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Supplemental Material: Ozonesonde climatology between 1995 and 2009: Description, Evaluation and Applications

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1 Impact of Applying the Correction Factor

For most ozone stations a correction factor is provided that is derived in scaling the entire ozone column to an independent measurement of ozone column measured by a Brewer-Dobson spectrometer. Profiles that have been corrected by a factor outside the range of 0.8 and 1.2 are often ignored to not employ profiles that are heavily corrected with regard to ozone column measured by Brewer and Dobson spectrometers (WMO, 1995, 1999). Since the correction factor was scaled with regard to the entire column, it is not necessarily valid for the tropospheric part of the profile. A comparison between MOZAIC aircraft data and ozone sondes has shown that tropospheric comparisons are better when omitting such correction factors (Thouret et al., 1998).

To dismiss profiles that have been corrected by a factor outside the range of 0.8 and 1.2 has little impact on the averaged ozone profiles between 1995 and 2009, as shown in Figure 1. Only those stations are shown, where the percentage difference between all profiles and only minor corrected profiles is larger than 0.5%. Differences up to 5-10% occur for a couple of stations.

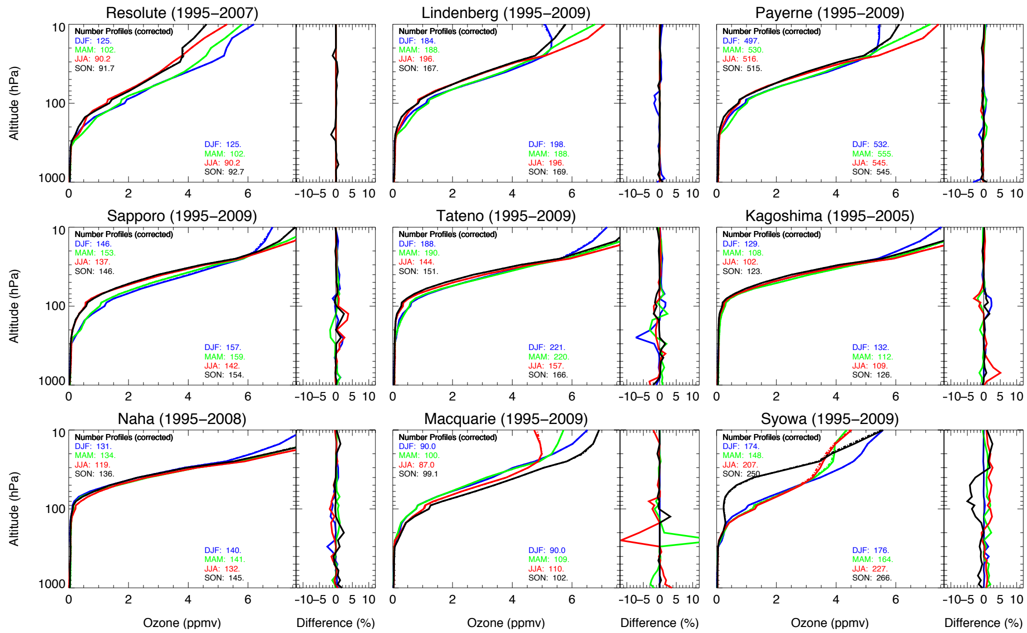


Fig. 1: Left plot of each panel: seasonally averaged ozone profiles for available years between 1995 and 2009. The average of all profiles, corrected in the way that those profiles are dismissed that are corrected by a factor of < 0.8 or > 1.2, are shown as solid lines. The average of all available profiles are shown in dashed lines (if not on top of the solid lines). The total number of profiles entering the average are given in the plot. Right plot of each panel: percentage difference between corrected profiles and all profiles. Only those stations are shown, where the percentage difference is larger 0.5%.

2 Comparison to other Studies

Figure 2: Comparison of seasonally averaged ozone profiles for all stations for the period between 1980 and 1994 with the climatology from Logan (1999a,b). The profiles constructed on the same pressure grid as used by Logan (1999a) and Logan (1999b) are in good agreement with earlier results. Some differences occur around the tropopause, very likely as a result of a different interval chosen to average over pressure levels around the tropopause, where the ozone gradient is very large. Besides that, differences between 10 and 20% occur when slightly different periods are considered or if a very different number of samples was included in the mean, as is the case for Payerne. The earlier period considered for Payerne in the climatology by Logan (1999a) covered the years between 1980-1989, whereas our climatology includes the period between 1980 and 1993. Especially between 1990 and 1993, ozone strongly increased over Payerne in the troposphere.

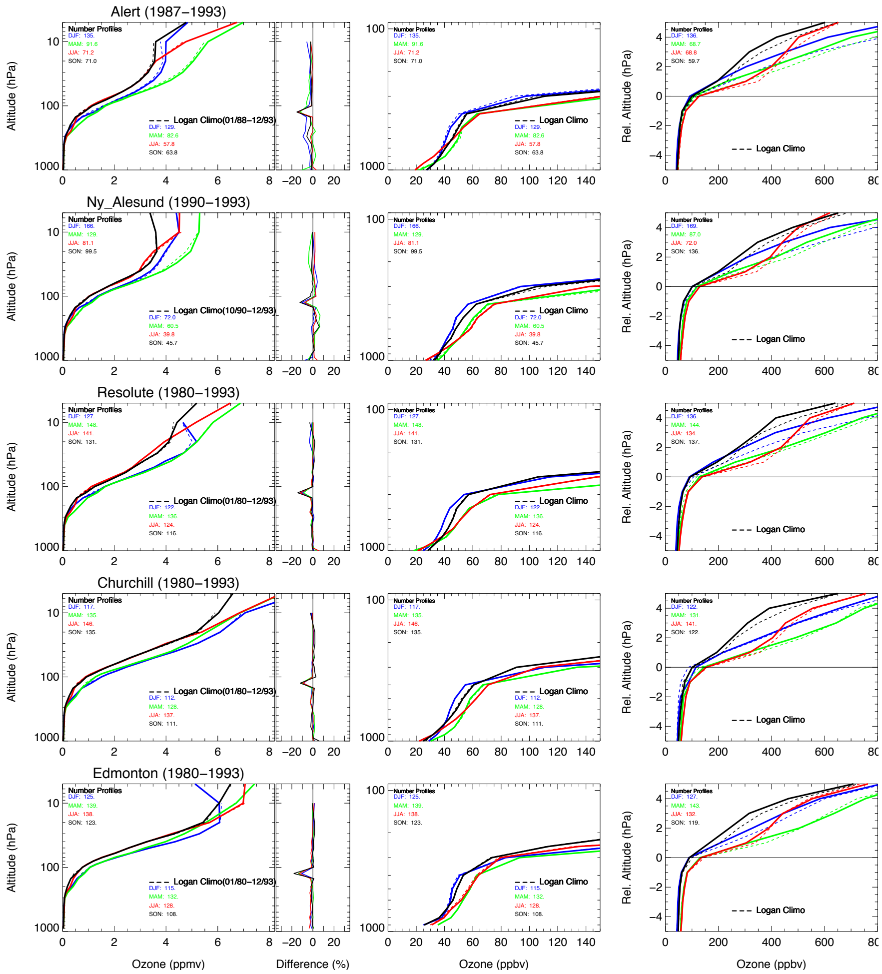


Fig. 2: Vertical median profiles of seasonally averaged ozone data between 1980-1993. Profiles derived here (solid lines) are interpolated to the same pressure levels used in (Logan, 1999a,b) (dashed lines). Differences between the two climatologies are shown on the right of the left panel. Different seasons are shown in different colors.

3 Timelines for each Station

Figure 3 shows timelines of the median of seasonally averaged ozone profiles between 1978 and 2009 (colored diamonds). Years that include less than 12 profiles per season are illustrated as colored points and are likely not representative. After 1995, for most stations at least 12 profiles per season and year are available and the sampling frequency stays rather constant for most stations. Therefore, we do not apply any annual weighting to calculate the 15 year average.

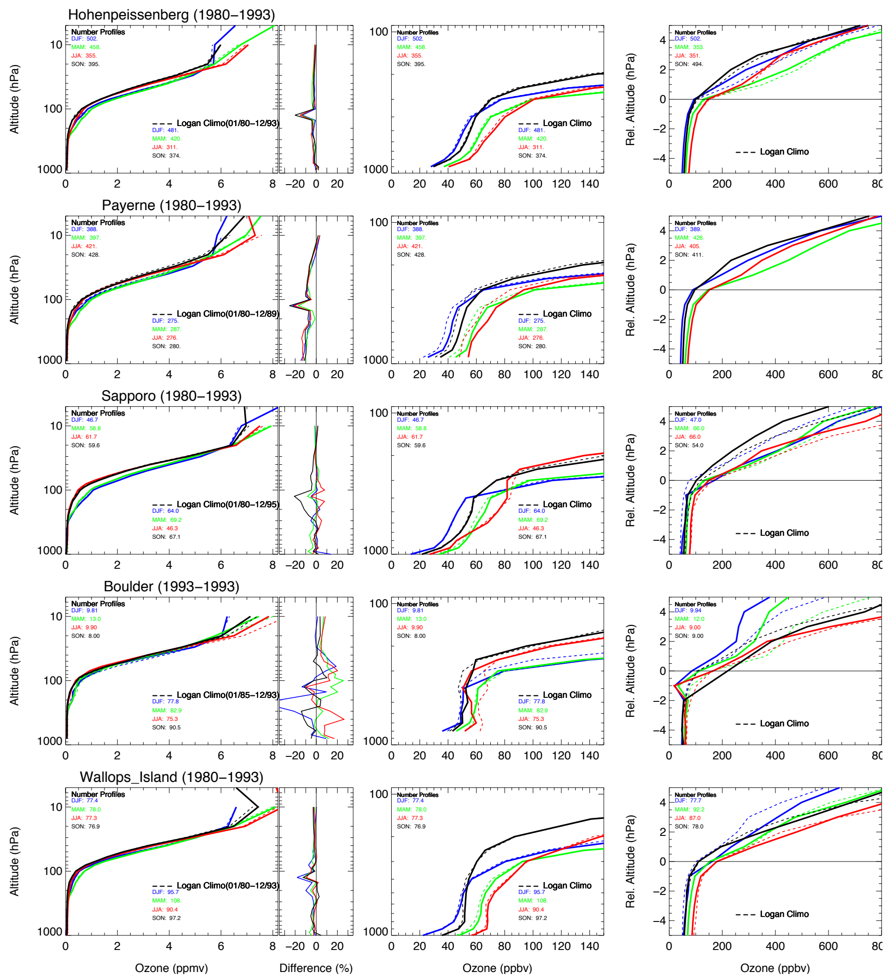


Fig. 2: continued

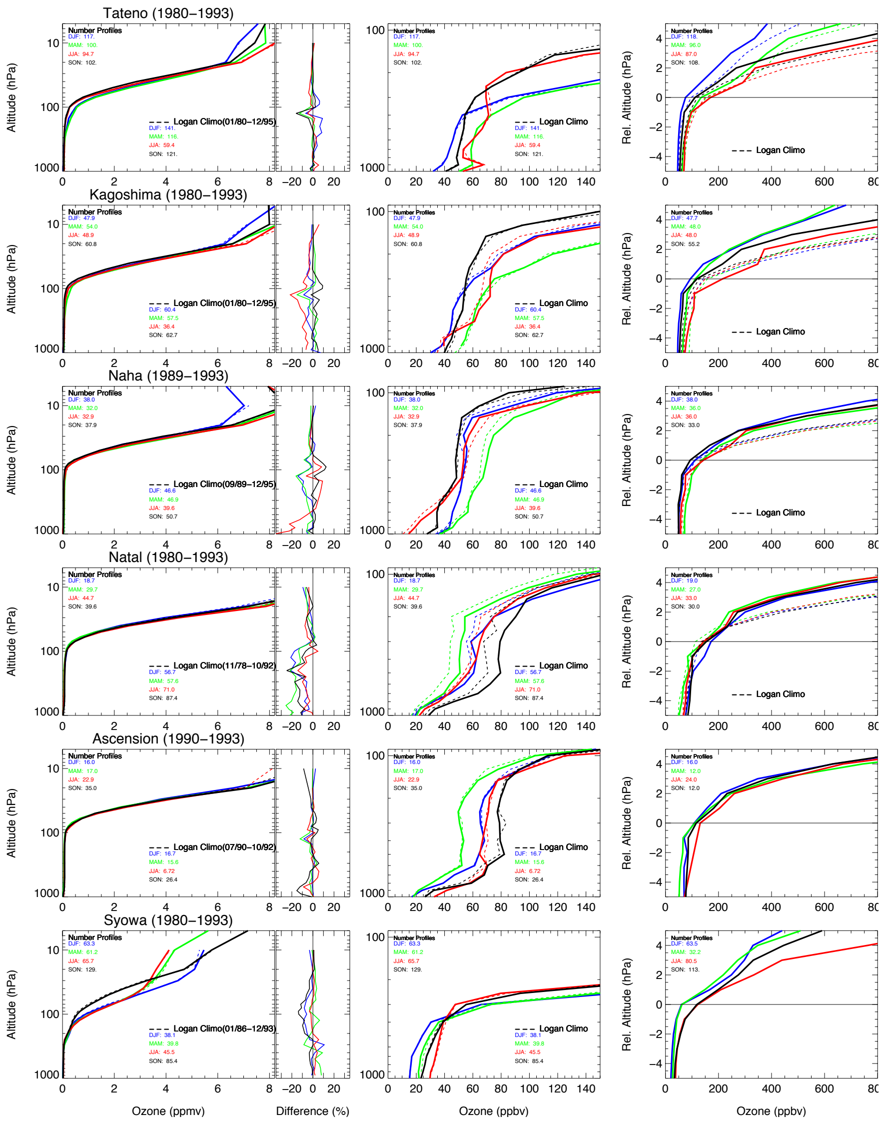
4 Representativeness of Ozone Averages in Comparison to Independent Observations

4.1 Northern Hemisphere Polar Region

Figure 5: Ozone timelines based on ozone soundings for the two different sectors chosen (see Figure 5, main text) differ significantly, especially at the surface (between 950-1050 hPa), as supported by surface observations. We therefore separate the NH Polar region into two parts.

4.2 Western Europe

Figure 6: The comparison of ozone timelines between ozone sounding, surface observation and MOZAIC aircraft observations shows an excellent agreement, especially in the lower troposphere.



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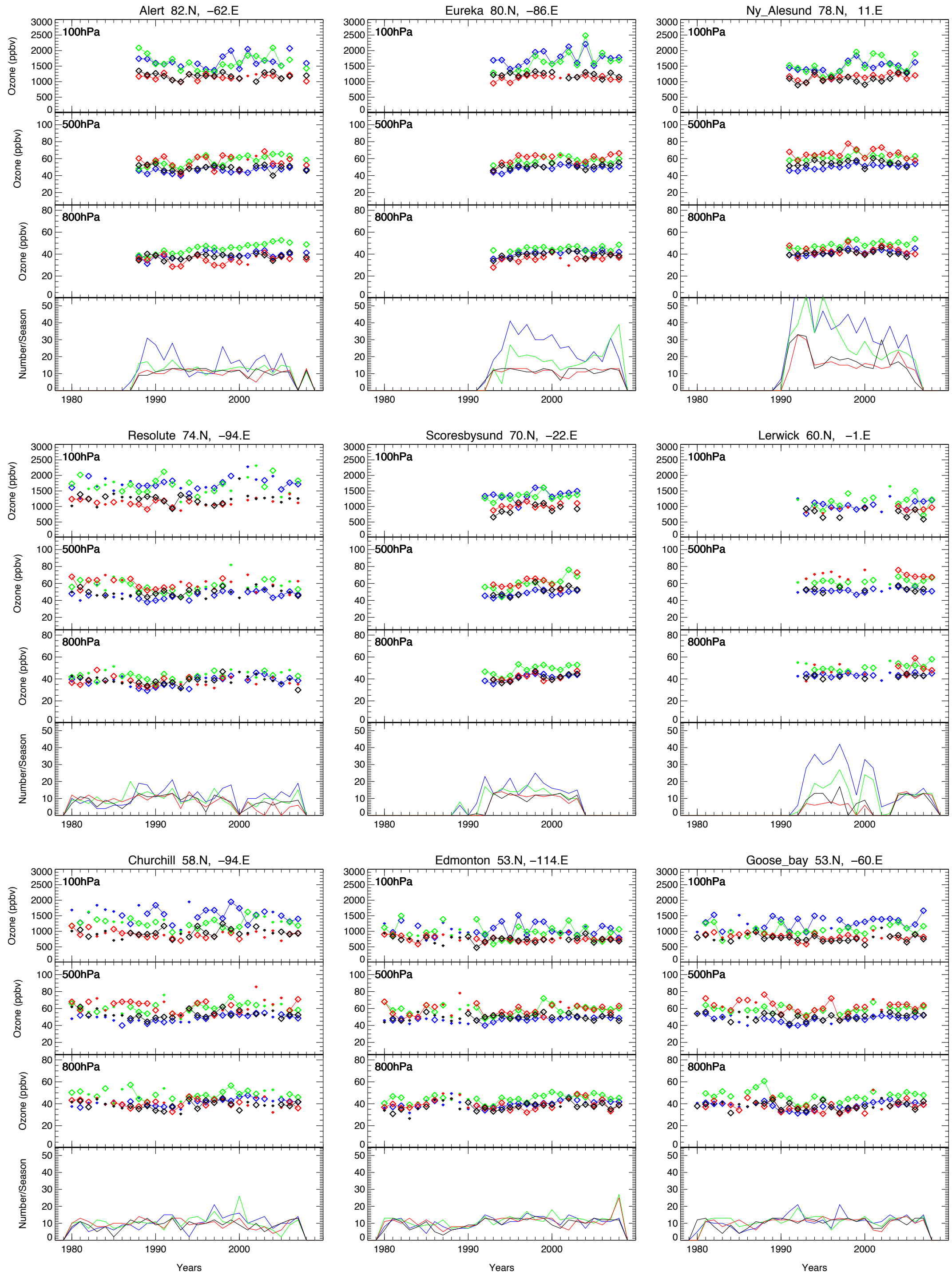
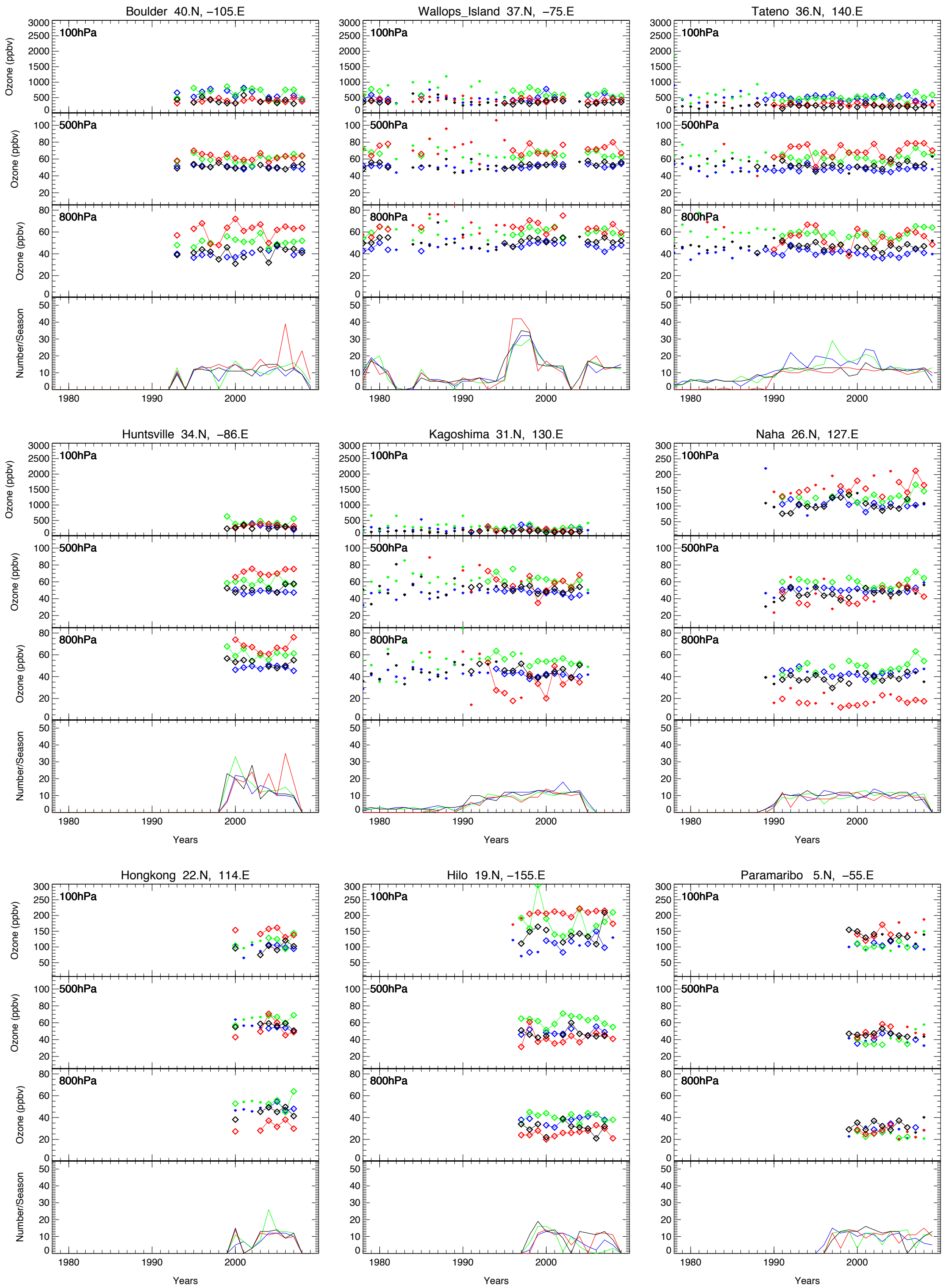


Fig. 3: Time evolution of the distribution (median) of ozone soundings for different pressure levels and different seasons (different colors) and stations for four different altitude levels. The total number of profiles per season for each year are illustrated in the bottom plot of each panel. Seasons that include less than 12 profiles per year are shown as dots.

Fig. 3: continued



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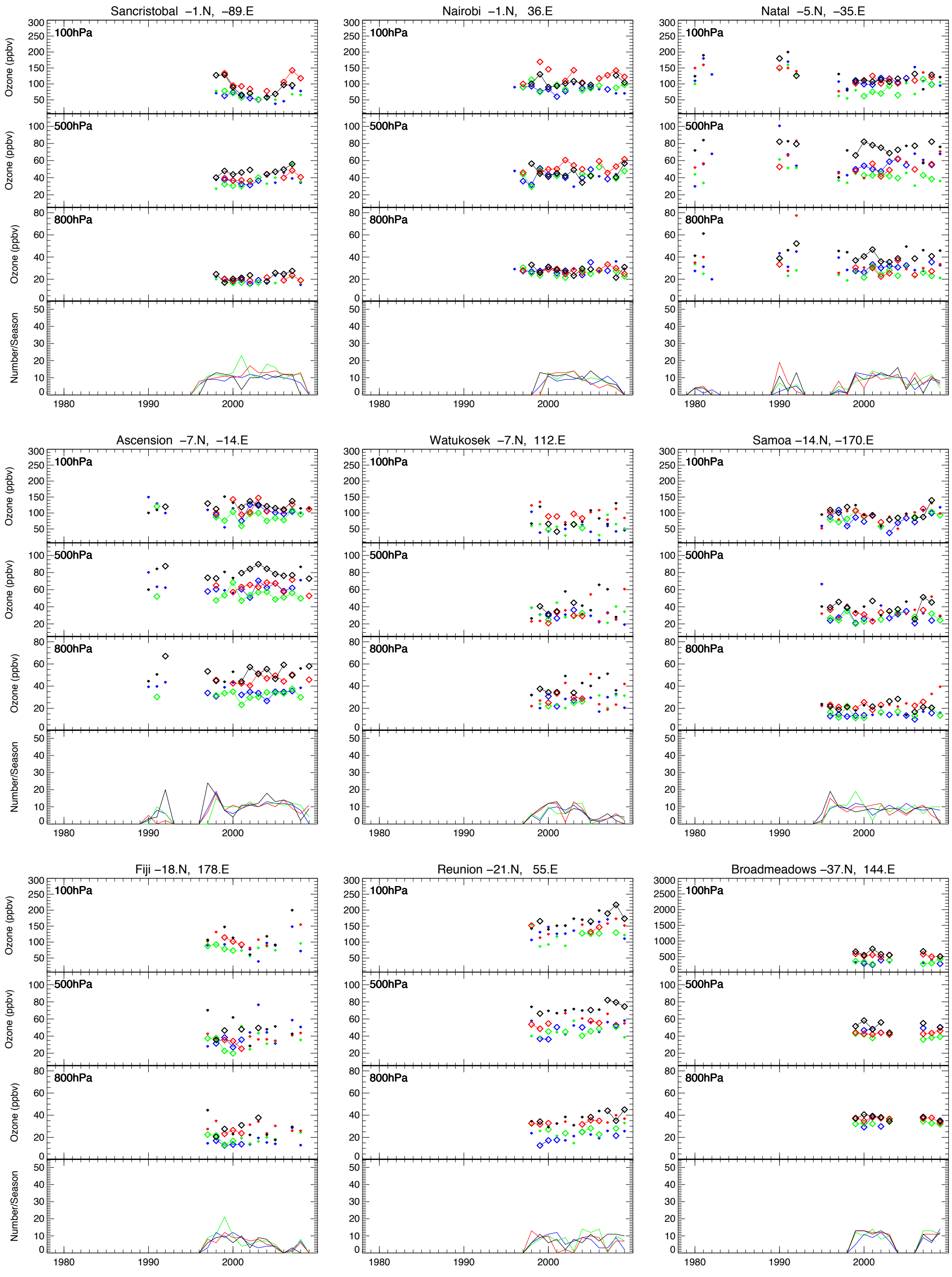

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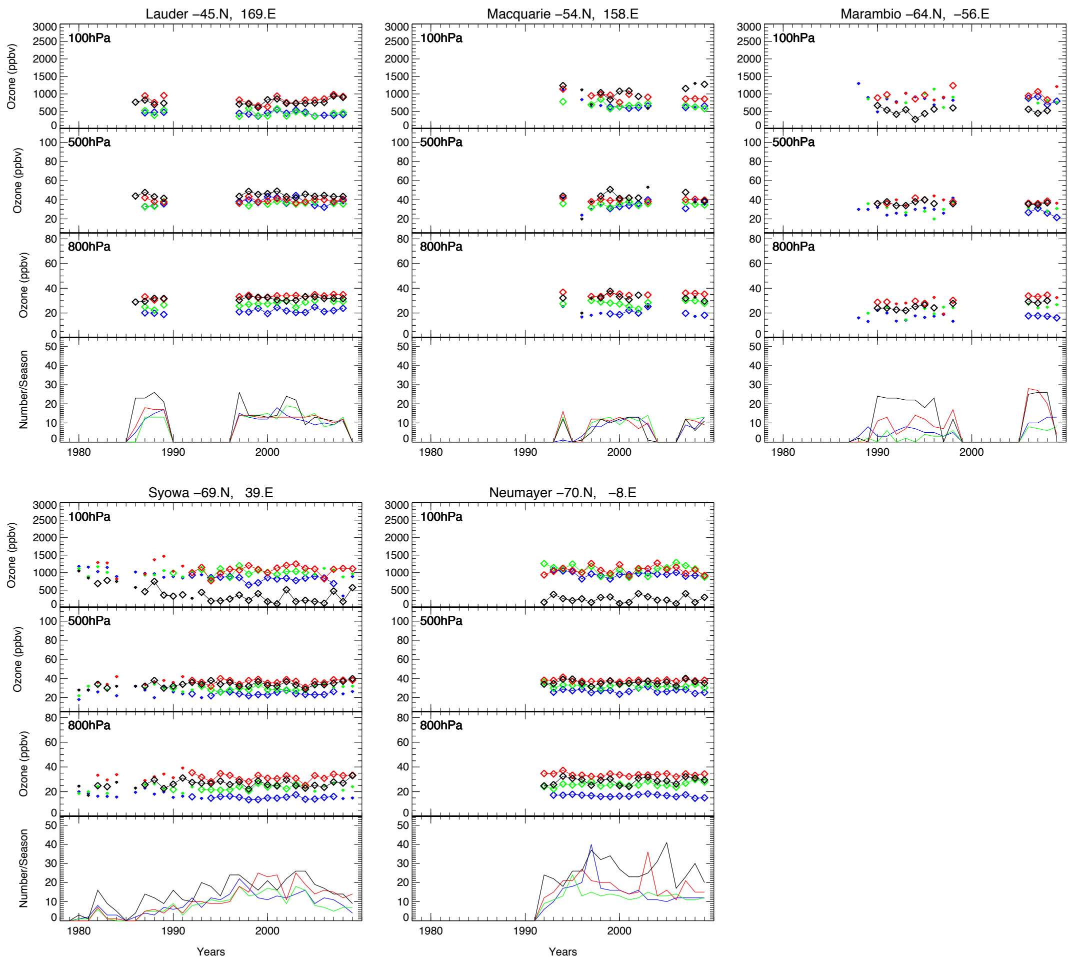

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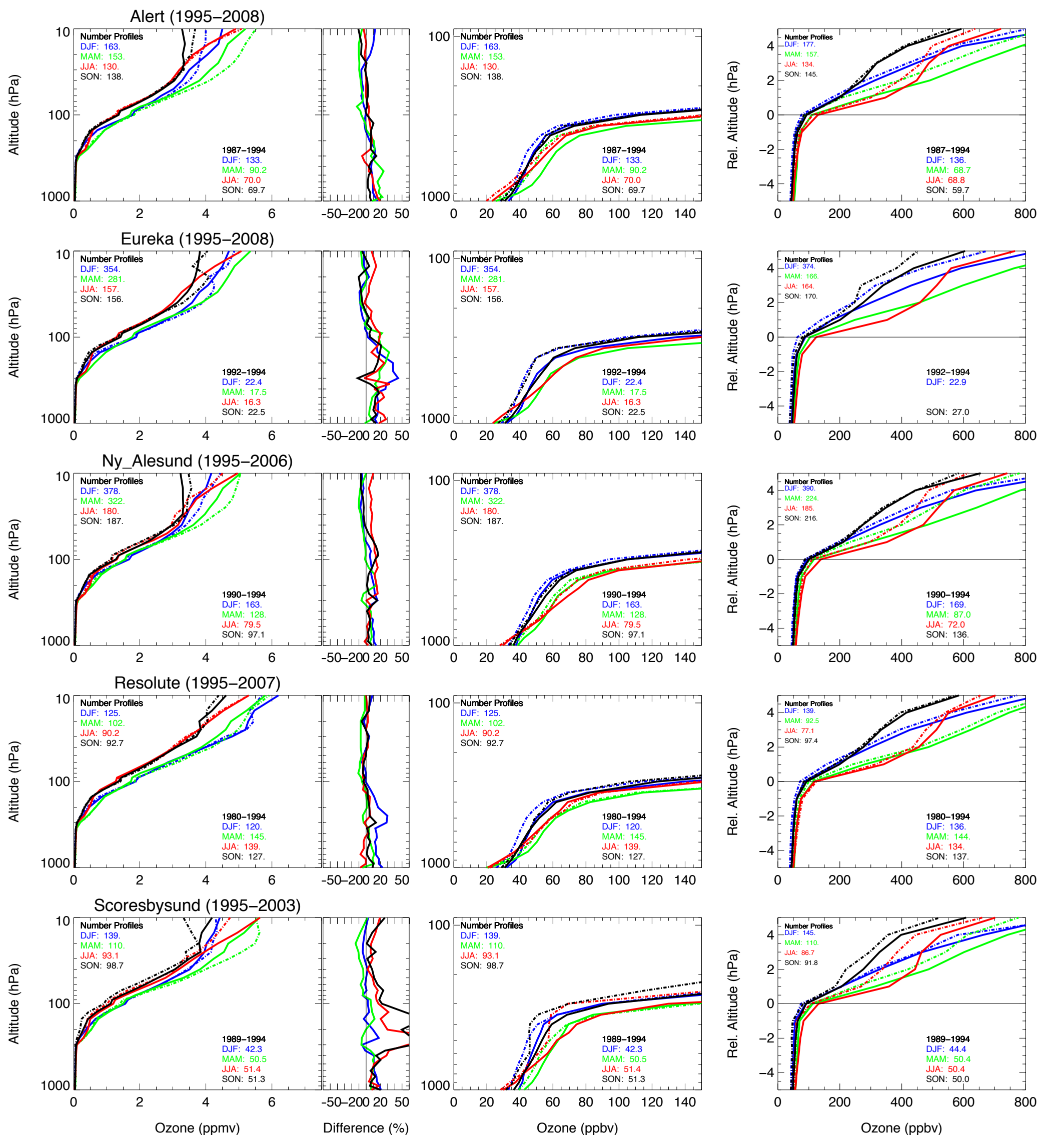
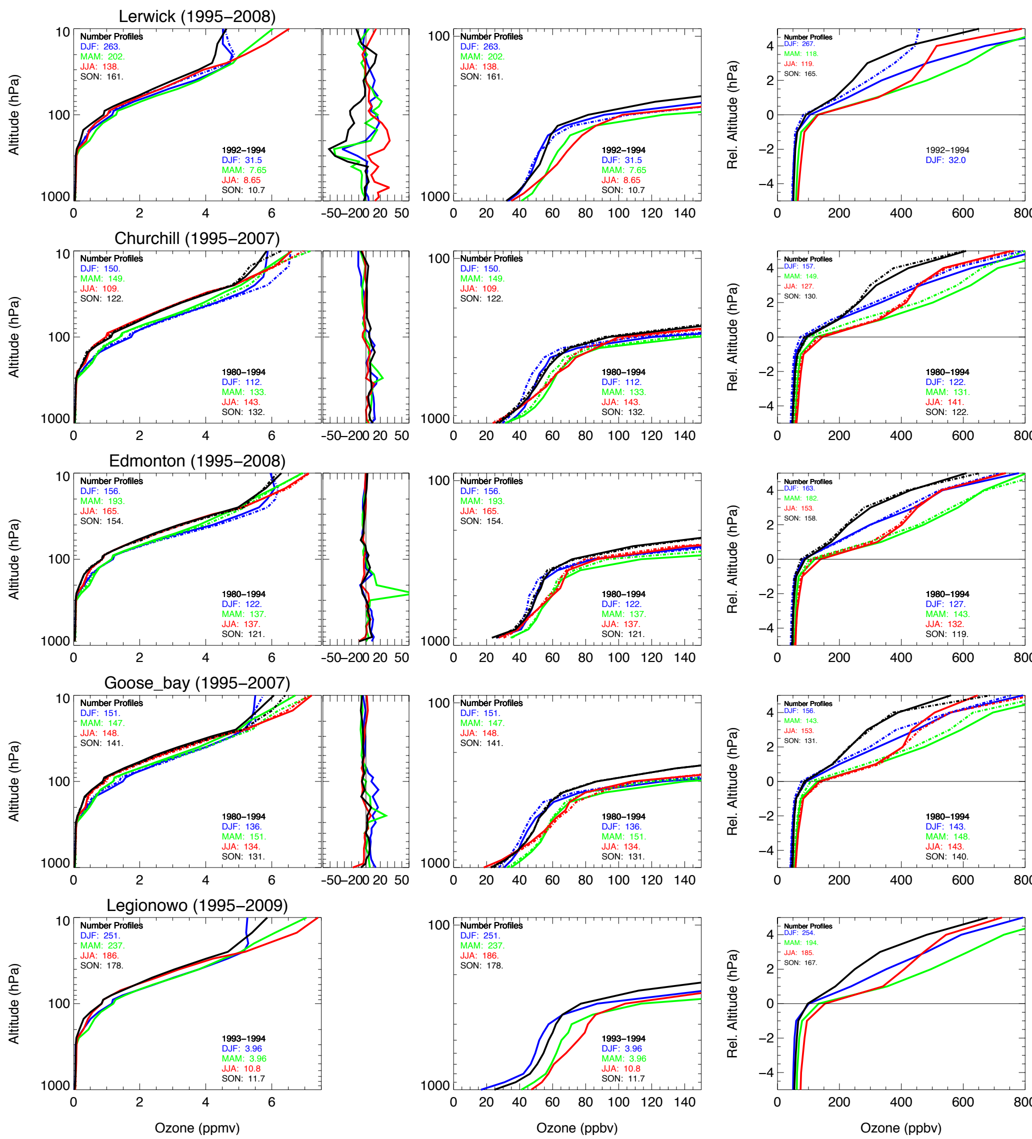


Fig. 4: Vertical profiles of seasonally averaged ozone profiles (median) between 1995 and 2009 (solid lines) and 1980 and 1994 (dashed-dotted lines, if available). The total number of profiles used for the period 1995-2009 are shown on the left top and for the period between 1980-1994 on the right bottom (if available) of each panel. In 1980-1994 most of the stations show a much smaller sampling frequency than 1995-2000. Differences between the two periods considered are shown on the right of the left panel. Different seasons are shown in different colors.



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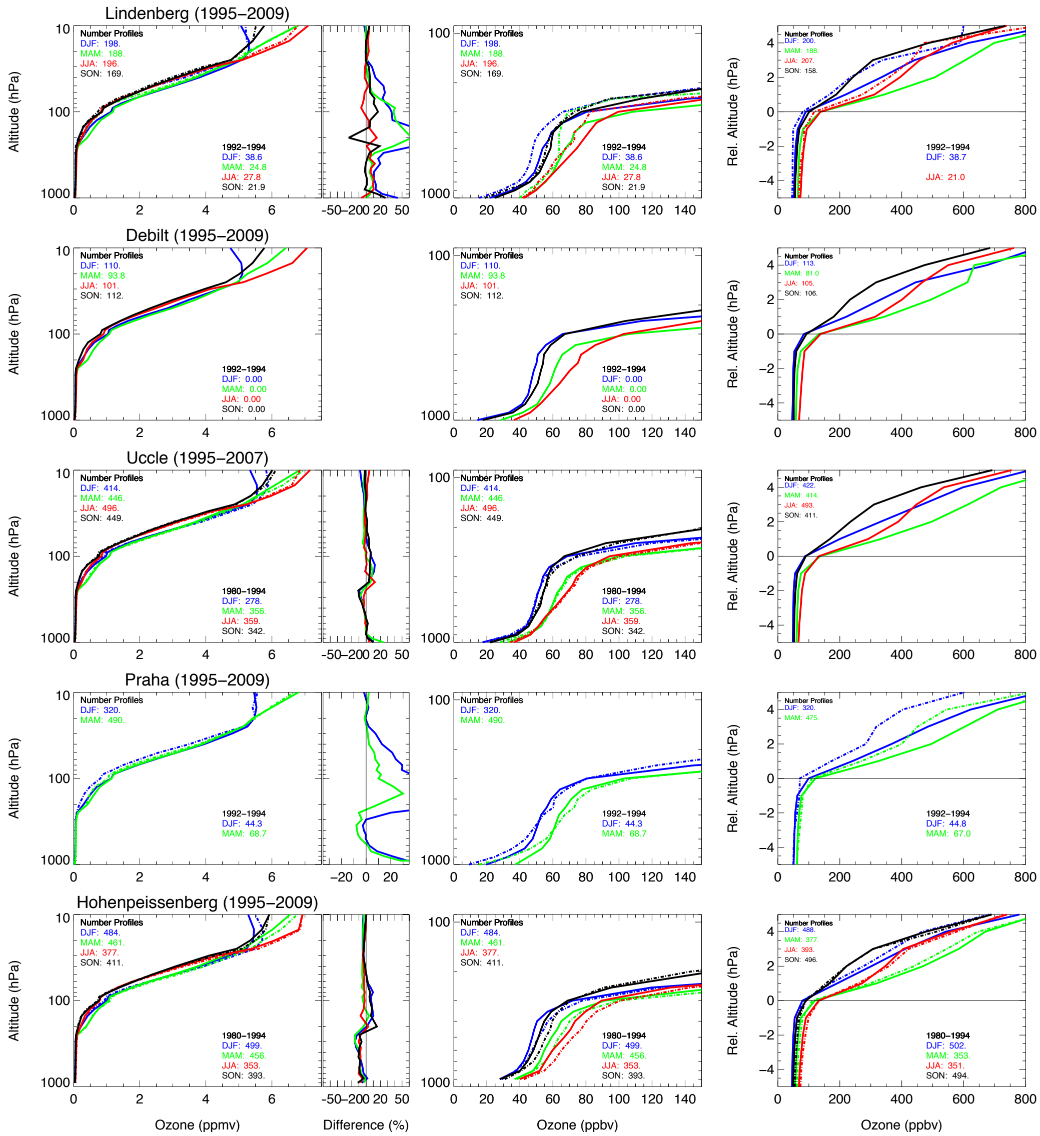

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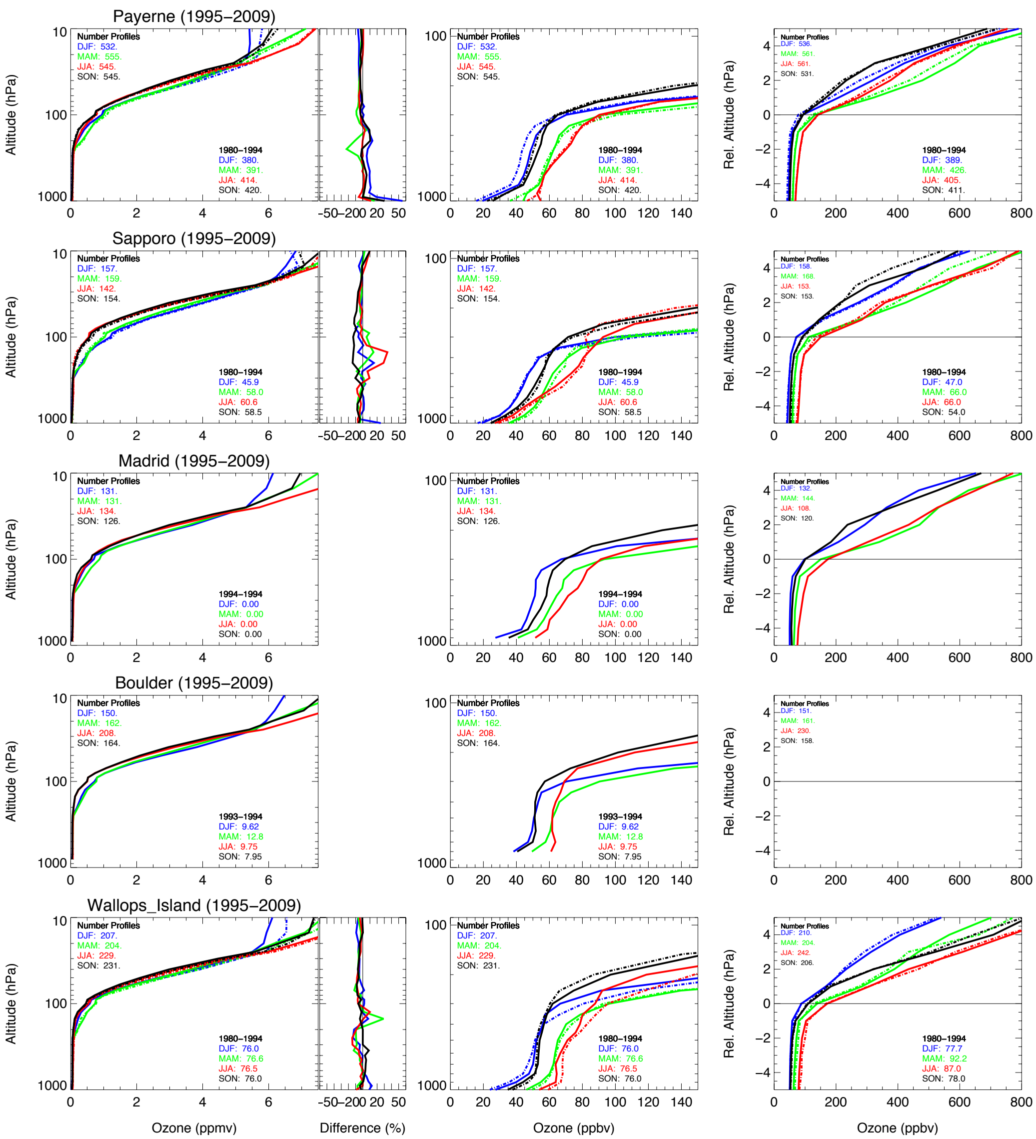

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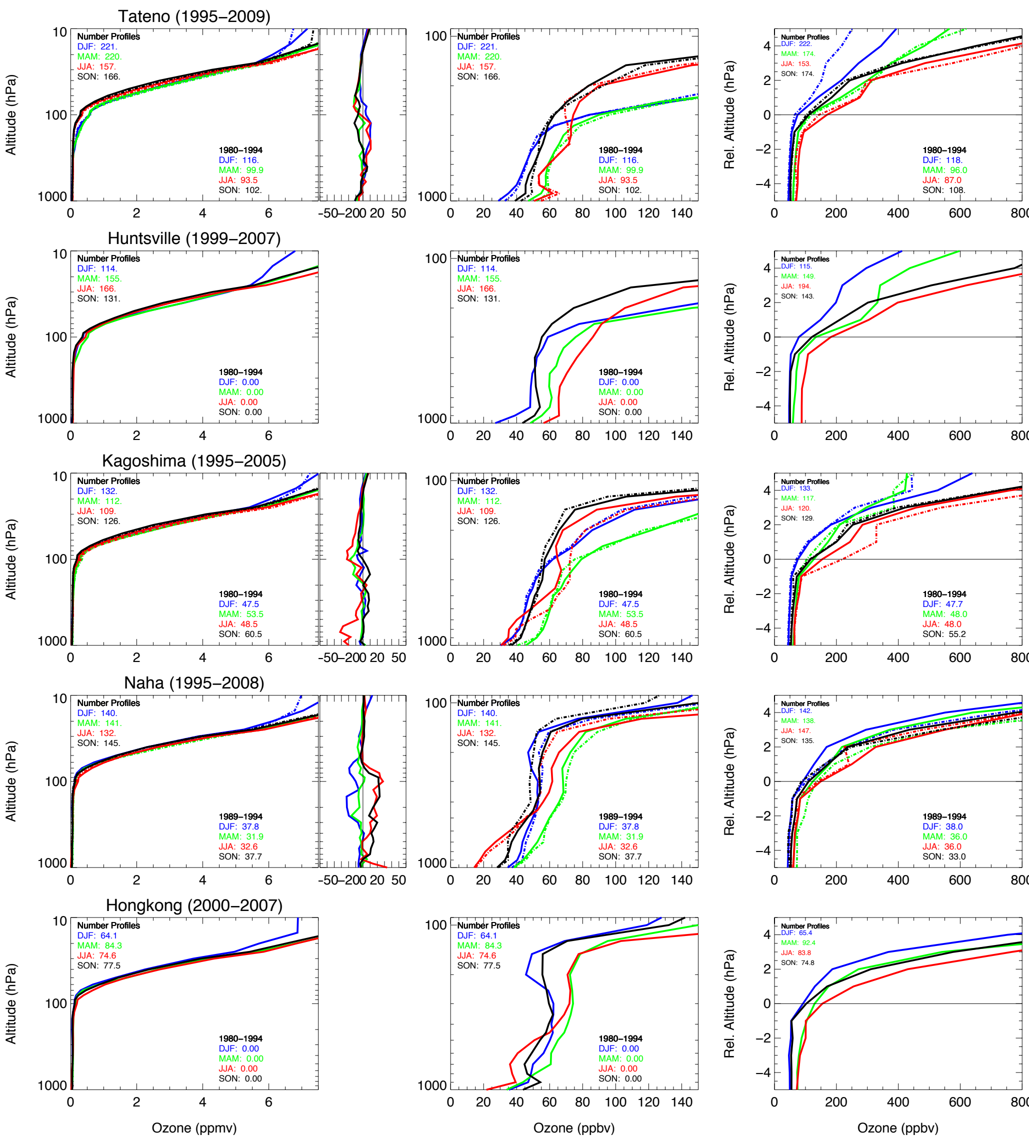

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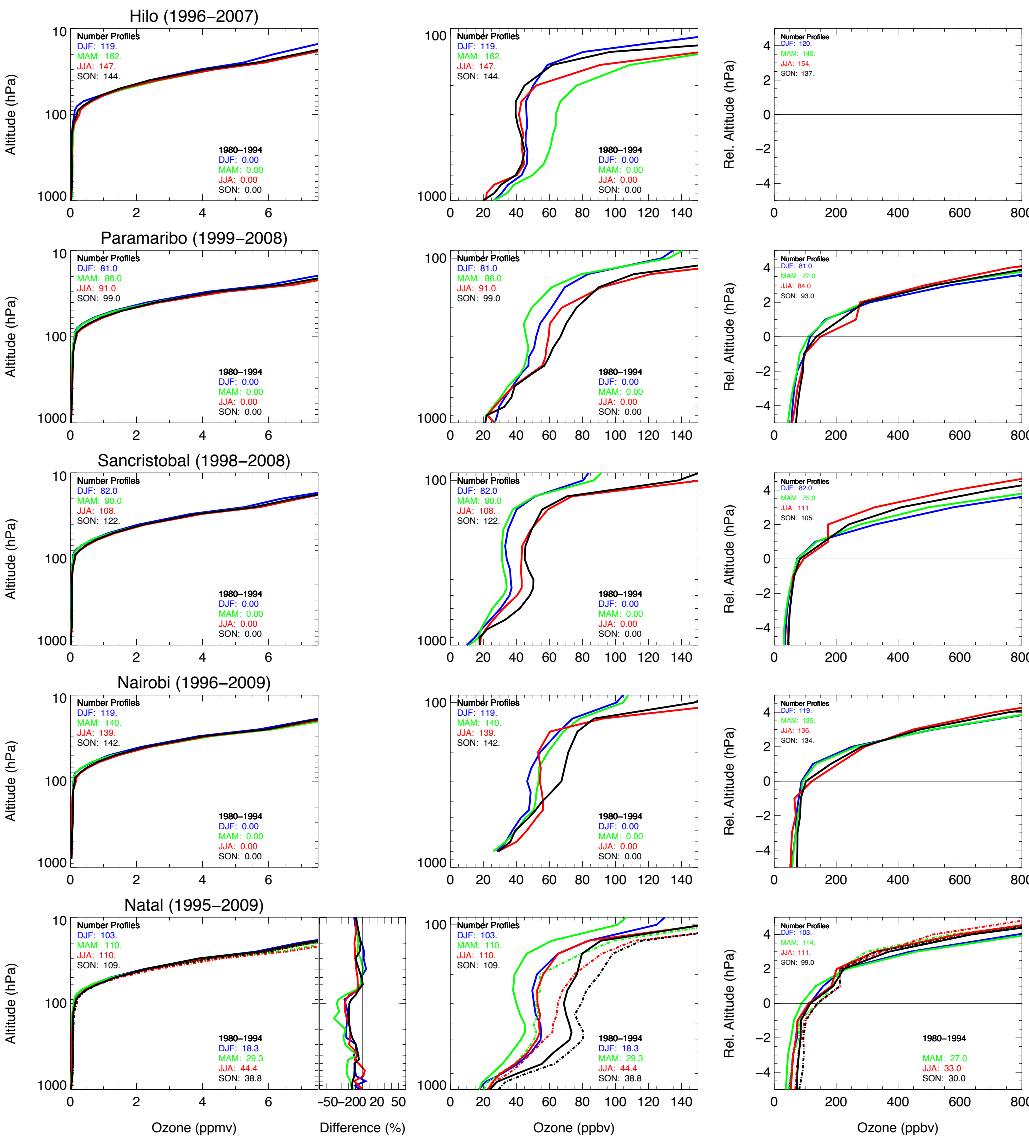

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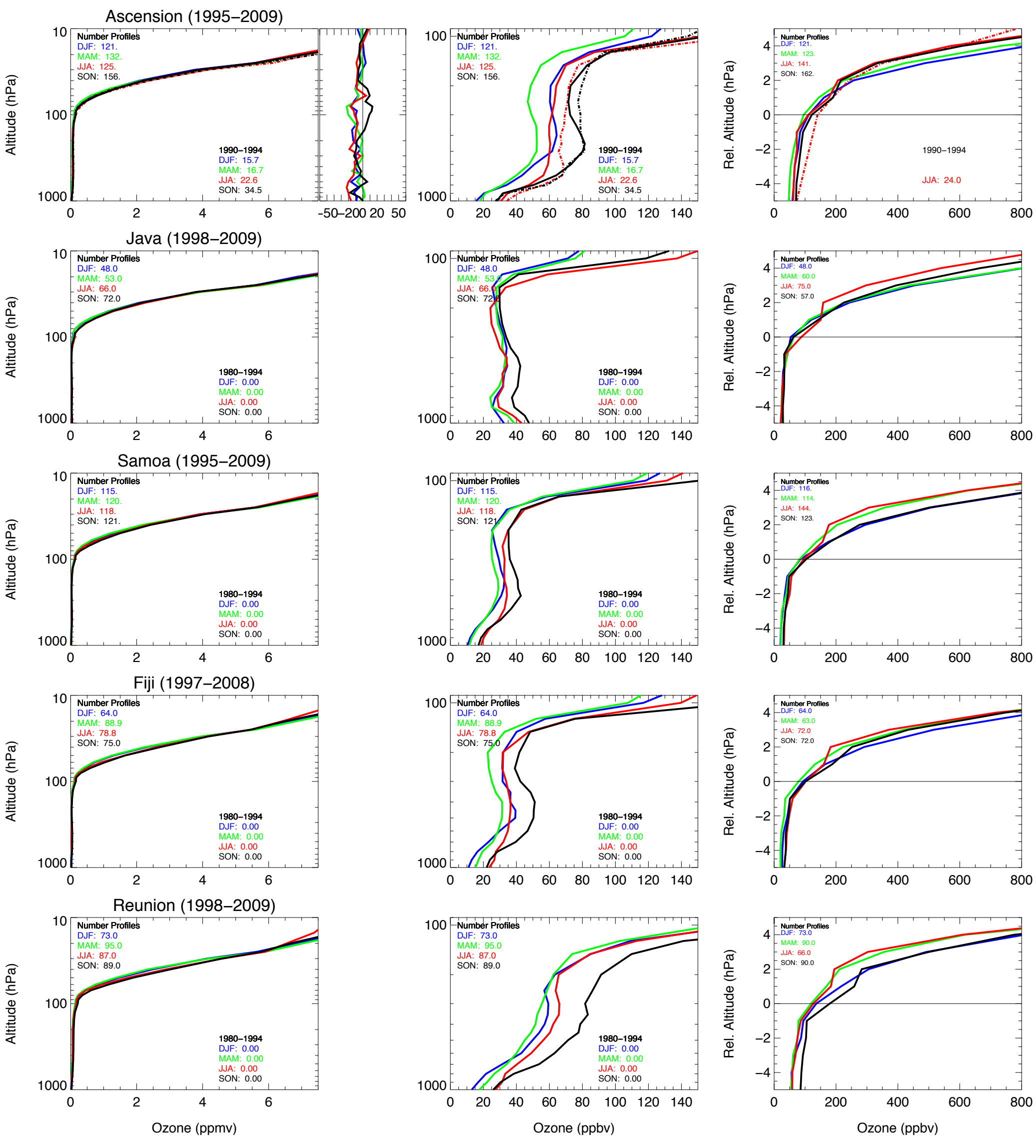

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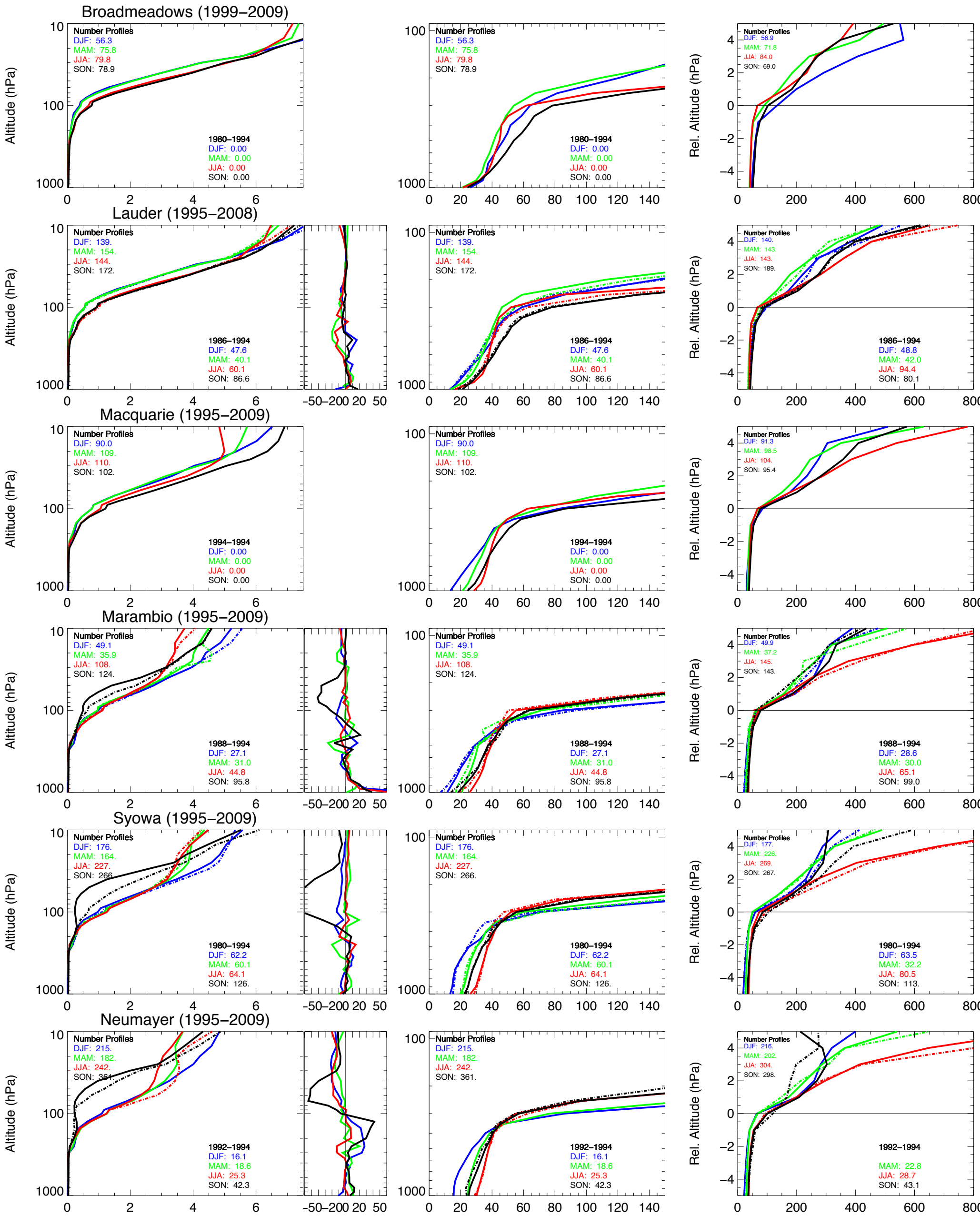

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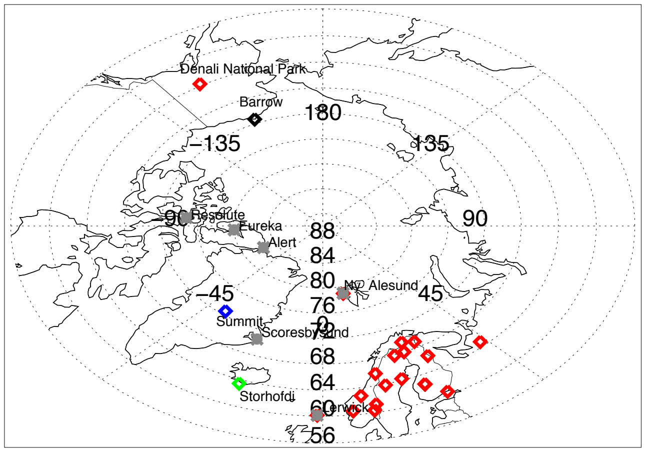

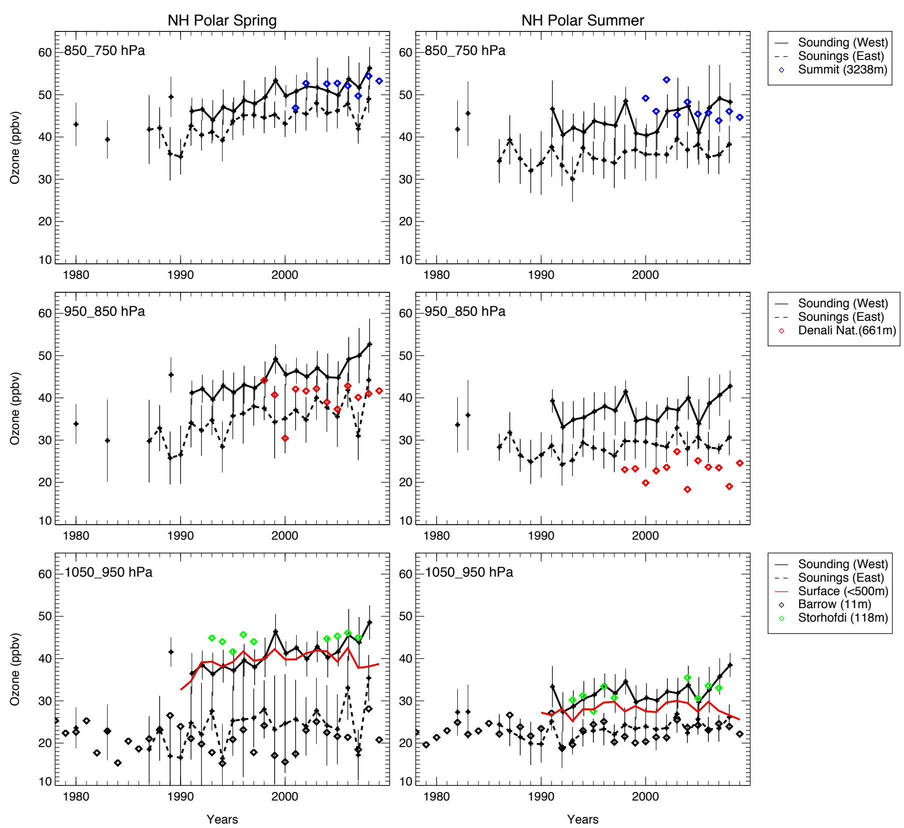

Fig. 5: Top panel: Map of ozone stations (gray asterisks) and surface stations (diamonds) considered. Second to fourth row: Comparison of ozone timelines between ozone soundings (gray asterisks: top panel, and black lines: bottom panels) and surface ozone observations (colored diamonds, and red lines: bottom panel) over the NH polar region for different pressure levels. Ozone soundings are divided into two parts, the eastern (dashed lines) and the western sector (solid lines).

At the surface, surface observations of different hourly intervals vary significantly, because of a strong diurnal cycle, most pronounced in summer. Ozone soundings agree best with surface observations if the time interval chosen is between 11am and 2pm, in agreement with the time, when most ozone soundings are launched in this area. In the upper troposphere, MOZAIC data and ozone from soundings agree rather well, besides some unexplained differences in the first 3-4 years, which result in larger ozone mixing ratios based on ozone soundings compared to MOZAIC over the 15-year period.

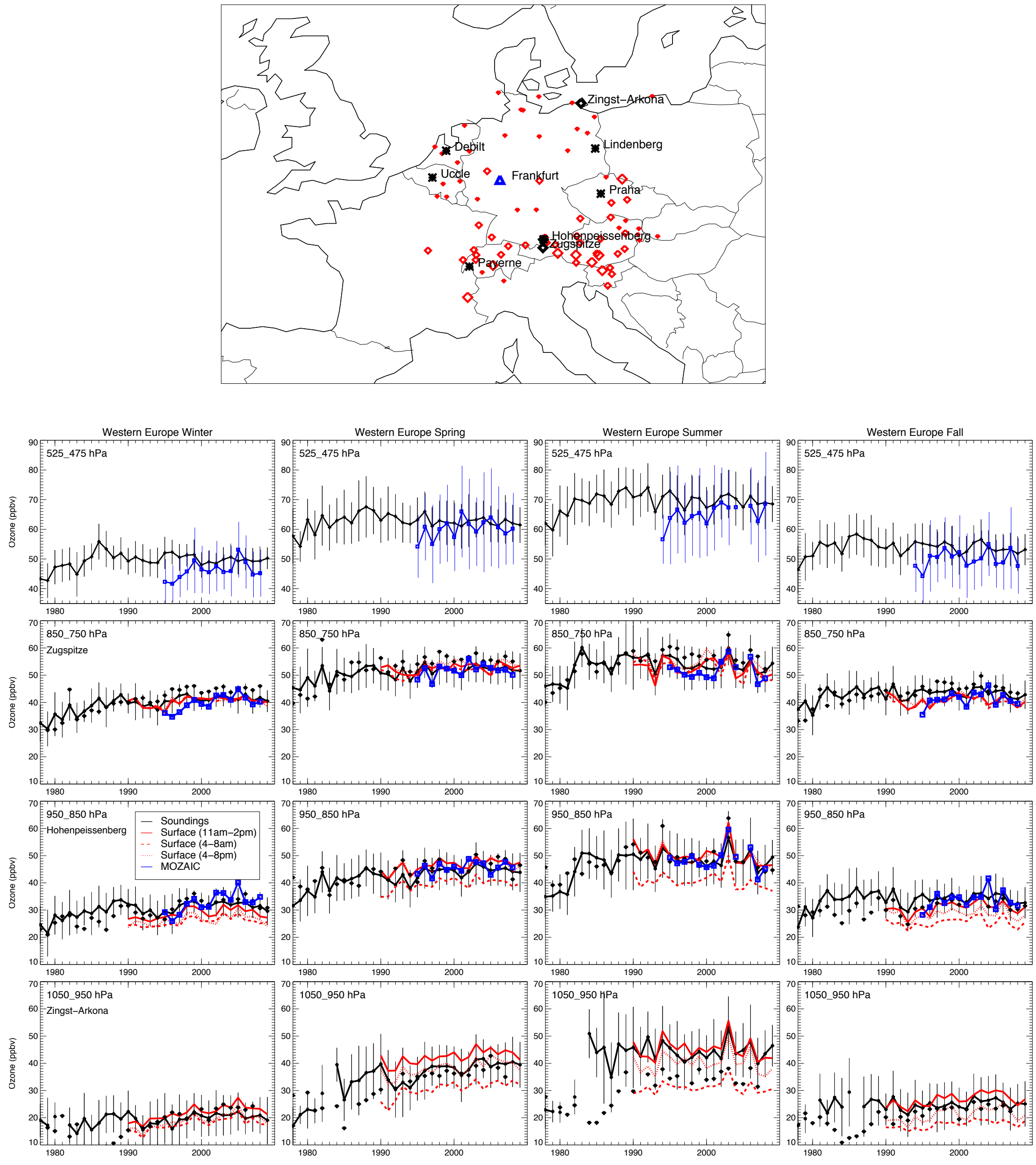

Fig. 6: Top panel: Map of ozone stations (black asterisks), surface stations (diamonds) and airport (triangle) considered. Second to fifth row: Comparison of ozone timelines between ozone soundings (black asterisk: top panel, and black lines: bottom panels), surface ozone observations (red diamonds, and red lines: bottom panels), and MOZAIC aircraft observations (blue triangle: top panel, and blue lines: bottom panels) over Western Europe for different pressure levels. Altitude information of surface stations are included (different sizes of diamonds, going from small to large with increasing altitude). Seasonal averages of hourly surface observations are further separated into three different time intervals of the day (see legend).

References

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