Diurnal Variation of Precipitation

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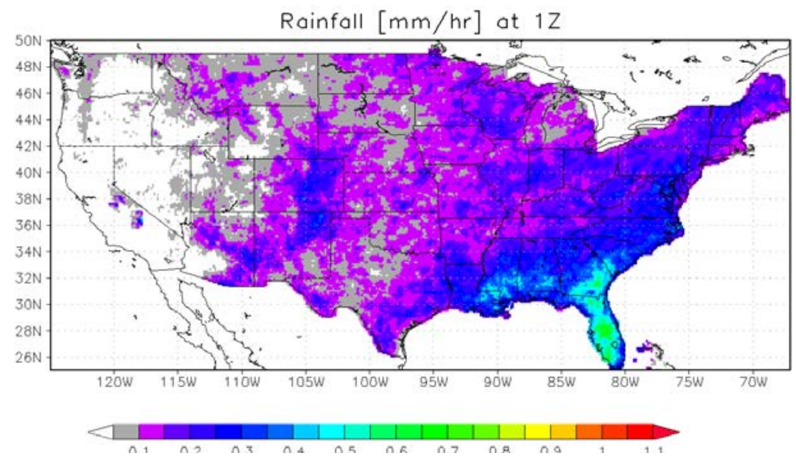
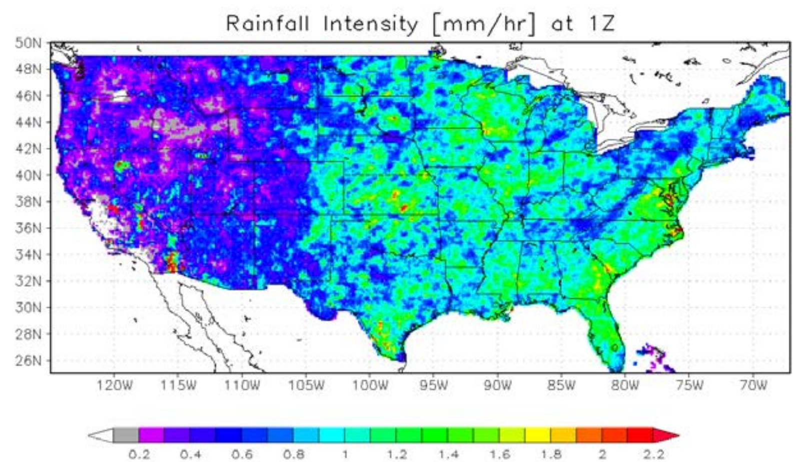
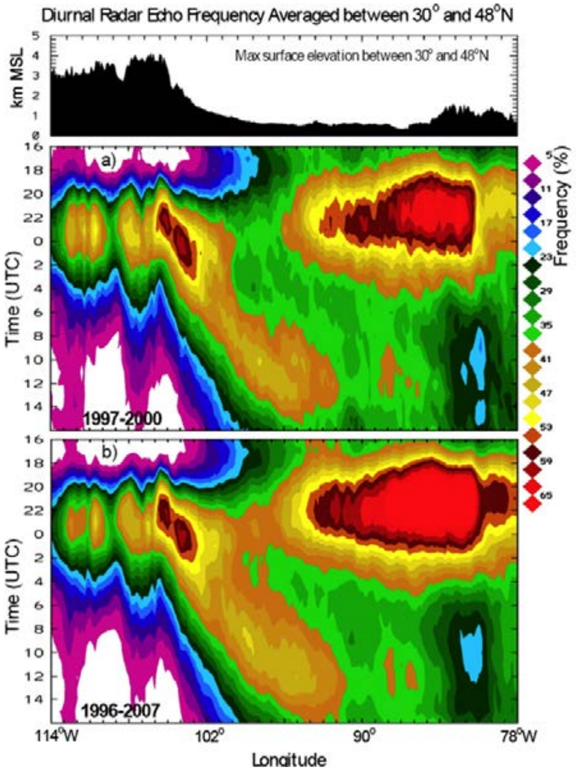
The diurnal variation of precipitation over US can also be generally categorized into three different types:

1) afternoon rainfall maxima due to mesoscale and local circulations over the south and east of the Mississippi and Ohio valleys,
2) nocturnal rainfall maxima from eastward-propagating mesoscale convective systems (MCSs) over the Lee side of Rocky Mountain regions and
3) afternoon rainfall maxima in the Appalachian Mountains, and then propagate eastward toward the coast.





R. Carbone



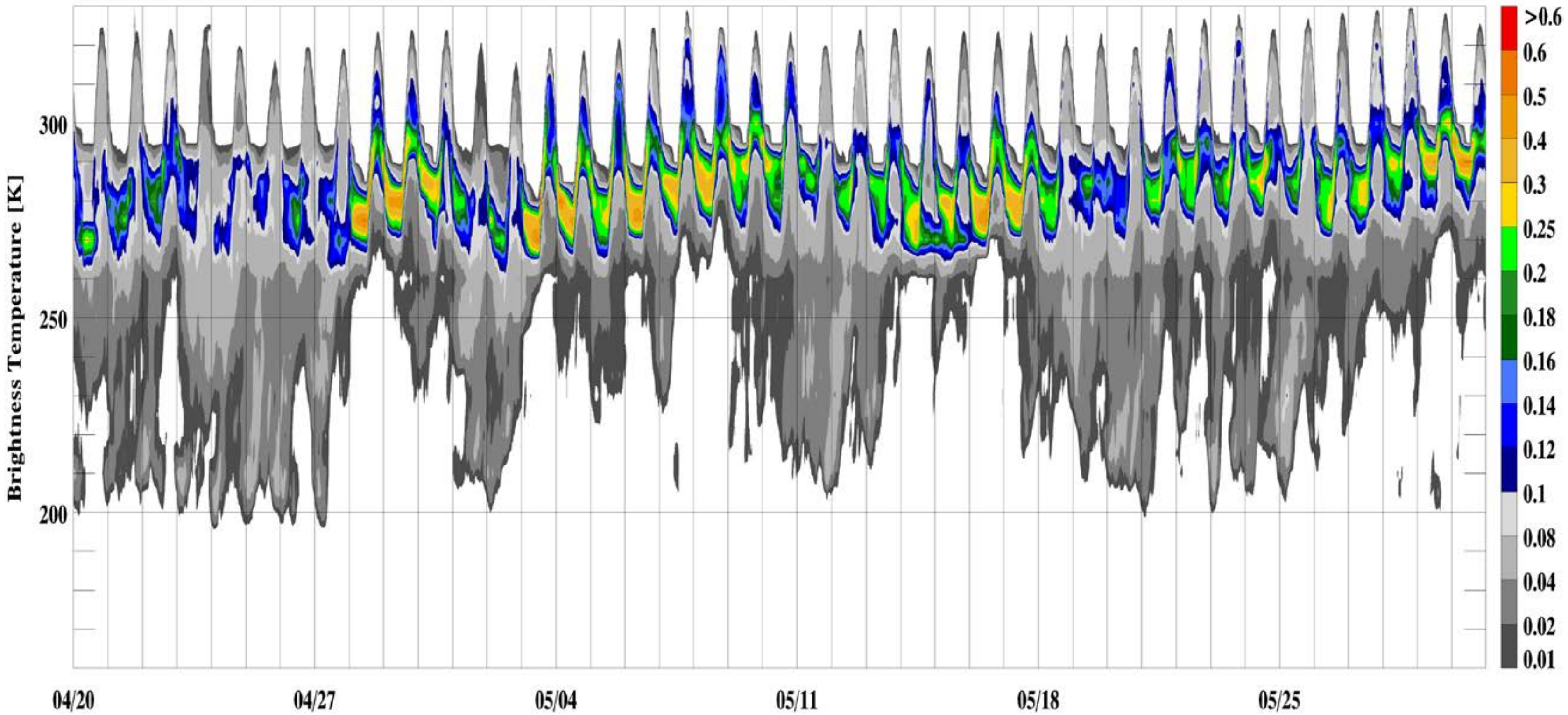
Key high resolution modeling papers to study the diurnal variation of the precipitation. Model types (MM5, WRF, GCE), microphysical schemes, cumulus parameterization, domain size (km), resolution (km), initial conditions, cases and integration time (hours) are listed.

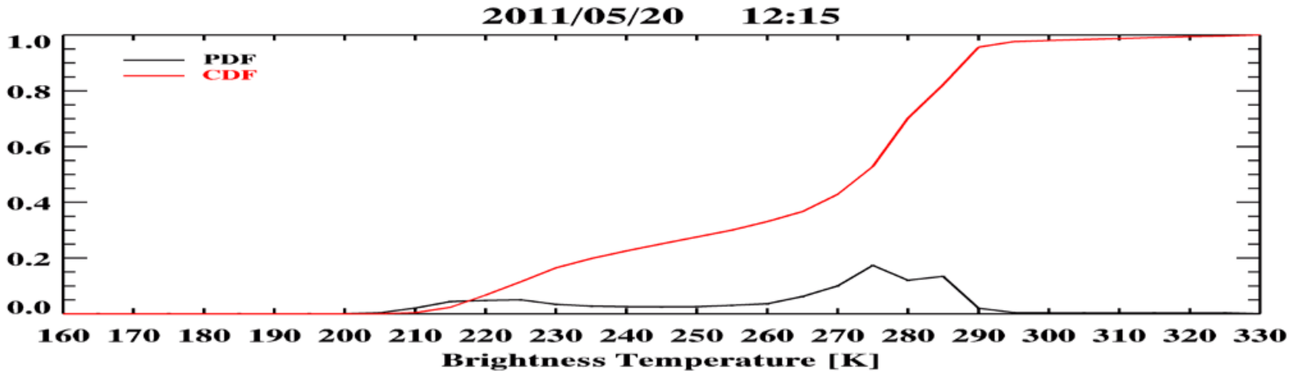
	Model	Forcing data	Physics	Domain Size	Resolution	Period
Moncrieff and Liu (2006)	MM5	Eta operational model analyses	Microphysics and Cumulus parameterization	2400 x 1800 km	3 and 10 km 40 layers	7 day simulation 3- 9 July 2003
Liu and Moncrieff (2007)	MM5	Eta operational model analyses	Different Microphysics Schemes	2400 x 1800 km	3 and 10 km 40 layers	7 day simulation 3- 9 July 2003
Surcel *et al.* (2010)	GEM	3DVAR regional Data Assimilation System	Kuo Kain and Fritsch	North America	15km 58 layers	30 h forecast Spring and Summer 2008
Clark *et al.* (2007)	WRF-NMM WRF-ARW	NAM 12km	Kain and Fritsch Ferrier	North Central US	5 km and 22km 38 layers	48 h forecast 1 April-25 July, 200
Davis *et al.* (2003)	Eta (NCEP) WRF	Eta forecast	Kain and Fritsch Simple ice scheme	Continental United States (CONUS)	22 km	1-3 day forecast 2001 (July–August) and 2002 (June–July
Trier *et al.* (2006)	WRF	Eta operational model analyses	Purdue - Lin	2500 x 1780 km	4 km	7 day simulation 3 - 10 July 2003
Lee *et al.* (2007)	GCE Model	DOE ARM SGP	Goddard 3-Ice scheme	128 km	1 km 41 layers	55 days Summer 1995, 1997 and 1999

The physical processes for the diurnal variation of rainfall over land during summer time in US, generally, are

(1) large-scale flow including eastward upper wind (Moncrief and Liu, 2006; and others),
(2) land surface (continental thermal) forcing including thermodynamic instability within PBL (Carbone *et al.* 2002; Warner *et al.* 2002; Lee *et al.* 2007; Trier *et al.* 2006);
(3) successive propagating organized convection caused by convective gravity wave (Carbone *et al.* 2002; Moncrieff *et al.* 2006);
(4) LLJ (Trier *et al.* 2006);
(5) diabatic heating effect (Moncrieff *et al.* 2066); and
(6) terrain effect (Carbone *et al.* 2002).

IR Bright Temperature – MC3E





Model Setup: Real-time and Post Mission

- Three nested domains: 18, 6, and 2 (1) km, and 40 (61) vertical layers.
- Physics:

  Goddard Improved Microphysics Scheme (is being tested for 6 cases using nu-WRF)

  2-Moment

  Spectral Bin

  Goddard Radiation scheme

  Grell-Devenyi ensemble cumulus scheme

  MYJ planetary boundary layer scheme

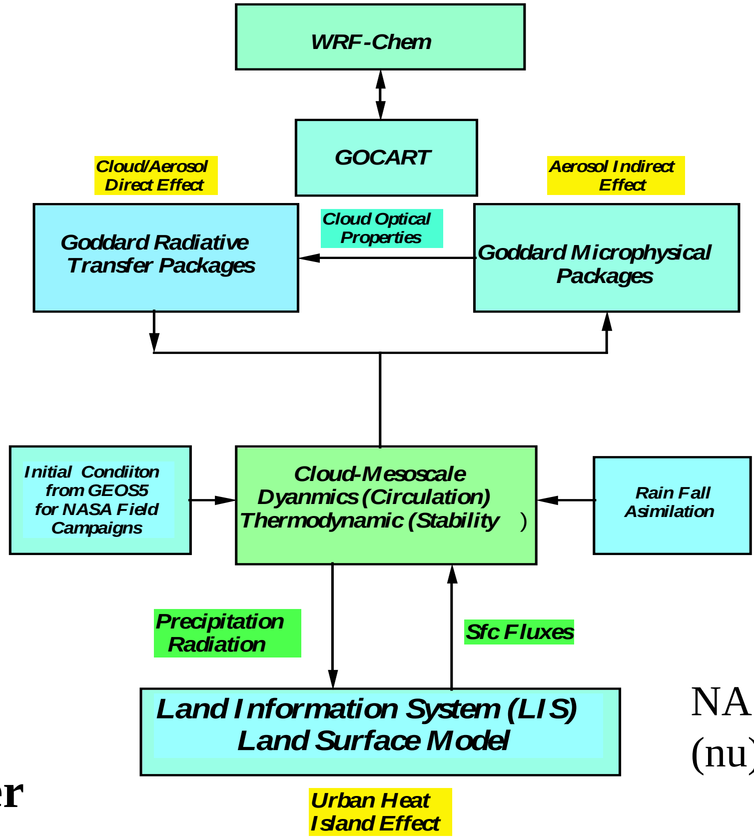
  Noah surface scheme

  Goddard LIS

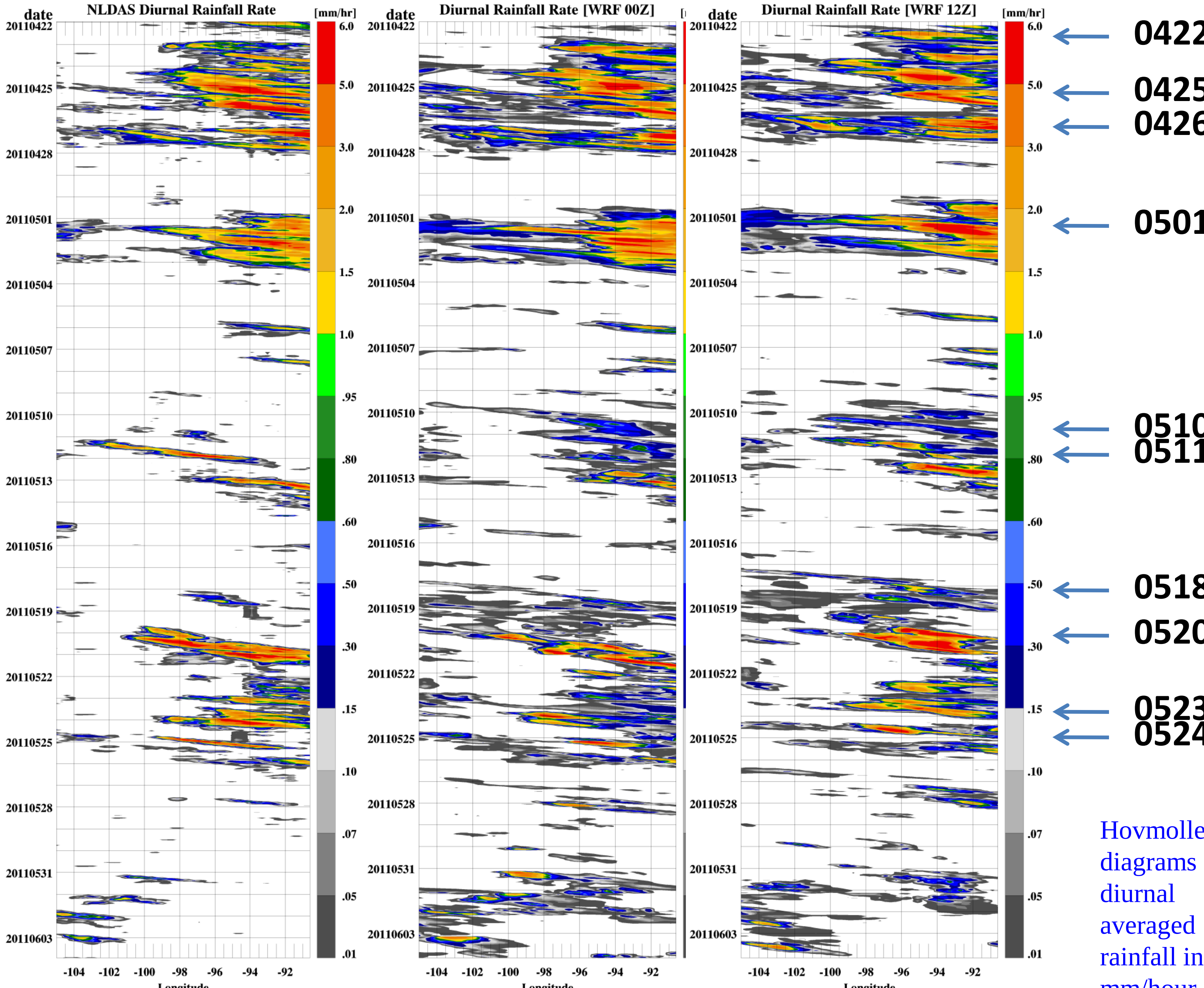
  Eta surface layer scheme
- Computational Cost: 360 CPUs, takes 1.5 hours to produce 48 hours forecast
- Initial condition: NAM, NARR, MERRA, GEOS5, ECMWF

REDs indicate those are still in testing

Inner domain will be modified – to be larger



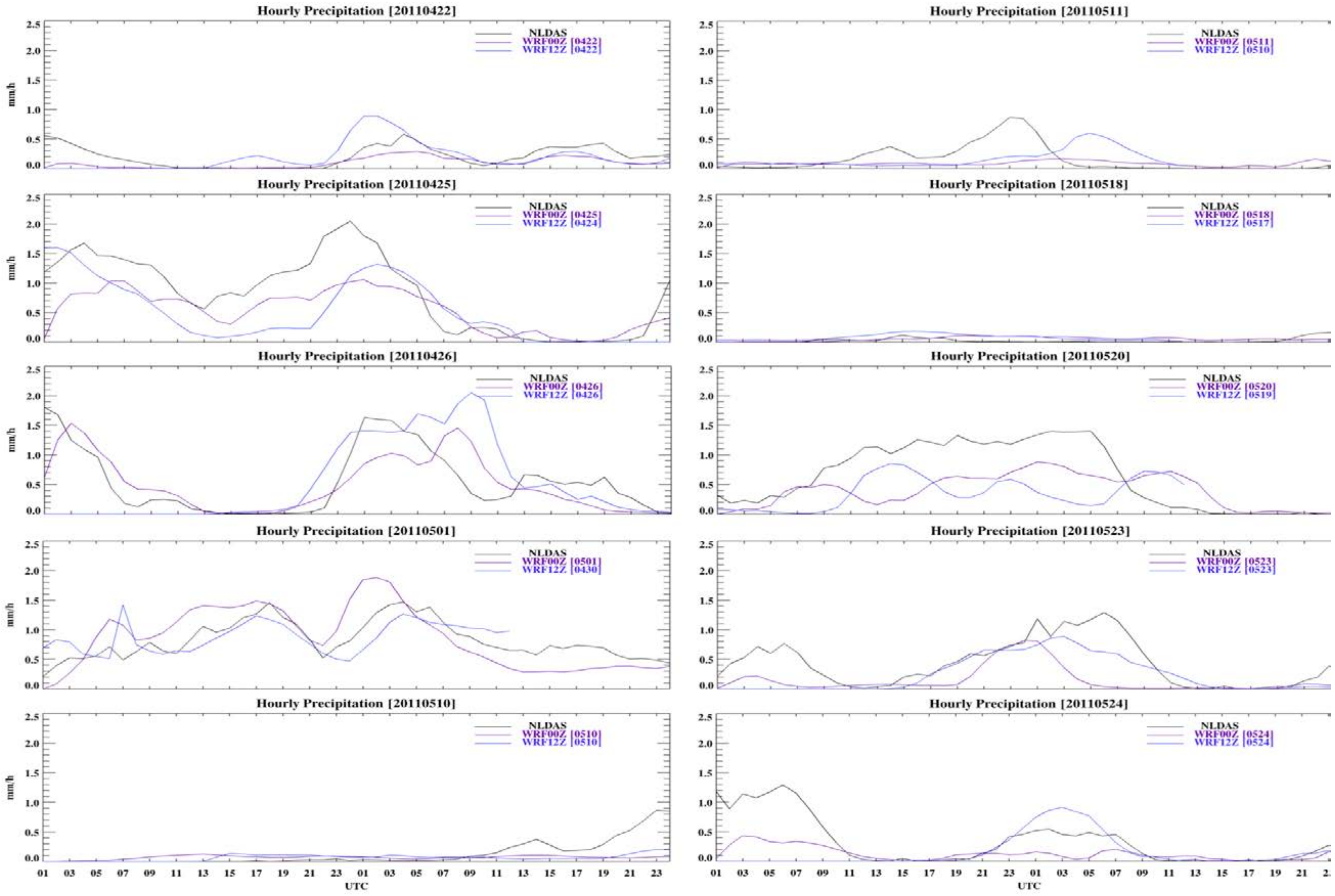
NASA Unified (nu) WRF



Hovmoller diagrams of diurnal averaged rainfall in mm/hour

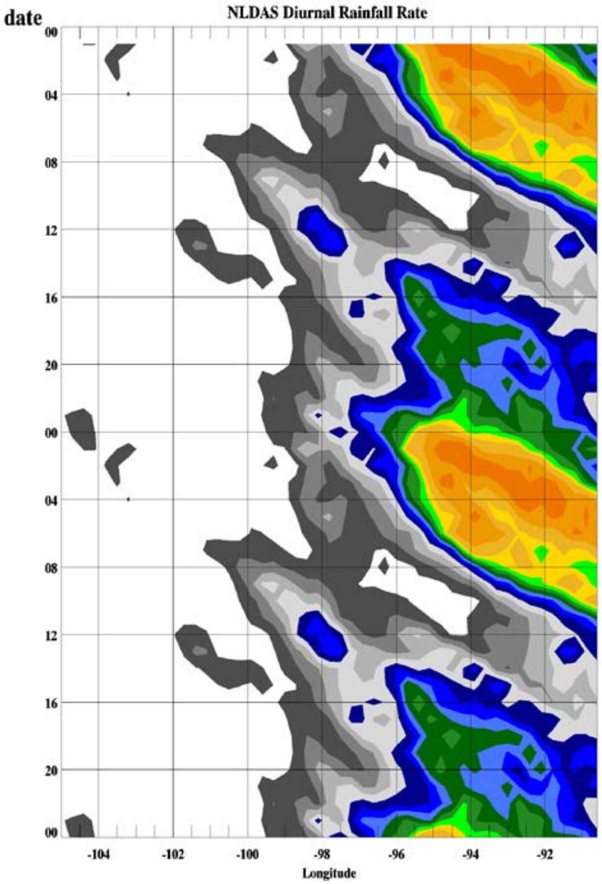
IOP #	Date	System	Forecast	Flight duration
1	21Z April 22 to 08Z April 23	Squall line with leading stratiform	Accurate	ER2: 1919Z on 22nd to 0113Z on 23rd Citation: 2234Z on 22nd to 0057Z on 23rd
2	07Z April 25 to 12Z April 25	Scattered storms	12Z previous day location is off	ER2: 0712Z to 1246Z on 25th 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

The MC3E precipitation events identified as the priority cases for post mission study.

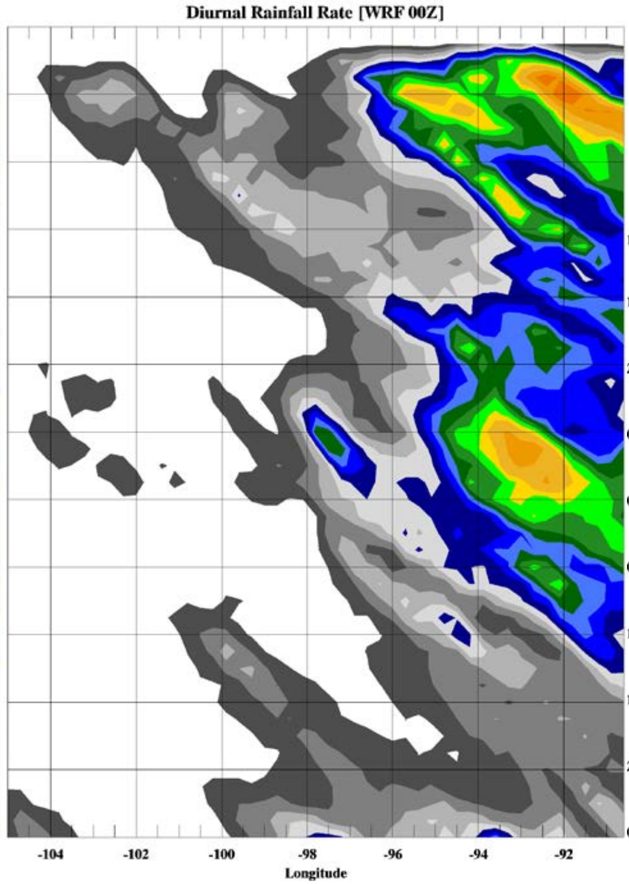


Time series of surface rainfall from all ten cases as shown in Table 2. Each panel shows observed and two WRF model simulations with different initial time (00Z and 12 Z). Note that the UTC time is 5 h ahead of local time.

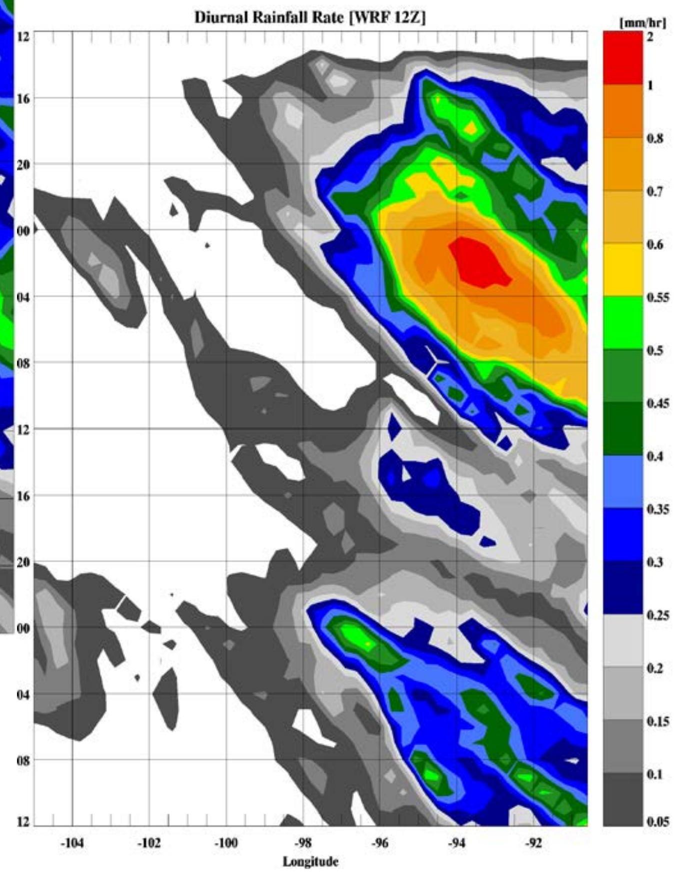
Obs.



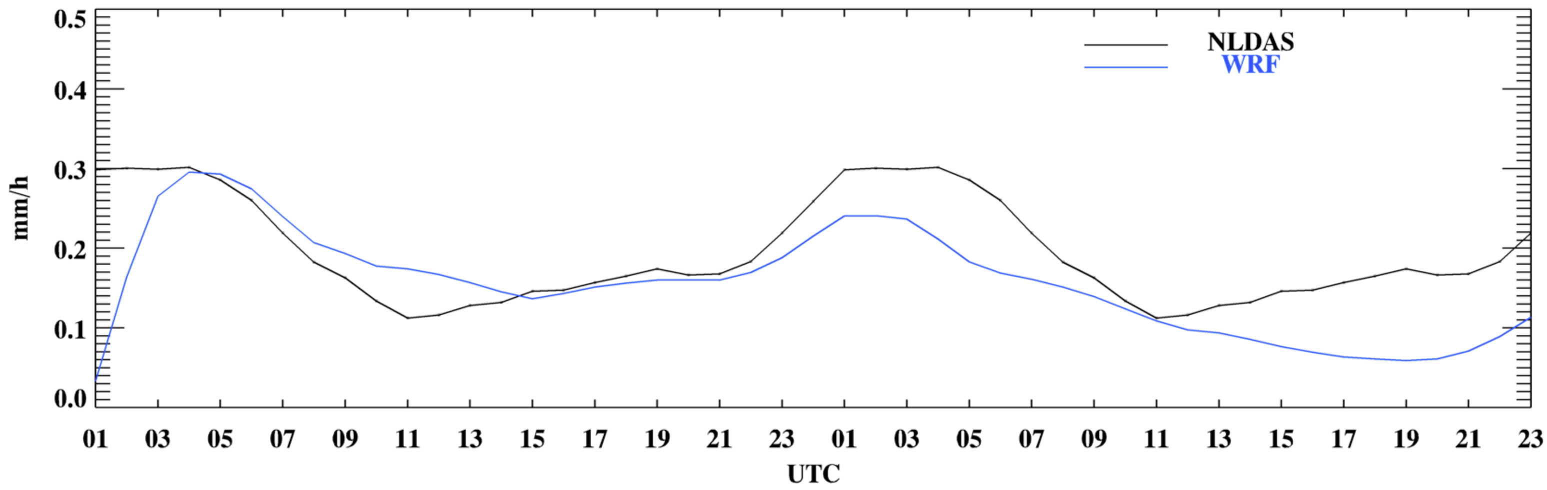
Real-time init. at 00z



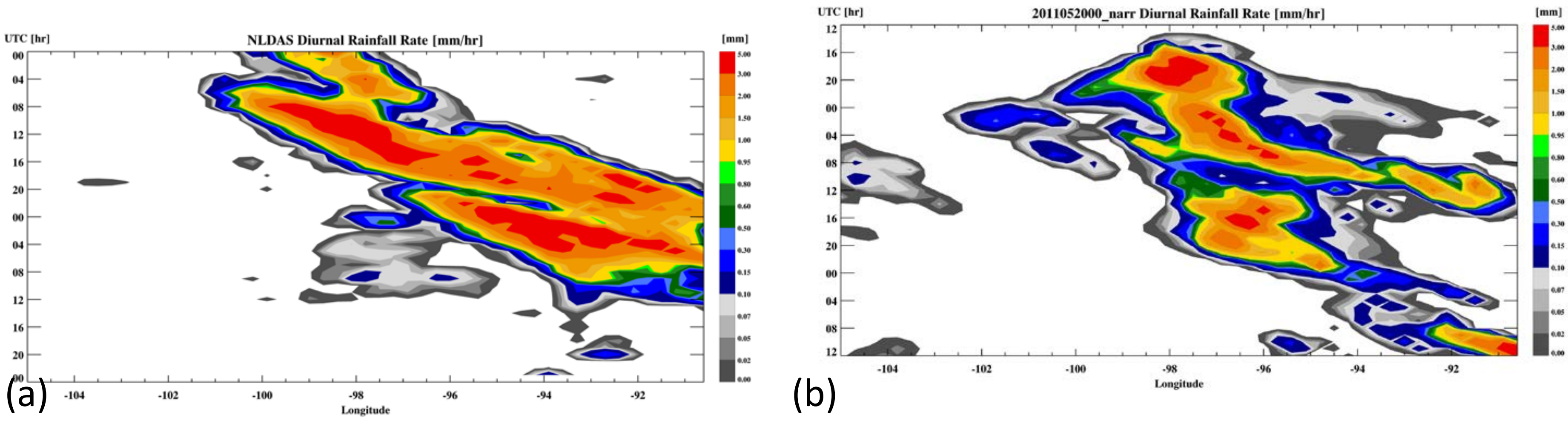
Real-time init. at 12z



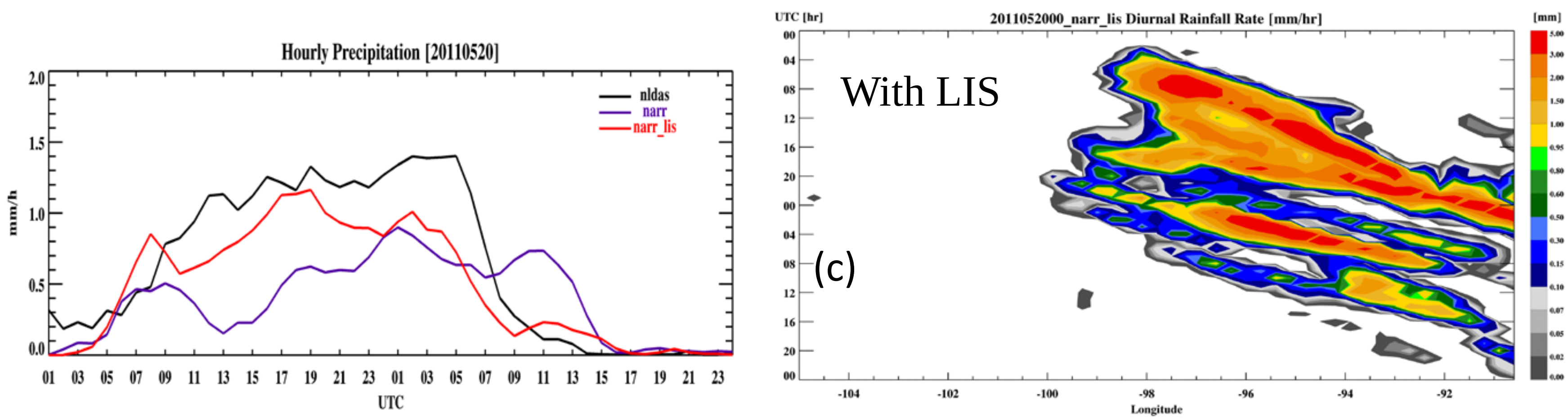
Averaged (or composite) over MC3E period



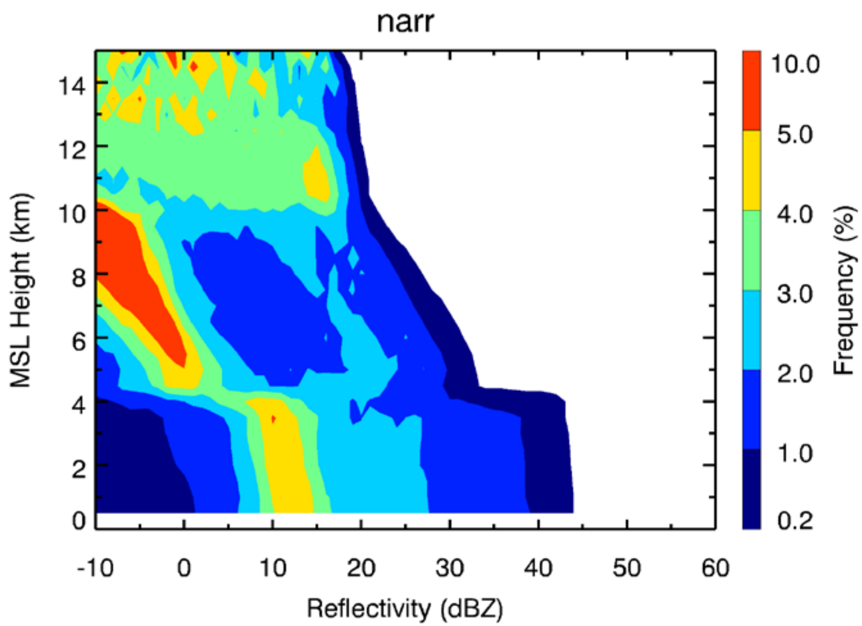
Time series of **composite** surface rainfall from 22nd April to 3rd June, 2011. Note that the UTC time is 5 h ahead of local time.

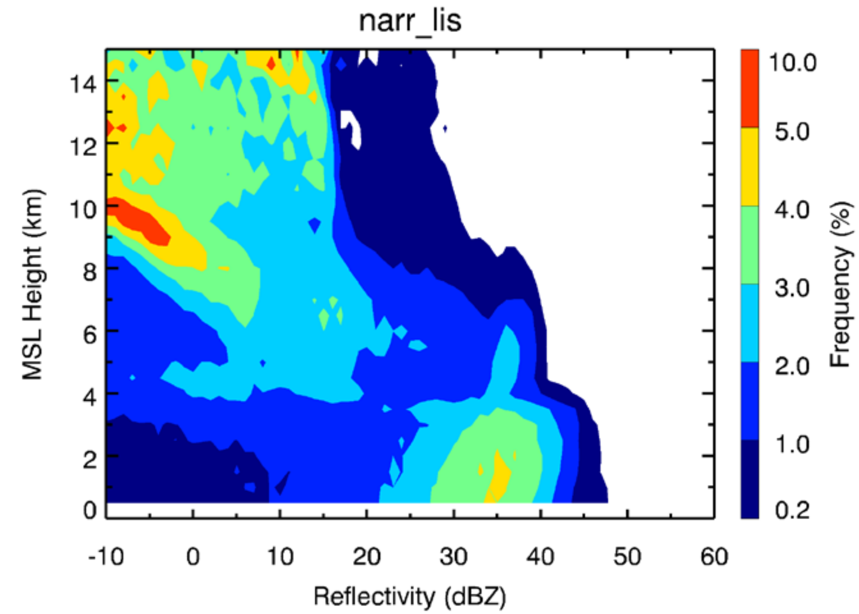


Results are better with LIS – diurnal variation and organization

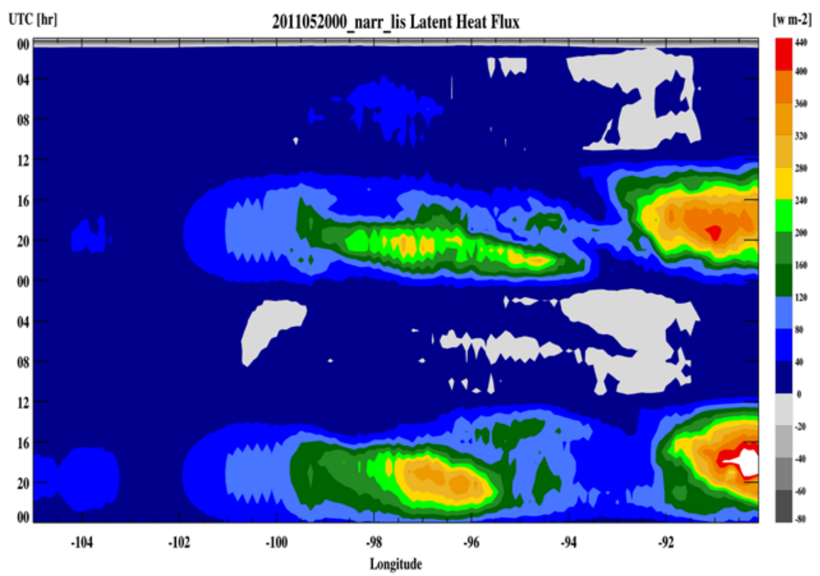


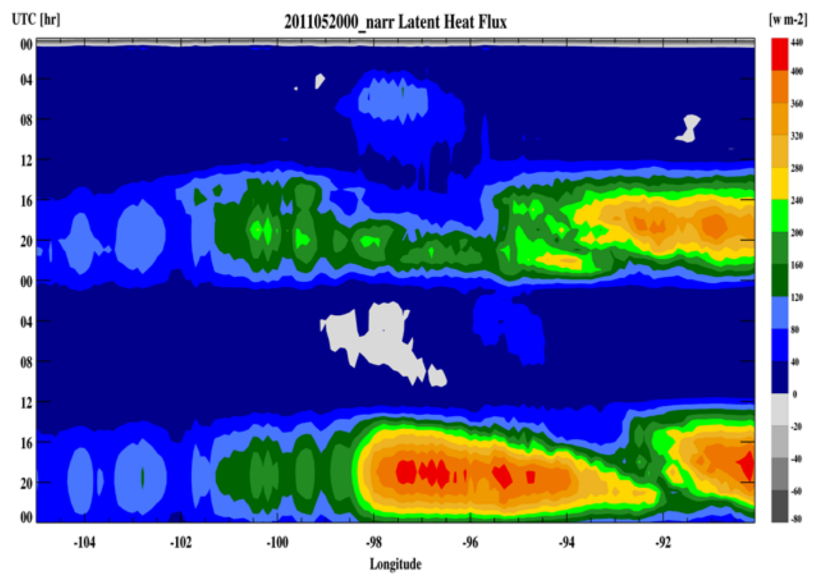
Conducting additional experiments in microphysics (3ice-hail, 4ice, 2-moment, spectral bin)



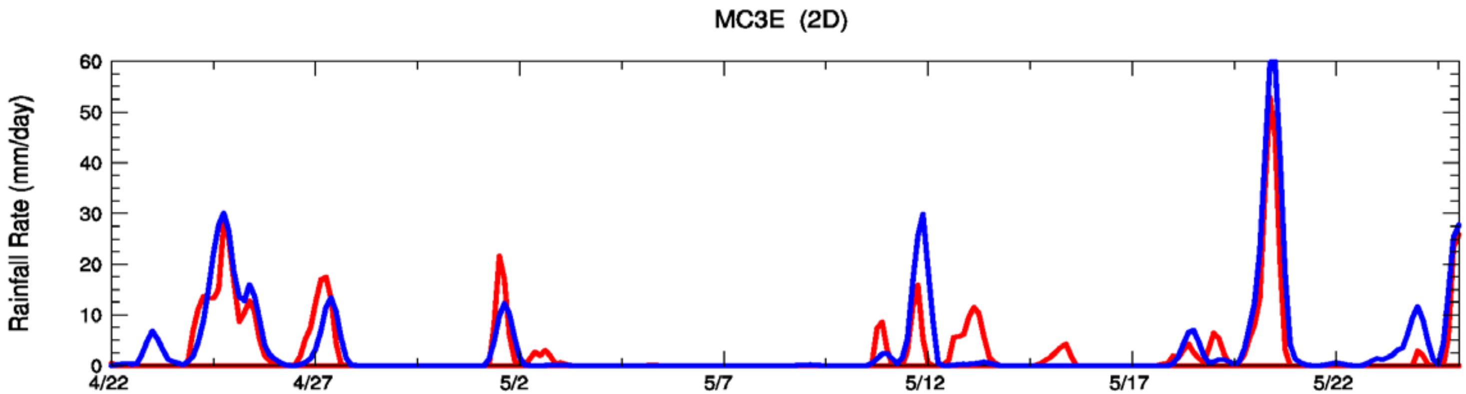


More stronger lower convective cloud precipitation with LIS

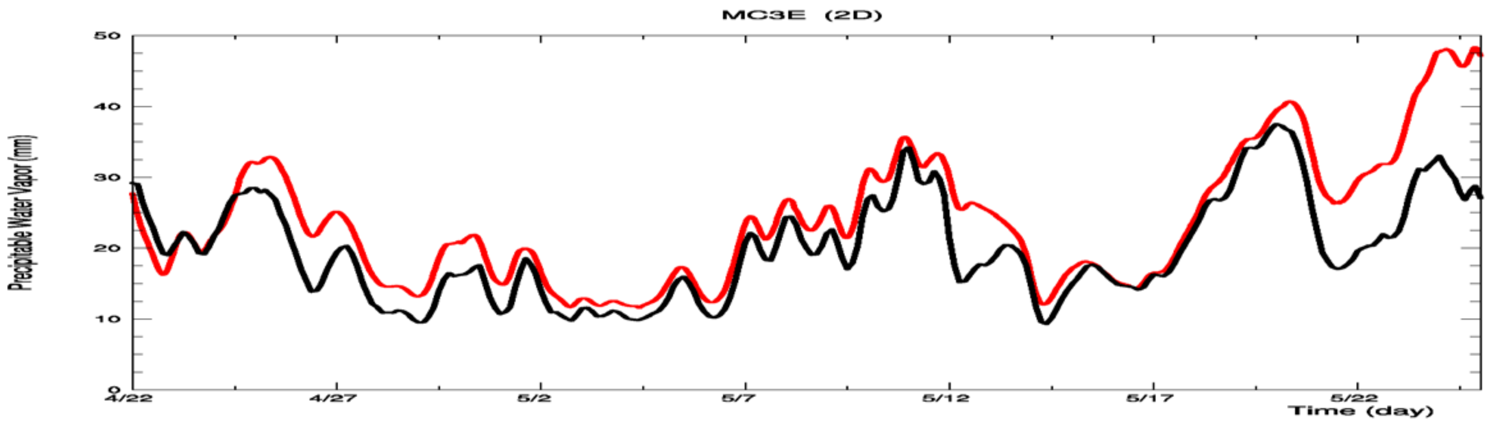




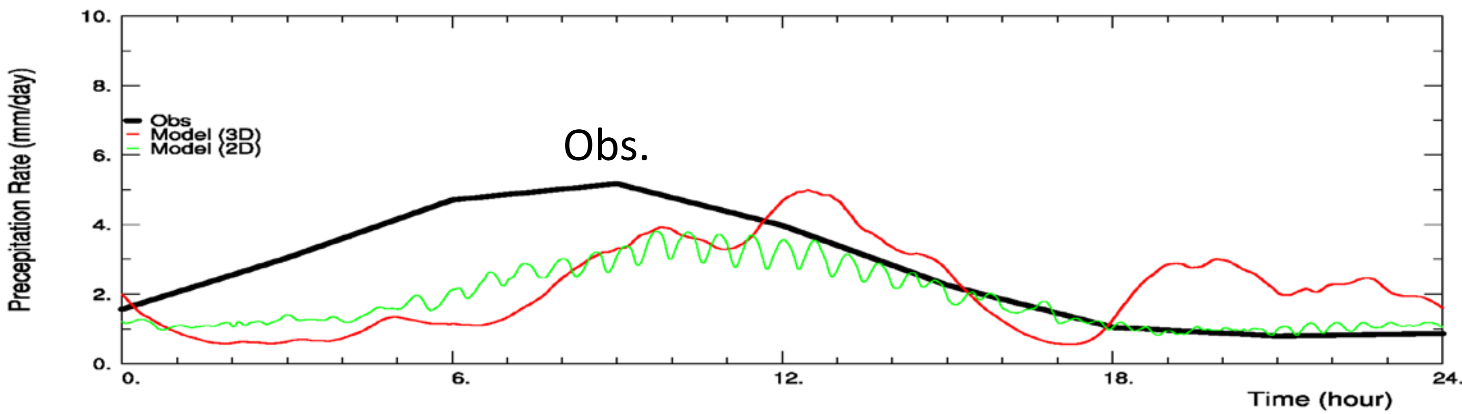
Rainfall



Total Precipitable water



Diurnal Rainfall



CRM Simulations using MC3E advective forcing