Response to reviewer' comments

Dear Editors and Reviewers:

Thank you for your comments on our manuscript. Your comments are valuable for improving our manuscript. We have tried our best to revise the manuscript according to your comments and suggestions, and we have responded to your comments and suggestions point by point. The following are our answers to your comments. Editor's and reviewers' comments are in black, and the authors' replies are in blue.

Thank you very much!

Yours Sincerely,

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Comments from reviewer:

Comment 1:

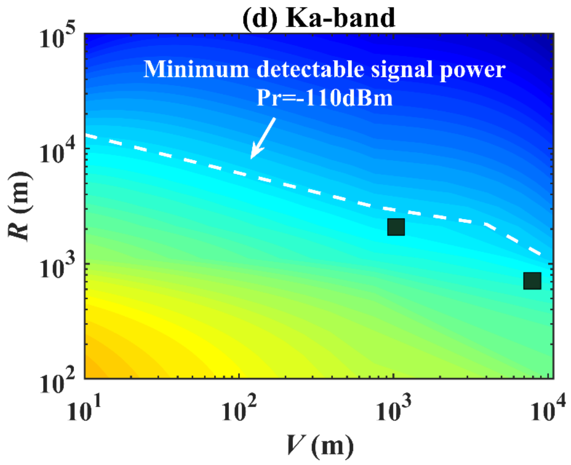
This manuscript presents theoretical calculations of radar sensitivity to dust particles for radar operating frequencies from L- to W-band. Radar detection thresholds are estimated as a function of range and dust storm intensity quantified by a visibility index. It appears that detecting sand and dust storms with currently deployed weather radars would be a good use of those radars to help protect cities and urban environments.

***Authors' reply*:** Thanks for your nice comments. Yes, we hope that a scheme can be established by using radars and lidar in the weather stations around cities to detect the dusty weather to protect cities and urban environment.

Comment 2:

While the manuscript presents theoretical calculations, the manuscript does not show any radar observations of sand or dust that validate the theoretical calculations. Also, contrary to the manuscript title, the manuscript does not present a method or 'scheme' to detect sand or dust with weather radars that discriminates sand or dust radar measurements from backscattered energy from raindrops.

***Authors' reply*:** We are so sorry that it makes confused because of our poor English description and statements. In the revised manuscript, we identified the title more clearly as "A scheme to detect the intensity of dusty weather by applying microwave radars and lidar". In this paper, the effective detection ranges of microwave radar and lidar to detect the intensity of dusty weather are investigated in view of the current shortcomings in detecting the intensity of dusty weather. Because the microwave radars are suitable to detect the intensity of severe dusty weather like sand storm, while lidar is suitable to detect the intensity of floating dust weather, it is proposed to detect the intensity of all kinds of dusty weather by using radars and lidar together, and that is the scheme. Yes, it is a good suggestion to discriminate sand and raindrop by backscattering energy or coefficient. It is a pity that we have no enough information about the radars and lidars at weather stations, so we cannot conduct out experimental study to validate the scheme, and here just a theoretical scheme of microwave radar and lidar to detect the intensity of all kinds of dusty weather is proposed. Hope all radars, lidars and even the meteorological satellites can be connected to detect the dusty weather such as sand storms. Fortunately, we find some experimental results of detection range, which can validate our calculated results shown as black squares in following figure, also to see Figure 2(d) in the revised manuscript.

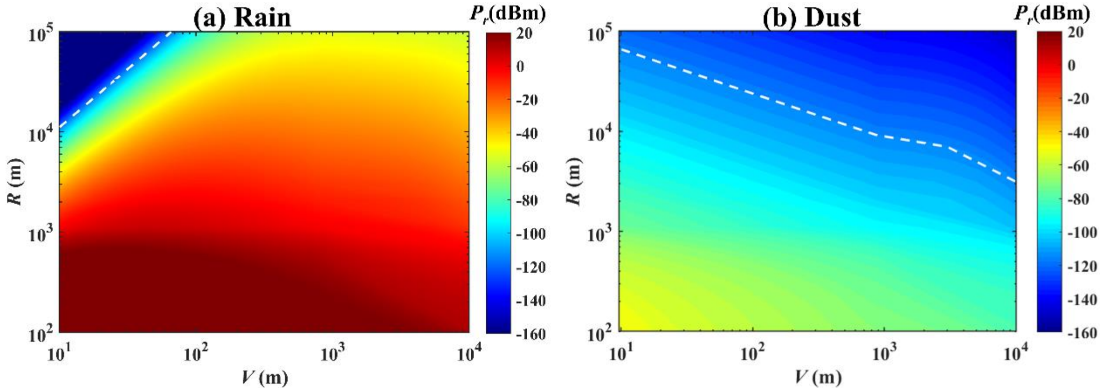


Comment 3:
The manuscript needs a review for English grammar and word usage.
***Authors' reply*:** We have carefully checked the whole manuscript and clarify all typos in expressions and corrected the mistakes in grammar in revised manuscript.

Specific Comments
1. Abstract. The abstract does not present the results of the study. Also, the abstract states (line 10) that 'The scheme can be efficient to detect sandy dust weather…" A scheme is not presented in this manuscript, just radar calculations to determine whether simulated radars have the sensitivity to detect sand or dust populations. Rewrite the abstract to describe the purpose of the study, methods of the study, results from the study, and potential impacts from the study.
***Authors' reply*:** Thank you for your patience, and we've rewritten abstract as "Detection of the intensity of the dusty weather is important for weather forecasting. In this paper, the effective detection ranges of microwave radar and lidar in dusty weather of different intensities were theoretically calculated, some of which are validated by comparing with the experimental results. The effects of excess charge carried by dust particles and relative humidity on the echo power and effective detection range are also investigated. Based on the effective detection range of microwave radar and lidar, a scheme of combined microwave radar and lidar to detect the intensity of dusty weather is proposed, by using which it makes a good supplement to the current detecting the intensity of dusty weather. Especially, it will be a cost-saving way by using the existed meteorological radars to establish the detection scheme, which will make the precaution against the disastrous weather promising."

2. The manuscript presents scattering calculations of sand and dust particles to determine range detection curves. But, the study does not repeat the calculations for raindrops which would show whether the simulated radars are capable of detecting raindrops. Do the simulated radars have the same sensitivity as operational weather radars? Can the simulated radars detect raindrops at 100 km, or 200 km? Please extend the calculations to raindrops.

***Authors' reply*:** The sensitivity is different for different radars and lidar, which is given in published papers as following table. We are so sorry that it makes confused due to our poor English description and statements. In this paper, we are concerned to detect the intensity of sandy dust weather by radars and lidar. It is a good suggestion to calculate the detection range of radars and lidar, and we calculated the detection range of C-band radar by raindrops as following Figure. From the figure, it can be found easily that detection range is extended compared to the sandy dusty weather, and it can be found that the effective detection range is beyond 100 km except visibility lower than 65 m for raindrops.



3. Section 2.2.2, line 74, and line 118. The maximum sand or dust particle is limited to diameters of 80 microns (line 74). The shortest radar wavelength is about 3 mm from W-band radar. The size parameter (line 118) is given as x = 2pi a /lambda. Using a = 40 microns and lambda = 3 mm, the size parameter is approximately 0.15. This maximum size dust particle is still within the Rayleigh scattering regime for W-band radar wavelengths. The Mie scattering approximations (equations 8 and 9) are superfluous and will revert to the Rayleigh approximation for these small size parameters. Section 2.2.2 is making the calculations more complicated than necessary.

***Authors' reply*:** Yes, you are right, by reverting Mie scattering theory to Rayleigh approximation, the calculation will become simple. We consider the contribution of charges carried by the particles on the scattering/extinction/echo power, therefore Rayleigh approximation is not suitable.

4. Line 158. I do not know of a civilian scanning weather radar operating at L-band. Most scanning weather radars have antenna beamwidths no larger than 1 degree. An L-band antenna would have to be large to produce a 1 degree beamwidth. If the authors know of an L-band scanning weather radar, it would be interesting to see details of that radar.

Authors' reply: We found a literature of a study on the detection of dusty weather intensity by L-band radar as following table (Wang et al., 2013), and some parameters of L-band radar are used in our calculation.

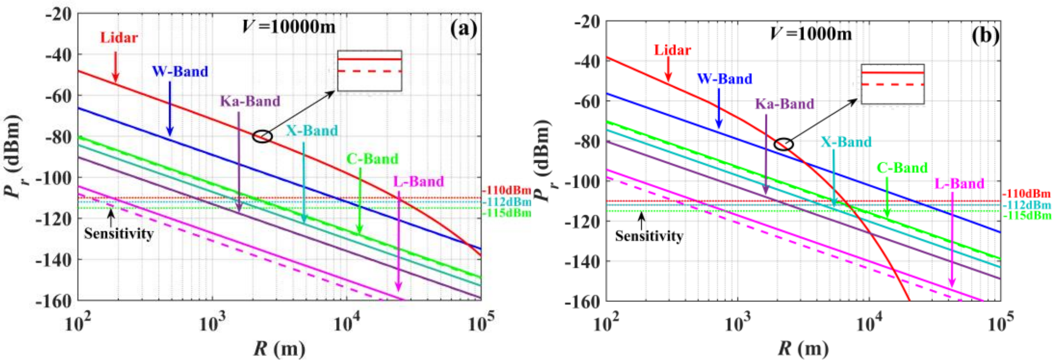
Name	Parameter	Name	High-mode parameter	Low-mode parameter
Radar wavelength	227 mm	Pulse width	0.66 μs	0.33 μs
Beam width	8°	Minimum detection height	600 m	50 m
Beam number	5	Noise coefficient	2 dB	2 dB
Antenna gain	25 dB	Height resolution	100 m	50 m
Feeder loss	2 dB	Coherent accumulation number	64	100
Receiver	Digital IF	FFT points	512	256
Transmitting peak power	2.36 kW	Bandwidth	1.5 MHz	3.0 MHz

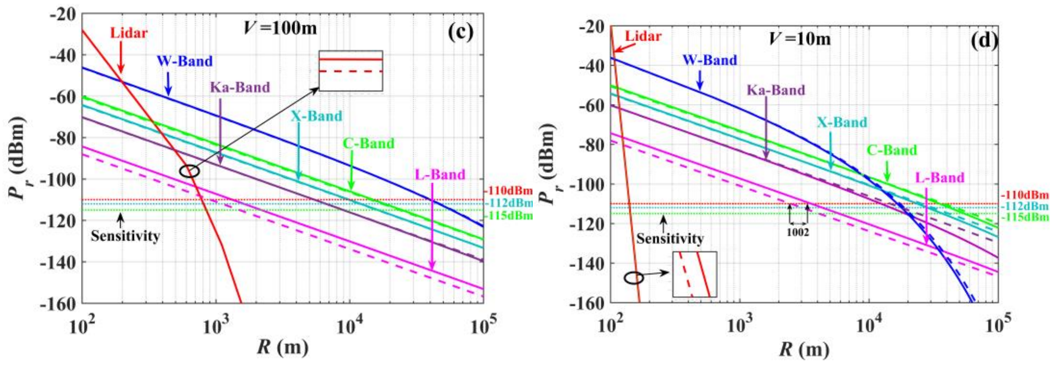
5. Lines 118 to 194. The manuscript presents effective detection ranges with 1-meter resolution. For example, line 159, the detection range is 2671 m. Given the assumptions in the calculations, this is a false sense of accuracy. What are the simulation uncertainties for detection range? Asked another way, given a 3 dB uncertainty in signal-to-noise ratio, what is the uncertainty of the detection range?

***Authors' reply*:** We determined the effective detection range by the sensitivity of radar and Lidar. When the calculated echo power of radars or lidar is equal to the sensitivity at a range, defined as the effective detection range. It is inevitable there is calculated error or their noise in the environment, and they will make the effective detection range shorten. But it is theoretical calculation in our manuscript, so we did not consider the uncertainty due to the errors and noise. We hope a detailed analysis to be done.

6. Figure 2. Why do the detection ranges only go out to 10 km when weather radars typically have ranges out to 100 to 300 km?

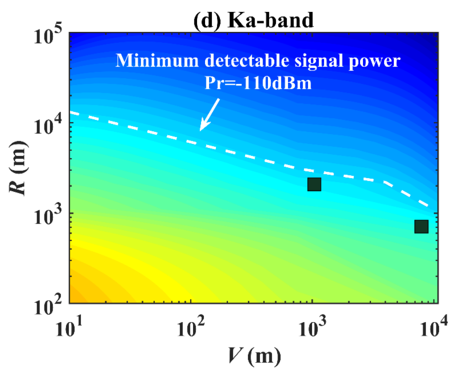
Authors' reply: We have extended the detection distance to 100 km in the revised manuscript as following figures, also to see Figures 5-6 in the revised manuscript. we assume the visibility is uniform along the wave transmit path.The detection range in our calcualtion means the distance of tranmisting path full of dusty particles not the distance between the transmit end and the dusty weather. Therefore, the attenuation of the radar waves on the transmission path is more severe in our calculations, resulting in a smaller effective detection range than the typical radar detection range.





7. Section 2 presented theoretical calculations of radar detection. Are there any radar observations of sand or dust storms that can validate these calculations? Without showing any real radar observations, the simulations have not been validated or put into real-life context.

Authors' reply: In this paper, we are concerned to detect the intensity of sandy dust weather by radars and lidar. Because the microwave radars are suitable to detect severe dusty weather like sand storm, while lidar is suitable to detect floating dust weather, it is proposed to detect all kinds of dusty weather by using radars and lidar together. Fortunately, we find some experimental results of detection range, which can validate our calculated results shown as black squares in following figure, also to see Figure 2(d) in the revised manuscript.



8. Section 3 "The scheme of using meteorological radar to detect sand and dust weather". This section does not present a "scheme" or method of detecting sand or dust weather. It appears that some thresholds have been set and shown in Fig. 4, but no flow diagram showing the decision logic is presented in the manuscript. Also, it does not present a method to discriminate scattering from sand or dust from scattering from raindrops. How does the method determine whether sand or dust is being detected rather than raindrops?

Authors' reply: We are so sorry that it makes confused because of our poor English description and statements. In this paper, we are concerned to detect the intensity of sandy dust weather by radars and lidar. Because the microwave radars are suitable to detect severe dusty weather like sand storm, while lidar is suitable to detect floating dust weather like W-band/C-band radar and lidar, it is proposed to detect all kinds of dusty weather by using radars and lidar together, and that is the scheme. Yes, it is a good suggestion to discriminate sand and raindrop by backscattering energy or coefficient. It is a pity that we have no enough information about the radars and lidars at weather stations, so we cannot conduct out experimental study to validate the scheme, and here just a theoretical scheme is proposed. Hope all radars, lidars and even the meteorological satellites can be connected to detect the dusty weather such as sand storms. Fortunately, we find some experimental results of detection range, which can validate our calculated results shown as black squares in following figure, also to see Figure 2(d) in the revised manuscript.

References

Wang, M., Wei, W., Ruan, Z., He, Q., and Ge, R.: Application of wind-profiling radar data to the analysis of dust weather in the Taklimakan Desert, Environmental Monitoring and Assessment, 185, 4819-4834, 10.1007/s10661-012-2906-4, 2013.