A Local Verification Study of Convective Allowing Model Performance During Convective Events in Eastern New York and Western New England

Part II: Environmental Breakdown

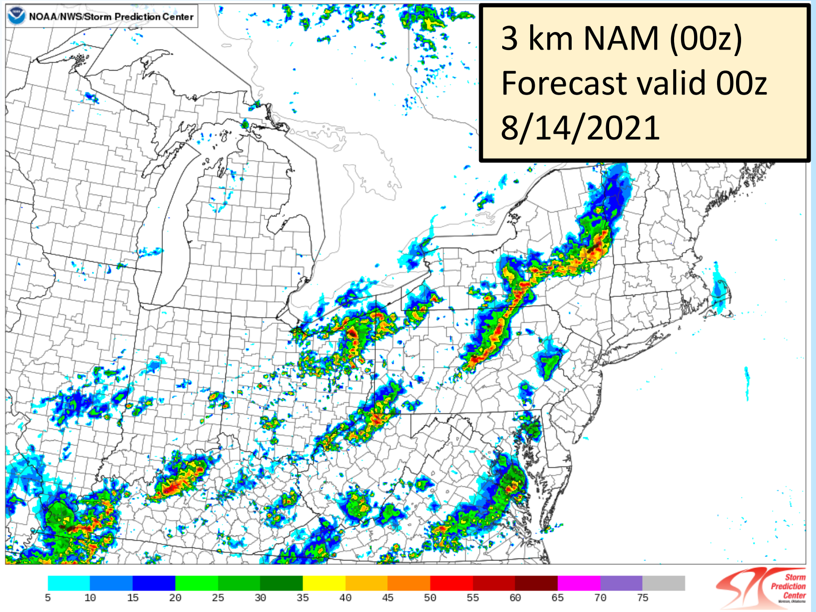
Michael Main and Michael Evans

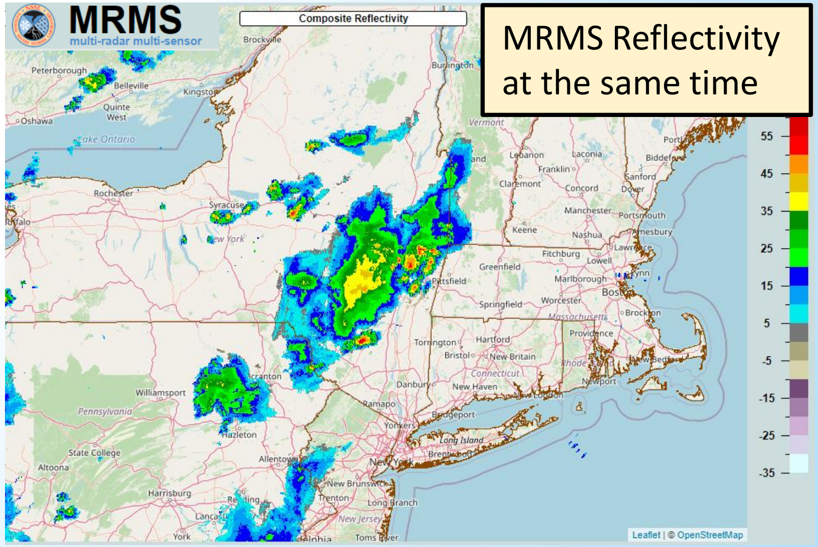
NOAA/NWS Weather Forecast Office, Albany, NY

Motivation (1/2)

- Part I of this study examined the performance of the HRRR and 3 km NAM in forecasting the coverage, timing, and evolution of convection.

- Results showed that:
    - Coverage was overdone for non-severe cases and underdone for severe cases.
    - Both models had a slow bias, especially for severe events.
    - Neither model was superior to the other.
    - There was little improvement from the 00z to 12z model runs for severe cases.

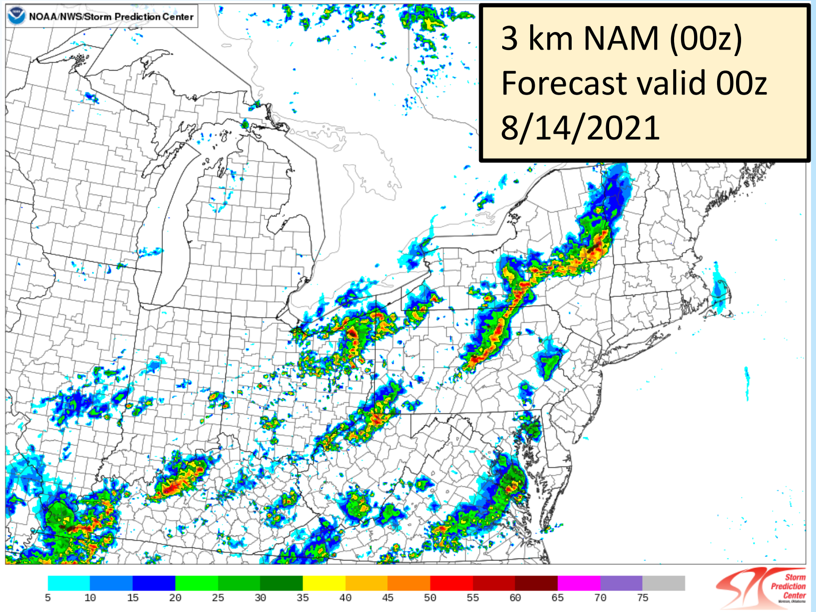


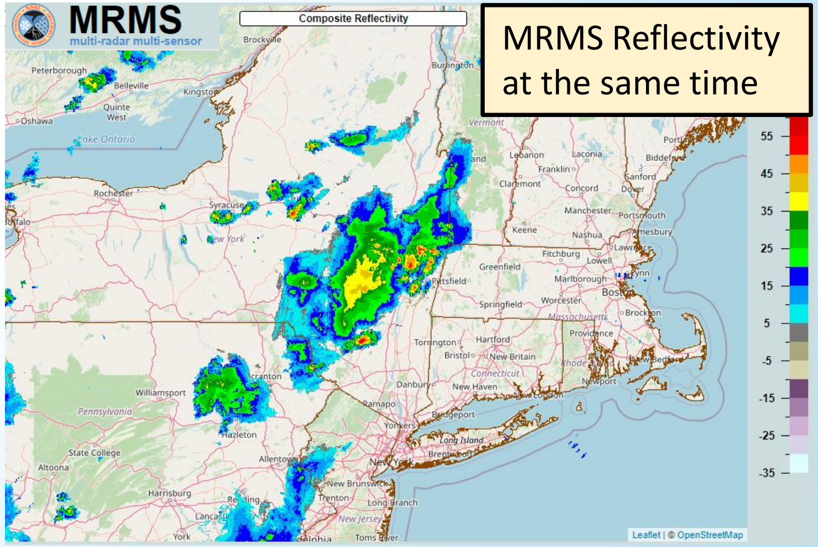


Motivation (2/2)

- These results are for all convective environments.

- Do the results change for certain types of environments?

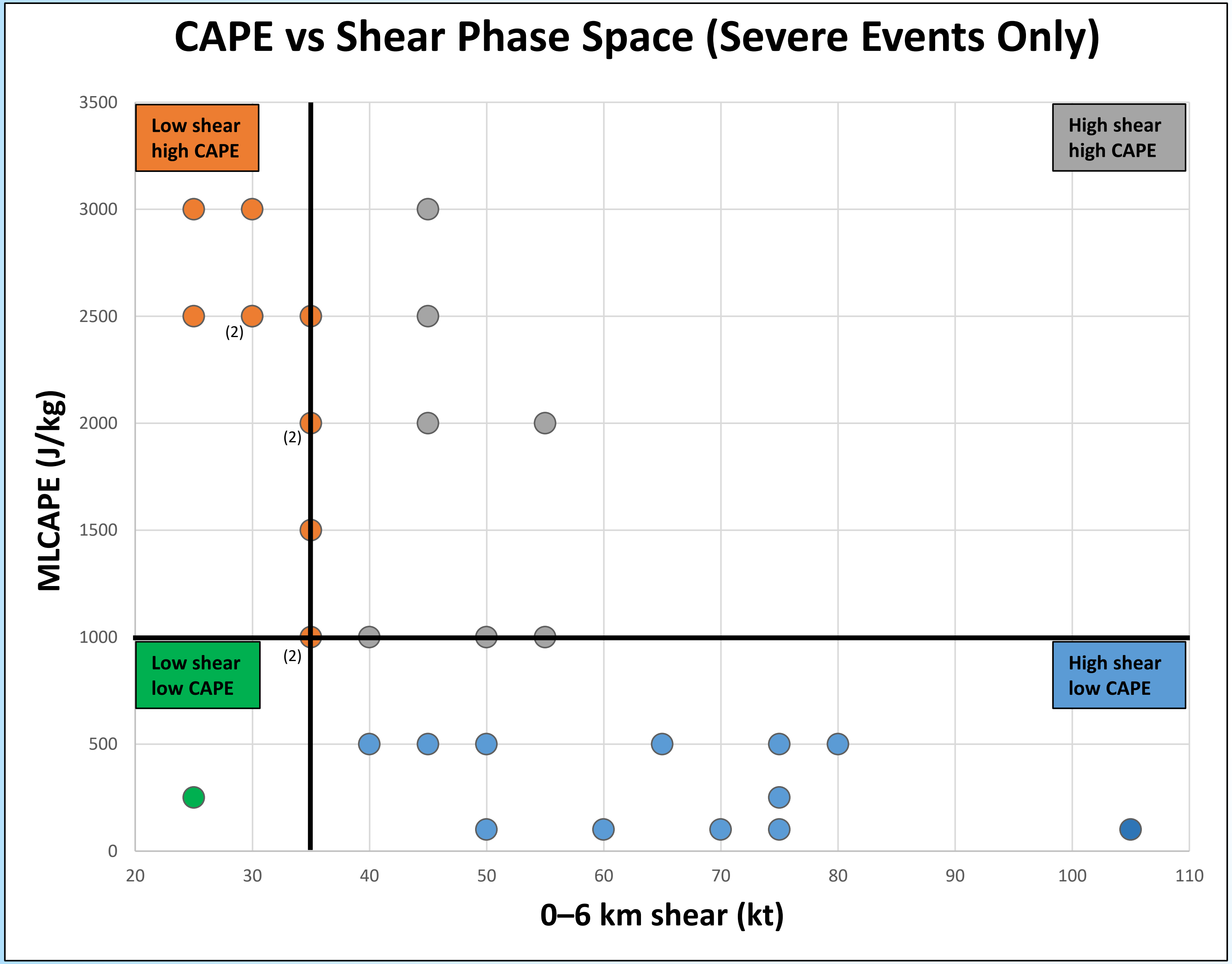




Methodology (1/3)

- The same 32 severe events and corresponding forecaster evaluations from Part I were used here. Null events were not included.
- For each event, the maximum MLCAPE and 0–6-km shear values were recorded from the SPC mesoanalysis archive.
- Convective environments were broken down into 4 categories:
  - High shear high CAPE (HSHC)
  - High shear low CAPE (HSLC)
  - Low shear high CAPE (LSHC)
  - Low shear low CAPE (LSHC)
- Environments were classified using both the Sherburn et al. (2016) criteria and the Vaughan et al. (2017) criteria.

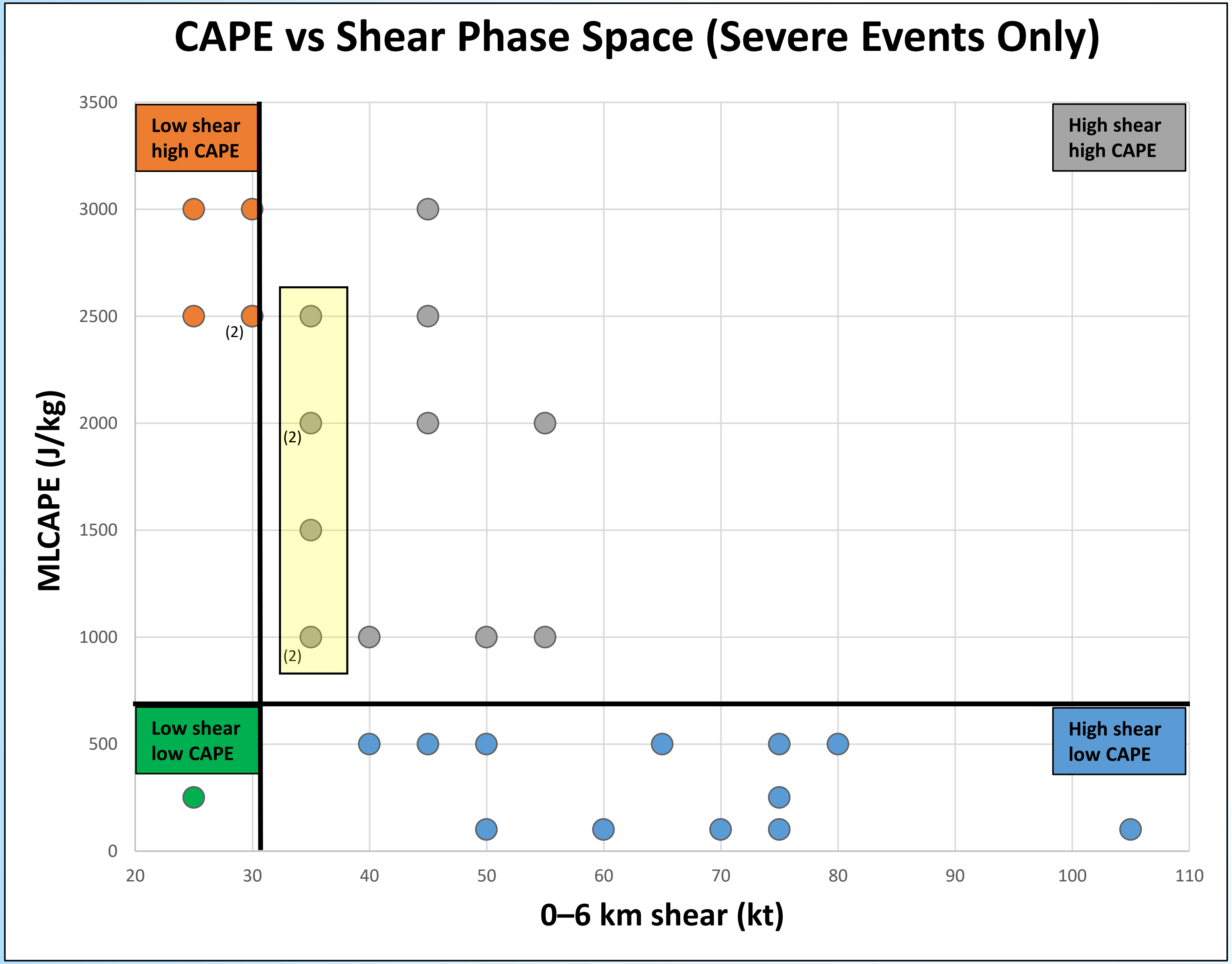
Methodology (2/3)



Sherburn et al. Criteria

Category	High shear low CAPE	High shear high CAPE	Low shear high CAPE	Low shear low CAPE
# of Events	12	7	11	1
Cape Limit (J/kg)	< 1000	≥ 1000	≥ 1000	< 1000
Shear Limit (kt)	> 35	> 35	≤ 35	≤ 35
Severe Reports	68	138	235	0
Flash Flood Reports	71	22	8	2

Methodology (3/3)

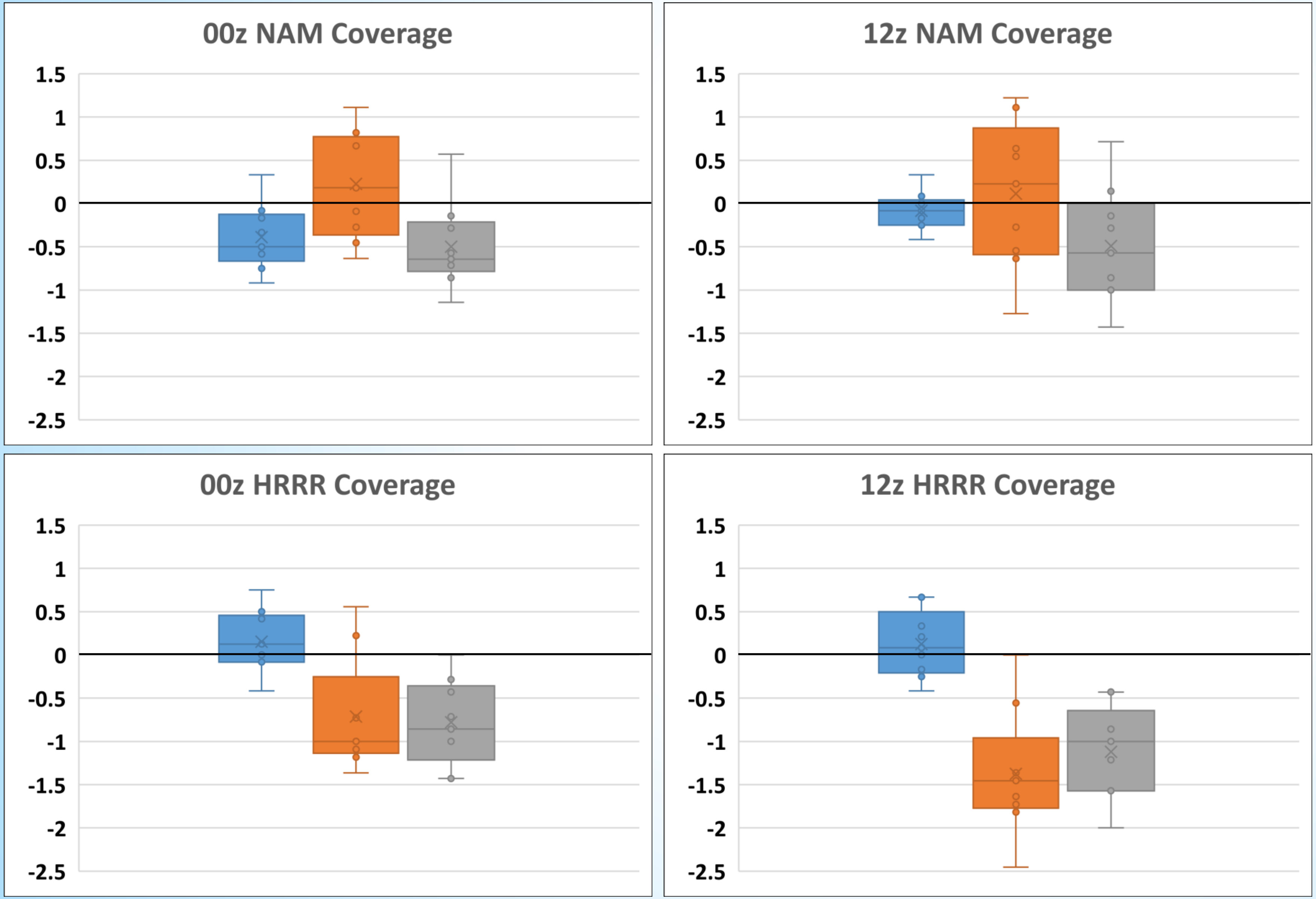


Vaughan et al. Criteria

Category	High shear low CAPE	High shear high CAPE	Low shear high CAPE	Low shear low CAPE
# of Events	12	13	5	1
Cape Limit (J/kg)	< 662	≥ 662	≥ 662	< 662
Shear Limit (kt)	> 31	> 31	≤ 31	≤ 31
Severe Reports	68	324	79	0
Flash Flood Reports	71	26	4	2

- **Changing the criteria shifts some cases from the LSHC category to HSHC**

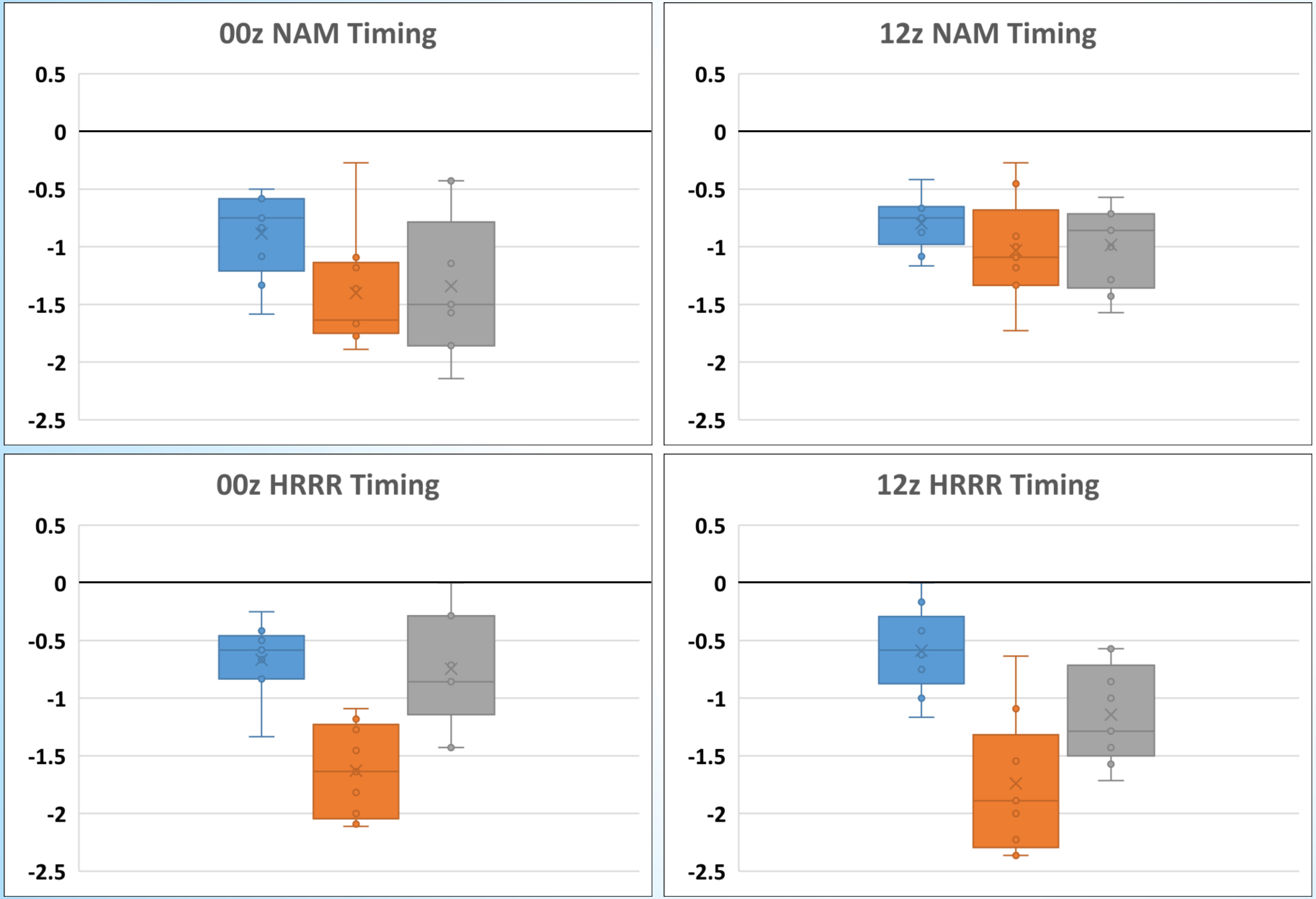
Results: Coverage (Sherburn et al. Criteria)



- NAM Coverage shows a small high bias for LSHC events
- HRRR Coverage is too low for LSHC and HSHC events
- NAM coverage overall is better than the HRRR
- There is little improvement in coverage from the 00z to 12z runs, especially with the HRRR

Legend
- High Shear Low CAPE
- Low Shear High CAPE
- High Shear High CAPE

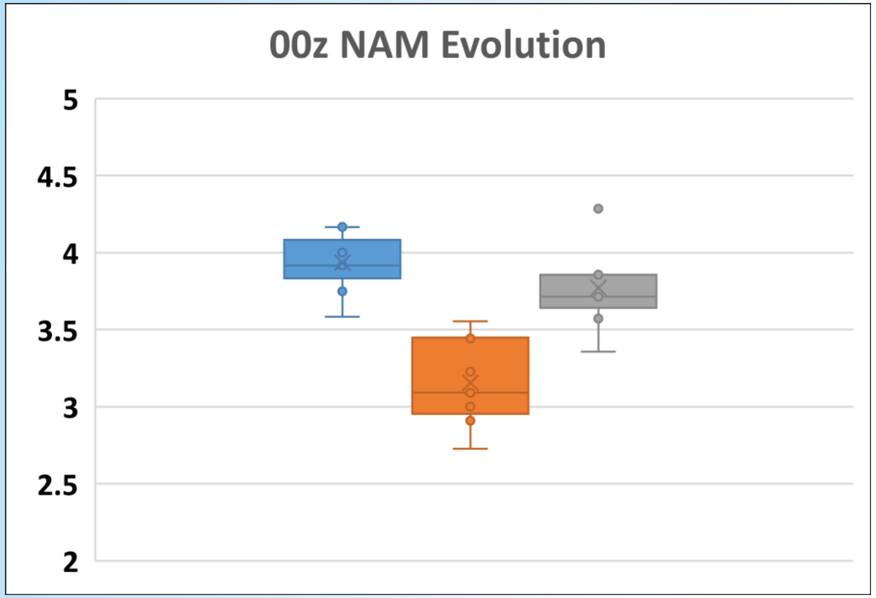
Results: Timing (Sherburn et al. Criteria)

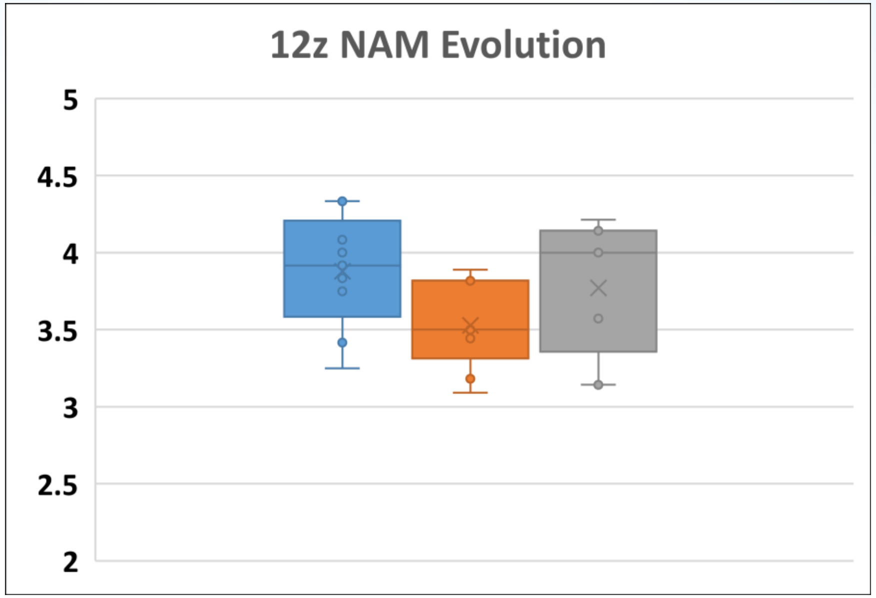


- CAMs are too slow with timing across all environments
- The HRRR slow bias is worse for LSHC events
- The NAM shows improvement from 00z to 12z while the HRRR does not
- High shear low CAPE events have the smallest slow bias for both models

Legend
- High Shear Low CAPE
- Low Shear High CAPE
- High Shear High CAPE

Results: Evolution (Sherburn et al. Criteria)



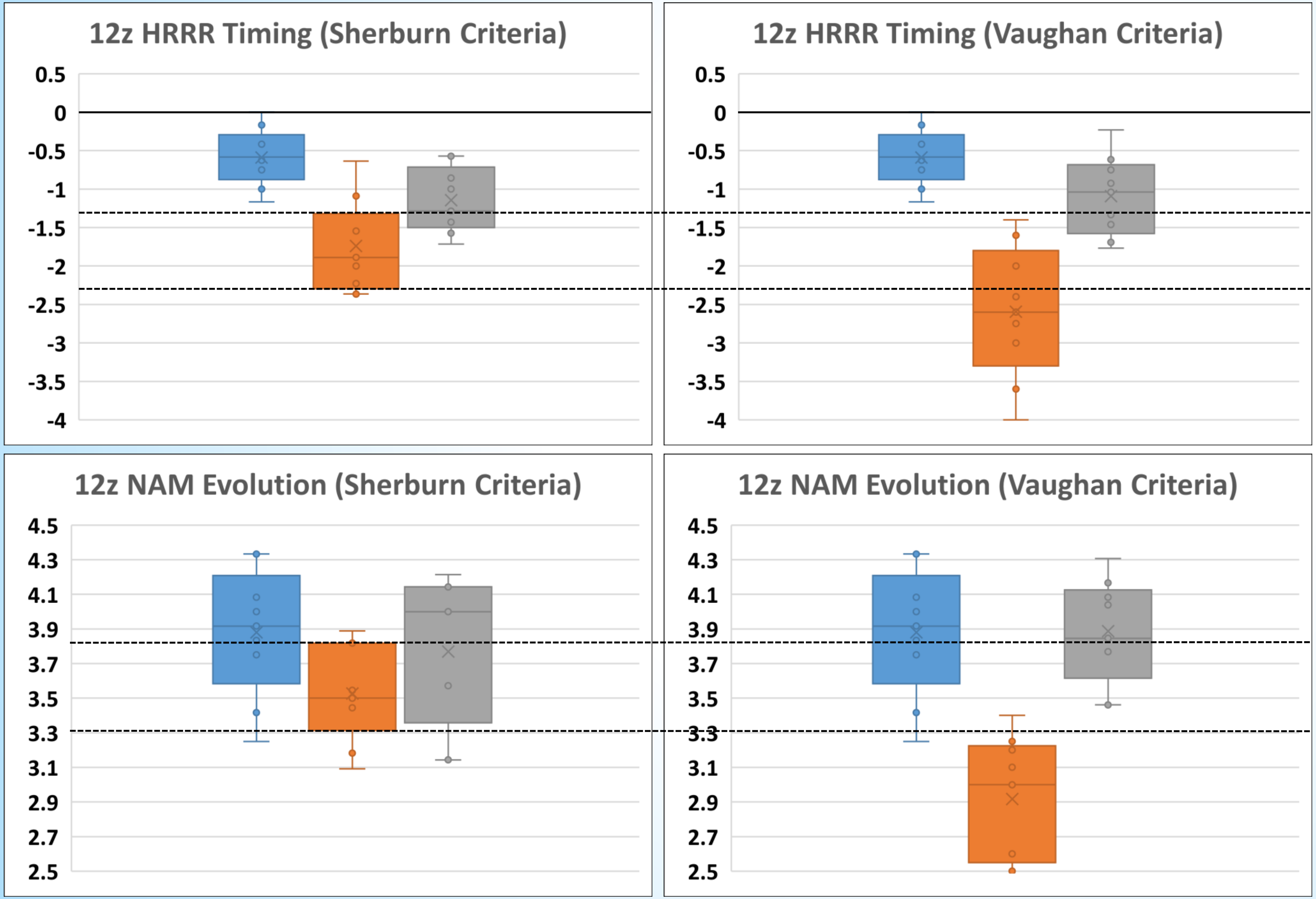


- **HSLC events received the highest evolution scores for both models**
- **LSHC events have the lowest evolution scores for both models**
- **The NAM shows improvement from 00z to 12z for LSHC cases while the HRRR actually performs worse at 12z vs 00z**

Legend

- High Shear Low CAPE
- Low Shear High CAPE
- High Shear High CAPE

Results: Sherburn vs Vaughan Criteria



- Changing criteria separated out the lowest shear events
- Changing the thresholds used to differentiate convective environments did not change the model biases noted above
- However, it did highlight these model biases
- This was true of both models

Legend
- High Shear Low CAPE
- Low Shear High CAPE
- High Shear High CAPE

Methodology: Forcing Strength

Category	Strongly Forced	Moderate Forcing	Weakly Forced
# of Events	7	11	14
500 mb Height Falls (m in 12 hr)	≥ 50	< 50 and > 0	≤ 0
Average CAPE (J/kg)	365	1560	1560
Average 0–6 km bulk shear	74	42	40
Severe Reports	56	268	137
Flash Flood Reports	0	69	34

- Same 32 severe events included
- Does not account for low-level forcing (i.e. cold fronts, convergence boundaries…)
- Strongly forced events are all of the HSLC variety
- Very similar environments for moderate and weak forcing
- Moderately forced events have the greatest number of reports per event

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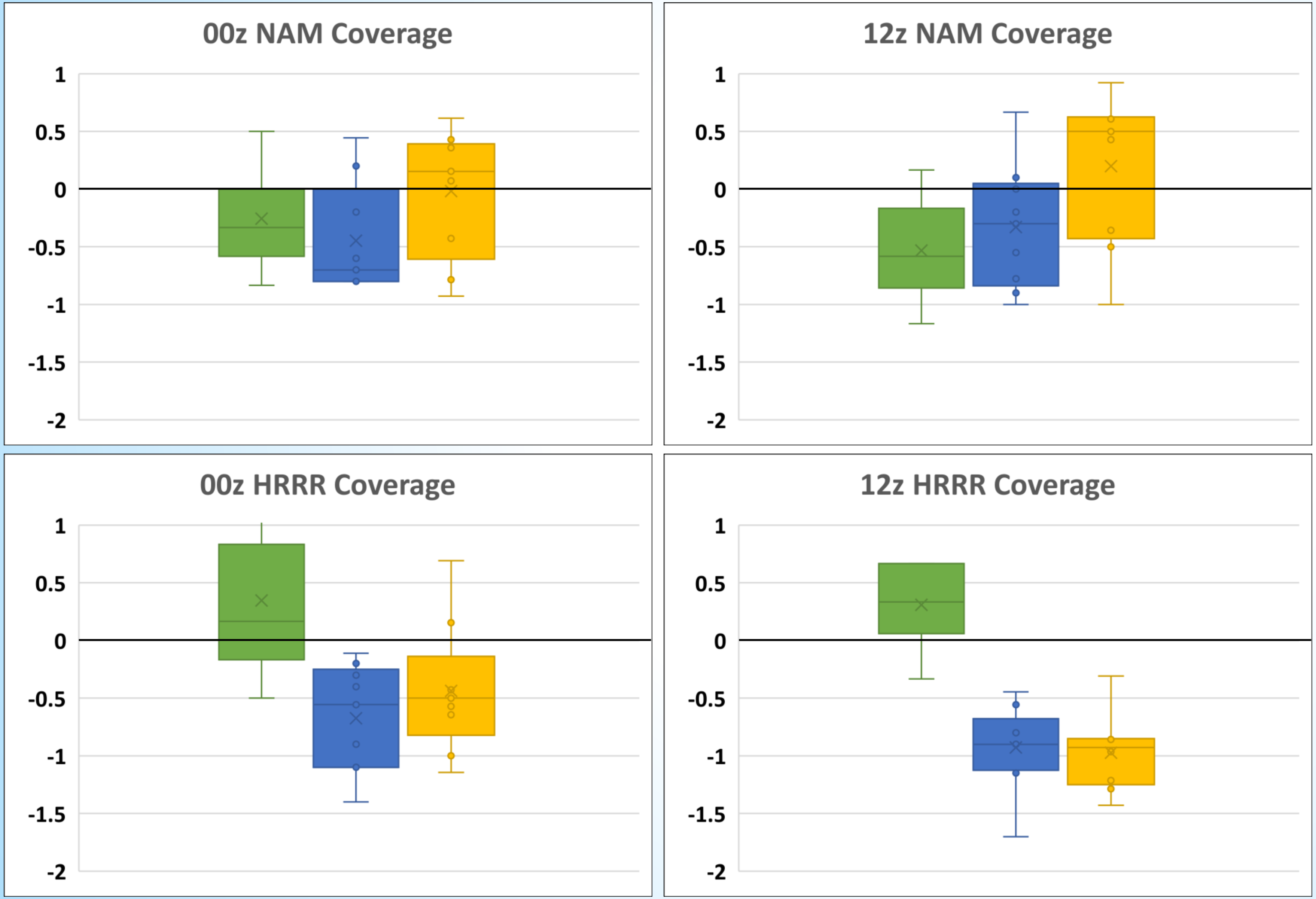
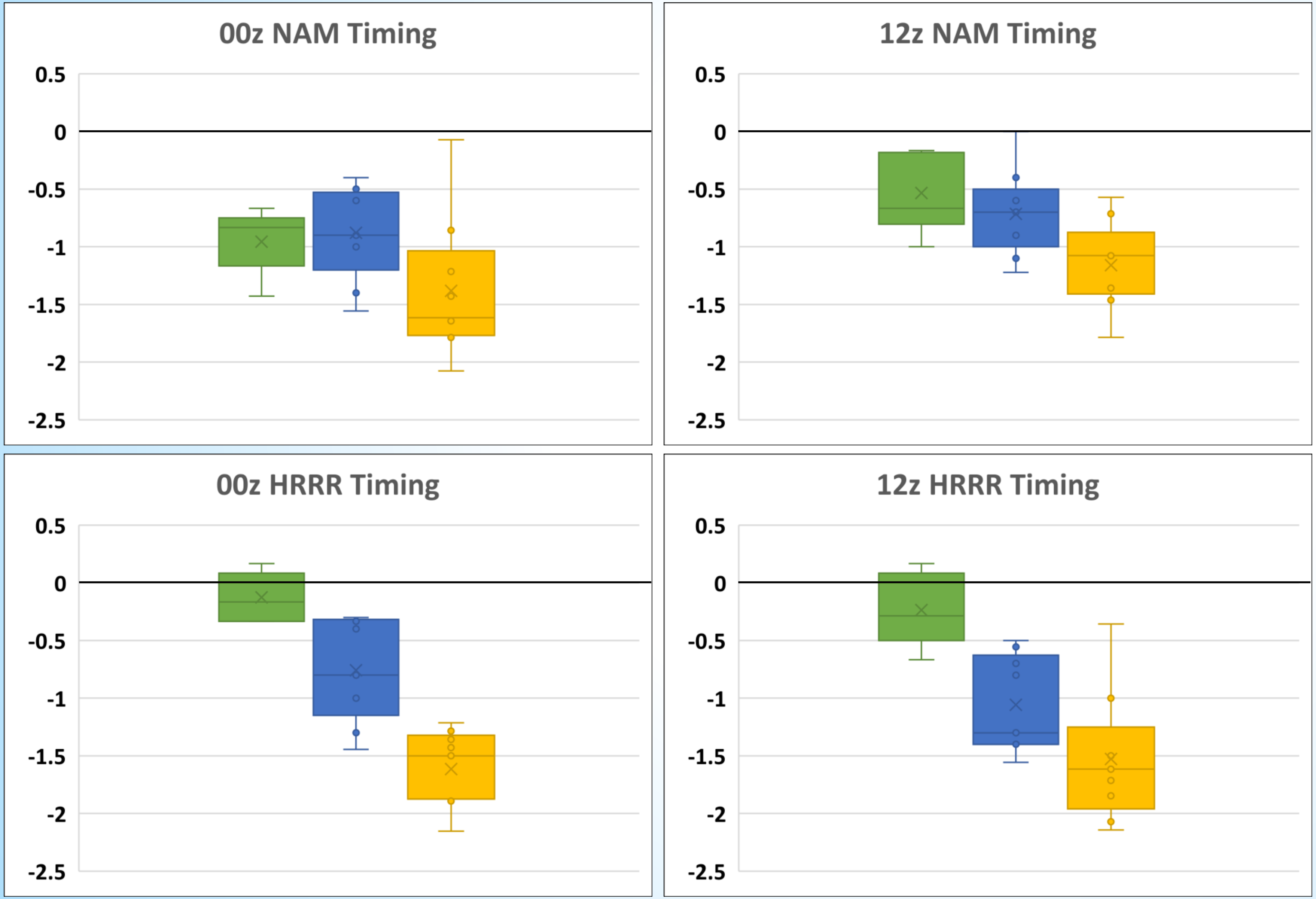
Results: Coverage (Forcing Magnitude Criteria)



- The NAM has a low bias for strong and moderate forcing but a high bias for weak forcing
- The HRRR over forecasts coverage for strongly forced events
- The HRRR under forecasts coverage for moderate and weak forcing, and is worse at 12z vs 00z

Legend
- Strongly Forced
- Moderately Forced
- Weakly Forced

Results: Timing (Forcing Magnitude Criteria)

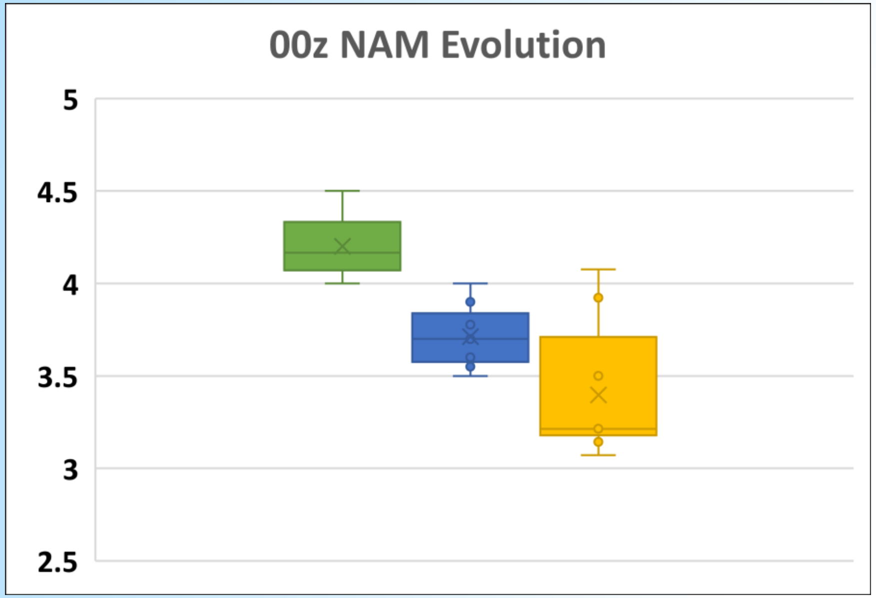


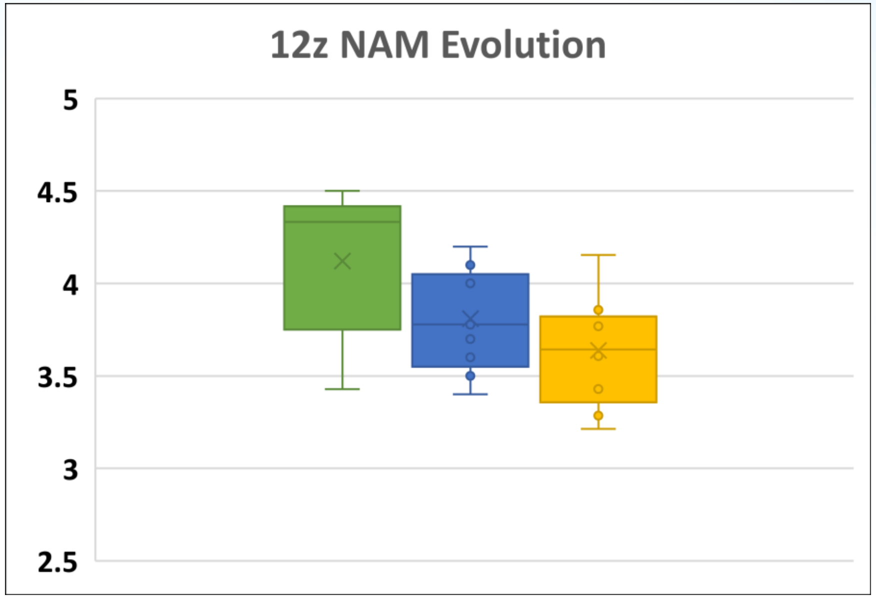
- CAMs are too slow for all events with timing
- The slow bias increases as forcing strength decreases
- HRRR timing is better for strongly forced events and worse for weakly forced events compared to the NAM
- The NAM improved from 00z to 12z but the HRRR did not

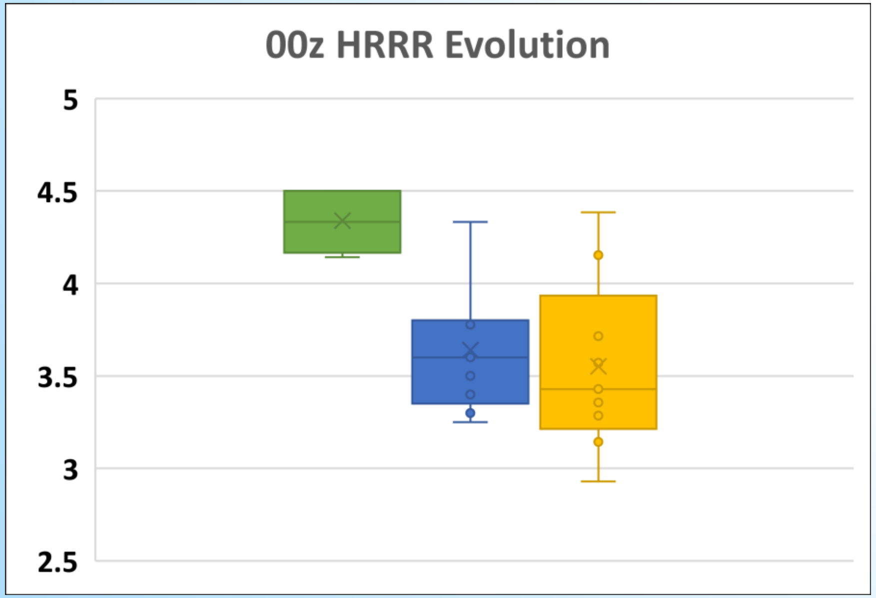
Legend

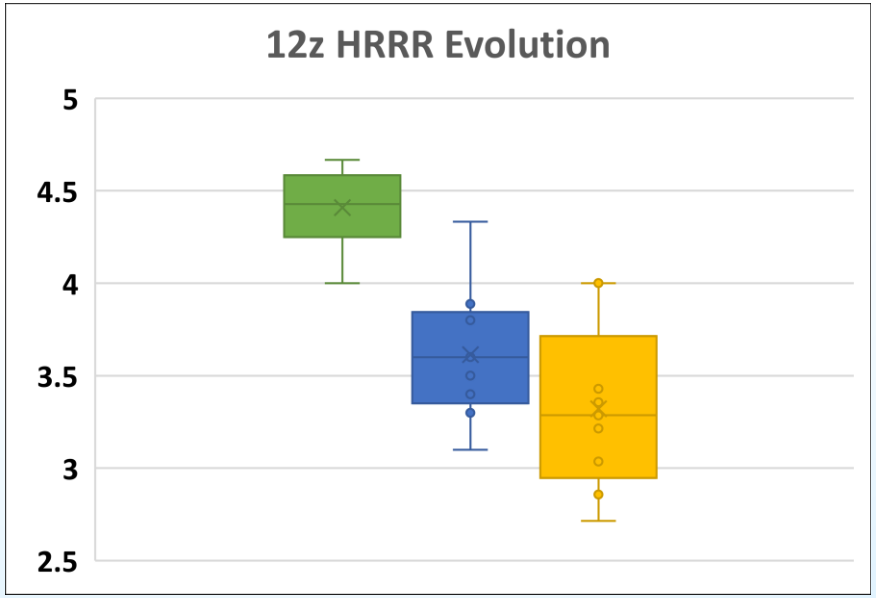
- Strongly Forced
- Moderately Forced
- Weakly Forced

Results: Evolution (Forcing Magnitude Criteria)









- **Evolution scores decrease for moderate and weakly forced events for both models**
- **The NAM scored better than the HRRR for moderately forced events while the HRRR scored better for strong forcing**
- **The HRRR showed slight improvement from 00z to 12z for strong forcing only**

Legend
- **Strongly Forced**
- **Moderately Forced**
- **Weakly Forced**

Conclusions

- The slow bias in both the HRRR and 3 km NAM is evident for all convective environments, but is worse when shear and upper-level forcing area weaker.
- Model simulated convective coverage is overdone by the 3 km NAM and underdone by the HRRR in convective environments with weak shear and weak upper-level forcing.
- Model-simulated convective evolution received the highest scores in convective environments with high shear and strong upper-level forcing.
- Changing the criteria for the convective environment magnified the model biases but did not change the overall results.

Future Work

- Examine model biases in temperature, dew point, CAPE… to see if there is any correlation between biases in these fields and the biases noted here.
- Perform the breakdown by forecaster scores instead of by the type of convective environment
  - May give us thresholds where models can be trusted more
  - Identify physical features/processes that may cause models to struggle
- Expand the analysis to the non-severe cases
- Add additional cases to increase sample size

References and Acknowledgements

NCEI, 2022: Storm Events database. NOAA/National Centers for Environmental Information, https://www.ncdc.noaa.gov/stormevents/.

Sherburn, K. D., M. D. Parker, J. R. King, and G. M. Lackmann, 2016: Composite environments of severe and nonsevere high-shear, low-CAPE convective events. *Wea. Forecasting*, **31**, 1899–1927, https://doi.org/10.1175/WAF-D-16-0086.1.

Vaughan, M. T., Tang, B. H. & Bosart, L. F. Climatology and analysis of high-impact, low predictive skill severe weather events in the northeast United States. *Wea. Forecast*. **32**, 1903–1919 (2017).

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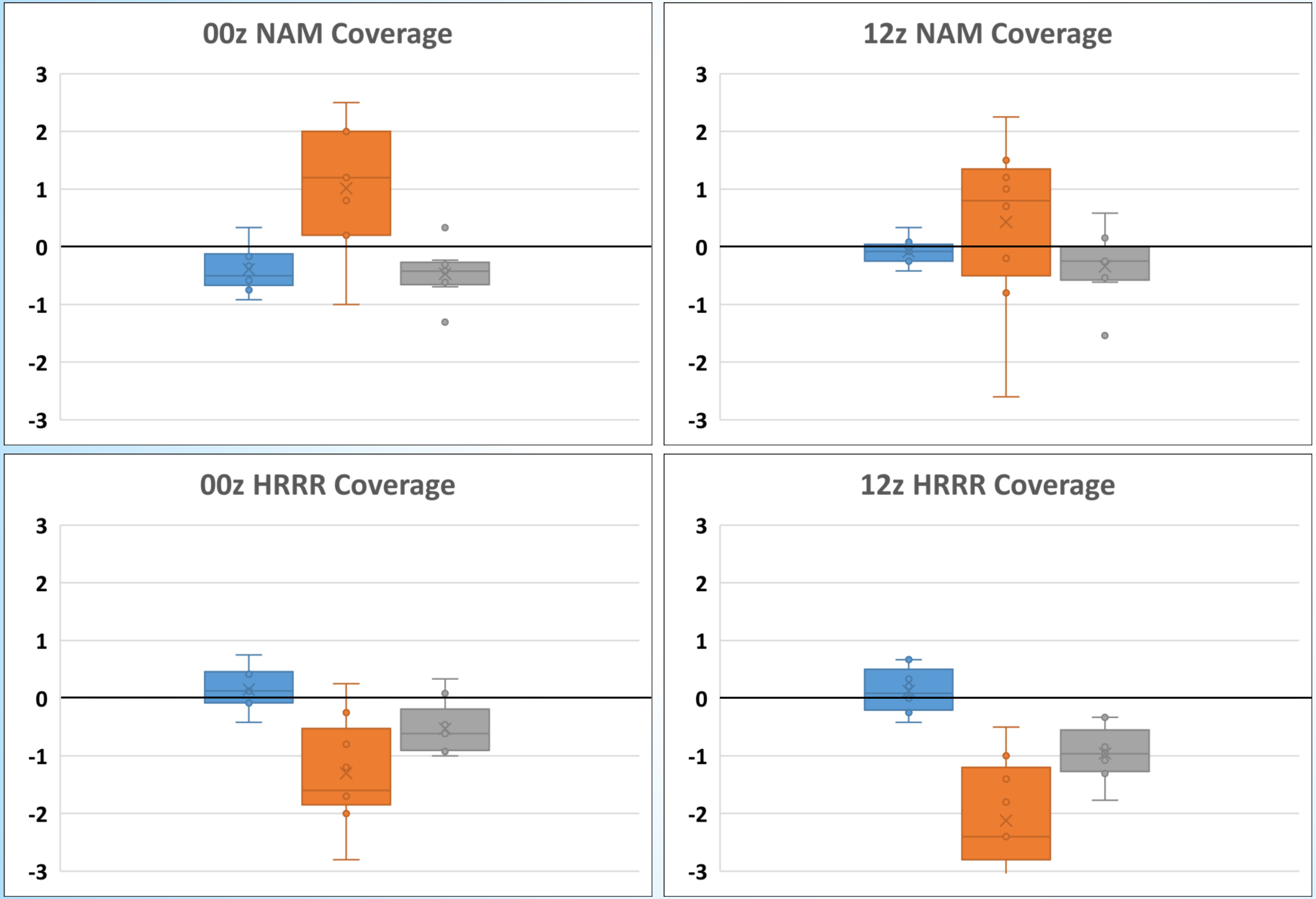
Supplemental Slides

Results: Coverage (Vaughan et al. Criteria)

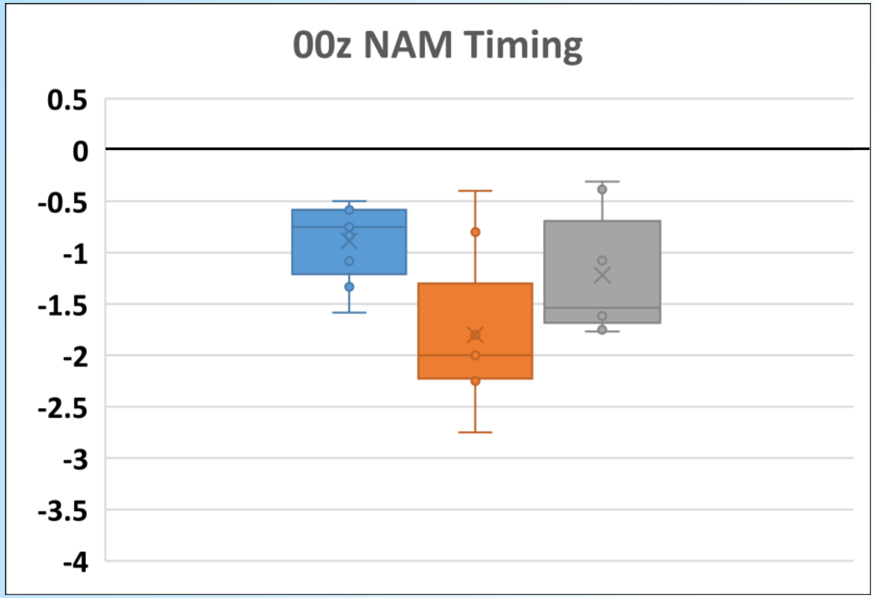


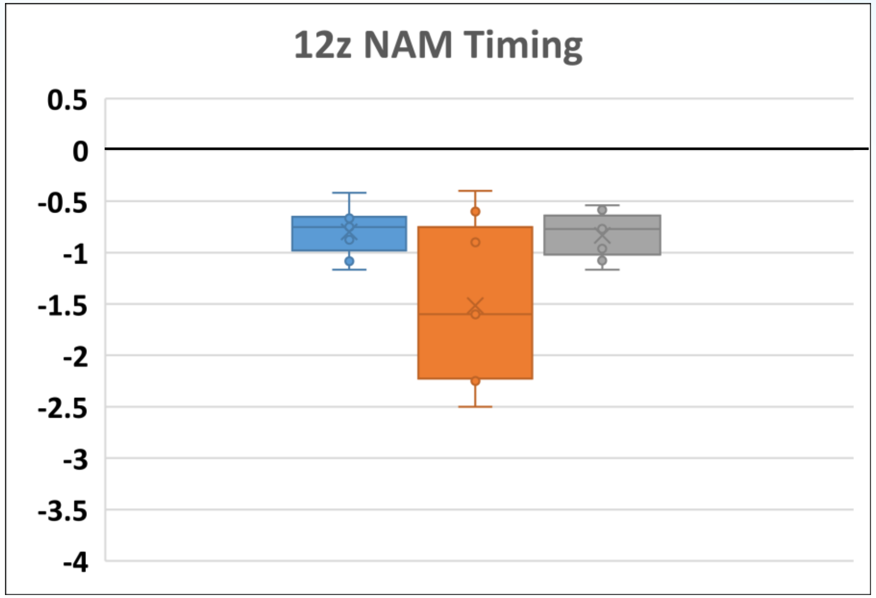
- HRRR Coverage is too low for LSHC events while the NAM is too high
- The HRRR does better with HSLC events vs HSHC while the NAM is similar for both types
- The NAM shows more improvement from 00z to 12z than the HRRR

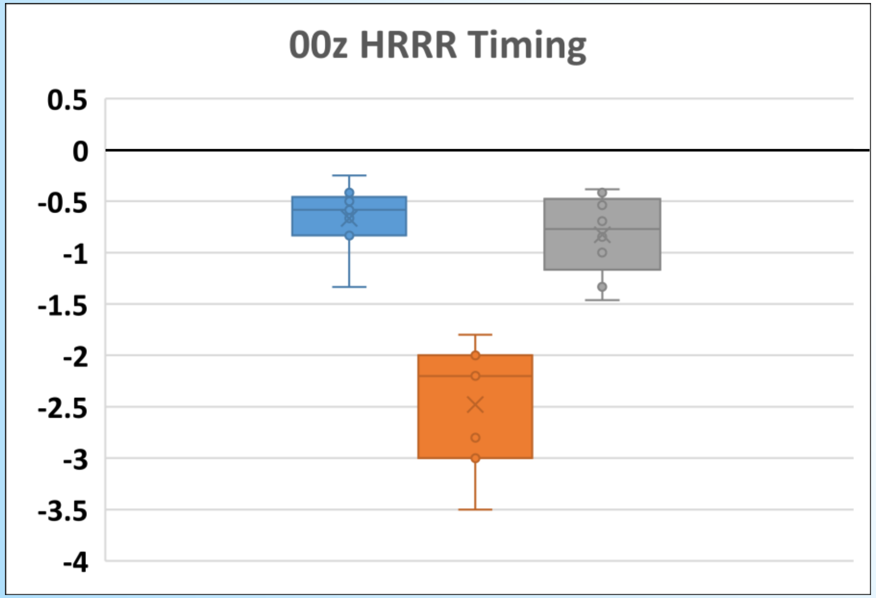
Legend

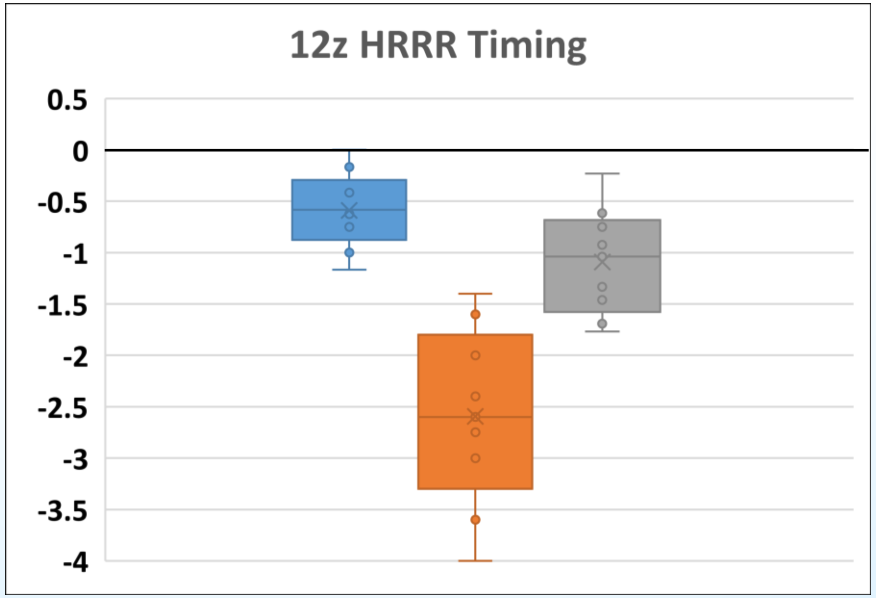
- High Shear Low CAPE
- Low Shear High CAPE
- High Shear High CAPE

Results: Timing (Vaughan et al. Criteria)







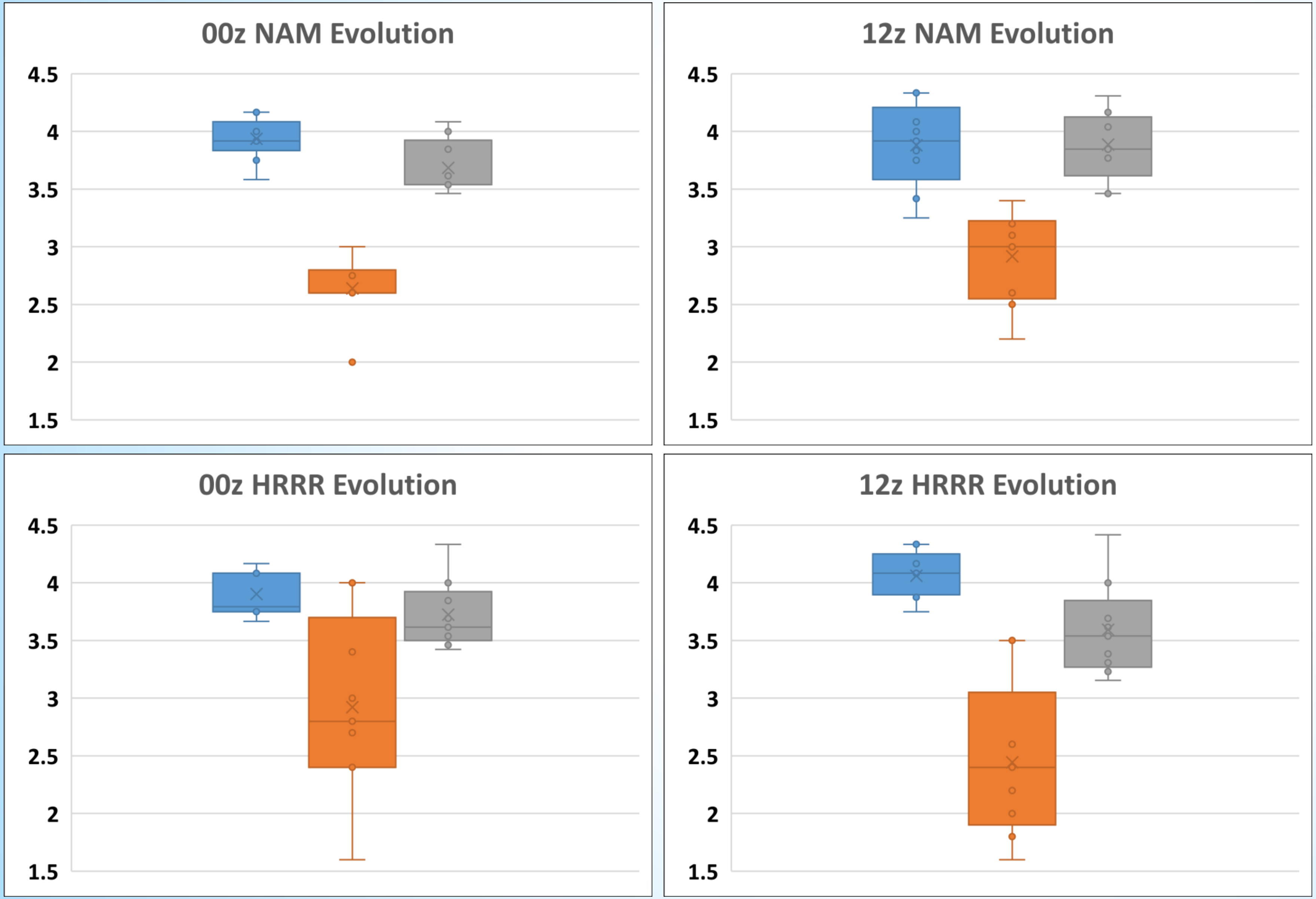


- CAMs are too slow across the board with timing
- Slow bias is worse for LSHC events.
- Slow bias is worse in the HRRR compared to the NAM
- The NAM improved from 00z to 12z for HSHC events but the HRRR was worse at 12z

Legend

- High Shear Low CAPE
- Low Shear High CAPE
- High Shear High CAPE

Results: Evolution (Vaughan et al. Criteria)



- HSLC events scored the highest evolution for both CAMS
- LSHC events have the worst evolution for both models
- From 00z to 12z, the HRRR evolution of HSLC events improved, but it decreased for LSHC and HSHC events.
- There was little change in the NAM from 00z to 12z.

Legend

- High Shear Low CAPE
- Low Shear High CAPE
- High Shear High CAPE