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 #1:

Specific comments:

1. The authors compared two very different radar DA methods. Therefore, there might be opposite results attained when tuning the parameters, e.g., number of ensemble members. It might be not suitable to tell which method is better. Especially, it seems that the authors used different radar reflectivity operators in the two methods. Please justify it. How about the results if the authors use the same observation operators for radar radial velocity and reflectivity in the two DA methods? How about the results if LETKF also assimilates water vapor indirectly not through covariance based on ensemble members?

   ⇒ The authors agree with the reviewer that there maybe different results when combining multitude of options used in this study. However, the purpose of this study is to compare two different radar data assimilation (DA) methods in assimilating winter precipitation over Pyeong-Chang area where intensive observation was performed in 2018. There have been numerous radar DA studies using LETKF or 3DVAR in studying summer precipitation but winter precipitation comparison studies have been seldom performed. The authors argue that 3DVAR and LETKF DA methods comparison is quite unique for winter cases. Large scale, broadly spread stratiform systems are seldom studied but are extensively examined in our research. The difference in radar operator between two DA methods arise from the way DA is performed.

   When performing radar reflectivity DA using 3DVAR, direct DA using an adjoint model or indirect DA method of classifying hydrometeors using the model's temperature field can be used (Xiao et al., 2007 ; Wang et al., 2013). However, since the currently developed adjoint model does not fully implement the cold-rain process, the error of the calculated hydrometeor mixing ratios during DA can be large. Therefore, indirect method is commonly applied as was the case in this study. In addition, in variational DA method, only the variables included in the observation operator changes, so even if hydrometeor mixing ratios are calculated through radar reflectivity DA, the water vapor mixing ratio and winds do not change unless prediction is performed. In radar DA, the wind is modified because the radial velocity is assimilated, but the water vapor mixing ratio is not updated, so the dynamic and thermodynamic balance is broken. Therefore, when assimilating 3DVAR radar data, the water vapor mixing ratio was calculated by applying the water vapor mixing ratio observation operator. However, when using the water vapor mixing ratio DA, it should be recognized that the S-band radar is an observation device that cannot observe water vapor, and the equation used for the water vapor mixing ratio DA is an empirically calculated equation.

   Since ensemble members are used in LETKF radar DA, the correlation between each variable can be considered. Therefore, reflectivity can be directly assimilated. Although, the water vapor mixing ratio is not included in the observation operator, through cross correlations the water vapor mixing ratio is also calculated. Accordingly, it is common not to consider the water vapor mixing ratio observation operator in most LETKF DA studies. In general however, the area where high reflectivity (about 30 dBZ) is observed can be considered saturated. But when considering only the correlation between hydrometeor mixing ratios and water vapor, the water vapor mixing ratio may decrease even in the area where high reflectivity is observed. In such cases, even if the mixing ratio of hydrometeors increase through RDA, the surrounding area may be dry and the hydrometeors will not grow and evaporate during the forecast period. Therefore, in order to solve this problem, when radar DA is performed, an observation operator including information on the water vapor mixing ratio must be used.

2. If the reviewer understood correctly, only one forecast was produced in each snowfall case in each DA experiment. The reviewer would suggest that one forecast can be produced in each DA cycle, and then there are enough samples for the authors to conduct statistical evaluation (RMSE, FSS, etc.), which will make a solid study.

⇒ 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.

3. Sections 3.2, 3.3, and 3.5: Please conduct quantitative analysis and comparison, not just full of "large" "more" "similar" "underestimate" "increase" "relatively small/dry" "low" …

⇒ This has been updated in quantitative terms.

L234–L235:

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.*

L235–L237:

This is because reflectivity of more than 30dBZ is observed in this area and the water vapor amount ***of about 0.3 g kg−1*** *and temperature* ***of about 1.5 K*** *increase in 3DVAR, but decrease according to the covariance between variables in LETKF (Fig. 6).*

L238–L40:

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.*

4. Lines 303-314: What spatial scale did the authors use to calculate FSS? Please examine the sensitivity of different spatial scales and precipitation thresholds.

⇒ The spatial scale used for FSS is 10 km because this is the representative horizontal resolution of AWS network in South Korea. Although not shown, some sensitivity tests on FSS have been performed. We found that the FSS will increase as distance increased. And the FSS decreased as the validation thresholds increased. While validating the hourly rainfall, we checked the rainfall during the forecast periods and took the average value which is about 0.5 mm. If we set a high threshold, the validation on rainfall night be meaningless while winter cases is tested.

5. Figures 12-15: How about the results of CTRL? Please include them for comparison.

⇒ Figures 12-15 with CTRL results have been redrawn and included in the revised manuscript.

Technical corrections:

1. Line 120: “component” -> “components”

⇒ The sentence has been modified as follows.

L118–L 120:

B is calculated using the National Meteorological Center (NMC) method (Parrish and Derber, 1992), considering 12-h and 24-h forecasts of winter periods (Dec 01, 2017–Mar 31, 2018) with five members of control variables (u, v wind ***components,*** *surface pressure, temperature, and pseudo-relative humidity).*

2. Line 125: “BE” -> “background error”

⇒ In the previous sentence (L80–L 81), we mentioned that BE means background error. Therefore, we did not modify the sentence.

L80–L 81:

The limitations of 3DVAR however is that the model background error (BE) only considers the climatic BE covariance and it was developed for large-scale observational data (Hamil and Snyder, 2002).

3. Line 126: Please justify the observation errors used in this study.

⇒ We have corrected the sentence in L126–L 127:

L126–L 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. Section 2.2.3 describes the observation operator method.*

4. Table 1: Please provide a brief description of prognostic variables.

⇒ The LETKF DA system is able to modify the prognostic variables by background error covariance. And these prognostic variables are listed below: 3-dimensional wind, hydrometer (cloud water, rain, cloud ice, snow and graupel/hail) mixing ratios and number concentration, water vapor, pressure and temperature.

L126–L 127:

For analysis, the system will update the prognostic variables, such as 3D wind, hydrometeor mixing ratio, potential temperature, and geopotential height, using their BE covariances. Besides, the variable-depend horizontal and vertical localization radii are set (Table 1)

5. Line 188: “compare” -> “examine”

⇒ We have corrected the sentence in L188.

L 189:

We considered several verification parameters to objectively examine compare the model’s prediction improvement.

6. Lines 194-195: Did the authors interpolate station data to the model grid?

⇒ While interpolating the model grids to AWS station location, the nearest model grid point is found first. Next, letting the first point as a pivot point, find another three points and make a square, which enclose the AWS point. Lastly, using inverse-distance method and giving the four points different weight using cubic spline to interpolate the values and calculated the statistics.

7. Lines 195 and 201: “using” -> “by”

⇒ The sentence has been modified as follows.

L 195-196:

where N is the number of horizontal grid points, P_i *is the precipitation (mm) in the model’s predicted field, and* O_i *is the precipitation observed by AWS (mm).*

L 202-203:

$\bar{P}$ *is the mean precipitation (mm) in the model’s predicted field, and* $\bar{O}$ *is the mean precipitation observed by AWS (mm).*

8. Line 196: “fractions skill score” -> “fractions skill score (FSS)”

⇒ We have corrected the sentence in L196

L 197:

The fractions skill score (FSS), proposed in Roberts and Lean (2008), illustrates a new method for forecast validation

9. Line 206: “at 3 km” means “at 3-km height” or “at the 3-km domain”

⇒ “at 3 km” means “at 3-km height”. 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 3 km for 0000 UTC, December 24, 2017.

10. Lines 218-220: Please conduct a quantitative comparison.

⇒ The sentence has been modified as follows.

L 220-222:

Where a reflectivity of 15 dBZ or more was observed, the inland water vapor mixing ratio is reduced 0.4 g kg−1, the temperature is reduced by 0.8 K in LETKF and in 3DVAR, it increased by 0.2 g/kg and 0.8 K, respectively.