MC3E: Real-time Forecast and Post Mission Simulations

Wei-Kuo Tao[1], Di Wu[1,2], Toshi Matsui[1,3], Christa Peters-Lidard[4], and Arthur Hou[5]

1Mesoscale Atmospheric Processes Laboratory (Code 612), NASA Goddard Space Flight Cente, Greenbelt, Maryland

2Science Systems and Applications, Inc., Lanham, Maryland

3ESSIC, University of Maryland, College Park, Maryland

4Hydrological Sciences Laboratory (Code 617), NASA Goddard Space Flight Center, Greenbelt, Maryland

5Earth Science Division (Code 610AT), NASA Goddard Space Flight Center, Greenbelt, Maryland

Objectives

- During field campaign: evaluate model performance and identify cases for post mission simulations.
- After field campaign: conduct high resolution model simulations (WRF and GCE) with an integration of microphysics, land surface model and satellite simulator.

Model Configurations

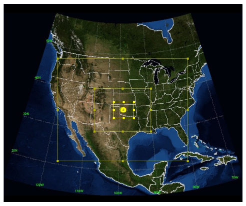


Figure 1. Model integration domain for MC3E forecast.

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

WRF real-time forecast were provided twice a day before morning briefing and afternoon update.

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

The simulation uses 360 CPUs, takes 1.5 hours wall clock time to produce 48 hours forecast.

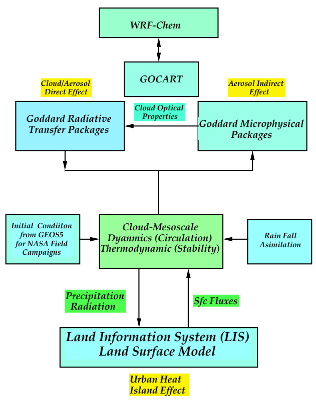


Figure 2. Schematic diagram for NASA nu-wrf modeling framework in Goddard, blue boxes are NASA physical packages.

Example of Real-time Forecast

1) May 01, 2011

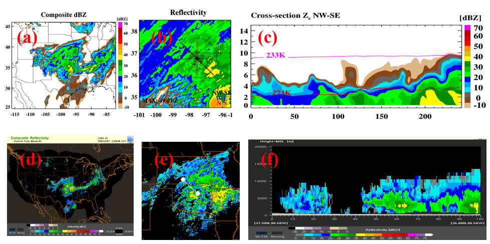


Figure. 3 (a) WRF simulated reflectivity over US at 15Z on May 01, 2011, (b) WRF Simulated reflectivity over SGP, (c) WRF Simulated reflectivity vertical cross-section in NW-SE direction, and (d), (e), (f) similar as (a), (b), (c), except for observed radar reflectivity from NEXRAD.
Modeled storm captures overall structure, but the strong convective system is outside of MC3E domain.

2) May 24-25, 2011

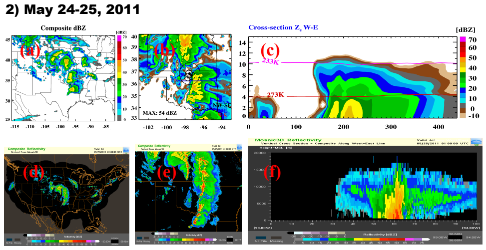


Figure. 4 Same as Fig. 3, except for 01Z on may 24-25, 2011.
Modeled storm captures observed arc-shape structure.

3) Diurnal Variation

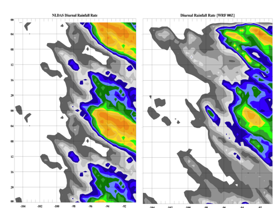


Figure. 5 Composited hovemollar diagram from April 22nd to June 3rd 2011 from NLDAS (left) and WRF (right)

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

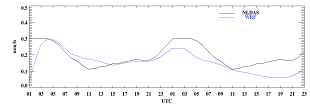


Figure. 6 Time series of WRF model estimated and NLDAS domain mean surface rainfall rate (mm/h).

The model simulation captures the feature of rainfall diurnal variation well.

For example, two peaks at 05 UTC and 03 UTC are well simulated.

Microphysics

1) May 15, 2009

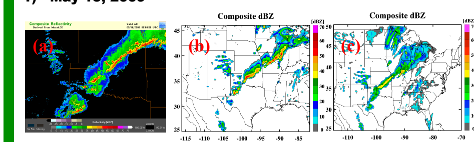


Figure. 7 Radar reflectivity from (a) NEXRAD, (b) WRF simulation using Goddard 3-ice microphysics scheme with hail option, (c) WRF simulation with graupel option.

2) May 20, 2011

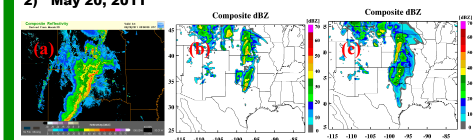


Figure. 8 Same as fig. 7, except for May 20, 2011

3-ice hail scheme is well-suited for simulating vigorous storms (w >20 m/s), such as tornadic and local thunderstorms.

3-ice graupel scheme is good for simulating tropical storms (hurricanes) and winter fronts.

Initial and Boundary Conditions

1) May 24-25, 2011

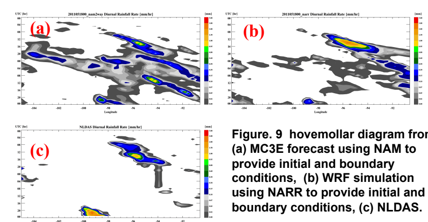


Figure. 9 hovemollar diagram from (a) MC3E forecast using NAM to provide initial and boundary conditions, (b) WRF simulation using NARR to provide initial and boundary conditions, (c) NLDAS.

Simulations using NARR to provide initial and boundary conditions has effectively removed spurious light precipitation, as well as increased the intensity for the major rain streak.
WRF simulation with NARR (the control run) does not assimilate rainfall from NARR.

Summary (Real-Time Forecast)

Goddard WRF model did a good job in the May 1st and May 24th-25th case.

Goddard 3-ice microphysics scheme with hail option is well-suited for strong convective storm simulations.

Simulations are quite sensitive to initial and boundary conditions.

Priority Cases

IOP #	Date	System	Forecast	Flight duration
1	21Z April 22 to 08Z April 23	Squall line with leading stratiform	Accurate	ER2: 1919Z on 22nd to 0113Z on 23rd Citation: 2234Z on 22nd to 0057Z on 23rd
2	07Z April 25 to 12Z April 25	Scattered storms	12Z previous day location is off	ER2: 0712Z to 1246Z on 25th Citation: 0921Z to 1222Z on 25th
3	23Z April 26 to 15Z April 27	Scattered storms with stratiform	Location is a bit off, too much cloud	ER2: 0500Z to 1123Z on 27th Citation: 0802Z to 1123Z on 27th
4	09Z May 01 to 21Z May 01	Scattered storms with widely covered stratiform	Accurate	Citation: 1629Z-1842Z on 01st
5	19Z May 10 to 03Z May 11	Scattered storms with Stratiform and mixed type of precipitation	Location is a bit off, too much cloud	Citation: 2151Z on 10th to 0011Z on 11th
6	12Z May 11 to 00Z May 12	Squall line with trailing stratiform	00Z missed the event	ER2: 1505Z to 1923Z on 11th Citation: 1602Z to 1927Z on 11th
7	07Z May 18 to 15Z May 18	Squall line with leading stratiform	Accurate	ER2: 0512Z to 0955Z on 18th Citation: 0720Z to 0922Z on 18th
8	05Z May 20 to 06Z May 21	Squall line with extended trailing stratiform	19 12Z missed the event, 00Z doing ok	ER2: 1315Z to 1855Z on 20th Citation: 1306Z to 1702Z on 20th
9	20Z May 23 to 07Z May 24	Organized quasi-linear storms	Accurate	ER2: 2055Z on 23rd to 0235Z on 24th Citation: 2130Z on 23rd to 0041Z on 24th
10	19Z May 24 to 05Z May 25	Squall line	00Z missed the event, 12Z is good	Citation: 2018Z to 2228Z on 24th

Post Mission Simulations

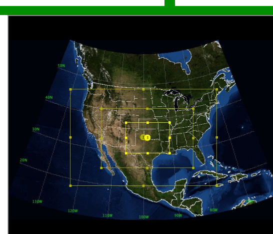
Three nested domain: 18, 6, and 2 (1 or finer) km, and 61 vertical layers. Larger inner domain

Physics:

- Goddard Microphysics scheme
- (Spectral bin, 2-moment)
- Grell-Devenyi cumulus scheme
- Goddard Radiation schemes
- MYJ planetary boundary layer scheme
- Land Information System (LIS)
- Eta surface layer scheme

Initial condition (NFS)

- MERRA, GEOS5, ECMWF



Post Mission Physics Validation

Conduct high resolution CRM (GCE and WRF) simulations

Compare the model-simulated cloud microphysical properties (DSDs at various layers, 3D liquid and ice water contents and median diameters, mixed phase information, and the liquid water fraction of melting snow, graupel and hail, over the life cycle of cloud systems)

Use satellite simulators and CRM results to provide to GPM rainfall algorithm developers

Provide better CRM-simulated data to GPM LH algorithm developers