Dear Referee #1:

Thank you for your valuable comments and suggestions which helped us significantly to improve our manuscript. We have considered all comments carefully and revised the manuscript. Our point-by-point responses to all your comments are listed below in blue fonts and the changes in the manuscript are listed in *blue italic fonts*.

Anonymous Referee #1:

Manuscript presents the experimental results intending on demonstration of the possibility of vertical profiling the refractive index structure constant based on estimation of the turbulent kinetic energy dissipation rate and gradients of wind velocity and potential temperature from data of wind coherent lidar and microwave radiometer. For determining the refractive index structure constant, Eq. (4) in the manuscript is used. Eq. (4) follows from the formulae listed in Tatarskii, 1961 (see References in the manuscript).

General Comments:

The main remark to the manuscript is following. V.I. Tatarskii wrote in Tatarskii, 1961, that these formulae are true for the surface layer of the atmosphere. As to the heights above the surface layer, he noted, a lot of experiments are required to test applicability of these formulae. Actually, as it follows from the ground experiment described in the manuscript, Eq.(4) does not work even in the surface layer under the stable conditions, it gives the refractive index structure constant values which differ from the scintillometer results by two orders. The temperature stratification in the atmosphere is stable one at the heights exceeding the boundary layer height independently on the stratification in the boundary layer. Thus, Eq. (4) does not work over the boundary layer in any case.

Response: Firstly, thanks for your comments about the limitation of Eq. (4) under different circumstances. Based on our horizontal experiment, the reviewer points out that Eq. (4) doesn't work under stable conditions even in the ground, then he/she mentions this method is limited in the atmospheric boundary layer (ABL).

Actually, in the ground experiment, the discrepancy between the method using Eq. (4) and the scintillometer mainly within the transition period around 16:00-20:00 as shown in Fig. 2(g). When the stratification structure becomes stable at night, the TKEDR also gradually decreases, so the C_n^2 obtained from them becomes consistent again. However, the results in the night coincide not as well as in the daytime. To study the limitation of this method, we added the uncertainty analyses in the revised manuscript by calculating the relative error of C_n^2 and the integral scale of turbulence.

In the horizontal results, we find that the integral scale of turbulence L_v drops to the scale smaller than the length used to calculate the TKEDR during the transition period around 16:00-20:00 (Fig. 3(b) in the revised manuscript). This verified the difference between the two instruments is mainly due to the state of the atmosphere changing from isotropic to anisotropic. In the vertical profiles, the L_v grows when the TKEDR decreases with height, which causes the larger relative error of the estimation of C_n^2 in the high altitude (Fig. 8 in the revised manuscript).

According to the point of the reviewer, we tested the limits of this method and find the rationality within the ABL, especially within the convective boundary layer (Fig. 7 in the revised manuscript). Thanks again for your comments to make this manuscript more convincing and practical.

Specific Comments:

Comments 1: Lines 15-16: "... the mean error and standard deviation is 1.09×10-15 m-2/3 and 2.14×10-15 m- 2/3, respectively."

That says about nothing. Relative units are more informative.

Response 1: Thanks for your suggestion, we have added the relative error in the revised Fig. 3(c). It should be mentioned that due to the value of the C_n^2 being very small and normally changing between 2-3 orders of magnitude, the calculated relative error could be quite large even a small difference. For example, $\left(2 \times 10^{-15} m^{-\frac{2}{3}} - 1 \times 10^{-15} m^{-\frac{2}{3}}\right) / (1 \times 10^{-15} m^{-\frac{2}{3}}) = 100\%$. So, the relative error is calculated on a logarithmic scale.

Changes 1: *Line 179: When using all data for analysis, the correlation coefficient, mean error, and relative error between the two methods are 0.6723, 1.34×10^{-15} m$^{-2/3}$, and 2.83%, respectively. When using the black dots, the correlation coefficient, mean error, and relative error are 0.8389, 1.09×10^{-15} m$^{-2/3}$, and 2.04%, respectively.*

Comments 2: Line 70. Eq. (1) is listed in Tatarskii, 1961, for the temperature structure constant. Relation between the refractive index structure constant and the temperature one is commonly known.

Response 2: Indeed, the method using the relationship between the C_n^2 and C_T^2 is a common way to estimate the refractive index structure constant. As we discussed in the introduction, most of them acquire the C_n^2 profiles through the sounding balloon with a Radiosonde. It normally takes a long time to obtain one profile. However, considering the fast-changing turbulence environment, our purpose and innovation are to seek a method that can detect the turbulence profiles with high temporal and spatial resolution at the same time. Therefore, we use Eq. (4), which contains the dynamics and thermodynamics part, to estimate the C_n^2 profiles.

Comments 3: Lines 108-109: " In the vertical direction of 0-2.17 km, 2.17-4.76 km, and 4.76-11.26 km, the range resolution is 26 m, 52 m, and 130 m, respectively."

Pulsed lidars have dead zone, diapason "0-2.17 km" is not true. The same is for Figs. 2,4,6.

In Fig. 2e, instead of "-8 -2" should be "10-8 10-2". The same is for Figs.4g, 6d.

Response 3: Thanks for your reminder, the lidar we used has a pulse width of 200 ns, which has a blind zone of around 30 m. Now we have corrected the expression and the data in the figures are plotted from 51.96 m (first bin at 60 m and the elevation is 60 degrees).

The value of TKEDR ("-8 -2") are the units in log scale to simplify the expression and the same with Fig. 4(g), 6(d). And we have added the "$\log_{10}$()" in these figures for convenience.

Changes 3: *Line 115: The lidar has a pulse width of 200 ns, which has a blind zone of around 30 m. So, in the vertical direction of 0.03-2.20 km, 2.20-4.79 km, and 4.79-11.29 km, the height resolution is 26 m, 52 m, and 130 m, respectively.*

Comments 4: What means " the DAVIS weather station"?

Response 4: It means the weather station of model DAVIS6162: Wireless Vantage Pro2 Plus. We have added this information to the manuscript.

Changes 4: *Line 130: the weather station (DAVIS6162: Wireless Vantage Pro2 Plus).*

Comments 5: Line Lines 123,129: "The receiving and transmitting ends of LAS are located at the height of 55 m at site A and site B respectively. "… "temperature data recorded at the height of 2m, 8m, and 18m"

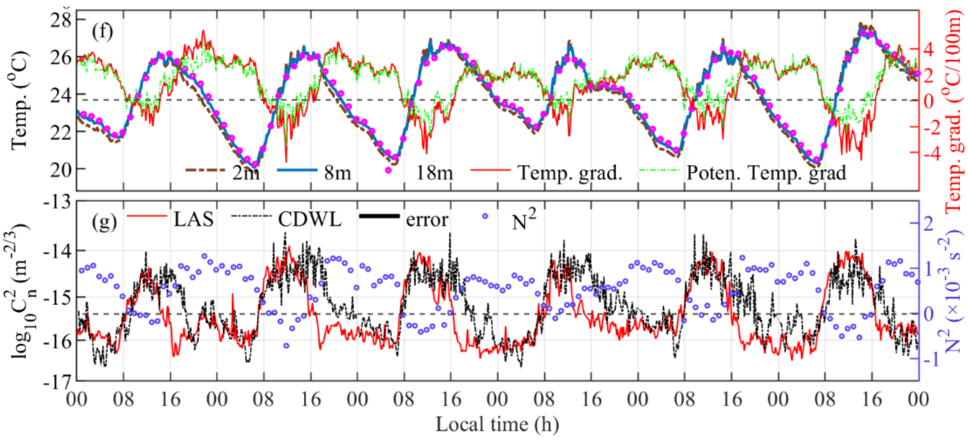
Difference in heights leads to difference in the refractive index structure constant about three times. The structure constant decreases with height.

Response 5: Thanks for reminding, actually the temperature data were recorded at the height of 2m, 8m, and 18m of the wind tower which was placed on the top of a 6-story building about 30 meters high. So, the height difference is quite small and now we explained in the paper.

Changes 5: *Line 134: The wind tower is placed on the top of a 6-story building about 30 meters high at site C to record the continuous data of temperature and for the calculation of temperature gradient.*

Comments 6: Figs. 2f, 5 say about nothing. The potential temperature and its gradient should be instead of temperature and temperature gradient to see the temperature stratification and its variations with height.

Response 6: Thanks for your advice, the temperature and its gradient were plotted in Fig. 2(f) to discover the temperature inversion phenomenon and the strong negative correlation with the C_n^2. And the Brunt-Väisälä frequency squared N^2 in Fig. 2(g) was drawn to reflect the temperature stratification structure. As shown in the green line in the following: the potential temperature gradient has a similar trend with the temperature gradient, especially with the N^2. So, to avoid giving redundant information and reveal the negative correlation between temperature inversion and the C_n^2, we kept the temperature gradient result in the horizontal experiment.



Besides, we have added the potential temperature and its gradient profiles to see the temperature stratification in Fig. 5 in the revised manuscript according to your suggestion.

Changes 6:

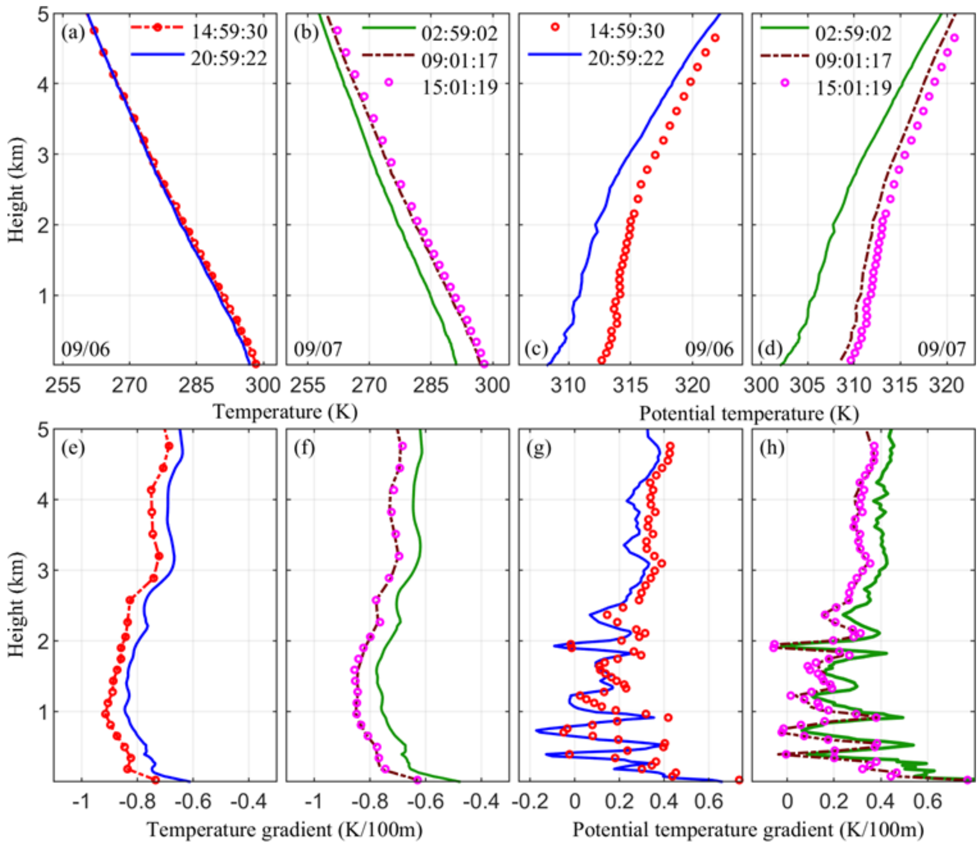


Figure 5. The results of temperature profiles (a)-(b), temperature gradient profiles (e)-(f), potential temperature profiles (c)-(d), and potential temperature gradient profiles (g)-(h) derived from MWR and the barometric formula at different times on September 06-07, 2019, local time.

Comments 7: The Richardson number in Fig. 6c is positive. That means, during measurements there was stable temperature stratification in the atmosphere. The applicability of Eq. (4) in such conditions is under question. As well as correctness of the profiles in Fig.7. Figs. 2g, 3 (green dots) demonstrate that at stable conditions there is large difference between the results of the scintillometer and calculations based on Eq. (4).

Response 7: Firstly, the Richardson number was calculated using the "bubble sort" algorithm proposed by Thorpe (Thorpe, 1977) to re-sort the potential temperature in a monotonically increasing order, which caused the positive value of the Richardson number. From Eq. 11, one can see that the sign of the R_i should be the same as N^2. Secondly, the R_i is the ratio of N^2 to wind shear S^2. When $0 < R_i < 1$, turbulence is easy to occur due to the domination of wind shear. So, the positive R_i doesn't mean a stable layer, and a more specific illustration about R_i can be found in Line 281 in the revised manuscript. Thirdly, the differences in Fig. 2(g), 3 (green dots) have been explained in the general comments, which are mainly within the transition period around 16:00-20:00 rather than all of the stable conditions at night. Moreover, the green lines in Fig. 7 are the HAP turbulence model that takes into account the power-law relationship with height near the ground. So, they are drawn here mainly to compare the surface layer and the model cannot represent a specific local feature. Finally, we have supplemented the analysis of the applicability and uncertainty of this method under different circumstances in the revised manuscript.

Changes 7: There are several changes related to the analysis of the limitation of this method. Parts of them are listed in the following:

Figure 3. The relative error of the estimation of TKEDR and $\boldsymbol{C_n^2}$ *(a), integral scale* $\boldsymbol{L_v}$ *(b), and comparative statistical analysis of LAS and CDWL observation results from September 26 to October 01, 2020, local time.*

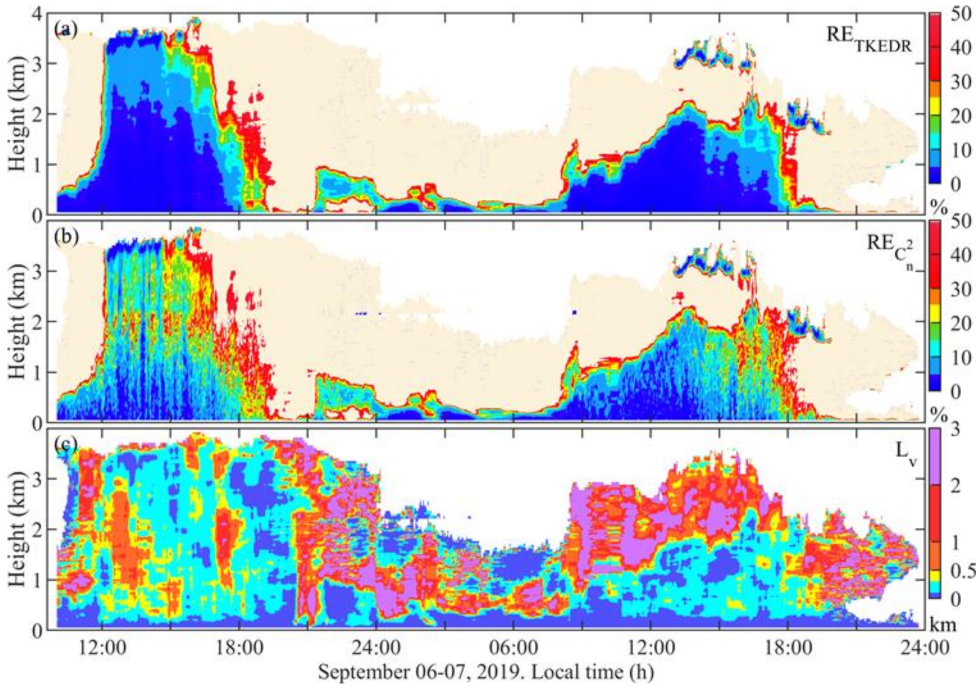


Figure 7. The relative error of the estimation of TKEDR (a), $\boldsymbol{C_n^2}$ *(b), and integral scale* $\boldsymbol{L_v}$ *(c) calculated from CDWL and MWR in the observations from September 06 to September 07, 2019, local time.*

Line 315: Then, the relative error of estimation of TKEDR, C_n^2 *and the integral scale* L_v *are calculated vertically in Fig. 7. The region with a relative error greater than 50% are marked in light yellow in Fig. 7(a) and (b). From the results, it can be seen that when using this method to obtain the profiles, a small relative error (*$RE_{C_n^2}$ *is mostly within 30%) can be maintained in the ABL, especially in the CBL. In the meantime,* L_v *is basically under 1 km in this area, so that* $R' > L_v$ *is satisfied, which means a low* RE_{TKEDR}*. After 18:00, with the height of the boundary layer decreases, the TKEDR drops rapidly at high altitude, and the* L_v *becomes larger than 2 km. As a result, the calculated* RE_{TKEDR} *and* $RE_{C_n^2}$ *also grow as shown in the figure. During the period of the atmosphere changes from convection to laminar flow (around 18:00 to 21:00), a sudden increase in relative error can be found similar to the horizontal experiment. After the atmosphere stabilized at night, the relative error of TKEDR and* C_n^2 *begin to gradually decrease, but mainly within the mixing layer.*

Best regards!
Sincerely yours,
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