Response to reviewer 2:

Thank your valuable comments and questions concerning our manuscript entitled "Error analyses of a multistatic meteor radar system to obtain a 3-dimensional spatial resolution distribution" [MS no. amt-2020-353]. These comments are all valuable and very helpful for revising and improving our manuscript, as well as the important guiding significance to our researches. We have found a mistake in equation 10 and corrected it. We have studied the valuable comments from you carefully, and tried our best to revise the manuscript. These changes in the revise manuscript have been marked in the track changes version manuscript, as well as the point to point responses have listed as following:

Major comments:

1) The manuscript is very difficult to follow, and the English writing needs some improvement.

   Response: We apologize for our unreasonable article structure, English writings and denominations to make you have difficulties in reading our article. Following your comments, we carefully rearrange our manuscript and English writing trying to make our manuscript easy to understand. We do those changes in revised version:

   1. we had removed all denoted primes in coordinate system in revised manuscript. This makes our expression in manuscript more concise and readable. And the three introduced coordinate systems can be well distinguished by only using subscripts. Coordinate systems or axes with prime only appear in coordinate rotations.

   2. In original manuscript, we established left-hand coordinate systems with right-hand screw rule which is not idiomatical for most readers. Thus, in revised version, we change the coordinate systems to idiomatically right-hand coordinate systems with right-hand screw rule. We hope this change may increase the readability of our manuscript.

   3. Section 2 is the main body of this manuscript and we divide it into four parts to make its structure more clearly. We add a brief conclusion of the analytical

process in the end of section 2 (line 275-284). And we add a flow chart to descript our analytical process (Figure 5(a)). In Figure 5(a), the variables and equations in section 2 are all included. We hope that reading section 2 while seeing Figure 5(a) will help readers understand the tedious analytical process.

4. some units or quantitative expressions examples: use the specific angle and distance values to help readers understand the parameters settings in our program (line 282-293); use the specific location error values and resolution values to explain their relationships (line 298-301); use specific rotation angle values to explain the slant of the receiver antennas plane (line 334).
5. Apart from correct the grammar and spelling mistakes you suggested in minor concern, we reread our manuscript to carefully check the spelling, grammar and wording. For example, "traditional meteor radars" is corrected as "classic meteor radars"; "wind retrieving" as "wind retrievals"; "AoA" and "AoAs" are unified as "AoAs"; "clockwise rotation is" as "clockwise rotation satisfies " et.al.
6. We have found that equation 10 in original version is not correct. We have corrected it and reorganized the relative content in section 2 (line 237-268), figures and code et.al. In corrected version, except there is no "good horizontal resolution area split when baseline is long" , other results are the same.

If you have any confusion, comments or suggestions in revised manuscript, don't hesitate to feedback to us. And we would very pleasure to revise our manuscript and try to make our manuscript better. Thanks for your precious comment.

2) Using the term "wind fields" when referring to monostatic systems is not correct. Monostatic meteor radars can be used to retrieve a mean wind vector, but not wind fields. To obtain the latter, one needs to solve for the gradients. And [du/dy], [dv/dx] can only be estimated when at least a bi-static configuration is taken into account. In connection with this issue, please re-write lines 35-50. Even with a good azimuthal sampling, the shearing term (besides the vorticity) cannot be estimated using a monostatic system. Only [du/dx], [dv/dy] can be estimated from monostatic measurements, but not [du/dy], [dv/dx]. The latter means that not only the vorticity

cannot be obtained, but neither the shearing term. Besides, there is no need to have a measure of the vertical wind in order to estimate the horizontal divergence.

Response: Thanks for your comments very much. We apologize for our inaccurate wording in original manuscript. Although monostatic using VAD or VVP could obtain $\frac{du}{dx}, \frac{dv}{dy}$ in certain situations, all four gradient components can not be obtained. Thus, "wind field" is not accurate for monostatic meteor radars. Following your comments, we substitute "wind field" in line 34 to "wind" for accuracy.

In original manuscript in line 35-50, we are actually discussing the case of Doppler weather radars used in troposphere measurement. We apologize for our straying from the point which had mislead you. In troposphere, atmospheric activities are strong in vertical, thus the vertical wind component projected to radial sight of the radar can not be neglected (in MLT however, the vertical wind component can be ignored). Moreover, those weather radars need to measure vertical wind components to study precipitation process of the troposphere. To obtain horizontal wind information, the vertical wind component should be removed from radial Doppler shift at first. A simple way to resolve it is using a vertical beam to detect the vertical wind. In the sampling volume, the vertical wind are assumed as the same. However, inspired by your comments, we reconsider the paragraph in line 35-50 and realize that the discussion of weather radar in this text is not suitable and will mislead the readers. Thus, we rewrite lines 35-50 only discuss the case of classic meteor radar. This makes our text more concise and keep to the point. Thanks very much for your comments.

Finally, after carefully recheck the issue of gradient components retrieving, we find that the shearing term can be obtained. Although "$\frac{du}{dy}$" and "$\frac{dv}{dx}$" can not be solved individually, their sum value (i.e. shearing term) can be obtained (Browning and Wexler, 1968). Or in other words, their subtract value (i.e. vorticity) can't be known thus can't obtain "$\frac{du}{dy}$" and "$\frac{dv}{dx}$" individually. Details can be seen in **RC2 supplement.**

3) Instead of referring to a previous work, it would better if the authors included a simple sketch in order to understand how equation (1) is obtained.

   Response: Thanks for your suggestions very much. Following your suggestion, the figure 4(a) is used as a sketch to help readers understand eq.(1) and we simply explain how to obtain this equations (line 124).

4) Furthermore, the algebraic deductions of the error propagation matrixes presented in the appendixes should be treated with more care. For example, in appendix A.2, it would be helpful to have clearly indicated in its corresponding figure the angles γ_1, γ_2, θ, and φ. This would help to understand, e.g., how equations A2.3 and A2.4 are obtained.

   Response: Very kind of you for your suggestions. We apologize for our carelessness in treating with appendix. Following your suggestions, we carefully revise the appendix.

   Some of the grammar and wordings changes are as follows:

   1. In appendix A.1 in line 461 and 463, we delete Z' which will cause the misleading and substitute it with "the new coordinate".
   2. In appendix A.1 in line 471, "For any two coordinate systems XYZ and $X'Y'Z'$" , we add with co-origin for more accurate.
   3. In appendix A.2 in line 479, "The AoAs is determined by two phase difference $\Delta\Psi_1$ and $\Delta\Psi_2$. Taking one antenna array as an example and Assuming " is deleted and substitute it with "In the plane wave approximation,"
   4. In original manuscript, "using Taylor expression of …" is not concise and accurate. In revised manuscript, we substitute it with "Expand XXX in eq.X to first order, …"
   5. In original manuscript, too many "We …" are used. In revised manuscript, we change most of them to passive voice.

Figure A.1 and A.2 are also revised following your suggestions. Figure A.1's rotation marks aren't conformed to three-dimensional perspective and will cause misleading in original version. In new version, we replot it and it can show the relationship of cover between objects. We hope this may help readers. Figure A.2 in new version adds θ and ϕ to help readers understand the deducing of equations.

5) In the case of appendix A.1, please modify its corresponding figure. Since the authors use lefthanded coordinate systems but follow the right-hand corkscrew rule, figure A.1 in its present form does not help to understand appendix A.1.

   Response: In original manuscript, we established left-hand coordinate systems which is not idiomatical for most readers. Thus, in revised version, we change the coordinate systems to idiomatically right-hand coordinate systems. We hope this change may increase the readability of our manuscript. Corresponding, we modify figure A.1 in righthanded coordinate systems and follow the right-hand corkscrew rule.

6) Figures 5 to 8 contain the most important results of this work but they are poorly described and barely discussed. Besides, some of the statements based on these figures are not evident, at least for this reviewer. For example, what is stated in lines 225-226 is not obvious for the eyes of this reviewer.

   Response: We apologize for Figure 5-7's poor plots to make you having difficulties in reading the manuscript. Following your suggestion, we carefully replotted original manuscript's Figure 5-7 and the new figures are Figure 6-8 in revised manuscript (because we add an algorithm flow chart and is shown in Figure 5 in new manuscript, the results figures are start from Figure 6). However, due to our rearrange of original manuscript, the new figures do not correspond to original one to one. In original version, we only label the axes with denoted coordinate axes with prime (X_0',Y_0',Z_0'), which is not intuitionistic. And in revised version we label the axe with noun of locality: altitude, east, north and horizontal distance. We hope this change would understand figures at a glance. In original version, there lack figure captions or corresponding text which makes the figures hard to understand. Therefore, in new version, we add more descriptions in figure captions not only in Figure 6-8, but also Figure 1-5's Schematic diagram or flow chart. We try to provide information as much as possible in figure captions. Moreover, in Figure 6-8 we add subplots titles and colorbar unit (km) to help understand the pictures.

For the reason that E_2 related resolution is very smaller comparing with E_1 related and total resolution, we change the colorbar of E_2 related to make this difference visible at a glance, which is not shown well in original one. Thanks very much for your comments and suggestions about our figures. If you have any other confusion, comments or suggestions about revised figures, don't hesitate to feedback to us. And we would very pleasure to carefully revise our manuscript and try to make our pictures more intuitional.

7) This reviewer understands that the authors' objective is to analyse the errors that result from the multistatic configuration. However, the existence of other errors should be mentioned in the paper and a brief discussion on how they compare to the errors here analysed should be included. For example, it is known that the echoes do not originate on a single point in space. So, how large would it be the impact of this on the vertical resolution? Or can it be neglected?

Response: Thanks very much for your suggestion. Inspired by your comments, we mention and discuss the issues of other error sources (line 348-353). The antenna design and site selection are important for meteor radars and HFSS is a powerful tool to study those issues. We only discuss the mathematic error propagation starting from phase difference measuring errors and put emphasis on multistatic configurations. We try to induce things in general, thus the discussion of some specific case of the interferometry maybe beyond the scope of our text. However, if substitute the phase difference measuring errors in our text (set as constant) to values in specific case, our method will still work(line 338-347). There are many detailed works in discuss the interferometry and their AoAs measuring errors in a more specific case, such as (Kang, 2008; Vaudrin et al.,Younger and Reid, 2017). These results of AoAs error distribution can be taken into our method to study a more specific case.

Following your suggestions, we had carefully thought the issue of the radio wave scattered from Fresnel zones. The fact that radio wave scattered from a few Fresnel zones around specular point will cause an antenna pair's phase difference deviation from an ideal expectant value. The ideal expectant value will resolve a AoAs pointing to specular point. This phase difference deviation is one error source of phase difference measuring errors. Thus the impact of Fresnel scatter on measuring errors is included in phase difference measuring errors ($\delta(\Delta\Psi_1)$ and $\delta(\Delta\Psi_2)$). However, this issue is not clearly point out in our manuscript. Thus, we mention this issue briefly in new version (185-190, 348-350 and Figure 1-2's caption). The details of this issue can be seen in the **RC2 supplement.**

8) Maybe it is out of the scope of this work, but it would be helpful if some data were considered in the study. For example, what does really mean having a spatial resolution of let us say, 2-3 km? How would this impact on winds and horizontal gradients estimates? Have the authors made any rough estimation of this? It would be very useful for the readers if some information on this was included in the manuscript.

Response: Very kind of you for your suggestions. After carefully thinking your suggestions, your suggestions inspired us to add an important discussion about our results to briefly mention the issues of wind retrieving (line 354-369). Also, we add examples to explain the meaning of the spatial resolution, to use specific location error values and resolution values to explain their relationships (line 298-301).

The location error, Doppler shift errors and other issues will determine the accuracy of the wind retrievals. We intend to discuss this in a future work. The location error of the meteor trail's specular point, or the spatial resolution in other words, is discussed in this manuscript. Our manuscript is about 8500 word and includes the tedious analytical process with many equations. we think it would be better for our manuscript concentrate on the discussion of spatial resolutions. We will try our best to make up real data and wind retrieving discussion as soon as possible in the next.

Minor comments:

1) Line 30: please include more references here. Studies from other scientific institutions, e.g., Leipzig University and the Leibniz-IAP (Germany), which have long traditions on studies based on meteor radar measurements should be included.

Response: Thanks for your suggestion. We apologize for our omissions of citing Leipzig University and the Leibniz-IAP (Germany) in line 30. Leipzig University and the Leibniz-IAP have long traditions on studying meteor radars and done many excellent works about multistatic radars in recent years. Therefore, following your suggestion we add "(Jacobi et al., 2008; Stober et al., 2013)" in line 31 in revised version.

2) Line 32: please change "… same height range be processed…" to "… same height range are processed…"

Response: corrected.

3) Line 48: "Even by releasing…". I think the authors meant "relaxing".

Response: corrected. Thanks for pointing out this typo.

4) Lines 53 and 59: it is MMARIA, not MMARA. Please change that.

Response: corrected. Thanks for pointing out this typo.

5) Line 62: it should be "… Chau et al. used two adjacent…" and not "Stober et al."

Response: corrected. Thanks for pointing out this typo.

6) Lines 65-66, what do the authors mean with "meteor radar data processing method"?

Response: Thanks for your comment. Following your comment, we change "meteor radar data processing method" to "coded continuous wave meteor radar".

7) Lines 68: please change "… of received signals, we can determine…" to "… of received signals, one can determine…". The same change should be applied in lines 69 and 71.

Response: corrected. Thanks for your suggestion. We also do same changes in line 151,153,155. We change the sentences using "we …" to passive voice, too.

8) Line 101: “to the cosine of the zenith angle”

Response: corrected. Thanks for your suggestion.

9) Line 199: “and is president in supplement…”. Do the authors mean “and is presented in the supplement”?

Response: yes. Thanks for pointing out this typo. We corrected “president” to “presented”.

10) Please make figures 5 to 8 self-contained. One should be able to understand the main message of a figure without reading the caption.

Response: corrected. We add titles for Figures and the labels of axes are changed to “Altitude”, “East”, “West” and “Horizontal distance” to make figures visualized. The figure 8 in new version is a 3D contourf plot for intuitional.

Reference:

Browning, K. A., and Wexler, R.: The Determination of Kinematic Properties of a Wind Field Using Doppler Radar, Journal of Applied Meteorology, 7, 105-113, 10.1175/1520-0450(1968)007<0105:Tdokpo>2.0.Co;2, 1968.

Browning, K. A., and Wexler, R.: The Determination of Kinematic Properties of a Wind Field Using Doppler Radar, Journal of Applied Meteorology, 7, 105-113, 10.1175/1520-0450(1968)007<0105:Tdokpo>2.0.Co;2, 1968.

Jacobi, C., Hoffmann, P., and K¨¹rschner, D.: Trends in MLT region winds and planetary waves, Collm (52¡ã N, 15¡ã E), Annales Geophysicae (ANGEO), 2008.

Stober, G., Sommer, S., Rapp, M., and Latteck, R.: Investigation of gravity waves using horizontally resolved radial velocity measurements, Atmos. Meas. Tech., 6, 2893-2905, 10.5194/amt-6-2893-2013, 2013.

Hocking, W. K.: Spatial distribution of errors associated with multistatic meteor radar, Earth, Planets and Space, 70, 93, 10.1186/s40623-018-0860-2, 2018.

Kang, C.: Meteor radar signal processing and error analysis, 2008.

Vaudrin, C. V., Palo, S. E., and Chau, J. L.: Complex Plane Specular Meteor Radar Interferometry, Radio Science, 53, 112-128, 10.1002/2017rs006317, 2018.

Younger, J. P., and Reid, I. M.: Interferometer angle-of-arrival determination using precalculated phases, Radio Science, 52, 1058-1066, 10.1002/2017rs006284, 2017.

RC2 Supplement

1. The issue about how to obtain shearing term for a monostatic radar

In MLT region, we assume that the horizontal wind field in a certain altitude H can be expressed as:

$$u(x,y) = u_0 + \frac{\partial u}{\partial x}x + \frac{\partial u}{\partial y}y \qquad (1)$$

$$v(x,y) = v_0 + \frac{\partial v}{\partial x}x + \frac{\partial v}{\partial y}y \qquad (2)$$

u_0 and v_0 are mean wind component. Without loss of generality, the origin of coordinate-xy can be set in right above the radar. The vertical wind can be ignored.

A radial Doppler shift correspond to a radial wind velocity, denoted as $V_R(\theta,\phi)$. θ,ϕ are zenith and azimuth angle of a radial direction. The unit vector in radial, denoted as $\overrightarrow{n_R}$ is:

$$\overrightarrow{n_R} = (sin\theta cos\phi, sin\theta sin\phi, cos\theta) \qquad (3)$$

The wind field is projected to the radial direction and is measured by radars as V_R:

$$V_R(\theta,\phi) = \overrightarrow{n_R(\theta,\phi)} \cdot \overrightarrow{V(x,y)} \qquad (4)$$

$$\overrightarrow{V(x,y)} = (u(x,y), v(x,y), 0) \qquad (5)$$

$$(x,y) = (Htan\theta cos\phi, Htan\theta sin\phi) \qquad (6)$$

simultaneous equation (1)-(6):

$$V_R(\theta,\phi) = sin\theta cos\phi u_0 + sin\theta sin\phi v_0 + Htan\theta cos\phi sin\theta cos\phi \frac{\partial u}{\partial x} + Htan\theta sin\phi sin\theta cos\phi \frac{\partial u}{\partial y} + Htan\theta cos\phi sin\theta sin\phi \frac{\partial v}{\partial x} + Htan\theta sin\phi sin\theta sin\phi \frac{\partial v}{\partial y} \qquad (7)$$

In equation (7), there are 6 variables need to be solved (mean wind and four gradient components: $u_0, v_0, \frac{\partial u}{\partial x}, \frac{\partial u}{\partial y}, \frac{\partial v}{\partial x}, \frac{\partial v}{\partial y}$). However, the coefficients ahead $\frac{\partial v}{\partial x}$ and $\frac{\partial u}{\partial y}$ are the same. This means that at most 5 variables can be obtained. By combing four and five term in right of equation (7), we can obtain:

$$V_R(\theta,\phi) = sin\theta cos\phi u_0 + sin\theta sin\phi v_0 + Htan\theta cos\phi sin\theta cos\phi \frac{\partial u}{\partial x} + Htan\theta sin\phi sin\theta sin\phi \frac{\partial v}{\partial y} + Htan\theta sin\phi sin\theta cos\phi \left(\frac{\partial u}{\partial y} + \frac{\partial v}{\partial x}\right) \qquad (8)$$

In equation (8), the five coefficient are mutually different thus five variables can be solved. They are mean wind u_0, v_0, two gradient components $\frac{\partial u}{\partial x}, \frac{\partial u}{\partial y}$ and shearing term $(\frac{\partial u}{\partial y} + \frac{\partial v}{\partial x})$.

2. The issue of the radio wave scattered from Fresnel zones

Specular meteor radars (SMR) usually utilize undersense meteor trails. (Ceplecha et al., 1998) discussed radio wave backscatter process with meteors passing though the SMR . In short, for idealized case that ignoring diffusion of meteor trail and assuming that secondary radiative and absorptive effects can be neglected, the return signal received by one antenna can be expressed as:

$$E_{R1}(x_t) = E_0 e^{i(\omega t - 2kR_0)} \int_{-\infty}^{x_t} e^{i(-\pi x^2/2)} dx \tag{1}$$

See figure 1, R_0 is the distance from this antenna 1 to the specular point, or the orthogonal point (t_0-point hereafter) in other words. $x = \sqrt{\frac{4}{\lambda R_0}} S$ and $k = \frac{2\pi}{\lambda}$. If origin time is when meteor arrives at t_0 point, it will get that $x_t = 2(\lambda R_0)^{-\frac{1}{2}} Vt$ (V is meteor velocity). $\int_{-\infty}^{x_t} e^{i(-\pi x^2/2)} dx$ is a complex Fresnel integral and can be expressed as $C - iS$,where:

$$C(x_t) = \int_{-\infty}^{x_t} \cos(\pi x^2/2) dx$$

$$S(x_t) = \int_{-\infty}^{x_t} \sin(\pi x^2/2) dx \tag{2}$$

Thus, apart from ideal specular reflection signal term "$e^{i(\omega t - 2kR_0)}$", there is a complex Fresnel modulation term $C - iS$. This modulation will cause amplitude occasion ($\sqrt{C^2 + S^2}$) and phase variation ($\phi_{add} = \arctan\frac{S}{C}$) in the period a meteor passing through. See figure 2, curve A represent the process based on eq. (1) and curve B, C, D show the effect of including an increasing degree of diffusion of the trail.

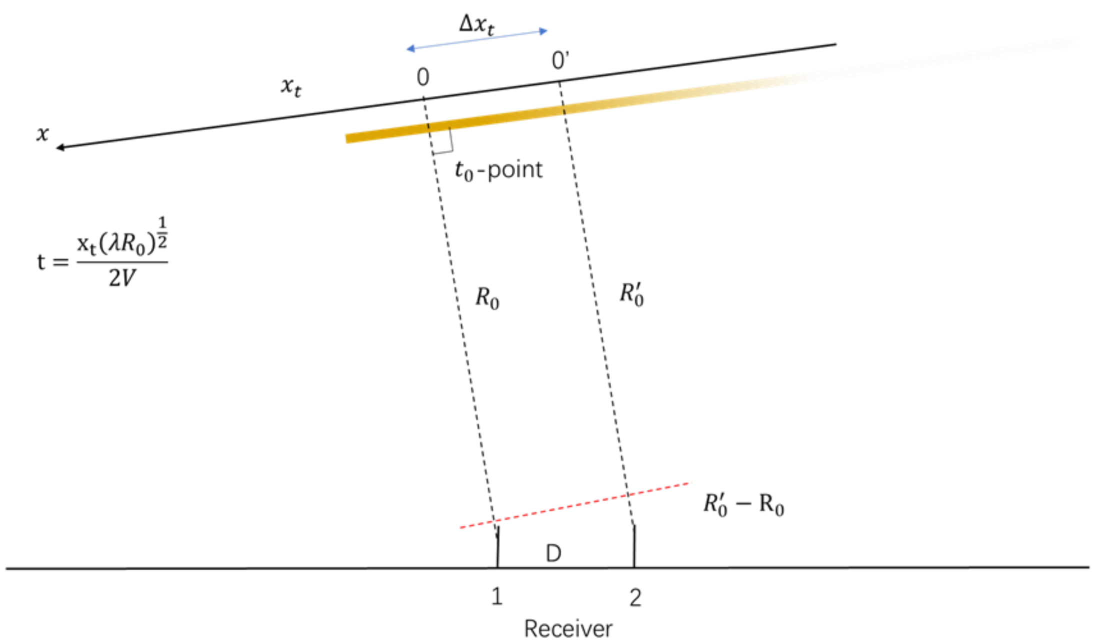

Figure 1

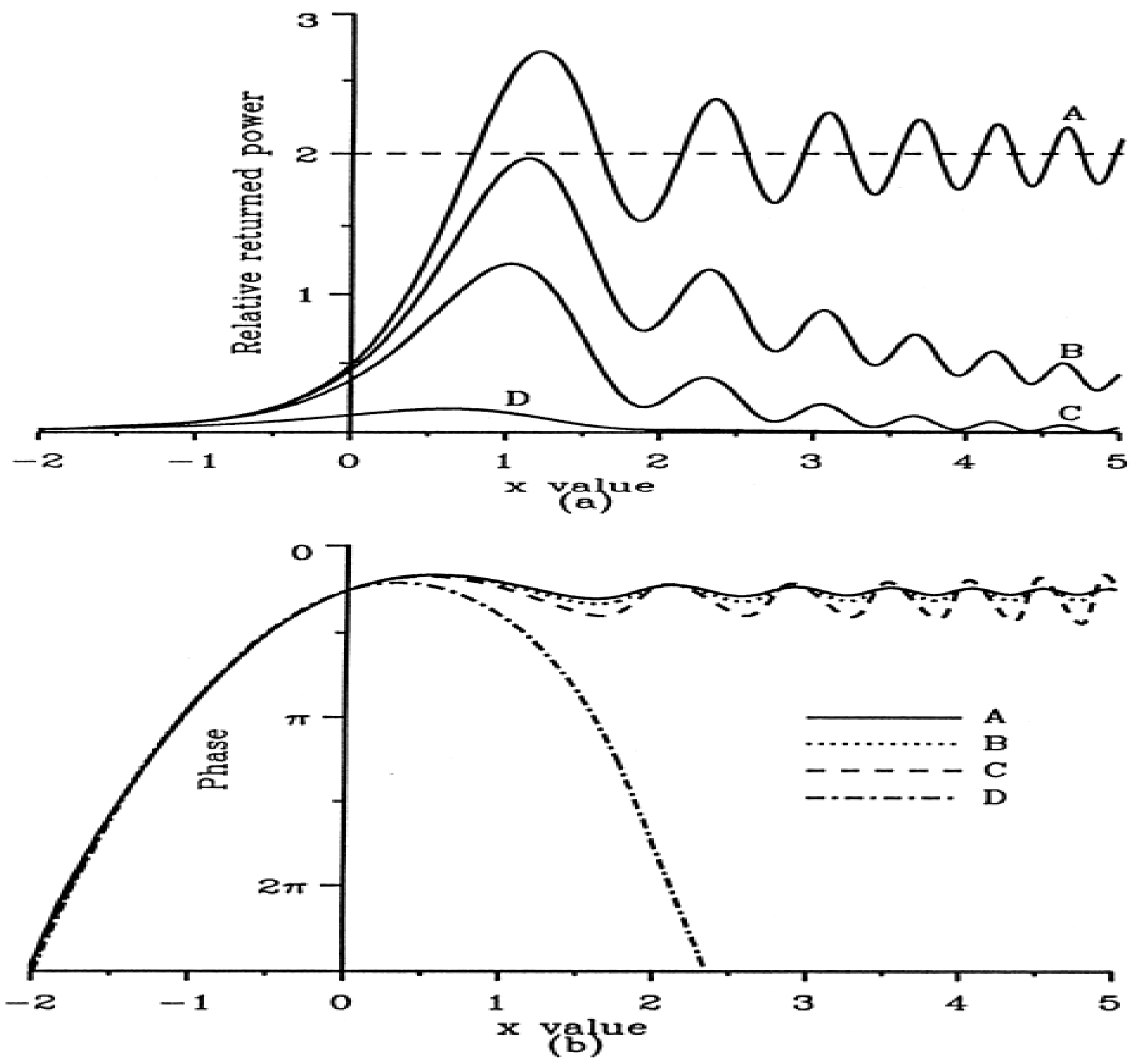

Figure 2(pick from (Ceplecha et al., 1998))

Similarly, the return signal received by antenna 2 is

$$\mathrm{E}_{\mathrm{R2}}(x_t) = E_0' \mathrm{e}^{i(\omega t - kR_0 - kR_0')} \int_{-\infty}^{x_t+\Delta x_t} e^{i(-\pi x^2/2)} dx \tag{3}$$

See eq. (1) and (3), the phase difference between two antennas is from second term and third term in right side of the equations. The phase difference caused by second term is $k(R_0' - R_0)$ which is the theoretical basis of interferometer to obtain AoAs. And this phase difference will solve an AoAs pointing to specular point. However, the third term, which is related to the radio wave scattered from a few Fresnel zone, will cause additional phase difference between two antennas. This additional phase difference is caused by a delay integer length Δx_t between two antennas. For:

$$\Delta x_t = \sqrt{\frac{4}{\lambda R_0}}\ Dsin\alpha \tag{4}$$

Take a 30MHz meteor radar for example, since $Dsin\alpha \leq 4.5\lambda$ and R_0 is about 100km, Δx_t will not exceed 0.1. The major concern is how big this additional phase difference is. The change rate of the Fresnel modulation phase Φ, i.e. the derivative function of $\arctan(\frac{\mathrm{S}}{\mathrm{C}})$, will determine the magnitude of this additional phase difference. The Phase changes dramatically in pre-t_0 period and in small concussion after t_0. The additional phase difference is $\Delta x_t \frac{\mathrm{d\Phi}}{\mathrm{dx_t}}$ and it's no more than 25 degree around $x_t = -1$ (figure 3). Furthermore, a meteor radar system generally set an amplitude threshold to judge a meteor event and thus IQ analyze is nearly in post-t_0 period which additional phase is very small.

Multistatic meteor radars utilizing the forward scatter is a more general case. The effect of Fresnel zone scatter on measuring errors is nearly the same as monostatic case. See figure 4, t_0-point is the point where the radio wave path is shortest. Thus t_0-point is also the specular point where the angle of incidence equals the angle of reflection. T_x' is the symmetry point of T_x about meteor trail (axis-x). For a scatter point x_i alongside the trail, the radio wave propagation path length is the sum of the length from T_x' to x_i and from x_i to an antenna. Therefore t_0 point is the intersection of the trail path and the line from T_x' to an antenna, which represents shortest path length. t_0 point is also specified as the origin of axis-x (or time) . For a scatter point x_i which is S away from t_0, the radio wave propagation path length can be expressed as:

$$R = \sqrt{R_i^2 + S^2 - 2R_i Scos(90° + \theta)} + \sqrt{R_s^2 + S^2 - 2R_s Scos(90° - \theta)} \tag{5}$$

R_i and R_s are specular reflection path length for incident and reflection wave. θ is the incident angle (or reflection angle). Eq. (5) can be expanded to second order because S is very small compared to R_i and R_s. Thus, R can be expressed as:

$$R = R_i + R_s + \left(\cos^2\theta\,(\frac{1}{R_i} + \frac{1}{R_s})\right) S^2 \tag{6}$$

$R_i + R_s$ correspond to $2R_0$ in monostatic case which represents the shortest path for the radio wave. If substitute $\mathrm{x} = \sqrt{\frac{4\cos^2\theta(R_i+R_s)}{\lambda R_i R_s}}S$, other process is the same as monostatic case.

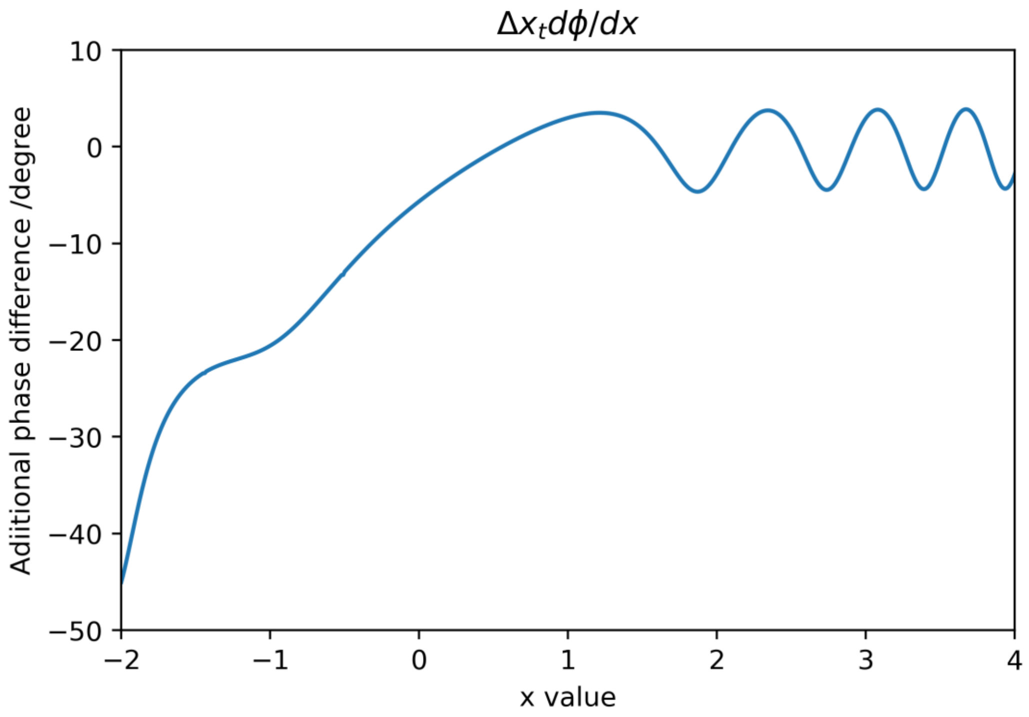

Figure 3

It worth noting that a meteor trail, transmitter and receiver are not always coplanar and a meteor trail and different receiver antenna pairs are not always coplanar too. We only give a semiquantitative analysis.

Additional phase difference and other measuring errors constitute the phase difference measuring errors ($\delta(\Delta\Psi_1)$ and $\delta(\Delta\Psi_2)$). Different radar system set different $\delta(\Delta\Psi_1)$ and $\delta(\Delta\Psi_2)$. For a receiver in Jones configuration which use at least four pairs of antennas to get AoAs, due to the phase difference measuring errors in those antennas pairs, the system should fit those four measured phase differences to get an expectant AoAs. If the RMS phase difference between the fitted and CCF phase exceeds a preselected threshold (default 20 degree) for any receiver pair the candidate is rejected (Holdsworth et al., 2004).In our program, the default value of $\delta(\Delta\Psi_1)$ and $\delta(\Delta\Psi_1)$ is 35 degree and our error propagation starts from this values. That is to say, the error that caused by the radio wave scatter from a few Fresnel zones of several kilometer length along the trajectory is included in the phase difference measuring errors

$(\delta(\Delta\Psi_1)$ and $\delta(\Delta\Psi_2))$ in our analytical method .

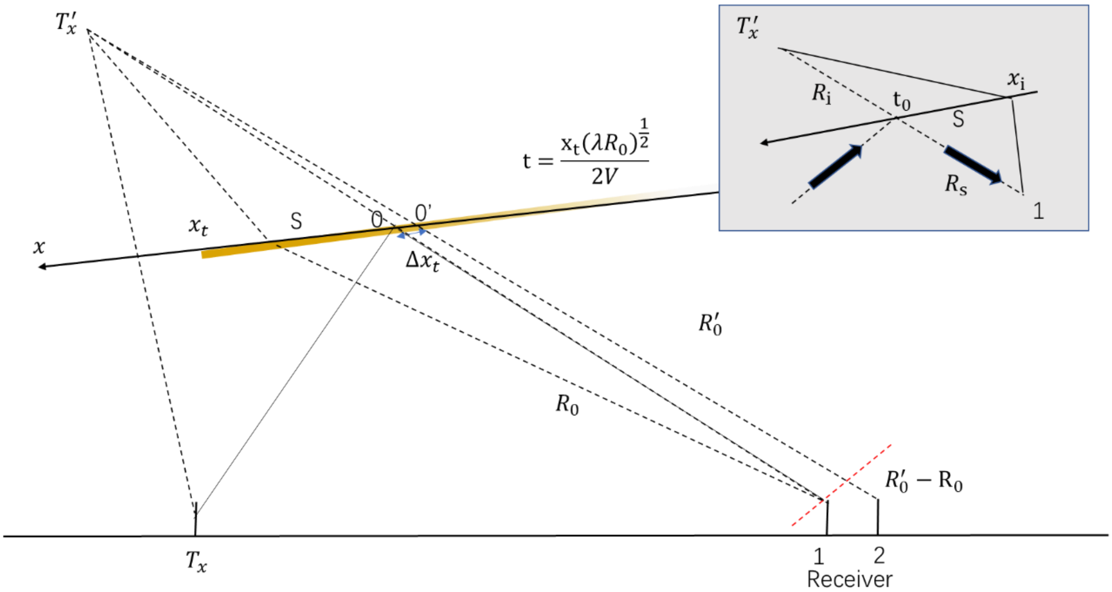

Figure 4