My previous comments have been adequately addressed in the author's response, I think the revised manuscript is more convincing, and it should been accepted after minor revisions with respect to the following suggestions:

Comment 1.The eddy diffusion K and decay constant λ were described with more details, however, it should be explicitly shown if they are constants or they vary with factors such as voltage, wind speed, humidity, temperature and pressure.

Response:

We greatly appreciate your comment. The eddy diffusivity *K* is calculated though the meteorological data of the test place, including: the atmospheric boundary layer height (about 300~1000m, determined by the potential temperature profile), the frictional velocity (calculated through the scale of the roughness (roughness length), which is about 0.01-0.04 for the ground), Monin-Obukhov length (about -59.8 m calculated in the model), and wind speed (which is varied with vertical height).

The detail formula can be found in Ref [1]. The simulation results show that the eddy diffusion is larger at higher vertical height (<100 m due to the simulated geometry restriction), and the value is about 4.82 m^2/s at 20 m vertical height (the corresponding wind speed is 5.77m/s).

For the decay rate λ, it represents the ions decay rate due to the recombination between ions and electrons, such as $e + N_2^+ \rightarrow 2N$, $e + O_2^+ \rightarrow 2O$, etc. Table 1 shows the recombination rates of all reactions selected in the model. [2]

Table 1 the recombination reactions

Reactions	Rate	Ref.
$e+N_2^++M \rightarrow N_2+M$	$3.12\times10^{-35}T_e^{-1.5}$	2
$e+N_2^+ \rightarrow N+N(^2D)$	$1.50\times10^{-12}T_e^{-0.7}$	2
$e+N_2^+ \rightarrow N+N$	$1.66\times10^{-12}T_e^{-0.7}$	2
$e+N^++M \rightarrow N+M$	$3.12\times10^{-35}T_e^{-1.5}$	2
$e+O_2^++M \rightarrow O_2+M$	$3.12\times10^{-35}T_e^{-1.5}$	2
$2e+O_2^++M \rightarrow e+O_2$	$1.00\times10^{-31}T_e^{-1.5}$	2
$e+O_2^+ \rightarrow O+O(1D)$	$1.24\times10^{-11}T_{eg}^{-4.5}$	2
$e+O_2^+ \rightarrow O+O$	$1.68\times10^{-11}T_e^{-0.7}$	2
$e+O^++M \rightarrow O+M$	$3.12\times10^{-35}T_e^{-1.5}$	2
$e+H_2O^+ \rightarrow H+OH$	$2.73\times10^{-12}T_e^{-0.5}$	2
$e+ H_2O^+ \rightarrow O+H_2$	$1.37\times10^{-12}T_e^{-0.5}$	2
$O^-+O_2^+ \rightarrow O+O2$	$2.00\times10^{-13}T_{eg}^{-0.5}$	2
$O^-+N_2^+ \rightarrow O+N2$	$2.00\times10^{-13}T_{eg}^{-0.5}$	2

where, M represents the neutral species, $T_{eg}=T_e(eV)/T_g(eV)= T_e(K)/T_g(K)$, and T_e is electron temperature, T_g is gas temperature.

The reaction rates shown in Table 1 are related to the electron temperature and gas temperature. Since the electron temperature is determined by the discharge voltage according to the Poisson's equation and the energy conservation equation, therefore, besides the number densities of ions, the decay rate λ is also related to the gas temperature and the applied voltage (at 1 atm).

However, due to the tremendous complexity of reactions of air plasma, it is currently really difficult for us to compute the decay λ precisely. Therefore, we have to simplify the decay λ to be a constant. In this paper, the fitted decay constant λ is obtained through experimental results, specifically, the value is 1.5113/s at the 90 kV voltage condition (outdoor). Precise calculation of the decay rate λ will be a subject of our future work.

[1] Albani, R. A. S., Duda, F. P. and Pimentel, L. C. G.: On the modeling of atmospheric pollutant dispersion during a diurnal cycle: A finite element study, Atmospheric Environment, 118, 19–27, 2015.
[2] Sakiyama, Y., Graves, D. B., Chang, H. W., Shimizu, T., & Morfill, G. E. (2012). Plasma chemistry model of surface microdischarge in humid air and dynamics of reactive neutral species. Journal of Physics D: Applied Physics, 45(42), 425201.

Comment 2. The steady-2D equation (1) seems not complex, and the results in Fig. 4 and Fig. 7 seems regular, thus I guess there may exist an analytic solution of ion density for varying wind speeds and voltages, at least along the x-axis. Is it possible to reach such a result in the further?

Response:

Thanks for your constructive comment. Figure. 4 is the results of corona discharge, which were obtained through plasma governing equations, including Poisson's equation, particle balance equations and energy conservation equation. The corona discharge simulation provides the initial value of ion density to equation (1).

The ion density distribution shown in Figure 7 is obtained through 2D finite element method. These results were based on an extremely fine mesh, of which the minimum element size is less than 0.001m (shown in Figure.1), to guarantee the accuracy as high as possible.

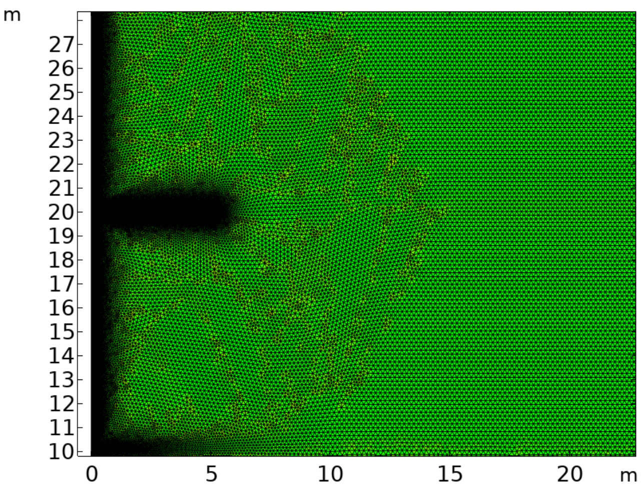


Figure.1 finite element mesh.

We note that the eddy diffusion and wind velocity vary with vertical height (z). Therefore, it is really difficult to solve the analytic solution, and we have not found any report on the analytic solution of equation (1) under relevant conditions.

For the 1d case, when the equation (1) reaches the stationary state ($\frac{\partial c}{\partial t} = 0$), the equation can be simplified as follows:

$$u\frac{\partial c}{\partial x} = K\frac{\partial^2 c}{\partial x^2} - \lambda c,$$

where u and K are the constants at z=20m position, therefore, the above equation is a typical second order ordinary differential equation, and therefore the analytic solution has the general form: $c_1 e^{\gamma_1 x} + c_2 e^{\gamma_2 x}, c_1 + c_2 = c_0$ and γ_1, γ_2 are the roots of the characteristic equation: $K\gamma^2 - u\gamma - \lambda = 0$ 。

Figure 2 below shows that the analytic solution is well consistent with the numerical results (1d model, -90kV, 5.77m/s), which also proves the accuracy of our 2D simulation.

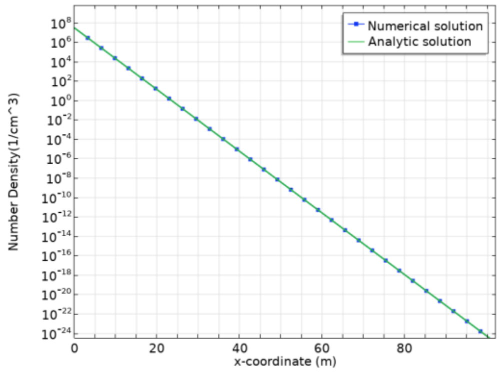
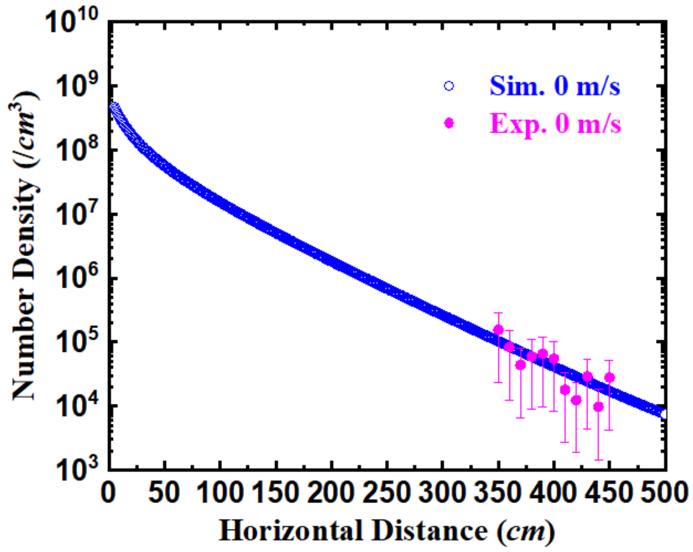


Figure.2 1d model results.

Comment 3. In comparison with the single-discharge-point results of simulation and indoor experiment in Fig. 5, I prefer to see the relevant multi-discharge-point results, which is more realistic.

Response:

The multi-discharge-point results is more realistic indeed. The indoor high voltage experiment is very dangerous especially when the applied voltage is -40 kV. The single discharge point is chosen because of its smaller discharge power. The figure below is the result of multi-discharge-points on the 1m long wire electrode. Because of much larger discharge power, the measurement has to start from 3.5m and end at 4.5m (the limited space in our lab obviously affect the measurement result). The electric fan only 1m behind the discharge point is shut down due to static problem, so the effect of wind speed is not measured for this case.



Comment 4. In page 9: "the whole coverage volume was approximately 30m*20m*90m". Firstly, how the width of 90m was obtained? as in Fig. 1(b) the distance between two poles is only 60m. Secondly, according to Fig. 6(d), the superimposed ion density decays at the boundary, what is the length of boundary? should it be taken away from the width of 90 m?

Response:

The overall discharge system configuration is a hexagon with the side length of 60 m, therefore, the distance between two opposite sides is 103.92m. The horizontal measurement range is ~95m with the consideration of surrounding buildings. Therefore, the width of 90 m is obtained.

Because 90m is less than 103.92m, the decays at the boundary is avoided in this range. The coverage volume of 30m*20m*90m is therefore a relatively conservative range.

Comment 5. Although the coverage of ion density in Fig. 6(b) is coincident with that in Fig. 6(a), the ion density in Fig. 6(a) ranges between 10^6 and 10^5 at the distance of 20m~30m, while in Fig. 6(b) it is less with about one order of magnitude, ranging between 10^5 and 10^4. Please discuss where the difference results from and how to improve it. Besides, the x-ticks in Fig. 6(a) seems to be not in line with the x-names.

Response:

The measurement value in Fig.6 (a) is about 3 or 4 times higher than the calculated value shown in Fig. 6 (b). The measurement error of the ion counter and unstable wind speed are the reason for that. More measurement at low wind speed condition can provide more accurate parameters for model correction.

The discharge device shown in Fig.6 (a) is the horizontal “0” position, and the measurement starts at 20m from the wire electrode, therefore, x-ticks in Fig. 6(a) seems to be not in line with the x-names.

Comment 6. The results in Fig. 8 support that the ion density in the region of 30m-35m in Fig. 6(a) contributes to precipitation, however, the minimum of ion density which can enhance settling should be obtained in order to estimate the largest effective distance in Fig. 6(a).

Response:

The minimum ion density to induce precipitation in the cloud chamber is ~$2\times10^4/cm^3$. We do acknowledge that our work is the relatively early step towards the exhaustive studies of the precipitation effect of charged aerosols. In part, this is because the cloud chamber provides an idealized laboratory-scale condition for the precipitation experiment of charged particles. The outdoor experiment on the large-scale corona discharge system is being tested on the high mountains. Although it has some effect, we still try to find the relation between the discharge power, ion coverage range, and precipitation range. However, currently this is really a challenge, because of the strong wind, thick fog, and frozen snow. Until the end of 2019, we lost two UAVs because of sudden appearance of fog, 1 high voltage sources burned out because of the dehumidifier out of order. The estimated minimum ion density to induce precipitation in the open air will be found when the experiment starts again after we will return back to normal working conditions after COVID-19 and its aftermath are over. It is impossible to predict when exactly this will happen.

Comment 7. The authors should carefully check the values, units, references (a lot errors), figures (obscures seen in printout) in the paper one by one, to avoid unnecessary mistakes.

Response： 12 errors have been corrected.

Comment 8. Some of above suggestions maybe beyond the scope of this paper, it is preferable to add a section to discuss further works to make the paper more coherent.

Response:

We thank the reviewer for this comment and the appreciation that some of the comments are indeed beyond the scope or current physical abilities of the authors to carry further research.

As recommended, we have added a brief section named “3.5 Future work” to discuss the challenges and future work. In particular, we have stressed that the precipitation by charged particles actually depends on the relations between temperature, humidity supersaturation and ion concentration. The more indoor experiments within larger temperature range and humidity range can provide more detailed data to determine the relations above. The future outdoor experiment on the high mountains will determine the effect of wind, temperature and terrain on the ion coverage and precipitation range. Although the wire icing is a challenge for the outdoor experiment, the reliable ice melting system can solve this problem.