Response to Anonymous Referee #2

We thank the reviewer for his/her constructive comments and suggestions on this manuscript, which are very helpful for us to improve our paper. Our responses to these comments are given below.

-This manuscript presents a step by step procedure to process Doppler spectrum data collected by a millimeter wavelength weather radar. The presentation is clear and detailed but it is unclear what is new in the proposed technique.

Response:
Thank you for pointing out the deficiencies in our writing. The main improvements compared with conventional methods include 2-D segment method for noise level estimation, a new adaptive filter based on Gaussian kernel for cloud signal detection, and half-folded dealiasing processing before conventional dual PRF processing.

-In the first step of the processing for example the noise floor is estimated using the standard segment method, but extended to multiple range gates. Seems like an insufficient contribution to prior publications. Also, addressing such a mature topic should include a comparison of other techniques based on the quality of results. The well known Hildebrand and Sekhon (1974) (H-S) noise estimation technique for example is mentioned to require significant calculations. This may have been a deterent for real-time processing in 1974, but since then computers have significantly improved so a comparison using real and simulated data of the proposed 2-D segment method would be interesting. If the H-S method is still computationally too demanding, then let's show that.

Response:
The 2-D segment method comes from our demand on the low bias estimated noise level, which is directly related to the number of points used for noise estimation. Because our pulse Doppler system with SSPA, weak cloud signal detection must pay attention. As shown in Fig.1, even 1 dB higher estimation will have a great impact on weak signal detection.

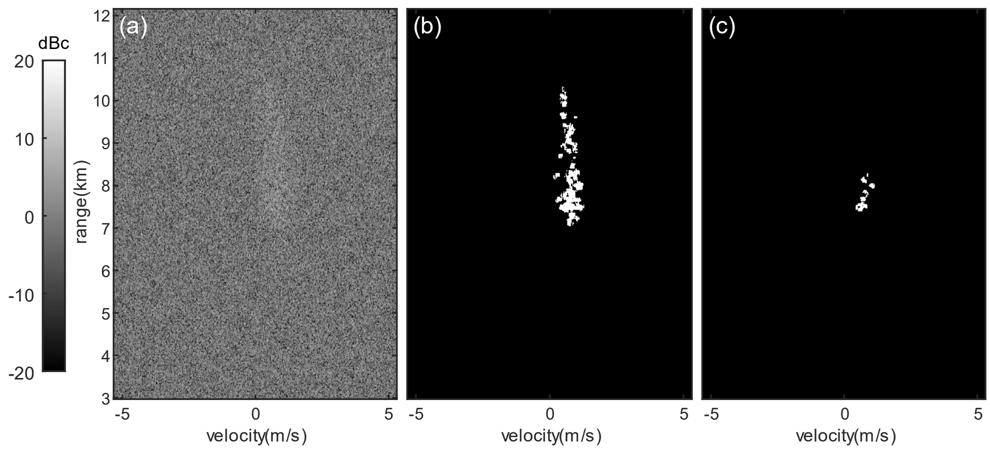

Fig.1 Effect of noise level estimation bias on weak signals. (a) Raw power spectrum (b) cloud signal mask result with noise level estimated by our method (c) cloud signal mask result with noise level 1dB higher than (b)

The well-known Hildebrand and Sekhon(H-S) method did be evaluated. The computational demand of H-S method relays on the optimization of program, including ranking and calculation algorithm. A basic demo of H-S method we did in MATLAB consumed about 33 ms. The parameters for simulation were 512 points per range gate with 128 points signal, and 800 range gates. As a comparison, 2-D segment method only took 3 us. Also, even the next cloud signal detection took only about 10 ms. The average frame time is 64 ms (125 us per pulse and 512 pulses). The H-S method almost took over half of frame time.

A much high-end processor or algorithm optimization can decrease the time, but computational demand is not the key. The key is that the stability of estimated noise level by H-S method don't meet our requirement. The strength of cloud signal will affect the bias of estimated noise level, as shown in Fig.2 and Fig.3. Strong cloud signal works fine while Weak signal leads to higher estimation. However, it is also weak signals that are more susceptible to noise bias as shown in Fig.1. Fig.4 shows an actual example of our observation data and confirms this phenomenon. Therefore, we did not use the H-S method.

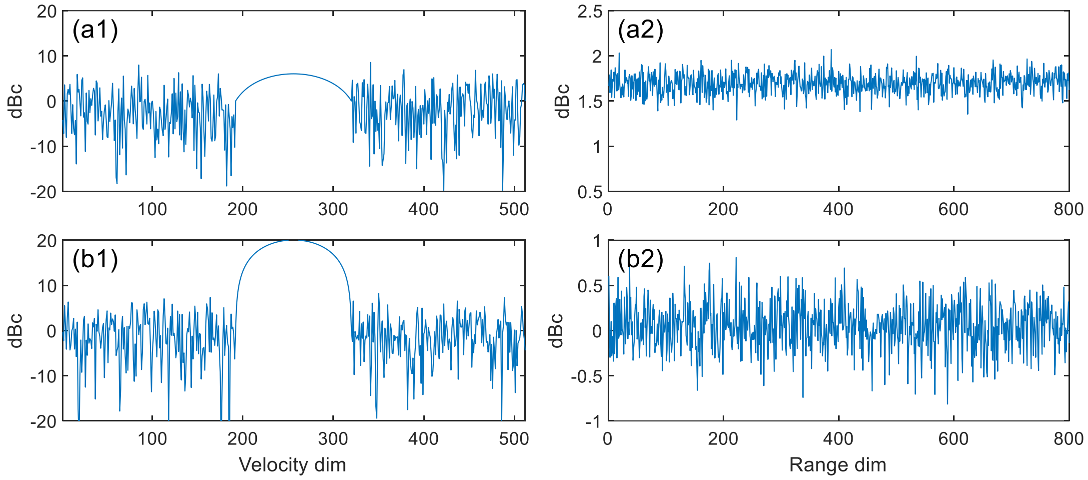

Fig.2 Simulation of H-S method with 512 points per range gate with 128 points signal with different peak SNR. (a1) is the spectral lines for simulation with peak SNR 6 dB. (a2) is the noise level estimated by H-S method. (b) is the same as (a) with peak SNR 20 dB.

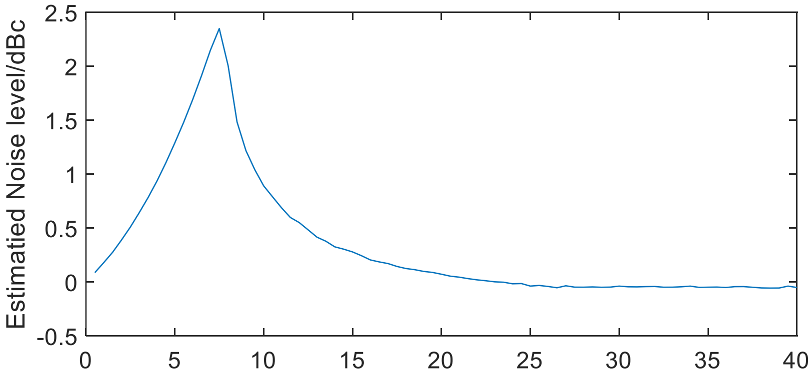

Fig.3 Estimated noise level by H-S method with different peak SNR

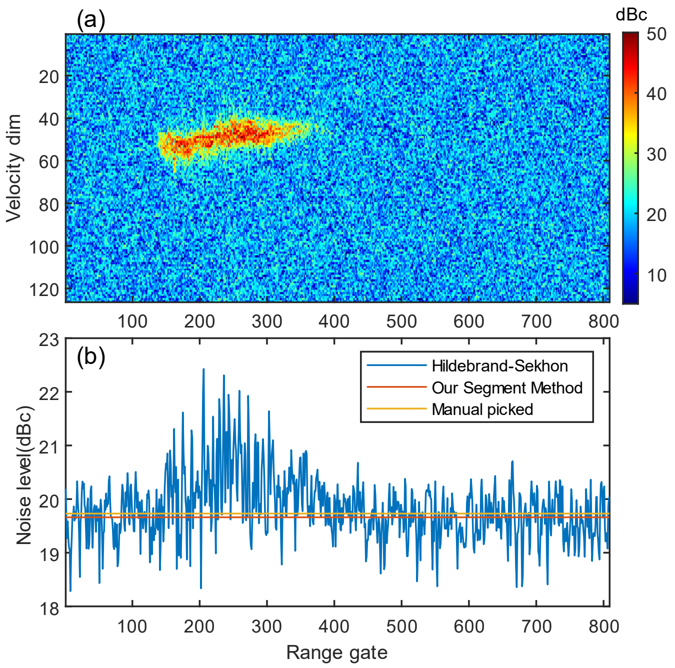

Fig.4 Example of one TJ-II observation data (a) Raw power spectrum (b) Noise level estimated by three methods.

-It is also not clearly stated if any new technique is proposed in the second step of identifying the cloud signals. It seems that this processing sequence follows the two references provided, yet it is presented with great detail like this was a novel method.

Response:

In the step of cloud signal detection, an adaptive Gaussian filter based on deviation of the mean value in the filter window and threshold.

$$\sigma_g = \sigma_0 \cdot \max\left(\frac{T_s}{\mu(x,y)}, \frac{\mu(x,y)}{Ts}\right)$$

The main idea is to use the statistics of the window area to judge the trend of edge side and then change the weighting (σ_g) to enhance the trend.

During open discussion, another adaptive Gaussian filter combined with Kuwahara filter was proposed based on the same idea. Here is the description of the new improved filter:

1 Divide the window $(2k+1)$ into four subregions (k+1) as the Kuwahara filter do, as shown in Fig.5

a	a	a/b	b	b
a	a	a/b	b	b
a/c	a/c	a/b /c/d	b/d	b/d
c	c	c/d	d	d
c	c	c/d	d	d

Fig.5 Subregion division

2 Calculate the ratio of mean m_i and standard deviation σ_i of the four subregions.

$$r_i = \frac{m_i}{\sigma_i}$$

3 Generate four Gaussian filters $(2k+1)$ with four standard deviations σ_{gi} according to

the ratio r_i, and normalize them with their center pixel.

$$\sigma_{gi} = (\frac{r_i}{0.88})^2 \sigma_0$$

4 Fill the four subregions of final filter with the corresponding subregions of corresponding Gaussian filter factors. The overlap areas use the mean value of factors.

5 Normalize the final filter and apply to the original window.

The ratio of mean and standard deviation of mixed signal are shown in Fig.6. Both noise and signal are exponential distribution with rate parameter 1 and 3, respectively. When the mixed signal is purer, the ratio is closer to 1. Based on this feature, we use the ratio to determine the mixing degree of the subregion, the lower the mixing degree (closer to 1), the greater the weighting ratio (larger σ_{gi}). The factor 0.88 is the mean of 1 and lowest ratio about 0.77. The square is to enhance the trend.

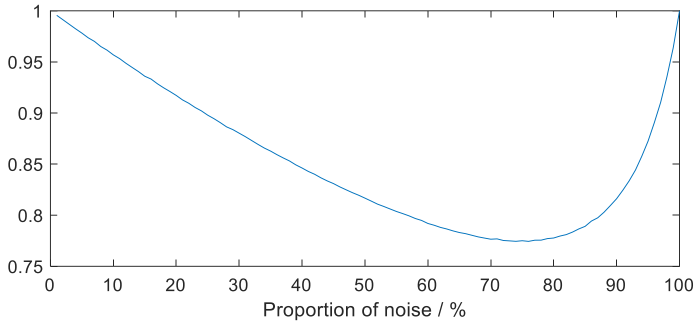

Fig.6 Ratio of mean and standard deviation of mixed signal.

The performance of the new adaptive filter is shown in Table. The simulation parameter is the same as the one in preprint, where noise and signal rate parameters are 1 and 3, respectively and the threshold T_s is 1.8.

Table.1 Simulation performance of FAR and MDR using different filters.

Filter type	Performance	Offset 0	1	2	3
Filter in Response	FAR	30.3%	2.94%	0.66%	0.56%
	MDR	16.96%	5.67%	2.55%	1.30%
	Mean	**23.63%**	**4.31%**	**1.60%**	**0.93%**
Filter in preprint	FAR	33.2%	2.25%	0.45%	0.14%
	MDR	19.27%	4.97%	2.24%	1.33%
	Mean	26.24%	3.61%	1.35%	0.74%
Gaussian filter	FAR	29.55%	2.16%	1.07%	1.07%
	MDR	22.04%	7.26%	5.27%	4.97%
	Mean	**25.80%**	**4.71%**	**3.17%**	**3.02%**
Signal rate parameter 10					
Filter in Response	Mean	43.95%	8.48%	1.26%	0.22%
Filter in preprint	Mean	49.99%	44.41%	5.29%	0.03%
Gaussian filter	Mean	48.64%	11.90%	0.67%	0.46%

Compared with the normal Gaussian filter, the mean failure rate (FAR and MDR) of our new filter is better at all offsets. Another improvement is the stability. We found our previous filter in preprint are less robust when the signal rate parameter increase. As shown in the bottom of the Table.1, when the signal rate parameter raised to 10, performance of the filter in preprint deteriorates rapidly at offset 1. The improved filter in this response is still better than the Gaussian filter overall.

-Similarly the velocity dealiasing using dual PRF is not new.

Response:
Velocity dealiasing using dual PRF is indeed quite common. In this preprint, it is not mainly about how to perform dual PRF processing, but about the pre-processing before dual PRF processing. There will be a phenomenon called half-folded, shown in Fig.7(a1), caused by the wide spectral width of cloud signals, which does not exist in general point target radar. Half-folded will result in a wrong initial velocity not the equal to the $V_t \pm 2nV_m$ when calculation the initial velocity. It breaks the principle of dual PRF and results in wrong final velocity. There are few references talk about this phenomenon when applying dual PRF in vertical sensing cloud radar. The preprint proposed the method to detect the half-folded and a simpler and universal method of dividing positive and negative intervals, the median method.

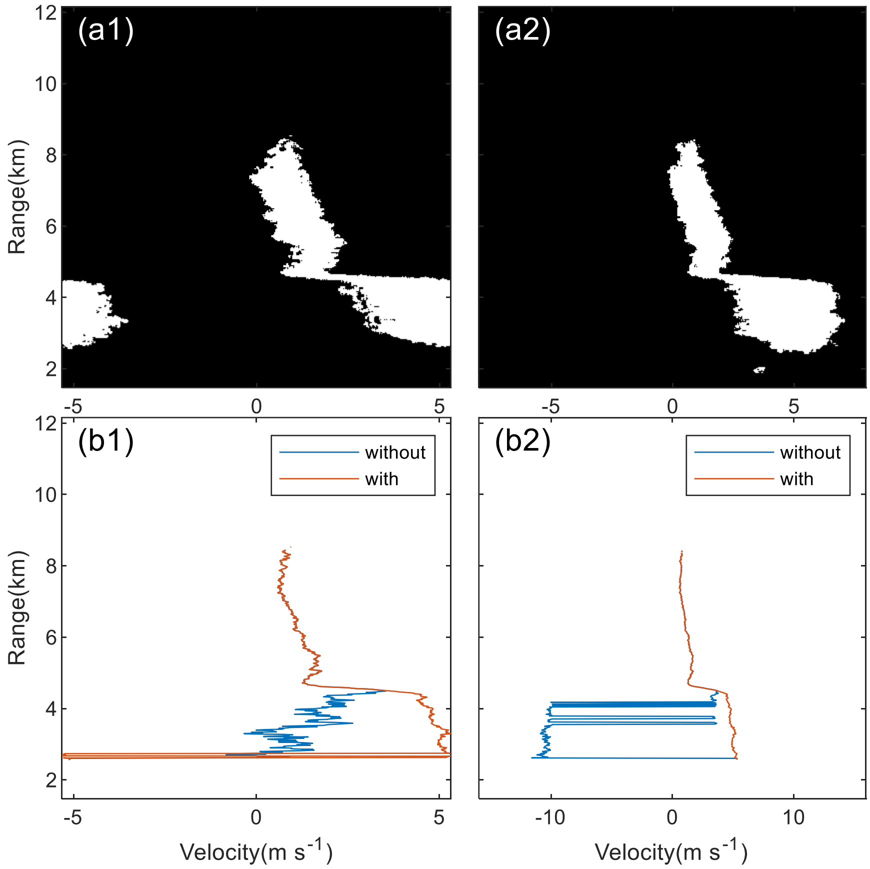

Fig.7 One example of TJ-II observation data with a half-folded state. (a1) and (a2) is the mask result by cloud signal mask processing with PRT 150us and 100us, respectively. (b1) is the raw mean velocity of (a1) with and without pre-defolding processing. (b2) is the final dealiased velocity with and without pre-defolding processing

-The presentation needs to make a clearer distinction between what's new and when an existing technique is applied - when the reference is sufficient instead of a lot of detail. Overall this is nice work, but it is more like a documentation of the radar than a journal

publication advancing the state of science.

Response:

Thanks for your comments, we will improve revision to clear what is new in the proposed technique.