Response to Reviewer Comments

Manuscript Title: Improving turbulent airflow direction measurements for fiber-optic distributed sensing using numerical simulations

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General Comments:

This manuscript presents a comprehensive numerical investigation of microstructure geometries for fiber-optic (FO) cables used in turbulent airflow measurements. The research addresses an important gap in fiber-optic distributed sensing (FODS) regarding the effects of microstructures' geometry used in FO cable on dynamic parameters important for atmospheric boundary layer studies. The study builds upon previous work by Lapo et al. (2020), and extends the analysis to include hollow-cone microstructures while examining a broader range of geometric parameters and airflow direction effects.

The introduction of hollow-cone microstructures represents a meaningful innovation that demonstrates superior performance compared to filled-cone designs. The authors systematically investigated 64 geometric combinations, providing a thorough exploration of design parameters. In addition, the authors incorporated appropriate real-world factors, such as turbulence intensity variations and wind attack angles, and considered the detection limits of commercial FODS systems.

The study is well-written, providing practical guidance for future FODS implementation while clearly stating the main limitations and highlighting the need for future field/lab experiments. These findings establish a foundation for more accurate wind direction measurements, distributed turbulent heat flux assessments, and the detection of vertical wind speed perturbations using FODS, representing substantial progress toward enhanced atmospheric monitoring capabilities.

Dear Dr. Rosalem,

Thank you very much for your positive and constructive general comments. We sincerely appreciate your recognition of our work and its contribution to advancing fiber-optic distributed sensing for atmospheric applications. We have carefully considered all your general and technical comments and have addressed them thoroughly in the revised manuscript.

The all line numbers referenced here is based on the revised version.

Specific Comments:

Comment 1.

The computational approach is well-described with appropriate boundary conditions and mesh considerations. However, the authors should consider adding some references that applied the k-ε model and commenting on the model's limitations and constraints. Additionally, it would be beneficial (if possible) to include information about uncertainty quantification or confidence intervals for the computed results.

References applying the k-ε model have been added (Lines 121–129), and the limitations and constraints of the model are now discussed. In addition, we assessed the quality of the numerical simulations through a mesh independence test. A representative geometry configuration was simulated using four different mesh sizes, and the resulting fiber temperatures were compared for both forward- and backward-oriented fibers. Across all cases, the standard deviation between meshes remained below 0.4 °C at the lowest wind speed and decreased further with increasing wind speed, reaching values below 0.1 °C at 4 ms^{-1} (Lines 174-176)

Technical Comments:

Comment 1.

Line 74: "In this numerical study, we aim to overcome the major weaknesses of the existing microstructure approach in order to enhance wind speed and direction measurements using filled-coned FO cables while minimizing their sensitivity to lateral wind flows."

Response: It is not entirely clear what is meant by this comment. Could the reviewer please clarify what specific aspect should be demonstrated or elaborated on? This will help us address the concern more accurately in the revised manuscript.

Comment 2.

Line 108: Is it "at lower wind speeds" right?

Response: It is actually for both higher and lower wind speeds. Here we discussed the magnitude of temperature difference between the electrically heated fiber optic cables in comparison with air temperature. It should be large enough to maintain a positive temperature difference within the wind speed range of the environment (in this modeling 0-4 ms^{-1}).

The text edited to “In addition, the temperature difference between air and FO cables was chosen to be large enough to prevent excessive cooling at wind speed range of the modeling.”

Comment 3.

Line 160: "Similarly, ..."

Response: The “In contrast ..” is true here, since we discuss the contrast of behavior of filled-coned and hollow-coned temperature difference. The combinations with higher K and ΔU in filled-coned does not mean necessarily the highest ΔT combinations, but in hollow-coned does.

We edited “In contrast,…” to “In contrast to filled-coned, ”

Comment 4.

References: Please review this section to ensure consistency in the formatting of the reference list.

Response: Done!