# Simulations of warm season MCS rainfall using mixed physics in the Eta and WRF models

William A. Gallus, Jr. and Isidora Jankov
Dept. of Geological and Atmospheric Science, Iowa State University, Ames, IA
email: wgallus@iastate.edu

Warm season mesoscale convective systems (MCSs) have been simulated over the Central United States in two regional domains to determine if any particular combination of model physics consistently produces the best rainfall forecast. All model runs were integrated for 24 hours, and rainfall was evaluated within 6 hour periods. In one domain of roughly 1000 × 1000 km centered over Iowa, 20 MCSs were simulated with both a 10 km version of the NCEP Eta model, and a 10 km version of the Weather Research and Forecasting (WRF) model, with both the Kain-Fritsch (KF) and Betts-Miller-Janjic (BMJ) convective schemes used in each model. In the other domain covering the International $H_20$ Project (IHOP) region of the Central United States, a 12 km version of the WRF model was run with 18 different combinations of convective, PBL and microphysical schemes to simulate 8 MCS events occurring during the 2002 IHOP period. Specifically, the BMJ and KF convective schemes were used, along with a fully explicit run. Both the Eta and MRF PBL packages were used. For explicit microphysics, the Lin et al. (MP2), NCEP 5-class (MP4) and Ferrier (MP5) schemes were used.

In experiments over the Iowa domain, it was found that Equitable Threat (ET) scores were generally similar on average between the Eta and WRF models. Runs with the BMJ scheme in the Eta model earned slightly higher ET scores than those with the KF scheme, but enough variability was present that the results were not statistically significantly different (in a Wilcoxon signed-rank test). In the WRF runs, both schemes earned comparable scores. Of interest, spread ratios (Stensrud and Wandishin 2000) indicated more similarity in the rainfall forecasts from two different models having the same convective scheme than in the same model running two different convective schemes. This result supports previous findings about the prominent role the convective parameterization plays in the simulation of rainfall during the warm season.

In tests over the IHOP domain, it was found that no particular set of physical parameterizations (out of 18 possibilities) consistently resulted in the best rainfall forecast skill. Table 1 shows ET scores for the first 6 hours of forecasts when the WRF model was initialized using the LAPS "hot start" diabatic initialization. During this time, the highest ET scores for lighter rainfall thresholds were associated with runs that did not use a convective scheme. For heavier amounts, higher scores occurred in some of the KF and BMJ runs, but varied as a function of the microphysical scheme. At later times in the 24 hr integrations, ET scores decreased and results changed so that overall, no particular convective, PBL, or microphysical scheme was favored. These results suggest that the combination of WRF physical configurations may yield a useful ensemble, assuming sufficient spread is present.

Standard deviations were computed for the ET scores when one physical process was varied while the other two were held constant (not shown). These results suggest that the convective scheme has a bigger impact on the forecast for light rainfall amounts at early times (prior to 12 h) but that the microphysical and PBL schemes have a comparable influence by the 18-24 h forecast period. For heavier rainfall amounts, the microphysical and convective schemes exert similar influences at all times, and the PBL scheme has less impact.

| | Precipitation Threshold (mm) | | | |
|---|---|---|---|---|
| Model Physics | .254 | 2.54 | 12.7 | 25.4 |
| BMJ-ETA-MP2 | .246 | .167 | .100 | .053 |
| BMJ-ETA-MP4 | .249 | .182 | .070 | .026 |
| BMJ-ETA-MP5 | .249 | .177 | .079 | .029 |
| BMJ-MRF-MP2 | .249 | .179 | .099 | .054 |
| BMJ-MRF-MP4 | .249 | .178 | .100 | .046 |
| BMJ-MRF-MP5 | .252 | .180 | .074 | .038 |
| KF-ETA-MP2 | .235 | .187 | .077 | .055 |
| KF-ETA-MP4 | .242 | .201 | .066 | .033 |
| KF-ETA-MP5 | .272 | .205 | .090 | .063 |
| KF-MRF-MP2 | .255 | .196 | .073 | .059 |
| KF-MRF-MP4 | .265 | .211 | .067 | .041 |
| KF-MRF-MP5 | .276 | .206 | .075 | .038 |
| NC-ETA-MP2 | .349 | .247 | .086 | .044 |
| NC-ETA-MP4 | .327 | .215 | .048 | .022 |
| NC-ETA-MP5 | .298 | .203 | .055 | .041 |
| NC-MRF-MP2 | .308 | .201 | .066 | .039 |
| NC-MRF-MP4 | .304 | .191 | .057 | .029 |
| NC-MRF-MP5 | .311 | .208 | .057 | .032 |

Table 1: ET scores averaged for 8 IHOP cases for 18 WRF physical configurations (BMJ, KF, and no convective schemes, ETA and MRF PBL schemes, and MP2-Lin et al., MP4-NCEP 5 class, and MP5-Ferrier microphysical schemes) for 4 rainfall thresholds in the 00-06 forecast hour period.

Initial tests of the use of the WRF runs as an ensemble show rather high areas under the Relative Operating Characteristic (ROC) curve during the early times for lighter rainfall amounts, with a peak value of over .8 in the first 6 hours for .254 mm of rainfall. The skill of the ensemble forecast does appear to be better than that of any single deterministic run, but the ensemble forecasts, like the deterministic ones, show little skill for heavier amounts (such as 12.7 mm).

In summary, we are finding that no particular combination of common physical parameterizations in the Eta and WRF models consistently results in a better rainfall forecast for warm season MCS events. The impact of the convective parameterization is so substantial that forecasts from two different models using the same convective scheme will typically resemble each other more than forecasts from the same model using varied convective schemes. This result could influence the design of short-range ensembles.

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## References

Stensrud, D. J., and M. S. Wandishin, 2000: Correspondence and spread ratios in forecast verification. *Wea. Forecasting*, **15**, 593-602.