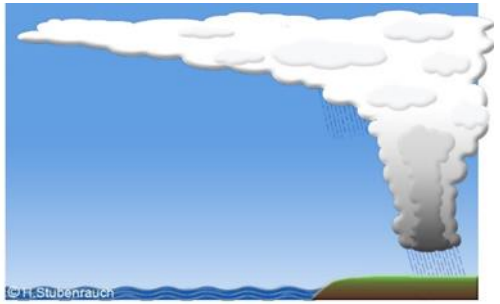
Some elements on radiative heating rates of UT clouds

critical to feedbacks : cirrus radiative heating in upper troposphere
Cirrus anvils may regulate convection as they stabilize the atmospheric column by their heating



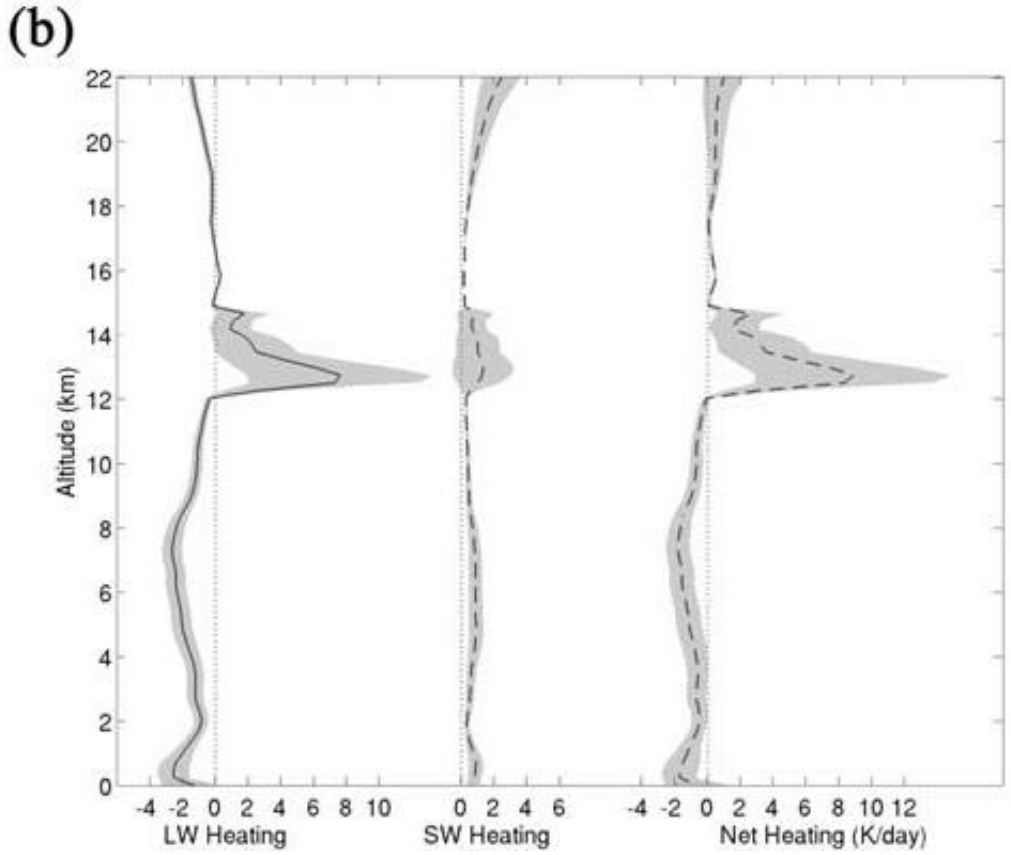
Challenges in estimating radiative heating rates:

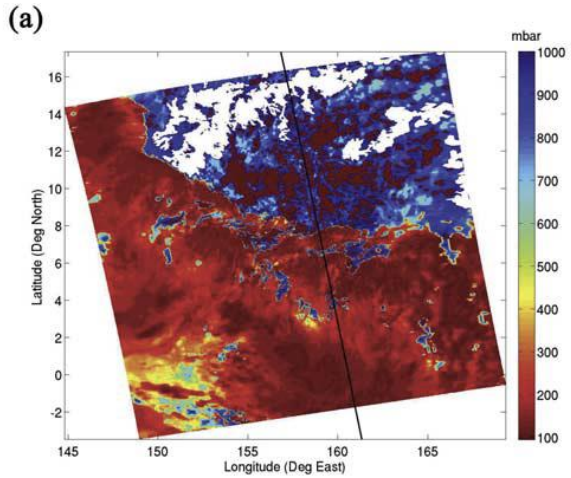
- radar-lidar sparse sampling
- ice crystal habit, size distribution -> SSP
- retrieval uncertainties in IWC / De profiles
- multiple cloud layering

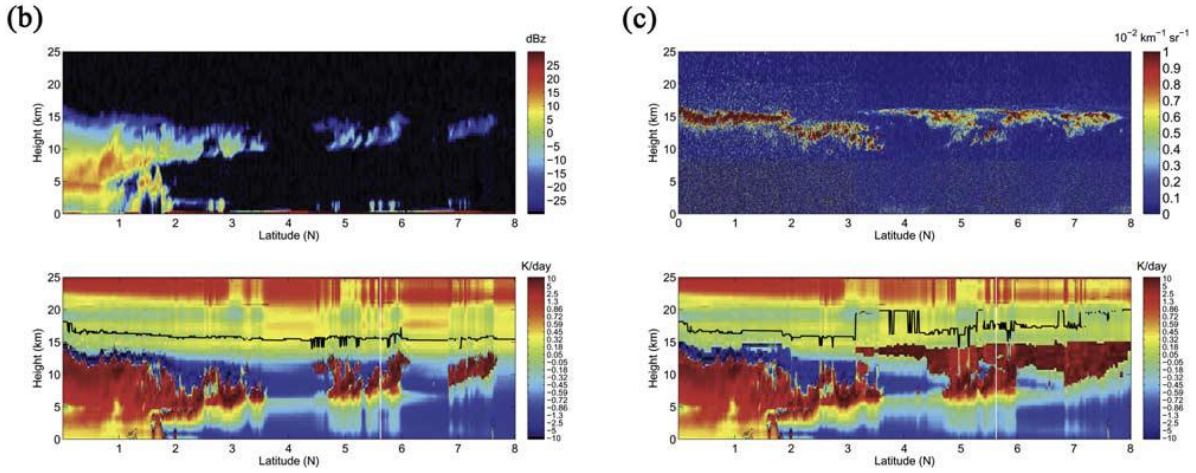
retrieval methods applied to CloudSat-CALIPSO data -> ***FLXHR v4 FLXHRv5 ; CCCM***

Radiative Heating in the TTL

Feldman, D. R., T. S. L'Ecuyer, K.N. Liou, and Y. L. Yung, J. Climate 2008
DOI: 10.1029/2008JD010158



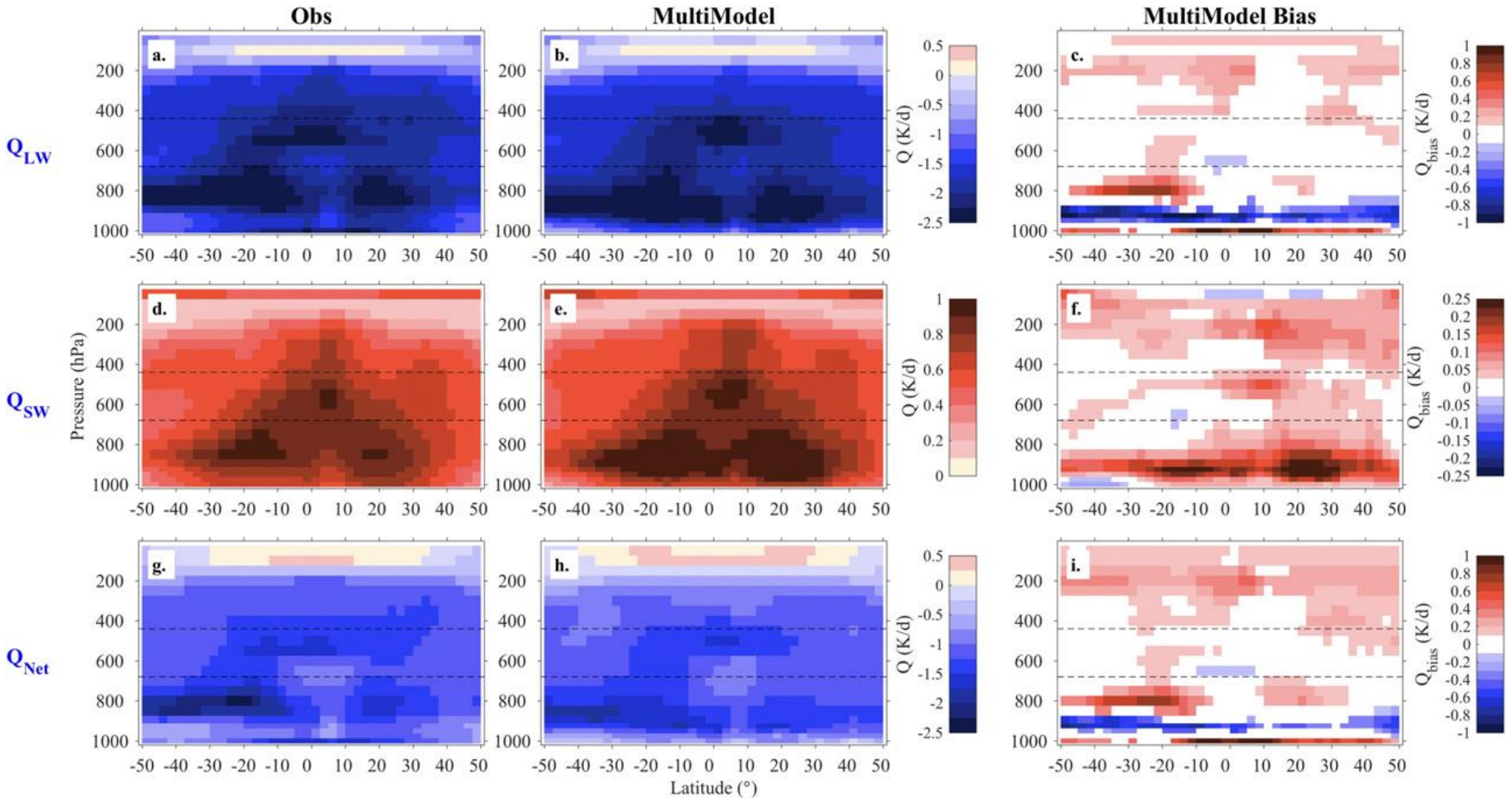




- Vertically-resolved heating rates were first generated ~40 years ago for ISCCP, but at only a few vertical layers
- In 2006, CloudSat and CALIPSO offered vertically-resolved measurements needed to estimate to full $Q_R(z)$ profiles
- These data are under-utilized but have been used to determine the level of zero heating in the tropical troposphere layer and to evaluate heating in models

Climate Model Evaluation

Cesana, G. et al, J. Climate 2019
DOI: 10.1175/JCLI-D-17-0136.1



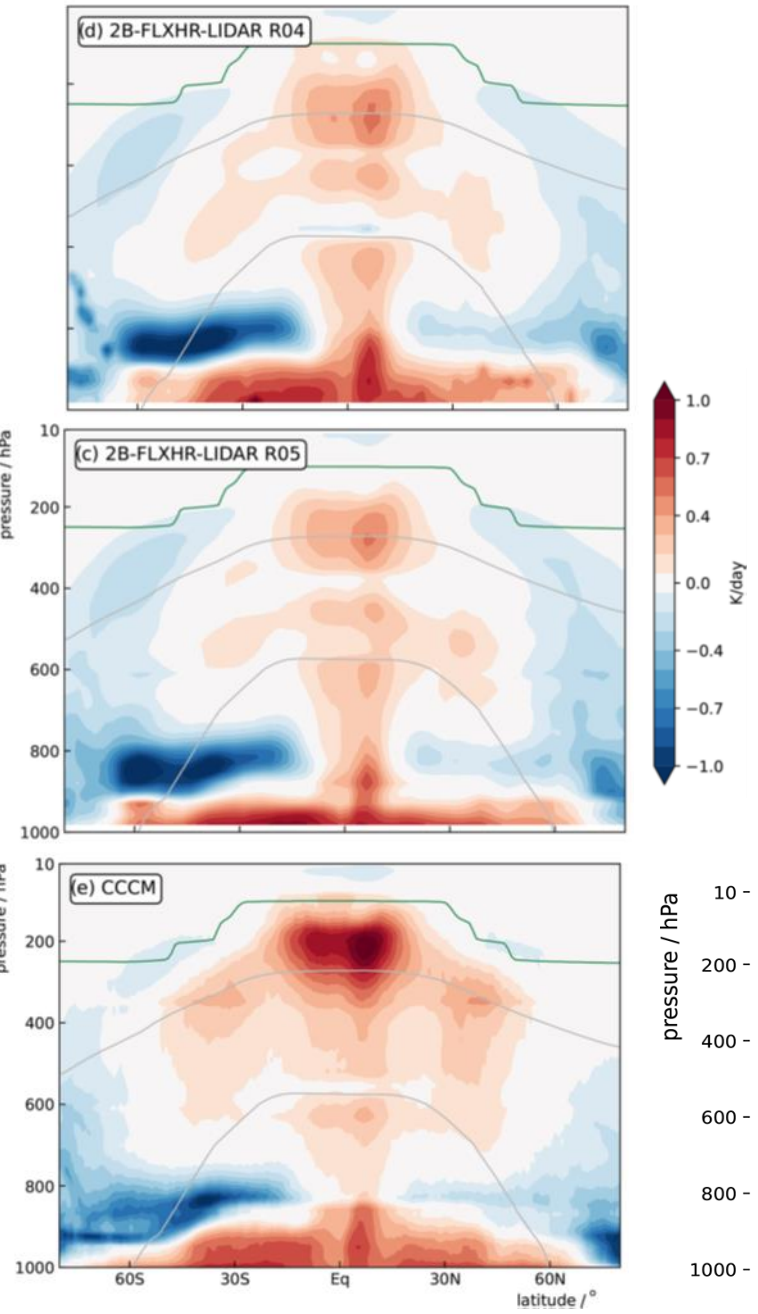
- The 5 GASS-YoTC models that provide vertically-resolved heating rate products collectively exhibit biases in low cloud cooling and high cloud heating relative to FLXHR

Uncertainties & biases in heating rates

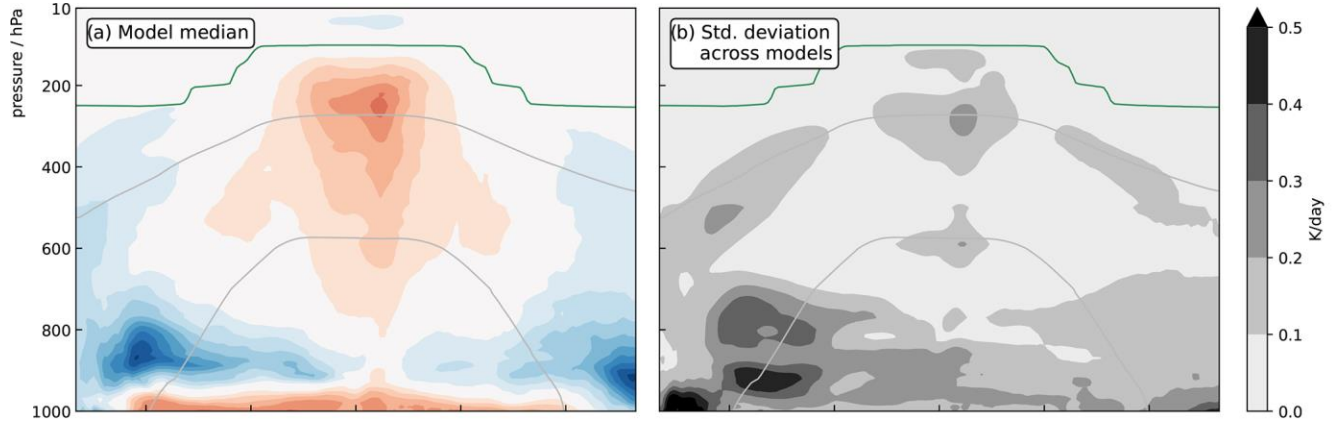
CloudSat-CALIPSO observations

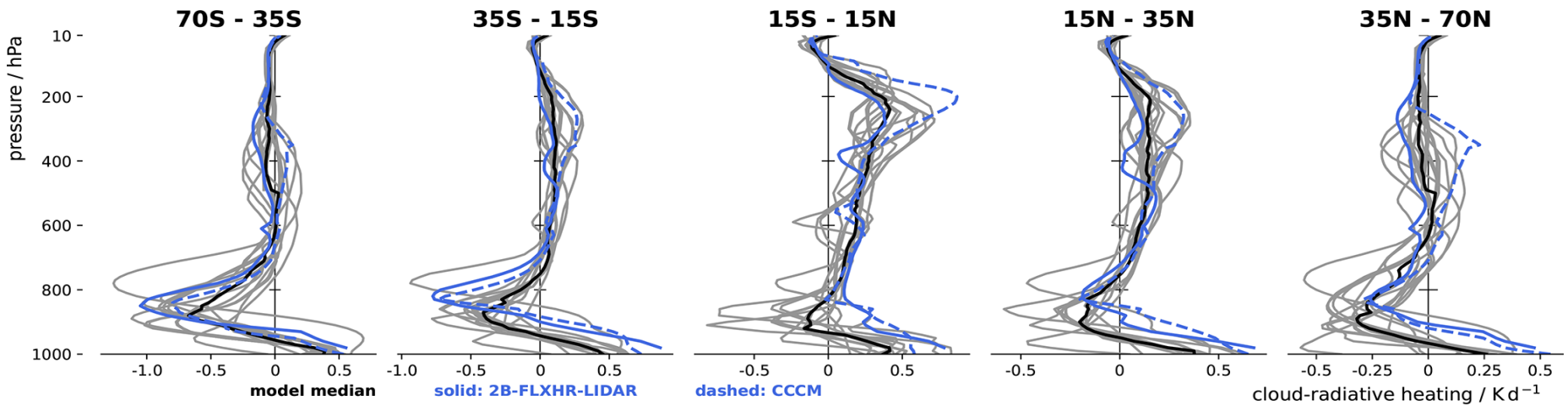
Aiko Voigt, Stefanie North, Blaž Gasparini, Seung-Hee Ham, 2024
DOI: 10.5194/acp-24-9749-2024

- larger difference between FLXHR & CCCM than between versions of FLXHR
- FLXHRv5 is even less close to CCCM than FLXHRv4 !
- tropical UT heating of CCCM is much stronger than the one of FLXHR



CMIP6 simulations





Differences in heating rate retrievals

Ham et al. JGR 2017

	CloudSat lidar FLXHRv4	CERES-CALIPSO-CloudSat-MODIS (CCCM)
hor. resolution:	1.5km x 2km	20km, merged cloud profiles
vert. resolution:	240m	30/60m
separate cloud layers:	> 960m	> 480m
Ice: D_e, IWC (uncertainties < 40/50%)	2B-CWC-RO products	2B-CWC-RO products
Cloud phase:	ice < 253K	ice < 253K; liquid > 273K, lin frct inbetween
Optical depth:	2B-TAU product	MODIS-CE (advanced retrieval, z from CALIPSO-CloudSat)
CALIPSO only clouds:	D_e=60μm, IWC=1.5mgm^{-3}	
Precipitating clouds:	2C-PRECIP-COLUMN	
Ancillary data:	ECMWF	GEOS-5.2
Aerosols:	CALIPSO-5km aerosol	Cloud Aerosol Determination score > 70
…		

differences in chosen resolution, ancillary data & assumptions lead to relatively large HR differences

Ham et al. JGR 2017

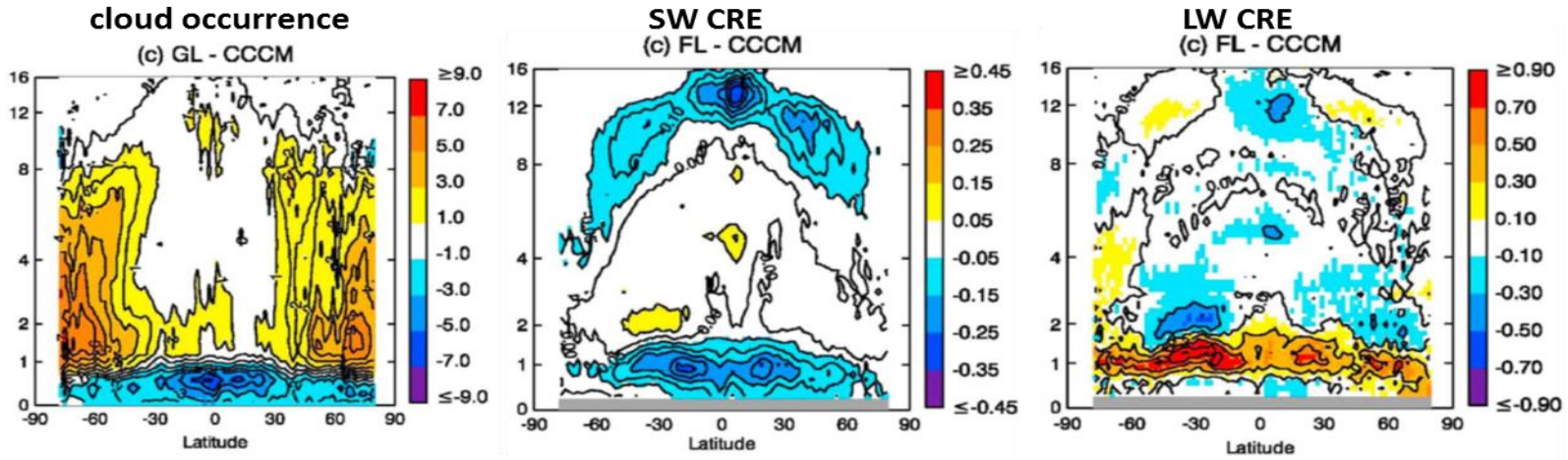
overestimation of cloud base heights for bases < 1km because of CloudSat surface clutter
CCCM uses finer vertical resolution & smaller threshold in CALIPSO Cloud-Aerosol distinction

-> CCCM occurrence of clouds below 1km larger than FLXHR-lidar
over tropical ocean & along west coasts of America, Africa

Comparison with CERES: *SW CREs of FLXHR-lidar not large enough*

CCCM LW TOA CREs larger than FLXHR-lidar in West Pacific & ITCZ
because cloud extinction at 13-18km larger
(CALIPSO extinction normalized by MODIS COD & spherical sizes converted to equivalent non-spherical
-> larger absorption)

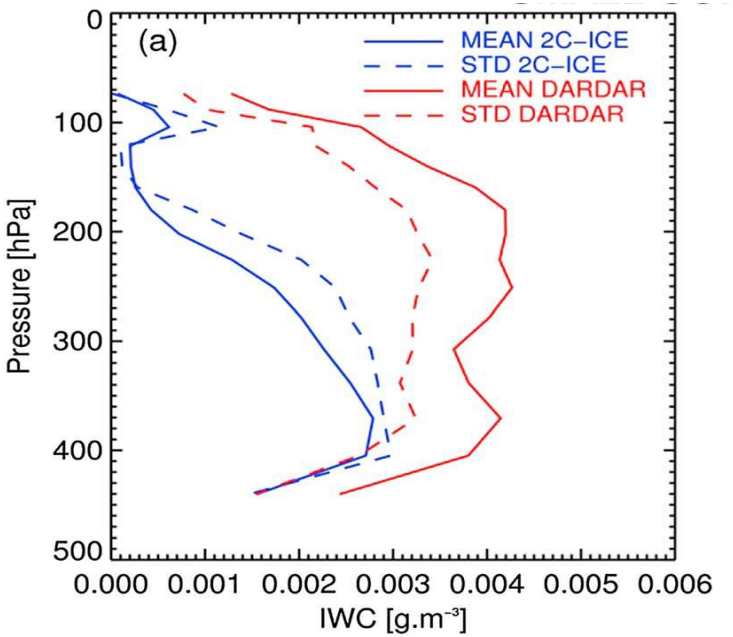
Comparison with CERES: *CCCM might be overestimated*



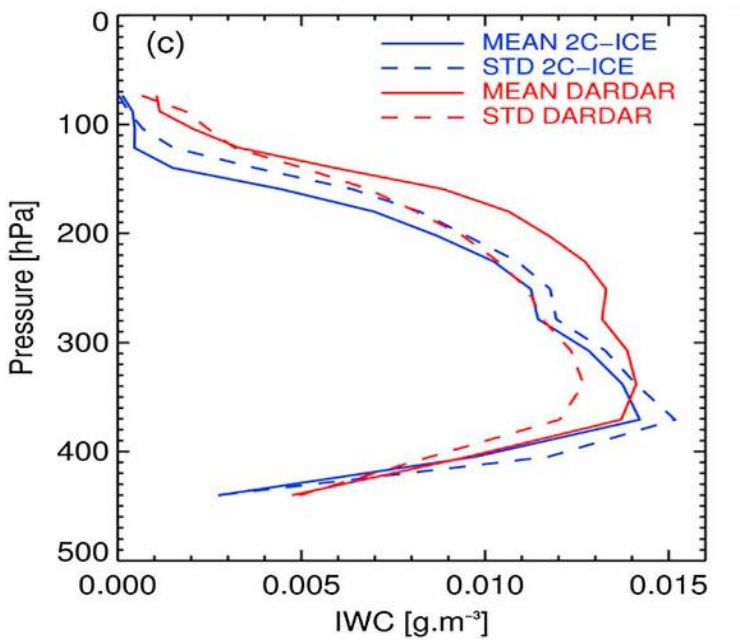
Uncertainty in IWC profile retrieval

Vidot et al. JGR 2015

small COD: 0.03-0.5



large COD: 0.5-4



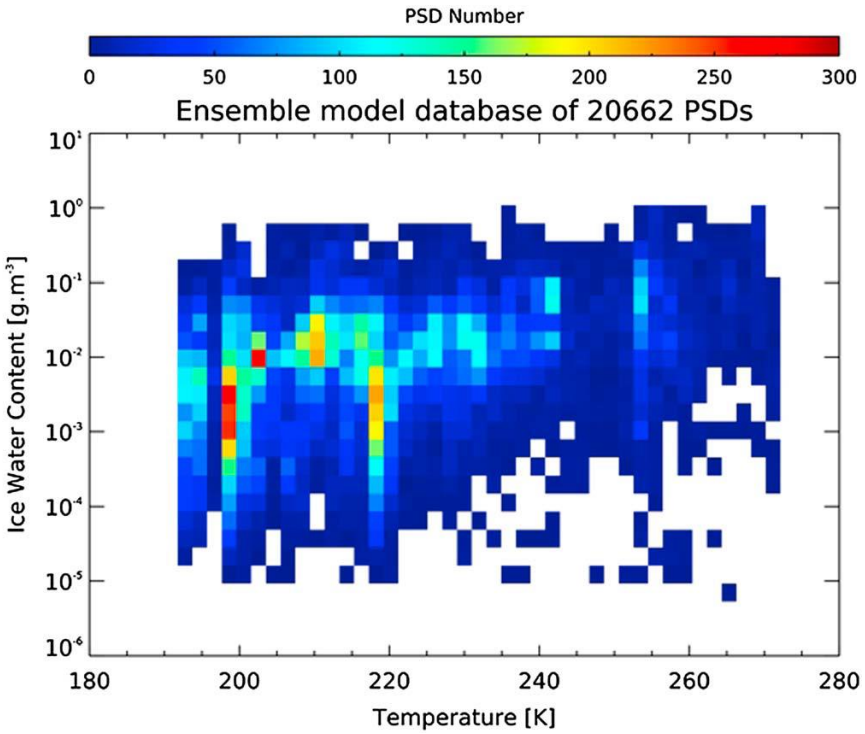
DARDAR retrieval provides larger values than 2C-ICE retrieval,

esp. for small COD *(up to a factor of 4)*

De <-> ice crystal size distribution

cloud physics – radiation parameterization

Baran et al. JGR 2014, 2016



describe single scattering properties (β_{ext}, β_{sca}, g) as function of IWC / T

using parameterized in situ size distributions

ensemble model size distribution has 6 habits as fct of size

integrated in Met Office Unified Model, ECRAD

Discussion points

Two different retrieval approaches on CloudSat-CALIPSO data lead to two datasets of radiative heating rates (FLXHR - CCCM)

Should one use a mean & the difference as uncertainty ?

Would it be worthwhile to assess all input parameters (IWC, microphysical properties….) ?

Should it be part of a new flux assessment ?

Who will lead such an assessment ?