

Overview:

Liao et al. conducts a detailed case study, accompanied by a longitudinal observational assessment, of lofted foehn impacts on surface ozone through boundary layer modifications in Beijing during the summer. In doing so, the authors utilize various observational datasets including ground-monitoring and lidar ozone measurements, radar wind profiles, and radiosondes. The authors focus on ozone and winds before and after a single lofted foehn event (occurring overnight on August 29) that doesn't result in surface warming as typical foehn events. The authors also assess back trajectories and conduct WRF-chem simulations to confirm elevated foehn impacts on residual layer warming. Finally, a climatological analysis of radiosonde data from 2015 – 2024 reveals that elevated foehn winds caused 87% of identified nocturnal residual layer warming ($n = 63$, 6.85% of summer nights) with elevated surface ozone concentrations the next day after every one of the events. The work mainly concludes elevated foehn increase surface ozone concentrations through three mechanisms: 1) increasing boundary layer temperature leading to increased ozone production; 2) reduction of residual/boundary layer height causing a subsequent decrease in ozone vertical diffusion; and 3) slowing boundary layer winds resulting in reduction of horizontal dispersion.

Major comments:

The paper effectively uses observations to characterize foehn influence on the nocturnal residual layer and traces those impacts through to the following day's convective boundary layer. The associated layer changes (increased temperature, reduced boundary layer height, and weaker winds) are well documented in both observations and model simulations. However, the physical justifications for mechanisms 1 and 3 warrant further support and considerations of nuances.

Reply: Thank you very much for your positive comments. We have carefully considered your suggestions, and made corresponding revisions and clarifications accordingly.

Regarding mechanism 1, the authors use changes in ozone, which is a function of production and loss, both of which can be independently impacted by temperature. While elevated temperatures are known to enhance ozone production, temperature also modulates chemical loss pathways and this is not addressed. Reduced PAN transport into the study region (due reduction in vertical mixing as mentioned in mechanism 2), could suppress ozone loss and independently contribute to the observed surface ozone increases. The current attribution of higher ozone concentrations solely to enhanced production is incomplete. The paper would benefit from discussion of temperature-sensitive loss processes, or at minimum acknowledgement of them as a potential contributing factor.

Reply: Thank you for your thoughtful comment. We agree that the discussion of temperature-sensitive processes was one-side in our original manuscript. In the revised version, we expanded our analysis and discussion to address this point as follows.

“As observed, the afternoon boundary layer temperature on 30 August showed a significant increase compared to the previous afternoon, and this higher temperature further promotes photochemical O₃ production by accelerating photochemical reaction rates and enhancing emissions of volatile organic compounds and soil nitric oxide (Gu et al., 2020; Wu et al., 2024). Thus, in addition to promoting daytime O₃ accumulation by reducing the boundary layer height, residual layer warming also enhances daytime photochemical O₃ production. Moreover, these changes in boundary layer thermal properties can facilitate O₃ accumulation by lowering O₃ loss. For instance, the lowered CBLH can reduce the transport of PAN (peroxyacetyl nitrate, a NO_x reservoir in the upper atmosphere) into urban Beijing (a NO_x-saturated zone), which may suppress O₃ loss from NO titration and independently contribute to the observed O₃ increases (Flowerday and Hansen, 2026).” **Lines: 231-239.**

Mechanism 3 is more directly supported by the observations, though a brief clarification would strengthen it specifically, whether the reduced boundary layer winds are an elevated foehn-driven signal or a signature of the converging synoptic systems (specified on page 6) within which the foehn occurs.

Reply: Thank you for this constructive comment. It is difficult to define this point, as the elevated foehn identified in this study is also a local manifestation of converging synoptic systems. Our observations indicated that the post-foehn convergent stagnation (i.e, the reduced boundary layer winds) results from the confrontation between the emerging northwestern foehn winds and the prevailing southwestern winds within the boundary layer. We thought that relatively strong boundary-layer southwesterly winds serve as a necessary prerequisite for the occurrence of elevated foehn in summer Beijing, as they inhibit the intrusion of shallow foehn toward plain areas and, in turn, force the foehn to develop upward. During this “inhibit” process, the confrontation between the opposite-direction winds lead to reduced boundary layer winds and elevated foehn aloft in tandem.

We clarified this point in **Lines: 435-442.**

Specific comments:

Figure 7c seems to have the middle hollow marker (~06, 2024-08-30) cut off. Also, please include time zone (e.g. local time vs UTC) as well as for other time relevant plots (e.g. Fig 6).

Reply: Thank you for pointing it out. The software of MATLAB R2016b cut off some markers in their output figures. In the revision, we re-plotted our figures using an updated MATLAB version (R2020a). Also, we included time zone (i.e., Beijing Time) for relevant plots.

Figure 10b is missing longitude and latitude coordinates.

Reply: We added the longitude and latitude coordinates in Figure 10b.

Figure 11b seems to have a cut off marker in the fourth box-whisker.

Reply: We re-plotted this figure using an updated MATLAB version.

For all site-relevant figures, it would be helpful to delineate the specified sites (CXT, SDZ, and YQ); e.g. Figure 3b and c and Figure 12.

Reply: Thank you for your suggestions. We marked the specified sites in relevant plots, e.g., Figure 3b and c and Figure 12.