Probability of Cloud-Free Line of Sight (PCFLOS) derived from CloudSat Cloud Profiling Radar (CPR) and coincident CALIPSO lidar data
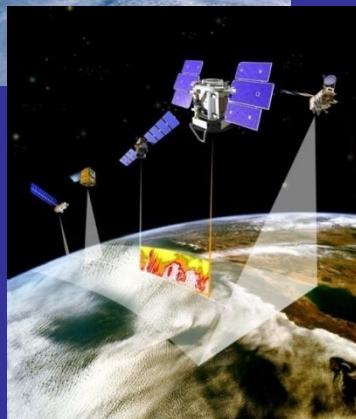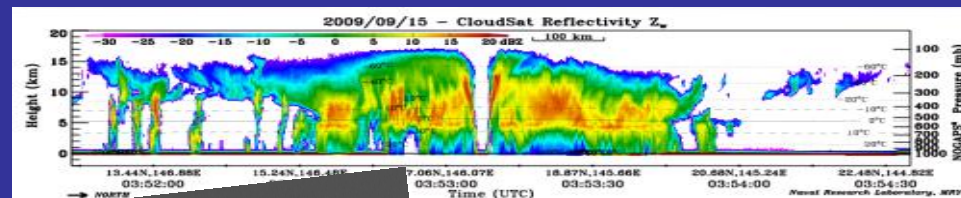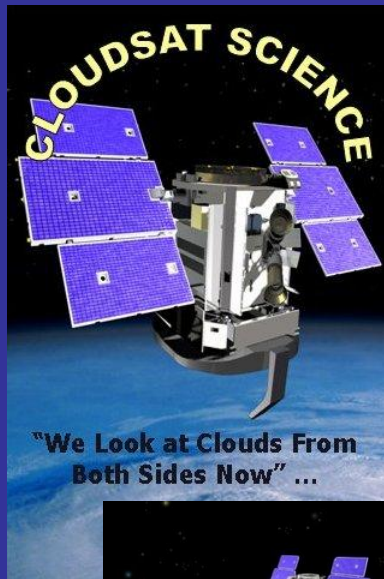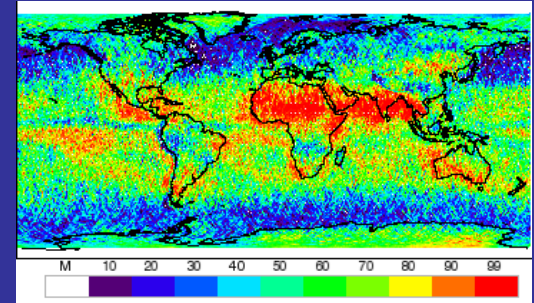
Donald L. Reinke, John M. Forsythe, Karen E. Milberger, and Thomas H. Vonder Haar
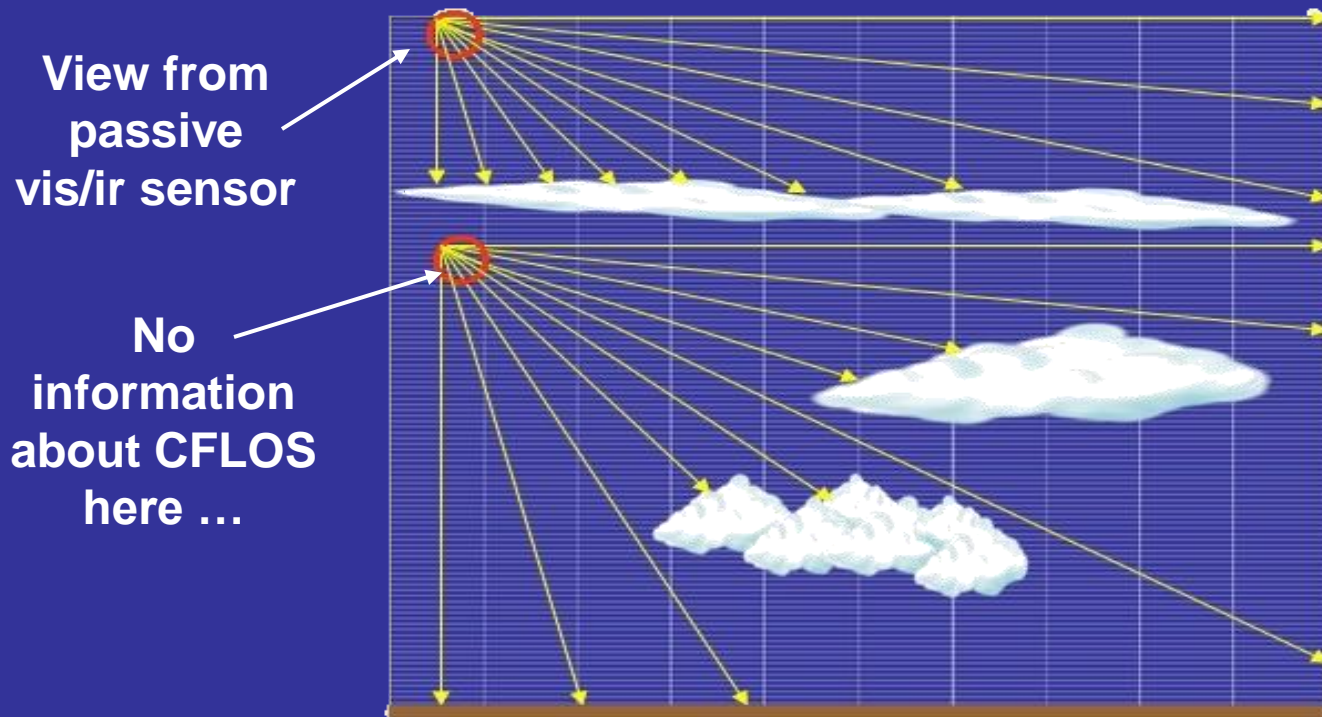
CIRA
Colorado State Univ.
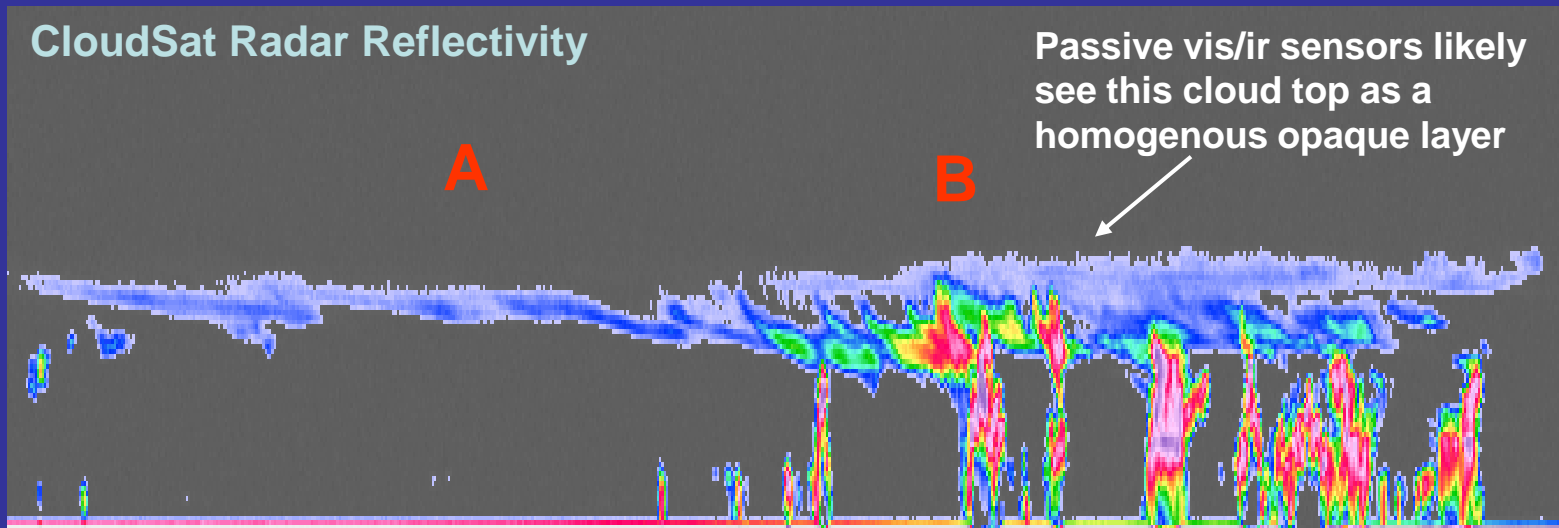*Fort Collins CO*
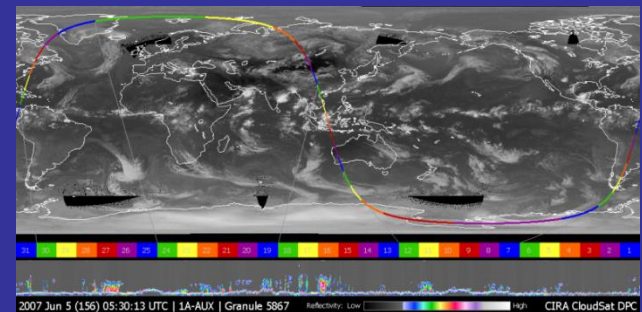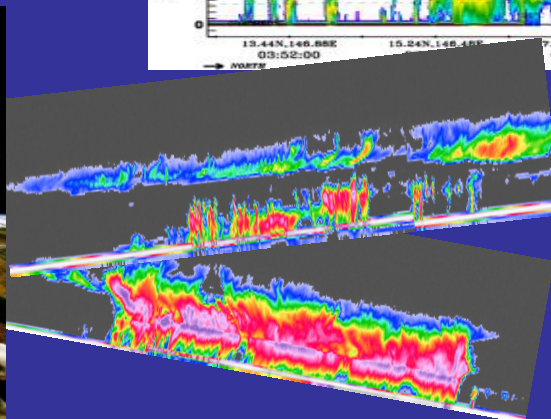
CFLOS "Problem"

The Problem: CFLOS, beneath an opaque cloud layer, has been impossible to determine, directly, from passive space sensors

Corollary: Passive satellites measure cloud tops well … and surface observers the bases … but neither do an adequate job of characterizing the intervening layers …

View from passive vis/ir sensor

No information about CFLOS here …

Addressing the Problem – Cloud Profiling Radar

TOA

CloudSat Radar Reflectivity

Passive vis/ir sensors likely see this cloud top as a homogenous opaque layer

A

B

Sfc

Here an opaque cloud at "B" hides the fact that there is a poor CFLOS at levels below the cloud top, while at "A" it hides a significantly better CFLOS just below the upper cloud layer.

CloudSat: 94 GHz Cloud-Profiling Radar

Near circular, sun-sychronous orbit … ~705km altitude, 14.5 orbits/day, 16-day revisit cycle
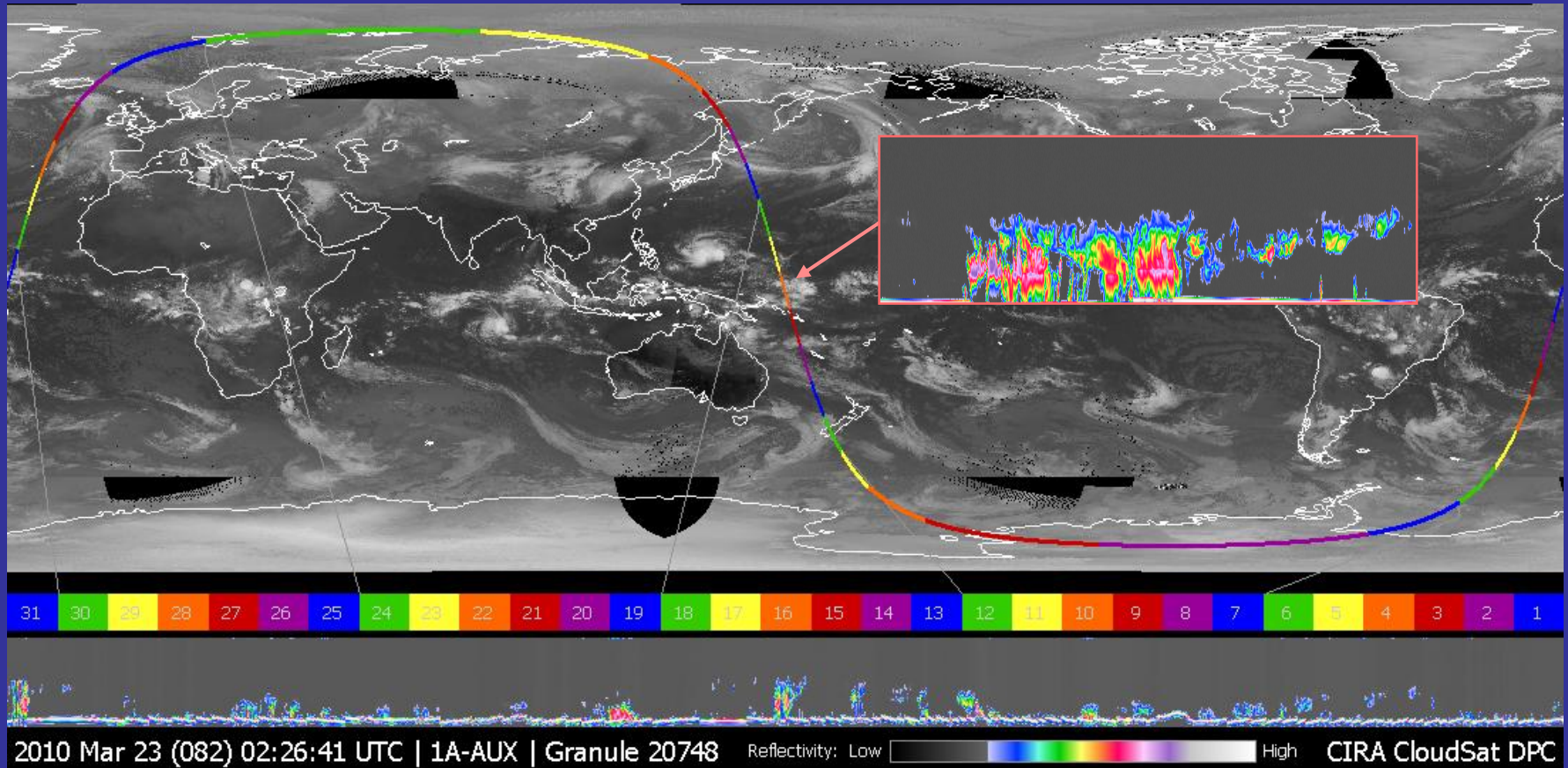
CloudSat: 94 GHz Cloud-Profiling Radar

Wavelength ~ 3 mm

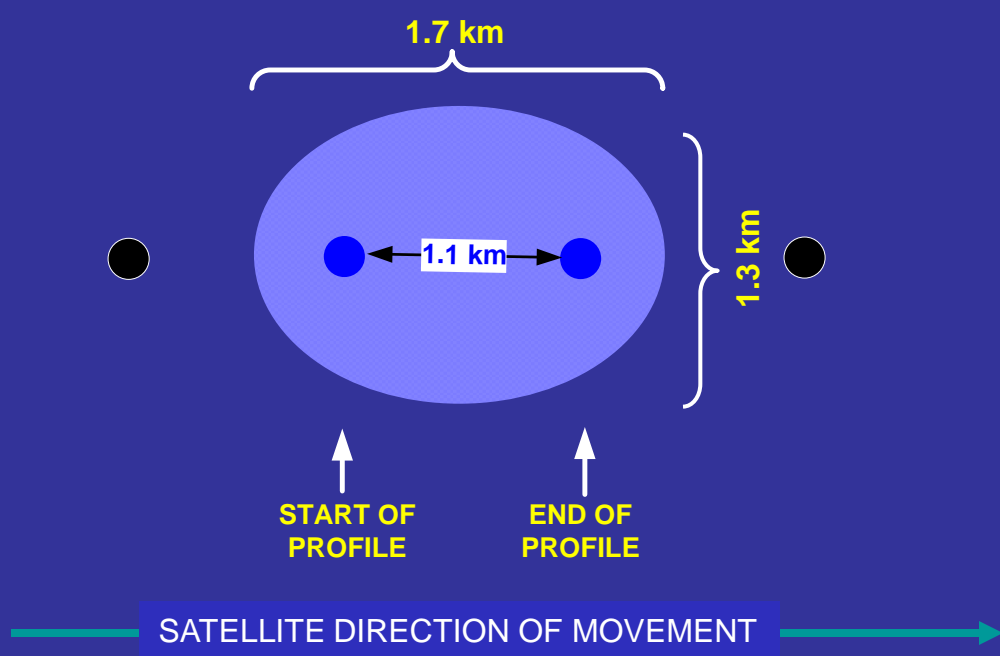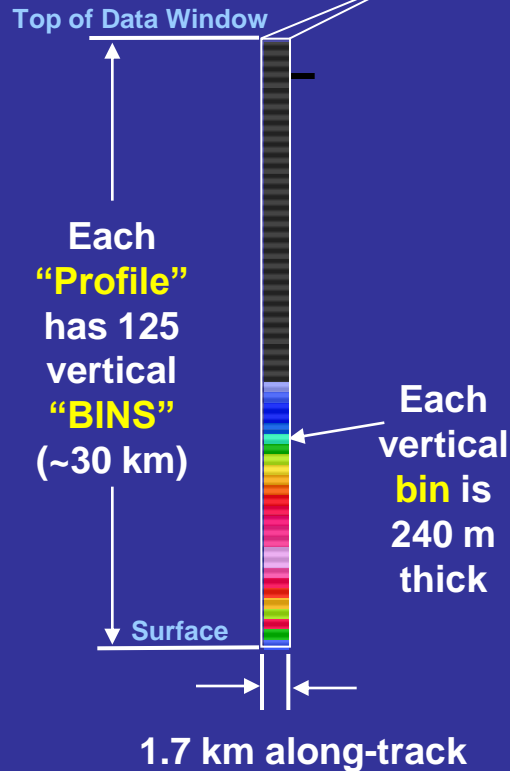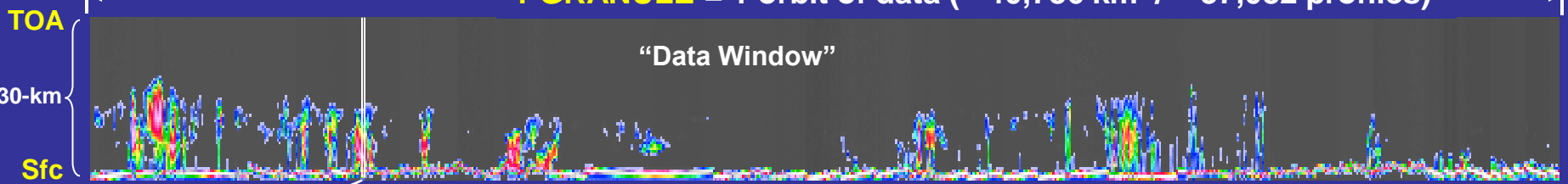**Near-nadir Pointing (0.16^o forward)**

Pulse Repetition Freq. ~ 4000

- **Return signal processed every 160 milliseconds (~ 6 times/sec)**

- **at 4000 PRF … ~ 630 pulses are averaged to produce a vertical cloud image ("profile")**

160 msec = 1.07 km along ground track

# Granules, Profiles and Bins : CPR footprint & granule size

1 GRANULE = 1 orbit of data (~ 40,786 km / ~ 37,082 profiles)

TOA

30-km

Sfc

"Data Window"

Top of Data Window

Each "Profile" has 125 vertical "BINS" (~30 km)

Each vertical bin is 240 m thick

Surface

1.7 km along-track

1.7 km

1.3 km

1.1 km

START OF PROFILE

END OF PROFILE

SATELLITE DIRECTION OF MOVEMENT

98.9 minutes per orbit   14.56 orbits/day

CALIPSO: Dual-Channel Lidar

– (CALIOP) "Cloud-Aerosol Lidar with Orthogonal Polarization"
  - 532 and 1062 nm wavelengths
  - Nadir Pointing
  - Vertical resolution 30m, 60m (< 8km)
  - 80m instantaneous footprint
  - Products generated at a horizontal resolution of 333m, 1km, and 5km

CloudSat Footprint   CALIPSO Footprint

CFLOS calculation

CFLOS computed at 20 vertical levels
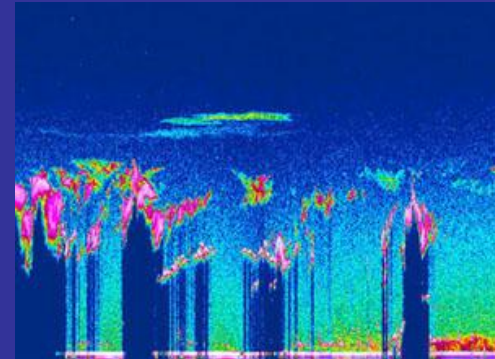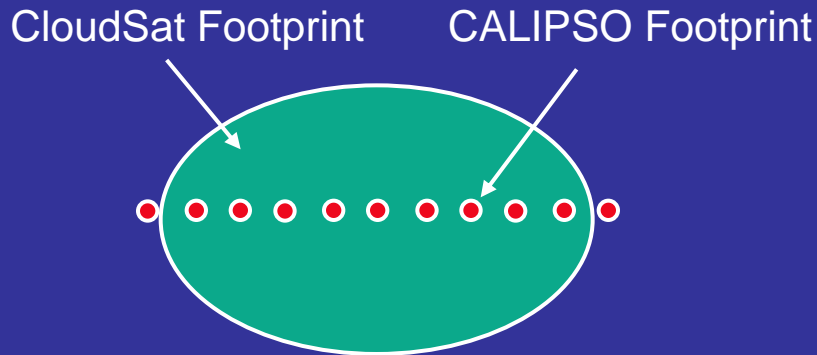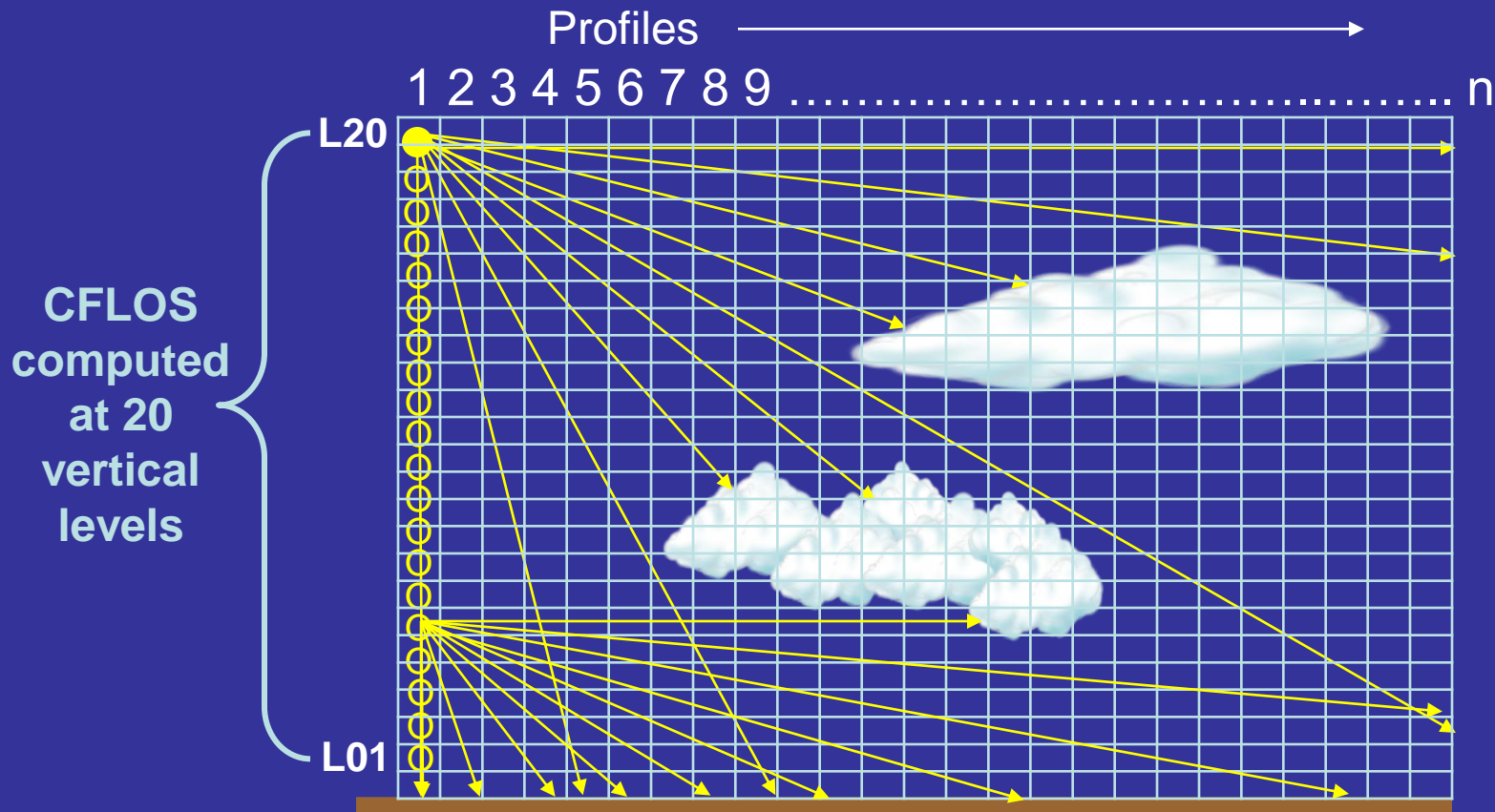
For each CloudSat profile, CFLOS is determined by looking at 10° intervals from nadir to 90° (horizontal) at each of 20 vertical levels. These levels extend from .96-km to 19.2-km altitude at ~1-km intervals. (every 4 bins in the vertical = 4X240m = .96km)

CFLOS Calculation

CFLOS is calculated by determining the distance (km) that we can see before encountering a cloud.

"0" indicates that we did not have a cloud in the line-of-sight.

View angle from Nadir

Vertical Level	0	10	20	30	40	50	60	70	80	90
20	6	7	7	7	8	10	13	19	30	0
19	5	6	6	6	7	9	12	16	28	0
18	4	5	5	5	6	7	9	14	25	0
17	3	4	4	4	5	6	7	11	21	0
16	2	2	3	3	3	4	5	8	15	0
15	1	1	2	2	2	3	3	5	11	33
14	1	1	1	1	1	1	1	2	4	26
13	1	1	1	1	1	1	1	1	1	1
12	1	1	1	1	1	1	1	1	1	1
11	0	0	0	0	0	0	0	0	0	2
10	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	92
2	0	0	0	0	0	0	0	0	0	91
1	0	0	0	0	0	0	0	0	0	43

PCFLOS – Observation Count & CFLOS Distance

The probability of Cloud-Free-Line-of-Sight (PCFLOS) was generated for each month from June 2006 – Aug 2010
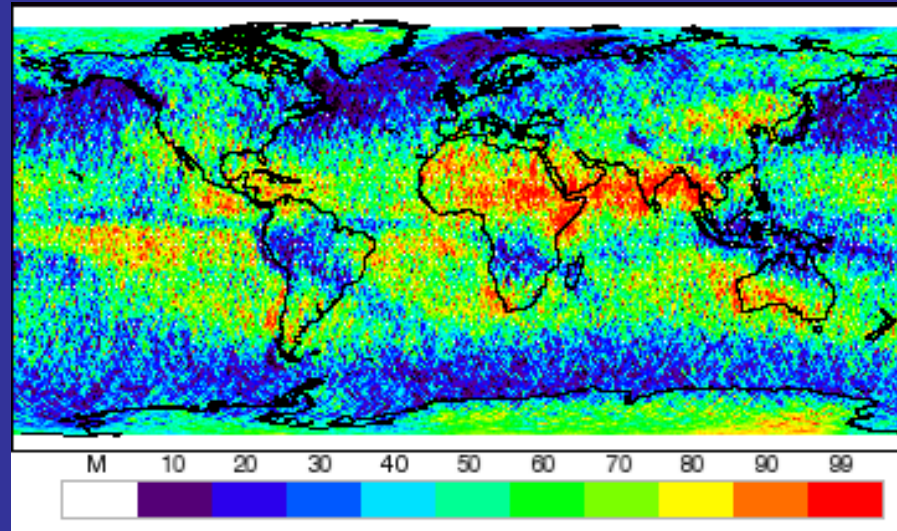
January (2007-2010)

Observation Count
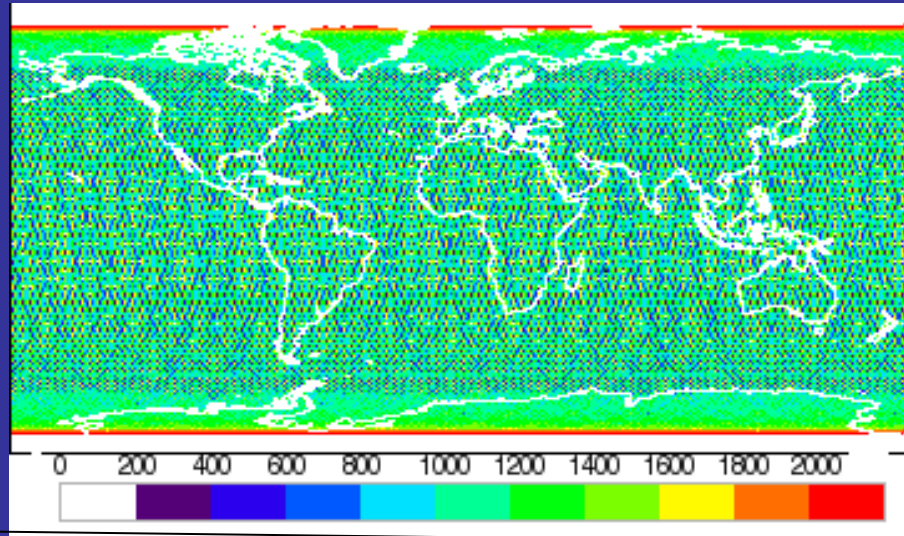
CFLOS Distance: **For all of the following examples, if the distance to the first cloud encountered was greater than 25km, it was considered a <u>Cloud-Free-Line-of-Sight</u>. (or … if there was a cloud-free view to the land/ocean surface)**

Comparison With Typical Cloud Fraction Products

**Probability of CFLOS
from CloudSat CPR
Location: L20 (TOA)
View: Nadir
January**

**MODIS Cloud Fraction
(January 2007)**
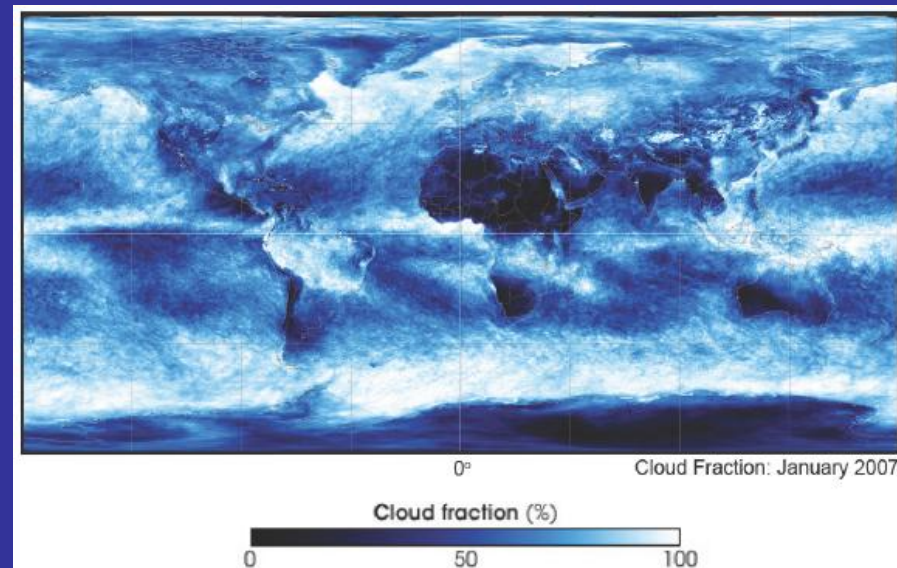
PCFLOS from CloudSat CPR

**Probability of CFLOS
from CloudSat CPR
Location: L20 (TOA)
View: Nadir
January 2007-2010**
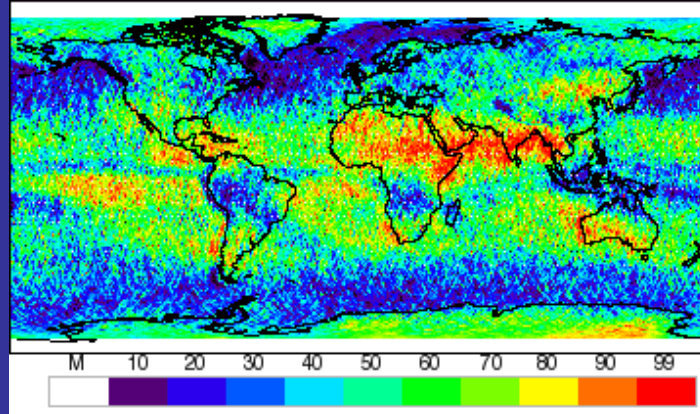
**Probability of CFLOS
from CloudSat CPR
Location: L20 (TOA)
View: Nadir
July 2006-2010**
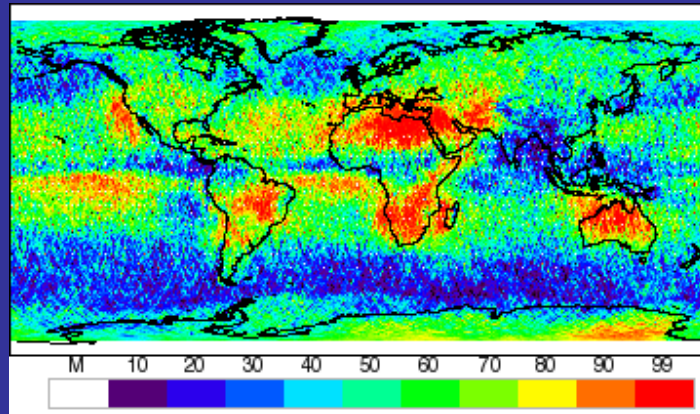
PCFLOS from CALIPSO Lidar

**Probability of CFLOS
from CloudSat CPR
Location: L20 (TOA)
View: Nadir
January 2007-2010**
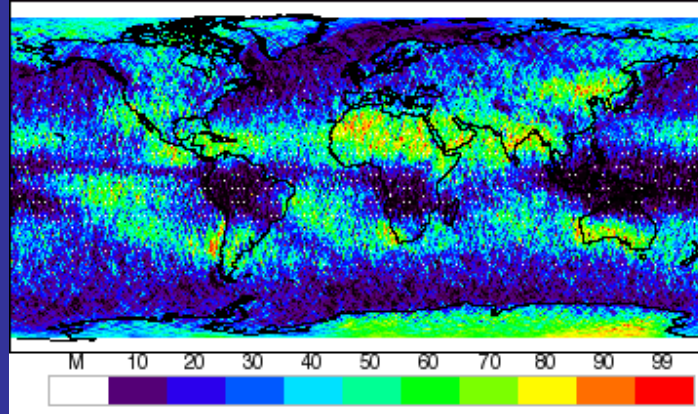
**Probability of CFLOS
from CloudSat CPR
Location: L20 (TOA)
View: Nadir
July 2006-2010**
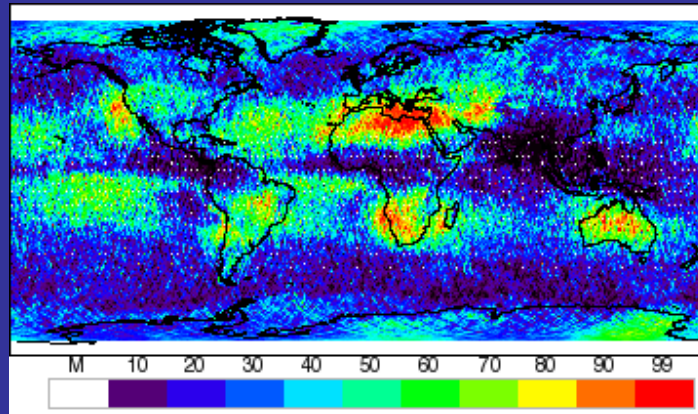
CFLOS from CloudSat CPR ... Varying Levels
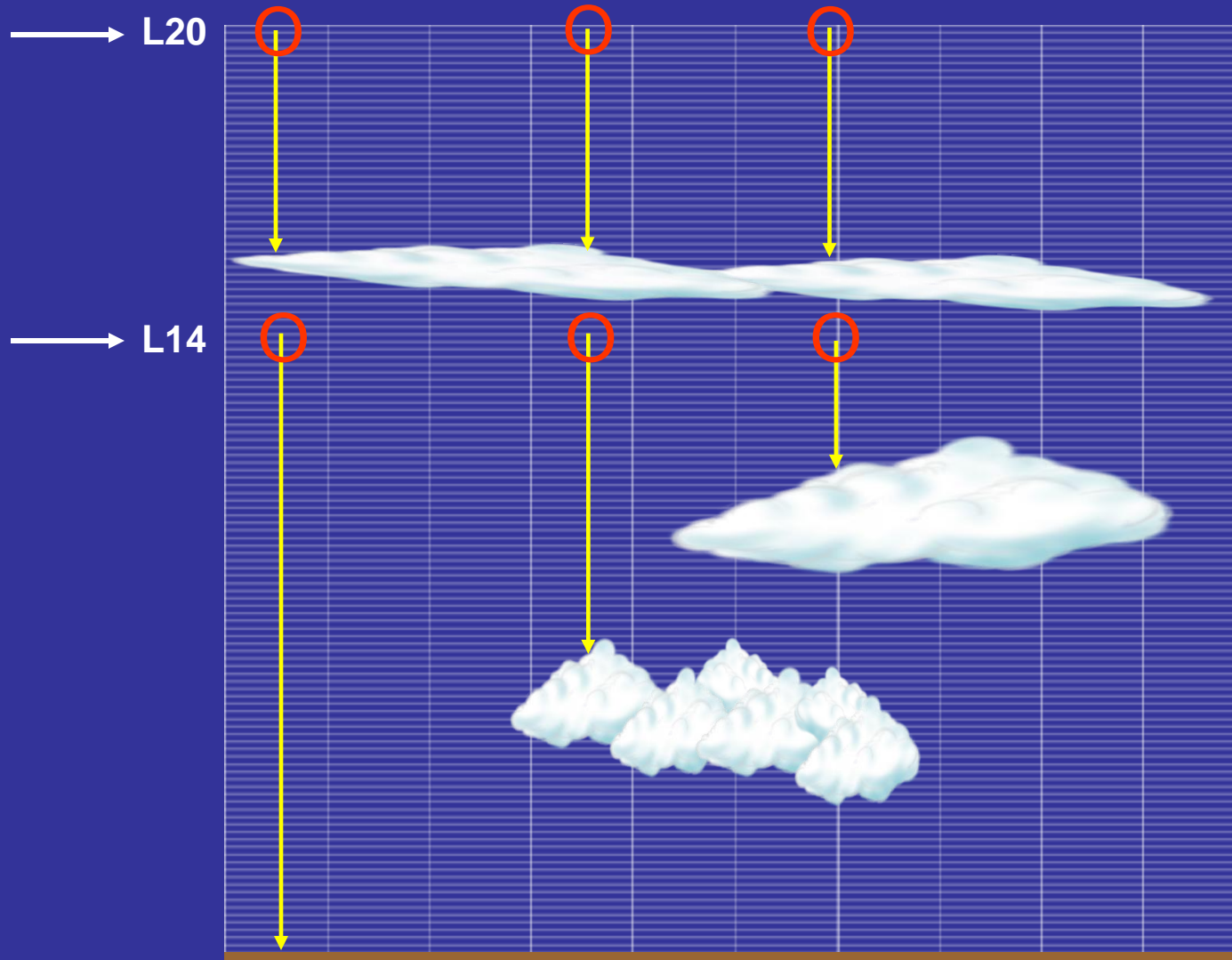
CFLOS from CloudSat CPR ... Varying Levels

Probability of CFLOS from CloudSat CPR January 2007-2010
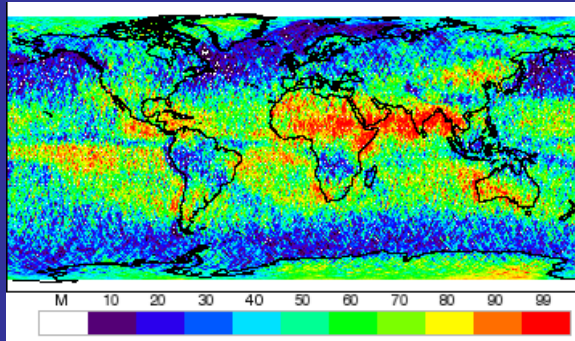
10-km altitude view: nadir
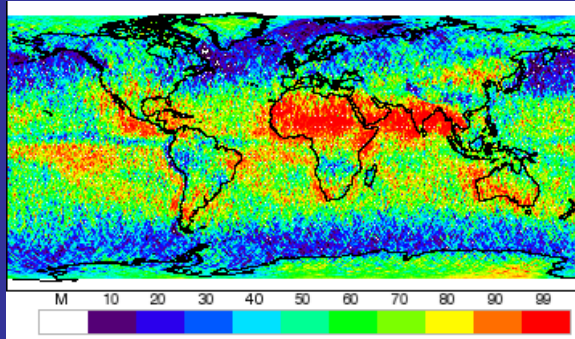
5-km altitude view: nadir
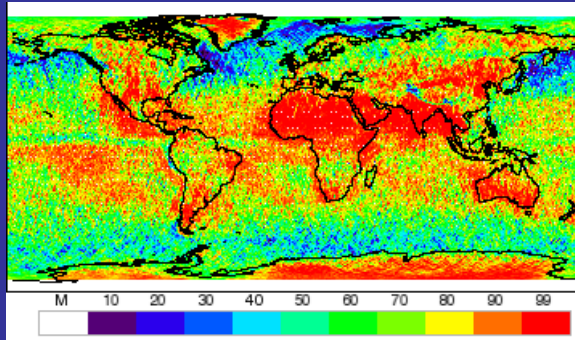
2-km altitude view: nadir

CFLOS from CloudSat CPR ... Varying View Angle

L20

L14
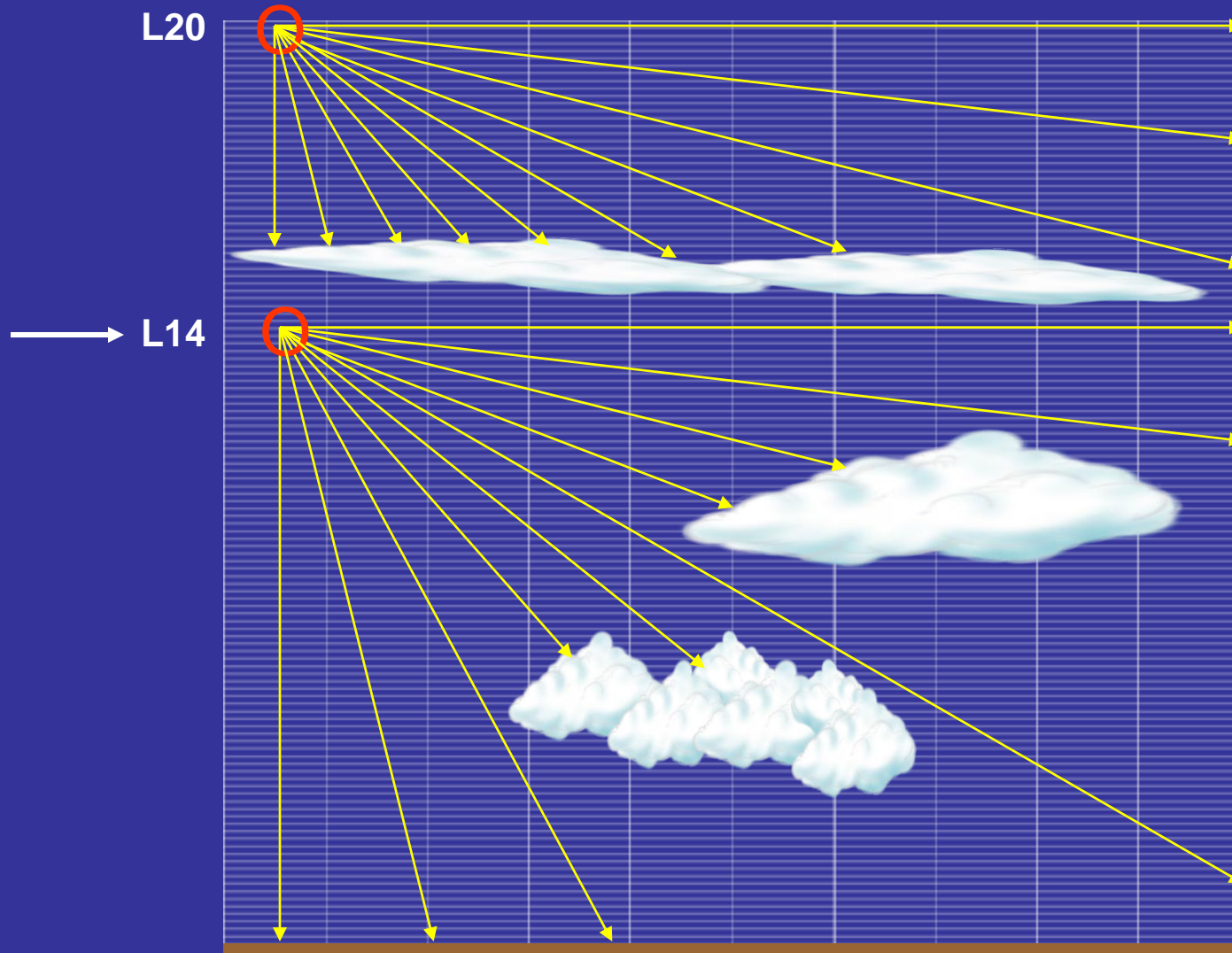
PCFLOS from CloudSat CPR … Varying View Angle
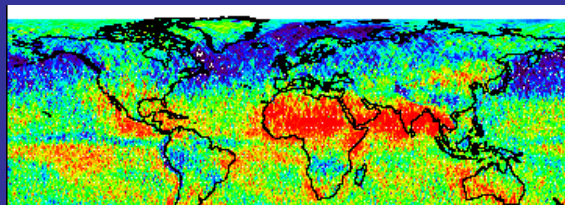
5-km altitude
view: Nadir
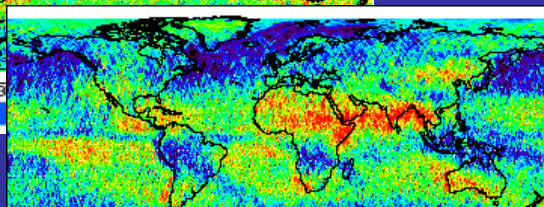
5-km altitude
view: 50º off nadir
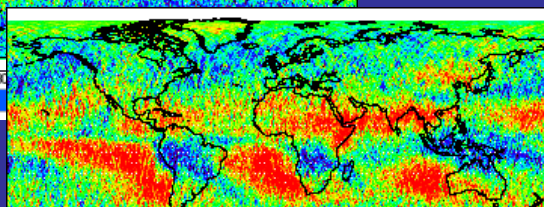
5-km altitude
view: 60º off nadir
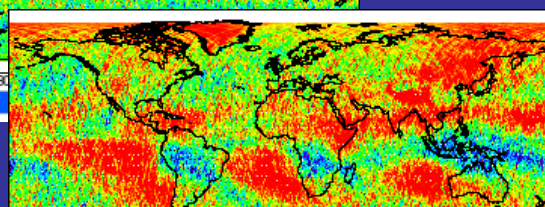
5-km altitude
view: 70º off nadir
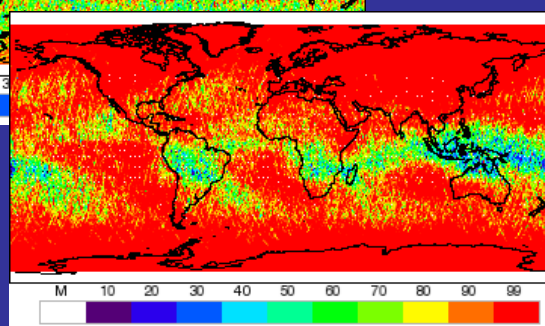
5-km altitude
view: 80º off nadir

**Probability of CFLOS
from CloudSat CPR
January 2007-2010**

Summary …

- CloudSat CPR data provides and exciting new view of the vertical distribution of cloud
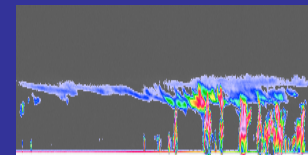
- This 3-D view can be used to calculate CFLOS at varying vertical levels and view angles
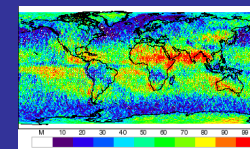
- CPR-derived CFLOS can be used to validate CFLOS derived by "apriori cloud thickness" methods … or for model cloud fraction initialization

- PCFLOS Viewer

Visit the CloudSat Data Processing Center Website …

Order Data →

Quicklook Images

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News

http://www.cloudsat.cira.colostate.edu