Some elements

on computing radiative heating effects of high-altitude cloud systems

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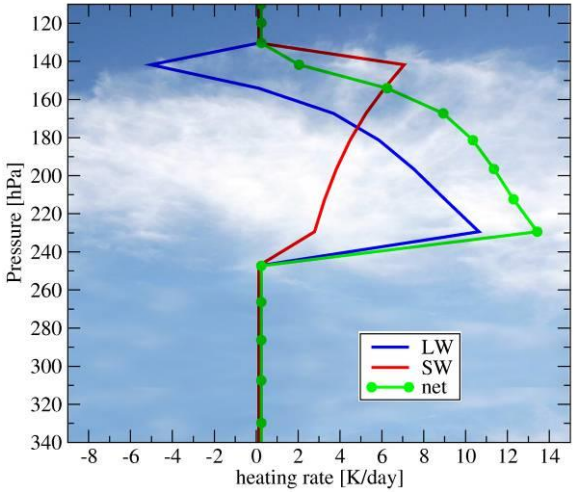
Motivation

Critical to feedbacks : cirrus radiative heating in upper troposphere

➢ Cirrus anvils might regulate convection as they stabilize the atmospheric column by their heating *(Stephens et al. 2008, Lebsock et al. 2010)*



Heating will be affected by:

- areal coverage
- emissivity distribution
- vertical structure of cirrus anvils
  (microphysics & multiple layering)

Goal: gain a better understanding of relation between
convection and heating induced by cirrus anvils

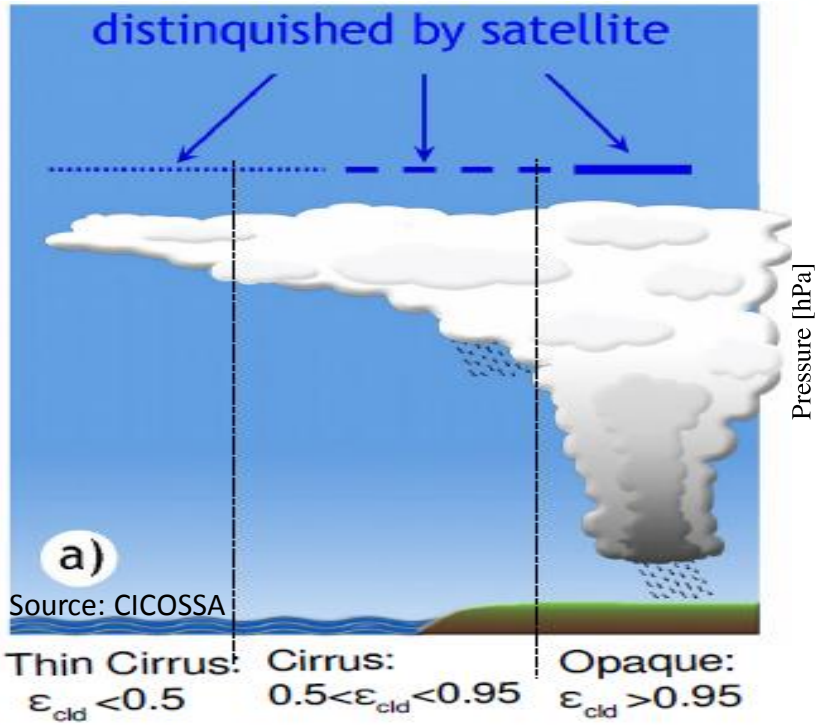
-> determine radiative fluxes & heating rates using RRTM
by categorizing atmospheric situation wrt T & H_2O profiles
by categorizing cloud types wrt cloud emissivity & vertical structure

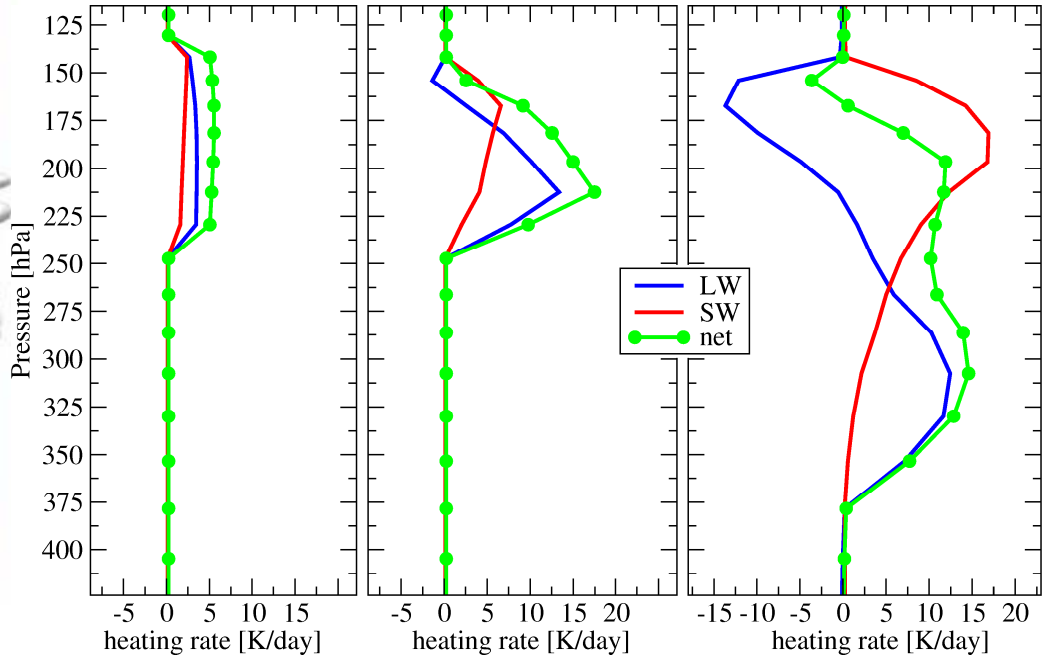
Challenges

- microphysical properties:
  ice crystal habit, size distribution, eff. size De & its profile
- IWP, vertical profile of IWC
- multiple cloud layering
- retrieval uncertainties in IWC / De profiles

-> build parameterizations of vertical profiles of De / IWC / multiple layering as function of ε_{cld}, distance to convective core ...

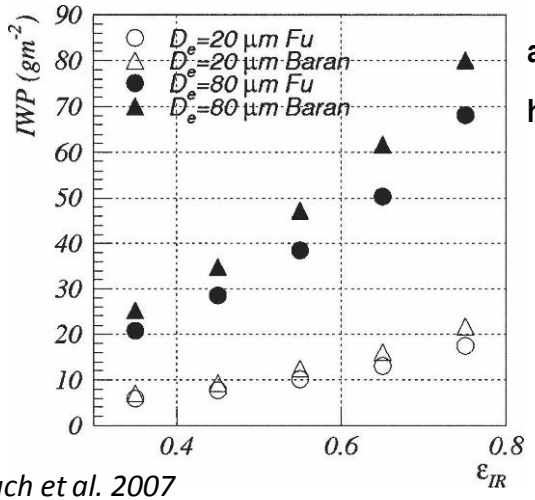
heating rates of anvil parts





same ε_{cld} reached by small or large(IWP,De)

IWP= 10, 30, 300 gm^{-2}
De = 30, 50, 80 µm
box, trapezia, increas. IWC profile



aggregates

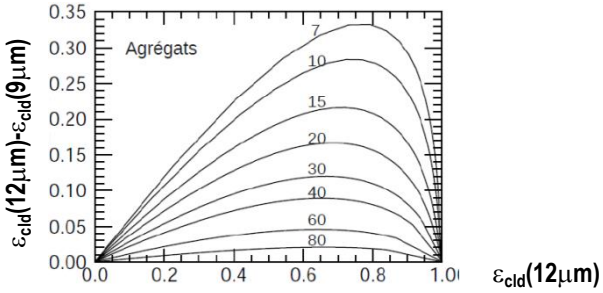
hex. columns

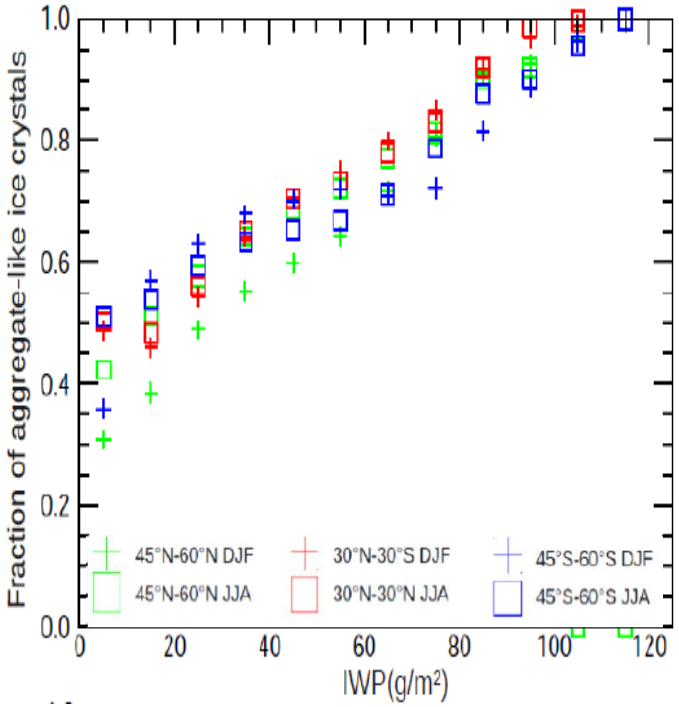
Stubenrauch et al. 2007

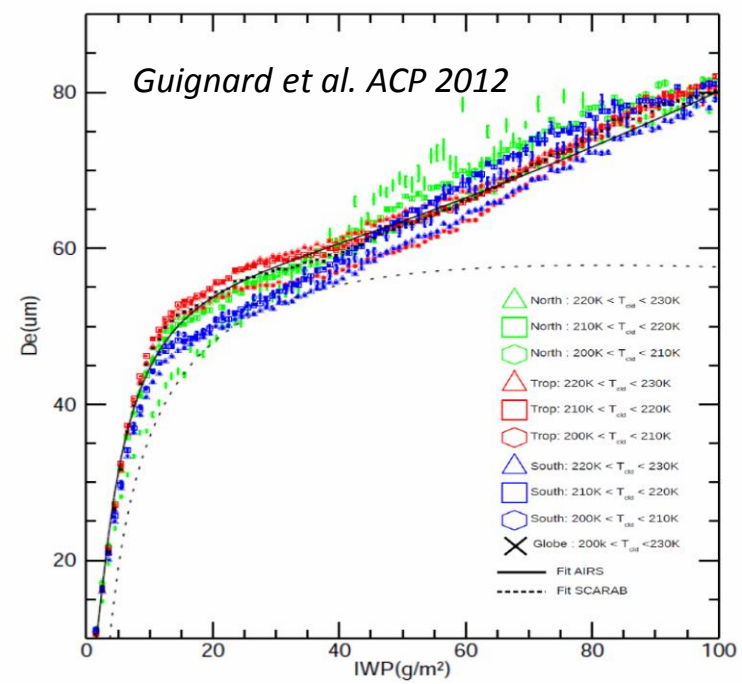
=> need information
on De or IWC / De profiles

relationship between ice crystals & IWP

AIRS observations: ε_{cld} slope (8-12μm) -> De; IWP = f(ε_{cld}, De)



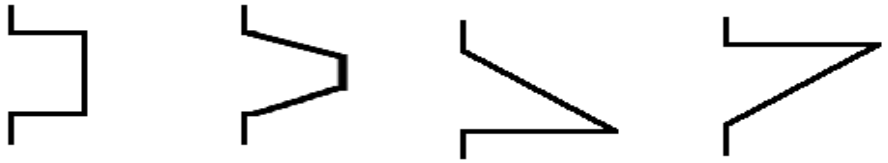




Fraction of aggregate-like ice crystals & De increase with IWP

IWC profile dependency on IWP

Clouds with same IWP may have different IWC & De profiles
-> influence on radiation? Shape probablility parameterization wrt IWP



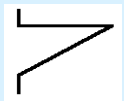
AIRS-GEOPROF-liDARraDAR data

(Delanoë & Hogan 2010)

RFO	IWP(g/m²)	const	trapecia	increas	decreas
18	0-10	**42%**	**32%**	**12%**	**14%**
21	10-30	**28%**	**51%**	**14%**	**7%**
23	30-100	**25%**	**55%**	**16%**	**3%**
17	100-300	**18%**	**59%**	**21%**	**2%**
12	300-1000	**13%**	**53%**	**33%**	**1%**

const & trapecia ≈ 80% of all profiles

increases with IWP from 10 to 26%



only for IWP < 30 g/m²

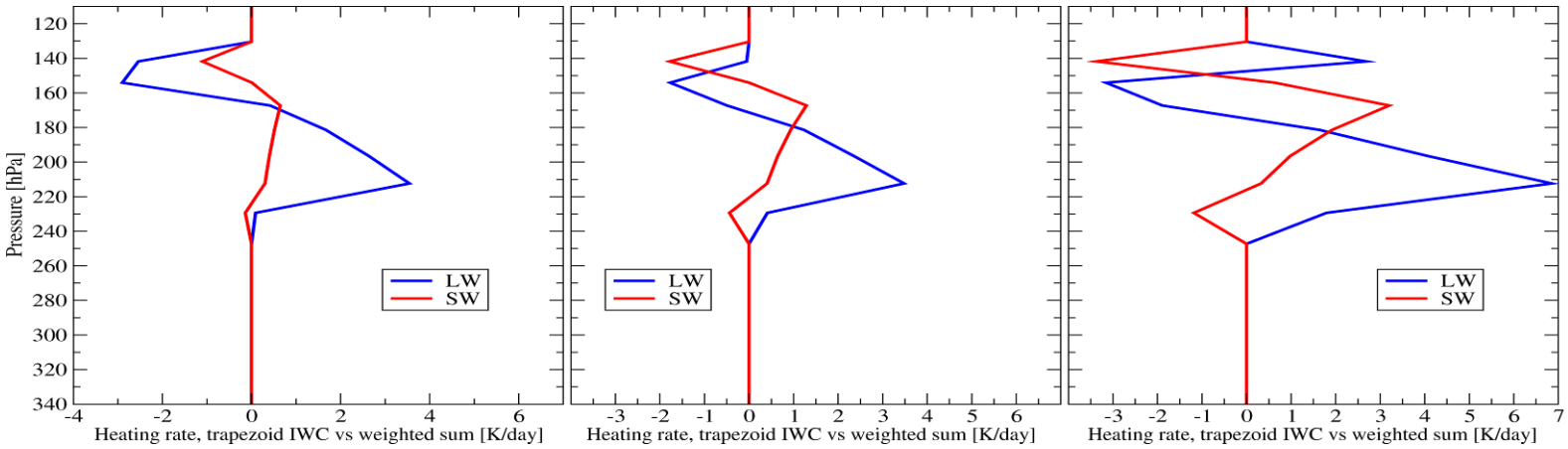
independent of location / season !

strong vertical winds only affect lower triangles

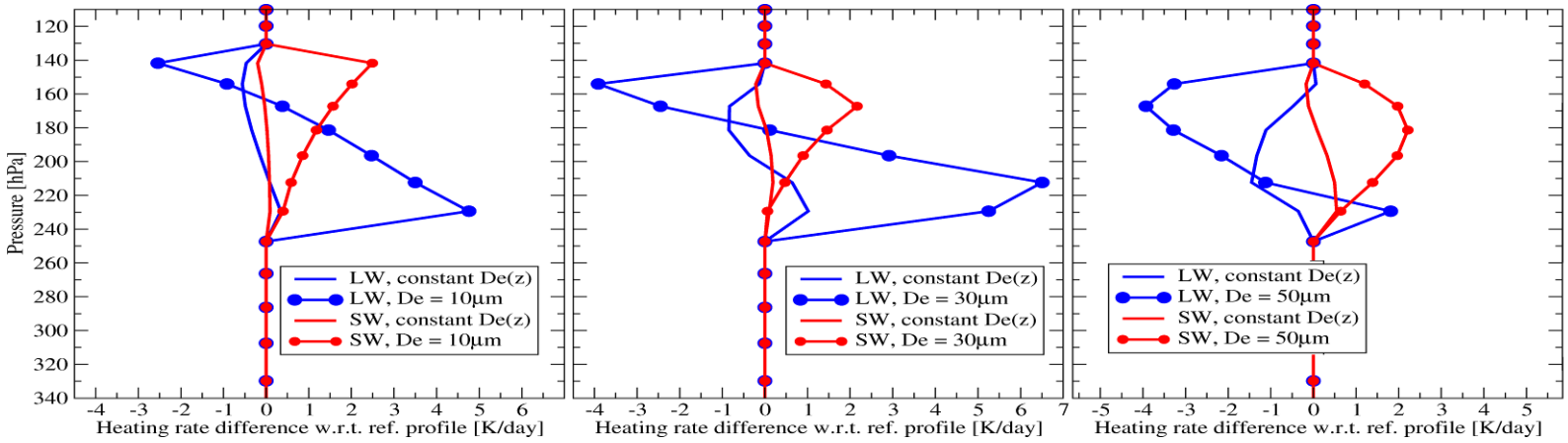
Feofilov et al., ACP 2015

heating rates of anvil parts: effect of microphys. profiles

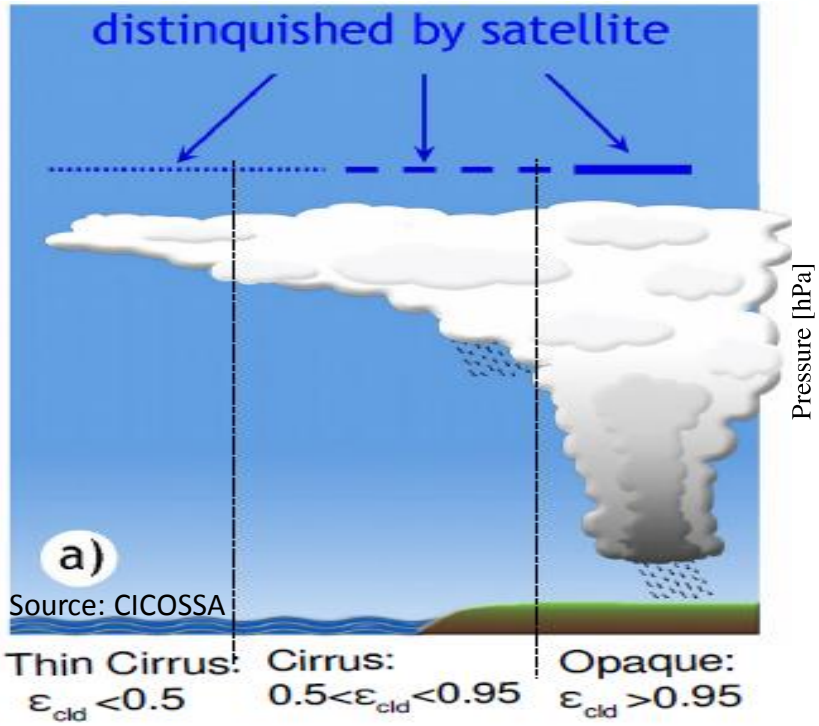
wrt to IWC profile shape

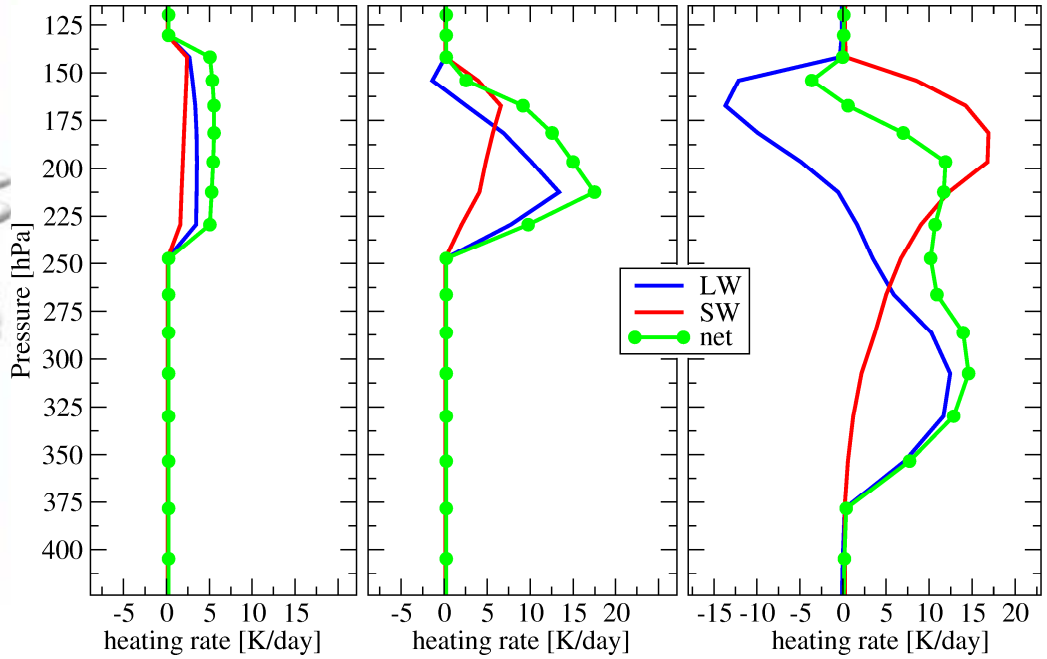


wrt to De profile shape & size



heating rates of anvil parts





IWP= 10,	30,	300 gm^{-2}
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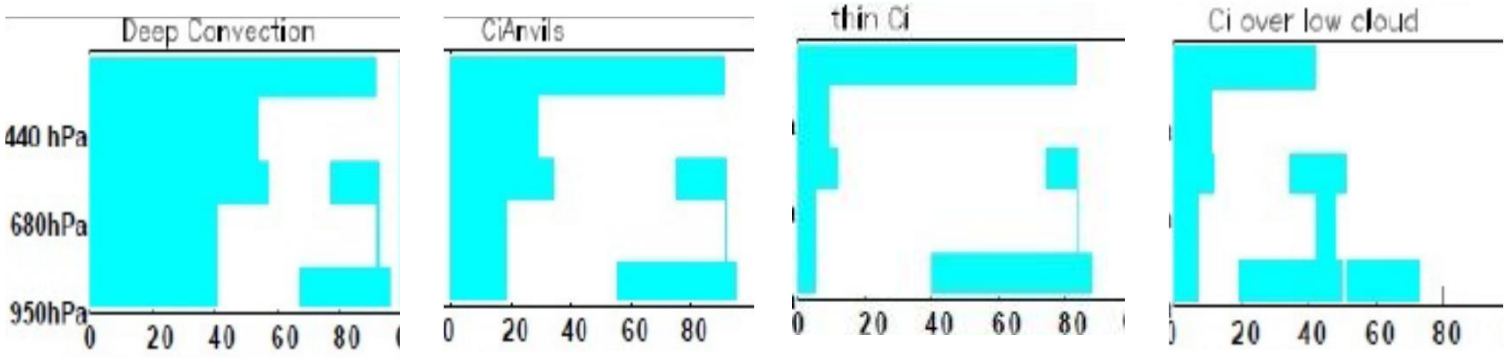
box,	trapezia,	increas. IWC profile

Stubenrauch et al. 2007

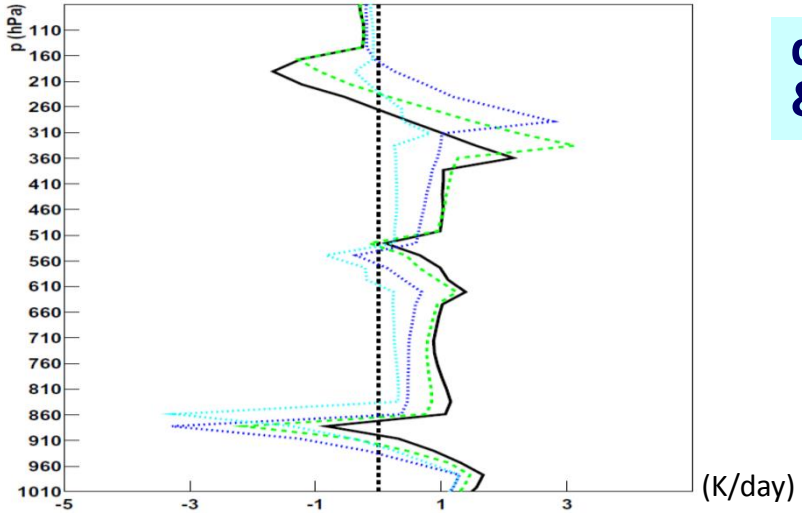
Heating rates of anvil parts: effect of layering

AIRS Weather States, build from (p_{cld} – ε_{cld}) histograms (*Nicolas 2014*)



vertical structure from coloc. GEOPROF data CALIPSO-CloudSat

WS – clear sky LW heating rate



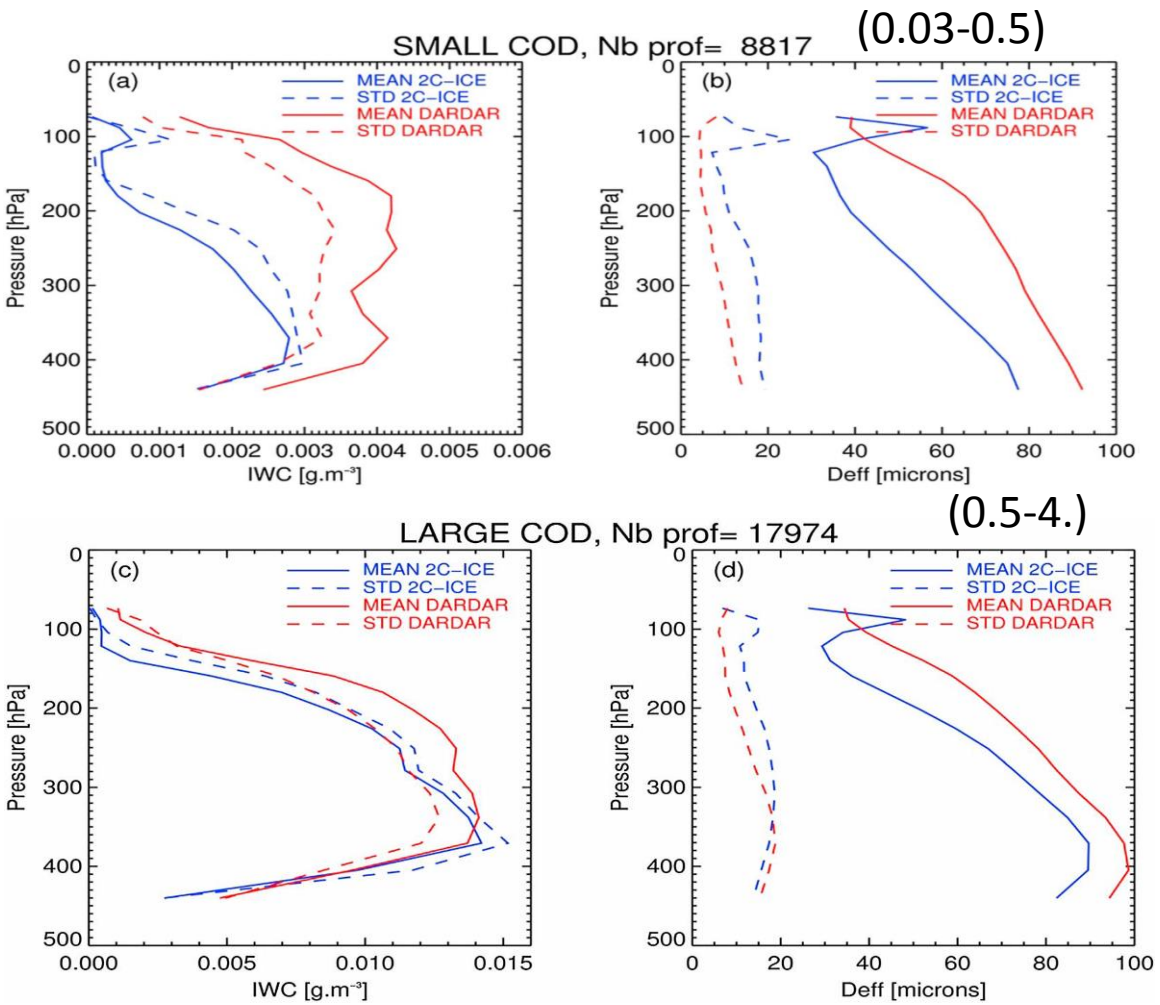
distinct vertical & horizontal structures & radiative effects

interesting for model evaluation (*Gehlot & Quaas 2012*)

observational radiative-convective feedback (*Lebsock et al. 2010*)

Uncertainty in IWC / De profile retrieval

Vidot et al. JGR 2015

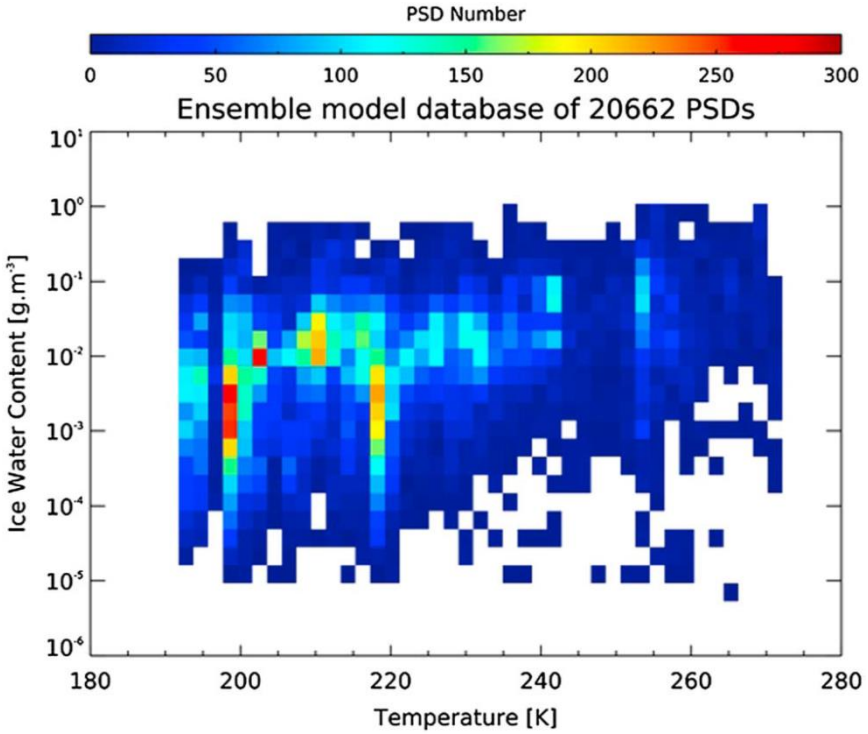


DARDAR retrieval gives larger values than & 2C-ICE retrieval, esp. for small COD

De <-> ice crystal size distribution

cloud physics – radiation parameterization

Baran et al. JGR 2014



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


Discussions
H.Stubenrauch

Synergies

synergetic data base:

A-Train (AIRS-CALIPSO-CloudSat-AMSR-E):

- **retrieval evaluation**
- **vertical structure of cloud types**
- **comparison of proxies for convective strength**

ISCCP – geostationary – TRMM – Megha-Tropiques - AIRS – IASI:
life cycle of cloud systems

ERA Interim : mesoscale winds, thermodynamics

atmosph./cloud properties & Lagrangian transport model
-> cirrus origin & evolution

atmosph./cloud properties & radiative transfer model
-> cirrus heating rates

vertical cloud layering, vertical IWC / De profiles

-> parameterizations as fct of COD / ε_{cld} / distance to convective core ….