HOW WELL CAN WE SIMULATE CLIMATE CHANGES IN MIDLATITUDE STORMS?

Tony Del Genio

NASA/Goddard Institute for Space Studies

(with help from

Audrey Wolf, Mao-Sung Yao, Mike Bauer)

Why should we pay attention to midlatitude storms?

- **Regional cloud feedback important to regional temperature trends**
- **Changes in storm frequency/strength affect drought/flood occurrence, water availability, forest fires**
- **Community has mostly shifted attention to the tropics, forgotten that we never actually tested our ability to simulate these "well-understood" phenomena**

Why do we need a good global precipitation/microphysics dataset at high temporal resolution?

Topics to be discussed:

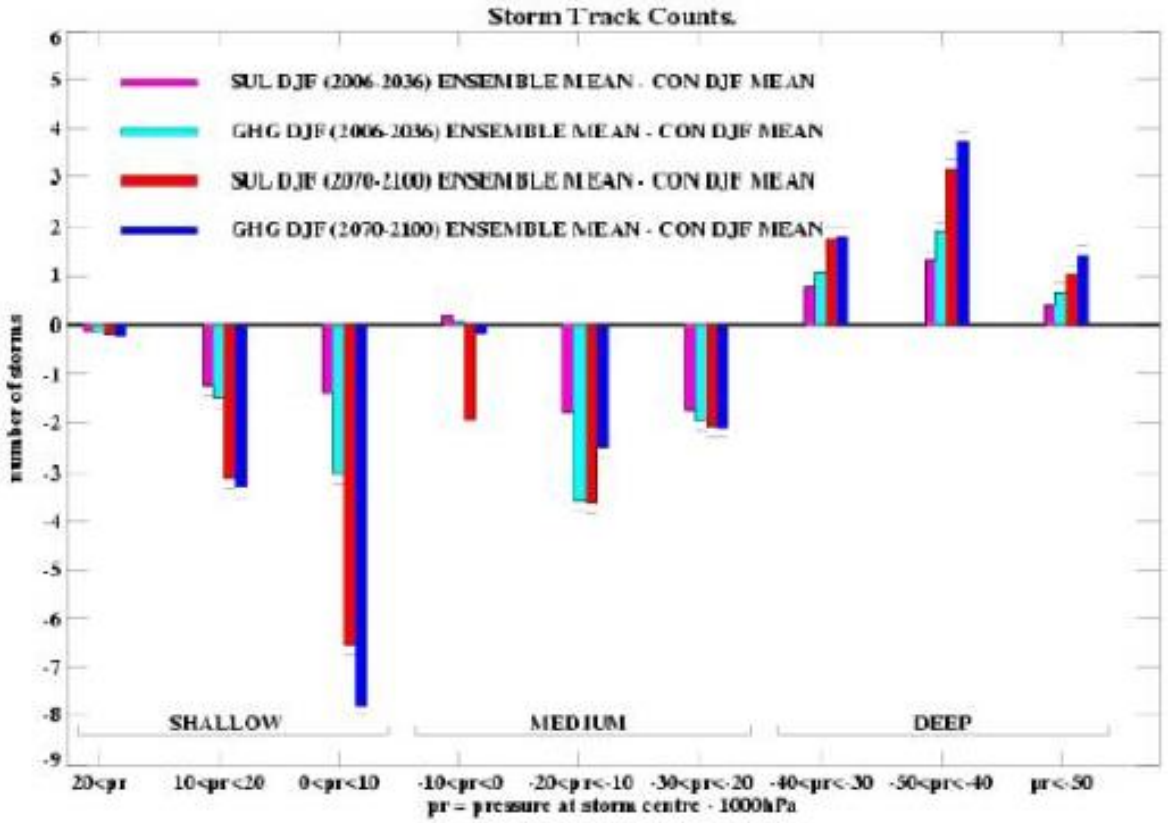
- GCM predictions of climate changes in storm occurrence and strength
- Simulated vs. analyzed vs. observed composite storm precipitation patterns
- Use of precipitation data to improve analysis advective forcing
- Simulated vs. observed storm cloud anomalies in response to 2xCO_2-like advective forcing
- Simulated vs. observed hydrometeor structure in midlatitude cold front passage case study

GCMs predict that midlatitude storms will be less frequent overall (decreased $|\partial T/\partial y|$) but strong storms will be more frequent (increased latent heating?) in the future

STORM CHANGES WITH CLIMATE IN THE HADLEY GCM

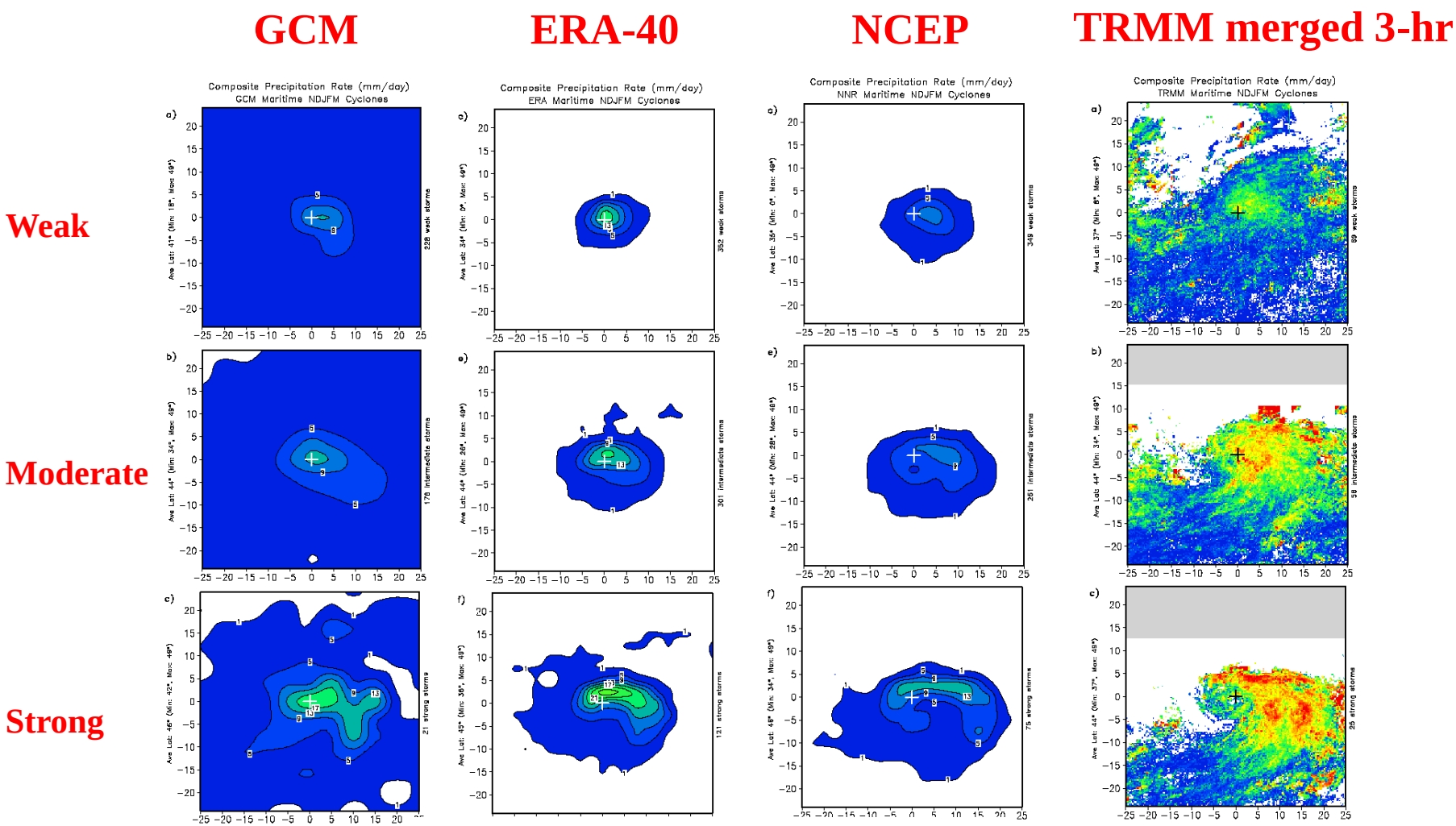
Early 21st C.

Late 21st C.



Carnell and Senior (1998)

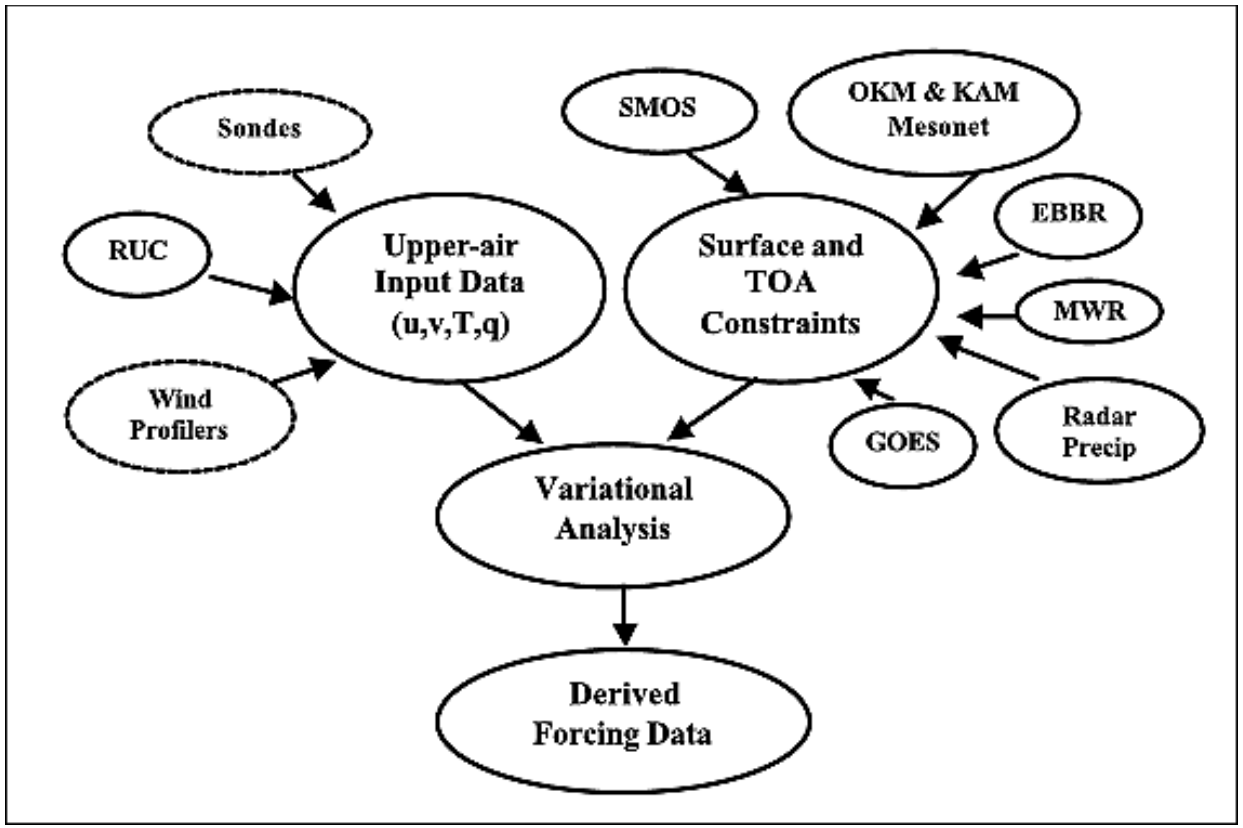
GCM composite storm precipitation pattern centered more on surface low than frontal locations; reanalysis precipitation magnitudes differ from other and TRMM



6/17/04
GPM Workshop

Goddard Institute for Space Studies at Columbia University in New York

Constrained variational analysis (Zhang and Lin): uses TOA and surface observational constraints to adjust analysis atmospheric state variables (s, q, u, v, ω) to conserve column mass, moisture, static energy, momentum



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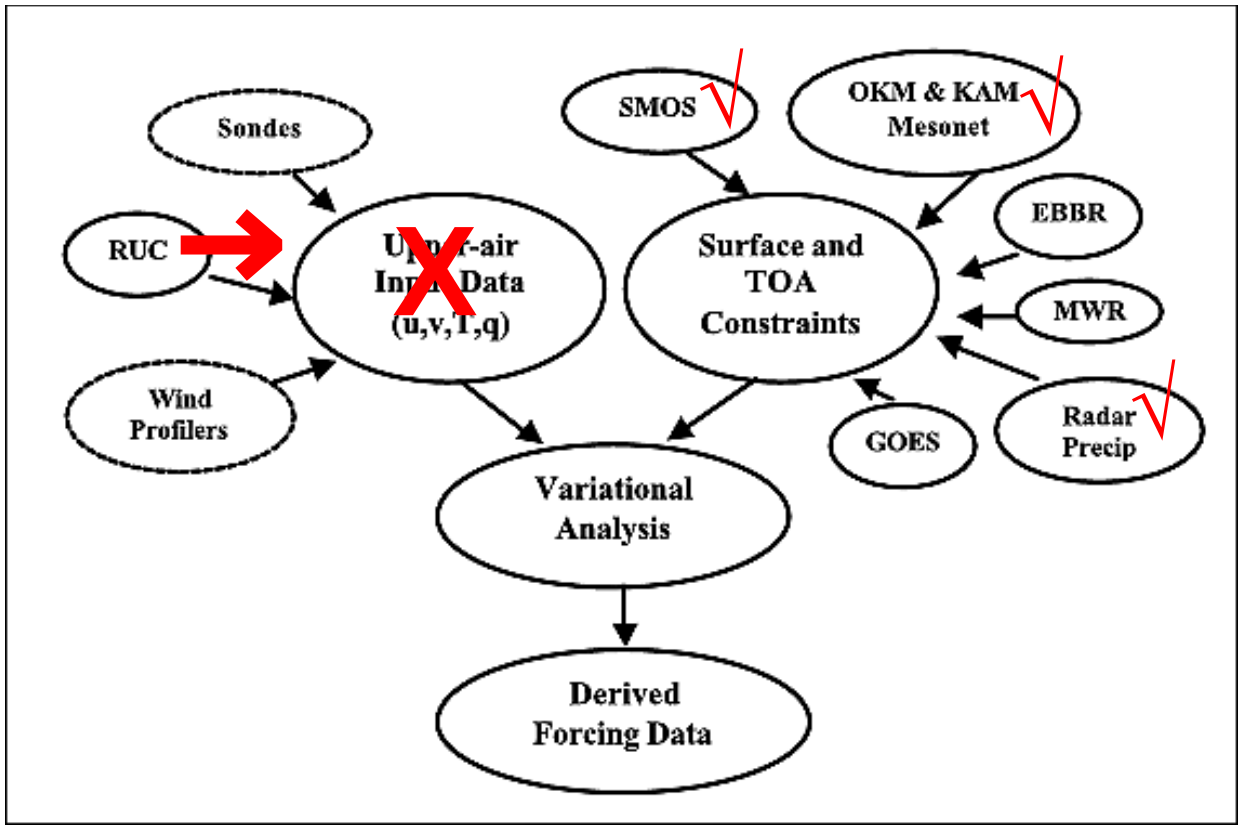


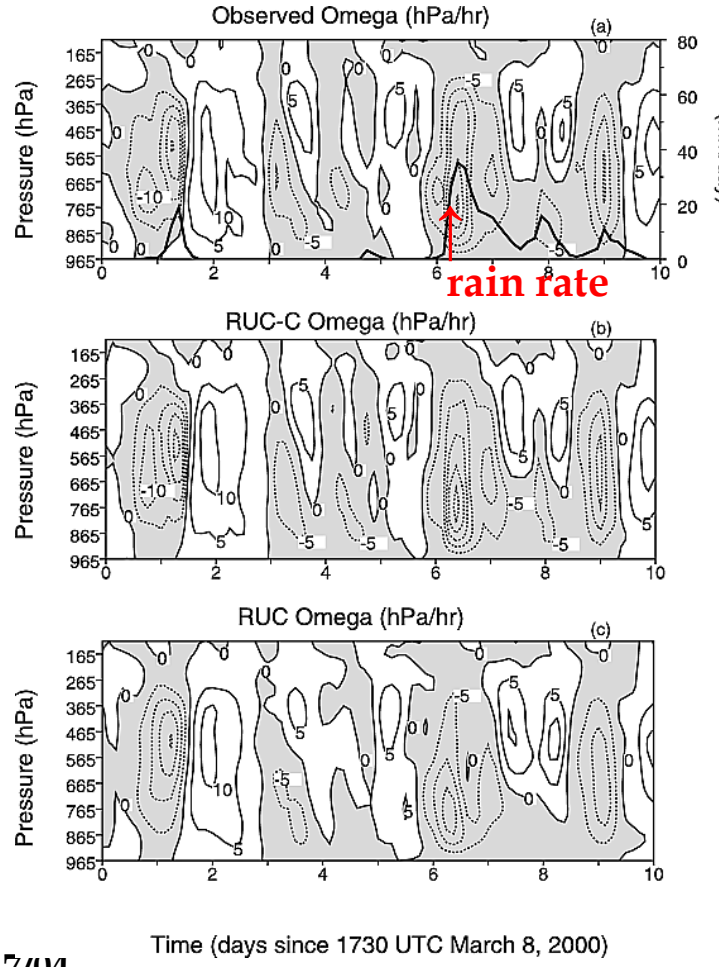
Apply to analysis products to get long-term forcing for CRMs, SCMs; precipitation data are the major impact

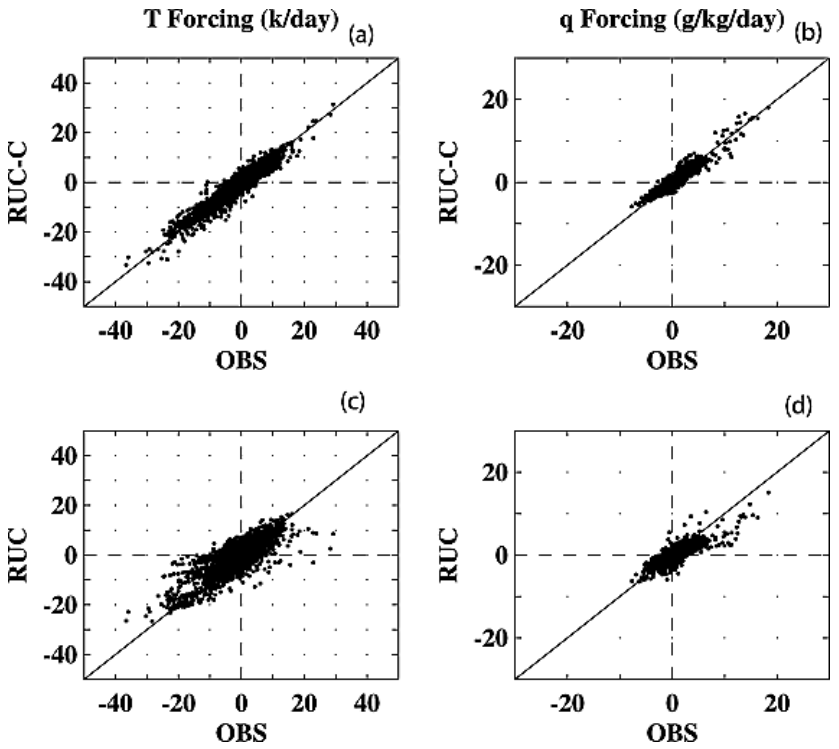
Improved vertical velocities during precipitating periods allow creation of long-term advective forcing data sets for SCMs, CRMs; with accurate global P could be applied to global reanalysis products to directly test parameterizations

sondes + profilers

corrected analysis

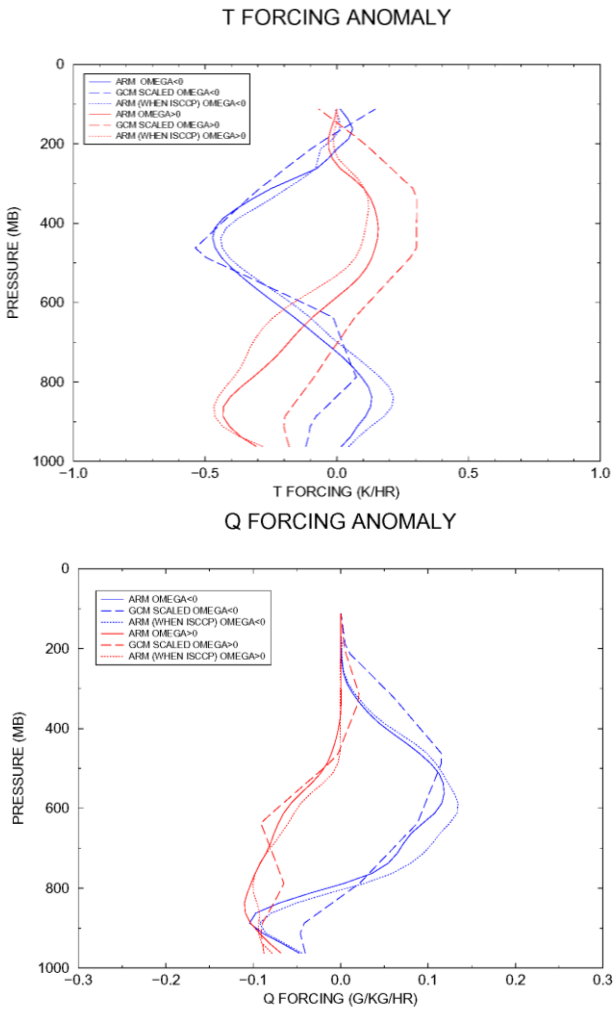
original analysis





Xie et al. (2004)

$2xCO_2$ advective forcing anomalies correspond to upward shift in adiabatic cooling/moistening and warming/drying; current climate analogs for $\omega < 0$ ~ strong synoptic storms



Red = visible
Green = water vapor
Blue = window IR

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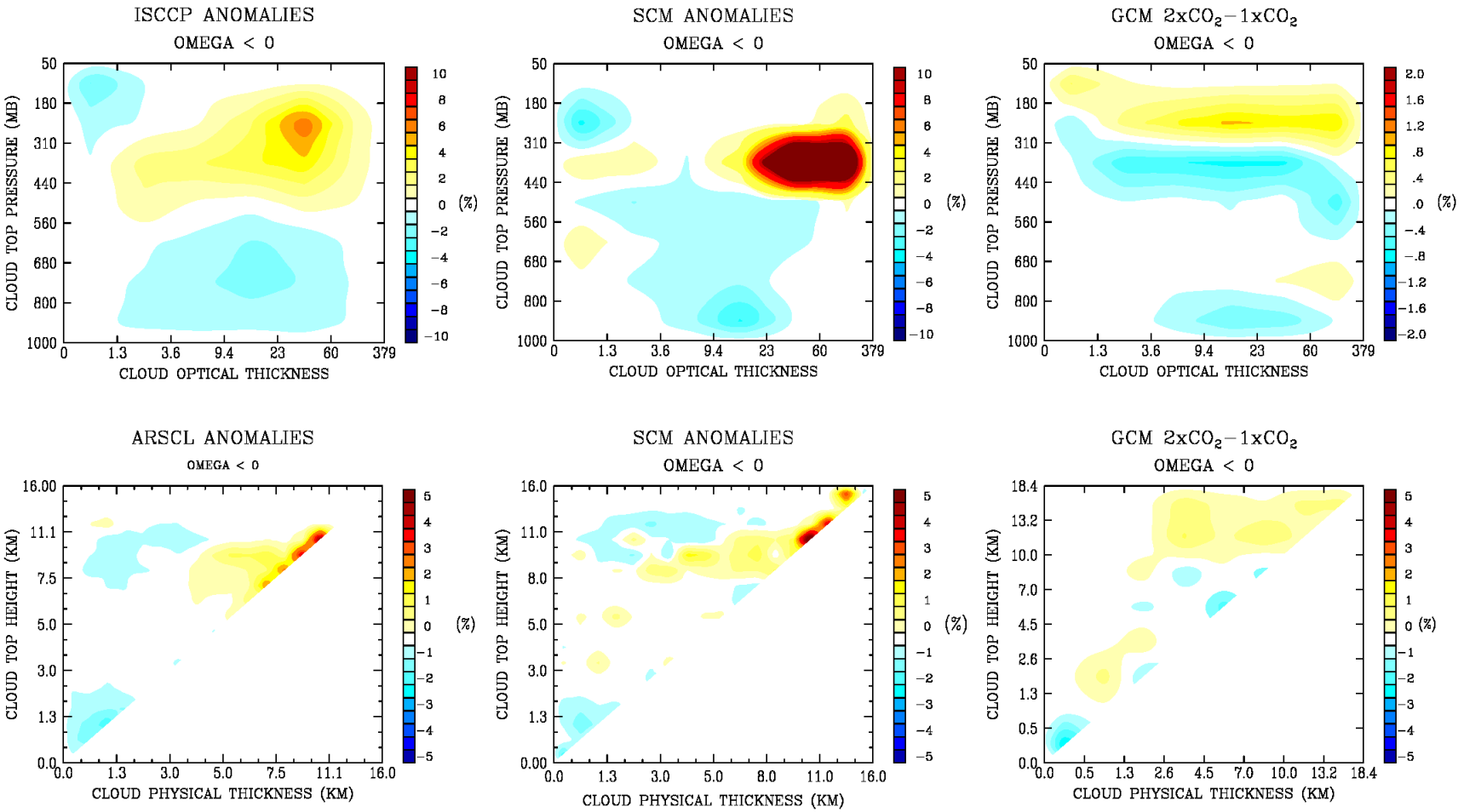
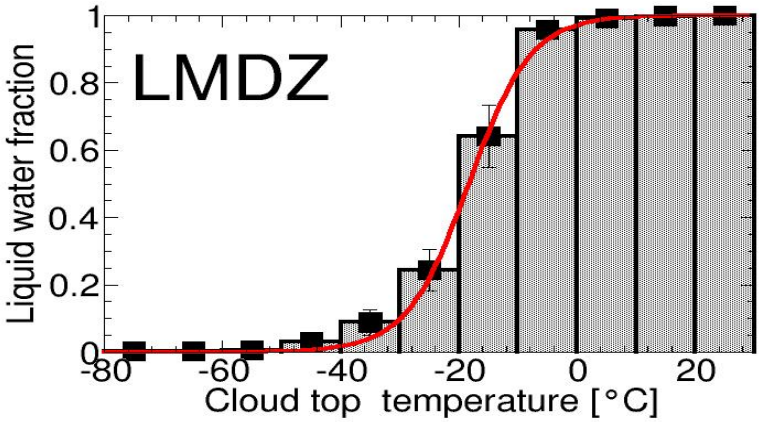
Note: Only 23 ISCCP
(3-hr) examples over 10 cold months

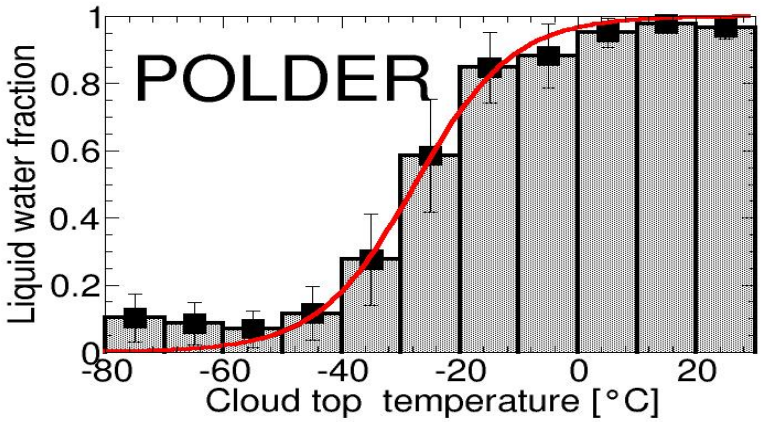
SCM overpredicts response of high, optically thick (= precipitating) clouds to climate forcing



Del Genio et al. (2004)

GCM vs. observed temperature dependence of liquid-ice transition- dependence on dynamical regime (e.g., cyclogenesis vs. mature storms)? Effect on precipitation?

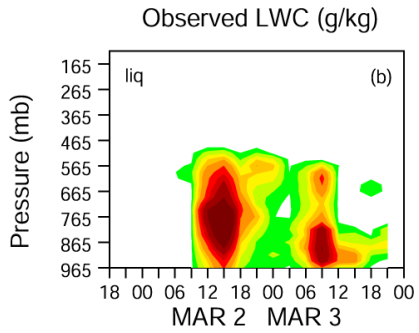




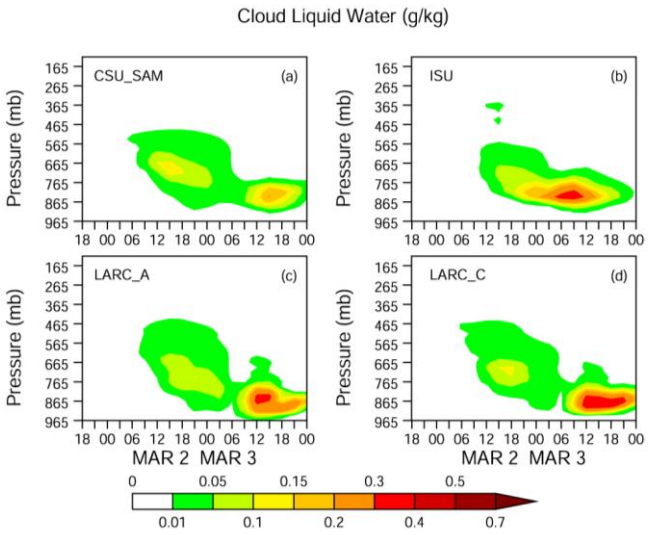
Doutriaux-Boucher and Quaas (2004)

Liquid water content during cold front passage over Oklahoma – CRMs no better than SCMs, do not develop mesoscale dynamical structure

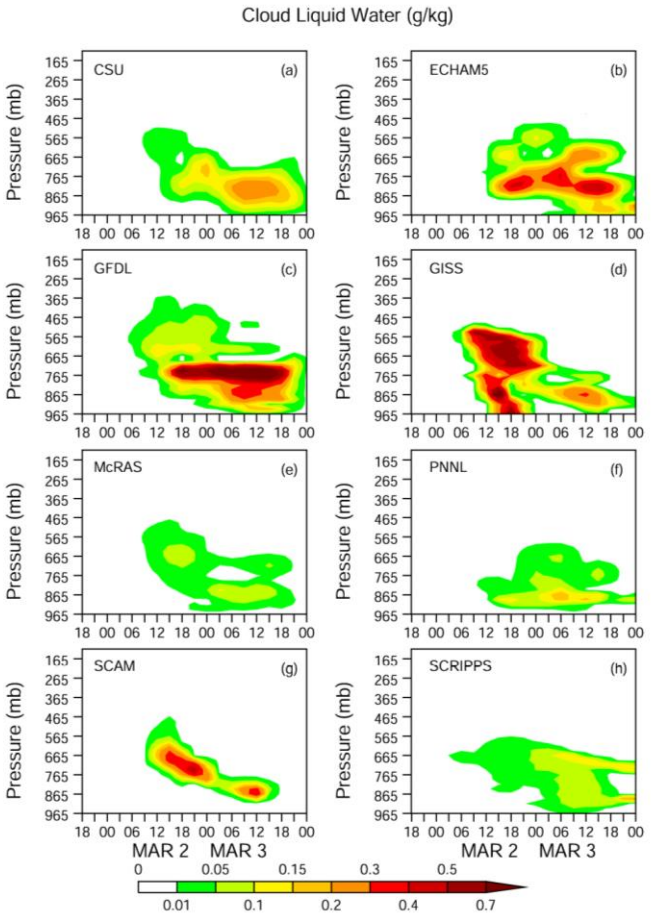
cloud radar



CRMs

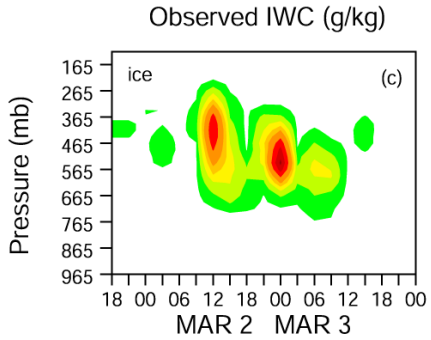


SCMs

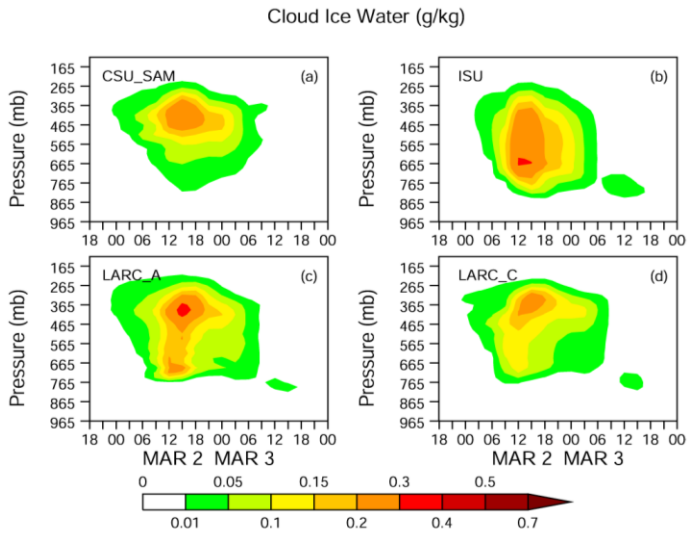


Ice water content during cold front passage over Oklahoma – ditto

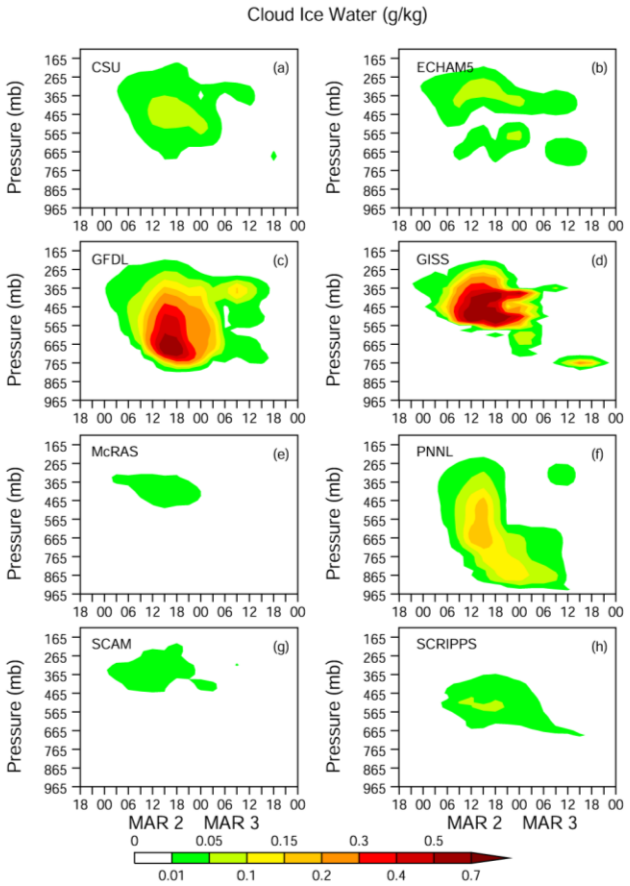
cloud radar



CRMs



SCMs



Potential uses of GPM data for climate model studies of midlatitude storms:

- Statistical studies of large populations of "objects" (e.g., composite precipitation patterns around lows → development of ageostrophic frontal circulation, liquid-ice transition, rain-snow formation parameterizations
- Devlopment of precipitation intensity pdfs for input to land surface/ground hydrology parameterizations
- Creation of accurate global adjusted reanalysis products for forcing SCMs, CRMs
- Studies of response of model storms to climate-change-like forcing anomalies