Some stuff about free tropospheric moist processes and climate change feedbacks

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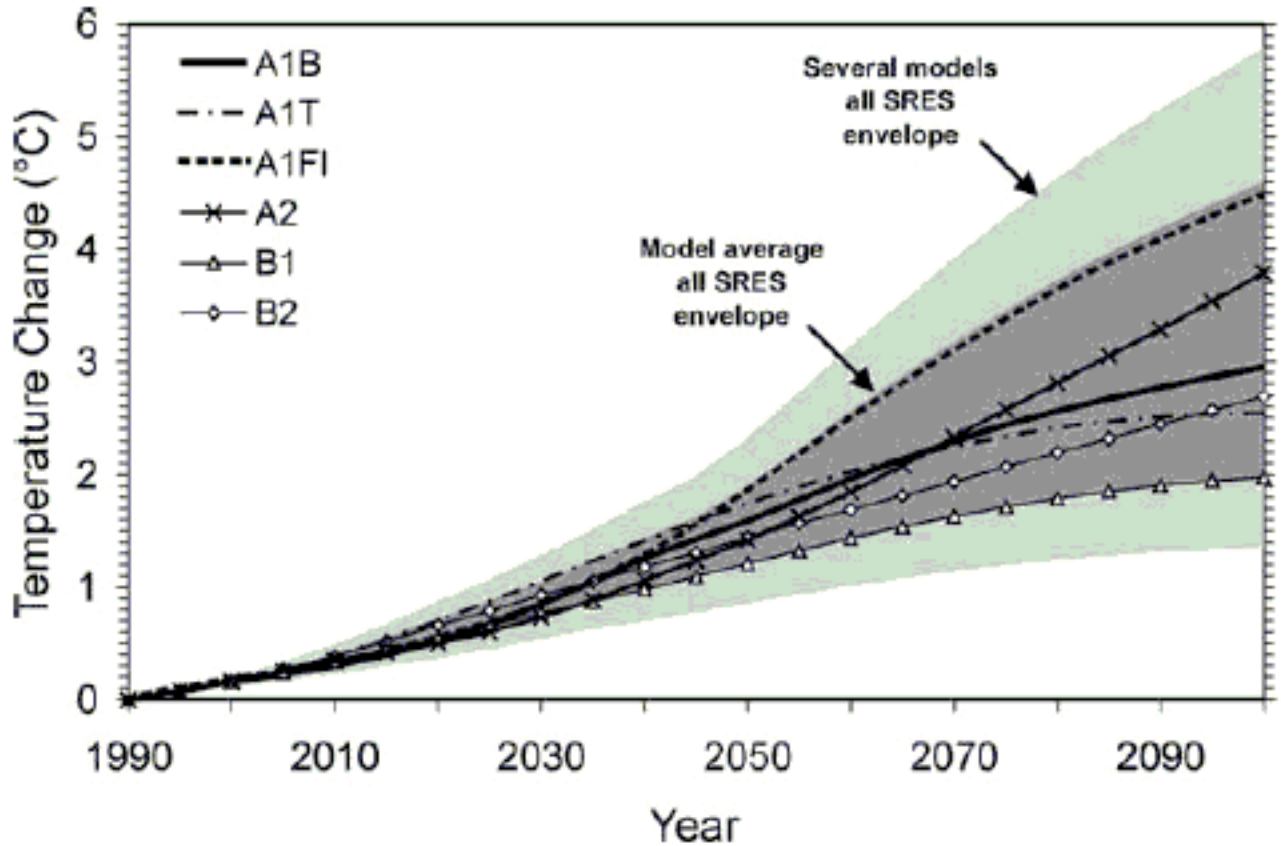
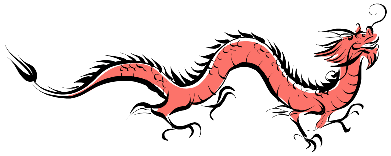
Climate change
You know the graph



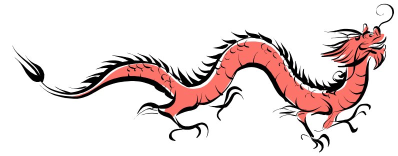
feedbacks and sensitivity

- Climate sensitivity α 1/ (Σ feedbacks)
- Σ feedbacks $\rightarrow$ 0 means unstable climate

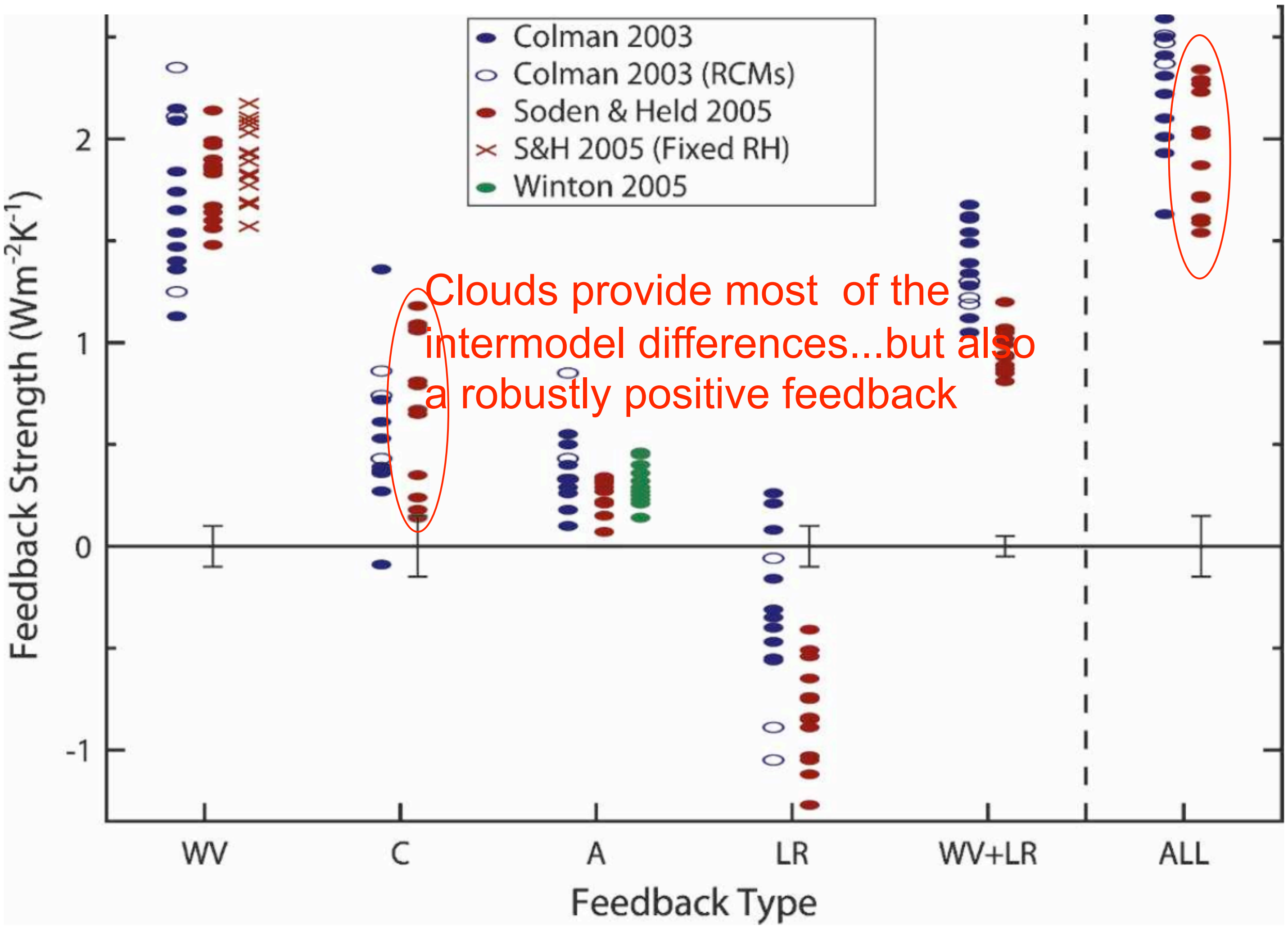
- 'base' negative feedback too obv. to mention!
  - ~ -3.2 W m^{-2} per K
    - (from Soden and Held 2000 review article)
  - "Largely" Planck feedback d/dT (σT^4)
    - -3.8 at global T_{eff} of 255K



Runaway feedbacks !!

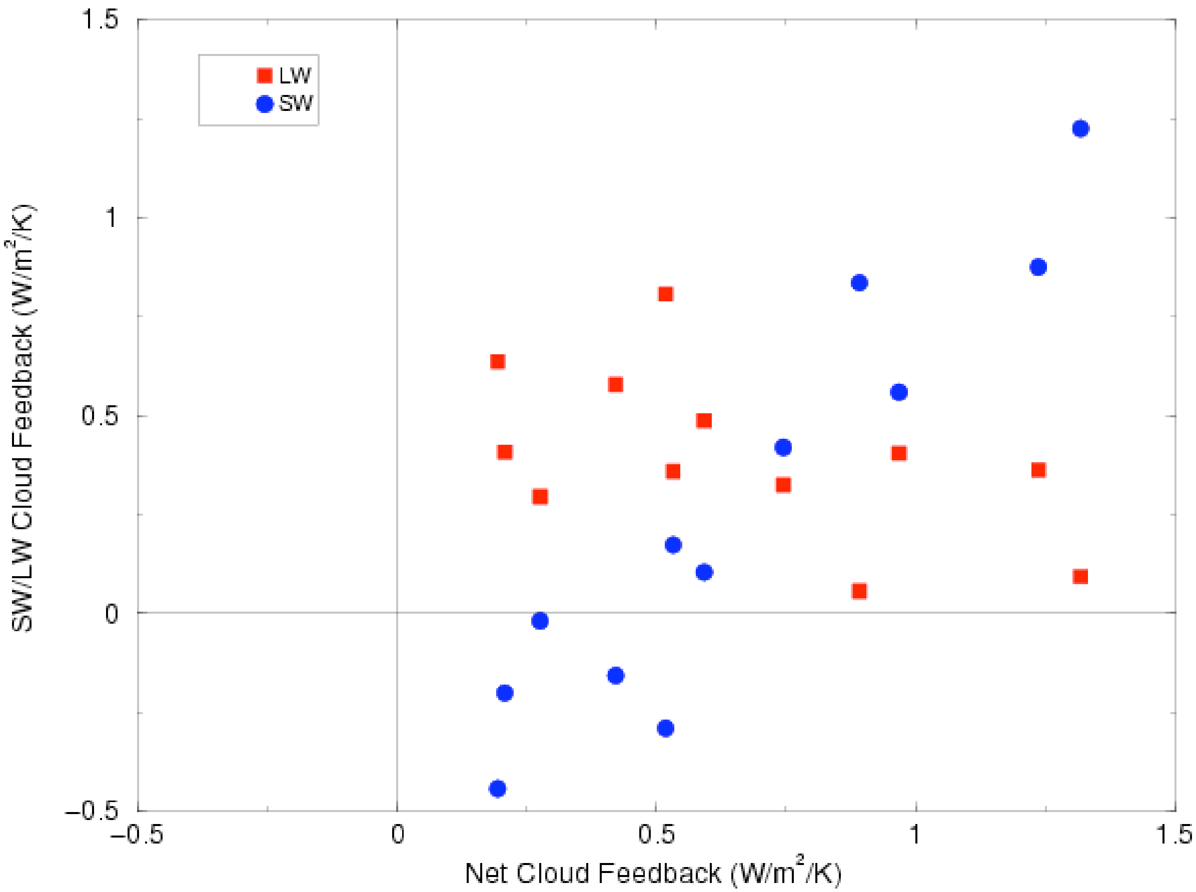


3.2



Bony et al. 2006

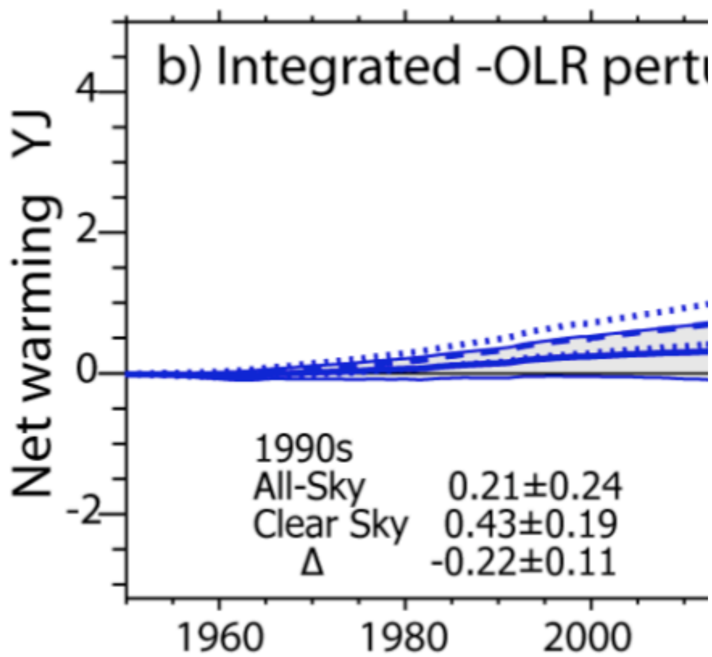
SW and LW cloud feedback



Net cloud feedback
from 1%/ yr CMIP3/AR4
simulations

courtesy of I. Held
who credits B. Soden
Jan clim feedbacks mtg.

Step back from feedback framing: raw energetics in IPCC AR4 model ensemble

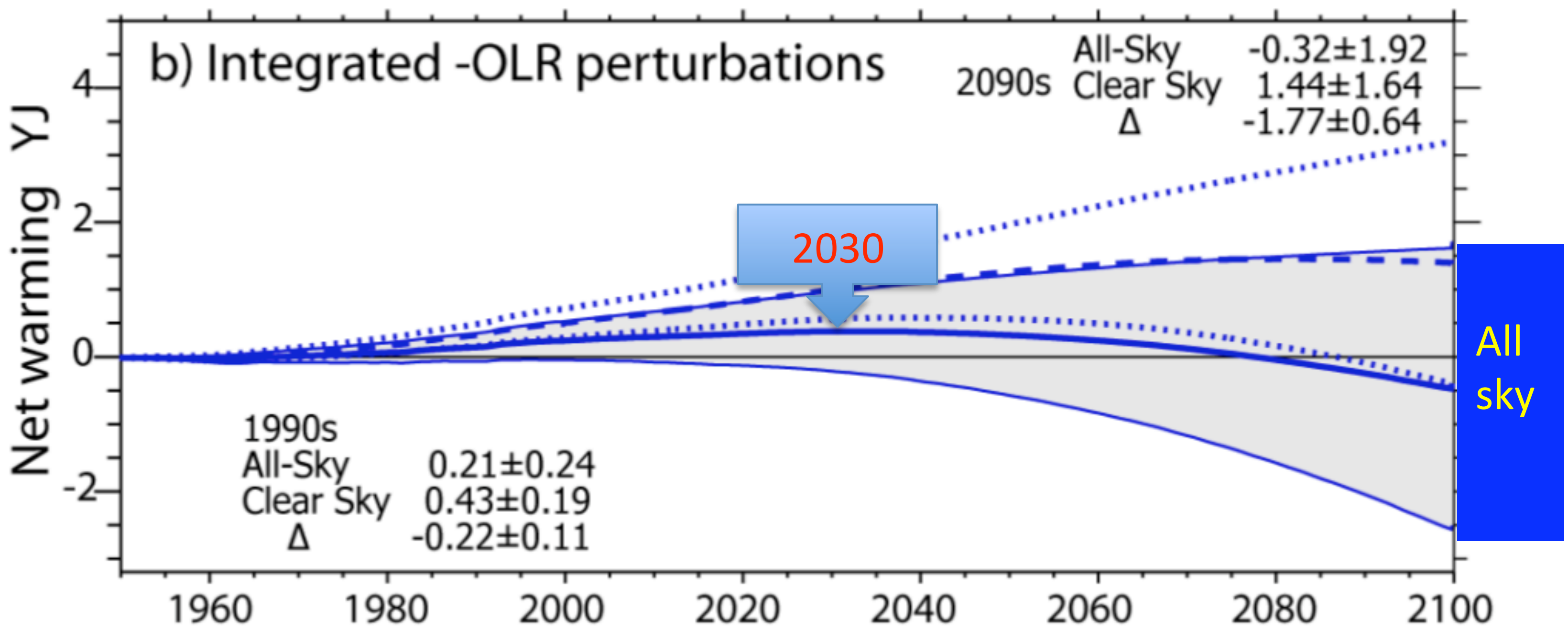


Solid lines delineate multimodel ensemble of actual (all-sky) TOA radiation budget.

(Broken lines = “clear sky” radiation outputs from models, not used in their integration – just for our interpretation (good luck!!)

Trenberth and Fasullo 2009 GRL

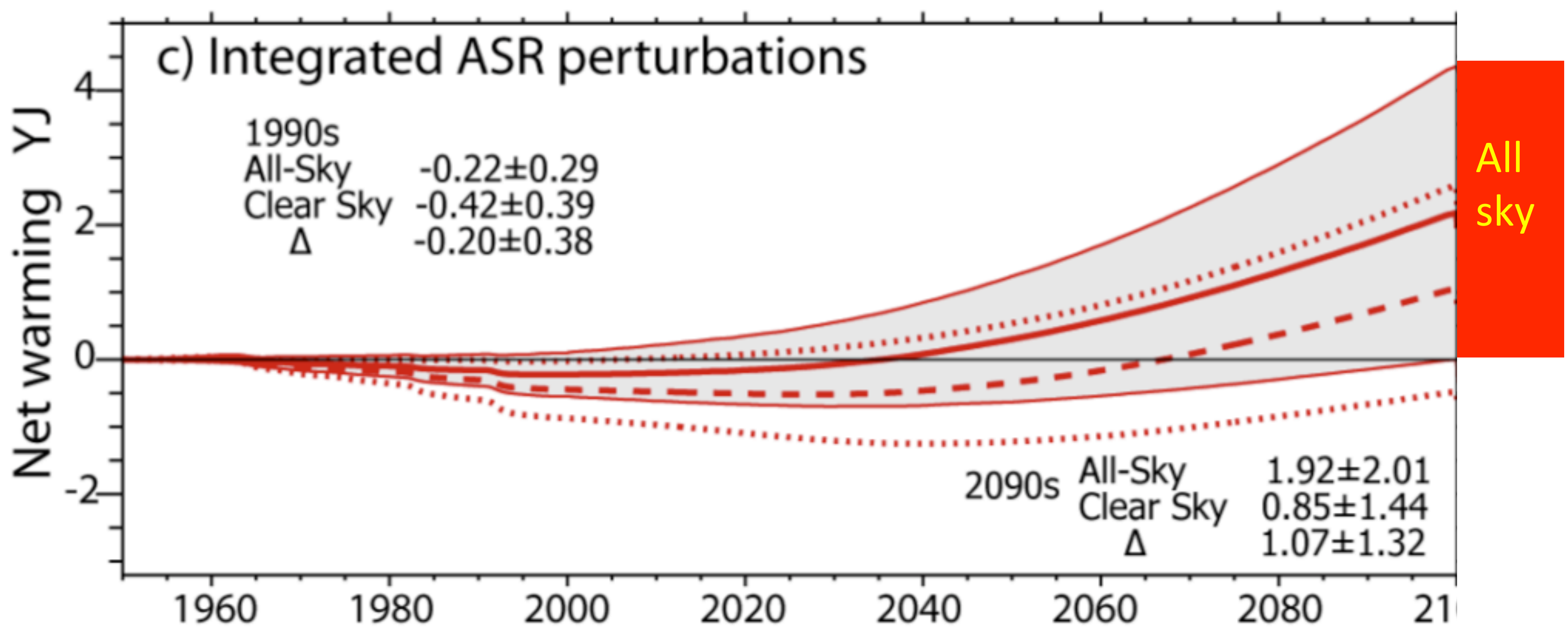
- Longwave trapping quits by 2030 in model ensemble mean



Trenberth and Fasullo 2009 GRL

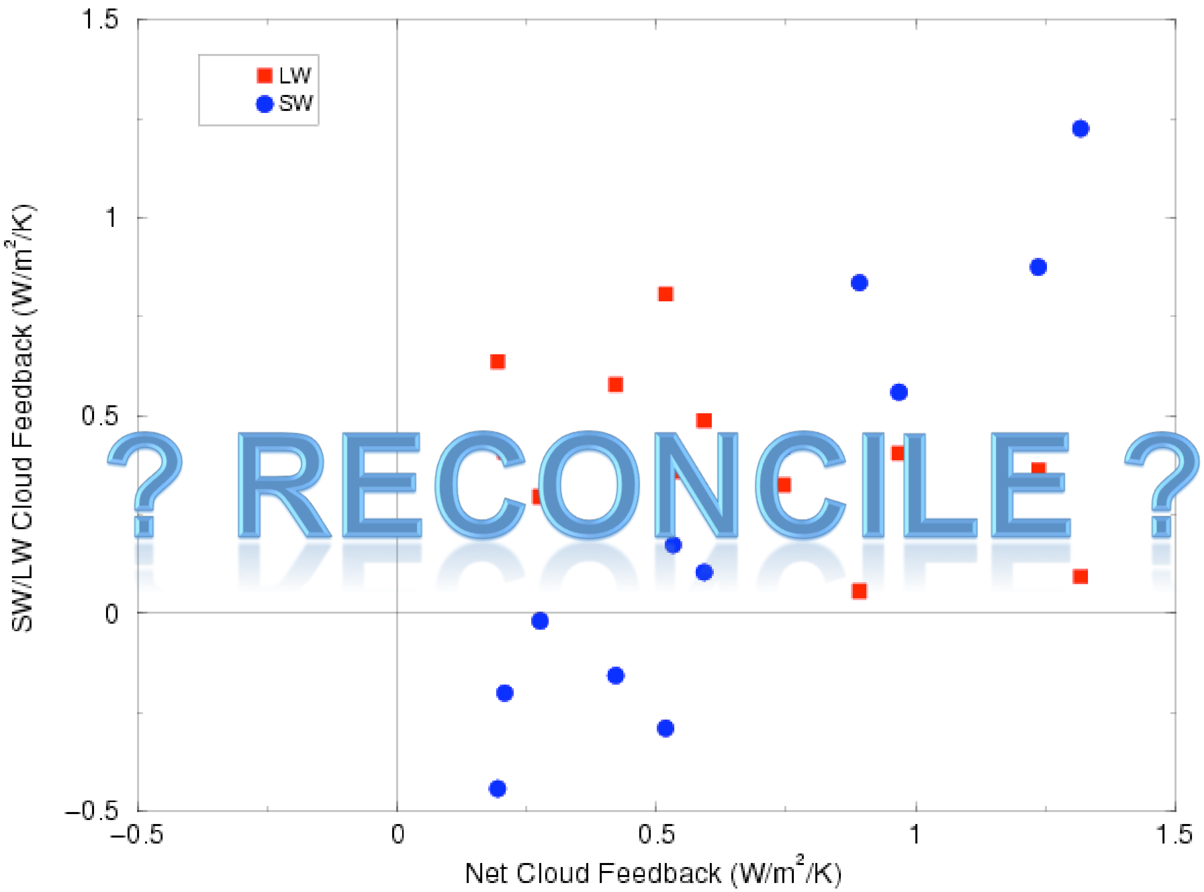
Global warming due to increasing absorbed solar radiation

- From 2030, models warm by reduced albedo



Trenberth and Fasullo 2009 GRL

SW and LW cloud feedback



Net cloud feedback
from 1%/ yr CMIP3/AR4
simulations

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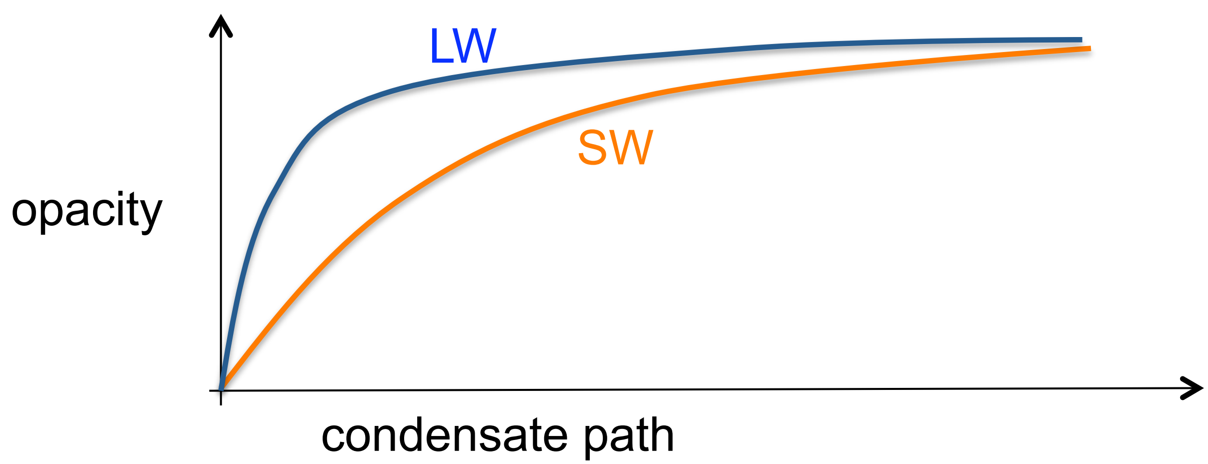
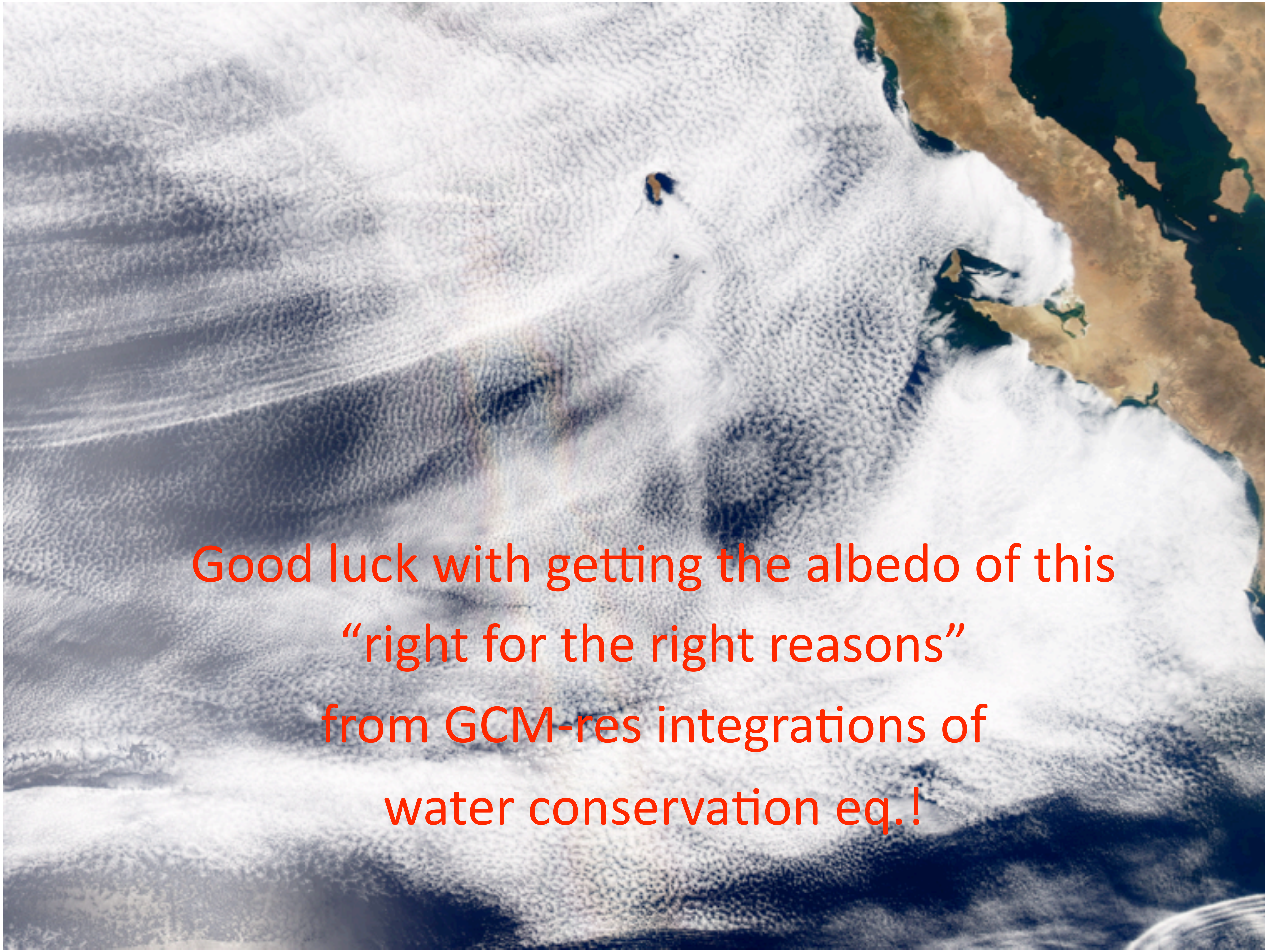
Jan clim feedbacks mtg.

Preview of next week's trouble

- Radiative impact is highly *nonlinear* in amount of condensed water
  - much worse than our "log of RH" problem for vapor




Good luck with getting the albedo of this
“right for the right reasons”
from GCM-res integrations of
water conservation eq.!

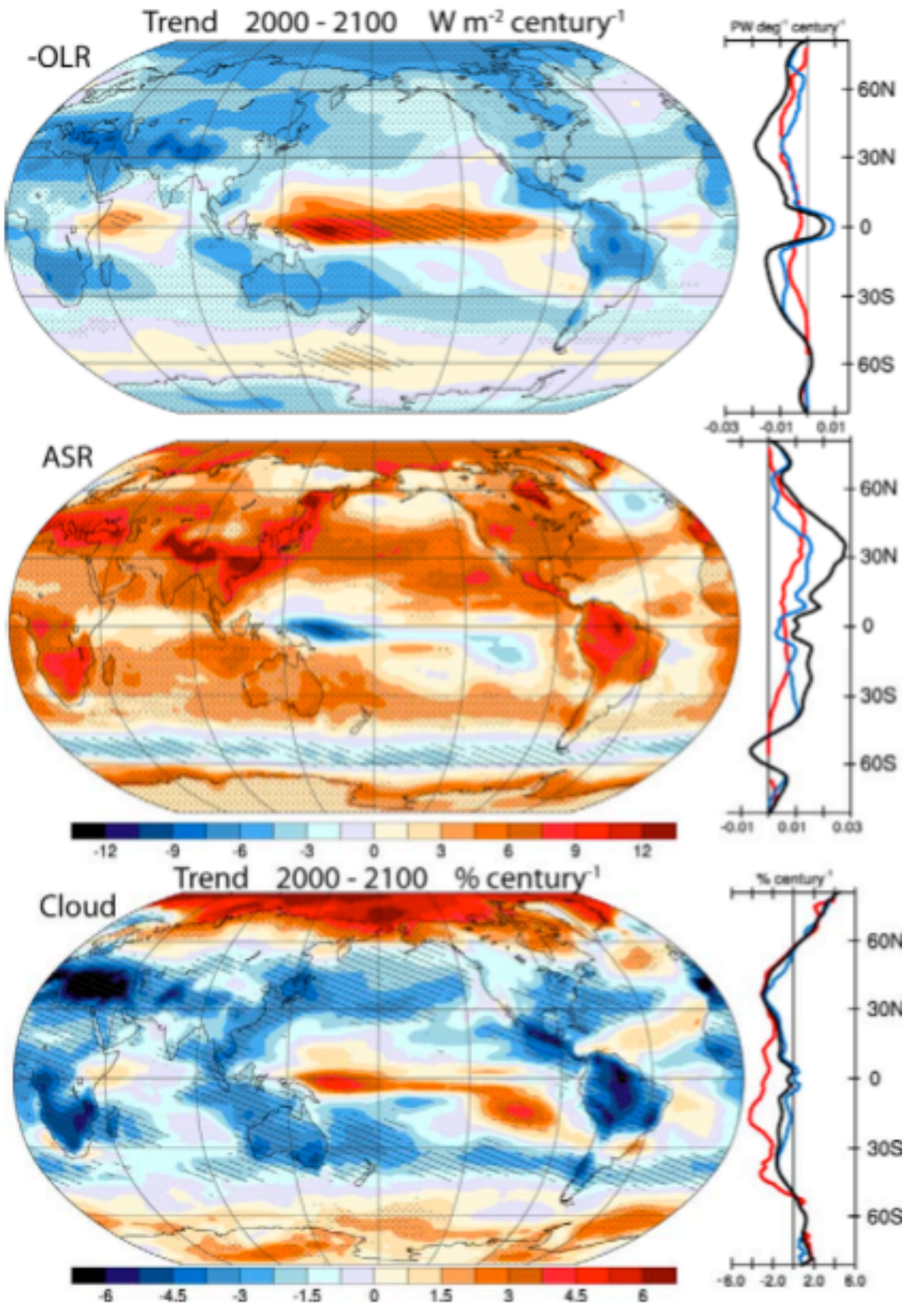


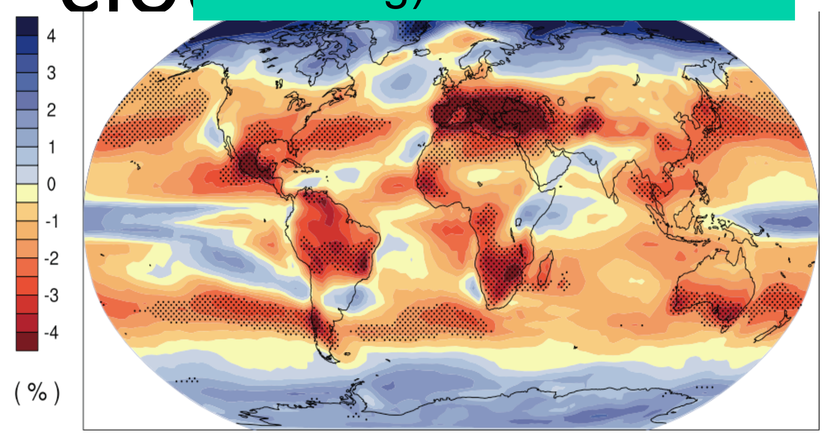
Fig. 4. Linear trends from 2000 to 2100 in annual mean –OLR, ASR, (

Map of models' OLR trapping

ASR absorbtion

clou

IPCC AR4 figure (opposite color scale & longitude centering)



Trenberth and Fasullo 2009 GRL

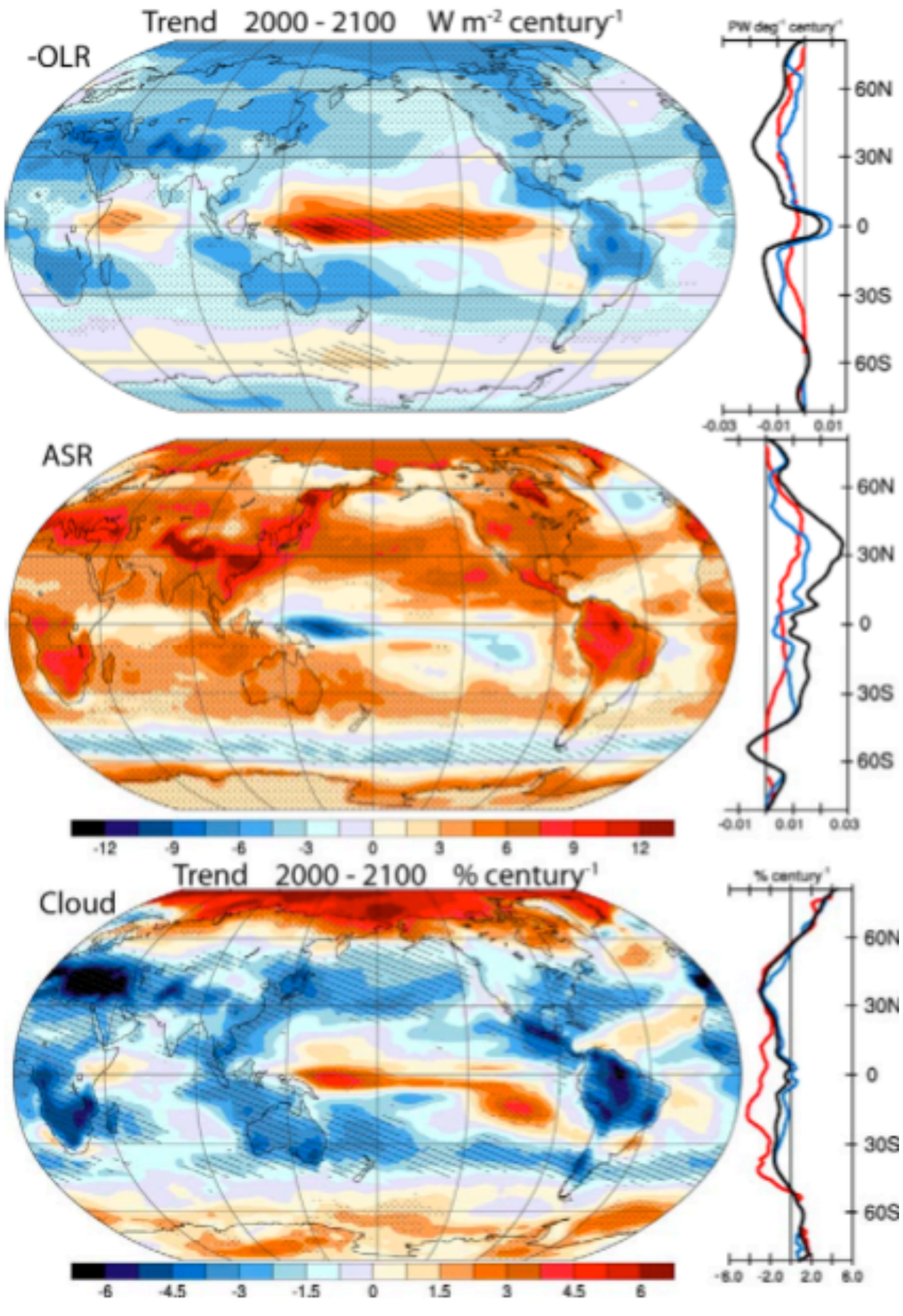
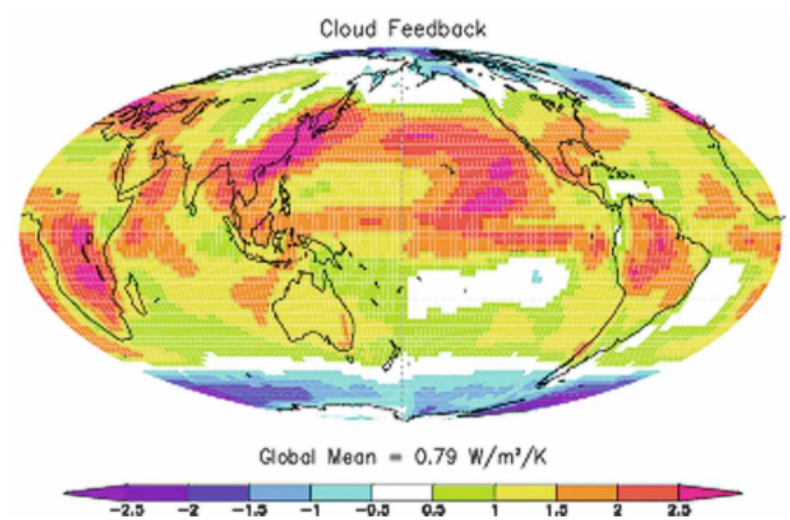
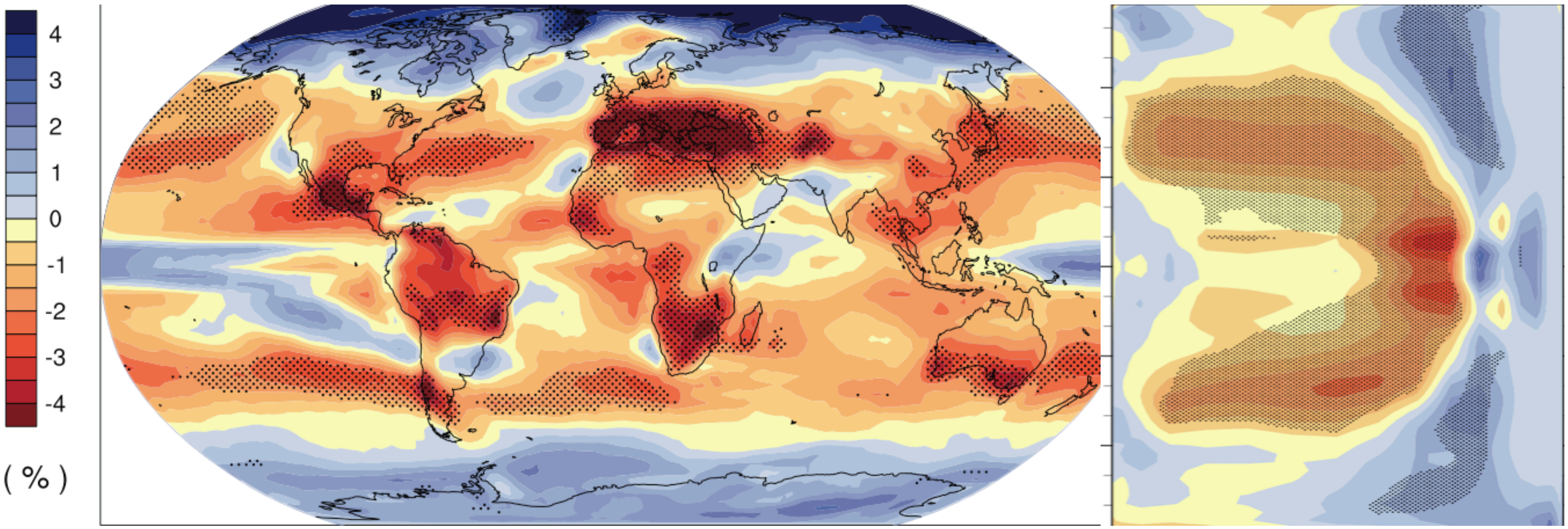


Fig. 4. Linear trends from 2000 to 2100 in annual mean –OLR, ASR, (

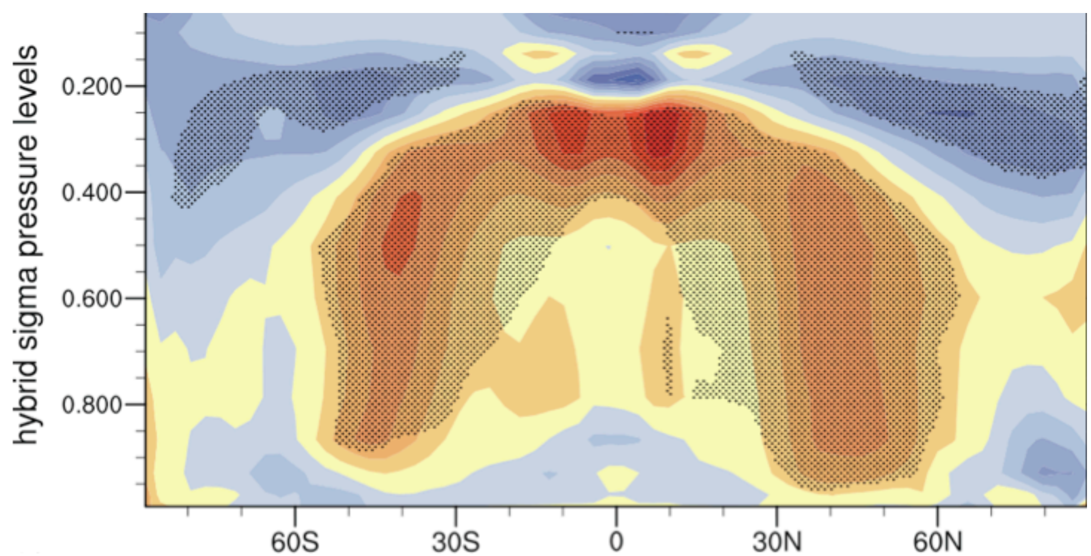
Cloud feedback (net) from Soden Held 2008 method (kernels)



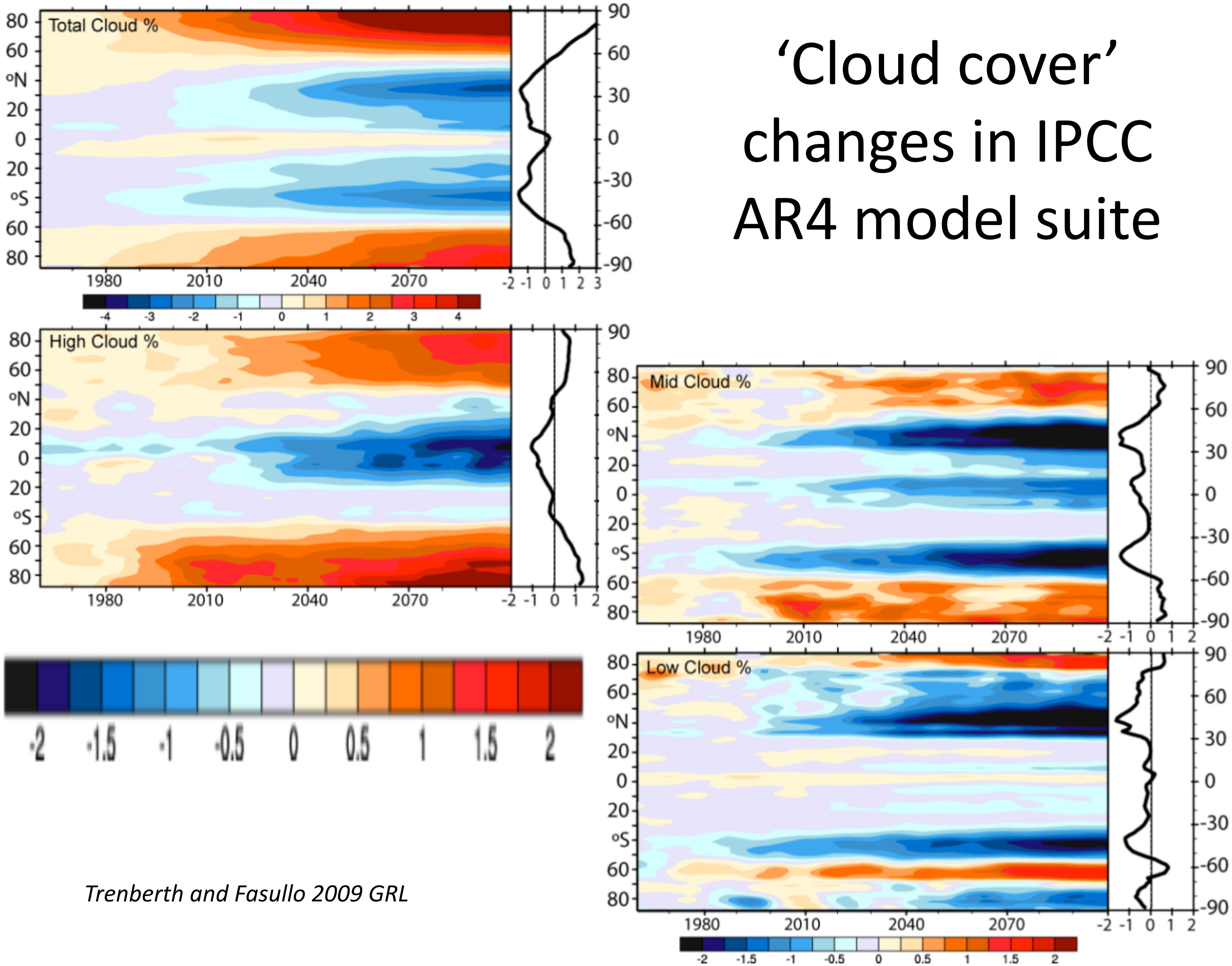
IPCC AR4 report cloud changes



IPCC ch 10
"The mid-level mid-latitude decreases are very consistent, amounting to as much as one-fifth of the average cloud fraction simulated for 1980 to 1999."

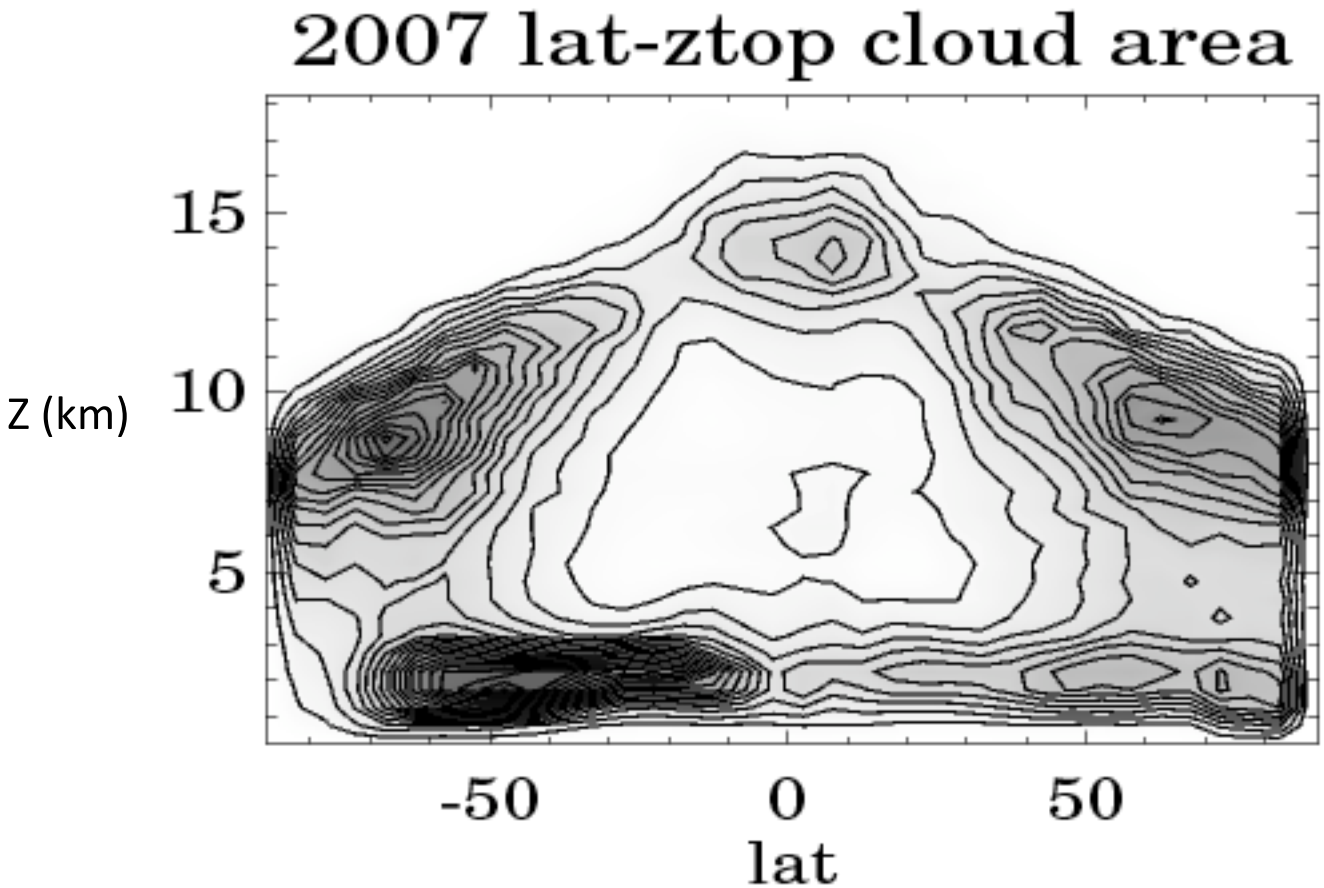


‘Cloud cover’ changes in IPCC AR4 model suite

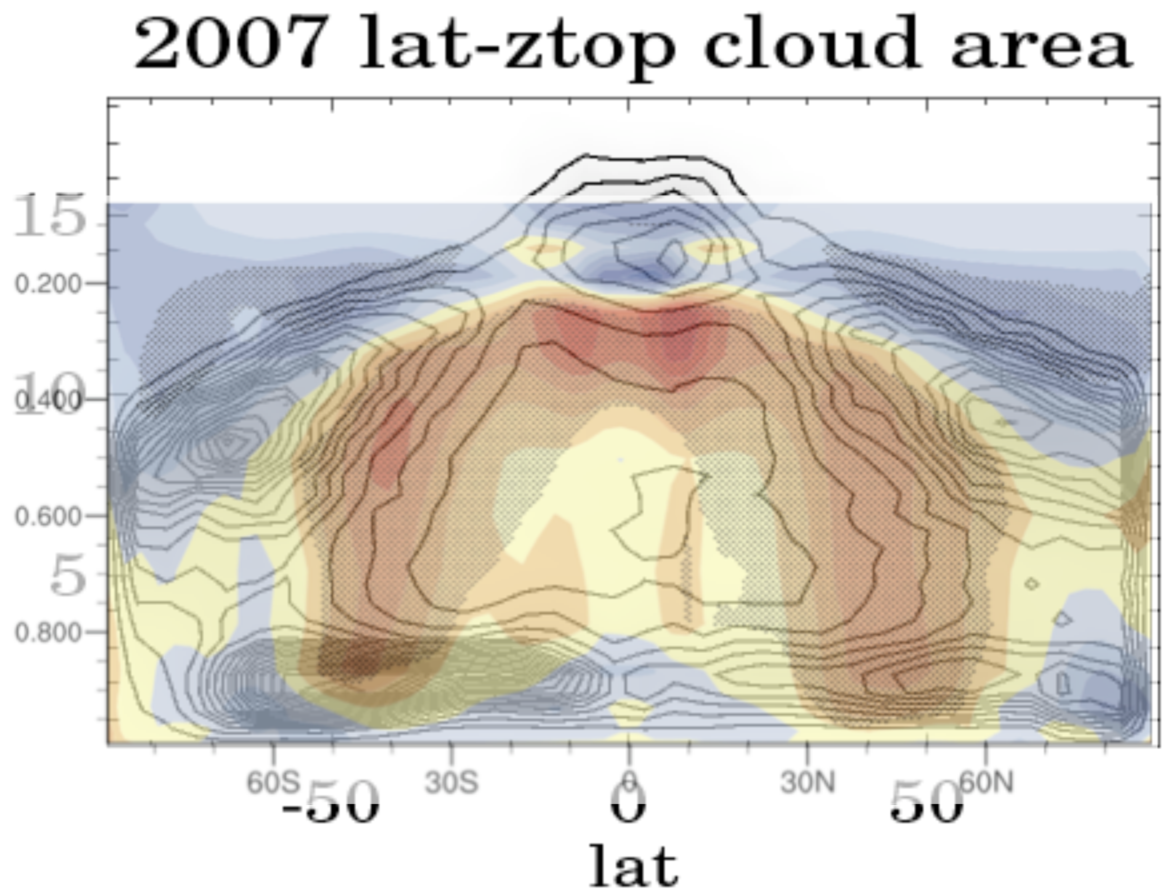


Trenberth and Fasullo 2009 GRL

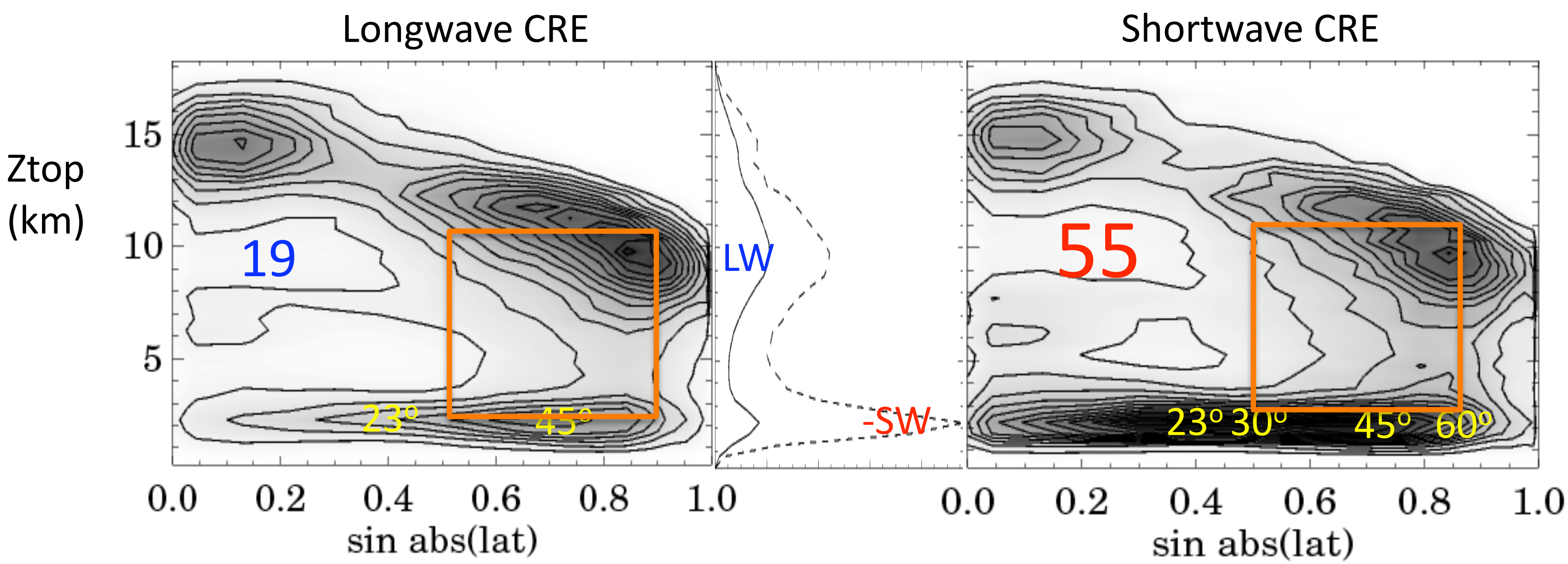
CloudSat view of current cloudiness by latitude and echo object top



Crude overlay (sigma coords vs. z)



Current climate Cloud Radiative Effect CRE (=CRF) from CloudSat FLXHR product



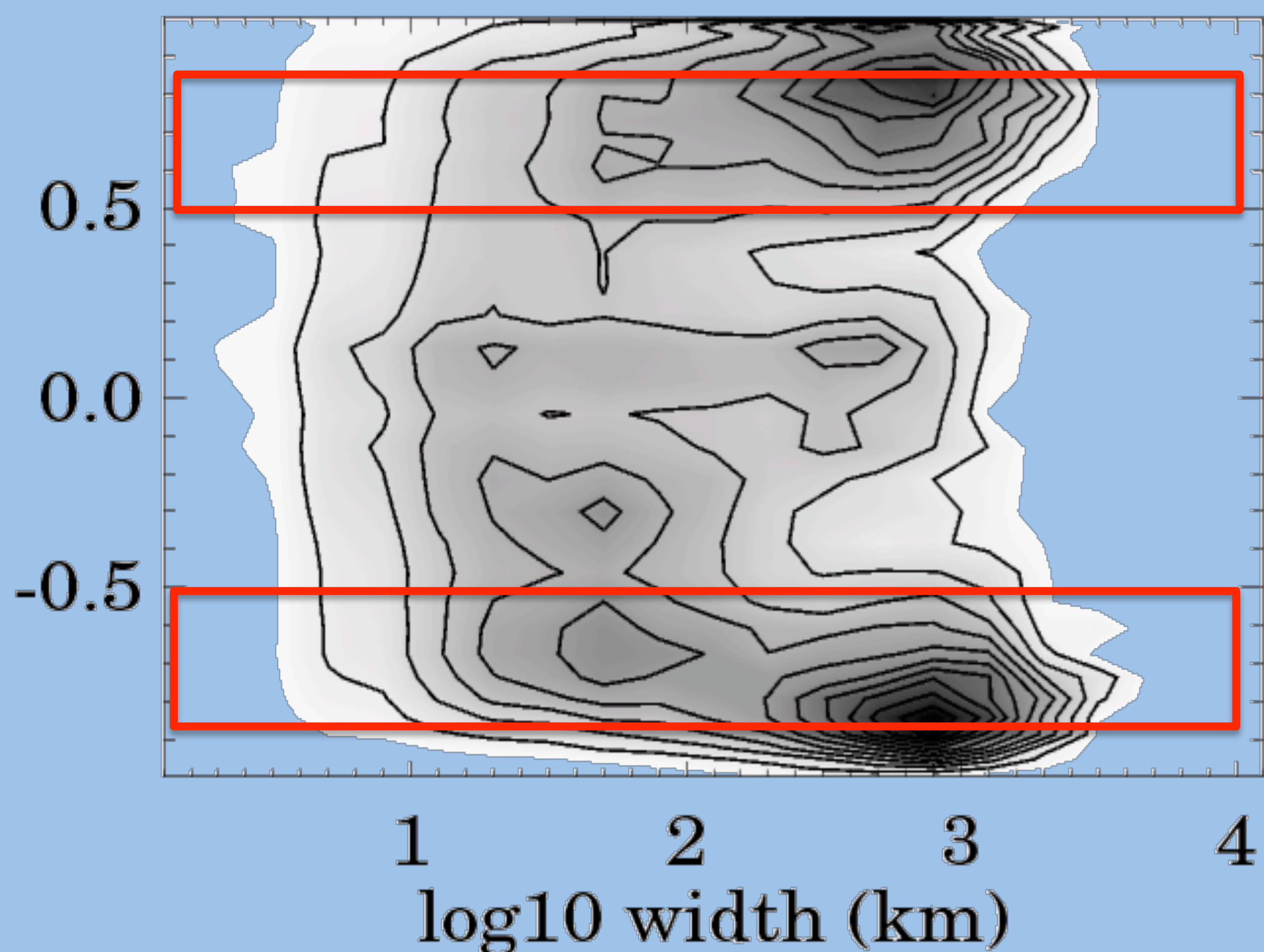
19 LW **global mean** 55 SW

(Wm-2)

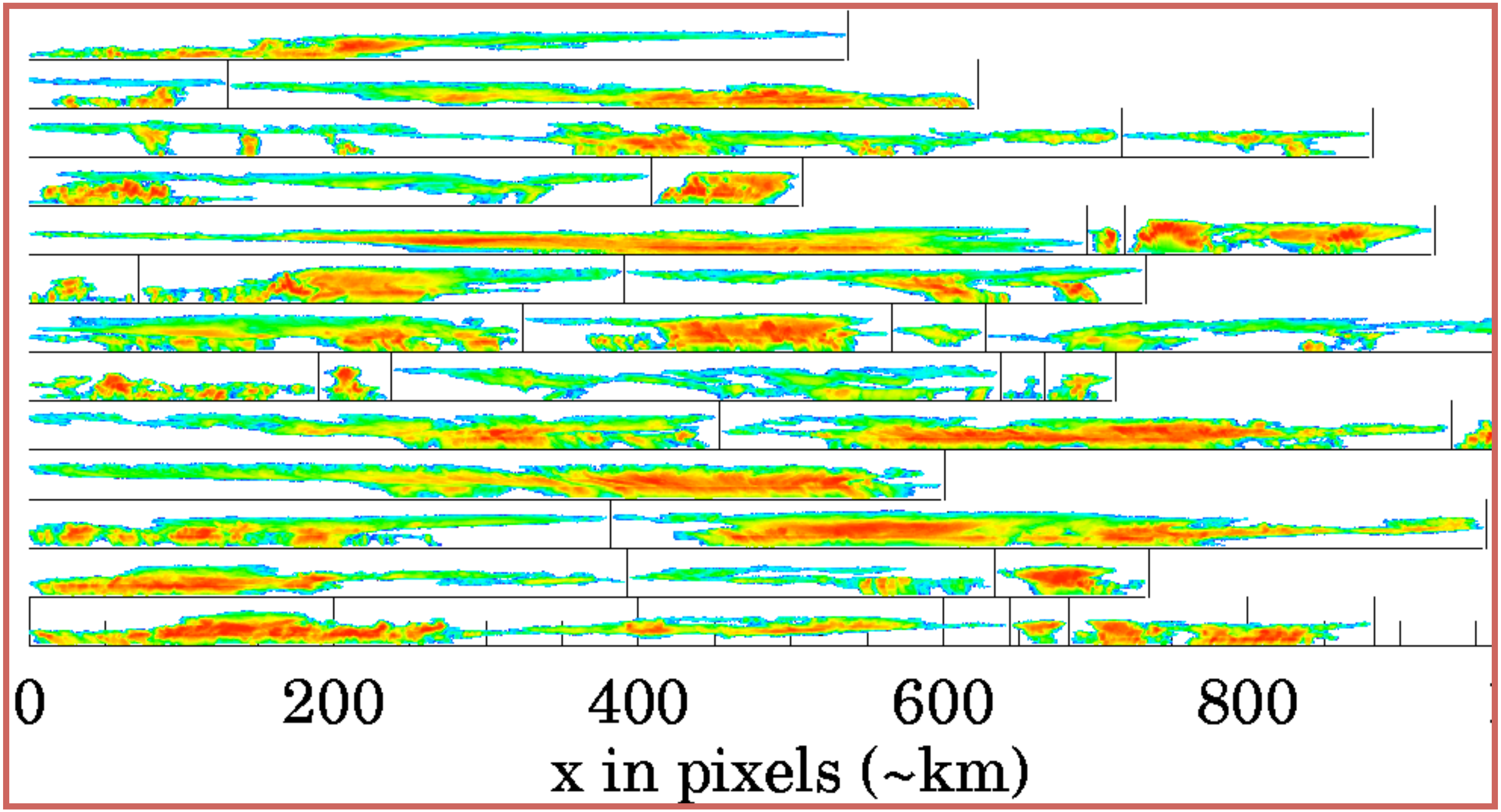
Caution: Simple average of 0130 and 1330 local time samples, not true diurnal mean estimate!

Shortwave cloud forcing dist. by echo-object size

Integral of distribution is -55 Wm-2 global mean



Big midlat cloud systems
will get narrower? thinner? fewer?

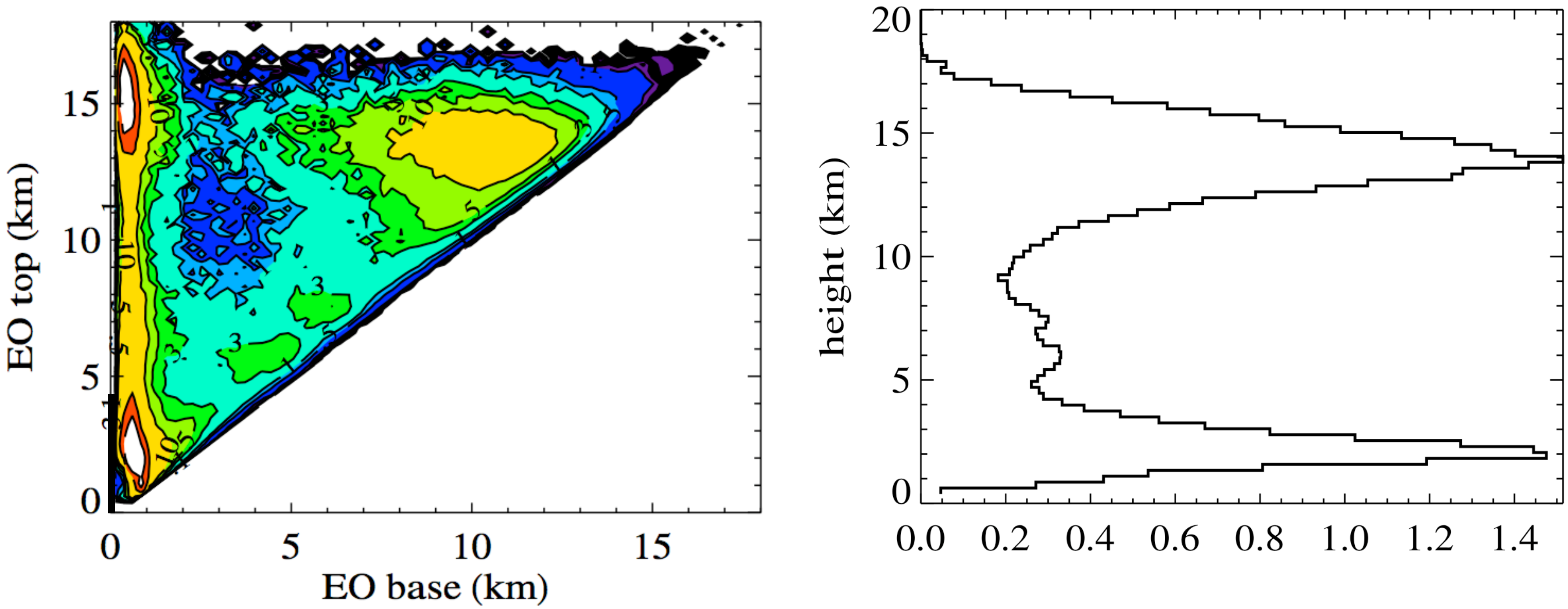


Feedbacks so tricky, I give up.

Indulge me – an interesting ob:

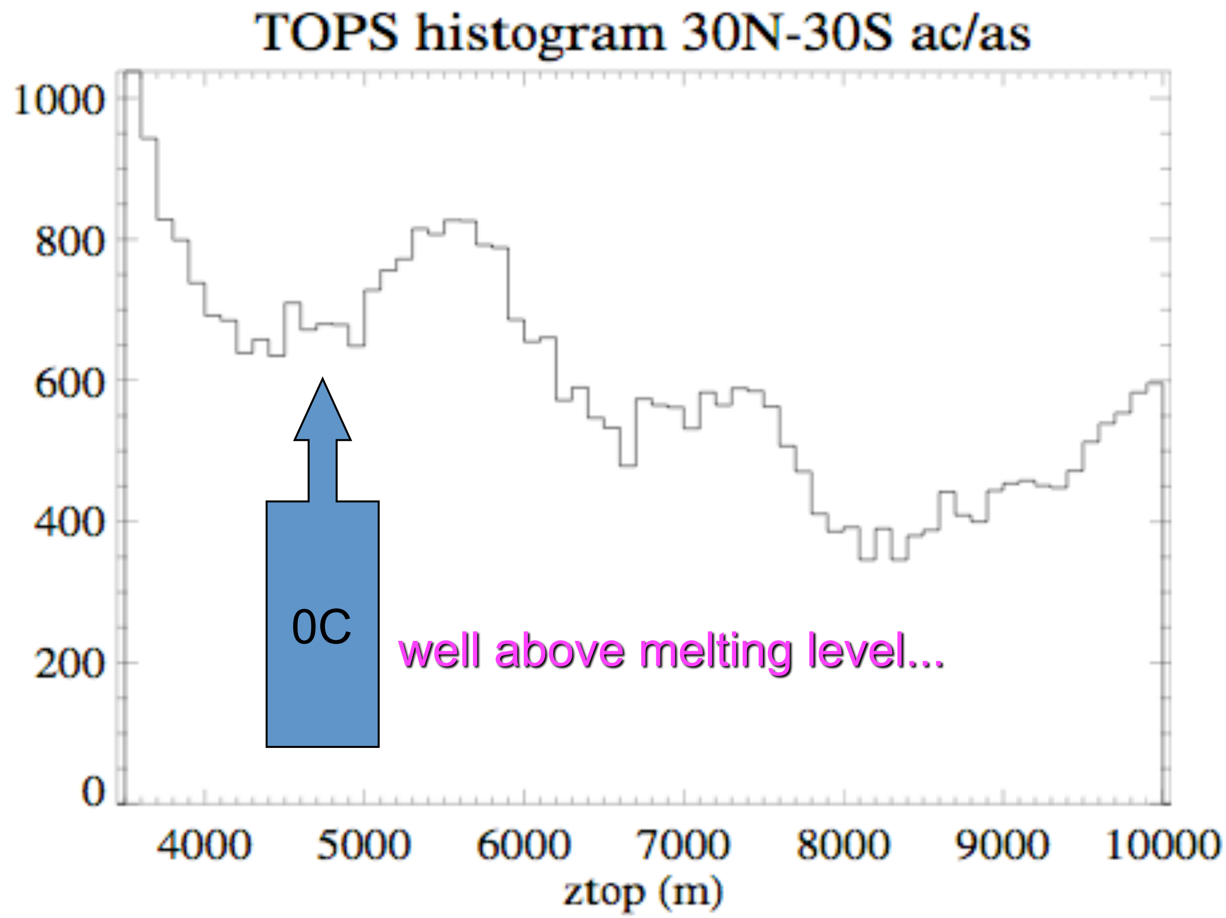
- WARNING! TALK IS OFF TRACK!
- SHOWING PET OBSERVATION OF A FEATURE TOO TINY TO BE CLIMATE CHANGE RELEVANT!

Cloudsat: Tropical EO altitude distributions

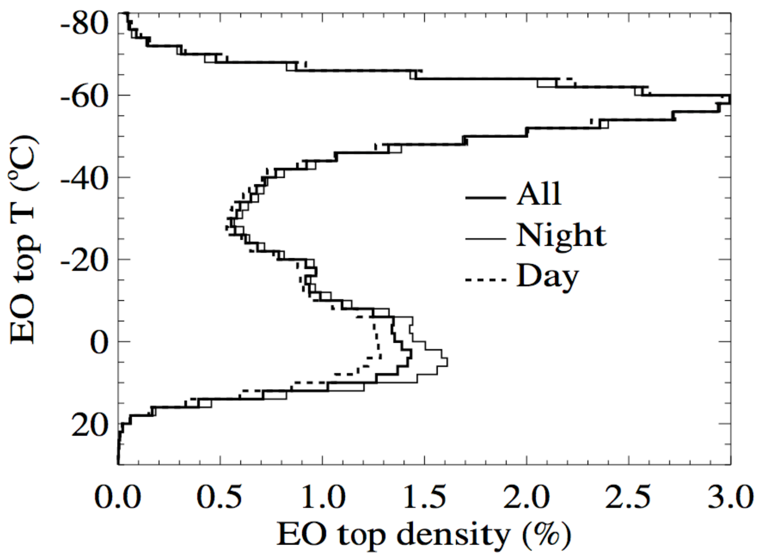


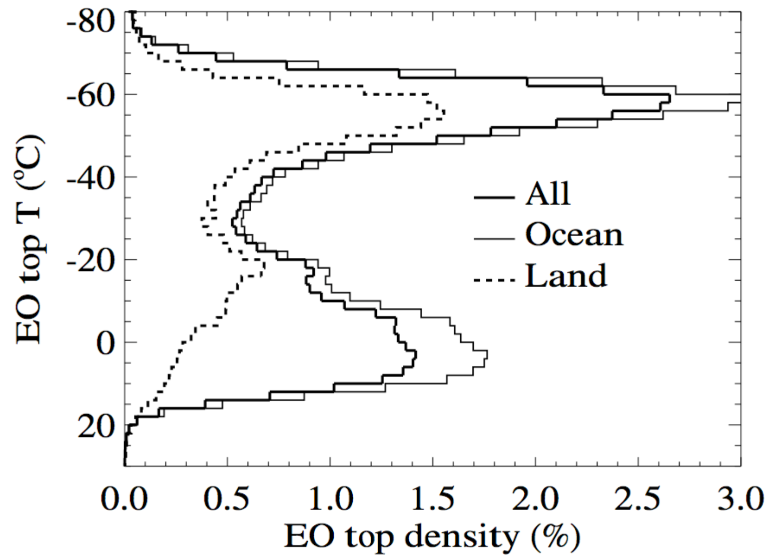
Midlevel clouds: a bimodal population

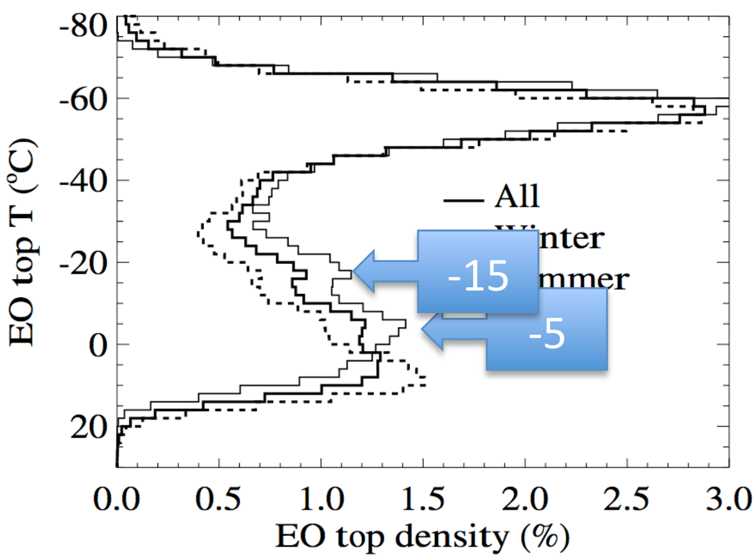
in global tropics



Extra-tropical (20°-60°N/S) EO top Vertical Distribution

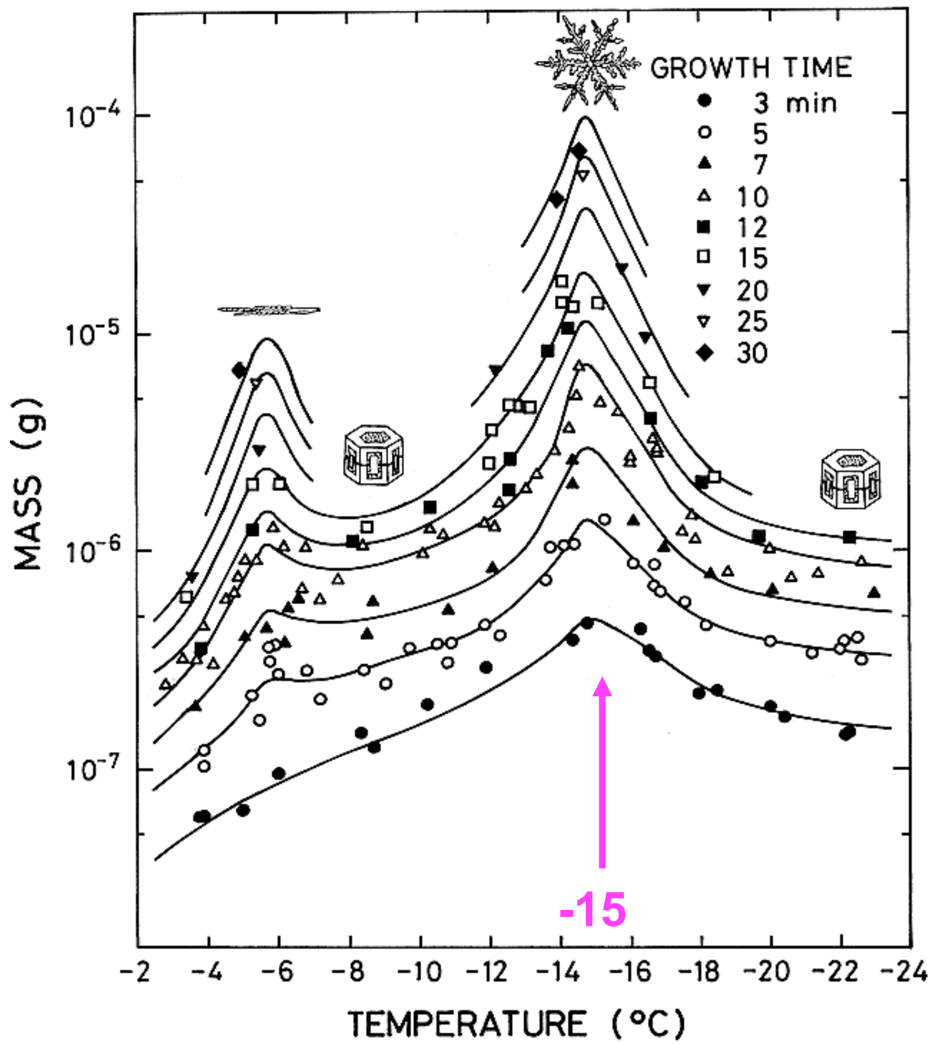






- Temperature is vertical coordinate

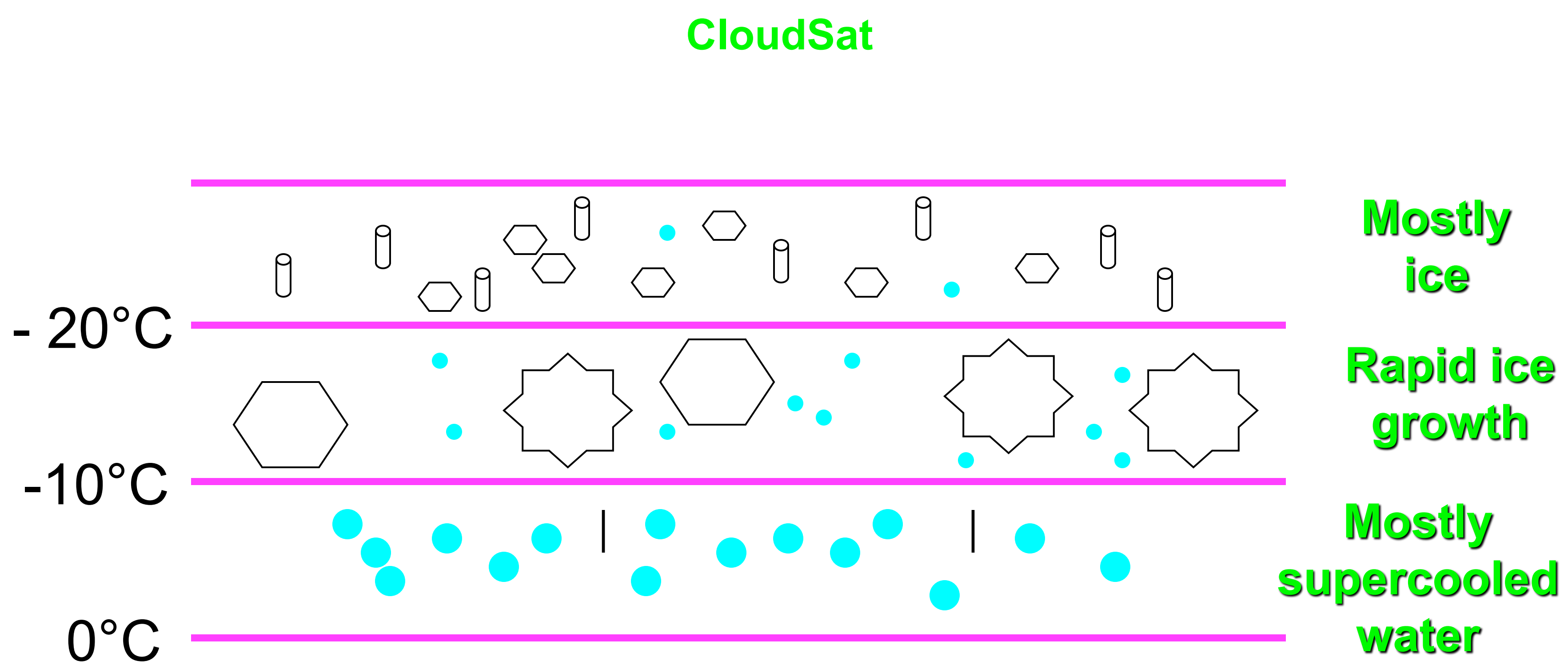
Ice Microphysics



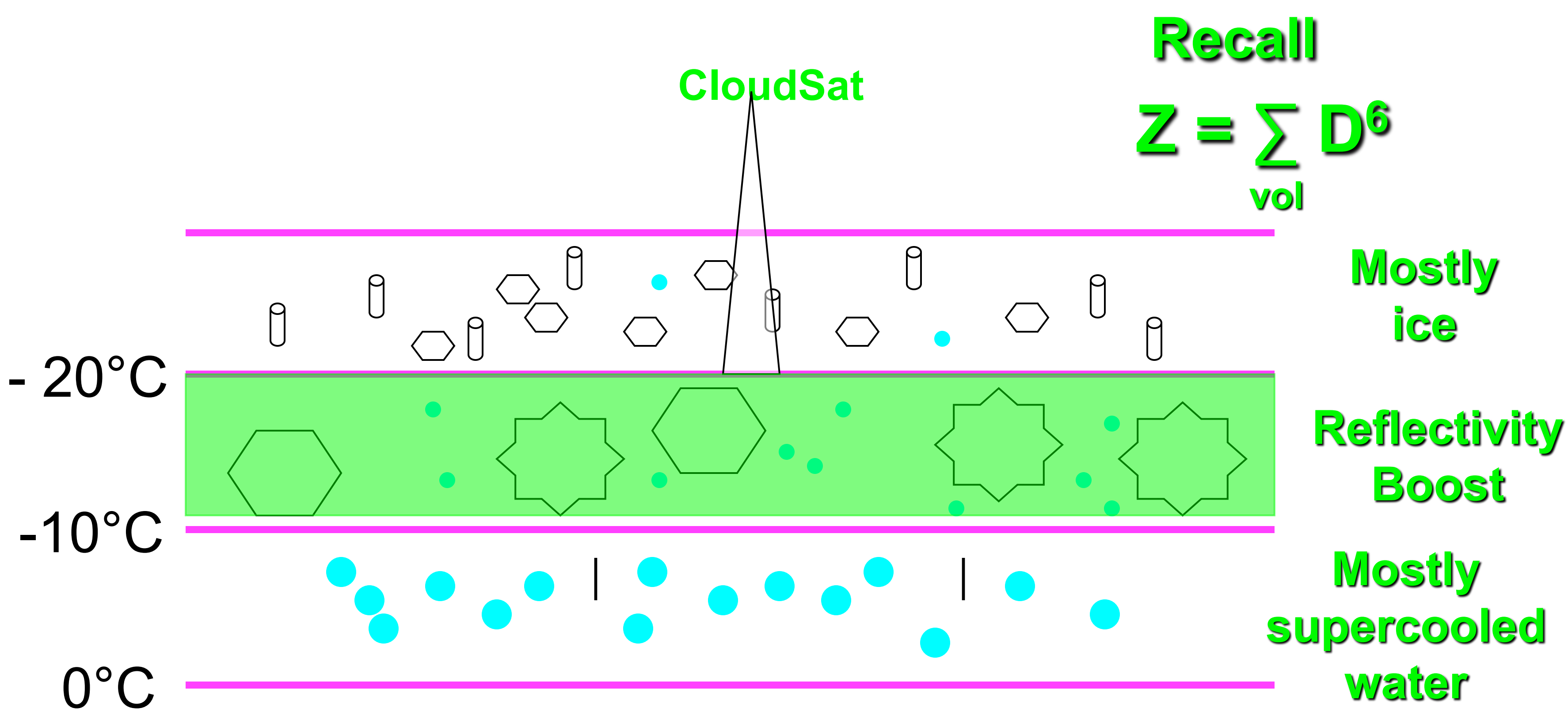
Fukuta and Takahashi (1999)

- Maximum dendritic ice growth at -15°C to -20°C
- Secondary growth maximum near -5C

Is peak just because ice Particles are fewer, larger, more reflective than droplets?

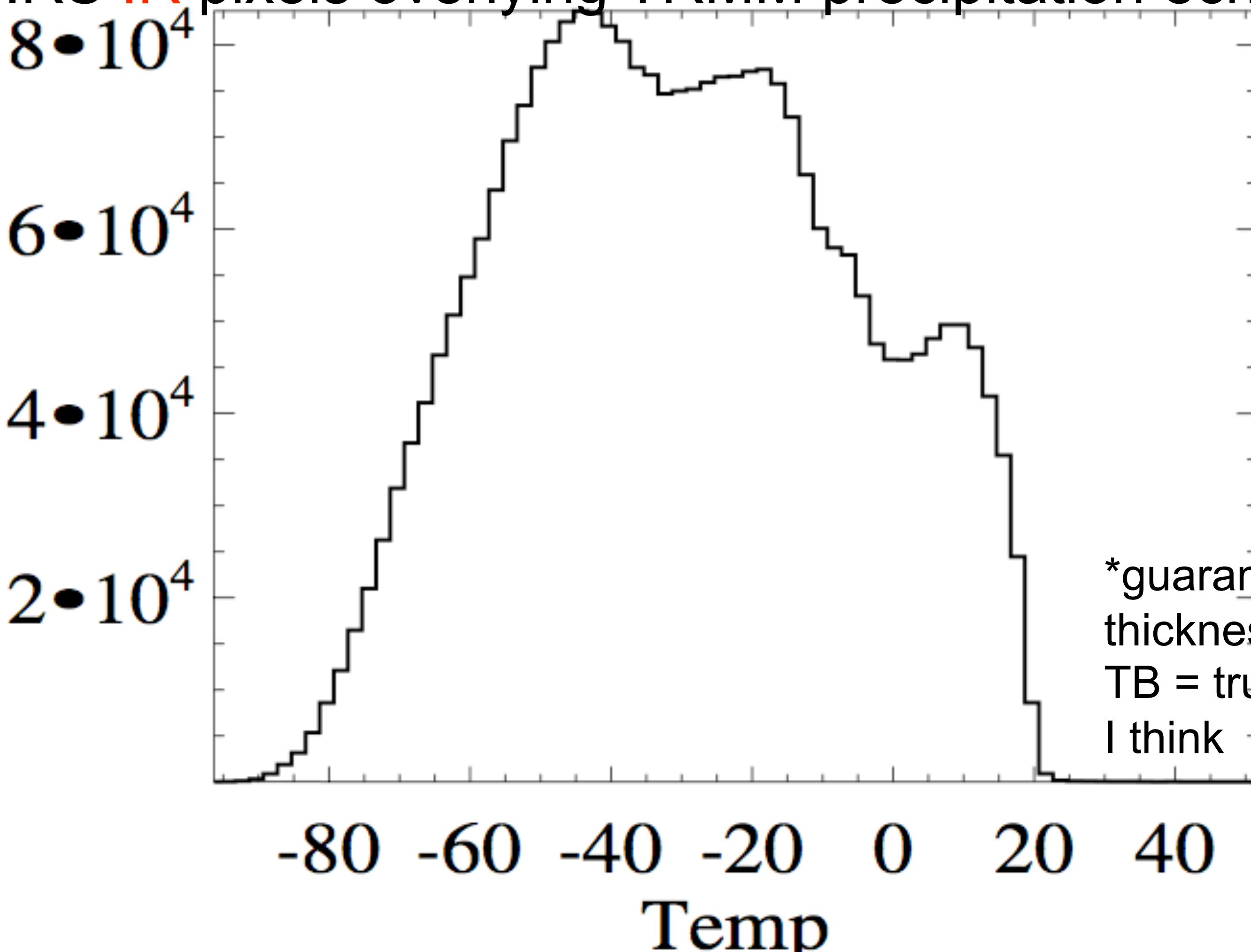


Particles more reflective?



Not just a particle size effect – there's a peak in IR cloud tops at -15C too!

VIRS IR pixels overlying TRMM precipitation echoes*



*guarantees optical thickness so TB = true Ttop, I think

plot Emily Riley, data H. Masunaga

Back on track - conclusions

Feedbacks:

(WV+LS) coupled, should be thought of as one thing

- 1 +/- 0.25 W m-2 K-1

Clouds:

- 0.5 +/- 0.5 W m-2 K-1

Total excluding the Planck -3.2:

- 2 +/- 0.5 → clouds dominate uncertainty

Climate sensitivity ~ 1/(Total -3.2)

Conclusions

- “Enhanced longwave trapping” warming is what IPCC AR4 models do til about 2030
- After that, OLR is near present levels, and enhanced shortwave absorption becomes dominant energy input for warming
- Deep layer of cloud reductions in 30-60 latitude belts – midlatitude storms, not just cloud-topped PBL we hear so much about
- Climate change problem hopeless. Uncle. Let’s play and learn instead.
- Intriguing signal of ice uphys in cloud climo...


postdoc wanted (avail. now)
• Convection scheming in a GCM
• and eval thereof (using at least some ARM data)
RSMAS
UNIVERSITY OF Miami
ROSENSTIEL SCHOOL
OF MARINE & ATMOSPHERIC SCIENCE