We greatly appreciate your constructive comment for thoughtful evaluations of the manuscript and helpful suggestions for its improvement. We did our best to response to all your comments. Author's responses were written in blue text below every referee's comment.

This paper clearly presents an evaluation of a method for estimating atmospheric temperature near the mesopause using the heights of meteor radar detections. As such, the content is of scientific interest and worthy of publication. The writing is clear with a few small grammatical errors that will be easy to correct. The figures are clearly presented and are integrated well with the text.

There are, however, some problems with missing references and poorly described processes that are not fully justified in the text. It is my recommendation that the paper be published following minor revisions.

Overall, it should be noted that while the authors are inferring an estimate of MLT temperature from the width of the meteor radar detection zone, the most directly related parameter is the density scale height. A discussion of the role of scale height on the vertical extent of meteor trails is curiously absent from the manuscript. This was first discussed by Eshleman, 1957 and was investigated in detail in Younger's publicly available 2011 PhD thesis, which the lead author is familiar with.

- We agree that it is very important to mention about density scale height. From the ideal gas law and hydrostatic equation as shown from Eq(1) to Eq(3), scale height (mg/kT) should correspond to ln(P1/P2)/FWHM because we can readily derive the simple formula from ideal gas law and hydrostatic eqution as below,

  $$\ln\frac{P_1}{P_2} = \frac{mg}{kT}(Z_2 - Z_1)$$

  As described in the manuscript, $Z_2 - Z_1$ is identical to the FWHM.

- Since we defined layer mean temperature <T>, the height region of interest in this study can be considered isothermal. In the manuscript, the ideal gas law was written as P=ρRT instead of P=nkT. According to your comment, we added description of the scale height in temperature estimation from the height width of meteor distribution with relevant references. (Eshleman, 1957; Younger, 2011).

General: The authors neglect the significant effect that meteoroid velocities have on determining the FWHM of the meteor height distribution. Faster meteors will have a smaller FWHM and are more susceptible to high-altitude cutoff. Furthermore, the relative numbers of different velocity meteoroids changes with time of day and season for a fixed observation location. Thus, the authors should calculate FWHM for a number of velocity bins and construct a fitted value for a single representative velocity, say, 30- 35 km/s.

- We totally agree with your comment and we'll calculate FWHM from representative meteor velocity like 30-35 km/s after we check the dependence of the FWHM on meteoroid speed.

General: The asymmetry of the meteor detection height distribution is due primarily to the high-altitude cutoff. What is the effect of using the standard deviation of heights calculated separately above and below MPH?

- Although we have not calculated standard deviation of heights separately above and below MPH, we obtained separate height widths from meteor detection region below and above MPH by independent Gaussian curves to height regions. That means the FWHM can be expressed as sum of half widths of two fitted curves. Unfortunately, the FWHM from two separated height widths gave us worse temperature estimation compared to the FWHM from a unified Gaussian fitting curve or even to traditional meteor decay method. As the figure 1 in Lee et al. (2016) clearly shows, the magnitude of asymmetry in meteor height distribution is very small.

Page 1, line 18-19: Here and throughout the paper, the authors state that they are measuring the mesopause temperature, but what is actually being estimated is a temperature near the mesopause. The height of the mesopause varies substantially more than the meteor peak height for which the authors state that their estimates are representative of.

- According to your comment, we changed "mesopause temperature" to " temperature near the mesopause". Thanks.

Page 1, line 18-25: The authors should include some references to general meteor radar operation, such as McKinley, 1961, Ceplecha et all, 1998, or Holdsworth et al., 2004 (Radio Science). Furthermore, a discussion of meteor radar temperatures is incomplete without reference to Tsutsumi et al., 1994 (Radio Science) and Hocking, 1999.

- Following your comment, we added all references in radar operation and meteor radar temperature description. Thanks.

Page 1, line 28-30: The authors fail to acknowledge the theoretical foundation of Eshleman, 1957, which provides the basis for their link between the height range of detected meteors and density scale height, and thus approximate temperature.

- We added statement "Eshleman [1957] provided a theoretical basis for the relationship between the atmospheric density scale height and the height range of detected meteor echoes. This relationship was developed by showing that the width of the height distribution of detected meteors is a nearly linear function of the density scale height [Younger 2011].” based on your comment.

Page 2, line 5-6: The authors should cite a paper describing the meteor radar response function, such as Cervera and Reid, 2004 or just the review paper of Ceplecha et al., 1998.

- We cited Cervera and Reid, 2004. Thanks.

Page 2, line 16-22: For a description of what is now a standard design for meteor radars, the authors should include a reference to Jones et al., 1998 for basic concept and Holdsworth et al., 2004 (Radio Science) for the detection and analysis software used by the King Sejong MR.

- According to the comment, we cited Jones et al., 1998 for the configuration of receiver array and Holdsworth et al., 2004 for the meteor radar data analysis.

Page 2, line 29: When the authors say that they limit phase error to less than six degrees, do they mean for each of the receiver channels, individual antenna pair combinations, or the array mean?

- Phase error in the manuscript means that mean value of phase difference error for the individual antenna pair combinations. We added description to make it clear. Thanks.

Page 3, line 27: It should be noted that atmospheric density is the determining factor in meteoroid ablation. Pressure is really only relevant in a discussion of diffusion of the meteor trail after formation.

- We agree that density primarily controls meteoroid ablation and pressure is a function of density and temperature from the ideal gas law. When we compared density field derived from Aura/MLS and height width of meteor distribution (FWHM), we found that the FWHM had better correlation with the pressure than the density. Based on this, we think the height distribution of detected meteor echoes is determined by not only density but background temperature.

Page 3, line 25-29: A discussion of meteoroid ablation should include a relevant reference, such as Love and Brownlee, 1999 or Rogers et al., 2005.

- According to your comment, we added two papers as reference. Thanks.

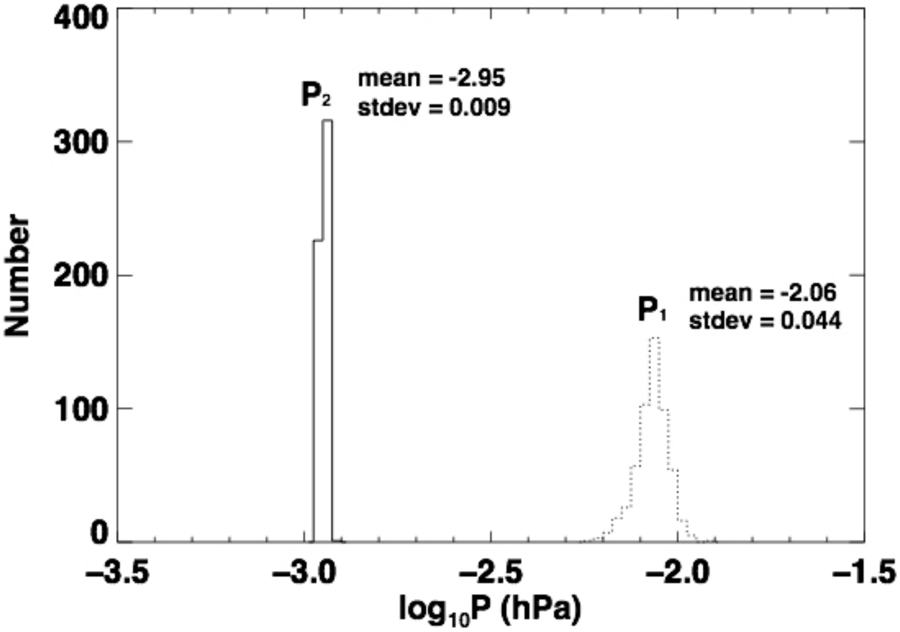
Page 4, line 1-10: It should be noted that this formulation is only valid for an isothermal atmosphere. This is implied later via the use of <T>, but it should be stated in the derivation. I would like to see how the FWHM compares with the density scale height, which includes a temperature gradient term.

- Once the layer mean temperature, <T> is defined as eq (4), eq (3) can be readily derived by dividing eq (2) by $\int_{P_2}^{P_1} d\ln P$. From the FWHM, we can estimate averaged temperature within a layer of two pressure values and the layer mean temperature can define any kind of atmosphere even rapid varying temperature profile. As shown in figure 1, FWHMs well follow constant atmospheric pressure region (P1, P2) and this observationally supports eq (3).

Page 4, general: The authors' derivation and method depends on meteor detections starting and ending at two well defined pressures, P1 and P2, but they do not state why this assumption is valid. Furthermore, they provide no concrete values for P1 and P2 as used in this study and do not provide information on where they obtained theses values, although perhaps the reader is meant to infer that SABER values were used? At the very least, the authors should supply the values and uncertainties.

- As Lee et al., (2016) did, we assumed that meteor height distribution is mainly determined by background atmosphere from two independent observations for 5 years such as meteor height distributions from meteor radar and atmospheric pressures from Aura/MLS. To prove this assumption is correct, we used two fundamental equations (ideal gas law, hydrostatic equation) and derived hypsometric equation which obviously showed the linear relationship between the layer mean temperature and the FWHM.

- Based on your comment, we presented 5-year averaged values of P1, P2 with standard deviation calculated from SABER measurements in the manuscript and relevant histogram is added as below,



Page 5, line 9-12: It is worth noting that 92 km is around (and sometimes past) the upper limit of reliable measurements by the MLS instrument. As such, the vertical resolution is less important than the accuracy of values extrapolated from MLS data.

- We agree with your comment, but please note that so many previous studies evaluating temperature [Meek et al., 2013; Kozlovsky et al., 2016; Yi et al., 2016; Lee et al., 2016] and density [Younger et al., 2015; Yi et al., 2018] estimation from meteor radar used MLS temperature/pressure measurements. In this study, we try to find specific height of temperature estimated from the meteor height distribution and this is a main reason why we used SABER data instead of MLS. Because the SABER has better vertical resolution and larger altitude coverage than MLS does.

Page 5, line 17: The authors are comparing a "theoretical" prediction based on C in equation 3, but C itself is derived from experimental observations for the individual radar system. This seems like circular reasoning.

- Firstly, we calculated proportionality constant (C1) between the SABER temperature and the FWHM by least-squares method and C1 should be considered empirical value of proportionality constant. From hypsometric equation, we calculated $C2 = \frac{g}{R}\left[\ln\left(\frac{P_1}{P_2}\right)\right]^{-1}$, which corresponds to proportionality constant, C in eq (3). Although both C1 and C2 represent the proportionality constant between the temperature and the FWHM, they have been derived from independent methods. When we obtained C2 from the hypsometric equation, realistic values of (P1, P2) are required and those pressure values were obtained from SABER measurements.
- Based on your comment, we replaced "theoretical values" by "constant in eq (3) with SABER pressure measurements".

Page 5, line 26: The authors need to provide more detail than "seems plausible". It would be helpful to compare <T> obtained from their method with an average of SABER values, weighted by the distribution of meteor detections. Given the asymmetry of the meteor height distribution, would this result in a value of <T> corresponding to the lower than MPH maximum correlation height in figure 3?

- Since the FWHM can be defined around the MPH, it is natural to assume that the temperature derived from the FWHM can represent the mean temperature at near the MPH. However, we showed that the representative height of temperature estimated from the FWHM is slightly lower than the MPH by 3-4 km in correlation analysis. We thought that the lower representative height and the asymmetry of the meteor height distribution should be caused by the meteor height ceiling (MHC) effect.

Page 6, line 11: Needs reference. Page 6, line 13-14: This statement should, at the very least, cite Jones, 1995.

- We added Thomas et al., 1988; Steel and Elford, 1991 as references. Jones, 1995 was cited as you commented in line 13-14. Thanks.

Page 6, line 16-17: The destructive interference of backscatter from off-axis portions of the trail is described in detail in Younger, 2008.

- Younger 2008 paper was added in line 16-17. Thanks.

Page 6, line 26: It is not just the reduced electron volume density responsible for reduced backscatter from trails with large initial radii. Backscatter from cylindrically symmetric distributions experiences significant destructive interference past the first maximum of the Bessel function in the backscatter amplitude integral (see e.g. McKin- ley, 1961 eq. 8-22 or Younger, 2008 figure 2).

- We're grateful for your comment in Bessel function dependence of backscattered signal amplitude. According to the comment, we corrected the statement as "The reduced electron density and its weighting function (zeroth-order Bessel function) oscillating positive and negative regions with a radial distance in the meteor trail…"

Line 32-33: The precision of the FWHM is a purely statistical quantity determined primarily by the height accuracy of the radar and number of meteors detected. While attenuation terms do determine the behaviour of the high-altitude cutoff in detectability, it does not make sense to invoke attenuation terms in a discussion of the precision of the FWHM term.

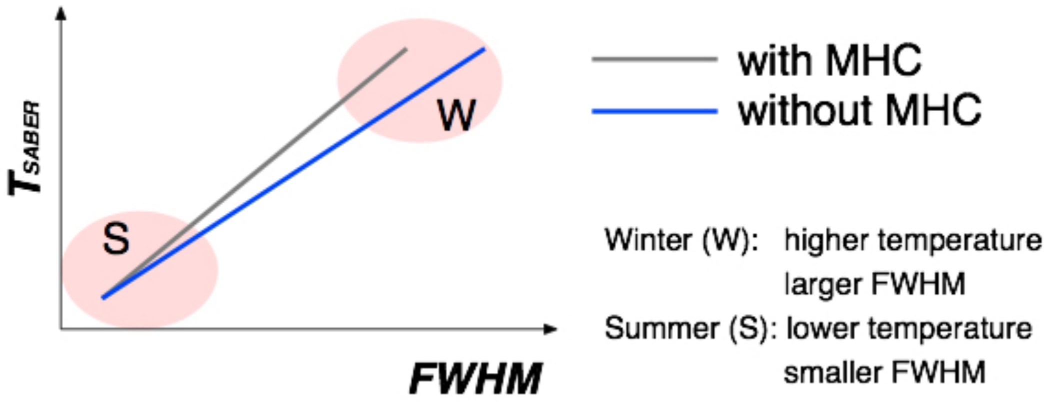
- we totally agree with your comment and we modified the sentence to avoid misunderstanding. Thanks. The corrected statement is as follows,
- "Although the background atmospheric pressure field primary factor to determine the FWHM, the MHC also contributes to the FWHM by reducing the detection of high altitude meteor trails."

Page 8, line 2-4: I fail to see how a demonstration of established meteor radar attenuation theory validates the authors' temperature estimation technique. The method is validated by correlation with independent measurement techniques. An assessment of attenuation coefficients is valuable for describing the shape of the meteor detection height distribution, but does not validate the method.

- As we described in the last paragraph in page 7 with figure 4 and figure 5, the MHC effect is mainly controlled by initial radius factor. From the relationship between neutral density (molecular mean free path) and initial radius, the MHC mostly occurs within a fixed mean free path supporting previous studies.

- Since the MHC produces asymmetric structure in meteor height distribution due to the high-altitude cutoff in detectability and this means that the MHC decreases the FWHM in meteor height distribution. As shown in table 1, proportionality constants (C1) from the least-squares method using SABER temperature and the FWHM tend to be slightly larger (by 1.4 ~ 3.7 %) than values (C2) from eq (3) with SABER pressure measurements. We thought that underestimated FWHM under the MHC effect provided the reason why C1s are systematically larger than C2 over the entire observation period.

- It should be noted that the MHC reduce the FWHM more effectively in winter when broader meteor height distributions (larger FWHMs) appear than summer because the upper part of FWHM in winter easily reaches cutoff height (~97 km) of MHC. This makes the empirical slope (C1) larger as shown in the figure below,



- In summary, although the MHC affects the absolute value of the FWHM and produces lower representative height of temperature estimation, it well reflects background atmospheric condition because it only happens at a constant atmospheric density (or mean free path).

Figure 2: Label text in the plot area is too small to be legible.

- We used bigger label text for legibility in figure 2. Thanks.

Figure 4: This figure would be improved if the authors also showed the cumulative attenuation coefficient (product of all 3).

- We added the normalized cumulative attenuation coefficient in the right hand. Thanks.