We thank the reviewer's detailed suggestions and constructive remarks. The authors addressed all of the points made by the reviewer and included a point-by-point response to the reviewer's comments.

Correspondence to reviewer #3:

General comments:

The paper uses radar data to run two different data assimilation methods, LETKF and 3dVAR, during two snowfall events observed in ICE-POP 2018 fleld campaign. The authors compared the analysis and the forecasted data of different variables including wind, water vapor, temperature, and snowfall to show the importance of water vapor assimilation. The logic and structure of the paper are clear and easy to follow. However, several sentences need to be rewritten/reconsidered as well as some concerns which need to be considered before publication.

Specific comments:

1. It seems the authors run only one forecast cycle to compare two methods which cause few samples to do the verification methods. Please consider running more forecast cycles to have enough samples which make the verification as well as the results more reasonable.

   ⇒ Multiple forecast can be produced if we launch the forecast at each DA cycle, but this can create spin-up issues and adjustment problems. Thus, we think that using the analysis at the first several cycling to conduct the forecast might not be appropriate. We assimilate the radar information in the model, and hope the impact could last for a long time. The large scale forcing weather system over south Korea area needs time to develop during DA cycles, especially for stratiform precipitation. Based on the study of You et al. (2020), 3-hr assimilating period can obtain optimal analysis. Therefore, we did not launch the deterministic forecast in each DA cycle.

You, C.-R.; Chung, K.-S.; Tsai, C.-C. Evaluating the Performance of a Convection-Permitting Model by Using Dual-Polarimetric Radar Parameters: Case Study of SoWMEX IOP8. Remote Sens. 2020, 12, 3004. https://doi.org/10.3390/rs12183004

2. The authors use two different data assimilation methods; however, in many sentences particularly in the results and summary sections, the "simulation" word was used to refer to the LETKF or 3DVAR methods. Please note that this is the wrong word referring to the assimilation method. The LETKF and 3DVAR do the "assimilation" not "simulation". Sentences like „The snowfall in GWD was less simulated in LETKF" are logically wrong and need to be rewritten.

   ⇒ Thank you for the comment. Because we used the experiment naming the same as the DA method, we noticed it can be confusing. For simulations we will specify that it is from an experiment model run.

3. The word "underestimate" was used many times in sections 3 and 4 to compare two assimilation methods. Since none of these methods were considered as a reference experiment or reference data, using the words "underestimation"or "overestimation" for this comparison is meaningless. The words "underestimation" or "overestimation" could be used when the results are compared with reference data such as observation. Please consider rewriting these sentences.

⇒ The sentence has been modified as follows.

L 233-234:

There is an underestimation in the temperature and dew point in the region below 500 hPa by up to 2 K and 6 K respectively derived from the LETKF

L 238-242:

In Case 2, at altitudes below 700 hPa at all two sites, the LETKF underestimates the temperature of about 2 K, The atmospheric humidity of LETKF is similar to that of observed from 700 to 800 hPa, but because the temperature and the dew point temperature is 2K lower than observed, mixing ratio of water vapor is relatively small. A relatively dry area exist from ground to 900 hPa, and this area is also simulated more accurately by 3DVAR than LETKF.

4. In section 2.2.2 the radial wind and the reflectivity errors are assumed 3 ms-1 and 5 dbz respectively; however, the authors did not mention the source of these numbers.

   ⇒ To conduct the data assimilation(DA), observation errors are needed to be set. Generally, the observation error contains the representative error, instrumental error, and data processing and quality control error. The radar system has it owns instrumental error. And there can be some errors included while the data are being quality controlled and/or interpolated to coarser superobing or data thinning. As a result, considerable values of observation error are set for reflectivity and radial winds. We added the following reference of You et al. 2019 and Do et al. 2022.

   You, C.-R.; Chung, K.-S.; Tsai, C.-C. Evaluating the Performance of a Convection-Permitting Model by Using Dual-Polarimetric Radar Parameters: Case Study of SoWMEX IOP8. Remote Sens. 2020, 12, 3004. https://doi.org/10.3390/rs12183004

   Do, P.-N., K.-S. Chung, P.-L. Lin, C.-Y. Ke, and S. M. Ellis, 2022: Assimilating Retrieved Water Vapor and Radar Data from NCAR S-PolKa: Performance and Validation Using Real Cases. Mon. Weather Rev., 1177–1199.

   L 126-127:

   The observation errors including instrumental errors and random errors for radial wind and reflectivity are assumed as 3 m s−1 and 5 dBZ (You et al., 2020; Do et al.,2022).

5. In section 2.3 was mentioned that the precipitation up to 24.8 mm was recorded in the red box area from 00 to 12 UTC. It is an unclear sentence. The precipitation reported from an SYNOP station (which probably is the concern of the author in this sentence) would be for a specific point not for a whole specific area. The sentence could be rewritten by pointing to the minimum and maximum precipitation amount in this area as well as the location of the station which had a maximum report of precipitation. Please consider also the last paragraph in this section which has the same problem.

   ⇒ The exact station name was specified and latitude and longitude information of the station was added. The sentence has been modified as follows.

   L 178-180:

   As the center of the cyclone passed through southern Korean Peninsula (Fig. 5 (a)), 13.4-cm snow was recorded in Daegwallyeong, and precipitation up to 24.827.0 mm was recorded in at the

Deogyu mountain (in red boxed area: latitude: 35.894, longitude: 127.773) from 0000 UTC to 1200 UTC on December 24, 2017.

L 183-186:

In total, 8.0-cm snowfall was observed in Yongpyong, and a maximum of 15.5-mm precipitation was recorded at the Sabuk (in the blue boxed area : latitude: 37.220, longitude: 128.821), and a maximum of 64.5-mm precipitation was recorded at the Cho island (in red boxed area: latitude: 34.238, longitude: 127.244) from 1200 UTC on March 18 to 0000 UTC March 19, 2018.

Table 2. Selected cases for numerical experiments and their storm characteristics.

	Characteristics	**Total period**	**Data assimilation (DA) period**	**Forecast period**	**Maximum accumulated precipitation**	
					Southern part of the Korean Peninsula (red box)	**Pyeongchang region (blue box),**
Case 1	Shallow precipitation system, (Warm Low*)	0000 UTC, Dec 23, 2017–1200 UTC, Dec 25, 2017	2100 UTC, Dec 23, 2017–0000 UTC, Dec 24, 2017	0000 UTC, Dec 24, 2017–1200 UTC, Dec 25, 2017	27.0 mm (Deogyu mountain: latitude: 35.894 longitude: 127.773)	16.0 mm (Guryongnyeong: latitude: 37.879 longitude: 128.515)
Case 2	Shallow precipitation system, (Warm Low*)	0000 UTC, Mar 18, 2018–0000 UTC, Mar 19, 2018	0900–12000 UTC, Mar 18, 2018	1200 UTC, Mar 18, 2018–0000 UTC, Mar 19, 2018	64.5 mm (Cho island: latitude: 34.238 longitude: 127.244)	15.5 mm (Sabuk: latitude: 37.220 longitude: 128.821)

6. In section 3.1 the sentence „The snow mixing ratio is higher in LETKF“ is a general sentence that of course is not generally correct. Please consider mentioning clearly about the specific case (time/location) where the assimilated snow mixing ratio is higher than assimilated snow mixing ratio in 3DVAR.

   ⇒ The exact station name was specified and latitude and longitude information of the station was added. The sentence has been modified as follows.

   L 219-221:

   The increase in the wind and snow mixing ratio is similar, regardless of the DA method, and the snow mixing ratio increased by 0.2 g kg−1 where a reflectivity of 35 dBZ or more was observed in LETKF, but the increase in the southwestern part of the Korean Peninsula was not evident in 3DVAR, the snow mixing ratio in the analysis field at 1200 UTC, March 18 was higher in the LETKF.

7. In Fig. 8, there is no explanation for the dashed lines.

   ⇒ Information about each line has been added as in the sentence below.

   Figure 8 caption:

   Figure 8: Skew-T Log-P diagrams in (a), (c) OSAN and (b), (d) MOO for radiosonde (black line), LETKF (red line) and 3DVAR (blue line) for (a)–(b) 0000 UTC, December 24, 2017, (c)–(d) 1200

UTC, March 18, 2018, respectively and the solid line represents the temperature and the dased line represents the dew point temperature.

8. Fig. 14(d), there is a weird feature regarding the FSS score. The FSS scores for both LETKF and 3DVAR methods are very low at the first forecast hours and they increase after about 6 hours. This is not a common behavior in the FSS score of a forecast validation. It would be good if the authors recheck this case or explain a bit about such a weird behavior of the FSS score.

   ⇒ Please check the figures shown below, which depict the horizontal rainfall distribution by hourly basis. Some difference between the interpolated AWS rainfall distribution and DA forecasts are shown, especially in Pyeong-Chang area (blue boxed region). When we focus on the first three hours of the forecast period, the rainfall distribution of DA simulation cannot capture the exact position of the rainfall. After the first several hours forecast, the rainfall distributions are better and performs well.

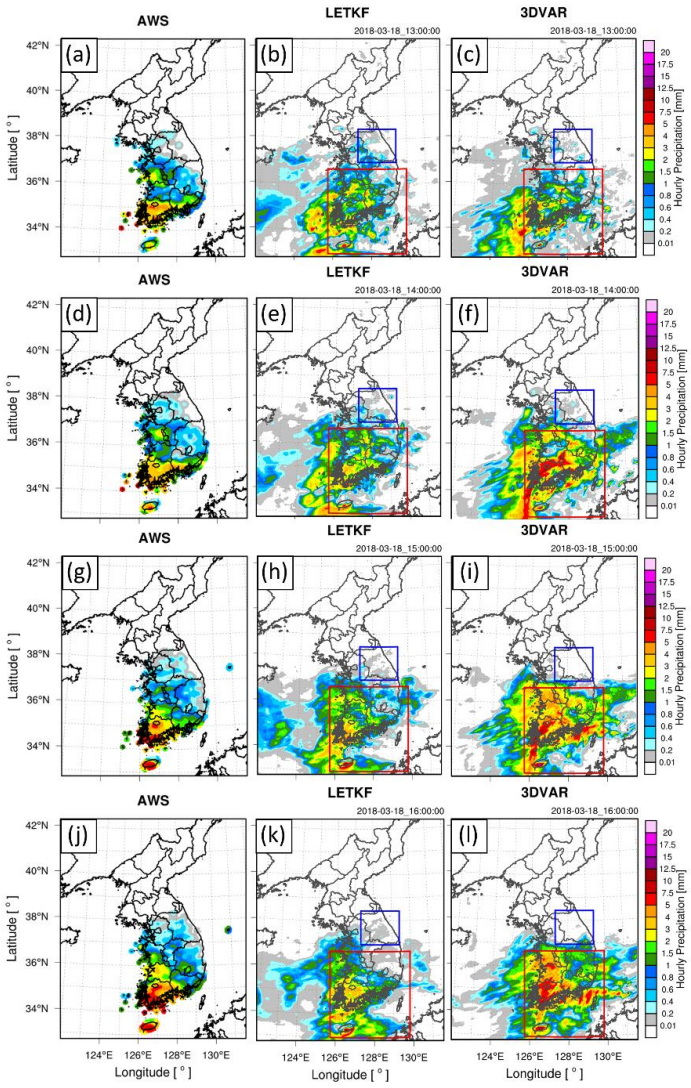

Figure 1 Hourly precipitation (mm) distribution of (a)–(c) 1300 UTC, March 18, 2018, (d)–(f) 1400 UTC, , (g)–(i) 1500 UTC and (j)–(l) 1600 UTC for Case 2. (a), (d), (g) and (j) is AWS observations, (b), (e), (h) and (k) is LETKF, and (c), (f), (i) and (l) 3DVAR experiment, respectively.

Technical correction:

(1.) Line 35: „cool ocean winds“ → „cold ocean winds“

⇒ The sentence has been modified as follows.

L 35-37:

The area of the East Sea is approximately 106 km2, and the average depth is 1,800 m, providing relatively cold ocean winds to GWD region in summer, and relatively warm ocean winds in winter, serving as heat storage and supplying water vapor to the atmosphere.

(2.) Line 49: „has“ → „get“

⇒ The sentence has been modified as follows.

L 49-50:

The GWD region get a stronger effect from the East Sea and the mountain range because the slope from the top of the Taebaek Mountains to the East Sea is steep.

(3.) Line 69: „only include information → „include only information“

⇒ We have corrected the sentence in L69-71

L 69-71:

Because radar data include only information on hydrometeors in the atmosphere and exclude information on water vapor, several radar data assimilation (RDA) studies do not assimilate the water vapor mixing ratio (Chen et al., 2021; Liu et al., 2019; Tong et al., 2020).

(4.) Line88: „Further“ → „Furthermore“

⇒ The sentence has been modified as follows.

L 88:

Furthermore, sampling error can occur when the ensemble members are small.

(5.) Line 141: „improves“ → „calculates“. Please consider changing all other „improve “ in this paragraph and the next one to „calculate“ or „produce“

⇒ The sentence has been modified as follows.

L 140-142:

Because the radar does not directly observe water vapor, the 3DVAR method calculates the water vapor amount and temperature through assumptions based on the empirical relation between relative humidity and reflectivity (Wang et al., 2013).

L 12-14:

LETKF produced the water vapor amount and temperature using the covariance of the ensemble members, but 3DVAR produced the water vapor mixing ratio and temperature through an operator that assumed the atmosphere was saturated when reflectivity was above a certain threshold

L 115-117:

The observed value y (= H(x)) is derived from the observation operator (H) and the observed input value y_0, and the analysis field x is calculated through DA with the initial background field value x_b.

L 148:

RH is relative humidity and T is temperature which are control variables calculated through DA.

L 337-340:

The LETKF experiment considered BEs of ensemble members, and the 3DVAR experiment considered only climatic BEs. LETKF produced the water vapor amount and temperature using the covariance of the ensemble members, but 3DVAR produced the water vapor amount and temperature through an operator that assumed the atmosphere was saturated when reflectivity was above a certain threshold.

(6.) Line 206: „at 3 km“, 3km resolution? Or 3km height? Please specify it.

⇒ The sentence has been modified as follows.

L 208-209:

Figure 6 shows the radar reflectivity, wind, snow, water vapor amount, and temperature increments at 3-km height for 0000 UTC, December 24, 2017

(7.) Line 208: The sentence „Increment in wind and hydrometeors show similar patterns, depending on the DA method“. Please consider rewriting this and the similar sentences in this section. The sentence is unclear and ambiguous.

⇒ The sentence has been modified accordingly. It means 3DVAR and LETKF are showing similar improvements on snow mixing ratio and wind.

L 219-221:

The increase in the wind and snow mixing ratio is similar, regardless of the DA method, and the snow mixing ratio increased by 0.2 g kg−1 where a reflectivity of 35 dBZ or more was observed in LETKF, but the increase in the southwestern part of the Korean Peninsula was not evident in 3DVAR, the snow mixing ratio in the analysis field at 1200 UTC, March 18 was higher in the LETKF.

(8.) Line 235: „„the LETKF underestimates the temperature,“ → „.there is an underestimation in the temperature derived from the LETKF method,“

⇒ The sentence has been modified as follows.

L 232-233:

There is an underestimation in the temperature and dew point in the region below 500 hPa by up to 2 K and 6 K respectively derived from the LETKF

(9.) Line 253: „Note the amount of change in the snow mixing ratio“, what is the point of this sentence?

⇒ The sentence has been modified as follows.

L 258-259:

In LETKF the maximum difference of the snow mixing ratio come to a decrease of 0.17 g kg−1 comparing to CRTL, however, the 3DVAR, it decreased by 0.22 g kg−1.

(10.) Line 278: „The observed GRS radar CFAD“ → „The observed CFAD of the GRS radar“

⇒ We have corrected the sentence in L 282-284

L 282-284:

The observed CFAD of the GRS radar shows that the reflectivity increases from 10 km for Case 1, indicating that the hydrometeors formed from above 10 km and slowly grew as they reached the ground (Fig. 12(a)).

(11.) Line 294: „In Case 1, The“ → „In case 1, the“

⇒ Changed accordingly.

L 300-302:

In Case 1, the snowfall in GWD was less simulated in LETKF, whereas snowfall of 10.0 mm or more was simulated in 3DVAR, showing a precipitation pattern similar to the observation (Fig. 13(a)-(c)).

(12.) Line 305: „hour prediction“ → „forecast hours“ please also consider replacing the „prediction“ with „forecast“ in this and the next section.

⇒ The sentence has been modified as follows.

L 310-311:

In Case 1, the 3DVAR FSS score showed a high value of 0.6 or more in all and blue regions from 2 to 4 forecast hours.

L 311-312:

However, the accuracy of 3DVAR decreases after 4 hours, and LETKF showed higher FSS value than 3DVAR in the 8 forecast hours in the all-region and the 7 forecast hours in the blue region.

L 317:

Even in Case 1, the FSS score in the 1 forecast hours of 3DVAR was as low as 0.49.