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CLOUD-RADIATIVE AND MICROPHYSICAL IMPACTS FROM LARGE HYDROMETEORS IN SIMULATIONS OF THE SOUTH ASIAN SUMMER MONSOON

Wanchen Wu and Wen-wen Tung

Department of Earth, Atmospheric, and Planetary Sciences
Purdue University

Email: wu237@purdue.edu

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Drs. Jui-Lin F. Li, Hugh Morrison, Duane E. Waliser and Guang Zhang

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Outline

- Introduction and hypothesis
  - Large hydrometeor fallout assumption in global climate models (GCMs)
- Model setup
- Results
  - Month-long South Asian Summer Monsoon simulations
- Summary and conclusions

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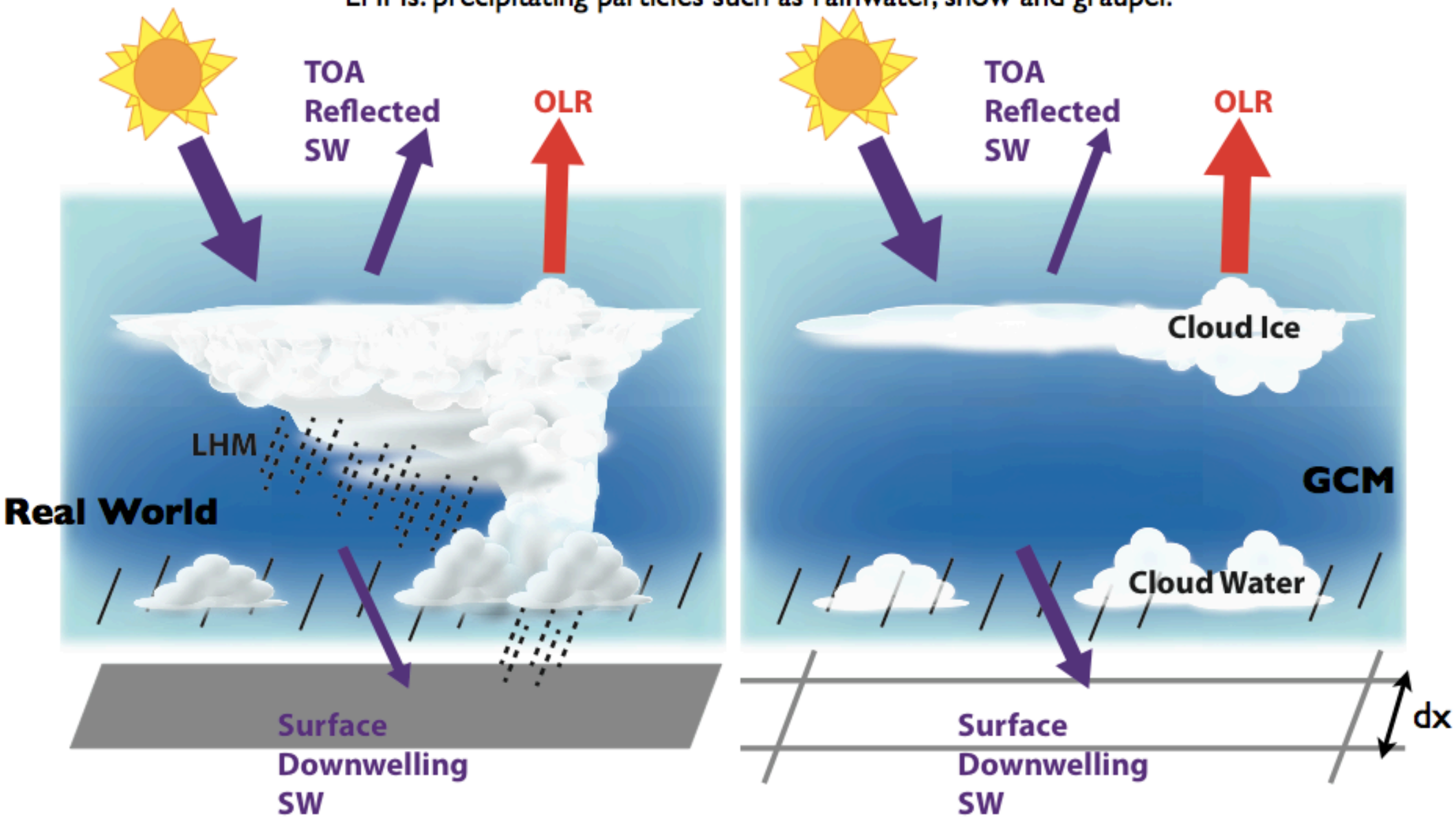
LHM assumption in GCM

All LHMs in cumulus parameterization are instantaneously precipitated every time step. The instantaneous fallout of LHM in this assumption is possible to introduce biases in long-term integration through the radiative and microphysical processes

LHMs: precipitating particles such as rainwater, snow and graupel.



- Hypothesis: The persistent radiative bias attributed to this common treatment of LHM, especially ice species, could introduce biases in atmospheric circulations. (Waliser et al. 2011 and Li et al. 2013)
- The purpose of this study is to examine the possible biases caused by radiative and microphysical impacts of LHM assumption on the mesoscale convective systems (MCSs) and monsoon depressions (MDs) in the WRF model setting an upper bound for the GCM.

WRF Cloud-System Resolving Model

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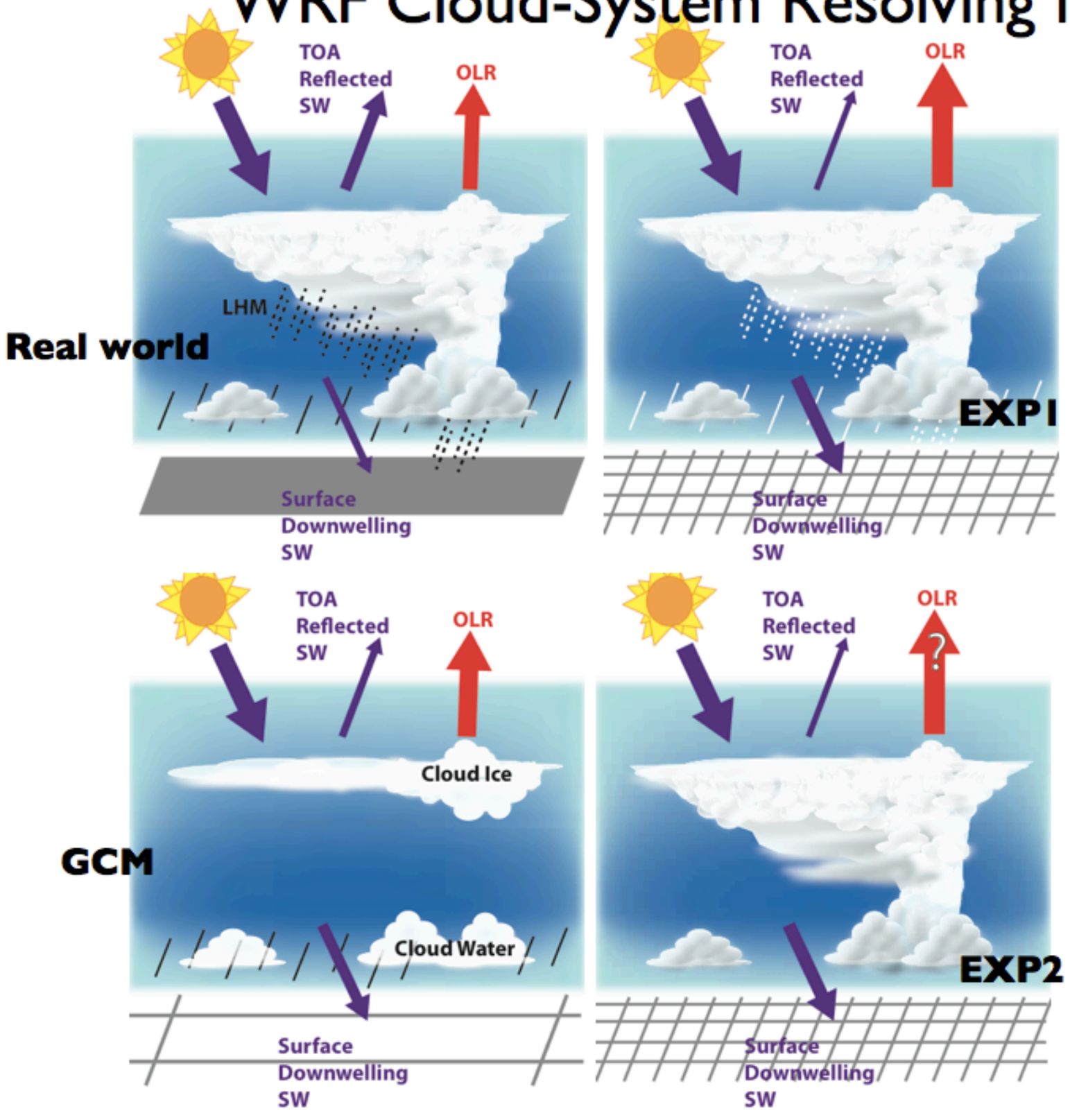

Examine the possible radiative effects of LHM assumption to MCSs and MDs

Cloud water content category

Category 1	Qc	
Category 2	Qi	~~Qs~~
Category 3	~~Qr~~	~~Qg~~

Table 2.1

Remove LHM entirely from radiative and microphysical schemes.

The resulted bias may serve as an upper bound of the overall effects of LHM assumption in GCM.

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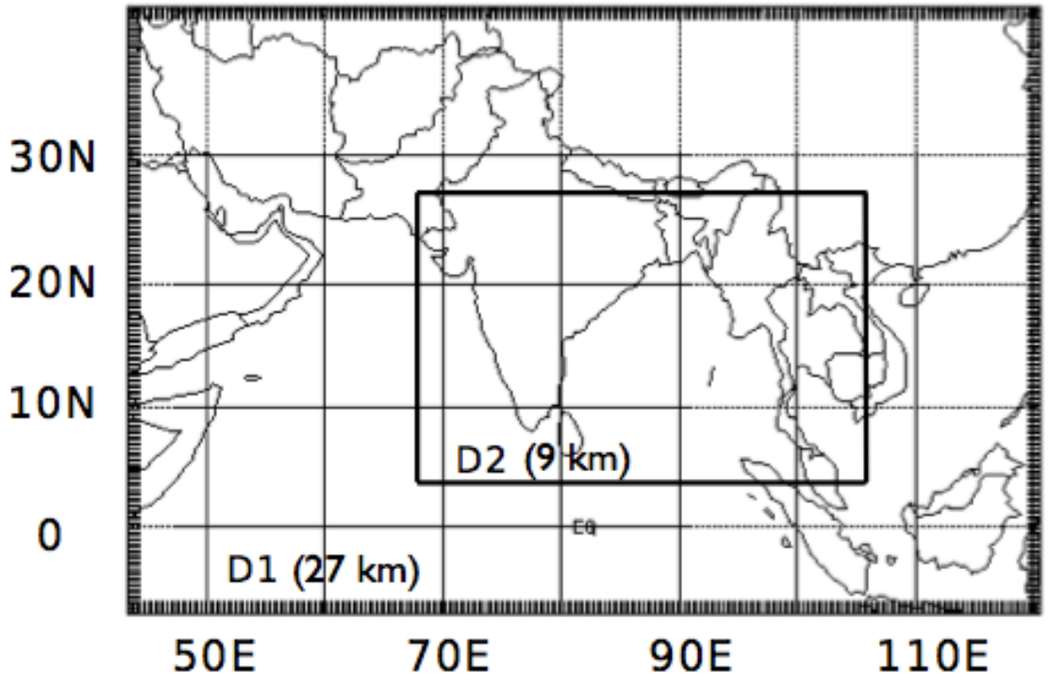
WRF-ARW Model (V3.3)

- Domains and grid intervals
- Vertical coordinate: 36 levels from surface to 10 mb
- Initial and lateral boundary conditions for D1 are from NCEP GFS Final Analysis
- Updated SST every 6 hours from FNL Analysis
- No data assimilation involved

- Period
  - 00Z July 25, 2006 ~ 00Z September 1, 2006 for D1
  - 00Z July 31, 2006 ~ 00Z September 1, 2006 for D2



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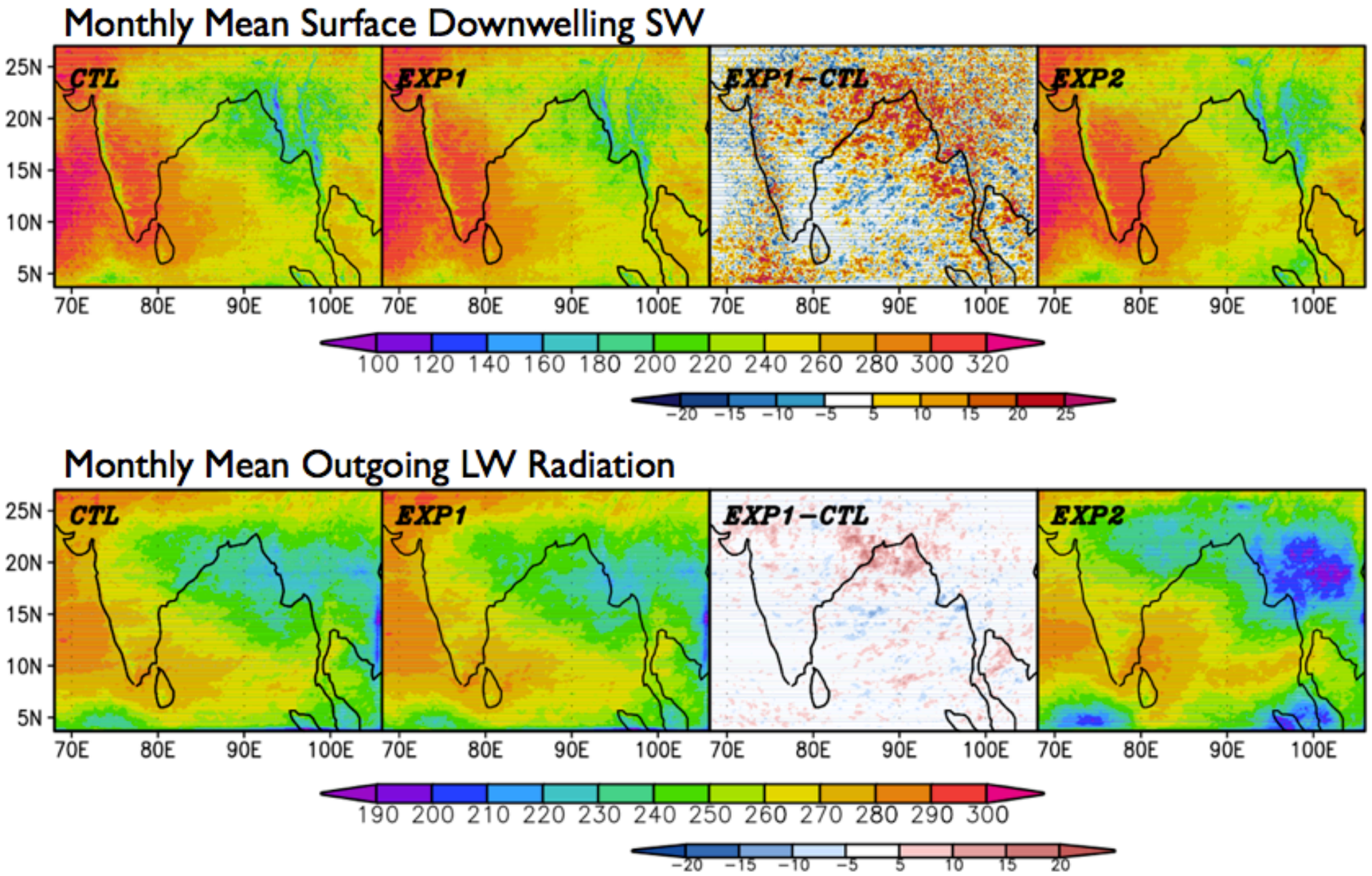
Control Run (CTL)

- New GODDARD SW and LW radiative schemes calculated every 30 minutes
- Kain-Fritch cumulus parameterization (CP) scheme for D1
- WRF single-moment 6-class microphysics (WSM6)
- University of Washington PBL scheme
- University of Washington shallow cumulus scheme
- MM5 similarity theory for surface layer
- One-way interaction between D1 and D2

LHM-radiative feedbacks (EXP1) vs LHM assumption (EXP2)



LHM assumption in EXP2

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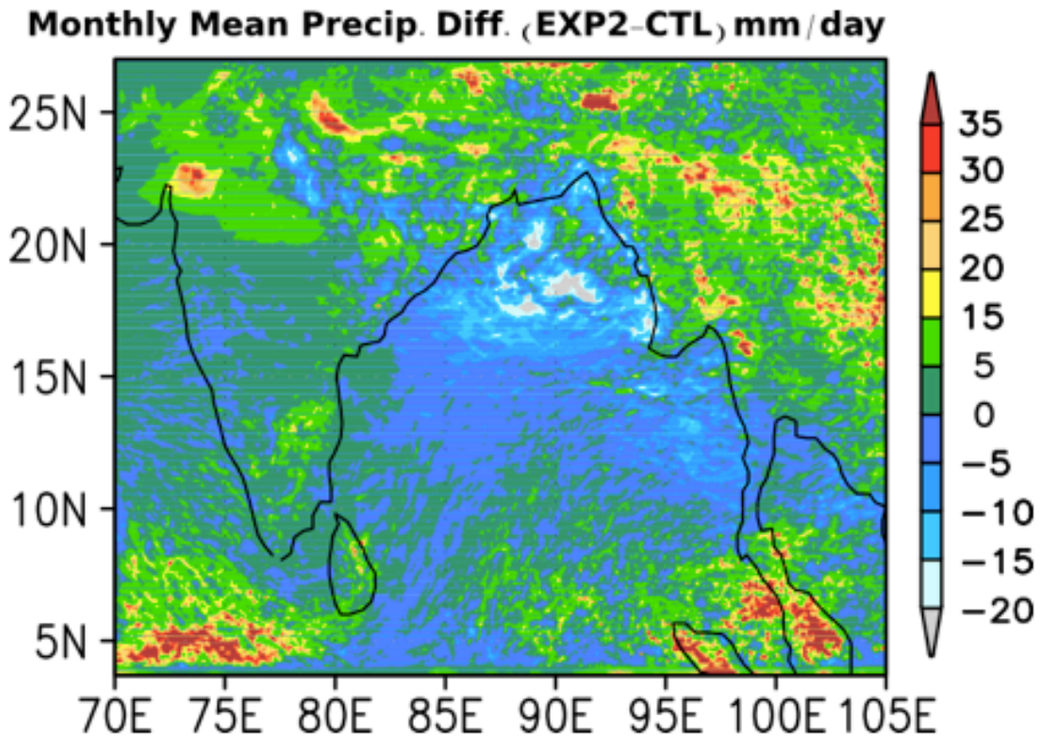
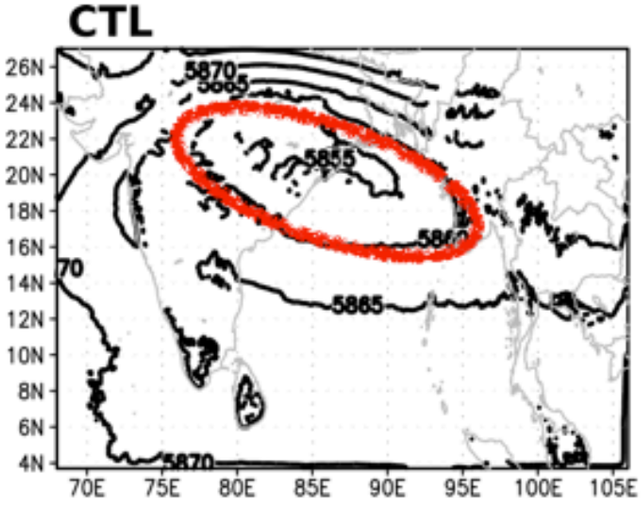
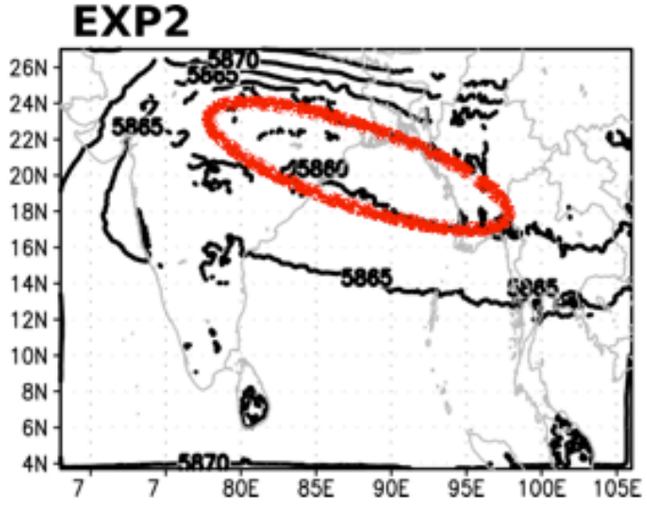
- Speed up hydrological cycle and increase precipitation
- Monsoon trough tilts less southward with height
- Northward shift of convective systems



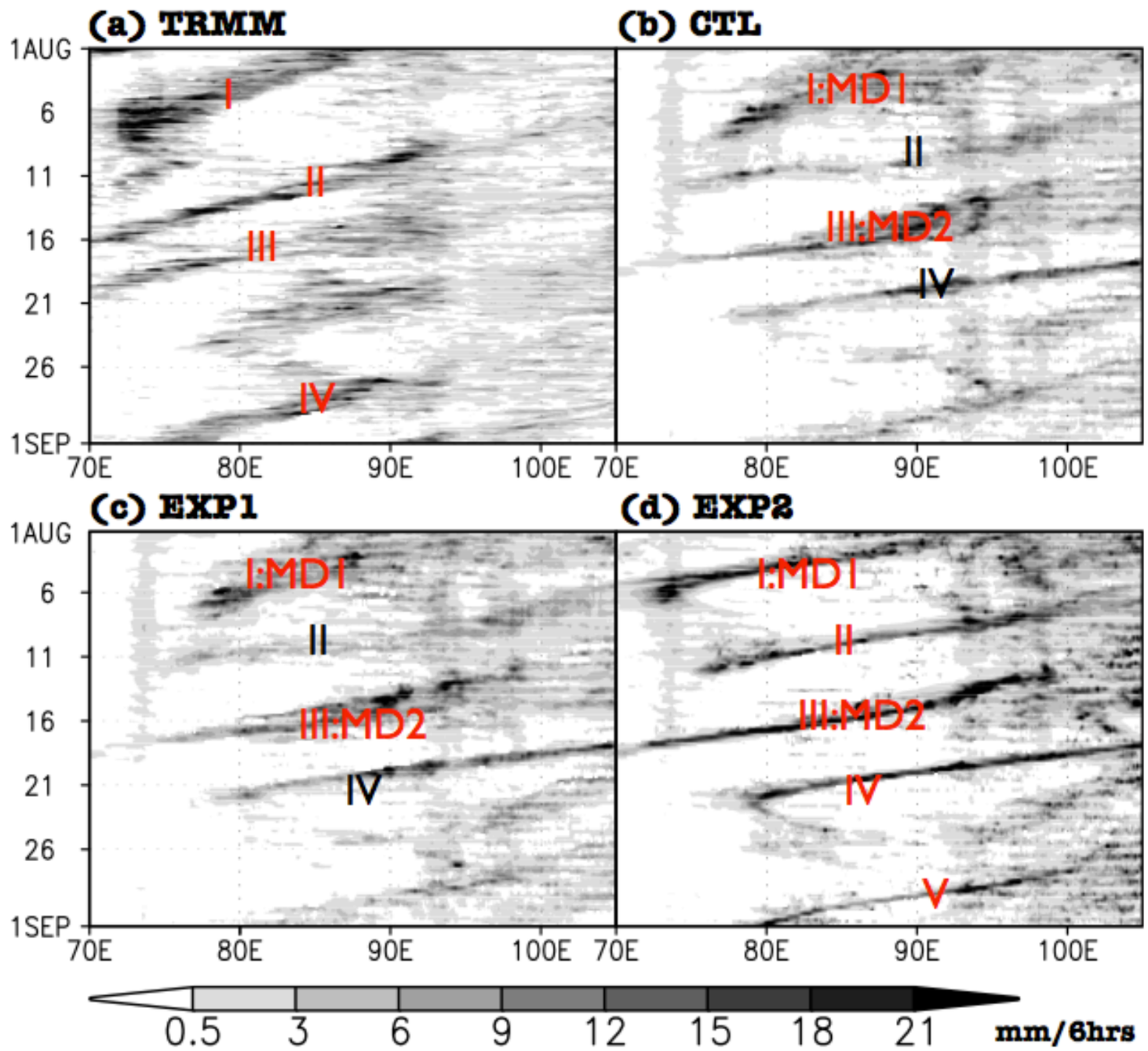
500 hPa Monthly Mean geopotential height





- 4 MDs are documented in IBTrACs. IBTrACs: International Best Track Archive for Climate Stewardship
- Some disturbances simulated in CTL and EXP1 are not strong enough to be identified as MDs.

Rain rate
15~25N
August, 2006



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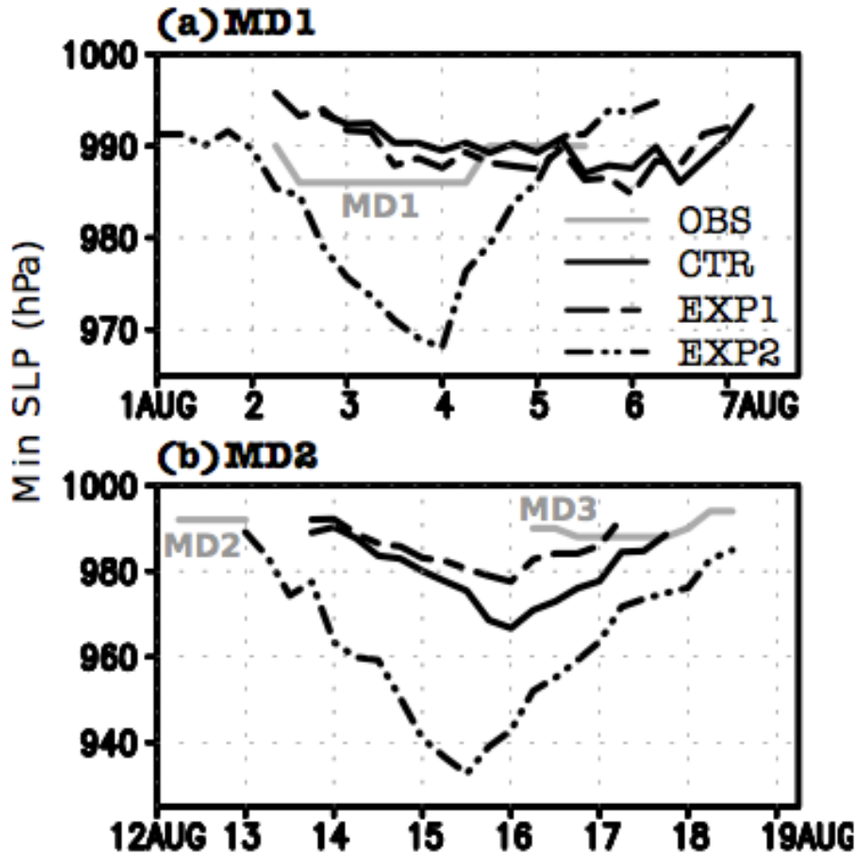
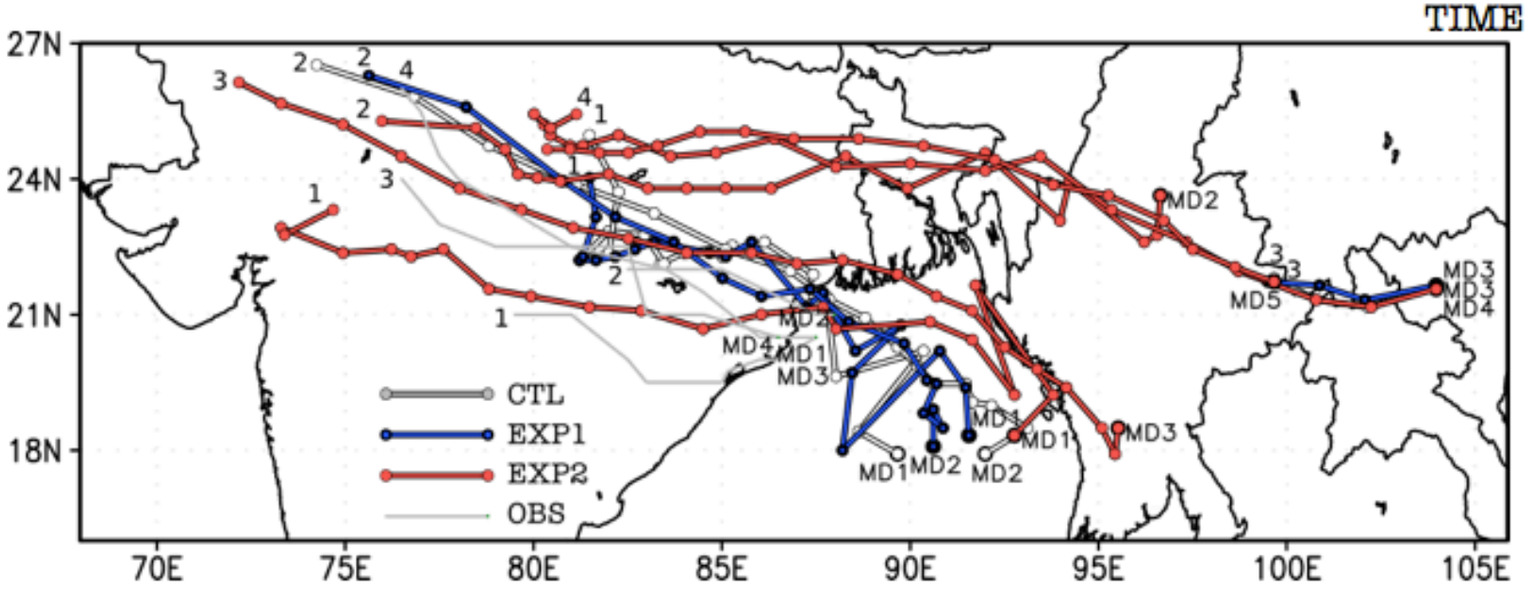
MD intensity and track

- EXP1 (LHM-radiative feedbacks)
  - No systematic influences on MD intensity and track
- EXP2 (LHM assumption)
  - MD frequency is increased
  - MD can live longer
  - MD becomes much stronger
  - MDs still move westward and some started further north

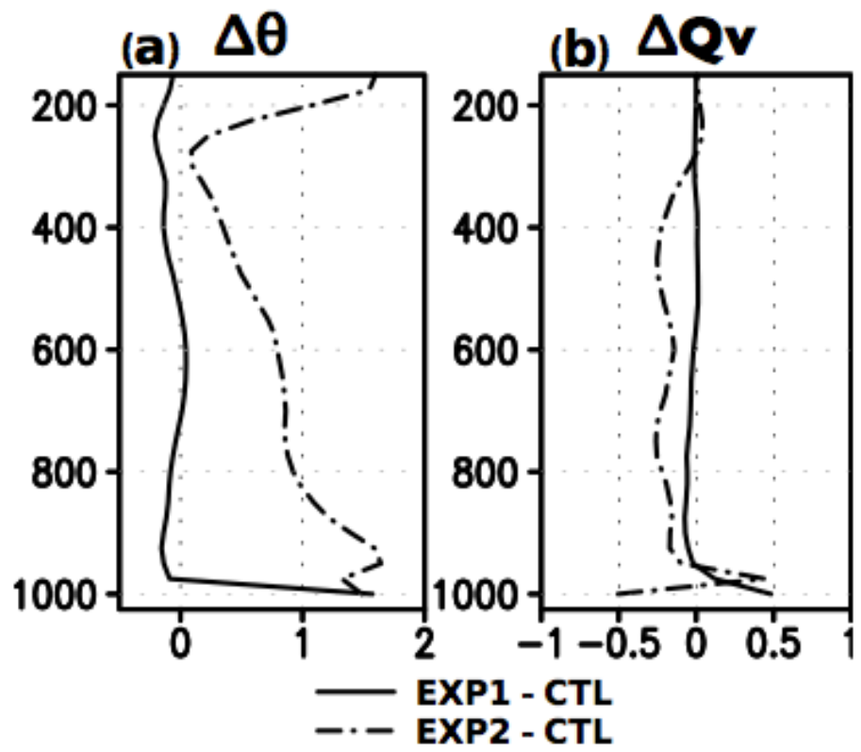




Changes in mesoscale convective systems

500 hPa	Downdraft Area (%)	Updraft Area (%)
CTL	27.0	49.5
EXP1	26.6	49.4
EXP2	2.9	52.9

500 hPa extremes	Max W	Min W
CTL	7.41	-3.86
EXP1	7.87	-3.84
EXP2	10.23	-3.94



- EXP2 vs CTL
  - The downdraft area is reduced 90% without evaporative cooling of LHMs, resulting in warmer low troposphere and triggering more convections.
  - Both of the maximum updraft speed and updraft area are increased.

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Summary and conclusions

- Ignoring LHM-radiative feedbacks can overestimate downward SW at surface and OLR about 20 W/m^2 in vigorously convective area. (EXP1)
- However, the LHM-radiative feedbacks do not have systematic influences to the intensity and track of MDs. (EXP1)
- The major convective systems are found to migrate northward from Bay of Bengal under the LHM assumption. (EXP2)
- The downdraft area is reduced 90% without evaporative cooling and moistening of LHMs, which have profound impacts on the MCSs and MDs. (EXP2)

Thanks for your attention.

- The influences on vertical radiative heating rate are not discussed here since it is highly affected by small particles.