Author Response

Dear Editor and Reviewers,

Thank you for the comments.

We gratefully thank the editor and all reviewers for their time spent making their constructive remarks and useful suggestions, which has significantly raised the quality of the paper and has enabled us to improve the paper. Each suggested revision and comment brought forward by the reviewers was considered and incorporated. In addition, following the editor's previous comments, the references have been revised to comply with the AMT citation format.

The text style for revision is as follows:

- All comments are in **black**.
- All responses to the comments are in **blue**.
- All pages and line numbers refer to the revised manuscript.

Reply on RC#1

General Comments

I think the manuscript improved but still needs some minor corrections. Please see below. Specific Comments

1. Page 1, section 1, first sentence. Please remove "(not means ground conditions)" and instead add afterwards. "Despite SPT and ground conditions (i.e., snow or rain on ground) are related, note that they are different."

2. Page 3, last paragraph: sunny -> sunny or cloudy conditions;

3. Page 3, last paragraph: mainly refers to rain, snow, graupel, is primarily attractive to professional meteorological researchers. -> specifically refers here to rain, snow and graupel.

4. Page 9, 1st paragraph: Meteorological and physical studies -> Previous meteorological studies

5. Page 9, 1st paragraph: graupel refers specifically to the solid state, and the mixed-phase state is not considered -> graupel, also known as snow pellets, refers specifically to solid particles "consisting of crisp, white, opaque ice particles, round

or conical in shape and about 2–5 mm in diameter" according to the World Meteorological Organization terminology (WMO, 2017). In this study, no mixed phase precipitation is considered. Reference:WMO 2017, International Cloud Atlas Glossary. Graupel, https://cloudatlas.wmo.int/en/glossary.html#G [last accessed April 2025]

Reply: Authors have accepted the suggestions and revised the manuscript accordingly.

6. Page 14, is Figure 7 quoted in the text? Please check.

Reply: Yes, please see Line 316 of the revised manuscript.

7. Page 14, please provide proper references for each terminal fall speed plotted in Figure 7.

Reply: Added in lines 346-347.

8. Page 15, Figure 8 caption, typo: presents -> present

Reply: Accept and revised.

9. Page 21, Table 7; also in Table 8, Figure 12 and elsewhere, suggest (change adjective into noun): Rainy, Snowy -> Rain, Snow

Reply: Revisions have been made, and Figures 9 and 10 have also been corrected.

Reply on RC#2

1. The article introduces an interesting deep-learning based algorithm to identify the precipitation type based on Surveillance camera. The work is timely to support the surge of citizen science for urban precipitation monitoring. I have one major comment for the authors:

By reviewing the manuscript and the authors' response to reviewer 1, it is clear that they did not consider fixed form (solid & liquid) of precipitation in their algorithm. However, fixed form of precipitation is very common, espcially during winter as the authors have addressed in Introduction. It is recommended that the authors include a new category 'unidentified precipitation tyle' in addition to the existing four categories ('rainy', 'snowy', 'graupel', and 'no precipitation'). At minimum, the authors need to explain their choice and its impact on the accuracy of their algorithm.

Reply:

Many thanks for your valuable comments and suggestions.

As you have pointed out, mixed-phase precipitation is a very important and commonly occurring form of precipitation in meteorology, especially prominent during winter. Surveillance videos capture precipitation particle groups, and in mixed precipitation scenarios, variations in the proportions of solid and liquid particles lead to significant differences in image and video features. The images of mixed precipitation are not merely a simple superposition of different particle images; optical effects such as refraction and reflection between particles cause the visual features in the videos to differ markedly from those of single-phase precipitation. These optical effects increase the complexity of image features and pose new challenges for modeling the image characteristics of mixed precipitation.

Furthermore, the overall fall velocity of the precipitation particle group in mixed precipitation fluctuates considerably, making it difficult to accurately describe using the theoretical formulas for single-phase precipitation shown in Figure 7. This further increases the difficulty of modeling the spatiotemporal characteristics of precipitation.

The current study provides a solid foundation for recognizing mixed-phase precipitation, but the algorithm design is mainly based on microphysical features of single-phase precipitation (such as color, size, fall velocity), which introduces some uncertainty in identifying mixed-phase precipitation. Future work will consider introducing a “mixed precipitation” category or subdividing it into multiple types such as “rain-snow mixture” and “snow-graupel mixture” to more precisely reflect the complexity of actual precipitation processes.

Moreover, limited by the current scarcity of surveillance video samples for mixed precipitation, we plan to further enrich the training and testing datasets, especially by increasing the number of mixed precipitation video samples. By expanding the dataset and optimizing the algorithm, we expect to achieve more accurate and stable recognition of various precipitation types in practical applications, thereby enhancing the model’s utility and potential for wider deployment.

Relevant content has been supplemented in the discussion and conclusion sections of the manuscript. Please see lines 694-708.

We are deeply grateful to the reviewer for their time, thoughtful feedback, and valuable suggestions, which have significantly enhanced the quality and clarity of the manuscript.