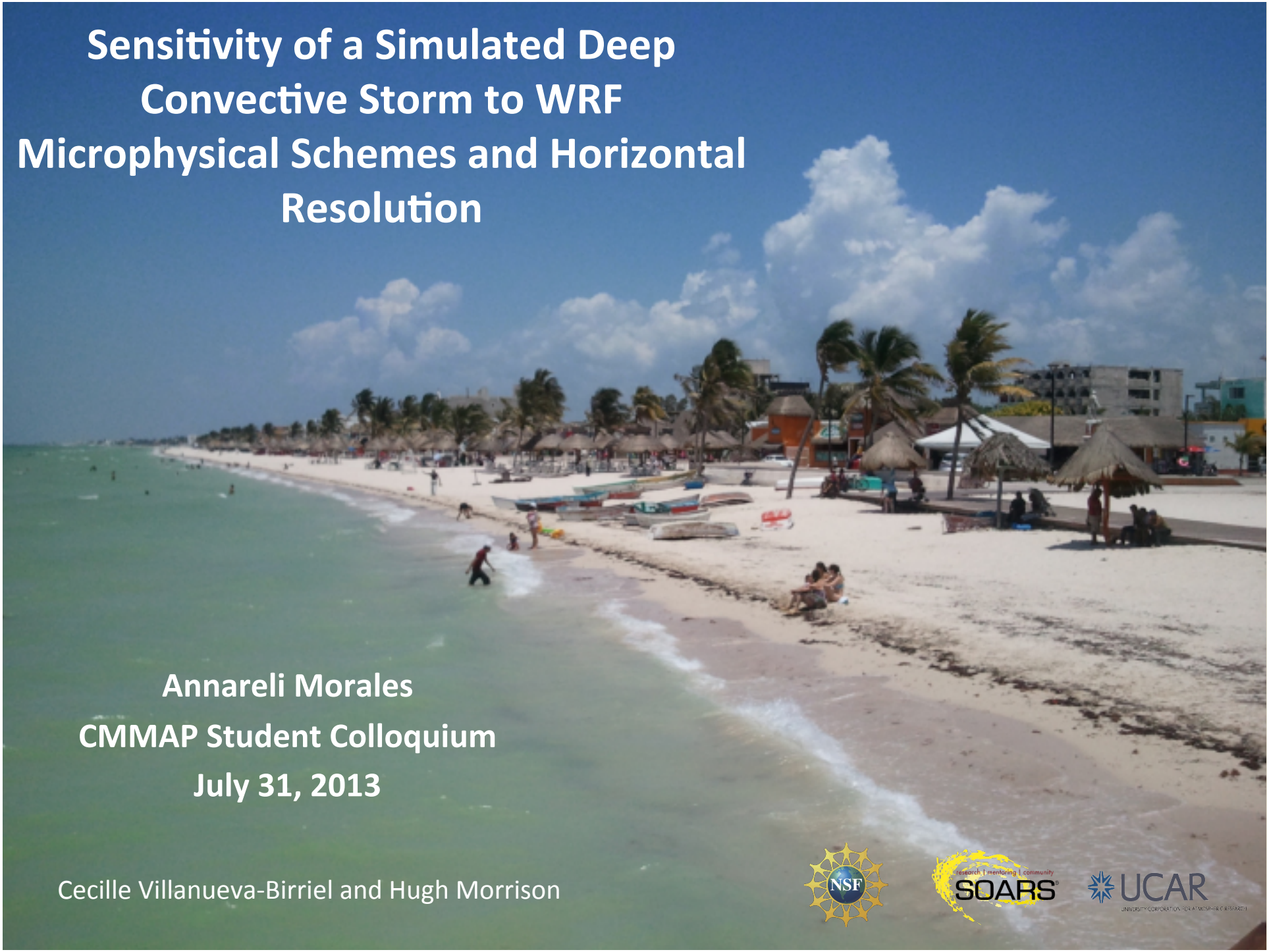
Sensitivity of a Simulated Deep Convective Storm to WRF Microphysical Schemes and Horizontal Resolution



Annareli Morales

CMMAP Student Colloquium

July 31, 2013

Cecille Villanueva-Birriel and Hugh Morrison

NSF SOARS UCAR

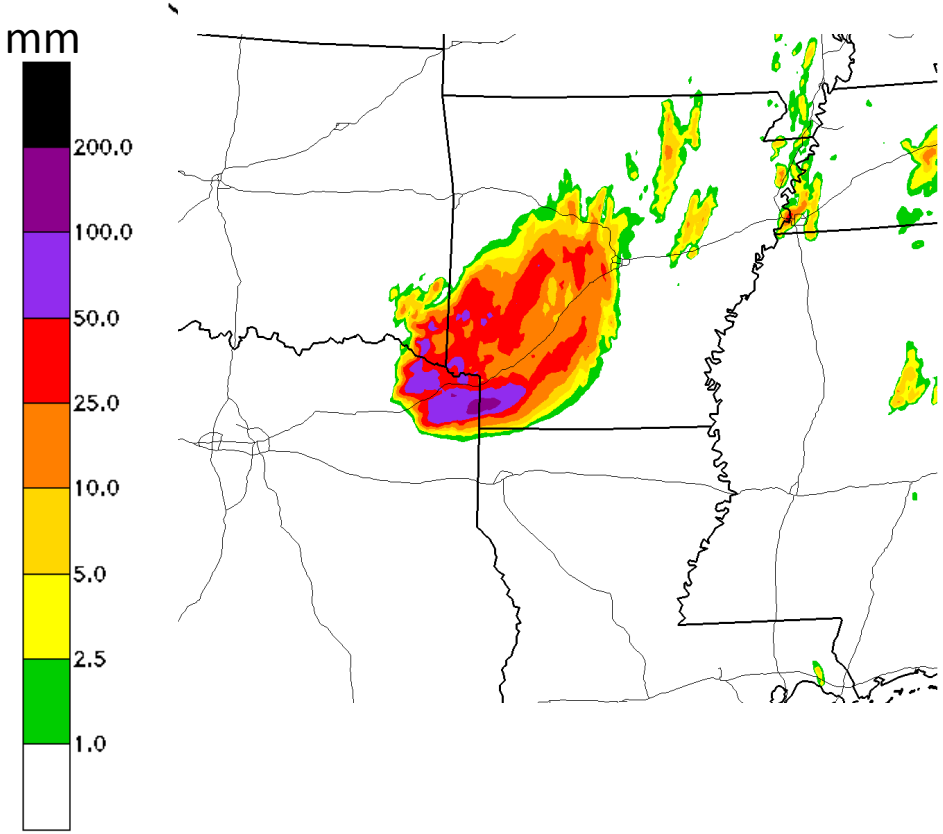
Motivation

- Uncertainties remain in operational forecasts and climate simulations due to choice of microphysics parameterization and resolution
- Past studies have shown
  - Microphysics can impact surface precipitation and cold pool development (Bryan and Morrison 2012)
  - Resolution can impact updraft strength (Bryan et al. 2003) and convective mass flux (Petch and Gray 2001)

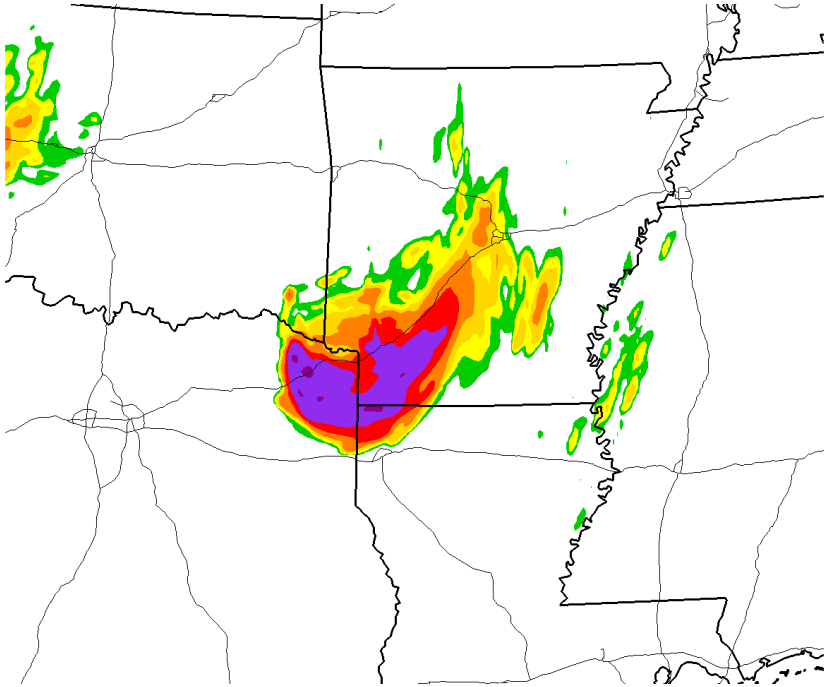
11 June 2010

Ensemble member forecasts range from very good…

Stage IV analysis, 6 hr ending 06Z/11 June



24-30 hour forecast (init 00Z/10)
Member s4m5_arw

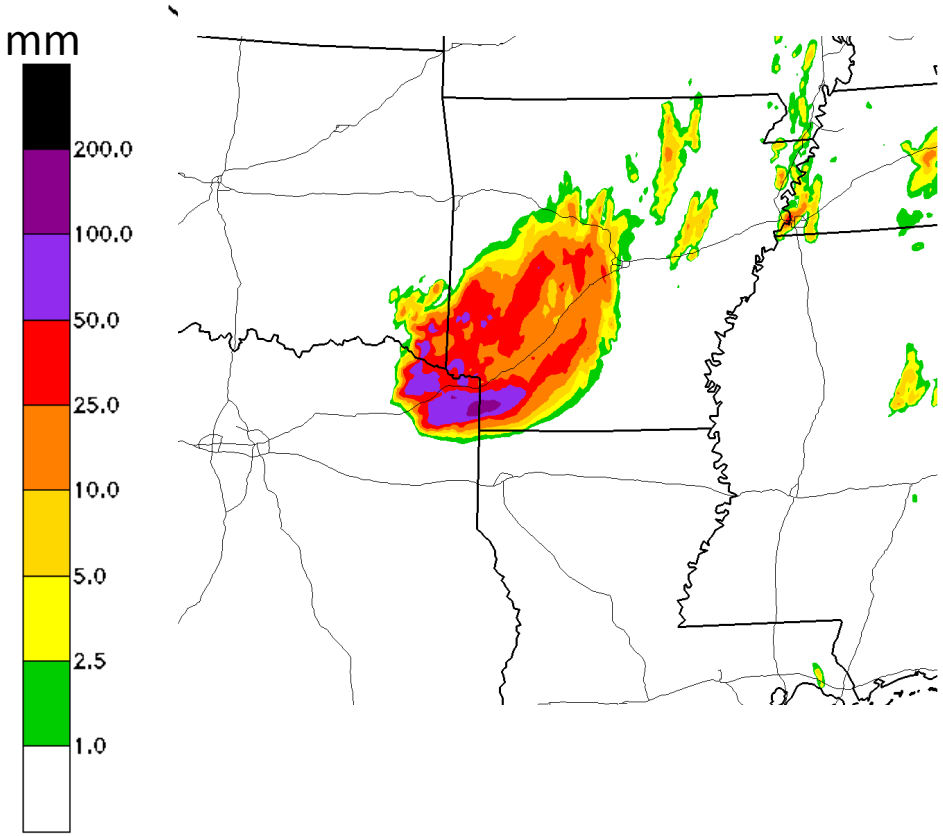


Courtesy of Russ Schumacher
(Schumacher et al. 2013)

11 June 2010

…to not so good

Stage IV analysis, 6 hr ending 06Z/11 June



24-30 hour forecast (init 00Z/10)
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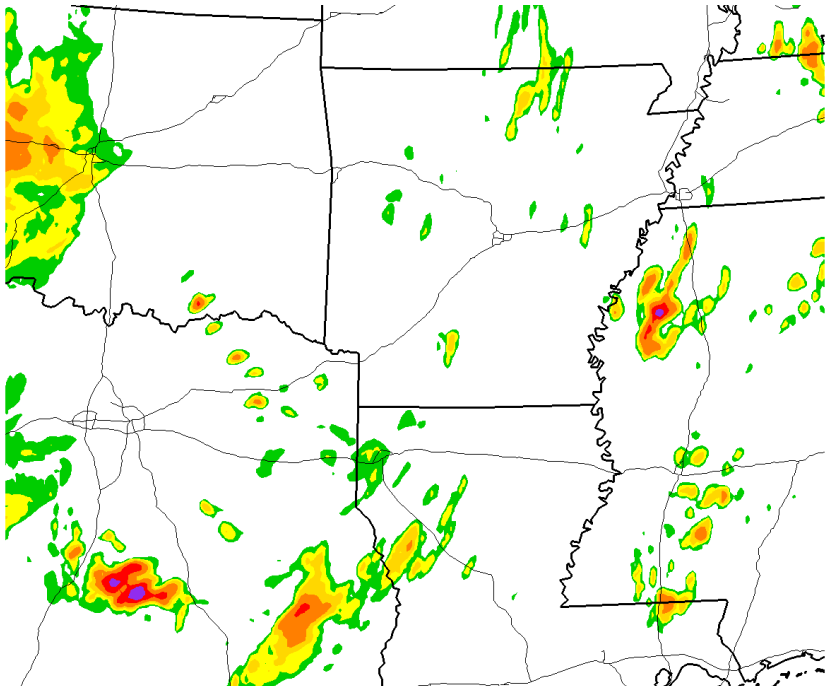


Courtesy of Russ Schumacher
(Schumacher et al. 2013)

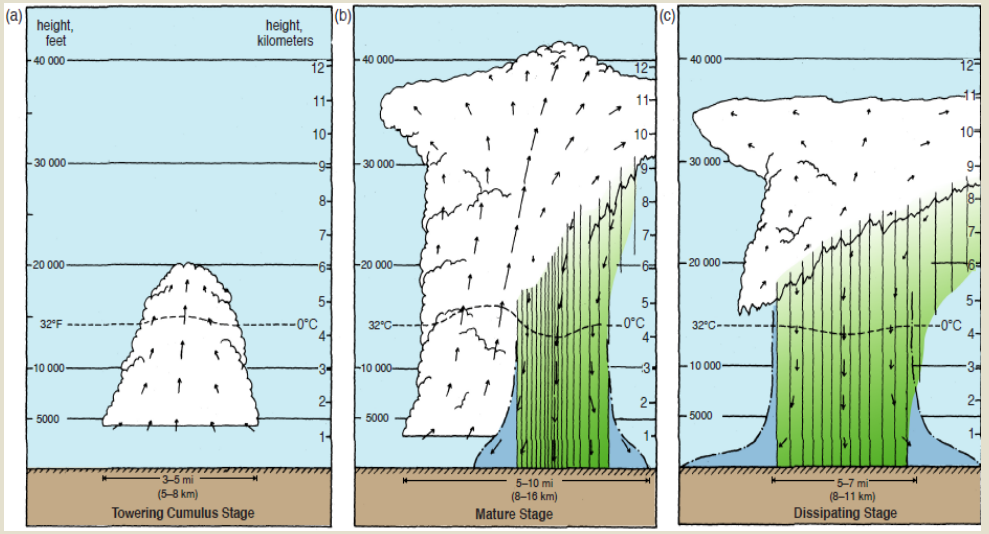
Research Objective

Understand the sensitivity of a deep convective storm simulation to changes in both microphysics parameterization and horizontal resolution

- Variety of resolutions, including high resolutions
- Different microphysical schemes
- Comparison of results with different atmospheric profile

Storm Simulation

- Advanced Research WRF Model (ARW) version 3.3.1
  - 3D non-hydrostatic meteorological regional model
- Idealized, single-cell deep convective storm
  - At "convection-permitting" scale (no convective parameterization)
  - Low vertical wind shear
  - Everything turned off (no radiative heating, surface fluxes) to only focus on effects due to microphysics
  - 90 minute simulation



Markowski and Richardson 2010

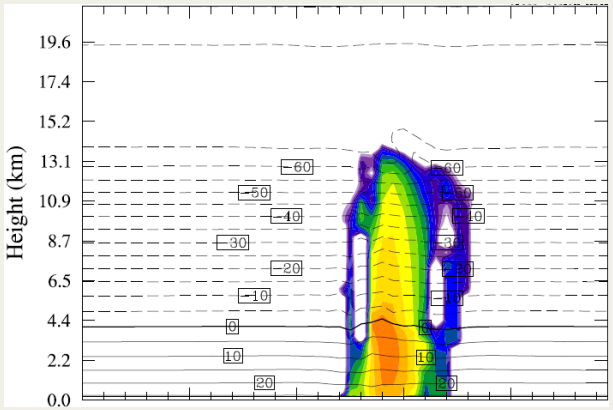
Test Setup

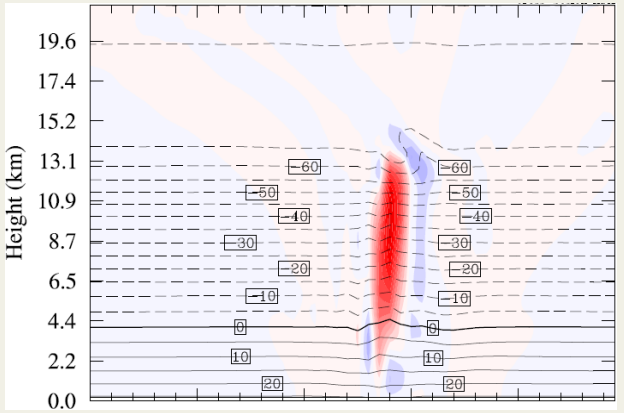
Resolution	2-Moment	"Mix"	1-Moment	
	Morrison	Thompson	WSM6	Morrison
2000 m	x	x	x	
1000 m	x	x	x	x
250 m	x	x	x	x
125 m	x	x	x	

RESULTS

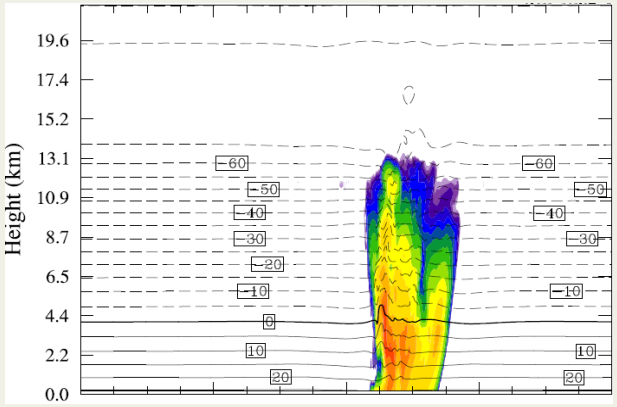
Structure varies with resolution

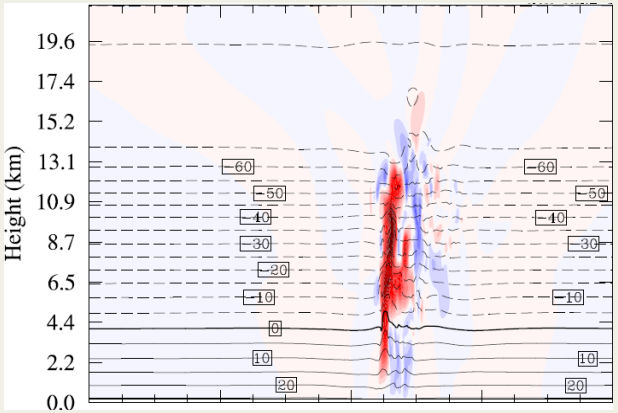
Δx = 2 km

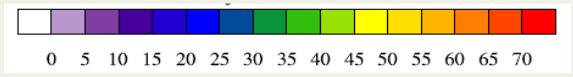


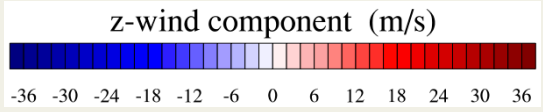


Δx = 125 m

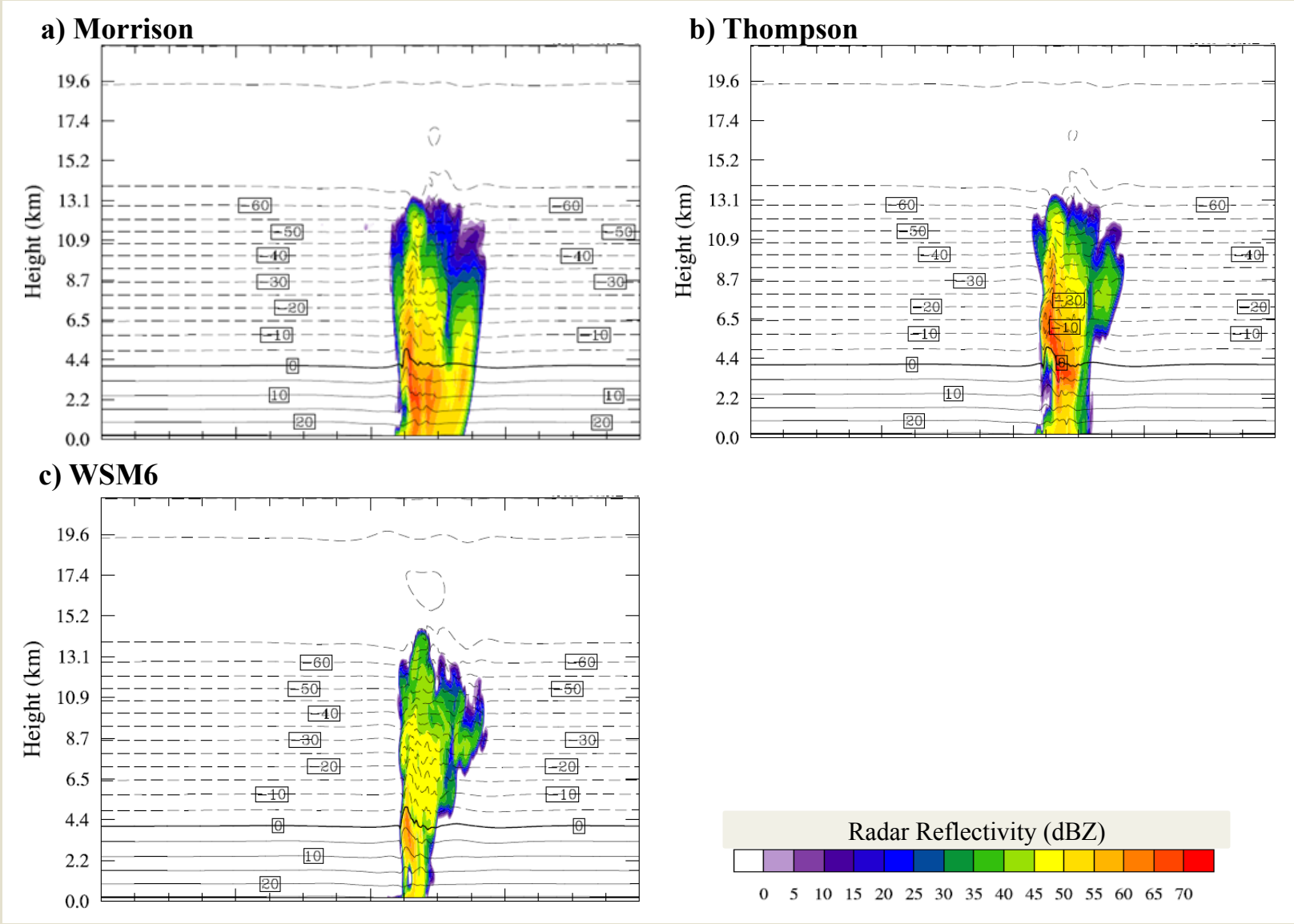






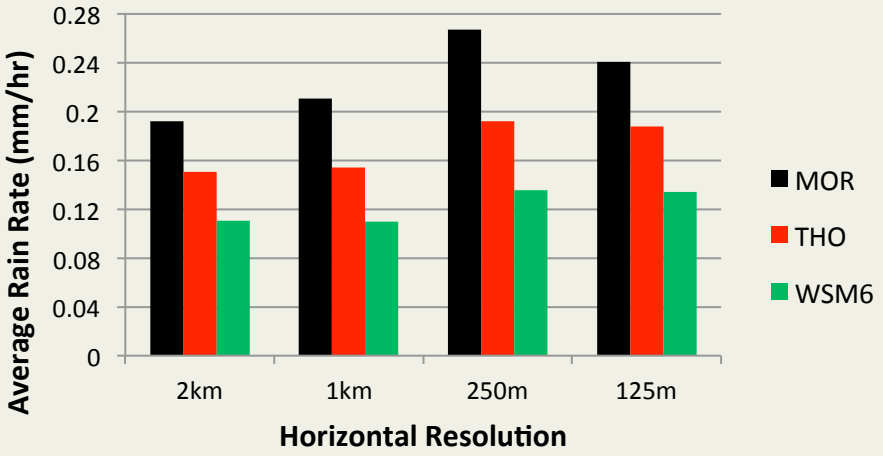


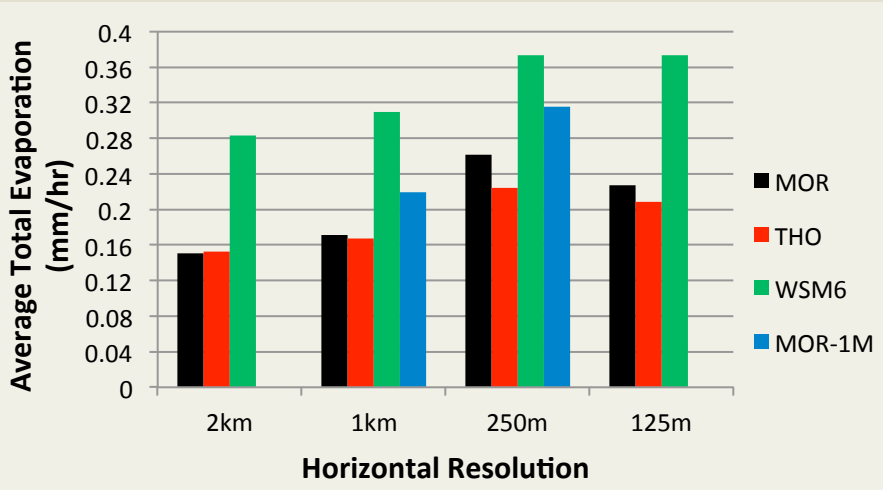
Structure varies with scheme



Surface precipitation

- WSM6 has lower surface precipitation across all grid spacings
  - Due to **higher evaporation**
  - Partly due to N_0 parameter set at relatively large value (shown by MOR 1M test)
    - Large N_0→ more numerous, smaller drops that evaporate faster

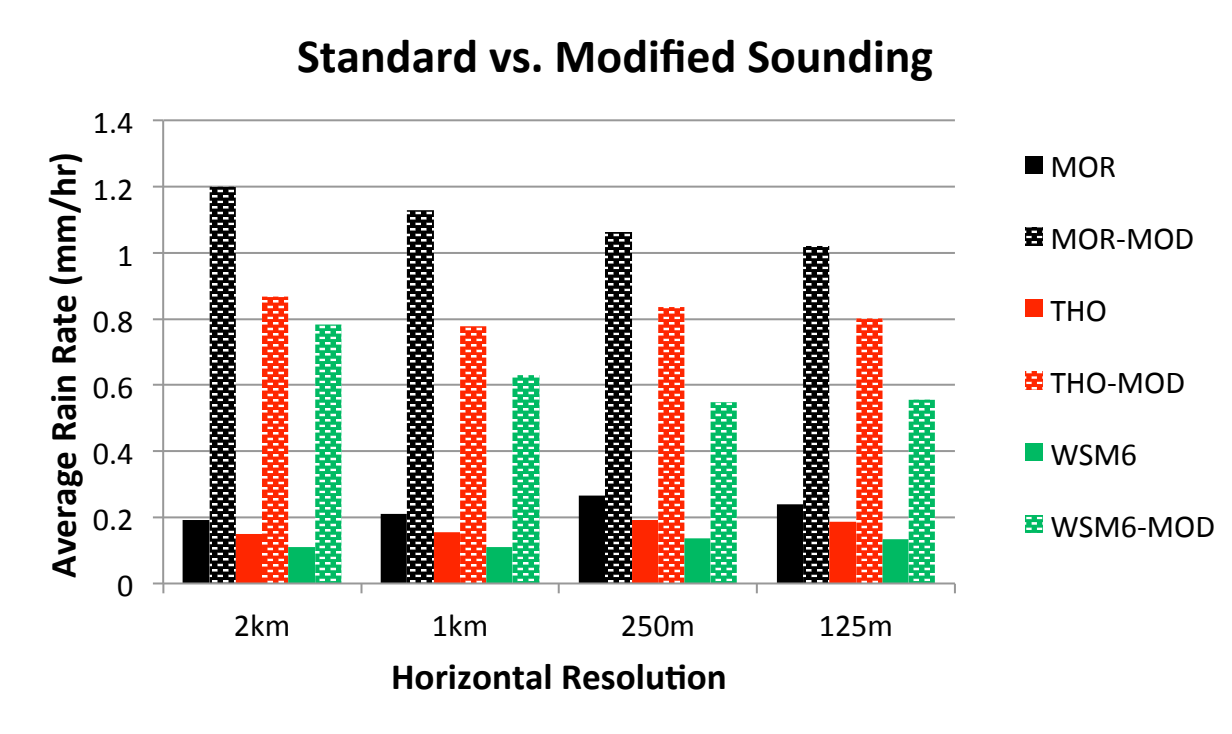




Values Courtesy of Cecille Villanueva-Birriel

Sensitivity to sounding

- Surface precipitation very sensitive to environmental sounding
  - Standard sounding: CAPE ~1000 J/kg
  - Modified sounding: CAPE~4000 J/kg



Values Courtesy of Cecille Villanueva-Birriel

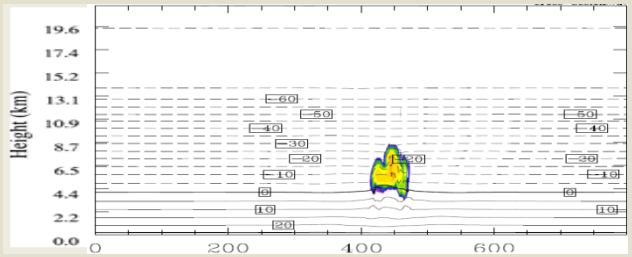
Conclusions

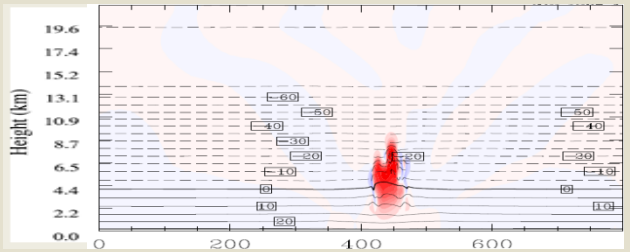
- Both microphysics and horizontal grid spacing sensitivities are important
- Microphysics differences are consistent across different resolutions
  - WSM6 has lowest surface rain fall across grid spacings
- Sensitivity of surface precipitation to horizontal grid spacing is VERY sensitive to the environmental sounding

Thank you!
Questions?

Simulation-Storm Evolution

20min





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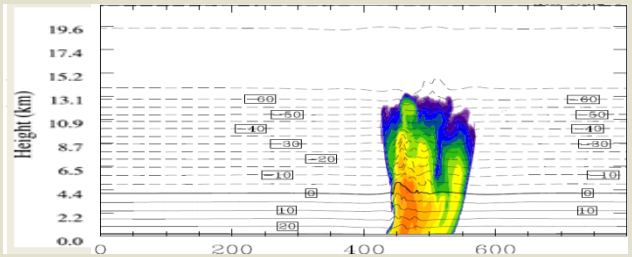

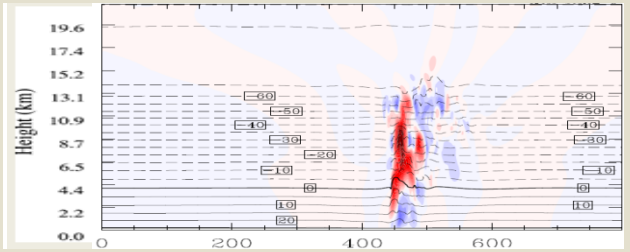

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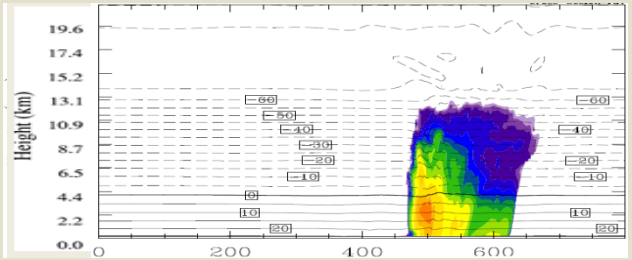

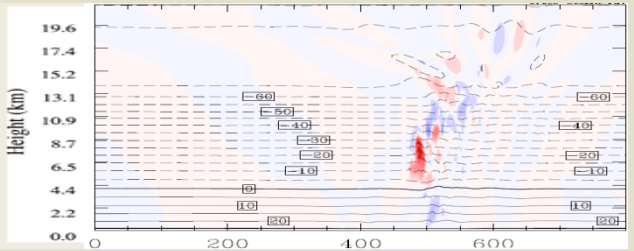

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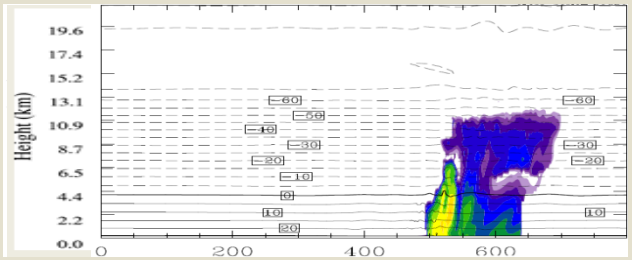

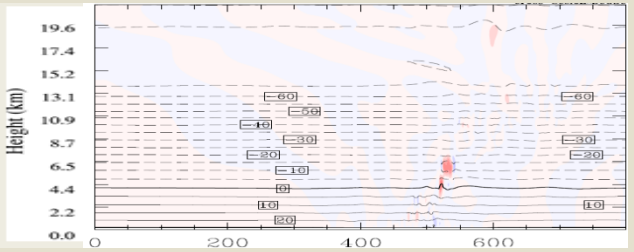

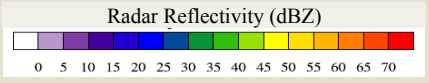

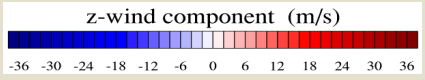

Master Table-Standard Sounding

Resolution (km)	Average Total Condensation (mm/h)	Average Rain Rate (mm/h)	Precipitation Efficiency (%)	Average Total Evaporation (mm/h)
Morrison				
2	0.2233	0.1921	86.03	0.1502
1	0.2327	0.2104	90.41	0.1713
0.25	0.4017	0.2666	66.38	0.2619
0.125	0.3360	0.2406	71.59	0.2271
Thompson				
2	0.2084	0.1502	72.08	0.1530
1	0.2093	0.1542	73.69	0.1669
0.25	0.3289	0.1922	58.42	0.2244
0.125	0.3121	0.1875	60.08	0.2089
WSM6				
2	0.2237	0.1102	49.29	0.2834
1	0.2136	0.1095	51.25	0.3095
0.25	0.3098	0.1354	43.71	0.3737
0.125	0.3135	0.1340	42.73	0.3737
Morrison 1M				
1	0.2654	0.1600	60.29	0.2190
0.25	0.4067	0.2055	50.52	0.3156