Coherence of rainfall propagation in WRF simulations using two 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 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 50° N. 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 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 Figure 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.

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.
- The BMJ (Fig. 4a) has lesser amounts of precipitation than the observed data (Fig. 4b) and is more widespread in placement. The KF (Fig. 4c) has higher amounts of precipitation compared to the observed data and propagates the precipitation slightly faster than observed.
- BMJ longitude does not have a bias (Fig. 5a) while the KF has a slight bias to start precipitation further east in longitude (Fig. 5b).
- Start time of precipitation has no bias for either BMJ (Fig 6a) or KF (Fig. 6b).
- BMJ is slightly slower in speed (Fig. 7a) while the KF is slightly faster in propagation speed (Fig 7b).

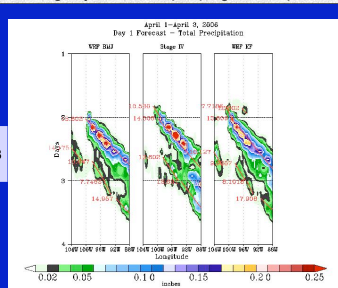

Figure 1: Example of calculating propagation speed for BMJ, KF, and Stage IV observations during the period of 1 April - 3 April 2006 in Hovmöller space.

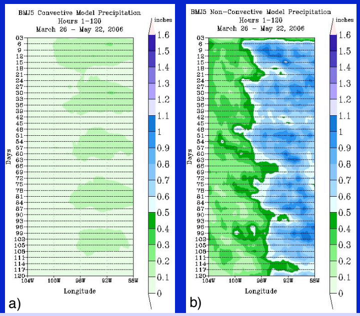

Figure 2: WRF model output using the BMJ convective scheme with a) only convective model precipitation and b) only non-convective model precipitation in Hovmöller space.

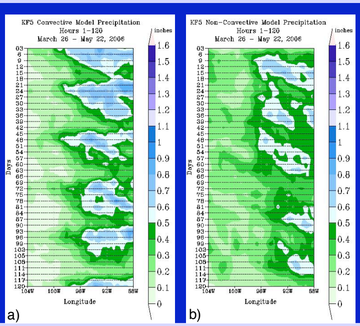

Figure 3: WRF model output using the KF convective scheme with a) only convective model precipitation and b) only non-convective model precipitation in Hovmöller space.

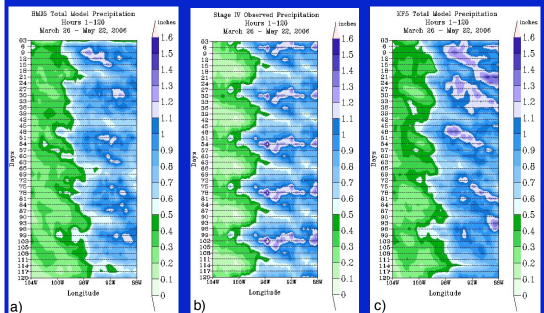

Figure 4: Hovmöller diagrams of WRF total model precipitation with a) BMJ convective scheme, c) KF convective scheme, and b) NCEP's Stage IV multi-sensor analyses for comparison

Results

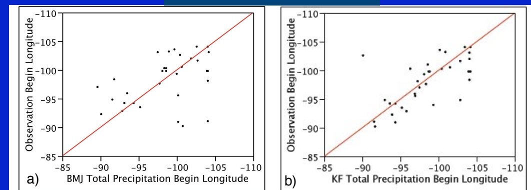

Figure 5: Day 1 forecast of beginning longitude of convective propagating precipitation vs. observations for the a) BMJ total precipitation and b) KF total precipitation. Points above the 1:1 line (red line) are further east in the forecast; points below the 1:1 line are further west in the forecast.

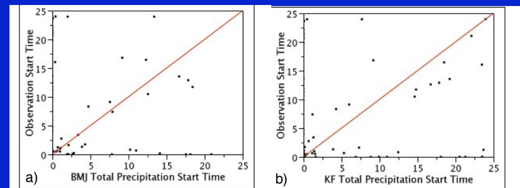

Figure 6: Day 1 forecast of start times (hours) of convective propagating precipitation vs. observations for the a) BMJ total precipitation and b) KF total precipitation. Points above the 1:1 line (red line) begin earlier in the forecast; points below the 1:1 line begin earlier in the forecast.

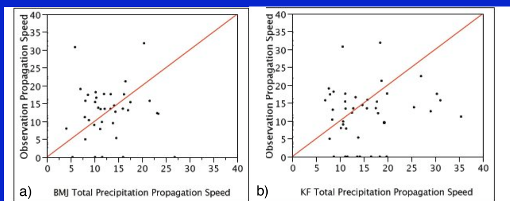

Figure 7: Day 1 forecast of propagation speeds (m/s) of observations compared to the a) BMJ total precipitation and b) KF total precipitation. Points above the 1:1 line (red line) are propagating faster in the observed data; points below the 1:1 line are propagating faster in the convective scheme.

Acknowledgments

Grid Analysis and Display System (GrADS) was used to calculate propagation speed and the propagation's beginning longitude and time. Thanks to Adam Clark for providing the data and software support and Jon Hobbs for statistical assistance.

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