Dear Reviewer, thank you for your thorough feedback on our revised manuscript. Your comments have further improved the quality and readability of our manuscript.
In response to your comments, we have incorporated some new insights and modified the revised manuscript further. Specifically, we have incorporated the ramp statistics from ERA5 and CERRA wind speed data, along with a paragraph detailing the consequences of not incorporating the data assimilation into the conclusions.

Our responses to your comments are given below. We have only included the comments that are unanswered or needed revision.

Major comments

2. Thank you for the clarification; it should be mentioned in the paper also.

   The choice of the cases is mentioned in the revised manuscript at P5L147-148 and is provided here for reference.

   > The choice of the two cases for primary focus are arbitrary.

4. Thank you for the clarification. You should describe at least these non-default settings in the paper to allow others to reproduce the results.

   The MYNN PBL settings are provided at P11L239-240, in the revised manuscript, and is provided here for reference.

   > For the simulations with MYNN2.5 PBL scheme, we set bl_mynn_tkebudget = 1 and bl_mynn_tkeadvect. = true for the bl_mynn_settings, while the other settings are unaltered, taking their default settings.

5. Your paper strongly emphasizes modeling the timing of ramp events, so data assimilation remains a relevant missing factor. I will maintain that you should do more to discuss the possible consequences of not including DA here as it relates to the conclusions about choosing your nesting and model domains.

   We acknowledge the reviewer's comment that data assimilation plays a key role in short-term weather forecasting. While our study mainly focusses on modelling aspects to better understand the dynamics and physical processes involved in the extreme-ramp event simulations, we would extend our study to examine the influence of data assimilation on extreme-ramp forecasting in the future.

   In the revised manuscript, we have incorporated the following text at P29L521-535.

   > Data assimilation (DA) is a crucial factor in numerical weather prediction, particularly for real-time forecasting, where accurate initialization of model states enhances short-term predictability. As demonstrated in the studies by Wilczak et al. (2015, 2019), DA has been shown to significantly improve short-term wind power forecasts by reducing forecast biases

and enhancing the representation of wind ramps. Specifically, the assimilation of in situ and remote sensing observations into high-resolution models has led to up to a 6\% reduction in RMSE for short-term wind power predictions, with notable improvements in the first few forecast hours. However, the effectiveness of DA is highly dependent on factors such as the type of observations assimilated, the assimilation technique employed, and the forecast lead time. Ivanova et al. (2025) demonstrated the benefits of Four-Dimensional Data Assimilation (FDDA) of lidar observations in improving wind speed and wind power forecasts for Belgian offshore wind farms. However, they also identified key limitations, including the dependence on specific wind directions, the scarcity of real-time offshore observations, and the restriction of FDDA to prognostic variables. While these findings reinforce the potential benefits of DA, our study had a different objective. Rather than focusing on assimilation techniques, we aimed to assess the sensitivity of modeling parameters and evaluate the WRF model's ability to simulate frontal low-level jets and extreme ramp events. In addition, we sought to improve our understanding of the underlying atmospheric processes. Future work could explore the added advantage of DA and assess its impact on extreme wind events at the resolutions and configurations considered here.

Wilczak, J., Finley, C., Freedman, J., Cline, J., Bianco, L., Olson, J., Djalalova, I., Sheridan, L., Ahlstrom, M., Manobianco, J. and Zack, J., 2015. The Wind Forecast Improvement Project (WFIP): A public–private partnership addressing wind energy forecast needs. *Bulletin of the American Meteorological Society*, *96*(10), pp.1699-1718.

Wilczak, J.M., Olson, J.B., Djalalova, I., Bianco, L., Berg, L.K., Shaw, W.J., Coulter, R.L., Eckman, R.M., Freedman, J., Finley, C. and Cline, J., 2019. Data assimilation impact of in situ and remote sensing meteorological observations on wind power forecasts during the first W ind F orecast I mprovement P roject (WFIP). *Wind Energy*, *22*(7), pp.932-944.

Ivanova, T., Porchetta, S., Buckingham, S., Glabeke, G., van Beeck, J. and Munters, W., 2025. Improving wind and power predictions via four-dimensional data assimilation in the WRF model: case study of storms in February 2022 at Belgian offshore wind farms. *Wind Energy Science*, *10*(1), pp.245-268.

8. I agree that the forcing datasets are probably less appropriate for extreme wind ramps due to the reasons you list. However, that is precisely why it would be valuable to show the significant improvements from your dynamical downscaling relative to the forcing data. Both ERA5 and CERRA are available hourly at many levels. See, e.g., https://cds.climate.copernicus.eu/datasets/reanalysis-cerra-height-levels?tab=download, and https://cds.climate.copernicus.eu/datasets/reanalysis-era5-complete?tab=d_download. I agree with you that adding more datasets to the figures could lead to cluttering. However, you could add them to Tables 2 and 4, which would indicate the improvements from downscaling.

We thank the reviewer for the suggestion. Accordingly, we included the ramp statistics from CERRA and ERA5 wind speeds available at different model levels. In the revised manuscript, the statistics are added in Tables 2 and 4, while the following text is included at P14 L280-285 and P26L488-490.

To highlight the necessity of dynamical downscaling, wind power output is computed using wind speed from ERA5 model levels (https://cds.climate.copernicus.eu/datasets/reanalysis-era5-complete?tab=d_download) and CERRA height levels (https://cds.climate.copernicus.eu/datasets/reanalysis-cerra-height-levels?tab=download). The corresponding ramp statistics are presented in Table \ref{ramp_in_capacity_factor_combined}. The results indicate that ramp timings derived from both datasets closely align with those from WRF simulations and observations. However, the ramp intensity is significantly underestimated by ERA5, whereas CERRA exhibits a moderate underestimation.

Similar to Cases 1 and 2, both ERA5 and CERRA significantly underestimate the ramp intensity in these additional cases, with CERRA exhibiting an overestimation in Case 5. However, the ramp timings remain comparable to those obtained from the WRF simulations.

9. The new levels help, but I recommend choosing a different colormap without so many discontinuities/breaks. See, e.g., https://www.fabiocrameri.ch/colourmaps/.

   In the revised manuscript, Figures E1 and F1-4 are redraw with suggested colour map, without having many discontinuities.

10. Thank you for the clarification here. You should also clarify this in the paper.

    In the revised manuscript, a clarification is provided at P10L194 and L196 and is provided here for reference.

    We have used the pressure level data set from both ERA5 and CERRA as initial and boundary conditions in our simulations.

13. It's highly appreciated that you extended your analysis to the three remaining cases. The trend appears reasonably consistent, with CERRA-1d1kmMYFP performing best (at least for 4 out of 5 events). Perhaps you could highlight (bold text, perhaps?) the best-performing simulation in Tables 2, 3, and 4 for intensity and timing.

    In the revised manuscript, the best performing simulations are underlined in Tables 2, 3, and 4.

14 See my answer under 5)

   As stated in response 5, we have incorporated a detailed text regarding consequences of not using data assimilation and a scope for future work.

Additional comments

1. Please complete the "data availability" section related to all the data used and produced in your study. What about the availability of your simulations, the LiDAR data, and so on?

   In the revised manuscript, an elaborated "data availability" section is provided, explaining how to obtain the simulated data and observations. For reference, the text is provided here.

   The datasets used in this study are publicly available. The ERA5 and CERRA reanalysis are downloaded from ECMWF CDO, available at https://cds.climate.copernicus.eu/cdsapp\#!/search?type=dataset. The scripts and workflows for data processing and analysis can be accessed in the GitHub repository https://github.com/HarishBaki/Modeling-Frontal-Low-Level-Jets-and-Associated-Extreme-Wind-Ramps.git. The wind model simulations and observational datasets supporting this study are hosted on Zenodo, at https://doi.org/10.5281/zenodo.15033463. These repositories ensure transparency and reproducibility, allowing further exploration and validation of the study's findings.

2 Consider providing more detail in the "author contribution" section. See, e.g., https://publications.copernicus.org/services/contributor_roles_taxonomy.html

The author contribution section is modified according to the journal standards. For reference, the text is provided here.

HB is responsible for Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Visualization, and Writing – original draft preparation. SB is responsible for Conceptualization, Supervision and Writing – review & editing. GL contributed Supervision and Writing – review & editing.