General statement

Referee comment #2

This work offers a relevant contribution in the field of meteorological nowcasting, presenting a method to quantify the uncertainty in high resolution analysis at surface level by using a perturbation approach. Nowcasting accuracy is crucial for short term weather events forecast, so this work offers a good contribution because the ideas of using perturbations combined with an inflation factor allows a detailed description of uncertainties derived from the differences between observation and initial estimates. The method has been verified in a specific region through several crucial variables, confirming the robustness of the proposed approach. In my opinion, the manuscript can be considered for publication, but a general revision is needed, in order to address the following comments.

The introduction of the inflation factor represents an important improvement; however, it could be not sufficient to represent the complexity of the interpolation uncertainty. For this reason, I recommend the authors to better clarify the limitation of the proposed approach and to describe the possible potential future improvements.

Reply 1:

Thanks for the comments. Before describe the limitation, we will start with "the observation perturbation in this study is …" to describe the generation of perturbation, and then use the comparison of RMSE and spread (the Fig. 2 in manuscript) to explain why we proposed using inflation factor to amplify the spread. This description will be traceable in Section 4. Then, we will explain more about the limitation of the proposed approach in Section4.1.2. The inflation factor is calculated based on the test stations and is then extrapolated to the grid mesh by interpolation, in order to amplify the variance of first guess in the areas without station information. However, this interpolation process is limited by the locations of the test stations, meaning that areas outside these stations can only receive partial information. For this reason, it does not account for the uncertainty of the stations that are not used in the computation of analysis, nor in the computation of the inflation factor (the Fig. 5 in manuscript). Therefore, the limited impact of the inflation factor on the entire grid mesh is a key limitation of the current method. A possible improvement would be to see if there are some predictors which could help inflation factors to extrapolate this information to the outside stations site (not used in the computation of analysis nor in the computation of the inflation factor).

The revision will be traceable in the manuscript.

The method works well with temperature and humidity, but has some difficulties with wind components. The authors claim that it is due to the lack of appropriate observational perturbations,

however I recommend to add a more convincing explanation of this limitation.

Reply 2:

Thanks for the comments. We will add the explanation in the Section4. One reason for the difficulties with wind components is that no perturbation is introduced to the observations. In the calibration of wind components, vertical wind is used to calculate divergence to constraint the horizontal wind. Hence, the interpolation of wind differs from that of temperature. The divergence constrains causes the first guess error to incorporate additional information to calibrate the first guess. For this reason, it is difficult to fully understand the impact of the perturbation in observation. As a result, the reliability of wind components is no as high as that of temperature. Hence, it is necessary to account for the impact of divergence constraint in future research and address these difficulties.

The English style is sufficiently accurate, but it is necessary to improve the readability and clarity. Some complex phrases must be simplified, in order to enhance the readability. There are some grammatical errors; in the following I have reported some errors and imperfections, but there are many others scattered over the text, so a general revision is required.

Reply 3:

Thanks for the comment. We will carefully go through the whole paper and check the grammar issue. The revision will be traceable in the manuscript.

Detailed comments:

1. L 29 Avoid repeating the word "nowcasting" twice on the same line.

Thanks for pointing it out. We will rephrase it i.e. "However, due to the chaotic nature of the atmosphere, errors in data and the imperfect numerical models, nowcasting involves uncertainties."

2. L 29 Change "nowcasting is with uncertainties" with "nowcasting involves uncertainties".

Thanks for the comment. We will change this sentence i.e. "… models, nowcasting involves uncertainties." The revision is in line 31.

3. L 36 Avoid repeating the word "uncertainty" twice on the same line.

Thanks for pointing it out. We will rephrase it i.e. "The analysis contains uncertainty, which has a significant impact on nowcasting, due to both measurement errors from instruments and errors produced during the computation."

4. L 51-52 Something is wrong in the English syntax, this sentence is not clear.

Thanks for pointing it out. We will rephrase it i.e. "Horányi et al. (2011) and Bellus et al. (2016, 2019) proved that perturbation can simulate the observation error in analysis. However, they did

not delve into other errors in analysis, such as errors produced by interpolation."

5. L 54 Change "consider" with "considering".

Thanks for the comments. We will revise it in this sentence.

6. L 65 (NWP) - I do not understand which NWP are you talking about.

Thanks for pointing it out and sorry for the confusion. We will rephrase this sentence i.e. "The first guess used in INCA is the numerical weather prediction (NWP) provided by the Austrian operational version of the Aire Limitée Adaptation dynamique Développement InterNational (ALADIN) limited-area model described by Wang et al. (2006)" The revision is in line 65-67.

7. L 66 Haiden et al., 2010, 2011 were already cited at line 64, please remove here.

Thanks for the hint and we will remove this citation in line 66.

8. L 72-78 This paragraph is confusing and hard to be read. I suggest to remove it and to replace it with a description of the importance of this approach (i.e. strengthens), while this technical description could be moved elsewhere.

Thanks for the comment and sorry for the confusion. We will replace this paragraph as suggested. We will describe the importance of this approach and its potential application prospects. This technical description will be moved to Section2. The revision will be traceable in the manuscript.

9. L 102-103 "are to match the stations at different altitudes ensure that NWP can be corrected in combination with the topographic parameters at station location". There is something wrong in the English style.

Thanks for pointing it out. We will rephrase it, i.e. "In addition, 21 vertical levels corresponding to various altitudes, such as 0 m, 200 m, and up to 4000 m above the ground, are used to match stations at different elevations. The wind speed is represented in 32 vertical levels with intervals of 125 m. This approach ensures that the first guess can be calibrated by incorporating the topographic parameters at the station location."

10. L 119-121 Avoid using the word "ensemble" five times in the same sentence.

Thanks for the comment. We will rephrase it, i.e. "This work proposes a perturbation method to accurately quantify the uncertainty represented by the errors in analysis. …. The ensemble nowcasting starts at each hour and extrapolates up to a lead time of 2 hours". The revision will be traceable in the manuscript.

11. L 121 "is covered". Do you probably mean "covers"? Otherwise there is a syntax error.

Thanks a lot for pointing it out. We will rephrase this sentence i.e. "… nowcasting covers the test stations shown in Figure 1."

12. L 296 change "for nowcasting at initial time" with "at the initial time of nowcasting".

Thanks for the comment. We will revise it: "… uncertainty at the initial time of nowcasting."