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

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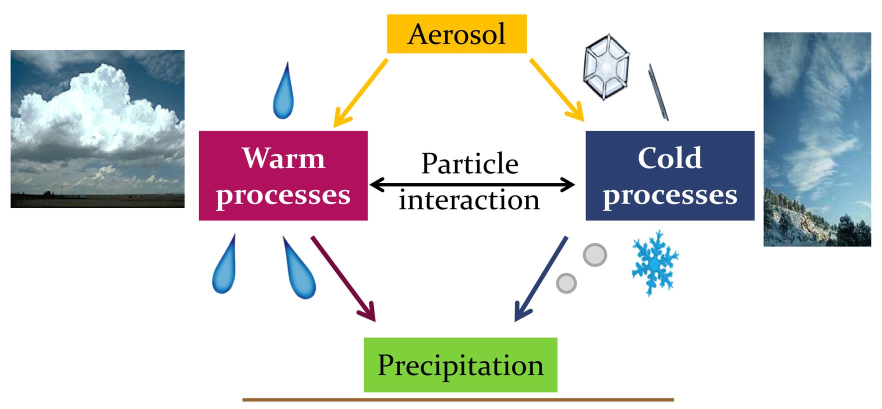
Motivation

- Microphysical (MP) parameterizations describe the processes by which water and ice particles grow and precipitate
  - Allow models to represent cloud processes that occur on the microscale and cannot be properly resolved
- Uncertainties in climate simulations and operational forecasts remain due to choice of scheme and resolution



Our research compares different microphysical schemes at different horizontal resolutions to understand their effect on a simulated deep convective storm

Methods

Model used

- Advanced Research WRF (ARW) version 3.3.1—in idealized mode
  - Simulation:
    - -single, isolated deep convective storm
    - - low wind shear environment
  - Horizontal Grid Spacing:
    - Δx = 2 km
    - Δx = 1 km
    - Δx = 250 m

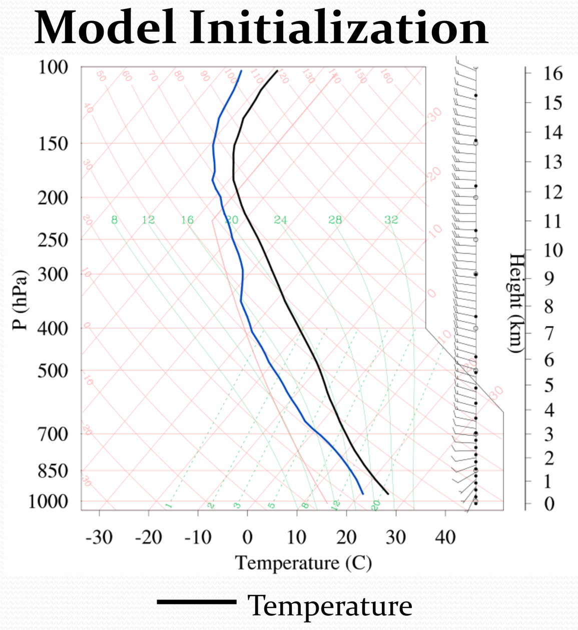
Microphysical Schemes Used

Parameterization*	Mass Variables	Number variables
WSM6	Qc Qr Qi Qs Qg	
Thompson	Qc Qr Qi Qs Qg	Nr Ni
Milbrandt-Yau	Qc Qr Qi Qs Qg Qh	Nc Nr Ni Ns Ng Nh
Morrison	Qc Qr Qi Qs Qg**	Nr Ni Ns Ng

* all include mixed-phase processes
** contains switch to include either graupel or hail

Mass mixing ratio (Qx), Number concentration (Nx), and Hydrometeor species (x), where x = cloud water (c), rain (r), ice (i), snow (s), graupel (g), and hail (h)

Model Initialization



- Initial Sounding calculated from the NCAR Community Climate System Model version 3 (CCSM3)
  - CAPE threshold of 1000 J/kg
  - Averaged for the summer months (June, July, August) for 1970-1999 at Jasper, IN

Results

Master Table

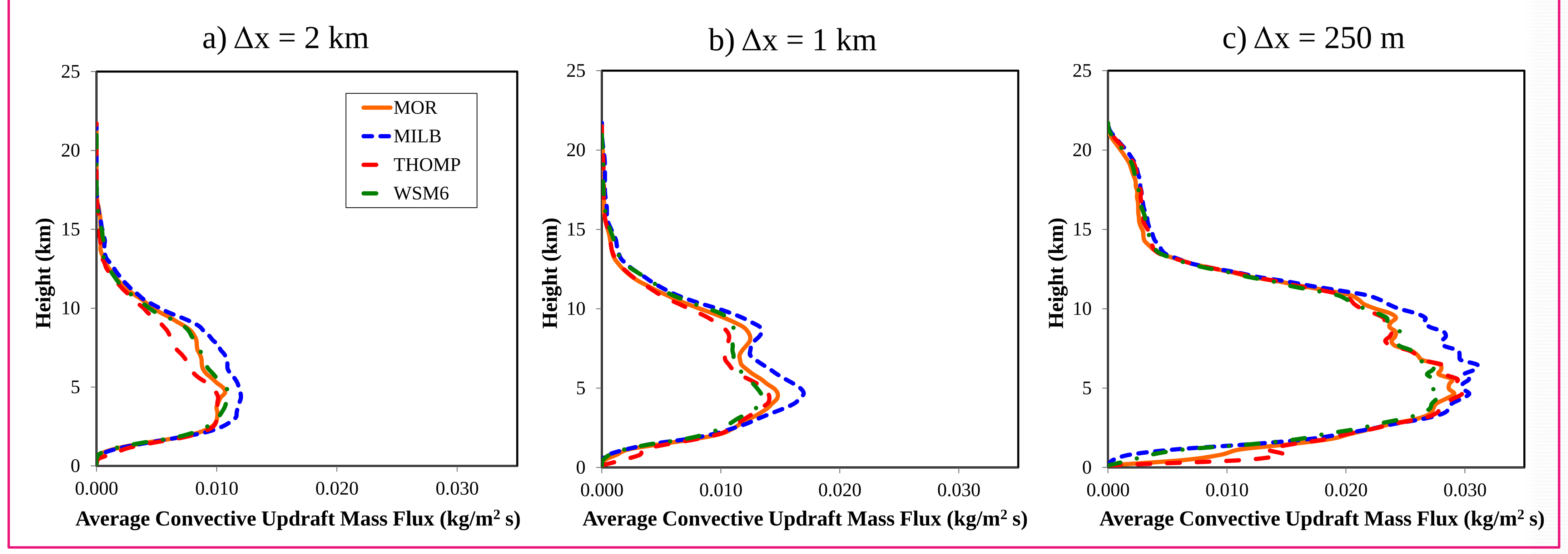
	Average Condensation (mm/h)	Average Rain Rate (mm/h)	Precipitation Efficiency	Average Evaporation (mm/h)	Accumulated Rain (mm)
WSM6					
2 km	0.2931	0.0782	26.68%	0.2171	0.1173
1 km	0.3081	0.0821	26.63%	0.2274	0.1231
250 m	0.5326	0.1482	27.83%	0.3824	0.2223
Thompson					
2 km	0.2885	0.1077	37.34%	0.0901	0.1616
1 km	0.3151	0.1133	35.96%	0.0918	0.1699
250 m	0.5591	0.1967	35.19%	0.1448	0.2951
Milbrandt-Yau					
2 km	0.3717	0.1303	35.04%	0.1838	0.1954
1 km	0.3809	0.1232	32.36%	0.1906	0.1849
250 m	0.6398	0.1910	29.85%	0.3230	0.2865
Morrison					
2 km	0.3136	0.1303	41.56%	0.1487	0.1955
1 km	0.3390	0.1352	39.90%	0.1583	0.2029
250 m	0.6187	0.2532	40.93%	0.2651	0.3799

1. **Large increases in precipitation with increasing resolution**
2. **WSM6 produces lowest surface precipitation amount**
3. **Differences among schemes consistent at different resolution (see Master Table)**

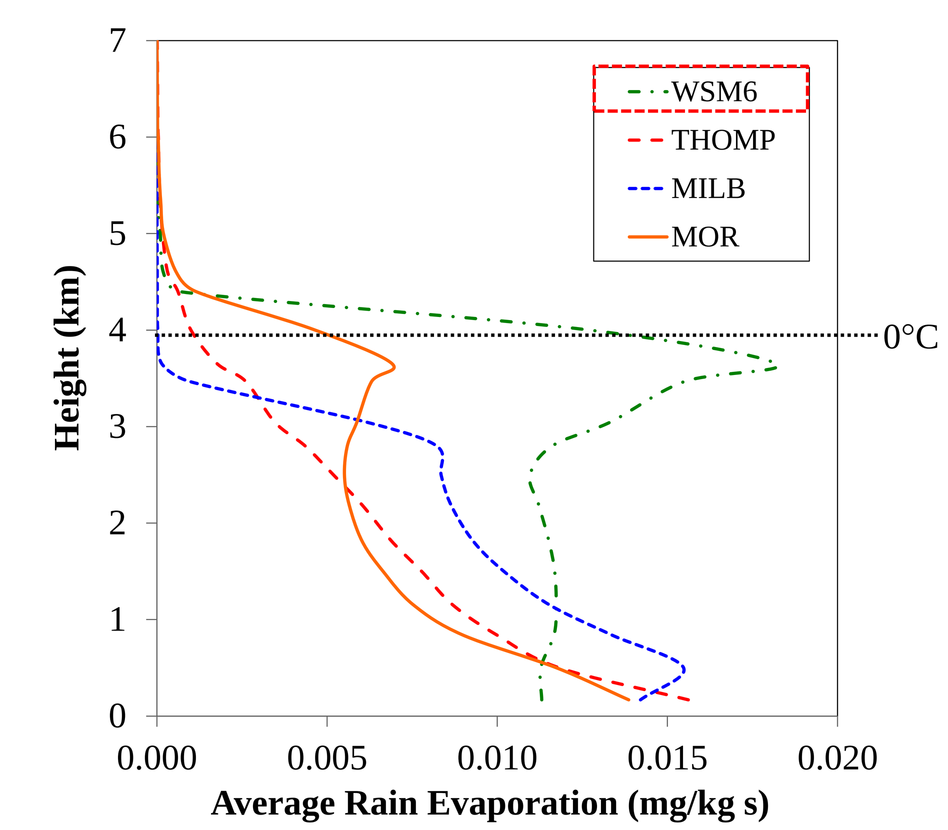
1.

Increased rain rate a result of increased condensate

↳ Greater condensate associated with increased convective updraft mass flux



2.



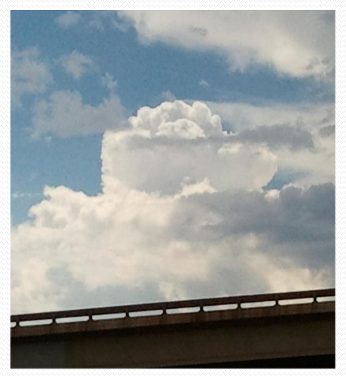
Low surface precipitation for WSM6

↳ Result of high evaporation rate

- Raindrops evaporate at a higher rate over a greater depth
  - Peak is near 4km (melting level)
- Evaporation in other parameterizations peaks near the surface
  - Less impact on surface precipitation

Conclusion

- Choice of microphysical parameterization and horizontal resoltion has a large impact on surface precipitation, storm structure and dynamics



Future Work

- Running simulations at a higher resolution (e.g. 125 m grid spacing)
- Initializing storms with different soundings
- Perform further microphysical analysis

Photo credit to Rene Velazquez

Acknowledgements & Contact Info

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