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Technical Note: Supplemental Material: Ozonesonde climatology between 1995 and 2011: Description, Evaluation and Applications

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1 Ozonesonde observations available for each station

Figure 1 shows timelines of the median of seasonally averaged ozone profiles between 1978 and 2011 (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 were available and the sampling frequency stays rather constant. Therefore, we do not apply any annual weighting to calculate the 17 year average, shown in Figure 5.

2 Impact of the correction factor

For most ozone stations a correction factor is provided that is derived by 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 in order to not employ profiles that are heavily corrected (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).

Removing profiles that have been corrected by a factor outside the range of 0.8 and 1.2 has little

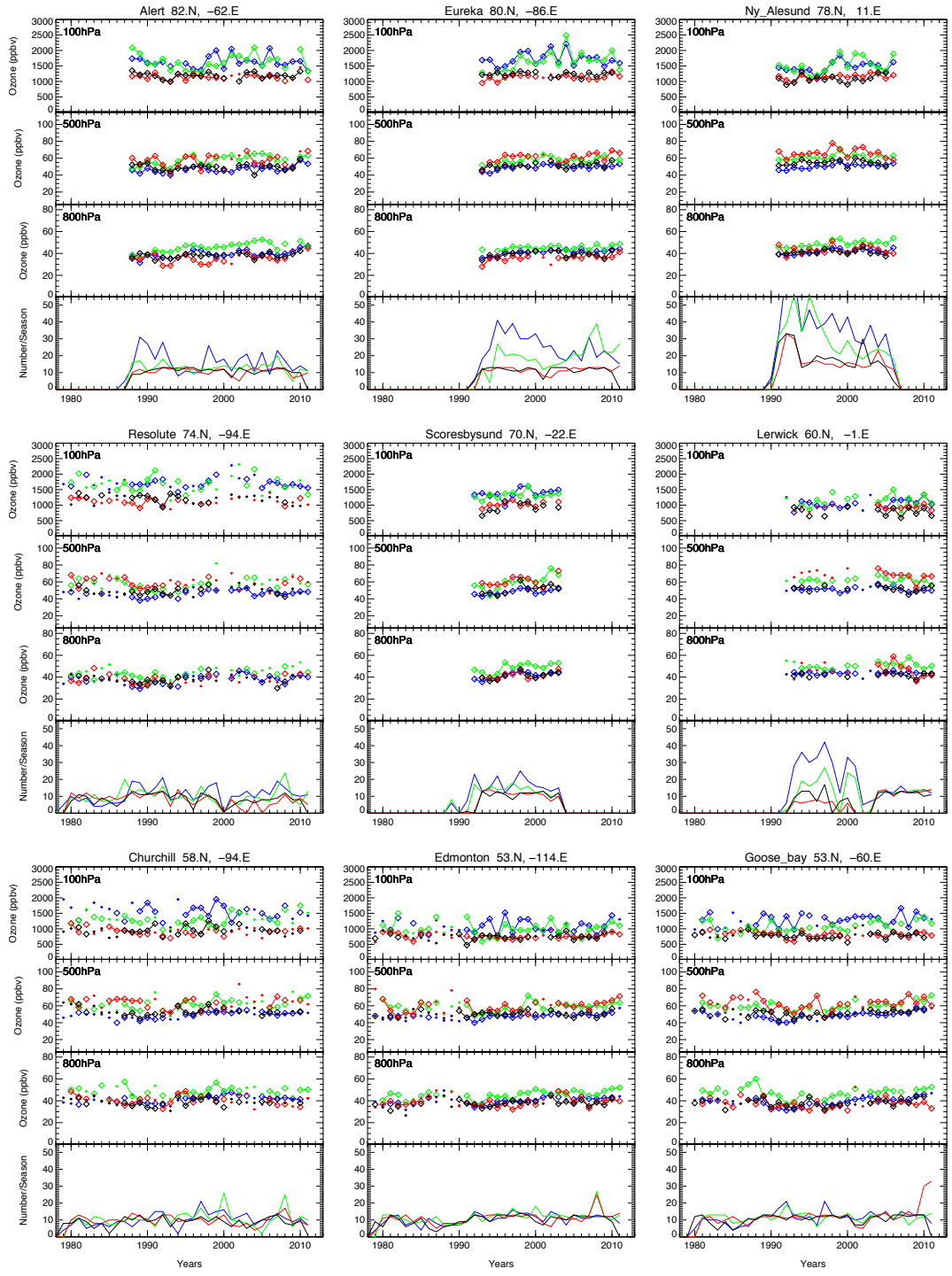
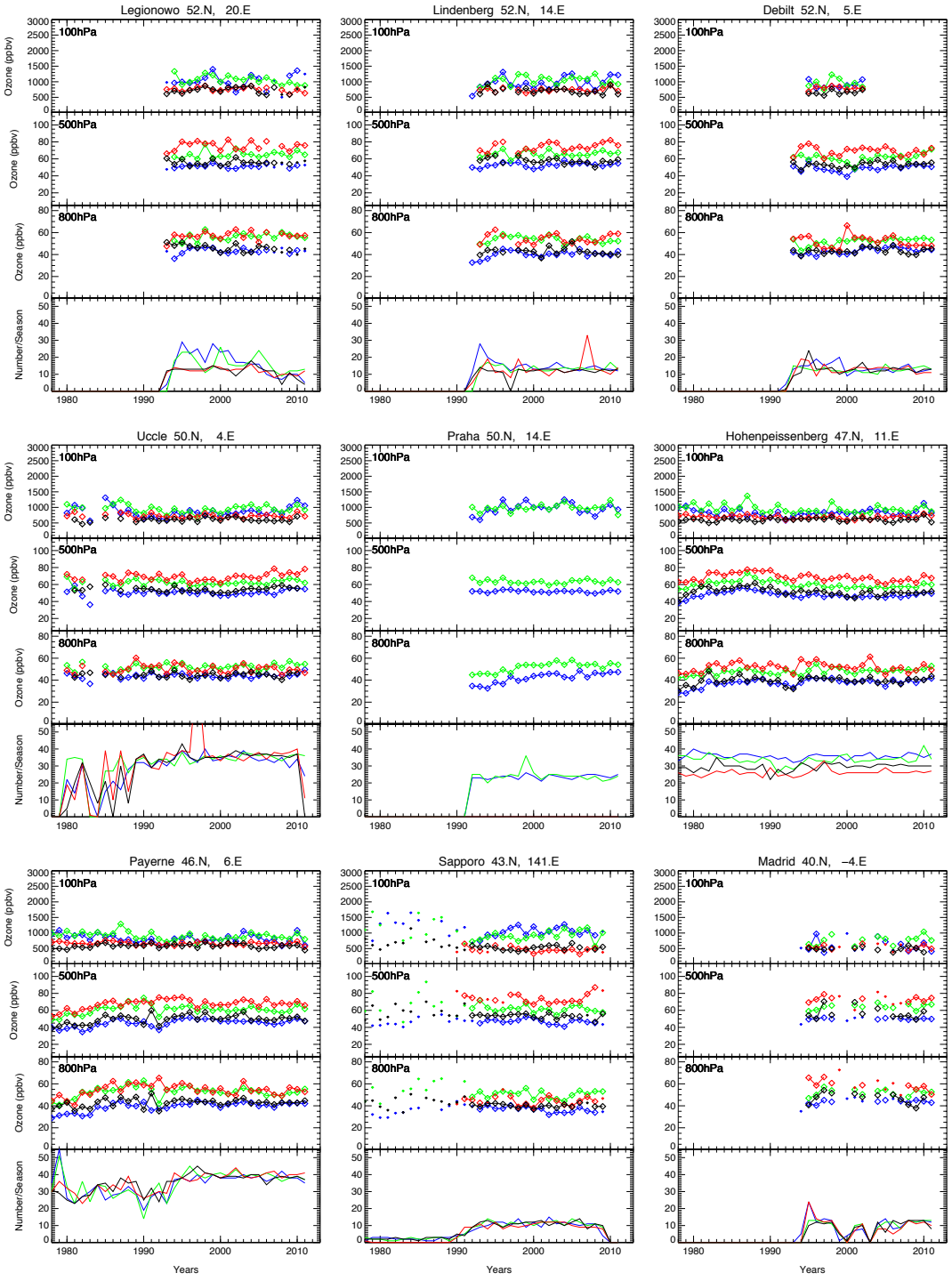


Fig. 1: Time evolution of median ozone mixing ratios derived from the ozone soundings at three different pressure levels and different seasons (DJF: blue, MAM: green, JJA: red, SON: black) for 42 stations. The total number of profiles per season for each year are illustrated in the bottom plot of each panel. Seasons that include less than 12 profiles per year are shown as dots.



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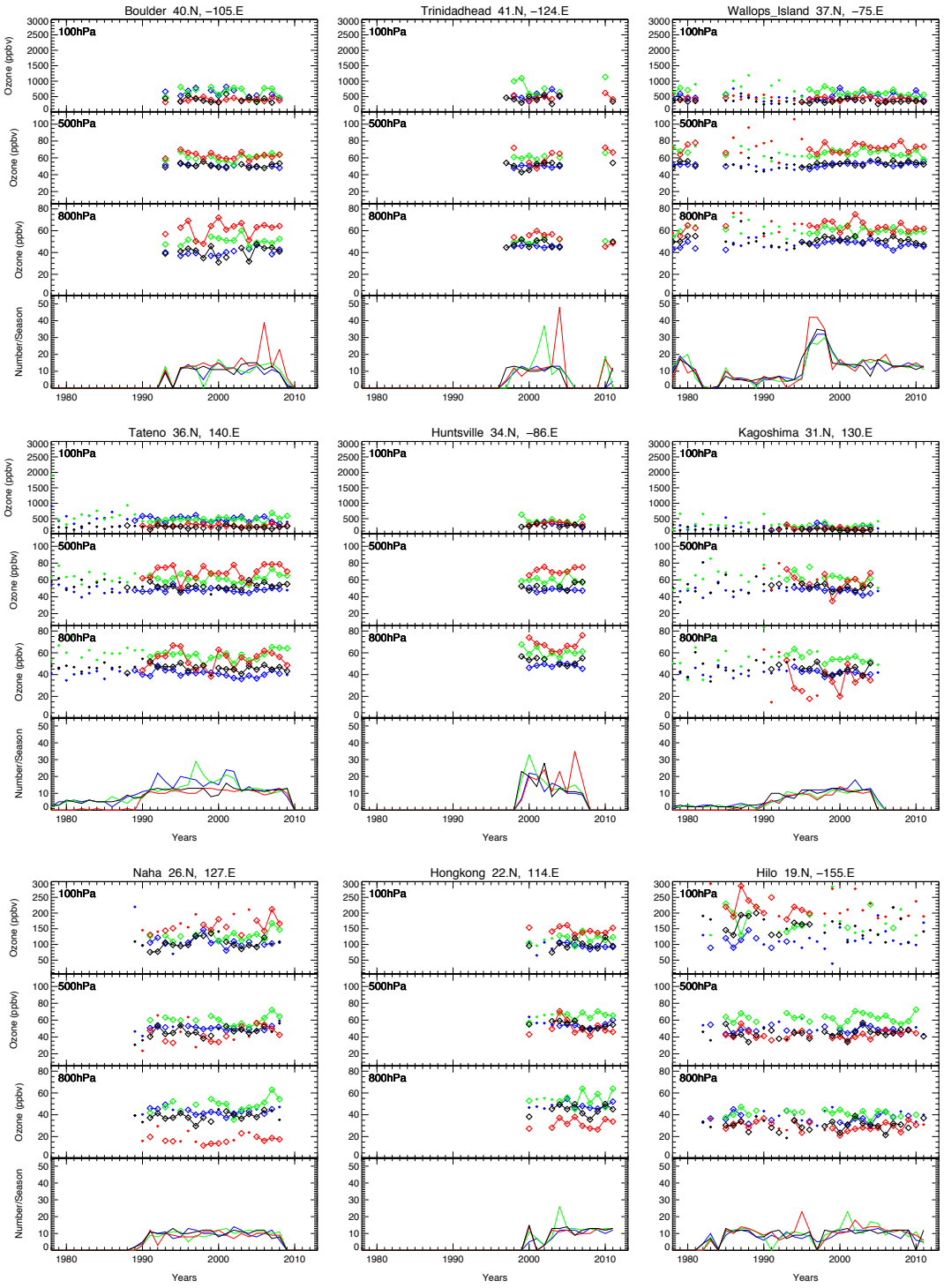

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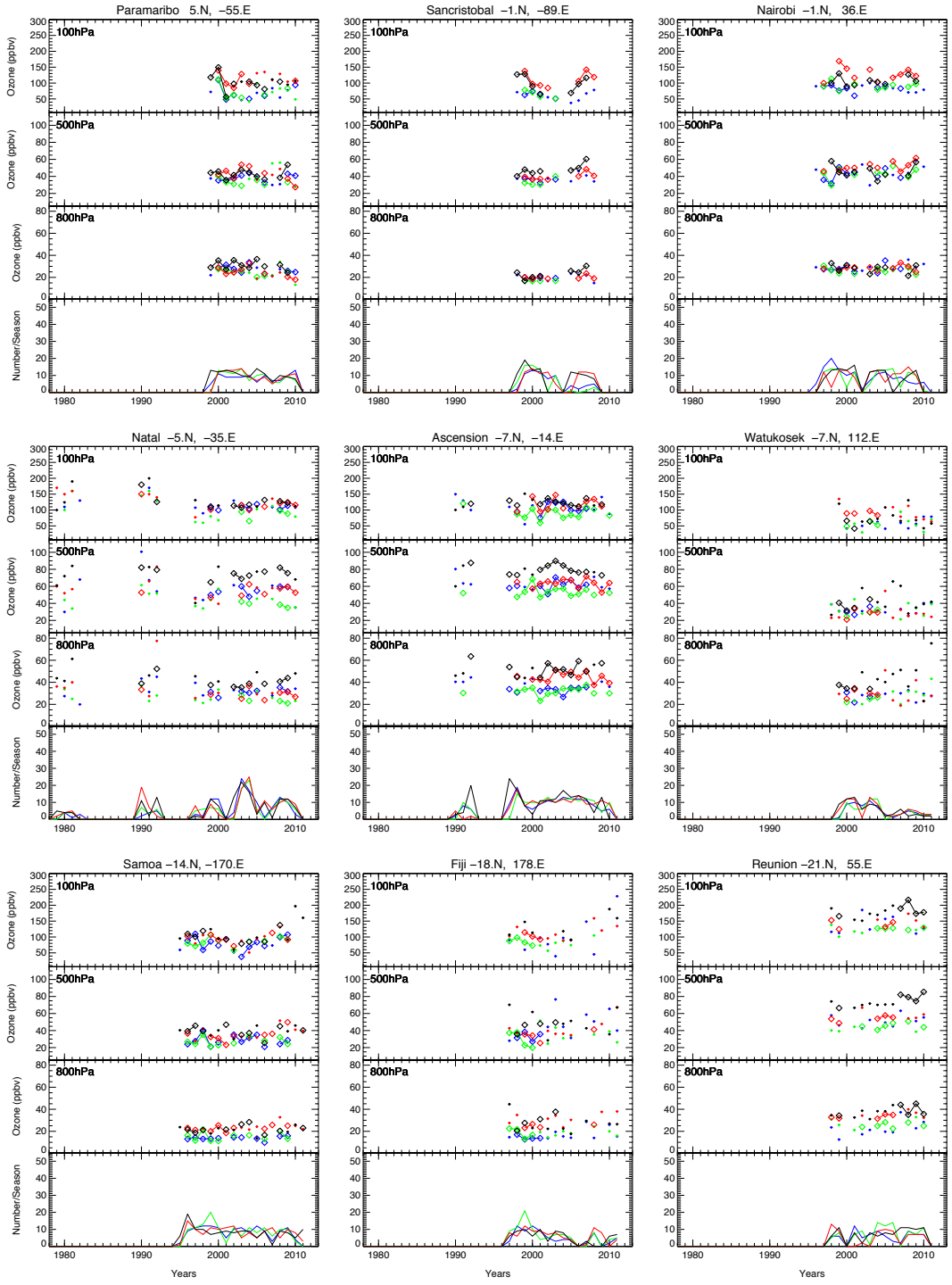

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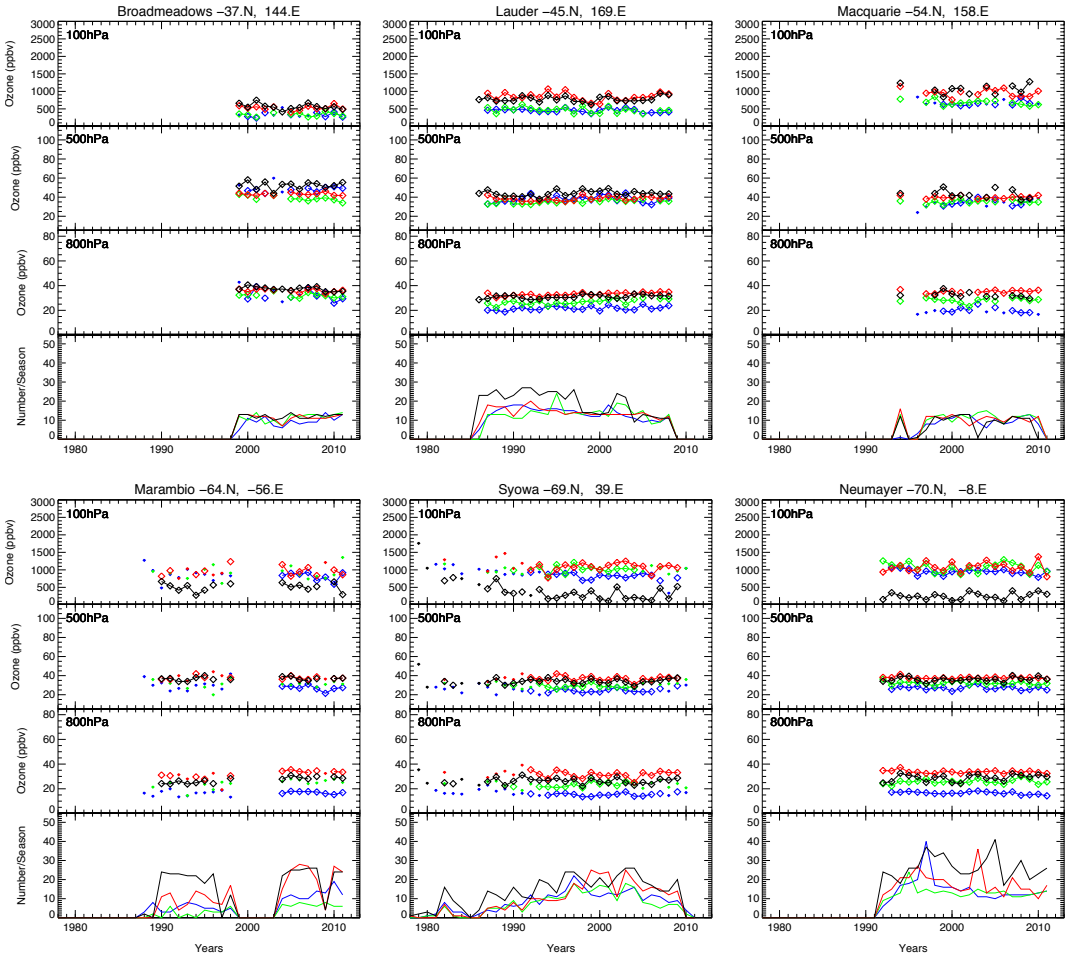

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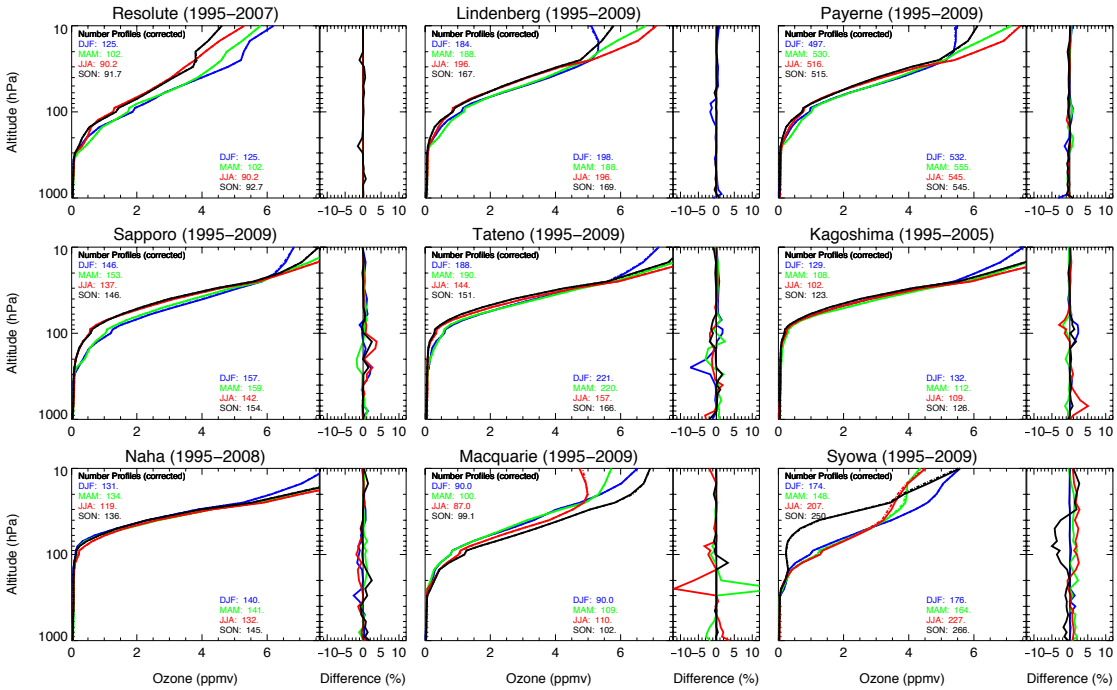


Fig. 2: Left plot of each panel: seasonally averaged ozone profiles for available years between 1995 and 2009. The average of all profiles, corrected in the way that those profiles are dismissed that are corrected by a factor of < 0.8 or > 1.2, is shown as solid lines. The average of all available profiles is 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 all but corrected profiles and all profiles. Only those stations are shown, where the percentage difference is larger 0.5%.

impact on the averaged ozone profiles between 1995 and 2009, as shown in Figure 2. Only those stations are shown, where the percentage difference between all profiles and only minor corrected profiles is larger than 0.5%. For a few stations, differences can reach up to 5-10%.

3 Comparison to other studies

A comparison of seasonally averaged ozone profiles for all stations for the period between 1980 and 1994 with the climatology from Logan (1999a,b) is illustrated in Figure 3. We construct ozone profiles on the same pressure grid as done by Logan (1999a) and Logan (1999b), which results in a good agreement with these 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 it 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. Further, problems with data over Payerne exist in earlier years, as summarized in Logan et al. (2012).

4 Representativeness of ozone averages in comparison to independent observations, Western Europe

The comparison of ozone timelines between ozone soundings, surface observations and MOZAIC aircraft observations in Figure 4 shows very good agreement in the lower troposphere. At the surface, surface observations of different hourly intervals vary significantly, because of a strong diurnal cycle, more 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 differences in the first 3-4 years. A detailed discussion of differences between ozonesonde, MOZAIC and surface observations for Western Europe is given in (Logan et al., 2012).

5 Altitude distribution of ozone profiles as disucssed in the main text

The altitude distribution on pressure altitudes and tropopause-referenced altitudes is given for each station considered in this climatology between 1995 and 2011 (see Figure 5. In addition, the median of monthly averaged profiles between 1995-2011 is compared to 1980-1994 values if data are available.

In Figure 6 and 7, the altitude distribution of the median of monthly averaged profiles is presented using regional aggregates between 1995-2011 for all regions considered. In addition, the half-width of the distribution (left) and the interannual variability (right) of each averaged profile are illustrated.

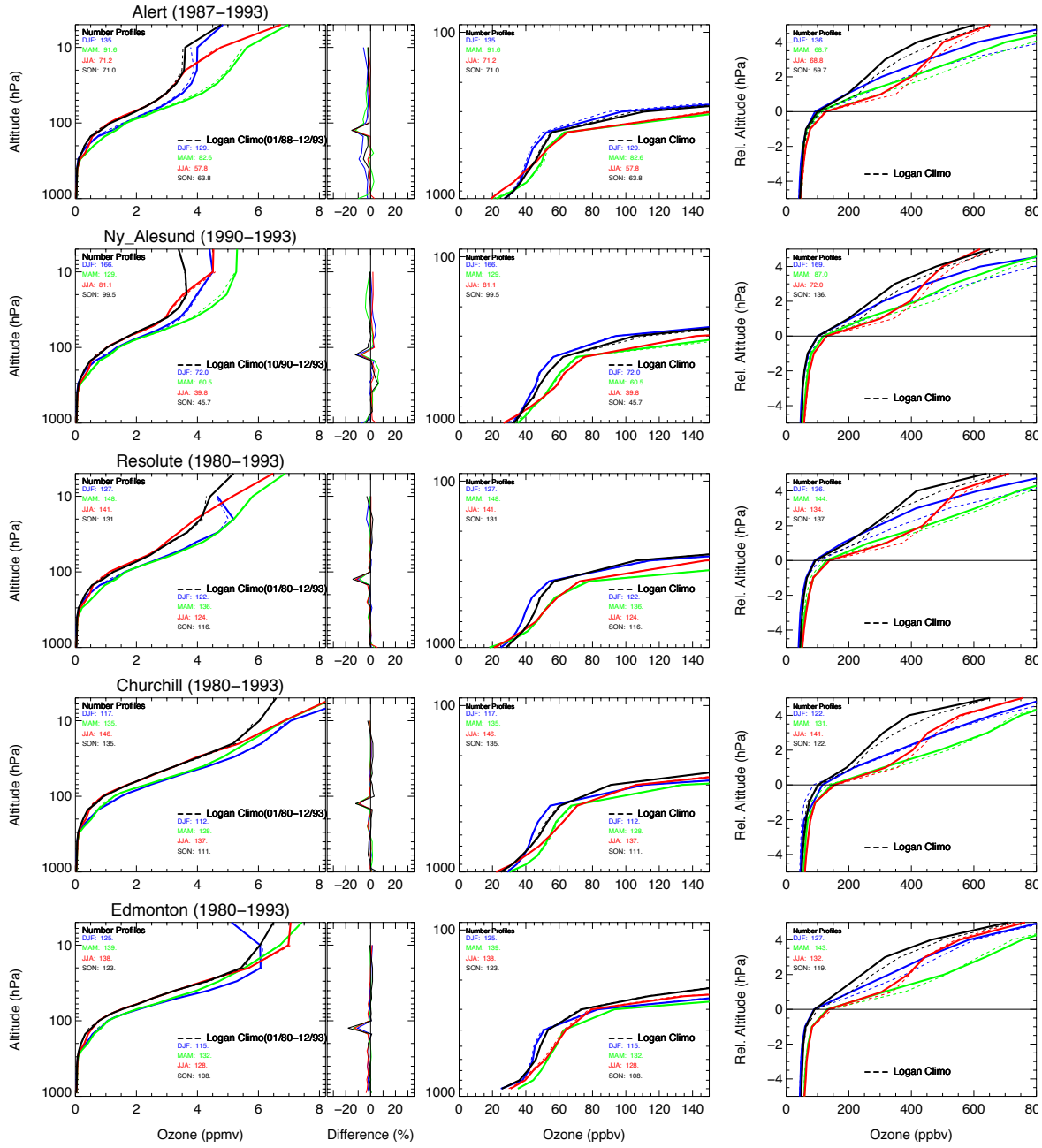
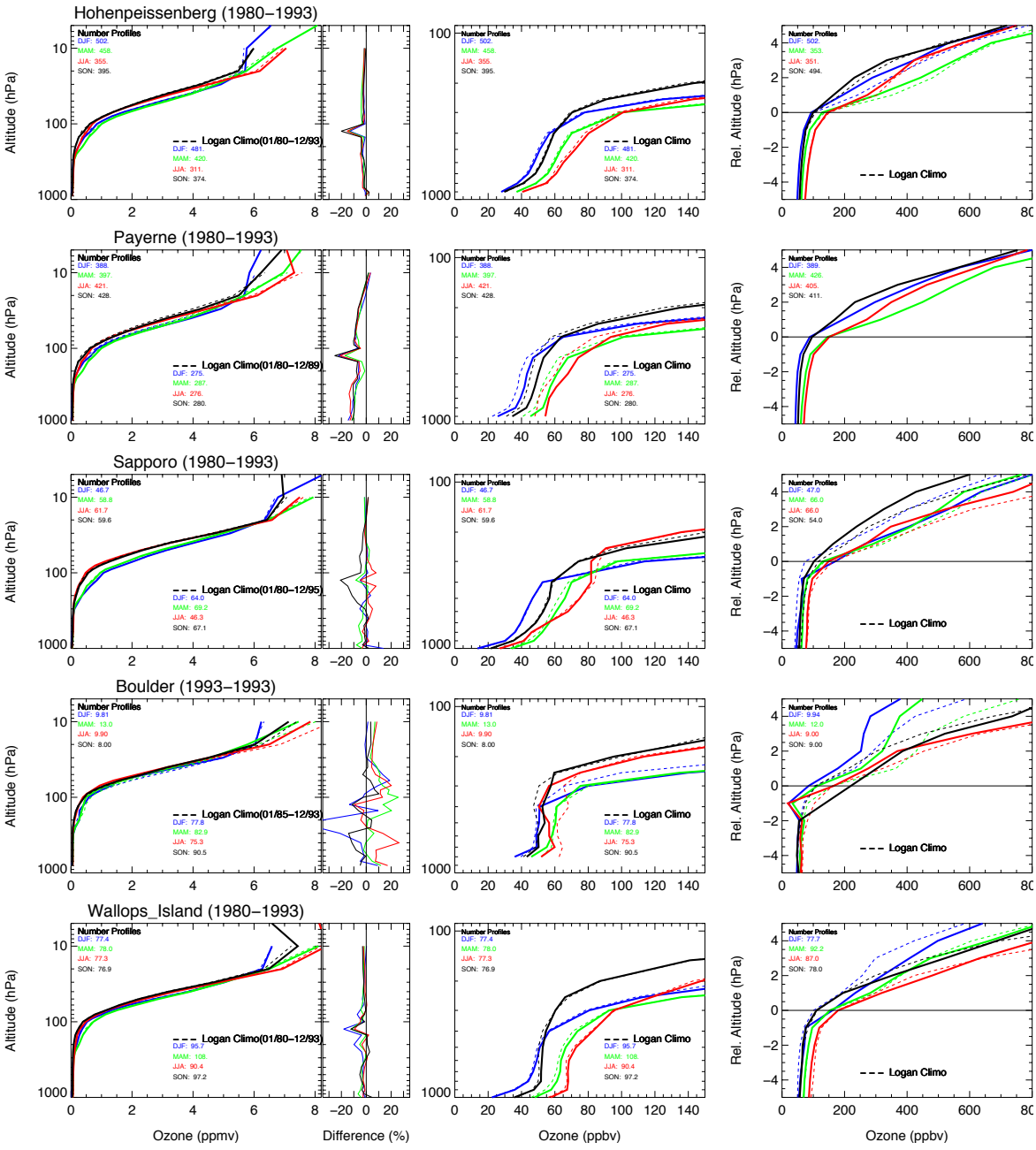


Fig. 3: Vertical median profiles of seasonally averaged ozone data between 1980-1993. The profiles derived for this figure (solid lines) are interpolated to the same pressure levels used in (Logan, 1999a,b) (dashed lines). Differences in % between the two climatologies are shown on the right side of the left panel. Different seasons are shown in different colors.



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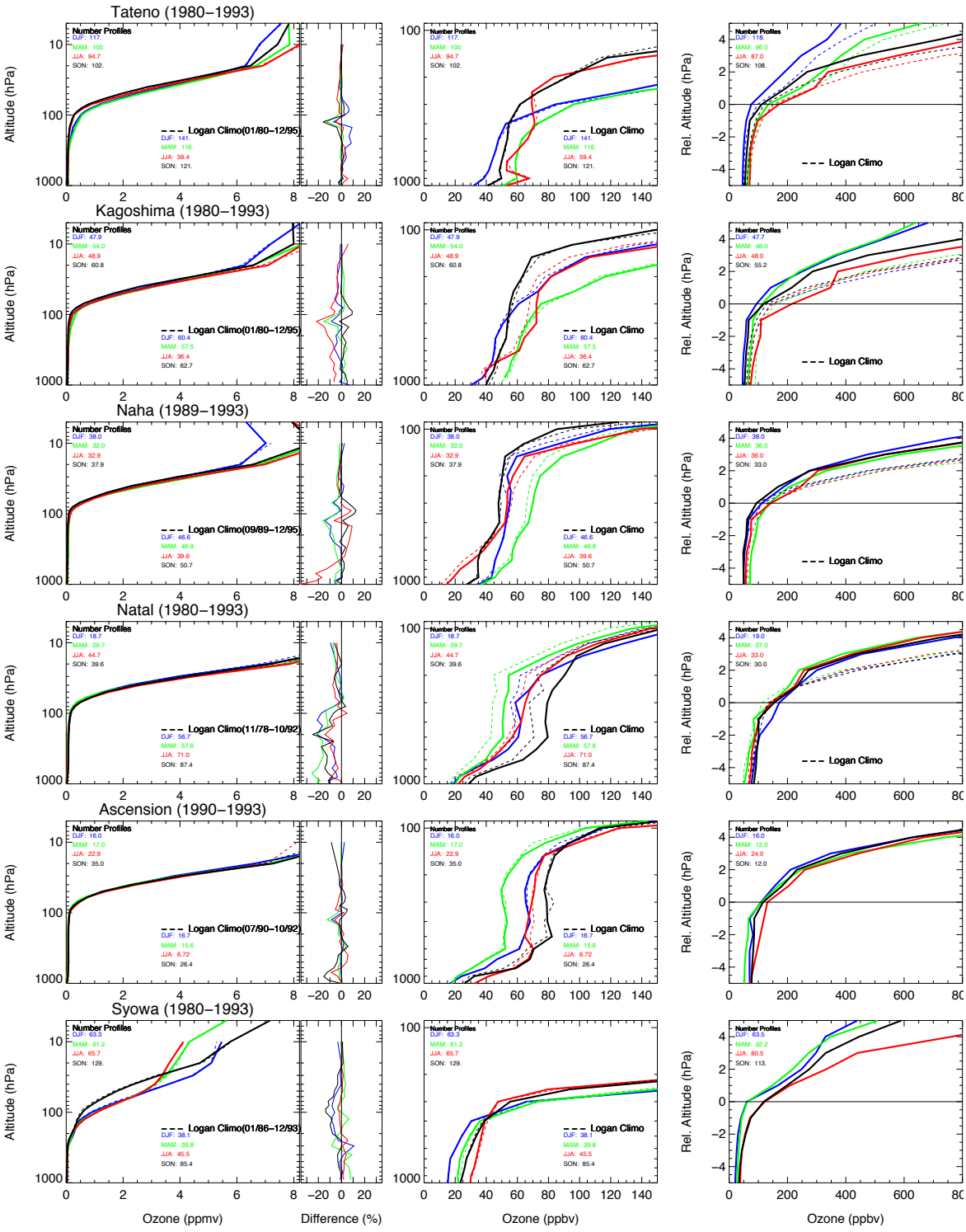

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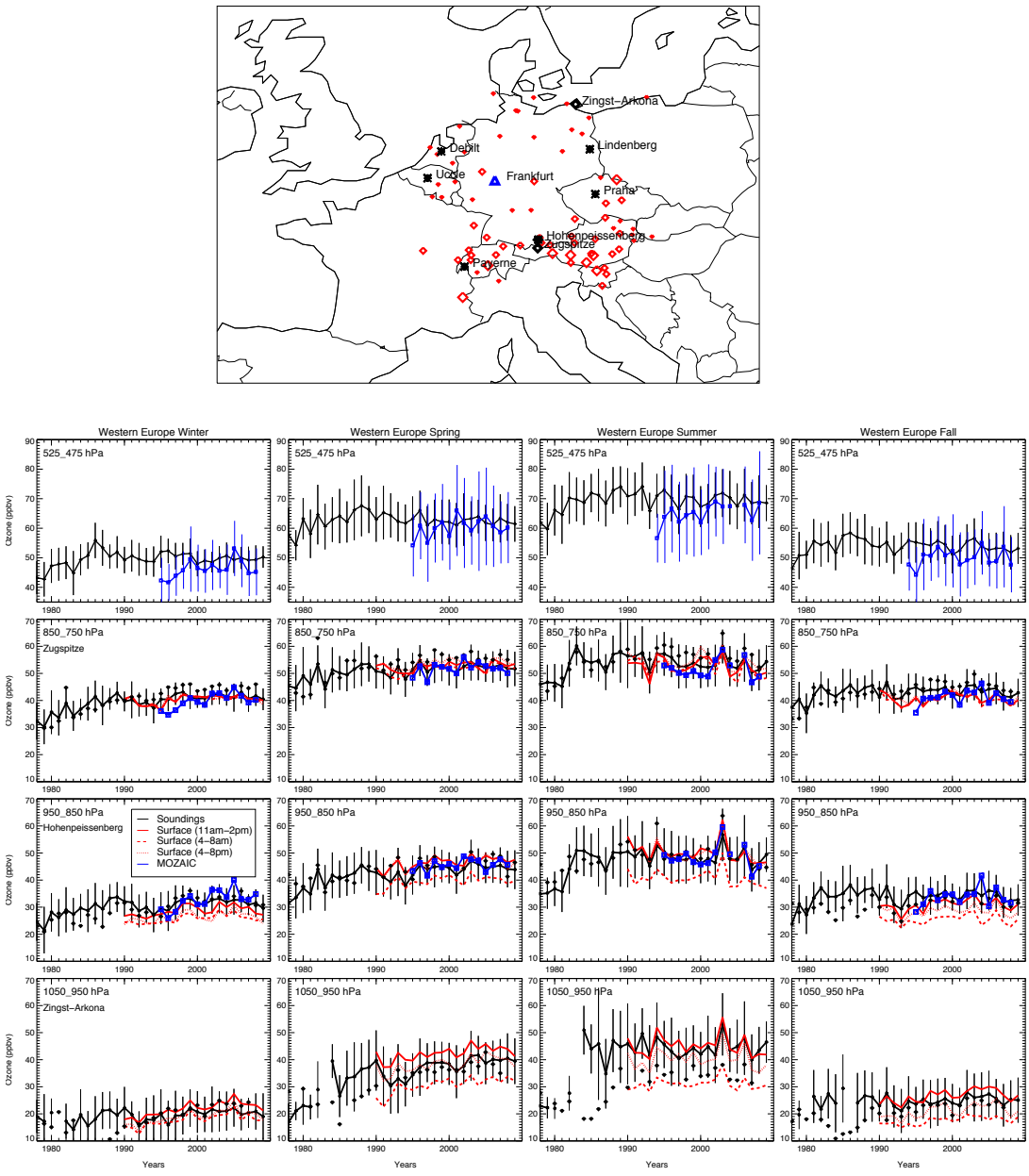


Fig. 4: Top panel: Map of ozone stations (black asterisks), surface stations (diamonds) and airport (triangle) considered. Second to fifth row: Comparison of ozone timelines between ozone soundings (black asterisk: top panel, and black lines: bottom panels), surface ozone observations (red diamonds, 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).

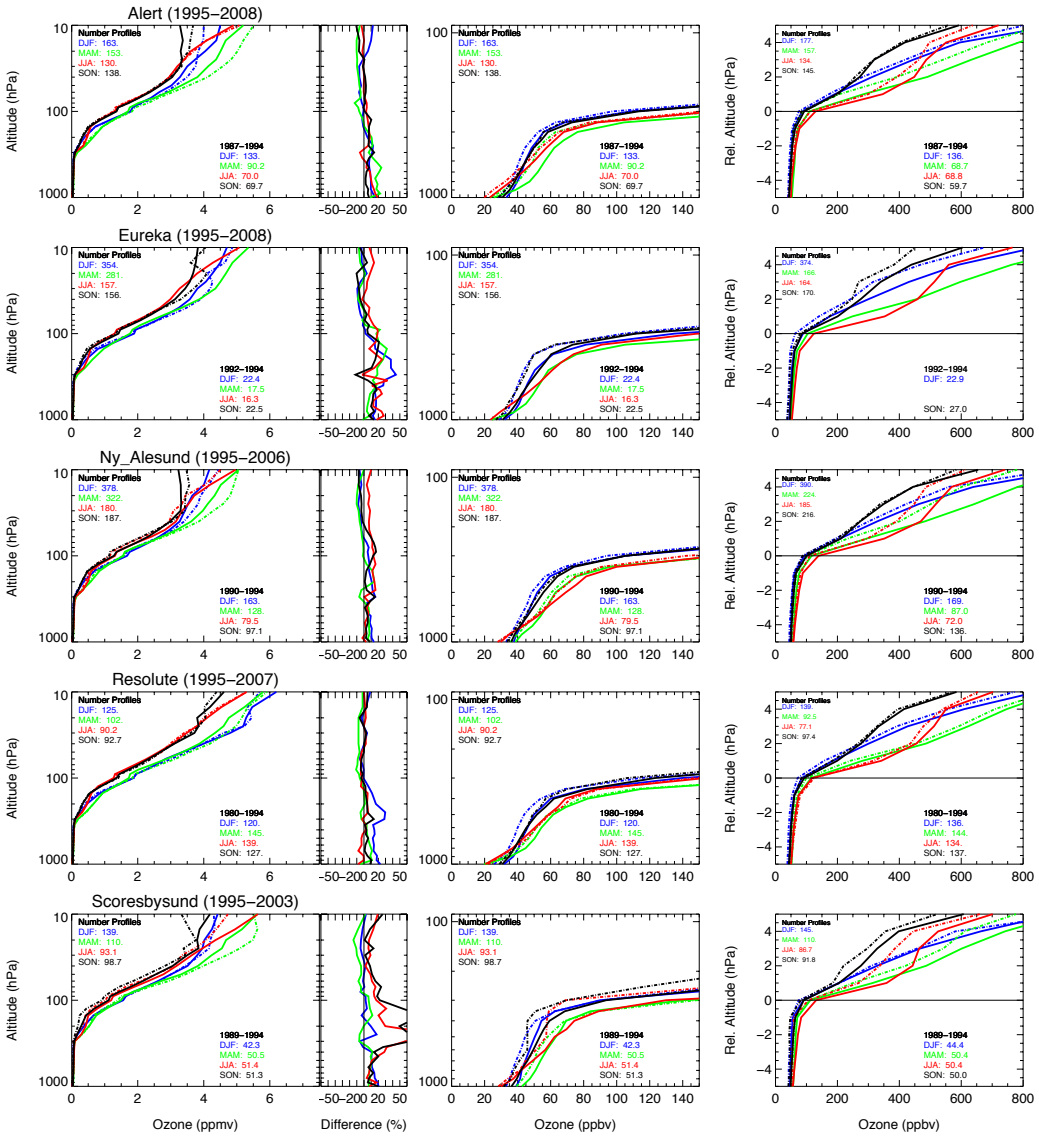
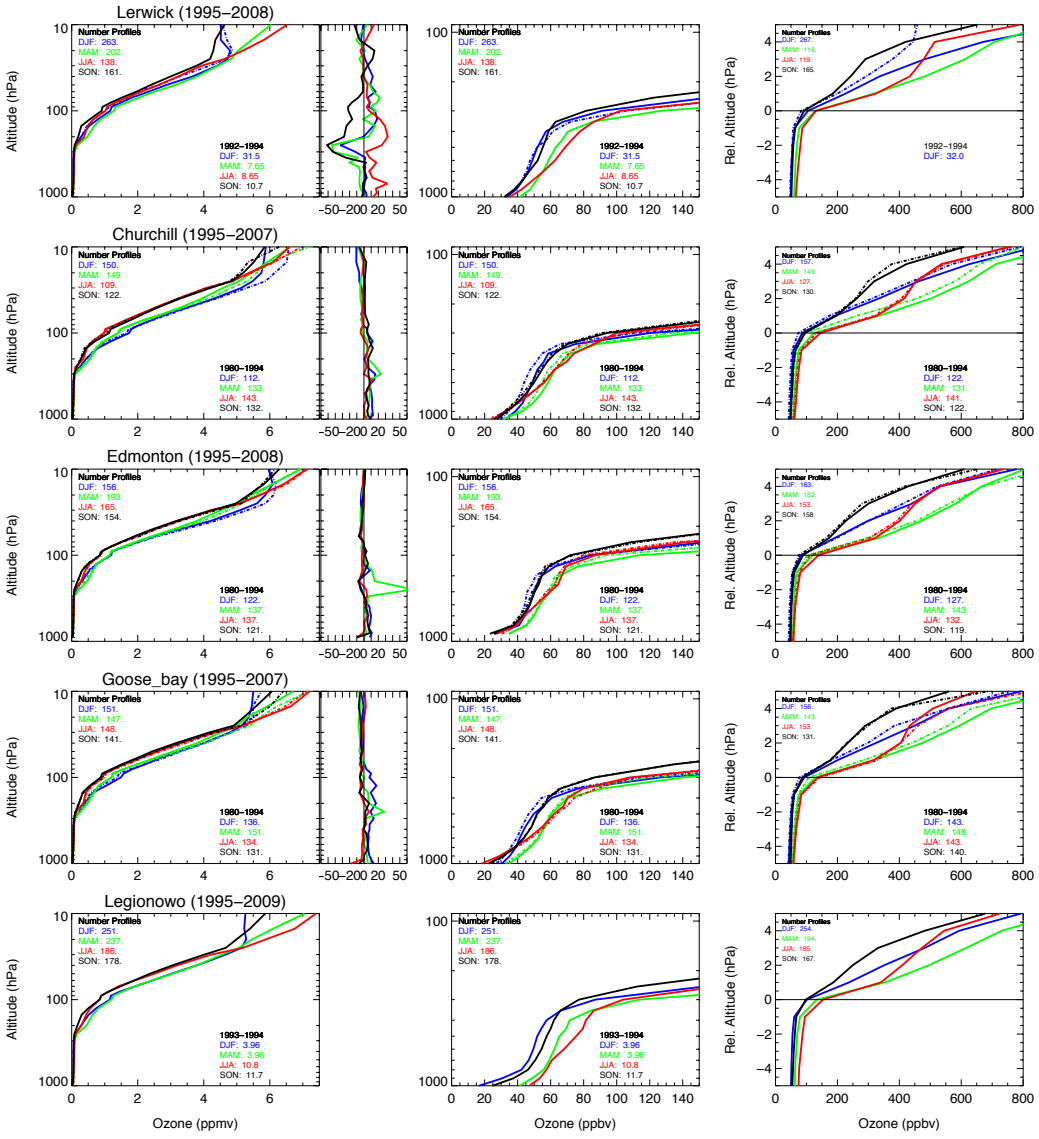


Fig. 5: Vertical profiles of seasonally averaged ozone profiles (median) between 1995 and 2011 (solid lines) and 1980 and 1994 (dashed-dotted lines, if available). The total number of profiles used for the period 1995-2011 are shown on the left top and for the period between 1980-1994 on the right bottom (if available) of each panel. In 1980-1994 most of the stations show a much smaller sampling frequency than 1995-2011. 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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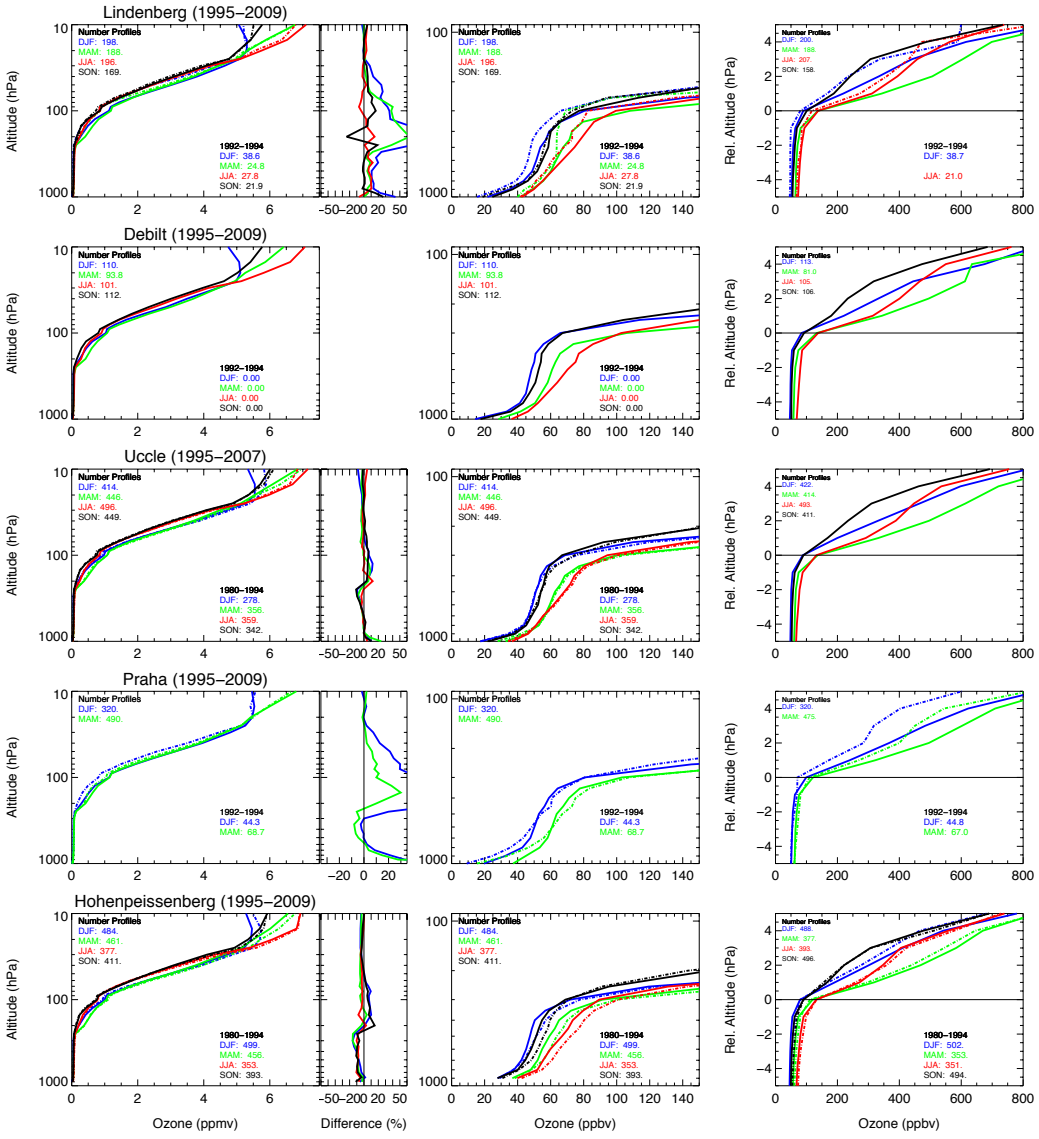

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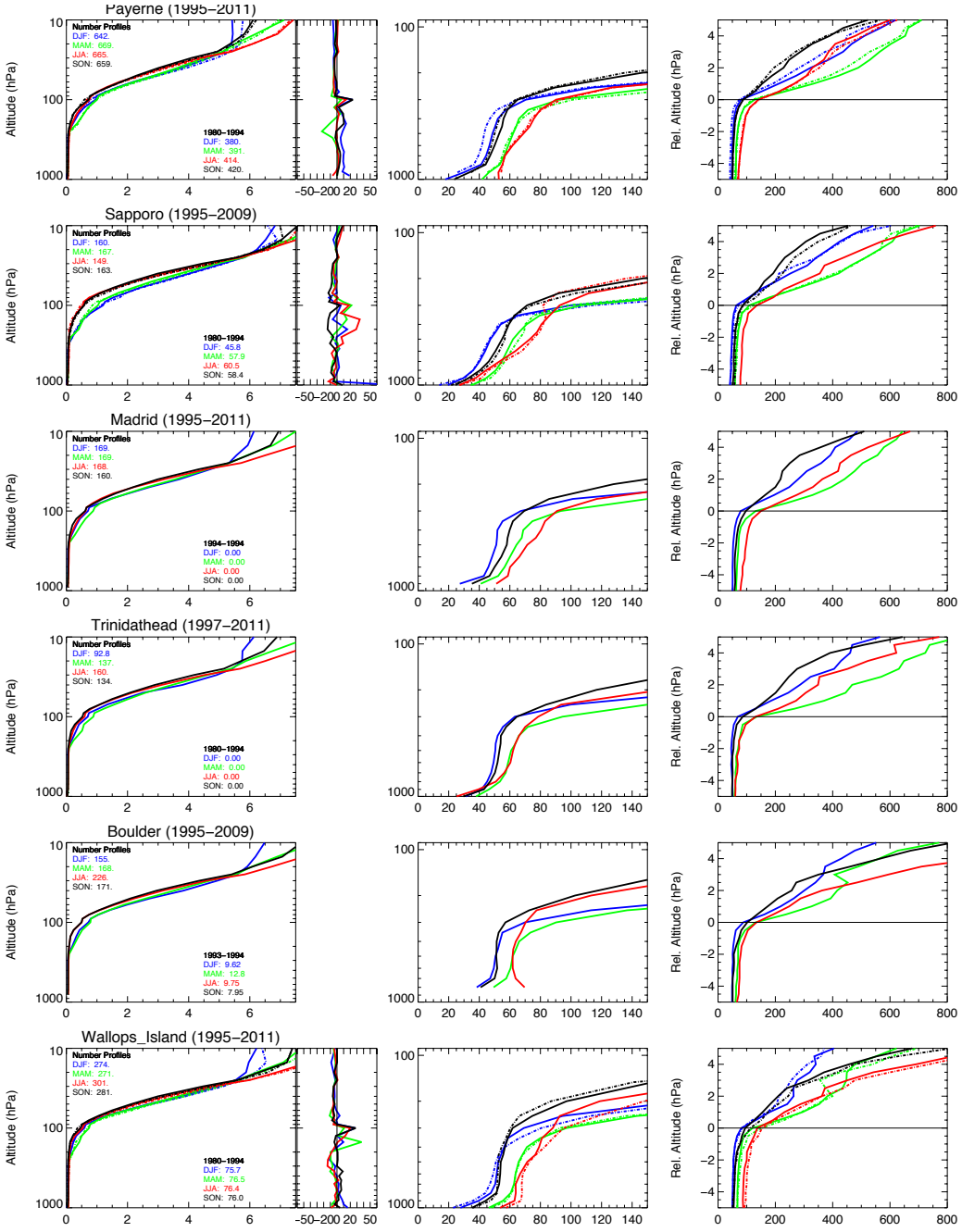

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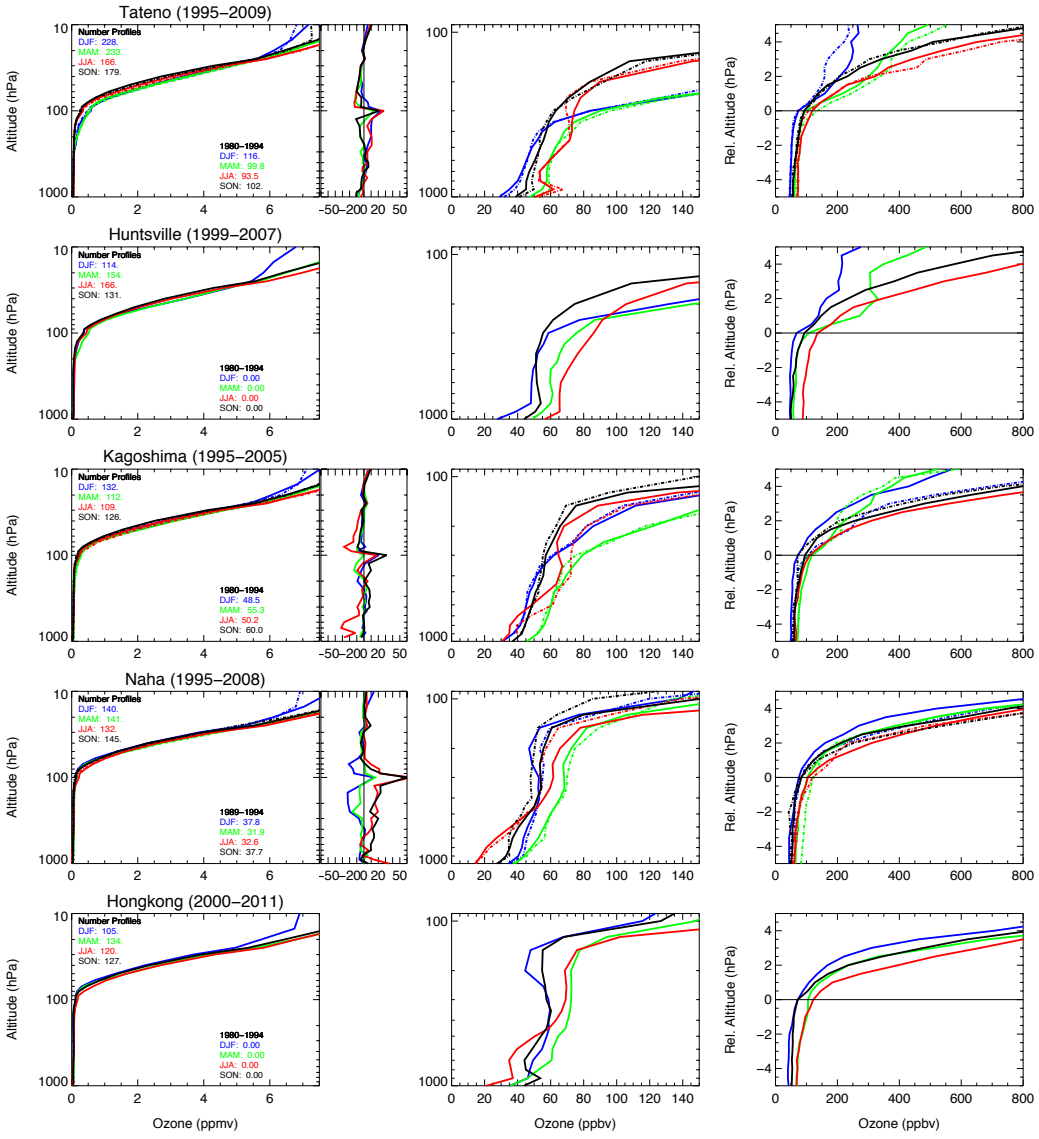

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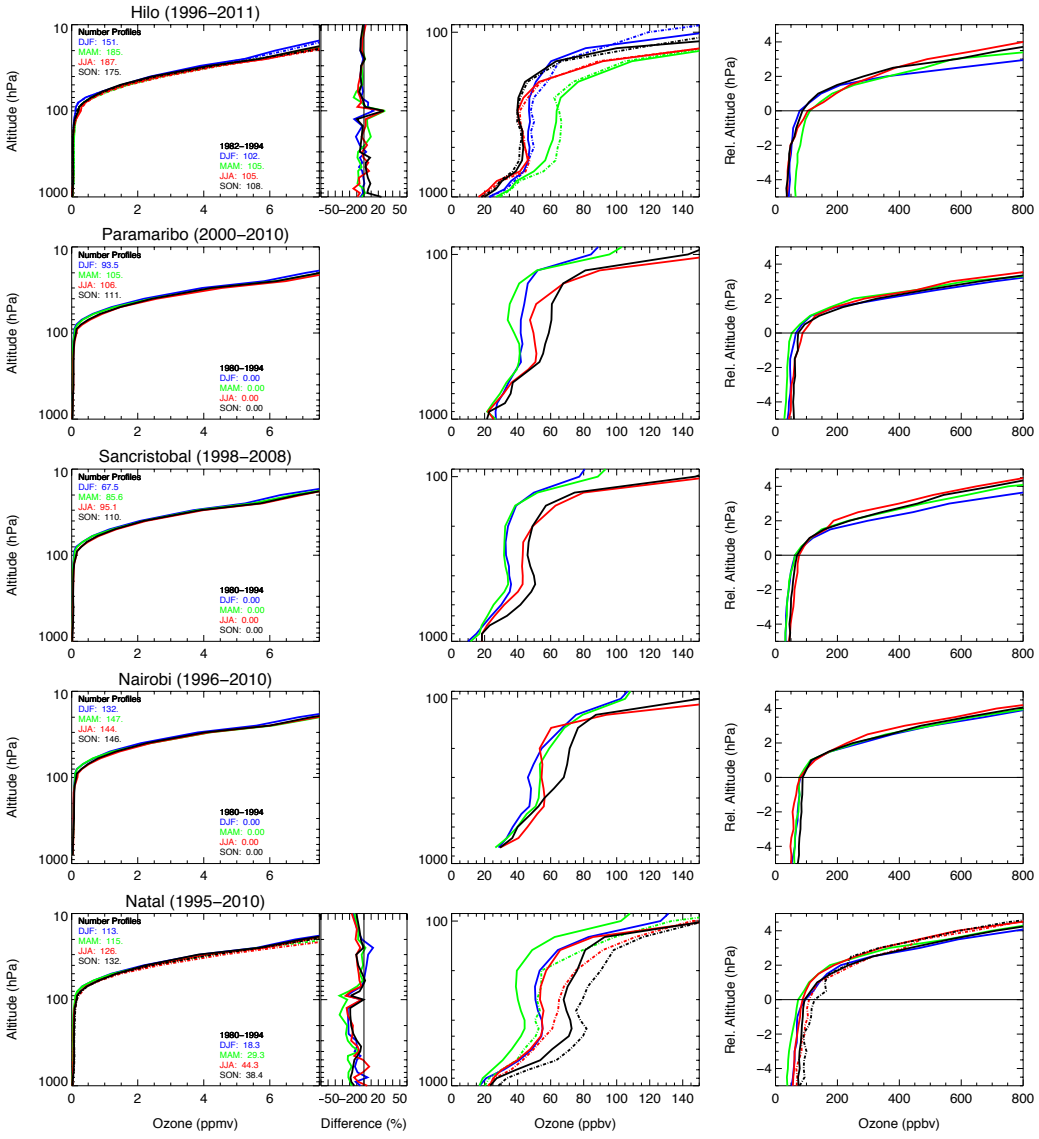

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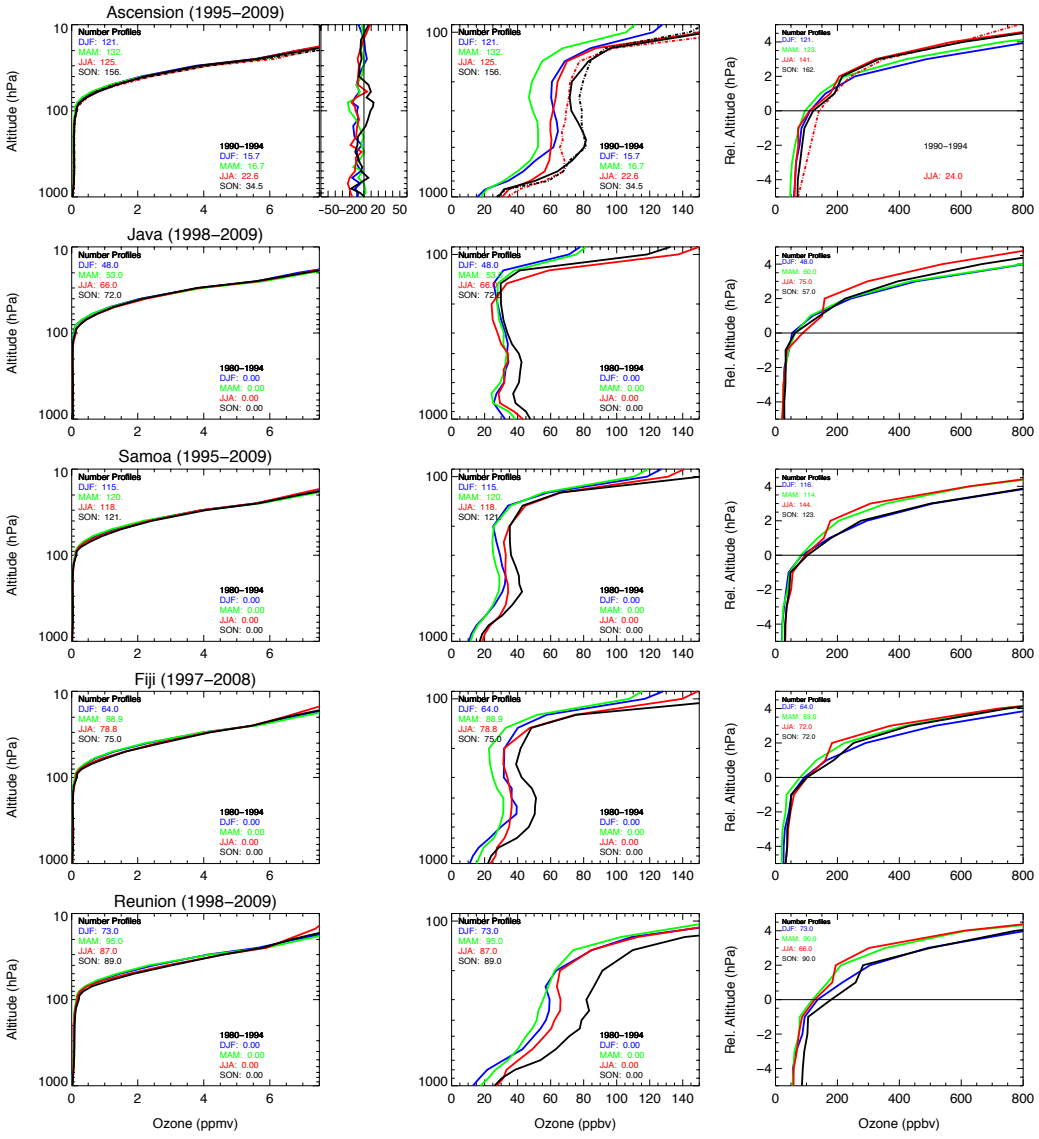

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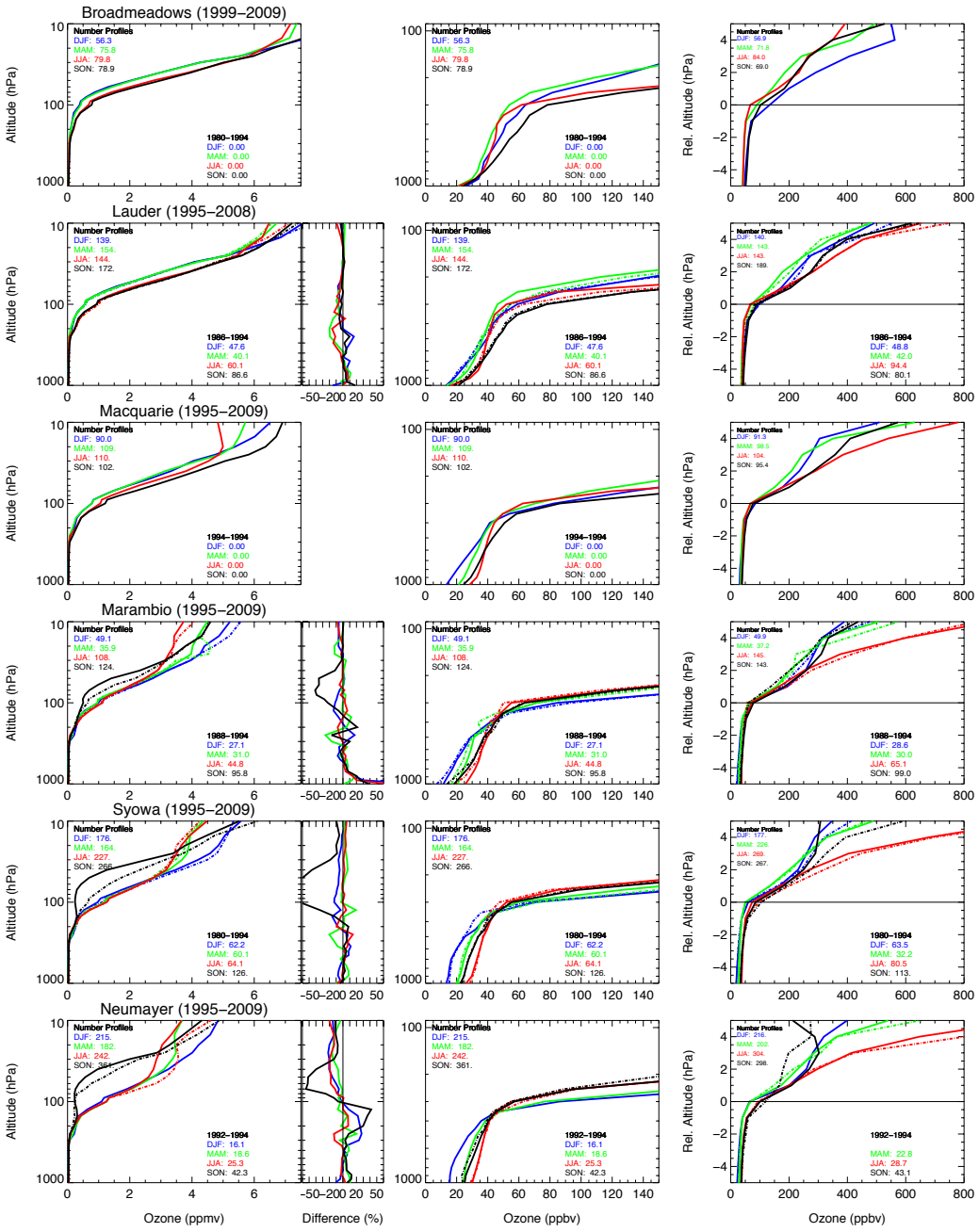

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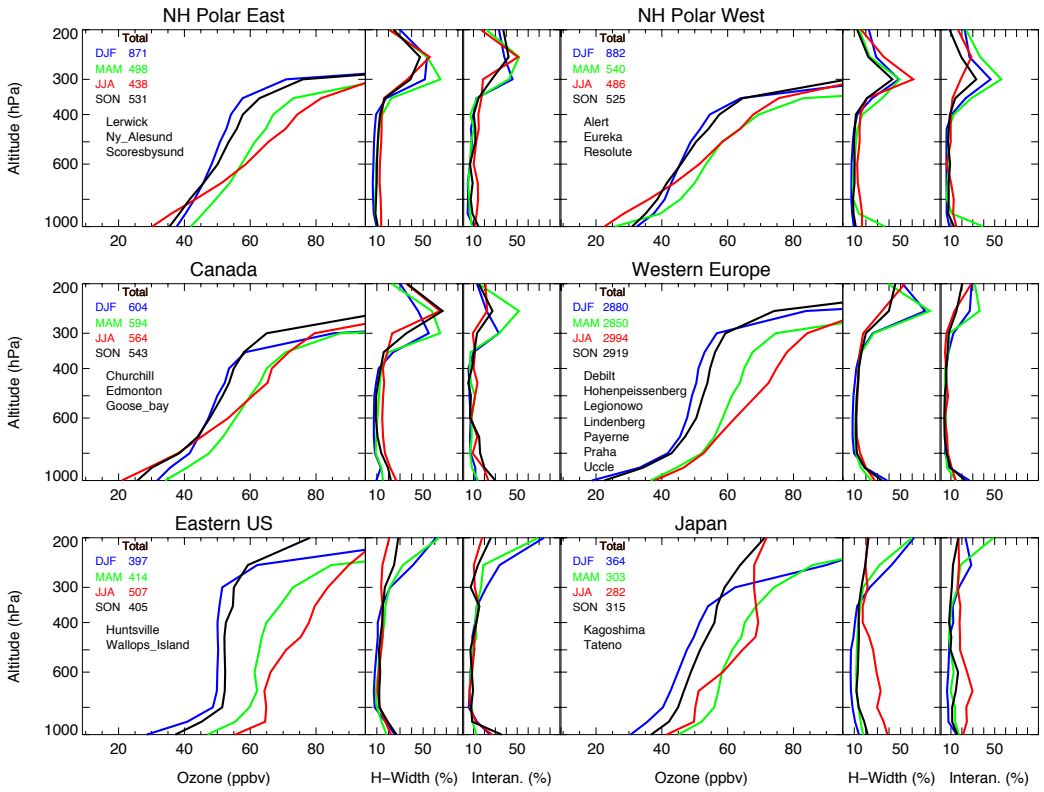

Fig. 6: Altitude distributions (median) of ozone soundings averaged for different seasons and regions in the Northern Hemisphere between 1995 and 2011. Different colors indicate different seasons. The total number of profiles used for each season and region is shown on the top left of each panel. The stations entering the profiles are noted in the lower right of each panel. The half-width of the distribution (left) and the interannual variability (right) of each averaged profile are illustrated on two sub-plots on the right of each panel. The half-width of the distribution is defined here as the range of the 25th and 75th percentile of the regionally-aggregated ozone distribution (calculated as: (75th percentile - 25th percentile)/2). The interannual variability is defined as the range of the 5th and 95th percentile of the annual median ozone value (calculated as: (95th percentile - 5th percentile)/2) for all seasons and regions.

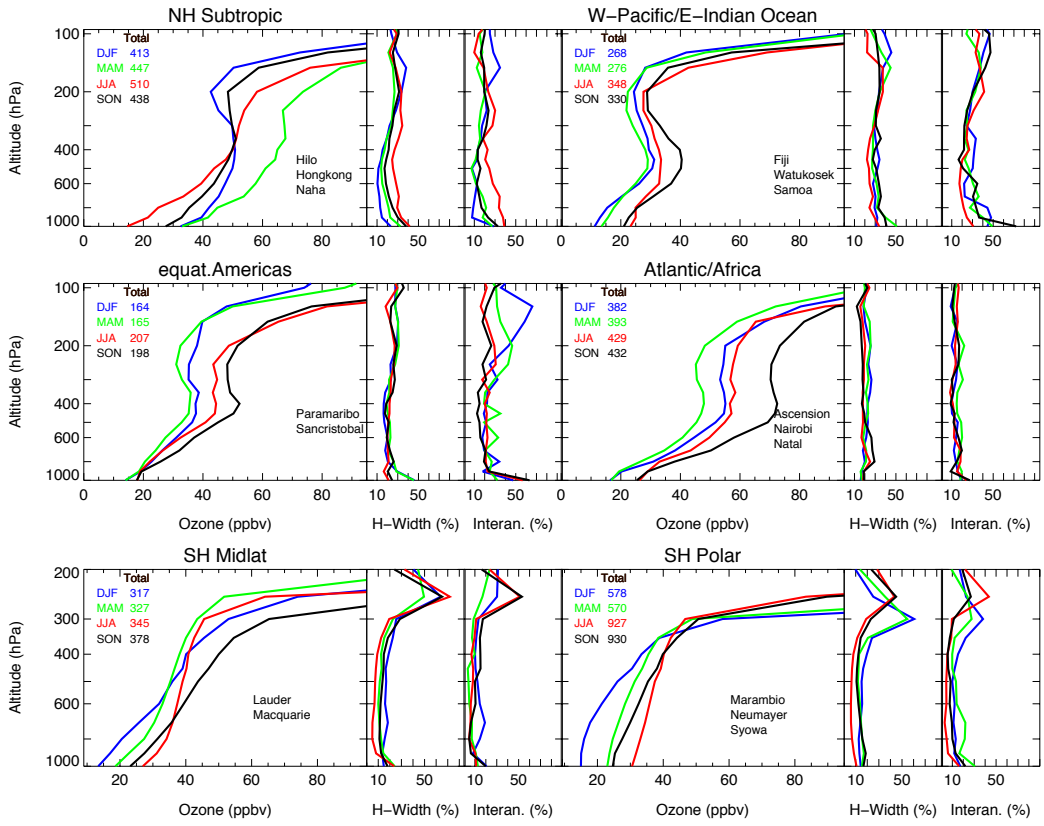

Fig. 7: As Figure 6, but showing regions in the tropics and the Southern Hemisphere.

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