The Diurnal Variation of Precipitation during MC3E

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Background

- Previous studies have identified three different types of diurnal precipitation variation over the conterminous U.S.: localized afternoon rainfall maxima over Mississippi and Ohio valleys, propagating mesoscale convective systems (MCSs) over Rocky Mountain regions, and propagating MCSs over the Appalachian Mountains.
- This study focuses on the second type, which involves nocturnal rainfall maxima from eastward-propagating MCSs on the lee side of the Rocky Mountains.
- This study evaluates model simulations with regard to rainfall using observations and assesses the impact of microphysics, surface fluxes, radiation and terrain on the simulated diurnal rainfall variation.

Model Configuration

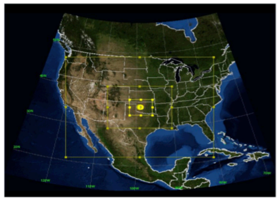


Figure 1 Model integration domain for MC3E forecast.

Table 1 Model configurations

	WRF
Dynamic core	WRF-ARW
Domain	3 nested domains
Horizontal resolution (km)	18 km, 6 km, 2 km
Vertical levels	40
Microphysics parameterization	Goddard
Radiation	Goddard
Cumulus parameterization	GD for the 18 km domain, none for the rest

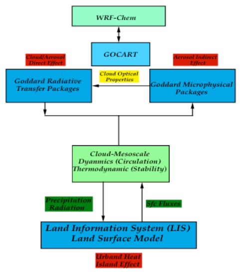


Figure 2 Schematic diagram for NASA unified WRF, blue boxes are NASA physical packages.

WRF real-time forecast were provided twice a day during April 22nd to June 3rd 2011.

The forecast used North American Mesoscale model (NAM) 00UTC and 12UTC forecast to provide initial and boundary conditions.

Data are available on GPM campaign ftp site.

MC3E Real-time Composite

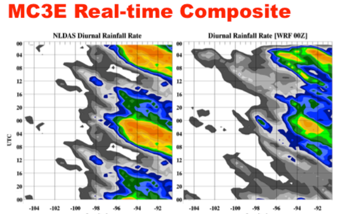
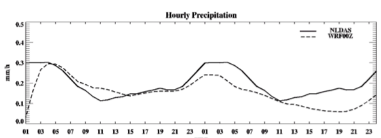


Figure 3 Composited Hovmöller diagram from April 22nd to June 3rd 2011 from NLDAS (left) and WRF (right).

Afternoon onset (4pm LST) of moist convection from the simulation agrees with NLDAS.



The model simulation captures the feature of rainfall diurnal variation well. Two peaks at 05 UTC and 03 UTC are well simulated.

Figure 4 Time series of surface hourly precipitation averaged over the period of 22 April to 3 June 2011 from NLDAS and WRF initialized at 00 UTC

Post Mission Simulations

1) Case Study (20 May 2011)

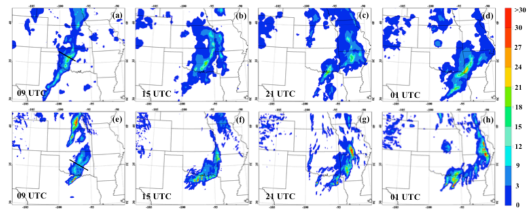


Figure 5 Hourly accumulated surface rainfall from (a)-(d) NLDAS, and (e)-(h) WRF simulation with LIS.

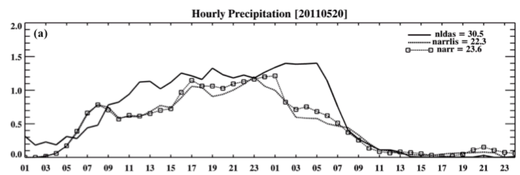


Figure 6 Time series of hourly precipitation from 00 UTC 20 May to 00 UTC 22 May 2011 from NLDAS (solid), WRF coupled with LIS simulated precipitation(dashed), and WRF without LIS (dashed with squares). Both simulations captured the peak of the precipitation and produced very similar results. While the forecast significantly under-estimated the peak of precipitation.

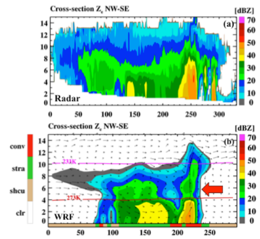


Figure 7 Vertical cross-sections of (a) radar reflectivity from NEXRAD, (b) reflectivity and winds from WRF with LIS (convective-stratiform partitioning is marked below the reflectivity field). Positions of cross-section lines are shown in Figures 5a and 5e for radar and WRF, respectively.

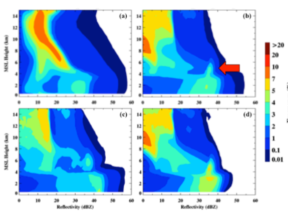
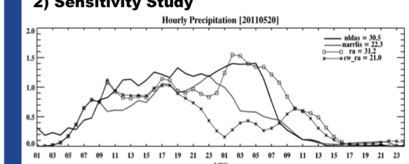


Figure 8 Radar reflectivity CFADs from (a) NEXRAD radar observations and WRF coupled with LIS for the (b) total, (c) convective and (d) stratiform region. WRF overestimated dBZ value at around 6 km (red arrow)

2) Sensitivity Study



Two opposing effects on surface rain by not allowing rain evaporation: Reduce the cold pool strength and increase the overall rain amount.

Figure 9 Same as Figure 6 except for the run without rain evaporative cooling (dashed with squares) and the run without rain or cloud evaporative cooling (dashed with asterisks).

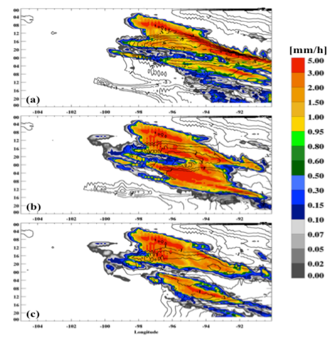
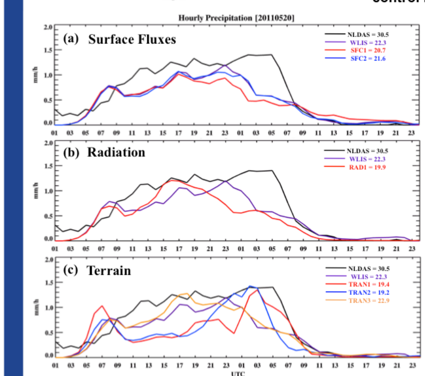


Figure 10 Hovmöller diagram of hourly precipitation (filled contours) and surface virtual potential temperature perturbation (overlaid in black) from the (a) WRF simulation with LIS, (b) WRF simulation with LIS but without rain evaporation, and (c) WRF simulation with LIS but without cloud or rain evaporation start from 09 UTC on 20 May. The cool pool is much weaker in the runs without rain or without cloud and rain evaporation than in the control run.



WLIS: WRF coupled with LIS
SFC1: same as WLIS but without surface fluxes
SFC2: same as WLIS but with 50% of surface fluxes

RAD1: same as WLIS but without radiation process

TRAN1: same as WLIS but terrain height is 0
TRAN2: same as WLIS but with 50% of terrain height
TRAN2: same as WLIS but with 110% of terrain height

Figure 9 Same as Figure 8a except for the run without rain evaporative cooling (dashed with squares) and the run without rain or cloud evaporative cooling (dashed with asterisks).

Summary and Future Work

- NU-WRF has the ability to predict heavy precipitation events as well as the collective diurnal variation of rainfall for the cases during MC3E. The model can capture the rainfall trend and main character of reflectivity CFADs of the 20 May 2011 MCS case.
- The results suggest that cold-pool dynamics were an important physical process. Terrain effects are important during the initial stages of MCS development. By increasing the terrain height by 10%, the simulated rainfall is increased and in better agreement with observations. On the other hand, surface fluxes and radiation processes only have a secondary effect for short-term simulations.
- Additional MC3E case studies are needed. Specifically, three cases, 25-26 April, 1 May, and 23 May will be studied. Further sensitivity tests with the other bulk microphysical schemes (i.e., Morrison et al., 2005 and a recently developed Goddard 4ICE scheme) as well as spectral bin microphysics [i.e., Iguchi et al., 2012] will be conducted.

Acknowledgements

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References

Tao, W.-K., D. Wu, T. Matsui, C. Peters-Lidard, S. Lang, A. Hou, and M. Rienecker (2012), The Diurnal Variation of Precipitation during MC3E: A Numerical Modeling Study. Submitted to JGR.