Coherence of rainfall propagation as simulated in the Weather Research and Forecasting model using two different convective schemes

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Introduction

Convective rainfall forecasting continues to be a challenge for Numerical Weather Prediction (NWP) models. This study looks at rainfall forecasts from a model using two different convective schemes along with observed data. Davis et al. (2003) cite the convective schemes as the main challenge to NWP as they tend to trigger precipitation too early and propagate it too slowly. The goal is to see if mesoscale convective rainfall propagation is depicted better in one of the two cumulus parameterization schemes.

Data Source and Method

Model data was obtained from the WRF-ARW (version 2.1.1) run at Iowa State University over a domain from -104 to -88° W and 35 to 50ºN. Both the Betts-Miller-Janjic (BMJ; Betts 1986, Betts and Miller 1986, Janjic 1994) and Kain-Fritsch (KF; Kain and Fritsch, 1993) convective schemes were run with Ferrier et al. (2002) microphysics. Observed data (Obs) was obtained from NCEP's Stage IV multi-sensor analyses.

To calculate convective precipitation propagation, time-longitude, or Hovmöller diagrams, were used as shown in Fig. 1. Radar data with watch boxes overlaid were used to determine if precipitation was convective and propagating. If this criteria was met, propagation speed was calculated by beginning at our minimum threshold of 0.02 inches (brown) and proceeding through the center of the precipitation streak, which must contain a relative maximum of 0.03 inches or greater. Propagation ends when our minimum threshold is met, at the edge of our domain, or at the end of a day.

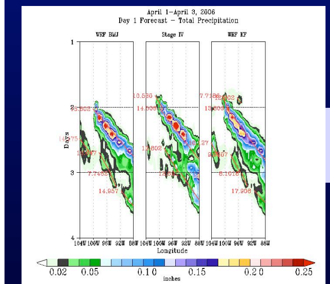


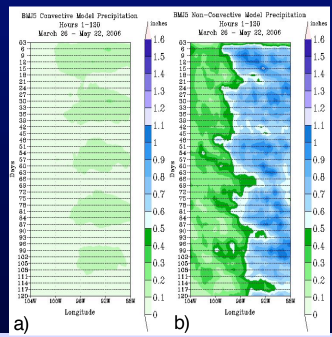
Figure 1: Example of calculating propagation speed for BMJ, Stage IV observations, and KF during the period of 1 April - 3 April 2006 in Hovmöller space.

Main Points

- BMJ convective precipitation lacks defined rainfall streaks (Fig. 2a). BMJ non-convective precipitation has more indications of propagation streaks (Fig. 2b). Comparing Fig. 2a) and 2b), it is shown that BMJ convective precipitation has less precipitation being forecasted than the non-convective precipitation.
- Both KF convective (Fig. 3a) and non-convective (Fig. 3b) show well-defined rainfall streaks. However, the convective precipitation has slightly higher amounts of precipitation forecasted than the non-convective.
- BMJ (Fig. 4a) and KF (Fig. 4b) show that when the convective scheme is compared to observations for propagation speed, both show faster propagation speeds compared to observations.
- Both BMJ (Fig. 5a) and KF (Fig. 5b) exhibit propagation speeds that are on average about 1.85m/s faster than the observed propagation speed.
- BMJ (Fig. 6a) is slightly further to the west in beginning longitude compared to observations whereas KF (Fig. 6b) is slightly further to the east in beginning longitude compared to observations.

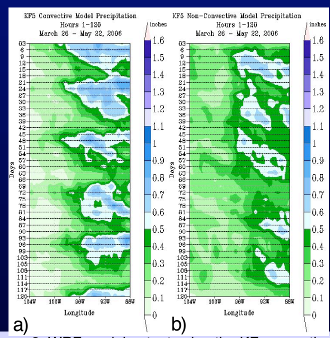
Summary

If convective schemes could better model warm-season rainfall, forecasts of mesoscale convective complexes, which produce 30-70% of warm-season rainfall, could provide vital information for the public. These may include enhanced asset protection, less wasteful agricultural practice, mitigation of threats to outdoor activities and saving life and property. Accurate forecasts could assist in risk assessment to homeland security such as biological, chemical, and nuclear attacks.



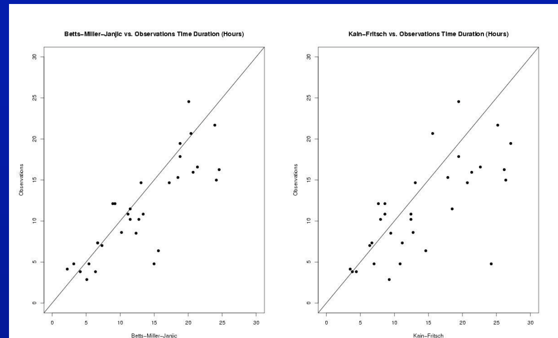
a) b)

Figure 2: WRF model output using the BMJ convective scheme with a) only convective model precipitation and b) only non-convective model precipitation in Hovmöller space.



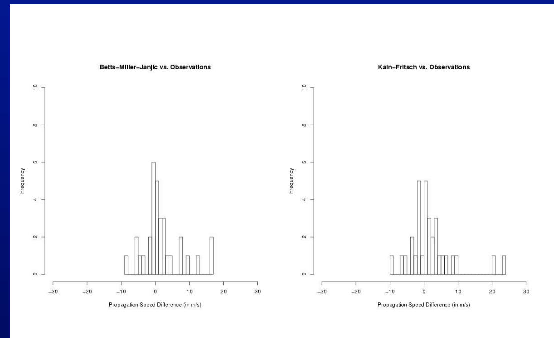
a) b)

Figure 3: WRF model output using the KF convective scheme with a) only convective model precipitation and b) only non-convective model precipitation in Hovmöller space.



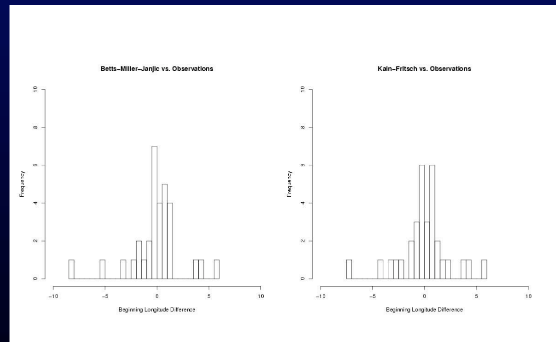
a) b)

Figure 4: Comparison of BMJ vs. Obs. and KF vs. Obs. for duration of a propagation streak (in hours). Points above the 1:1 line (black line) begin earlier in the forecast; points below the 1:1 line begin earlier in the forecast.



a) b)

Figure 5: Comparison of BMJ vs. Obs. and KF vs. Obs. for difference in propagation speed in m/s.



a) b)

Figure 6: Comparison of BMJ vs. Obs. and KF vs. Obs. for beginning longitude difference.

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