Statistical Comparison of HRRR and RRFS Convection-Allowing Models During Severe Weather Risks in 2023

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Introduction

Over the past thirty years, numerical weather prediction (NWP) has undergone vast improvements in capabilities. While NWP models are more accurate than ever, they still show biases during high-impact weather events that affect people's lives. Convection-allowing models (CAMs) run at higher resolutions to better resolve local geography details and smaller-scale storm processes. The High-Resolution Rapid Refresh (HRRR) is one of the primary operational CAMs. To increase efficiency in model development, the National Centers for Environmental Prediction is developing a Unified Forecast System. The GFS was upgraded to this new framework in March 2021. Meteorologists are now in the process of developing the Rapid Refresh Forecast System (RRFS), which is destined to replace the HRRR and other CAMs.

We aim to compare the HRRR to the experimental RRFS models and answer the following questions:

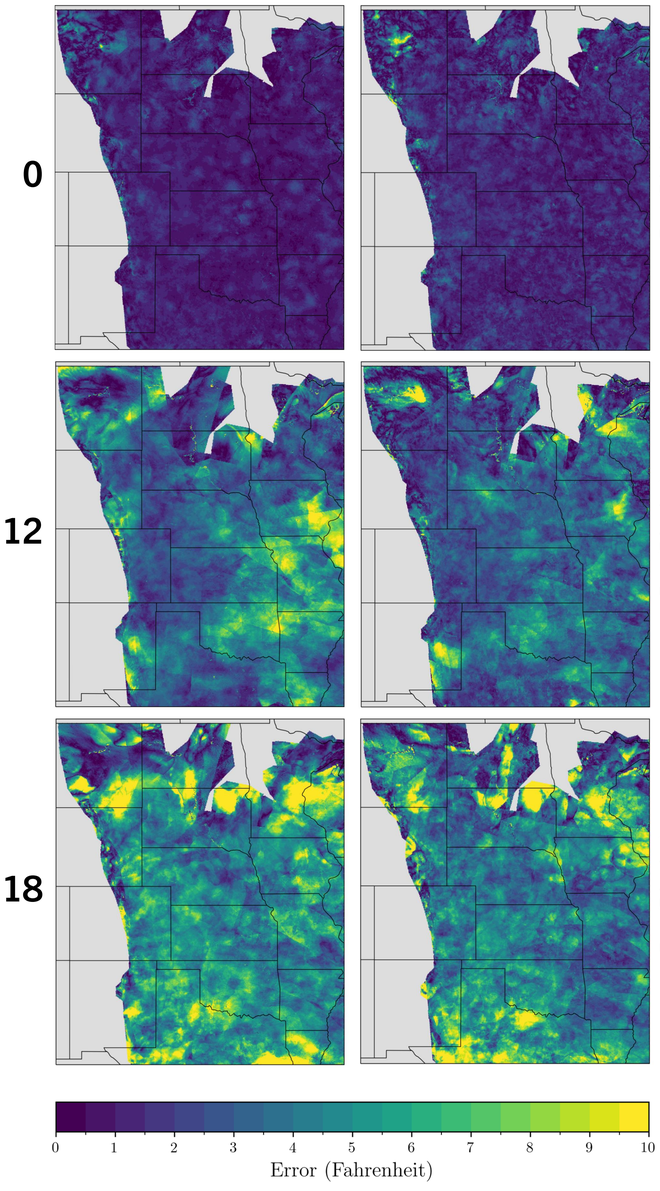
- **How do the HRRR and RRFS models differ in predictions of surface temperature and dew point during severe weather risks in the central US?**
- **What statistically significant errors found can be classified as systematic bias?**

Data & Methods

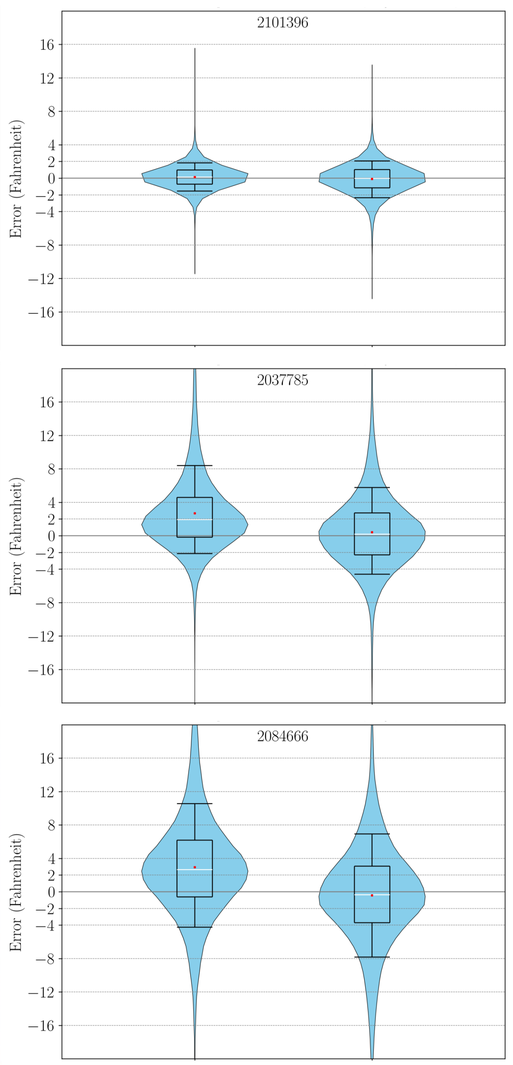
- HRRR, RRFS, and URMA data acquired from the NOAA Registry of Open Data AWS server
- SPC Day 1 13z Convective Outlook boundaries acquired from SPC Severe Weather Event archive
- Data from 10 May 2023 to 12 October 2023
  - 78 Slight Risk or greater days included in analysis
- Data truncated to regions of Day 1 13z Slight Risk greater as determined by SPC outlooks
- 6z model runs utilized to represent forecaster analysis for 13z Day 1 Outlooks, analyzed at forecast hours 00, 06, 12, 18, and 24
- URMA data regridded to 3-km gridpoint spacing to match HRRR and RRFS
- Error determined by subtracting URMA analysis from CAM output at each gridpoint

Results

Temperature Mean Absolute Errors



Temperature Error Distributions



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Conclusions

- **HRRR and RRFS both show error in initial conditions**, with more significant error present over terrain features
  - HRRR has smaller variance in initial conditions
    - May be due to changes in data assimilation techniques
- Both models demonstrate bias in forecasting temperatures and dew points, especially in **periods of maximum diurnal heating**
  - **RRFS is more accurate** at predicting temperature and dew point values at the surface
  - HRRR and RRFS have similar variance in surface temperature and dew point forecasts
  - **HRRR shows a consistent warm and dry bias** during these periods
    - Likely a result of **incorrect mixing parameterization**

This study could aid developers of the RRFS model in making decisions about data assimilation techniques and physical parameterizations. However, these results from the warm-season could be different from the cool-season.

Overall, there is still room for the RRFS to improve in its assessment of initial conditions. However, the RRFS appears to be at least as good as the HRRR in forecasting surface temperature and dew point during severe risks, suggesting that it may soon be ready to become operational.

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