Cover letter

Dear Editors and Reviewers:

Thank you for your letter and for the Reviewers' comments concerning our manuscript entitled "Turbulence parameters measured by the Beijing Mesosphere–Stratosphere–Troposphere radar in the troposphere/lower stratosphere with three models: Comparison and analyses" (ID: amt-2021-309). Those comments are valuable and helpful for revising and improving our paper and the important guiding significance to our research. We appreciate for Editors' and Reviewers' warm work earnestly and hope that the correction will meet with approval.

We have studied each comment carefully and have made corrections as far as possible. We recalculated the turbulence parameters and reorganized the overall manuscript, by taking the correct value of wind shear as $\frac{\partial u}{\partial z_{\phi}}$, where ϕ is the azimuth direction of the mean wind. In the revised version, we take the zonal (meridional) winds to explore the shear broadening effects of the east and west (north and south) beam. These changes do not affect the structure of the article. Revised portions are marked in red in the paper. For details of the revised manuscript, please refer to the document "Author's track-changes" and uploaded manuscript. The main corrections in the paper and the responses to the Reviewers' comments are as flowing:

RC1 referee comment 1

Q1 l.100 is related to (not with)

Response：

Thank you very much for your suggestion.

The modified content revised version(clean) for Q1 is as follows:

Line No:92 (Section 1, Page No:3 of 22)

"That is, several studies pointed out that the velocity variance measured by the radar is related to the transverse one-dimensional spectrum function for the direction radial from the radar (Dehghan &Hocking, 2011; Hocking, 1999)."

Q2 Table 1 – Coherent integration (combining signals from the same height bin over successive radar pulses, according to phase)

Incoherent integration (averaging of spectra)

Add to the table or the following text how long it takes to make one observation with the radar (your reply to me stated 5'6" but you didn't put that in the paper)

Response:

Thank you very much for your suggestion.

We have Added to the following text how long it takes to make one observation with the radar.

The modified content revised version(clean) for Q2 is as follows:

Line No:143 (Section 2.1, Page No:4 of 22)

Coherent integration (combining signals from the same height bin over successive radar pulses, according to phase)
Incoherent integration (averaging of spectra)

Line No:141-142 (Section 2.1, Page No:4 of 22)

"In middle mode, it takes about 5min for five beams to complete once data acquisition."

Q3 l.156-7 '… tropopause region, where the echo signal spectrum is narrow and unrelated to turbulence (e.g Fukao…..' l.158 based on isotropic scattering

Respnse:

Thank you very much for your suggestion.

The modified content revised version(clean) for Q3 is as follows:

Line No:148-150 (Section 3.1, Page No:5 of 22)

"However, the vertical beam is more susceptible to specular reflection, especially in the tropopause region, where the echo signal spectrum is narrow and unrelated to turbulence (e.g., Fukao et al., 1994; Tsuda et al., 1986; Birner, 2006), which based on isotropic scattering."

Q4 l.210-230. When thinking about the physics of the way wind shear affects the spectral width, we must recall that the Doppler shift is due to the component of velocity along the beam direction. If the beam is tilted along the same azimuth as the wind, and there is a vertical wind shear in the same direction, the spectrum is affected as shown in Dehgan and Hocking (2011), fig 5a. For example, positive wind shear makes the Doppler shift of the 'top' of the beam larger relative to the 'bottom', reducing the difference between them. But if the wind rotates with height in the range gate (transverse wind shear), the extra wind components add in quadrature to the mean wind, and their impact on the wind speed is much smaller. So the correct value of wind shear should be $\frac{\partial u}{\partial z_{\phi}}$, where ϕ is the azimuth direction of the mean wind.

Response:

Thank you very much for your reminder and suggestions.

As you may have considered, we have considered the issue of "component of the horizontal wind" in the new version, and recalculated shear broadening effects.

There are two main jobs, 1. The preparations of calculating shear broadening effects. 2. The selection of statistical samples.

1. Preparations

This study used the the absolute value of the component of the horizontal wind vector, did not overdiscuss the effect of wind direction, where $\frac{\partial u}{\partial z}$ contains positive and negative values.

1.1 The beam direction component of the horizontal wind

Only the beam direction component of the horizontal wind vector contributes to the broadening of the radar spectrum. So the correct value of wind shear should be $\frac{\partial u}{\partial z_{\phi}}$, where ϕ is the azimuth direction of the mean wind (Nastrom, 1997; Dehgan and Hocking, 2011). In this study, we take the zonal (meridional) winds to explore the shear broadening effects of the east and west (north and south) beam. The vertical shear of horizontal wind $\frac{\partial u}{\partial z}$ is as following:

For the east and west beams:

$$u = u_x,\ \frac{\partial u}{\partial z} = \frac{\partial u_x}{\partial z} \tag{6}$$

For the north and south beams:

$$u = v_y,\ \frac{\partial u}{\partial z} = \frac{\partial v_y}{\partial z} \tag{7}$$

where u_x and v_y is zonal and meridional wind, respectively.

1.2 The directions of u_x and v_y

The models take the u as the horizontal wind speed(Nastrom, 1997; Dehgan and Hocking, 2011). In fact, the direction of the component of the horizontal wind is indicated by a positive or negative number, such as th positive value of u_x means the wind blows from west to east. So we do some simulation experiments for these three models, the results show that the directions of u_x and v_y have no effect on the results of H model, and have very little effect on D-H model and N-2D model, as shown in Fig.R-1.

This study used the the absolute value of the component of the horizontal wind vector, did not overdiscuss the effect of wind direction, where $\frac{\partial u}{\partial z}$ contains positive and negative values.

Simulation experiments:

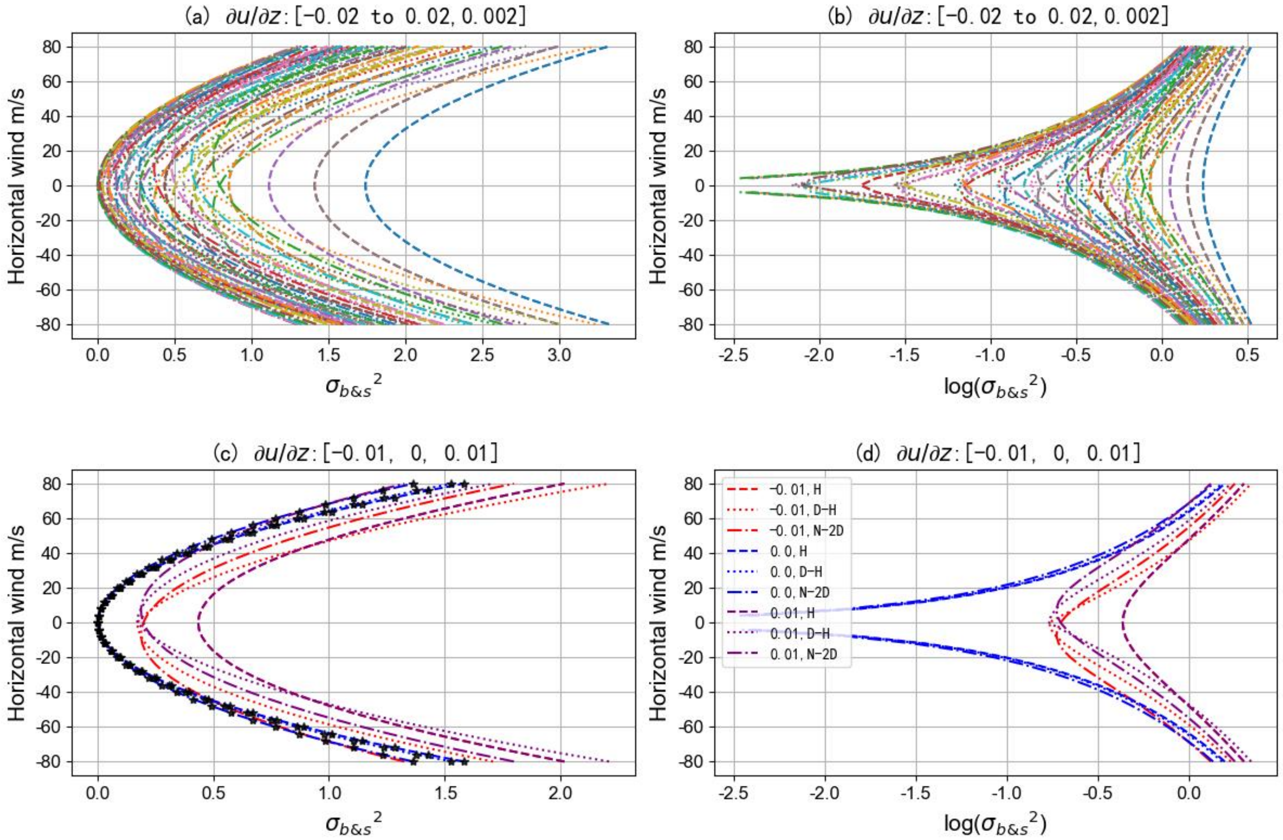

Figure R-1 The $\sigma^2_{s\&b}$ estimated from the three models relate to the vertical shear and horizontal wind speed. The horizontal wind speed is in the range of -80 to 80 m/s, per 4m/s. (a)(b) $\frac{\partial u}{\partial z}$ is in the range of -0.02 to 0.02 s^{-1}, per 0.002 s^{-1}. (c)(d) $\frac{\partial u}{\partial z}$ has just 3 numbers, -0.01 s^{-1}, 0 s^{-1}, 0.01 s^{-1}. (a)(c) are $\sigma^2_{s\&b}$, (b)(d) are log ($\sigma^2_{s\&b}$). (c)(d) red lines are $\frac{\partial u}{\partial z}$=-0.01 s^{-1}, blue lines are $\frac{\partial u}{\partial z}$=0 s^{-1}, purple lines are $\frac{\partial u}{\partial z}$=0.01 s^{-1}. (c) The stars are $\frac{\partial u}{\partial z} = 0$ s^{-1}. The broadening components estimated from H model is just related to $|\frac{\partial u}{\partial z}|$, so it is the same line for H model taking $\frac{\partial u}{\partial z}$ as 0.01 s^{-1} or -0.01 s^{-1}.

The modified content revised version(clean) for calculating shear broadening effects is as follows:

Line No:198-208 (Section 2.3.1, Page No:6 of 22)

"In fact, only the beam direction component of the horizontal wind vector contributes to the broadening of the radar spectrum. So the correct value of wind shear should be $\frac{\partial u}{\partial z}_{\phi}$, where ϕ is the azimuth direction of the mean wind (Nastrom, 1997; Dehgan and Hocking, 2011). In this study, we take the zonal (meridional) winds to explore the shear broadening effects of the east and west (north and south) beam. The vertical shear of horizontal wind $\frac{\partial u}{\partial z}$ is as following:

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where u_x and v_y is zonal and meridional wind, respectively. And the directions of u_x and v_y have no effect on the results of H model, and have very little effect on D-H model and N-2D model. This study used the the absolute value of the component of the horizontal wind vector, did not overdiscuss the effect of wind direction, where $\frac{\partial u}{\partial z}$ contains positive and negative values."

2. The statistical samples – four oblique beams

The "**Preparations**" showed clearly how to recalculated shear broadening effects. But how to choose the the statistical samples is another thing that needs careful consideration. We have the observational datasets of four oblique beams, but there are obvious variation in the distributions of u_x and v_y (as shown in Fig. R-2). here u_x and v_y is zonal and meridional wind, respectively.

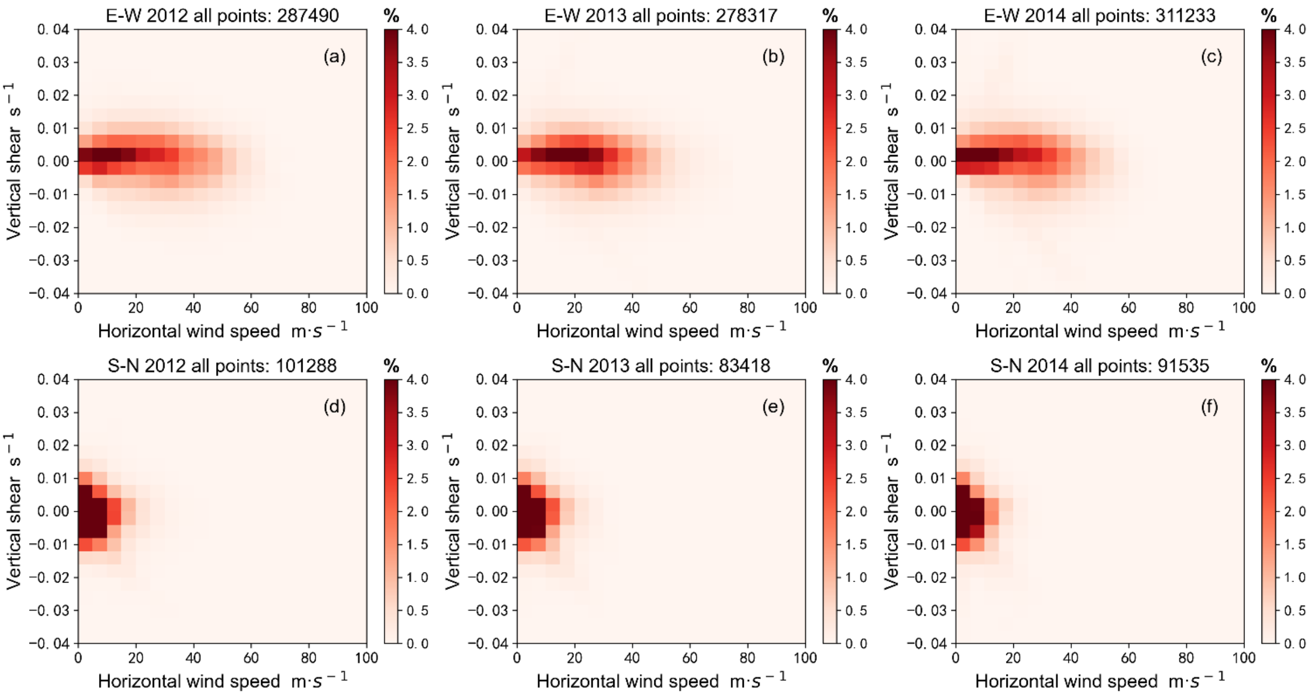

Figure R-2. Two-dimensional frequency distribution characteristics of horizontal wind speed and vertical shear of horizontal wind speed within the height range of 3–19.8km above the Beijing MST radar station from 2012 to 2014. (a)(b)(c) The east-west component of horizontal wind, (d)(e)(f) The north-south component of horizontal wind.

The east-west component of the horizontal wind speed over the radar site is distributed between 0 m s^{-1} and 60 m s^{-1}, and the vertical shear of the horizontal wind speed ranges from −0.014 to 0.014 s^{-1}. The north-south component of the horizontal wind speed in Beijing is distributed between 0 m s^{-1} and 20 m s^{-1}, and the vertical shear of the horizontal wind speed ranges from −0.014 to 0.014 s^{-1}. As shown in Table R-1, for the east and west beams, the rates of N-TKE ($\sigma_t^2 < 0$) of the H model, N-2D model and D-H model are in the range of 27%–32%, 15%–21% and 9%–15%, respectively. And for the north and south beams, the rates are in the range of 5%–8%, 2%–4% and 0.6%–1.0%,. The probability that the turbulence spectrum width is less than 0 calculated by different oblique beams are different. But results of the symmetric beams (such as east and west beams/ north and south beams) are similar.

Table R-1. Total frequency of $\boldsymbol{\sigma_t^2} < \mathbf{0}$ in the range of 3–19.8 km.

Beams	Time	Total numbers	H, $\sigma_t^2 < 0$	N-2D, $\sigma_t^2 < 0$	D-H, $\sigma_t^2 < 0$
East	2012	287490	78484 (27.30%)	43253(15.05%)	28067(9.76%)
	2013	278317	76038(27.32%)	43886(15.77%)	27836(10.00%)
	2014	311233	90633(29.12%)	54988(17.67%)	34219(10.99%)
West	2012	288060	82821(28.75%)	46925(16.29%)	32467(11.27%)
	2013	280769	82019(29.21%)	48156(17.15%)	32931(11.73%)
	2014	313848	103226(32.89%)	64997(20.71%)	44683(14.24%)
North	2012	102079	7924(7.76%)	3870(3.79%)	923(0.90%)
	2013	84402	6377(7.56%)	3206(3.81%)	724(0.86%)
	2014	92084	5900(6.41%)	3115(3.38%)	726(0.79%)
South	2012	101288	6932(6.84%)	3583(3.54%)	985(0.97%)
	2013	83418	5635(6.76%)	2985(3.58%)	696(0.83%)
	2014	91535	5061(5.52%)	2674(2.92%)	573(0.63%)

So if the distributions of u_x and v_y won't affect the statistical results, we take the observational datasets of four oblique beams as a total sample. Otherwise, we take the datasets of east and west beams as one sample and that of north and south beams as the other sample.

The modified content revised version(clean) for **The statistical samples** is as follows:

Line No:252 (Section 3.1, Page No:8 of 22)

For Tabel 2. We take four samples for every year.

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Table 1. Total frequency of $\boldsymbol{\sigma_t^2 < 0}$ in the range of 3–19.8 km.

Beams	Time	Total numbers	H, $\sigma_t^2 < 0$	N-2D, $\sigma_t^2 < 0$	D-H, $\sigma_t^2 < 0$
East	2012	287490	78484 (27.30%)	43253(15.05%)	28067(9.76%)
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North	2012	102079	7924(7.76%)	3870(3.79%)	923(0.90%)
	2013	84402	6377(7.56%)	3206(3.81%)	724(0.86%)
	2014	92084	5900(6.41%)	3115(3.38%)	726(0.79%)
South	2012	101288	6932(6.84%)	3583(3.54%)	985(0.97%)
	2013	83418	5635(6.76%)	2985(3.58%)	696(0.83%)
	2014	91535	5061(5.52%)	2674(2.92%)	573(0.63%)

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Line No:260 (Section 3.1, Page No:8 of 22)

For Fig1, We take the datasets of east and west beams as one sample and that of north and south beams as the other sample.

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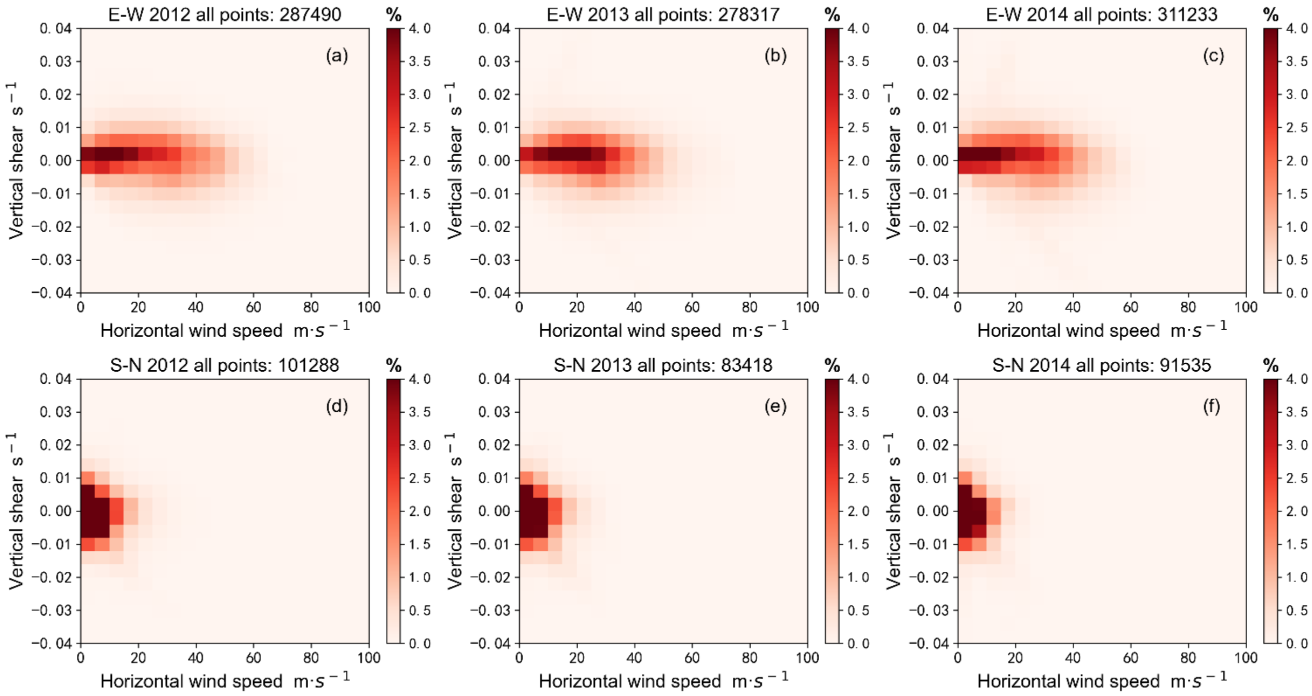

Figure 3. Two-dimensional frequency distribution characteristics of horizontal wind speed and vertical shear of horizontal wind speed within the height range of 3–19.8km above the Beijing MST radar station from 2012 to 2014. (a)(b)(c) The east-west component of horizontal wind, (d)(e)(f) The north-south component of horizontal wind.

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Line No:276 (Section 3.1.1, Page No:10 of 22)

For Fig2 This paper just gives the resultes of the east-west component of horizontal wind. Beacause the north-south component of horizontal wind speed in Beijing is distributed between 0 m s^{-1} and 20 m s^{-1}.

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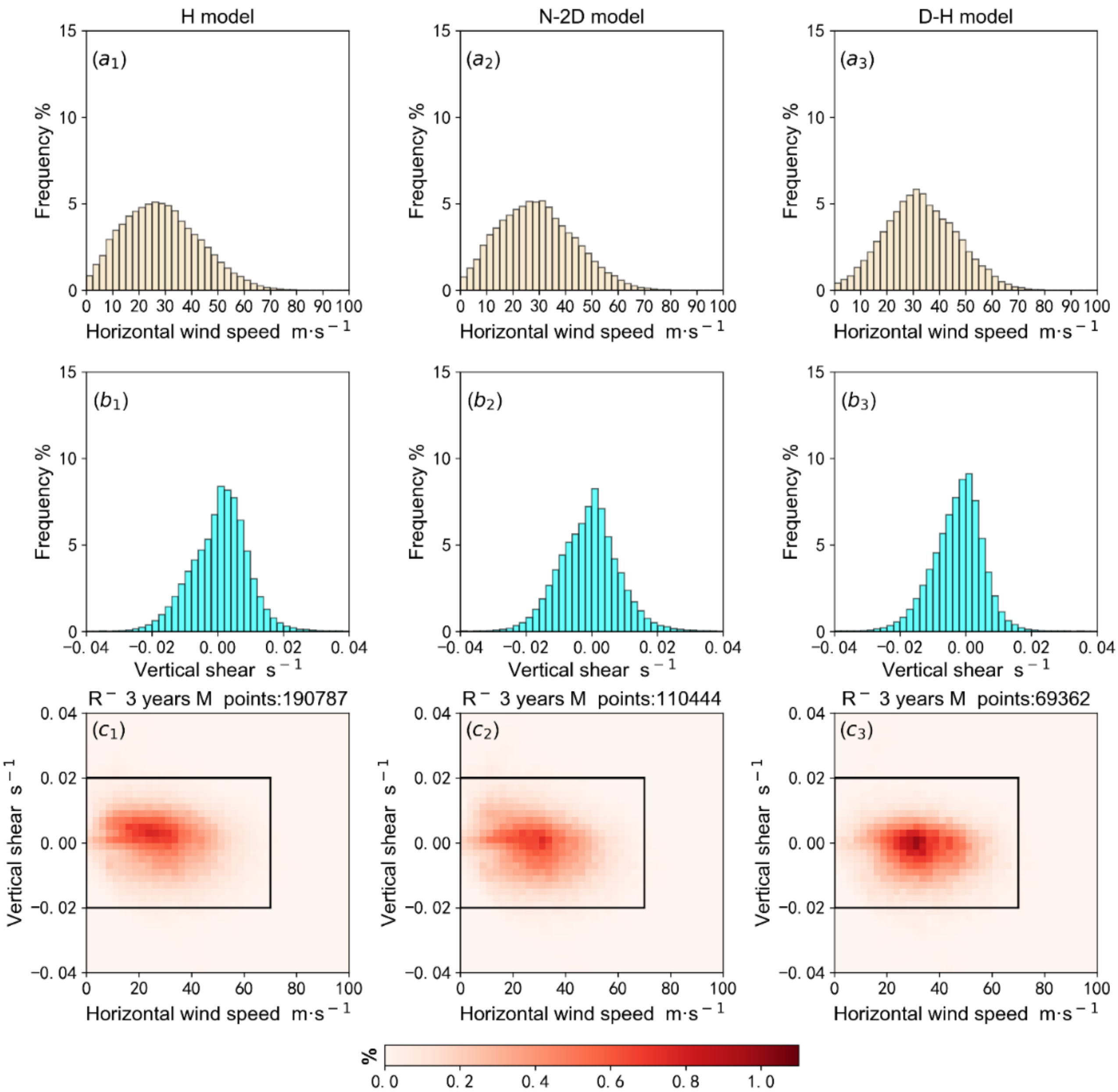

Figure 4. Frequency distribution of (a_1–a_3) horizontal wind speed and (b_1–b_3) the vertical shear of horizontal wind speed, along with (c_1–c_3) the two-dimensional frequency distribution characteristics

of horizontal wind speed and the vertical shear of horizontal wind speed for H model (a_1, b_1, c_1), N-2D model (a_2, b_2, c_2) and D-H model (a_3, b_3, c_3) when the turbulent kinetic energy is negativie."

Line No:304 (Section 3.1.2, Page No:11 of 22)

For Fig. 3. This paper gives the result of taking four oblique beams as a total sample. Beacuse the results were relatively consistent, although the horizontal wind component of the north and south beams was concentrated in 0 to 20 m/s (Fig. R-3, Fig. R-4).

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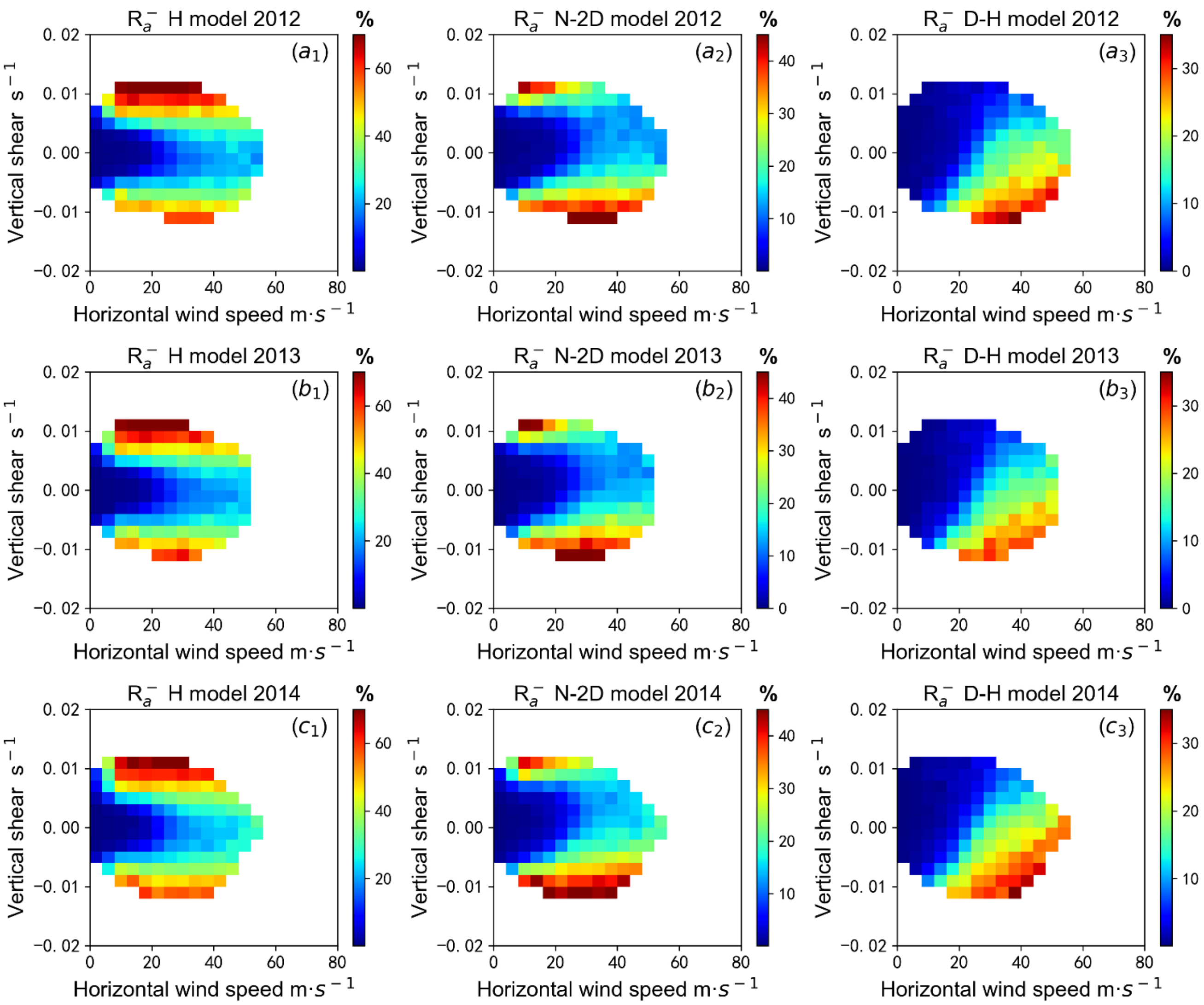

Figure 5. Distribution of $\boldsymbol{R_a^-}$ for the $(\mathbf{a_1})$ H model, $(\mathbf{a_2})$ N-2D model, and (a_3) D-H model in 2012. Panels $(\mathbf{b_1})$– $(\mathbf{b_3})$ and $(\mathbf{c_1})$– $(\mathbf{c_3})$ are the same as (a_1)–(a_3) but for the results of the three models in 2013 and 2014, respectively. The subgraph at the lower right corner of $(\mathbf{a_1}, \boldsymbol{b_1}, \mathbf{c_1})$ is the same as $(\mathbf{a_1}, \boldsymbol{b_1}, \mathbf{c_1})$, but for $\boldsymbol{log_{10}}$ $(\boldsymbol{R_a^-})$."

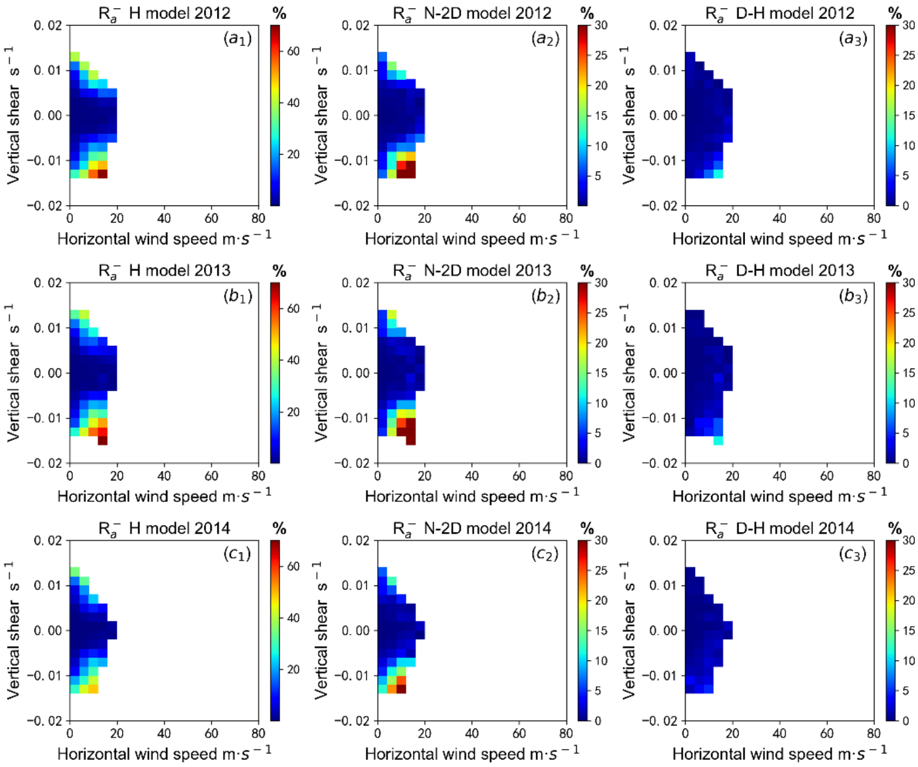

Figure R-3. The same as Fig. 3, but for North beam.

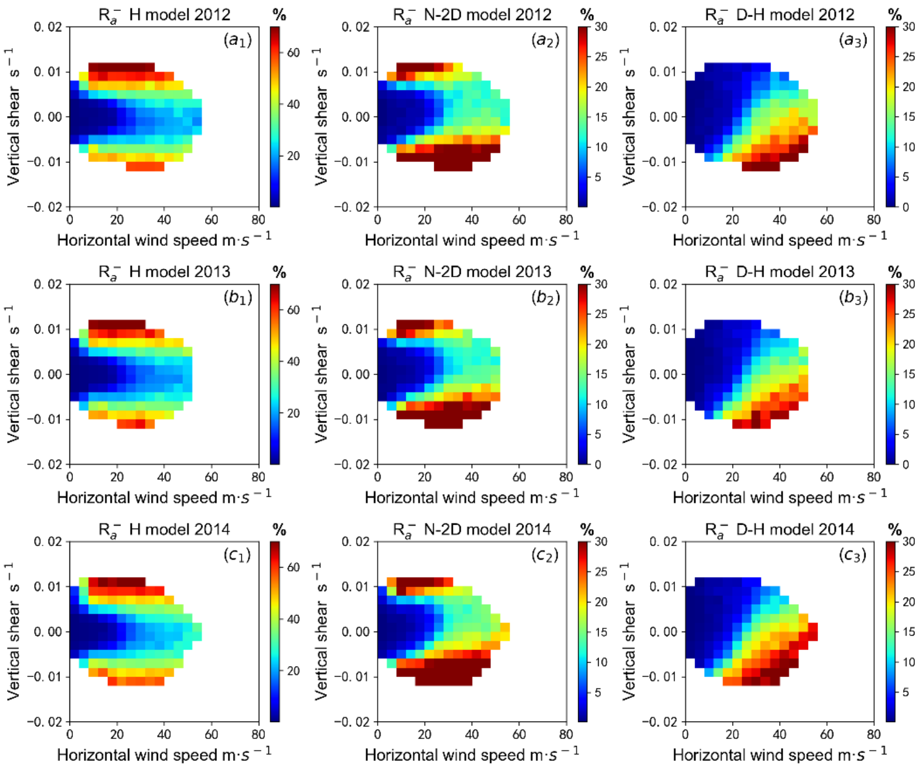

Figure R-4. The same as Fig. 3, but for East beam.

Line No:336 (Section 3.2, Page No:13 of 22)

For Fig.4, the result is based on the three years of observational data from the east and west beams. Beacause the north-south component of horizontal wind speed in Beijing is distributed between 0 m s^{-1} and 20 m s^{-1}.

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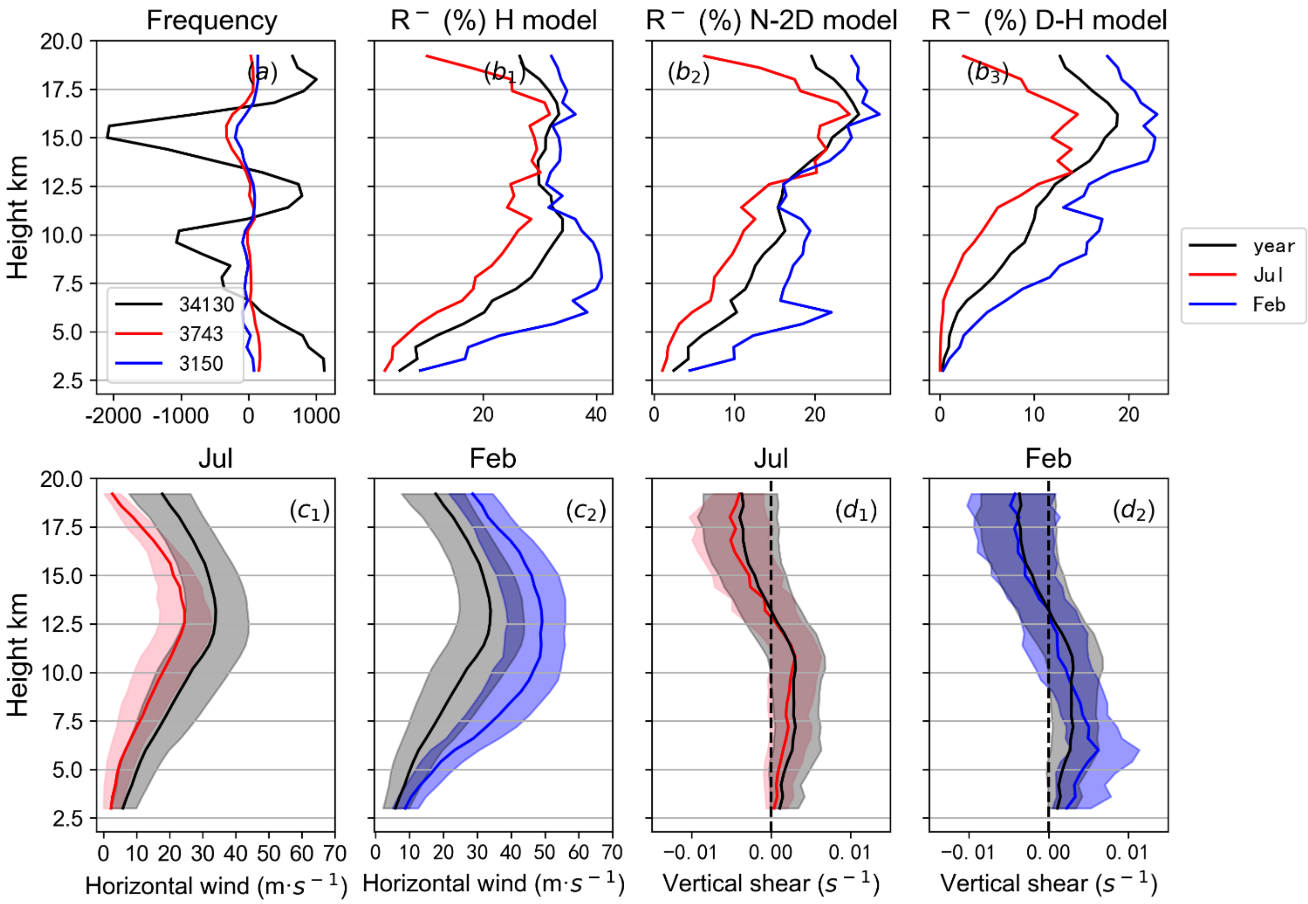

Figure 6. (a) Deviation profile of the data volume involved in the statistics and the mean value of the profile. The annual mean value is 34,130, the mean value in July is 3743, and the mean value in February is 3150. ($\mathbf{b_1}$–$\mathbf{b_3}$) Probability of N-TKE in each gate for the H model, N-2D model and D-H model, respectively. Panels ($\mathbf{c_1}, \mathbf{c_2}$) and ($\mathbf{d_1}, \mathbf{d_2}$) are the median, upper and lower quartile profiles of horizontal wind speed and the vertical shear of horizontal wind speed, respectively. Black/red/blue represents the characteristics of the year/July/February, respectively. Three years of radar observational data from 2012 to 2014 were used in the statistics.”

Line No:385 (Section 3.3, Page No:15 of 22)

For Fig. 5 and Table3, we take the observations of four oblique beams as a total sample.

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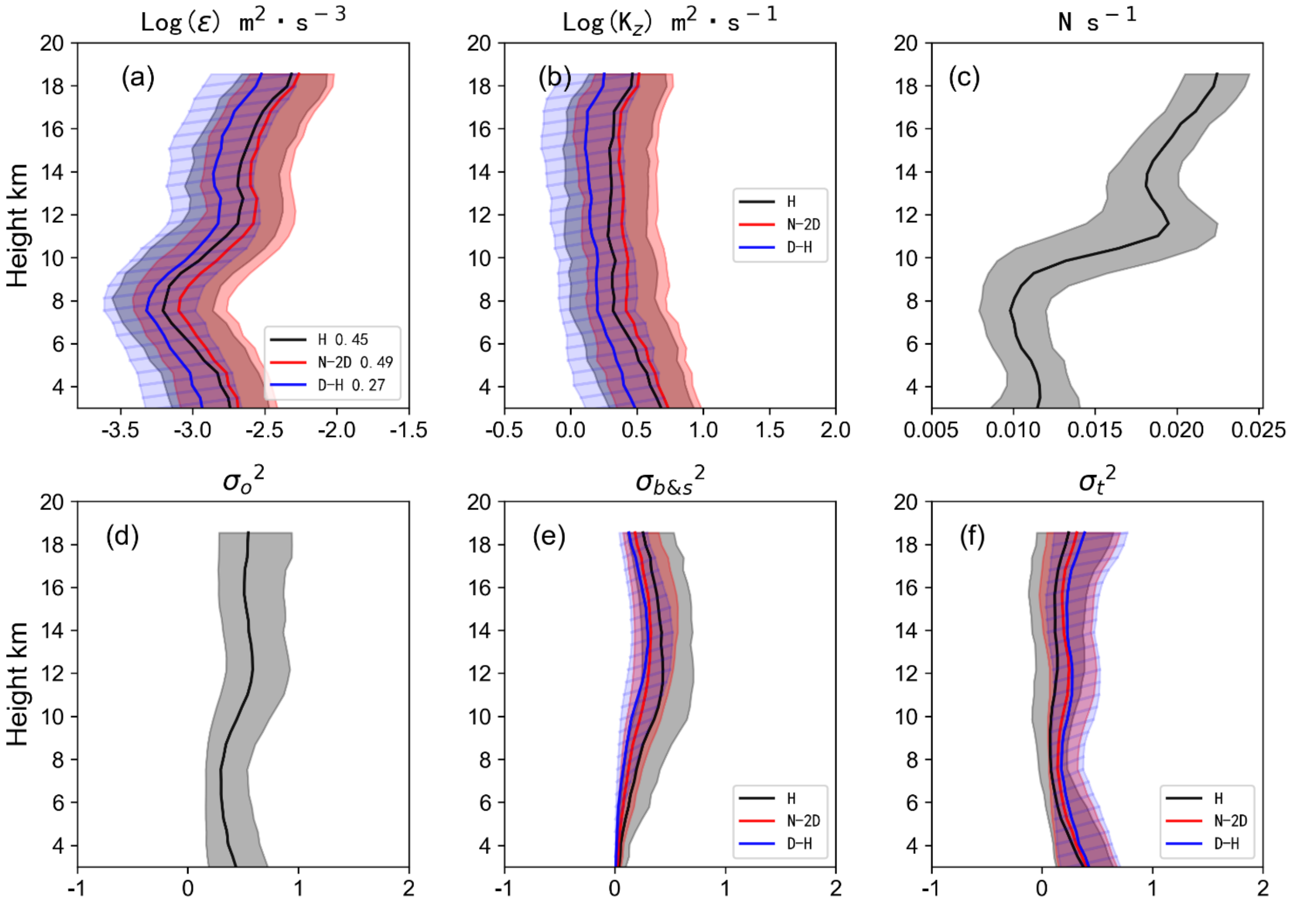

Figure 7. Profiles of (a) $\boldsymbol{\varepsilon}$, (b) Kz, (c) B-V frequency, (d) observation spectrum width, (e) beam and shear broadening, and (f) spectrum width caused by turbulence. The solid line is the median and the shaded area is the upper and lower quartiles. In panels (a, b, e, f), the black/red/blue solid lines and shaded areas represent the median and upper and lower quartiles of the H model/N-2D model/D-H model, respectively.

Line No:452 (Section 4.2, Page No:18 of 22)

Table 3. Turbulence parameters of the Beijing MST radar (39.78°N, 116.95°E) at the range of 3–19.8 km.

	H model, $c_1 = 0.45$	N-2D model, $c_1 = 0.49$	D-H model, $c_1 = 0.27$
Median log (ε) ($m^2\ s^{-3}$)	–3.2 (7 km) to –2.7(12 km)	–3.0 (7 km) to –2.6 (12 km)	–3.3 (7 km) to –2.8 (14 km)
Median log (Kz) ($m^2\ s^{-1}$)	0.3 to 0.7	0.4 to 0.7	0.1 to 0.5

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Line No:431 (Section 4.1, Page No:17 of 22)

For Fig.6, it is based on the east beam.

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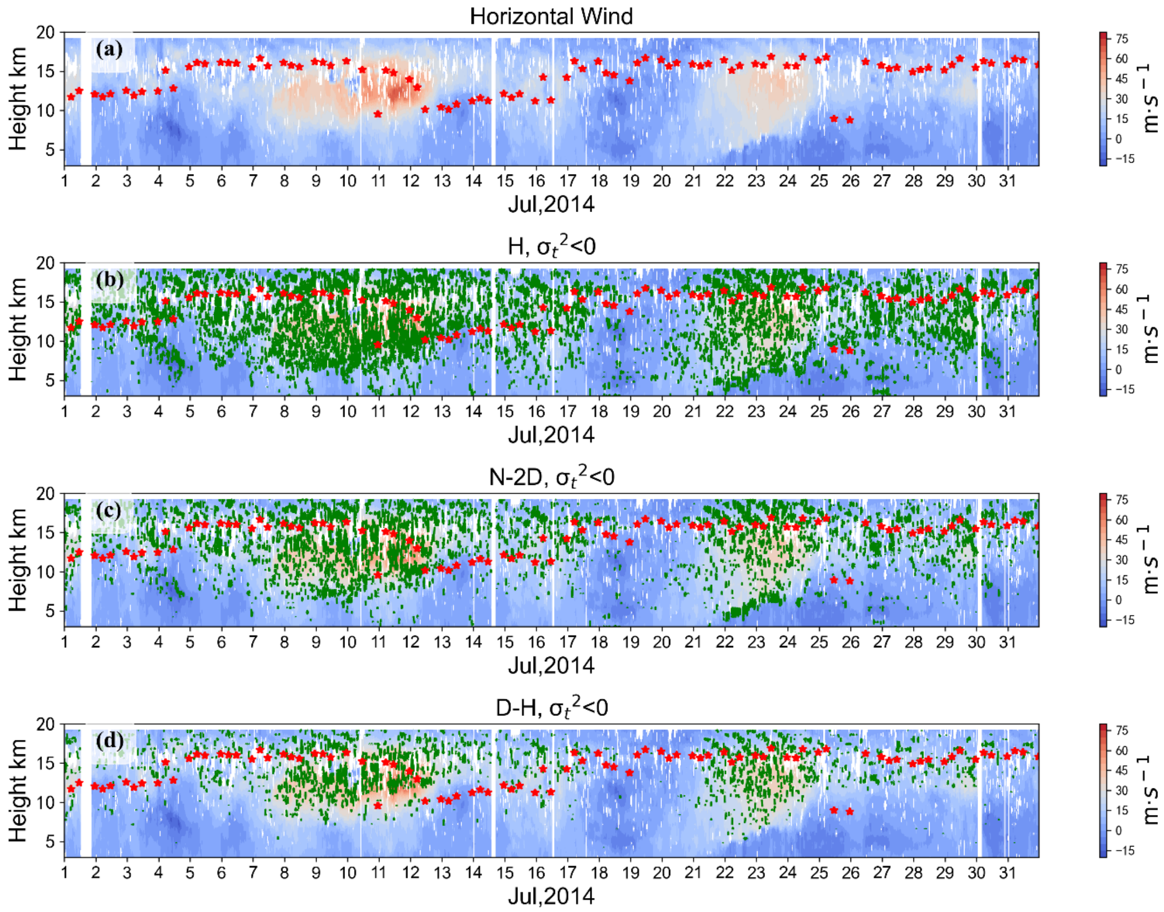

Figure 6. N-TKE distribution of three models over the Beijing MST radar site in July 2014: (a) the

east-west component of horizontal wind; (b–d) area of N-TKE (green shading) for the east beam using the (b) H model, (c) N-2D model and (d) D-H model. The red scattered points are the tropopause.”

Line No:468 (Section 4.2, Page No:19 of 22)

For Fig7, We take the datasets of east and west beams as one sample and that of north and south beams as the other sample.

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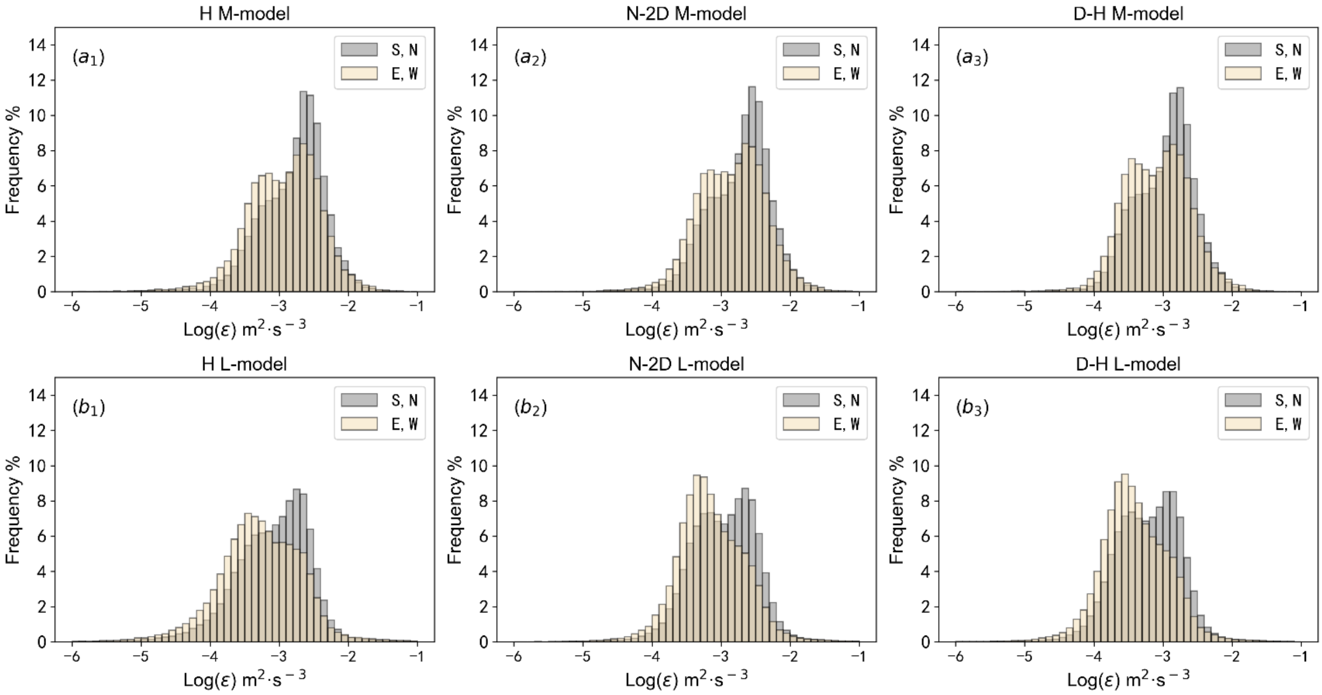

Figure 8. Distribution of $\boldsymbol{\varepsilon}$ in the middle and low mode of the Beijing MST radar in the range of 3–7.8 km from 2012–2014: $(\boldsymbol{a_1}-\boldsymbol{a_3})$ distributional characteristics of $\boldsymbol{\varepsilon}$ in the H model, N-2D model and D-H model (mid mode); $(\boldsymbol{b_1}-\boldsymbol{b_3})$ as in $(\boldsymbol{a_1}-\boldsymbol{a_3})$ but for low-mode data. The gray bars are the result of a north and south beams, the yellow bar are based on the east and west beams.

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RC2 referee comment 2

Specific comments

In the revised manuscript, the authors added a discussion on how to calculate the vertical shear of horizontal wind for estimating the shear broadening component, where the vertical shear is calculated as the vertical gradient of absolute value of horizontal wind vector. However, since shear broadening comes from the variation of the radial velocity within the radar volume, only the beam direction component of the horizontal wind vector contributes to the broadening of the radar spectrum. In fact, Nastrom (1997) shows scatter plots of spectral widths of the eastward (northward) beam versus vertical shear of zonal (meridional) winds to explore the shear broadening effects of WSMR observations. I recommend the authors to recalculate shear broadening effects.

Response:

Thank you very much for your reminder and suggestions.

As you may have considered, we have considered the issue of "component of the horizontal wind" in the new version, and recalculated shear broadening effects.

There are two main jobs, 1. The preparations of calculating shear broadening effects. 2. The selection of statistical samples.

1. Preparations

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Simulation experiments:

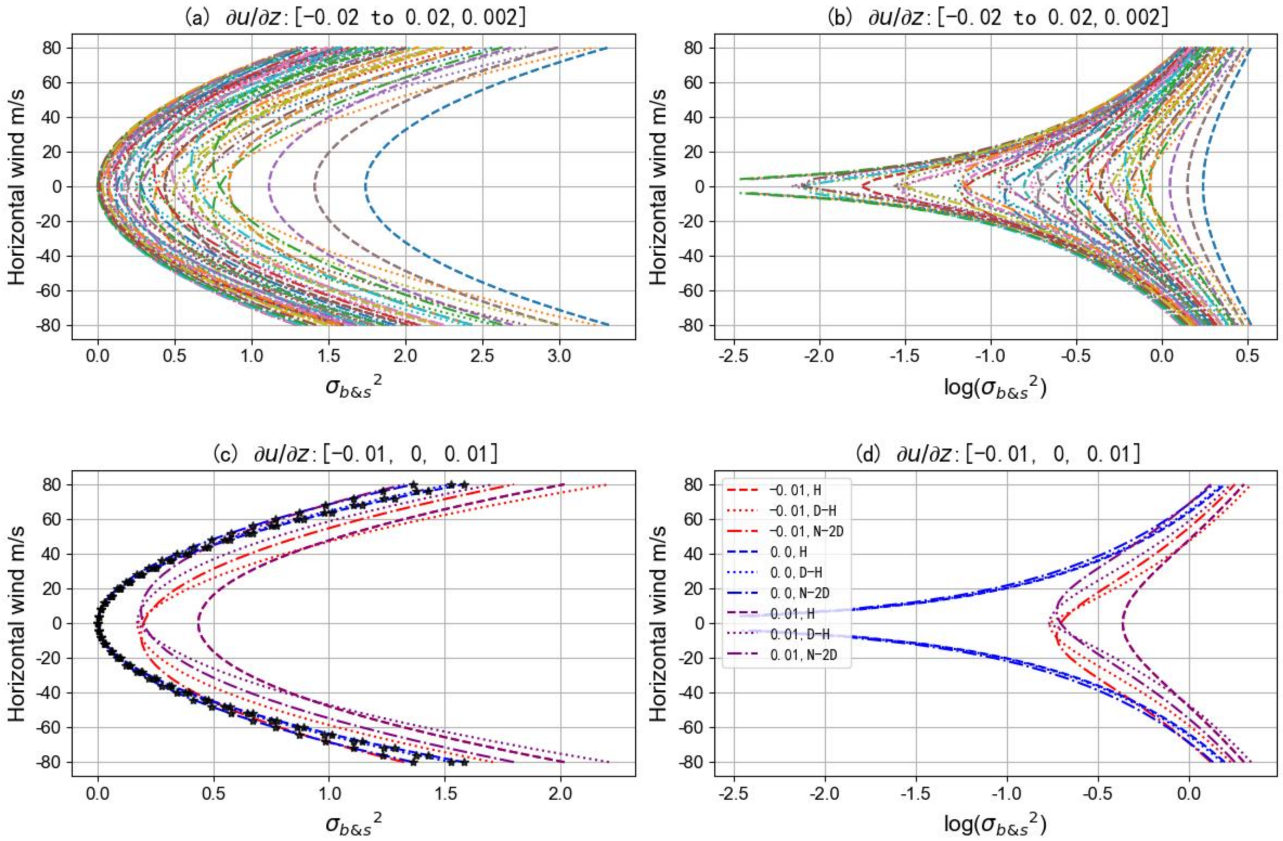

Figure R-9 The $\sigma_{s\&b}^2$ estimated from the three models relate to the vertical shear and horizontal wind speed. The horizontal wind speed is in the range of -80 to 80 m/s, per 4m/s. (a)(b) $\frac{\partial u}{\partial z}$ is in the range of -0.02 to 0.02 s^{-1}, per 0.002 s^{-1}. (c)(d) $\frac{\partial u}{\partial z}$ has just 3 numbers, -0.01 s^{-1}, 0 s^{-1}, 0.01 s^{-1}. (a)(c) are $\sigma_{s\&b}^2$, (b)(d) are log ($\sigma_{s\&b}^2$). (c)(d) red lines are $\frac{\partial u}{\partial z}$=-0.01 s^{-1}, blue lines are $\frac{\partial u}{\partial z}$=0 s^{-1}, purple lines are $\frac{\partial u}{\partial z}$=0.01 s^{-1}. (c) The stars are $\frac{\partial u}{\partial z} = 0$ s^{-1}. The broadening components estimated from H model is just related to $|\frac{\partial u}{\partial z}|$, so it is the same line for H model taking $\frac{\partial u}{\partial z}$ as 0.01 s^{-1} or -0.01 s^{-1}.

The modified content revised version(clean) for calculating shear broadening effects is as follows:

Line No:198-208 (Section 2.3.1, Page No:6 of 22)

“In fact, only the beam direction component of the horizontal wind vector contributes to the broadening of the radar spectrum. So the correct value of wind shear should be $\frac{\partial u}{\partial z}_{\phi}$, where ϕ is the azimuth direction of the mean wind (Nastrom, 1997; Dehgan and Hocking, 2011). In this study, we take the zonal (meridional) winds to explore the shear broadening effects of the east and west (north and south) beam. The vertical shear of horizontal wind $\frac{\partial u}{\partial z}$ is as following:

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where u_x and v_y is zonal and meridional wind, respectively. And the directions of u_x and v_y have no effect on the results of H model, and have very little effect on D-H model and N-2D model. This study used the the absolute value of the component of the horizontal wind vector, did not overdiscuss the effect of wind direction, where $\frac{\partial u}{\partial z}$ contains positive and negative values."

2. The statistical samples – four oblique beams

The "**Preparations**" showed clearly how to recalculated shear broadening effects. But how to choose the the statistical samples is another thing that needs careful consideration. We have the observational datasets of four oblique beams, but there are obvious variation in the distributions of u_x and v_y (as shown in Fig. R-2). here u_x and v_y is zonal and meridional wind, respectively.

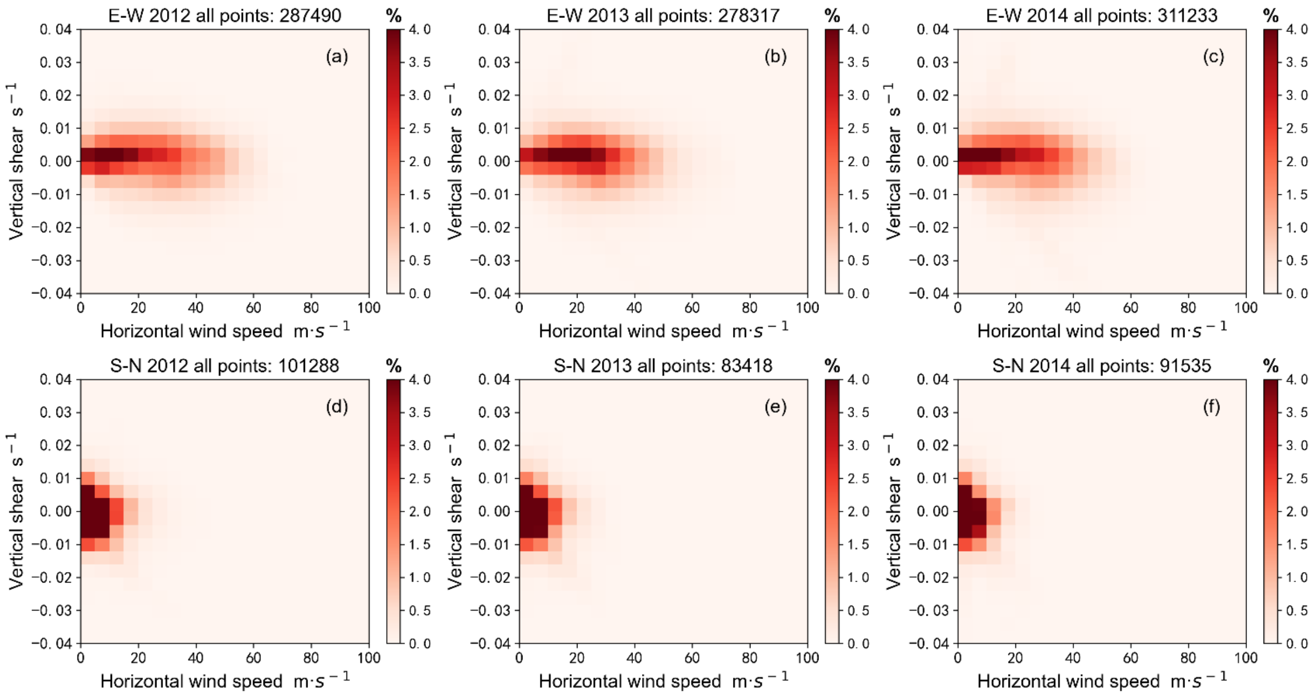

Figure R-10. Two-dimensional frequency distribution characteristics of horizontal wind speed and vertical shear of horizontal wind speed within the height range of 3–19.8km above the Beijing MST radar station from 2012 to 2014. (a)(b)(c) The east-west component of horizontal wind, (d)(e)(f) The north-south component of horizontal wind.

The east-west component of the horizontal wind speed over the radar site is distributed between 0 m s^{-1} and 60 m s^{-1}, and the vertical shear of the horizontal wind speed ranges from −0.014 to 0.014 s^{-1}. The north-south component of the horizontal wind speed in Beijing is distributed between 0 m s^{-1} and 20 m s^{-1}, and the vertical shear of the horizontal wind speed ranges from −0.014 to 0.014 s^{-1}. As shown in Table R-1, for the east and west beams, the rates of N-TKE ($\sigma_t^2 < 0$) of the H model, N-2D model and D-H model are in the range of 27%–32%, 15%–21% and 9%–15%, respectively. And for the north and south beams, the rates are in the range of 5%–8%, 2%–4% and 0.6%–1.0%,. The probability that the turbulence spectrum width is less than 0 calculated by different oblique beams are different. But results of the symmetric beams (such as east and west beams/ north and south beams) are similar.

Table R-1. Total frequency of $\boldsymbol{\sigma_t^2 < 0}$ in the range of 3–19.8 km.

Beams	Time	Total numbers	H, $\sigma_t^2 < 0$	N-2D, $\sigma_t^2 < 0$	D-H, $\sigma_t^2 < 0$
East	2012	287490	78484 (27.30%)	43253(15.05%)	28067(9.76%)
	2013	278317	76038(27.32%)	43886(15.77%)	27836(10.00%)
	2014	311233	90633(29.12%)	54988(17.67%)	34219(10.99%)
West	2012	288060	82821(28.75%)	46925(16.29%)	32467(11.27%)
	2013	280769	82019(29.21%)	48156(17.15%)	32931(11.73%)
	2014	313848	103226(32.89%)	64997(20.71%)	44683(14.24%)
North	2012	102079	7924(7.76%)	3870(3.79%)	923(0.90%)
	2013	84402	6377(7.56%)	3206(3.81%)	724(0.86%)
	2014	92084	5900(6.41%)	3115(3.38%)	726(0.79%)
South	2012	101288	6932(6.84%)	3583(3.54%)	985(0.97%)
	2013	83418	5635(6.76%)	2985(3.58%)	696(0.83%)
	2014	91535	5061(5.52%)	2674(2.92%)	573(0.63%)

So if the distributions of u_x and v_y won't affect the statistical results, we take the observational datasets of four oblique beams as a total sample. Otherwise, we take the datasets of east and west beams as one sample and that of north and south beams as the other sample.

The modified content revised version(clean) for **The statistical samples** is as follows:

Line No:252 (Section 3.1, Page No:8 of 22)

For Tabel 2. We take four samples for every year.

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Table 2. Total frequency of $\boldsymbol{\sigma_t^2 < 0}$ in the range of 3–19.8 km.

Beams	Time	Total numbers	H, $\sigma_t^2 < 0$	N-2D, $\sigma_t^2 < 0$	D-H, $\sigma_t^2 < 0$
East	2012	287490	78484 (27.30%)	43253(15.05%)	28067(9.76%)
	2013	278317	76038(27.32%)	43886(15.77%)	27836(10.00%)
	2014	311233	90633(29.12%)	54988(17.67%)	34219(10.99%)
West	2012	288060	82821(28.75%)	46925(16.29%)	32467(11.27%)
	2013	280769	82019(29.21%)	48156(17.15%)	32931(11.73%)
	2014	313848	103226(32.89%)	64997(20.71%)	44683(14.24%)
North	2012	102079	7924(7.76%)	3870(3.79%)	923(0.90%)
	2013	84402	6377(7.56%)	3206(3.81%)	724(0.86%)
	2014	92084	5900(6.41%)	3115(3.38%)	726(0.79%)
South	2012	101288	6932(6.84%)	3583(3.54%)	985(0.97%)
	2013	83418	5635(6.76%)	2985(3.58%)	696(0.83%)
	2014	91535	5061(5.52%)	2674(2.92%)	573(0.63%)

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Line No:260 (Section 3.1, Page No:8 of 22)

For Fig1, We take the datasets of east and west beams as one sample and that of north and south beams as the other sample.

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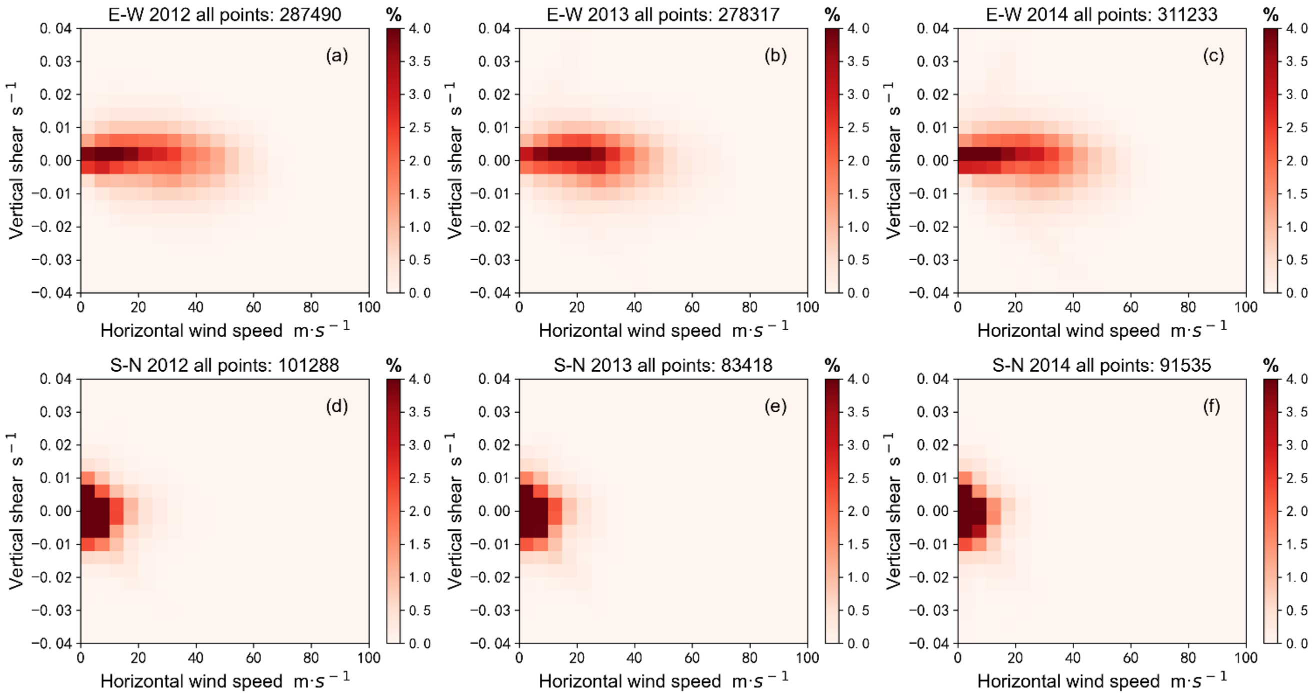

Figure 11. Two-dimensional frequency distribution characteristics of horizontal wind speed and vertical shear of horizontal wind speed within the height range of 3–19.8km above the Beijing MST radar station from 2012 to 2014. (a)(b)(c) The east-west component of horizontal wind, (d)(e)(f) The north-south component of horizontal wind.

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Line No:276 (Section 3.1.1, Page No:10 of 22)

For Fig2 This paper just gives the resultes of the east-west component of horizontal wind. Beacause the north-south component of horizontal wind speed in Beijing is distributed between 0 m s^{-1} and 20 m s^{-1}.

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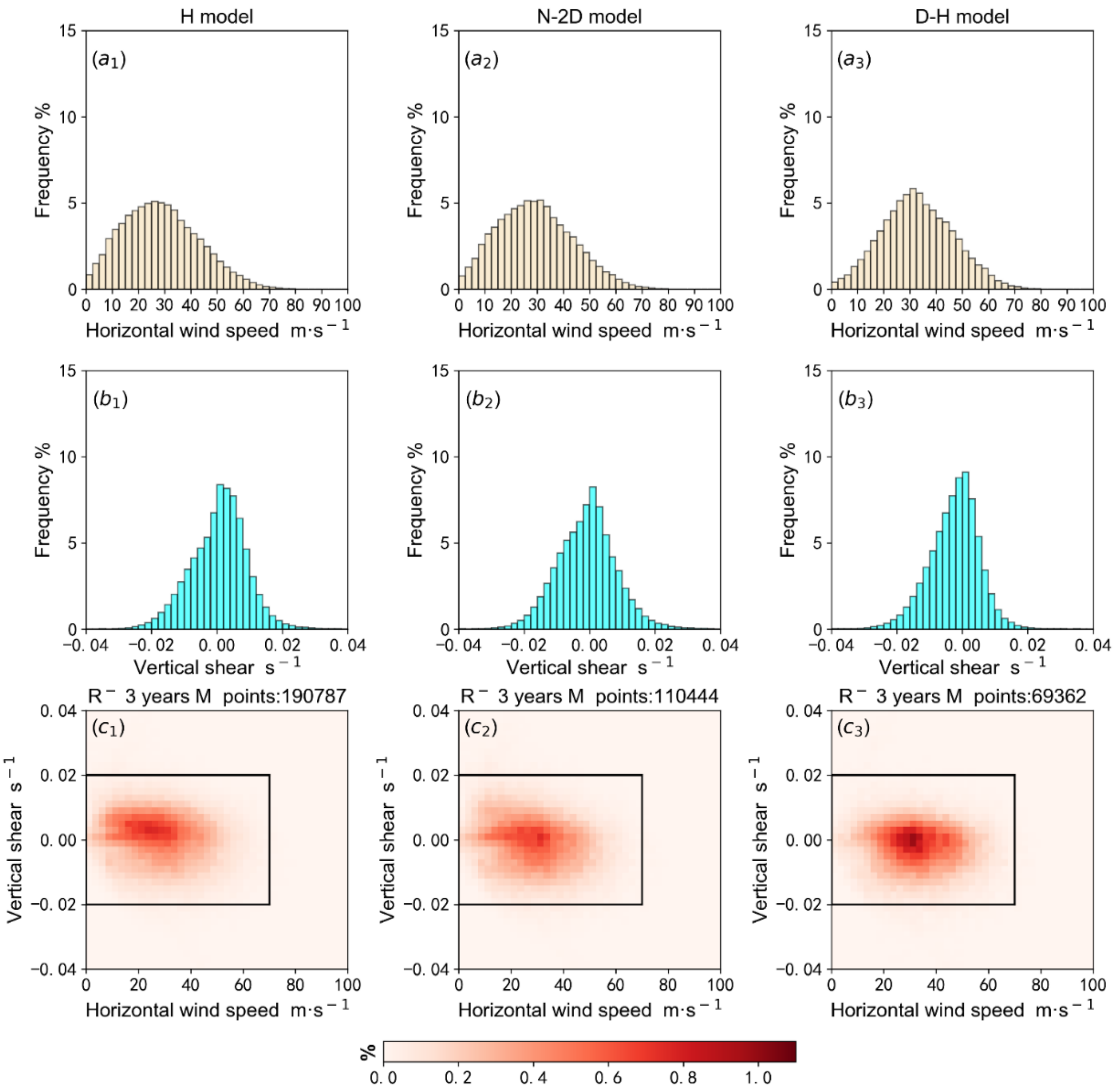

Figure 12. Frequency distribution of (a_1–a_3) horizontal wind speed and (b_1–b_3) the vertical shear of horizontal wind speed, along with (c_1–c_3) the two-dimensional frequency distribution characteristics

of horizontal wind speed and the vertical shear of horizontal wind speed for H model (a1, b1, c1), N-2D model (a2, b2, c2) and D-H model (a3, b3, c3) when the turbulent kinetic energy is negativie.”

Line No:304 (Section 3.1.2, Page No:11 of 22)

For Fig. 3. This paper gives the result of taking four oblique beams as a total sample. Beacuse the results were relatively consistent, although the horizontal wind component of the north and south beams was concentrated in 0 to 20 m/s (Fig. R-3, Fig. R-4).

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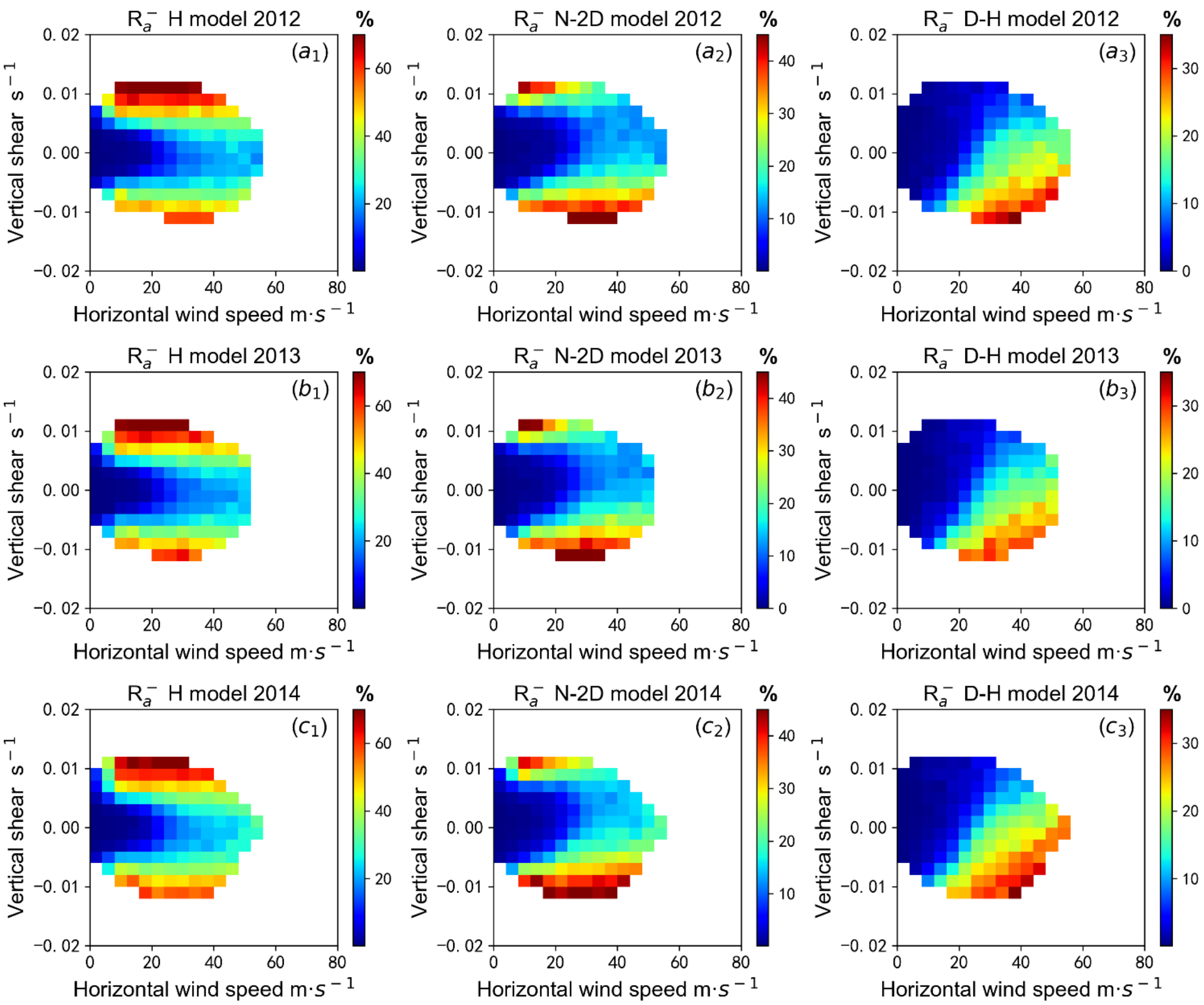

Figure 13. Distribution of $\boldsymbol{R_a^-}$ for the $(\mathbf{a_1})$ H model, $(\mathbf{a_2})$ N-2D model, and (a3) D-H model in 2012. Panels $(\mathbf{b_1})$–$(\mathbf{b_3})$ and $(\mathbf{c_1})$–$(\mathbf{c_3})$ are the same as (a1)–(a3) but for the results of the three models in 2013 and 2014, respectively. The subgraph at the lower right corner of $(\mathbf{a_1}, \boldsymbol{b_1}, \mathbf{c_1})$ is the same as $(\mathbf{a_1}, \boldsymbol{b_1}, \mathbf{c_1})$, but for $\boldsymbol{log_{10}}$ $(\boldsymbol{R_a^-})$.”

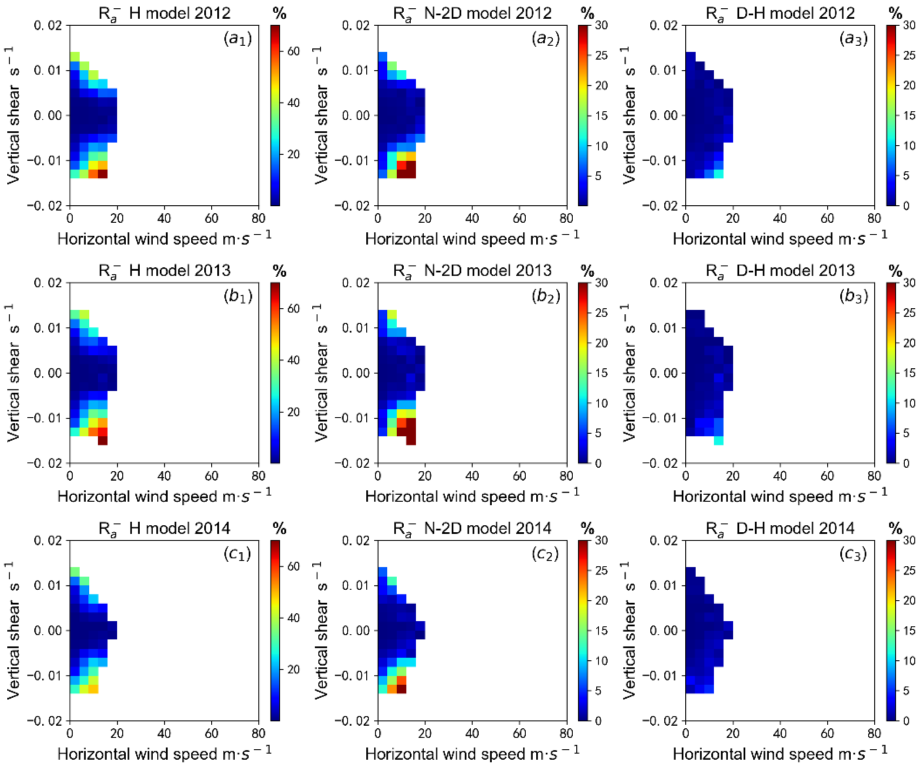

Figure R-3. The same as Fig. 3, but for North beam.

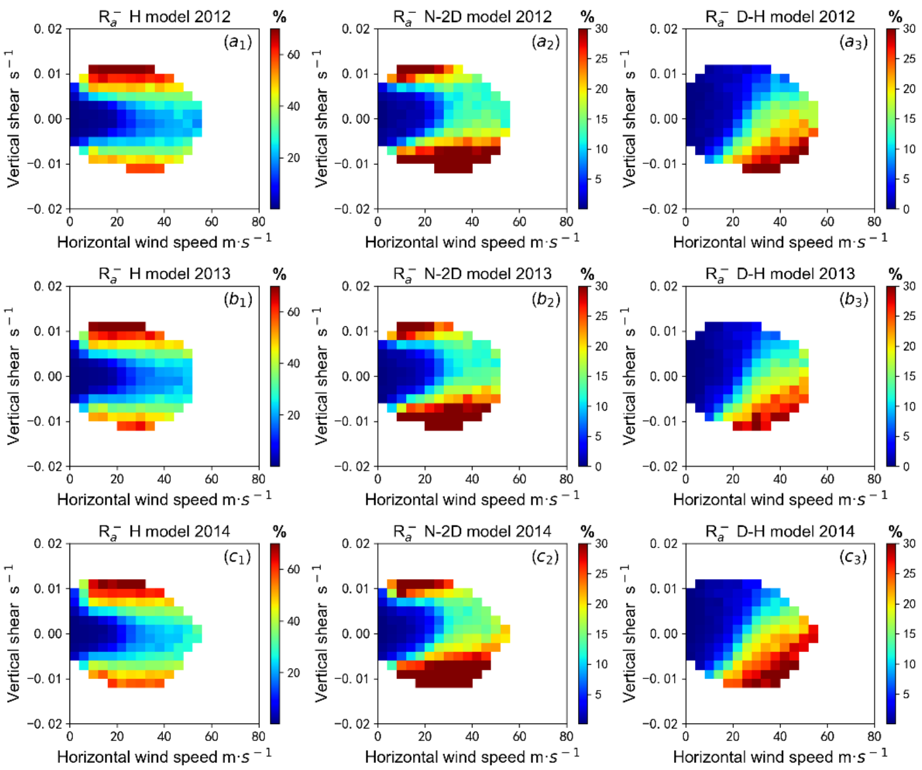

Figure R-4. The same as Fig. 3, but for East beam.

Line No:336 (Section 3.2, Page No:13 of 22)

For Fig.4, the result is based on the three years of observational data from the east and west beams. Beacause the north-south component of horizontal wind speed in Beijing is distributed between 0 m s^{-1} and 20 m s^{-1}.

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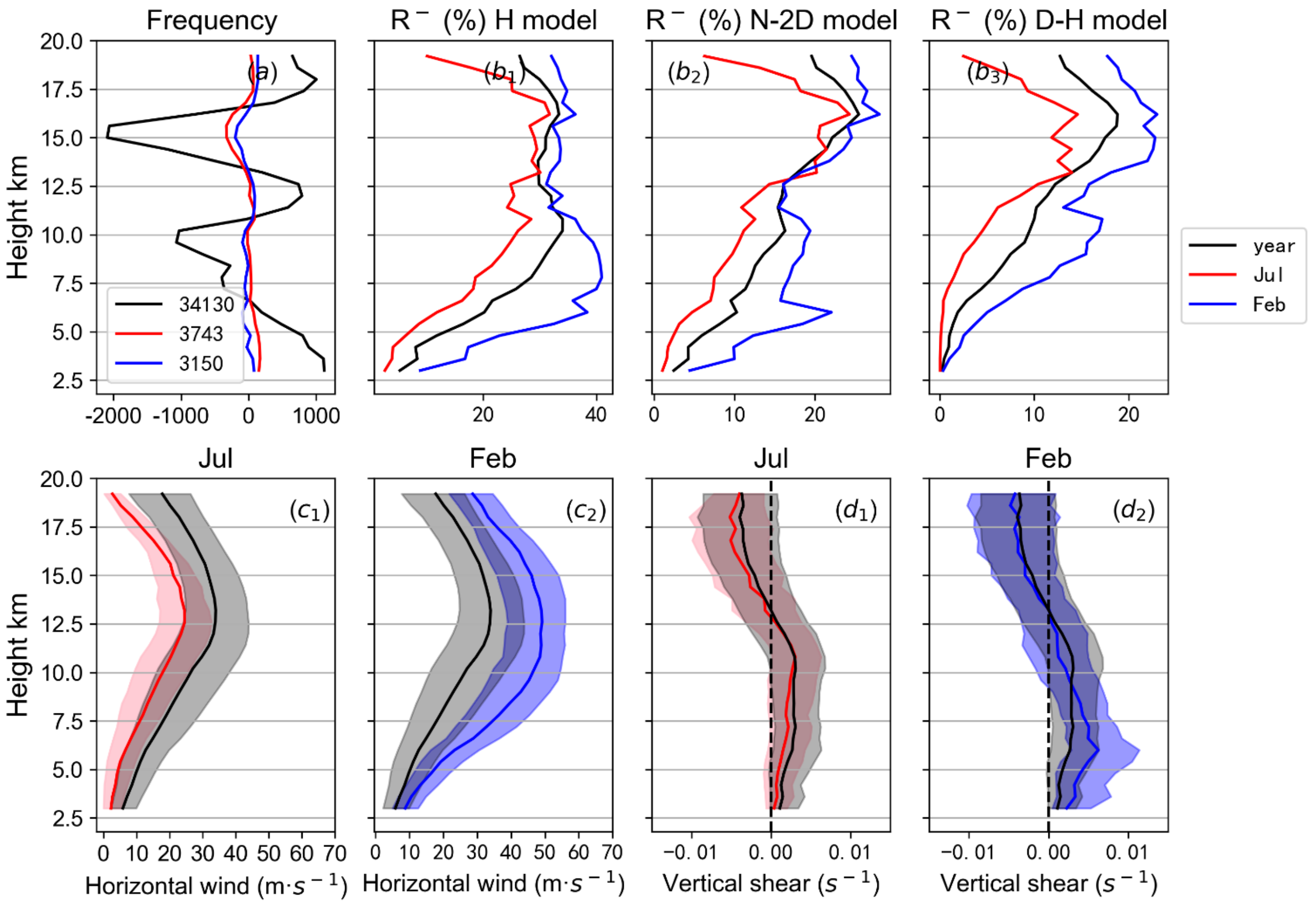

Figure 14. (a) Deviation profile of the data volume involved in the statistics and the mean value of the profile. The annual mean value is 34,130, the mean value in July is 3743, and the mean value in February is 3150. ($\mathbf{b_1}$–$\mathbf{b_3}$) Probability of N-TKE in each gate for the H model, N-2D model and D-H model, respectively. Panels ($\mathbf{c_1}, \mathbf{c_2}$) and ($\mathbf{d_1}, \mathbf{d_2}$) are the median, upper and lower quartile profiles of horizontal wind speed and the vertical shear of horizontal wind speed, respectively. Black/red/blue represents the characteristics of the year/July/February, respectively. Three years of radar observational data from 2012 to 2014 were used in the statistics.”

Line No:385 (Section 3.3, Page No:15 of 22)

For Fig. 5 and Table3, we take the observations of four oblique beams as a total sample.

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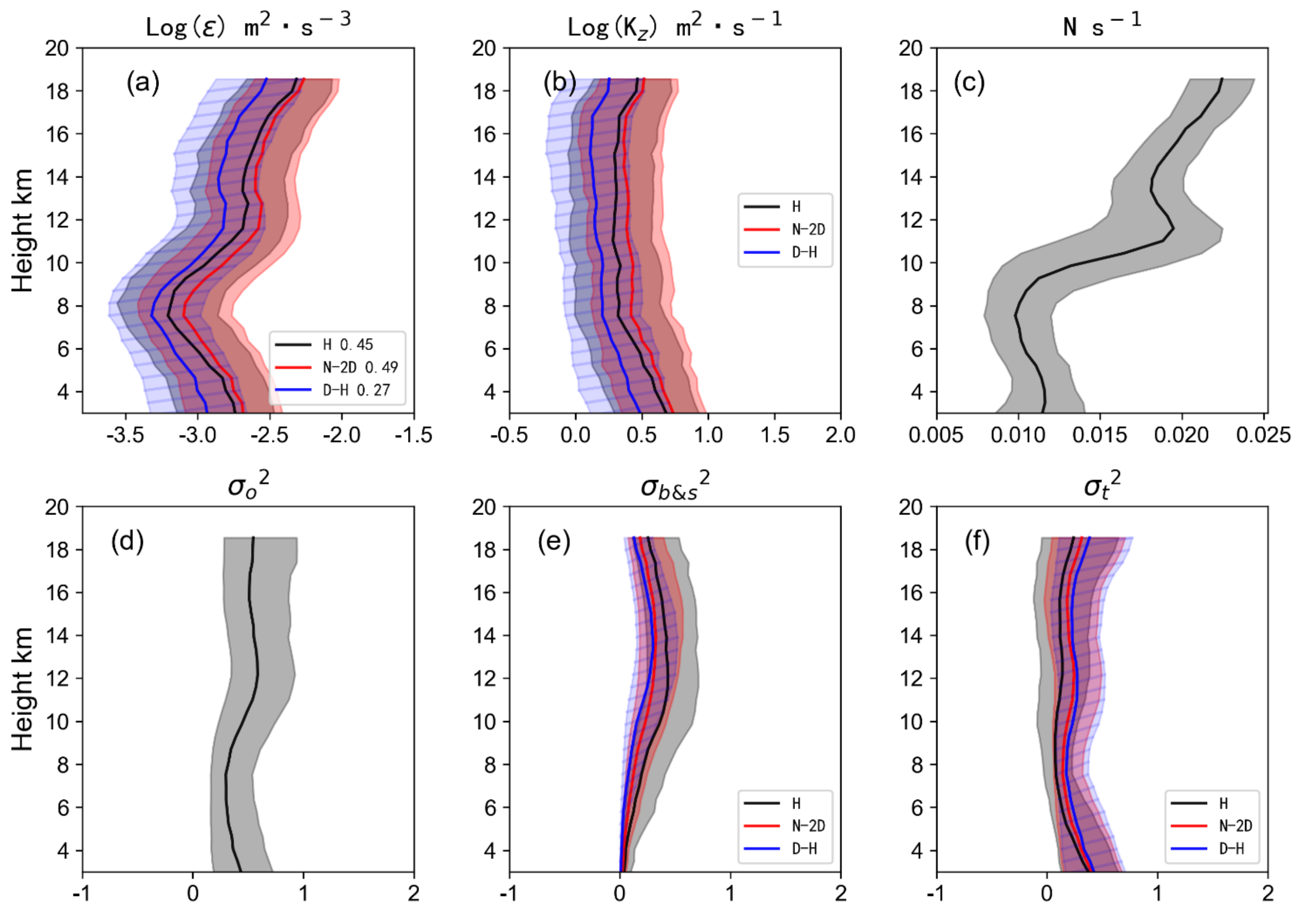

Figure 15. Profiles of (a) $\boldsymbol{\varepsilon}$, (b) Kz, (c) B-V frequency, (d) observation spectrum width, (e) beam and shear broadening, and (f) spectrum width caused by turbulence. The solid line is the median and the shaded area is the upper and lower quartiles. In panels (a, b, e, f), the black/red/blue solid lines and shaded areas represent the median and upper and lower quartiles of the H model/N-2D model/D-H model, respectively.

Line No:452 (Section 4.2, Page No:18 of 22)

Table 3. Turbulence parameters of the Beijing MST radar (39.78°N, 116.95°E) at the range of 3–19.8 km.

	H model, $c_1 = 0.45$	N-2D model, $c_1 = 0.49$	D-H model, $c_1 = 0.27$
Median log (ε) ($m^2\ s^{-3}$)	–3.2 (7 km) to –2.7(12 km)	–3.0 (7 km) to –2.6 (12 km)	–3.3 (7 km) to –2.8 (14 km)
Median log (Kz) ($m^2\ s^{-1}$)	0.3 to 0.7	0.4 to 0.7	0.1 to 0.5

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Line No:431 (Section 4.1, Page No:17 of 22)

For Fig.6, it is based on the east beam.

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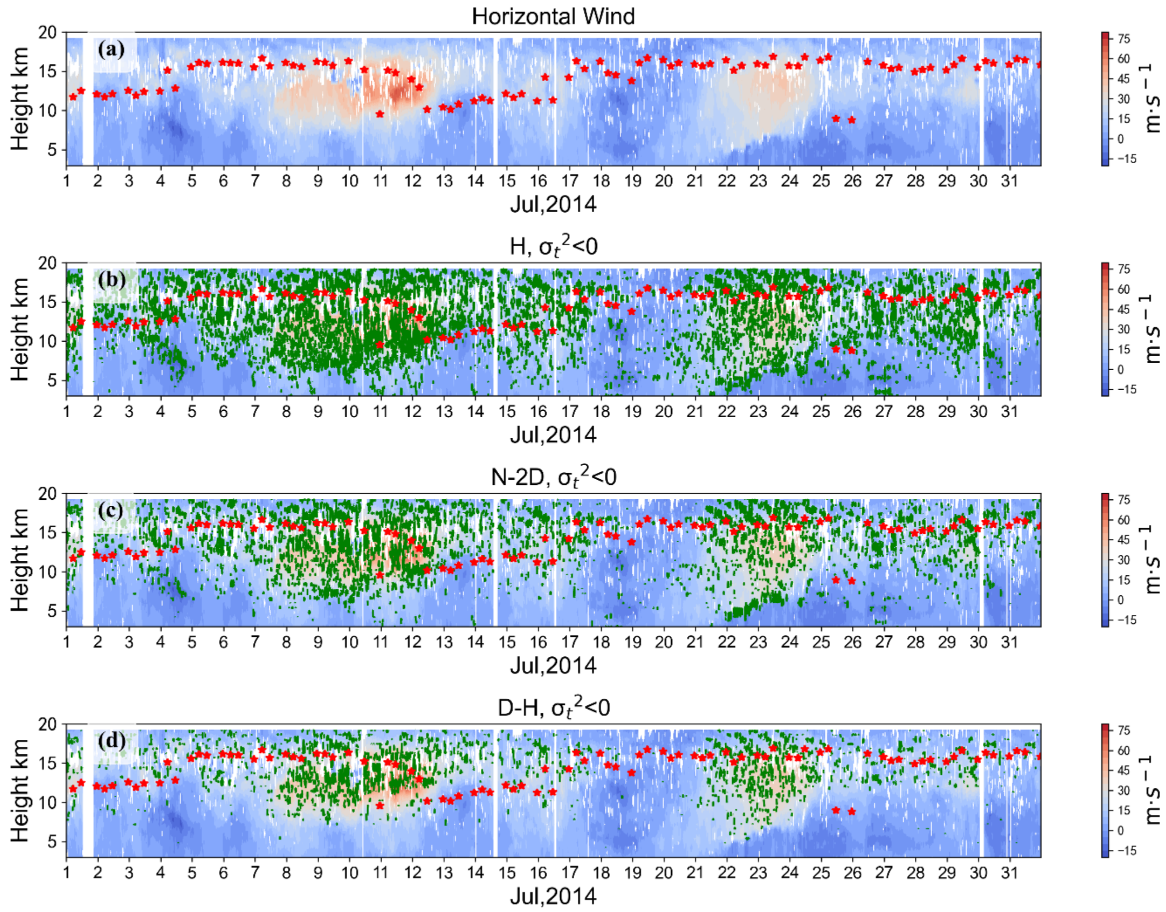

Figure 6. N-TKE distribution of three models over the Beijing MST radar site in July 2014: (a) the

east-west component of horizontal wind; (b–d) area of N-TKE (green shading) for the east beam using the (b) H model, (c) N-2D model and (d) D-H model. The red scattered points are the tropopause.”

Line No:468 (Section 4.2, Page No:19 of 22)

For Fig7, We take the datasets of east and west beams as one sample and that of north and south beams as the other sample.

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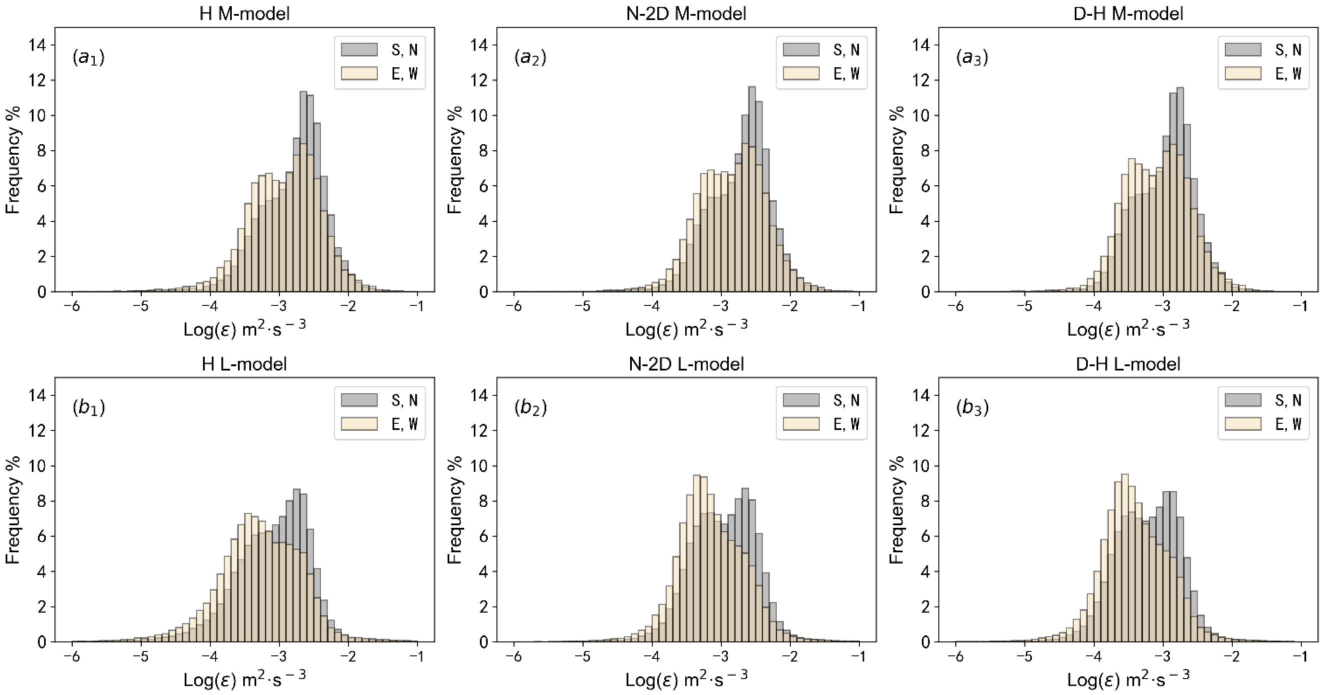

Figure 16. Distribution of $\boldsymbol{\varepsilon}$ in the middle and low mode of the Beijing MST radar in the range of 3–7.8 km from 2012–2014: $(\boldsymbol{a_1}-\boldsymbol{a_3})$ distributional characteristics of $\boldsymbol{\varepsilon}$ in the H model, N-2D model and D-H model (mid mode); $(\boldsymbol{b_1}-\boldsymbol{b_3})$ as in $(\boldsymbol{a_1}-\boldsymbol{a_3})$ but for low-mode data. The gray bars are the result of a north and south beams, the yellow bar are based on the east and west beams.

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