16B.6 VERIFICATION OF CONVECTIVE ENVIRONMENT FORECASTS FROM THE NAM PARENT AND CONUS NEST WITHIN SPC OUTLOOK AREAS

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1. INTRODUCTION

High resolution convection-allowing models (CAMs), which have the ability to generate explicit storms, are primarily used for identifying specific storm attributes via diagnostic output, such as simulated radar reflectivity and updraft helicity (Done et al. 2004; Weisman et al. 2008; Kain et al. 2008). While CAMs generate explicit storm structures, knowledge of the ambient near-storm environment remains an important aspect of understanding the potential severe weather hazard type. Storm Prediction Center (SPC) forecasters have a long history of examining aspects of the pre-convective and near-storm environment from relatively coarse numerical weather prediction (NWP) models which utilize convective parameterization schemes. However, as the usage of CAMs becomes more ubiquitous, it is important to consider their skill and characteristics in depicting the pre-convective and near-storm environments as well. In CAMs, instability and shear fields can be highly detailed and strongly modulated in-and-around explicitly modeled storms, potentially making a traditional diagnostic assessment of the near-storm environment more difficult.

In order to assess differences in representations of environmental fields between a convection-parameterizing and convection-allowing model, this study will examine forecasts of convective instability fields from the operational NAM parent (12-km grid spacing) in comparison to the NAM CONUS Nest (3-km grid spacing). Forecasts will be examined both on a traditional CONUS-wide scale, as well as on a regional scale with severe weather potential, which would be more meaningful to a SPC forecaster. The following section will describe the methodology used in this study for verification, including the use of SPC Convective Outlooks in masking the verification region. Section 3 will detail the overall verification results while providing an example to give additional context to the verification statistics. Section 4 will examine the model representations of the pre-convective environment by providing verification stats and an example of 24-hour maximum CAPE fields. The final section will summarize the findings.

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2. METHODOLOGY

Forecasts from the 0000 UTC 12-km NAM Parent and 3-km NAM Nest were examined over the 2017 convective season from April to August, during which convective environment variables are examined by forecasters on a daily basis to assess severe convective potential. Root mean square error (RMSE) and bias verification statistics were produced over this period by verifying hourly surface-based CAPE (SBCAPE) forecasts from the two models against SPC surface objective analysis (SFCOA) fields (Bothwell et al. 2002; Coniglio 2012). The SFCOA is a 40-km gridded analysis product produced hourly at the SPC by combining analysis grids from the 40-km RAP with objective analysis applied to surface observations to generate a 3D mesoanalysis grid. In order to produce verification statistics, the NAM Parent and NAM Nest SBCAPE forecast fields were re-gridded to the SFCOA 40-km grid using a nearest-neighbor technique. Traditionally, SPC forecasters are accustomed to viewing environmental information at this 40-km scale.

Verification statistics were produced both on a CONUS-wide scale, as well as over areas masked by slight risk areas from the daily SPC 0600 UTC Day 1 Outlook. These slight risk mask areas were produced by utilizing gridded outlooks available at SPC to mask the model and observation fields, allowing verification statistics to be calculated only over grid points contained in the slight risk area.

An example of the results of this procedure is shown in Fig. 1. Fig. 1a shows the unmasked 21-hour SBCAPE forecast from the Parent NAM valid 2100 UTC 18 May 2017. Fig. 1b shows the corresponding SPC 0600 UTC Day 1 outlook from 18 May 2017. Two slight risk areas were issued for this day, one in the Great Lakes area from Indiana to New York, and one in the central and southern plains from southern Nebraska to Texas. Finally,

Fig. 1c shows the same SBCAPE forecast from Fig. 1a, but masked by the two slight risk areas as shown in the outlook.

This masking technique allows for an examination of differences when verifying environmental forecast variables over different verification areas. Additionally, producing verification statistics over SPC slight risk areas may provide more meaningful information to SPC forecasters.

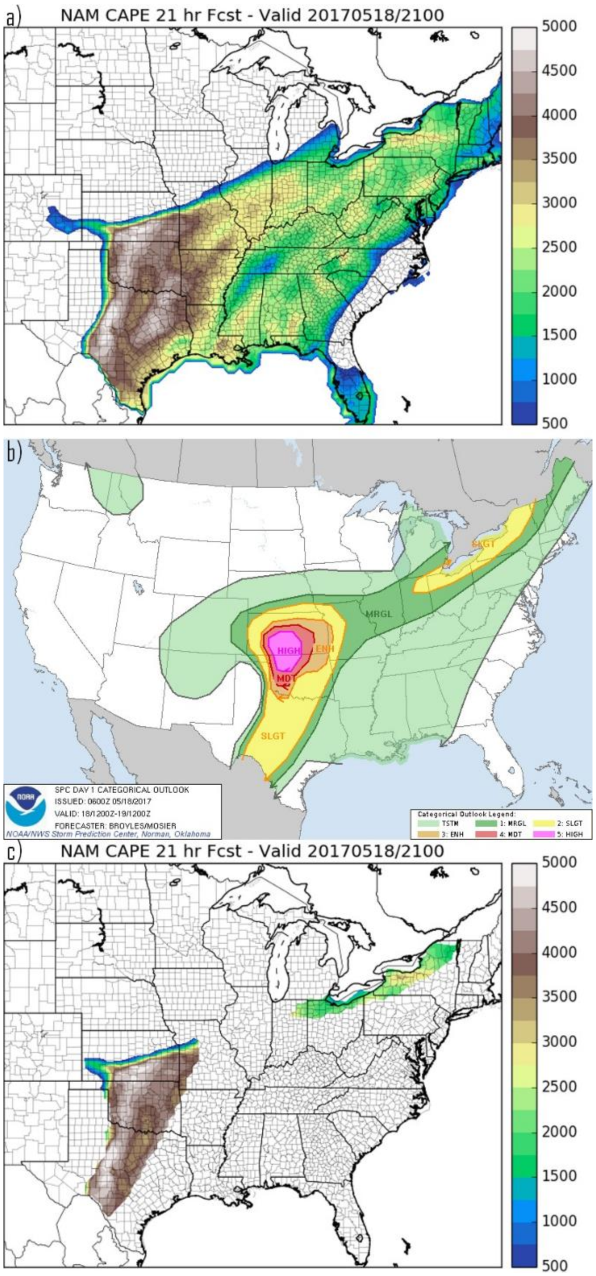

Figure 1. a) NAM Parent 21-hour CONUS-wide SBCAPE forecast valid 2100 UTC 18 May 2017. b) 18 May 2017 SPC 0600 UTC Day 1 Convective Outlook. c) NAM Parent 21-hour slight-risk masked SBCAPE forecast valid 2100 UTC 18 May 2017.

3. RESULTS

Forecasts of SBCAPE from the 0000 UTC NAM Parent and NAM CONUS Nest were verified hourly from forecast hour 12 through forecast hour 36 (i.e., valid over the convective day: 1200-1200 UTC). The verification days were limited to those in which a slight risk area was present in the 0600 UTC SPC Day 1 categorical convective outlook, resulting in 85 days from April 2017 through August 2017 in which verification statistics were generated.

When performing verification over the entire CONUS, the NAM Parent and NAM Nest SBCAPE error statistics are very similar, as shown in Fig. 2. In terms of RMSE (Fig. 2a), both look very similar and peak during the afternoon and evening. In terms of bias (Fig. 2b), both show a slight low bias during the afternoon and a slight high bias during the overnight, though the NAM Nest is slightly lower overall compared to the NAM Parent.

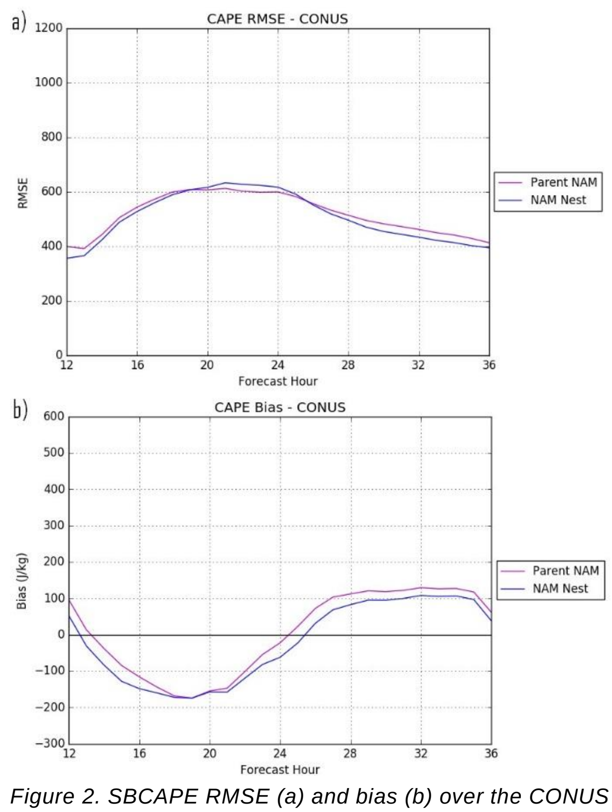

Figure 2. SBCAPE RMSE (a) and bias (b) over the CONUS for the NAM Parent (magenta) and the NAM Nest (blue) for 85 days from April-August 2017.

Larger differences in performance can be noted when calculating verification statistics over areas masked by daily SPC slight risks, as shown in Fig. 3. For SBCAPE RMSE (Fig. 3a), the NAM Parent and NAM Nest perform similarly through forecast hour 24 (i.e., 0000 UTC), while the NAM

Nest begins performing slightly better after forecast hour 24, during the late evening. In terms of bias, a rapidly increasing positive bias is evident in the NAM Parent during the afternoon and evening hours, peaking around forecast hour 27 (i.e., 0300 UTC). The NAM Nest, meanwhile is much more neutral biased during the same timeframe, indicating that its forecasts of the convective environment may be much more dependent on the placement and evolution of convection within the model.

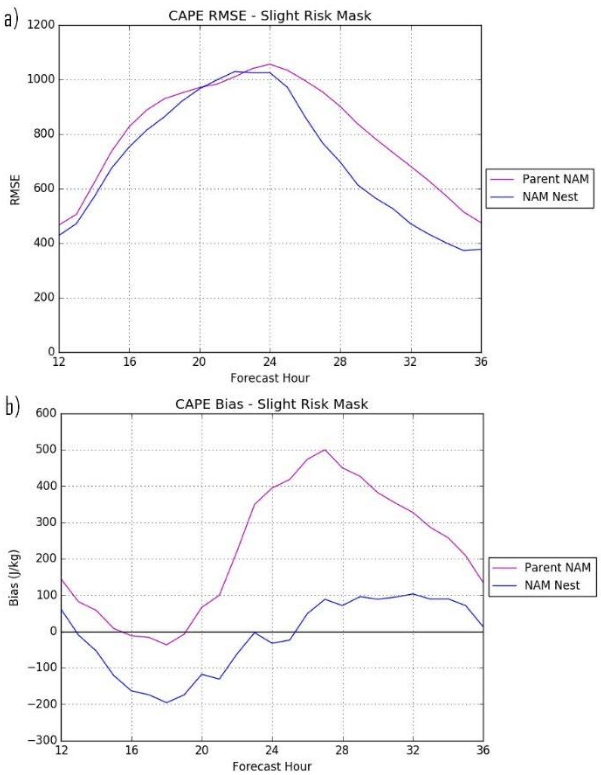

Figure 3. Same as Fig. 2, except for slight risk areas.

An example from 16 May 2017 (Fig. 4) shows how the explicit handling of convection within the NAM Nest affects its environmental fields, potentially allowing it to perform better than the NAM Parent after convective initiation occurs. At 2100 UTC, both models had a relatively good handle on the instability in the pre-convective environment, as shown in Fig. 4.

By 0300 UTC on the 17 May 2017 (Fig. 5), a large complex of convection had developed across eastern Nebraska and western Iowa, as depicted by the large minimum in in the SFCOA SBCAPE field over the area (Fig. 5c). The NAM Parent (Fig. 5a) failed to remove the SBCAPE from that convectively active area, and was also too high with SBCAPE values in non-convective areas of southeast Minnesota and the southern plains. This behavior in the NAM Parent is noted throughout the convective season, and contributes to its large positive bias seen in Fig. 3a during the late afternoon and evening.

While placement of convection in the NAM Nest across Nebraska and Iowa wasn't perfect, it does a much better job than the NAM Parent of removing SBCAPE in areas impacted by deep convection. A positive bias is still noted in the NAM Nest in non-convective areas, however.

This 16 May 2017 case exemplifies the behavior in errors seen during the late afternoon and evening after convective initiation from the NAM Parent and NAM Nest. The NAM Parent fails to remove instability from convectively active areas, while also maintaining too much instability in non-convective areas into the late evening, leading to a large systematic positive bias in instability. Meanwhile, the NAM Nest instability fields are more heavily modulated by explicit convection in the model. Its errors tend to be less systematic and more dependent on how accurately it handles the placement and evolution of convection through the afternoon and evening.

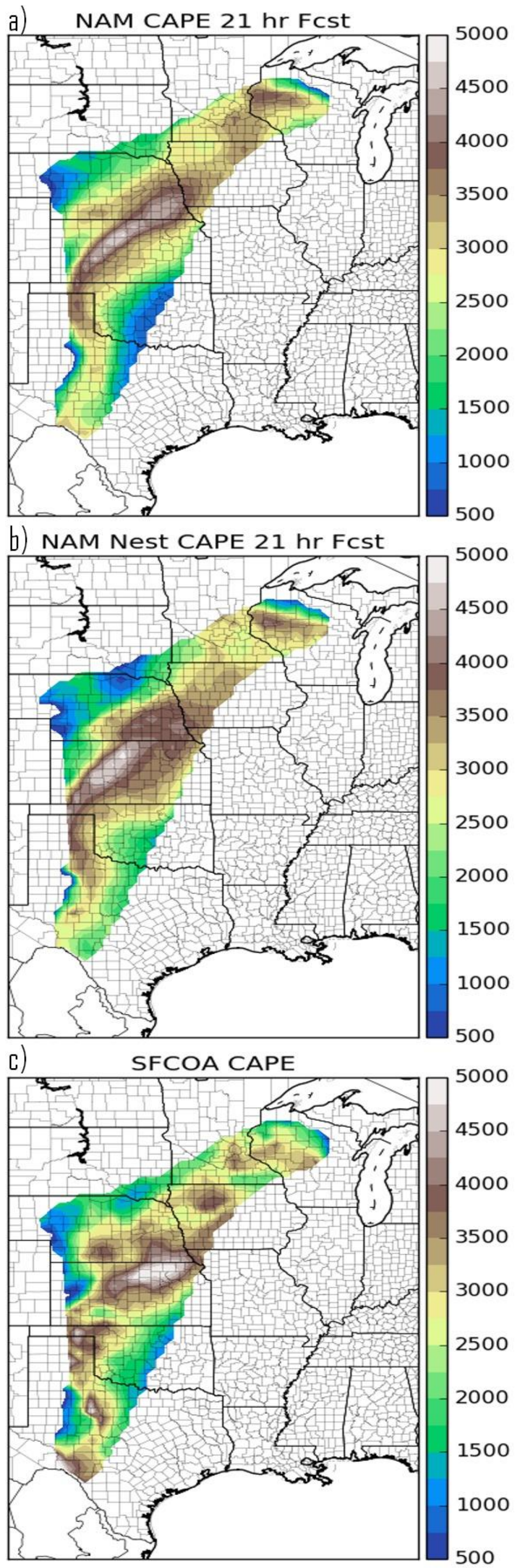

Figure 4. SBCAPE forecasts/analysis valid 2100 UTC 16 May 2017 from the NAM Parent (a), NAM Nest (b) and SFCOA (c).

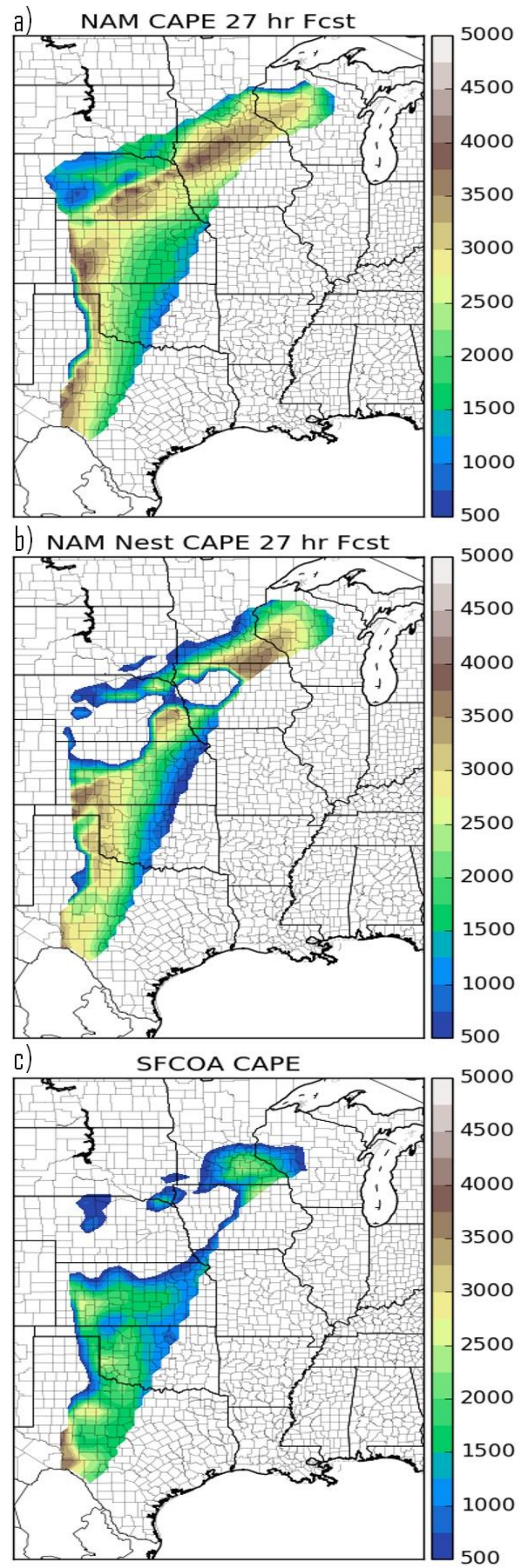

Figure 5. SBCAPE forecasts/analysis valid 0300 UTC 17 May 2017 from the NAM Parent (a), NAM Nest (b) and SFCOA (c).

4. EXAMINATION OF PRE-CONVECTIVE ENVIRONMENT FORECASTS

Producing objective verification metrics of model pre-convective environmental instability forecasts is made difficult by model errors in the timing and placement of convective development. More work needs to be done in developing a technique to allow for a more accurate examination of the strictly pre-convective environmental fields. As a proxy for pre-convective instability, this study will compare the 24-hour maximum of SBCAPE from the NAM Parent and NAM Nest forecasts with the 24-hour maximum of SBCAPE from the SFCOA analysis. The daily maximum of SBCAPE generally occurs in the late afternoon, prior to convective initiation, allowing it to serve as a simple estimation of the pre-convective instability.

Distributions of daily RMSE and bias statistics were produced for the 24-hour maximum CAPE forecasts from the NAM Parent and NAM Nest over slight risk areas, and are shown in Fig. 6. Overall, the distributions look fairly similar, and both bias distributions are centered near zero. The NAM Nest has a slightly lower overall RMSE, as well as a smaller envelope of distributions for both RMSE and bias.

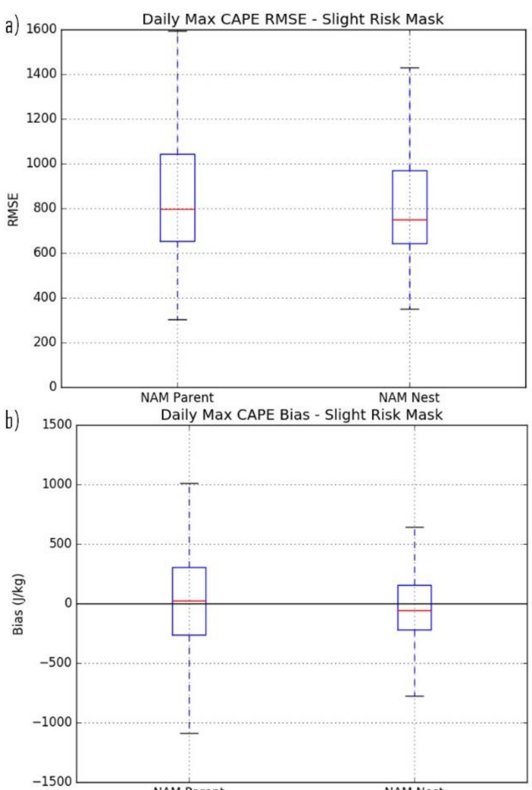

Figure 6. Box plots of daily maximum SBCAPE RMSE (a) and bias (b) distributions for the NAM Parent and NAM Nest for slight-risk areas from April-August 2017.

To examine depictions of pre-convective instability closer, a case example from 16 June 2017 was looked at. 16 June 2017 featured a mesoscale convective system producing multiple measured significant wind gusts greater than 65 knots from northeast Nebraska southeast-ward into western Missouri (Fig. 7).

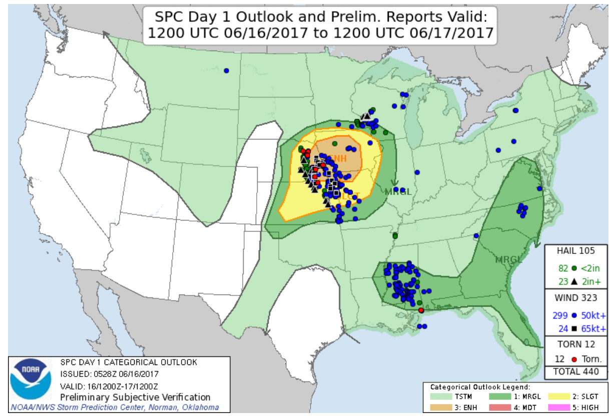

Figure 7. SPC storm reports and 0600 UTC SPC Day 1 Convective Outlook for 16 June 2017.

Plots of 24-hour maximum SBCAPE from 16 June 2017 are shown in Fig. 8. Both the NAM Parent and NAM Nest do a reasonably good job with the placement of the maximum instability axis across northeast Kansas into southeast Nebraska, though the magnitude of instability is underdone in the NAM Nest.

When looking at the time at which the 24-hour maximum SBCAPE occurred (Fig. 9), significant differences between the NAM Parent and NAM Nest can be noted. The maximum SBCAPE in the NAM Parent occurs much later along the track of the MCS in southeast Nebraska and southern Iowa. This indicates that the NAM Parent did not have a good handle on the MCS evolution and its resulting effects on the convective environment. Meanwhile, the NAM Nest does a better job capturing timing along the MCS track, though is too late in the non-convective area of eastern Iowa. This aligns with results from the previous section in that the NAM tends to maintain high instability values too long into the late evening over non-convective areas.

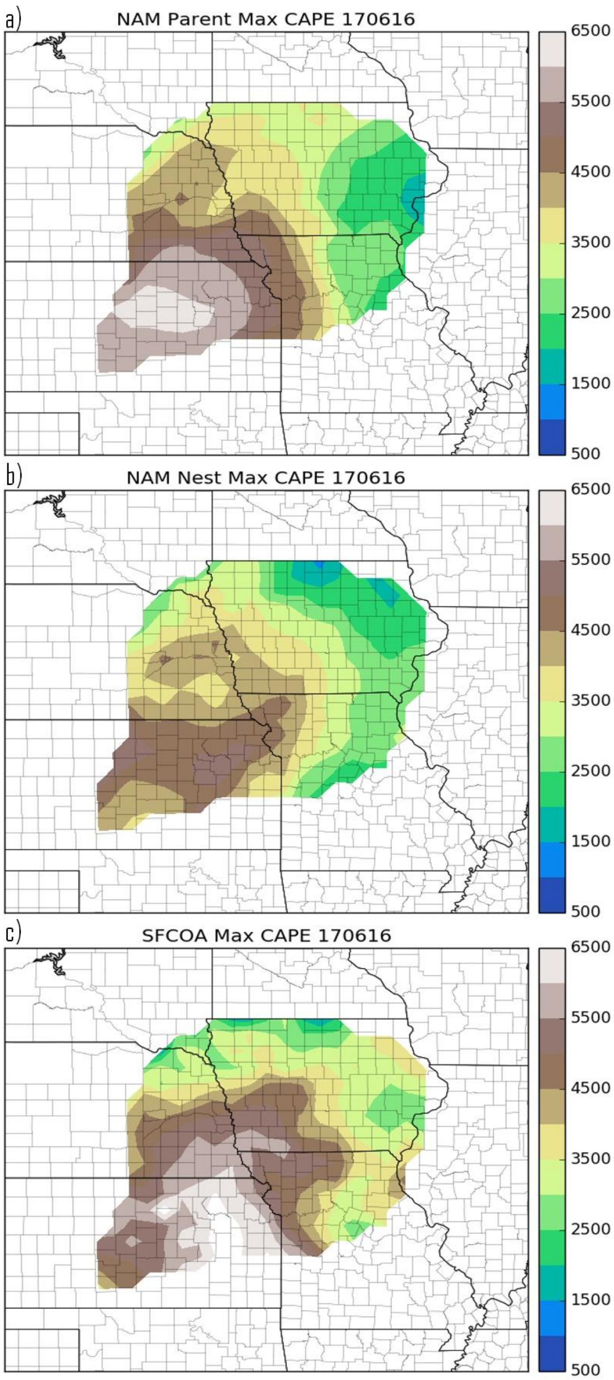

Figure 8. 24-hour maximum SBCAPE for 16 June 2017 from the NAM Parent (a) NAM Nest (b) and SFCOA (c).

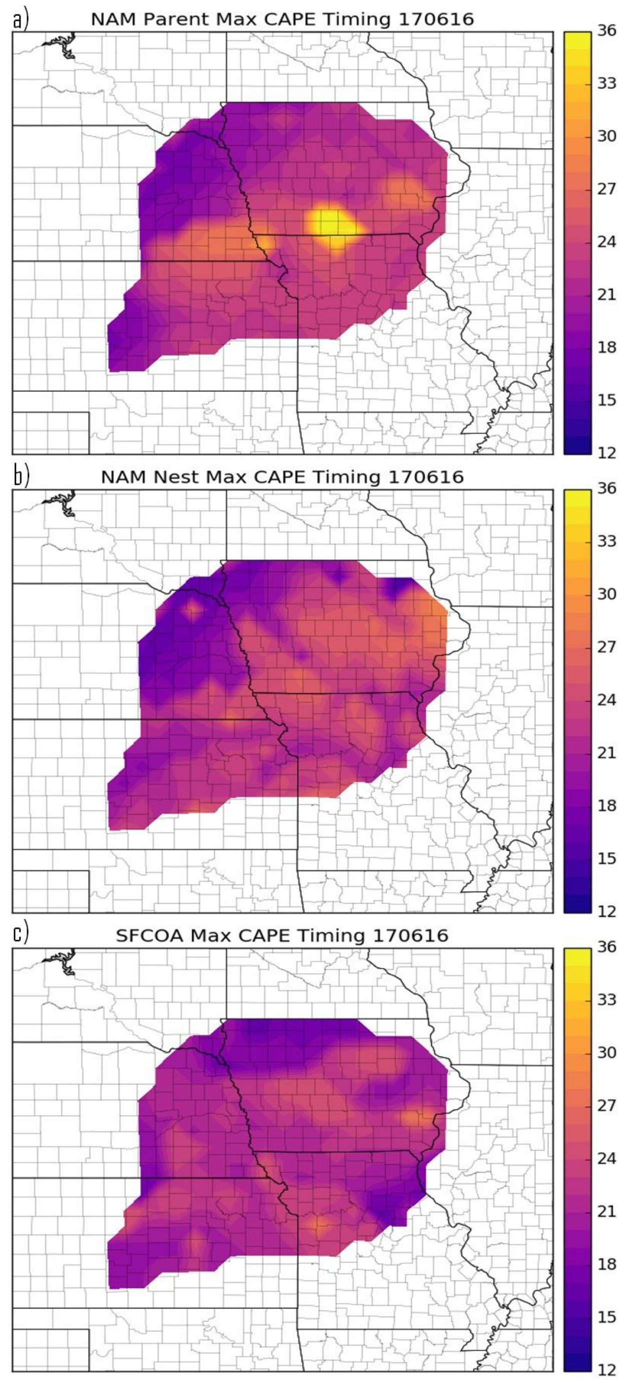

Figure 9. Timing of 24-hour maximum SBCAPE (in values of forecast hour from the 0000 UTC cycle) for 16 June 2017 from the NAM Parent (a) NAM Nest (b) and SFCOA (c).

5. SUMMARY

Forecasts of convective instabilty were examined from a convection-parameterizing model, the NAM Parent, and an upscaled convection-allowing model, the NAM Nest. Verification statistics were calculated both over a CONUS-wide area, as well as over regional areas of daily severe convective potential as outlined by SPC slight risk areas.

Results showed that the choice of verification domain can make a significant difference in the verification statistics which are produced. When looking over a CONUS-wide area, the NAM Parent and NAM Nest appeared to perform similarly. When limiting verification calculations to SPC slight risk outlook areas, however, the NAM Nest outperforms the NAM Parent, especially during the diurnal peak of convection. The skill of the NAM Nest after convective initiation occurred was heavily dependant on its placement and evolution of convective features. The NAM Parent was much more systematic in its errors, showing a strong high bias during the late afternoon and evening, with a tendency to hold on to instability too long into those periods.

Additionally, forecasts of strictly pre-convective instability were examined by using 24-hour maximum SBCAPE as a proxy. These results show that both the NAM Parent and NAM Nest were generally reasonable in their placement of pre-convective instability axes, but were subject to mostly random errors in instability magnitude, as indicated by daily bias distributions centered around zero. Finally, further work is needed in developing a technique to account for model errors in placement and timing of convective development for verifying pre-convective environment forecasts.

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