# Identifying Organized Convection in GPM Satellite Data

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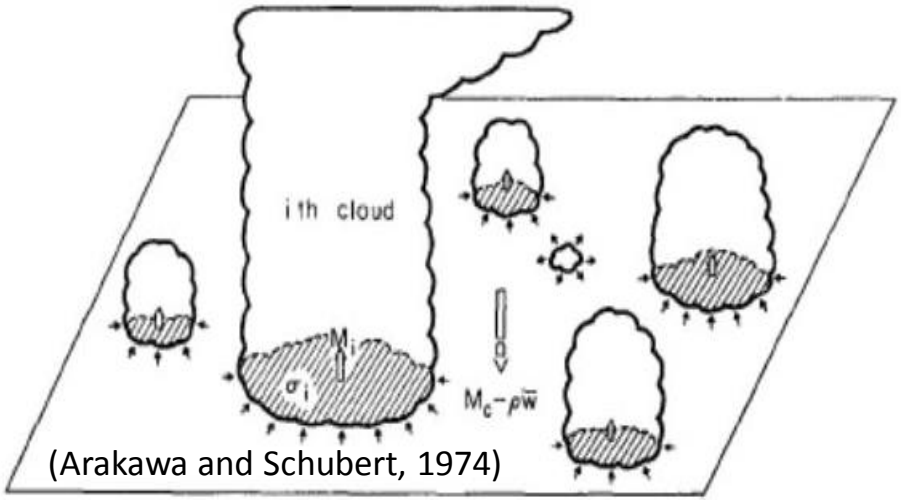
**NASA GISS**

**UTCC-PROES, 3/28/17**

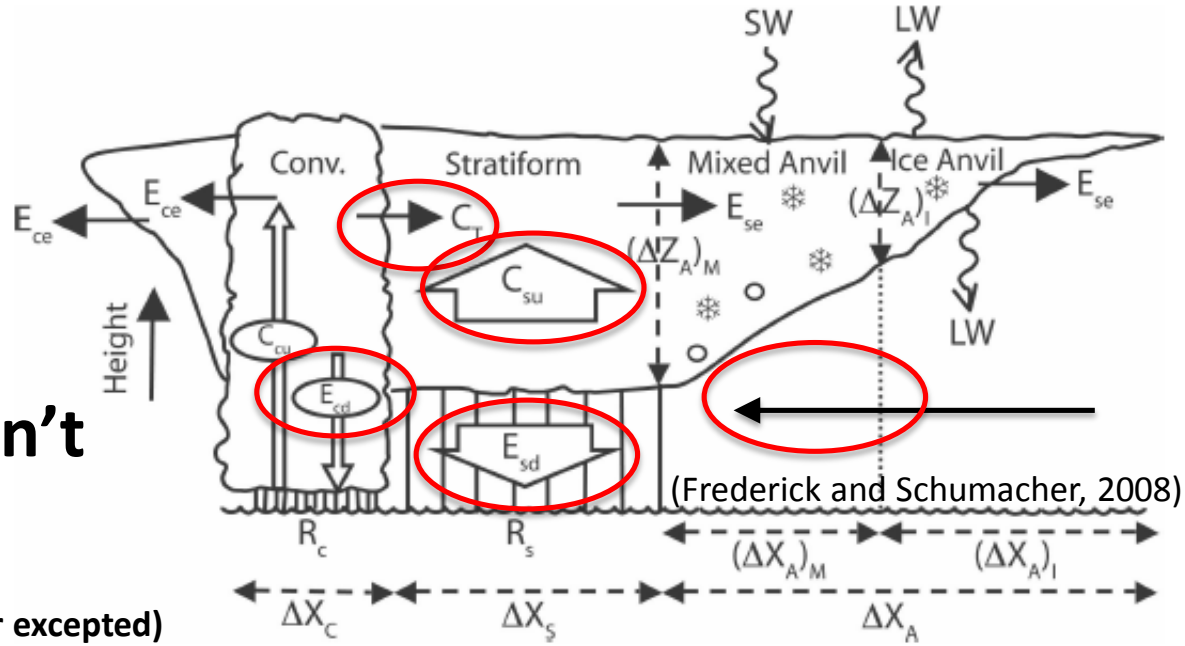
**GCMs see convection like this…**



(Arakawa and Schubert, 1974)

**and we don't even do this part very well.**

**But sometimes it's more like this...**

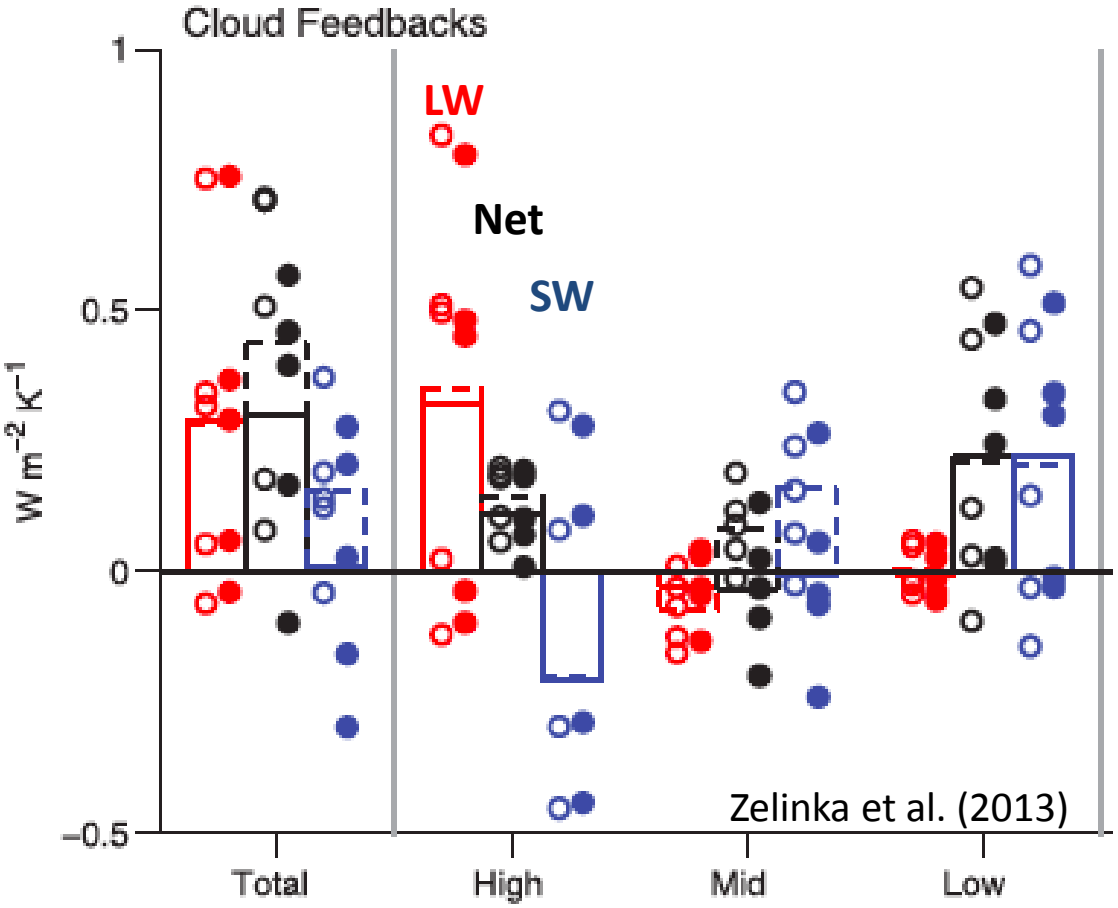


(Frederick and Schumacher, 2008)

**and mostly* we don't do this at all.**

**(*Leo Donner excepted)**

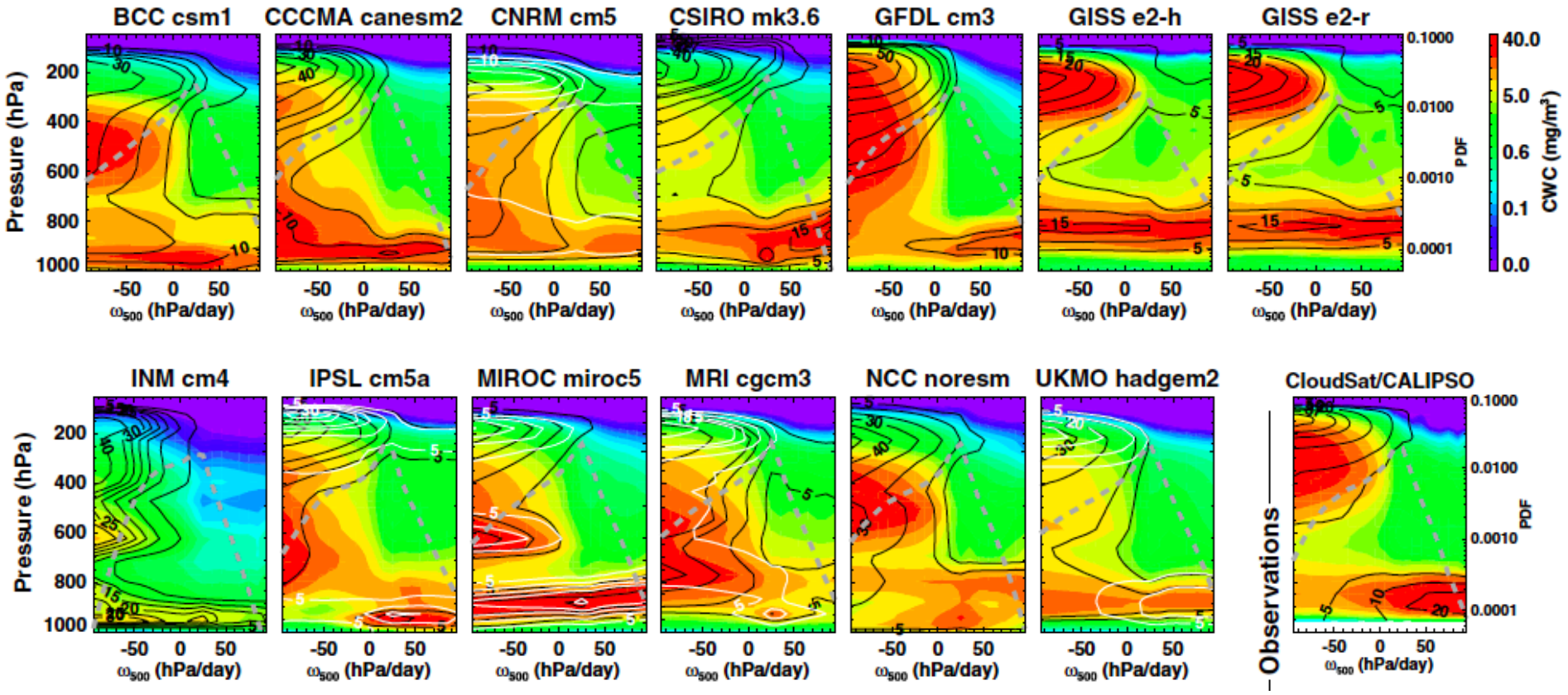
**We need to simulate the entire convective life cycle**




**There is less inter-model spread in high cloud feedback than in low cloud feedback. But**

- **lots of spread in SW and LW contributions**
- **spread ≠ uncertainty**

# GCMs have a tough time predicting the vertical structure of clouds in convective regions




Su et al. (2013)

Detrainment effect on climate sensitivity? (Zhao et al. 2016)

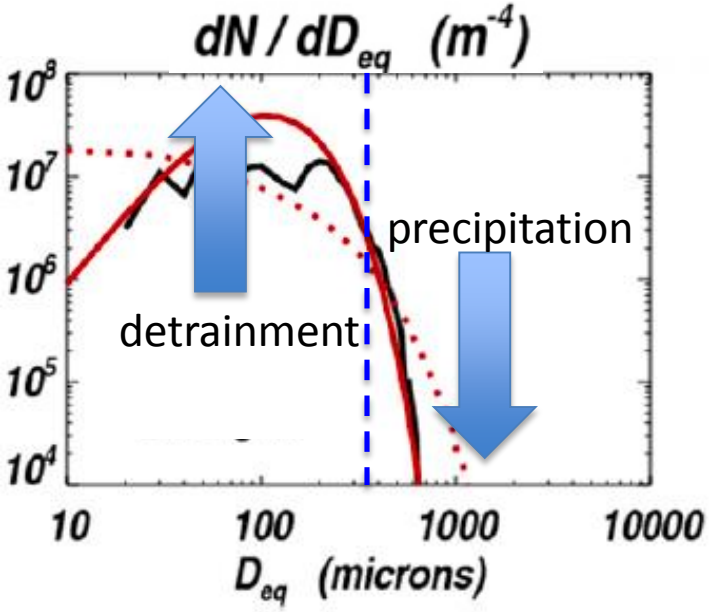
# Convective detrainment in the GISS GCM:

- Diagnostic updraft speed profile $w_c$ (Del Genio et al., 2007)
- Assumed particle size distributions and size-fall speed relationships $v_T(D)$ (Del Genio et al., 2005)
- Then partition PSD (after Fowler et al., 1996)

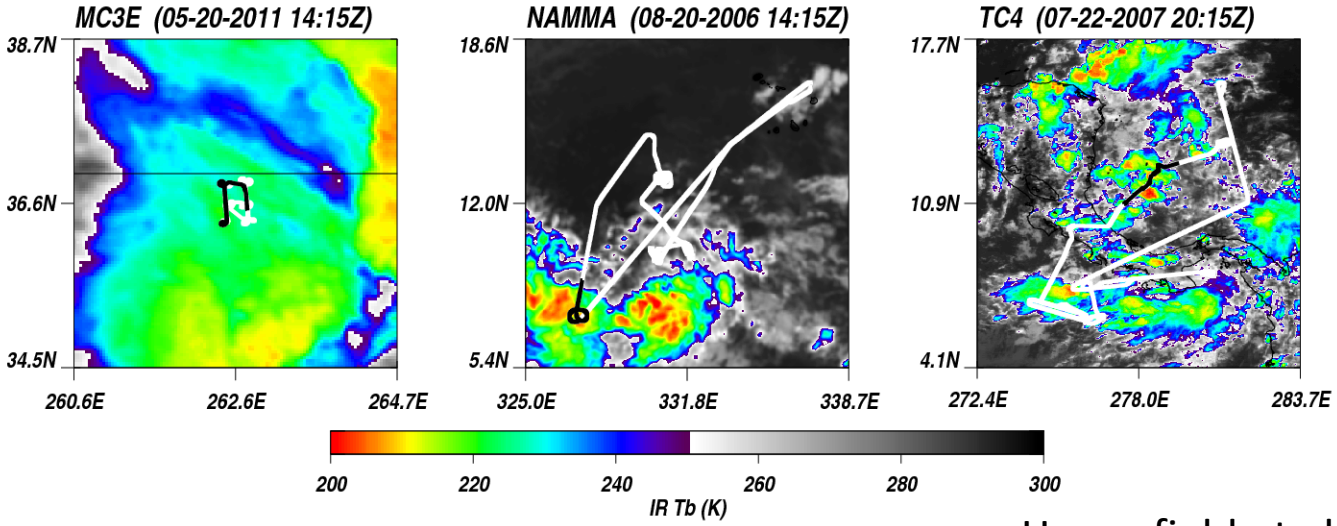
$w_c < v_T$ -> precipitation

$w_c \geq v_T$ -> detrainment/ upward transport

But need good $w_c$, PSDs, $v_T(D)$

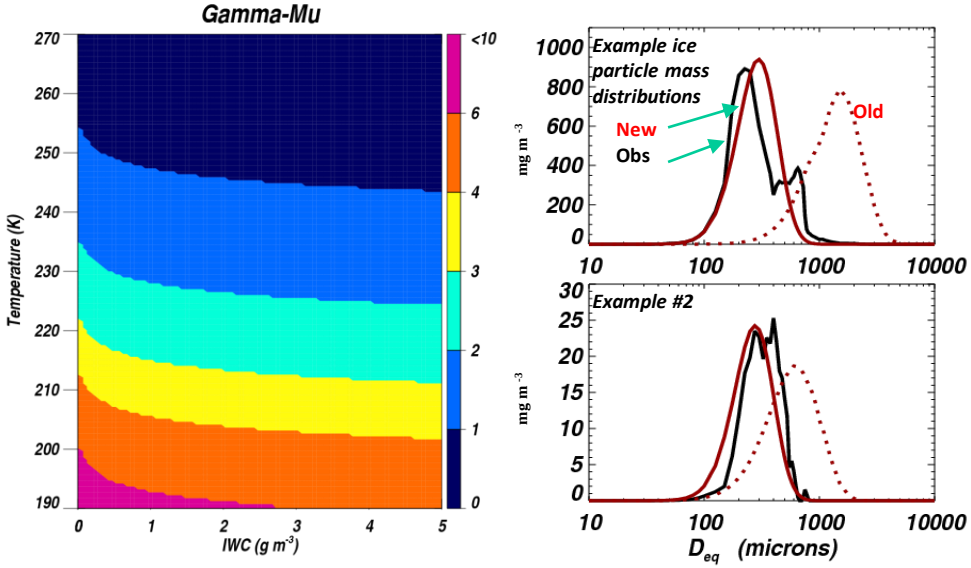


# Detrainment informed by field experiment data (Elsaesser et al., 2017)

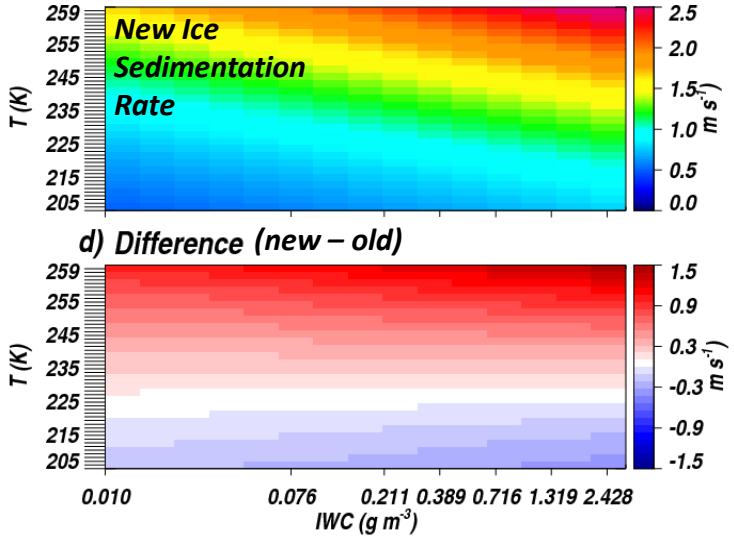



In situ PSDs from flight legs near deep convection (black line segments)

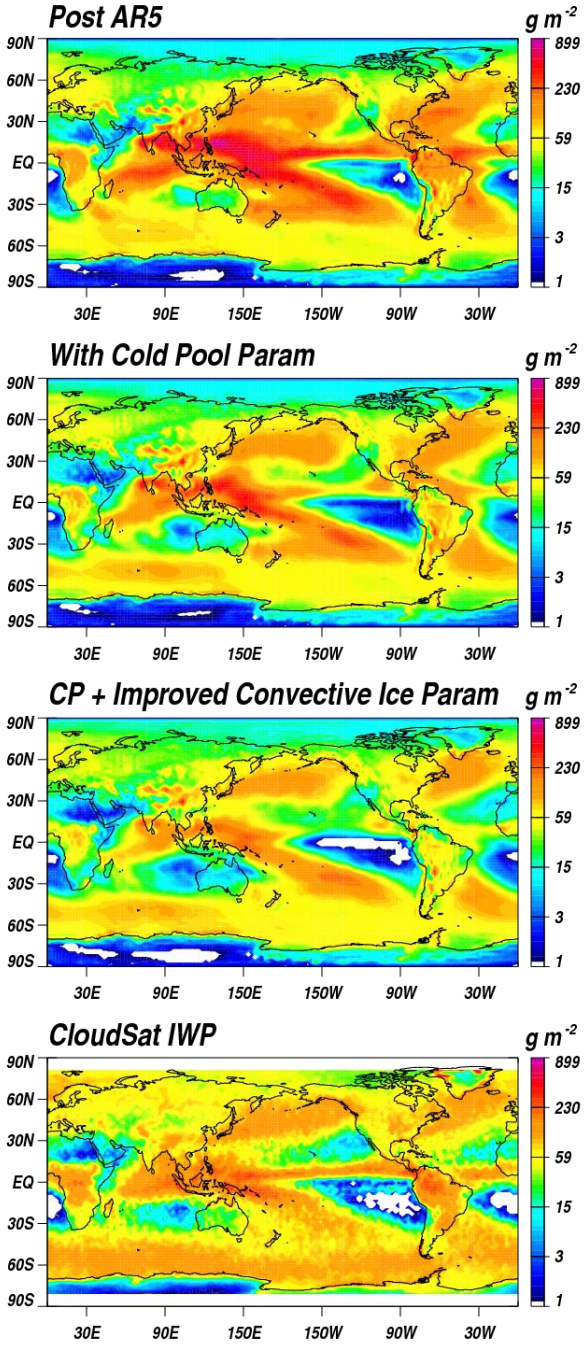
Gamma distribution fits to PSDs, with gamma-μ varying with IWC/T. Example fits (red) to obs. particle mass PSDs (black), new vs. old model

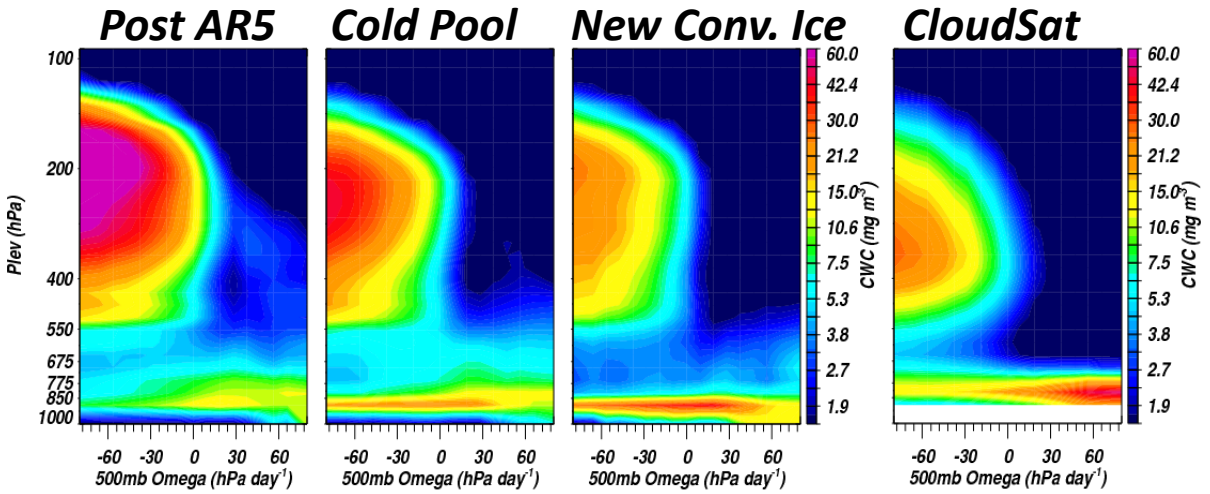


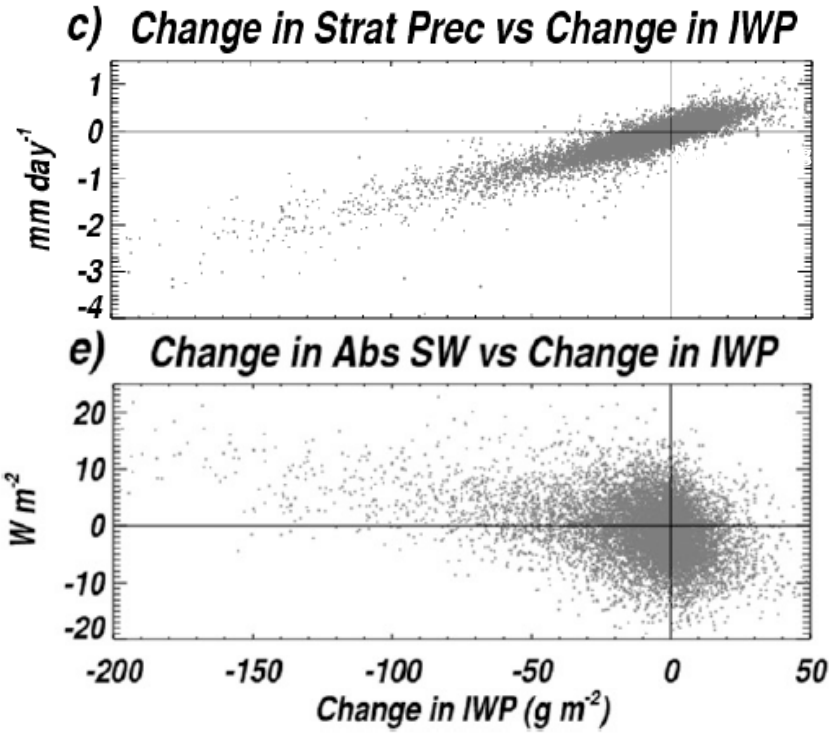

Heymsfield et al. (2013) formulations for particle $V_{fall}(D)$: smaller particles but faster fall speeds



# GCM Simulations vs. CloudSat



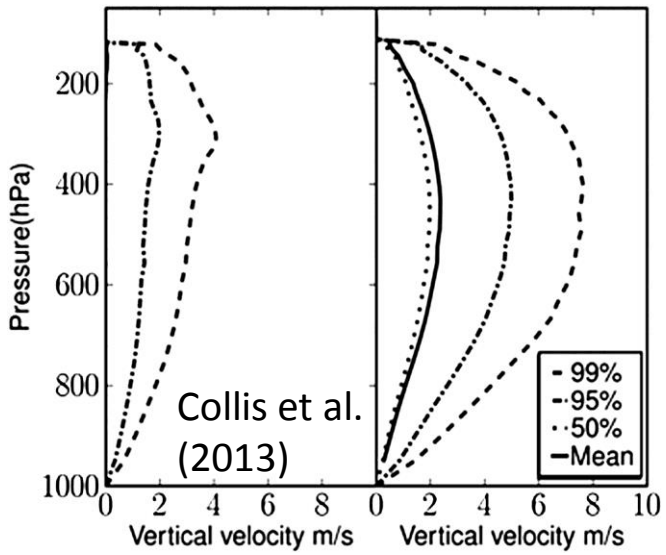




**$dP_s \alpha$ dIWP but little change in SW (and LW)**

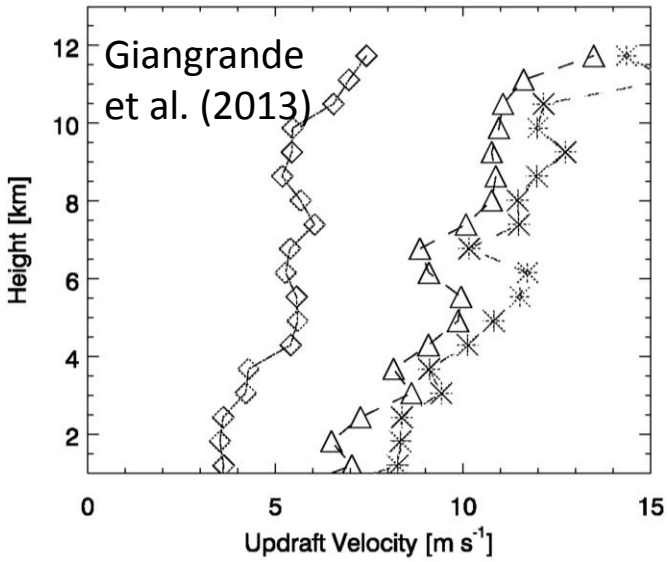
(Elsaesser et al., 2017)

## ARM updraft speed retrievals

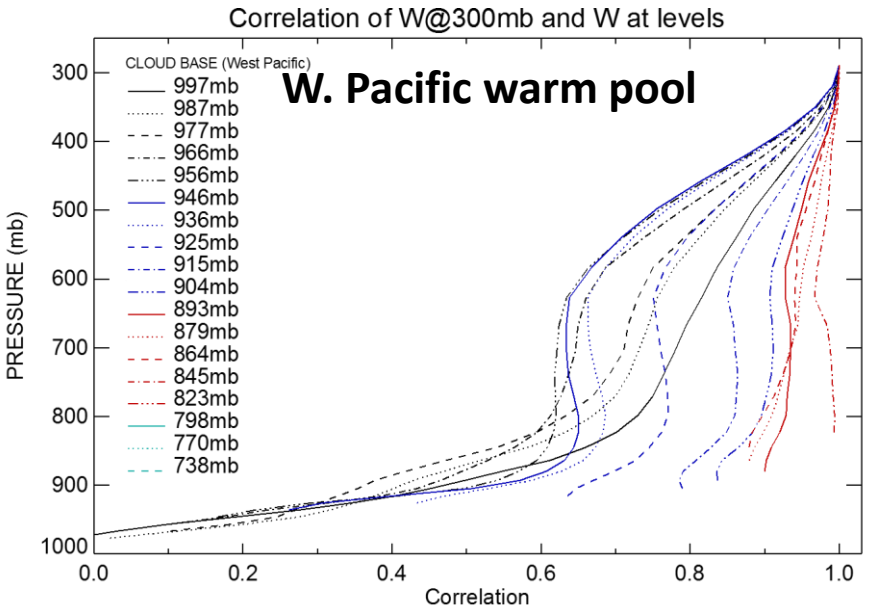
### Darwin

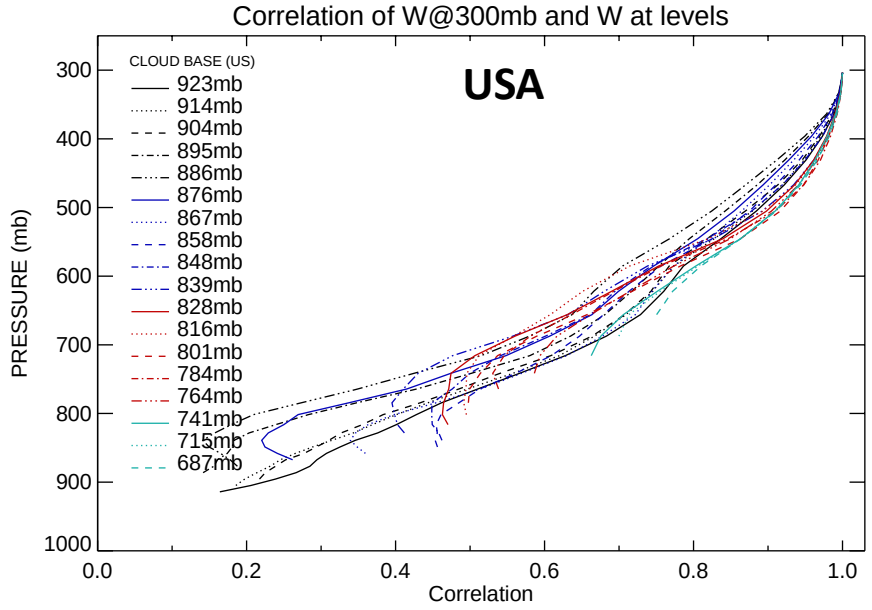


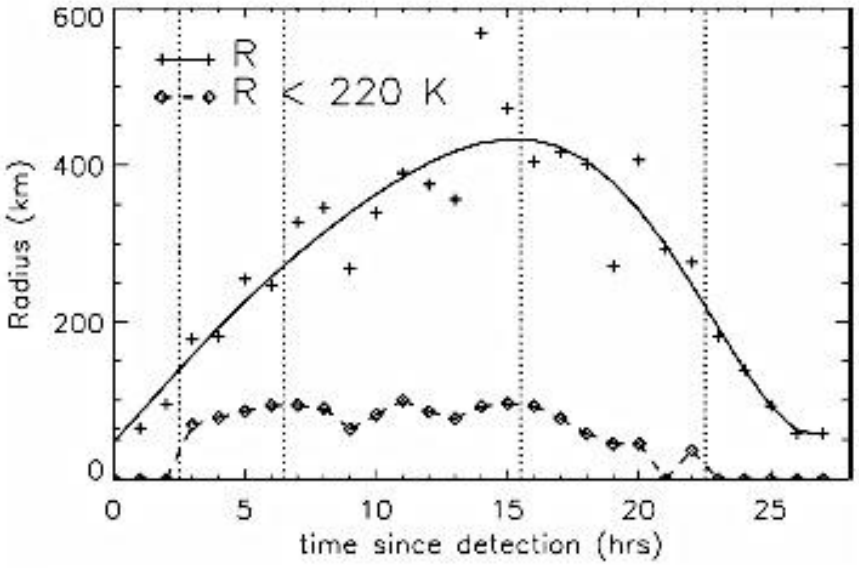

### Oklahoma

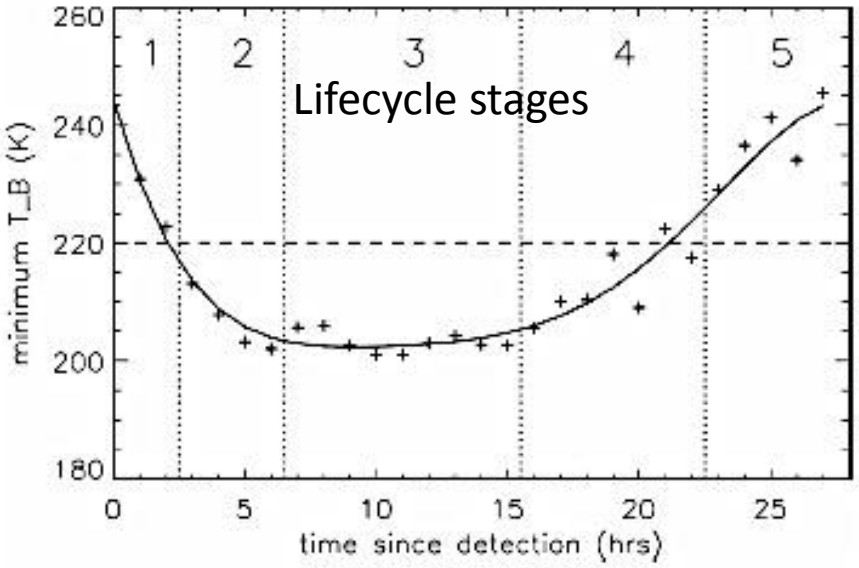


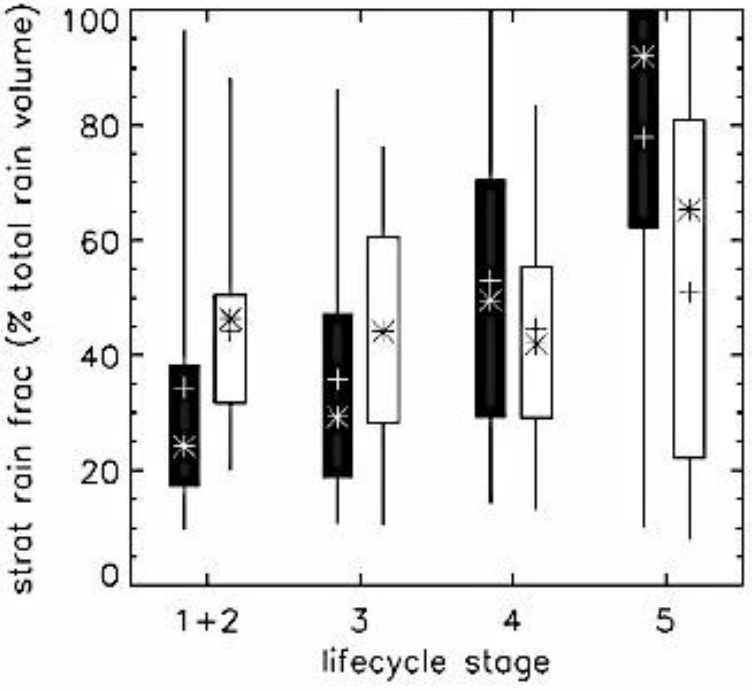

## GISS pre-CMIP6 GCM $w_c$ correlations



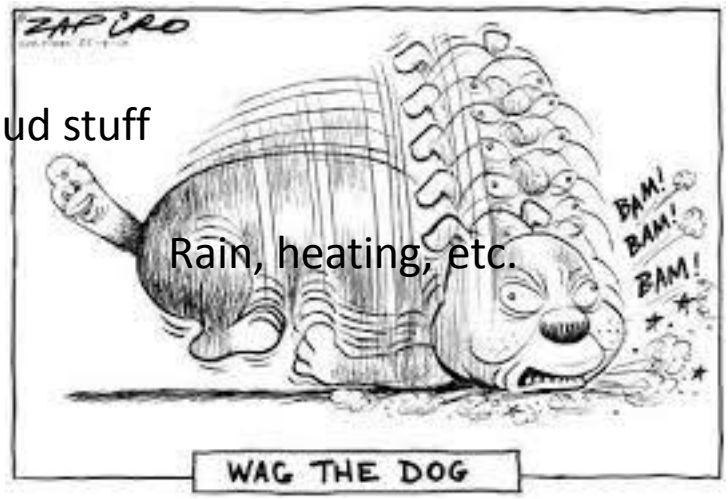



Cloud stuff

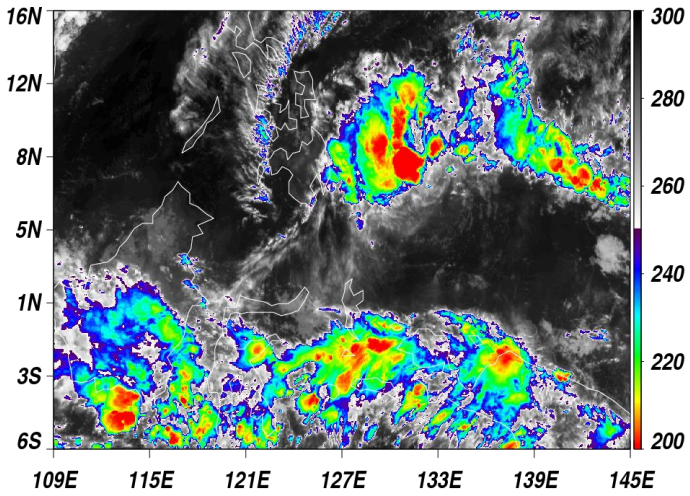
Rain, heating, etc.

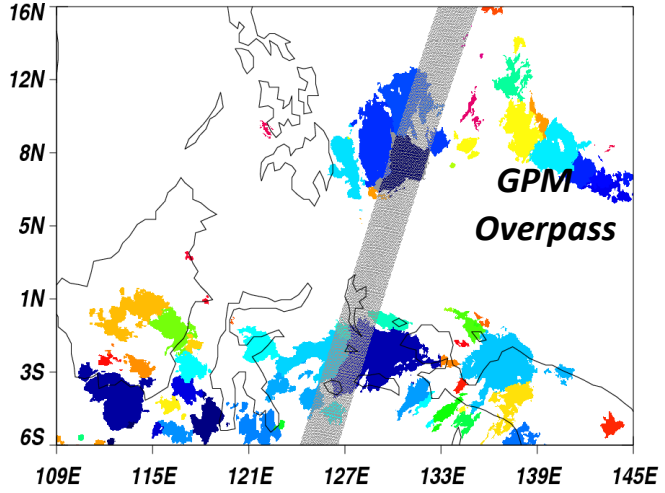



**Futyan and Del Genio (2007): Use geo IR for lifecycle stage, map LEO data onto it**

**Or should we be doing the opposite?**

# GPM overpasses mapped to IR-defined convective systems: Starting point to identify MCSs and environments in which they occur, grow, and dissipate

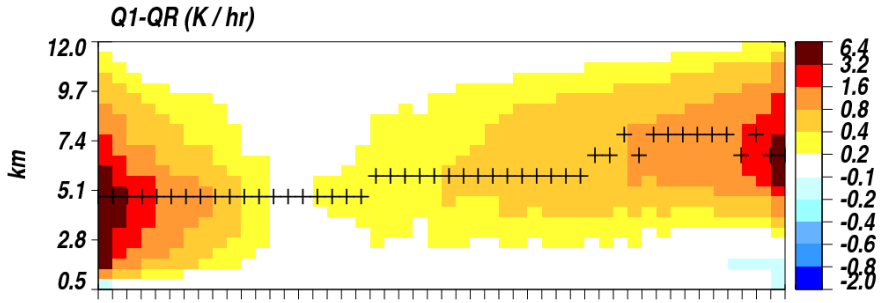


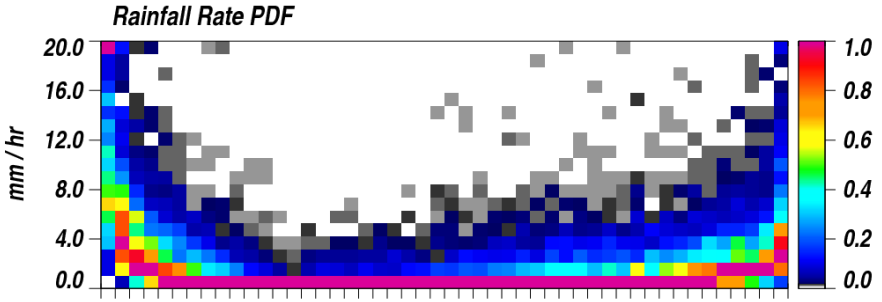



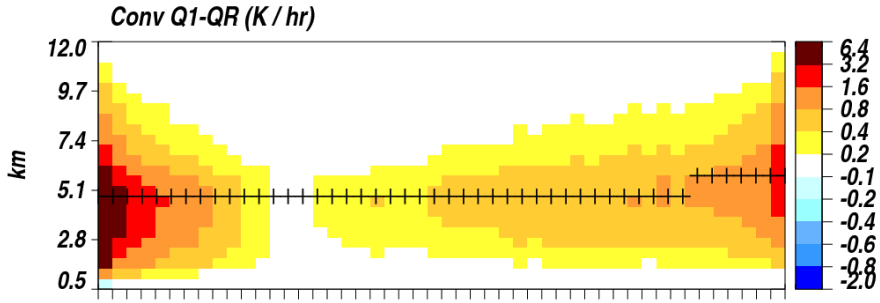

Systems identified and tracked through lifecycle in CPC Globally Merged IR product (~4 km, 30 min) using Fiolleau and Roca (2013) algorithm: ~20K systems, 3/14-12/14

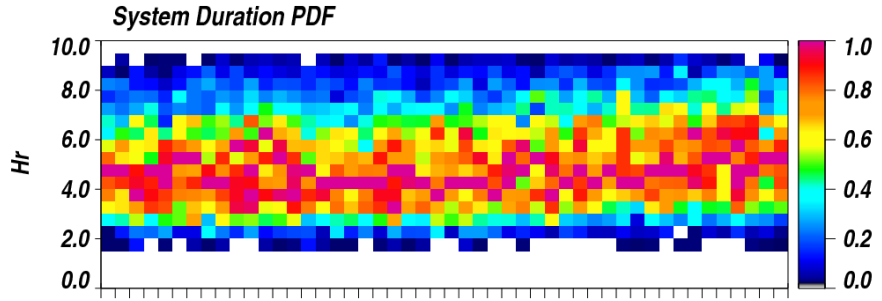
GPM retrieved quantities mapped to system lifecycle stage at time of overpass:

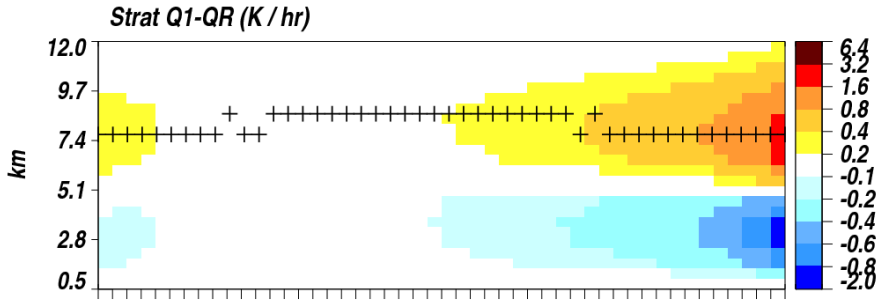
- SLH $Q_1$-$Q_r(z)$, LH(z), $Q_2(z)$
- DPR Conv/Strat Flag (2ADPR)
- DPR Rain Rate
- Precipitation Top Height
- CSH $Q_1(z)$, $Q_2(z)$ components
- Co-located T/q(z) – Reanalysis

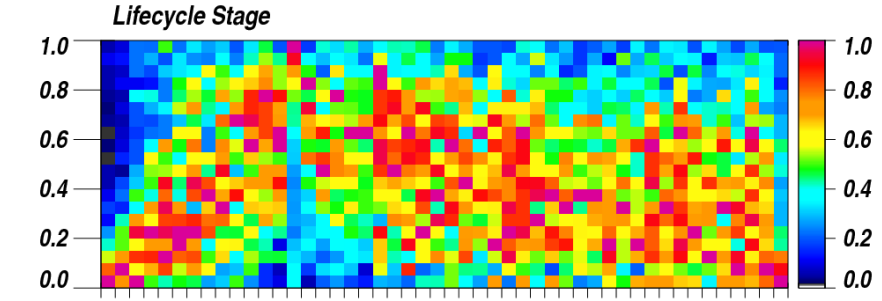


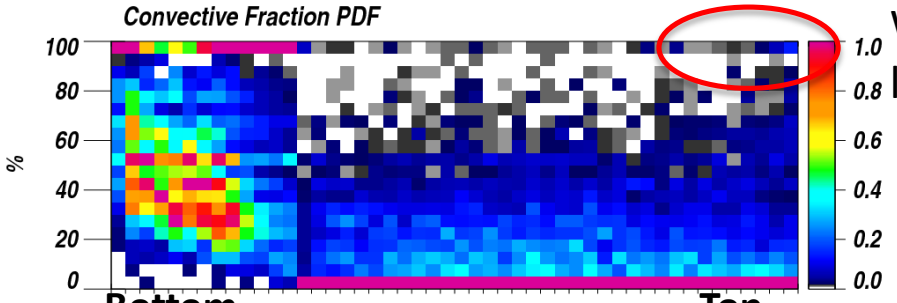



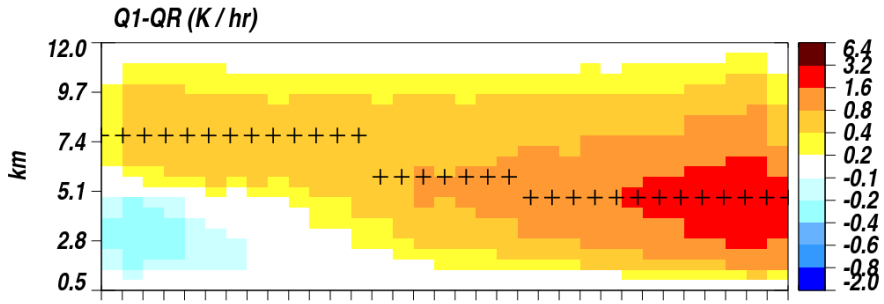



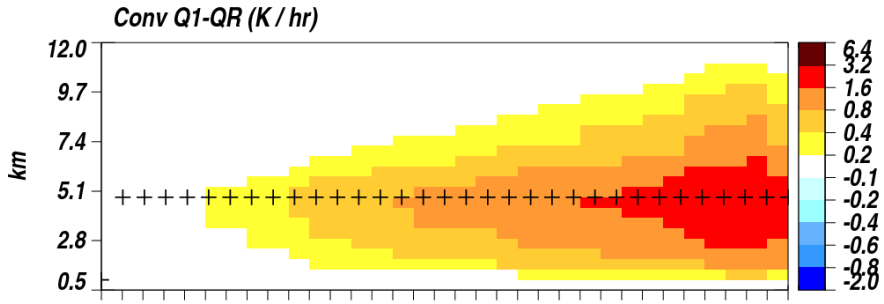

**Bottom-heavy**

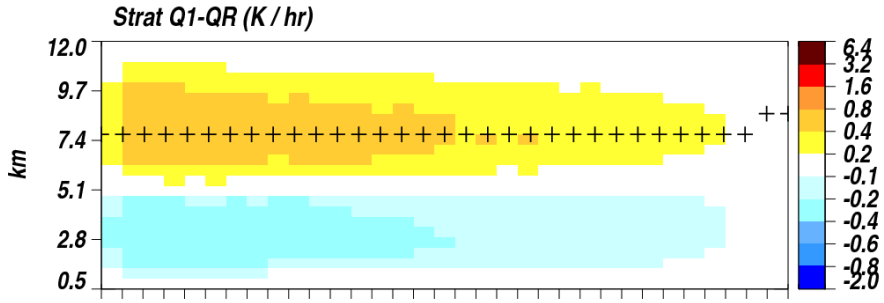
**Top-heavy**

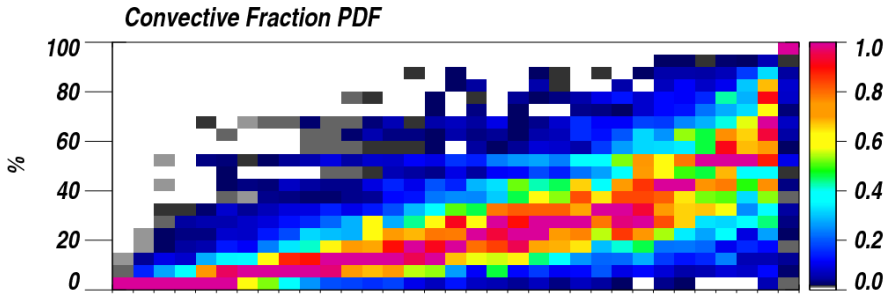
What GCMs like to do

**Sort by top-heaviness of $Q_1$-$Q_r$**

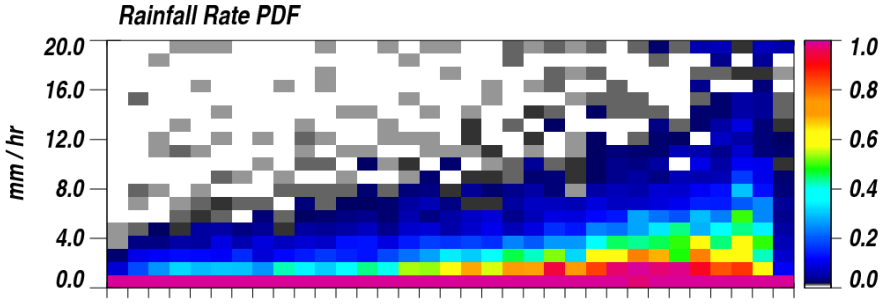


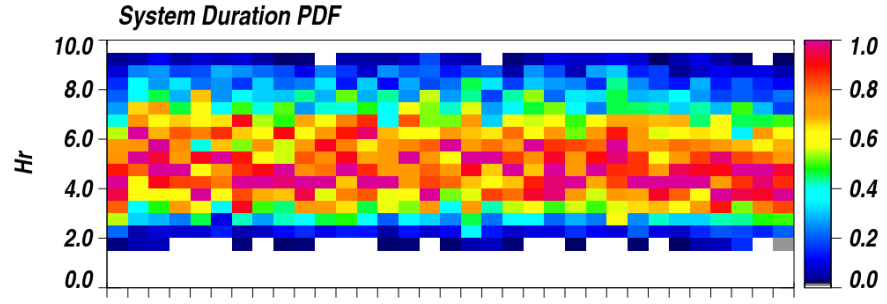



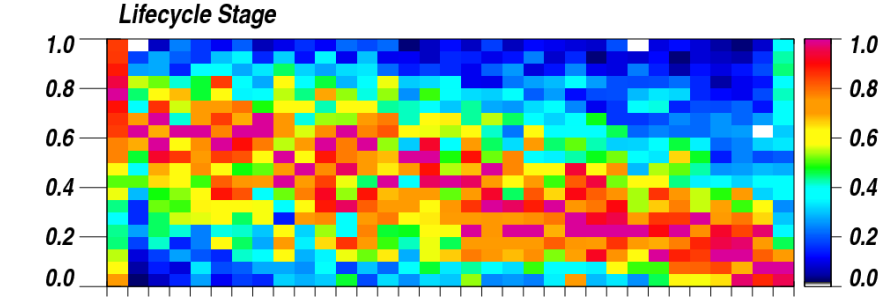



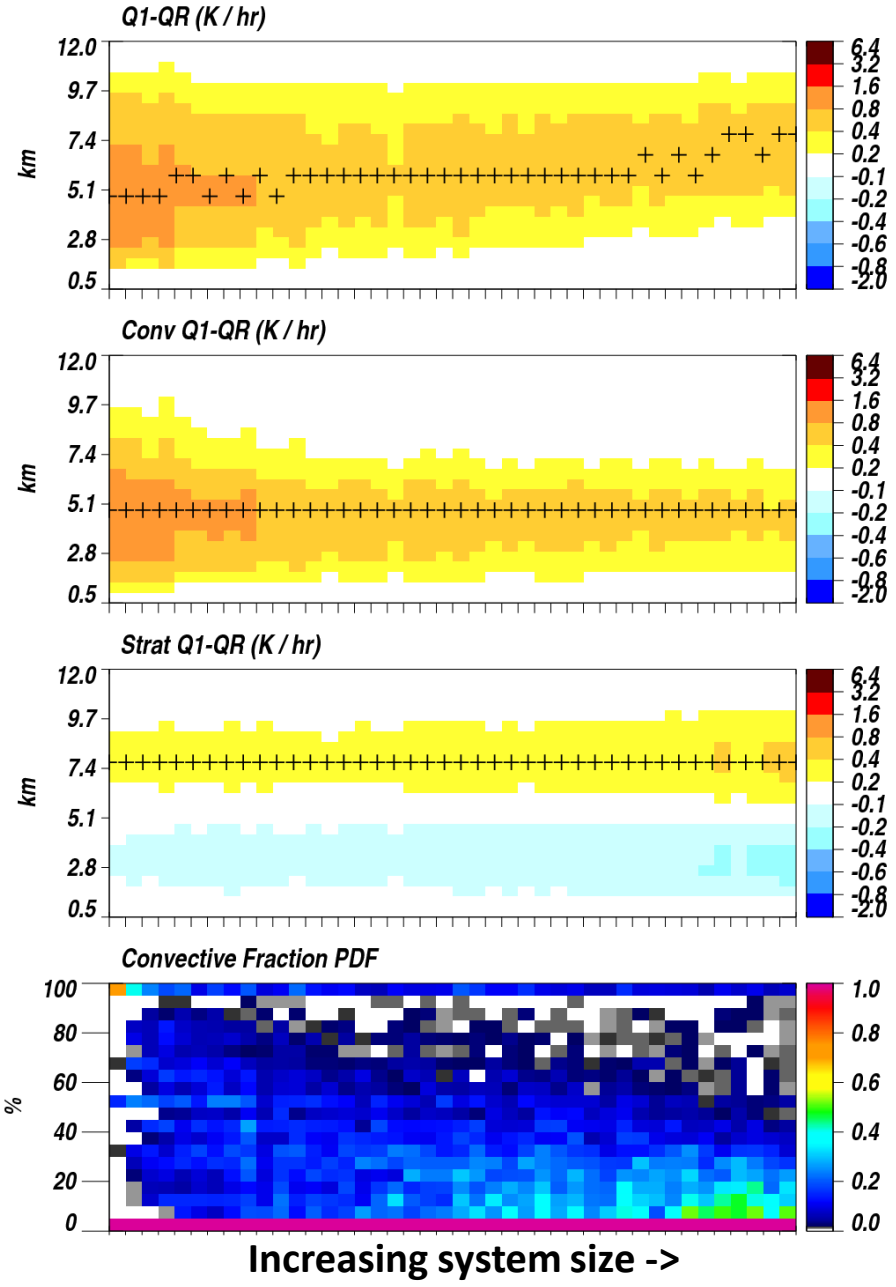

Increasing convective rain fraction ->




**Sort by convective rain fraction**




**Sort by system size**

# Summary:

- Field experiment constraints on PSD and $v_T$ can be exploited in GCMs to produce reasonable detrainment relative to CloudSat/CALIPSO constraints, with implications for convective-stratiform rain partitioning (but not for SW, LW)
- Convective updraft speed constraints now exist from ARM sites, potential for space-based information; may shed light on GCM physics that determines updraft speed profile
- The convective lifecycle is defined in satellite data as the life cycle of the associated high cloud shield. Should we define it instead as the lifecycle of (some aspect of) the convection itself?
- No single property uniquely identifies organized systems in GPM data, but each provides its own insights; $Q_1$-$Q_r$ and convective rain fraction seem to be good first choices, both to define the lifecycle, and to guide a parameterization of mesoscale organization