The Role of Cloud Microphysics in the Simulation of Mesoscale Convective Systems (MCS) in the Tropical Western Pacific

K. Van Weverberg[1,2], A.M. Vogelmann[1], W. Lin[1], E.P. Luke[1], A. Cialella[1], P. Minnis[3], M. Khaiyer[4], E.R. Boer[5], M.P. Jensen[1]

[1] Brookhaven National Laboratory, [2] Université catholique de Louvain, [3] National Aeronautics and Space Administration Langley Research Center, [4] Science Systems and Applications, Inc. , [5] Entropy Control, Inc.

Motivation

- Tropical deep convection and related high clouds are crucial to the global radiation and water balance, yet remain a challenge for CRMs
- Physical reasons for discrepancies between different models should be understood to improve the simulation of such clouds
- Sensitivity of CRM MCS simulations to various microphysics parameterizations using a very large TWP domain size

1. Simulation details

- WRF 6-day simulations December 2003, driven by GFS
- 1725 × 1110 × 35 gp, Δx=4 km, sensitivity with 3 microphysics schemes:

WSM6: 1-moment scheme *(Hong and Lim 2006)*

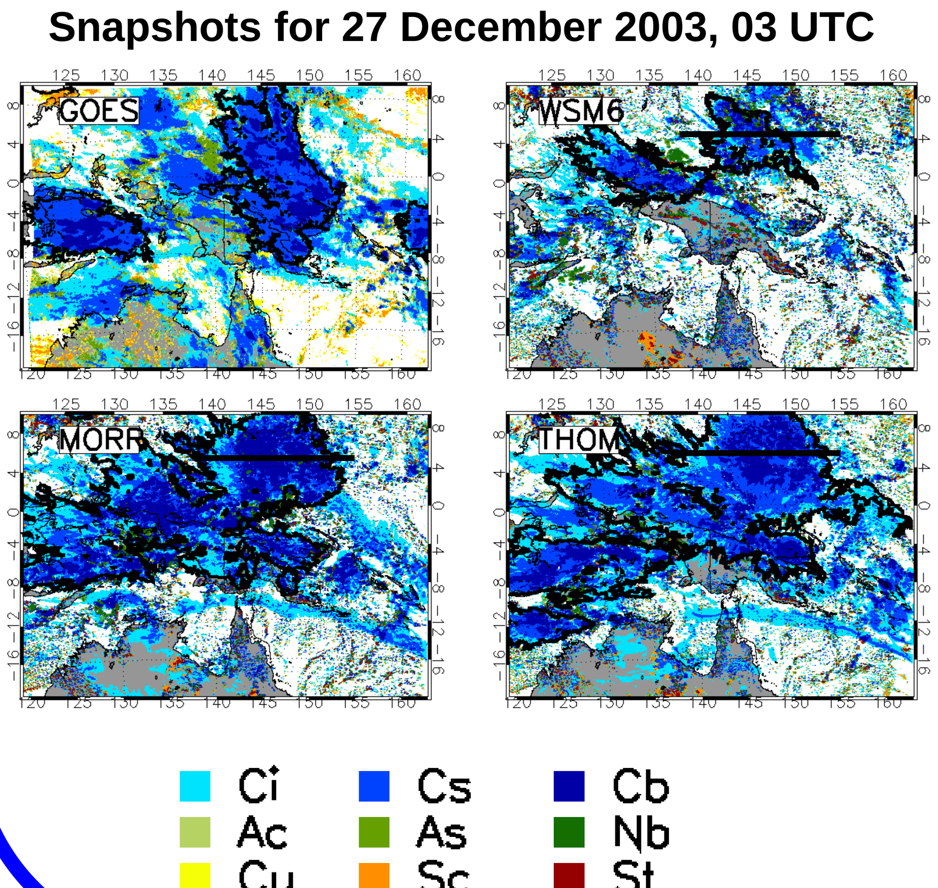
THOM hybrid scheme (2-moment for ice and rain) *(Thompson et al. 2008)*

MORR: 2-moment scheme *(Morrison et al. 2009)*

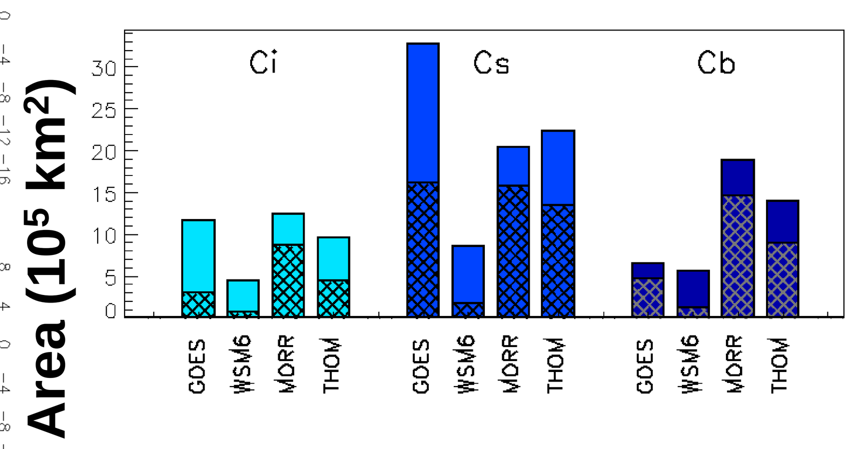
2. MCS ISCCP Cloud Classification

- ISCCP classifications based on CTP and COT for GOES and WRF

Snapshots for 27 December 2003, 03 UTC



Histograms for 6-day period



→ Overestimation of high clouds in THOM and MORR

→ Underestimation of high clouds in WSM6

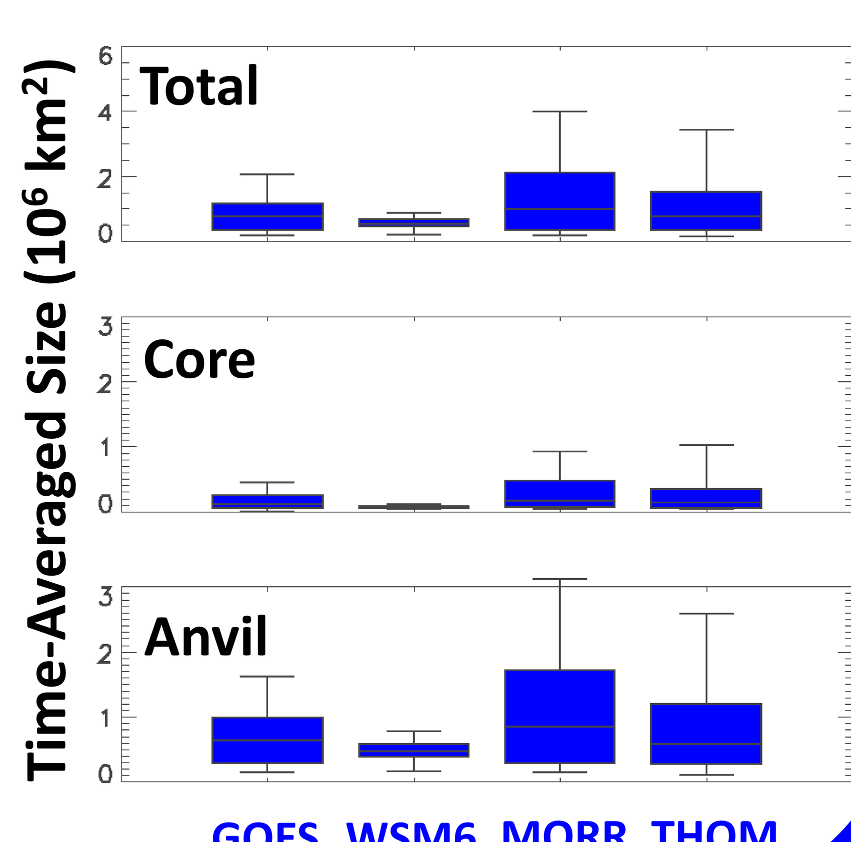
3. MCS Statistics

- MCS identification and tracking algorithm by Boer and Ramanathan (1997) applied to GOES and simulated cloud fields:

	No. Tracks	Size (10^5 km^2)			BT (K)		
		Core	Anvil	Total	Core	Anvil	Total
GOES	31	1.6	7.1	8.7	210	246	238
WSM6	18	0.7	4.8	5.6	215	237	233
MORR	15	3.0	11.2	14.2	215	238	232
THOM	30	2.6	8.6	11.2	214	239	232
	Longevity (h)	COT			CTP (hPa)		
		Core	Anvil	Total	Core	Anvil	Total
GOES	21	26.9	8.6	12.6	162	256	235
WSM6	19	26.1	19.0	20.3	208	370	341
MORR	32	23.4	15.6	17.4	131	201	184
THOM	24	29.8	12.2	17.1	129	231	203

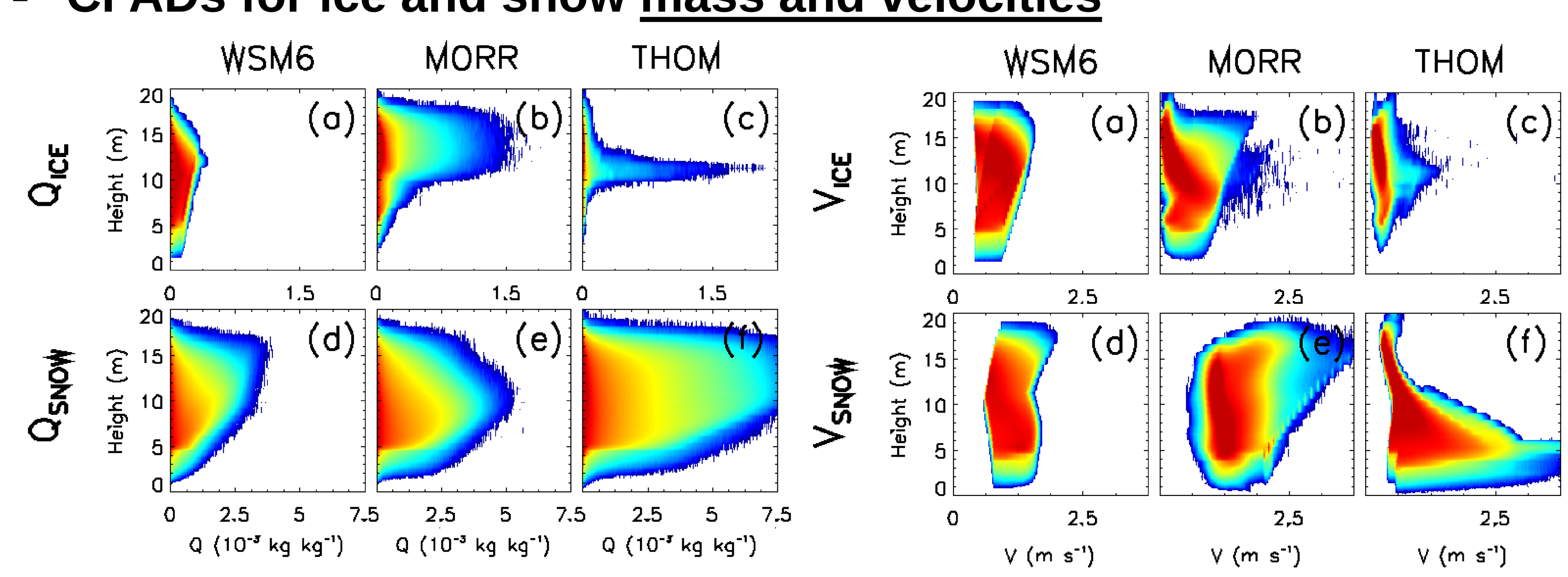
Larger MCSs and anvils in THOM and MORR ←

Overall most realistic MCS properties in THOM ←

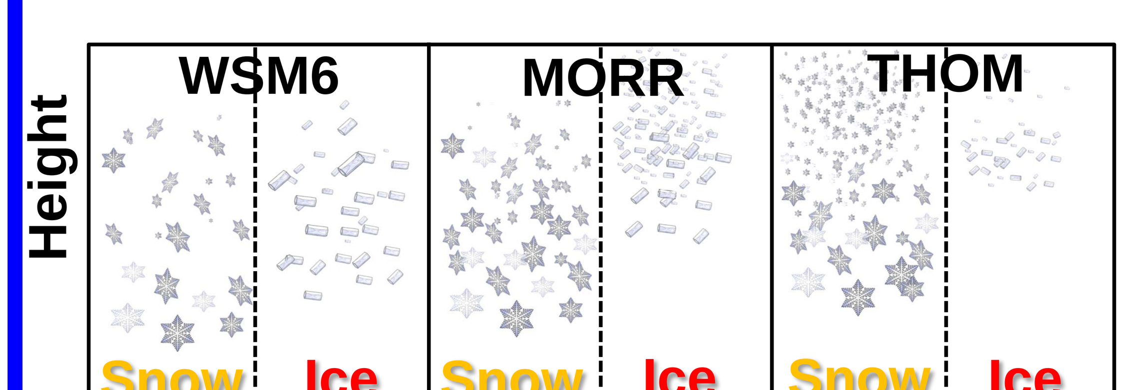


4. MCS Microphysics

- CFADs for ice and snow mass and velocities



- Artistic representation of snow and ice properties



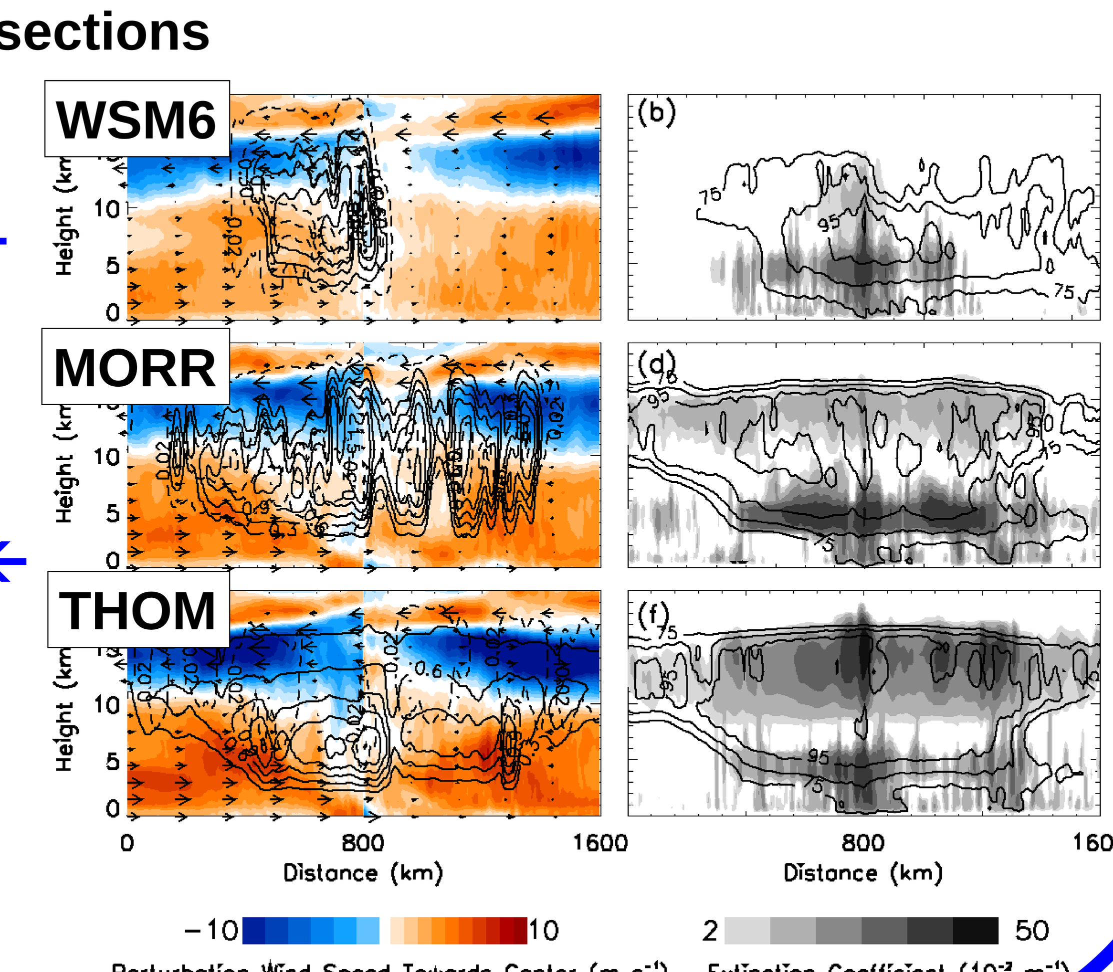
→ MORR high clouds: prevailing small, slow ice crystals

→ THOM high clouds: prevailing small, slow snow flakes

- MCS vertical cross sections

Fast fallout of condensate in WSM6 results in small anvils ←

MORR and THOM slower-falling condensate is dragged into upper level outflow, forming larger anvils ←



Summary

- Schemes that exhibit slow ice/snow sedimentation rates aloft have more numerous and larger MCSs with larger anvils
- Complex 2-moment schemes do not outperform 1-moment schemes (nucleation, sedimentation more important than size distributions)
- Limited variability among the investigated schemes in terms of surface precipitation. All exhibit overestimations of 20 % (not shown)

References

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