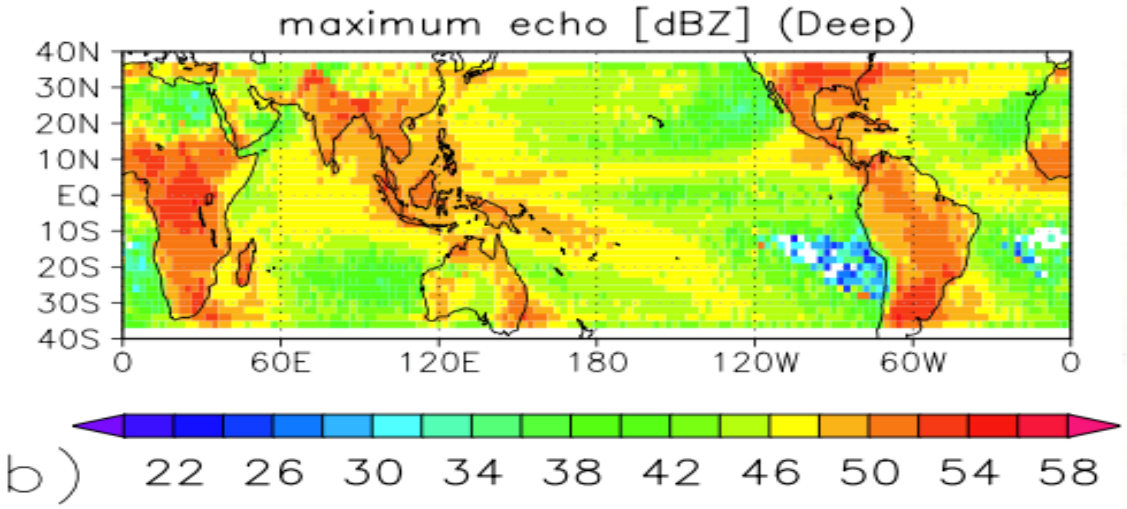
Comparative Analysis of Deep Convective Cores between MC3E and TWP-ICE Cases: Impact of Aerosols

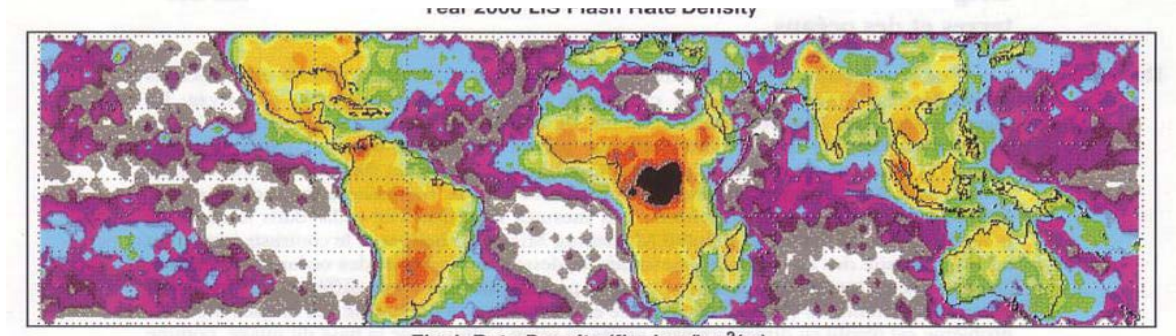
Wei-Kuo Tao, Toshi Matsui, Taka Iguchi,

Brenda Dolan, Steve Rutledge, and Julie Barnum

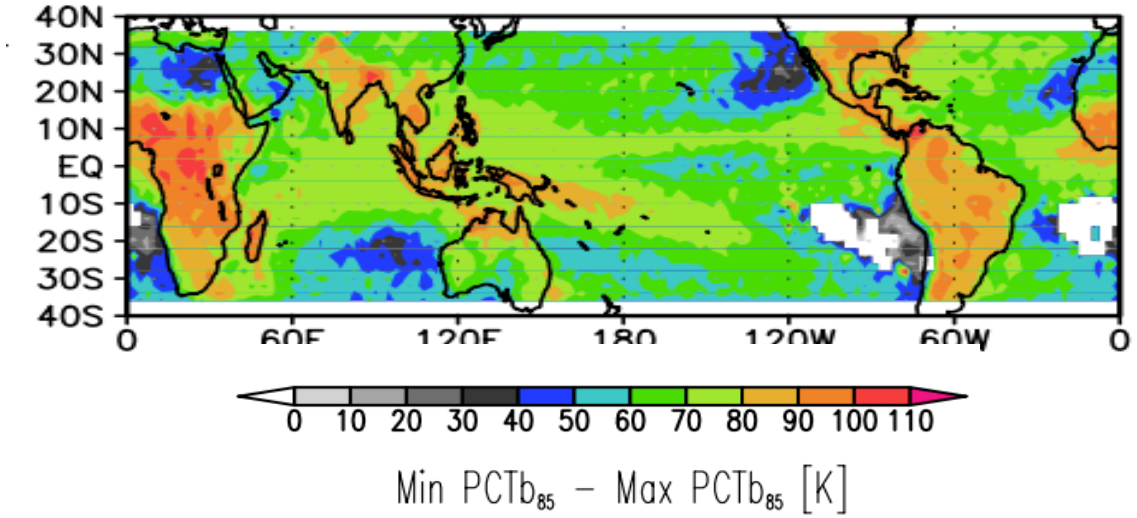
TRMM View of Continental Convective Vigor



Lightning Rate



Maximum $PCTb_{85GHz}$ Scattering index



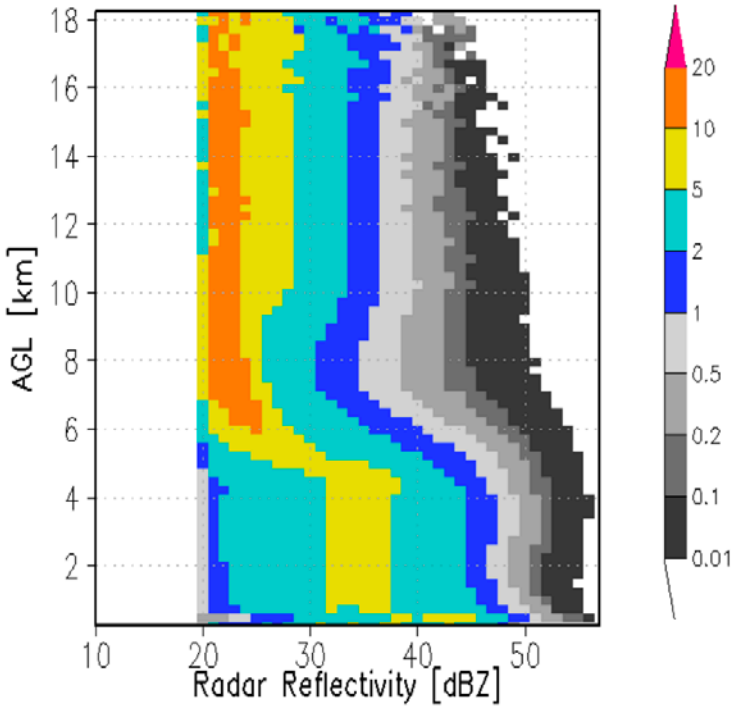
- *Deep convective clouds over land tend to have*
  1. *larger radar echo (bigger rain drops),*
  2. *larger microwave scattering (heavier riming), and*
  3. *more lightning flash rate (frequent ice-to-ice collision).*

Matsui et al. 2016, JHM

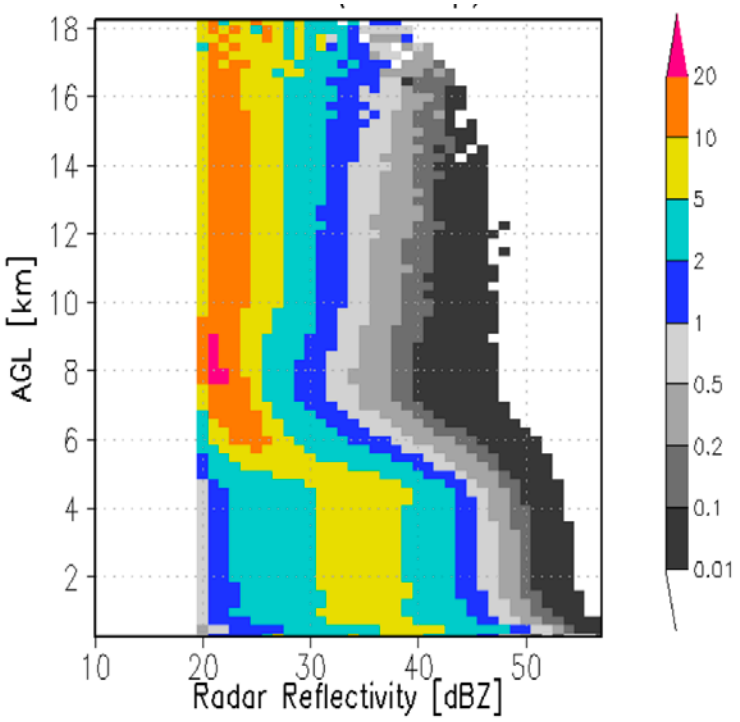
TRMM PR (Ku-band) Reflectivity CFADs

-climatology-

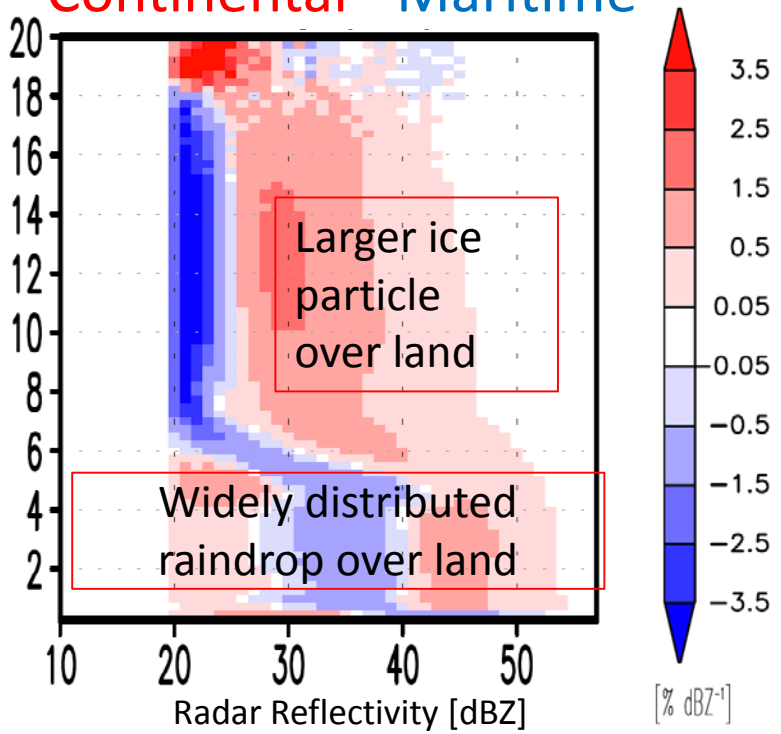
Continental



Maritime

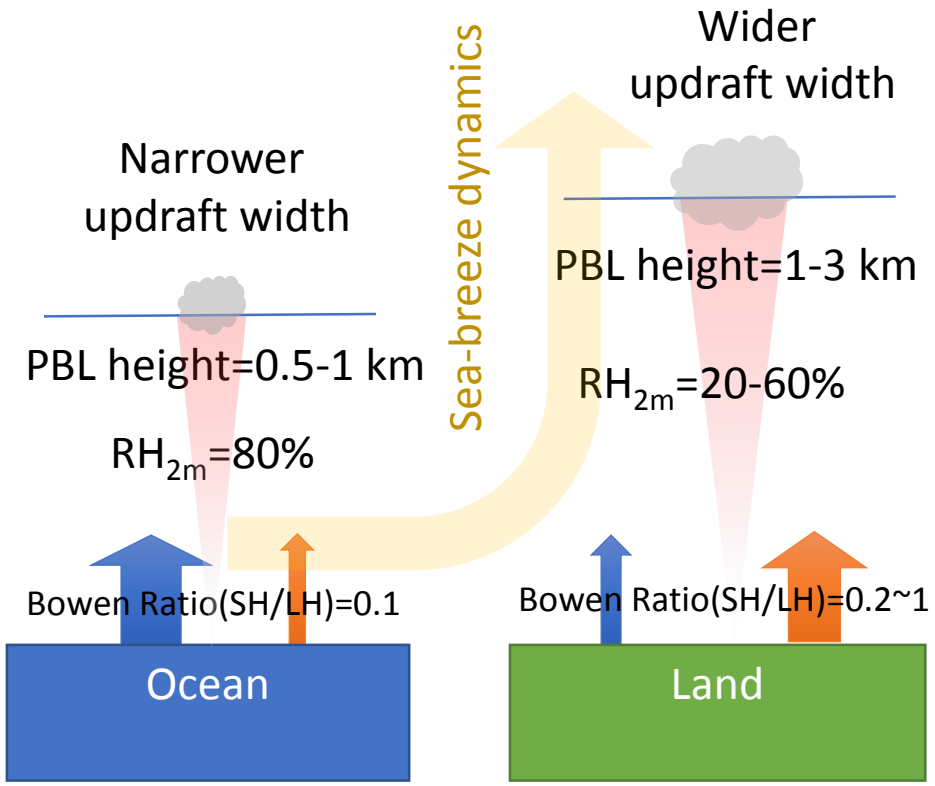


Continental - Maritime

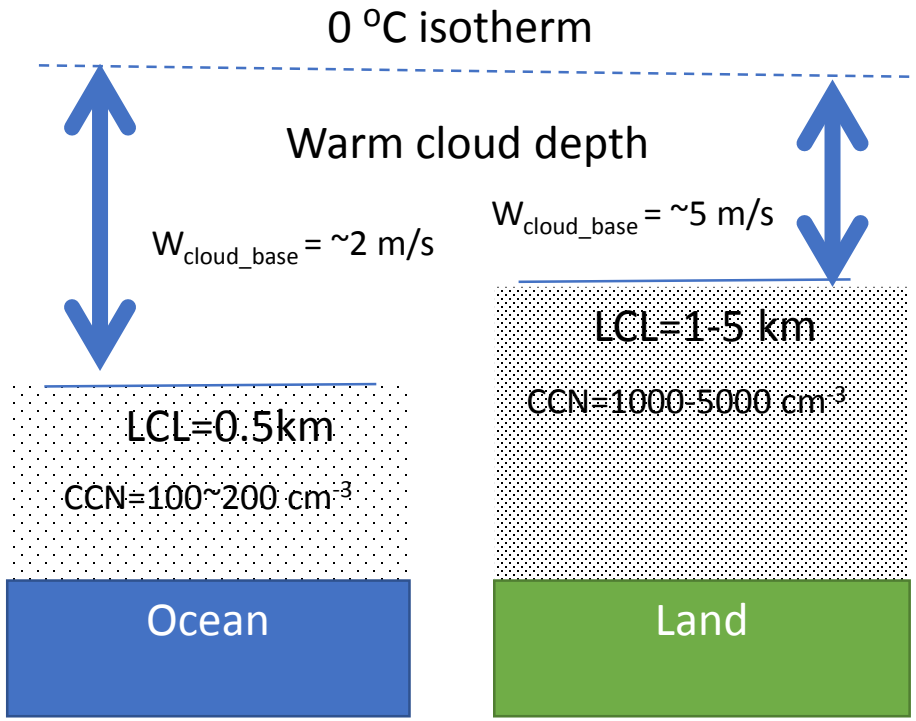


Physics Background

Thermodynamics



Microphysics



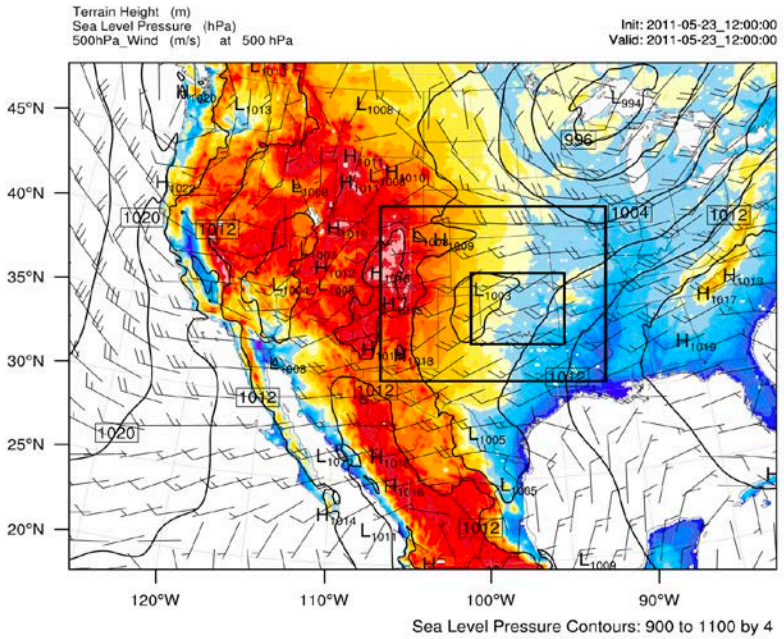
Deep convection is invigorated over land, because land is HOTTER, DRYER, and DIRTIER.

(Lucas et al. 1994, Williams and Stanfill 2002, Zipser et al. 2006, Robinson et al. 2011, Stolz et al. 2015, Matsui et al. 2016)

Land-Ocean cases from DOE ARM IOPs

-WRF Domains-

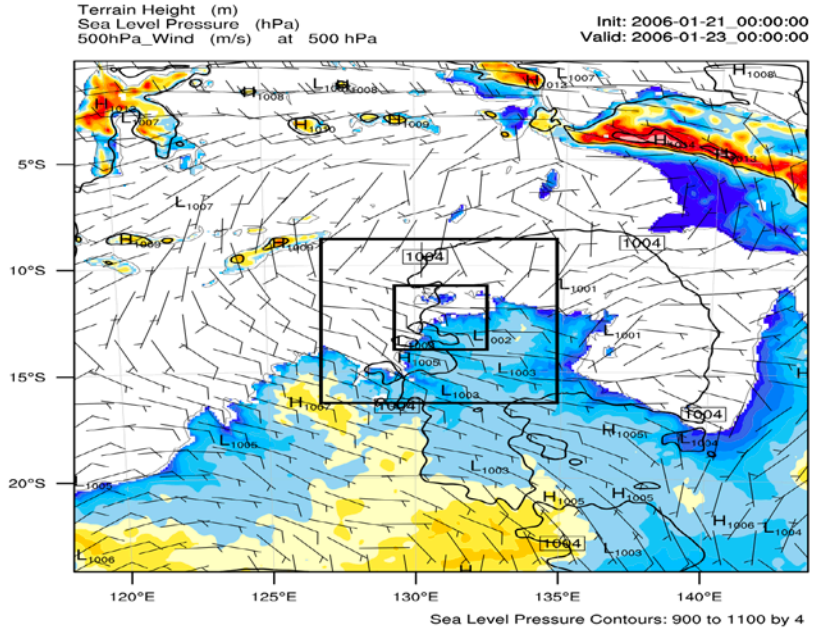
MC3E: Continental



Oklahoma, ARM site

May 23-24: Super cell

TWP-ICE: Maritime



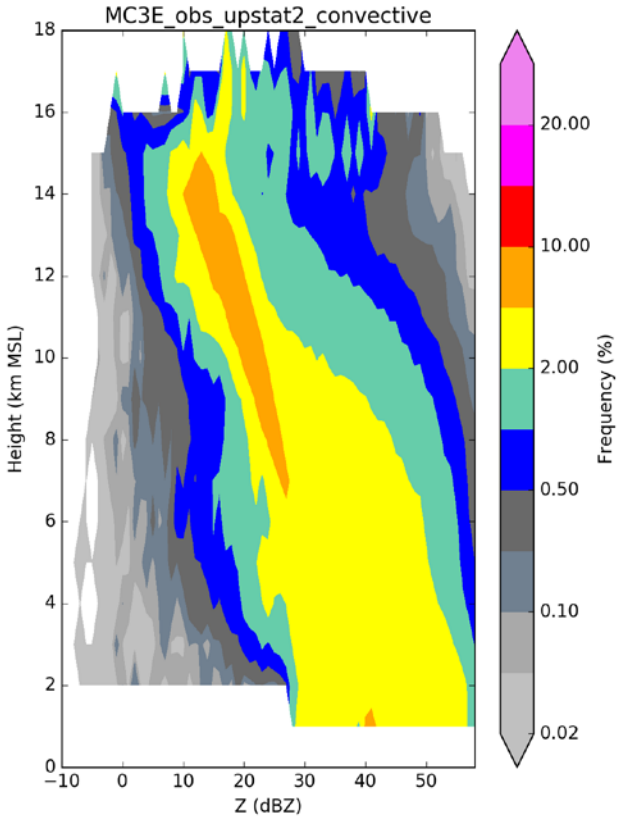
Darwin Island, Australia

Jan 23: Tropical MCS “Landphoon John”

dBZ: Reflectivity (OBS)

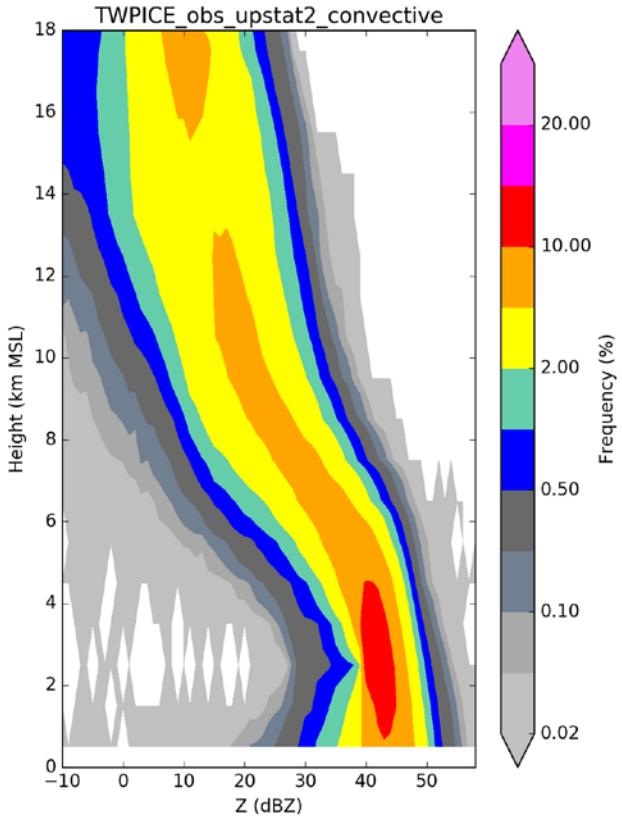
Sampled convective regime only!

MC3E



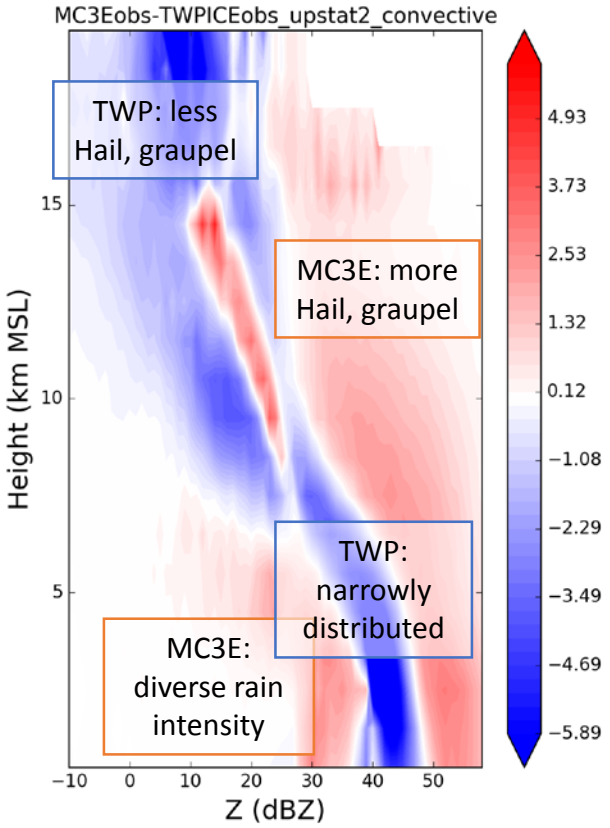
CSAPR

TWP

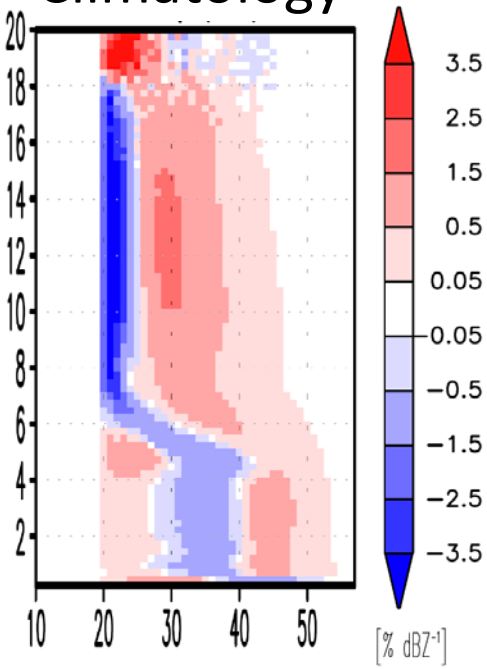


CPOL

MC3E - TWP



TRMM PR Climatology



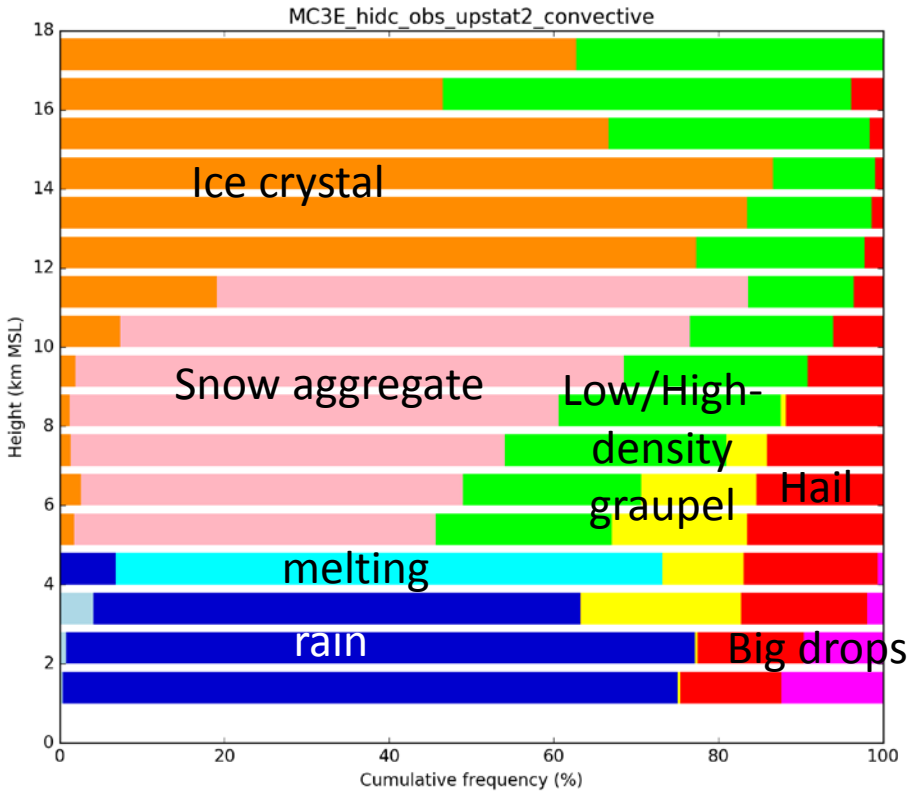
Z represents the size and density.

Good Agreement to TRMM PR climatology

HID: Hydrometeor Identification (OBS)

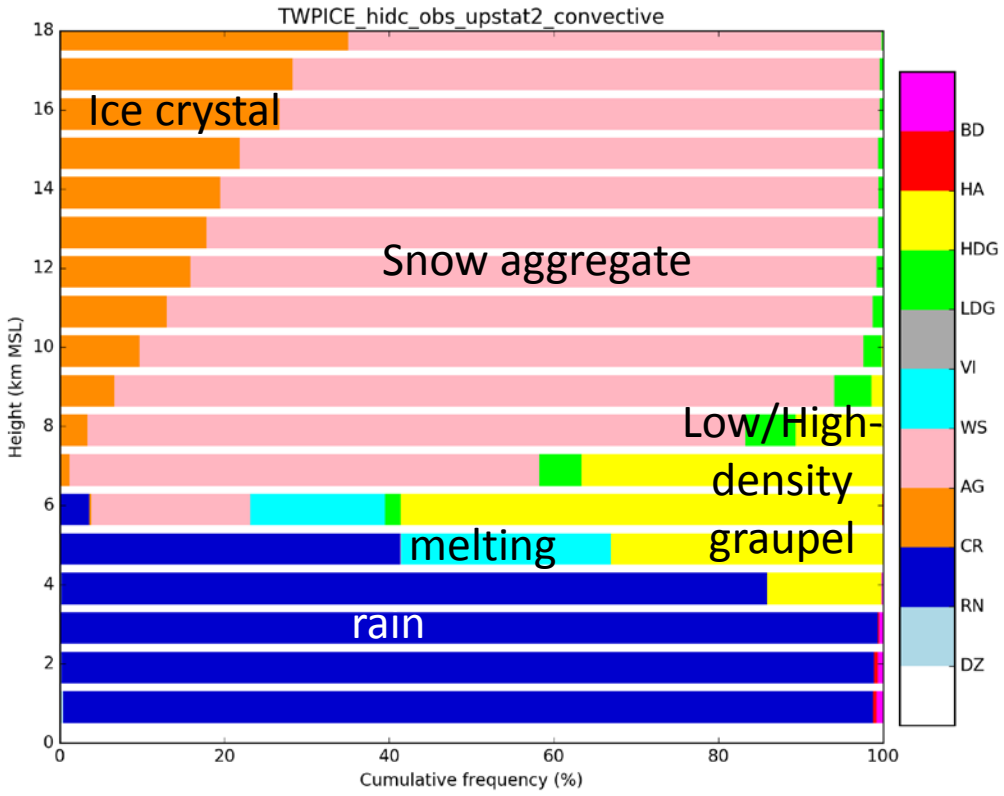
Sampled **convective regime** only!

MC3E



CSAPR

TWP



CPOL

HID Stacked Frequency of Altitude Diagrams (SFADs)

WRF-SBM

MERRAero Overview

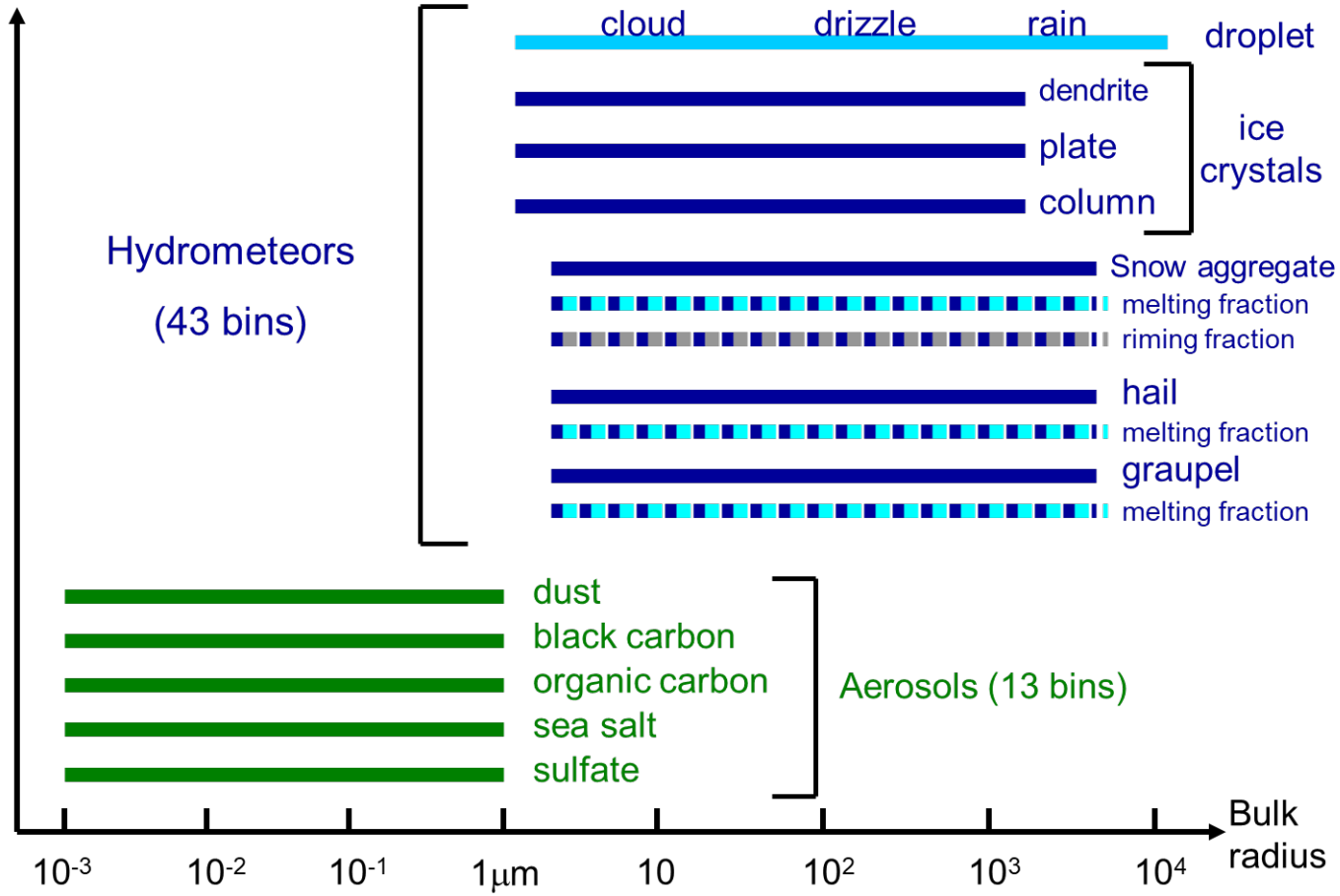
Feature	Description
Model	GEOS-5 Earth Modeling System (w/ GOCART) Constrained by MERRA Meteorology (Replay) Land sees obs. precipitation (like MERRA*Land*) Driven by QFED daily Biomass Emissions
Aerosol Data Assimilation	Local Displacement Ensembles (LDE) MODIS reflectances AERONET Calibrated AOD's (Neural Net) Stringent cloud screening
Period	mid 2002-present (Aqua + Terra)
	2000-mid 2002 (Terra only)
Resolution	Horizontal: nominally 50 km Vertical: 72 layers, top ~85 km
Aerosol Species	Dust, sea-salt, sulfates, organic & black carbon

da Silva (2012)

MERRAero2
WRFSBM

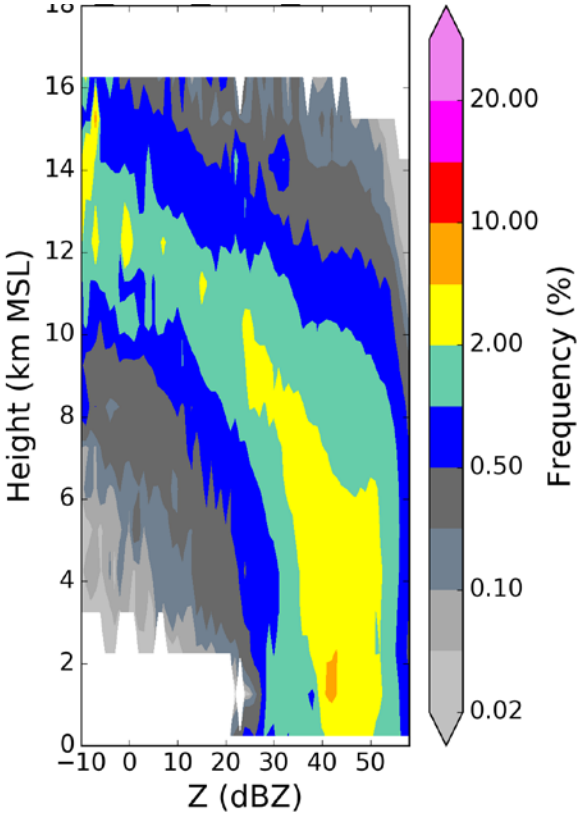
Dynamical Downscaling
(aerosol only)

Particles categories and bins in the updated WRF-SBM
43 bins

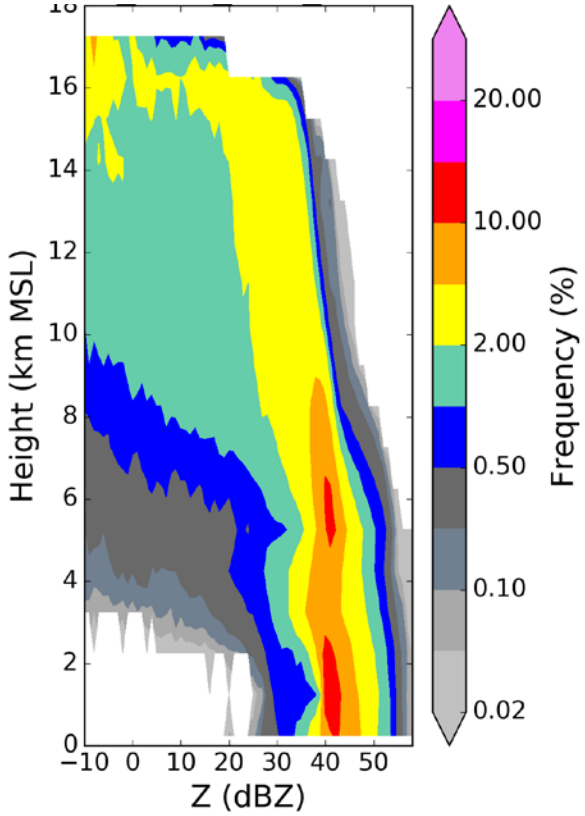


dBZ: Reflectivity (WRF-SBM)

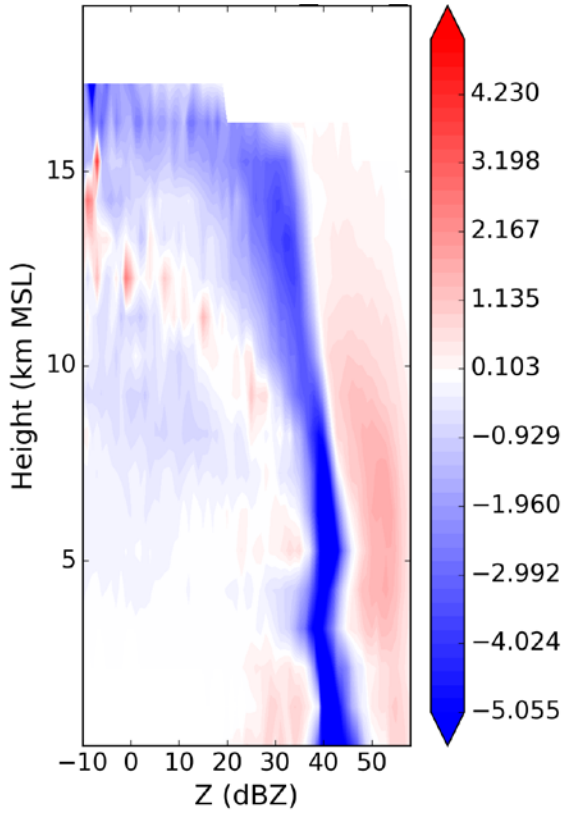
MC3E



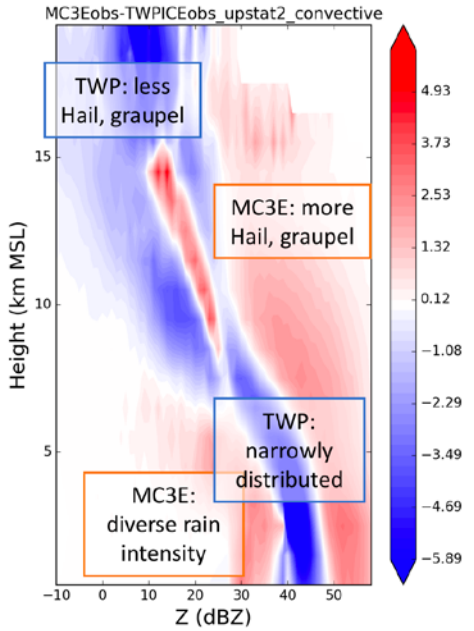
TWP-ICE



MC3E - TWP



OBS

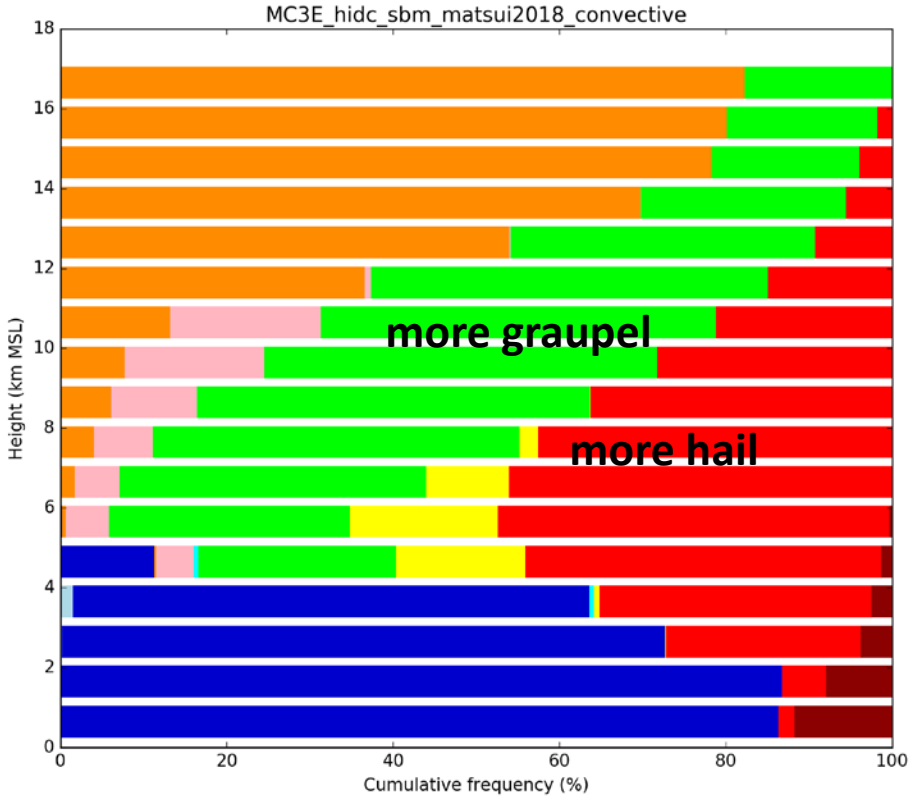


WRF-SBM captured the observed MC3E-TWP contrast in reflectivity CFADS

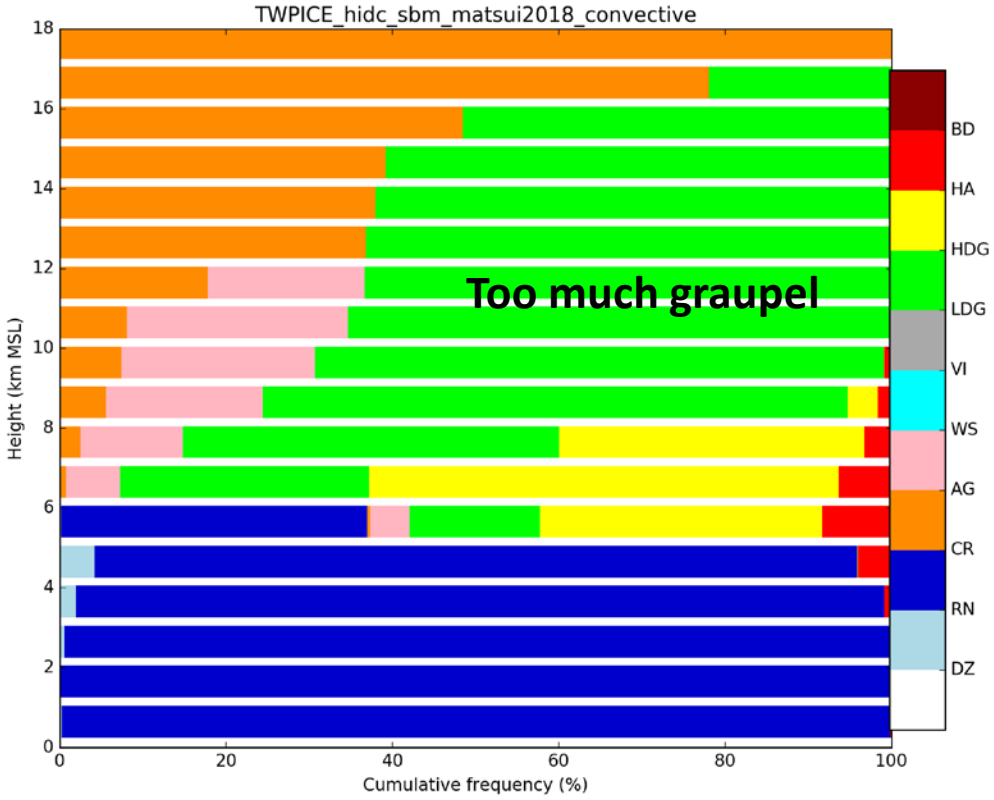
HID: Hydrometeor Identification (WRF-SBM)

HID SFADs

MC3E



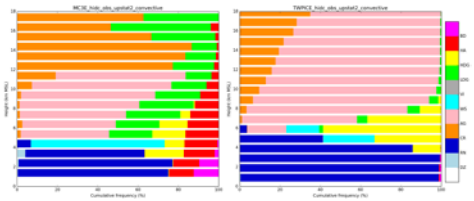
TWP



WRF-SBM overestimate riming process.
Too much dry collection?

obs

MC3E TWP



P-level (hPa)	CCN (#/cm3; SS1%)
500	146.8
700	638.2
850	2000.7
925	1398.5

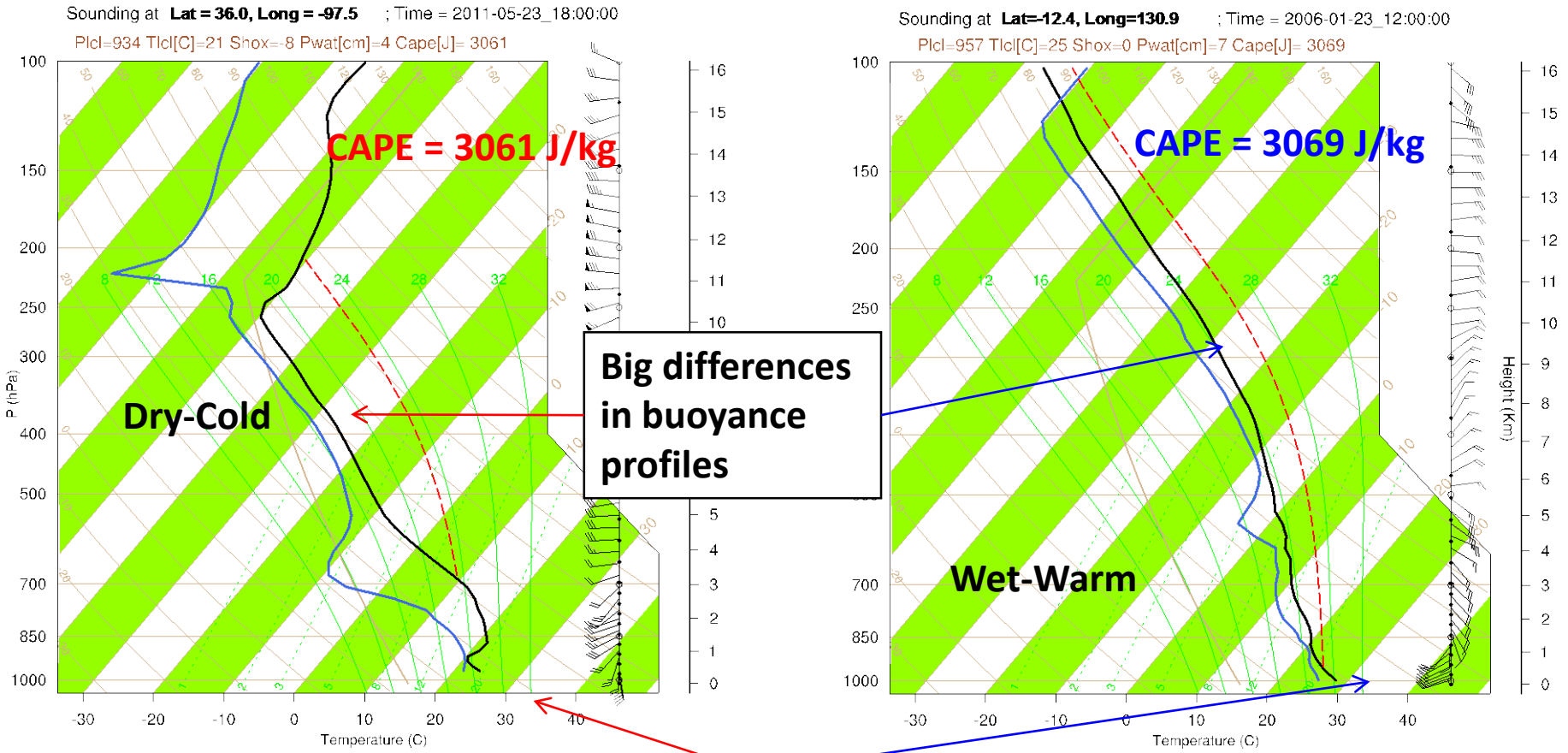
Pre-Storm Conditions

- WRF-SBM -

P-level (hPa)	CCN (#/cm3; SS1%)
500	2.7
700	3.5
850	39.3
925	77.2

MC3E

TWP-ICE



Similar Surface Air Temperature and Humidity and Near-surface wind shear

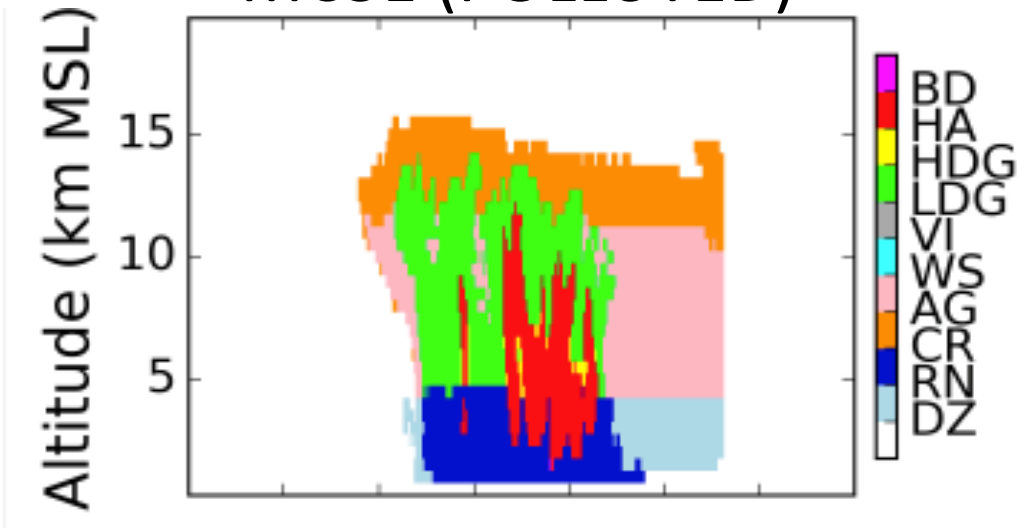
Q1) If we exchange background aerosols between TWP-ICE and MC3E , what will happen to deep convective core?

A. *TWP-ICE convection becomes stronger than MC3E (TWP-ICE > MC3E).*

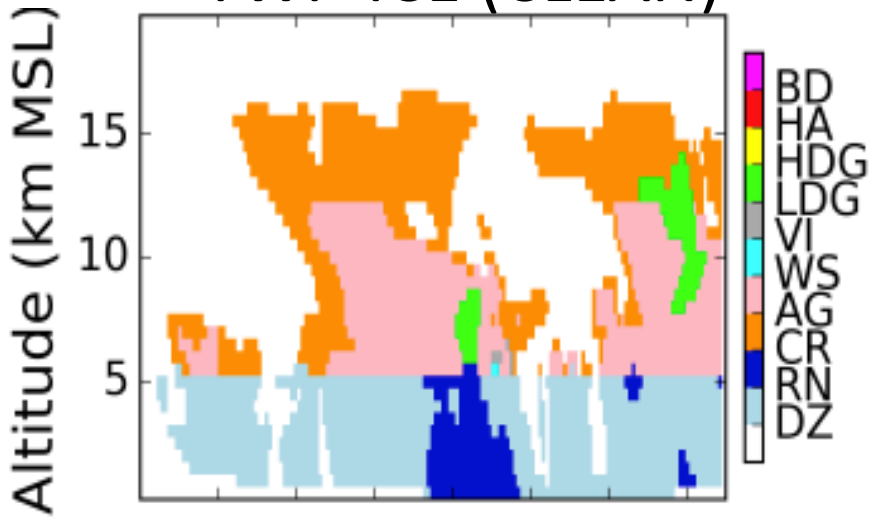
B. *TWP-ICE convection becomes equivalent to MC3E (TWP-ICE = MC3E).*

C. *TWP-ICE convection is still weaker than MC3E (TWP-ICE < MC3E).*

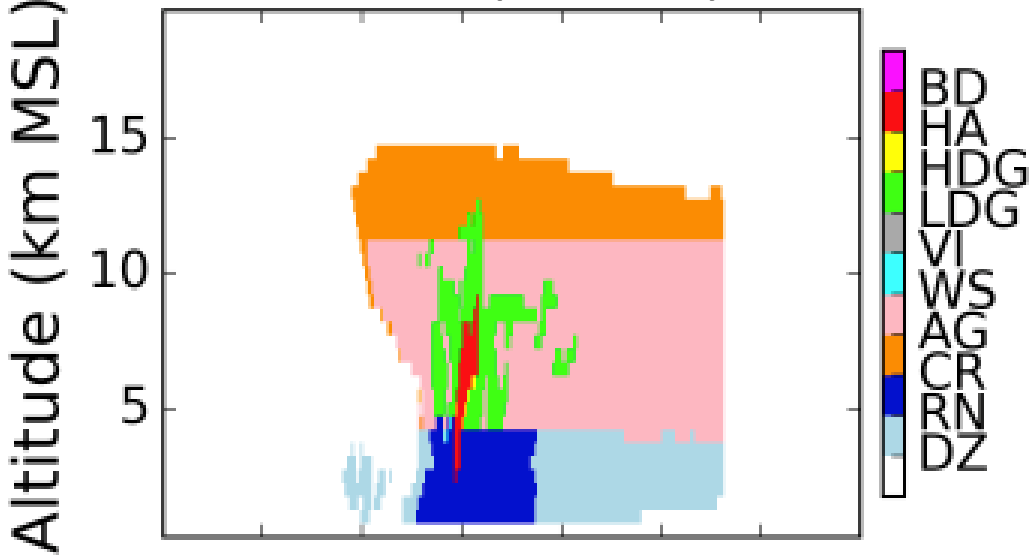
MC3E (POLLUTED)



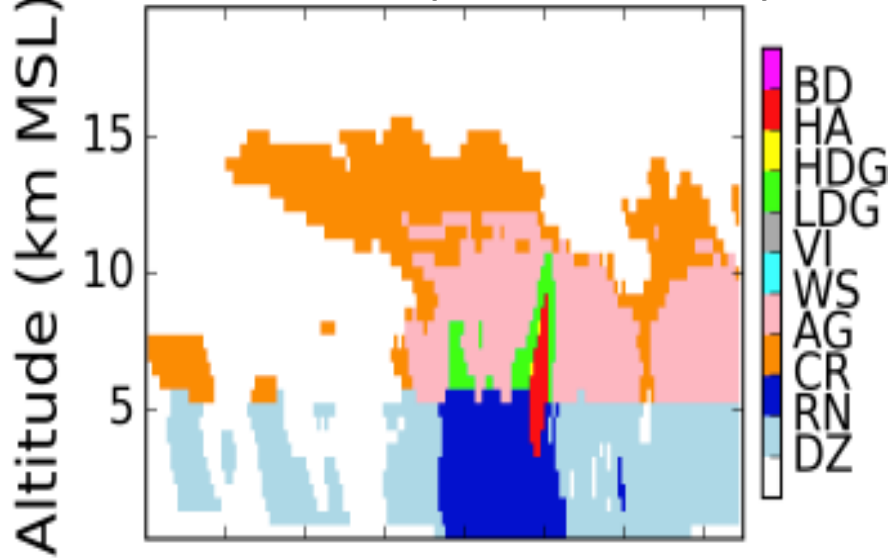
TWP-ICE (CLEAN)



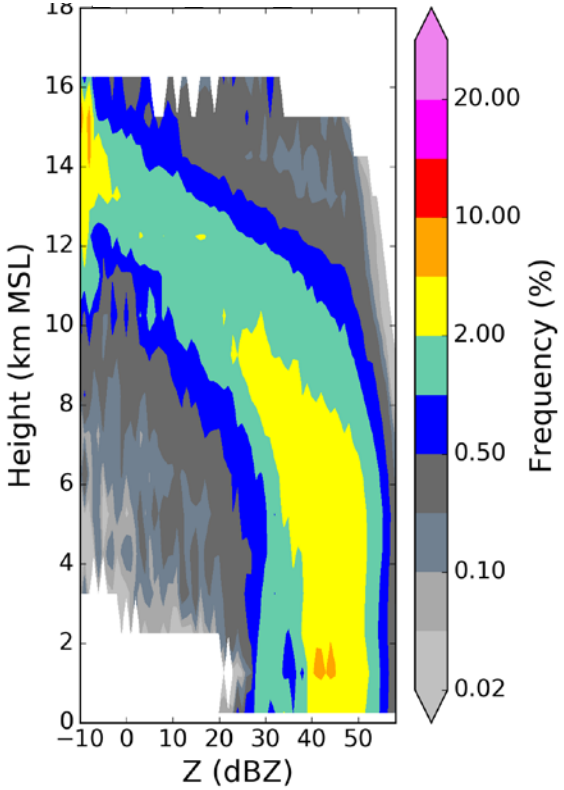
MC3E (CLEAN)



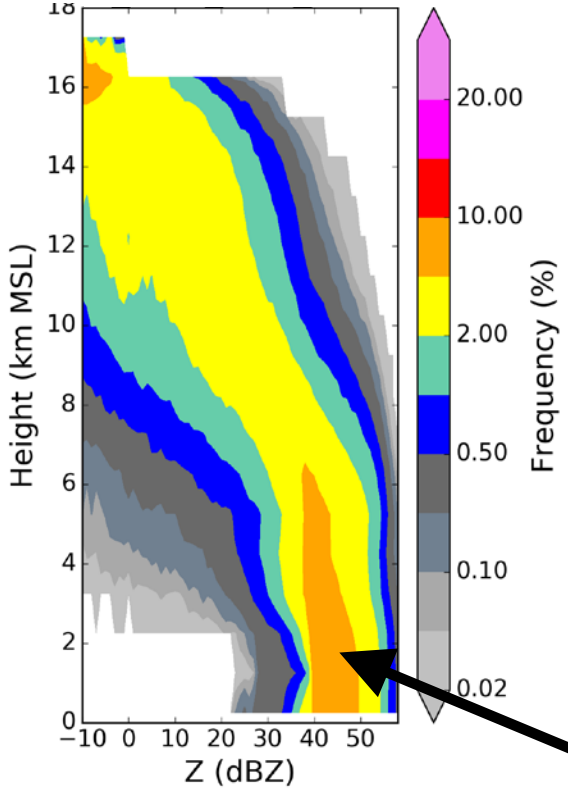
TWP-ICE (POLLUTED)



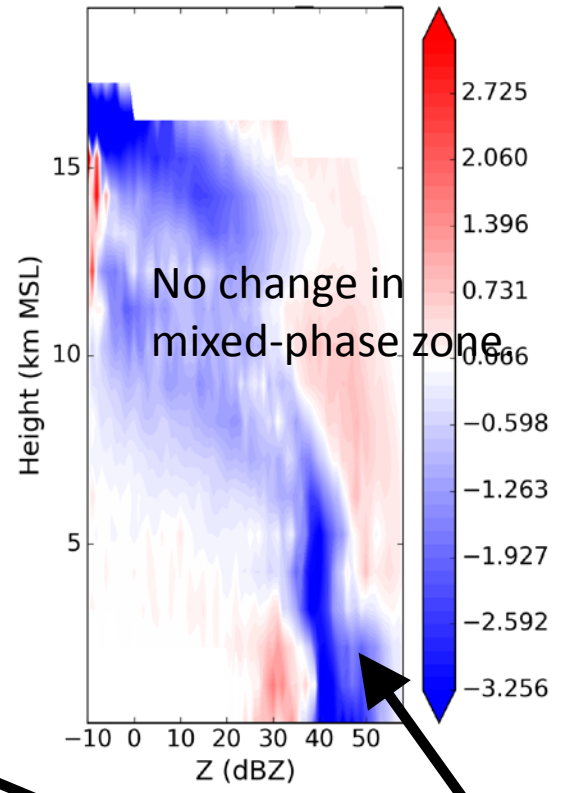
MC3E (CLEAN)



TWP (POLLUTED)



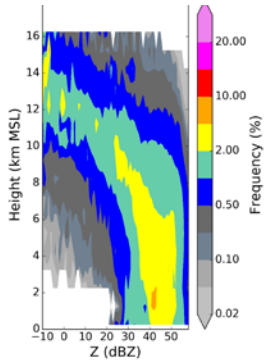
MC3E - TWP



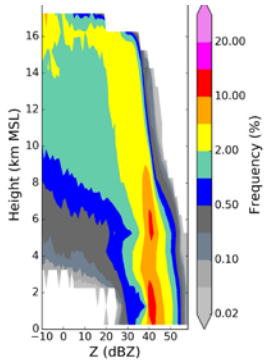
No change in mixed-phase zone.

Raindrop invigorated in TWP.

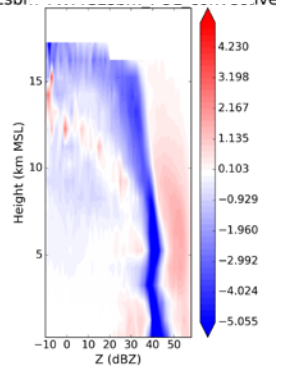
MC3E (POLLUTED)



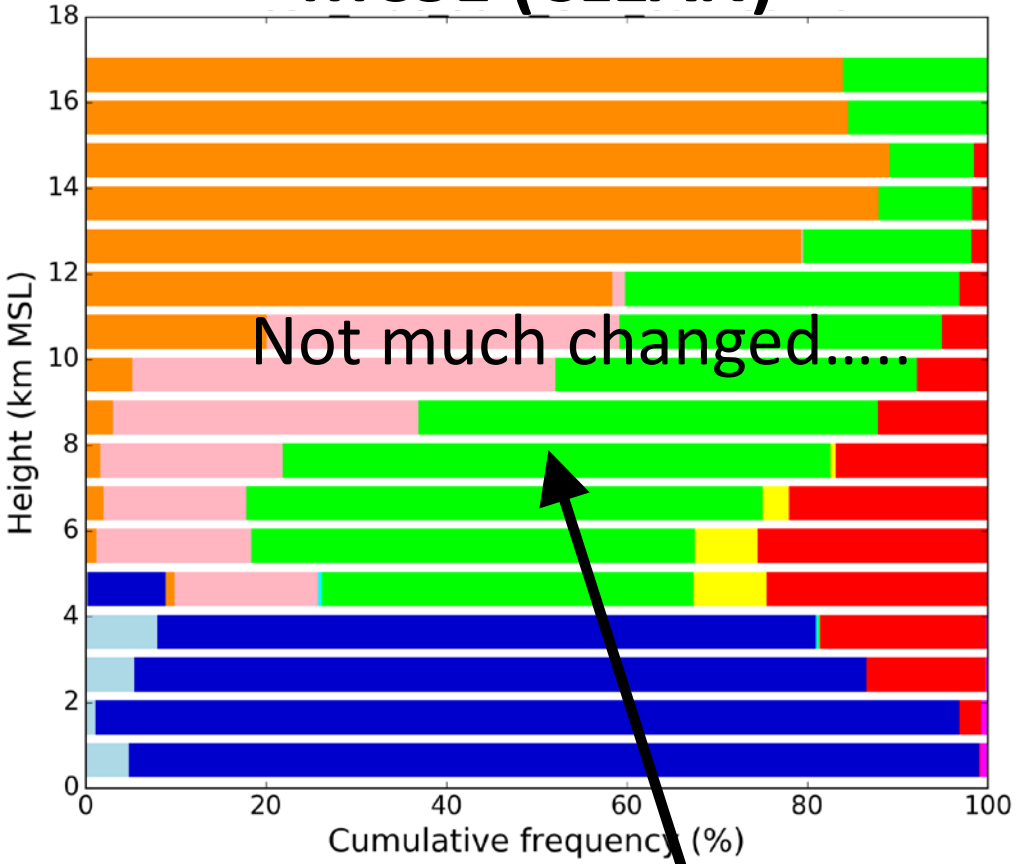
TWP (CLEAN))



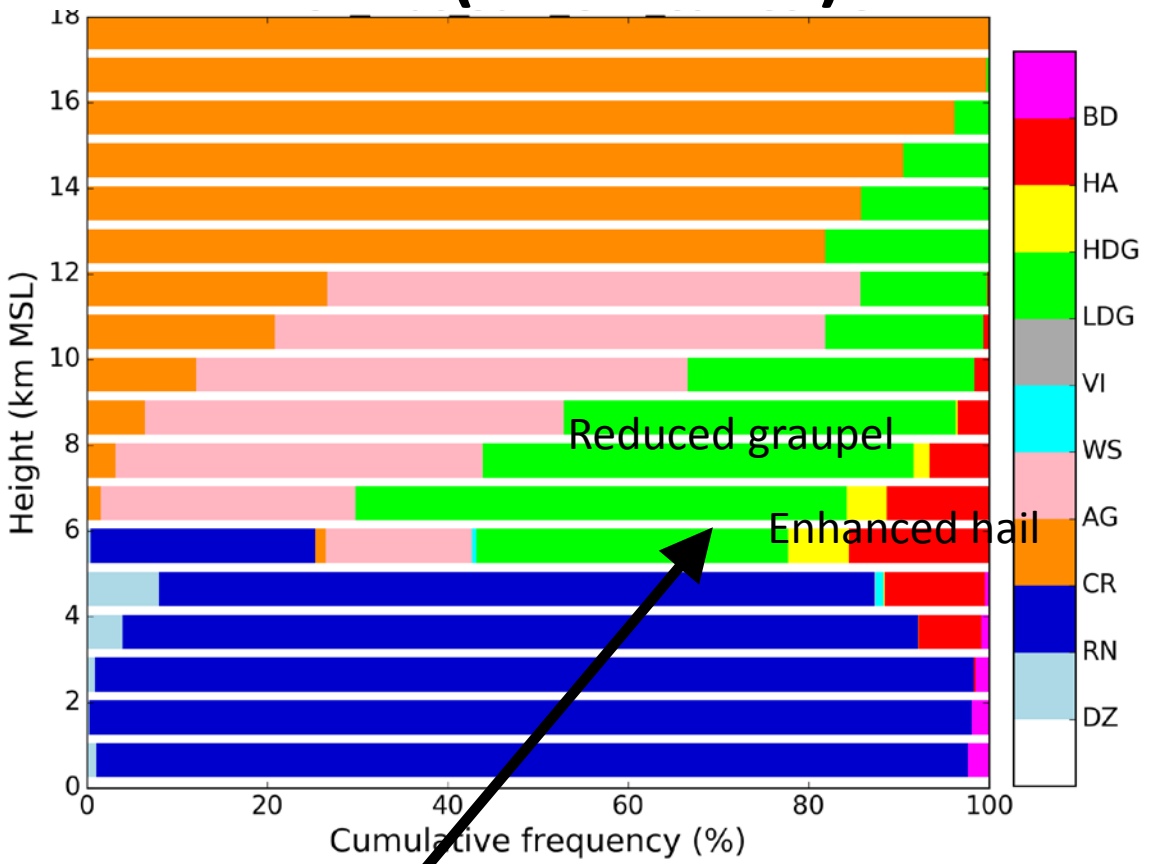
TWP (CLEAN))



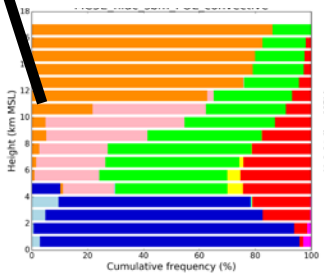
MC3E (CLEAN)



TWP(POLLUTED)



MC3E (POLLUTED)



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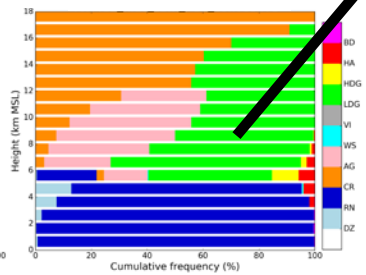
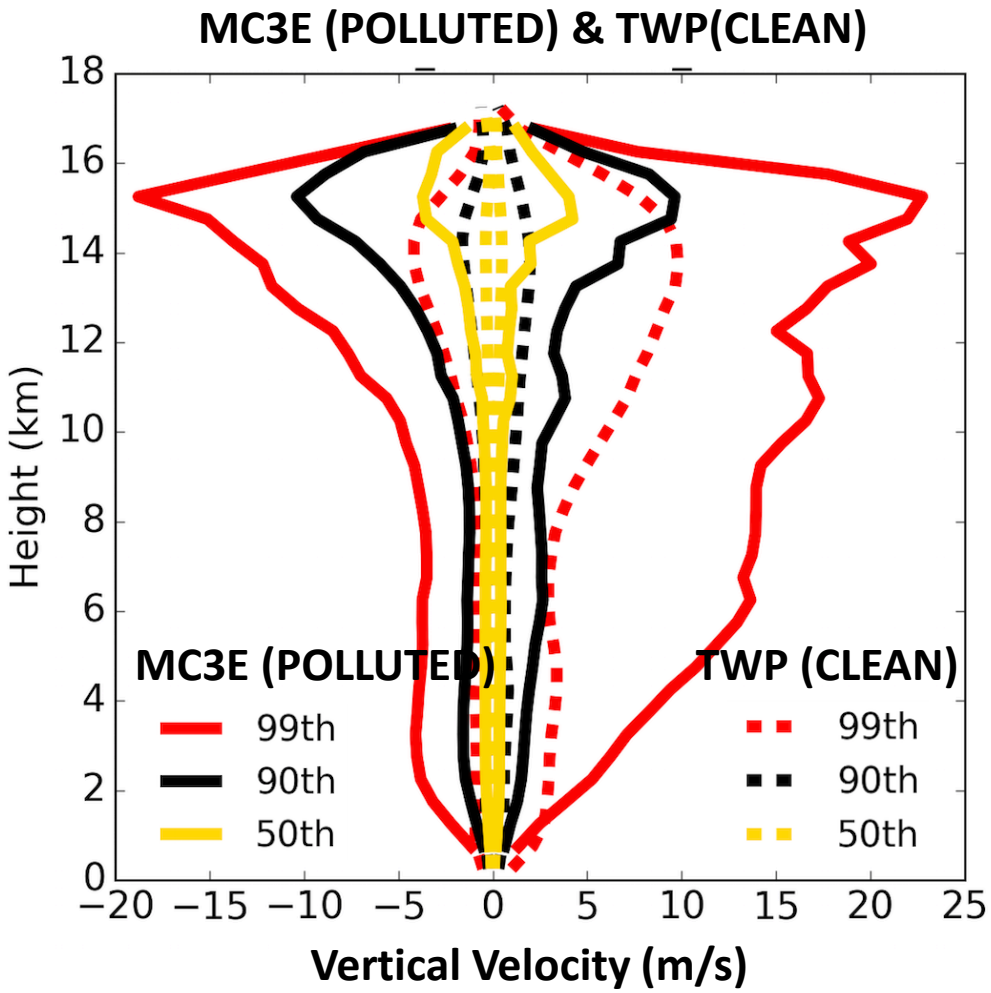
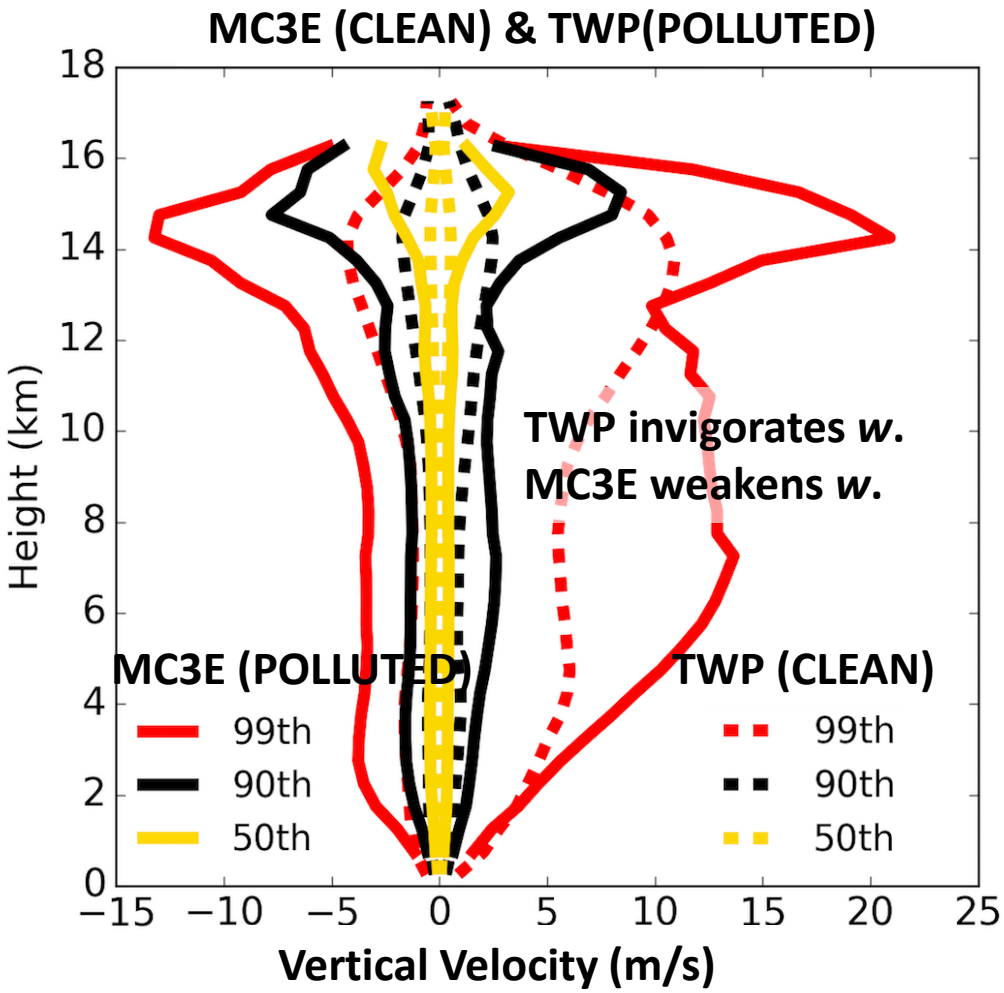


Vertical Velocity

Default Aerosols



Swapped Aerosols



The answer is C.

TWP-ICE convection is still weaker than MC3E.

Implication of Physics:

- Thermodynamics structure is 1st-order physics to invigorate deep convection.
- Continental (maritime) aerosols concentrations invigorate (weaken) deep convective cores, but does not overwhelm thermodynamics impact.
- MC3E thermodynamics likely activates large concentrations of CCN through stronger updraft velocity and super saturation regardless of background aerosol concentrations.