Evaluation of WRF Forecasts of Severe Weather Environments Against Mobile Upsonde Observations from the Mesoscale Predictability Experiment (MPEX)

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Introduction

- Coniglio et al. (2013) performed a study to explore the behavior of different planetary boundary layer (PBL) parameterizations in the Weather Research and Forecasting model (WRF) compared to observations at the standard sounding times 00 and 12 UTC.
- The Mesoscale Predictability Experiment (MPEX) ran from 15 May-15 June 2013 with the goal being to determine what locations of additional observations would best help improve numerical weather forecasts for convective activity (+6-24 hours).
- About 290 mobile soundings were collected during MPEX in the pre-convective and convectively disturbed environments, most of which were in the afternoon hours.
- This study focuses on evaluating WRF model performance in predicting thermodynamic profiles versus the MPEX observations at these "intermediate" times.

Questions To Consider

- Are the characteristics of the different PBL parameterizations consistent with findings of Coniglio et al. (2013) when compared against afternoon soundings in convective environments?
- What applications can the results give us to help better understand thermodynamic stability/instability in future convective episodes?

The Methodology

Step 1 — Identify pre-convective mobile soundings with a well-defined PBL. Convectively disturbed soundings and soundings with missing data are not used.

Step 2 — Calculate PBL height from each sounding using the method of Coniglio et al. (2013) and manually inspect calculated height. Any PBL height calculations deemed unreasonable, such as when the algorithm missed an obvious PBL top, were removed from the analysis.

Step 3 — Using points with model forecast soundings calculated from the CAPS ensemble, identify the nearest point to MPEX mobile sounding. If no model sounding station was within 50 km of the MPEX observation at the date and time, it is removed from the analysis.

Step 4 — Using the five members of the CAPS storm-scale ensemble forecast (SSEF; Clark et al. 2012) system with different PBL parameterizations, evaluate forecasts against observed soundings (see table 1 below for a list).

Step 5 — Calculate the errors in model forecasts of PBL height and mean-layer convective available potential energy (MLCAPE).

PBL parameterizations used in analysis
Mellor-Yamada-Janjic (MYJ)
Mellor-Yamada-Nakanishi-Niino (MYNN)
Asymmetric Convective Model- version 2 (ACM2)
Yonsei University (YSU)
Quasi-Normal Scale Elimination (QNSE)

Table 1: List of PBL parameterizations from the WRF model used in this study.

Locations of Interest and Cases

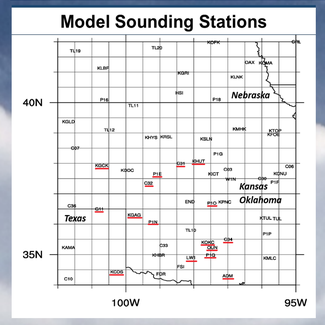


Figure 1: Grid map of the continental U.S. from 34° -42° N and 95°-102° W. The stations used in this study are underlined in red.

- This method left a sample size of 35 soundings from all four MPEX teams combined to be compared to the CAPS ensemble members.
- Soundings were from 13 different days from 15 May-15 June. All soundings were from 1600 UTC to 0100 UTC (+1), where most were from 1800-2200 UTC.
- Most soundings were in Kansas and Oklahoma; Fig. 1 shows locations of matched observed and model soundings.

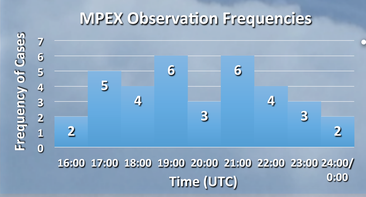
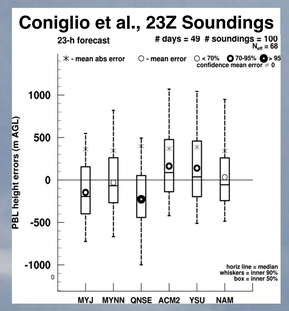


Figure 2: Graph of the distribution of MPEX observations at each hour used in this study.

Planetary Boundary Layer Heights



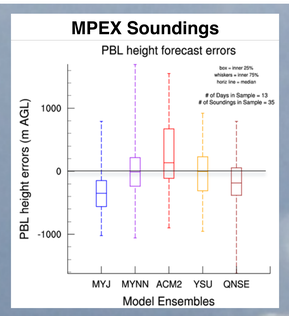
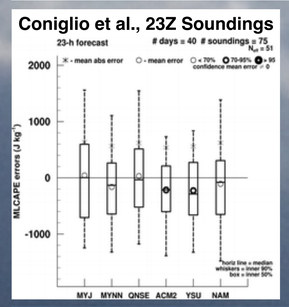


Figure 3: PBL height errors comparing the Coniglio et al. results (left) to the MPEX results (right).

- The MYJ and QNSE members were found to predict the PBL height to be too shallow in both the Coniglio and MPEX studies.
- The ACM2, YSU, and MYNN median PBL heights were near the observed PBL heights. These are also similar findings in both studies.

Mean-Layer Convective Available Potential Energy



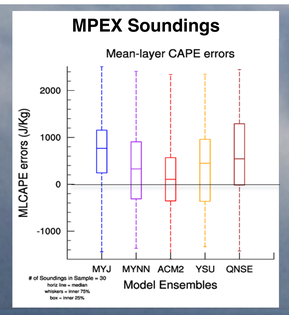
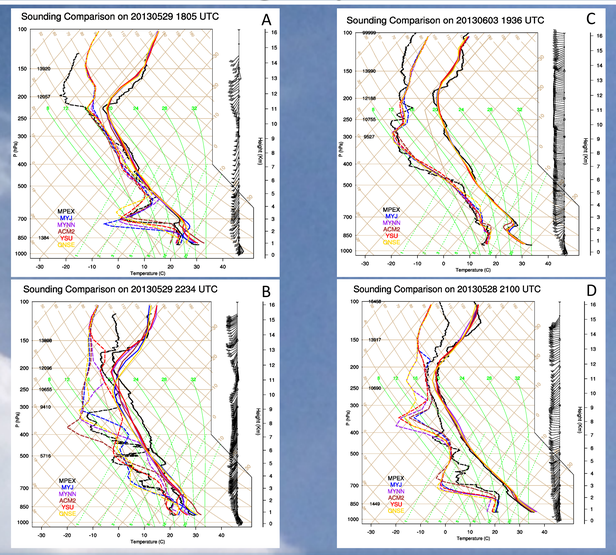


Figure 4: Same as for Figure 3 except for MLCAPE errors.

- All five models over-predict the MLCAPE values on average, which differs from the findings in the Coniglio et al. study.
- Is this difference a result of using mid-afternoon rather than 0000 UTC soundings?
- Could changes in the environment between 1800-0000 UTC be responsible for these differences?

Sounding Comparisons



- Figure 5: Upsonde profiles with WRF model ensembles superimposed over MPEX observations. Cases A & C are soundings that represent an accurate prediction of thermodynamic behavior; case B shows model ensemble uncertainties at the mid-levels; case D shows consistency in temperature changes but incorrectly predicting the location and depth of the dry boundary in the low to mid-levels.

Conclusions

- PBL height results are generally consistent with past studies!
- The member using the MYJ scheme predicted PBL height to be too shallow, whereas the YSU, ACM2, and MYNN schemes had a median height very close to observations, similar to Coniglio et al. (2013).
- For the upsonde profiles, model consensus was generally present despite a few cases of higher uncertainty in the prediction of the dewpoint values at the low to mid-levels of the atmosphere.
- MLCAPE was found to be over-predicted by all members of the ensemble, a difference from the Coniglio et al. study. This may be due to differences between mid-afternoon and 00 UTC thermodynamic profiles.

Acknowledgements

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References

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