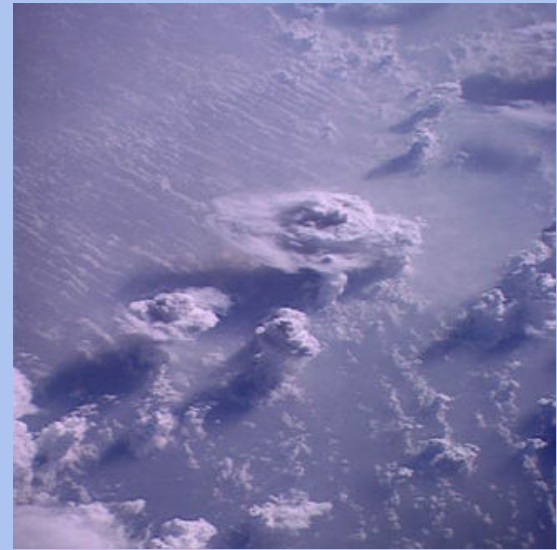
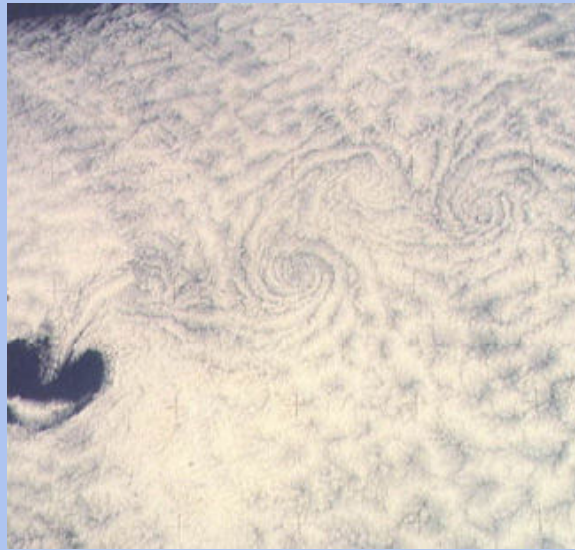


Interação entre Nuvens e Radiação



Importância das nuvens

- Nuvens cobrem ~ 60% da superfície da Terra
- Refletem, absorvem e transmitem a radiação solar
- Refletem, absorvem e emitem radiação terrestre

⇒ O efeito líquido resultante de sua interação com a radiação pode ser tanto de aquecimento quanto de resfriamento do sistema Terra-atmosfera!

Nuvens

Nas regiões espectrais do visível e infravermelho próximo do espectro:


- as gotas de nuvens são espalhadores não seletivos espectralmente
- a eficiência de espalhamento é alta
- água líquida não absorve radiação no visível, portanto, as nuvens apresentam mínima absorção nessa região do espectro.
- No NIR a absorção aumenta devido ao aumento dos coeficientes de absorção tanto do vapor quanto da água líquida
- Em média, sobre o espectro solar, as nuvens espalham 74%, absorvem 10%, e transmitem 16% da radiação incidente.

Nuvens

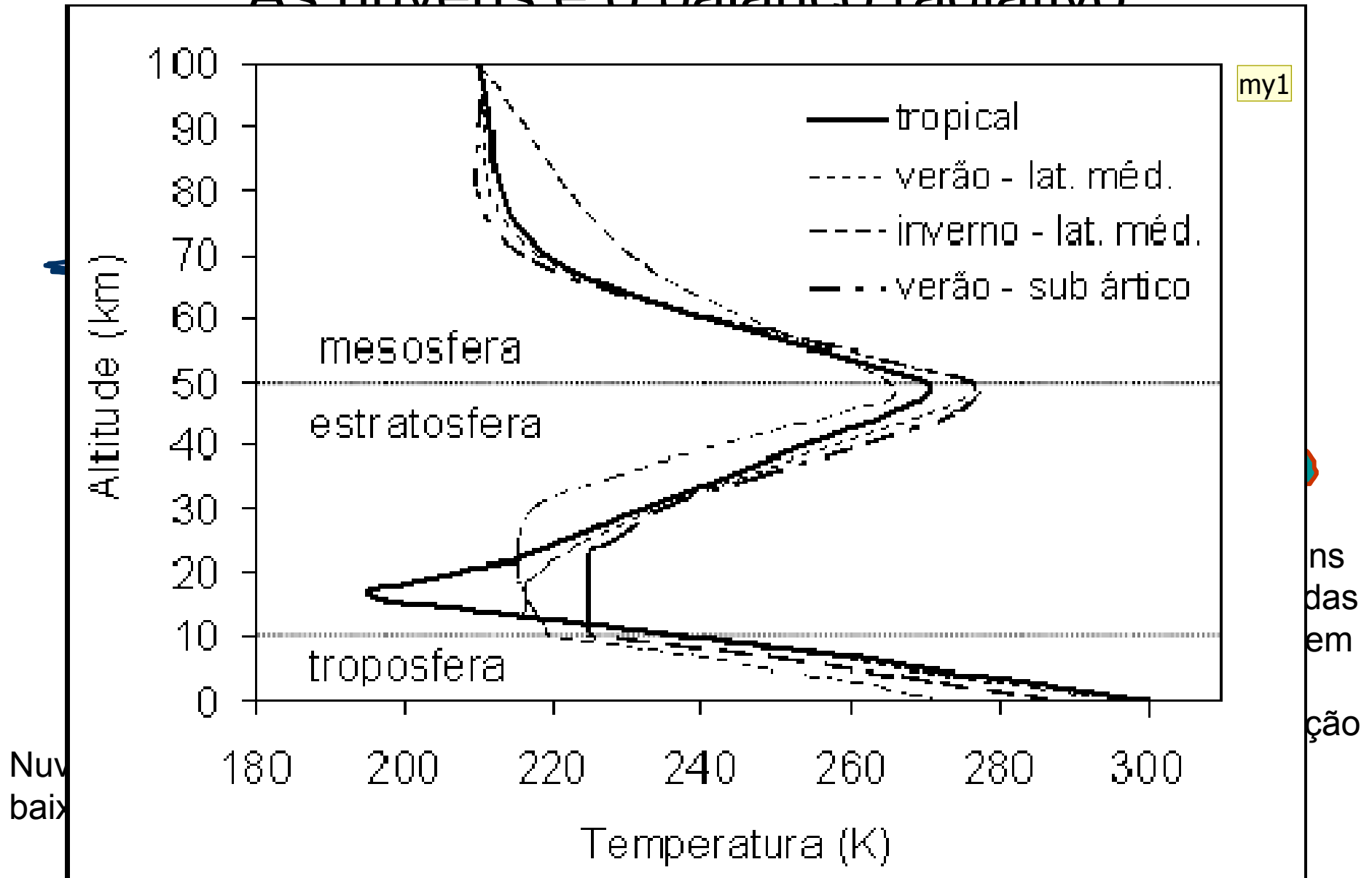
Na janela do infravermelho (8.5-12.5 μm):

- As gotas de nuvens são espalhadores, conforme a teoria Mie
- Absorvem praticamente toda a radiação no infravermelho
- Podem ser tratadas como corpos negros

Nas microondas:

- O parâmetro de tamanho $x \sim 0,01$ para nuvens, portanto,
  espalhamento Rayleigh
- absorção é muito pequena (transmitância > 90%)
- partículas de gelo absorvem menos ainda
- As partículas com tamanho de gotas de chuva interagem fortemente com a radiação em microondas, portanto, a transmitância é menor para nuvens precipitantes.

As nuvens e o balanço radiativo



(Adaptado de Protat, 2005)

Slide 5

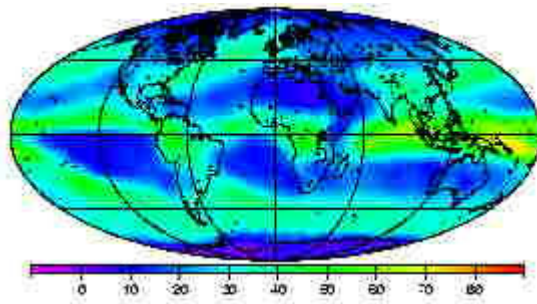
my1

capítulo 5 da apostila
Marcia Yamasoe; 23/11/2005

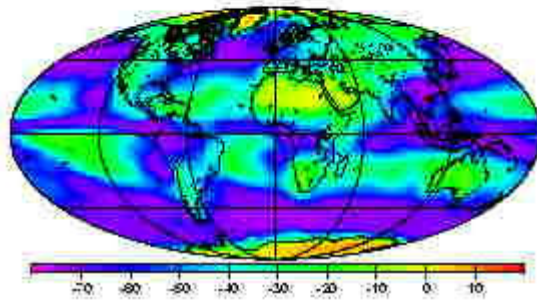
Média Anual da Forçante Radiativa de Nuvens (Wm^{-2})

	LW CRF	SW CRF	Net CRF
ERBE: 1985 – 89	+29.1	- 47.6	-18.5
ScaRaB: 1994 – 95	+27.2	- 48.2	-21.0

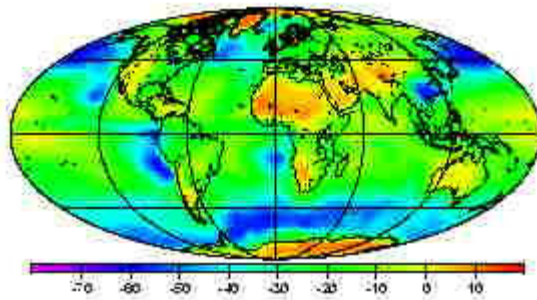
(<http://www.lmd.polytechnique.fr/~Scarab/english/ECRF.htm>)



LW CRF : the strongest (positive) values are associated with convective cloud in the ITCZ. Scale runs from -10 to +100 Wm^{-2} .



SW CRF : the strongest (negative) values are also observed in the ITCZ. Scale runs from -80 to +20 Wm^{-2} .



Net CRF is significantly negative over the globe as a whole, the strongest cooling (in blue) being observed over areas of persistent extended low clouds. Scale runs from -80 to +20 Wm^{-2} .

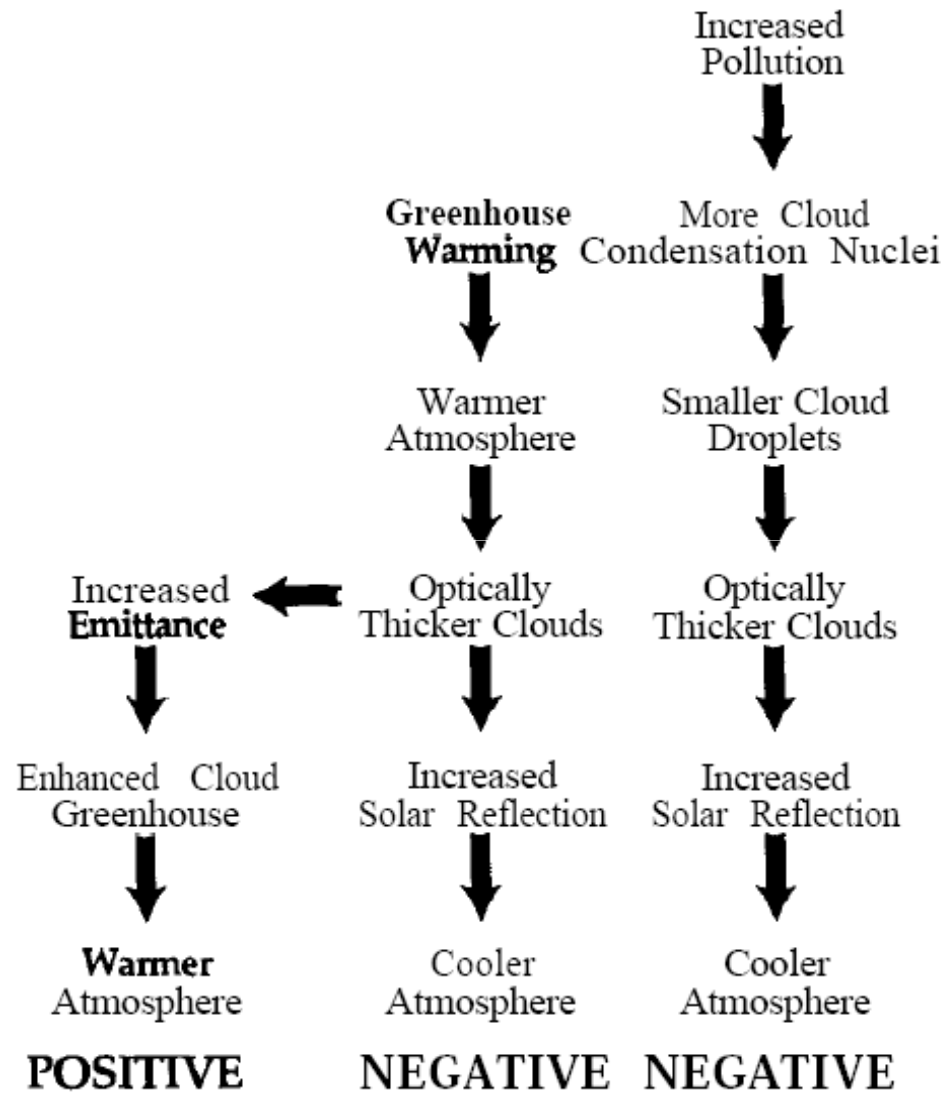


Fig. 1. **Some** plausible cloud feedback processes.

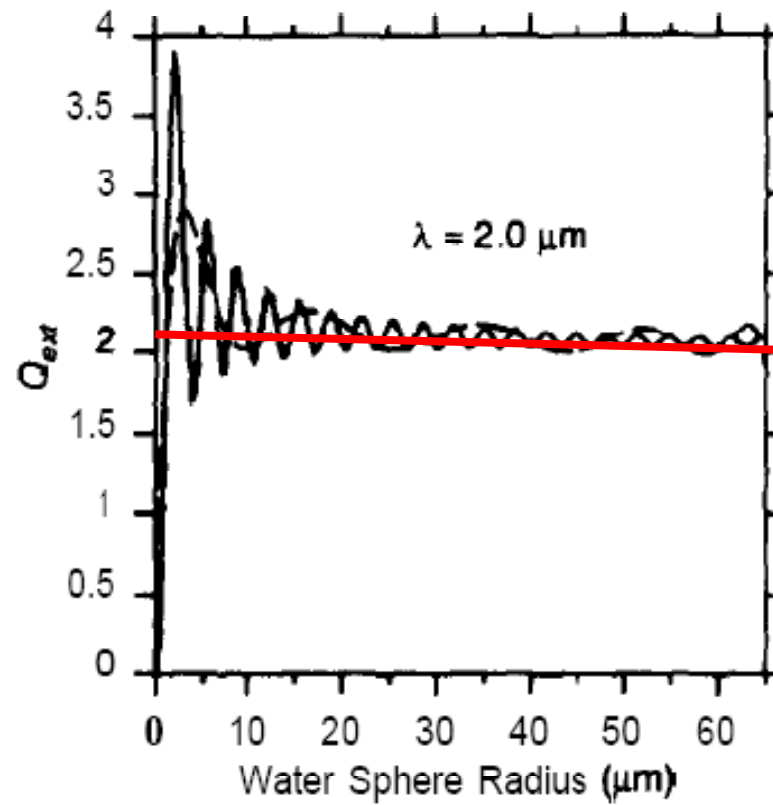
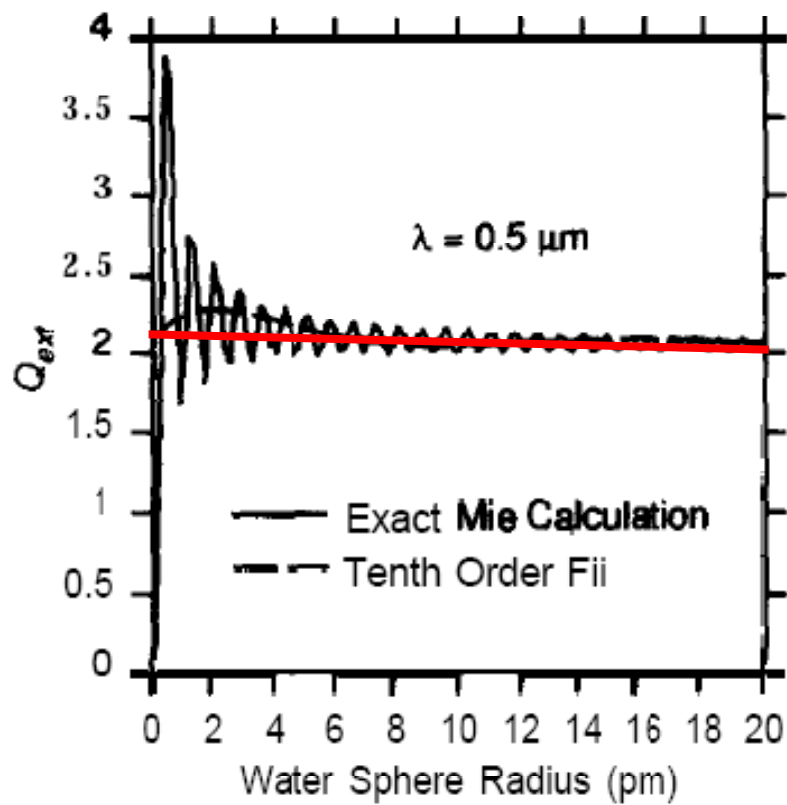
Espalhamento/absorção

- Distribuição de tamanho
 - Índice de refração
 - Conteúdo de água líquida e gelo
- + Teoria Mie (supondo que as gotas são esféricas):
- Albedo simples
 - Função de fase
 - Profundidade óptica

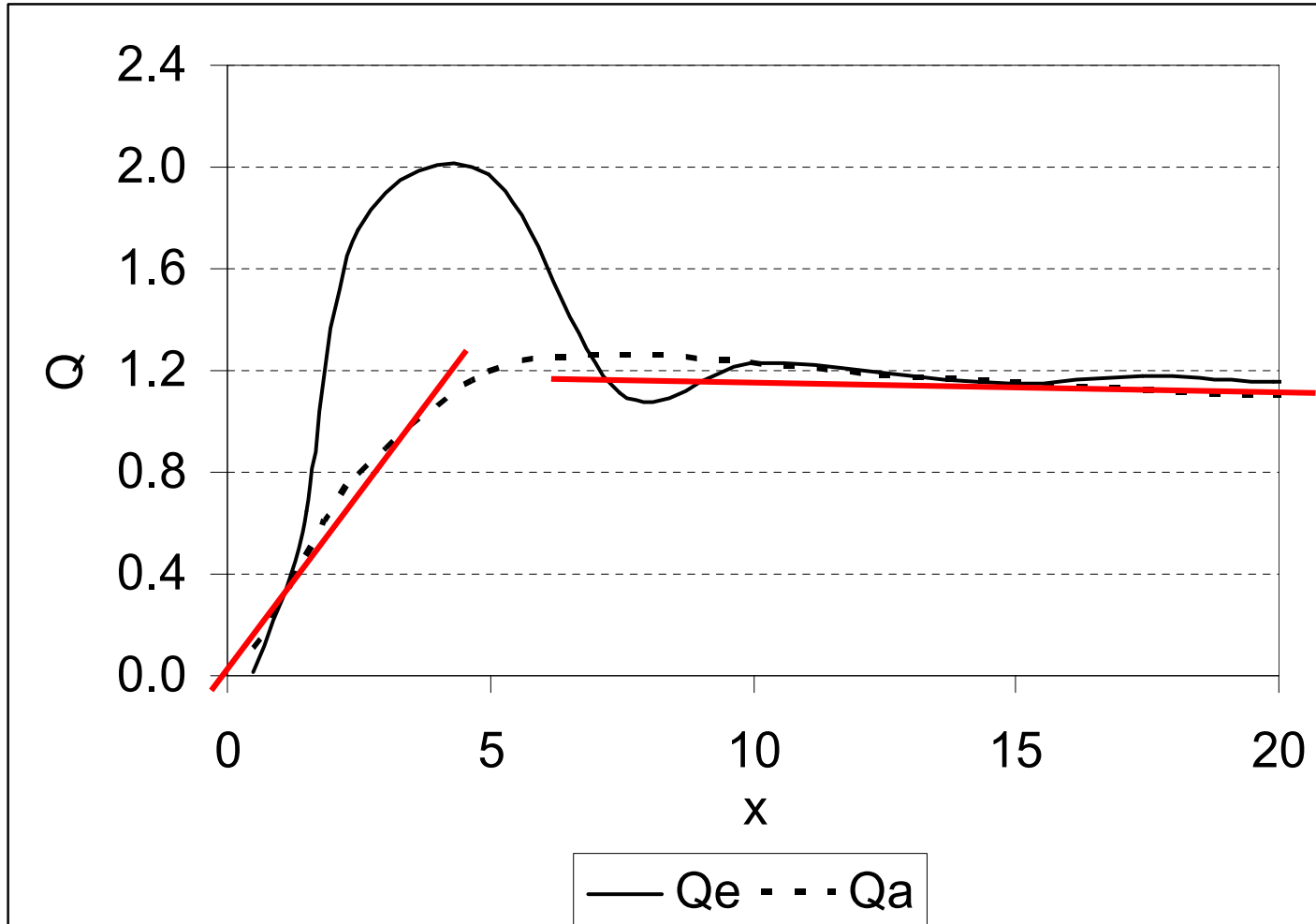
Espectro solar

P. Chylek et al. / Atmospheric Research 35 (1995) 139-156

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Infravermelho



Absorção/emissão

- Perfil vertical de temperatura, água e gelo

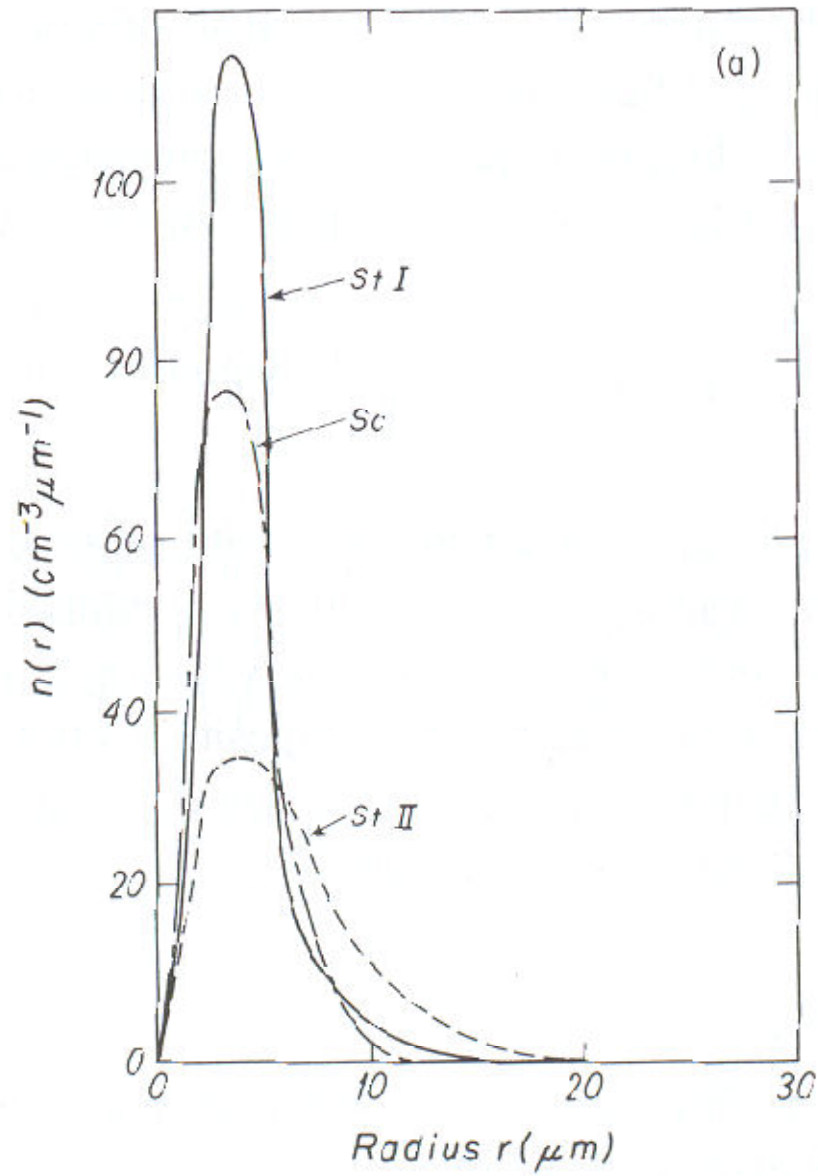


FIG. 4.10(a) Droplet size distributions of stratocumulus and stratus over land (St II) and (St I).

Liou, 1992

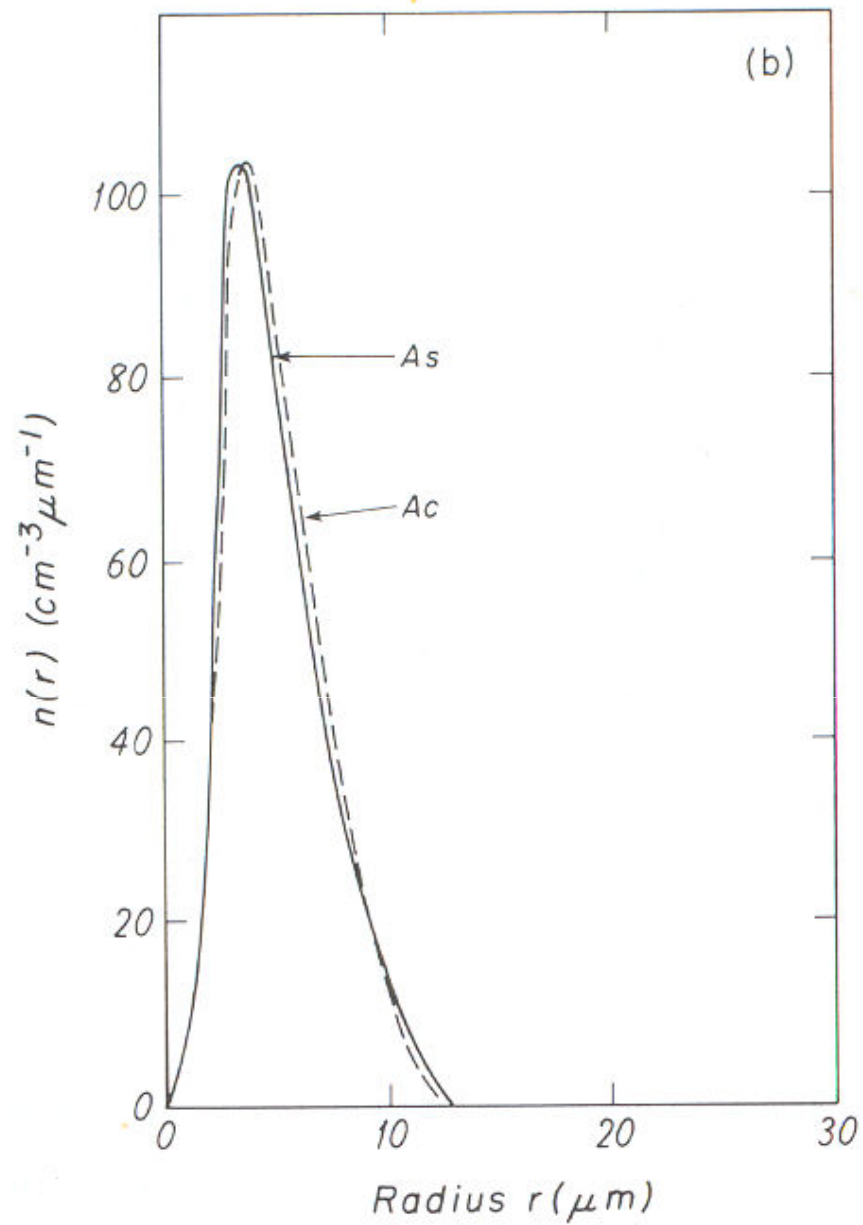


FIG. 4.10(b) Droplet size distributions of altostratus and altocumulus.

Liou, 1992

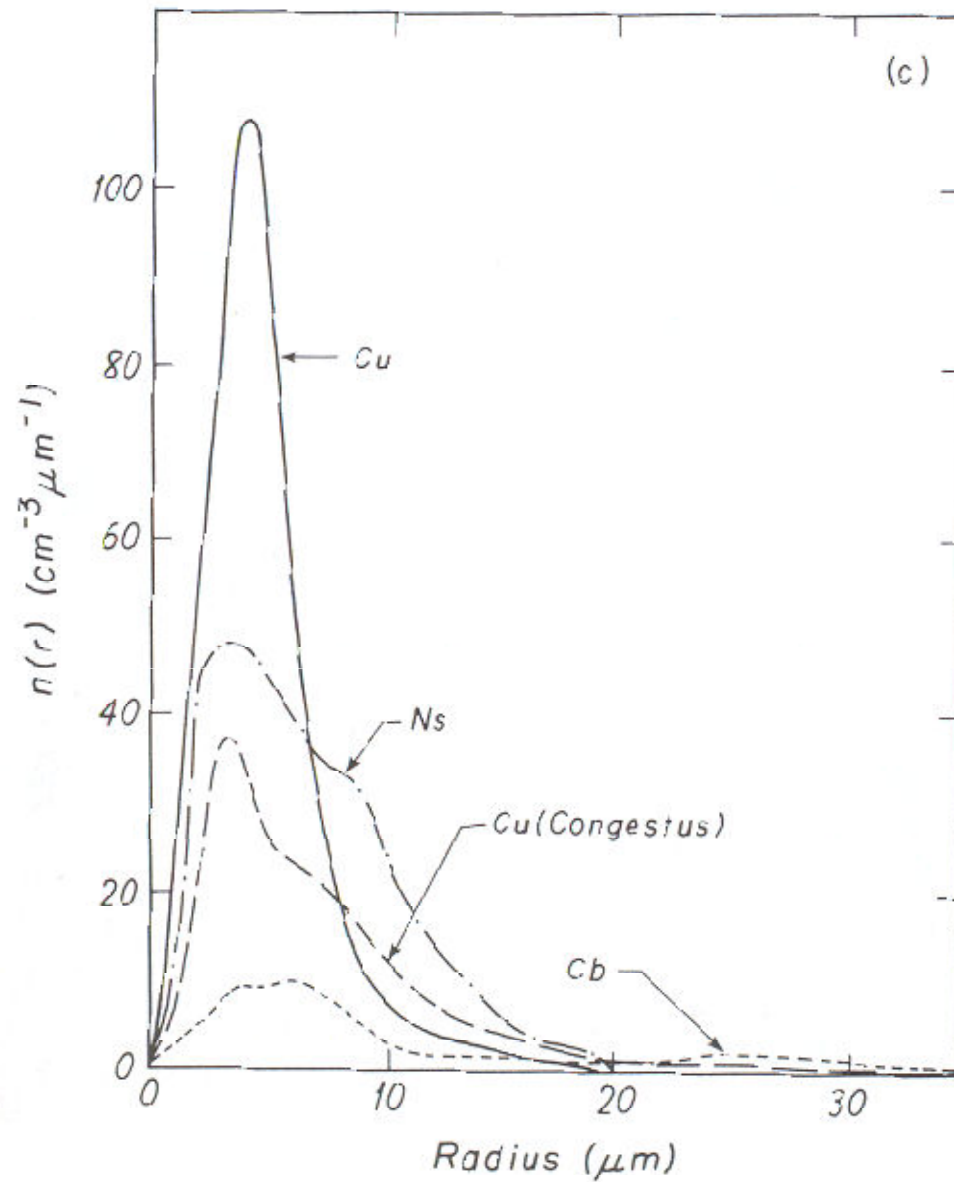


FIG. 4.10(c) Droplet size distributions of fair weather cumulus, nimbostratus, cumulus congestus, and cumulonimbus.

Liou, 1992

Liou, 1992

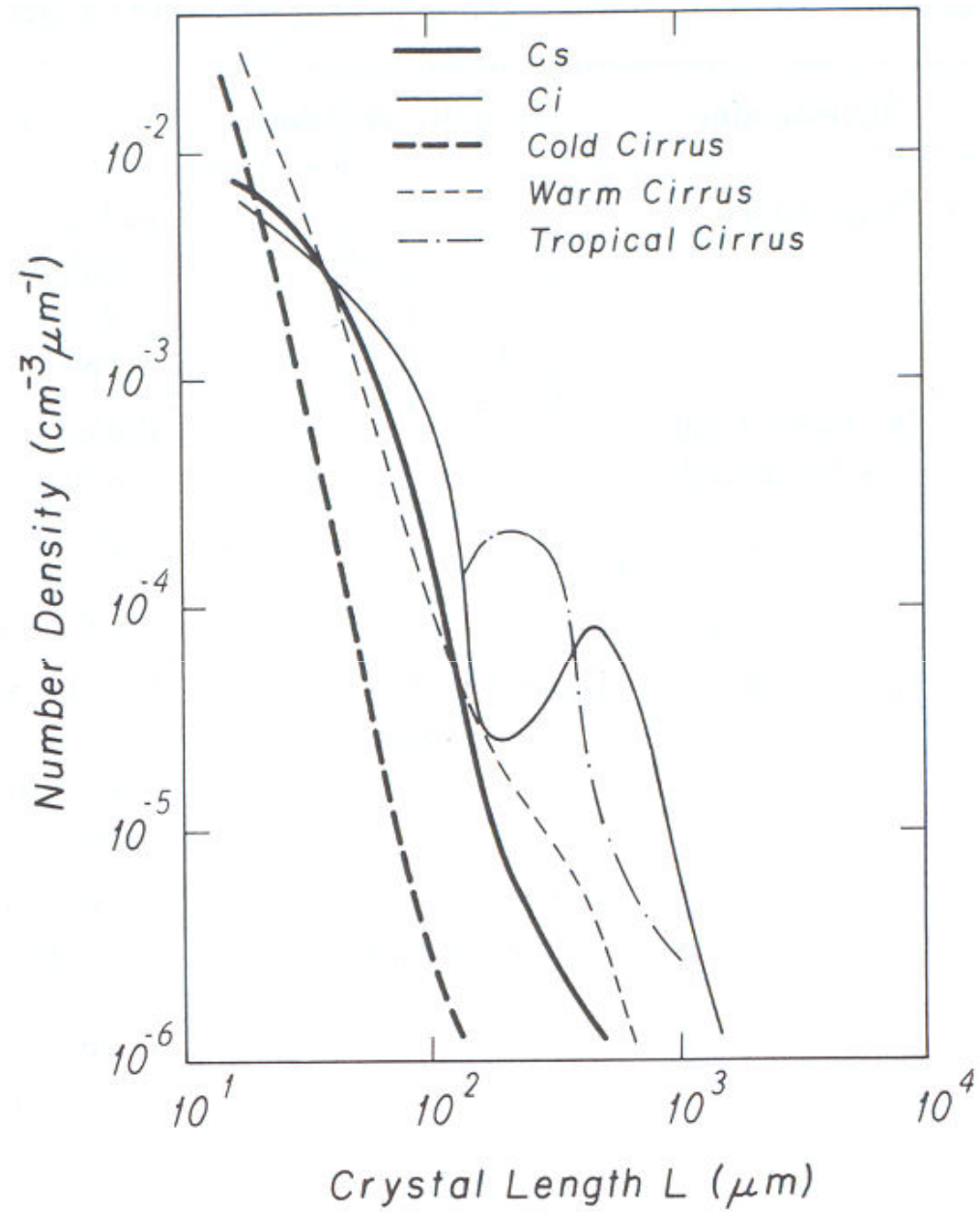
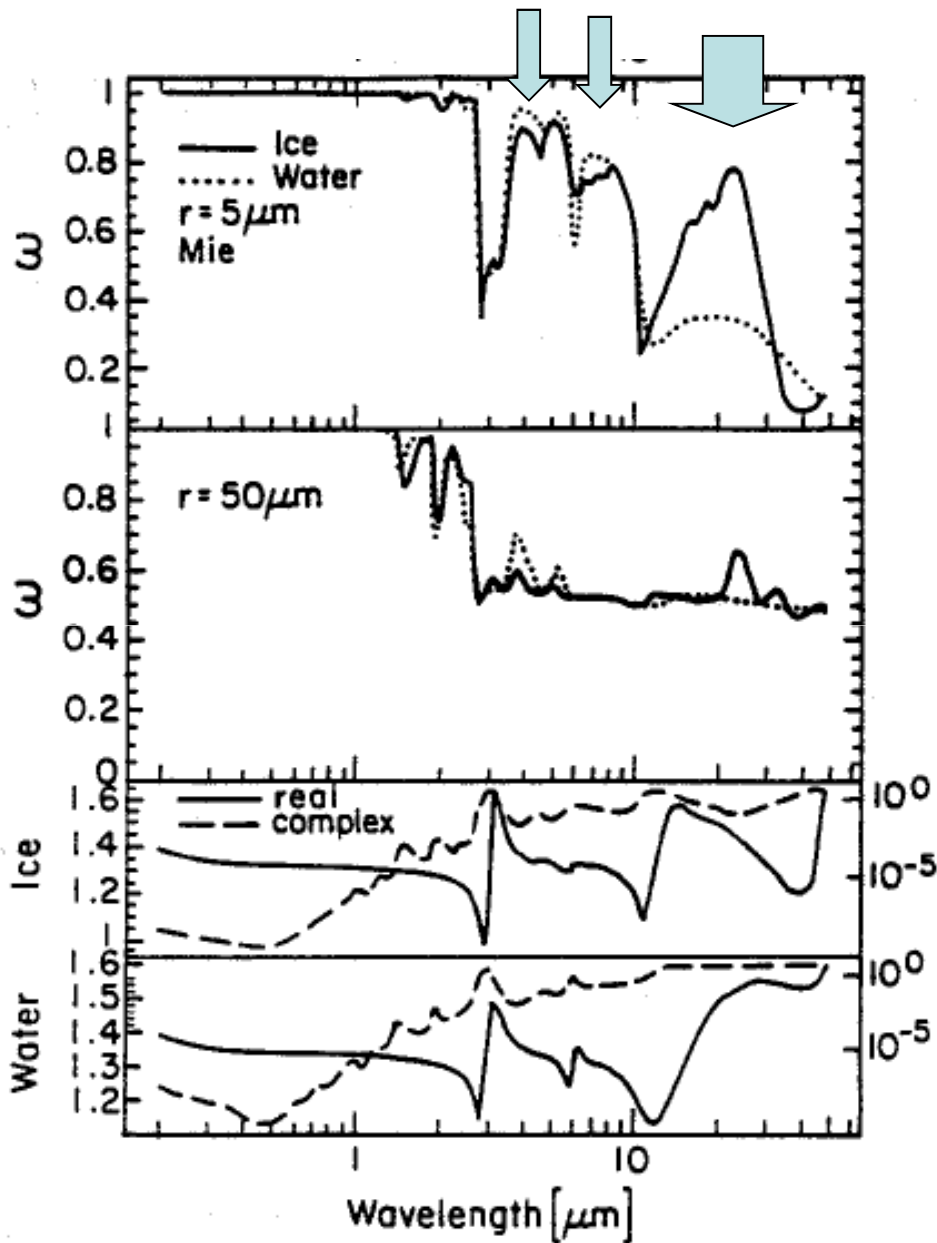


FIG. 4.12 Representative ice crystal size distributions for cirrus clouds.

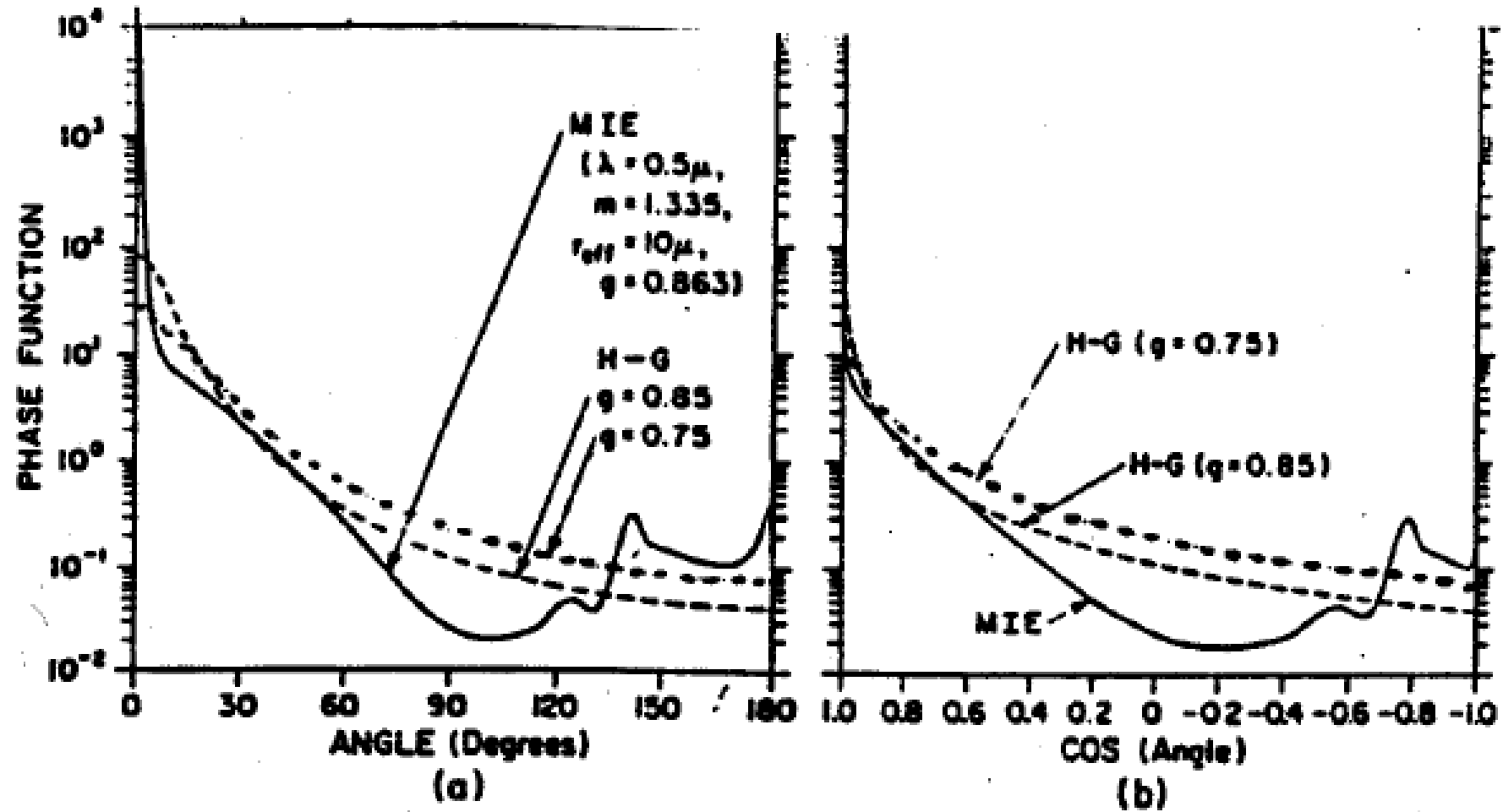


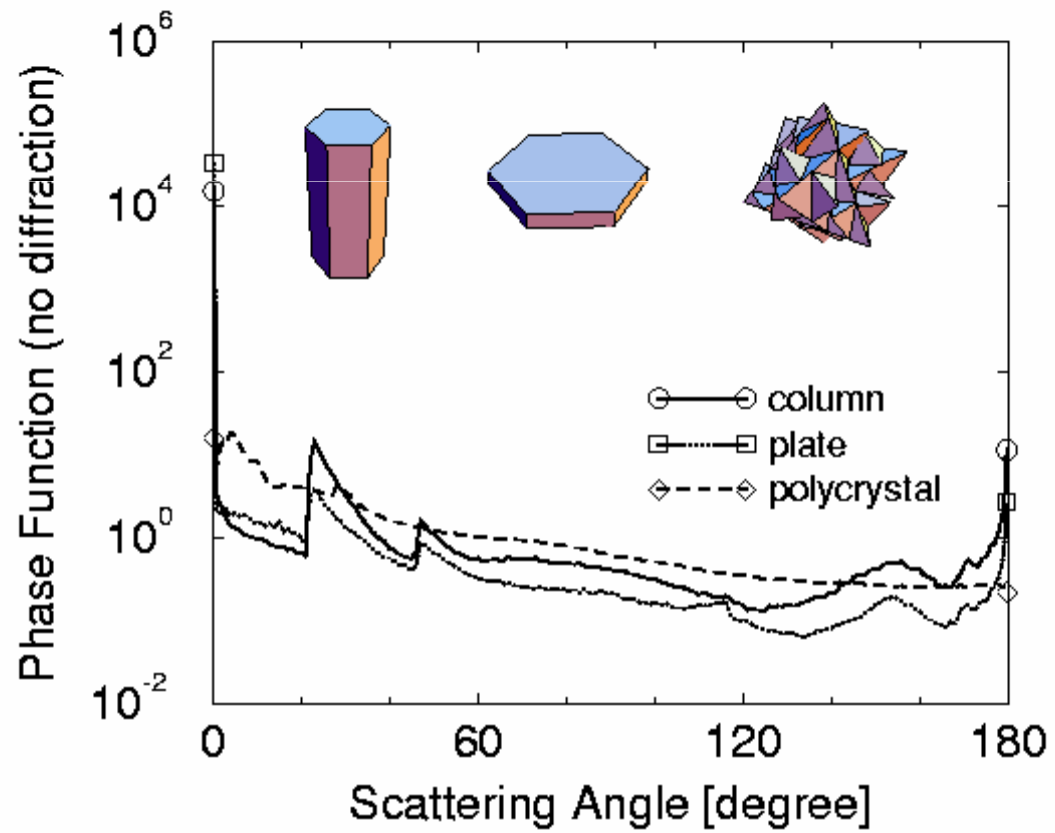
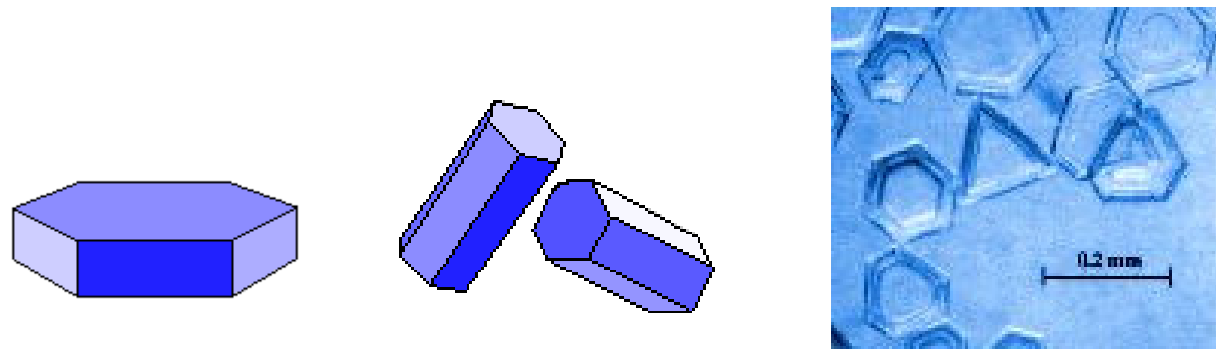
Twomey and Seton, 1980,

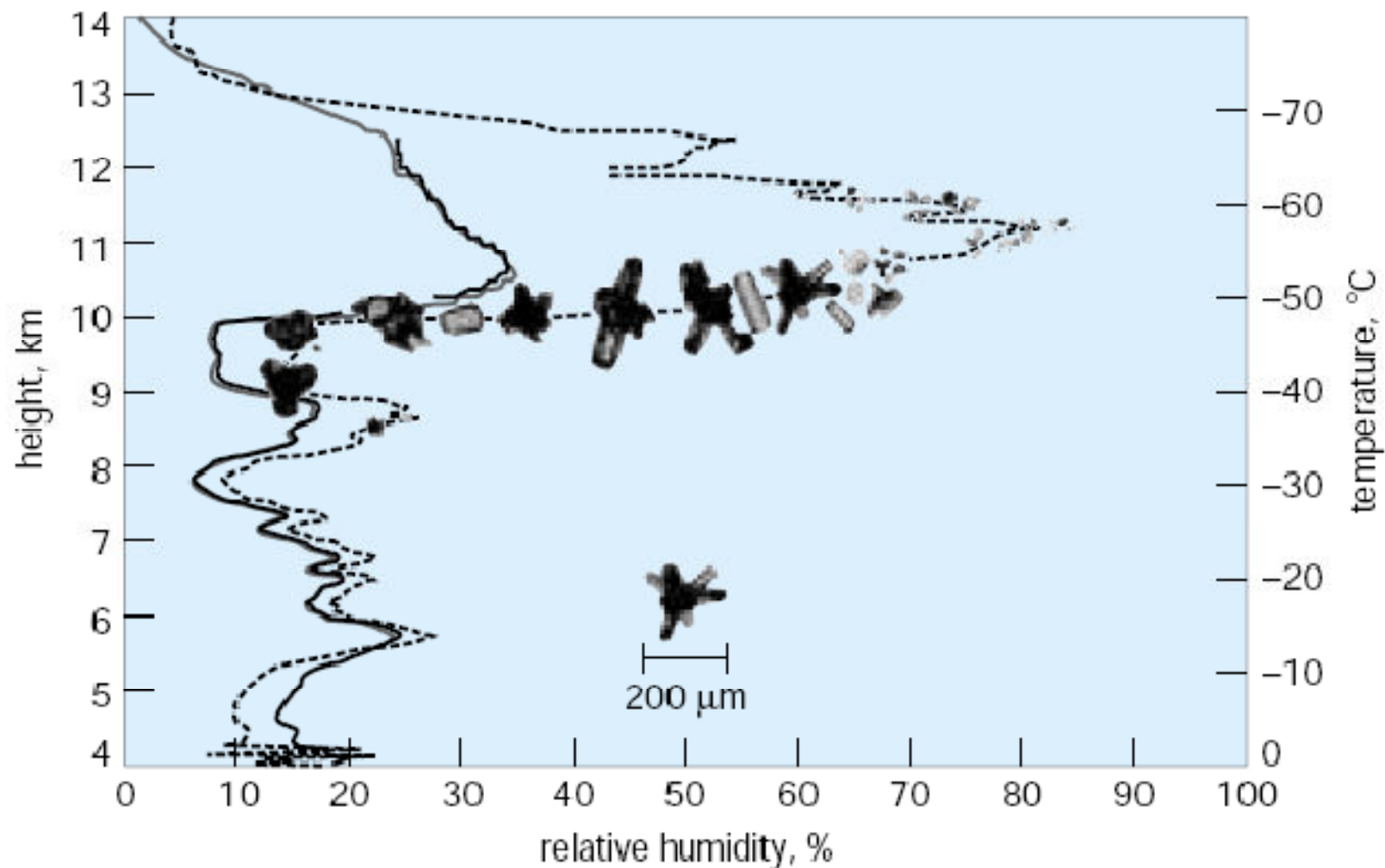
Albedo simples
para esferas de
gelo e água
com raio de
 $5\mu\text{m}$ e $50\mu\text{m}$

Índice de
refração
complexo para
gelo e água

Função de fase







Ice crystal size and shape as a function of height, temperature, and relative humidity captured by a replicator balloon sounding system in Marshall, Colorado, on November 10, 1994. The broken and solid lines denote the relative humidity measured by cryogenic hygrometers and Vaisala RS80 instruments, respectively. (Graphic by Andrew Heymsfield, National Center for Atmospheric Research. data from K. N. Liou, *An Introduction to Atmospheric Radiation*, 2d ed., Academic Press, 2002)