USING CLOUDSAT – CALIPSO TO DIAGNOSE THREE-DIMENSIONAL CLOUD STRUCTURES and CLOUDSAT L3 PRODUCT

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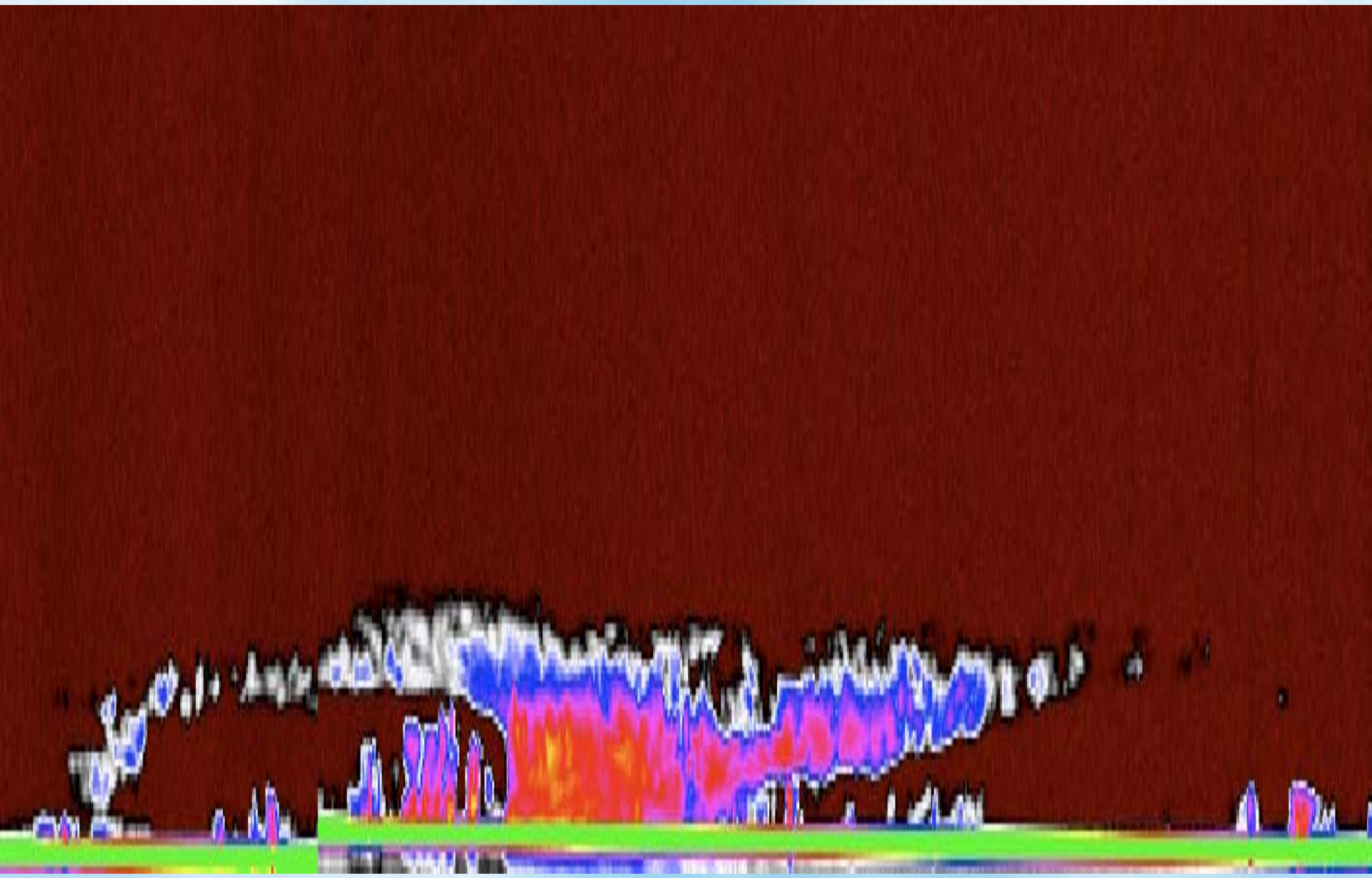
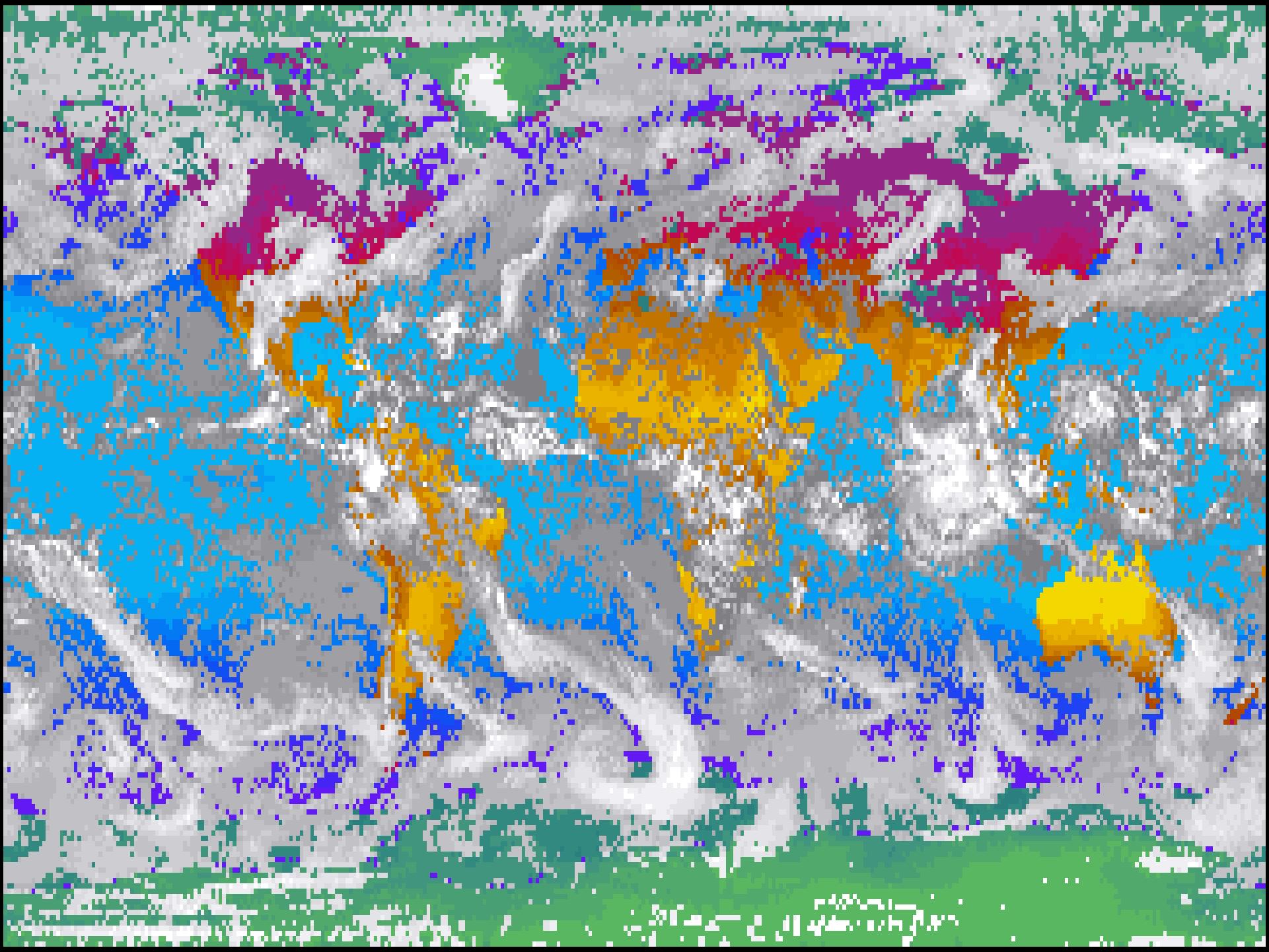
INVESTIGATIONS UNDERWAY

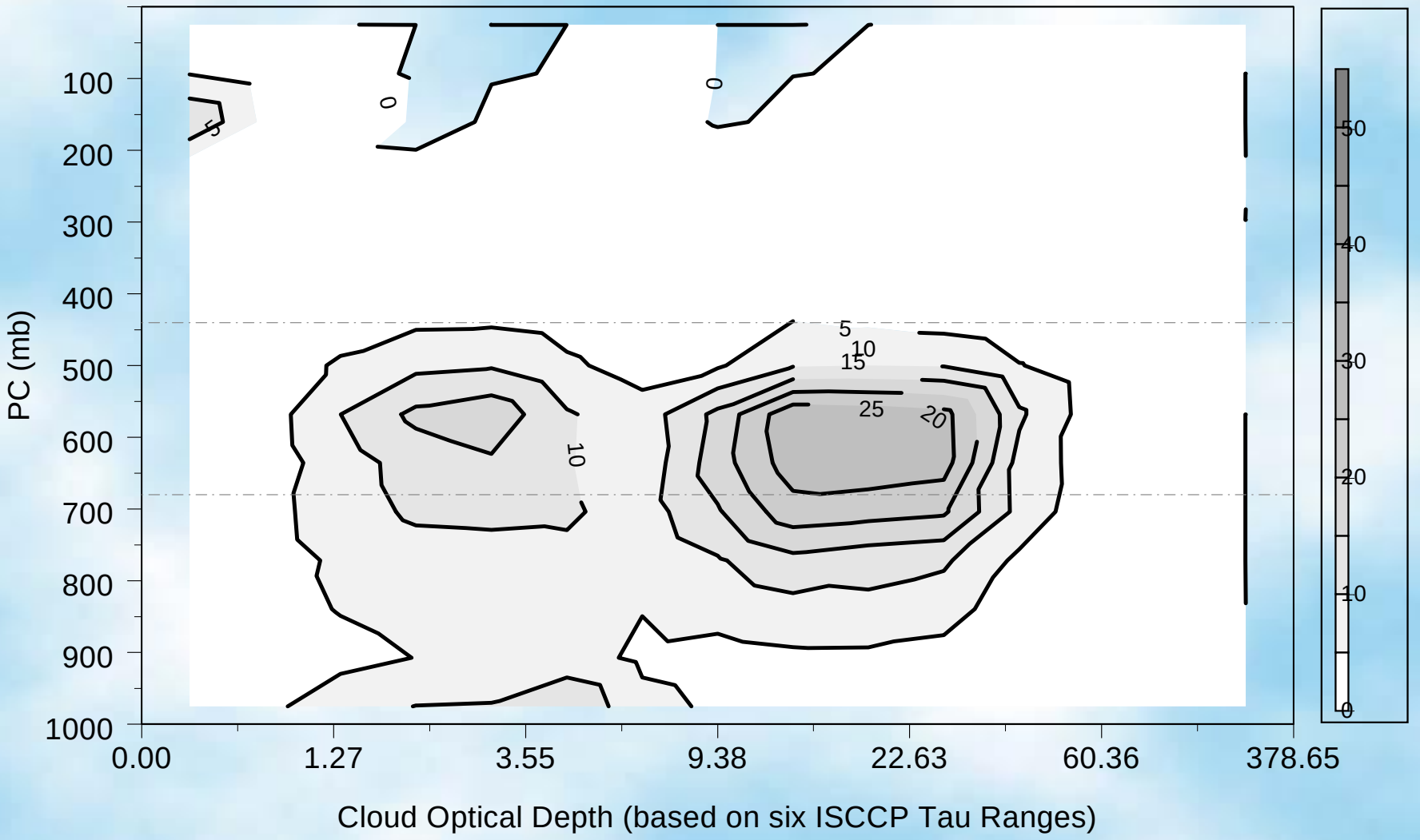
- **Describing Global 3D Cloud Structure and its Variations with the General Atmospheric Circulation**
- **Completing Characterization of Different Kinds of Convection (un-organized, mesoscale organized, squall-lines, frontal)**
- **Lifecycle of and Transformations of Convective Systems (atmospheric state, dynamics, energy & water exchanges)**
- **Cyclone Cloud Structures and Lifecycles**

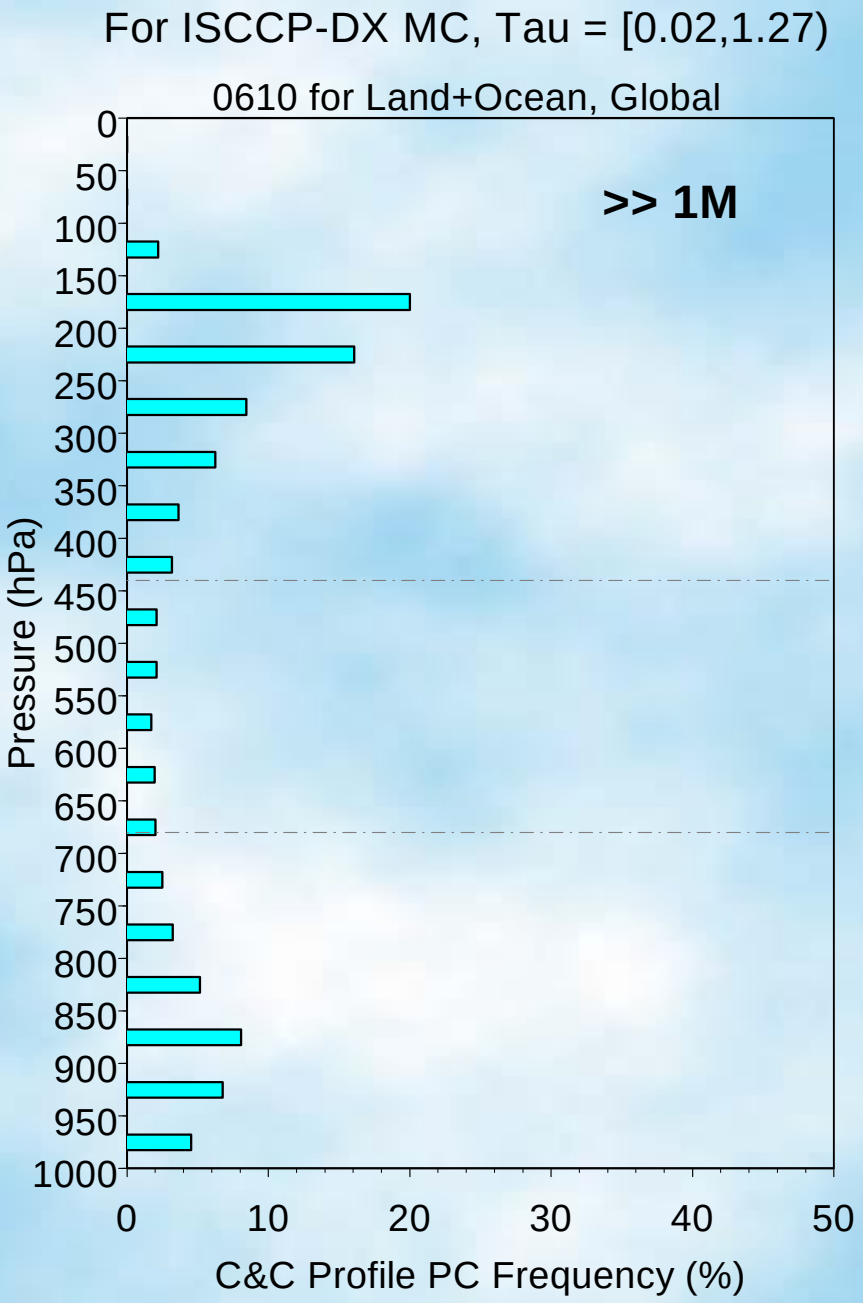
CloudSat First Light

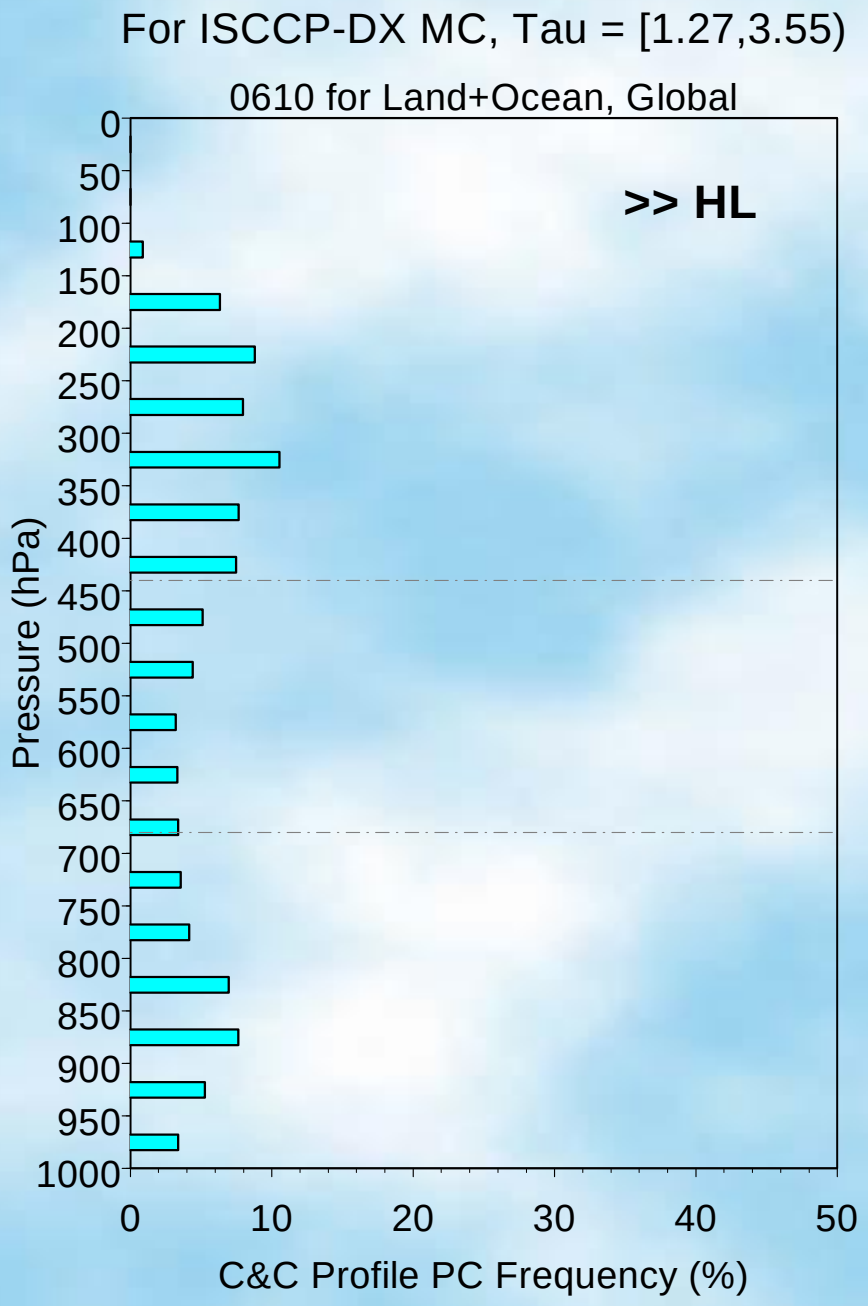


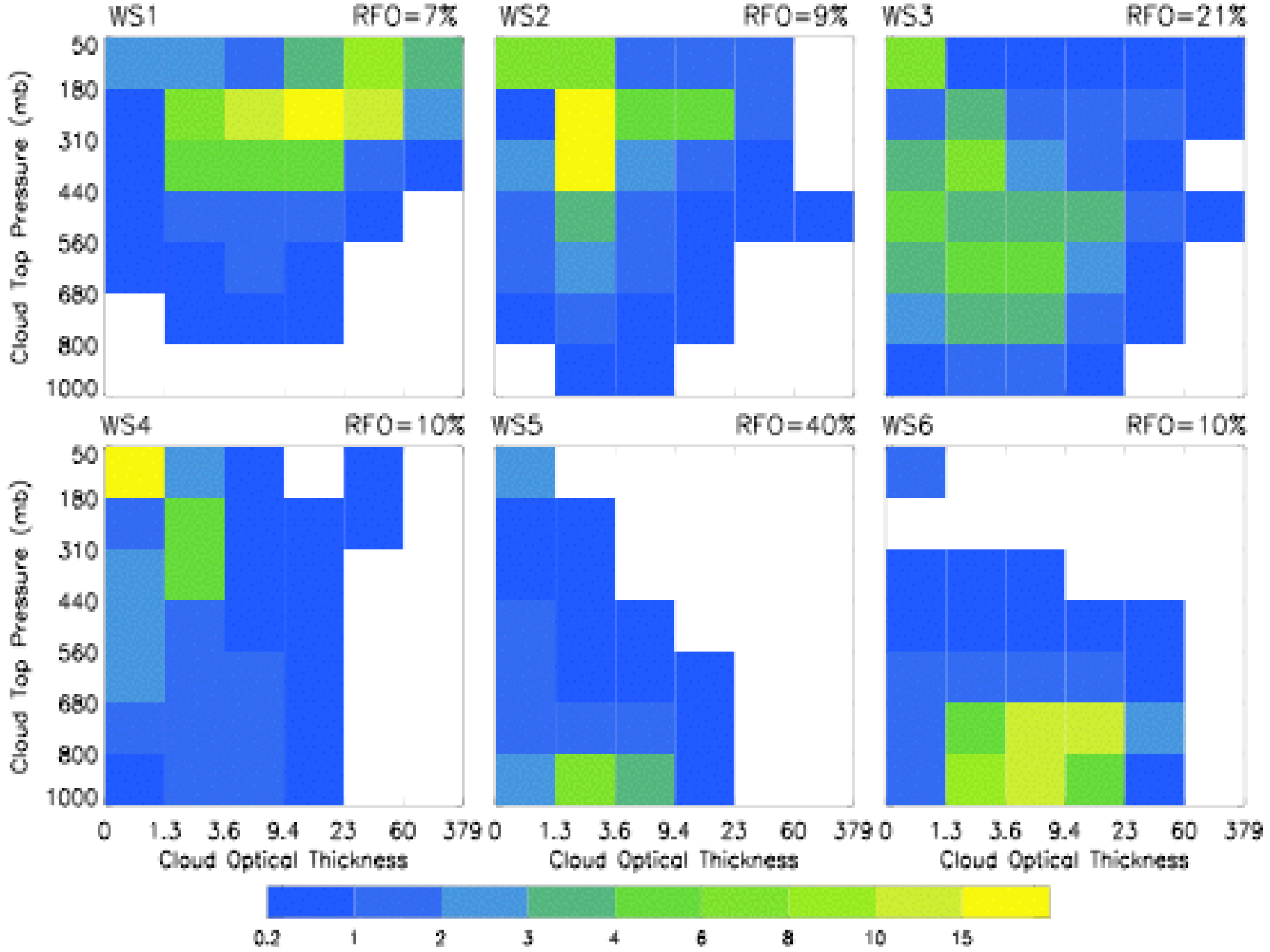


DX Frequency (‰) over C&C 1M: Land+ocean, 0610: Global




For ISCCP-DX MC, Tau = [0.02,1.27)
0610 for Land+Ocean, Global
>> 1M
Pressure (hPa)
0
50
100
150
200
250
300
350
400
450
500
550
600
650
700
750
800
850
900
950
1000
0
10
20
30
40
50
C&C Profile PC Frequency (%)

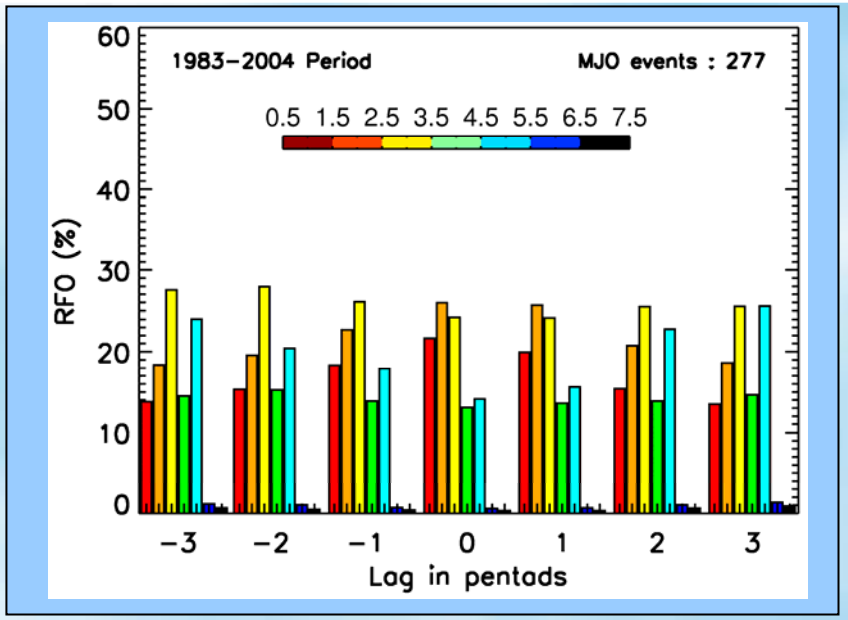

For ISCCP-DX MC, Tau = [1.27,3.55)
0610 for Land+Ocean, Global
>> HL
Pressure (hPa)
0
50
100
150
200
250
300
350
400
450
500
550
600
650
700
750
800
850
900
950
1000
0
10
20
30
40
50
C&C Profile PC Frequency (%)


WS1
RFO=7%
WS2
RFO=9%
WS3
RFO=21%
WS4
RFO=10%
WS5
RFO=40%
WS6
RFO=10%
Cloud Top Pressure (mb)
50
180
310
440
560
680
800
1000
0
1.3
3.6
9.4
23
60
379
Cloud Optical Thickness
0.2
1
2
3
4
6
8
10
15

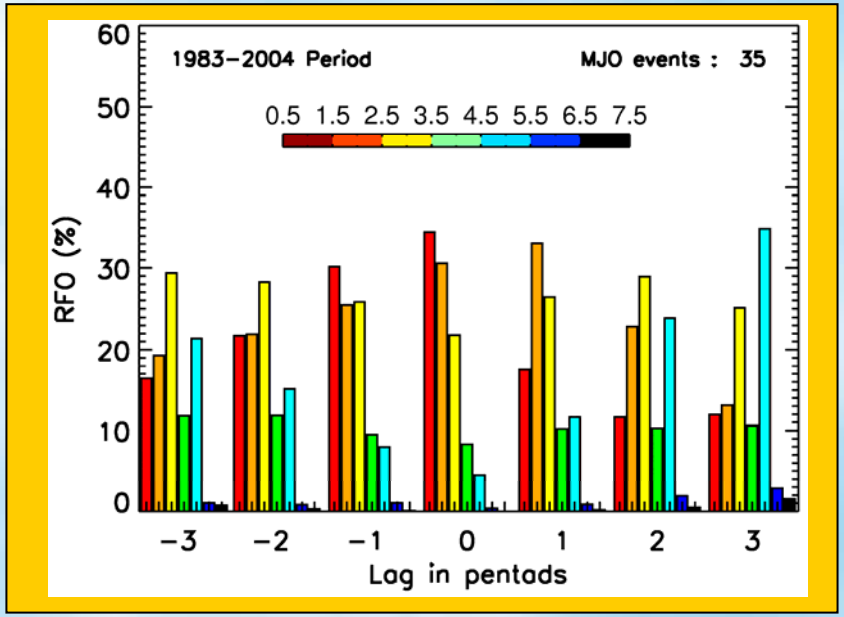
RFO of each cloud regime in 60E-180E region / 5S-5N latitude band

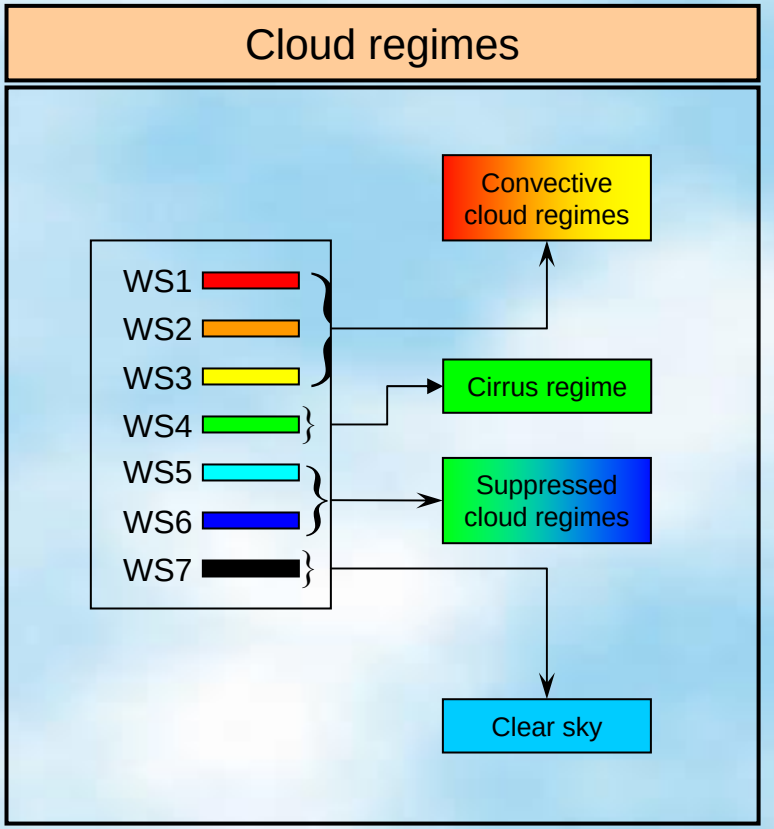
(MJO events in November-April periods from 1983 - 2004)

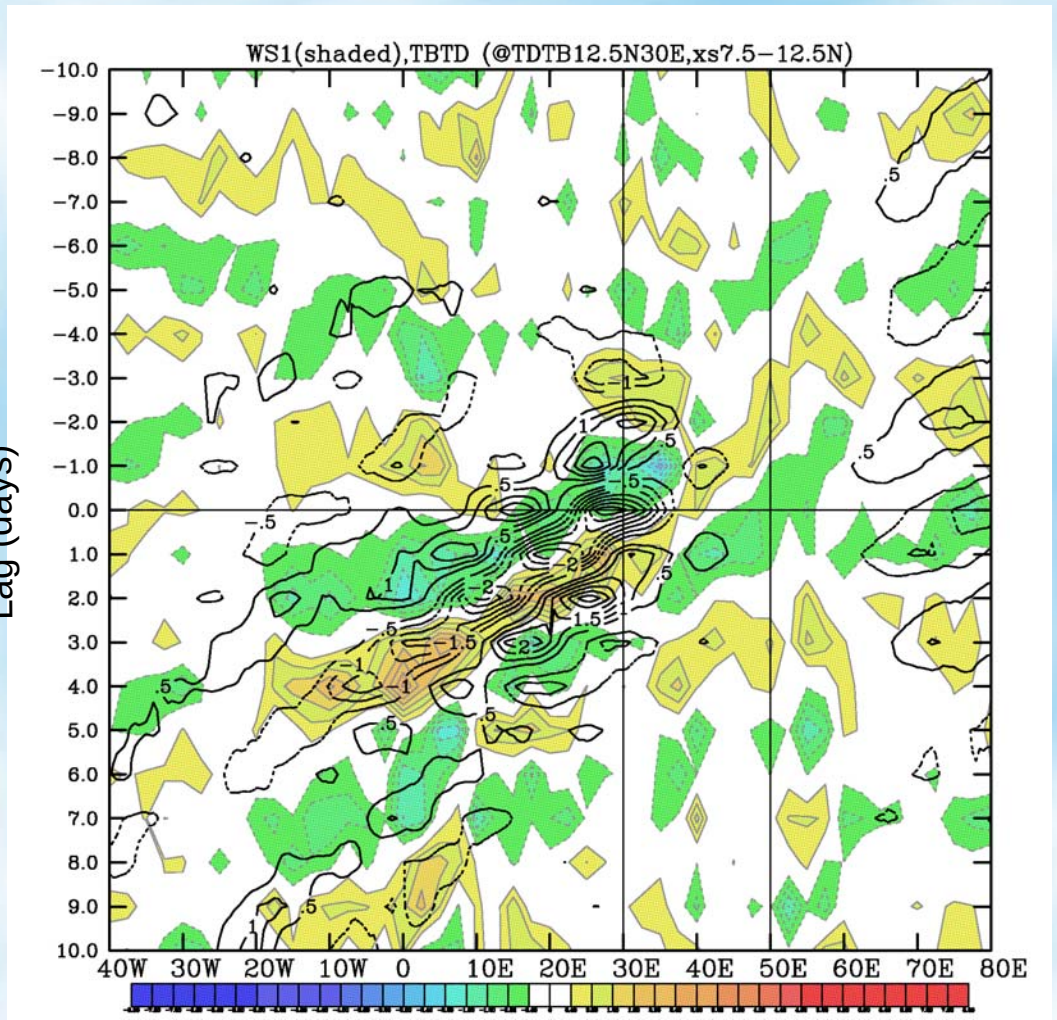
Weak MJO (index < -1)



Strong MJO (index < -2.2)



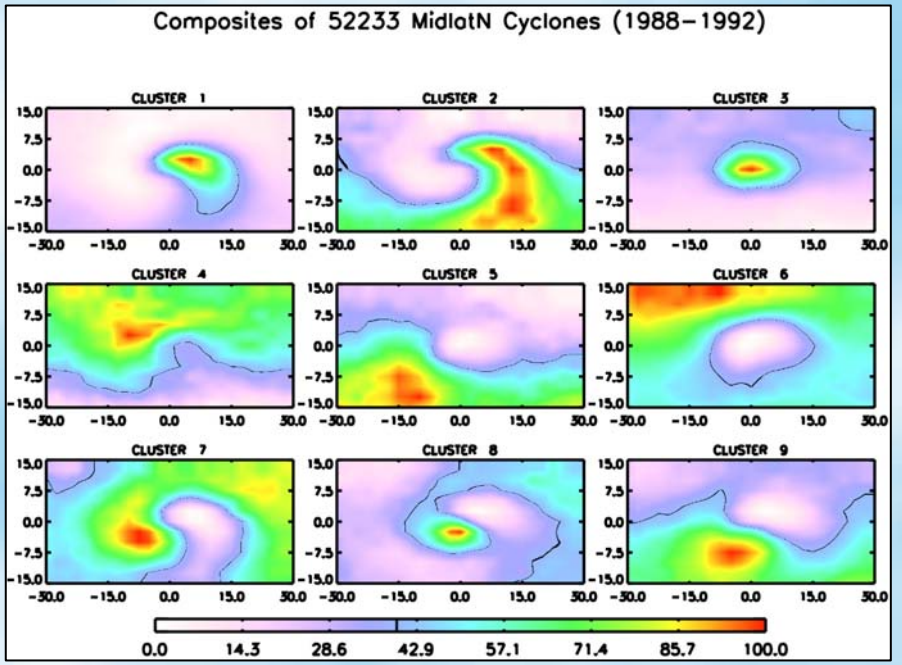


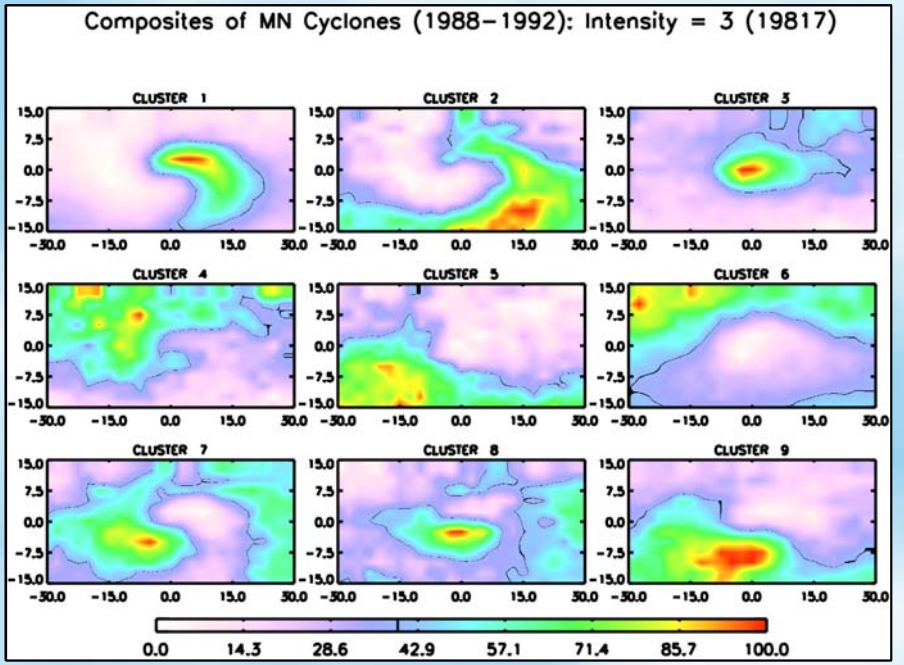


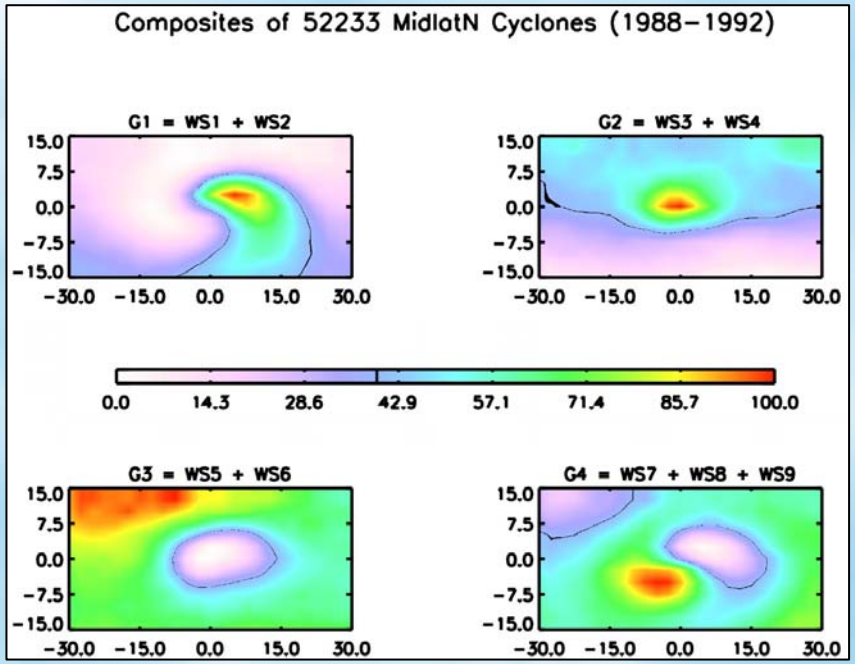
High positive anomalies of WS1 seem to be to the north and east of enhanced T_B anomalies.

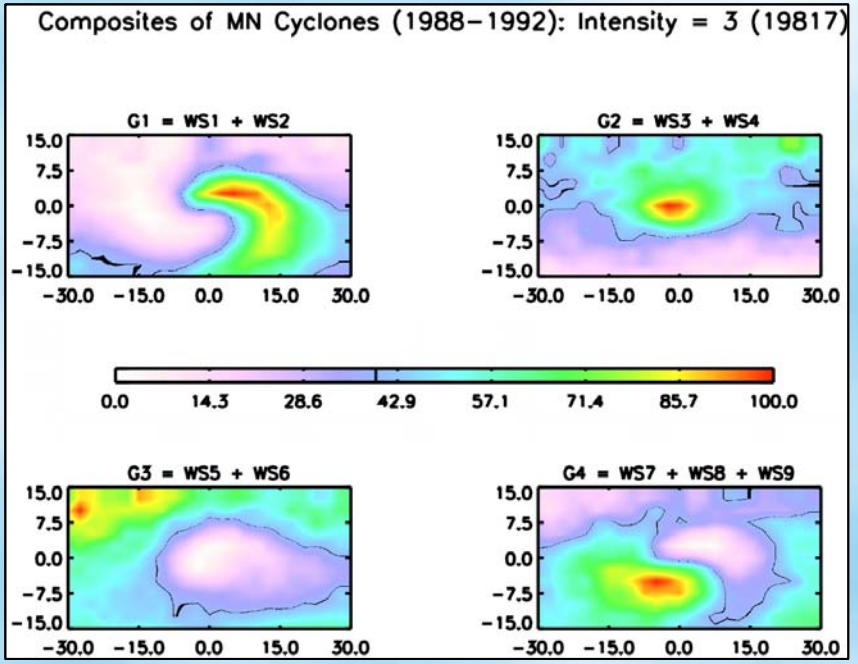
WS1 (shaded; negatives in blue-ish, positives in yellow-reddish), T_B (contoured; negatives enhanced, positives suppressed anomaly) regressed onto TD-filtered TB@12.5N30E

Northern Midlatitude Cyclone Composites per WS (1988-1992)



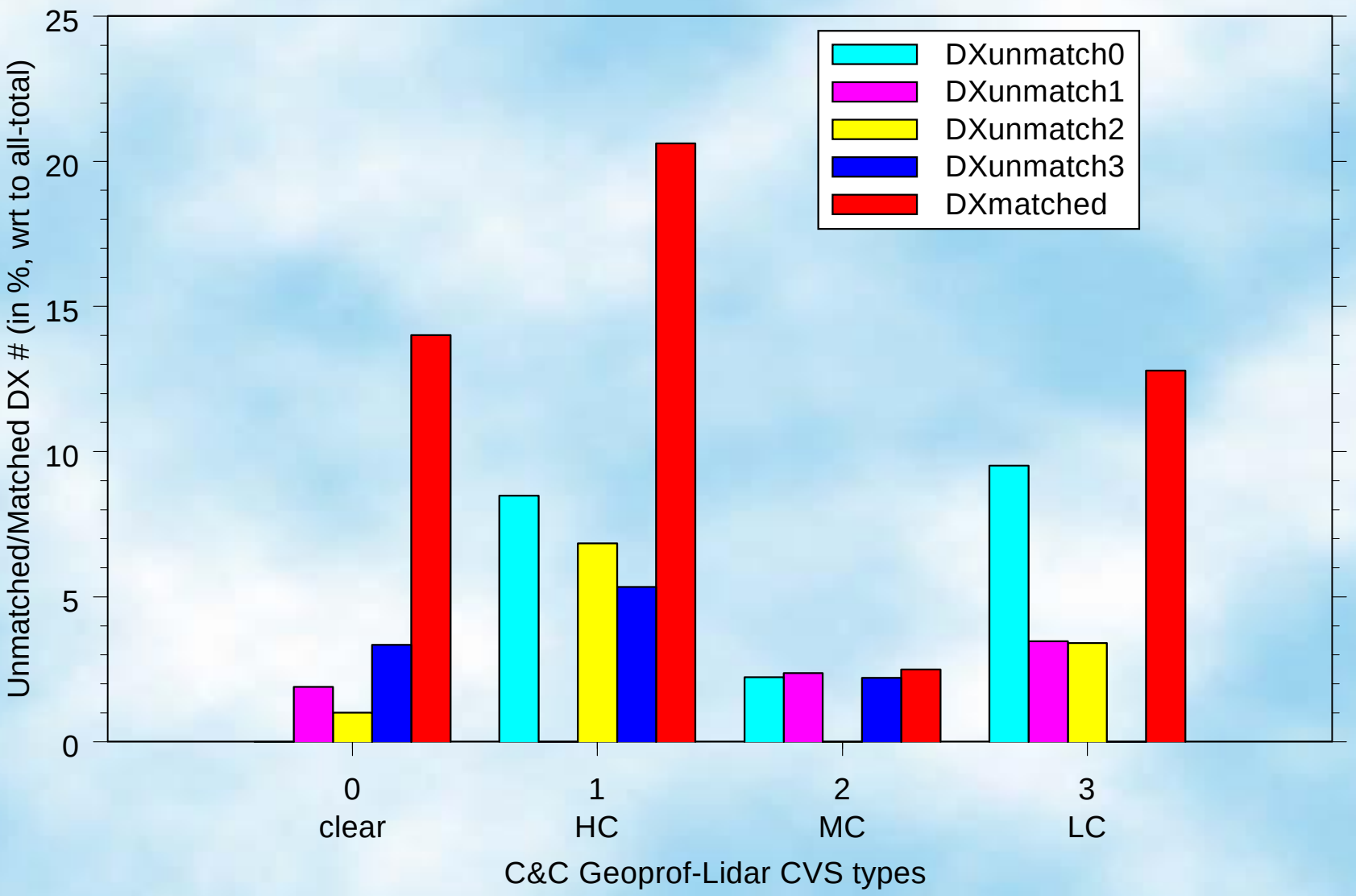






DATA ISSUES

- **Questions about lidar cloud identification**
- **Combining radar and lidar cloud masks**
- **Physical & Statistical Inconsistencies of L2 Products**
- **Mapping**
- **Sampling (space versus time)**
- **Final Volume of L3**

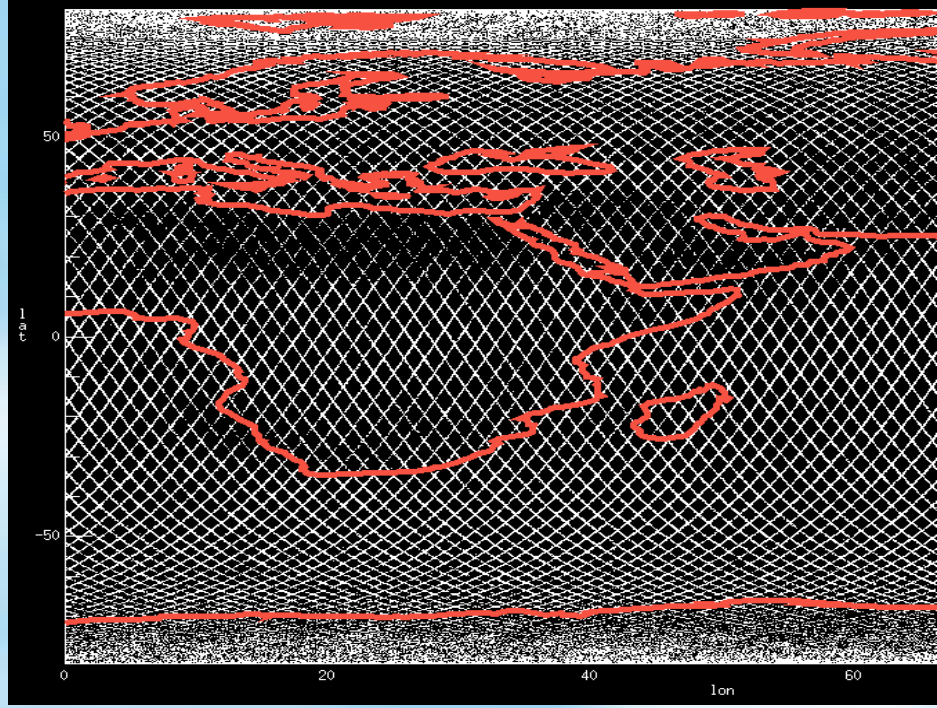

Unmatched/Matched DX # (% wrt all-total) for Land+Ocean, 0610: Global
Unmatched/Matched DX # (in %, wrt to all-total)
25
20
15
10
5
0
DXunmatch0
DXunmatch1
DXunmatch2
DXunmatch3
DXmatched
0
clear
1
HC
2
MC
3
LC
C&C Geoprof-Lidar CVS types

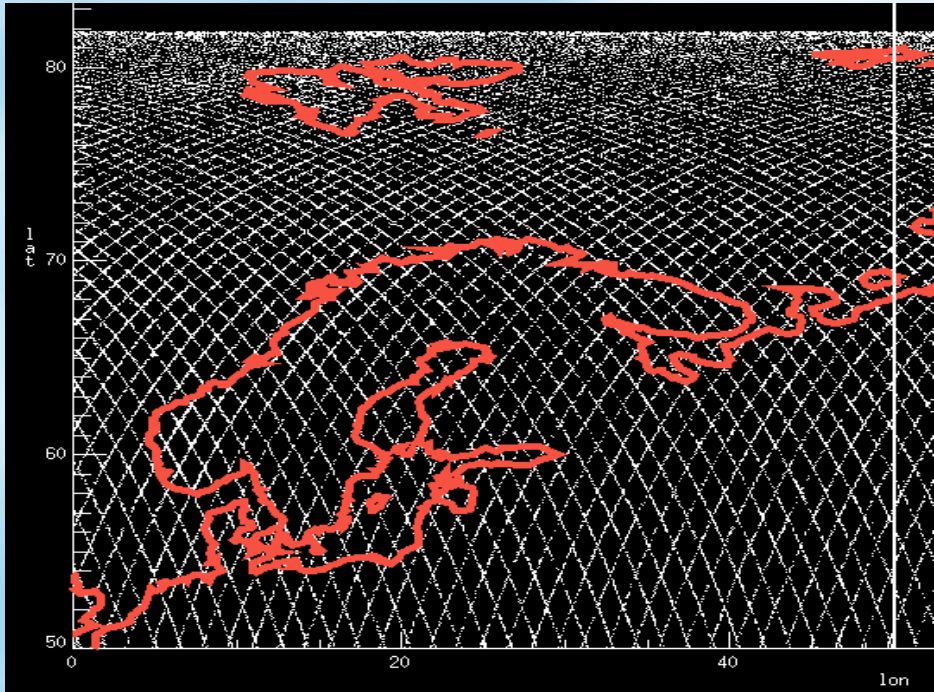
MAPPING ISSUE

(courtesy Brian Mapes)

-- A-train Orbit has 233 vertices in longitude, so any grid that is not a multiple of 360/233 = 1.545 (or 3.090) degrees produces spurious periodic features

-- Approximate latitude interval is 7.2727… degrees, so grid needs to be about 3.636 degrees





SAMPLING ISSUE

Given nadir track nature of C&C data

and 233 vertices in orbit track,

Number of Samples per 1.545 degree map grid per 16 days is only 2, so for 1.5 degree latitude interval, number of pixels is about 6

Implication: To have about 100 samples in averages, either we use a much coarser grid (6 x 6 degrees) to preserve monthly time interval or we report seasonal averages to have finer spatial scale (3 x 3 degrees)

OTHER ISSUES WITH L3 CREATION

- Speed of ftp for Cloudsat L2 collection slow
  - @10 times slower than TRMM collection from the same computer**
- Variable dimensions:
  - NBINS: Products such as (FLXHR) have 126 bins.
  - NRAYS: sometimes difference in length by 1 pixel
- Documentation:
  - A document should be available similar to the web interface, with clear definitions of each variable
  - Older versions of documents should be stored in a different location than the current versions

DATA PRODUCT VOLUMES

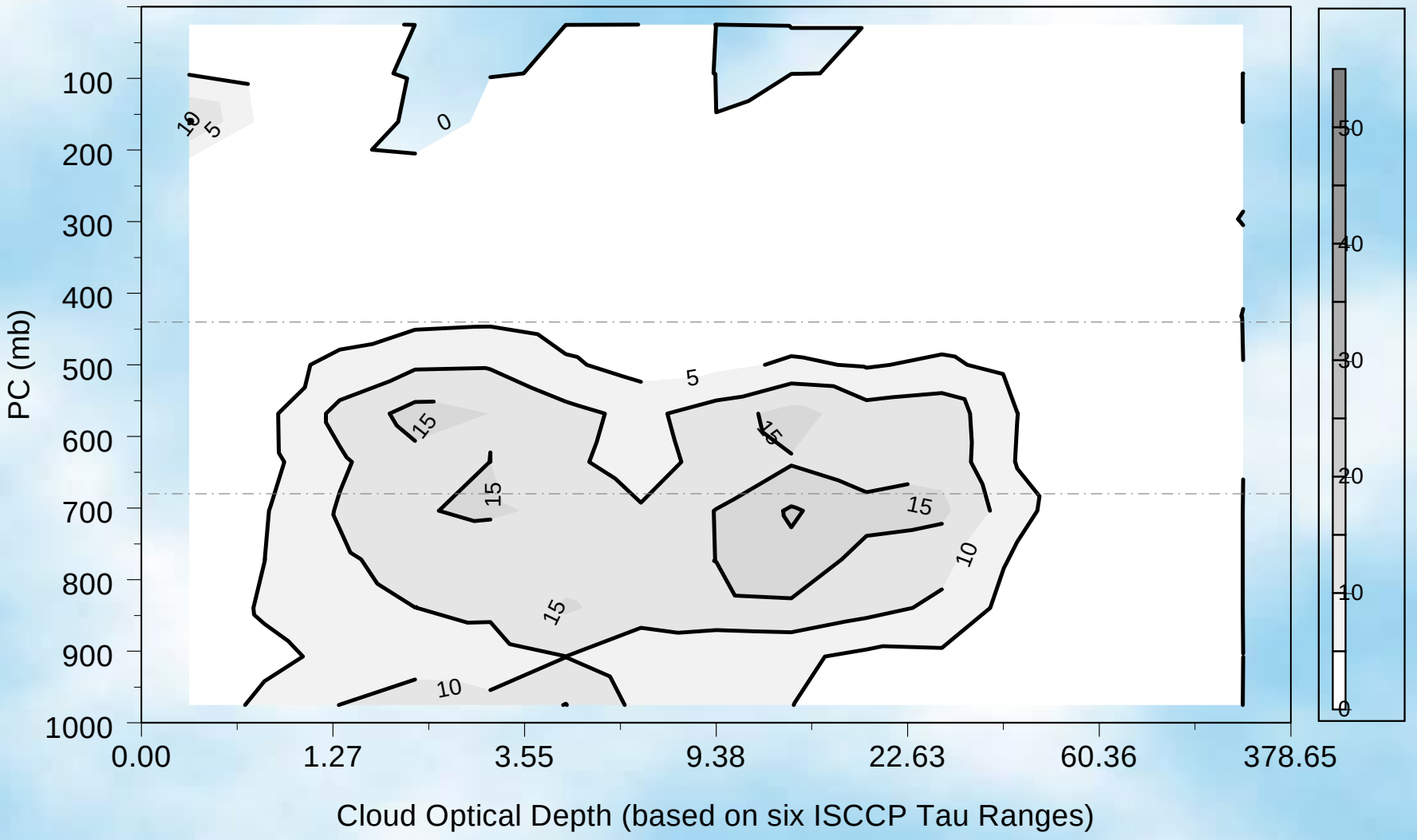
- CURRENT L2 VOLUME = 11 GB/day (9 expected)
- BINARY L2 VOLUME = 10 GB/day
- REDUCED L2 VOLUME = 5 GB/day
- EFFICIENT REDUCED L2 VOLUME = 4 GB/day
- L3 VOLUME at 25 km = 3 GB/month
- L3 VOLUME at 50 km = 1.5 GB/month (5x ISCCP D1)

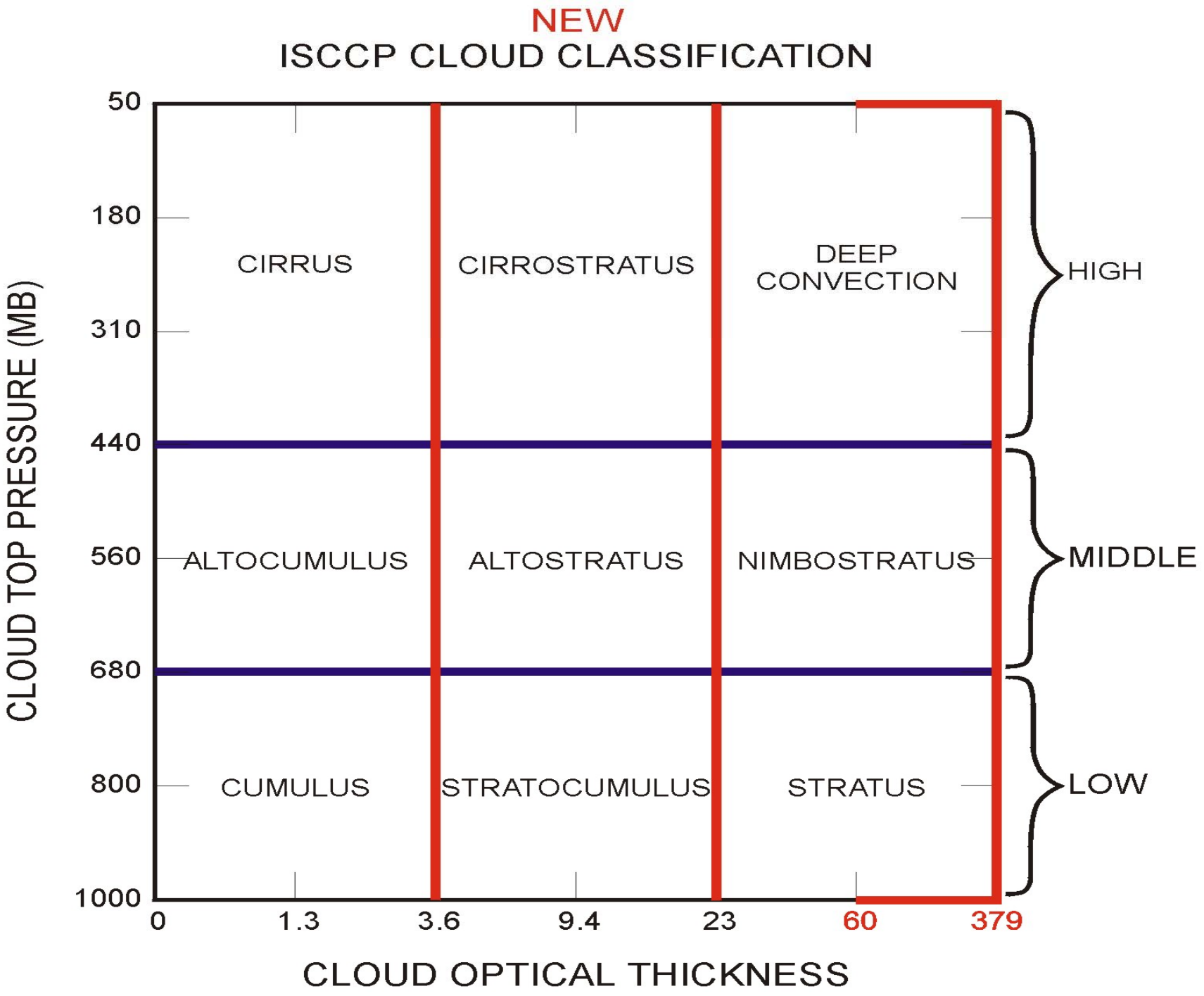
RECOMMENDATIONS

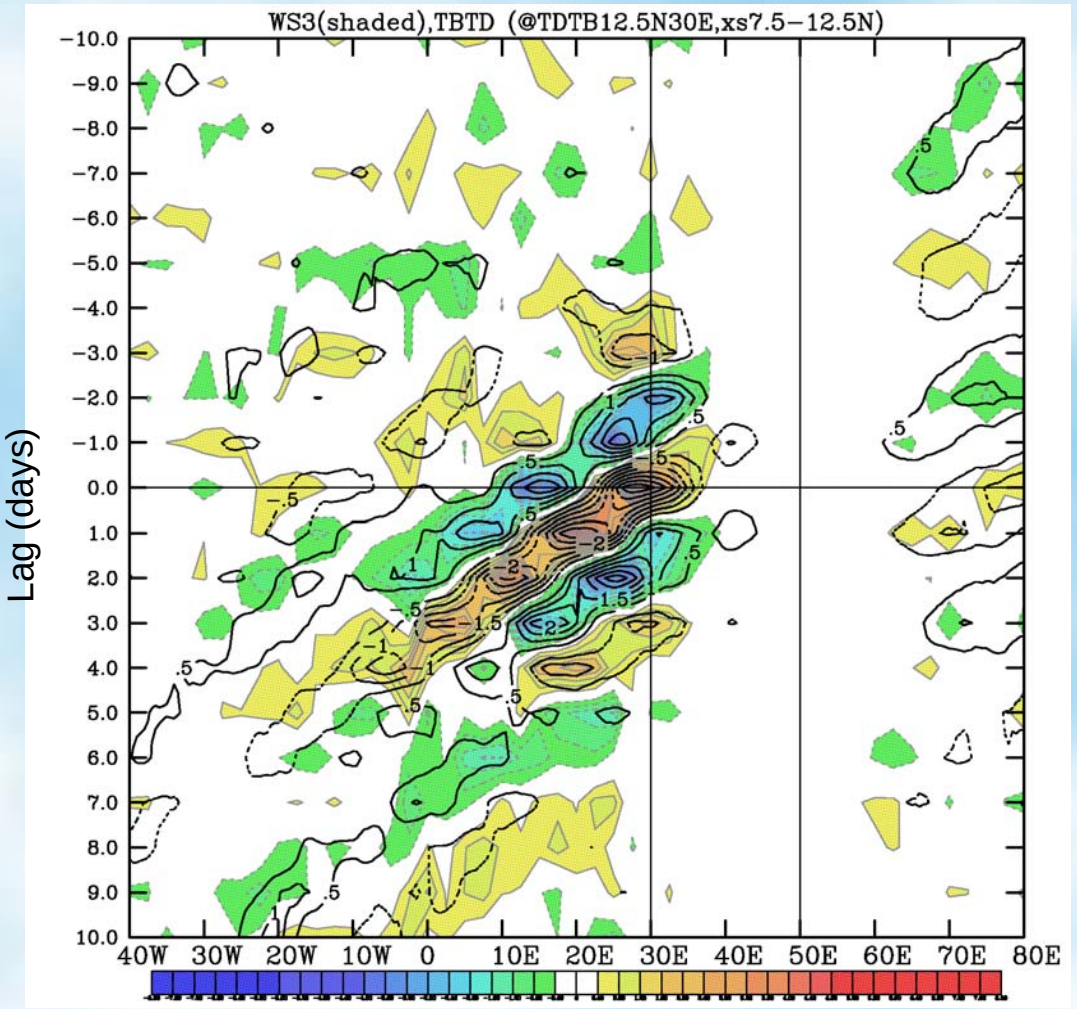
- Go Ahead with Current L3 using Current L2 ???
- Resolve Inconsistencies and Refine Thresholds
- Formulate Revised Rationales for Products
- Conduct Coordinated Re-Design of L2 (and L3) Products
- Re-Process

BACKUP SLIDES

DX Frequency (‰) over C&C ML: Land+Ocean, 0610: Global




NEW
ISCCP CLOUD CLASSIFICATION
CLOUD TOP PRESSURE (MB)
50
180
310
440
560
680
800
1000
CIRRUS
CIRROSTRATUS
DEEP CONVECTION
ALTOCUMULUS
ALTOSTRATUS
NIMBOSTRATUS
CUMULUS
STRATOCUMULUS
STRATUS
HIGH
MIDDLE
LOW
0
1.3
3.6
9.4
23
60
379
CLOUD OPTICAL THICKNESS

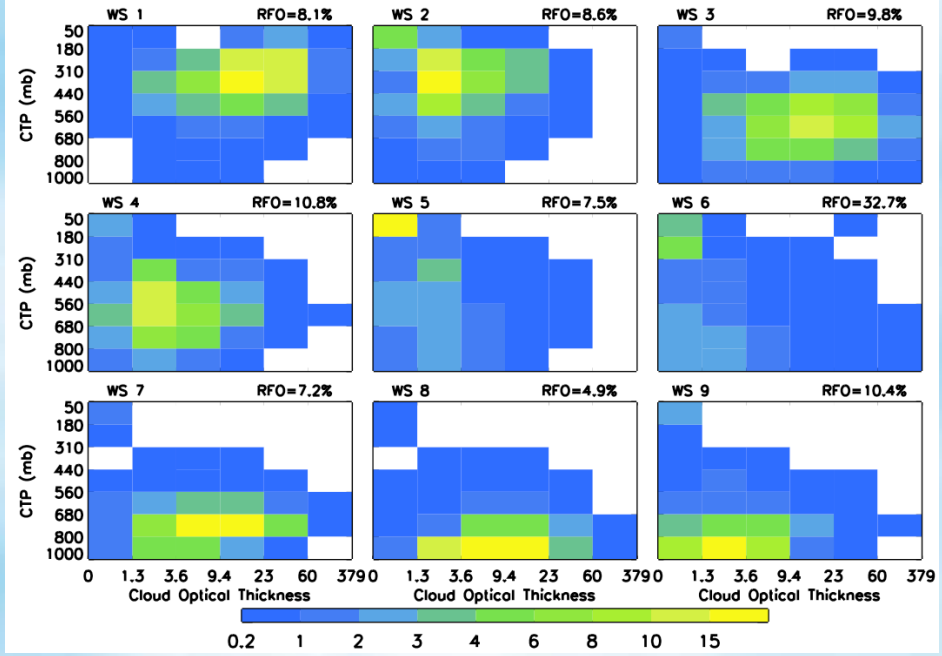


WS3 anomalies and T_B anomalies are completely in phase. Enhanced T_B in phase with increased WS3.

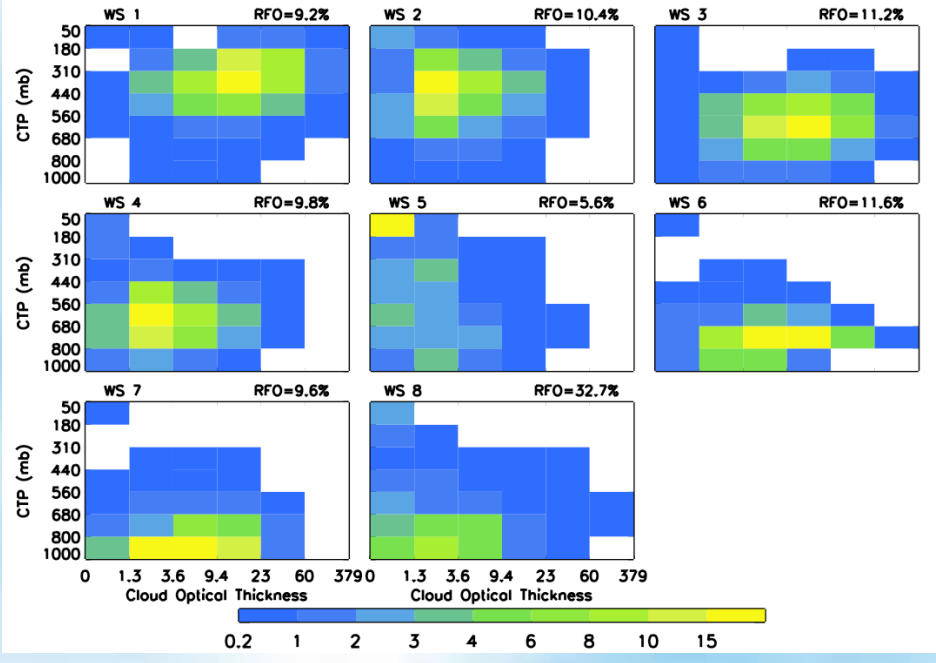
WS3 (shaded; negatives in blue-ish, positives in yellow-reddish), T_B (contoured; negatives enhanced, positives suppressed anomaly) regressed onto TD-filtered TB@12.5N30E

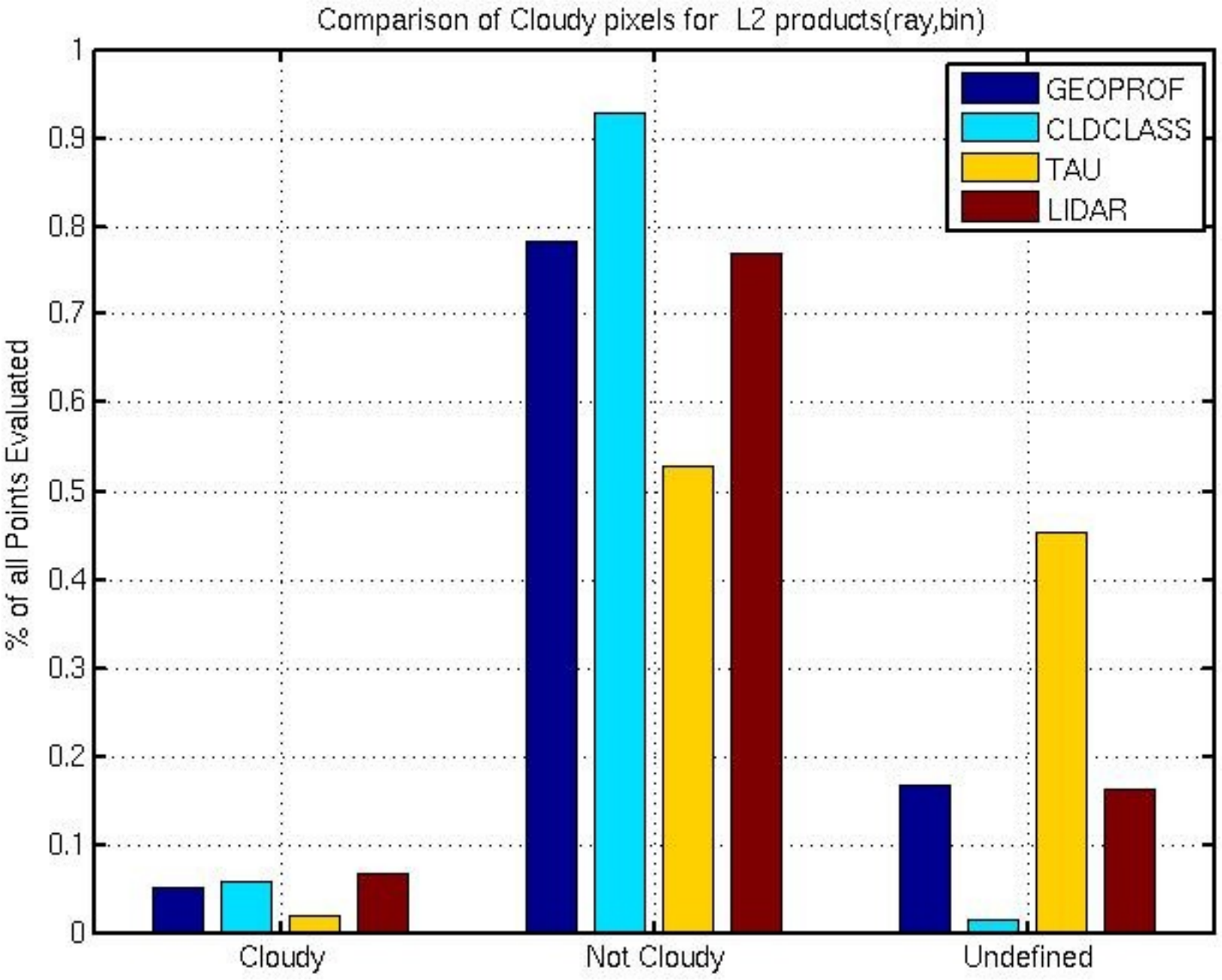
Midlatitude Weather States (1984-2004)

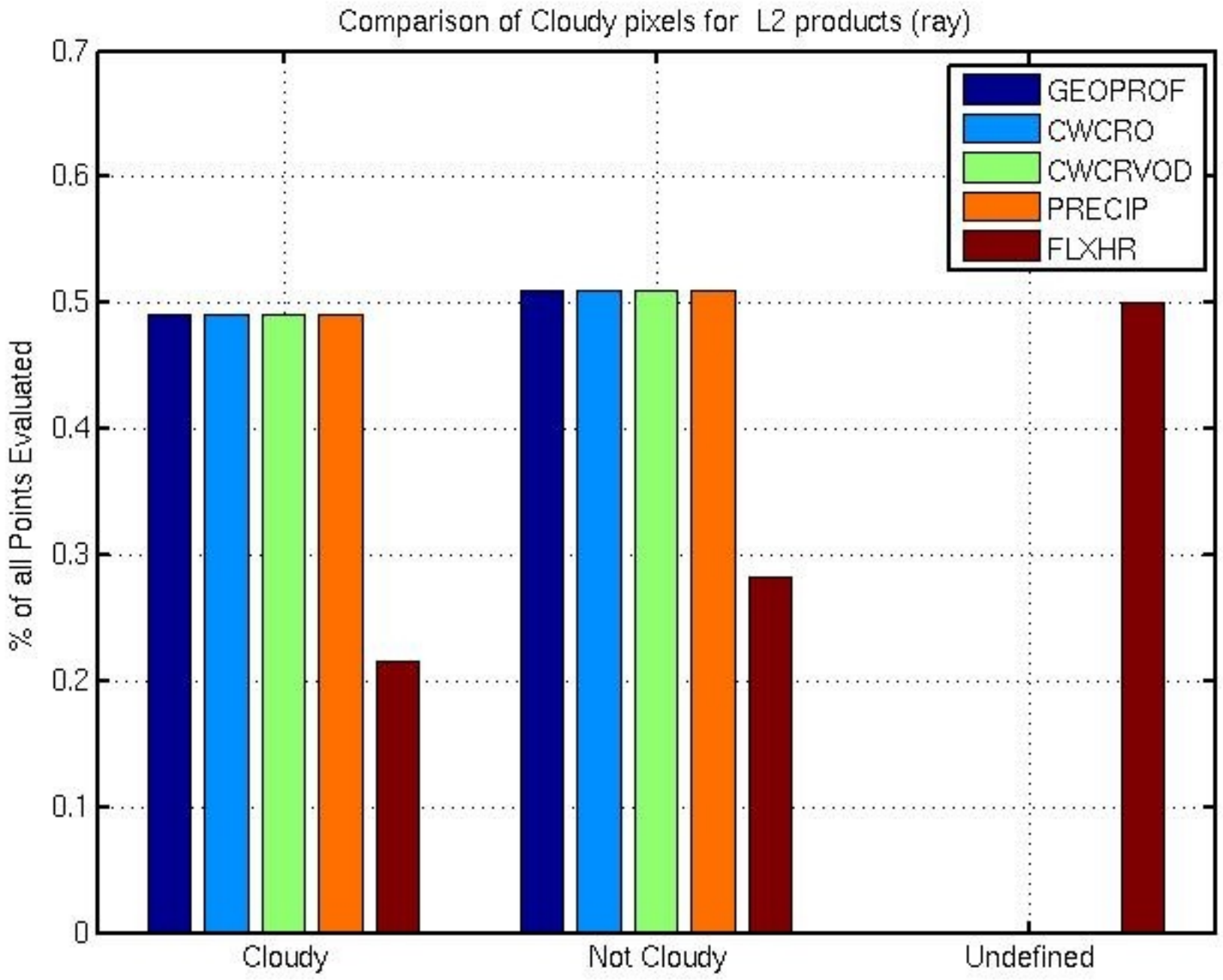
Northern Midlatitudes



Southern Midlatitudes




Comparison of Cloudy pixels for L2 products(ray,bin)
% of all Points Evaluated
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Cloudy
Not Cloudy
Undefined
GEOPROF
CLDCLASS
TAU
LIDAR


Comparison of Cloudy pixels for L2 products (ray)
% of all Points Evaluated
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Cloudy
Not Cloudy
Undefined
GEOPROF
CWCRO
CWCRVOD
PRECIP
FLXHR

LIST OF L2 PRODUCTS – RELEASE 4

Type	Expected Size (MB)*	Actual size (MB)	#Variables**
GEOLOC			16
2B – GEOPROF	33	34	15
2B – CLDCLASS	19	19	1
2B – CWC-RO	160	363	102
2B – TAU	9	20	8
2B – CWC-RVOD	160	18	108
2B – FLXHR	34	104	30
2B – GEOPROF-LIDAR	33	20	7
2C – PRECIP-COLUMN	?	4	27
MODIS-AUX	51	52	38
ECMWF-AUX	90	80	8
ECMWF2-AUX	??	1	3
TOTAL***	590	714	373

About 714 MB/orbit, @11 GB/day

*from the Cloudsat standard data products handbook (4/2008)

**# variables retrieved through hdf inquire, less the shared geoloc fields

LIST OF L2 PRODUCTS SAVED IN BINARY FORMAT

Type	Binary Size(MB)*	#Variables
GEOLOC	10	16
2B – GEOPROF	24	15
2B – CLDCLASS	9	1
2B – CWC-RVO	353	102
2B – TAU	9	8
2B – CWC-RVOD	10 **	108
2B – FLXHR	94	30
2B – GEOPROF-LIDAR	10	7
2C – PRECIP-COLUMN	3	27
MODIS-AUX	47	38
ECMWF-AUX	79	8
ECMWF2-AUX	<1	3
TOTAL	649	373

About 992 MB/orbit, @10 GB/day

* Binary size from variable definition and standard track length, total less duplicate geolocation fields

REDUCED LIST OF L2 PRODUCTS FOR L3

Type	Binary Size (MB)*	#Variables
GEOLOC	9	9
2B – GEOPROF	24	4
2B – CLDCLASS	0	0
2B – CWC-RO	0	0**
2B – TAU	10	6
2B – CWC-RVOD	131	25**
2B – FLXHR	94	9
2B – GEOPROF-LIDAR	5	3
2C – PRECIP-COLUMN	1	10
MODIS-AUX	1	1
ECMWF-AUX	79	8
ECMWF2-AUX	<1	2
TOTAL	355	77

ABOUT 355 MB/orbit, @5GB/day

* sample orbit 37083 pixels/ray;

** include a variable containing the difference between (RVOD/RO)

IF ALL *4 → *2

THEN 4GB/day

Approximate Volumes

PART A & B = 4 GB/month (3 GB/month)

(for 25 km, histograms coded as *1)

(about 10 times larger than ISCCP D1)

PART C = 85 MB/month

(histograms coded as *1)

(about 10 times larger than ISCCP D2)

CLOUDSAT L3 PRODUCT

Part A – Basic Cross-Sections

Twice-daily, Reduced Resolution (50 km - 500 m)

Merged, Averaged L2 Variables at Each Location

CLOUDSAT L3 PRODUCT

Part B -- Statistical Histograms

Reflectivity vs Particle Size

Optical Thickness vs Particle Size

Water Content vs Particle Size

Water Content vs Precipitation

CLOUDSAT L3 PRODUCT

PART C – Gridded Monthly Statistics

Gridded at 4.5^{o} x 4.5^{o} with Cloud Fraction

Cloud Layer (Type) Properties from Part A

Vertical Structure Statistics from Part A

Accumulated Histograms from Part B

Additional Histograms

Water Content– Particle Size– Temperature

Water Content—Particle Size—Relative Humidity

Cloudy Alpha & Beta Parameters

Clear Alpha & Beta Parameters

ENERGY AND WATER CYCLE OF CLIMATE