# Cirrus, Contrails and Indirect Effects of Ice Nuclei Modelling and Validation

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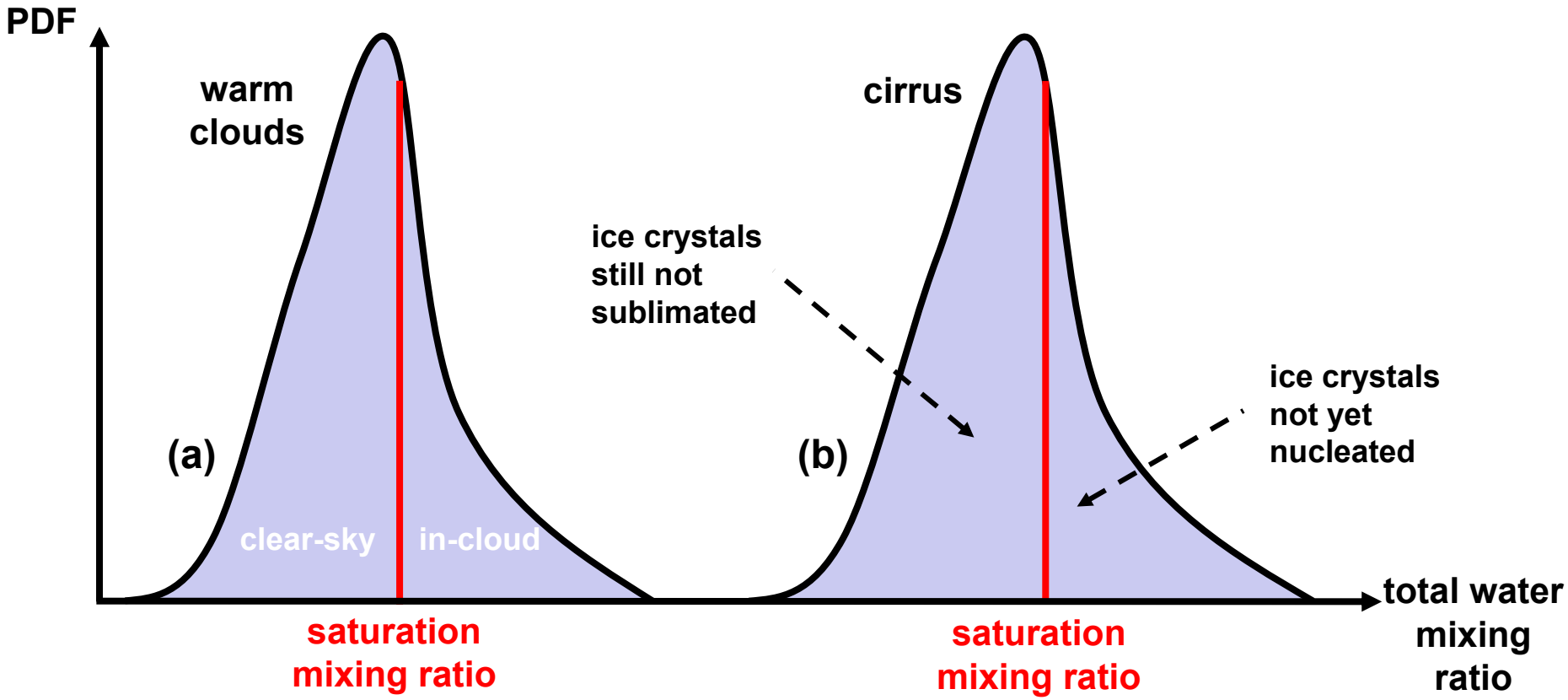
# Cirrus vs. warm clouds



# Ice supersaturation
## Validation with in situ and satellite estimates

frequency of tropospheric supersaturation

| | Midlatitudes | | | | Tropics | | | |
|---|---|---|---|---|---|---|---|---|
| | DJF | MAM | JJA | SON | DJF | MAM | JJA | SON |
| ECHAM4, 230 hPa | 0.19 | 0.21 | 0.18 | 0.19 | 0.13 | 0.14 | 0.11 | 0.14 |
| ECHAM4, 275 hPa | 0.18 | 0.18 | 0.17 | 0.17 | 0.11 | 0.12 | 0.10 | 0.12 |
| MOZAIC, 230 hPa | 0.27 | 0.19 | 0.18 | 0.24 | 0.13 | 0.10 | 0.10 | 0.10 |
| MOZAIC corrected | 0.26 | 0.18 | 0.17 | 0.23 | 0.10 | 0.08 | 0.08 | 0.08 |
| AIRS, 250–300 hPa | 0.22 | 0.31 | 0.22 | 0.17 | 0.02 | 0.02 | 0.02 | 0.02 |

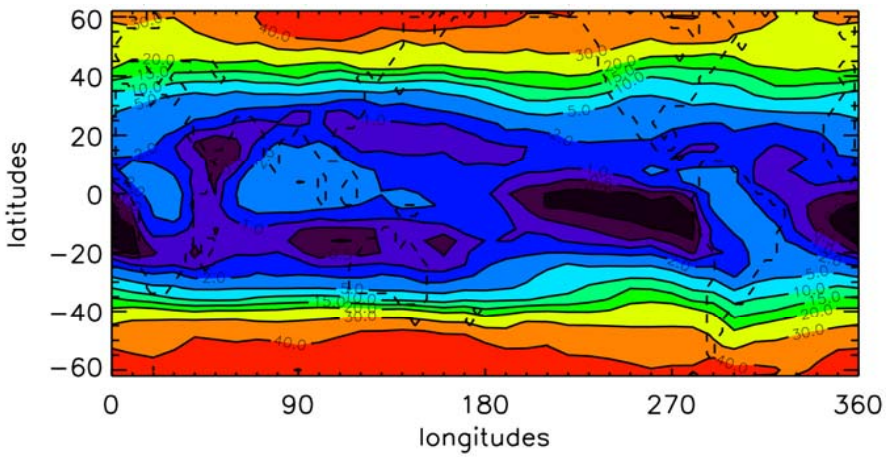
[a]Midlatitudes: 30N–60N/95W–35E and tropics: 30N–30S/80W–105E.

(MOZAIC — Measurements of ozone and water vapour by Airbus in-service aircraft)

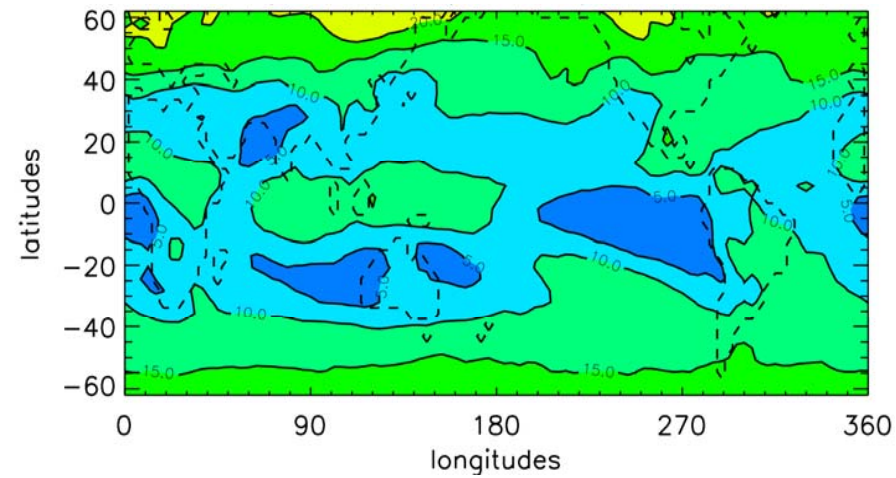
Burkhardt U. et al, 2008: Contrail cirrus supporting areas, GRL 35, 2008

# **Ice supersaturation**
# Validation of geographical patterns

AIRS supersaturation frequency (%)




ECHAM4 paramet. supersaturation

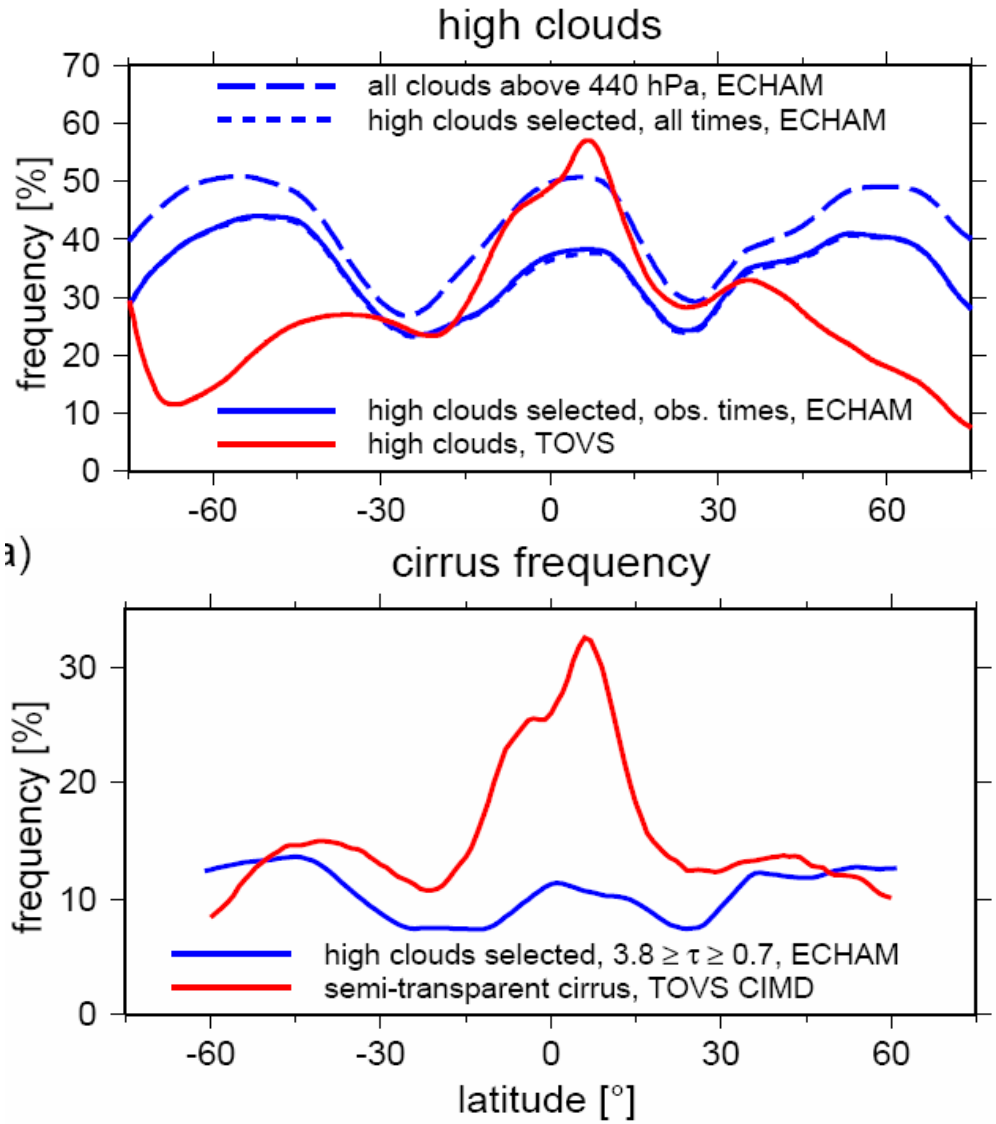



300 hPa

— vertical resolution

Burkhardt U. et al, 2008: Contrail cirrus supporting areas, GRL 35, 2008

# Cirrus coverage

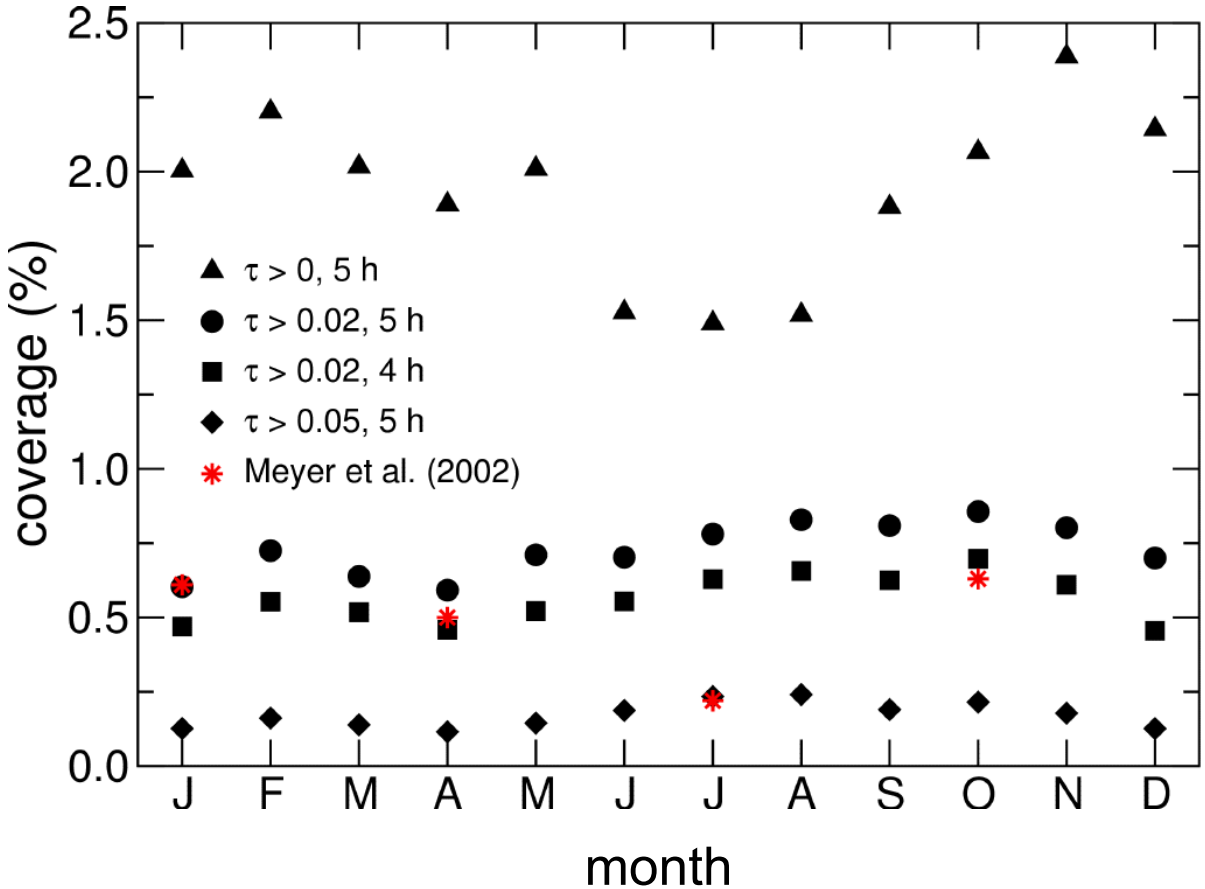



cirrus validation difficult since cirrus is only a subset of clouds above 440 hPa

comparing only semi-transparent clouds helps isolating problems in cirrus representation

Hendricks, J., C. Stubenrauch et al.: work in progress

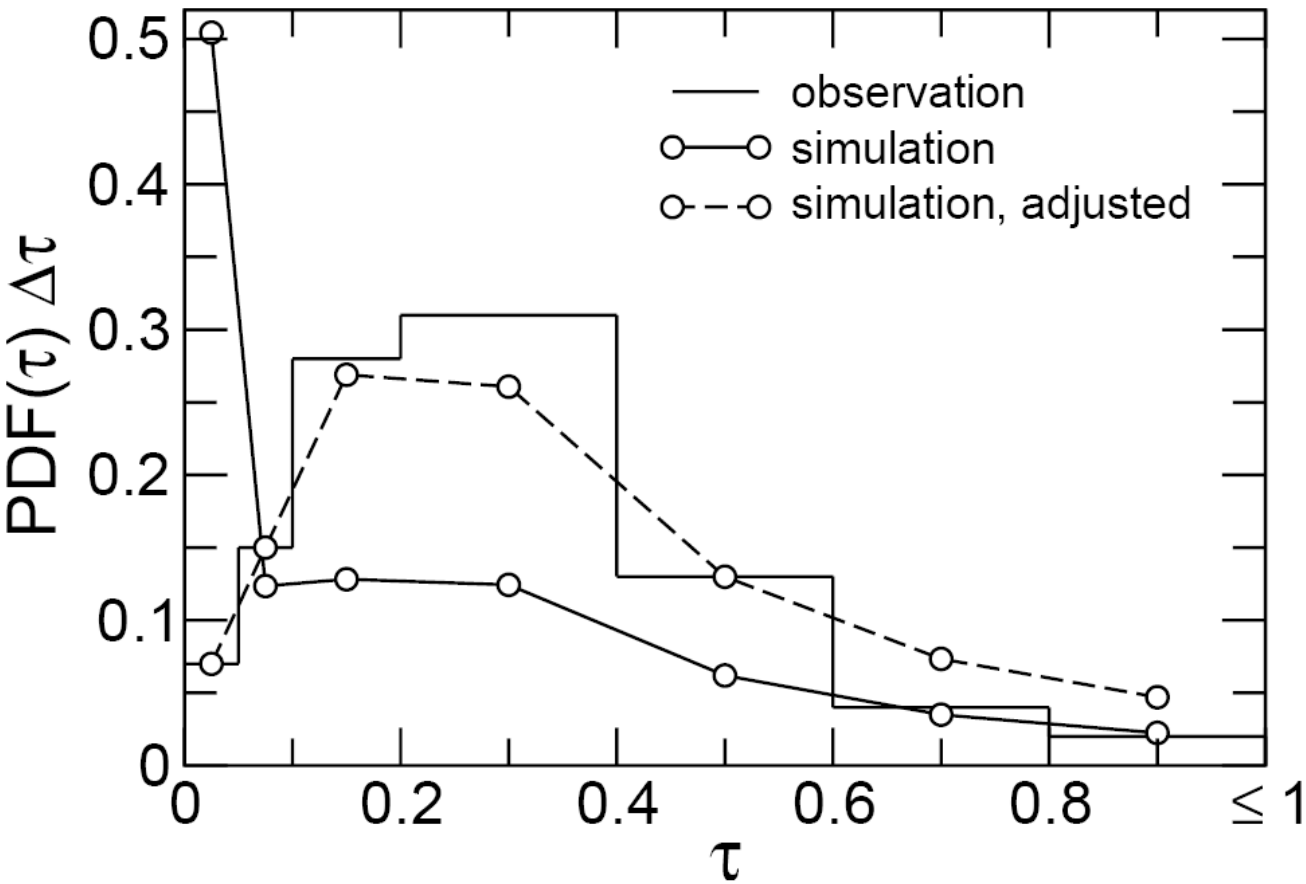
# Contrail coverage




for validational purposes detection efficiency as a function of optical depth needs to be known

Burkhardt U. and B. Kärcher submitted to JGR

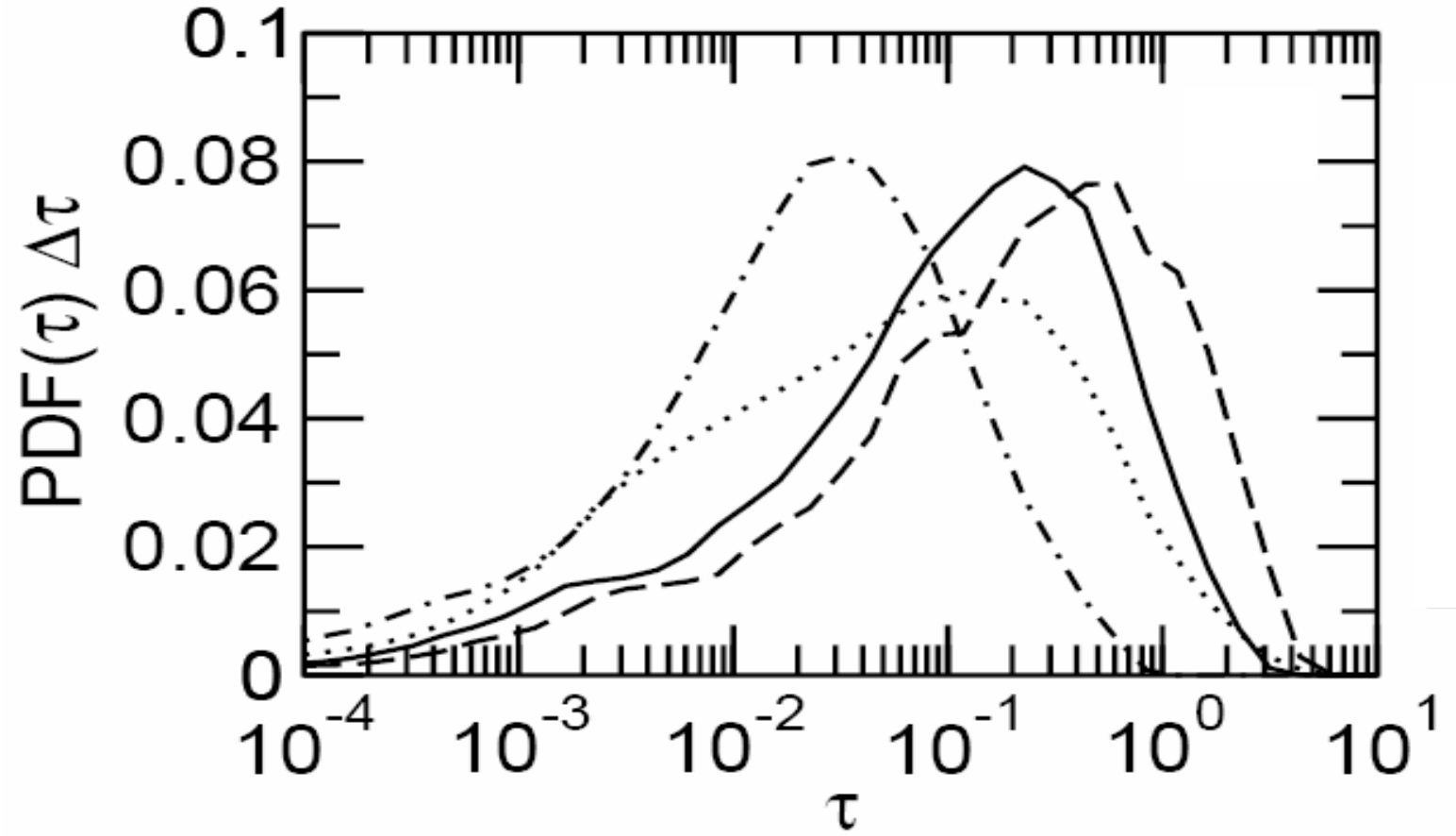
# Contrail cirrus optical depth



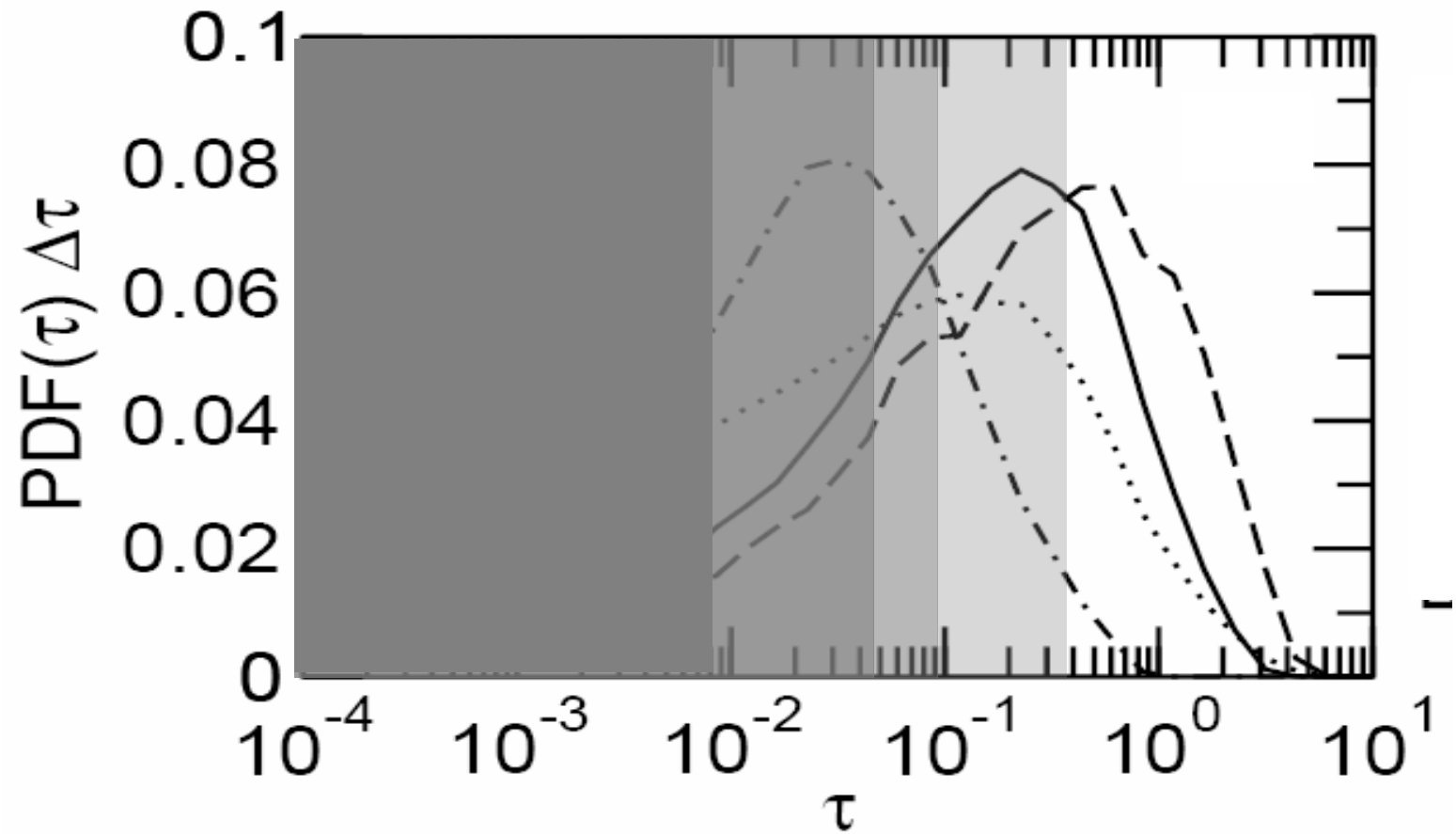

deriving a contrail detection efficiency

Kärcher, B. et al submitted to ACPD

# Contrail optical depth



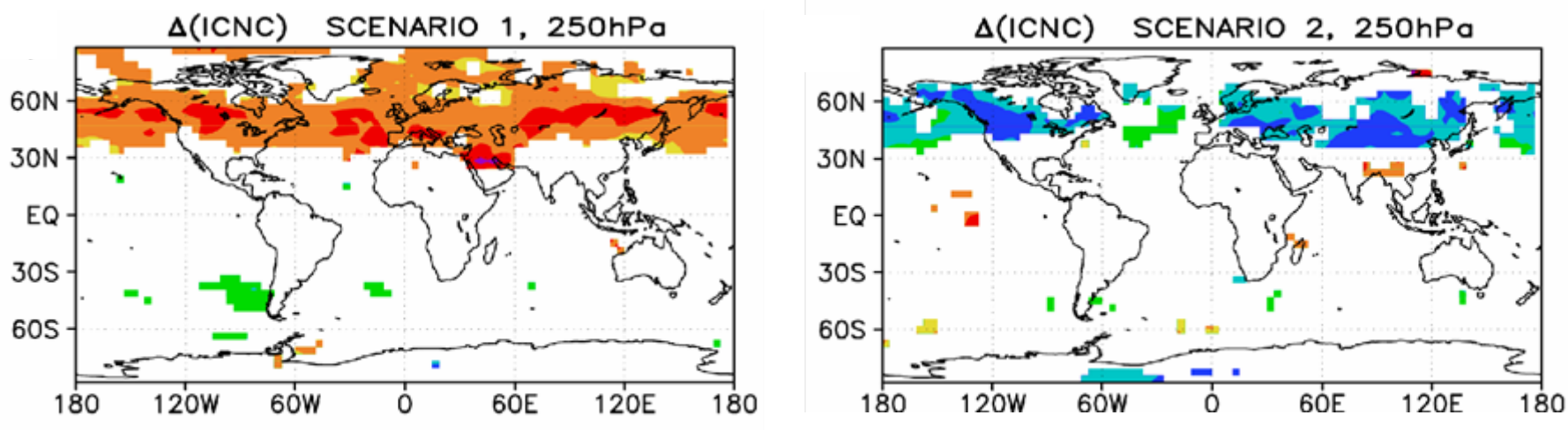
# Contrail optical depth




only about 50% of contrails are detected in satellite images
(passive remote sensing)

# Microphysics

Soot impact on cirrus particle concentrations




heterogeneous nucleation

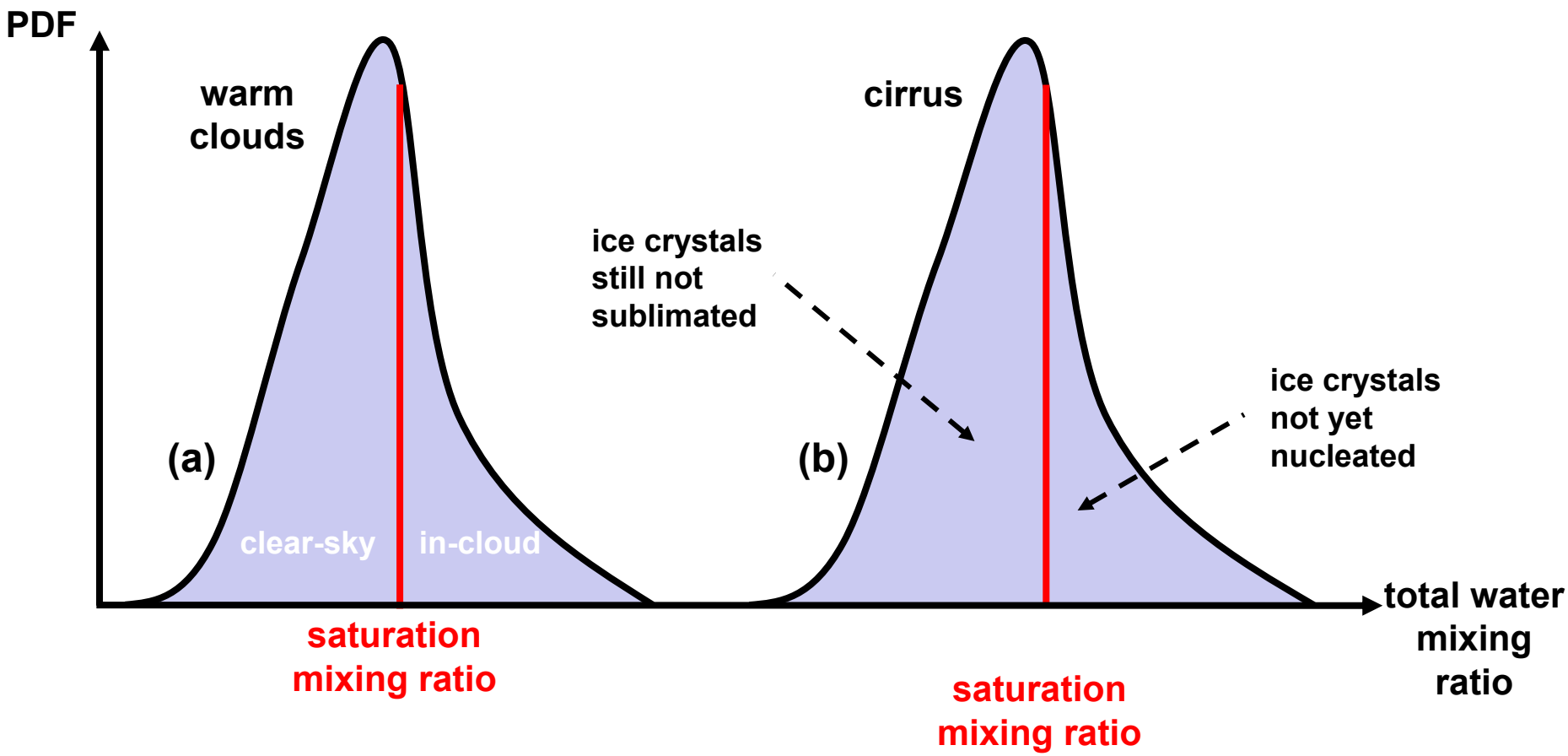
homogeneous nucleation

Hendricks J. et al. Do aircraft BC emissions affect cirrus clouds on the global scale? GRL, 32, 2005

in situ measurements give indication that heterogeneous nucleation can be important, particularly in areas of high aerosol loading

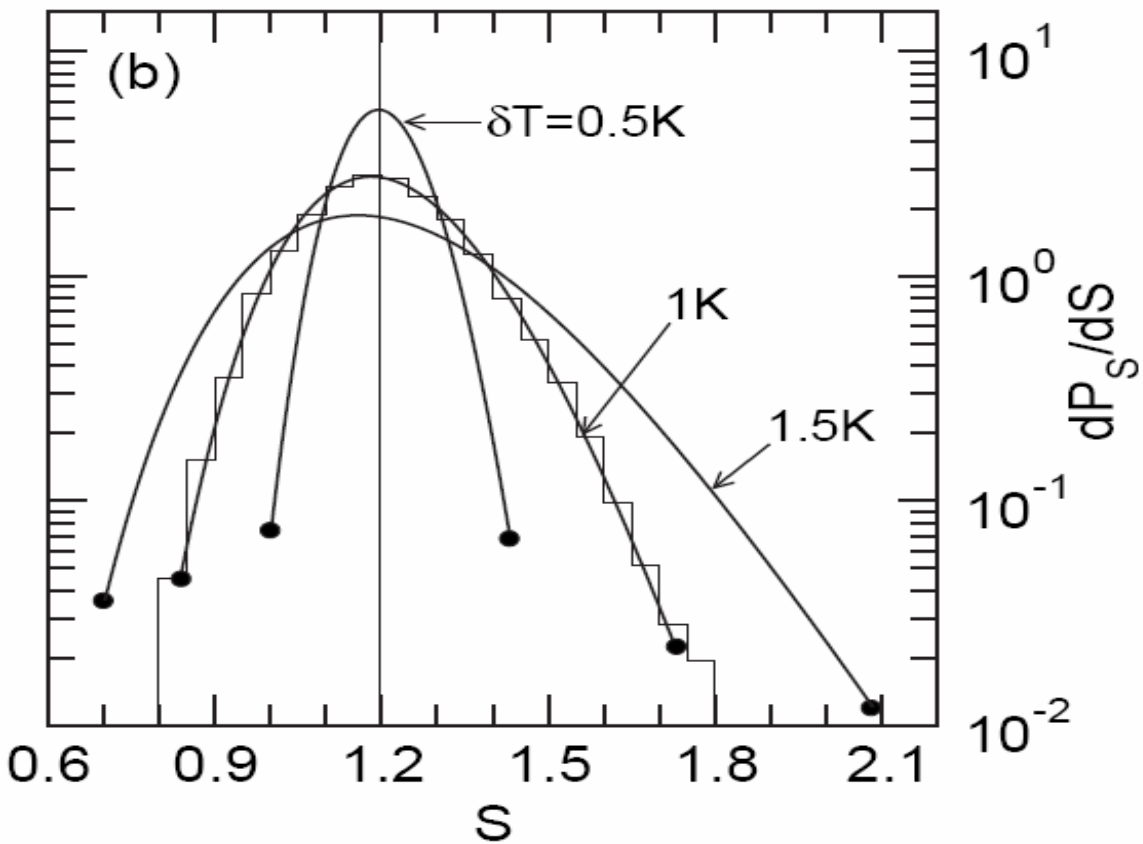
correlations between aerosol- and cirrus parameters may give indication about nucleation processes

# Cirrus vs. warm clouds



# Cirrus scheme

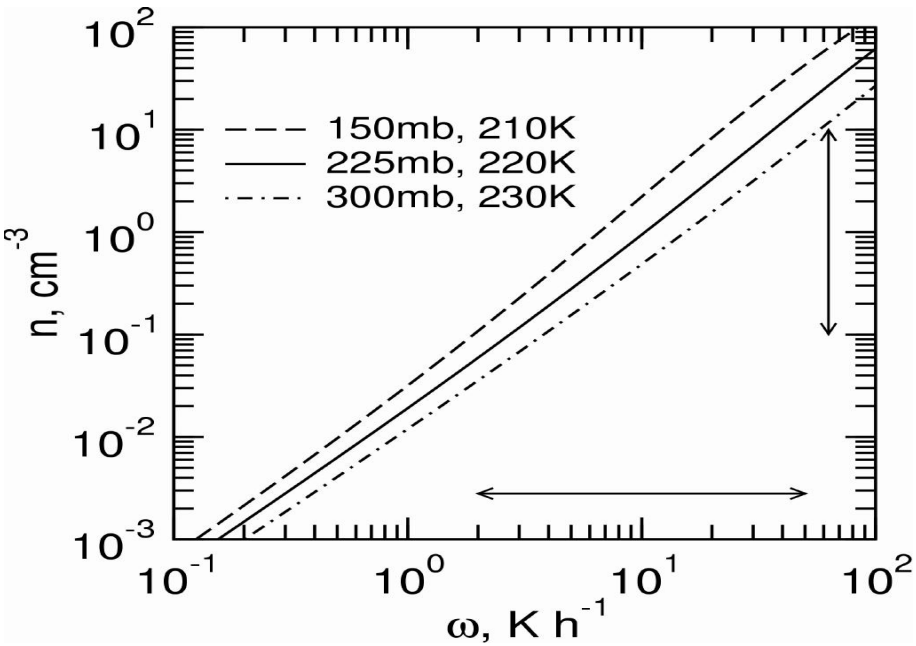
**Distribution of clear-sky ice saturation ratio S**



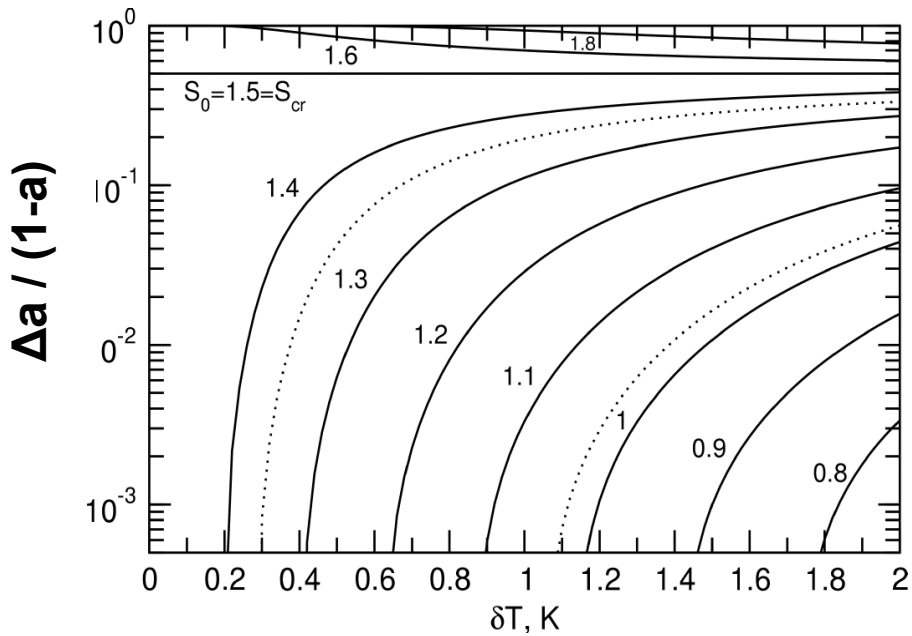

cirrus microphysics and coverage forced consistently by resolved variability and parameterized mesoscale temperature fluctuations

# Cirrus scheme

**Nucleated ice crystal concentration $n_i$**




**Increase in new cloud area $\Delta a$**




consistent treatment of ice nucleation, ice supersaturation and cloud fraction

# What do we need

- separation of cloud types
- characterization of cirrus/contrail cirrus
- reliable climatology of supersaturation
- combined aerosol/supersaturation/cirrus characterization

- specification of what has been observed
- vertical resolution