

1 Dear Referee #1,

2 Thank you for your helpful comment. Previously, constrained by simulation uncertainties, we avoided numerical specifics and
3 emphasized qualitative descriptions. Adding quantitative detail indeed helps readers grasp the model's performance and
4 limitations more intuitively. While preserving scientific rigor, we have accordingly inserted additional quantitative information
5 on the scattering simulation wherever possible.

6 These additions include:

7 (1) The magnitude of simulated scattering biases (horizontal differences);

8 (2) The relative changes in LOS speed among different directions;

9 (3) The relative changes in simulated scattering biases under different experimental conditions.

10 These revisions are concentrated in the Abstract, Discussions, and Conclusions, with additional supporting statements added
11 to the Results. Below we list the key revisions, highlighted in purple.

12 **Comment:**

13 *In ground-based optical observations, accurately understanding effects of the scattering is a significant concern that has been*
14 *highlighted for decades. Despite this long-standing recognition, our comprehension remains largely qualitative. The*
15 *quantitative analysis presented in this study could offer valuable new insights, yet there are notable discrepancies between the*
16 *simulation and measured results. Additionally, the study indicates that verifying effects beyond scattering is not feasible. These*
17 *factors obscure the extent to which this research has enhanced our previous understanding at a qualitative level. I believe*
18 *novelty of the study lies in advancing quantitative understanding, so please elaborate on this aspect more specifically. While*
19 *the current text contains the desired content, a clearer expression of its novelty would improve the paper. For instance, revising*
20 *the following points could enhance the overall quality.*

21 *“With fixed initial speeds, the simulation reproduced the temporal characteristics of the atypical winds, demonstrating that*
22 *scattering may contribute to these intense horizontal differences and downwelling. The simulation also shows that the*
23 *scattering-induced biases have directional inhomogeneity with characteristics linked to the location and background line-of-*
24 *sight speed of the brighter airglow region. The accuracy of the simulation is limited by the accuracy of airglow observations*
25 *and atmospheric optical depth.”*

26 *To emphasize the novelty in this field or to differentiate from our previous level of understanding, I believe it is crucial to*
27 *present results in a more quantitative manner rather than a qualitative one. In the abstract, I selected these sentences because*
28 *they contain potential information that highlights the novelty of this study. By revising them to include more qualitative details,*
29 *such as the possible percentage contribution of the scattering process, more specific information on directional inhomogeneity,*
30 *and additional data from other measurements that we can enhance the simulation quality in future work. Although the word*

31 *limit in the abstract makes it challenging to accommodate all my requests, please attempt to revise these points by*
32 *incorporating more quantitative information. In the text, it is beneficial to emphasize the novelty by adding these points, even*
33 *though some are already mentioned but dispersed throughout the text.*

34 **Key revisions:**

35 **(1) added the simulated horizontal-difference magnitudes:**

36 **L18 (Abstract)** “With fixed initial speeds, the simulation reproduced the temporal characteristics of the atypical winds,
37 demonstrating that scattering may contribute to these intense horizontal differences and downwelling.” **to** “With fixed initial
38 winds ($100 \text{ m}\cdot\text{s}^{-1}$ westward, $400 \text{ m}\cdot\text{s}^{-1}$ southward, zero vertical wind), the simulation reproduces horizontal differences of
39 approximately $400 \text{ m}\cdot\text{s}^{-1}$ on May 10th and $100 \text{ m}\cdot\text{s}^{-1}$ on Oct 10th, both capturing the temporal characteristics of the atypical
40 winds.

41 **Similar details have been added to L459 (Conclusions).**

42 **(2) added the relative changes in LOS speed among different directions:**

43 **L20 (Abstract)** “The simulation also shows that the scattering-induced biases have directional inhomogeneity with
44 characteristics linked to the location and background line-of-sight speed of the brighter airglow region.” **to** “The simulation
45 shows that scattering-induced biases on line-of-sight speed take their sign from the brighter region, while their magnitude
46 varies directionally with the angle to that region: at 45° elevation, biases $135\text{--}180^\circ$ azimuth away exceed those in the brighter
47 region by more than 10 times.”

48 **L346 (Discussions 4.1)** “The northward LOS speed changes slightly, the southward speed changes the most and nearly
49 reverses, while the eastward and westward speeds are intermediate.” **to** “Across all azimuths, the changes of LOS speed share
50 the same sign, but their amplitude scales with the angle to the northward direction. Relative to the roughly $300 \text{ m}\cdot\text{s}^{-1}$ LOS
51 speed change in the southward direction, the eastward and westward directions each attain about 60 %, whereas the northward
52 variation remains below 10 %. The scattering model shows LOS speed changes in dimmer airglow regions are more than 10
53 times those in the brighter zone.”

54 **(3) added the relative changes in simulated scattering biases under different experimental conditions**

55 **L22 (Abstract)** “The accuracy of the simulation is limited by the accuracy of airglow observations and atmospheric optical
56 depth” **to** “Limited by uncertainties in airglow images and optical depth of model inputs, the simulation incurs numerical errors
57 of roughly 75 % during some periods. Effective correction of the scattering impact will require improved accuracy of model
58 inputs in the future.”

59 **L396 (Discussions 4.2)** “ When the optical depth is artificially increased to a higher value, such as around 0.6, the model more
60 closely matches the Oct. observations.” **to** “When the optical depth is artificially raised to 0.5, the model produces a meridional
61 wind difference exceeding $400 \text{ m}\cdot\text{s}^{-1}$ at 18:30 UT, Oct. 10th, roughly triple the value obtained with an optical depth of 0.2 and
62 in much closer agreement with the observations. We find that the model underestimates scattering effects when the optical
63 depth is low. Once the optical depth reaches 0.6 or higher, the simulated wind bias accelerates nonlinearly until the model
64 diverges.”

65 **L411 (Discussions 4.2) add** “In our experiments, without the stray-light correction in Appendix B, the airglow brightness
66 gradient flattens slightly, the model becomes more inert, and the simulated horizontal wind differences shrink by about 30 %.”