Referee 2:

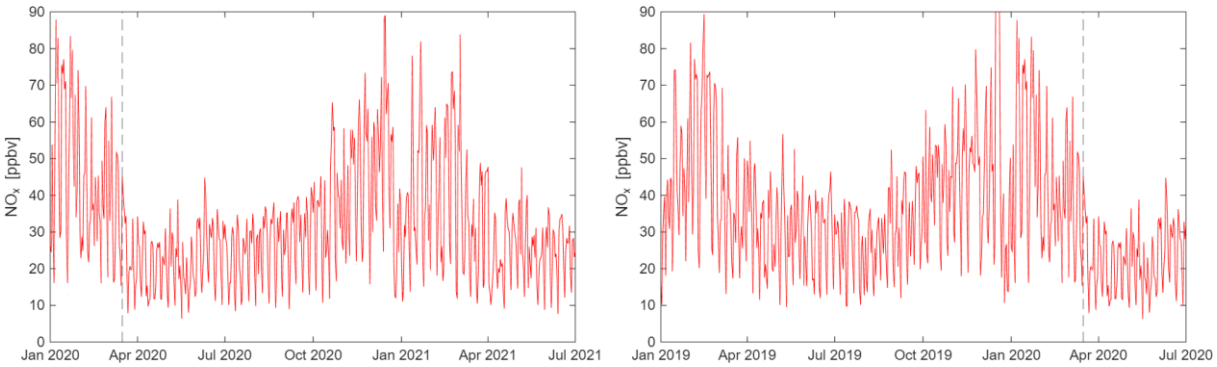
In this work, approximately two decades of oxidant measurements from a network of ground sites across Switzerland are analyzed to better understand the state of ozone formation chemistry across the region. Although the data streams are relatively simple, the analysis appears thorough and the analytical approach with respect to characterizing mechanistic sensitivities is appropriate for the target journal. This work is of clear importance in advancing the state of knowledge of air quality drivers in Switzerland and has broader implications for advancing the field of ozone and NOx chemistry characterization from ground-based measurements. I particularly commend the authors for a very clearly communicated and easy to follow manuscript which was a real pleasure to read. I believe that this work will be appropriate for publication once the following comments have been addressed:

We thank Referee 2 for taking the time to review our manuscript and for their positive feedback.

General Comments:

Some societal and historical phenomena which have great potential significance for analyses here described, specifically those related to traffic patterns, are not sufficiently addressed and should be considered (similarly to relevant phenomena around fuel standards and events such as Dieselgate, which are well discussed). Specifically, I request that the authors discuss changing work patterns (specifically increases in hybrid and remote work), which could be contributing significantly to changes in the weekend vs weekday phenomena here discussed. Is there available traffic data to demonstrate that the relative week day vs weekend number of vehicles on the road has remained constant? I would also request that the authors specifically address the COVID-19 pandemic and related changes in economic activity, which have been extensively studied as significant perturbations of normal traffic and emissions patterns across the world. I do not have sufficient local knowledge to comment on how policies may have impacted the regions in question, but the possibility of a perturbation should be acknowledged and assessed even if there is evidence that it was negligible and therefore ruled out.

We thank the referee for this suggestion. While the COVID-19 measures in Switzerland were generally more moderate compared to neighboring countries, changes in the mobility behavior can be observed in response to the pandemic. Due to the relatively short duration of the implemented measures, the response in precursor levels was rather small, particularly when investigating yearly summertime averages. According to the Swiss Federal Statistical Office the reduction in passenger transport was largest in aviation (~75% reduction in 2020) followed by railway transport (~35% reduction). Private motorized road transport declined by around 20%. All types of passenger transport increased again after 2020. Minor impacts in NO_x levels can be seen when comparing data from 2020 with 2019 (pre-COVID):



The left panel shows NO_x levels between January 2020 and July 2021; the right panel shows the previous year. The dashed lines indicate the legislative measure in Switzerland on 16th March 2020: Federal Council declares the 'extraordinary situation', followed by measures to decelerate the spread of the COVID-19 virus. Between the beginning of these measures and their relaxation approximately two months later (e.g. re-opening of schools on 11th May), NO_x mixing ratios were 22 ± 14 ppbv at traffic sites compared to 32 ± 21 ppbv in the previous year. In comparison, the difference was much smaller in the following three summer months with 24 ± 14 ppbv and 28 ± 16 ppbv, respectively. Overall, the NO_x reductions are visible both at traffic and (sub)urban stations with larger values in 2019 and 2021, than 2020. However, the difference is in the range of the observed year-to-year variability for other years.

According to a study of the Swiss Federal Statistical Office, the pre-pandemic share of hybrid or remote work was around 25%, peaked during the pandemic (~40%) and stabilized afterwards with around 37%. However, at the same time, the population in Switzerland is increasing by around 1% each year, and the number of private motorized vehicles has increased from 3.5 Mio. in 2000 to 4.8 Mio. today. The number of traffic congestion hours on national roads has continuously increased since the Covid pandemic and was approximately twice as high in 2024 compared to pre-Covid levels.

We have added a discussion of these aspects to the manuscript.

Lines 201 ff.: The COVID-19 pandemic led to governmental measures to decelerate the spread of the virus and resulted in decreases in primary pollutants in many countries (Gkatzelis et al., 2021). While the lockdown measures in Switzerland were overall more moderate in comparison to the European average, reductions of around 20 % in private motorized road transport in 2020 compared to 2019 were reported by the Swiss Federal Office of Statistics (Bundesamt für Statistik BFS, 2024, 2025b). On March 16, 2020 the Swiss federal council announced an "extraordinary situation" and introduced measures to contain the pandemic, which lasted approximately two months (Schweizerischer Bundesrat, 2020). For this time period, we observe reductions in NO_x mixing ratios by around 1/3 in comparison to the previous year. The reduction was only around 10-15 % in the following summer months. NO_x summertime averages were lower in 2020 compared to 2019 and 2021 at traffic and (sub)urban sites, which could be an outcome of the COVID-19 measures. However, the difference is in the range of the observed year-to-year variability for other years. Further aspects, which could impact the decadal NO_x trend are changes in hybrid and remote work, for which the Swiss Federal Statistical Office reported an increase from around 25 % for pre-COVID years to 37 % in recent years (Bundesamt für Statistik BFS, 2025a). However, the population in Switzerland is currently increasing

by around 1 % per year and the number of private motorized vehicles has increased from around 3.5 million in 2000 to 4.8 million today (Bundesamt für Statistik BFS, 2024). The number of traffic congestion hours on national roads has continuously increased since the COVID-19 pandemic and was approximately twice as high in 2024 compared to pre-pandemic levels (Bundesamt für Strassen ASTRA, Fachbereich Verkehrsmanagement, 2025).

I would also request that the authors comment, even if briefly, on continuity and quality assurance related to drift corrections in the main text of the paper, as any potential instrument drifts or instrument changes over such a long stretch of time would have significant potential to bias results.

The instruments are calibrated and zero point corrected on a regular basis to ensure the quality of the long-time measurements. Drifts are monitored and corrected for. We have added some text in the manuscript to highlight this important point.

Lines 137 ff.: The instruments are zero point corrected every four weeks. The maximum four-week zero point drifts are ± 0.2 ppbv for NO_x and ± 0.3 ppbv for O_3. Span calibrations of the NO_x instruments are also performed every four weeks. For O_3, span calibration requires the use of a transfer photometer, which is deployed twice a year (in April and September) at each site. Drifts of the O_3 instruments are corrected when the response deviates more than ± 2% of the calibration gas concentration.

Line 112: please clarify what differentiates the background sites from the rural sites, as the current background definition states that the sites are rural? Is this low elevation rural sites vs high elevation rural sites? If so why was this differentiation selected?

Yes, the referee is correct that background sites are defined as rural sites above 1000m altitude (as stated on line 126). With a low elevation the rural sites are continuously located within the boundary layer and therefore represent localized photochemical processes at sites, which are negligibly impacted by anthropogenic pollution sources. Due to the elevation of the background sites, they capture local photochemistry but are also impacted by the free troposphere and can indicate if European background conditions have changed over time and might dominate the observed processes. We have revised the manuscript to clarify the differences between rural and background sites.

Lines 130 ff.: We differentiate between rural sites at low and high elevations to capture the local photochemistry at sites with negligible anthropogenic pollution versus conditions which are impacted both by local processes as well as free tropospheric impacts due to the influence of the residual layer.

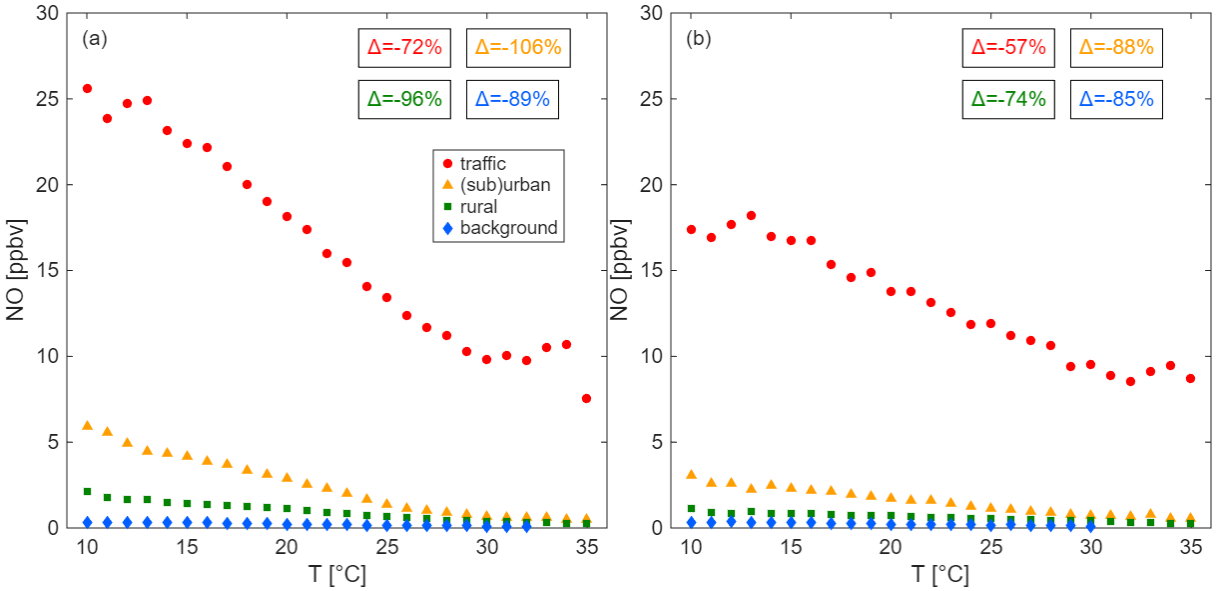
Line 118: Can you please comment on the potential interferences of VOC cross sensitivity for the UV-absorption method of ozone measurement? How were these either determined to be negligible or corrected for?

The interference from aromatic compounds, which possess absorption maxima near the 254 nm O_3 band, is known. The UV-absorption instruments used at the NABEL sites comply with the EN standard EN14625, which mandates a maximum interference of 1% for mixing ratios of 500 ppbv toluene and m-xylene. In Switzerland, total mixing ratios of BTEX (benzene, toluene, ethylbenzene and xylenes) and other aromatic compounds have remained well below 5 ppbv since

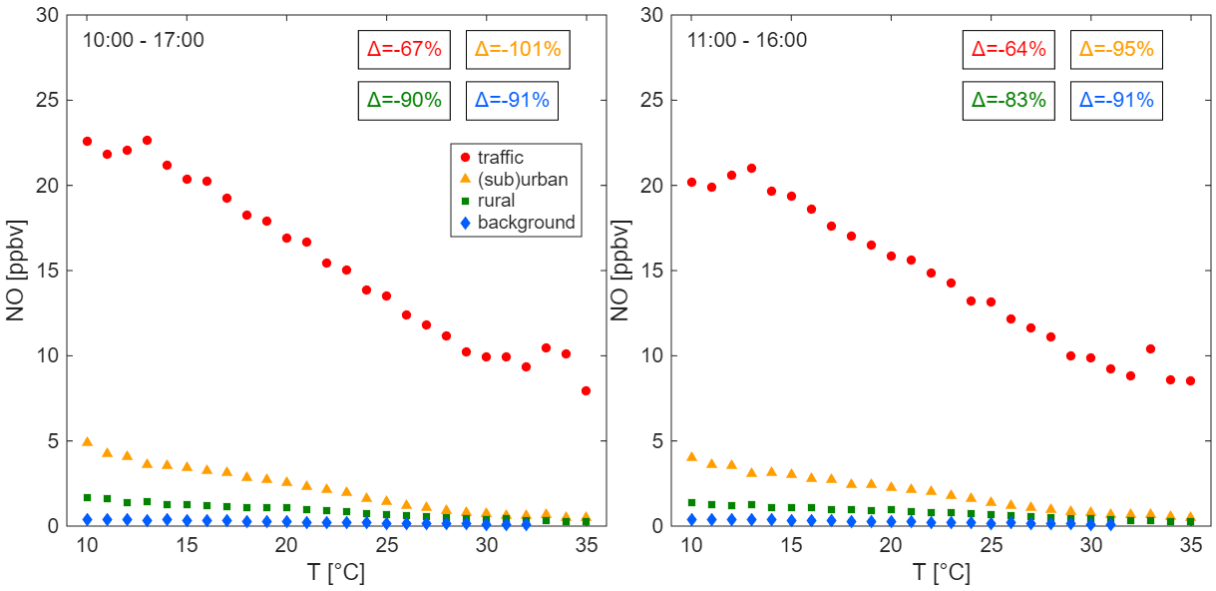
2000 (Le Bras et al., 2026, doi: 10.5194/acp-26-869-2026). Therefore, the interference from aromatic compounds is negligible.

Line 303: Please add additional evidence for the assertion that boundary layer height variability is minimized in the selected time area such that dilution is not the most likely explanation for the observed temperature effect on NOx. I understand the argument around hours after sunrise, but I would appreciate additional analysis to support ~2 hours after sunrise being sufficient to reduce the importance of this effect given the significant lag between light, and temperature and BLH and the importance of surface temperature in driving BLH dynamics.

We have investigated the NO-temperature correlation at 13:00-15:00 local time (radiation peaks at 14:00 local time), when we do not expect any significant diurnal changes in the boundary layer height, in comparison to the 09:00-18:00 data:

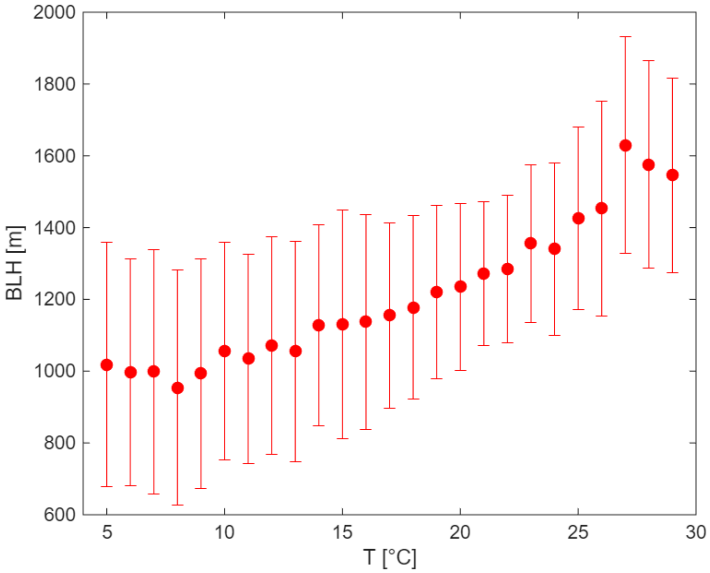


Panel (a) shows the 09:00-18:00 data and panel (b) presents the NO-temperature correlation for the 13:00-15:00 data. The figure shows that the temperature dependence of NO persists at all sites when eliminating the diurnal variability of the BLH. At the same time, the correlation decreases by around 15-20% (a bit less at background sites). While this could be an indication for the diurnal BLH variability affecting a part of the NO-temperature dependence, the 13:00-15:00 data eliminates NO emitted during the morning rush hour when temperatures are generally lower. Shortening the daily time window to ~3 and ~4 hours after sunrise and before sunset does not strongly affect the observed correlation (e.g. for traffic sites from -72% (09:00-18:00) to -67% (10:00-17:00) to -64% (11:00-16:00):



We therefore suggest that the chosen cut-off at 09:00 and 18:00 is a good trade-off between the diurnal BLH variability and the statistical robustness of our analysis.

Having said that, we will generally not be able to fully eliminate the impact of the BLH, as we expect a day-to-day BLH variability besides the diurnal BLH changes. We have investigated ERA5 reanalysis data of the BLH across Switzerland:



This figure shows the daily boundary layer height at 2pm binned to temperature (average across Switzerland). The resolution of the dataset is 0.25°x0.25°, which cannot resolve the topography of Switzerland. However, it can provide an estimation of the BLH-temperature correlation, which is strongly positive and solely results from the day-to-day variability.

We have added the NO-T correlation at 09:00-18:00 vs 13:00-15:00 and the BLH-T correlation to Figures S12 and S11 of the Supplement, respectively, and clarified these important aspects in the manuscript.

Lines 358 ff.: Figure S11 presents the BLH-temperature correlation across Switzerland, based on ERA5 reanalysis data of the daily summertime BLH and the 2m-temperature at 14:00 local time. While the resolution of the ERA5 data (0.25°x0.25°) is not sufficient to resolve the topography of Switzerland, it provides an estimation of the BLH-

temperature correlation. The positive correlation supports our theory that dilution effects could impact the temperature correlation of trace gases and that the day-to-day variability of the BLH is significant.

and

Lines 362 ff.: We observe a 15-20 % decrease in the NO-temperature correlation when eliminating diurnal BLH changes (Figure S12). While this observation could highlight the impact of BLH variations throughout the day, it could also indicate that a part of the NO-temperature correlation results from NO emissions during the morning rush hour, which is usually accompanied by lower temperatures.