CIRAMOSA WP 1000

- Compilation of cirrus microphysical data -

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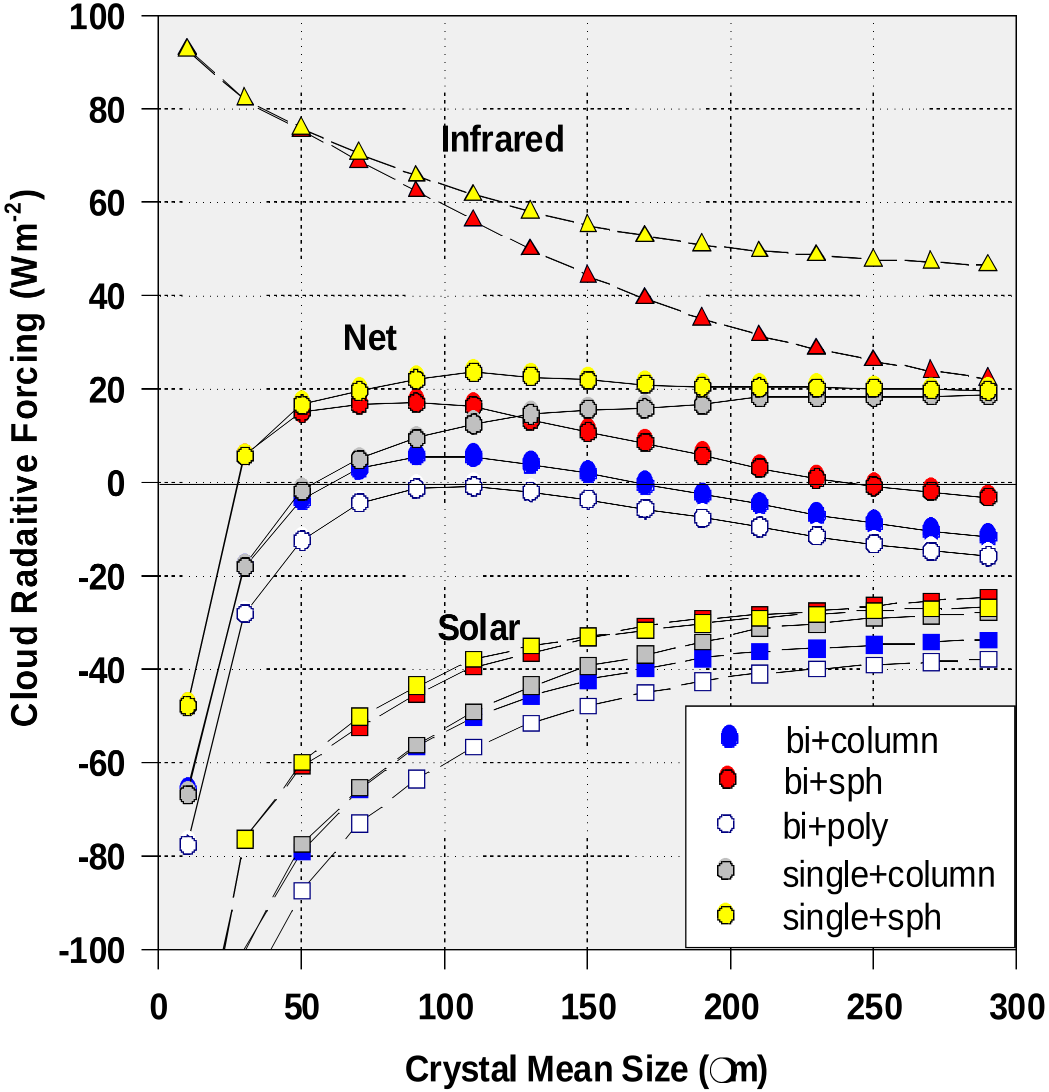
- Importance of ice cloud microphysics
- A paradigm
- Compilation of cirrus microphysical data from various field campaigns
- Conclusion (microphyics)
- Influence on cirrus radiative properties
- Conclusions (radiation)

Cirrus Microphysics and Radiation

- **Water clouds:** Cloud structure dominates radiative properties (fluxes, radiances)
- **Cirrus clouds:** Cloud Structure and microphysics are equally important
- Cirrus microphysics =
  - particle geometry
  - particle size distributions



Size Matters!!

Zhang et al. 1999

A Paradigm:

"deterministic ice particle size distributions"

Heymsfield and Platt '84: Size distribution is function of temperature

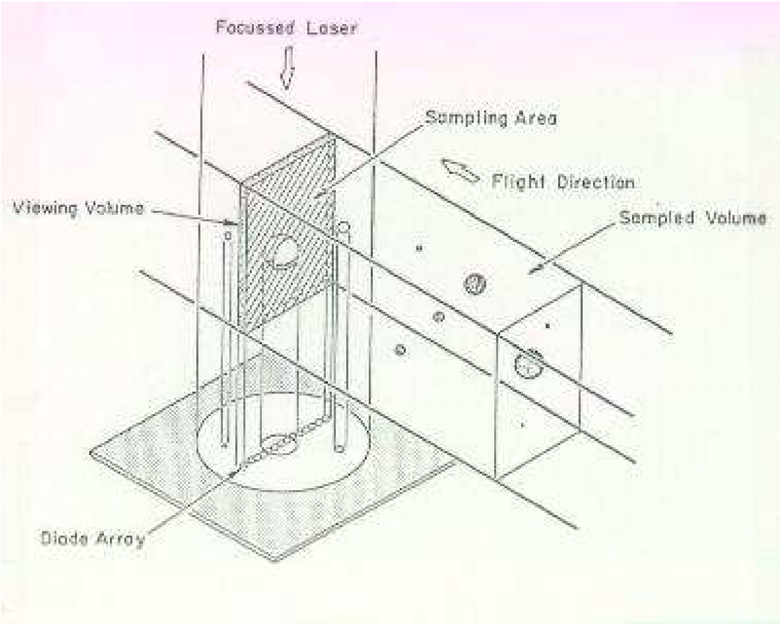
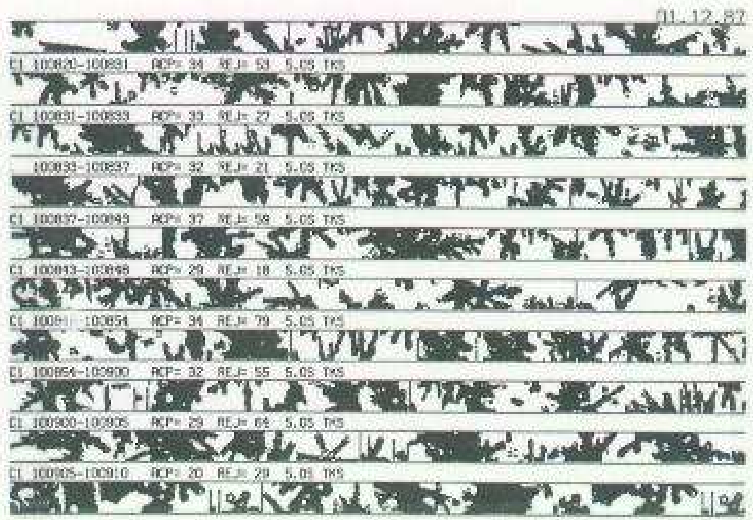


Figure 6.7



Data Sources

Scattering probes

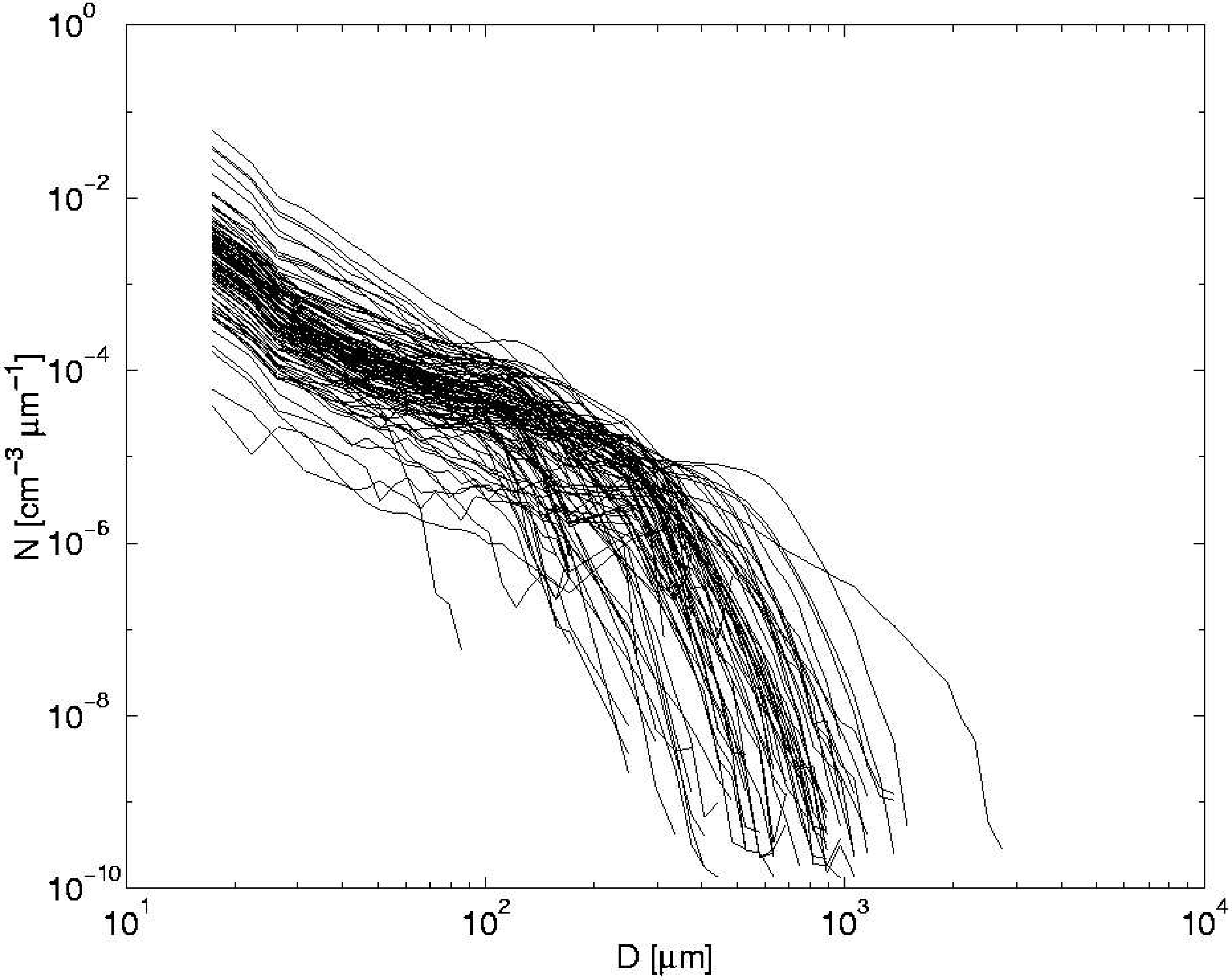
•FSSP (0.25 - 50 mu)

Optical Array Probes

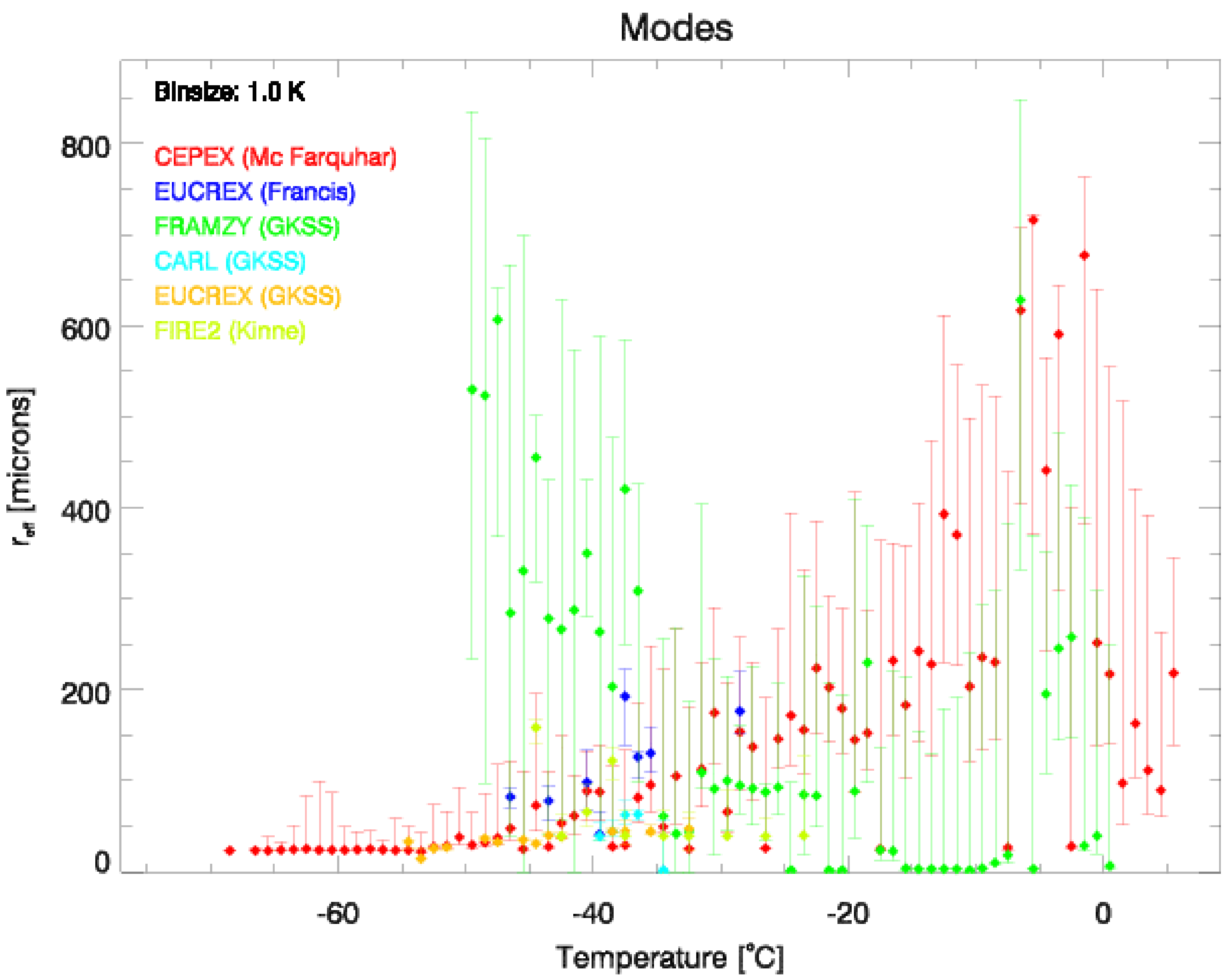
•2D-C (25/100 - 800 mu)

•2D-P (100 - 6000 mu)

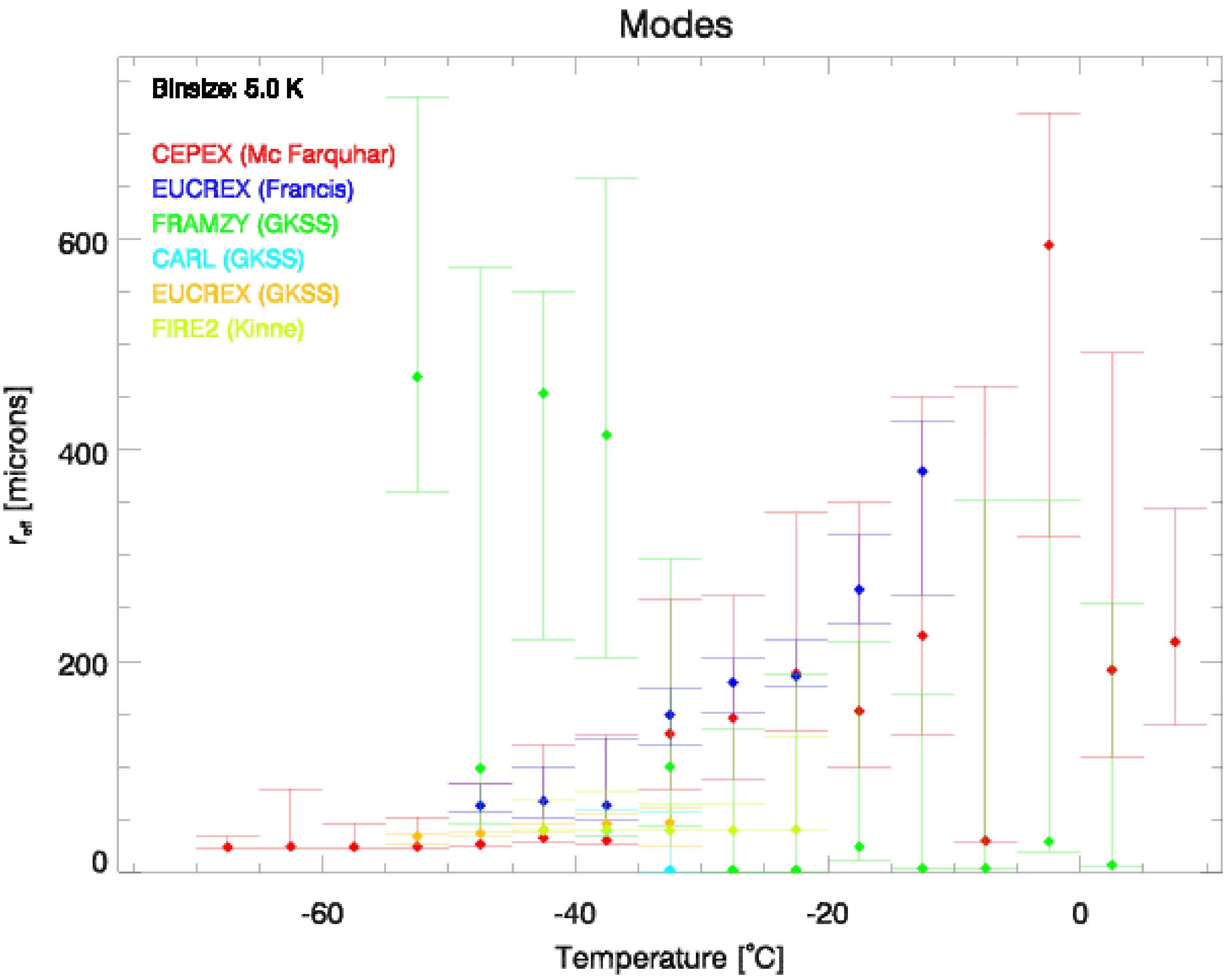
Size distributions

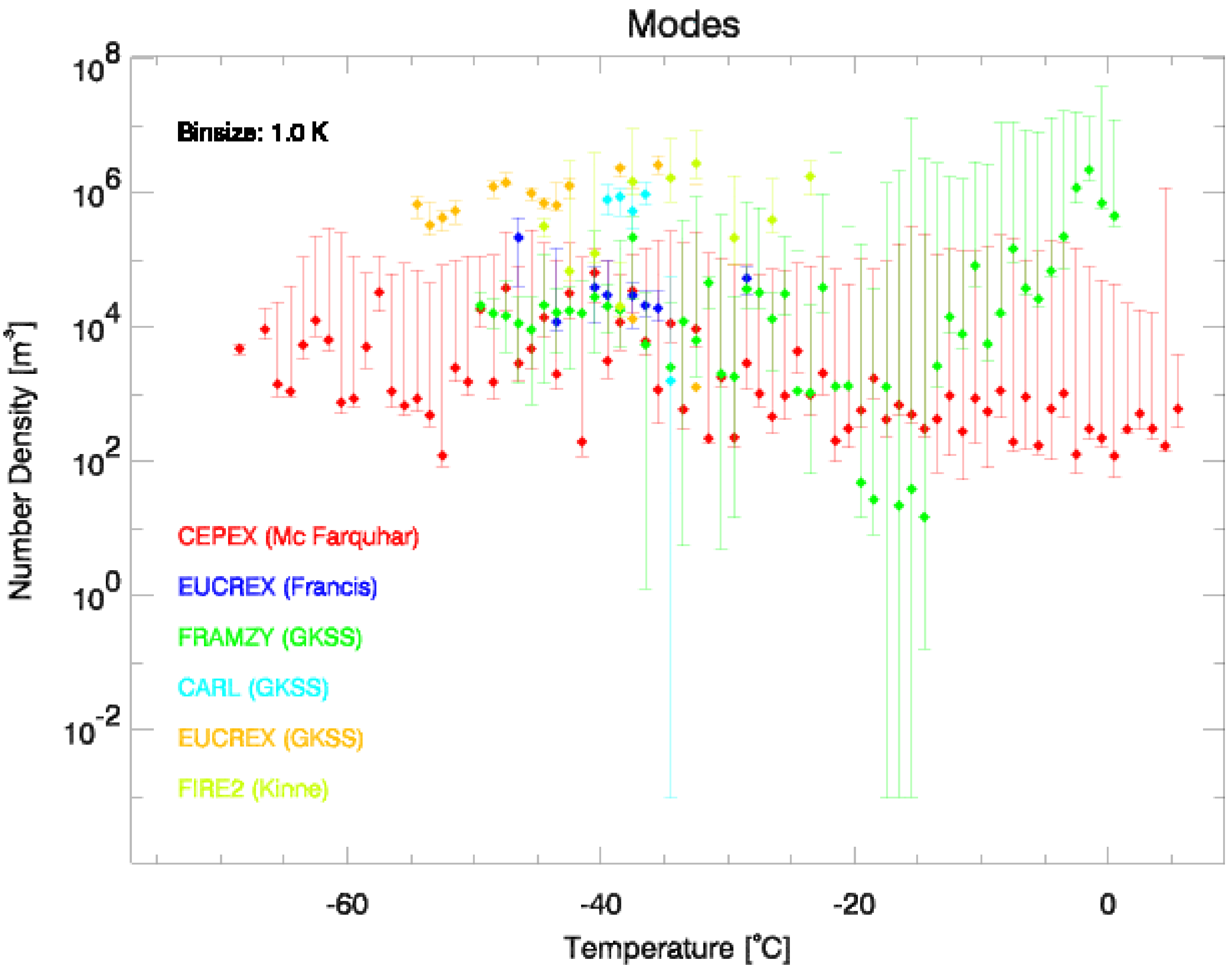


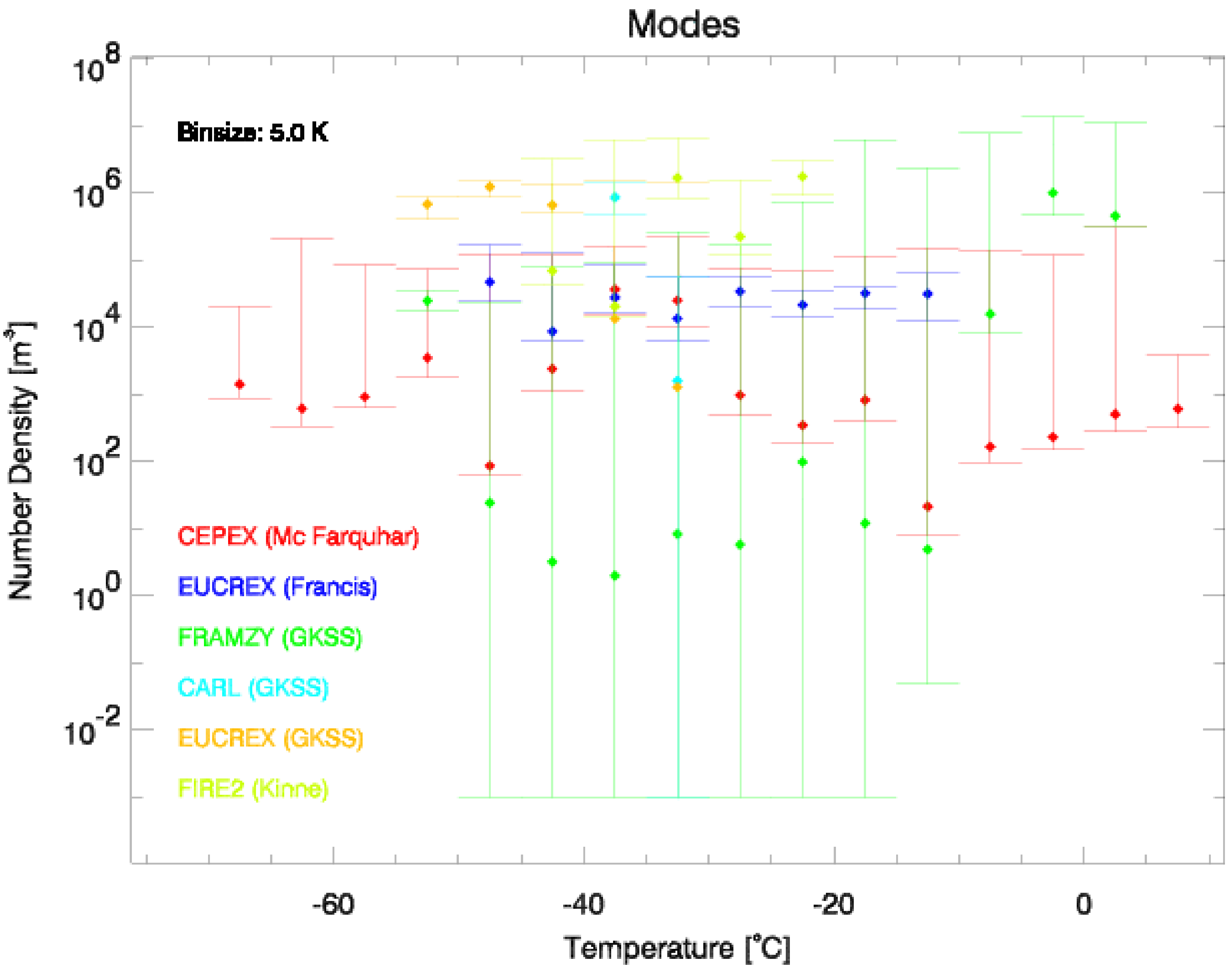
campaign	time	location	nb events	temperature	position	IWC	devices
CEPEX (McFarquhar)	3-4/93	Central Equat. Pacific	12507	X	X	X	ASSP, 1DC, 2DP
EUCREX (Francis)	4/92	North Sea	110	(X)			FSSP, 2DC, 2DP
FRAMZY (GKSS)	4/99	Fram Strait	2003	X			FSSP, 2DC, 2DP
CARL (GKSS)	4-5/99	North Sea	798	(X)	(X)		FSSP, 2DC, 2DP
EUCREX (GKSS)	4/94	Atlantic Ocean	420	X	(X)		FSSP, 2DC
FIRE2 (Kinne)	11-12/91	Mexican Gulf, Kansas	1254	X		X	2DC,2DP
INTACC			820	X			2DC, 2DP

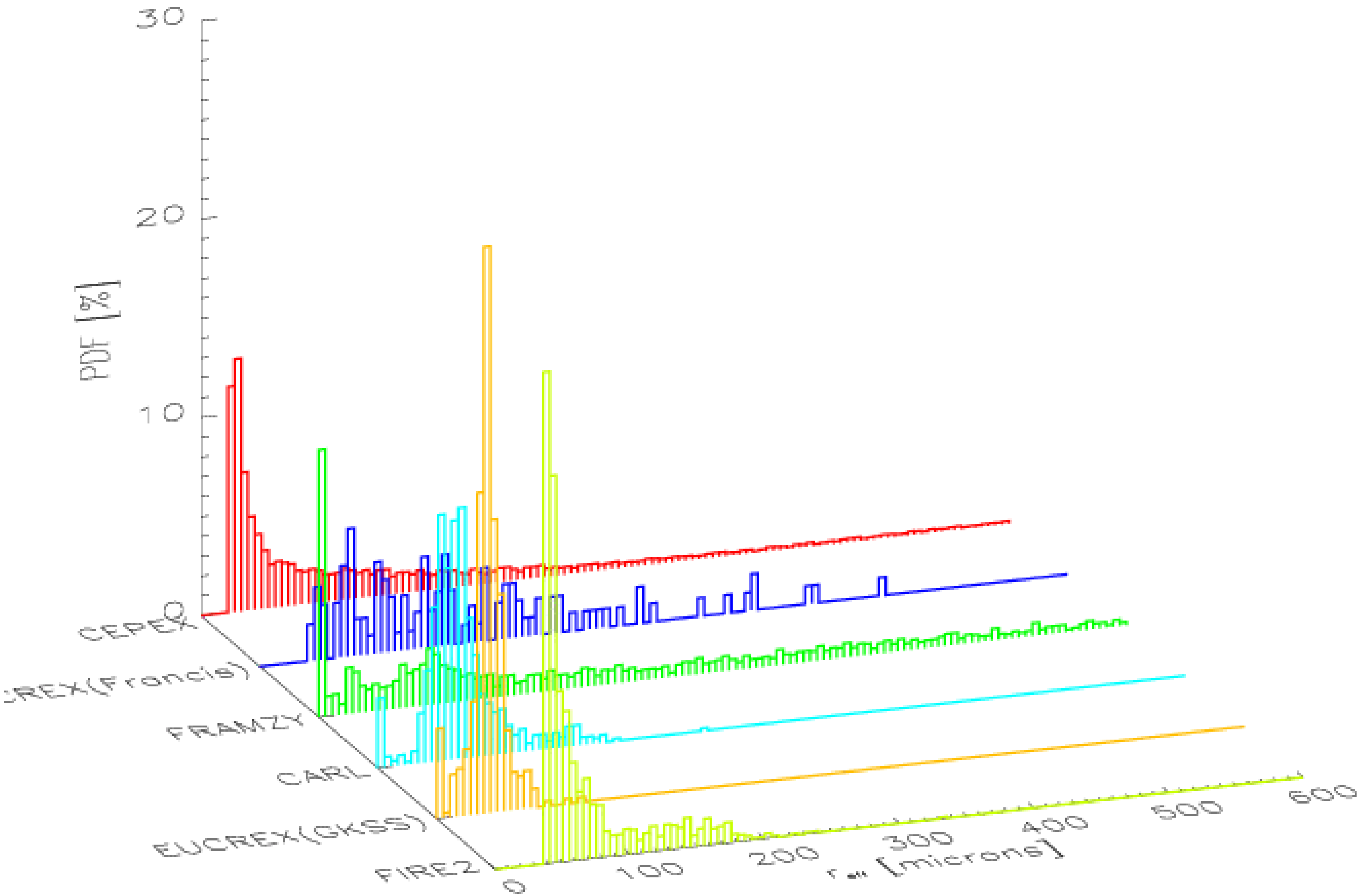


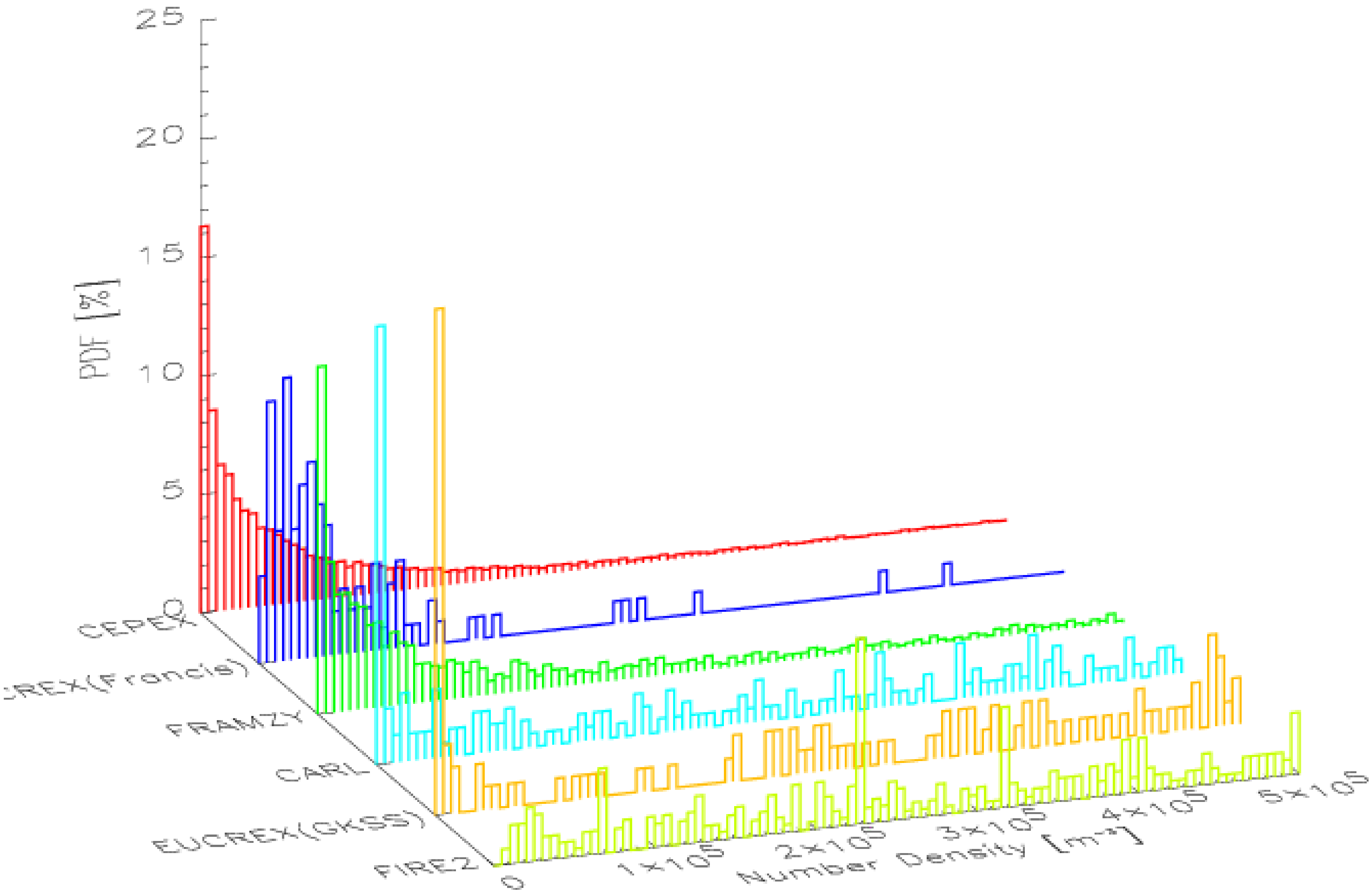
Modes
Binsize: 1.0 K
CEPEX (Mc Farquhar)
EUCREX (Francis)
FRAMZY (GKSS)
CARL (GKSS)
EUCREX (GKSS)
FIRE2 (Kinne)
800
600
400
200
0
r_eff [microns]
-60
-40
-20
0
Temperature [°C]


Modes
Binsize: 5.0 K
CEPEX (Mc Farquhar)
EUCREX (Francis)
FRAMZY (GKSS)
CARL (GKSS)
EUCREX (GKSS)
FIRE2 (Kinne)
600
400
200
0
r_eff [microns]
-60
-40
-20
0
Temperature [°C]

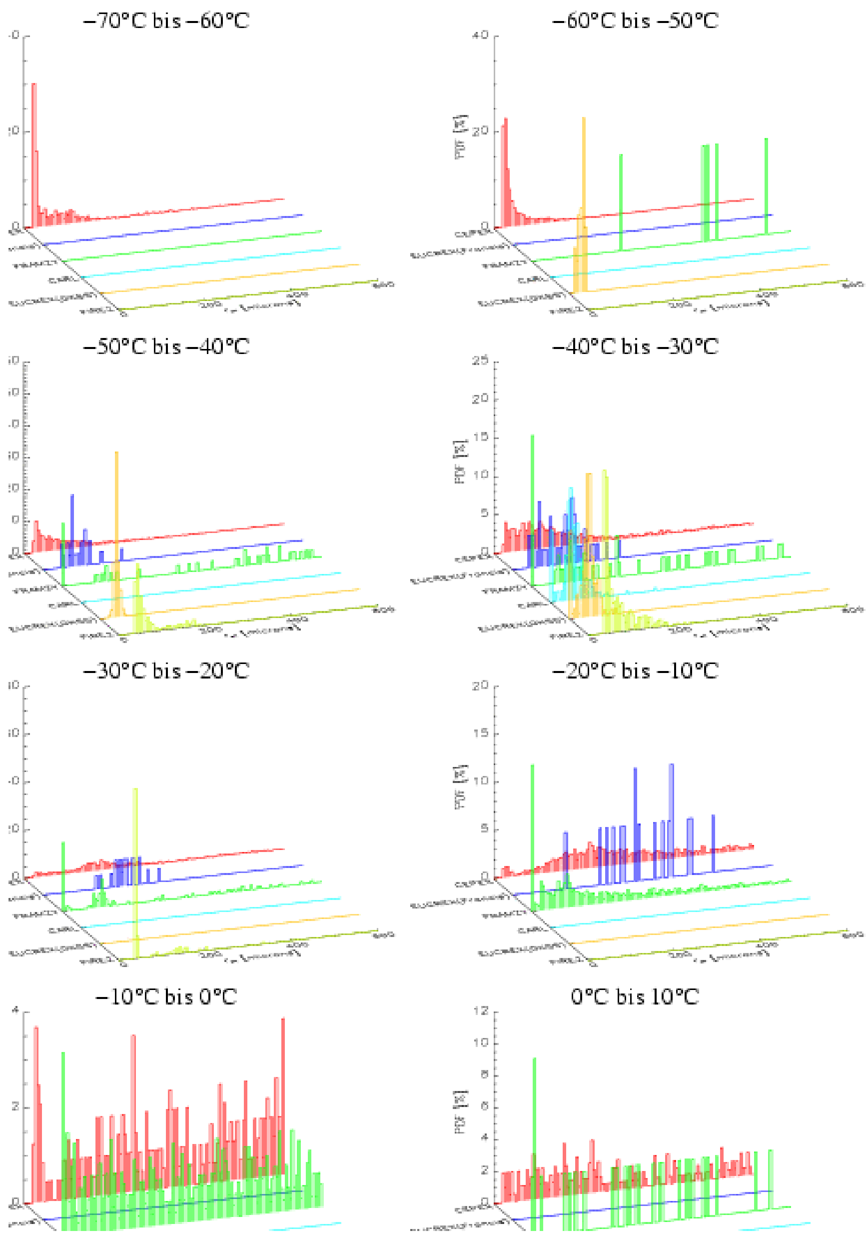

Modes
Binsize: 1.0 K
CEPEX (Mc Farquhar)
EUCREX (Francis)
FRAMZY (GKSS)
CARL (GKSS)
EUCREX (GKSS)
FIRE2 (Kinne)
Number Density [m^{-3}]
10^8
10^6
10^4
10^2
10^0
10^{-2}
-60
-40
-20
0
Temperature [°C]


Modes
Binsize: 5.0 K
CEPEX (Mc Farquhar)
EUCREX (Francis)
FRAMZY (GKSS)
CARL (GKSS)
EUCREX (GKSS)
FIRE2 (Kinne)
Number Density [m^-3]
Temperature [°C]

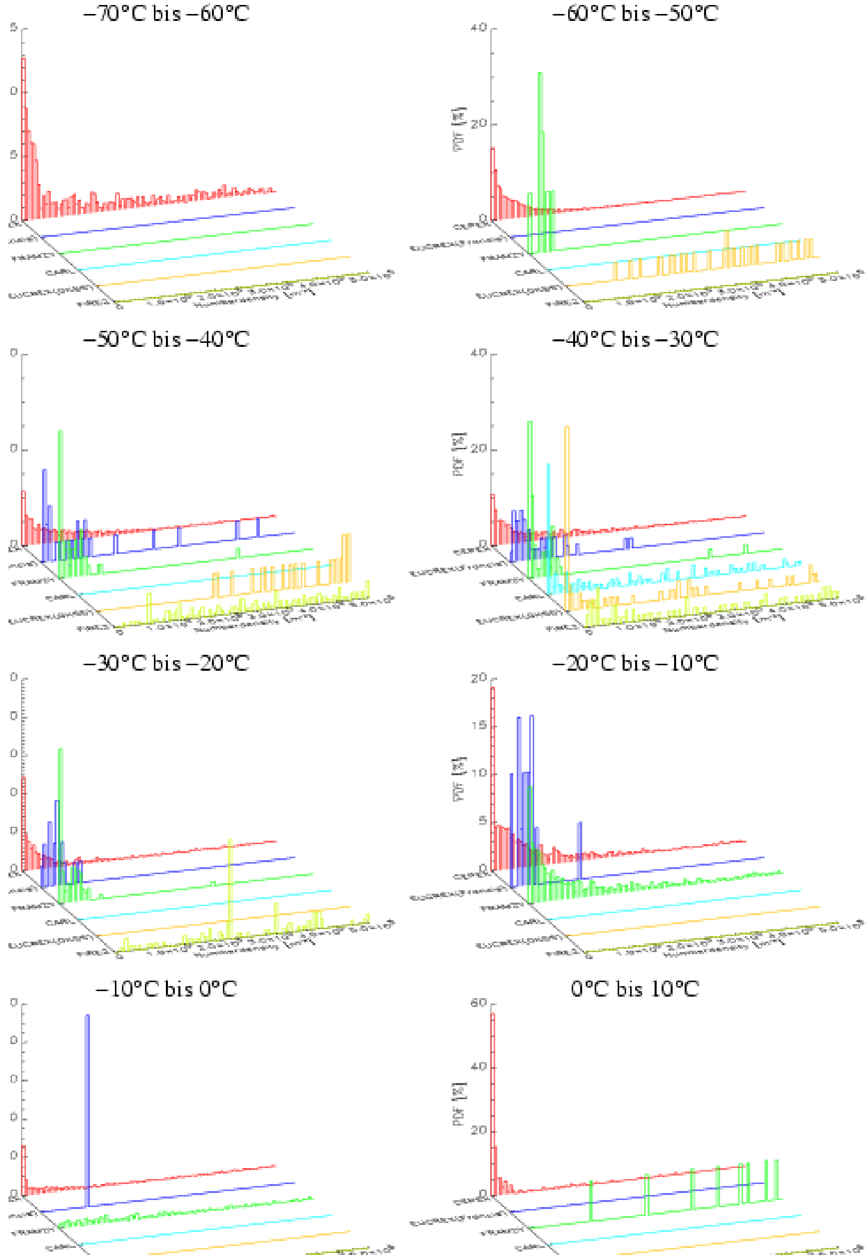

PDF [%]
30
20
10
0
CEPEX
CREX(Francis)
FRAMZY
CARL
EUCREX(GKSS)
FIRE2
0
100
200
300
400
500
600
[microns]


PDF [%]
25
20
15
10
5
0
CEPEX
FRAMZY
CARL
EUCREX(GKSS)
FIRE2
0
1x105
2x105
3x105
4x105
5x105
Number Density [m-3]

Effective Radii



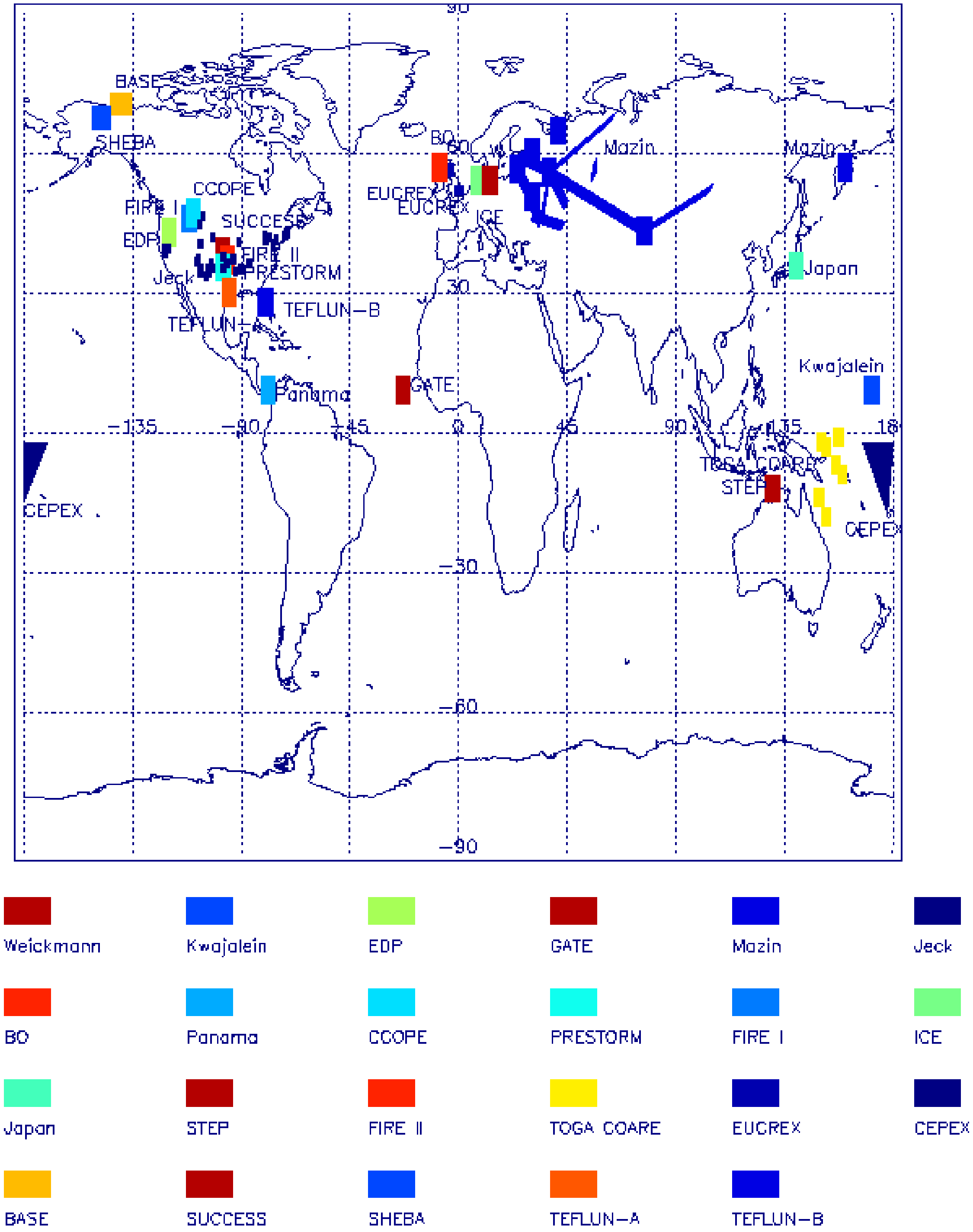
Number Density



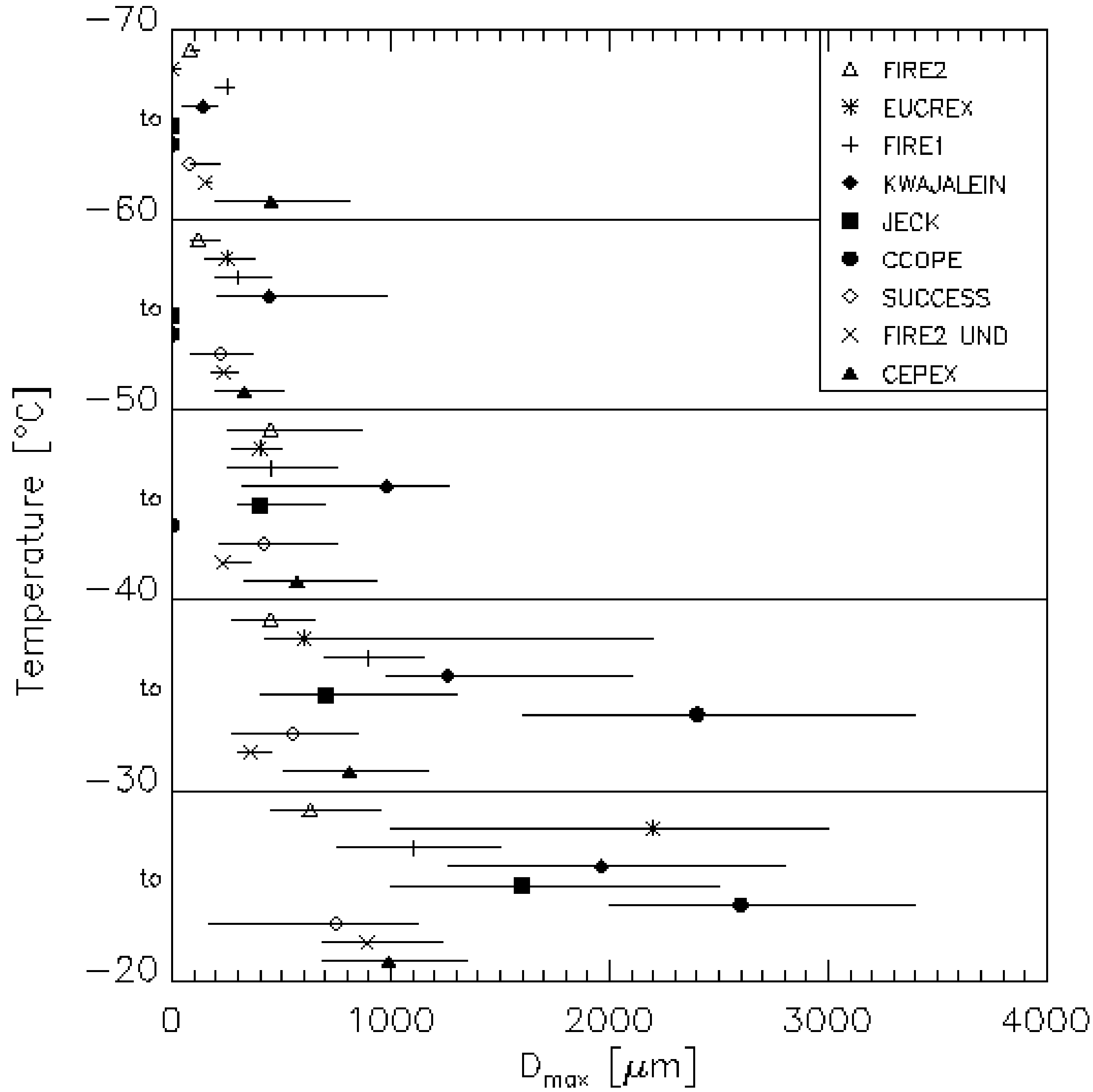
Recent Literature

"Parallel Processing"

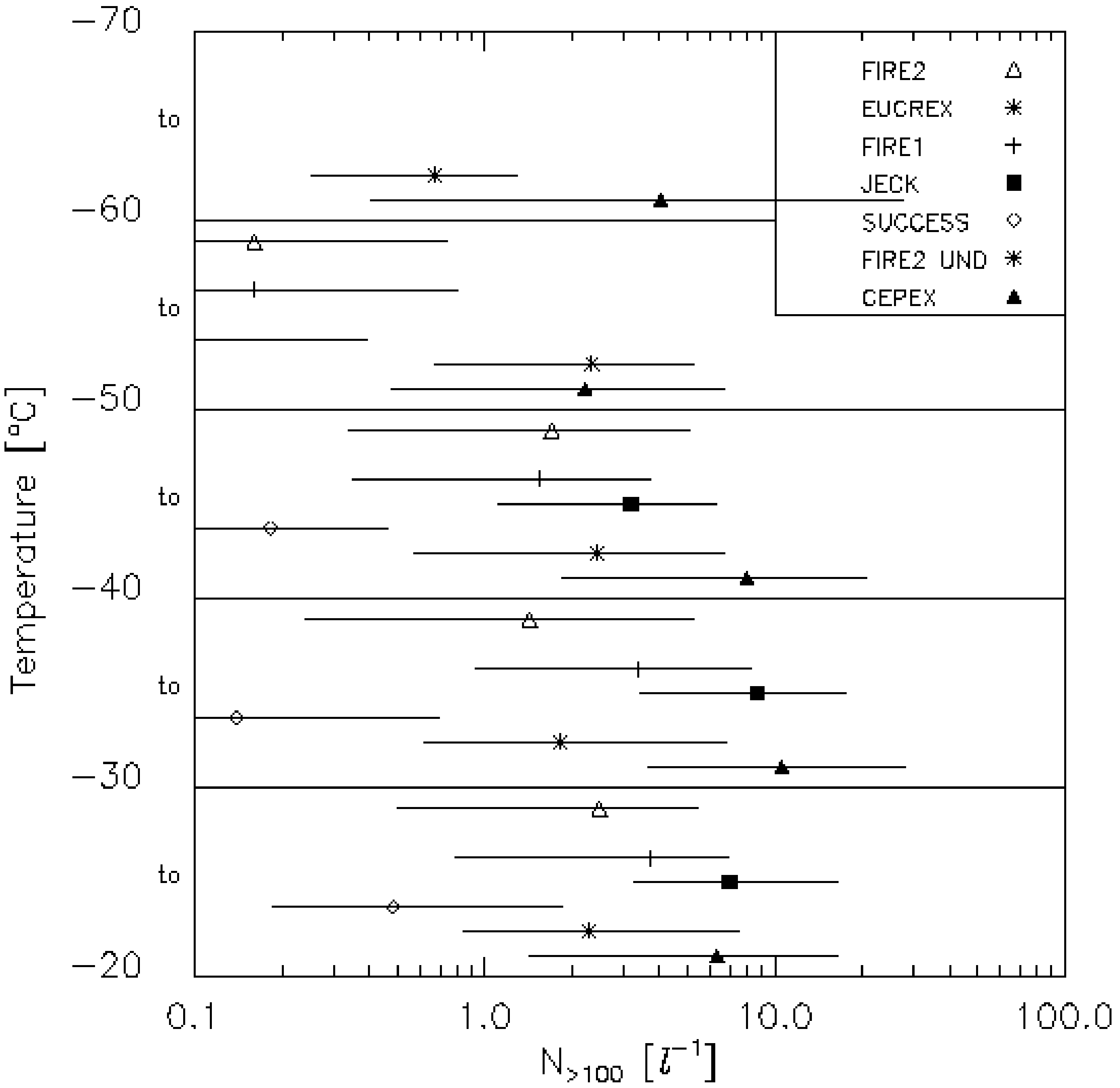
- Korolev et al. (2001): Microphyical properties of continental clouds from in-situ measurements, *QJRMS*
- Heymsfield & McFarquhar (2002): Mid-latitude and tropical cirrus - Microphysical properties -, *Cirrus*



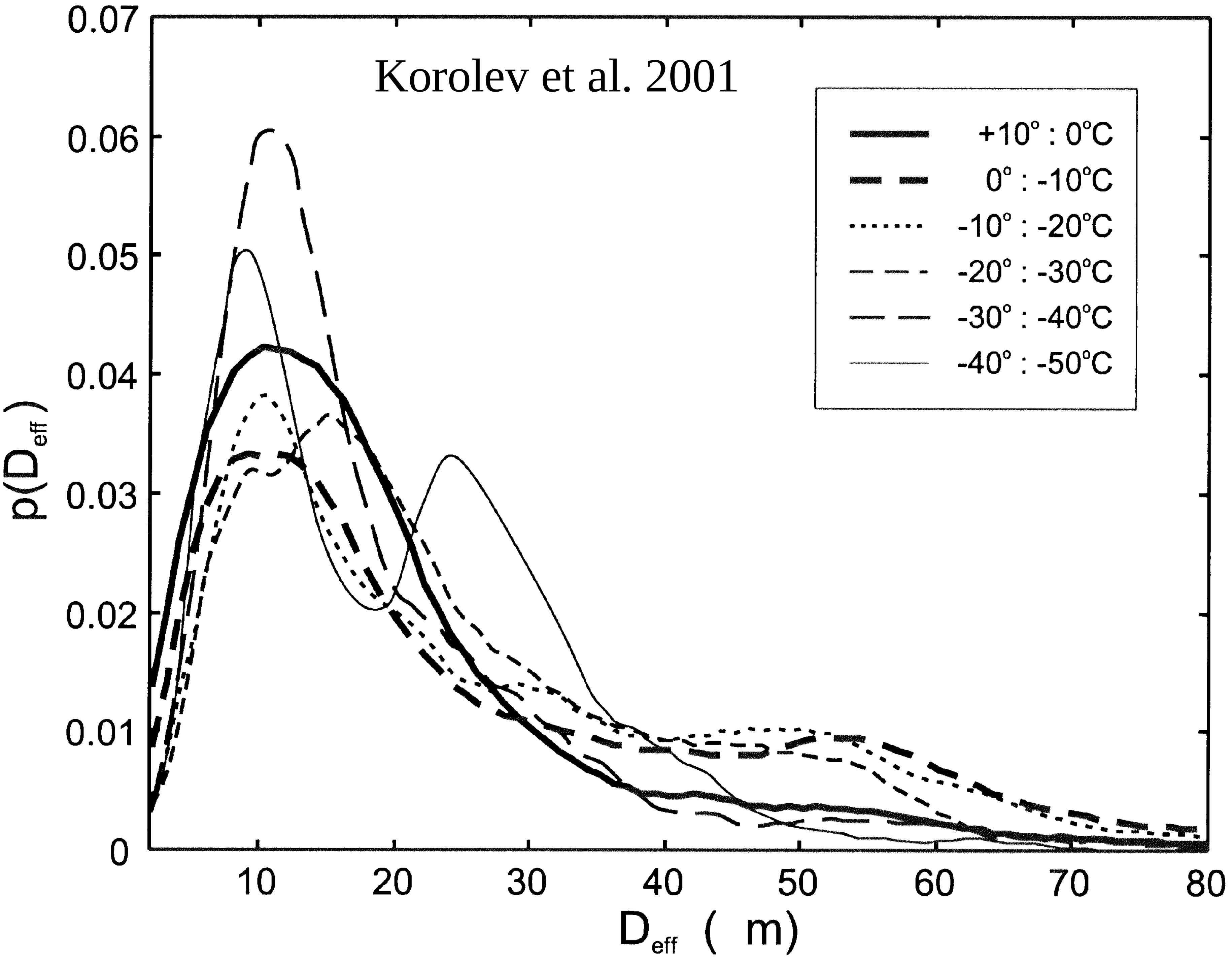
Heymsfield & McFarquhar (2002)



Temperature [°C]
−70
−60
−50
−40
−30
−20
to
to
to
to
to
0
1000
2000
3000
4000
D_{max} [μm]
FIRE2
EUCREX
FIRE1
KWAJALEIN
JECK
CCOPE
SUCCESS
FIRE2 UND
CEPEX



−70
−60
−50
−40
−30
−20
to
to
to
to
to
Temperature [°C]
0.1
1.0
10.0
100.0
$N_{>100}$ [l^{-1}]
FIRE2
EUCREX
FIRE1
JECK
SUCCESS
FIRE2 UND
CEPEX



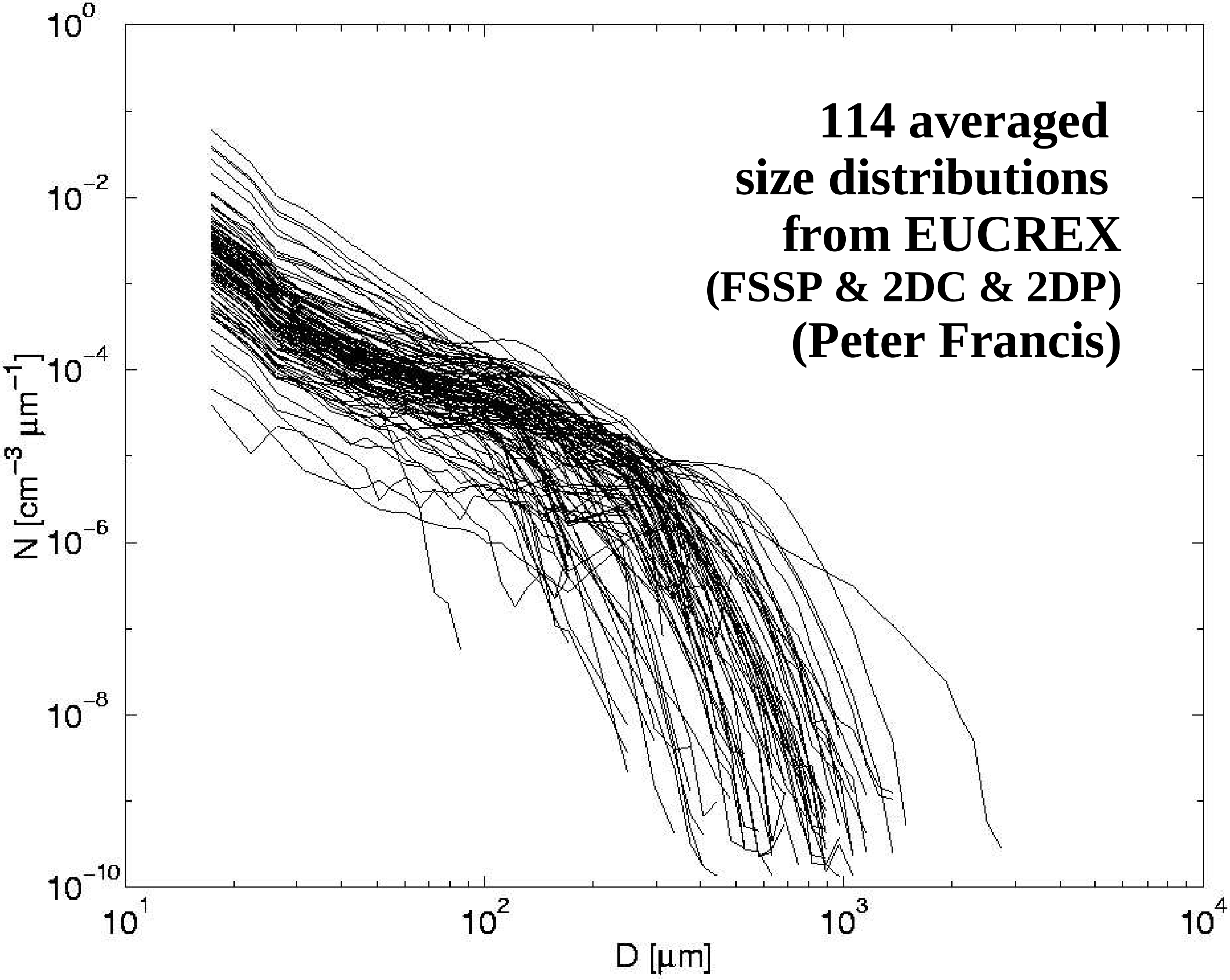
Korolev et al. 2001
+10° : 0°C
0° : -10°C
-10° : -20°C
-20° : -30°C
-30° : -40°C
-40° : -50°C
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
10
20
30
40
50
60
70
80
p(D_eff)
D_eff (m)

Summary

- No significant correlation between ice crystal size/number density and cloud temperature. **No climatology from in-situ data!**
- Variability of particle sizes increases with increasing temperature
- Heymsfield & McFarquhar (2002): "*There is a wide scatter in the data, both for an individual project and between projects. Some of these differences may be caused by probe calibration differences and differences in the manner in which the data are processed. The magnitude of the total concentration of the size spectra are uncertain because of the inability to reliably measure ice crystals with maximum dimension below 25 micron.*"
- Korolev et al (2001): "*To a first approximation, the effective diameter may be considered as a weak function of temperature.*"

Conclusions (microphysics)

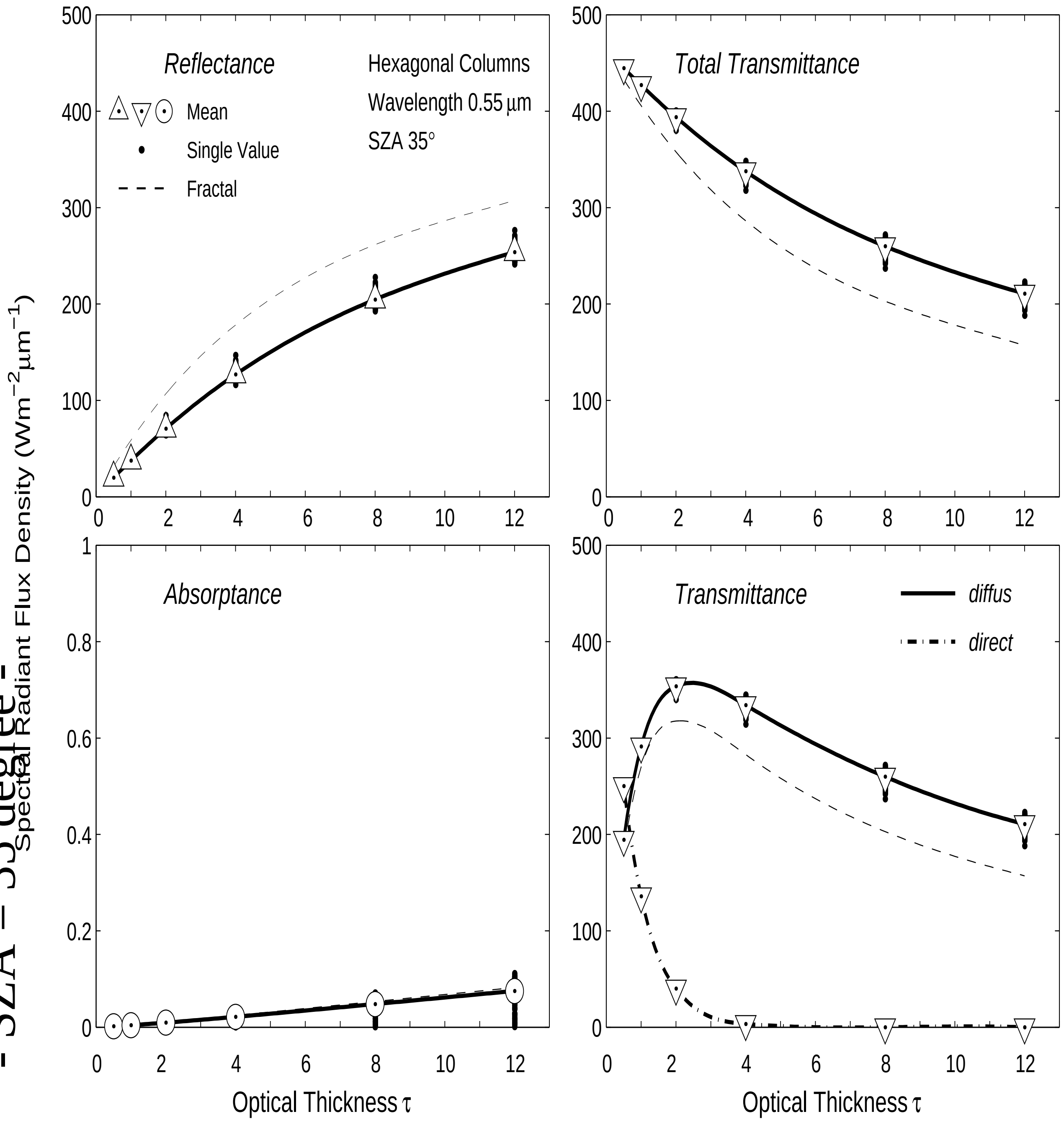
- **Particle sizes, shapes, and number densities may be a more direct function of the history of the air parcel. Dependencies on local atmospheric conditions low. -> GRP Note (GEWEX NEWS)!**
- **Cirrus cloud microphysical properties as white noise: Consequences for cirrus radiative transfer** (Macke & Schlimme, 2004, JAS, submitted)



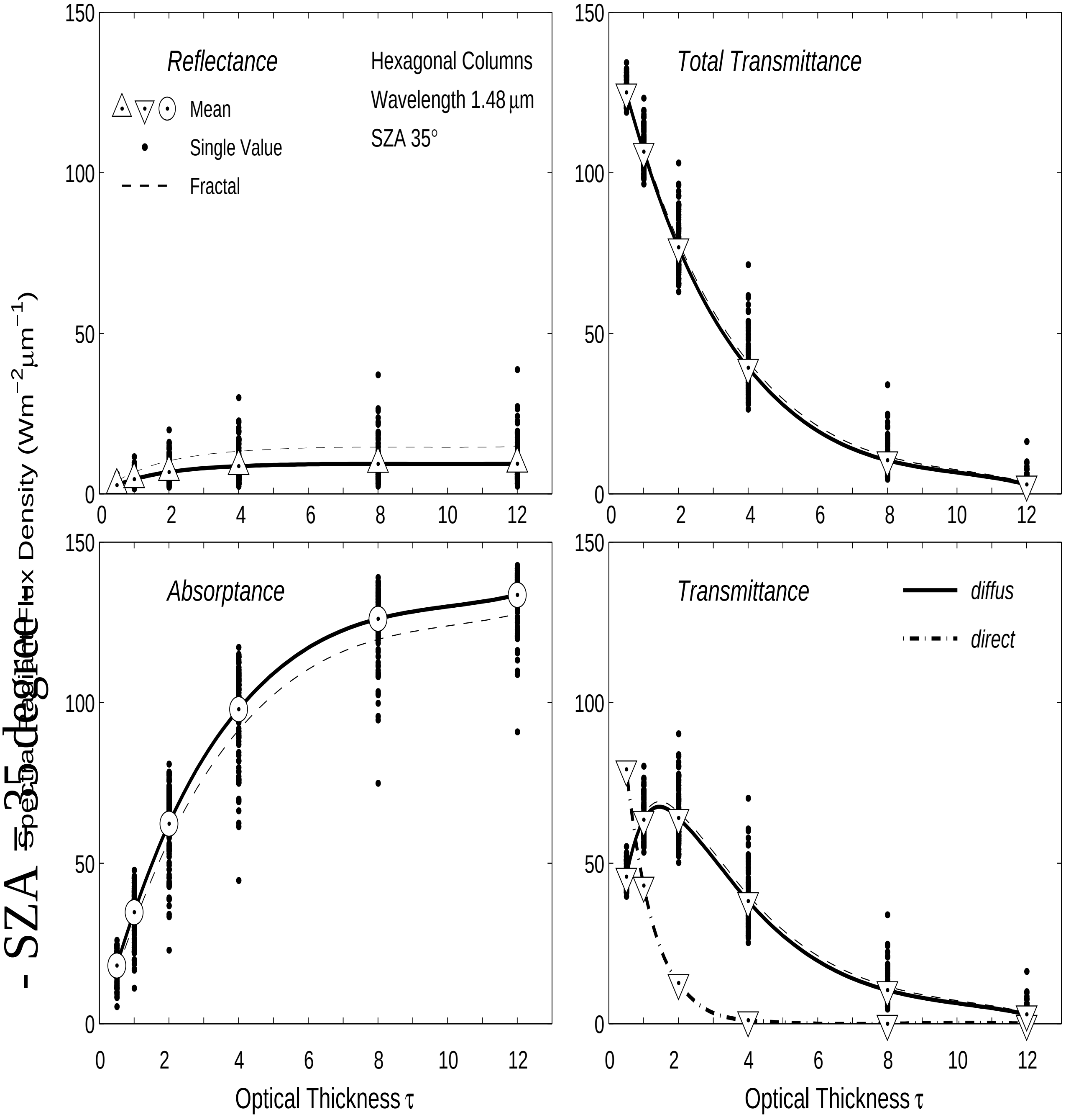
114 averaged
size distributions
from EUCREX
(FSSP & 2DC & 2DP)
(Peter Francis)
N [cm^{-3} µm^{-1}]
D [µm]
10^0
10^{-2}
10^{-4}
10^{-6}
10^{-8}
10^{-10}
10^1
10^2
10^3
10^4

Solar fluxes at visible (non-absorbing) wavelengths

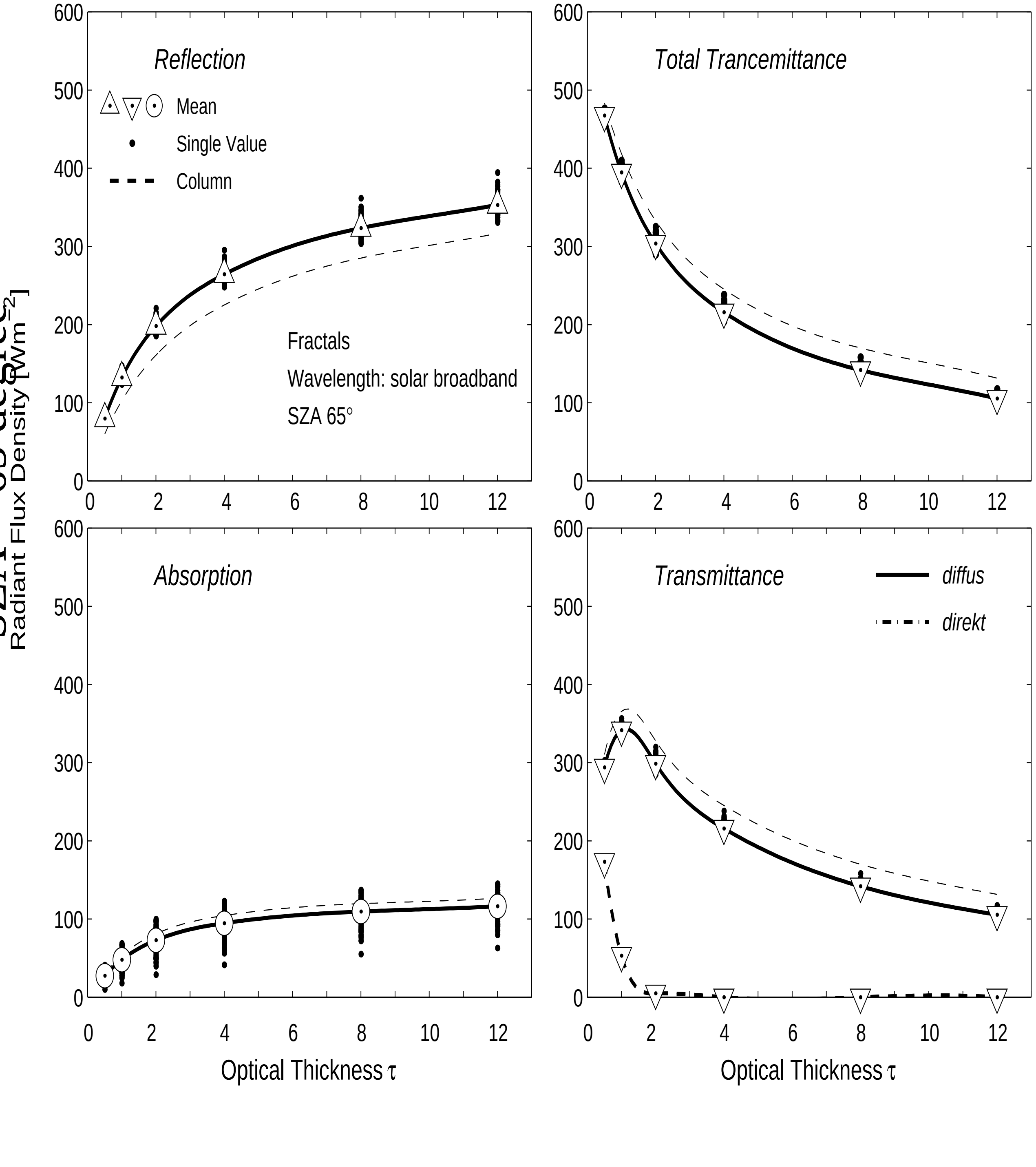
- SZA = 35 degree -

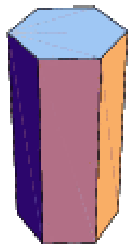
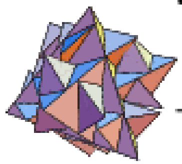


Solar fluxes at near IR (absorbing) wavelengths - SZA = 35 degree



Solar broadband fluxes
- SZA = 65 degree -



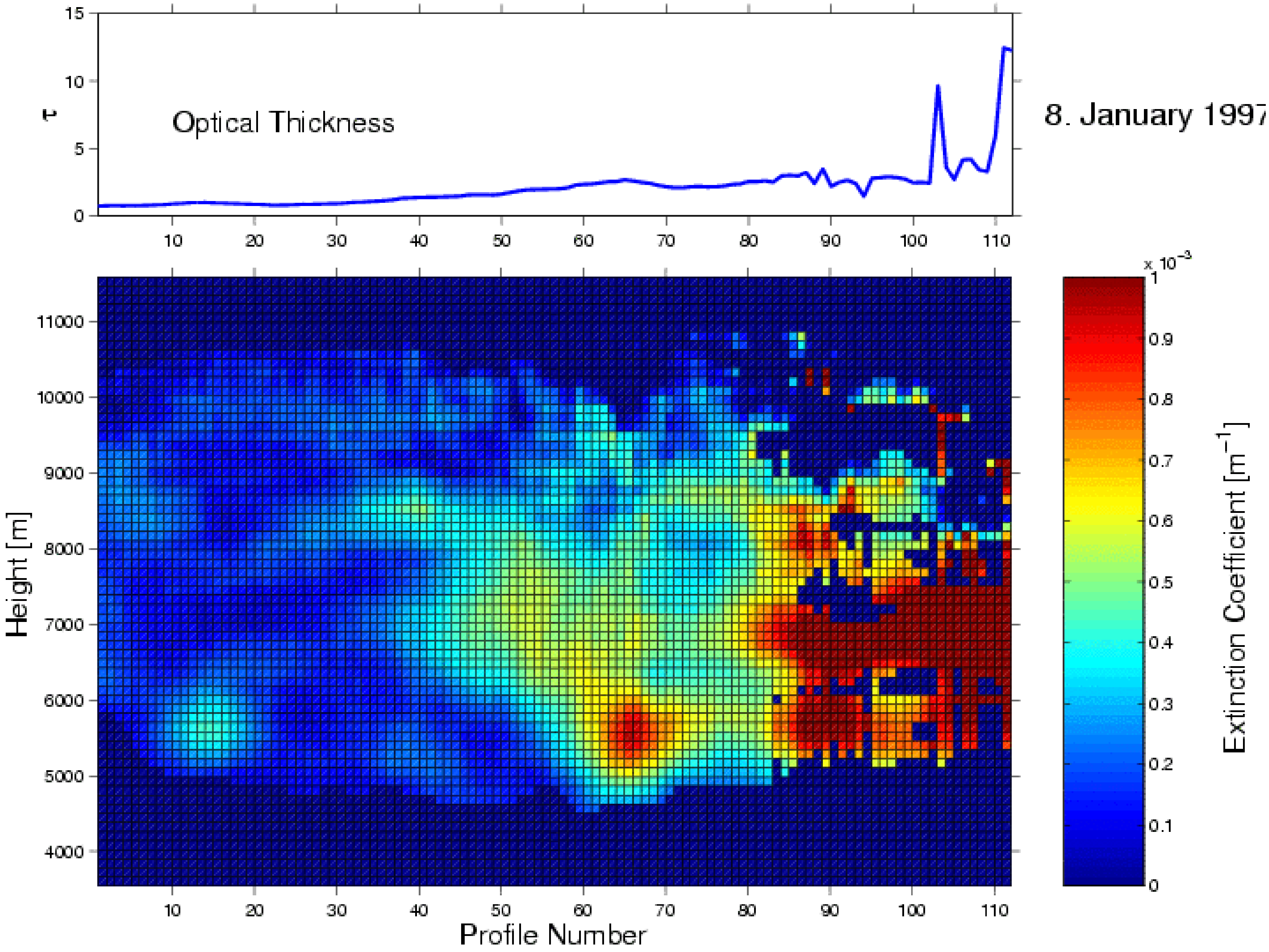
	Θ	τ	upward		down(diff)		absorbed	
			s	υ	s	υ	s	υ
	35	1	8.1	9.4	4.1	0.6	12.1	19.2
		4	21.3	7.9	4.1	0.6	24.9	14.2
	65	1	7.1	6.9	3.0	0.8	10.0	18.7
		4	12.7	5.6	2.1	0.9	14.6	14.0
	35	1	4.6	3.8	9.3	1.5	13.9	24.1
		4	14.0	4.0	15.9	2.7	29.9	18.3
	65	1	5.2	3.9	6.2	1.8	11.4	23.8
		4	10.0	3.8	7.1	3.3	17.1	18.1

Θ : Solar Zenith Angle [degree]

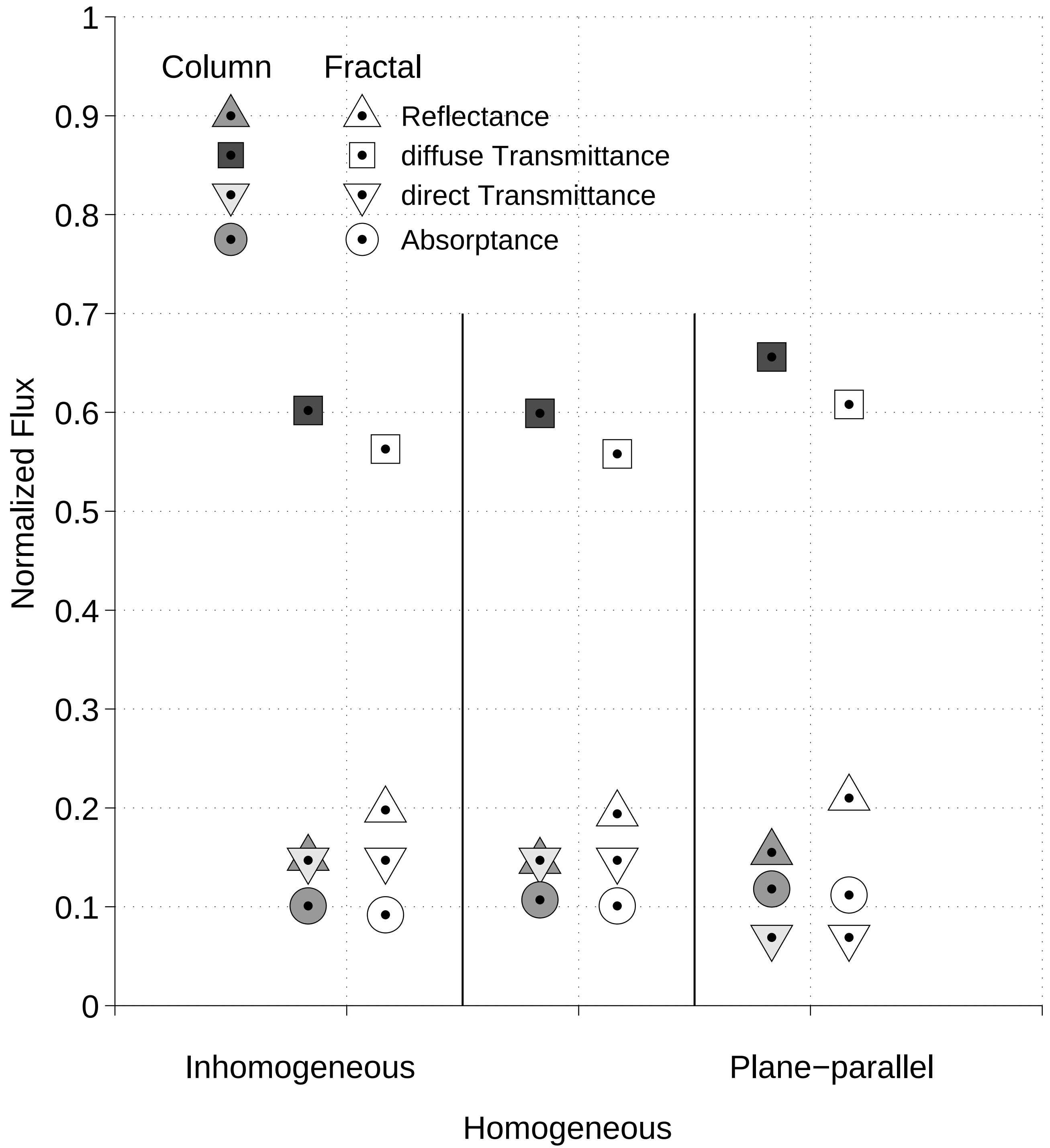
τ : Optical Thickness

s : Standard Deviation [Wm^{-2}]

υ : Standard Deviation [%]



Optical Thickness
τ
15
10
5
0
10
20
30
40
50
60
70
80
90
100
110
8. January 1997
Height [m]
11000
10000
9000
8000
7000
6000
5000
4000
Profile Number
Extinction Coefficient [m⁻¹]
x 10⁻³
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0



Normalized Flux
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Column
Fractal
Reflectance
diffuse Transmittance
direct Transmittance
Absorptance
Inhomogeneous
Plane−parallel
Homogeneous

Conclusions (radiation)

- natural variability of particle sizes causes uncertainties of O(10 Wm^{-2}) in solar broadband cirrus radiative fluxes
- cloud macrophysics and cloud microphysics are equally important