1-Year of Global Cloud Climatologies from CloudSat/CALIPSO: A New Era in Cloud Research

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OUTLINE

- The Satellites
- Cloud Detection Algorithms
- Cloud Type Results
- Cirrus Cloud Climatology
- Conclusions

Our Goal: To create remote sensor algorithms for identifying clouds that approximate what a trained human observer would report from the surface.

The Active A-train Satellites

1. CloudSat: 94 GHz (3.2 mm) Cloud Profiling Radar
   500 m vertical and 1.4 km horizontal resolutions
   -29 dBZ MDS

2. CALIPSO: CALIOP lidar
   1.06 μm and 0.532 μm (with depolarization) channels
   30-60 m vertical and 1.0 km horizontal resolutions

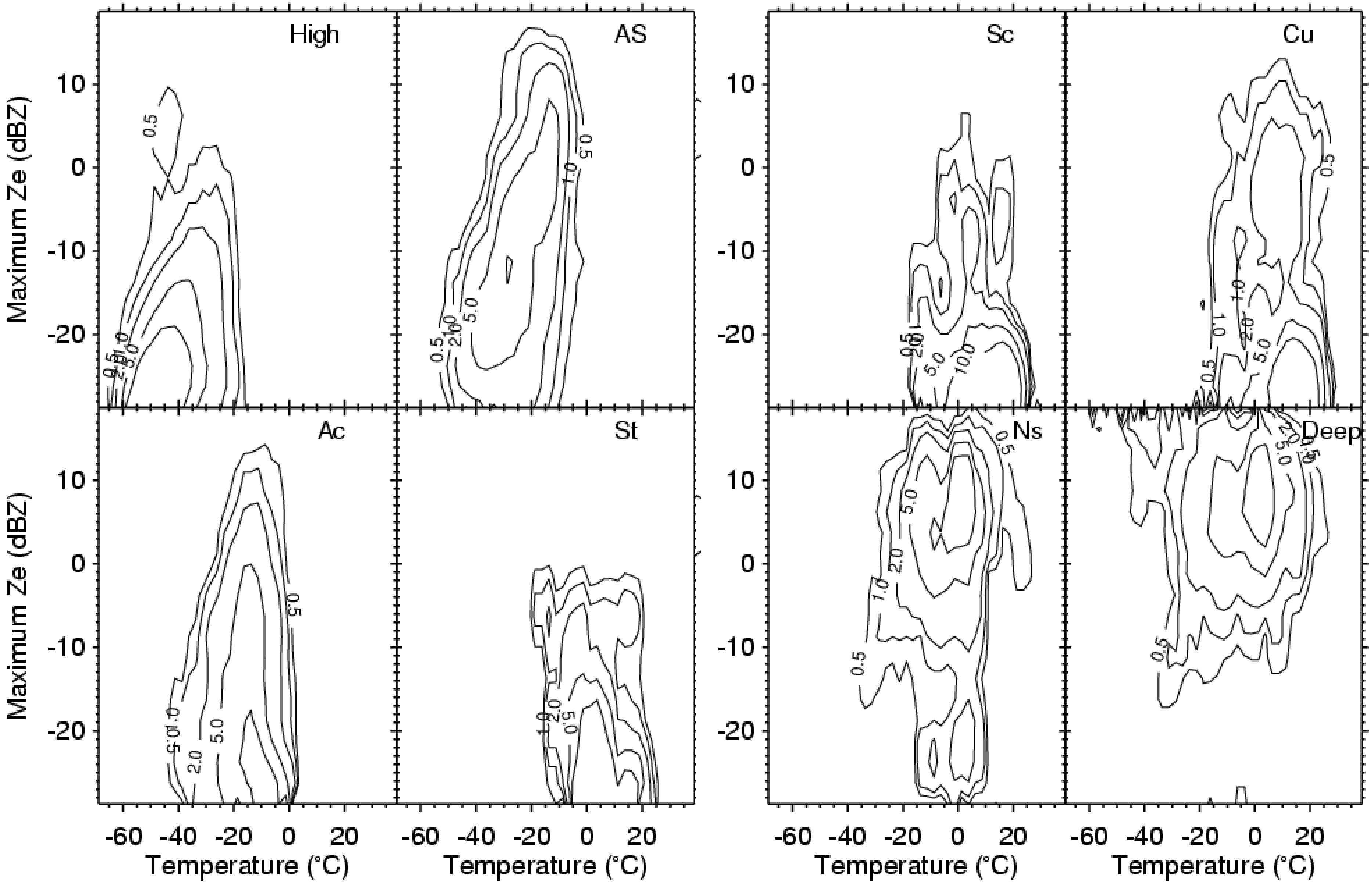
Cloud Detection Algorithms

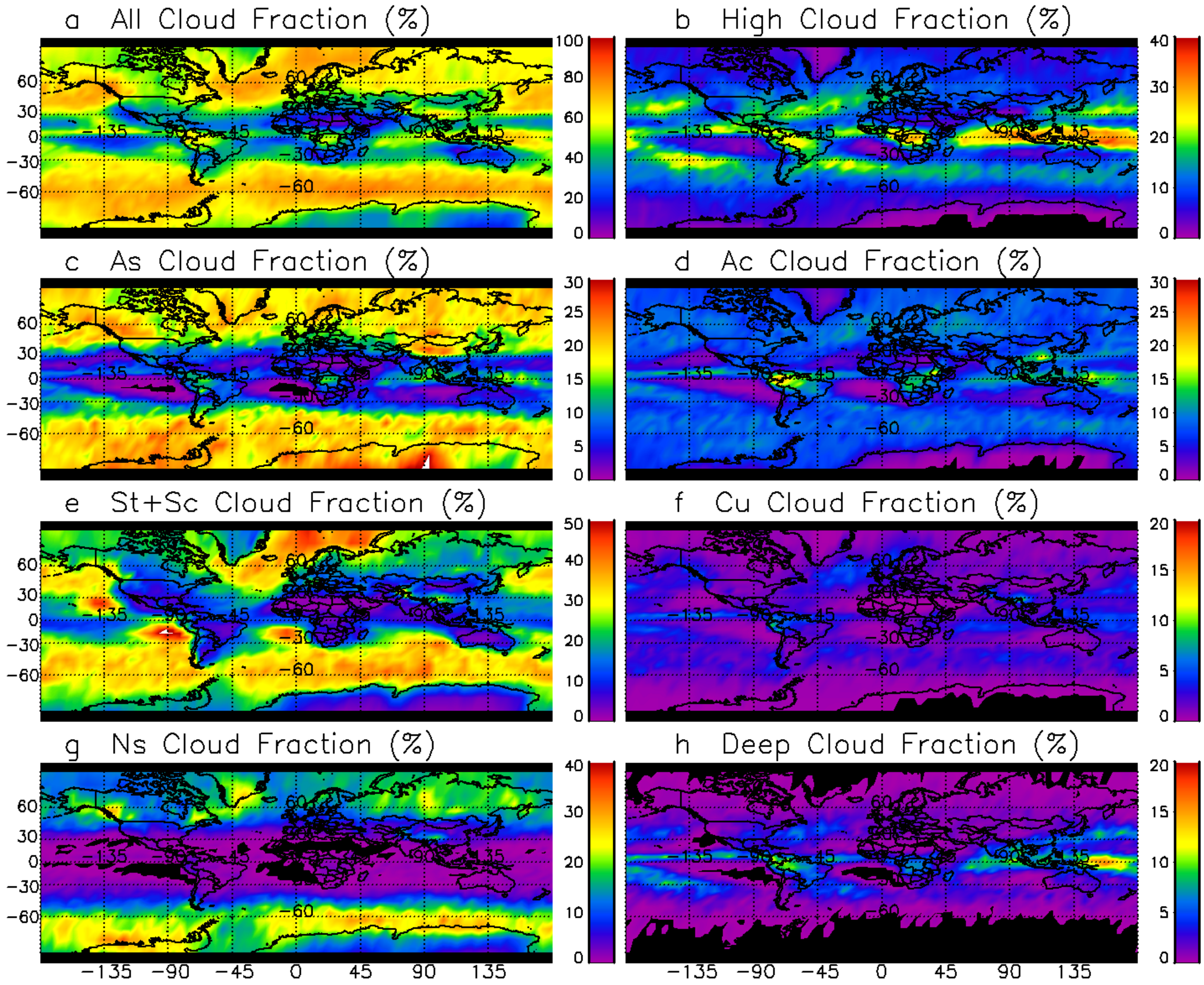
1. <u>CloudSat-only Cloud Type Algorithm</u>
   Based on extended ground-based mm-wave radar dataset.
   Uses maximum Z, temperature, and spatial layer properties.

<u>CloudSat Project: Level 2 Cloud Scenario Classification Product Process Description and Interface Control Document</u>

Sassen, K., and Z. Wang, 2008: Classifying clouds around the globe with the CloudSat radar: 1-year of results. *Geophys. Res. Lett.,* **35**, L04805, doi:10.1029/2007GL032591.

Type	Z_{max}	Precipitation	Length (km)	Highest Z_{max} frequency	Other
Cirrus	<-3 dBZ, $T < -22.5^oC$	No	2→>1000	-25 dBZ @ -40 ^oC	
Altostratus	<10 dBZ, $-20^o < T < -5\ ^oC$;	No	50→>1000	-10 dBZ @ -25 ^oC	
Altocumulus	<0 dBZ, $-20^o < T < -5\ ^oC$;	No	2→ >1000	-25 dBZ @ -10 ^oC	$T_{top} > -35\ ^oC$
St	<-5 dBZ, $-15^o < T < 25\ ^oC$	Yes/No	50→>1000	-25 dBZ @ 5^oC (bright bd)	Altitude of $Z_{max} < 2$ km
Sc	<-5 dBZ, $-15^o < T < 25\ ^oC$	Yes/No	2→ >1000	-25 dBZ @ 5^oC (bright bd)	Altitude of $Z_{max} < 2$ km
Cumulus	< 0dBZ, $-5^o < T < 25\ ^oC$	Yes/No	2-25	-25 dBZ @ 15 ^oC	$\Delta Z > 2$ km
Deep (cb)	>-5dBZ, $-20^o < T < 25\ ^oC$	Yes	10-50	10 dBZ @ 5 ^oC	$\Delta Z > 6$ km
Ns	$-10 < Z < 15$ dBZ, $-25^o < T < 10^o$ C	Yes	>100	+5 dBZ @ 0^oC	$\Delta Z > 4$ km


High
AS
Sc
Cu
Ac
St
Ns
Deep
Maximum Ze (dBZ)
Temperature (°C)


a All Cloud Fraction (%)
b High Cloud Fraction (%)
c As Cloud Fraction (%)
d Ac Cloud Fraction (%)
e St+Sc Cloud Fraction (%)
f Cu Cloud Fraction (%)
g Ns Cloud Fraction (%)
h Deep Cloud Fraction (%)

Comparison with ISCCP (+) and Surface Data (---)

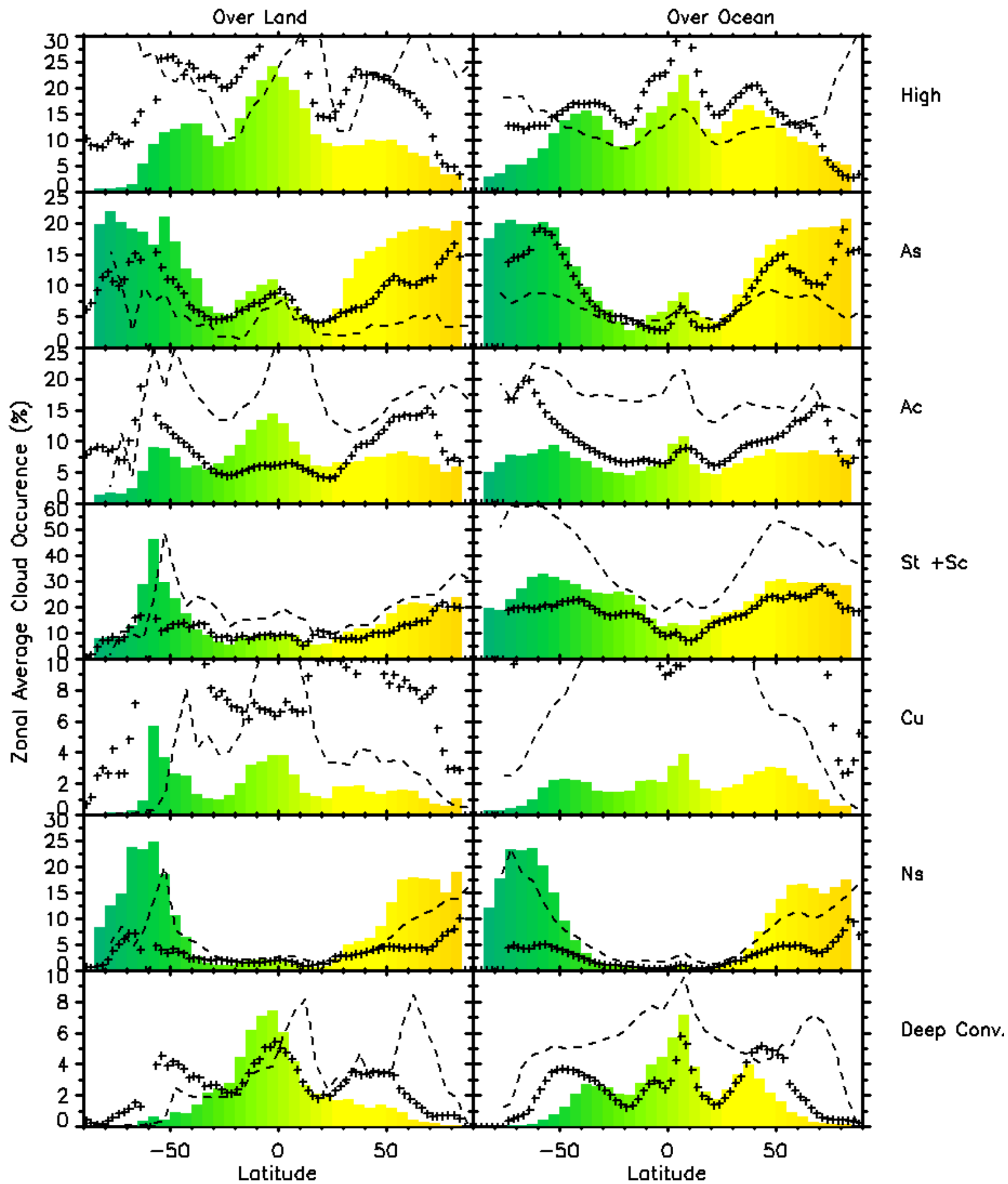


Table 1. Comparison of 1-y CloudSat global cloud type frequency averages over land and ocean with annual means of extended surface observer reports [*Hahn and Warren*, 1999] and ISCCP annual means from 1986-1993 [*Rossow and Schiffer*, 1999].

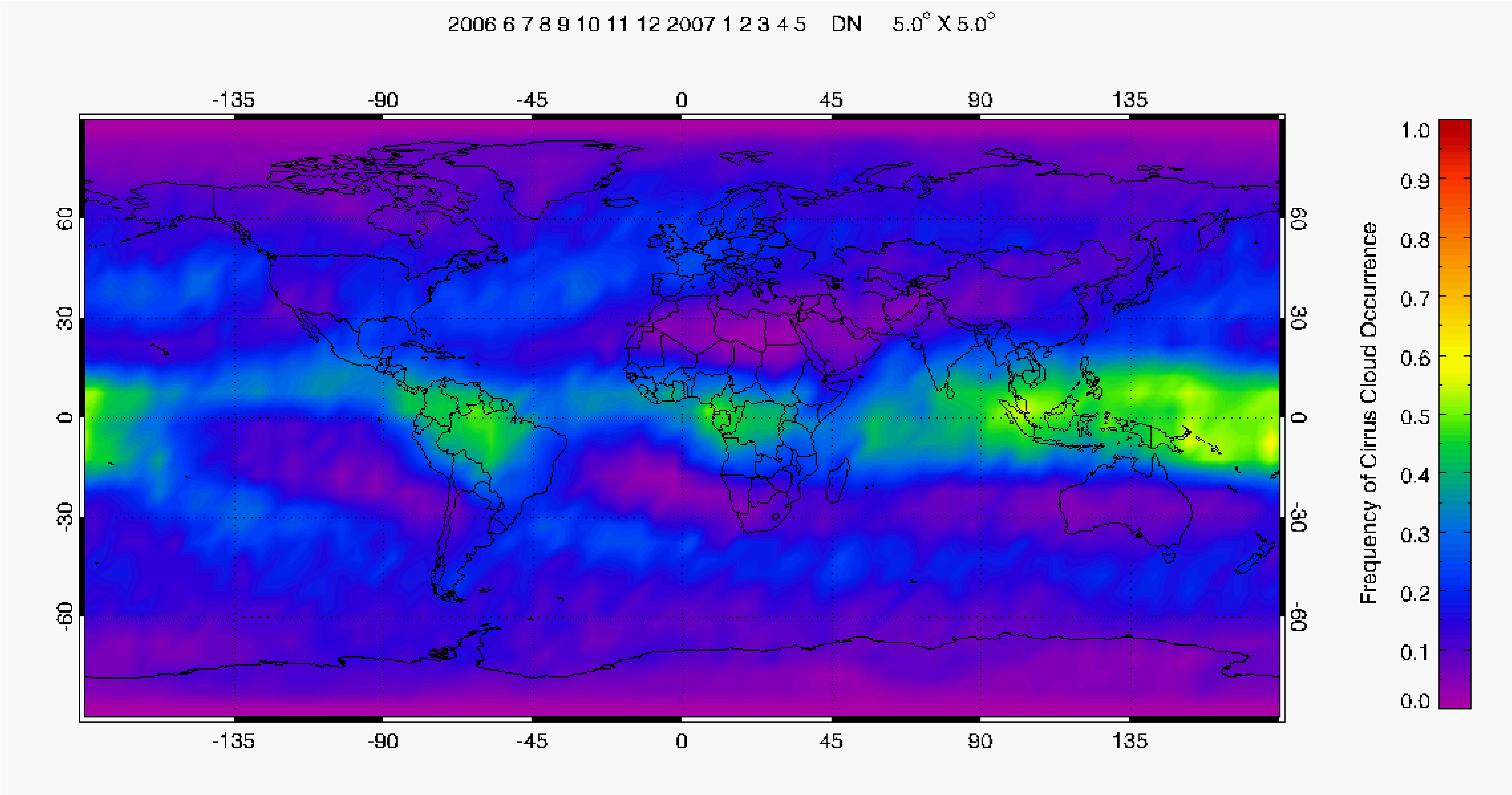
Type	CloudSat		Surface		ISCCP	
	Land	Ocean	Land	Ocean	Land	Ocean
High	9.6	10.9	23.1	14.0	19.3	15.6
As	12.7	12.0	4.8	6.50	8.7	9.7
Ac	6.8	6.7	17.2	17.2	8.6	10.2
St+Sc	13.5	22.5	18.9	39.4	10.7	18.3
Cu	1.7	1.7	4.2	9.8	7.7	12.7
Ns	8.6	8.4	6.3	7.9	3.2	3.0
Deep	1.8	1. 9	3.2	5.3	2.5	2.4

Cloud Detection Algorithms

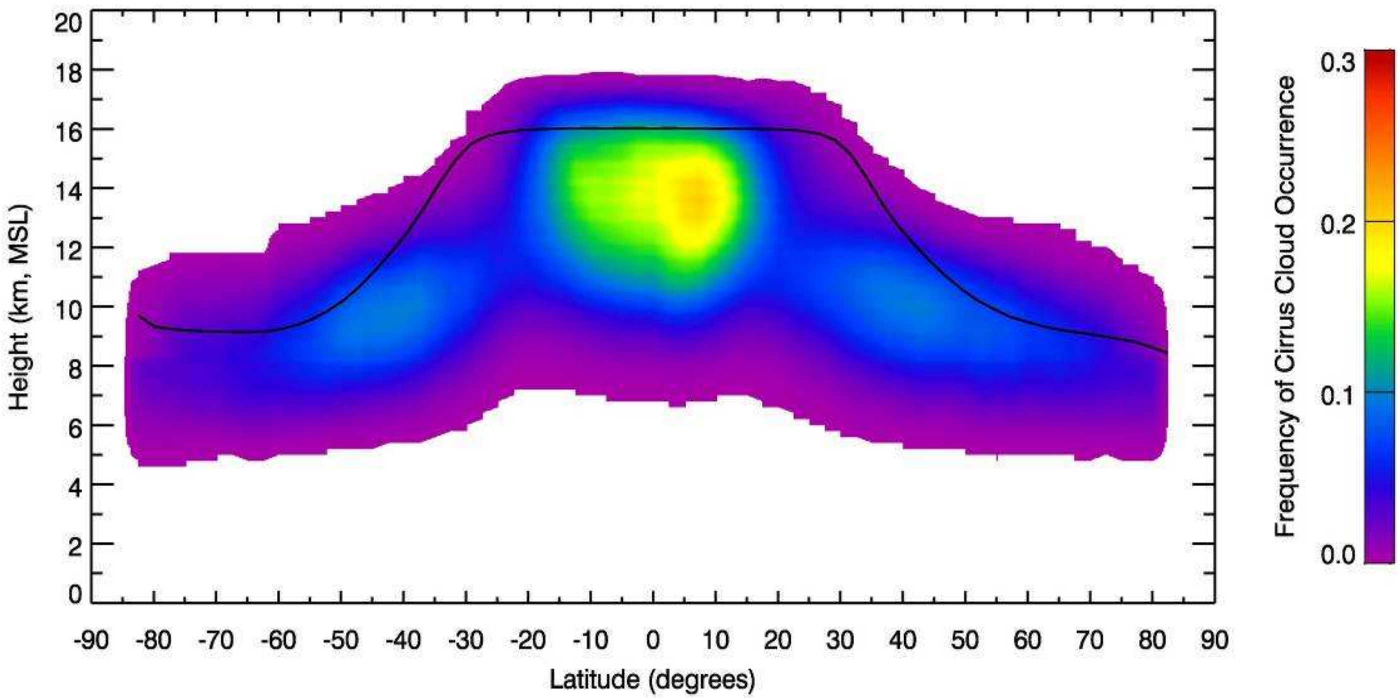
2. Combined CloudSat/CALIPSO Cirrus Algorithm
Based on radar-lidar cloudmask, τ <~4, cloud base T<-40C°, tropopause height.

Sassen, K., Z. Wang, and D. Liu. 2008: The global distribution of cirrus clouds from CloudSat/CALIPSO measurements. *J. Geophys. Res.*, (submitted).

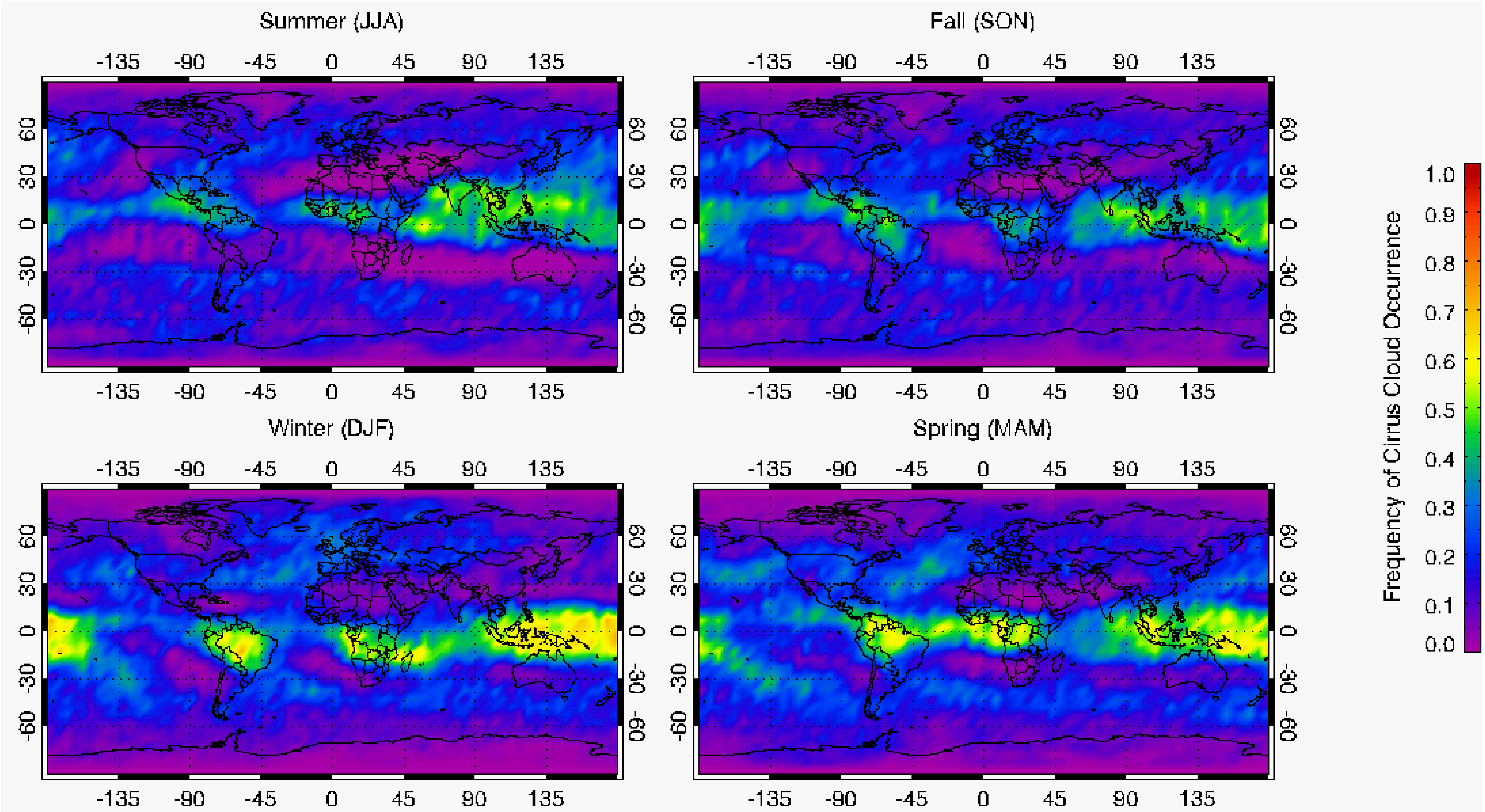
Average Global Cirrus Frequency



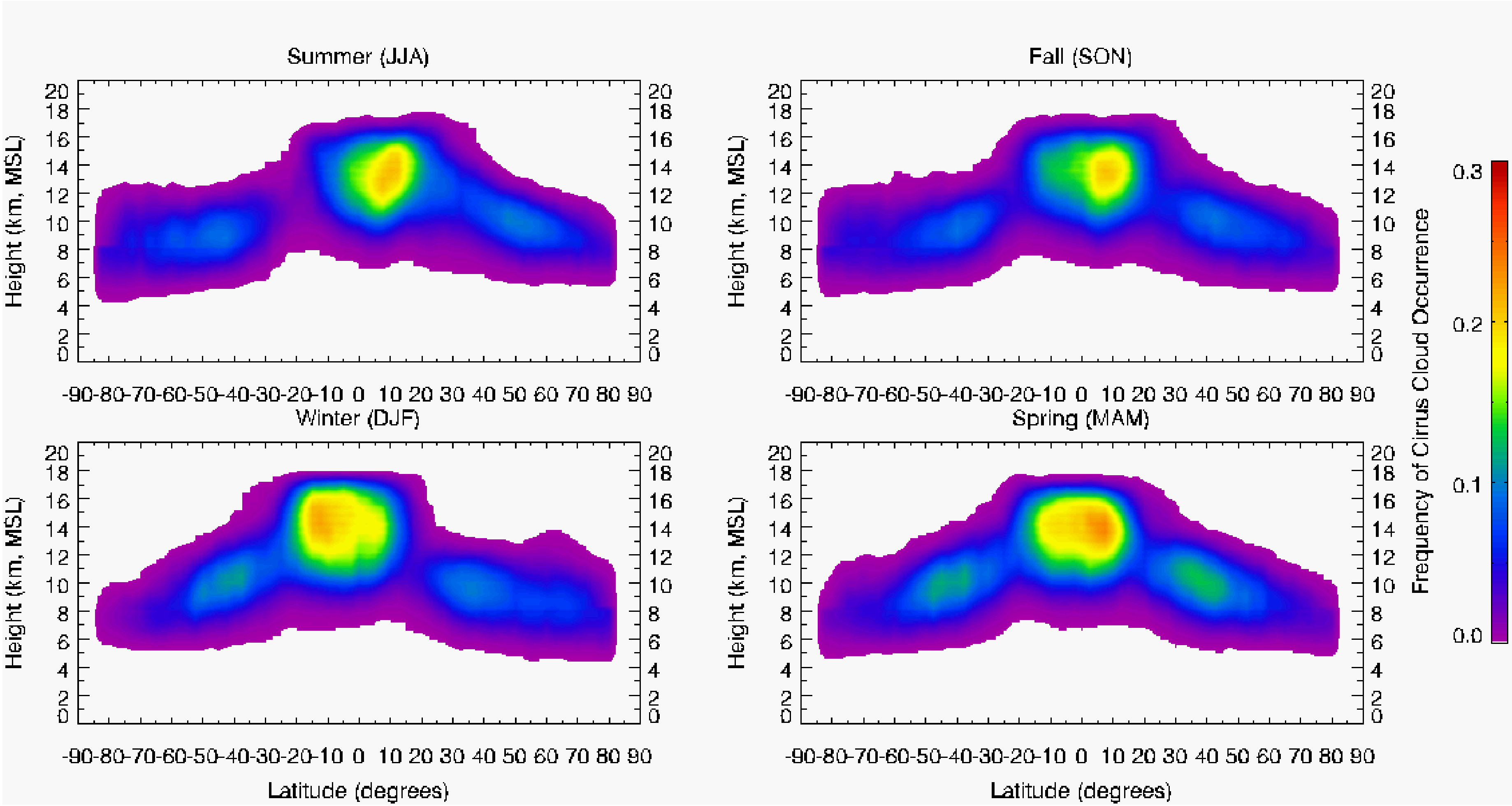
Latitudinal Cirrus Heights



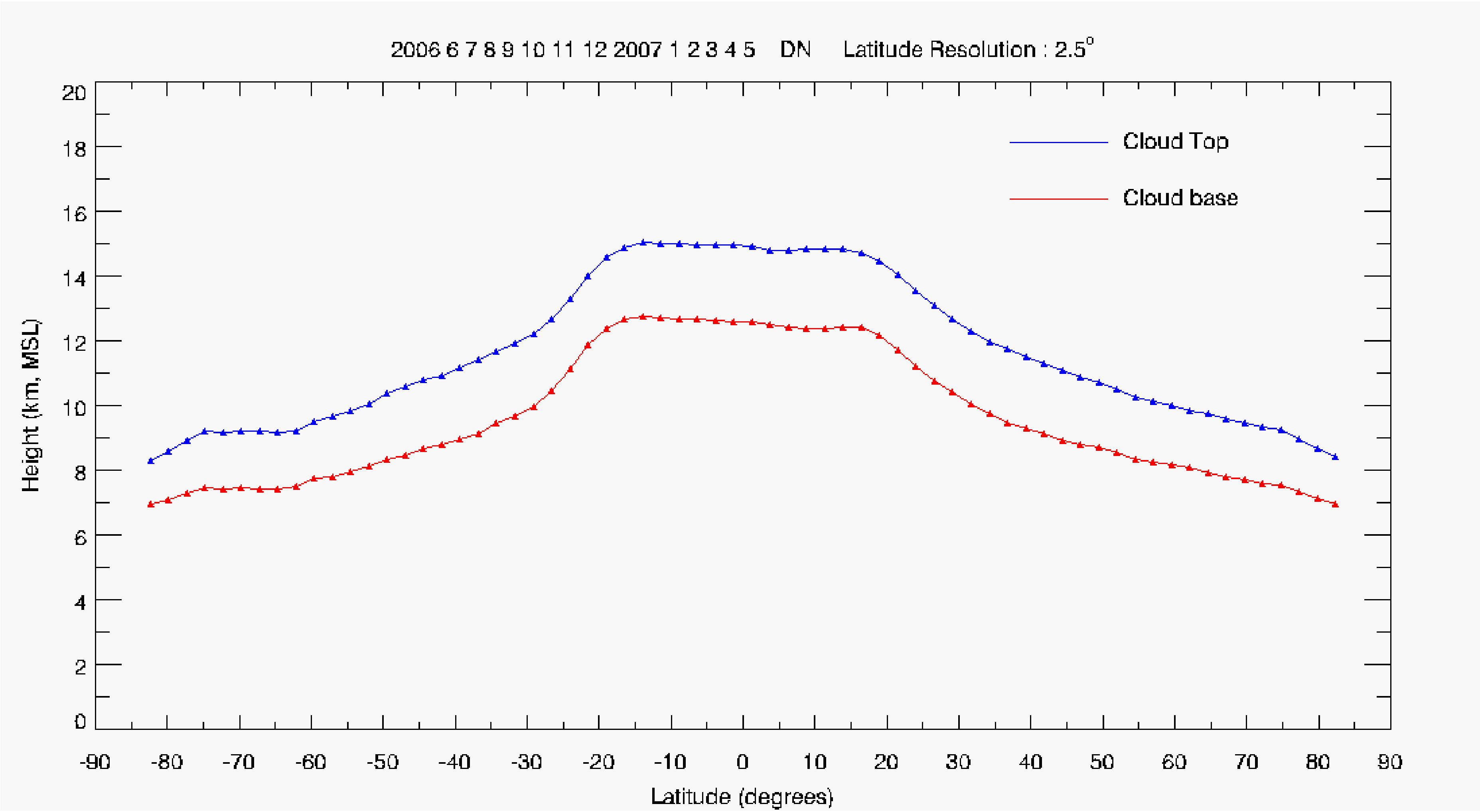
Seasonal Cirrus Dependence



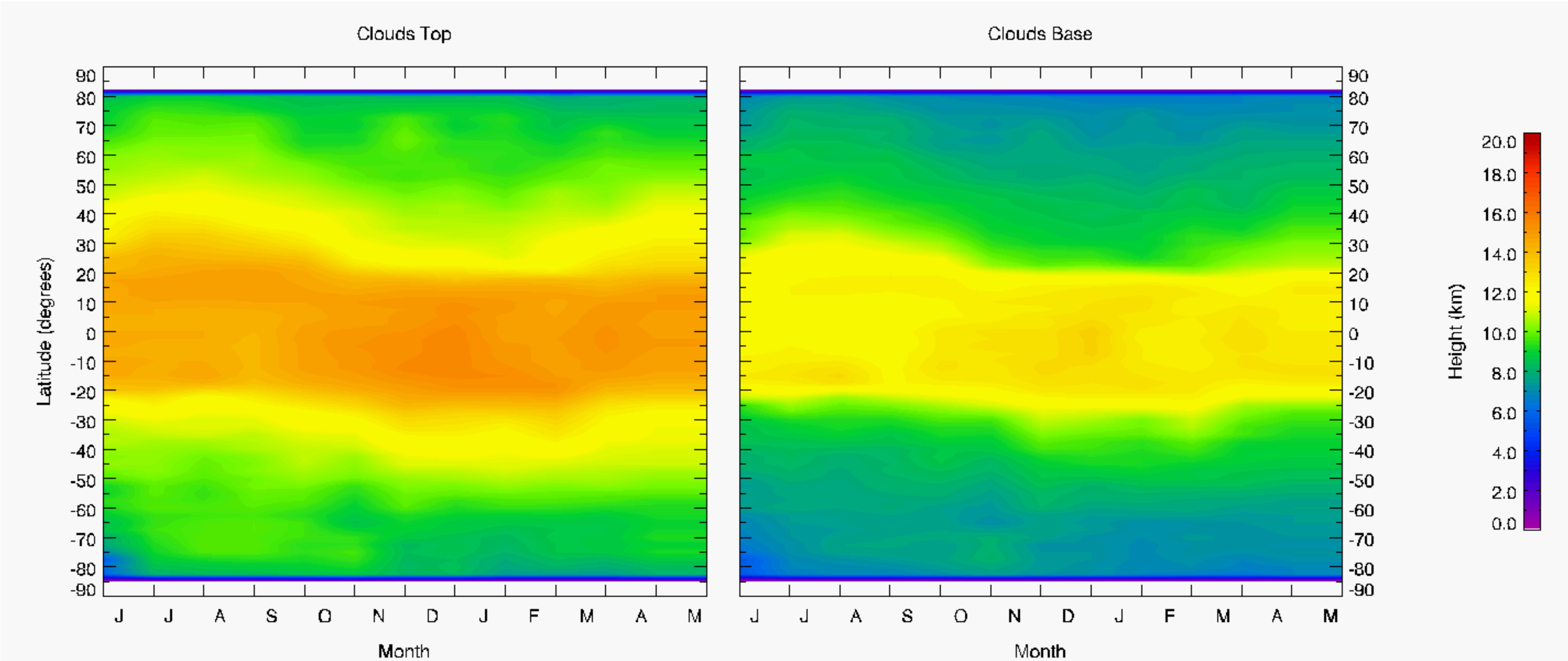
Seasonal Height Dependence



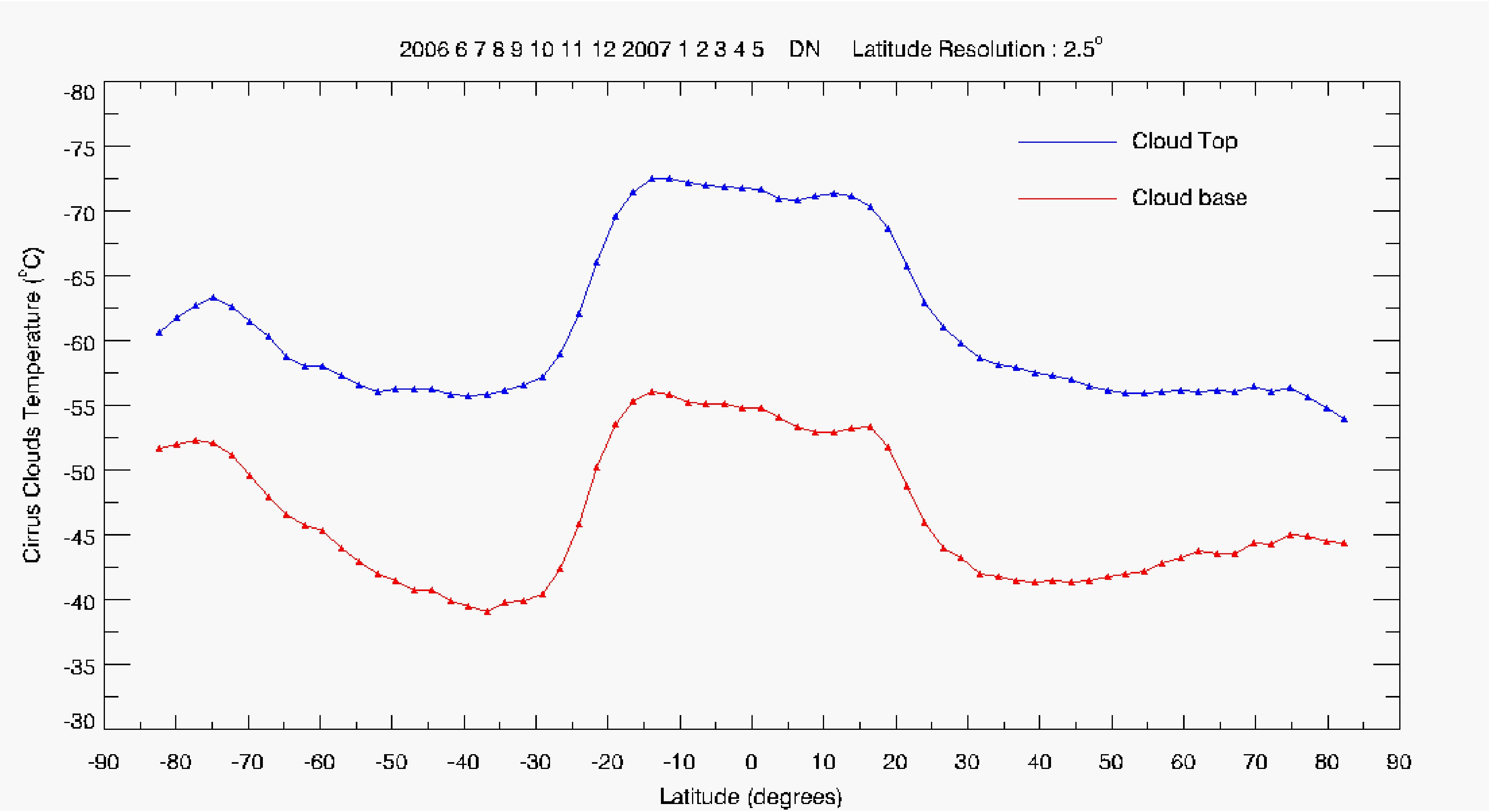
Average Cirrus cloud Heights



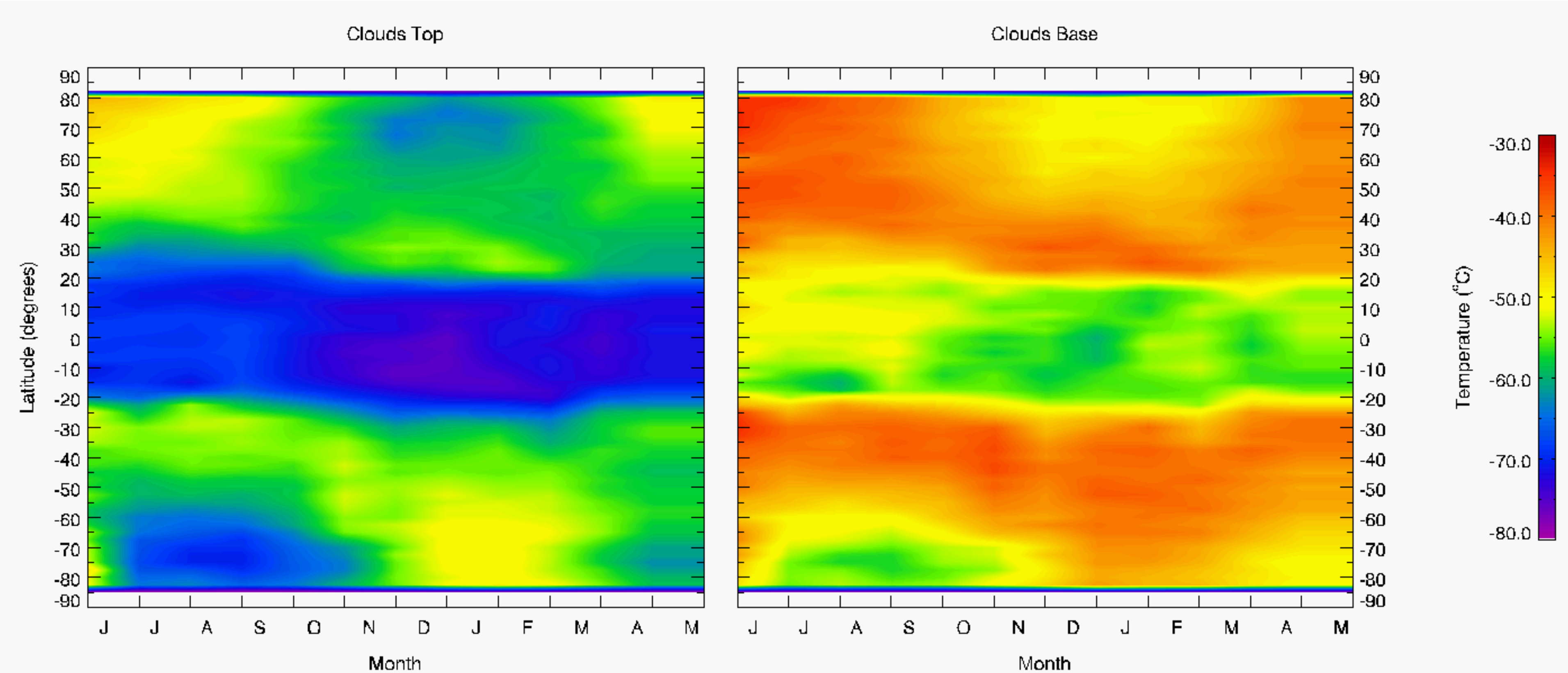
Seasonal Height Dependence



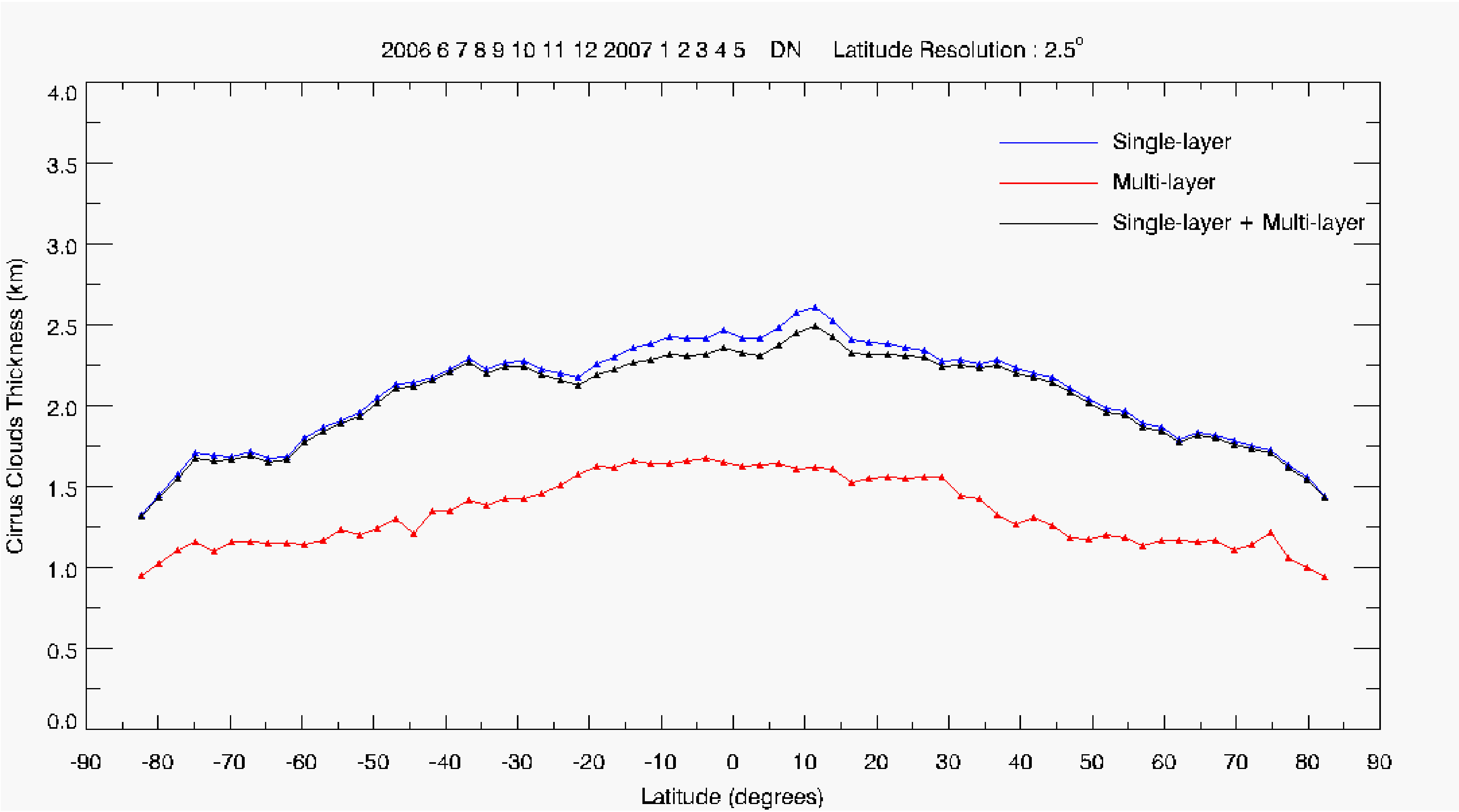
Average Cirrus Temperatures



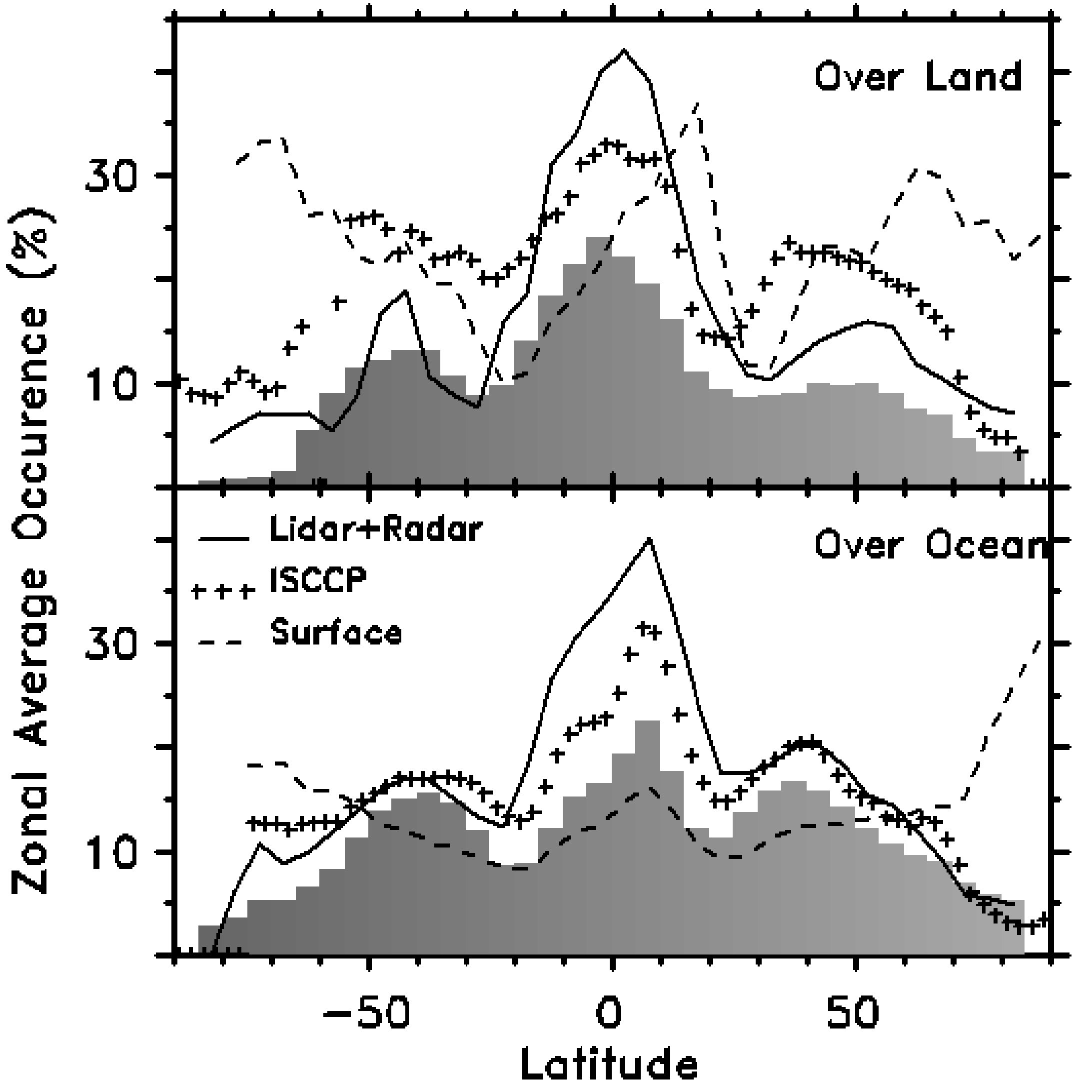
Seasonal Cirrus Temperatures



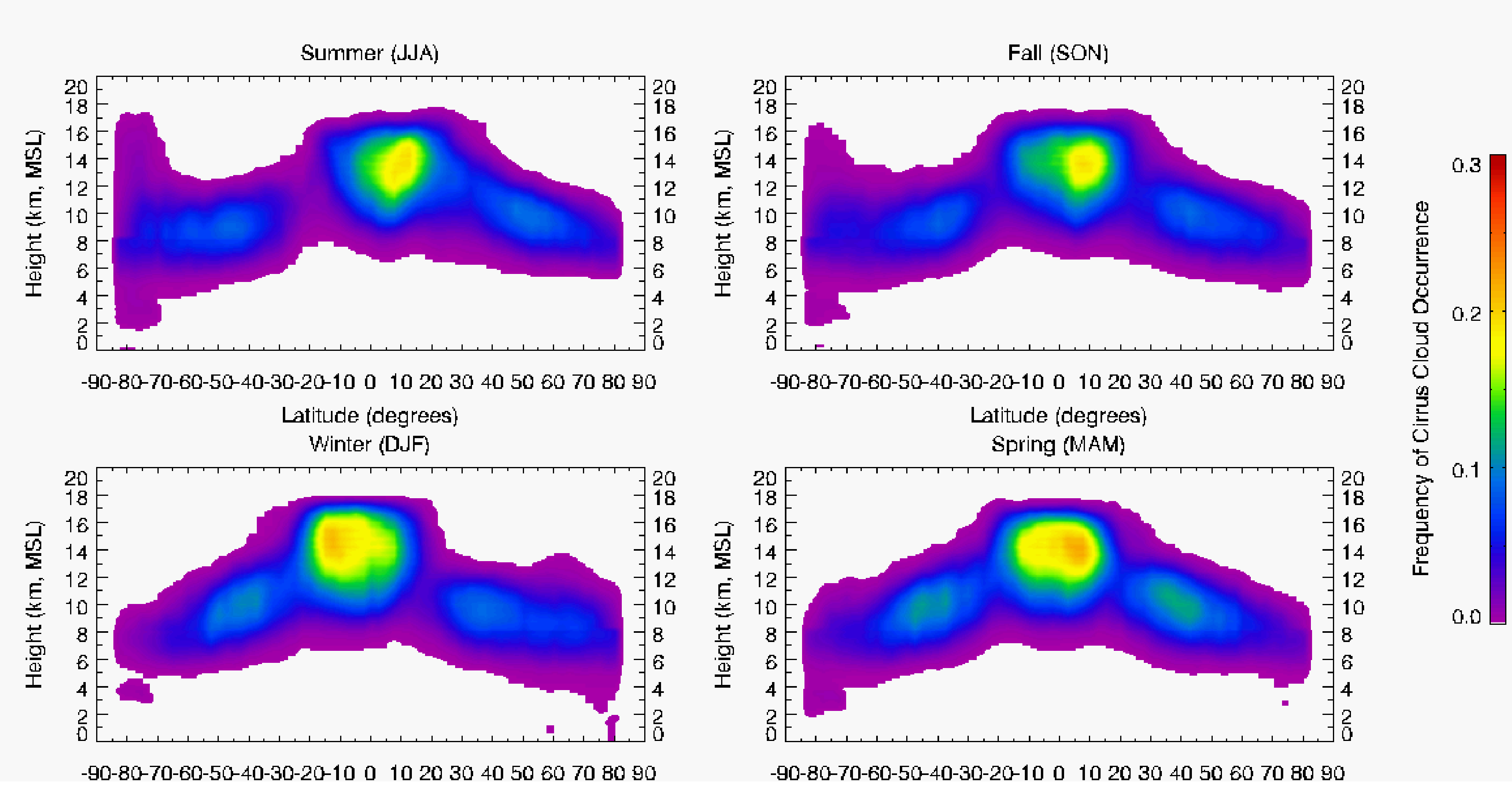
Cirrus Cloud Thicknesses



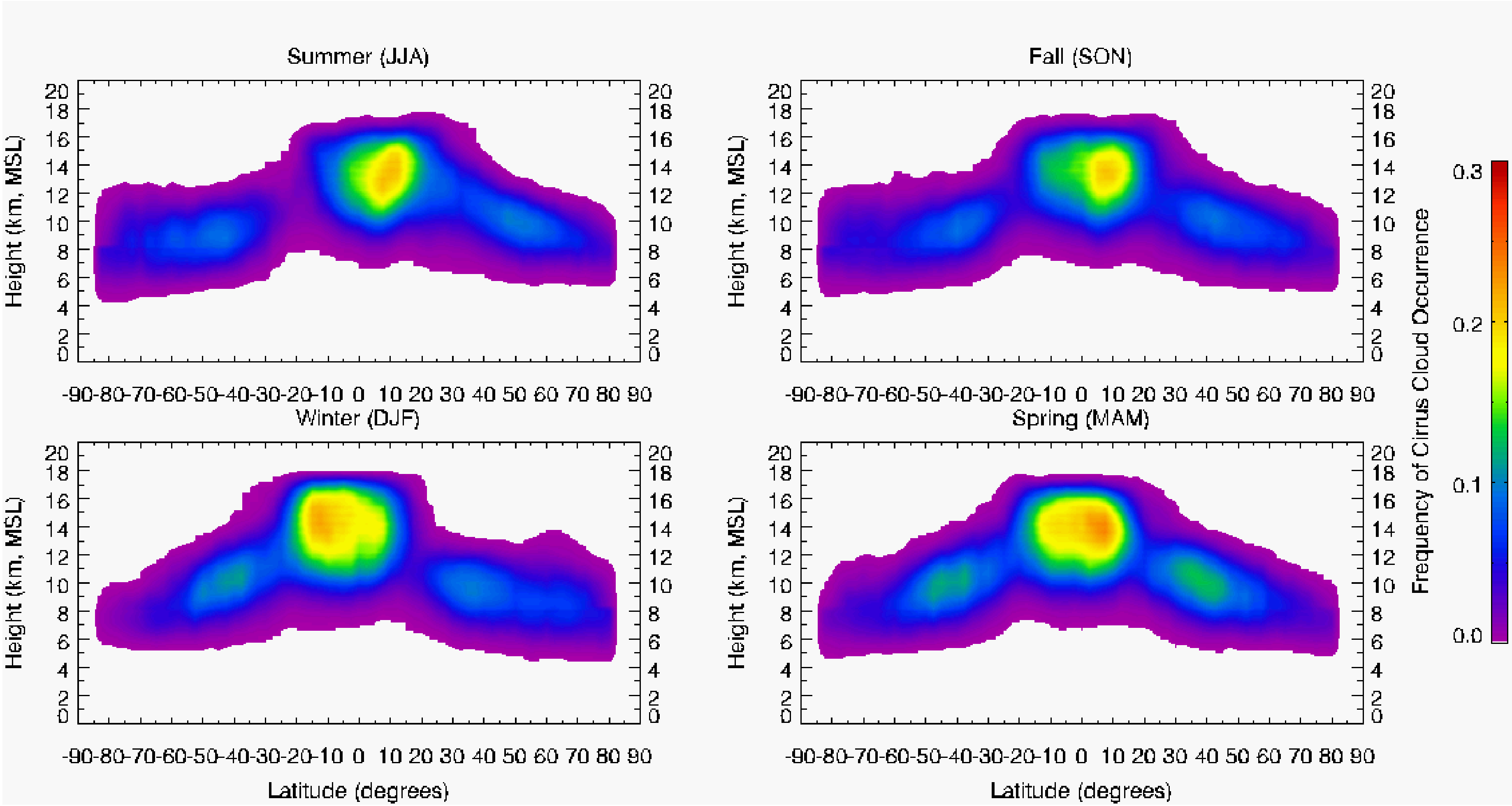
Zonal Average Comparisons



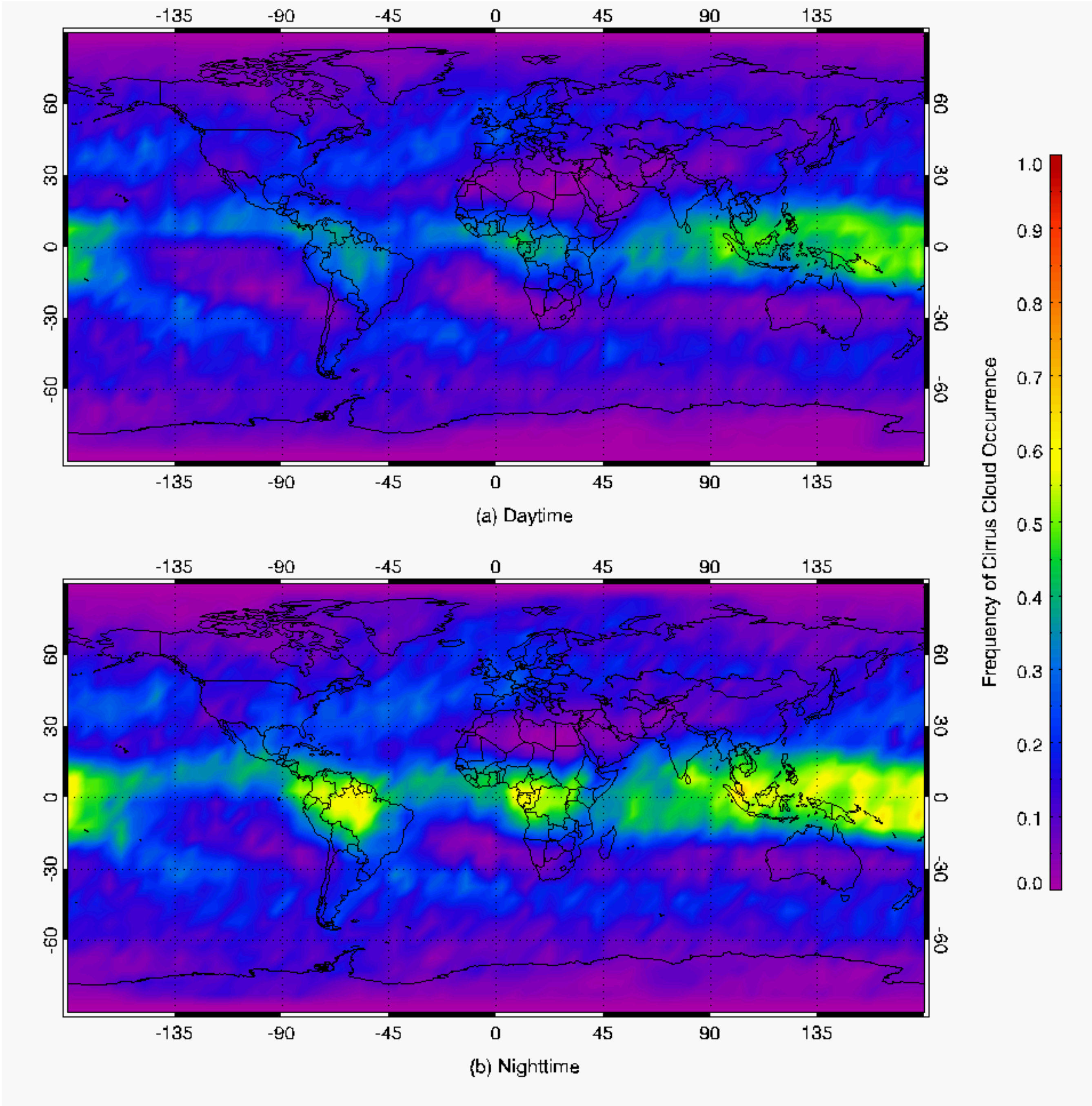
Height Dependence- ALL Cirrus



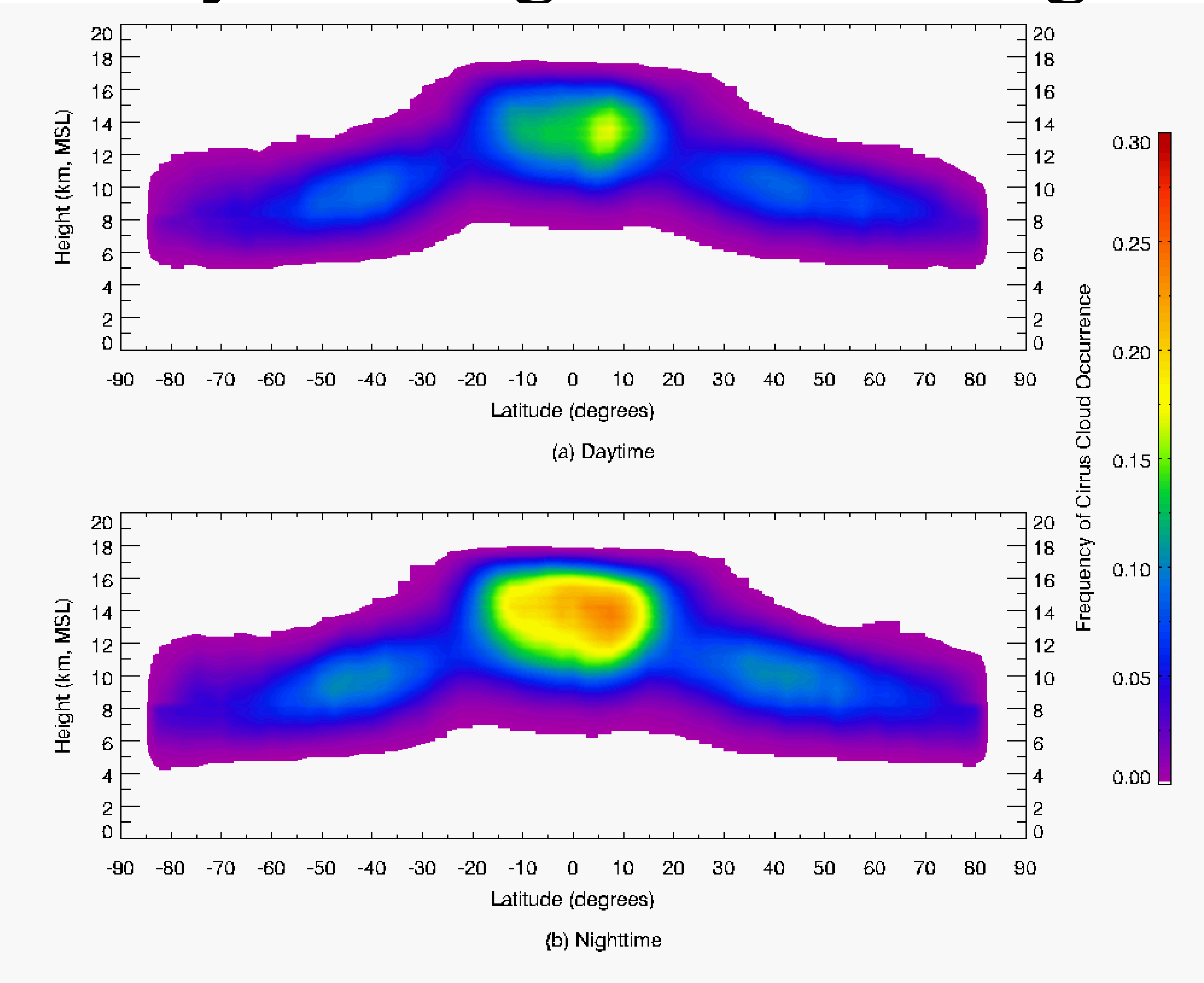
Seasonal Height Dependence



Global Cirrus Day Vs. Night



Day Vs. Night Cirrus Heights



CONCLUSIONS

- CALIPSO/CloudSat working admirably up there
- 1-Y of data applied to Cloud Detection Algorithms
- Radar-only Cloud Type Results have limitations
- Combined Cirrus Cloud Climatology very promising
- More algorithm development and applications to come…