Summer Rainfall Forecast Spread in an Ensemble Initialized with Different Soil Moisture Analyses

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Introduction:

- This study evaluates summer rainfall forecast spread in weakly forced and strongly forced events in an ensemble initialized with different soil moisture analyses.

Setup:

- 6 cases (3 weakly forced and 3 strongly forced)
- 12 UTC initialization, 24 hour integration period
- Model configuration: WRF 4 km, explicit rainfall, WSM 6-class microphysics, RUC LSM, YSU PBL scheme, Monin-Obukhov surface-layer scheme, RRTM longwave and Dudhia shortwave radiation schemes

Soil moisture analyses:

- Assume errors in RUC, NAM and GFS soil moisture analyses are distributed normally
- The 10 soil moisture analyses: RUC,NAM,GFS in addition to the mean, ±1, ±2 standard deviation (sd), 25th percentile and 75th percentile of the 3 operational models (Fig. 1)
- Two additional runs: an extremely wet soil (EW run; volumetric soil moisture set to saturated values and an extremely dry soil (ED run; volumetric soil moisture set to residual values, i.e., minimum possible volumetric soil moisture content).

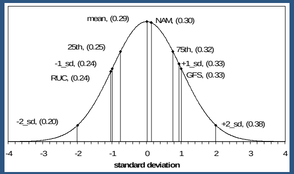
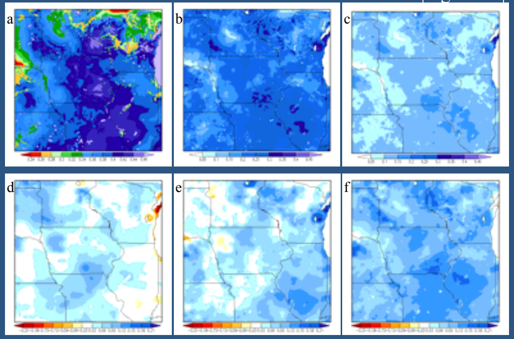


Fig. 1. Standard normal curve with the specification of the 10 volumetric soil moisture analyses (in parentheses) for a single grid point in the simulation domain for one of the cases discussed in more detail later.

Initial 0-10 cm soil layer volumetric soil moisture features: 09-10 June 2003

- Values: 0.3-0.44 in +2_sd run (Fig. 2a)
- Differences: 0.2-0.3 between +2_sd and -2_sd (Δ2_sd) runs (Fig. 2b), 0.1-0.15 between +1_sd and -1_sd (Δ1_sd) runs (Fig. 2c), 0.05-0.1 for NAM-RUC (Fig. 2d),GFS-RUC (Fig. 2e) and GFS-NAM (Fig. 2f).

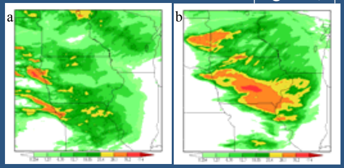
Figs. 2a-f



Rainfall features: 09-10 June 2003

- Observed 60 mm in northwestern MO (Fig. 3a), +2_sd run simulated 80 mm in central Iowa (Fig. 3b).
- Differences: 60 mm for EW-ED (Fig. 4a), 80 mm for Δ2_sd (Fig. 4b) and 20 mm for Δ1_sd (Fig. 4c).
- NAM-RUC (Fig. 4d) and GFS-RUC (Fig. 4e) differences up to 40 mm.
- GFS-NAM differences ≤ 10 mm (Fig. 4f).

Figs. 3a,b



Figs. 4a-f

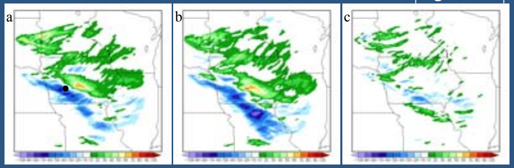


Fig. 4 cont.

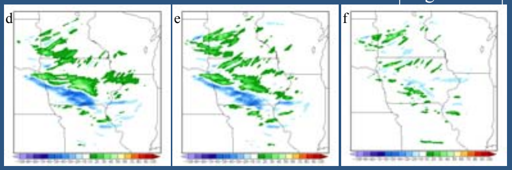
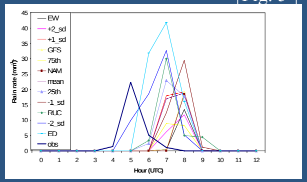
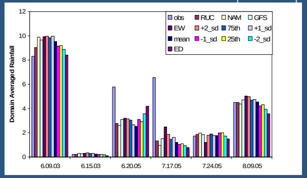


Fig. 5



- Peak observed and 25th percentile simulated rain rate (Fig. 5) were both around 23 mm h^{-1} for a selected grid point (see closed circle in Fig. 4a for location of grid point)
- Rain rates in driest soil runs occurred 1-2 hours earlier than in wettest soil runs

Fig. 6



- Domain averaged rainfall (Fig. 6) in +2_sd and EW runs were similar as was that in the -2_sd and ED runs (+2_sd > EW in 3 cases; -2_sd < ED in 1 case)
- Among the RUC, NAM and GFS, the NAM produced the most and least domain averaged rainfall in 3 cases, respectively.

Six hour rainfall differences: 20-21 June 2005

- More afternoon convection in ED run (Fig. 7a) as compared to EW run (Figs. 7b)
- More intense late night rainfall in EW run (Fig. 7c) as compared to ED run (Figs. 7d)

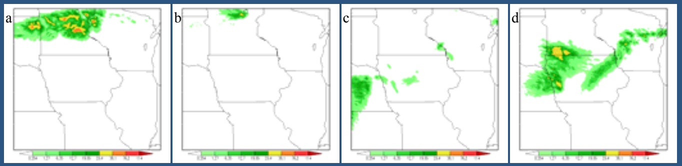
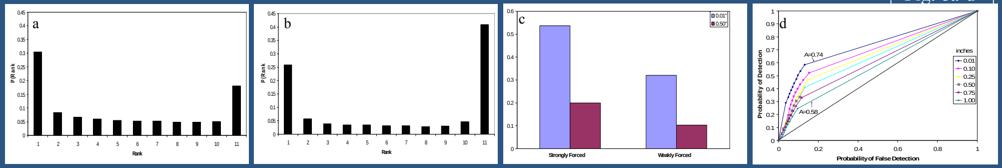


Fig. 7. The 18 – 00 UTC rainfall (in mm) for 20 - 21 June 2005 in the (a) ED run and (b) EW run as well as the 06 – 12 UTC rainfall in the (c) ED run and (d) EW run.

Spread and skill evaluation

- U-shaped rank histograms in both weakly forced (Fig. 8a) and strongly forced (Fig. 8b) cases with slightly more spread in weakly forced cases.
- Values of Correspondence Ratio (CR) are lowest in weakly forced cases, also suggesting these cases are most spatially divergent
- Area under Relative Operating Characteristic (ROC) curve (Fig. 8d) of 0.74 for lowest rainfall threshold indicates a useful forecast.

Fig. 8a-d



Conclusion

Subjectively, the soil moisture had in the present study a noticeable impact on predicted rainfall, but analyses quantifying the ensemble spread suggest that using different soil moisture analyses alone in an ensemble forecast system will not result in sufficient variability in rainfall forecasts.

Acknowledgements

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