The Houston Derecho: A HRRR Versus MPAS Case Study As Part Of The NOAA Hazardous Weather Testbed Annual Spring Forecast Experiment

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Introduction

- Every May, NOAA's Hazardous Weather Testbed (HWT), under the guidance of the Storm Prediction Center (SPC) and National Severe Storms Laboratory (NSSL), conducts the Spring Forecasting Experiment (SFE). In 2024, this effort was conducted from April 29 - May 31 and compared five different models' total.
- The SFE compares emerging technology to help scientists accelerate the transfer from research to operations, inspire new initiatives for research, and identify and document performance of modeling systems.
- This research focuses on the High-Resolution Rapid Refresh (HRRR) and the Model for Prediction Across Scales (MPAS), with the Houston Derecho used as a case study.

Research Questions

How well did the HRRR and MPAS models forecast the Houston Derecho event of May 16-17, 2024?

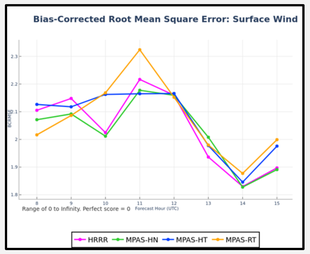
Data

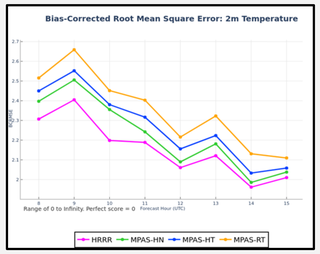
Model Run	Initial Conditions (ICs)	Micro-physics	Dynamic Core	Initialization Time (UTC)	Forecast Hours
HRRR	RAP/RR	Thompson	WRF	Every hour	36 hours
NSSL-MPAS-HN	HRRR	NSSL	MPAS	00 and 12	48 hours
NSSL-MPAS-HT	HRRR	Thompson	MPAS	00 and 12	48 hours
NSSL-MPAS-RT	RRFS	Thompson	MPAS	00 and 12	60 hours

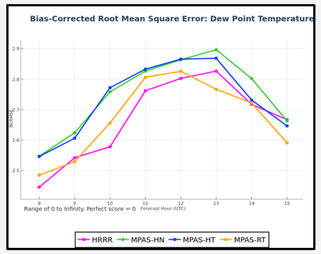
Methods

- Qualitative analysis focusing on four different variables: reflectivity, dew point temperature, surface gusts, and surface temperature.
- Forecast hours 08 - 15 from 12z initiation (3 - 9PM CST) on 5/16-5/17.
- Quantitative analysis via METplus & visualized via METviewer 5.1.0.
- Main statistical tests included Frequency Bias (FBIAS) and Bias-Corrected Root Mean Square Error (BCRMSE).

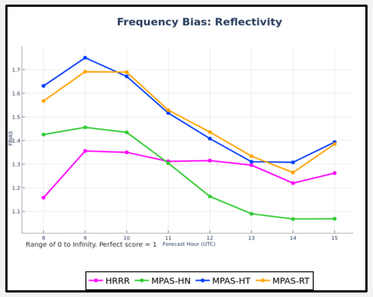
Houston Derecho Analysis Results

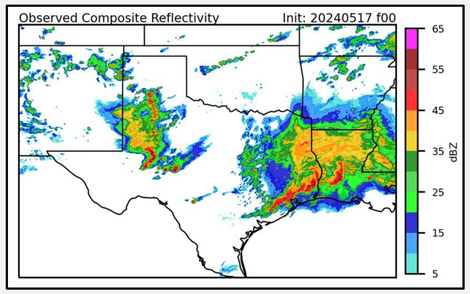




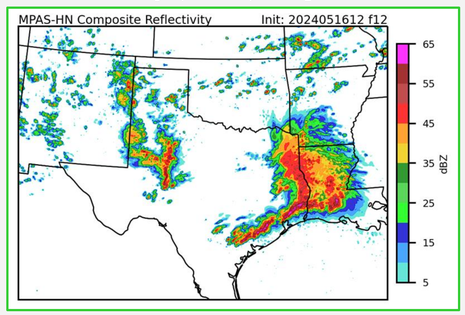


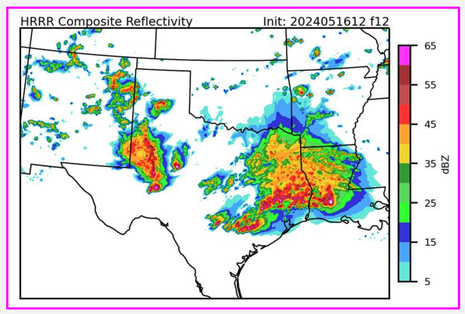
For near-surface wind, temperature and dew point, none of the four models matched the observed Houston Derecho data particularly well. Although, there are a few instances of variance (e.g. surface wind, left) and some models did relatively better than others (e.g. HRRR in surface temp, center), all models followed a similar pattern for these variables.

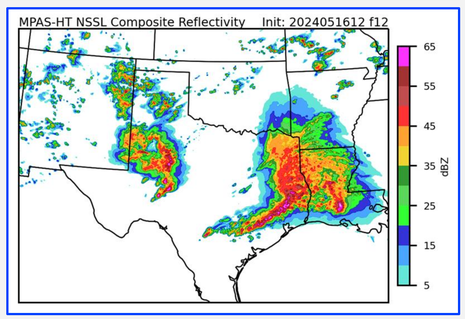


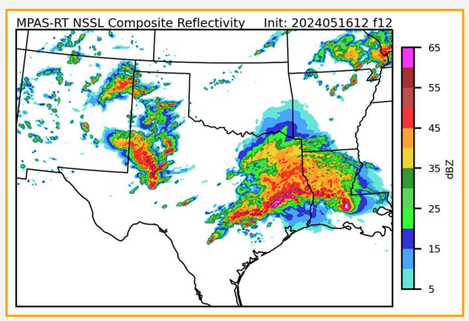


Model solutions for composite reflectivity displayed more variation at the beginning of the integration period with all lead times having a high FBIAS. MRMS (right) for 00 UTC on 17 May and corresponding model forecasts for 12-h forecasts initialized at 12 UTC on 16 May (below) are provided for comparison.









MPAS-HN (top left) closely resembles the observed in timing and structure. HRRR (top right) gets close to correct timing but misses on structure. Both MPAS-HT (bottom left) and MPAS-RT (bottom right) both hit on structure but miss on timing.

Conclusion

This case study has revealed that the MPAS configurations did nearly as well, if not better, than the HRRR. More specifically:
- the MPAS dynamic core was on par with the HRRR.
- RRFS ICs appear on par with HRRR ICs, sometimes even better.
- MPAS in a future version of the RRFS will likely be beneficial

Based off the results, forecasting for three of the four variables (surface winds, surface temperature and dew point temperature) has room for improvement. On the other hand, reflectivity was tracked relatively well, but models lagged in time and structure.

The biggest takeaway is that the models forecasted the Houston Derecho similarly to one another, which is promising for the development of the MPAS & for eventual implementation.

Implications & Next Steps

- With plans of implementing the MPAS configuration into operations, the results found will aid in ensuring it is ready.
- Because the results found that for the Houston Derecho, the MPAS dynamic core with RAP/HRRR physics was on par with the HRRR and RRFS and RRFS ICs were on par with HRRR ICs, this is useful in future development and experimentation.

Next steps include:
- Conduct further evaluation of quantitative verification for the derecho case, such as looking at precipitation data
- Examining longer timescales to evaluate day 2 performance
- Examining results between models of different parameterizations to further compare other ICs, microphysics and dynamic cores.
- Completion of DTCs part of the SFE

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