Extending HIRS High Cloud Trends with MODIS

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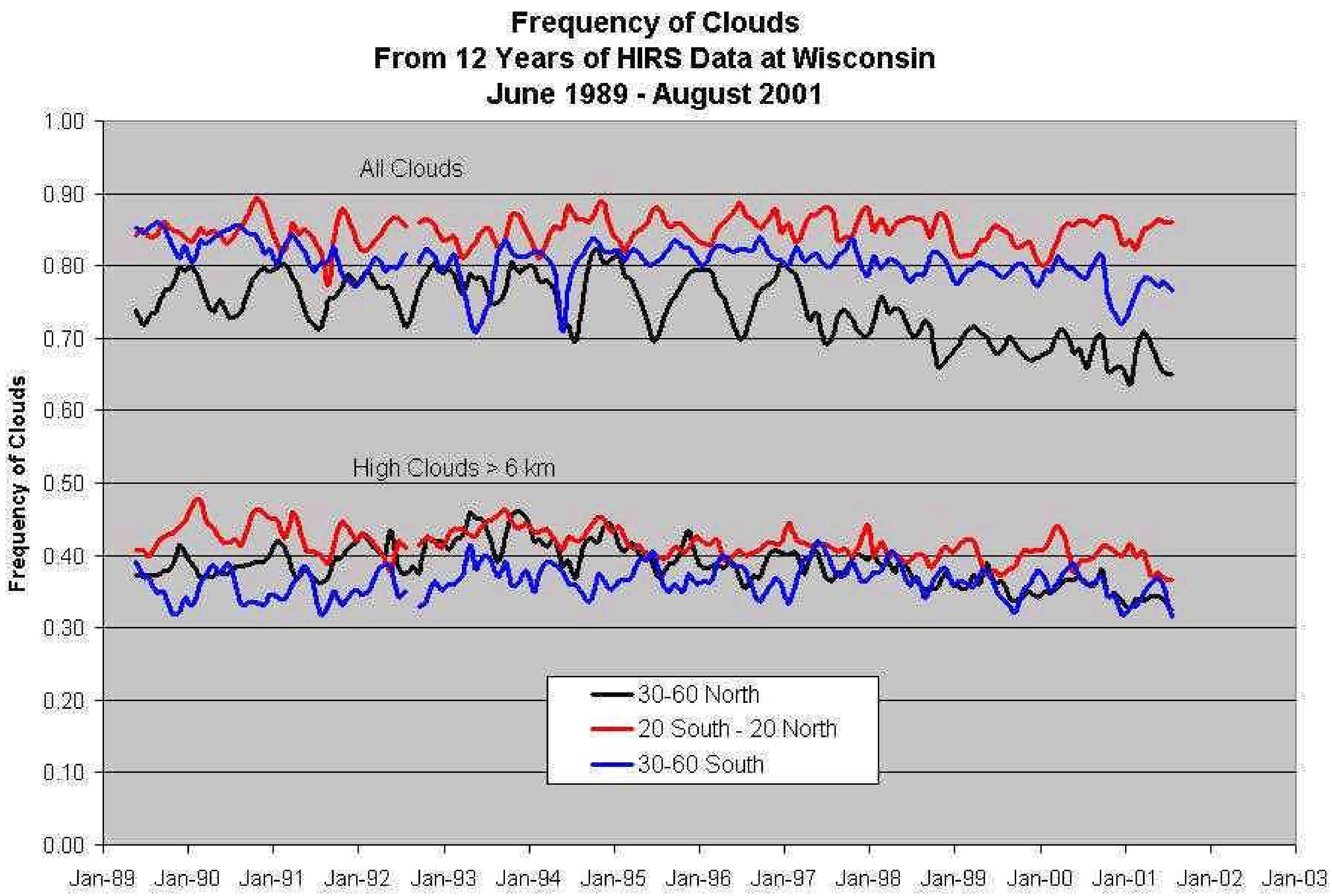
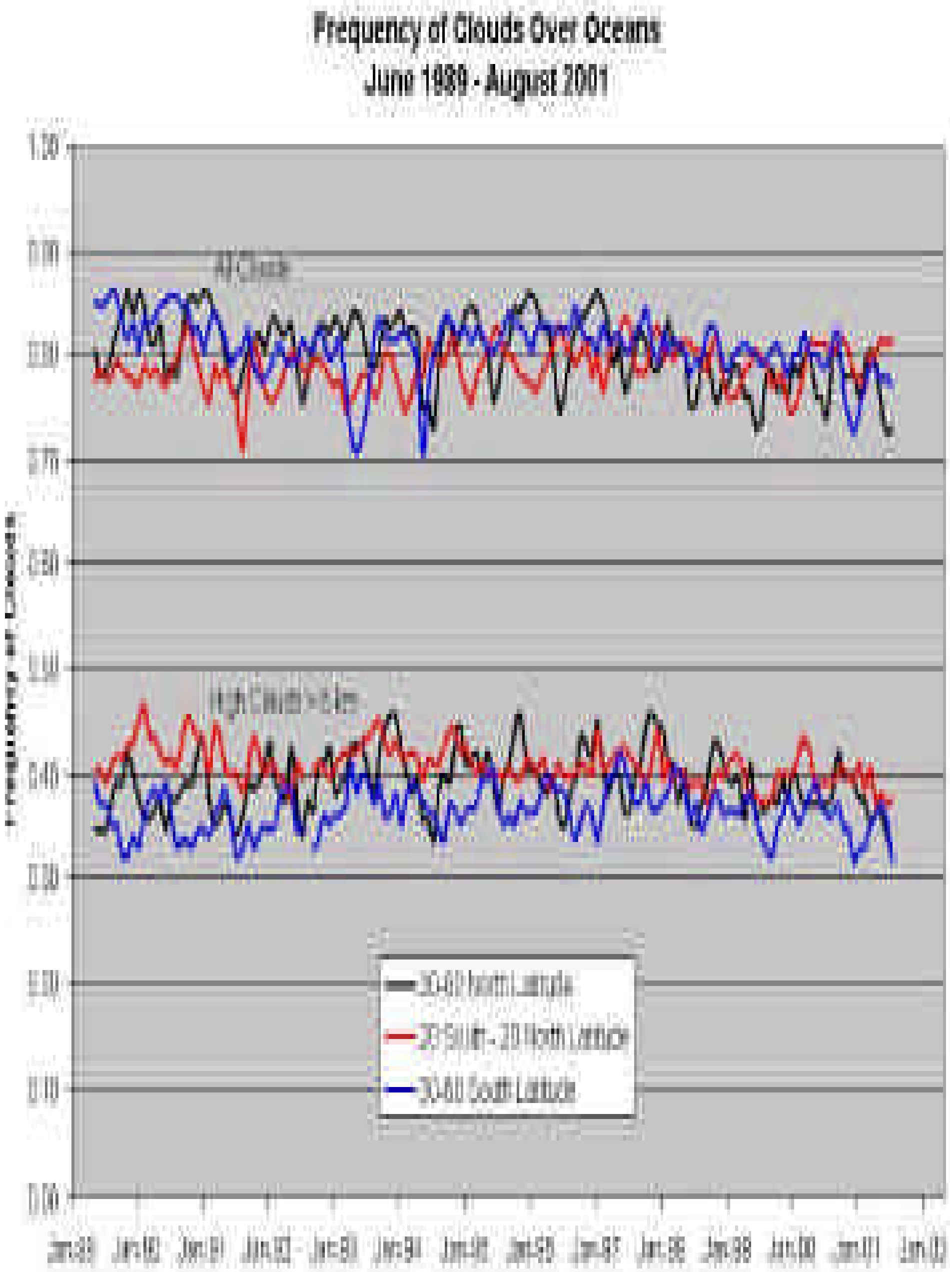
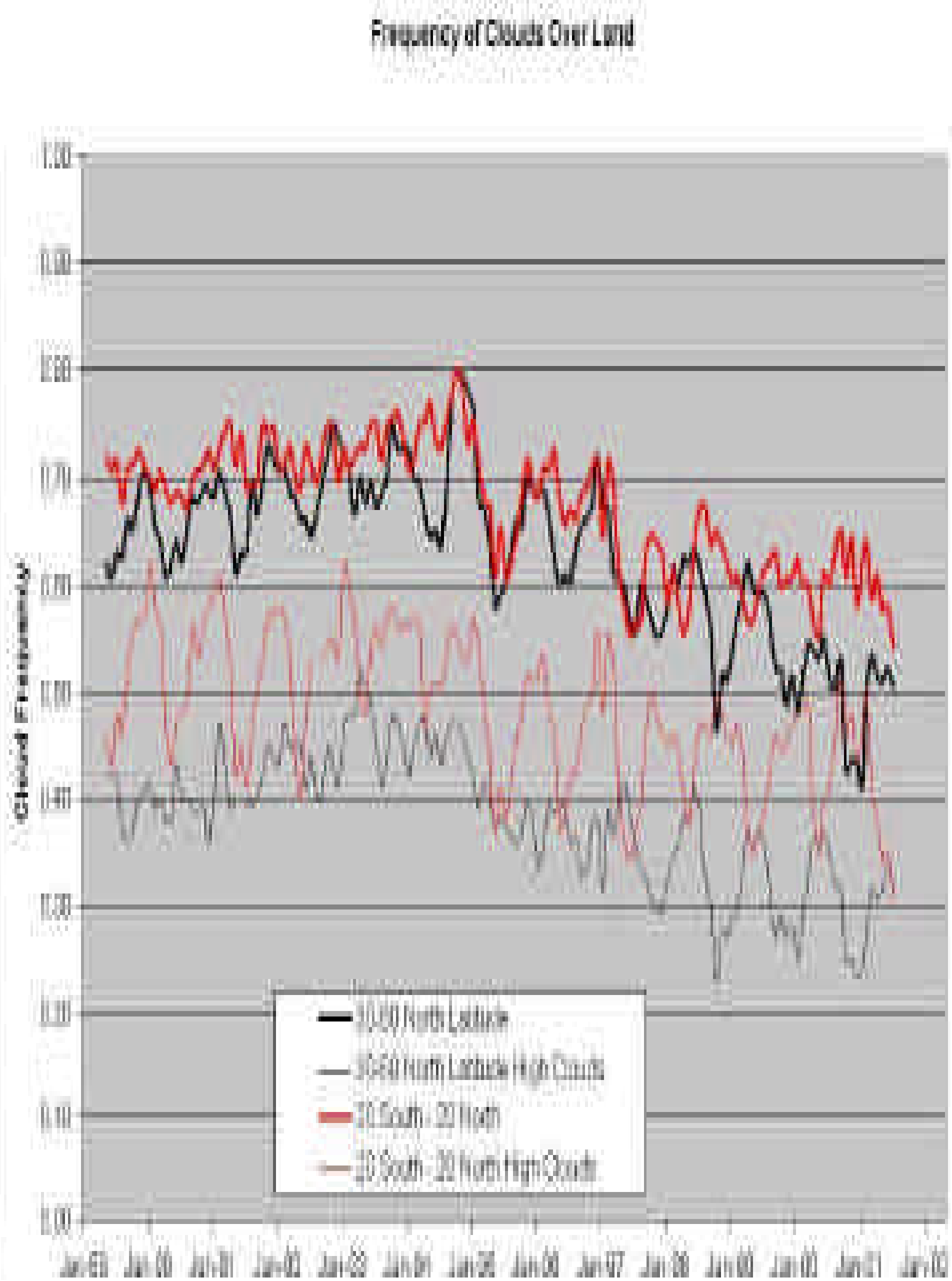
12 year trends
Effects of orbit drift and ancillary Tsfc
Comparison with MODIS

July 2002


Frequency of Clouds
From 12 Years of HIRS Data at Wisconsin
June 1989 - August 2001
All Clouds
High Clouds > 6 km
Frequency of Clouds
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
Jan-89
Jan-90
Jan-91
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
30-60 North
20 South - 20 North
30-60 South


Frequency of Clouds Over Oceans
June 1989 - August 2001
All Clouds
High Clouds
30-60 North Latitude
20 South - 20 North Latitude
30-60 South Latitude


Frequency of Clouds Over Land
Cloud Frequency
30-60 North Latitude
30-60 North Latitude High Clouds
20 South - 20 North
20 South - 20 North High Clouds

Cloud Properties from CO2 Slicing

RTE for cloudy conditions indicates dependence of cloud forcing (observed minus clear sky radiance) on cloud amount ($\eta\varepsilon_\lambda$) and cloud top pressure (p_c)

$$(I_\lambda - I_\lambda^{clr}) = \eta\varepsilon_\lambda \int_{p_s}^{p_c} \tau_\lambda \, dB_\lambda \, .$$

Higher colder cloud or greater cloud amount produces greater cloud forcing; dense low cloud can be confused for high thin cloud. Two unknowns require two equations.

p_c can be inferred from radiance measurements in two spectral bands where cloud emissivity is the same. $\eta\varepsilon_\lambda$ is derived from the infrared window, once p_c is known.

Different ratios reveal cloud properties at different levels

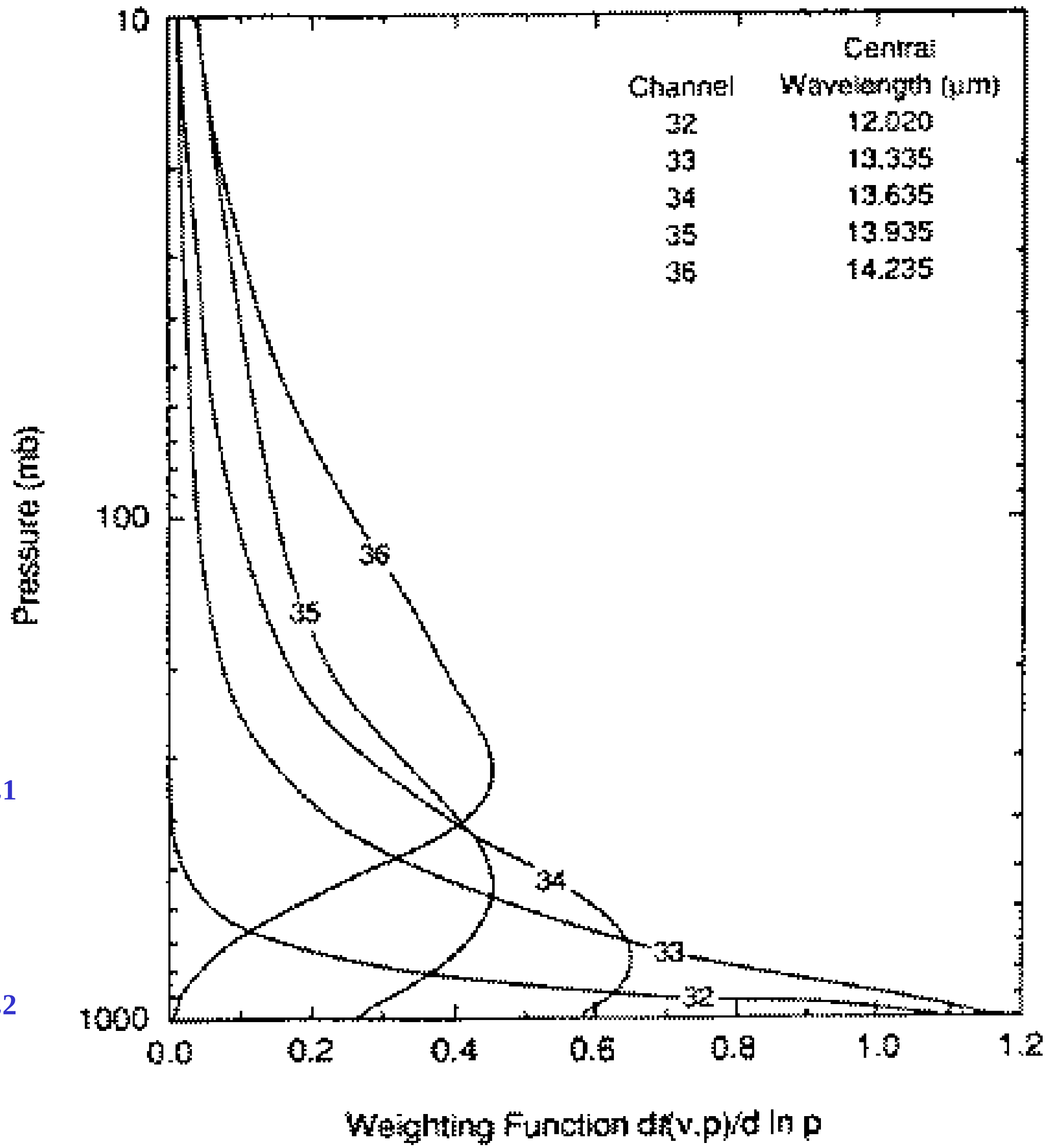
hi - 14.2/13.9

mid - 13.9/13.6

low - 13.6/13.3

Meas Calc

$$\frac{(I_{\lambda 1}-I_{\lambda 1}^{clr})}{(I_{\lambda 2}-I_{\lambda 2}^{clr})} = \frac{\eta \varepsilon_{\lambda 1} \int_{p_s}^{p_c} \tau_{\lambda 1}\, dB_{\lambda 1}}{\eta \varepsilon_{\lambda 2} \int_{p_s}^{p_c} \tau_{\lambda 2}\, dB_{\lambda 2}}$$



Generating HIRS Clear Sky Radiances in Cloudy FOVs

Use IR Window Moisture Corrected Brightness Temperature Test against a priori surface temperature to identify nearby clear sky FOVs

BT11 + aPW * (BT11 - BT12) - Sfc Temp < 2 C

aPW of 0.8 has been used

Sfc Temp estimated from GDAS

Estimate I_{λ}^{clr} *by interpolating nearby clear FOVs*

cld =	*x*	*x*	*x*	*o*	*o*	= *clr*
	x	*x*	*x*	*o*	*o*	
	o	*x*	*x*	*o*	*o*	
	o	*x*	***x***	*x*	*o*	
	o	*x*	*x*	*o*	*o*	
	x	*x*	*x*	*o*	*o*	

Attempt to derive CO2 cloud properties in x (note that CO2 cloud algorithm attempt on x can change FOV to o)

Determining Cloud Presence and Properties with HIRS

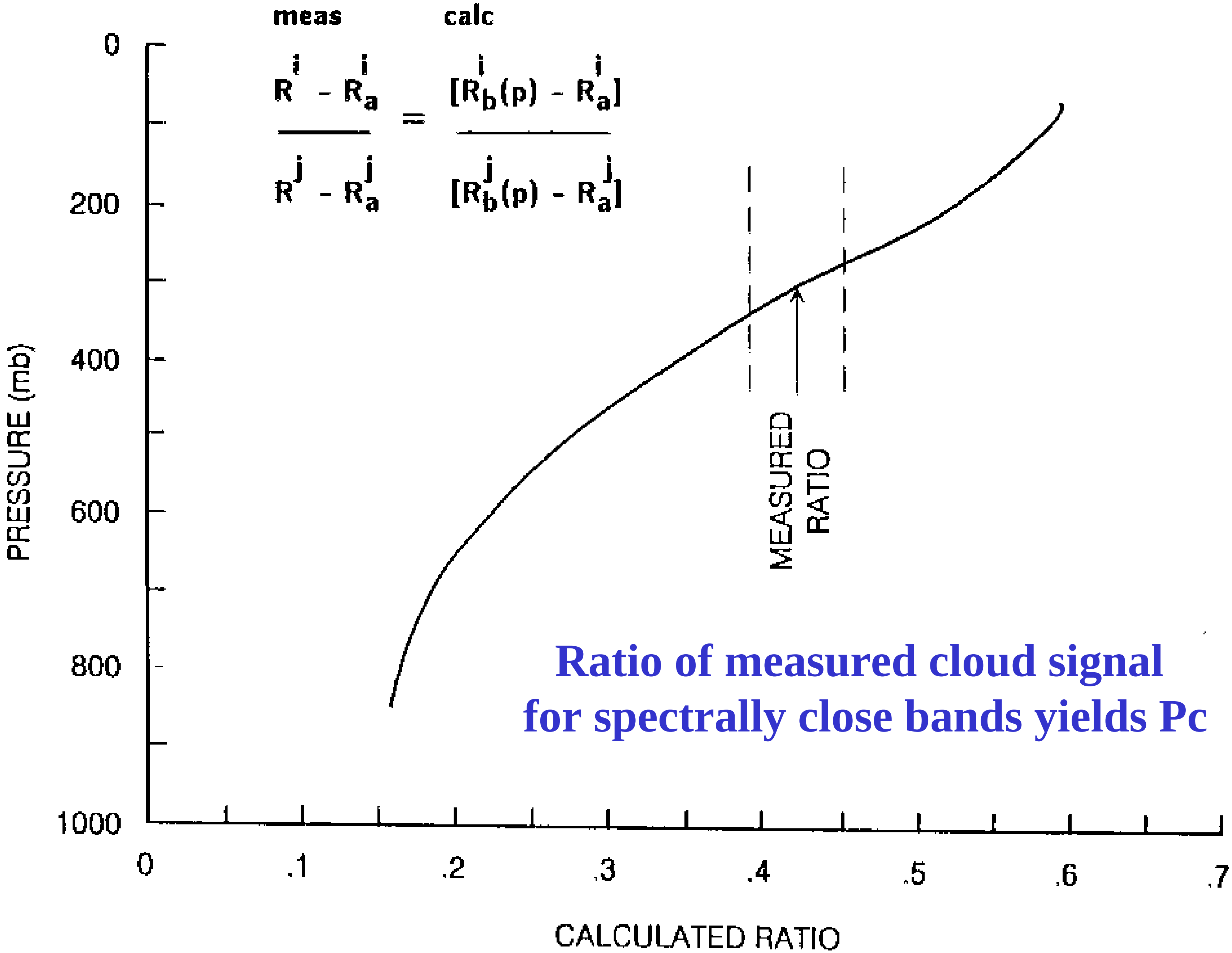
Use bands where $(I_\lambda - I_\lambda^{clr}) > 1$ *mW/m2/ster/cm-1 in CO2 slicing estimation of* p_c

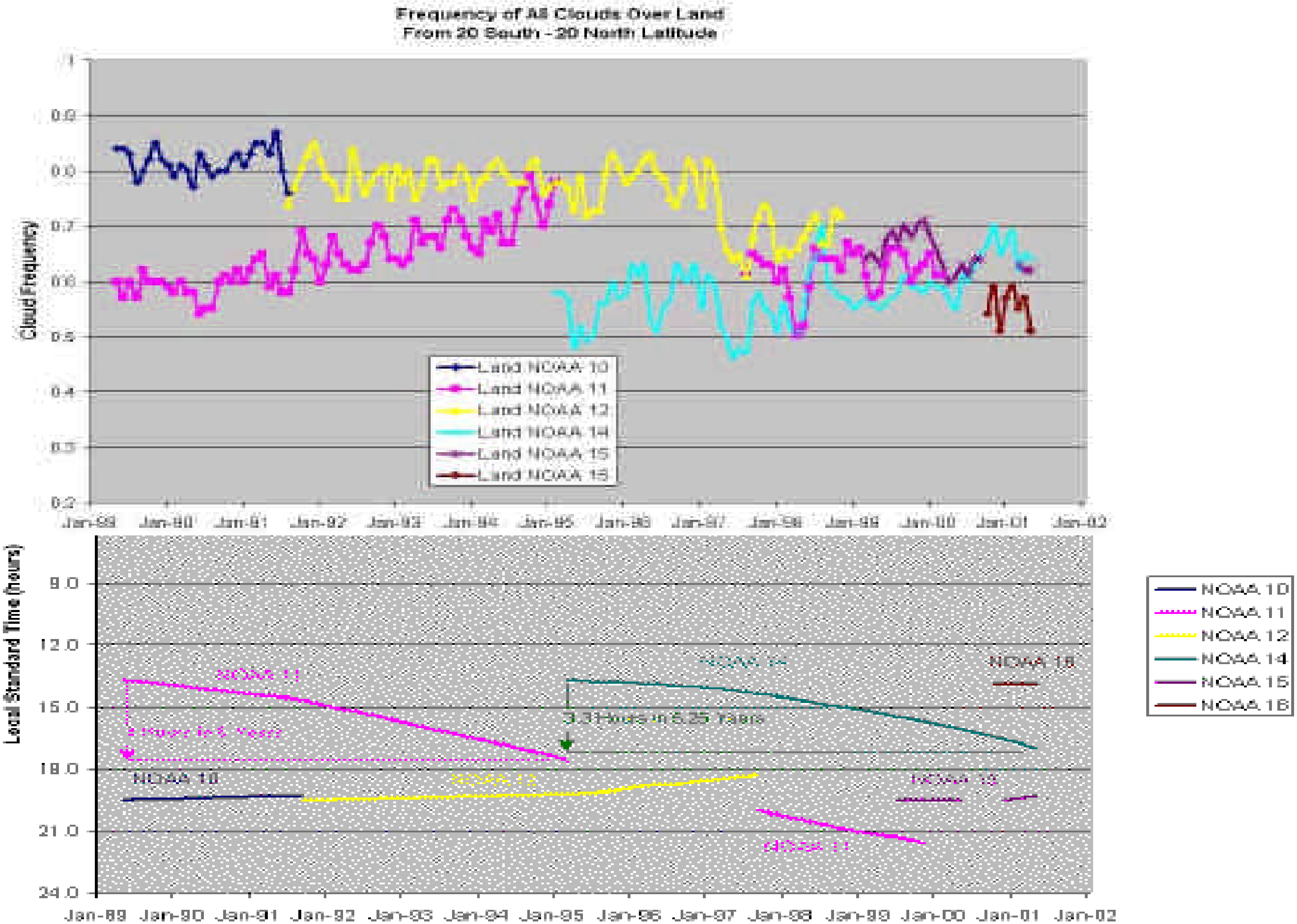
Estimate $\eta\varepsilon_{IRW}$ *using IRW radiances*

If more than one p_c *is estimated, use RTE for all bands to select best one*

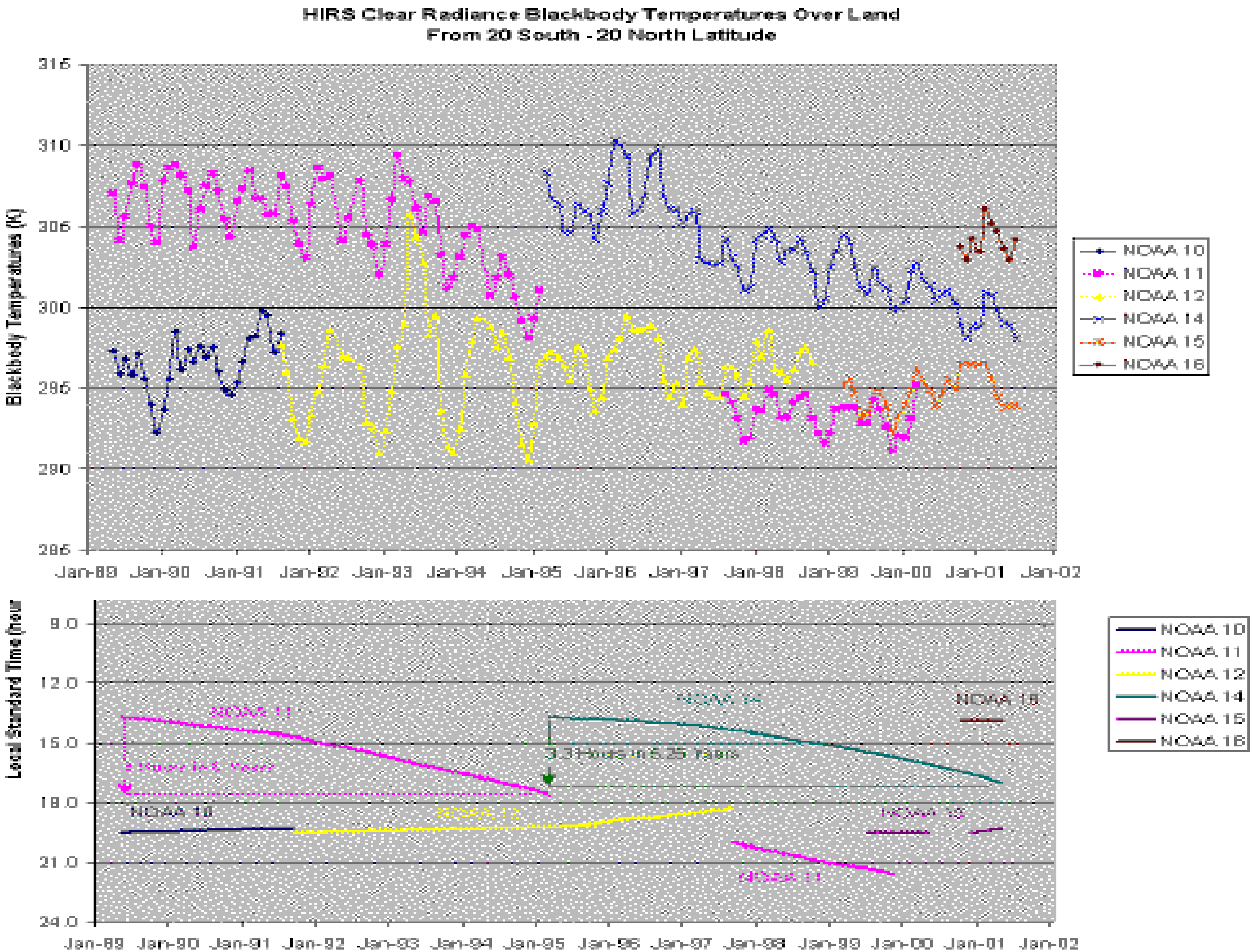
If no bands qualify, try IR window estimate for opaque cld

If too low in atmosphere, declare FOV clear

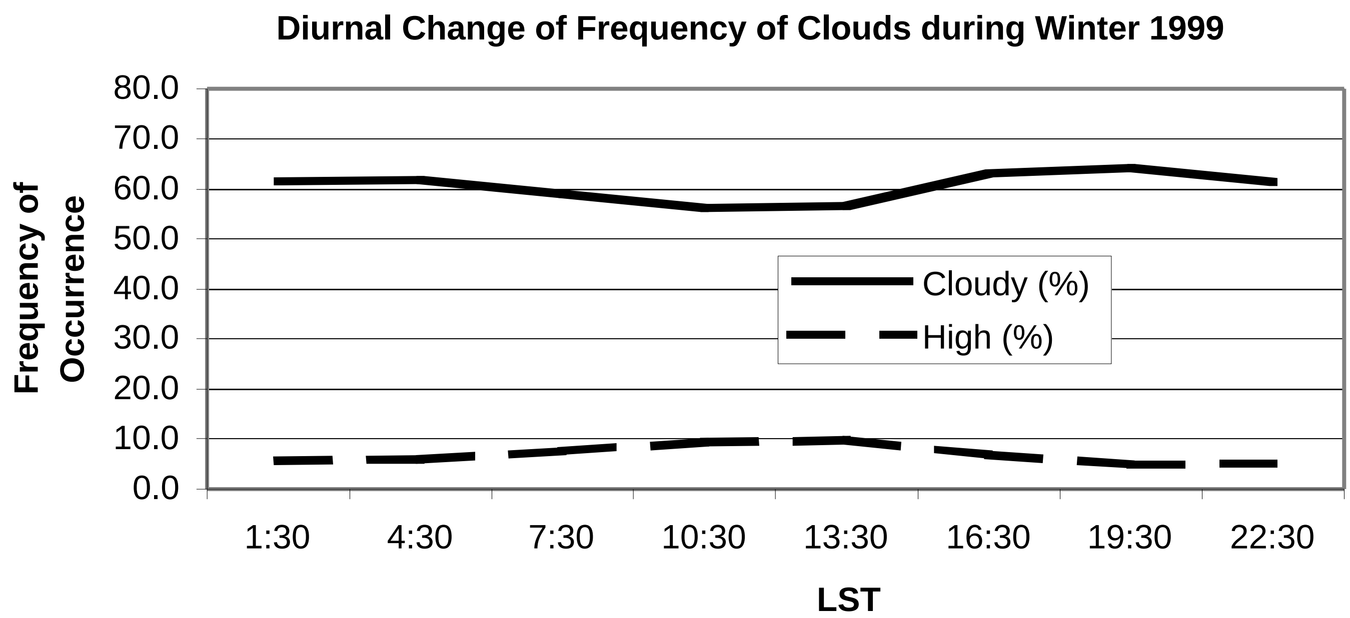

meas
calc
$$\frac{R^i - R^i_a}{R^j - R^j_a} = \frac{[R^i_b(p) - R^i_a]}{[R^j_b(p) - R^j_a]}$$
PRESSURE (mb)
0
200
400
600
800
1000
MEASURED RATIO
0
.1
.2
.3
.4
.5
.6
.7
CALCULATED RATIO
Ratio of measured cloud signal for spectrally close bands yields Pc

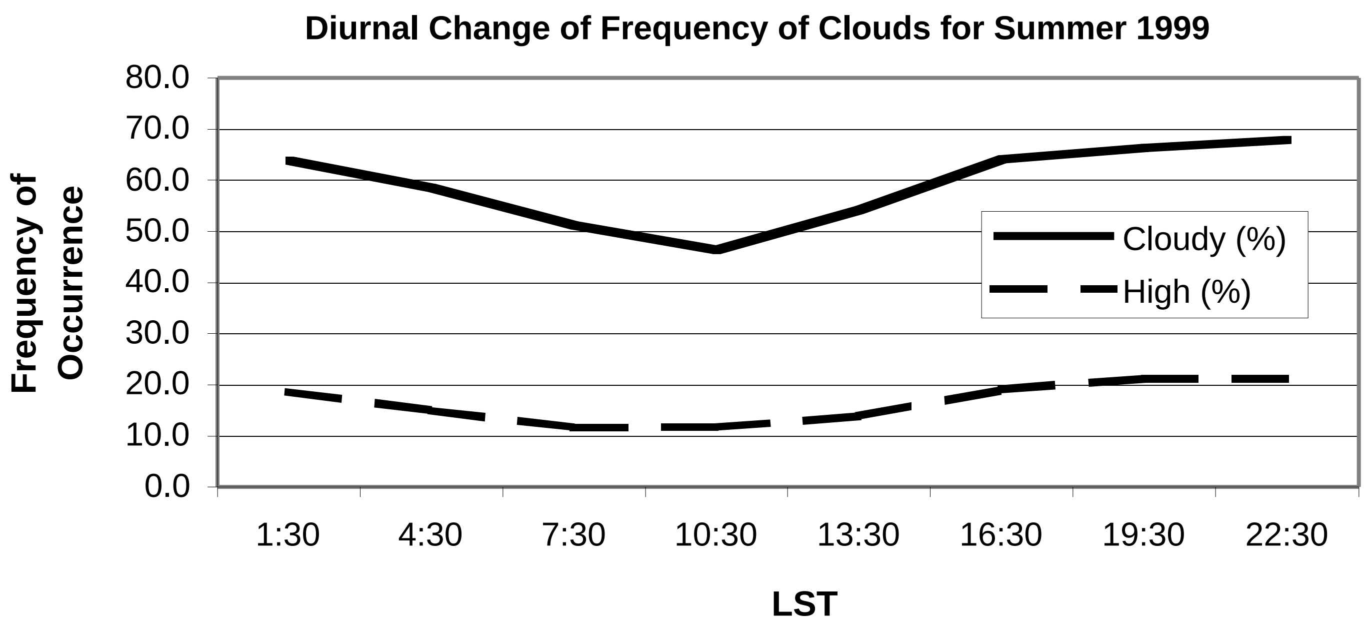


Frequency of All Clouds Over Land
From 20 South - 20 North Latitude
Cloud Frequency
Land NOAA 10
Land NOAA 11
Land NOAA 12
Land NOAA 14
Land NOAA 15
Land NOAA 16
Local Standard Time (hours)
9.0
12.0
15.0
18.0
21.0
24.0
NOAA 10
NOAA 11
NOAA 12
NOAA 14
NOAA 15
NOAA 16
Jan-89
Jan-90
Jan-91
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02

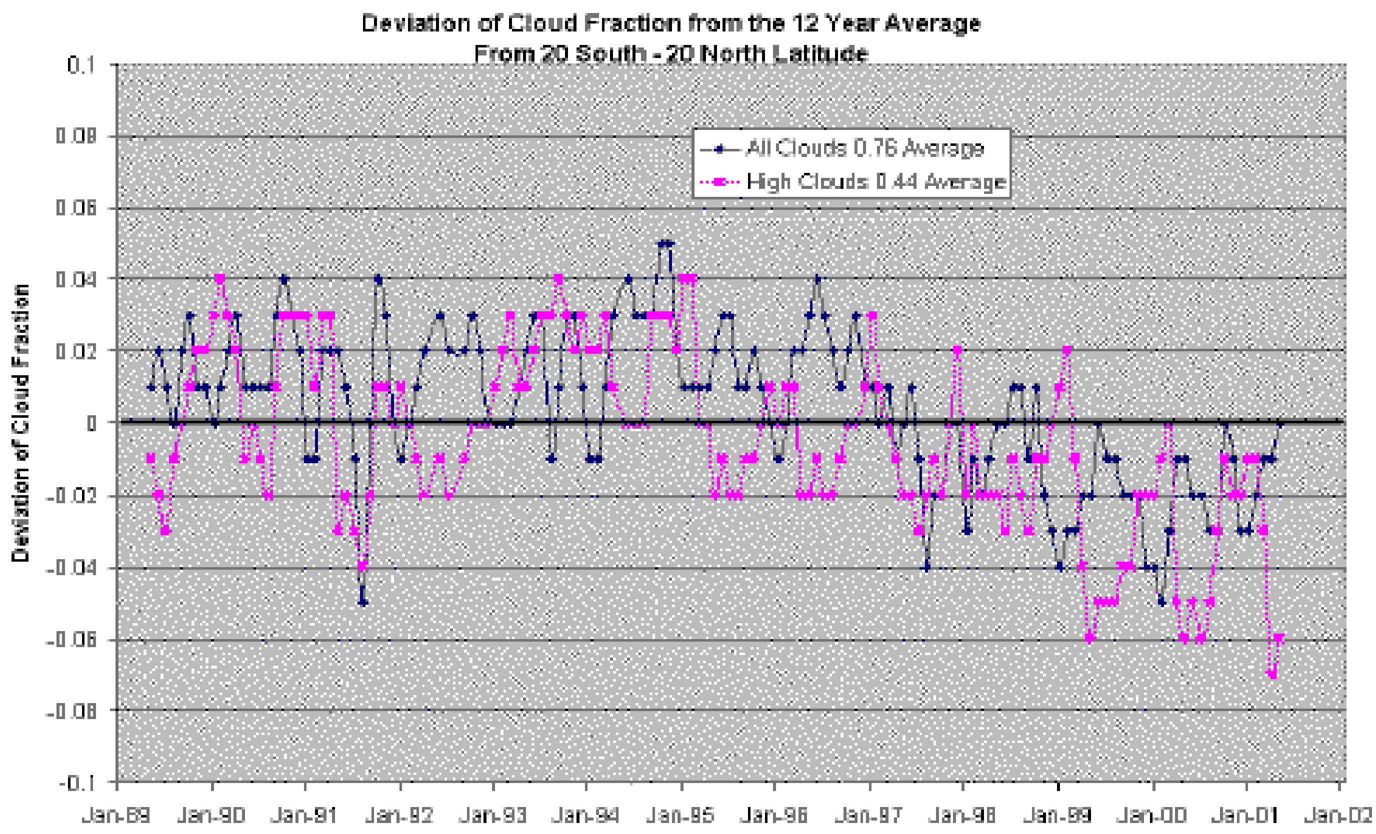

HIRS Clear Radiance Blackbody Temperatures Over Land
From 20 South - 20 North Latitude
Blackbody Temperatures (K)
315
310
305
300
295
290
285
Jan-89
Jan-90
Jan-91
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
NOAA 10
NOAA 11
NOAA 12
NOAA 14
NOAA 15
NOAA 16
Local Standard Time (hour
9.0
12.0
15.0
18.0
21.0
24.0
3.3 Hours in 5.25 Years
NOAA 10
NOAA 16

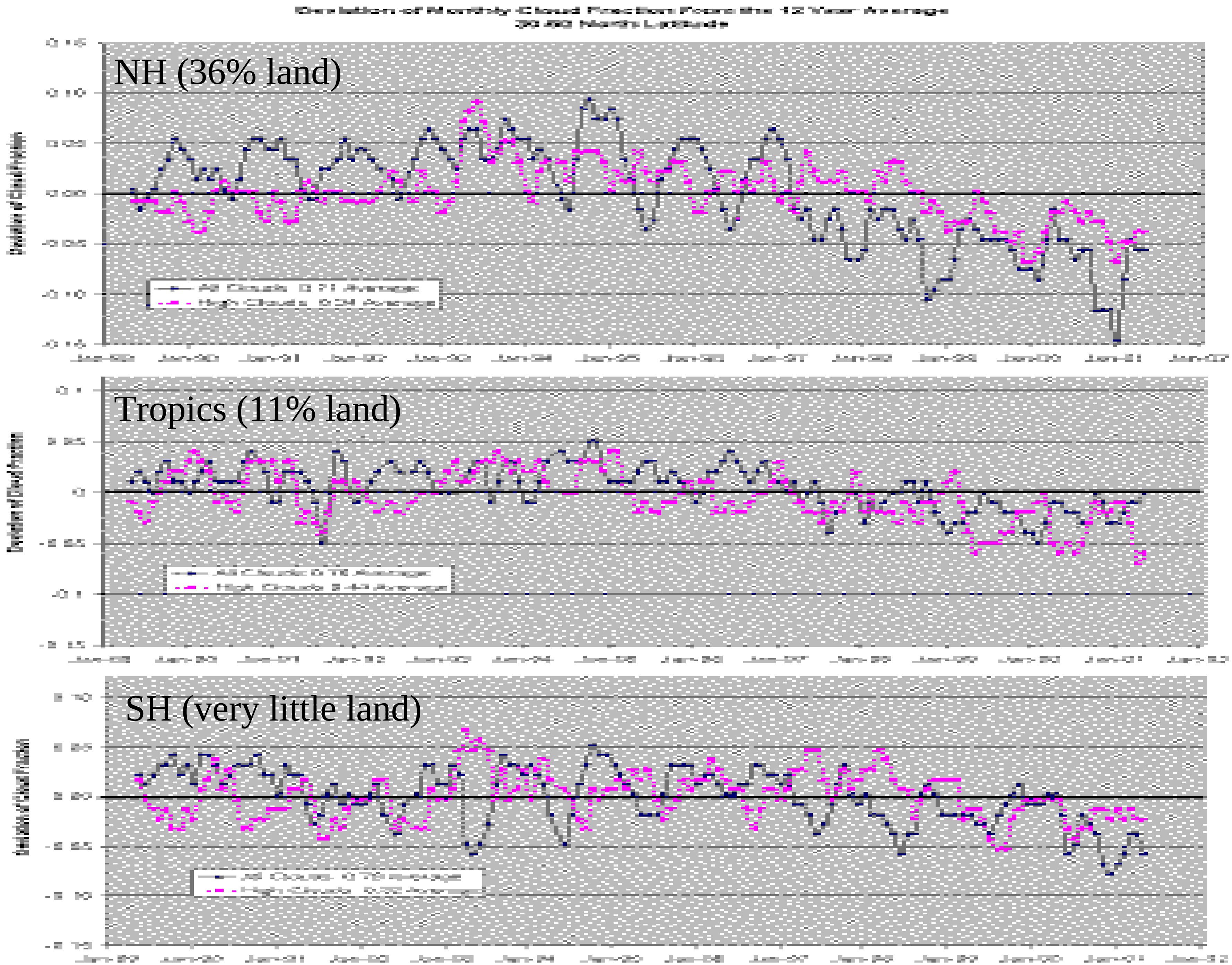
GOES Sounder detecting diurnal change of cloud cover





Wielicki et al (2002) CERES deviation of reflected shortwave flux wrt 1985-89 mean for 20N-20S




NH (36% land)
Tropics (11% land)
SH (very little land)

Determining Cloud Presence and Properties with MODIS

Use MODIS Cloud Mask to determine cloud presence

Calculate I_λ^{clr} *from GDAS*

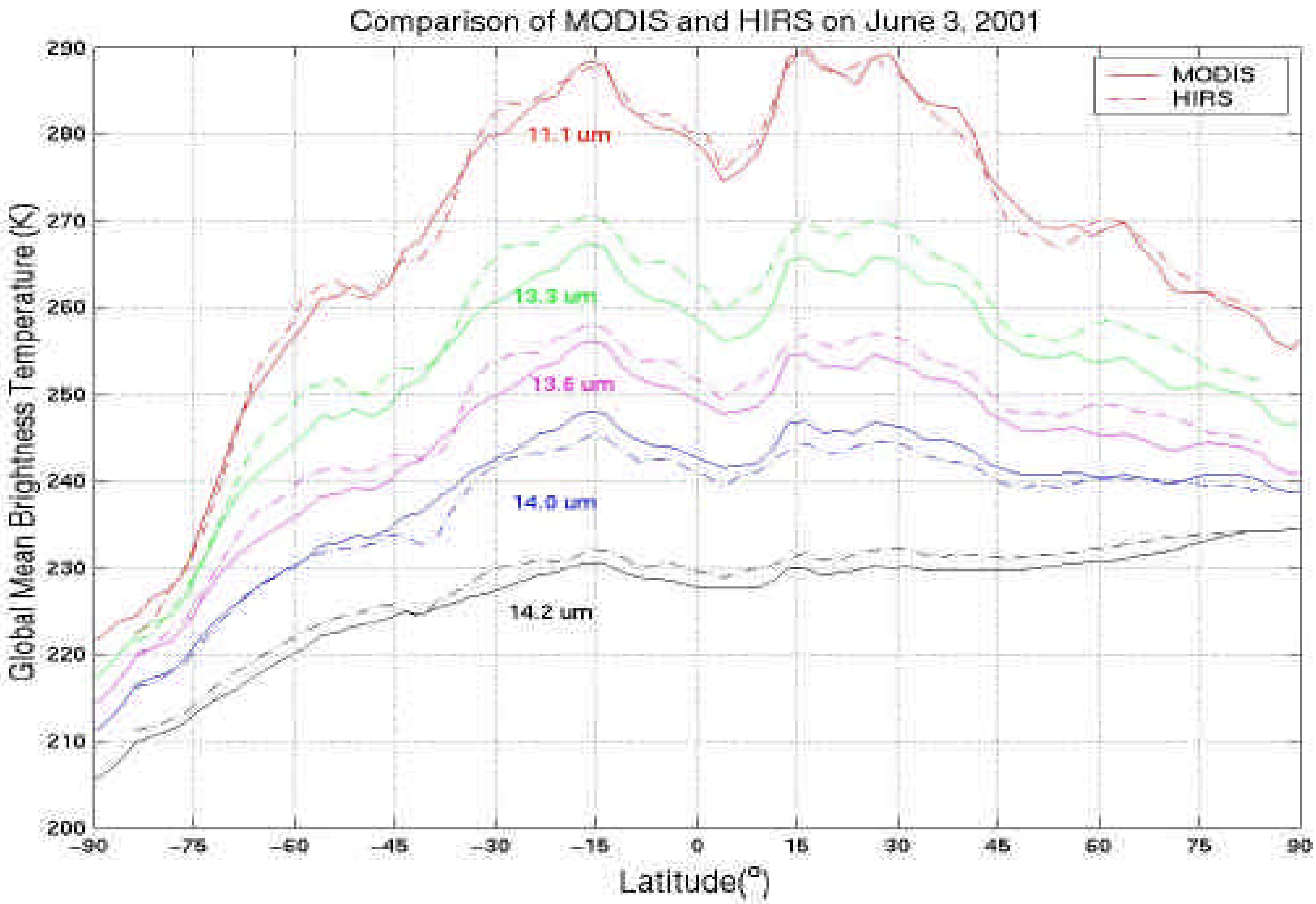
Attempt CO2 slicing estimation of p_c *on 5x5 FOV average*
when $(I_\lambda - I_\lambda^{clr}) > 1$ *mW/m2/ster/cm-1*

Estimate $\eta\varepsilon_{IRW}$ *using IRW radiances*

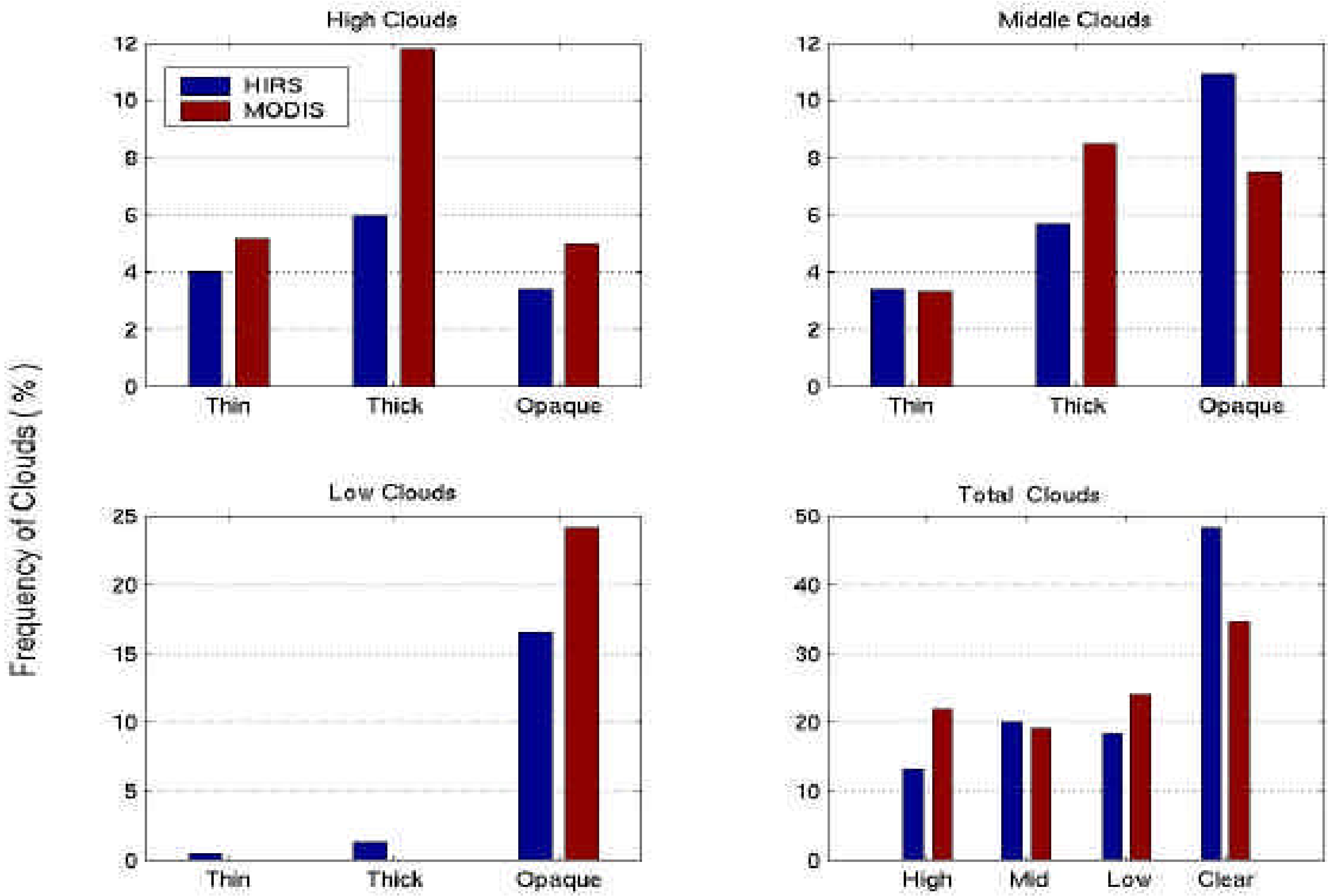
If no bands qualify, try IR window estimate for opaque cld

Differences in MODIS and HIRS Cloud Property Processing

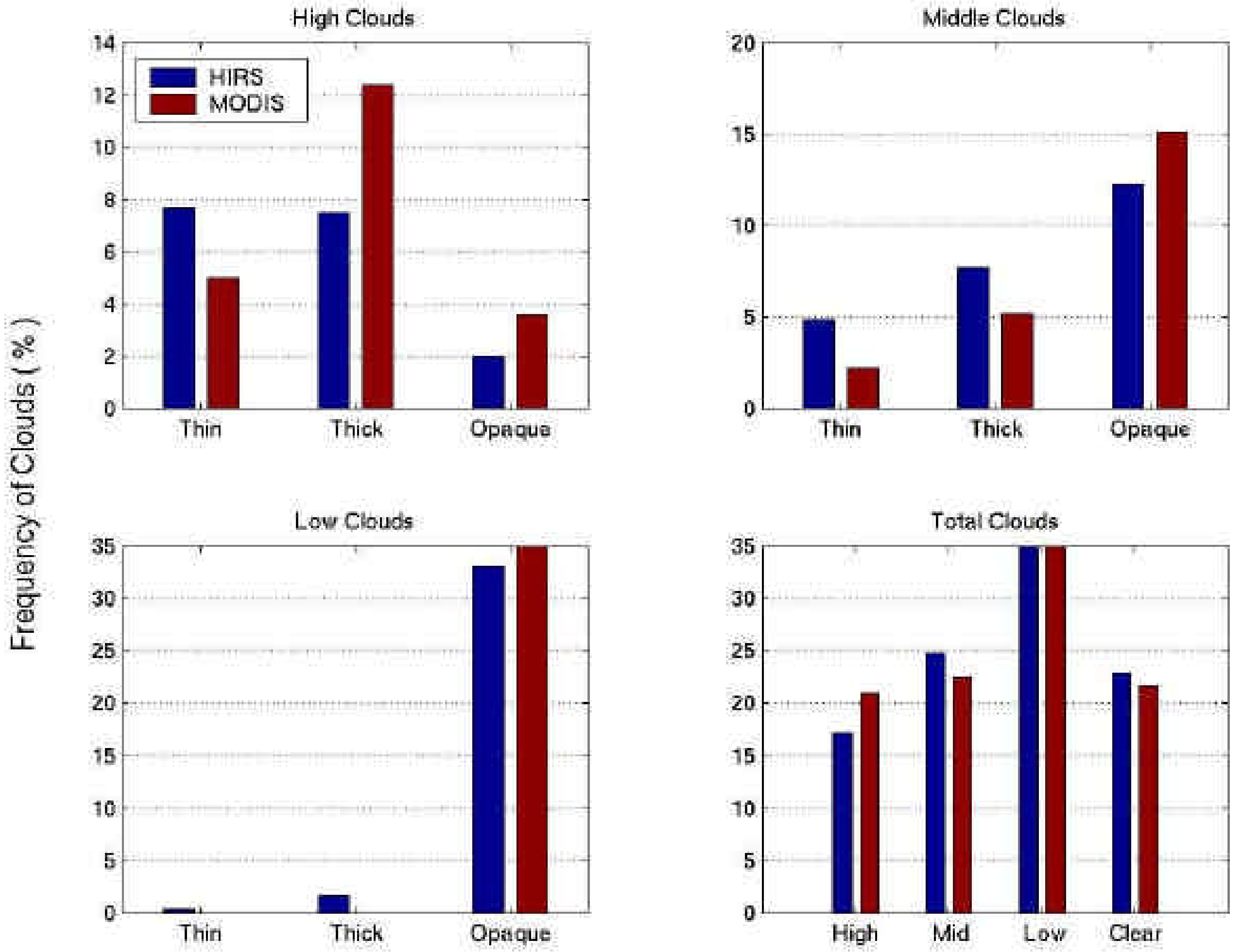
MODIS	**HIRS**
5 km	20 km
multi-detector	single detector
contiguous	every 3rd element every 3rd line
uses MODIS cloud mask	uses split window comparison with Tsfc
forward calc of I(clear)	interpolate neighboring I(clear)
no radiance bias correction	radiance bias correction



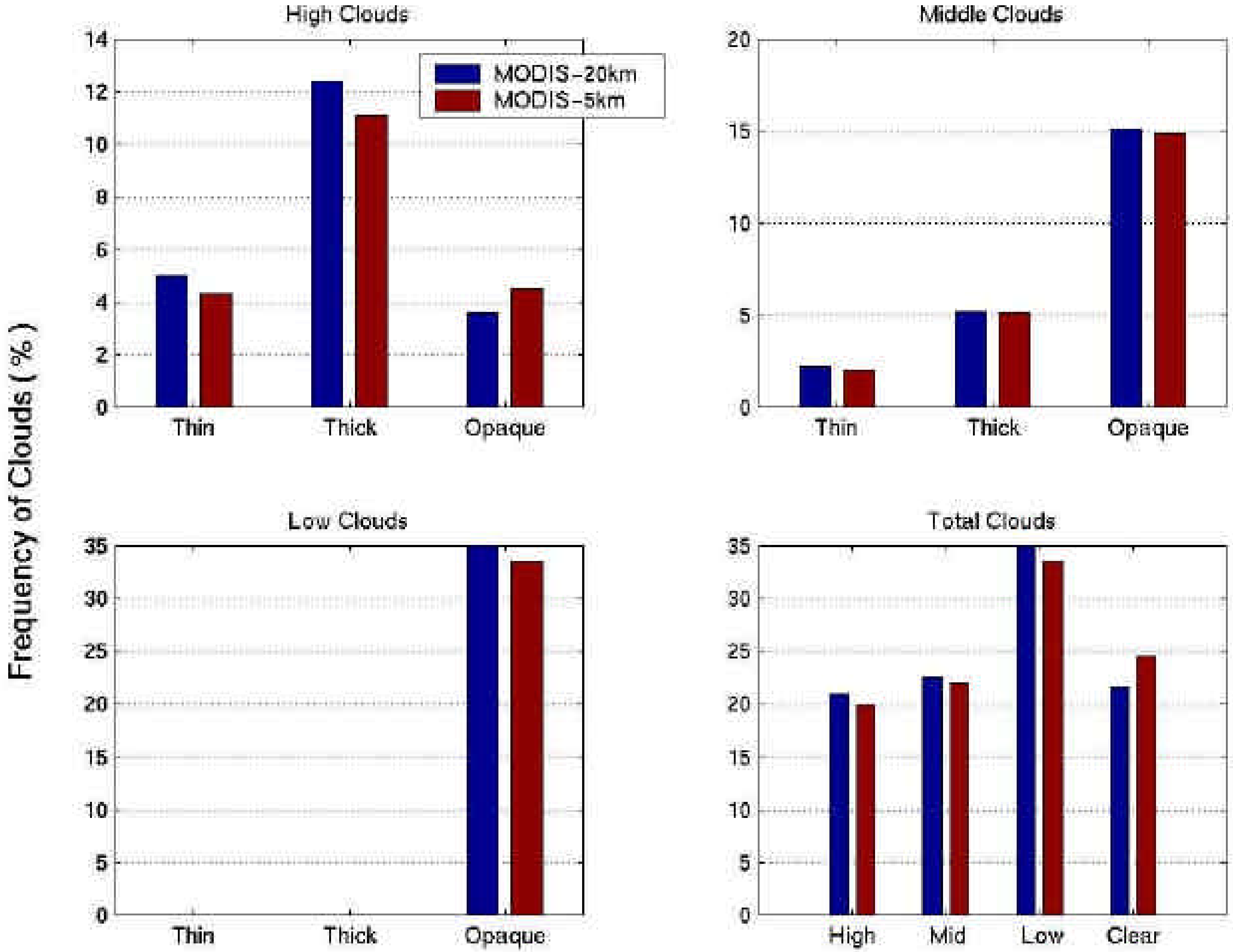
MODIS and HIRS global mean CO2 band brightness temperatures



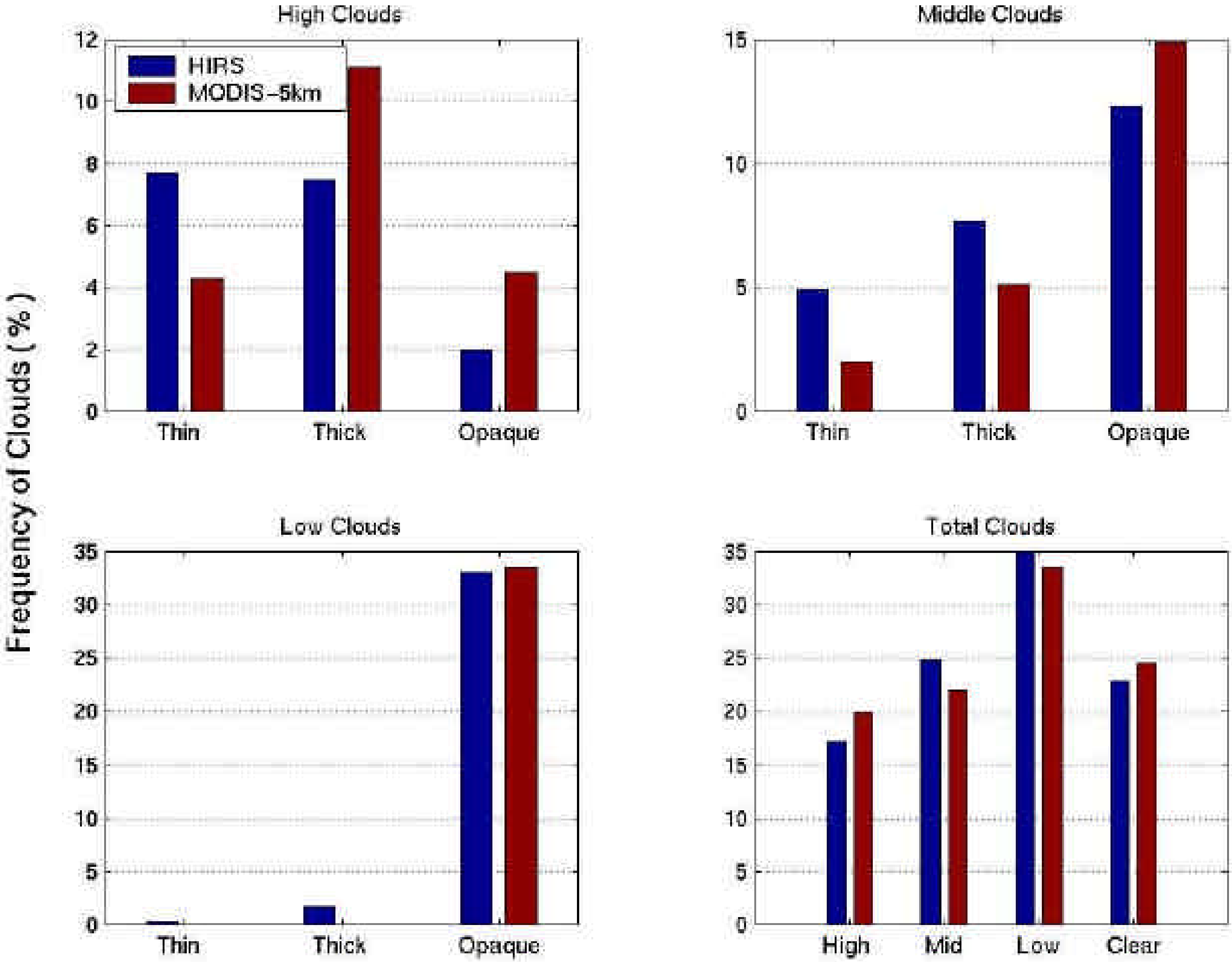
Comparison of MODIS and HIRS Cloud Products over LAND (20-60N) at day time



Comparison of MODIS and HIRS Cloud Products over WATER (20–60N) at day time



Comparison of MODIS Cloud Products over WATER (20–60N) at day time



Comparison of MODIS and HIRS Cloud Products over WATER (20-60N) at day time

Conclusions

(a) Trends are beginning to emerge in HIRS data; orbit drift issues; pathfinder reprocessing enabling new look
(b) HIRS & MODIS total cloud cover is roughly the same over water
(c) MODIS has more high and middle clouds than HIRS over both land and water surface;
(d) HIRS found more high thin clouds than MODIS in tropics over both land and water for day and night, but MODIS has more high thick clouds than HIRS in both tropics & 20-60N.
(e) More work remains