Evaluation of different shallow convection schemes in ECHAM5 using the CALIPSO and CLOUDSAT simulators

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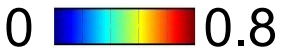
Low cloud fraction: Active vs. Passive



ECHAM5

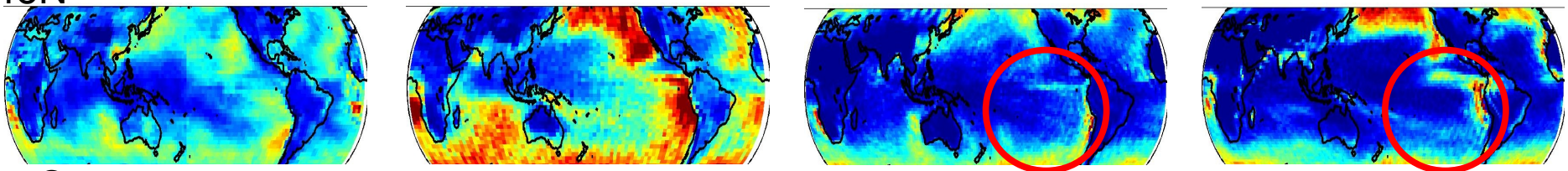
ISCCP
Passive Instruments

CALIPSO
Active Instruments

Standard + ISCCP Simulator

Standard + Lidar Simulator

45N



45S

- Both satellite simulators show standard ECHAM5 produces too little low clouds; particularly in (sub)tropics.
- Clouds in shallow cumulus regions of ECHAM5 not evident.

Satellite Data from CFMIP ClimServ (IPSL)
COSP v.1.2.1: Lidar and Radar Simulators

Representations of shallow clouds in ECHAM5

Convective Trigger
(E. Roeckner, 2010)

Convection is triggered at lifting condensation level when air parcel more buoyant than environment.

Subgrid variability in parcel buoyancy previously 0.5, now $\sqrt{\Theta_v'^2}$.

ETHZ
(C. LeDrian & F. Isotta, 2010)

Performs turbulent diffusion on conserved variables, cloud top entrainment & longwave cooling added to buoyancy production.

Von Salzen & McFarlane accounts for life cycle of shallow cumulus clouds using an entrainment plume model; and includes a double-moment microphysical scheme.

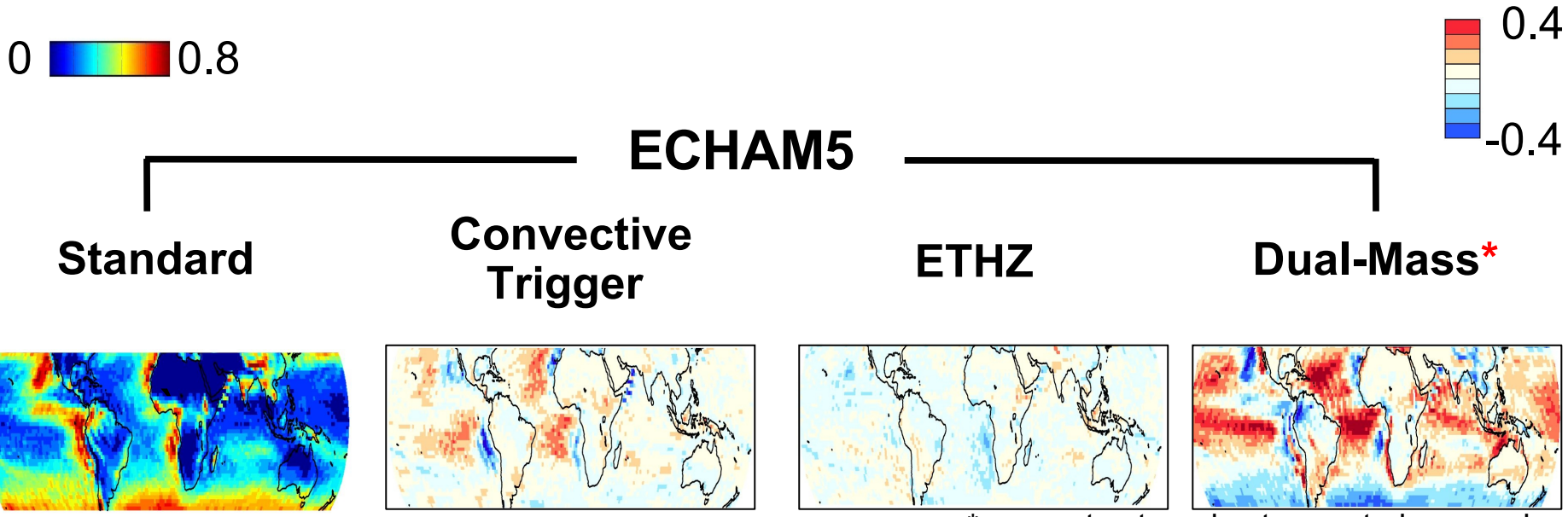
Dual-Mass*
(R. Neggers, 2009)

Turbulent mixing is parameterized in terms of turbulent kinetic energy and double mass-flux.

Mass-flux partitioning amongst moist and dry updrafts allow for gradual transition between boundary layer cloud regimes.

* Preliminary Verison

Low cloud fraction: Model



Difference compared to Standard ECHAM5.

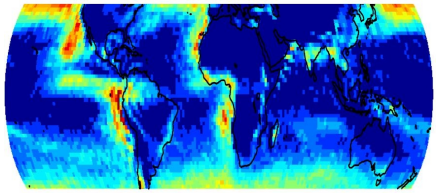
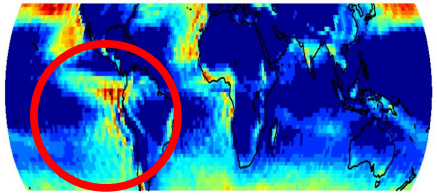
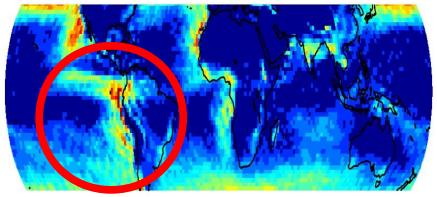
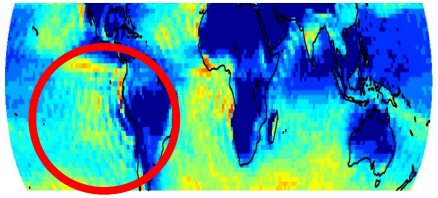
$CRF\|_{SW}$	-49.70	-49.38	-49.39	-67.66	W/m²
$CRF\|_{LW}$	28.15	28.34	28.18	31.43	W/m²

* Preliminary Verison

- C.Trigger & Dual-Mass parameterizations increase (sub)tropical low cloud fraction; particularly the shallow cumulus clouds.

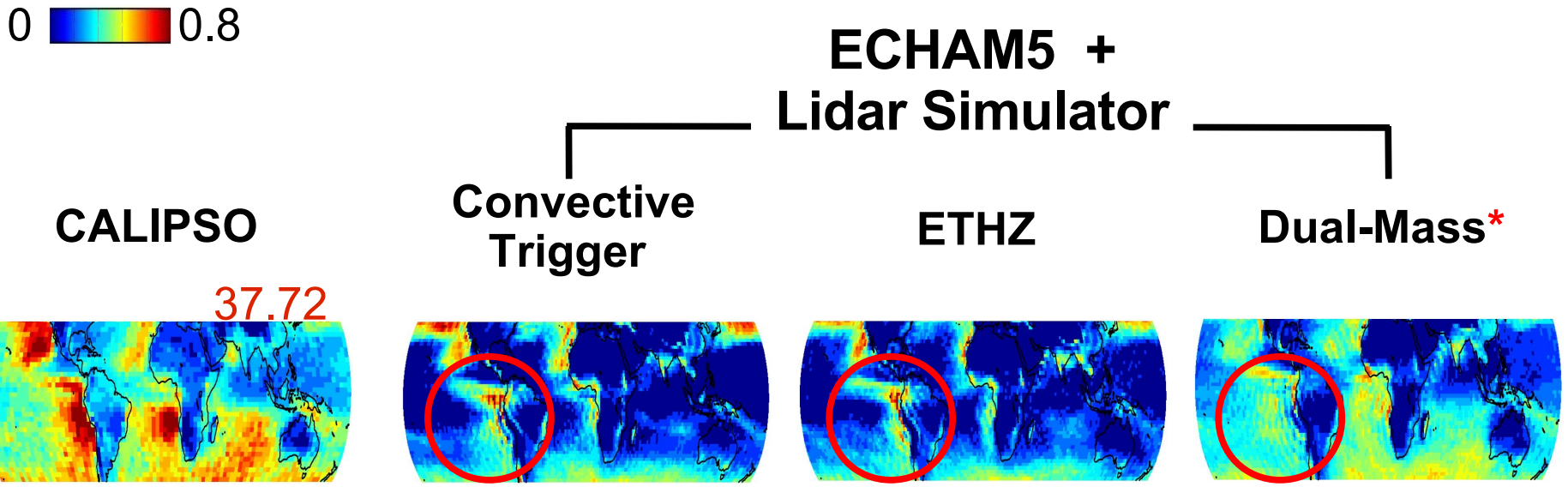
Low cloud fraction: COSP Lidar

ECHAM5 + Lidar Simulator

Standard	Convective Trigger	ETHZ	Dual-Mass*
			
Pure Model: 24.98	27.47	24.08	29.95
Model + Lidar Sim: 13.44	13.77	12.77	20.84

subtrop

Low cloud fraction: COSP Lidar

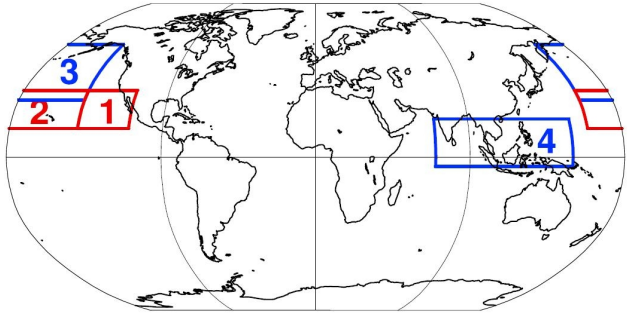


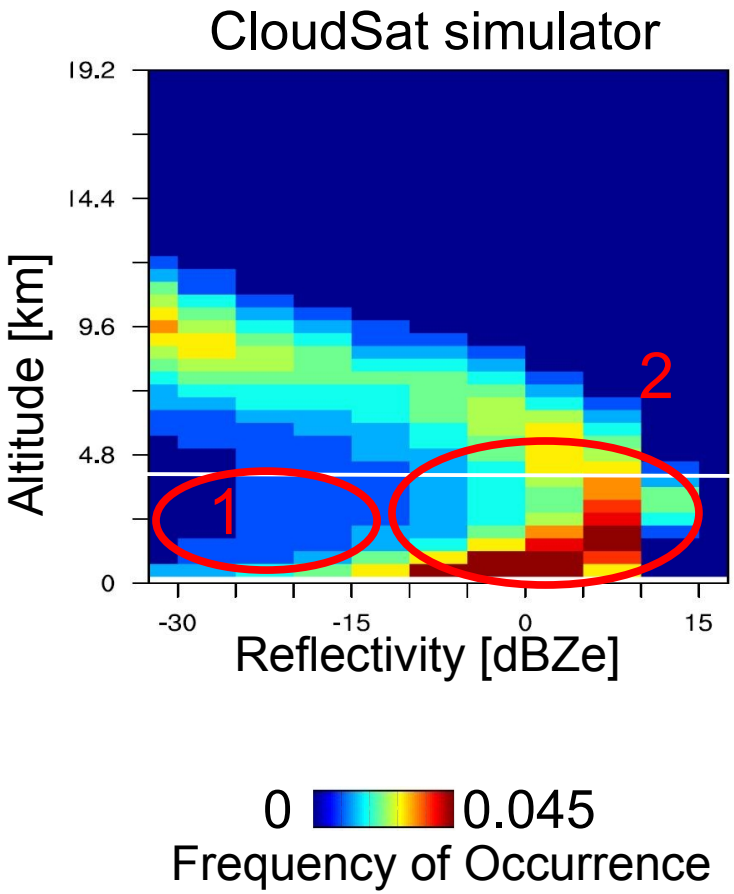
Pure Model:	24.98	27.47	24.08	29.95	subtrop
Model + Lidar Sim:	13.44	13.77	12.77	20.84	

- Lidar simulator does not detect all low-level clouds modelled.
- Though (sub)tropical low clouds improved in the model, they are still vastly underestimated, especially stratocumulus.
- Dual-Mass is most comparable with CALIPSO satellite retrievals.

Cloud-Reflectivity Histogram

Different cloud regimes have different signals.





Reflectivities Dominated by:

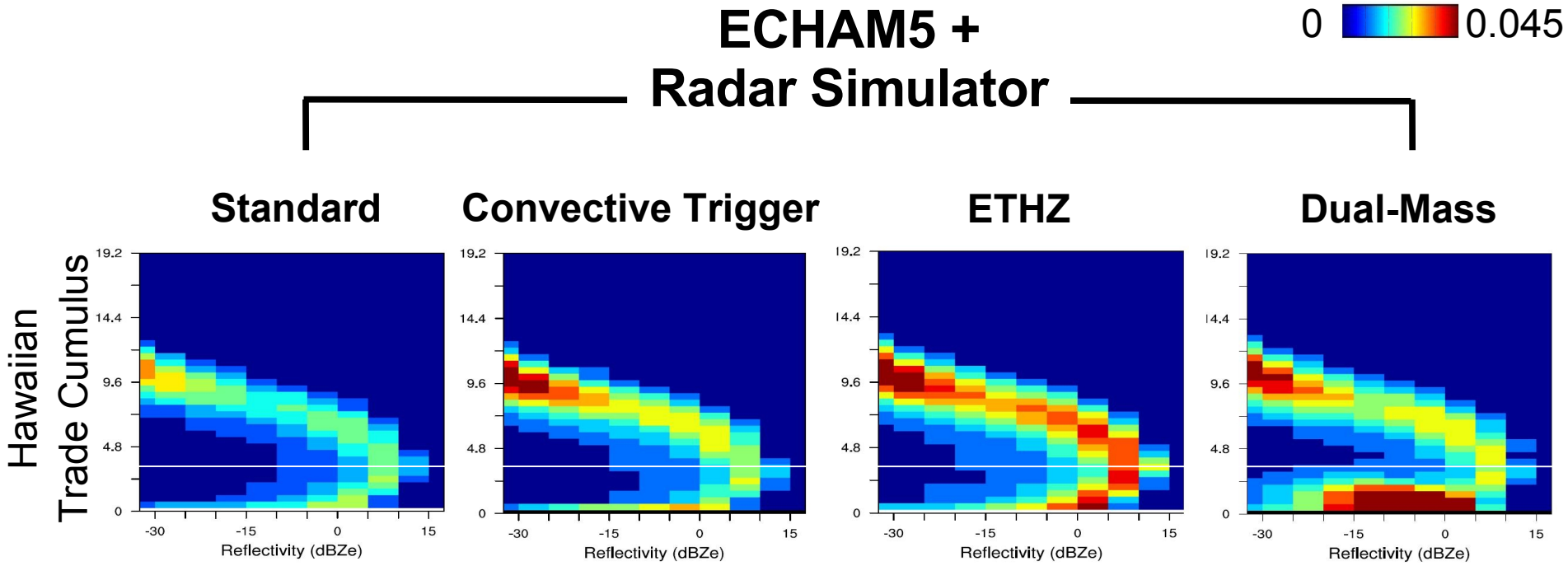
2 = Drizzle and Rain

1 = Non-drizzling Boundary Layer clouds

Hawaiian Trade Cumulus

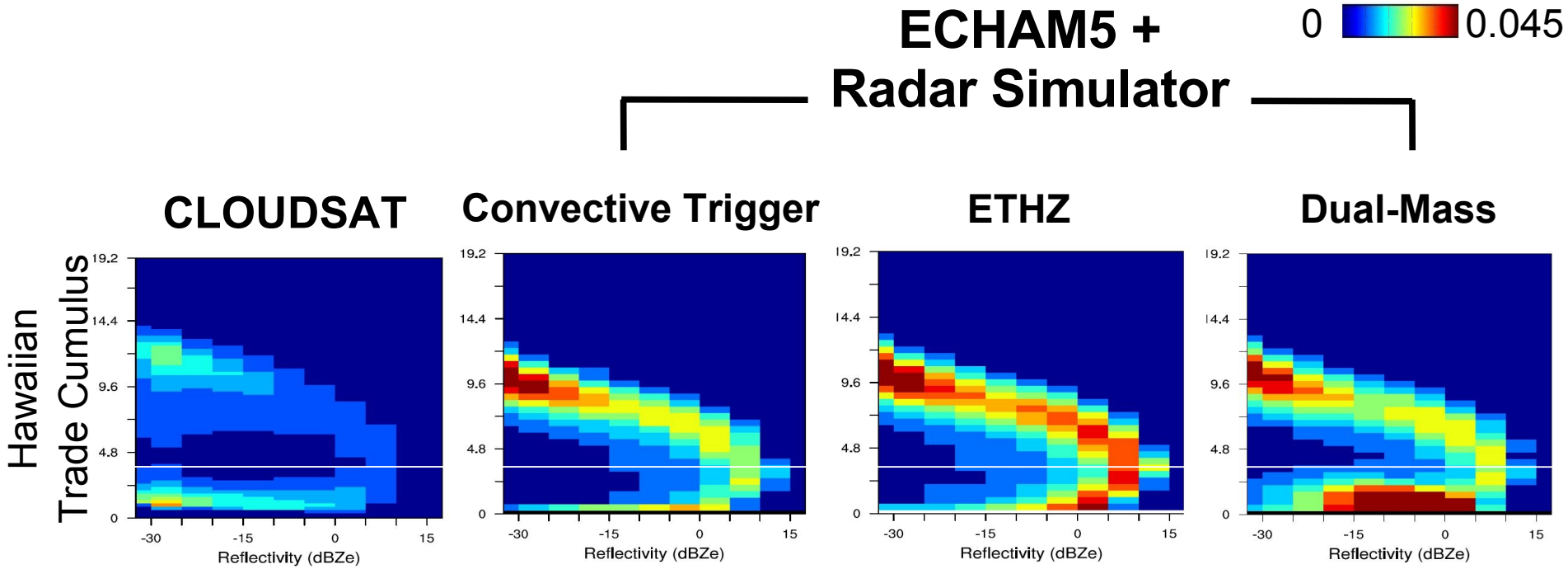
15-35N; 140W-160E

Cloud-Reflectivity Histogram



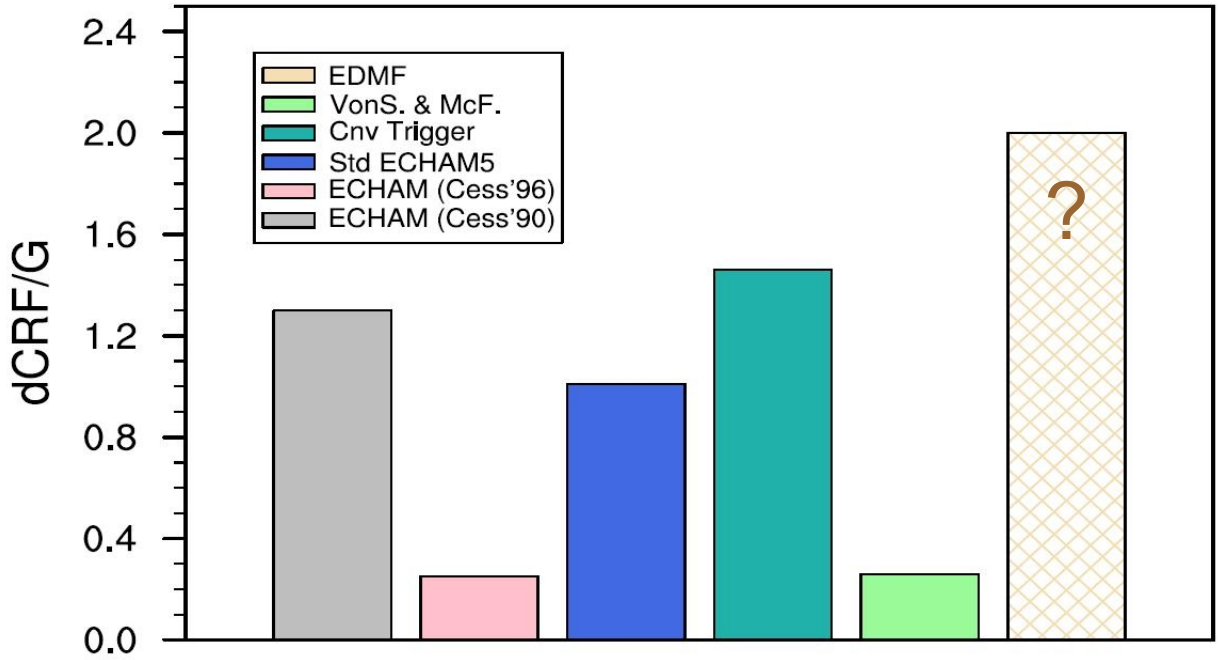
- Though C.Trig and ETHZ had similar cloud cover, histograms differ.
- Greatest changes occur in the precipitating regions of the histogram.

Cloud-Reflectivity Histogram



- Though C.Trig and ETHZ had similar cloud cover, histograms differ.
- Greatest changes occur in the precipitating regions of the histogram.
- ECHAM5 has a greater frequency of precipitating clouds. (Lower intensity).
- Differences amongst models < difference compared to observations.

Cloud - Climate - Feedbacks



- Idealized climate scenario following Cess et al., 1989.
- Perpetual July scenario, 6 month averaging time.
- Large spread amongst Cloud-Climate-Feedbacks, though all positive.
- Possibly related to initial amount of low cloud cover.

Summary

- Incorporated:
  - Three different low cloud parameterizations,
  - CALIPSO and CloudSat satellite simulators.
- Compared model results with active satellite observations which observe low clouds better.
- Lidar simulator shows:
  - New parameterizations improve (but not overcome) the problems in simulating large enough low cloud cover compared to CALIPSO.
- Radar simulator shows:
  - ECHAM5 has more reflective clouds than observations.
  - ECHAM5 has greater frequency of precipitation than observations.
- Both simulators show differences amongst schemes less than difference with observations.

Ongoing: Assess cloud climate feed-backs for the three low cloud parameterizations.