Response to Reviewer #1

The authors have carefully revised the manuscript and have addressed most of my previous concerns. In particular, the study is now more appropriately framed as an investigation of PM2.5/O3 responses to NOx–VOC precursor perturbations rather than a comprehensive emission-control assessment. The authors have also clarified the definition of aerosol–meteorology feedback, unified the O3 units, added a threshold-sensitivity analysis, included additional cloud and meteorological diagnostics, quantified changes in DHP elimination, and more clearly acknowledged the single-month scope of the study. These revisions have substantially improved the clarity and scientific balance of the manuscript. I believe that the manuscript can be considered for publication after the following relatively minor issues are addressed.

Reply: We thank the reviewer for the positive assessment and constructive comments. We have revised the manuscript accordingly. All changes are listed below and marked in the revised manuscript.

Comment 1

The new text appropriately states that EXP_W–EXP_WO represents a combined response to the chosen aerosol-coupling perturbation. However, the preceding statement that EXP_WO "excluded both ARI and ACI" remains too definitive. Prescribing CDNC at 10 cm−3 replaces aerosol-dependent cloud activation with an idealized fixed-CDNC configuration. It is not equivalent to simply switching off ACI. Please revise this description and consistently refer to the diagnosed quantity as the combined response to an idealized aerosol-coupling perturbation. The use of a clean-marine CDNC value over continental BTHS should also be explicitly identified as a methodological limitation.

Reply: We thank the reviewer for this correction and agree that our previous wording was too definitive. Prescribing a fixed CDNC does not switch off ACI; it replaces aerosol-dependent cloud activation with an idealized maritime microphysical state. We have revised the description in Sect. 2.3 and Table 1, and now consistently refer to the diagnosed quantity as the combined response to this idealized aerosol-coupling perturbation. The use of a clean-marine CDNC over continental BTHS is explicitly identified as a methodological limitation.

Changes in manuscript:

The first paragraph of Section 2.3 has been revised to:

"Two parallel sets of numerical experiments were conducted for July 2020 with a 5-day spin-up time (Table 1). The first experiment set (EXP_W) accounted for the full interaction between aerosols and meteorology including both ARI and ACI. The second experiment set (EXP_WO) replaced this full interaction with an idealized configuration: ARI was disabled by removing aerosol effects on radiation in the RRTMG scheme, and aerosol-dependent cloud activation was replaced by prescribing a fixed cloud droplet number concentration (CDNC) of 10 cm^{-3} in the Morrison double-moment cloud microphysics scheme (Zhao et al., 2017; Zhang et al., 2018; Xiong et al., 2025; Zhao et al., 2026b), a value consistent with satellite observations of clean marine liquid clouds (Bennartz, 2007; Zeng et al., 2014). Note that a fixed CDNC is not equivalent to switching off ACI: it replaces aerosol-dependent activation with an idealized clean-cloud microphysical state. Applying clean-maritime CDNC to the polluted continental BTHS region is therefore a methodological limitation of this design. Because EXP_WO differs from EXP_W simultaneously in ARI, cloud microphysical state, and subsequent meteorological evolution, the diagnosed feedback is hereafter referred to as the combined response to this idealized perturbation."

In Table 1, the aerosol-meteorology interaction entry for EXP_WO is changed from "Off" to "Idealized", and its description is revised from "without aerosol-meteorology interaction" to "ARI removed and CDNC prescribed at 10 cm^{-3}" as follows:

Table 1 Summary of WRF-Chem numerical experimental design.

Experiment Group	**Emission Scenarios**	**Aerosol-meteorology interaction**	**Description**
EXP_W	Baseline and 35 Sensitivity Matrix (36 scenarios)	On	with full aerosol-meteorology interaction
EXP_WO	Baseline and 35 Sensitivity Matrix (36 scenarios)	Idealized	ARI removed and CDNC prescribed at 10 cm^{-3}

Comment 2

The revised discussion argues that relative responses and internally consistent classification limit the influence of model biases. This is reasonable, but absolute model biases can still affect which grid-days meet the DHP thresholds and how samples are

assigned to meteorological classes. Please revise the statement and acknowledge that the effects of the PBLH, wind-speed, and O3 biases on sample membership and regime classification were not fully quantified.

Reply: We agree that while relative responses and the internally consistent classification limit the influence of the documented biases on type-to-type contrasts, absolute biases in PBLH, wind speed, and O3 can still affect DHP sample membership and regime assignment. We have revised the statement to acknowledge this explicitly.

Changes in manuscript:

We have added the following sentences to the end of Section 3.1.

"Nevertheless, absolute biases in PBLH, wind speed, and O_3 can still affect which grid-days meet the DHP thresholds and how samples are assigned to the meteorological condition types. These effects on sample membership and regime classification were not fully quantified and are acknowledged as a limitation of this study."

Comment 3

The response letter states that O3 formation is "entirely governed by NOx–VOC chemistry" and that the other emitted species are "photochemically inert, thus not influencing O3." These statements are too absolute because aerosols and other species can affect O3 through photolysis, heterogeneous chemistry, and radical chemistry. It would be more accurate to state that NOx and VOCs are the dominant controllable precursors considered in this study and that holding other emissions fixed isolates the targeted NOx–VOC sensitivity.

Reply: We thank the reviewer for this correction and agree that our previous statements were too absolute. NOx and VOCs are the dominant precursors considered in this study and holding all other emissions fixed isolates the targeted NOx–VOC sensitivity. Other emitted species (SO_2, BC, OC, primary PM, and NH_3) and aerosols can still influence O_3 through photolysis, heterogeneous, and radical chemistry. Because their emissions are unchanged across scenarios, these pathways are held approximately constant and constitute the background conditions rather than part of the diagnosed NOx–VOC sensitivity. We have revised the corresponding clarification to Section 2.3.

Changes in manuscript:

In the second paragraph of Section 2.3, the sentence "Other emitted species (SO_2, BC, OC, primary particulate matter, NH_3) are held at baseline levels to avoid

confounding the NOx–VOC sensitivity signal." has been revised to "Other emitted species (SO_2, BC, OC, primary particulate matter, NH_3) are held at baseline levels. Although these species and aerosols can still influence O_3 through photolysis, heterogeneous, and radical chemistry, they are not the dominant precursors considered here, and keeping their emissions unchanged holds these pathways approximately constant across scenarios, thereby isolating the targeted NO_x–VOC sensitivity signal."