A Role for Active Sensors in Constraining Cloud Feedbacks

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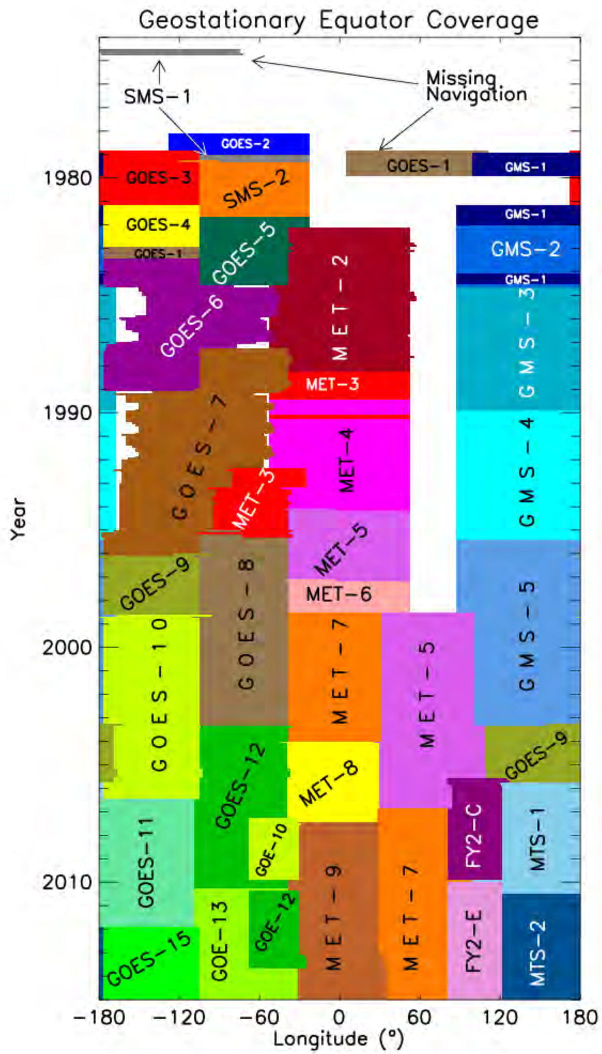
ISCCP Workshop, NY NY, 6-8 June 2017

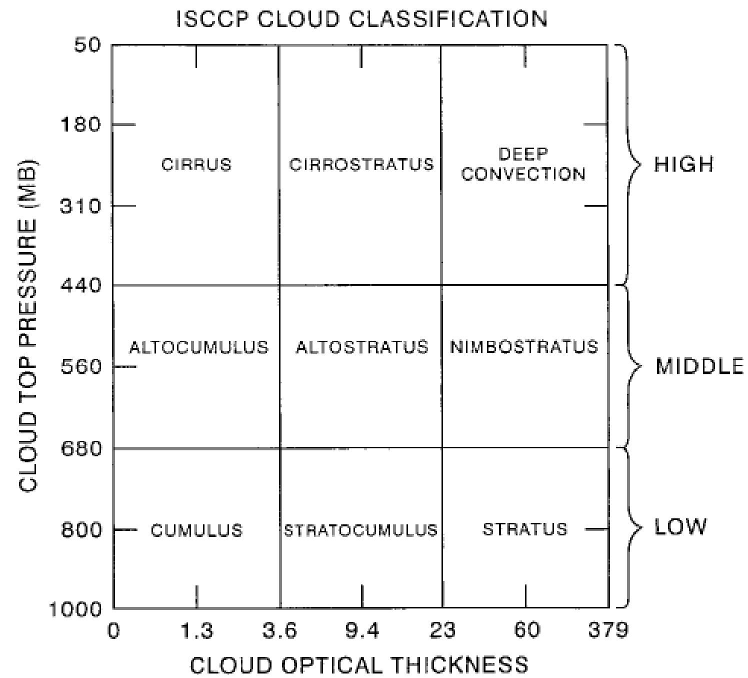
Advances in Understanding Clouds from ISCCP

William B. Rossow* and Robert A. Schiffer+



Since 1983 …

“planned collection was to last 5 years…”



Global Energy and Water Cycle Experiment

GEWEX WCRP

NASA

Assessment of Global Cloud Data Sets from Satellites

A Project of the World Climate Research Programme Global Energy and Water Cycle Experiment (GEWEX) Radiation Panel

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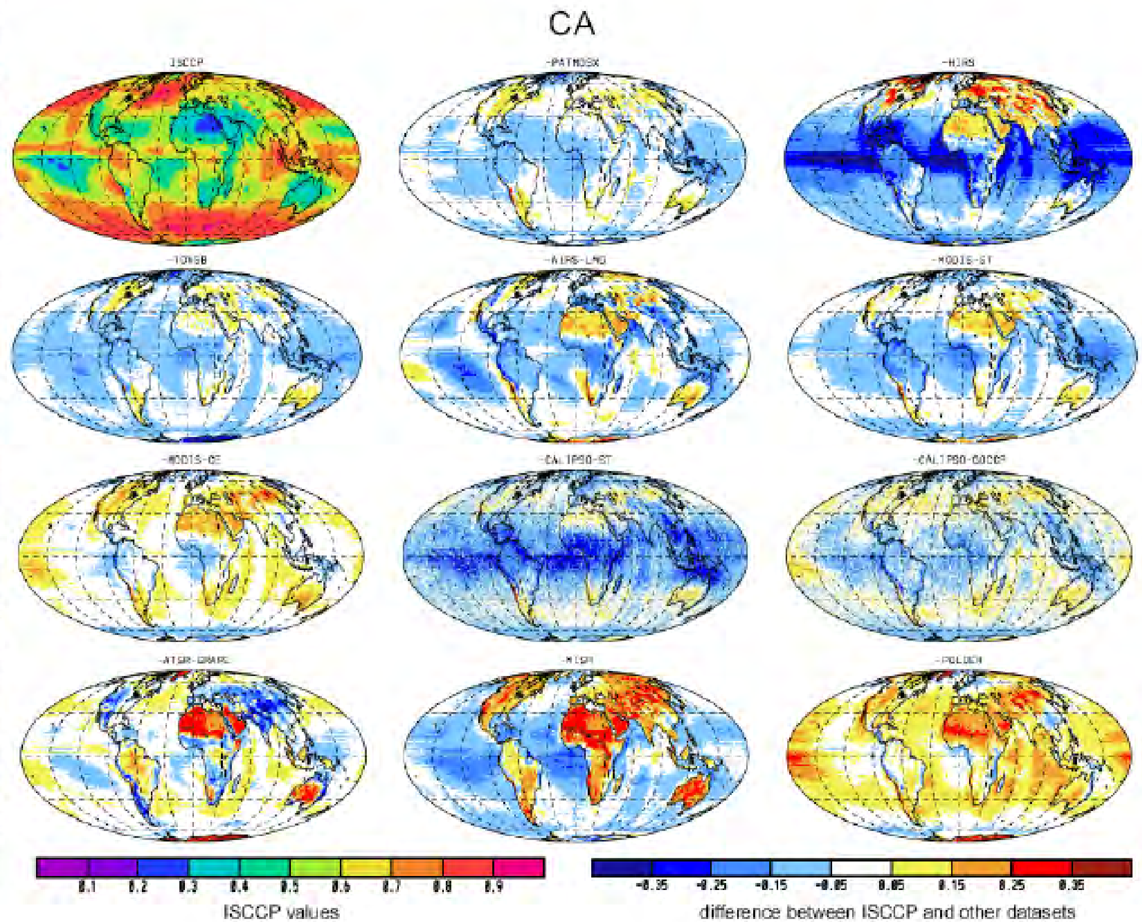
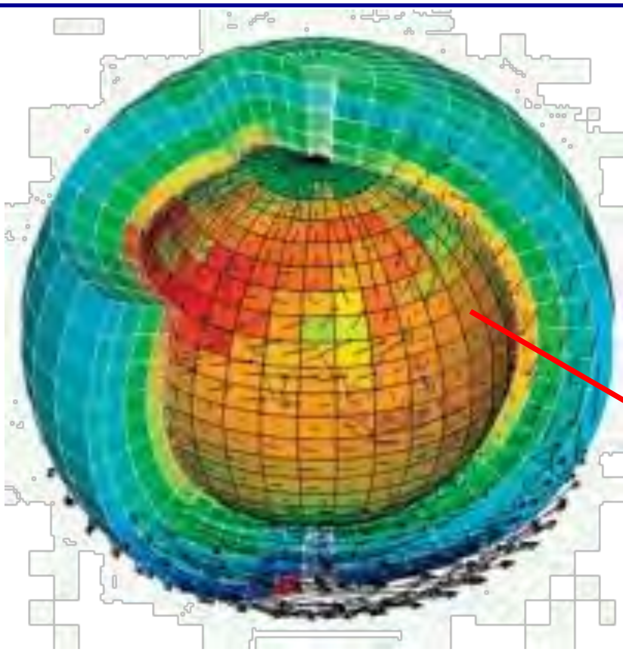


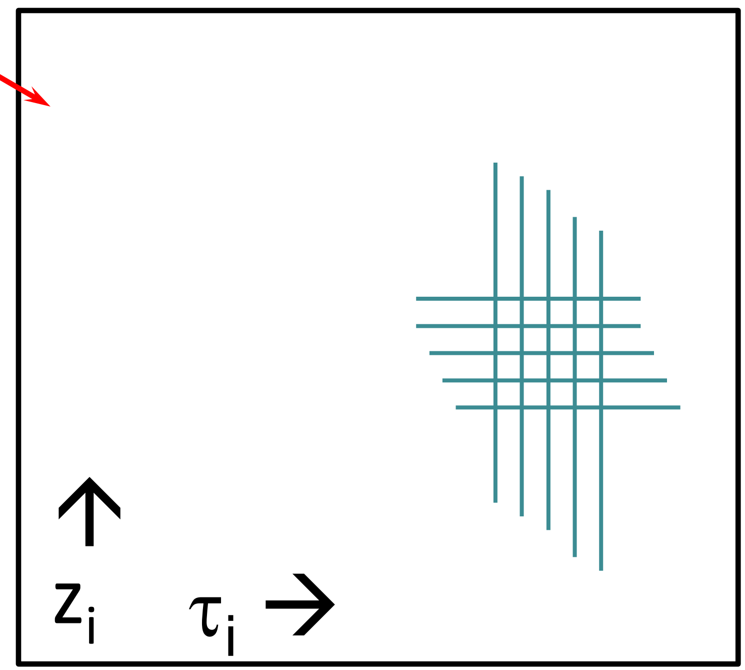
Figure 3.2: Geographical map of annual average of cloud amount (CA) from ISCCP as well as geographical maps of CA differences between ISCCP and PATMOSX, HIRS, TOVSB, AIRS-LMD, MODIS-ST, MODIS-CE, CALIPSO-ST, CALIPSO-GOCCP, ATSR-GRAPE, MISR and POLDER

CALIPSO Level 3 Cloud Product (coming soon)



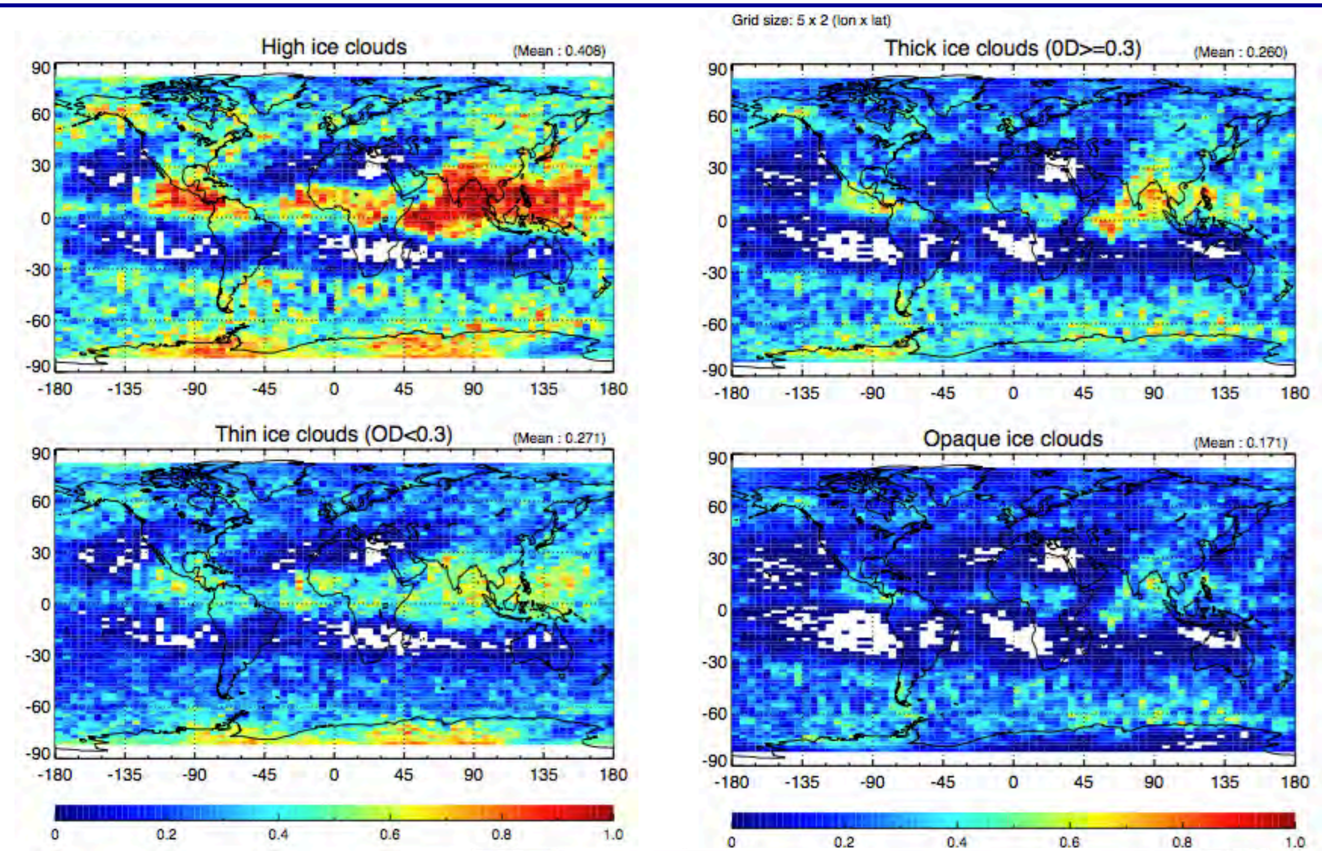
Instead of "cloud cover," contains cloud occurrence statistics as a function of layer optical depth

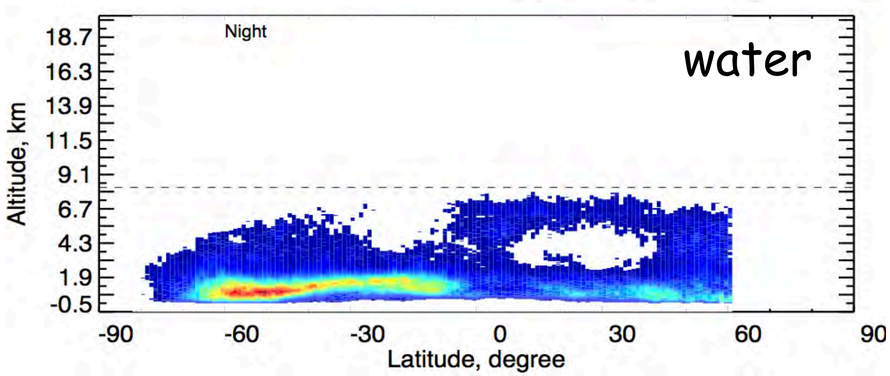
Each cell of the lat-lon grid holds a 2-D array … which holds the number of clouds at height z with $\tau_i < \tau < \tau_{i+1}$

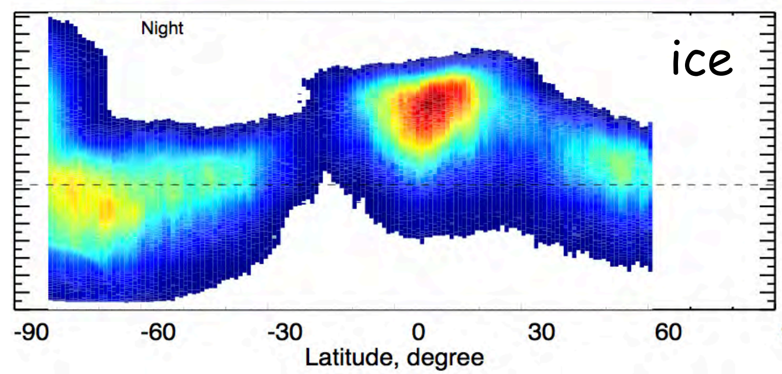


"Cloud Fraction": your choice

	CAI
All	0.41
$\tau < 0.3$	0.27
$\tau > 0.3$	0.26
$\tau > 3$	0.17







ISCCP / Geoprof-Lidar

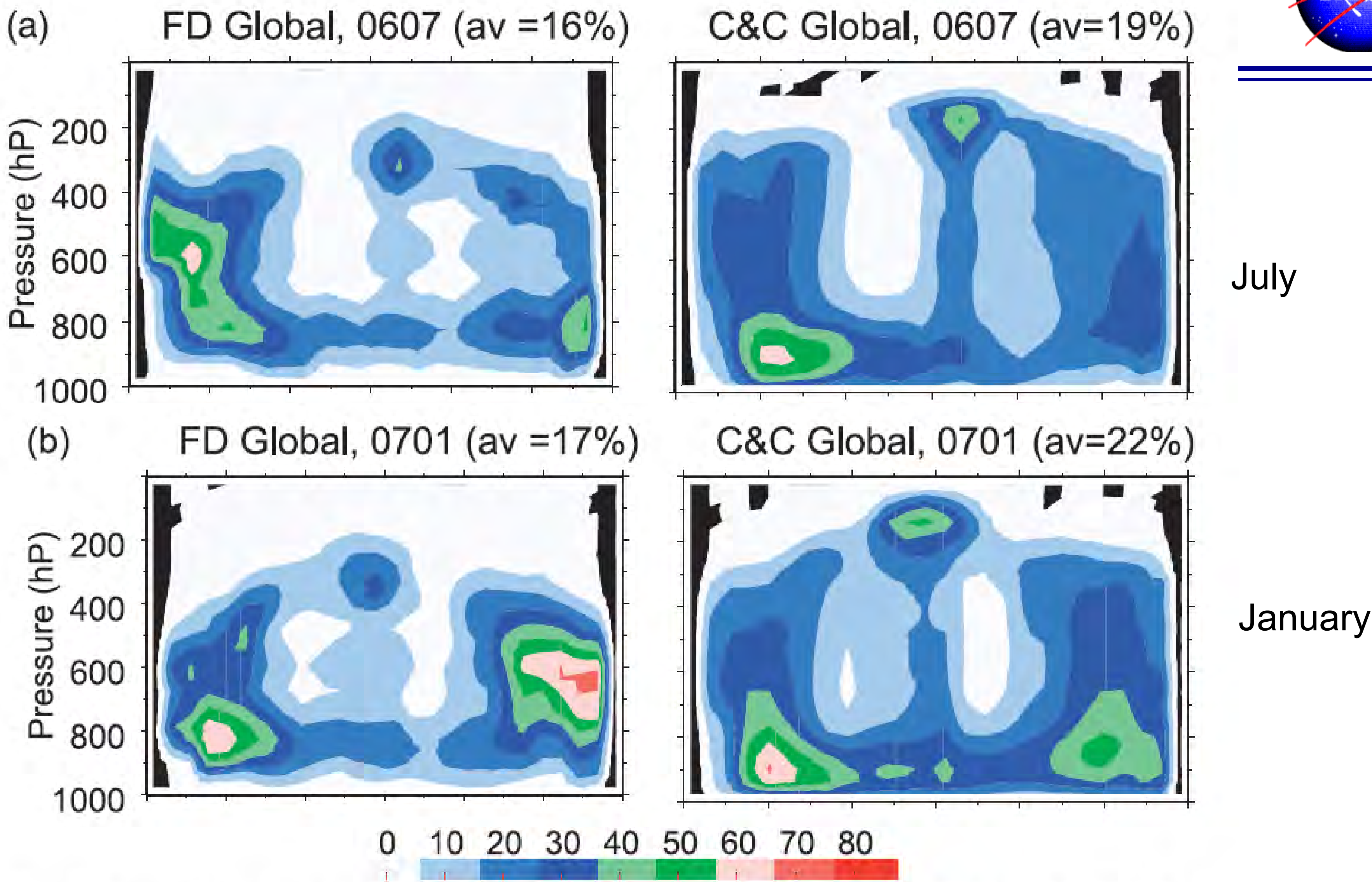


FIG. 5. Pressure–latitude cross sections of the zonal monthly-mean cloud amounts (in %) for (a) July 2006 and (b) January 2007: (left) ISCCP-FD CVS, (right) C&C CVS, (top) global results, (middle) averaged only over oceans, and (bottom) averaged only over land. Black color is for undefined values.

(Rossow and Zhang, 2010)

Vertical structure of WS, based on C-C

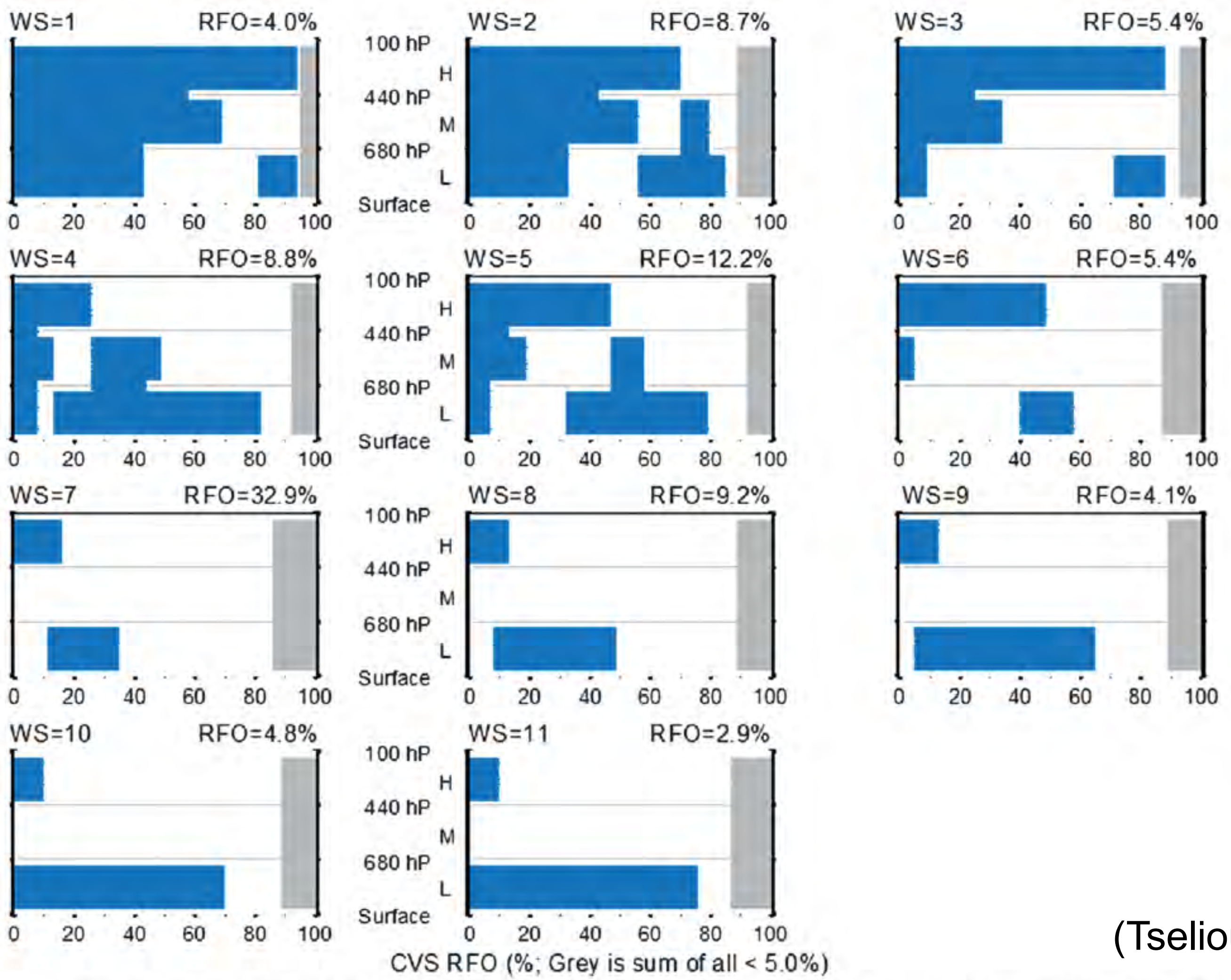


FIG. 4. CVS distributions for the 11 WSs. The width of each CVS bar indicates the frequency of occurrence of this CVS in the particular WS. The white bar (space) indicates clear sky, and the gray bar represents the sum of all CVSs that occur less than 5% of the time.

(Tselioudis, et al. J Clim 2013)

"A clear picture of Earth's clouds" (AR5)

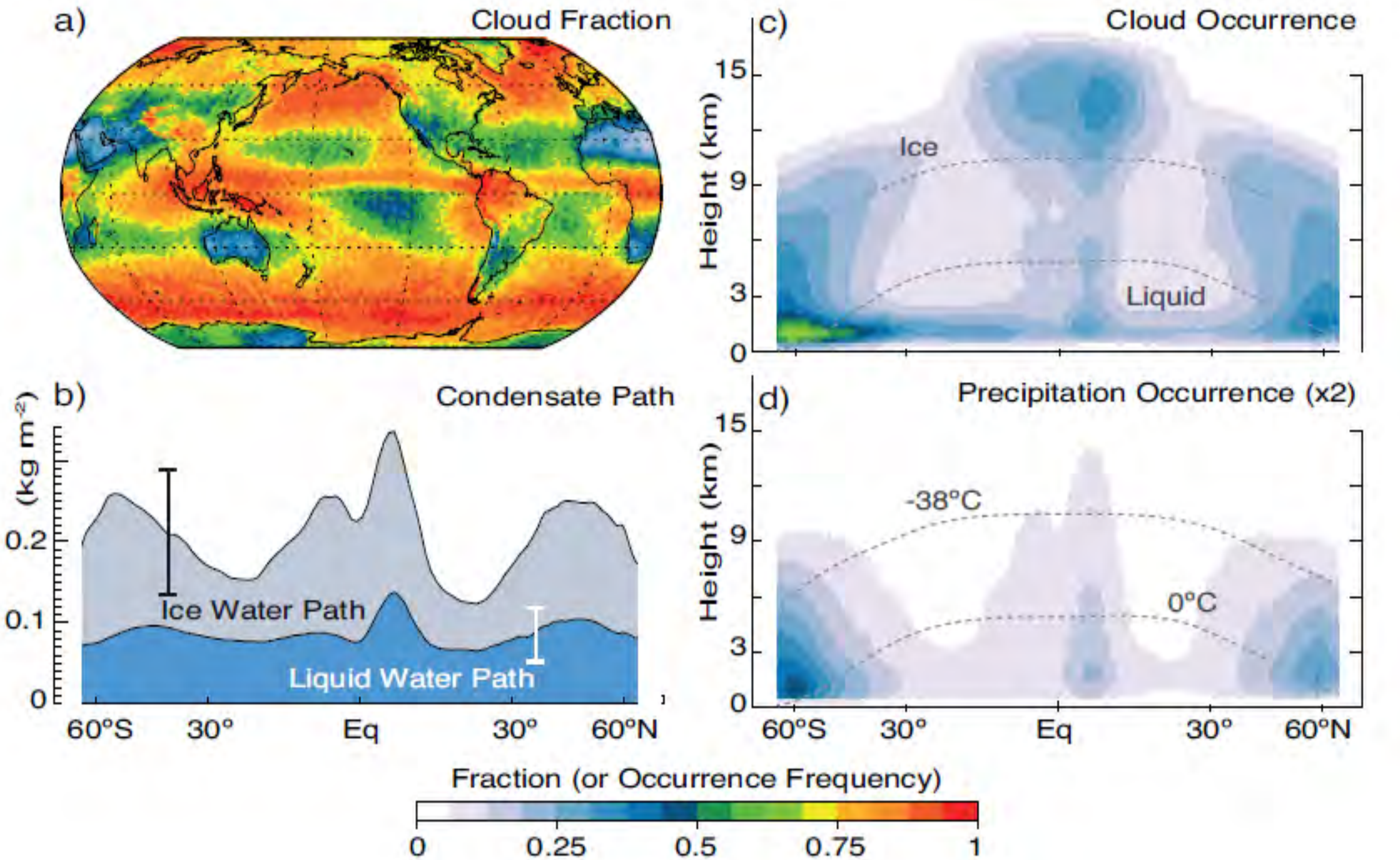
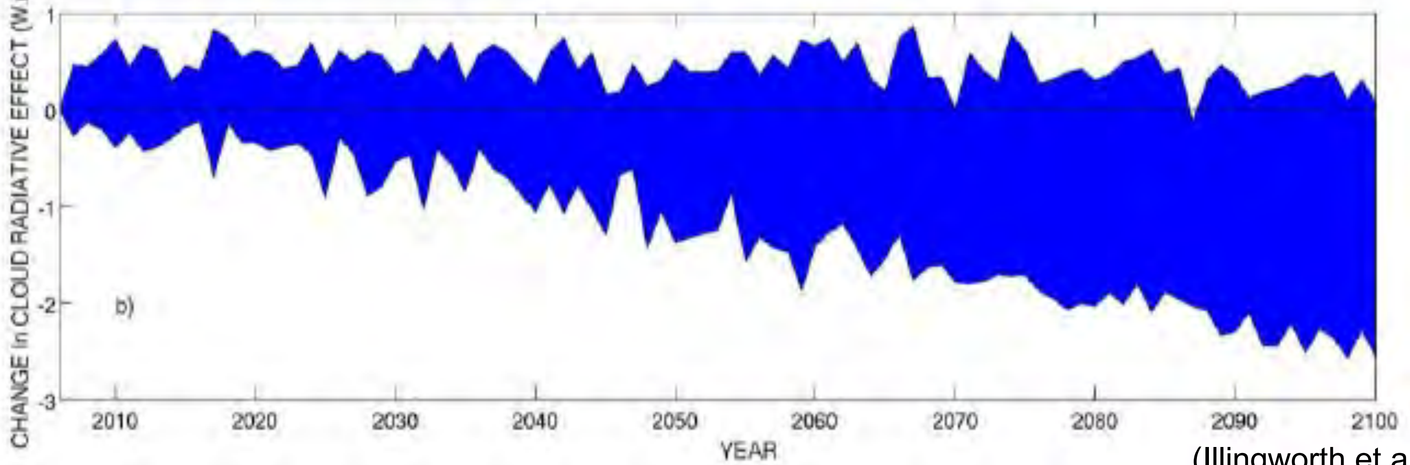


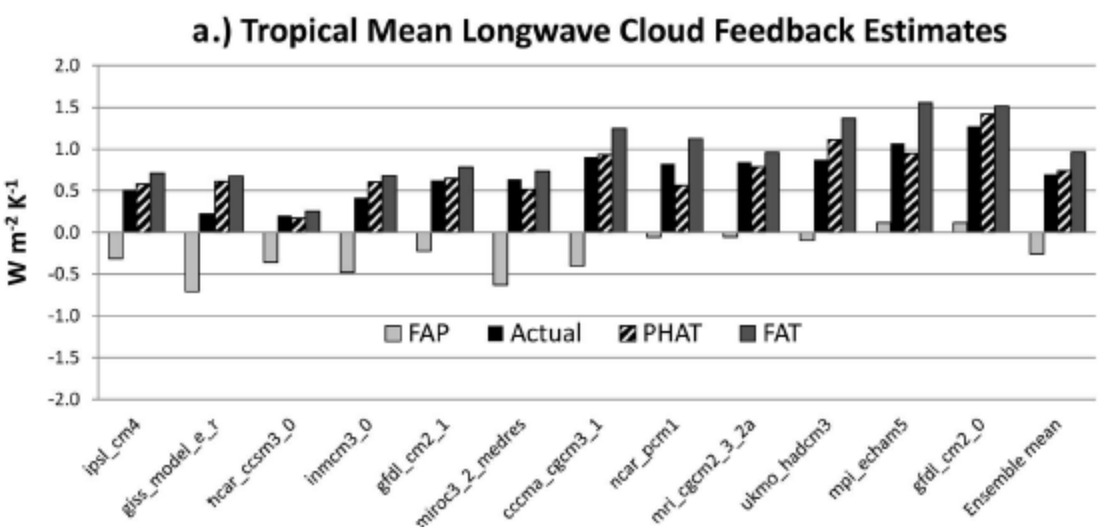
Figure 7.5 (a) Annual mean cloud fractional occurrence (CloudSat/CALIPSO 2B-GEOPROF-LIDAR data set for 2006–2011). (b) Annual zonal mean liquid water path (microwave radiometer data for 1988–2005) and ice water path (from CloudSat 2C-ICE data set for 2006–2011 from Deng et al. (2010)). (c–d) latitude-height sections of annual zonal mean cloud occurrence and precipitation occurrence; (2B-GEOPROF-LIDAR data set). (IPCC, 5th Assessment Report, 2013)

Cloud feedbacks remain uncertain

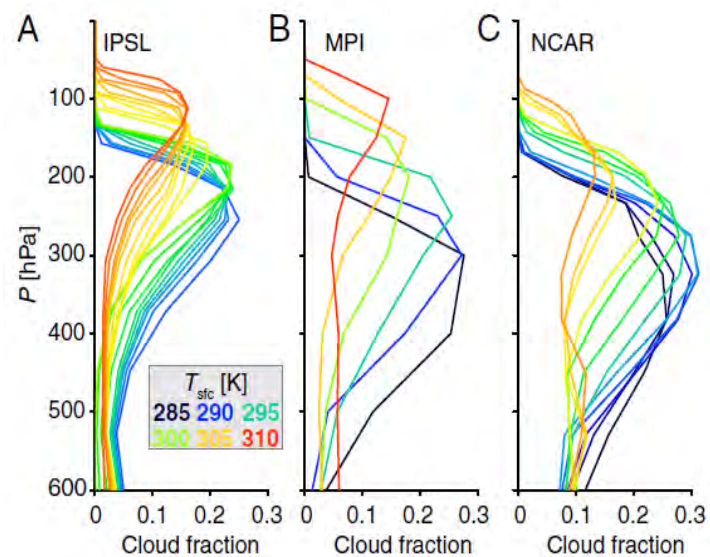
Envelope of predicted change in CRE from 2006 to 2100 (from eight GCMs)



(Illingworth et al. BAMS 2016)



Zelinka and Hartmann (JGR, 2010)

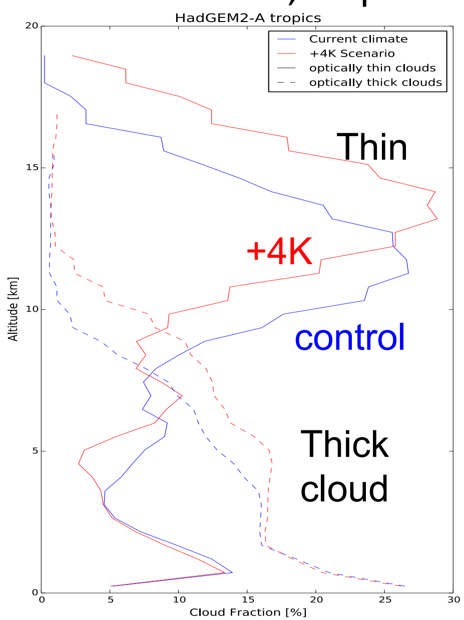


(Bony et al. PNAS 2016)

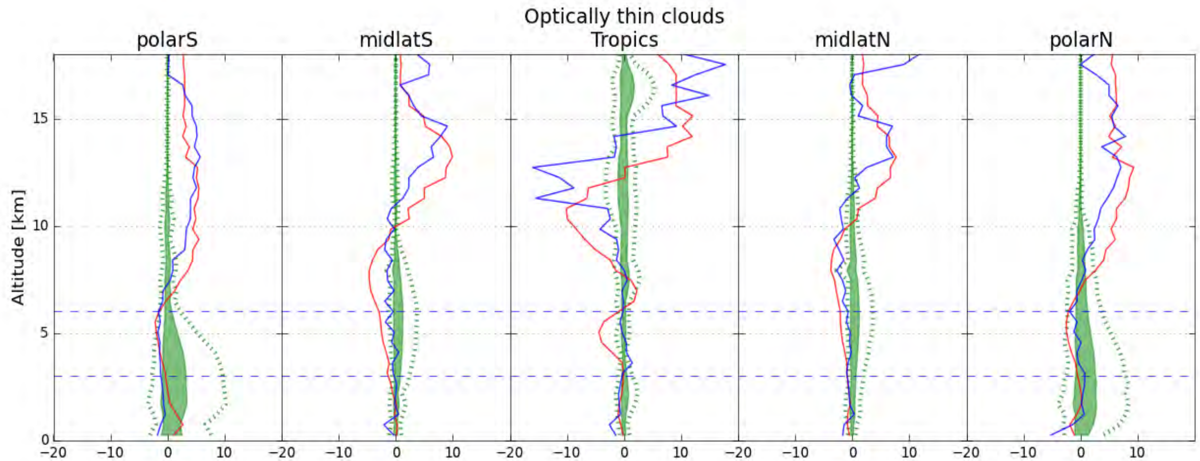
Cloud trends as observed by simulated lidar

Control and +4K AMIP experiments using "CALIPSO simulator": Observable signatures of cloud feedback show up sooner in vertically resolved cloud profiles

HadGEM2, tropics

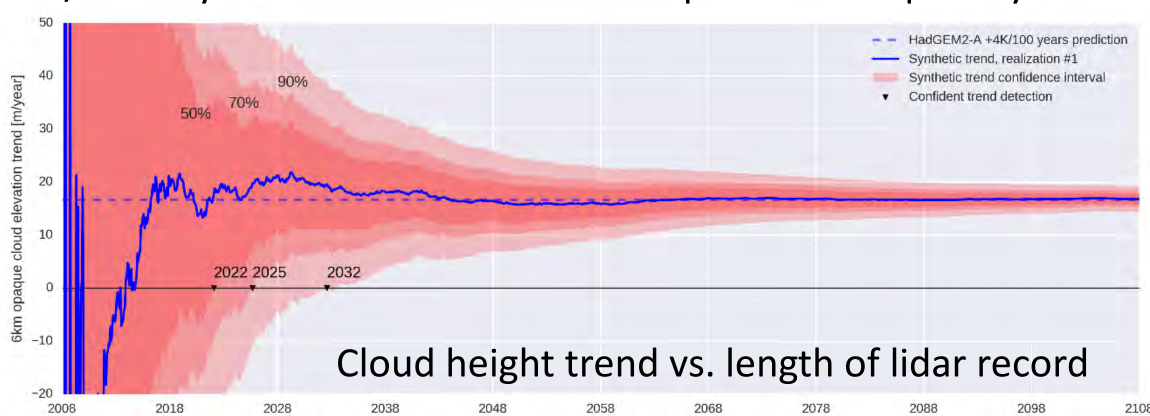


(Chepfer et al.,GRL, 2014)



Green: observed variability (2006-2012) from CALIPSO-GOCCP

Red/blue: Synthetic lidar cloud fraction profiles for optically thin clouds



(Chepfer et al., in preparation)

2008

2108

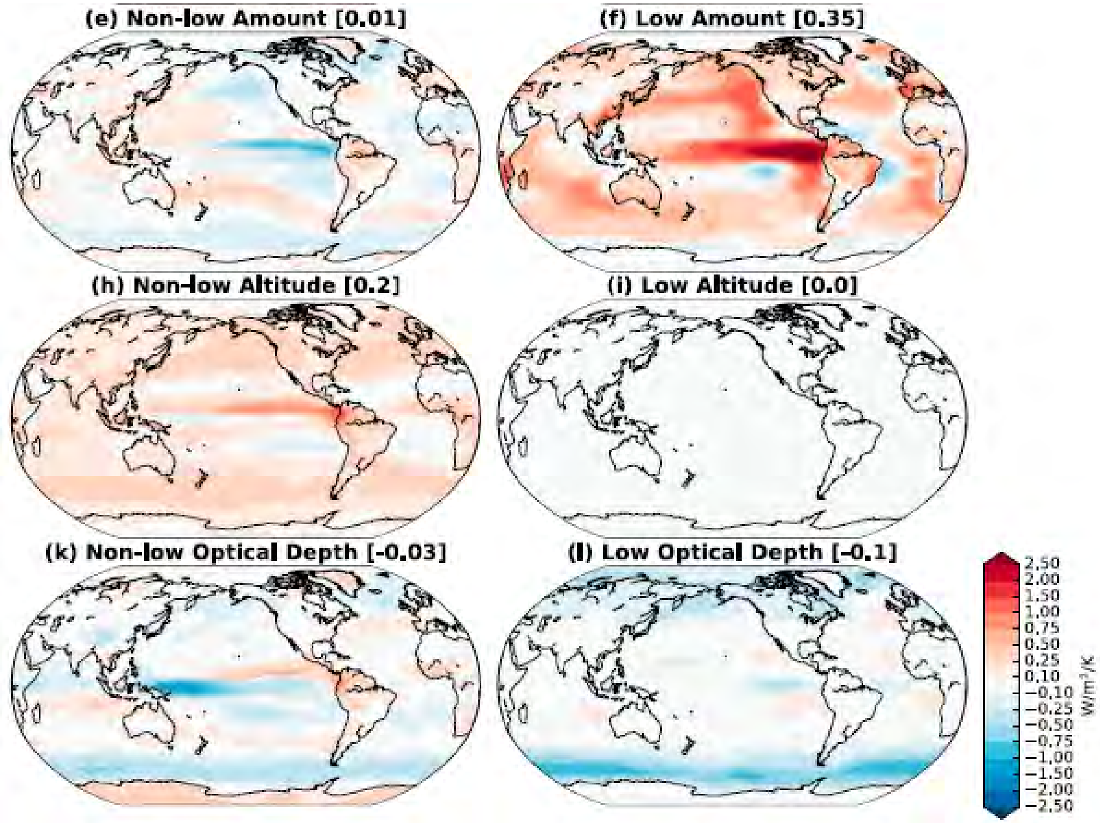
Cloud radiative feedbacks due to changes in cloud cover, height, optical depth

Global models consistently show:

1) SW cloud feedbacks primarily due to cloud-amount changes

2) Optical depth feedbacks (phase change?) important at high latitudes

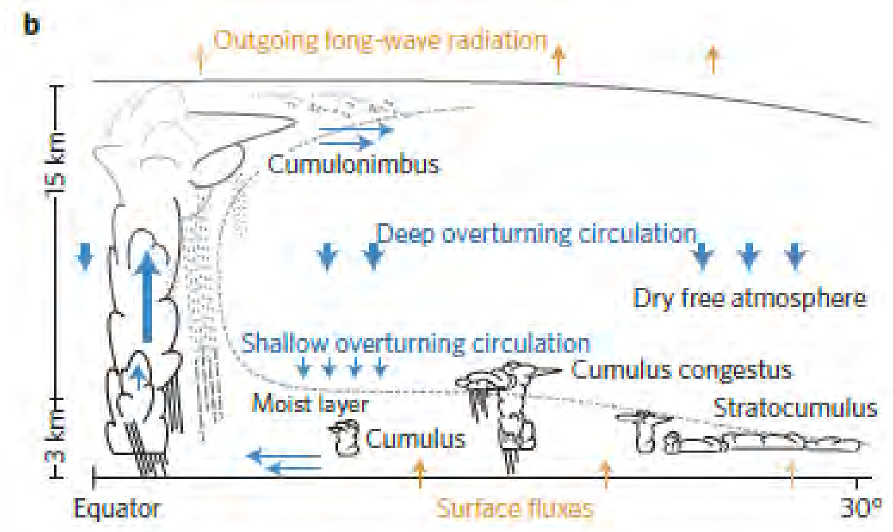
2) LW feedbacks driven by rising altitude, but also changes of amount and OD



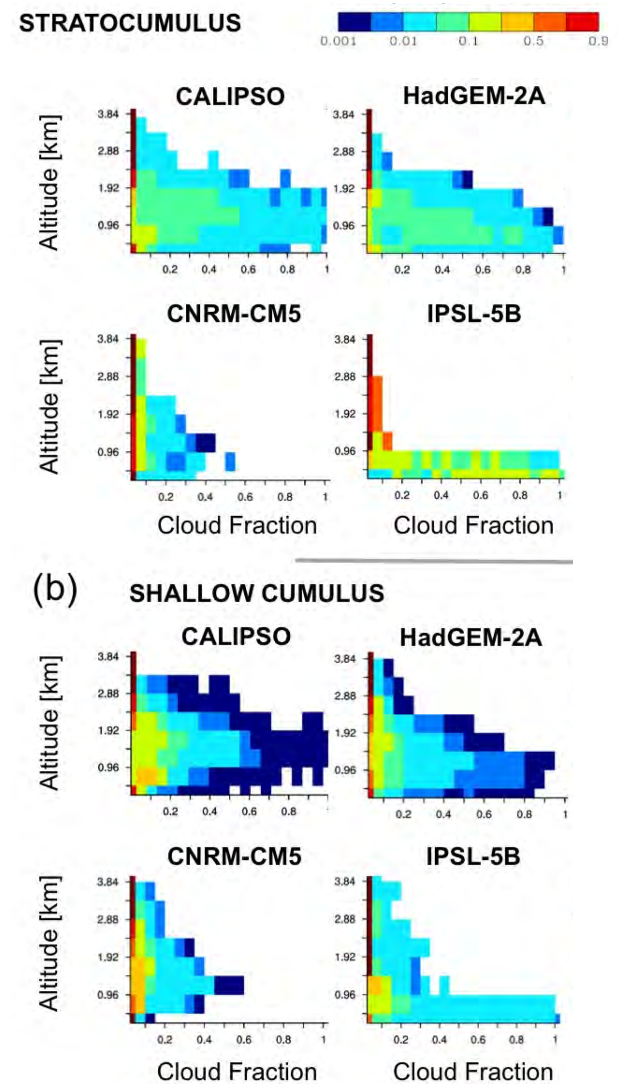
CFMIP ensemble-mean net cloud feedbacks

(Zelinka et al. 2016)

WCRP Grand Challenge on Clouds and Circulation and Climate Sensitivity



(Boney et al, Nat Geo, 2015)



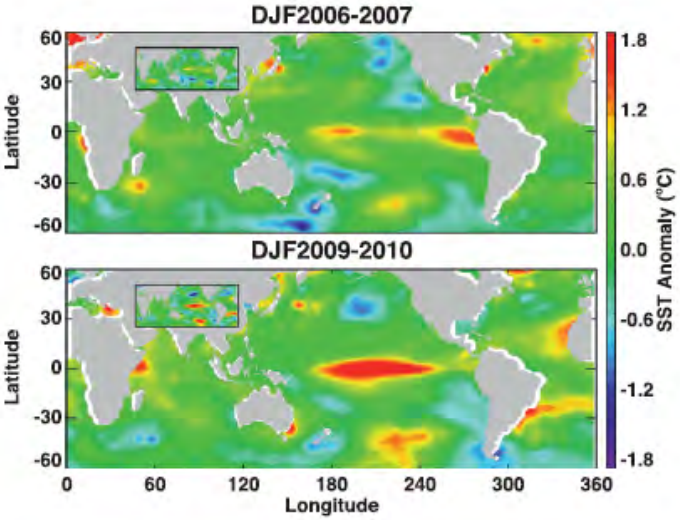
(Nam et al. 2012)

- New focus: coupling of clouds and circulation
- New appreciation: cloud feedbacks depend on patterns of SST change
- Shallow clouds are
  - sensitive to changes in their environment
  - poorly represented in GCMs

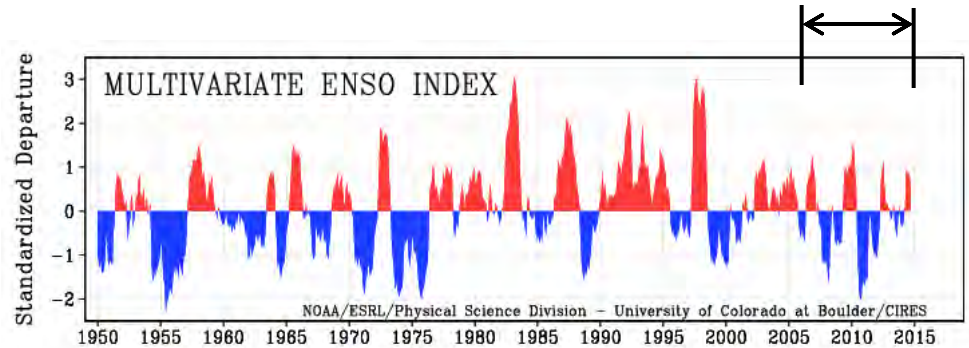
El Nino – 2 patterns of SST change

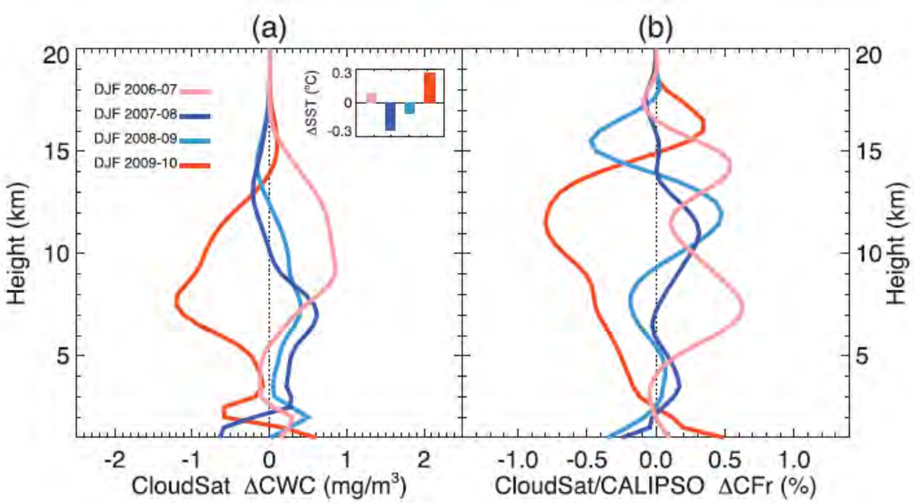
CP-El Nino
2009-10 DJF

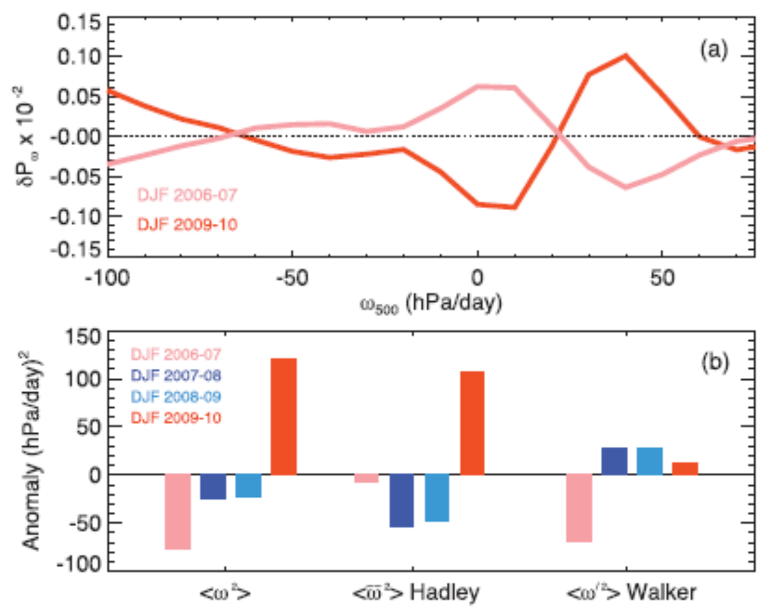
EP-El Nino
2006-07 DJF



CALIPSO-
CloudSat







Su and Jiang (JGR, 2012)

The view from 1999

- Rossow and Schiffer (BAMS, 1999):
  - "ISCCP might continue until NPOESS can take over the long-term monitoring of global cloudiness ... In the meantime, significant effort should be focused on satellite experiments that provide missing elements of cloud dynamical processes, such as *determinations of cloud vertical structure* and geostationary observations of *cloud system evolution at very high time resolutions (~ 15–30 min).*"
  - "NPOESS … presents an opportunity to improve the systematic monitoring of clouds with similar coverage and time resolution as ISCCP but with measurements at many more wavelengths"

Carrying the spirit of ISCCP into the future

- Following 10+ years of experience with the advanced sensors of the A-Train …
- With a new generation of GEO sensors now coming on line (Himawari, GOES-R) …
- And a new generation of operational polar orbiters (NPP, JPSS) …
- Addition of active sensors to the existing plan would significantly enhance observing capabilities …
- With the goal of producing a long-term A-Train-like record (or better) of cloud-precip processes