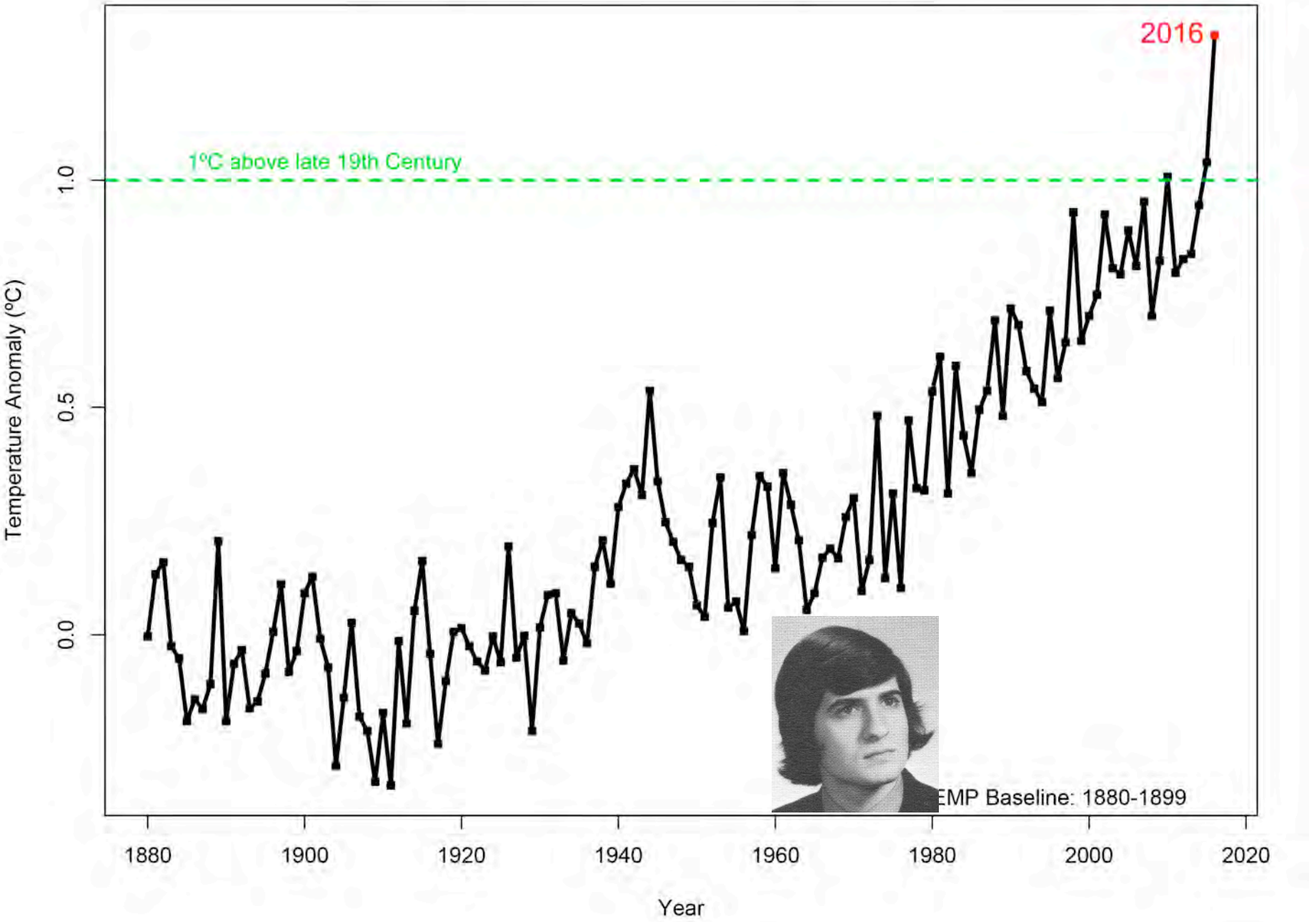
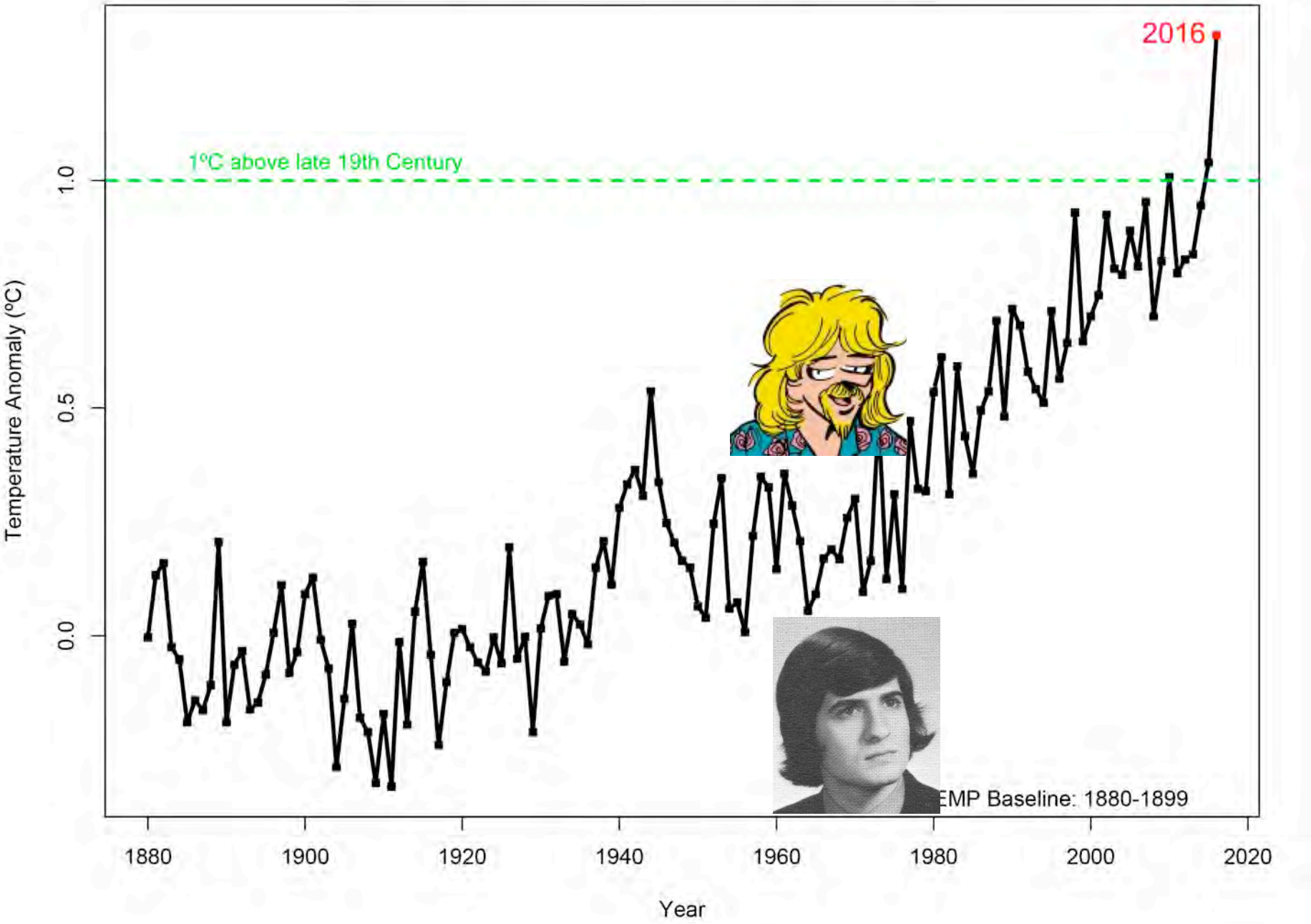
Toward the Representation of the Convective Lifecycle in GCMs

Tony Del Genio
NASA GISS

Rossow Symposium, 6/8/17


2016
1°C above late 19th Century
Temperature Anomaly (°C)
0.0
0.5
1.0
1880
1900
1920
1940
1960
1980
2000
2020
Year
EMP Baseline: 1880-1899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Climate Science Meets a Stubborn Obstacle: Students

By **AMY HARMON** JUNE 4, 2017

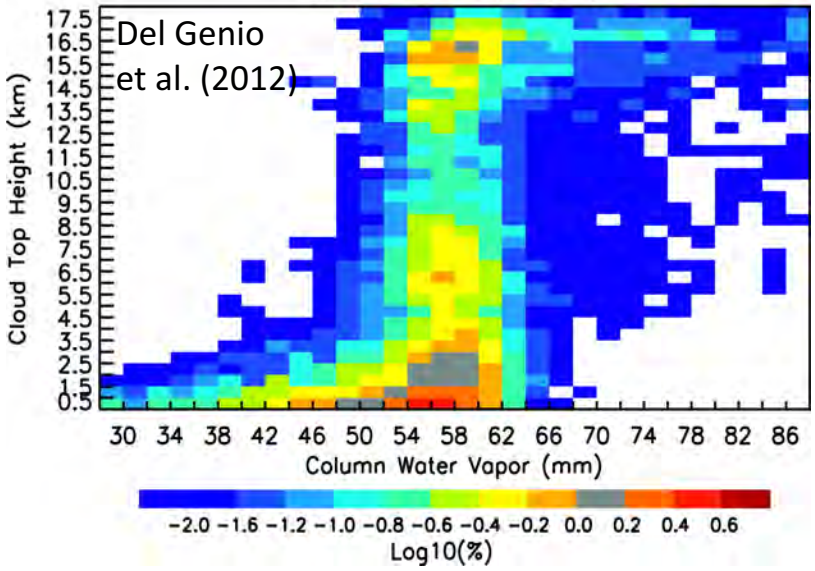
Gwen Beatty in James Sutter's classroom at Wellston High School in Ohio, where she and Mr. Sutter butted heads over the issue of human-caused climate change. Maddie McGarvey for The New York Times

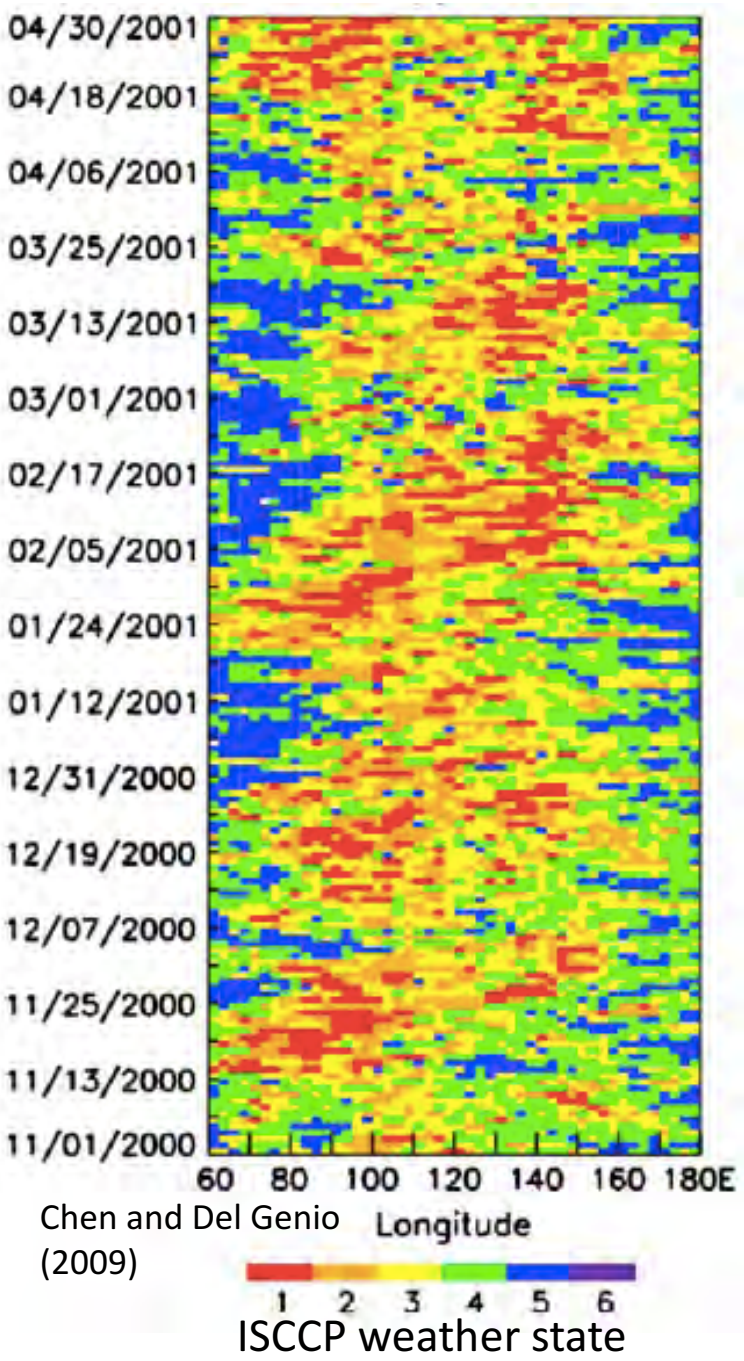
When he described the flooding, droughts and fierce storms that scientists predict within the century if such carbon emissions are not sharply reduced, she challenged him to prove it. "Scientists are wrong all the time," she said

ISCCP $\tau - p_c$ histograms enabled satellite depiction of dynamical cloud types

Weather state view of the convective life cycle during the MJO: shallow-deep-organized transitions

Controlled by water vapor



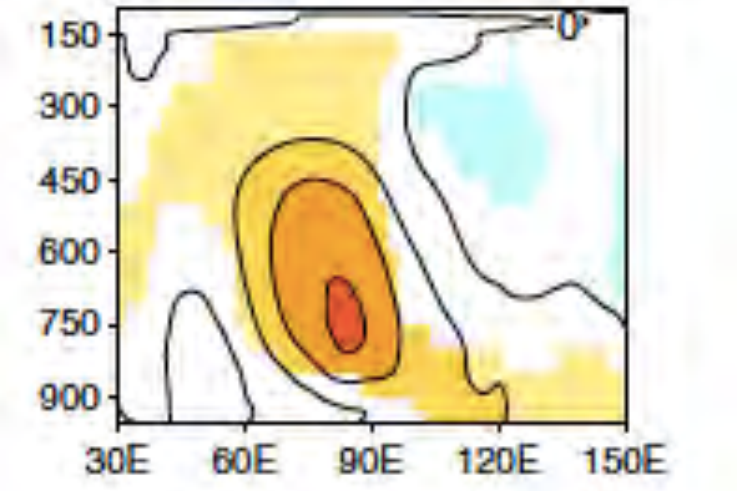


Chen and Del Genio (2009)

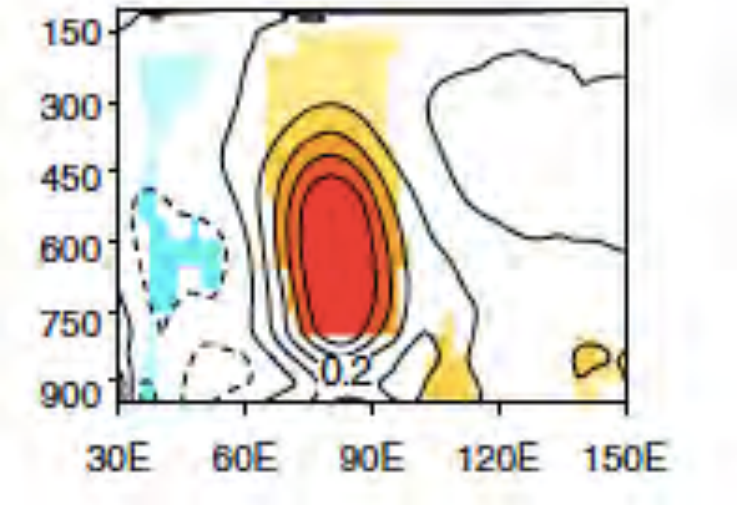
YOTC MJO intercomparison: Moisture sensitivity
Affects both shallow-deep transition and organization

Good GCMs

8 out of 27
(OK, scientists are only wrong 70% of the time)



Poor GCMs

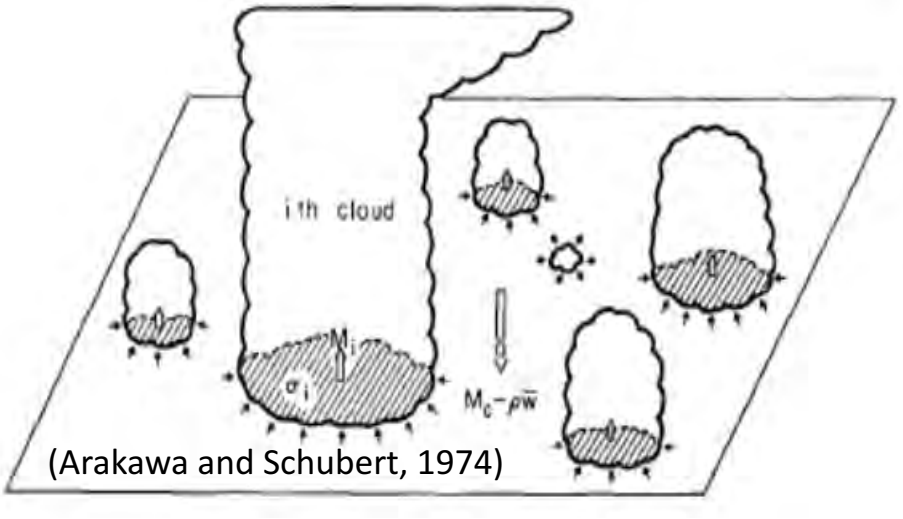


(Jiang et al., 2015)

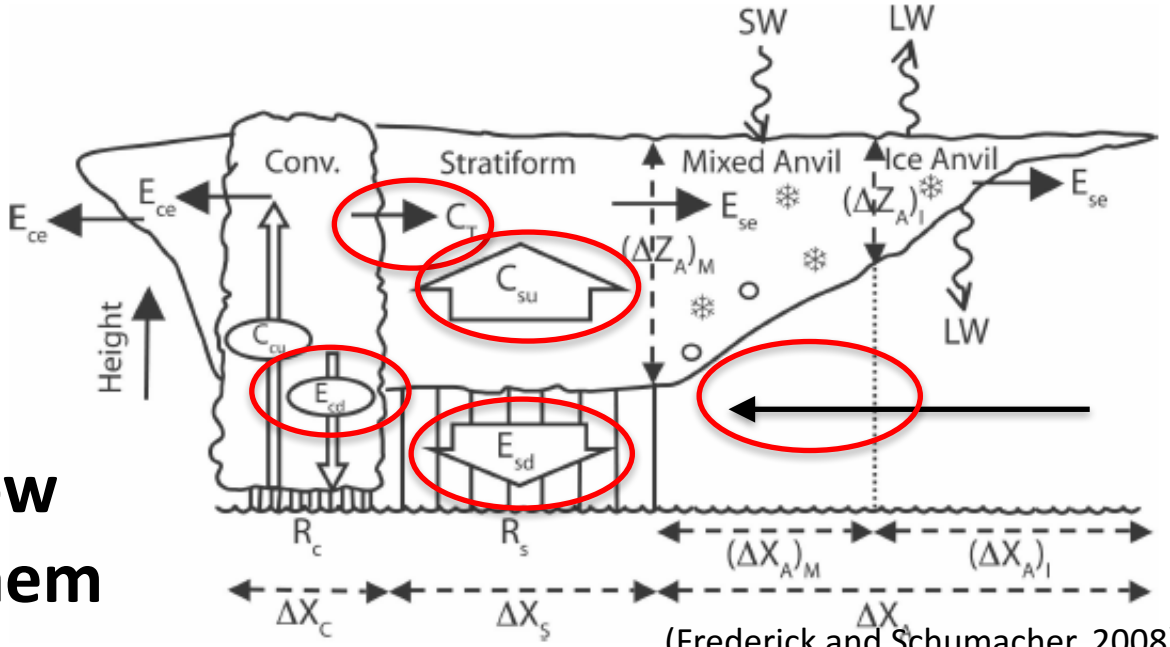
Need to get many things right, none of which we historically have done very well:

- **Entrainment**
- **Detrainment**
- **Sustainability**
- **Organization**

How would we know if we *were* doing them well?

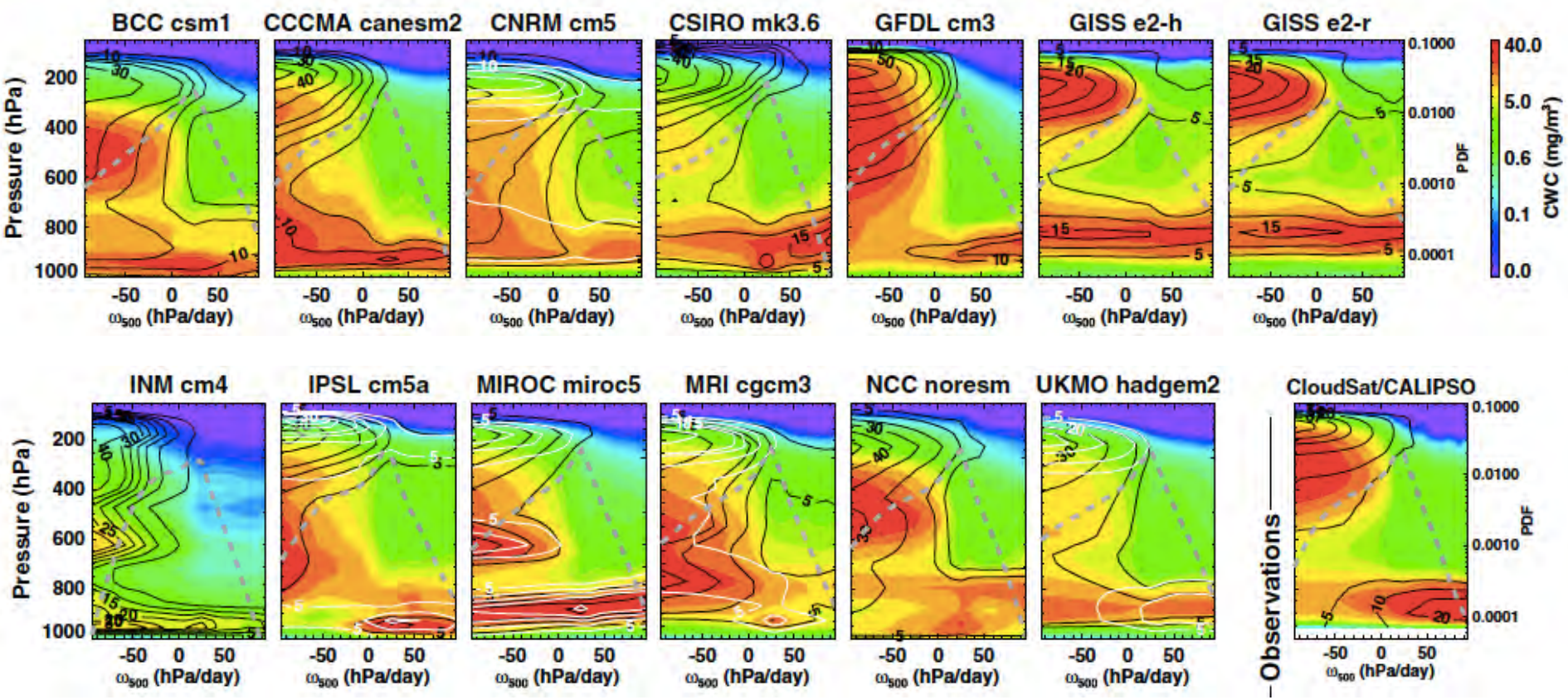


(Arakawa and Schubert, 1974)



(Frederick and Schumacher, 2008)
(adapted from Houze et al. 1980)

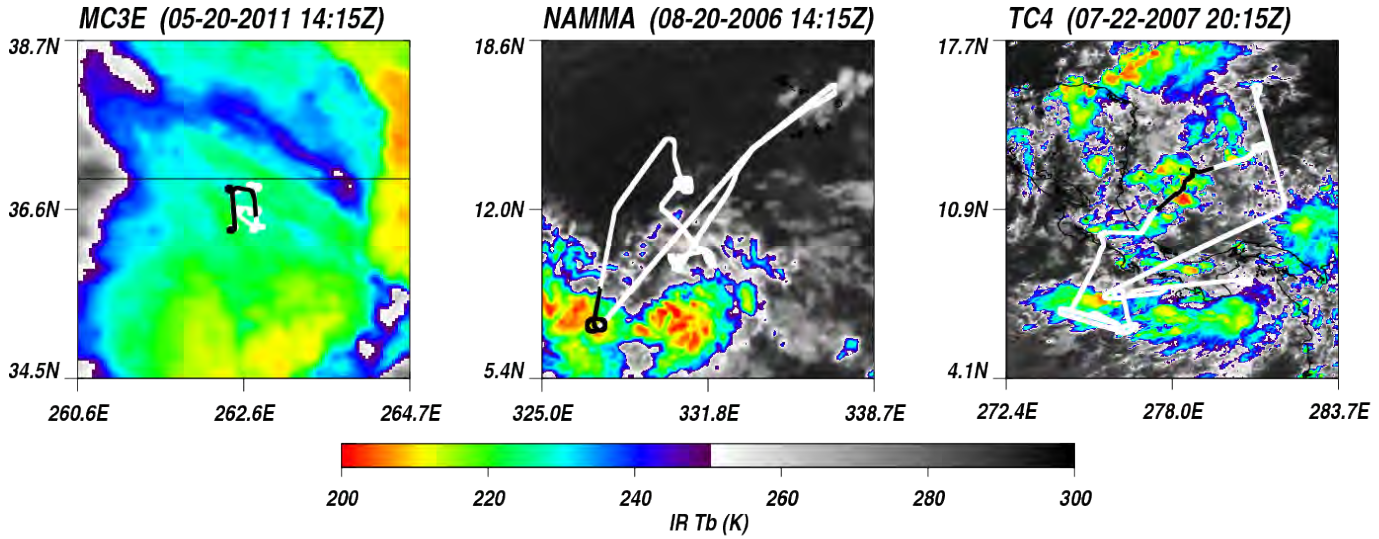
Cloud water content profiles in deep convective regions: Scientists *are* wrong all the time



Su et al. (2013)

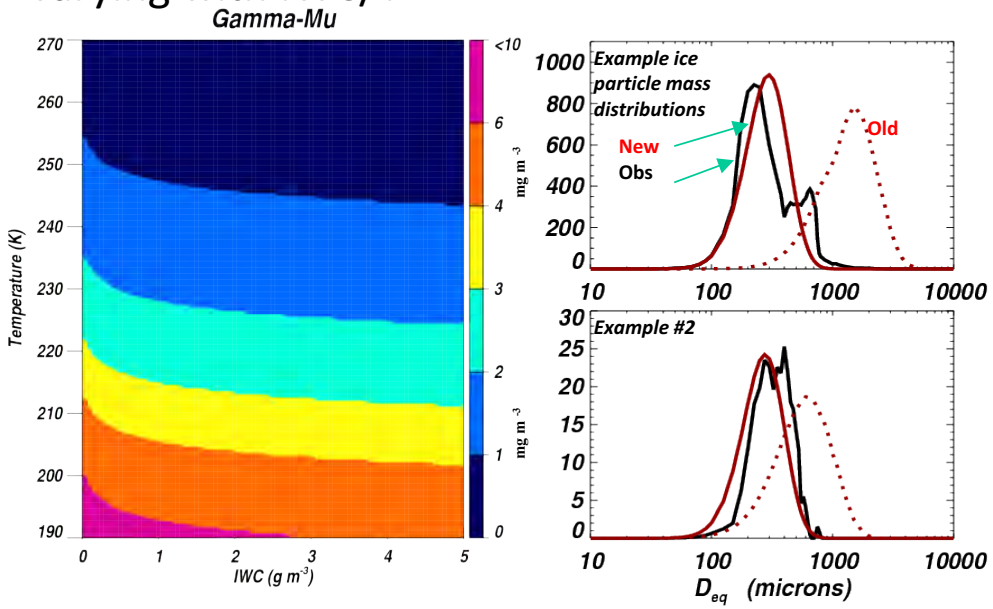
Detrainment effect on climate sensitivity? (Zhao et al. 2016)

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

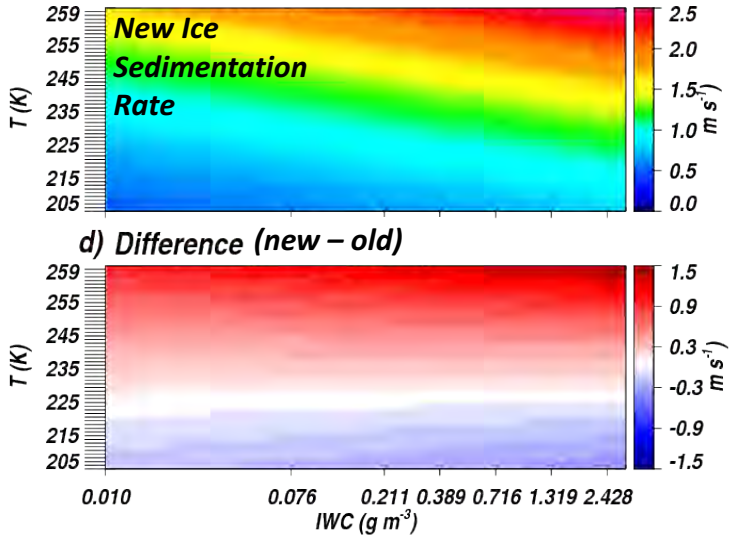


In situ PSDs from flight legs near deep convection (black line segments)

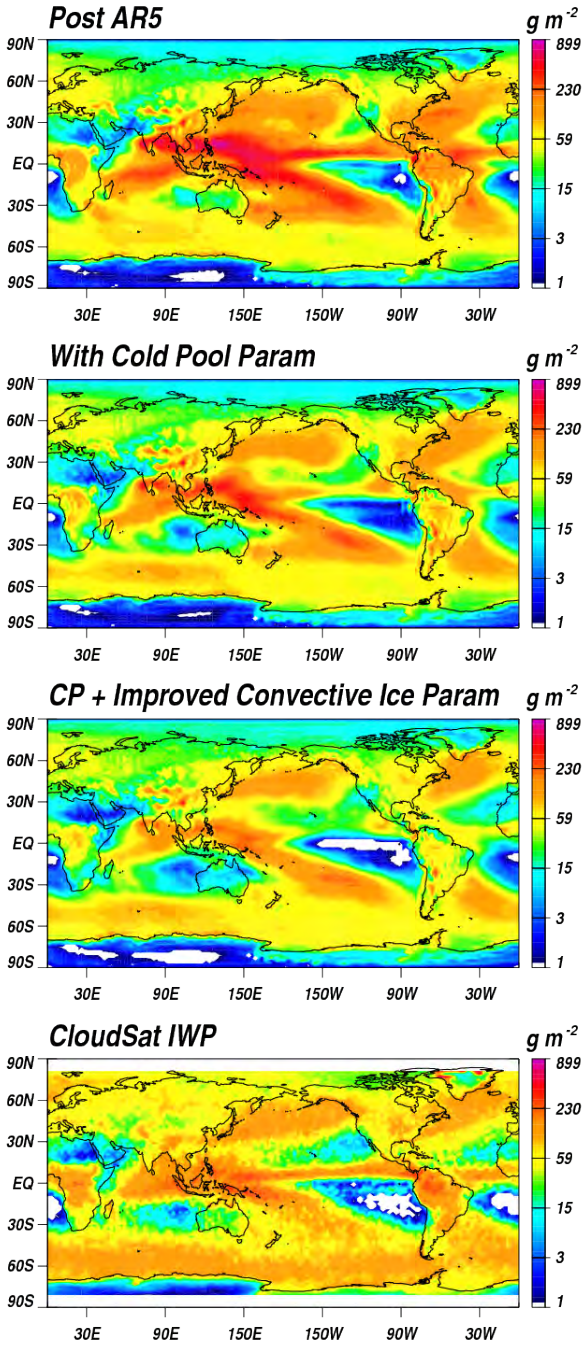
Gamma distribution fits to PSDs, with gamma-μ varying with IWC/T

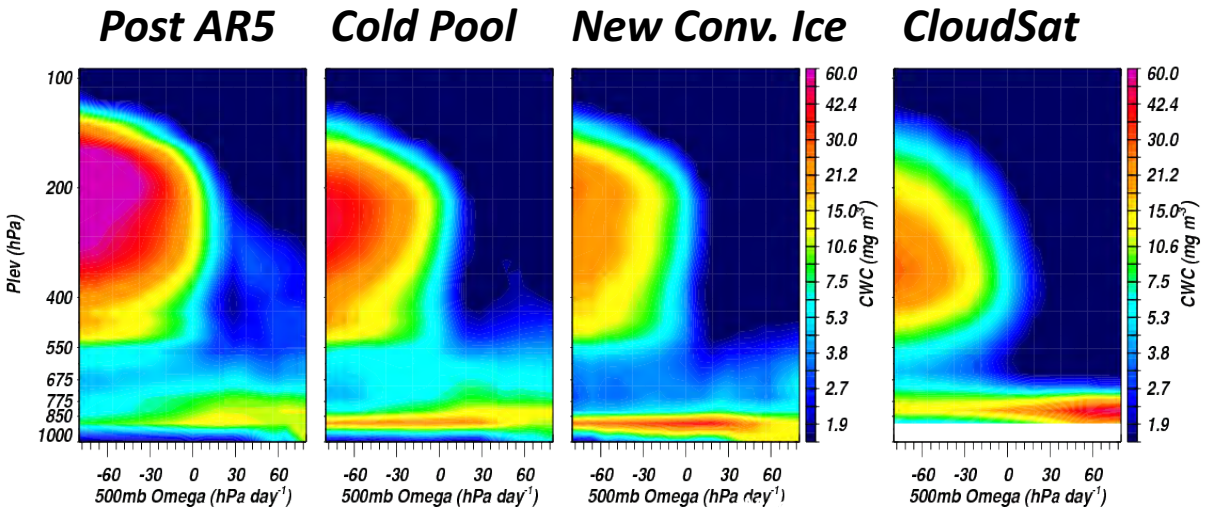


Heymsfield et al. (2013) $V_{fall}(D)$: smaller particles but faster fall speeds



GCM Simulations vs. CloudSat





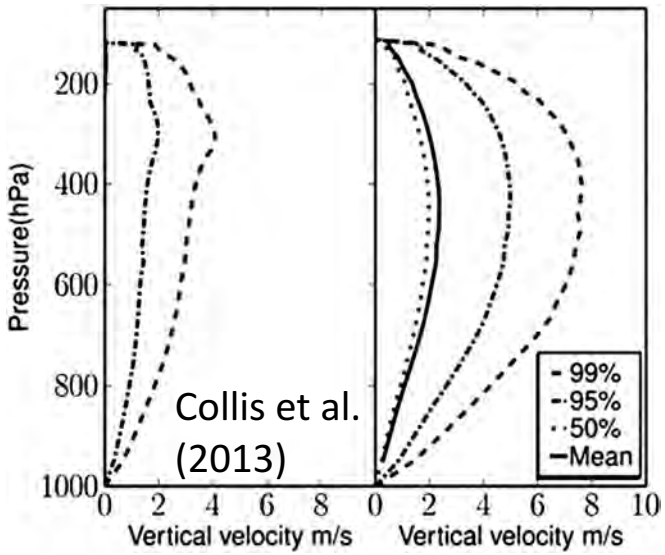
Not quite there yet, but at least now on the same planet

(Elsaesser et al., 2017)

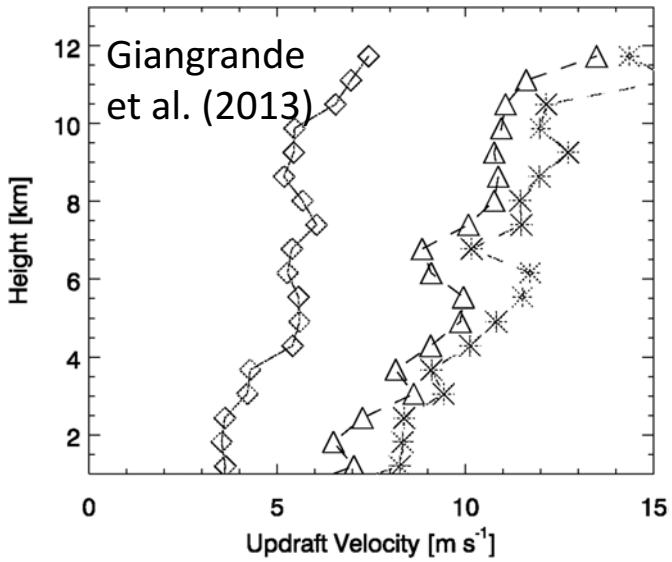
Now if we can just get the updraft speed right, for the right reason…

ARM updraft speed retrievals

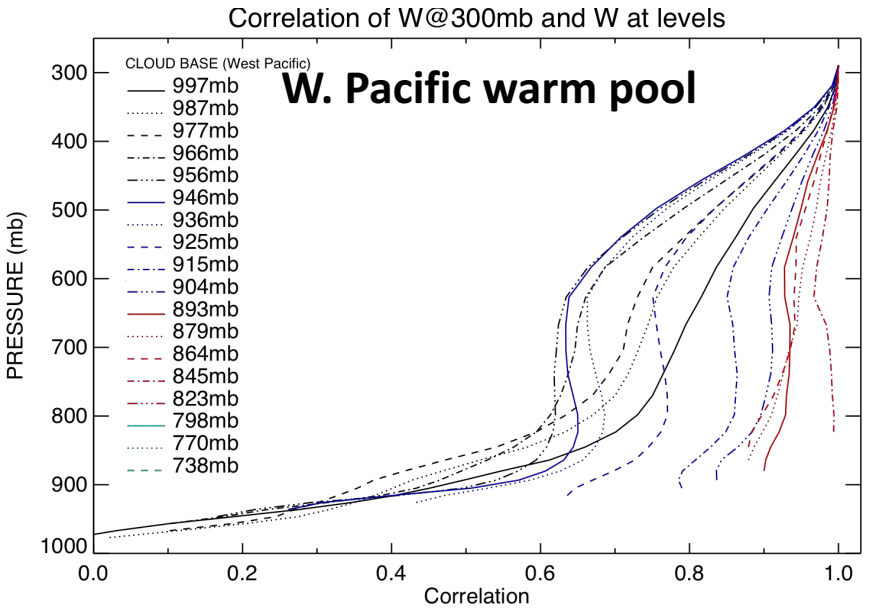
Darwin

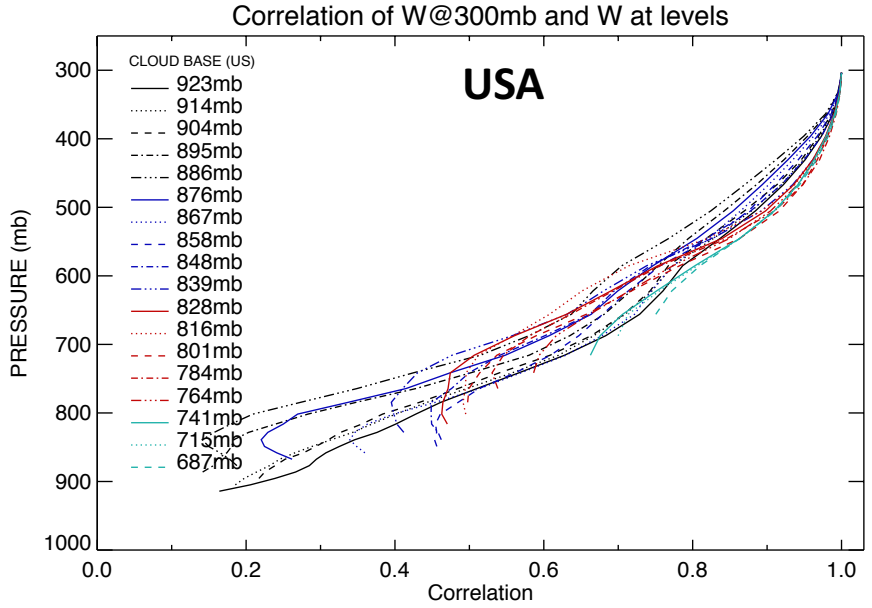


Oklahoma

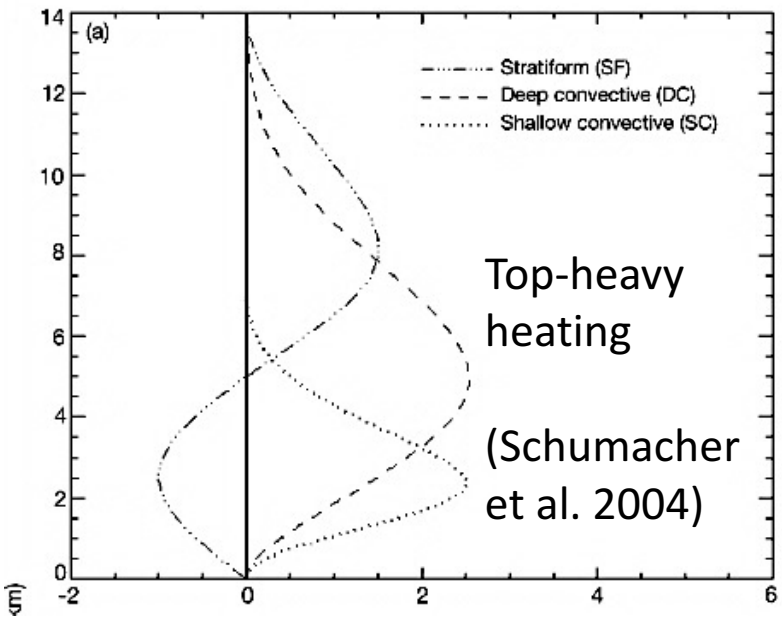


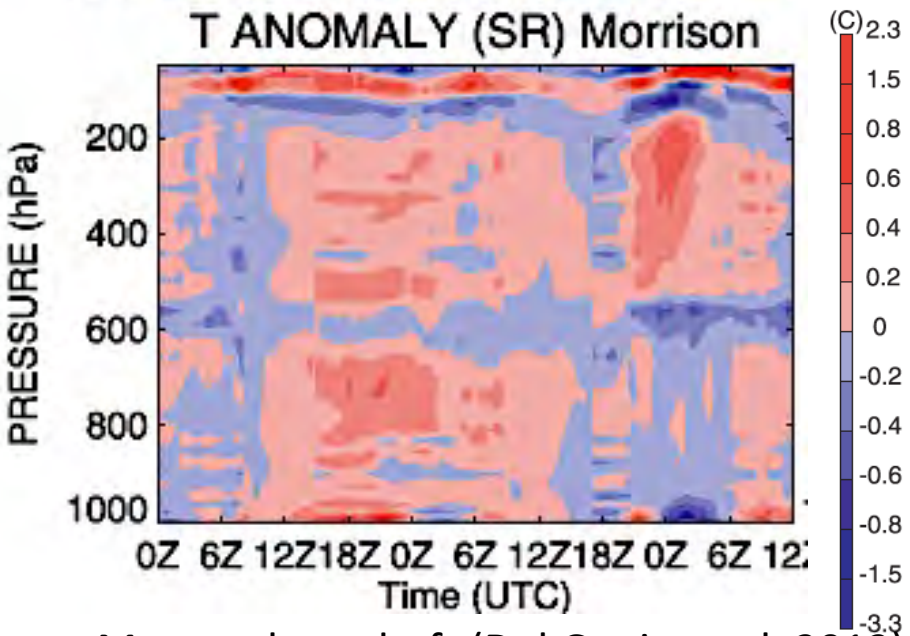
GISS pre-CMIP6 GCM w_c correlations



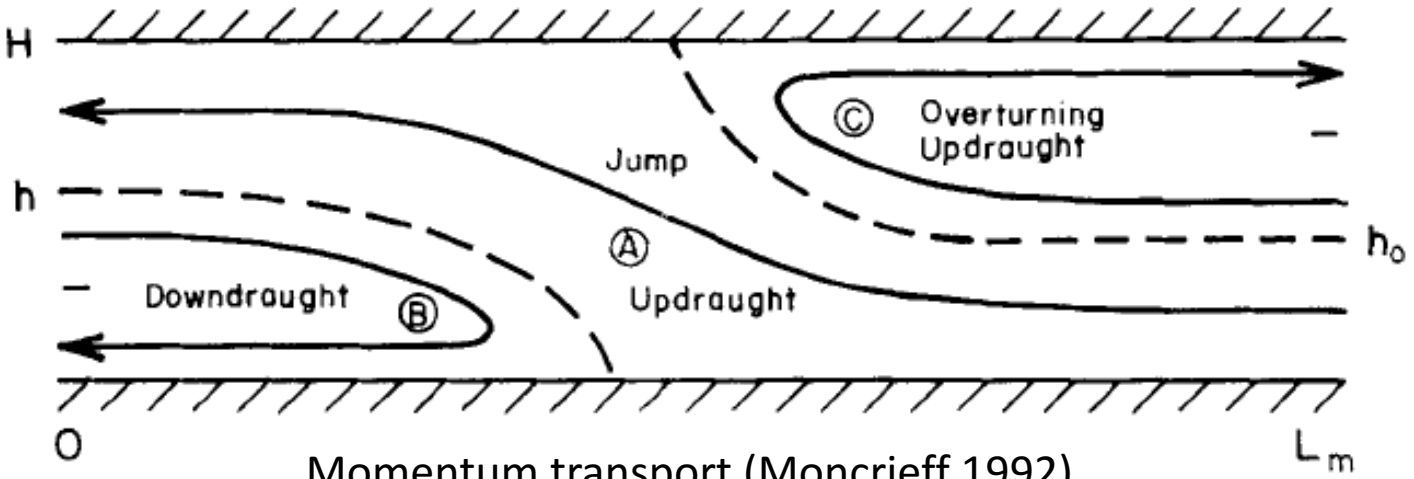


No one really does mesoscale organization (40 yr after GATE) – scientists *really are* wrong all the time





Mesoscale updraft (Del Genio et al. 2012)



Momentum transport (Moncrieff 1992)

Summary:

- ISCCP $\tau - p_c$ histograms were a major advance in how we viewed satellite data products – enable thinking about the convective life cycle, which is mostly missing from GCMs

- Updraft speeds from ARM sites may constrain physics that determines updraft speed profile; combined with obs-derived PSDs and fall speeds, it may be possible to determine which entrainment scheme is correct and make plausible estimates of detrainment and the convective role in climate sensitivity

- Four decades after GATE, we still don't represent mesoscale organization in GCMs – yet we make pronouncements about climate changes in big rain events produced by organization. This needs to change if we want to convince Gwen Beatty.

- Thanks, Bill!