



Supplement of

5 years of Sentinel-5P TROPOMI operational ozone profiling and geophysical validation using ozonesonde and lidar ground-based networks

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Table S1. List of ozonesonde stations (90° to 20° north) providing correlative data for the TROPOMI validation in this work. Subsequent columns show the station name, location, archive / PI institute abbreviation, validation period (Full for the entire five year TROPOMI time range: May 2018 to April 2023), and number of co-locations in the comparative validation. Horizontal black lines separate the latitude zones defined in Figure 3.

Name	Location [°N,°E]	Archive / PI inst.	Period [YY/MM]	Co-locs.
Alert	[82.45, -62.51]	WOUDC / MSC	18/05 - 22/06	91
Eureka	[79.99, -85.93]	WOUDC / MSC	18/05 - 23/03	151
Ny-Alesund	[78.93, 11.93]	NDACC / AWI	18/05 - 23/03	123
Resolute	[74.72, -94.98]	NDACC / MSC	18/05 - 20/04	56
Scoresbysund	[70.48, -21.95]	NDACC / DMI	Full	174
Sodankyla	[67.37, 26.63]	NDACC / FMI	Full	107
Jokioinen	[60.81, 23.50]	NDACC / FMI	20/01 - 22/04	9
Lerwick	[60.13, -1.18]	NDACC / UKMO	18/05 - 22/09	201
Churchill	[58.74, -94.07]	NDACC / MSC	19/01 - 22/02	103
Edmonton	[53.55, -114.10]	NDACC / MSC	Full	197
Goose Bay	[53.31, -60.36]	NDACC / MSC	18/05 - 22/06	126
Legionowo	[52.40, 20.97]	NDACC / IMGW	Full	238
Lindenberg	[52.21, 14.12]	NDACC / DWD	Full	245
De Bilt	[52.10, 5.18]	NDACC / KNMI	18/05 - 23/03	195
Valentia	[51.94, -10.25]	NDACC / ME	Full	128
Uccle	[50.80, 4.35]	NDACC / RMI	Full	659
Port Hardy	[50.68, -127.38]	WOUDC / MSC	18/06 - 23/03	117
Praha	[50.00, 14.44]	NDACC / CHMI	19/01 - 23/04	234
Hohenpeissenberg	[47.81, 11.01]	WOUDC / DWD	Full	626
Payerne	[46.82, 6.95]	WOUDC / MeteoSwiss	Full	548
Obs. Haute Provence	[43.94, 5.71]	NDACC / LATMOS	18/05 - 22/11	189
Yarmouth	[43.87, -66.11]	WOUDC / MSC	18/05 - 22/06	186
Trinidad Head	[40.80, -124.15]	NOAA / GML	Full	212
Madrid	[40.45, -3.72]	WOUDC / INM	Full	236
Boulder	[40.03, -105.25]	NOAA / GML	Full	275
Wallops Island	[37.93, -75.48]	NDACC / NASA	18/05 - 22/06	152
Tsukuba	[36.05, 140.13]	WOUDC / JMA	Full	210
Huntsville	[34.72, -86.64]	NOAA / UAH	18/05 - 20/03	22
Izana	[28.31, -16.50]	NDACC / AEMET	18/05 - 22/12	182
Taipei	[25.04, 121.51]	WOUDC / CWBT	18/11 - 22/03	17
Hong Kong Obs.	[22.31, 114.17]	WOUDC / HKO	18/05 - 22/06	183
Hanoi	[21.03, 105.85]	SHADOZ / GSFC	18/05 - 21/11	84

Table S2. List of ozonesonde stations (20° north to 90° south) providing correlative data for the TROPOMI validation in this work. Subsequent columns show the station name, location, archive / PI institute abbreviation, validation period (Full for the entire five year TROPOMI time range: May 2018 to April 2023), and number of co-locations in the comparative validation. Horizontal black lines separate the latitude zones defined in Figure 3.

Name	Location [°N,°E]	Archive / PI inst.	Period [YY/MM]	Co-locs.
Hilo	[19.72, -155.07]	NOAA / GML	Full	237
Costa Rica (3 locs.)	[9.94, -84.04]	SHADOZ / NCAR	18/05 - 23/03	112
Paramaribo	[5.81, -55.22]	NDACC / KNMI	Full	161
Sepang Airport	[2.73, 101.70]	SHADOZ / MMD	18/05 - 22/12	79
Quito	[-0.20, -78.44]	SHADOZ / USFQ	21/10 - 22/11	10
San Cristobal	[-0.92, -89.60]	SHADOZ / USFQ	21/12 - 22/12	23
Nairobi	[-1.27, 36.80]	SHADOZ / MeteoSwiss	18/06 - 20/03	43
Ascension Island	[-1.98, -14.42]	SHADOZ / GSFC	18/05 - 22/09	144
Natal	[-5.83, -35.20]	SHADOZ / INPE	18/05 - 22/12	83
Watukosek	[-7.50, 112.60]	SHADOZ / BRIN	21/03 - 22/12	23
Pago Pago	[-14.23, -170.56]	NOAA / GML	Full	155
Suva	[-18.13, 178.40]	NOAA / GML	Full	54
St. Denis	[-20.90, 55.48]	SHADOZ / LACY	18/05 - 20/12	87
Irene	[-25.92, 28.22]	SHADOZ / SAWS	18/05 - 22/08	33
Broadmeadows	[-37.69, 144.95]	WOUDC / ABM	18/05 - 23/02	226
Lauder	[-45.04, 169.68]	NDACC / NIWA	18/05 - 22/06	208
Macquarie	[-54.50, 158.95]	WOUDC / ABM	18/05 - 23/02	231
Ushuaia	[-54.85, -68.31]	WOUDC / SMNA	18/08 - 19/11	18
Marambio	[-64.23, -56.62]	WOUDC / FMI	18/08 - 19/11	43
Dumont d'Urville	[-66.67, 140.02]	NDACC / LATMOS	18/08 - 19/12	13
Davis	[-68.58, 77.97]	WOUDC / ABM	18/08 - 23/02	166
Syowa	[-69.01, 39.58]	WOUDC / JMA	18/08 - 23/04	176
Neumayer	[-70.68, -8.26]	NDACC / AWI	18/08 - 23/03	209
Belgrano	[-77.77, -38.18]	NDACC / INTA	18/10 - 23/02	52
Amundsen Scott	[-89.98, -24.80]	NOAA / GML	18/10 - 21/11	72
South Pole	[-90.00, -169.00]	NOAA / GML	19/11 - 23/03	55

Table S3. List of DIAL stations providing correlative data for the TROPOMI validation in this work. Subsequent columns show the station name, location, archive / PI institute abbreviation, validation period (Full for the entire five year TROPOMI time range), and number of co-locations in the comparative validation. The horizontal black line separates tropospheric (top) and stratospheric (bottom) lidar instruments.

Name	Location [°N,°E]	Archive / PI inst.	Period [YY/MM]	Co-locs.
Greenbelt	[38.99, -76.84]	TOLNet / GSFC	20/05 - 21/07	118
Langley	[37.10, -76.39]	TOLNet / LaRC	18/05 - 19/11	15
Huntsville	[34.72, -86.64]	TOLNet / UAH	18/05 - 20/08	103
Table Mountain (t.)	[34.40, -117.70]	TOLNet / JPL	18/05 - 20/07	456
Eureka	[79.99, -85.93]	NDACC / U. Toronto	20/03	2
Hohenpeissenberg	[47.81, 11.01]	NDACC / DWD	Full	532
Obs. Haute Provence	[43.94, 5.71]	NDACC / LATMOS	Full	595
Table Mountain (s.)	[34.40, -117.70]	NDACC / JPL	Full	722
Mauna Loa	[19.53, -155.58]	NDACC / JPL	18/05 - 22/11	592
Lauder	[-45.04, 169.68]	NDACC / NIWA	18/05 - 21/07	108

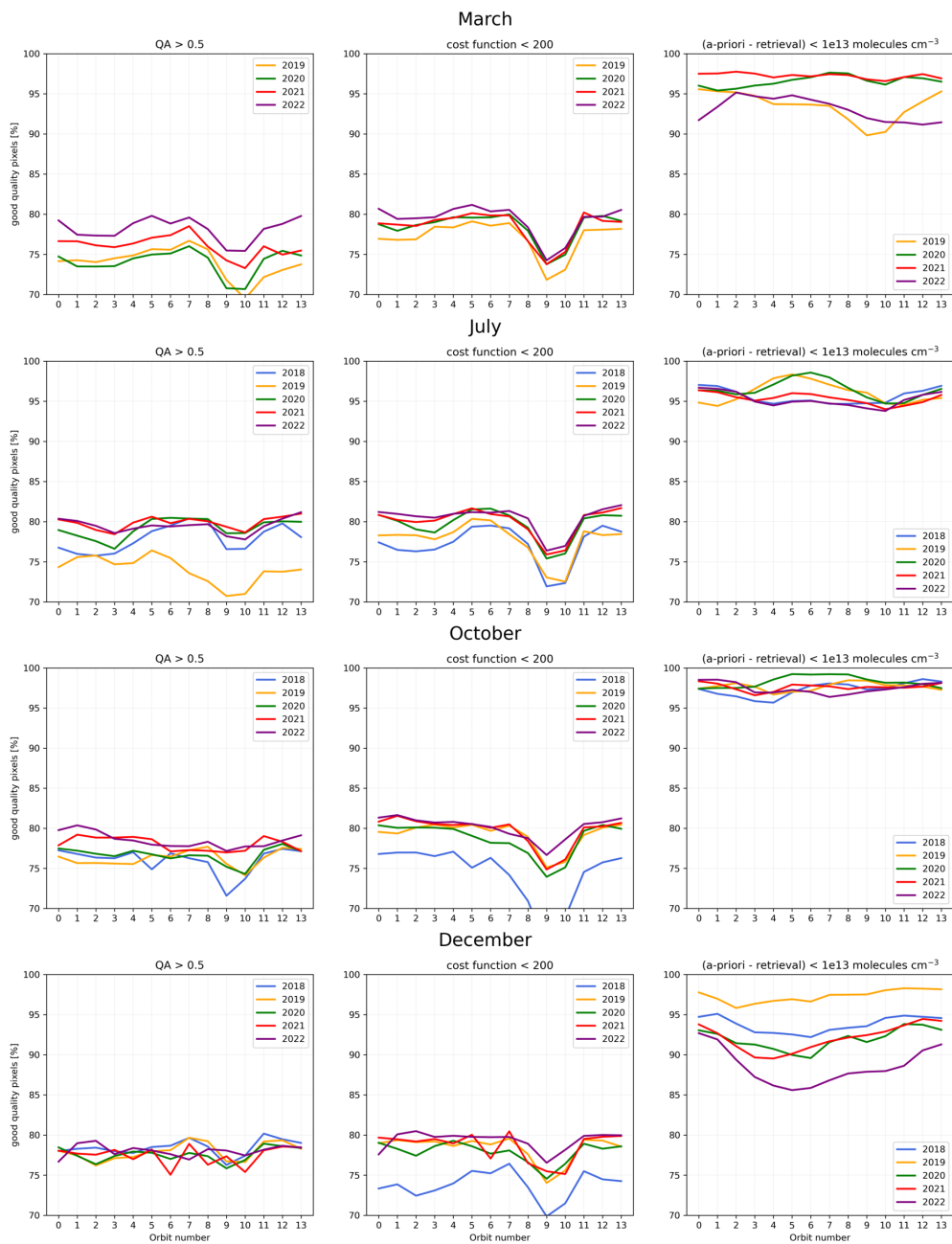


Figure S1. The percentage of good quality pixels after applying separately each of the recommended filters on the QA value, cost function, the a-priori condition in Eq. (2). Each line represents the average percentage of the same orbit number over all the days of the specific month analysed.

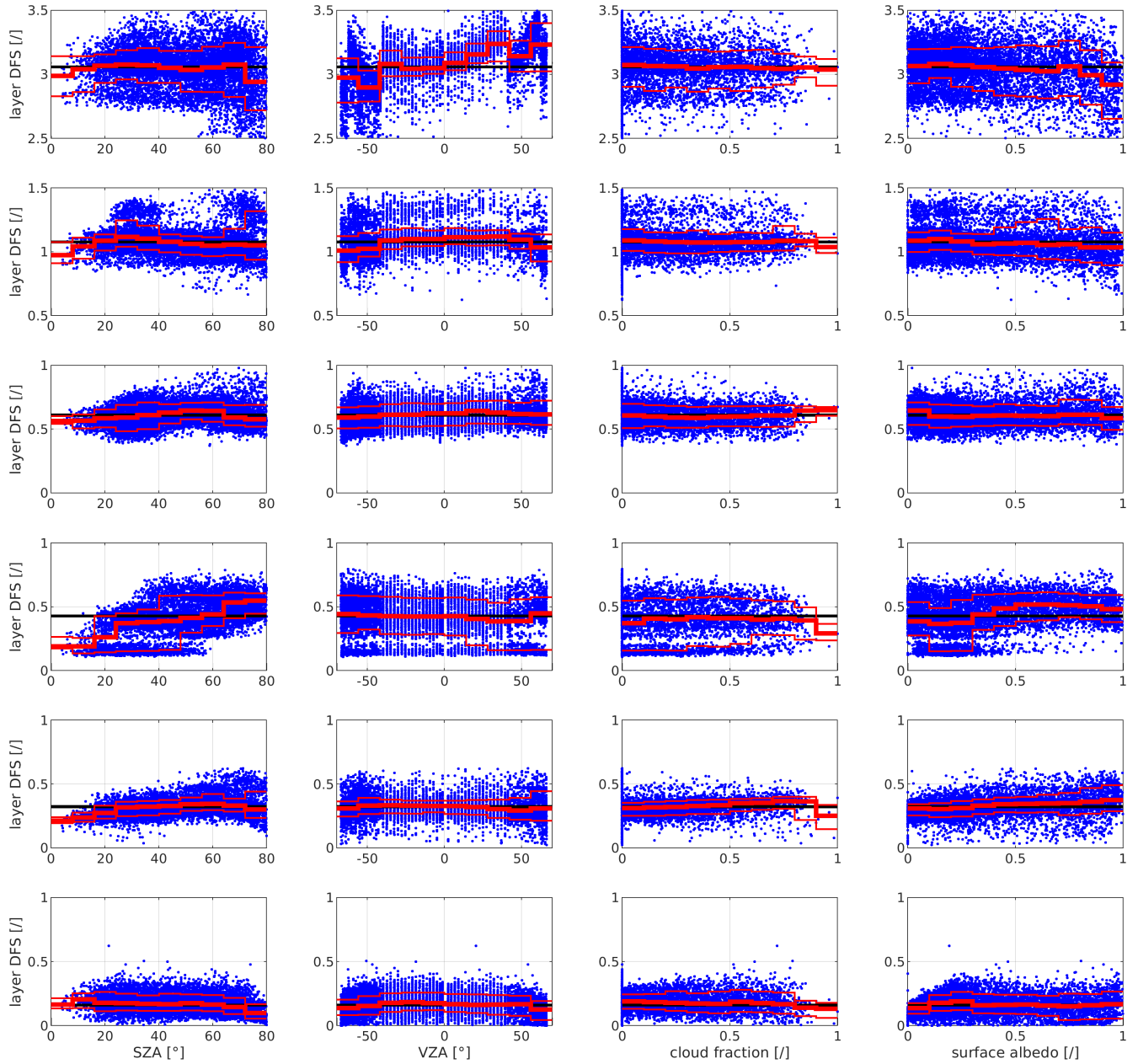


Figure S2. Layer-DFS (bottom to top row: 0-6 km, 6-12 km, 12-18 km, 18-24 km, 24-32 km, 32-82 km) as a function of (from left to right) solar zenith angle (SZA), viewing zenith angle (VZA), cloud fraction, and surface albedo. 84, 50, and 16 % quantiles are added in red for ten bins (with a thicker line for the median), together with the overall layer mean (black line).

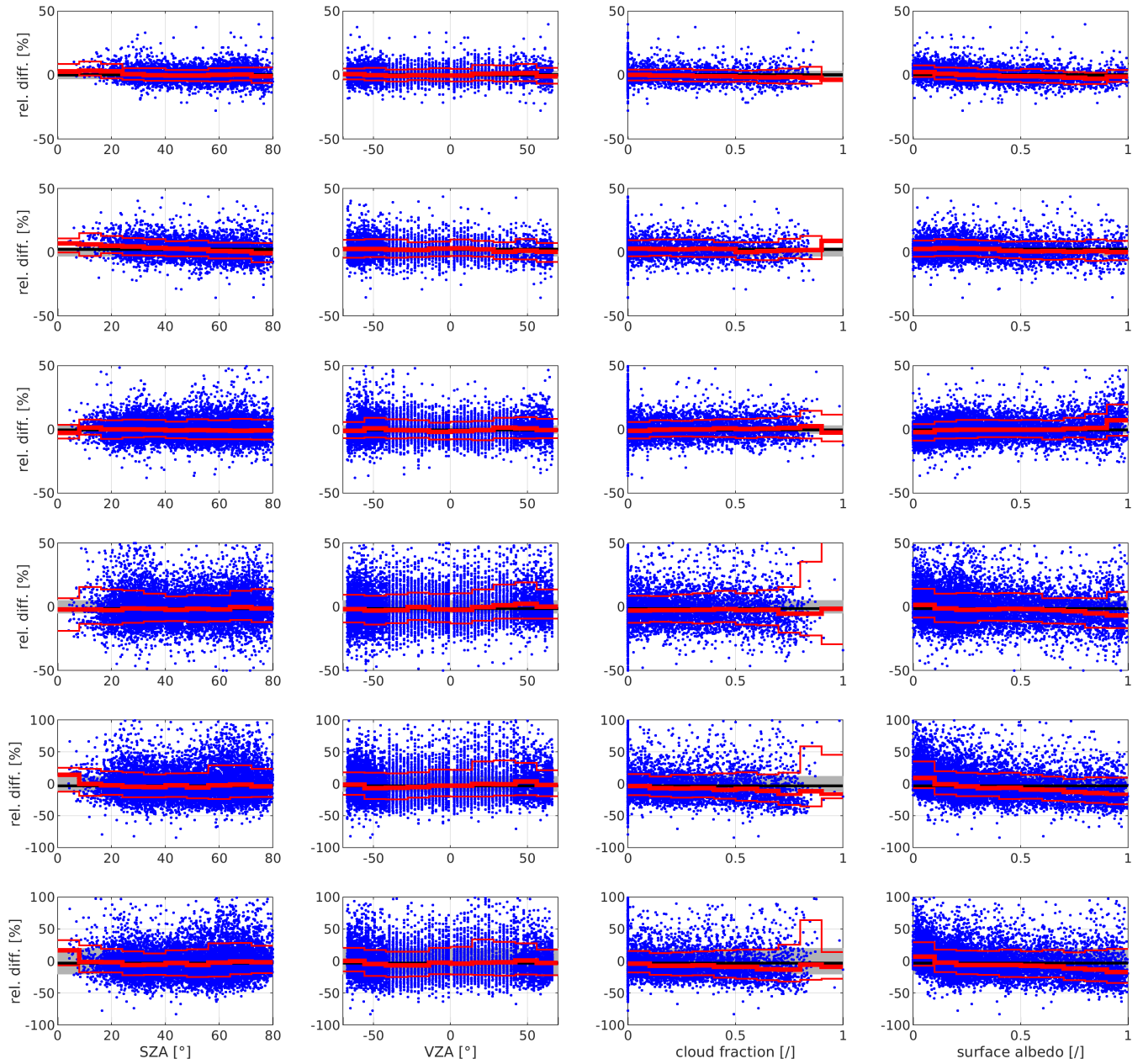


Figure S3. Differences between the lowest five ozone subcolumns as observed by TROPOMI and the coincident vertically integrated ozonesonde measurements (bottom to second row: 0-6 km, 6-12 km, 12-18 km, 18-24 km, 24-32 km), and their overall sum (top row). Subsequent columns show the differences as a function of solar zenith angle (SZA), viewing zenith angle (VZA), cloud fraction, and surface albedo. 84, 50, and 16 % quantiles are added in red for ten bins (with a thicker line for the median), together with the overall mean difference (black line), and the product requirements for each subcolumn (grey areas).

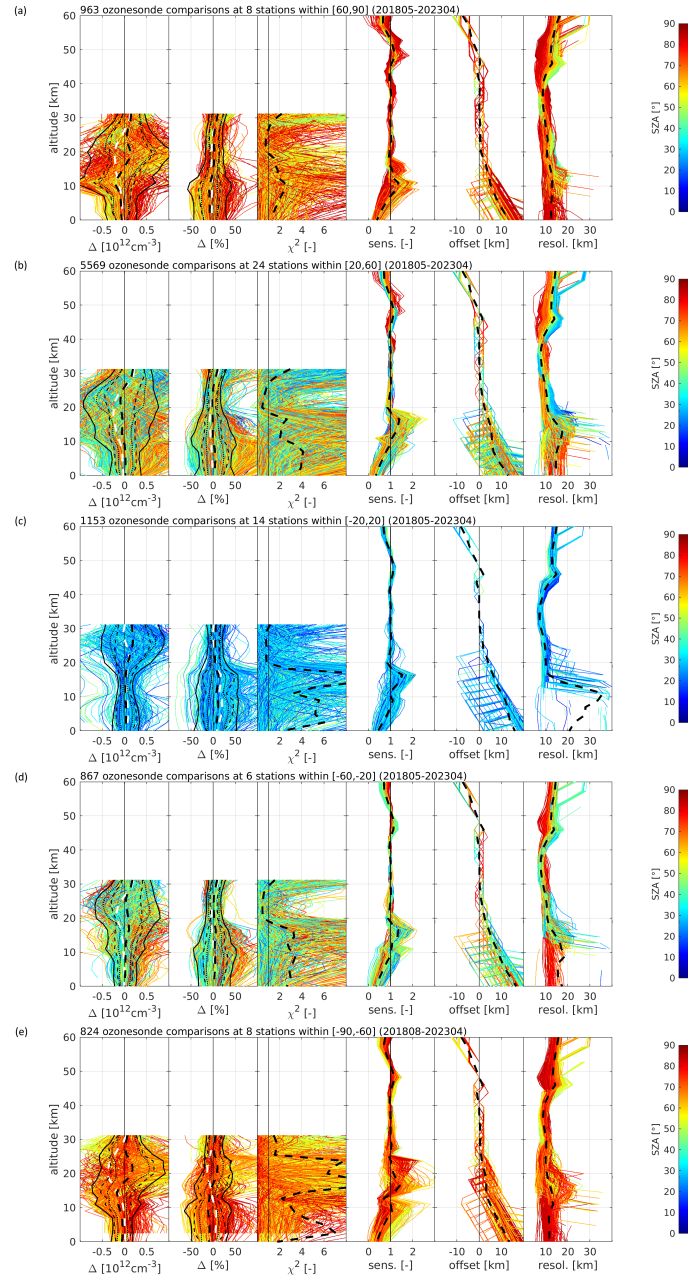


Figure S4. Comparison between S5P RPRO/OFFL ozone number density profile data and all co-located ozonesonde reference measurements, for five latitude bands sorted north (a) to south (e). Each panel shows six graphs, respectively, from left to right: the difference and the percent relative difference between S5P and ozonesonde, the chi-square (χ^2) profile, the vertical sensitivity, the altitude registration offset, and the averaging kernel FWHM associated with the satellite retrieval. The colour scale indicates the TROPOMI solar zenith angle. Black dashed lines show mean values (thick lines) and standard deviations (thin lines, around the mean), while white dashed lines indicate the mean difference between the a-priori profile and the reference measurement. Dotted black lines indicate the total ex-ante (inductive) uncertainty of TROPOMI and the reference measurements combined (around the mean difference). The black full lines show the same, after adding the retrieval's smoothing error.