Review – Bodini et al – HRRR Toolkit

Recommendation: Accept with minor revision.

Overall: This manuscript is a very important study in its description of the HRRR MET Toolkit dataset capability. It is unique in its use of over 20 hub-height wind observation locations across the US in evaluating the newer HRRR MET Toolkit vs. the previous WIND Toolkit. The manuscript will be improved by adding two references to previous studies comparing HRRR data to WIND Toolkit data. Most of my comments below are appreciation for specific aspects the manuscript. I found it to be a clever idea to repackage the HRRR datasets into a common format with WIND Toolkit and include interpolation to the needed hub-height levels. This study is also very relevant to the wider modeling community in using a few dozen observation locations (Table 2) for hub-height wind validation against both WTK and HRRR. I had not seen such a wide collection before of hub-height wind data. This study is a very strong improvement over previous WFIP studies with detailed terrain variations (e.g., Columbia Gorge) and subject to significant data representativeness issues comparing a single profile with 3-km grid data.

I assess the dataset described as excellent in all 3 categories: uniqueness, usefulness, and completeness. I assess the data quality as excellent, and the presentation also as excellent.

We sincerely thank the Reviewer for their positive and encouraging assessment of our manuscript and of the HRRR MET Toolkit dataset. We address the specific comments below.

Specific comments

The new HRRR Toolkit manuscript definitely needs to mention these two references below describing prior HRRR-based wind and solar energy datasets funded in part by DOE. Both of these studies mentioned earlier comparisons with the WIND Toolkit but for the 2013-2015 period. Therefore, they anticipated the new DOE NLR transfer to the HRRR Toolkit now described. Both studies (2018-offshore, 2017-land) used 80-m AGL winds. Obviously, the additional levels provided in the HRRR MET Toolkit data give a much more complete dataset for wind energy studies. James et al. (2017, 2018) both used the 2013-2015 period of the HRRR including before it became operational with NCEP in September 2014.

1. James, E.P., S.G. Benjamin, and M. Marquis, **2017**: A unified high-resolution wind and solar dataset from a rapidly updating numerical weather prediction model. *Ren. Energy*, **102**, 390-405. https://doi.org/10.1016/j.renene.2016.10.059
2. James, E.P., S. Benjamin, and M. Marquis, **2018**: Offshore wind speed estimates from a high-resolution numerical weather prediction model forecast dataset. *Wind Energy*, **21**, 264- 284. https://doi.org/10.1002/we.2161

We agree that these two studies are highly relevant precursors to the work described in our manuscript, and we thank the Reviewer for pointing us to them. We have added both references in the Introduction, where we introduce the potential of operational forecast model archives for energy applications:

"The National Oceanic and Atmospheric Administration's (NOAA's) High-Resolution Rapid Refresh (HRRR) model (Dowell et al., 2022) provides an hourly updating operational weather

forecast capability across the contiguous United States (CONUS). The potential of the HRRR archive for renewable energy applications was recognized early on: James et al. (2017) developed a unified high-resolution wind and solar energy dataset from the 2013–2015 HRRR record, and James et al. (2018) extended this effort to offshore wind speed estimates. Both studies included comparisons against the legacy WIND Toolkit using 80 m winds, thereby anticipating the transition to the HRRR-based energy dataset described herein."

As detailed below, we also now cite James et al. (2017) as the primary reference for the choice of a short-range forecast horizon over the f00 analysis.

L145-140. On use of a short-range forecast (f01 or f02) instead of f00, James et al (2017) explain the reasoning and would be a much better reference than VCE (2024).

We agree, and we have revised the text to cite James et al. (2017) as the primary reference for this choice, retaining VCE (2024) as a supporting reference:

"This choice allows for sufficient model spin-up, balancing the ingested observational data with the model's physical consistency. James et al. (2017) discuss the rationale for preferring short-range HRRR forecasts over the f00 analysis in detail, having adopted the same approach for their HRRR-based renewable energy dataset (see also VCE, 2024)."

L63-68. I also commend the co-authors on following guidelines from the ESIG (2023) study on best practices for energy datasets. NLR is following thinking from the larger community represented by ESIG.

We thank the Reviewer for this positive comment.

L165. Great idea to also use other times valid at the same time to fill in the entire 2015-2025 dataset.

We thank the Reviewer for this positive comment.

L205-206. This sentence gives the impression that the BC was going to be effective, but section 6 shows otherwise. Of course, since there is no known advantage of WIND Toolkit data vs. HRRR without BC, it seems better to leave HRRR as is. The wording in L17-21 makes it clear that BC provides marginal benefit at best and degrades performance in complex terrain. I suggest changing the wording to "… and the WIND Toolkit to consider the effectiveness of the BC approach as discussed in section 6."

We agree that the original wording could inadvertently suggest that the bias correction was expected to be beneficial, which the results in Section 6 do not support. Following the Reviewer's suggestion, we have revised the opening sentence of Sect. 2.4 to frame BC-HRRR as a test of the effectiveness of the BC approach:

"The BC-HRRR dataset is an experimental variant (2015-2023) derived from the HRRR MET Toolkit, developed to consider whether applying a statistical bias correction (BC) against a wind-energy-specific baseline could improve the accuracy of the operational data; the effectiveness of this BC approach is evaluated in Sect. 5 and discussed in Sect. 6."

L249, Table 2. It would be useful to add columns for land/offshore and for offshore stations, add the number of km offshore the site is. Many of them appear to be very close to shoreline.

This is a useful addition, and we have implemented it. Table 2 now includes two additional columns: one identifying each station as land-based or offshore, and one reporting, for offshore stations, the approximate distance to the nearest shoreline (computed as the geodesic distance from the station coordinates to the nearest point on the coastline). We have also updated the table caption accordingly.

L401-430 (Conclusions). I found these conclusions to be excellent, including the different sources of uncertainty including observation representativeness. Well done to the authors in testing bias correction (BC) and concluding that it did not help the HRRR Toolkit data overall. This test is a key point in the paper and will hopefully ensure that users of HRRR Toolkit data won't try to apply BC themselves since it has already been tested.

We thank the Reviewer for this positive assessment, and we share the hope that this result will discourage users from applying their own bias correction to the HRRR MET Toolkit data.

I note that the HRRR Meteorology, Energy, and Transmission (MET) Toolkit does not mention wind, so is it possible that it will be applied in the future also for solar data? If so, I strongly recommend use of 0-h solar radiation data from HRRR (not 2-h) as shown in a recent paper evaluating HRRR solar radiation forecasts by Benjamin, Turner, et al. (ttps://doi.org/10.1175/MWR-D-25-0094.1)

The Reviewer raises an excellent point. Solar radiation variables were not included in the current release, primarily for programmatic reasons (this development was funded with a focus on wind resource characterization), as now discussed in Sect. 2.3 of the revised manuscript. However, a future extension to solar variables is indeed possible, and we agree that the choice of forecast horizon would need to be revisited for radiation fields. We have added the recommended discussion and reference (Benjamin et al., 2025) at the end of the paragraph discussing solar variables in Sect. 2.3:

"Should solar radiation variables be incorporated into a future release of the HRRR MET Toolkit, we note that – in contrast to the wind fields, for which the f02 forecast is preferred to allow model spin-up – the HRRR downward shortwave radiation is most accurate at the 0-h analysis time (f00), as the HRRR exhibits a positive shortwave radiation bias that grows with forecast horizon (Benjamin et al., 2025)."

<u>Technical corrections</u>

L131. Suggest calling the HRRR a "forecast model" or "forecast capability". It is not a forecast itself.

We agree and have revised the wording in the two places where the HRRR was referred to as a "forecast": in the Introduction, the HRRR model now "provides an hourly updating operational weather forecast capability across the contiguous United States (CONUS)", and in Sect. 2.3 the HRRR is now described as "a highly accurate operational weather forecast model in the United States".

Overall – I found virtually no typos – very well done.

Thank you!