egusphere-2025-1908
Responses (highlighted in red) to Referee#1
25 August 2025

Review of "Advantages of using multiple Doppler radars with different wavelengths for three-dimensional wind retrieval." By Tsai et al.

This paper provides an overview of multi-Doppler analyses of a bow-echo that passed through South Korea on 2 August 2020. This convective system was sampled by a network of 11 radars of varying wavelengths. The authors conduct experiments where variational wind retrievals are made using only specific wavelength radars for given field experiments. While the authors conduct an exercise that would have potentially useful implications for how wind retrievals are calculated, there are numerous problems that prevent me from recommending this paper for publication.

We appreciate that Referee#1 provided helpful and insightful comments, which helped us substantially improve the manuscript. We have carefully checked the comments, and the context of the scanning strategies of the radars; statistical analyses and quantitative evaluations for earlier and late stages of WISSDOM synthesis have been added to this revision. In addition, we have emphasized the benefits of WISSDOM for recovering the winds along the radar baseline. The figures were modified in a new color setting, and the updraft code can be identified easily. A set of responses to the comments is provided below. Specific locations of modified portions (marked as underlines) were also noted as the number of lines in the revised manuscript.

Fatal flaws:

For one, the results are not placed in the context of the scanning strategies of the radars. Were the radars on a synchronous scan strategy? In addition, The S-band radars are all placed relatively close together, while the C and X band radars are further out, making a more optimal baseline for multiple Doppler retrievals. Could this also be a factor as well?

1. Thank you for the comments, the authors have provided more information related to the scanning strategies of the radars in the revision. The radars used in this study were operated in temporal resolution by around 6~15 min with the PPI (plan position indicator) elevations from −0.4° and 20° (45° for CIIA). The variances of these scanning strategies were because they were operate by different departments from the governments and universities. However, these radars can be synchronized in every 30 min time window because they have the similar purposes for detecting severe

weather systems in this region. The details of temporal resolution, PPI elevation angles, and basic setting for each radar were revised in the Table 1. The authors also have emphasized that the synchronized scanning strategies were applied appropriately in WISSDOM for wind retrievals in the revision:

L168-174: "The temporal resolution for each radar volume scan was 10 min except for CIIA (XDJK, XMIL, and XSRI), which was around 6-7 min (15 min), the complete volume scan can be synchronized every 30 min from the selected radars. In a complete volume scan of each radar, the PPI (plan position indicator) elevation angles were between −0.4° and 20° (45° for CIIA), the details of the elevation angles can be found in Table 1. Fundamentally, the radars used in this study are mostly synchronized in similar scanning strategies, even though they were operated from different departments of governments and universities.".

L183: Table 1. Specifications for the radars used in the present study

	Longitude (°E)	Latitude (°N)	Radar Height (m)	Wave Length (cm)	Beam Width (°)	Nyquist Velocity ($m\ s^{-1}$)	Range Resolution (m)	Max Range (km)	Time Interval (min)	Elevations (°)
SGDK	127.43	38.11	1066	10	0.89	64.3	250	250	10	–0.4 0.0 0.3 0.8 1.4 2.5 4.2 7.1 15
SKWK	126.96	37.44	615	10	0.93	68.3	250	250	10	–0.2 0.0 0.3 0.8 1.5 2.6 4.4 7.3 15
SBRI	124.62	37.96	170	10	0.96	64.7	250	250	10	0.1 0.4 0.8 1.4 2.2 3.4 5.1 7.6 15
SKSN	126.78	36.01	212	10	0.90	67.9	250	250	10	0.0 0.3 0.7 1.3 2.1 3.2 5.0 7.6 15
CIIA	126.36	37.46	142	5	0.53	29.7	250	130	~6	1.4 1.9 2.5 3.2 4.0 5.0 7.0 10 15 20 26 32 38 45
CSAN	126.49	36.70	45	5	0.95	47.9	250	130	10	0.5 0.9 1.4 2.0 2.6 3.4 4.5 5.9 7.6 10 13 20
XKOU	127.02	37.58	136	3	0.53	18.0	60	40	10	3.0 3.6 4.3 5.1 6.1 7.2 8.6 10.2 12.2 14.4 17 20
XYOU	126.93	37.56	79	3	0.45	18.0	60	40	10	2.5 3.0 3.7 4.4 5.4 6.5 7.8 9.4 11.4 13.6 16.4 20
XDJK	126.09	37.25	116	3	1.26	44.8	150	75	15	1.5 2.1 3.0 4.2 5.8 7.9 15
XMIL	126.44	36.93	295	3	1.26	44.8	150	75	15	0.8 1.4 2.2 3.5 5.2 7.9 15
XSRI	126.90	37.35	435	3	1.26	44.8	150	75	15	0.8 1.4 2.2 3.4 5.2 7.9 15

L312-313: "Note that the temporal resolution of WISSDOM retrieval was set to every 30 min to synchronize with radar observations.".

2. Yes, the S-band radar can detect data far from the radar rather than the C- and X-band radars (cf. Max Range in Table 1). Since WISSDOM is a variational-based approach to derive the 3D winds, the wind fields can be recovered well along the radar baseline [Please see L92: One of the advantages of this approach is that winds can be recovered along the radar baseline, and high-quality winds can also be derived over complex terrain (Liou et al., 2012, 2013, 2014, 2016; Lee et al., 2018)].
   Thus, the quality of retrieved winds along the radar baseline was not affected (or minor) with the location and distance of the radars. Based on these, your concern (the S-band is placed relatively closer, and C- and X-band radars are further out), which are not the key factors affecting the retrieved winds along the radar baseline in WISSDOM. The authors have explained and emphasized these statements in the revision: L316-319: "One advantage of WISSDOM is that the 3D winds along the radar baseline can be recovered well using a variational-based algorithm. Thus, the quality of retrieved winds along the radar baseline would not be a significant issue to the radars' relative location (or distance) in WISSDOM, especially when using multiple radars.".

In the analysis of the updraft cores I found it hard to determine the number of updraft cores simply by eye. Have the authors considered counting these using thresholding techniques (see Varble et al (2014?)). Finally, The MB and RMSD values in the quantitative analysis in Table 4 do not clearly favor the SCX regime, and do not seem to demonstrate any quantitative improvement of using SCX over just S. Do the authors have statistics for earlier and later stages of this storm, or other cases, that would provide a larger amount of data for analysis?

1. Thanks for pointing out this problem. The color bar has been adjusted in Figures 6 and 9, in the manuscript (L436 and 489). The number of updraft cores can be easily identified from the figures, and relatively stronger updraft was emphasized by the dark orange and red colors from 0.9 to 3 m s^{-1} . The revised figures are also shown below.

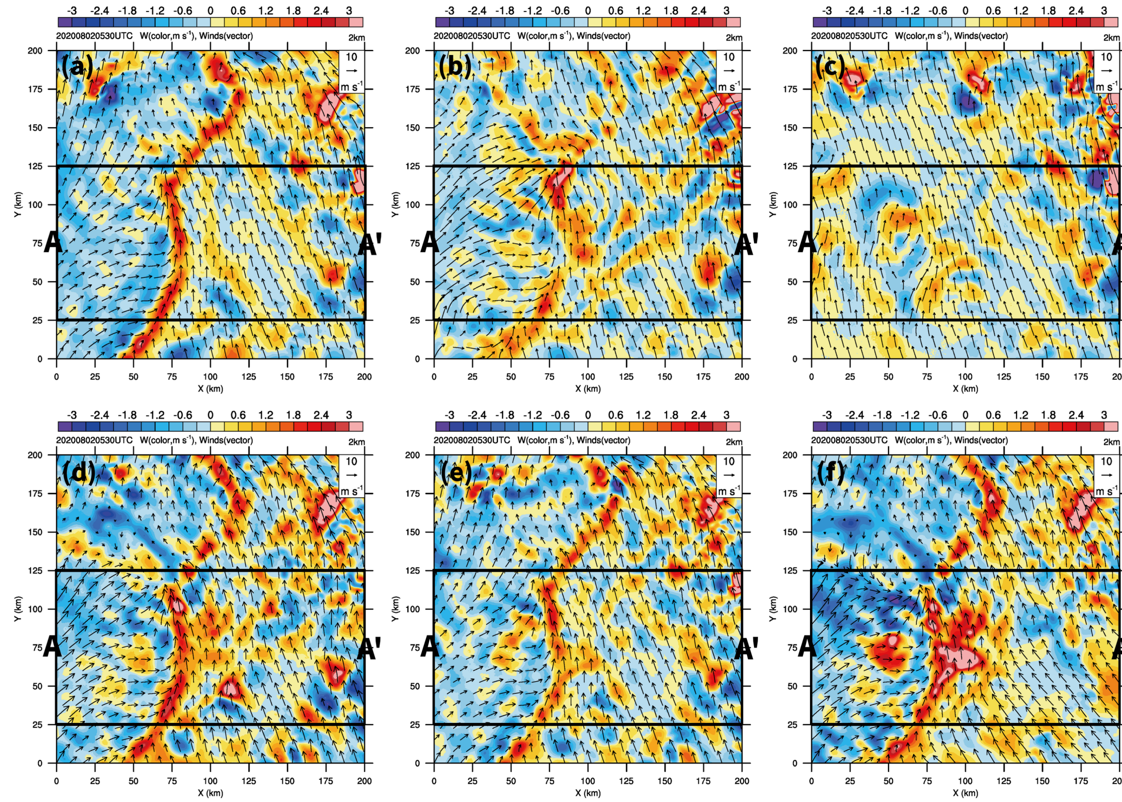

Figure 6. Retrieved vertical velocity (i.e., W-winds, color shading, m s^{-1}), and storm-relative flow (vectors) at 2 km MSL obtained from WISSDOM for scenarios (a) S, (b) C, (c) X, (d) SC, (e) SX, and (f) SCX. The two black lines indicate the box area corresponding to the mean vertical cross-section A-A' in Fig. 9.

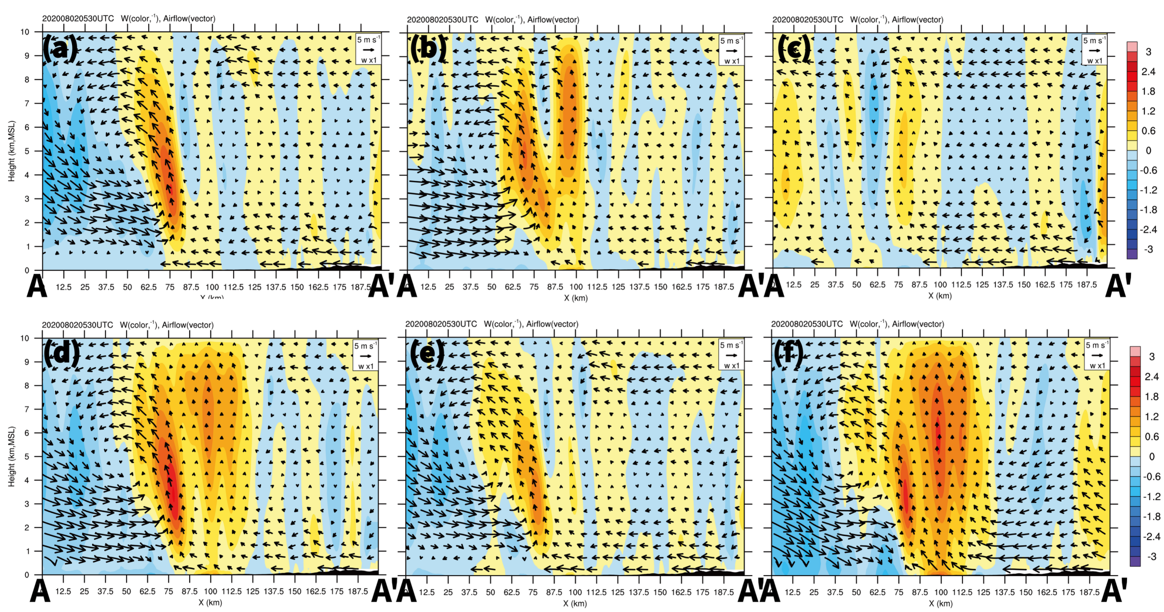

Figure 9. The same as Fig. 8, but for a mean cross-section of the vertical velocity (i.e., W-winds, color shading, m s^{-1}) and storm-relative flow (vectors) obtained from WISSDOM for scenarios (a) S, (b) C, (c) X, (d) SC, (e) SX, and (f) SCX corresponding to the A-A' box in Fig. 6.

2. The authors do not consider counting the vertical velocity using thresholding techniques (Collis et al., 2013; Varble et al., 2014) because WISSDOM has considered the terrain features with IBM and adopted the vorticity equation to be one of the constraints, which can supposedly improve the quality of retrieval wind over terrains in our study case. Thank you, reviewer#1, for providing more information and references to complete the context of variational approach techniques on the wind retrievals. These statements were emphasized as follows: "For example, Collis et al. (2013) and Varble et al. (2014) use variational techniques to retrieve the winds via scanning Doppler radar. Also, the 3D variational techniques (3DVAR) for radar wind retrieval were developed by Shapiro and Potvin and are now available on the Python platform named PyDDA (Jackson et al. 2020). However, the terrains in their schemes were not significantly considered." in L80-84.

3. The quantitative evaluation of the squall line in earlier and later stages had included in the revision. The results reveal that the statistical consistency with only one time step was used in the previous analyses. Overall, scenario SCX also shows good performance, and the quantitative value of mean MB and RMSD are relatively smaller than other scenarios (cf. Fig. 12 and Table 4). The minor changes to the value of winds, the new figures and table (Figs. 11, 12, and Table 4), and the additional descriptions were revised in the manuscript as follows:
   L260-261: The performance of WISSDOM wind retrieval was analyzed for this case study at 04:30, 05:30, and 06:30 UTC as the squall line moved from the ocean, coast to the land, respectively.
   L535-537: The RWPs provided the average vertical profiles of U-winds, V-winds, and W-winds, allowing the WISSDOM winds to be compared above these three RWPs during three stages from 04:30 to 06:30 UTC on 2 August 2020.

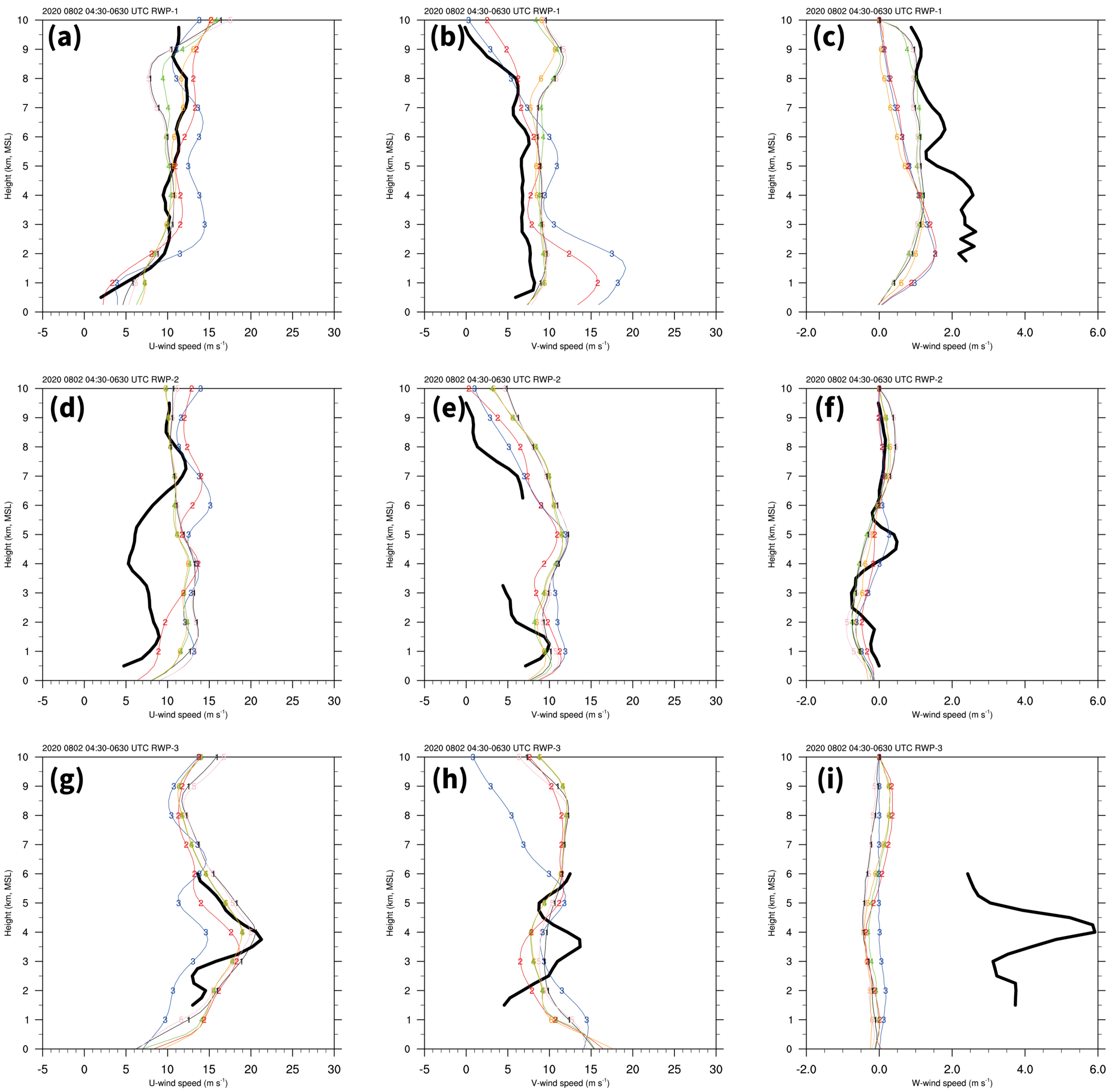

Figure 11. (a) Average vertical profiles of the U-wind speed (thick black line) observed at RWP1 at 04:30, 05:30, and 06:30 UTC on 2 August 2020. The thin lines with numbers and colors indicate different scenarios. Number 1 colored black indicates scenario S (see Table 3). Numbers 2, 3, 4, 5, and 6 colored red, blue, green, pink, and orange indicate the scenarios C, X, SC, SX, and SCX, respectively. (b), (c) The same as (a) but for V-winds and W-winds. (d), (e) and (f) are the same as (a), (b), and (c) but for RWP2. Note that only two time steps (04:30 and 05:30 UTC) were included in (f). (g), (h) and (i) are the same as (a), (b), and (c) but for RWP3.

L555-558: …[missing and smaller]…, …[were ~5 m s^{-1}].

L561-562: Smaller differences were found above 6 km MSL of only ~0.5 m s^{-1}, note that RWP-2 W-winds were not included at 06:30 UTC due to data missing.

L566-568: ...[scenario X (~20 $m\ s^{-1}$)]...; ...[exceeding 6 $m\ s^{-1}$]...

L576-581: ...[WISSDOM scenario (thin black lines)]...; ...[around 1 $m\ s^{-1}$ and 3.5 $m\ s^{-1}$, respectively, between each scenario (red lines)]. [The MB for the horizontal wind speeds was ~3.5 $m\ s^{-1}$]...; [The MB values]...[RWP3 (less than 2 $m\ s^{-1}$)]...[of 1.6 $m\ s^{-1}$ in scenario S]...[than 3 $m\ s^{-1}$ for scenario X (blue lines)].

L581-584: Although the lowest mean MB of horizontal winds (i.e., counting U-winds and V-winds) is 0.93 $m\ s^{-1}$ for scenario C (thick black line in Fig. 12a), a little higher of mean MB (1.01 $m\ s^{-1}$) was observed between the observations and scenario SCX.

L585-588: However, the MB for the W-winds ranged between ~ 2.5 $m\ s^{-1}$ in the comparison between RWP1 and the WISSDOM scenarios (red line in Fig. 12b), and the lowest mean MB of W-winds is 1.1 $m\ s^{-1}$ for scenario SCX (thick black line in Fig. 12b).

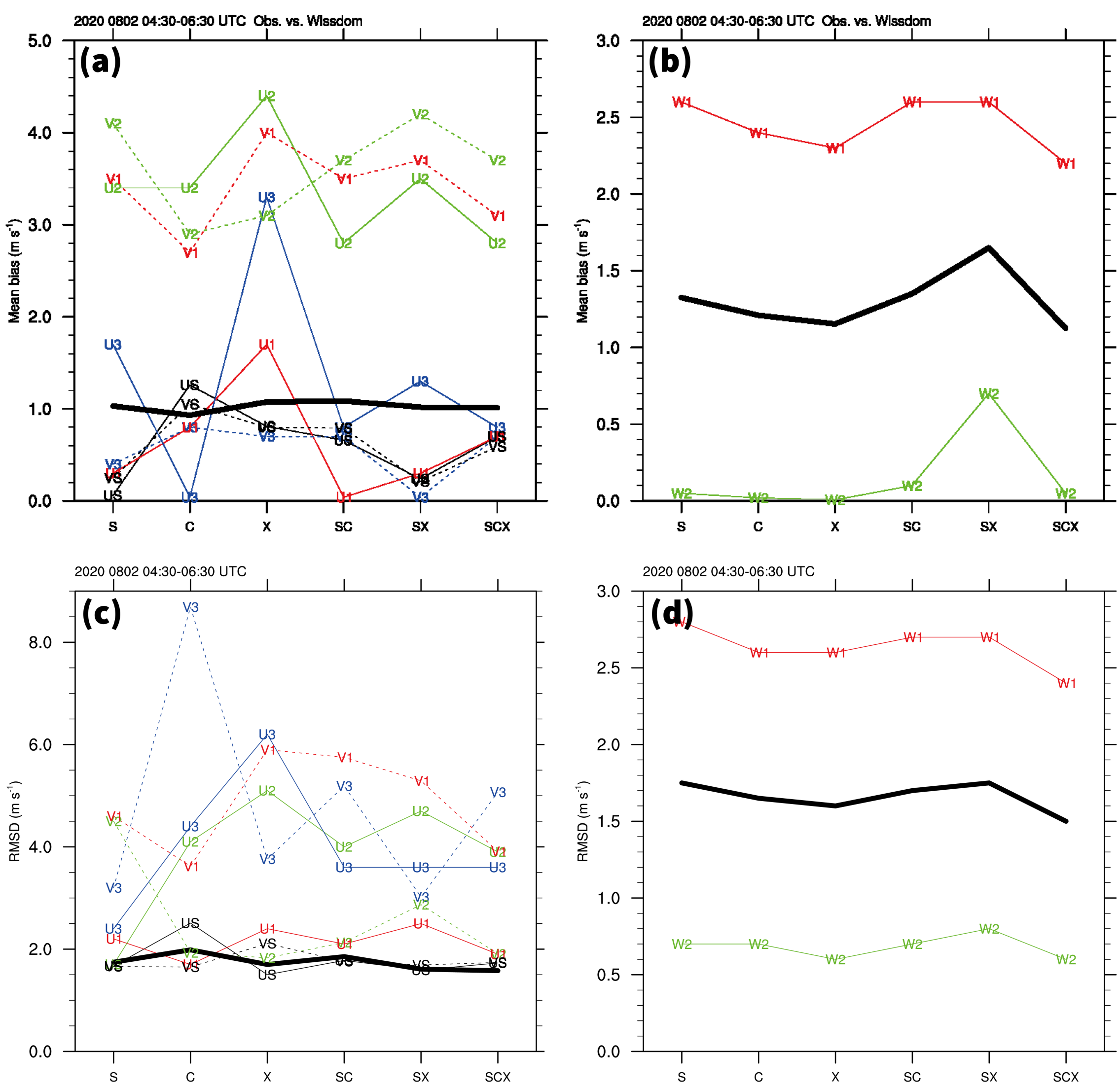

Figure 12. (a) Mean bias (MB) of the U-wind speed (solid lines marked with U) and V-wind speed (dashed lines marked with V) for every scenario in WISSDOM and for the sounding (black lines marked with S), RWP1 (red lines marked with 1), RWP2 (green lines marked with 2), and RWP3 (blue lines marked with 3) data. The thick black line indicates the mean MB of U-winds and V-winds. (b) The same as (a) but for W-wind speed (solid lines marked with W) and mean MB of W-winds. (c) The same as (a) but for the root mean square difference (RMSD), but The thick black line indicates the mean RMSD of U-winds and V-winds. (d) The same as (c) but for the W-wind speed (solid lines marked with W).

L599: ...[(thin black lines),]...; ...[and ~2–4 m s^{-1}]...
L603-604: The lowest mean MB of horizontal winds is 1.57 m s^{-1} for scenario SCX (thick black line in Fig. 12c).
L604-607: Fig. 12d presents the RMSD for the W-winds between RWP1 and RWP2. The RMSD was ~0.7 m s^{-1} and ~2.5–3.0 m s^{-1} at RWP2 and RWP1, respectively, in comparison with the WISSDOM scenarios. The lowest mean MB of W-winds is 1.5 m s^{-1} for scenario SCX (thick black line in Fig. 12d).
L610: [Overall]...

L616:Table 4. Comparisons between the sounding and RWPs for each scenario during 04:30 and 06:30 UTC on 2 August 2020.

	Mean Bias (MB, m s^{-1})			Root Mean Square Difference (RMSD, m s^{-1})		
	U-winds	V-winds	W-winds	U-winds	V-winds	W-winds
S	0.1 / 1.6*	0.2 / 2.6	— / 1.3	1.6 / 3.5	1.6 / 4.1	— / 1.7
C	1.2 / 1.4	1.1 / 1.6	— / 1.3	2.5 / 3.4	1.6 / 3.6	— / 1.6
X	0.8 / 0.9	0.8 / 2.6	— / 1.5	1.5 / 4.5	2.1 / 4.5	— / 1.6
SC	0.6 / 1.2	0.7 / 2.1	— / 1.2	1.7 / 3.2	1.7 / 4.0	— / 1.7
SX	0.2 / 1.5	0.2 / 2.6	— / 1.3	1.5 / 3.6	1.6 / 4.2	— / 1.7
SCX	0.7 / 1.4	0.5 / 2.0	— / 1.0	1.7 / 3.1	1.7 / 3.9	— / 1.5

*Sounding / RWPs

Major comments:

Lines 87: Cha and Bell (2023) also added the IBM method to SAMURAI. Please mention their work in your literature review.

The descriptions of IBM in SAMURAI have been added in L88-89 as "Cha and Bell (2023) upgraded the SAMURAI by implementing IBM so that the wind can be better retrieved over complex terrain.". This article has been cited in the texts.

The authors should also mention the 3DVAR work done by Shapiro and Potvin that are now in PyDDA (Jackson et al. 2020). These works should also be mentioned in the literature review.

This article has been cited in L82-84, and we also remarked on this work as "Also, the 3D variational techniques (3DVAR) for radar wind retrieval were developed by Shapiro and Potvin and are now available on the Python platform named PyDDA (Jackson et al. 2020).".

Minor/technical comments:

Line 100-103: Run on sentence.

The sentences were rewritten for clarity. Please check them in L104-107: "Although S-band radar usually covers a wide area, radar data may be missing at lower levels far from the radar site. At the same time, the radar gate volumes become larger if the gate locations are too far from the radar site, leading to ambiguous radar observations, which is why the combination of radars was important.".

Line 104: "lower" should be "coarser"
Revised as suggestion.

174: "frozing" should be "freezing"
Revised as suggestion.

Figure 2: The station measurements are difficult to read on the figure. I would suggest removing some and making the font size bigger, or removing all of them.

The Korea Meteorological Administration (KMA) officially provided these figures. The station measurements cannot be modified to keep the original information from the KMA.

The authors tried to clarify the revised figure and emphasized the locations of the short front and the Korean Peninsula by red circles. Please find the revised figures below. Thanks.

In L236:

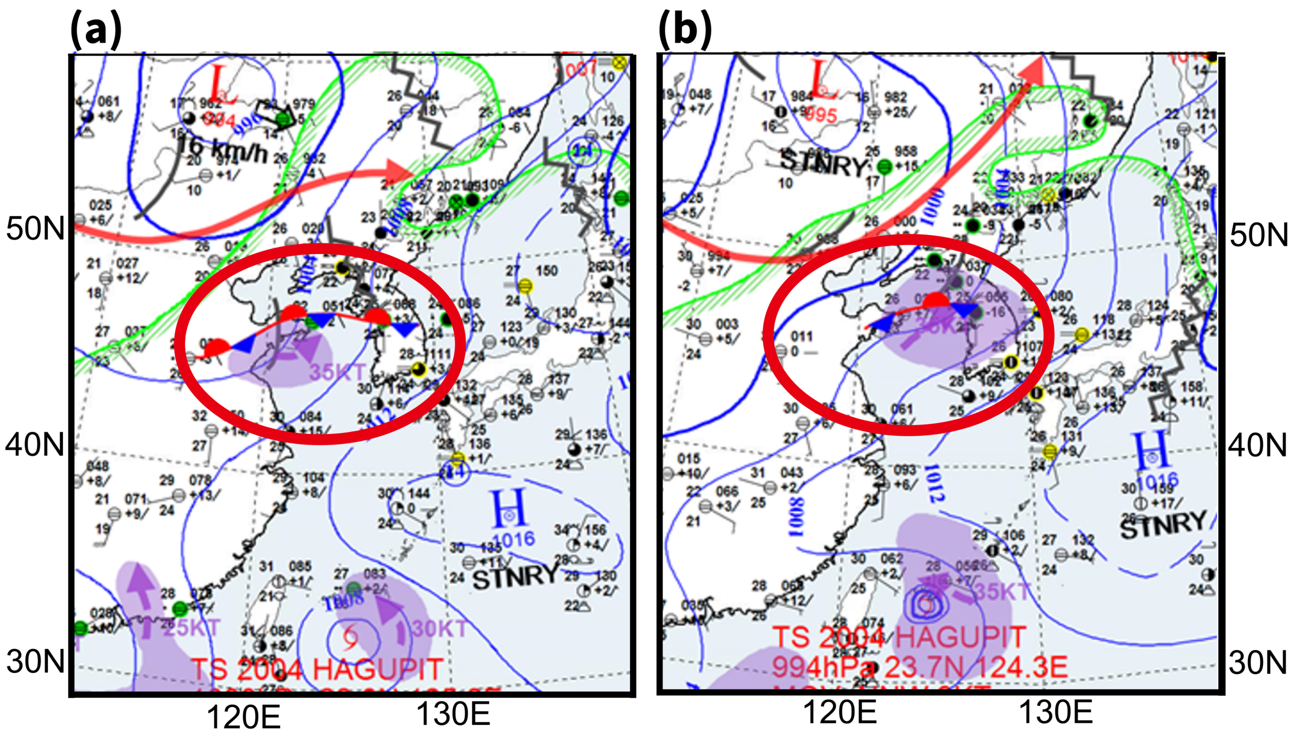

Figure 3. Korea Meteorological Administration surface analysis maps obtained at (a) 00:00 UTC and (b) 12:00 UTC on 2 August 2020. The purple shading indicates areas containing high moisture, while the arrows indicate the possible direction of movement. The red circle marked the locations of the Korean Peninsula and the short front.

Line 216: Extra "."

Revised as suggestion.

Line 361: "An"

The word was modified as "A".

Line 545: "leading edge"

The word has been added in the texts.

Figure 4: "reflectivity"

The word was modified.