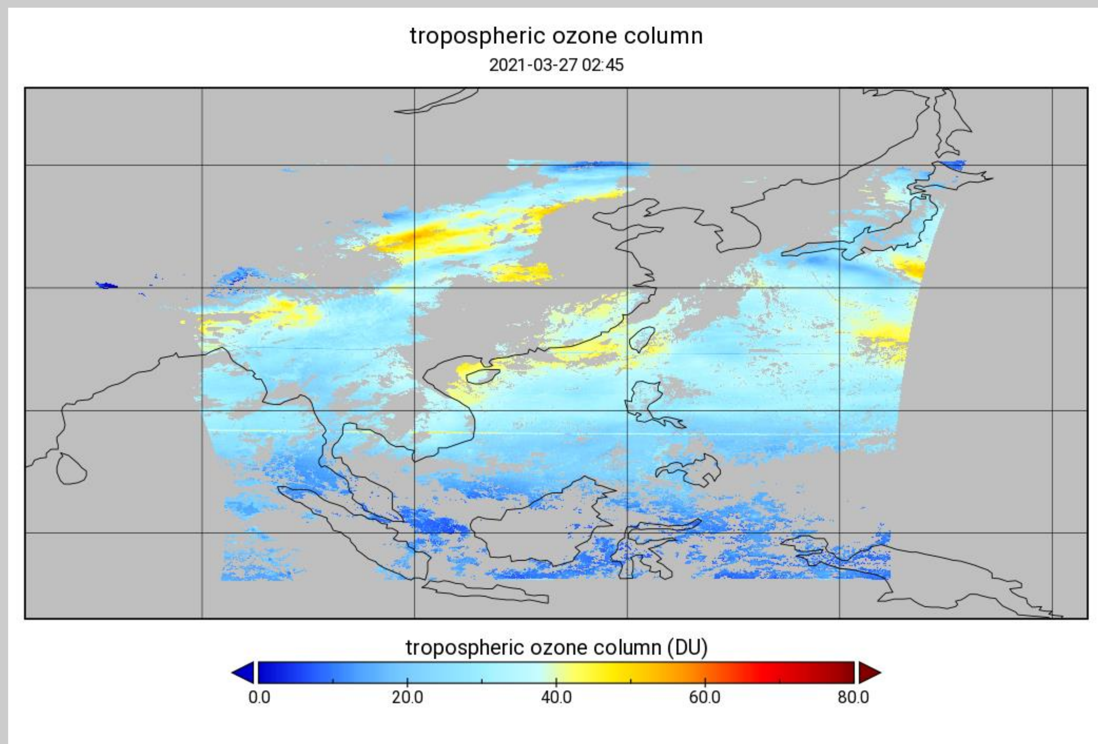


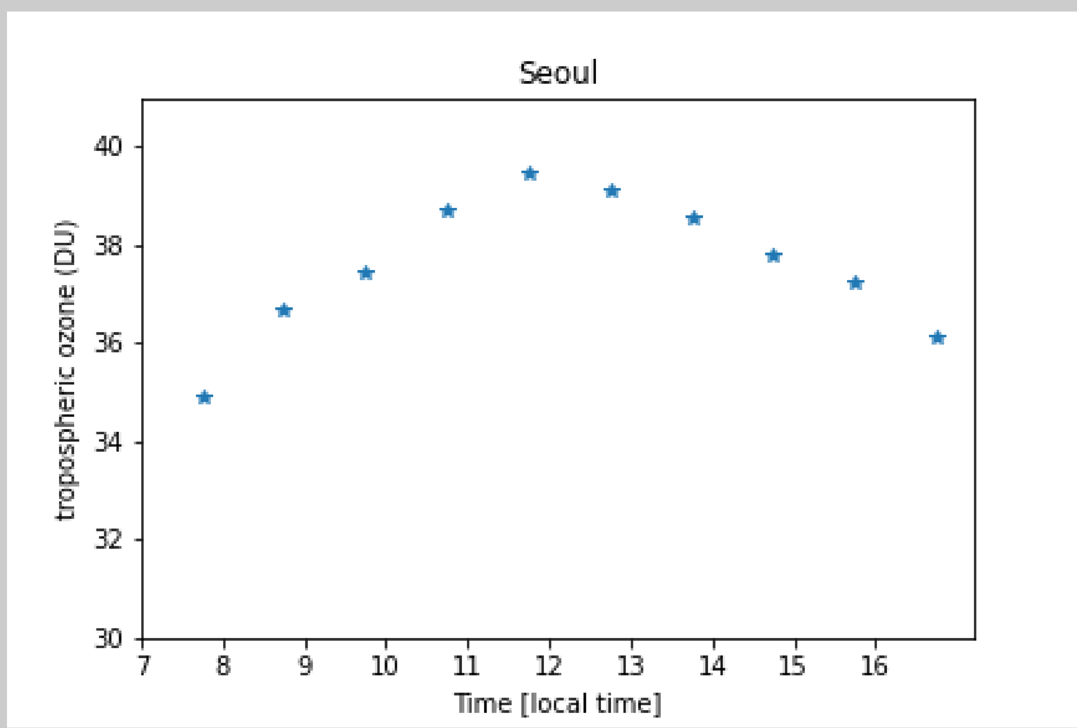
Tropospheric residual ozone

The same algorithm has been applied to CCI GODFIT data for OMI and the GOME_2 A and B instruments. For the harmonization we applied the correction factors to the total columns by Coldewey-Egbers et al. (2020 AMT)
We build a climatology based on the harmonized tropospheric ozone column.
Also the total columns from the geostationary GEMS instrument can be processed to tropospheric columns.

GEMS-BASCOE

The same algorithm can also be applied to GEMS total ozone columns. Here the maximum cloud fraction was slightly increased to 0.3. Nevertheless large parts of East Asia are covered by clouds, in the figure.





Based on the total ozone column from March 2021 to June 2021 a mean daily cycle was extracted for the South Korean Capital of Seoul. It shows the expected low values in the early morning hours and the afternoon maximum.

References:

Coldewey-Egbers, M., Loyola, D. G., Labow, G., and Frith, S. M.: Comparison of GTO-ECV and adjusted MERRA-2 total ozone columns from the last 2 decades and assessment of interannual variability, Atmos. Meas. Tech., 13, 1633â€"1654, https://doi.org/10.5194/amt-13-1633-2020, 2020.
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Heue, K.-P., Loyola, D., Romahn, F., Zimmer, W., Chabrillat, S., Errera, Q., Ziemke, J., and Kramarova, N.: Tropospheric ozone retrieval by a combination of TROPOMI/S5P measurements with BASCOE assimilated data, Atmos. Meas. Tech. Discuss. [preprint], https://doi.org/10.5194/amt-2022-23, in review, 2022.

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