Comparing CO2/IRW and H2O/IRW CTPs

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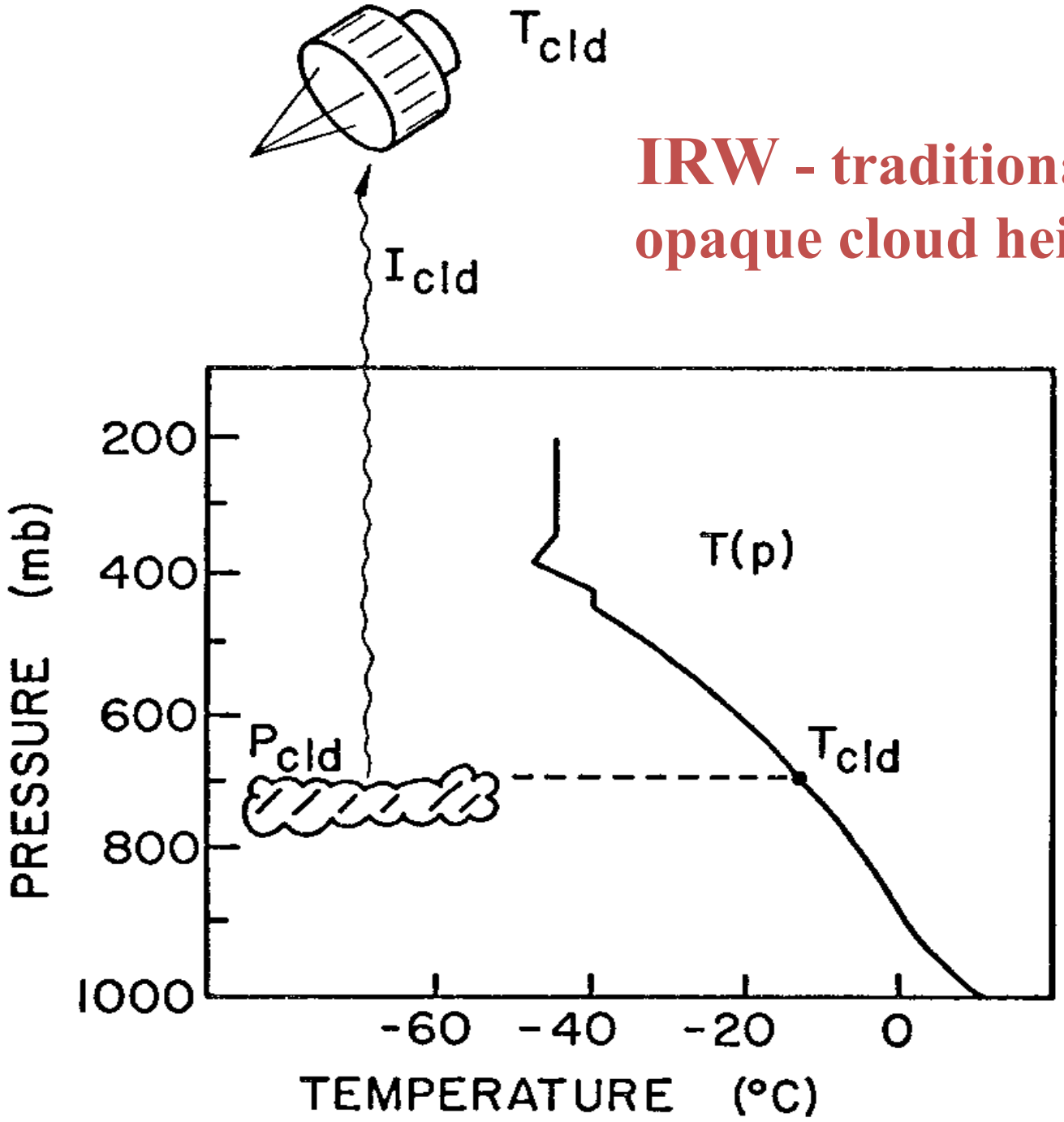
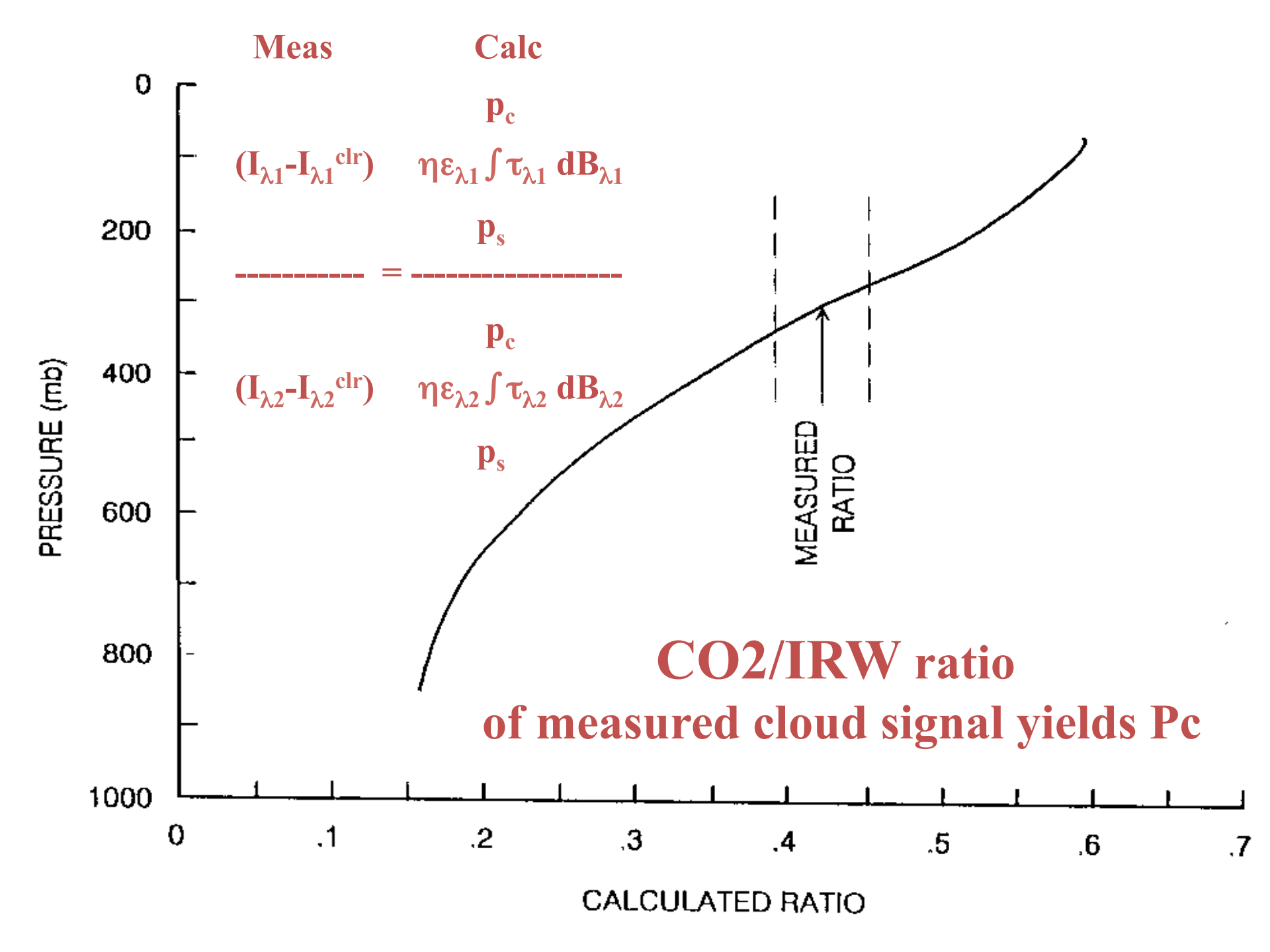
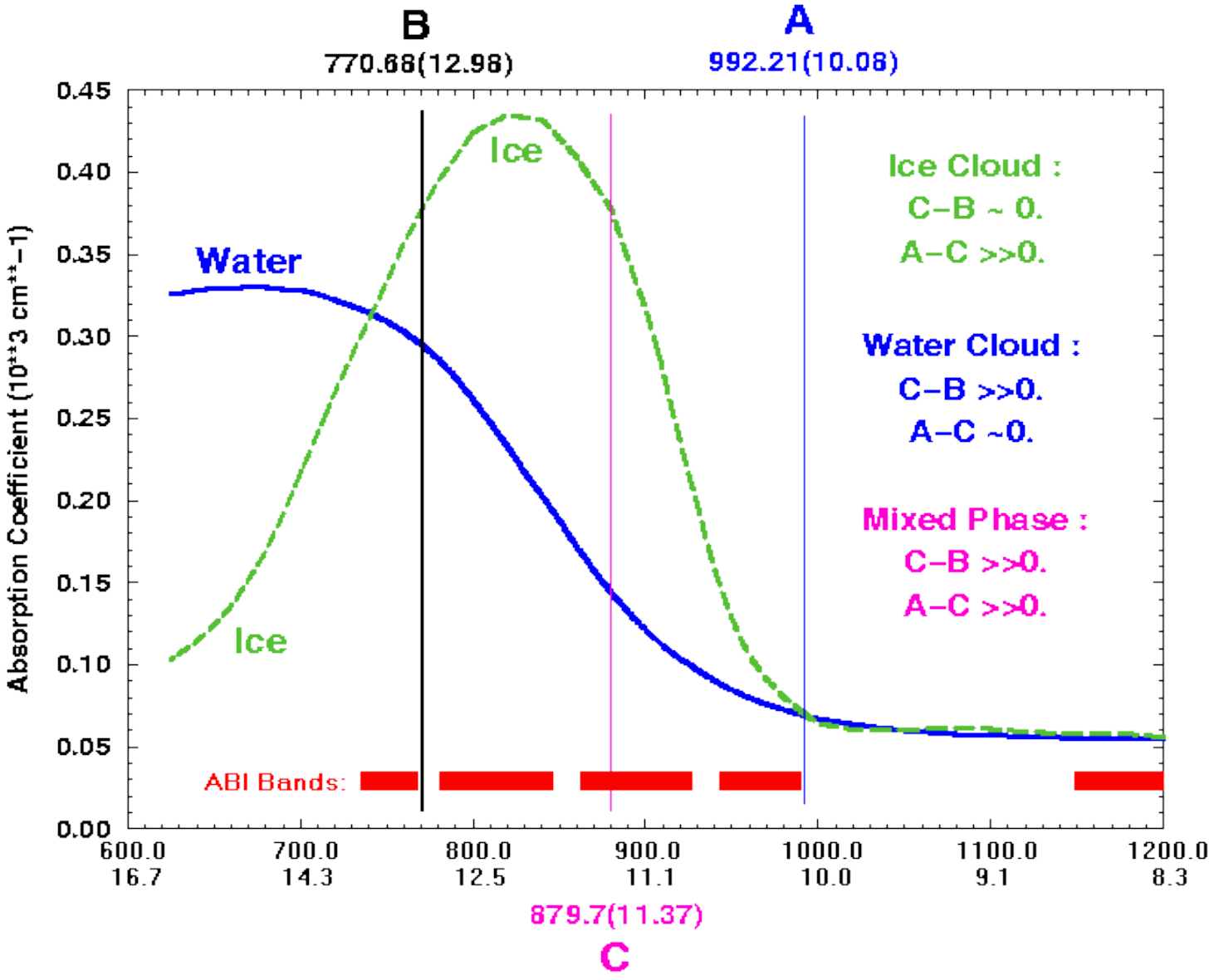
CO2 slicing and H2O intercept techniques are used to assign cloud tracer heights in Atmospheric Motion Vector determinations. Resulting CTHs using GOES-13 data are compared with CALIOP CTHs.

IRW - traditional relation of opaque cloud height and T(p)




Meas
Calc
p_c
$(I_{\lambda 1}-I_{\lambda 1}^{clr})$
$\eta\varepsilon_{\lambda 1}\int\tau_{\lambda 1}\,dB_{\lambda 1}$
p_s
$= \int_{p_c}^{p_s}$
$(I_{\lambda 2}-I_{\lambda 2}^{clr})$
$\eta\varepsilon_{\lambda 2}\int\tau_{\lambda 2}\,dB_{\lambda 2}$
p_c
p_s
PRESSURE (mb)
0
200
400
600
800
1000
0
.1
.2
.3
.4
.5
.6
.7
CALCULATED RATIO
MEASURED RATIO
CO2/IRW ratio
of measured cloud signal yields Pc

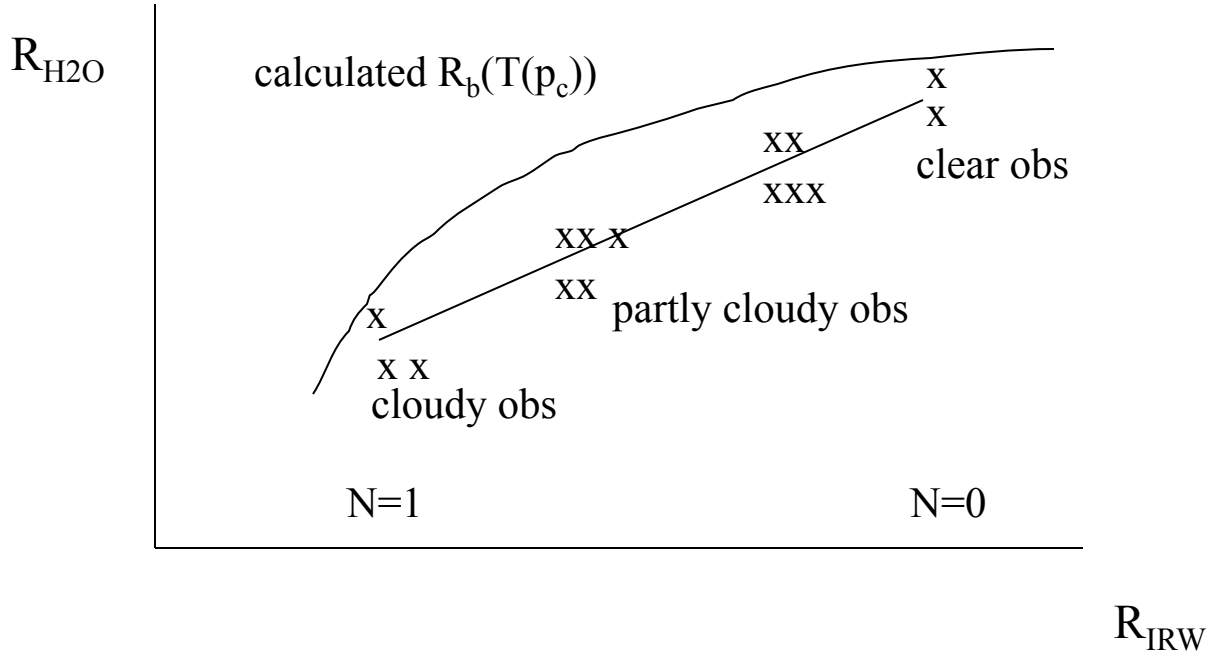
Emissivity for ice cloud is similar for 11 and 13.3 um bands



SSEC/CIMSS

H2O/IRW cloud top pressure (CTP)

For a single layer of clouds, radiances in one spectral band vary linearly with those of another as single layer cloud amount varies from one field of view (fov) to another. H2O/IRW technique for inferring CTP of a cloud cluster is based on this.



CTP can be inferred by extrapolating to opaque cloud conditions.

Some Details (1)

- Box size (line X element) used is 5 X 7 (35 observations), roughly [20 Km]**2 box at the GOES-13 Imager satellite subpoint.
- The IRW only algorithm uses measured 11 μm brightness temperature (BT) and an atmospheric profile to determine Cloud Top Pressure (CTP) at each cloudy field of view (FOV). Effective Cloud Amount (ECA) for each cloudy FOV is assumed to be 100%.
- For each FOV CO2 Slicing (CO2/IRW) determines a single CTP and ECA using 13.3 μm and IRW radiance measurements.
- Water Vapor Intercept (H2O/IRW) generates a single CTP for the entire box, where the assumption is that all the cloudy field of views represent a single cloud layer and only the ECA, or thickness, is changing.

Some Details (2)

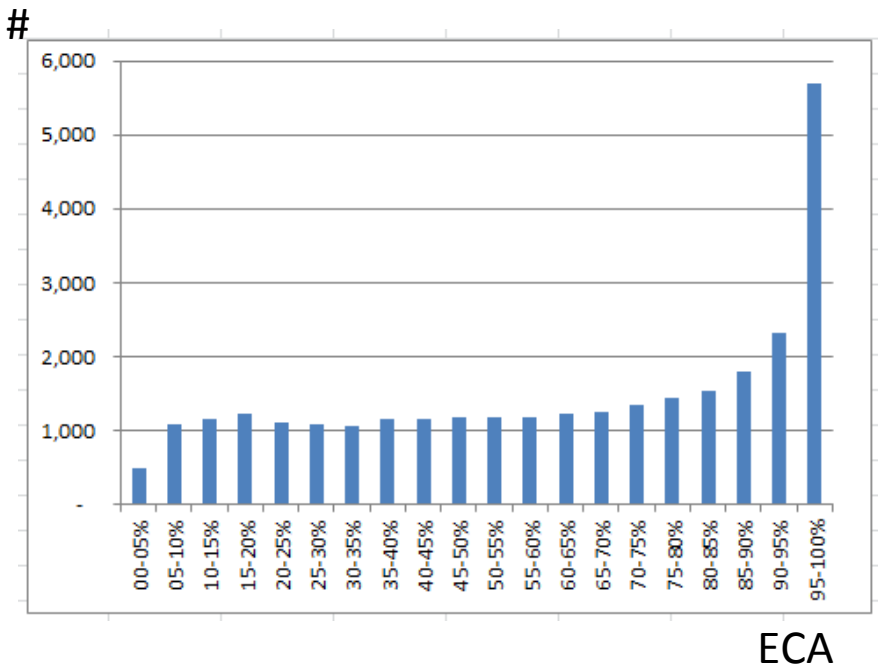
- The atmospheric first guess is based on hourly interpolated forecasts from the 3 hourly GFS. Horizontal resolution of first guess is 0.50 deg lat/lon, and vertical resolution is 25 hPa from 1000 hPa to 900 hPa and 50 hPa from 900 hPa to 100 hPa.
- The surface analysis (Temperature at Sea Level) is based on hourly surface observations over land and buoy observations over water using the atmospheric guess as a background. Over water (oceans only) a daily Sea Surface Temperature (12 UTC), which is based on NOAA Polar Orbiting observations.

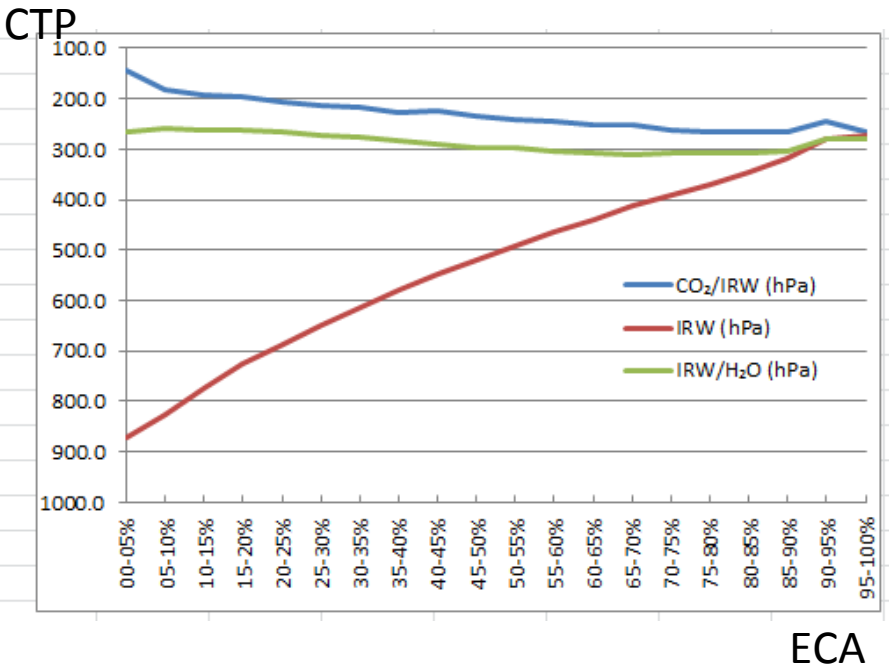
Some Details (3)

- AMVs are generated on an hourly basis using the XX:45 UTC as the processing time. This allows for one hemispheric image every three hours (00, 03, 06, 09, 12, 15, 18, and 21 UTC).
- CO2/IRW and IRW CTPs at full resolution (single FOV) and H2O/IRW at box resolution (5 line X 7 elements) are generated simultaneously.
- The statistics provided in the various figures are based on CO2 and IRW point data and H2O box data.

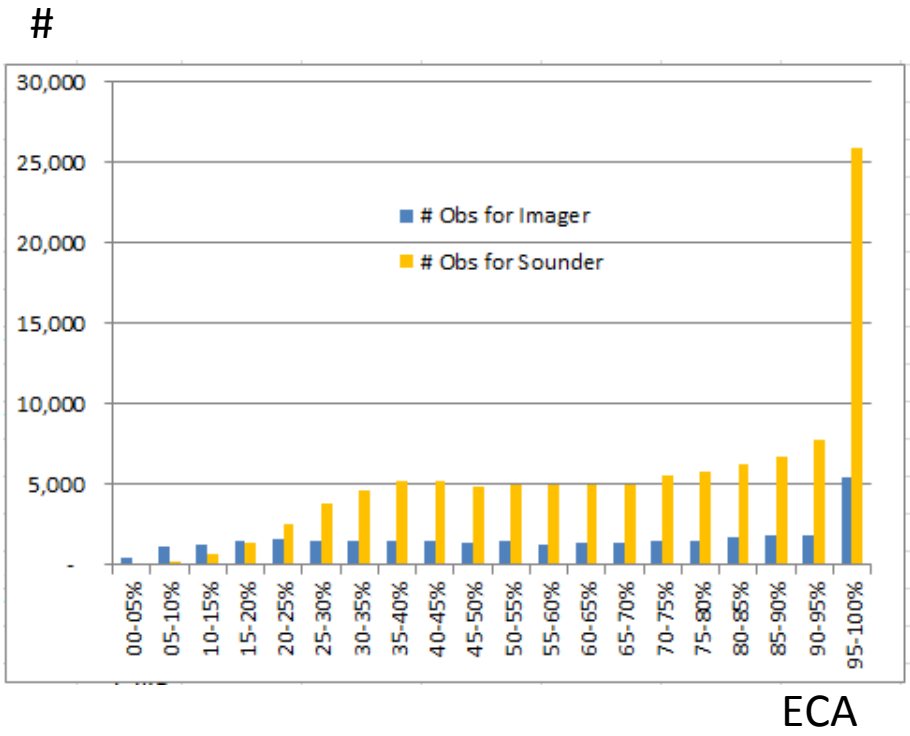
References

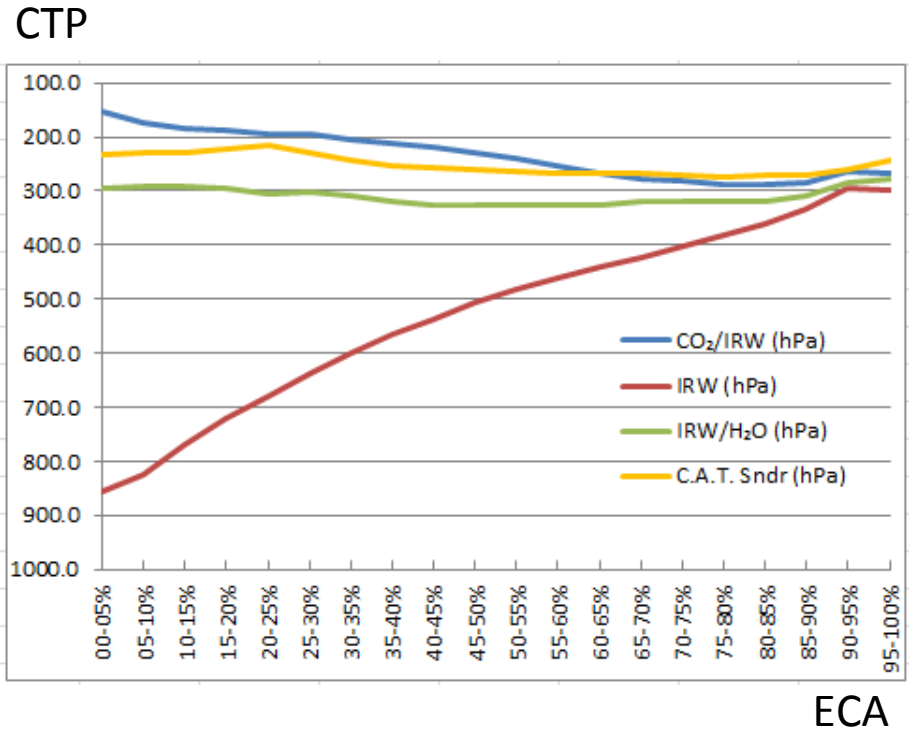
- Nieman, S., J. Schmetz and W.P. Menzel, 1993: A comparison of several techniques to assign heights to cloud tracers. *J. Appl. Meteor.*, **32** 1559-1568.
- Schreiner, A.J and T.J. Schmit, 2001: Derived cloud products from the GOES-M imager. In Proceedings of the Eleventh Conference on Satellite Meteorology and Oceanography, Madison, WI, Amer. Meteor. Soc., 420-423.





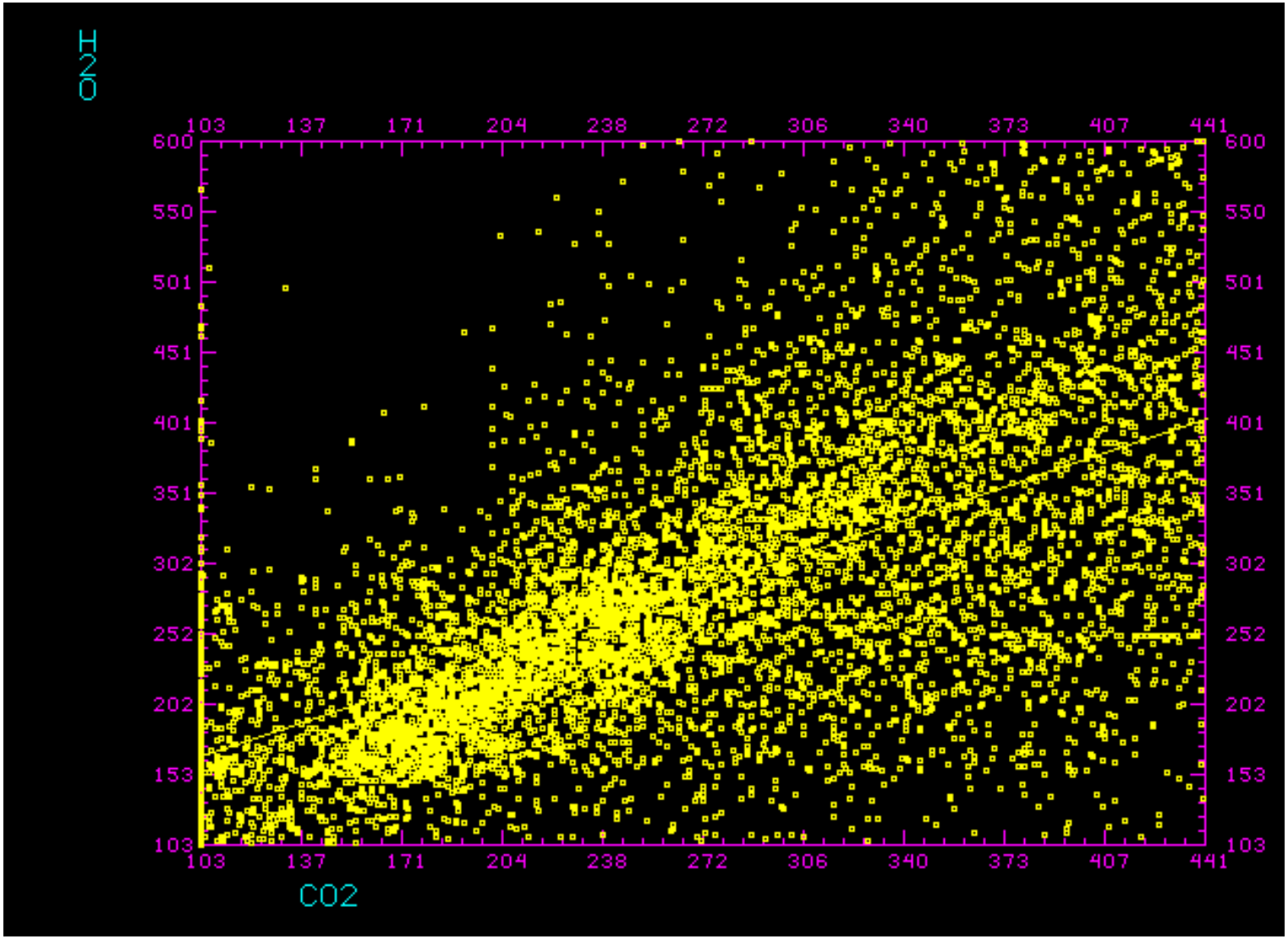
Comparison of IRW and IRW/H2O Cloud Top Pressure to CO2/IRW CTP between 440 and 100 hPa. (Left) Number of occurrences of CO2/IRW CTP's in the indicated ECA intervals. (Right) Average CTP for the three techniques at the varying ECA categories. The x-axis and y-axis are intervals of ECA (%) and Cloud Top Pressure (hPa), respectively.





Comparison of the four GOES Cloud Product algorithms - GOES Imager (CO2/IRW, IRW, and IRW/H2O) and GOES Sounder CO2 Slicing (Cloud Absorption Technique Sounder). This data set is from GOES-13 on 24 June 2011 at 12:00 UTC.

H2O/IRW vs CO2/IRW CTP Solutions

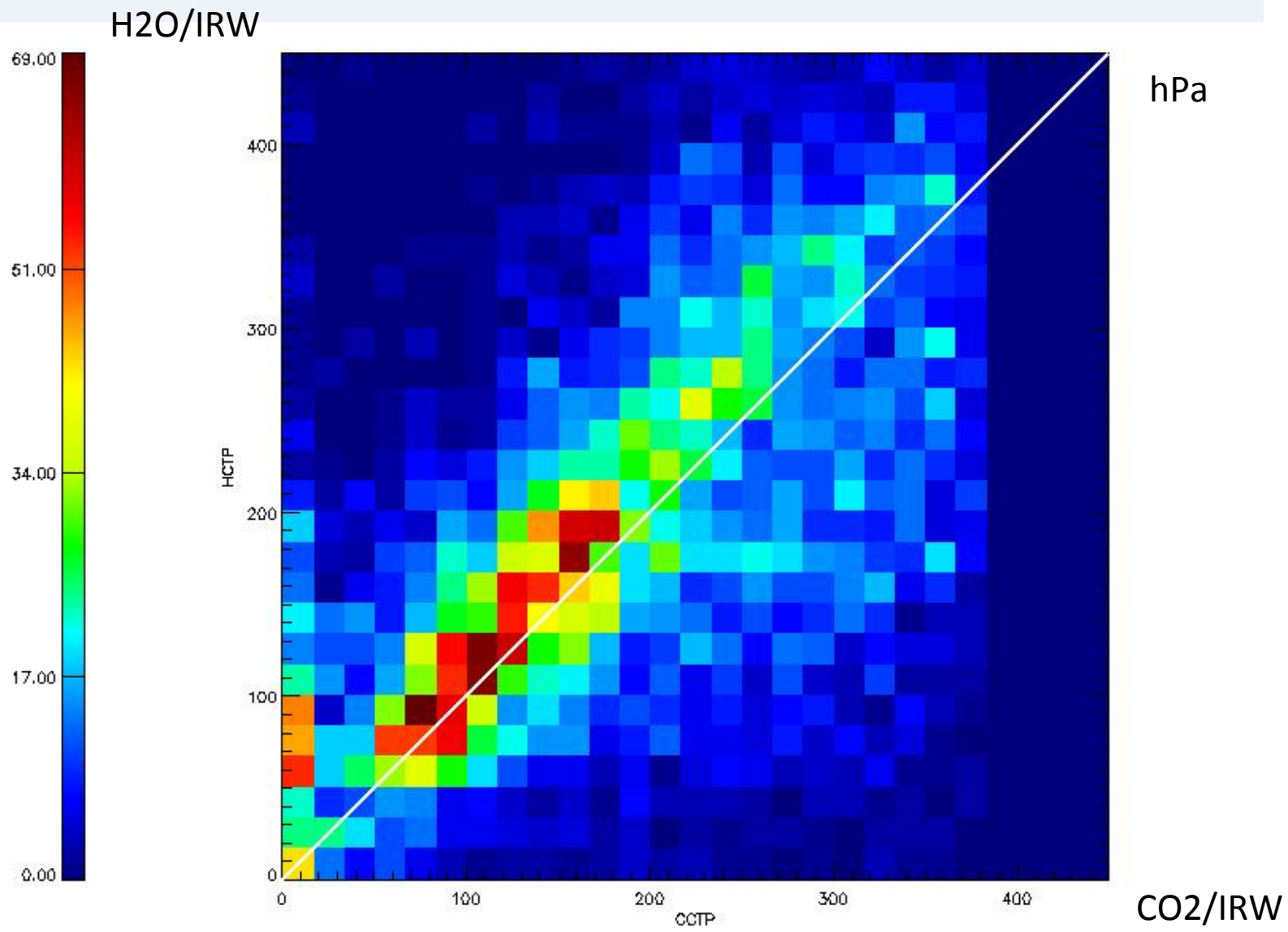


hPa

Between 600 hPa and the tropopause from GOES-13 on 24 June 2011 at 12:00 UTC

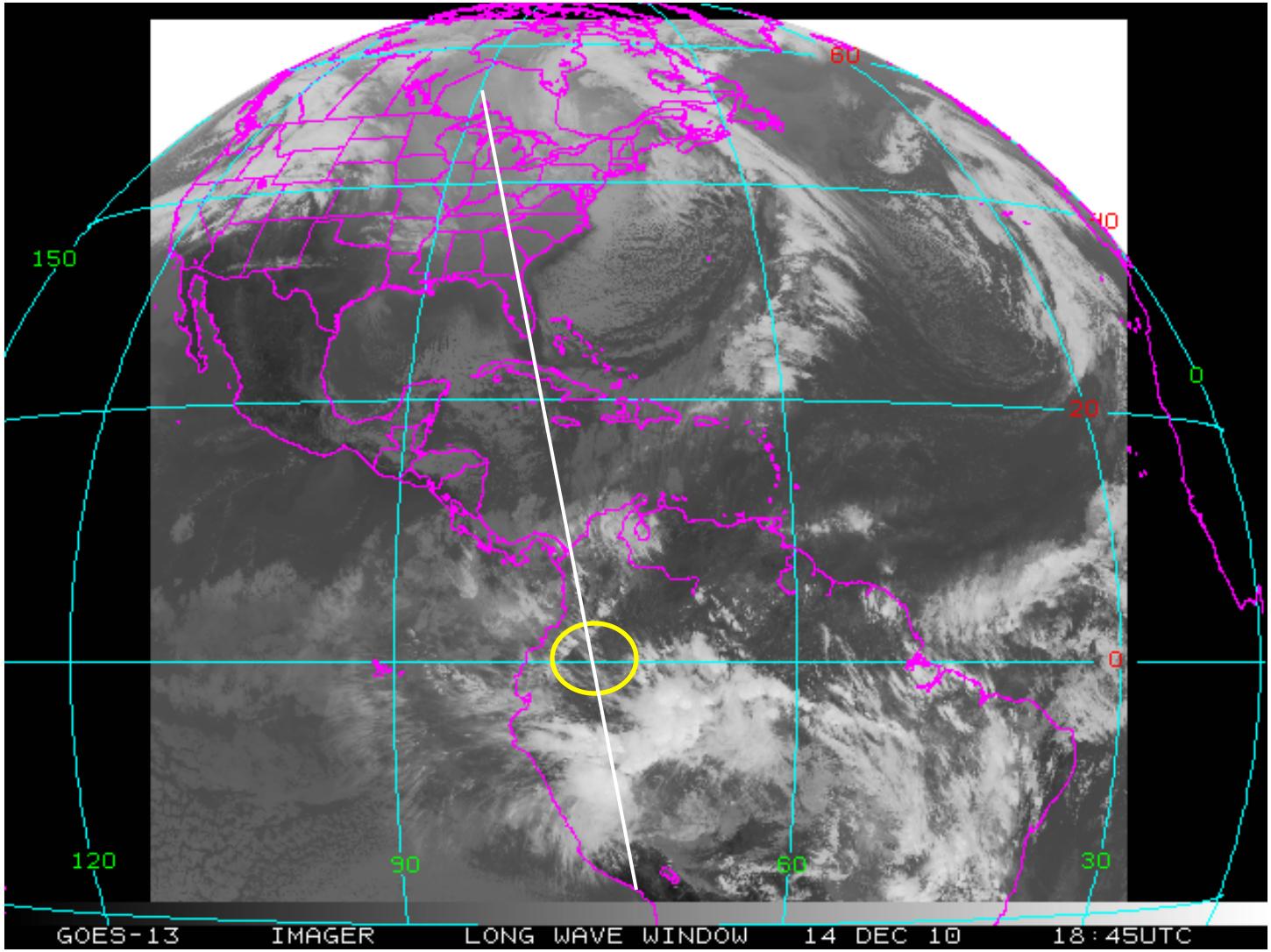
H20/IRW vs CO2/IRW Techniques

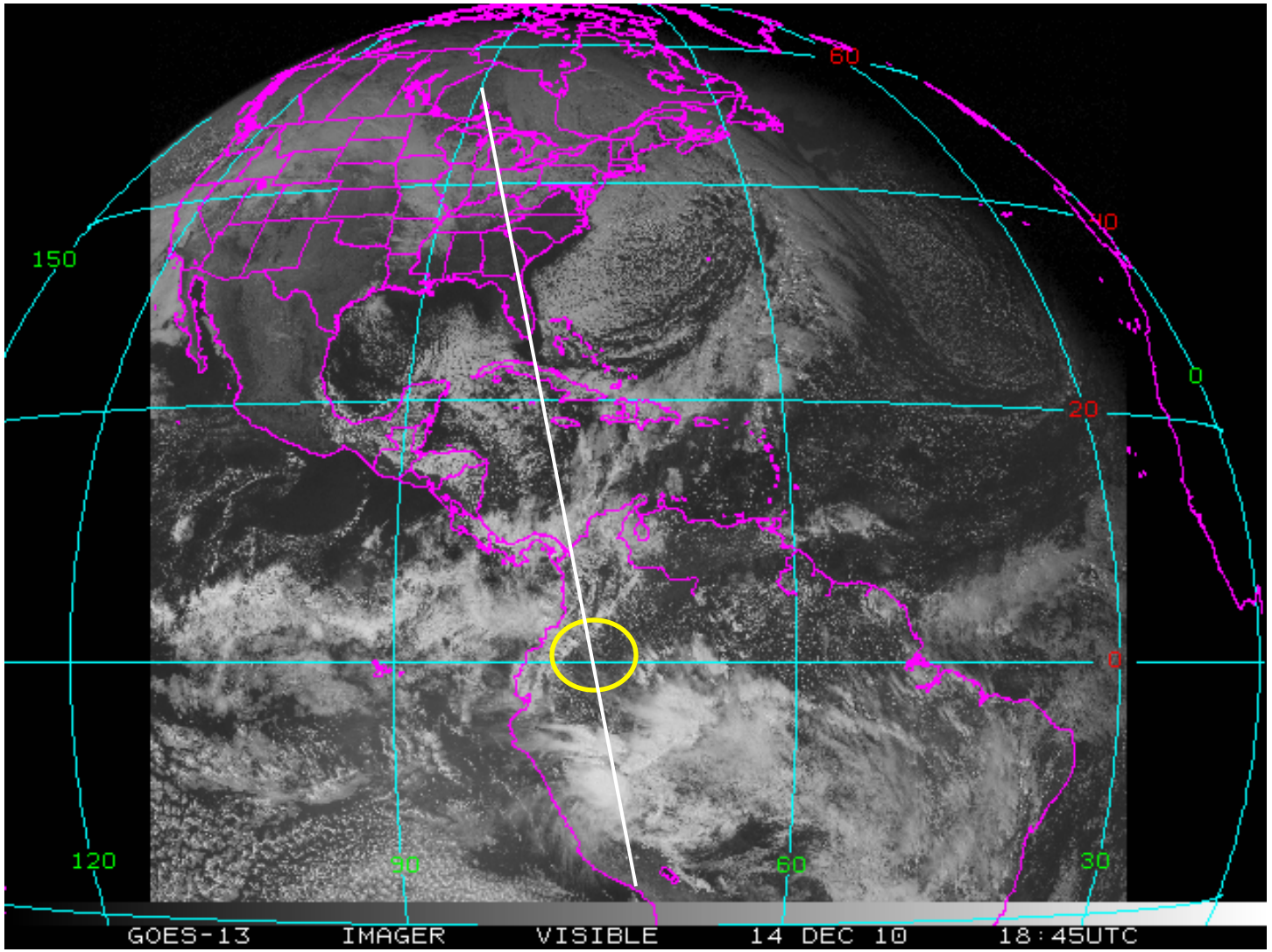
color bar represents number density per block.

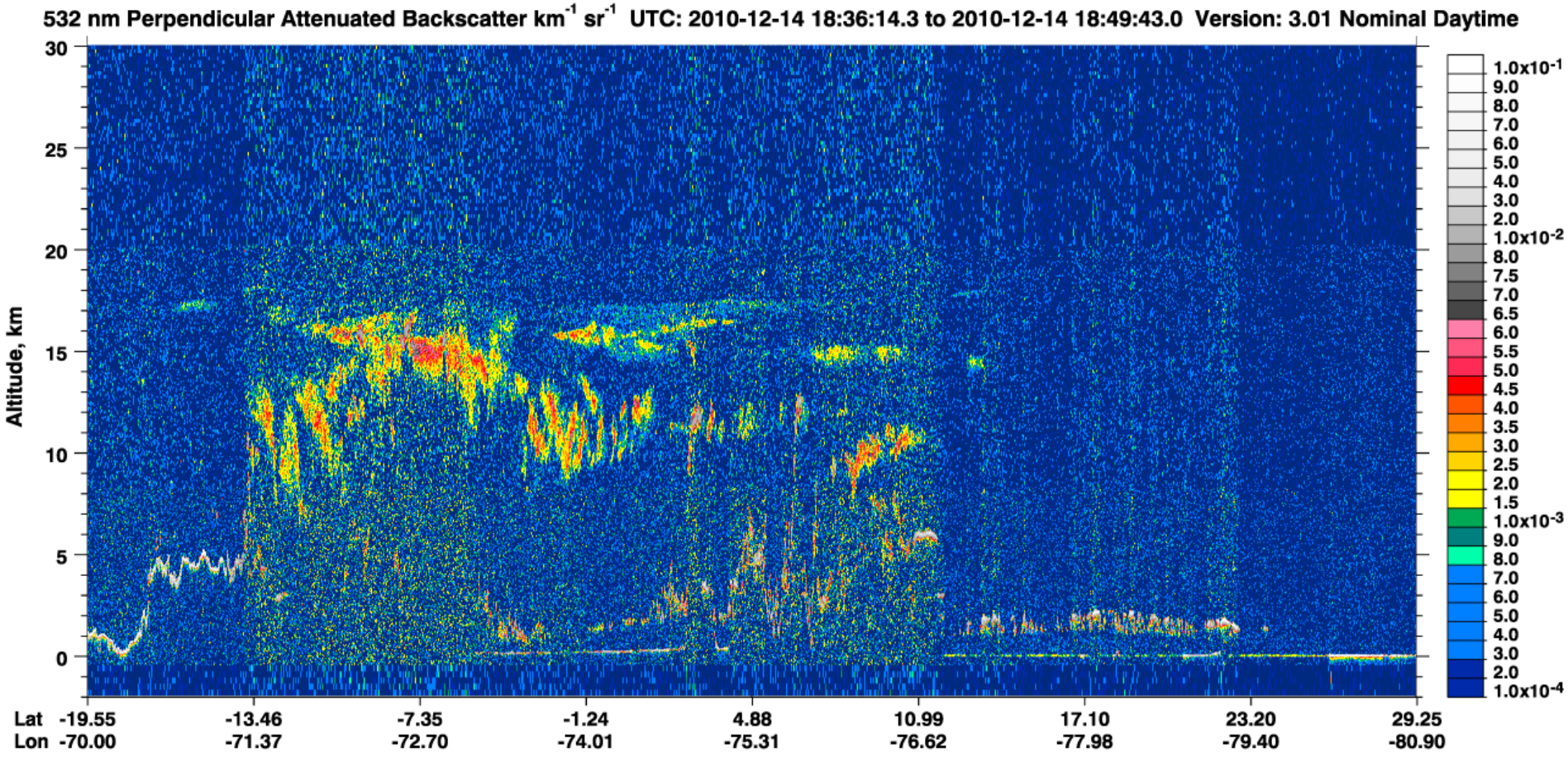


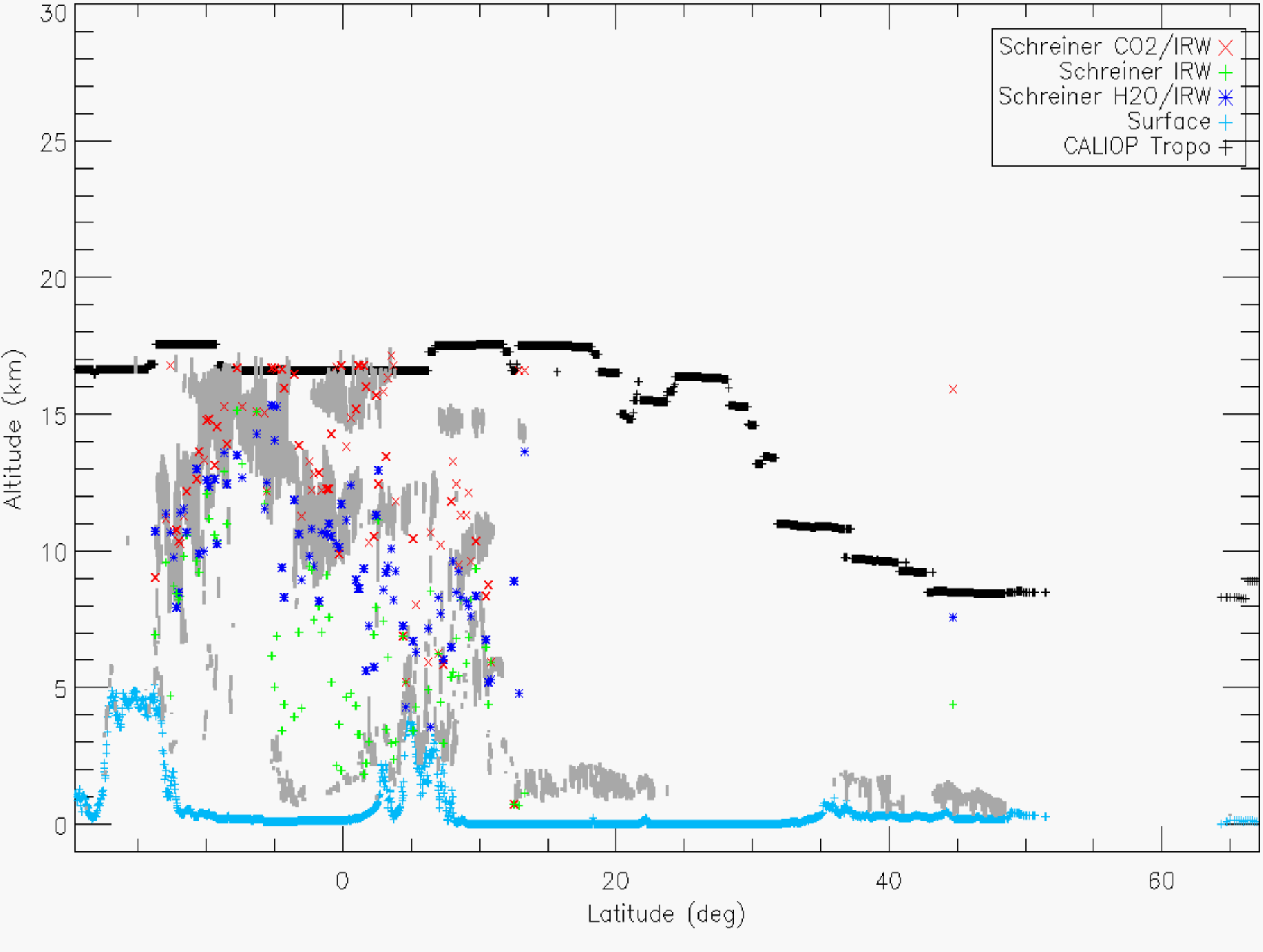
Comparisons with CALIOP

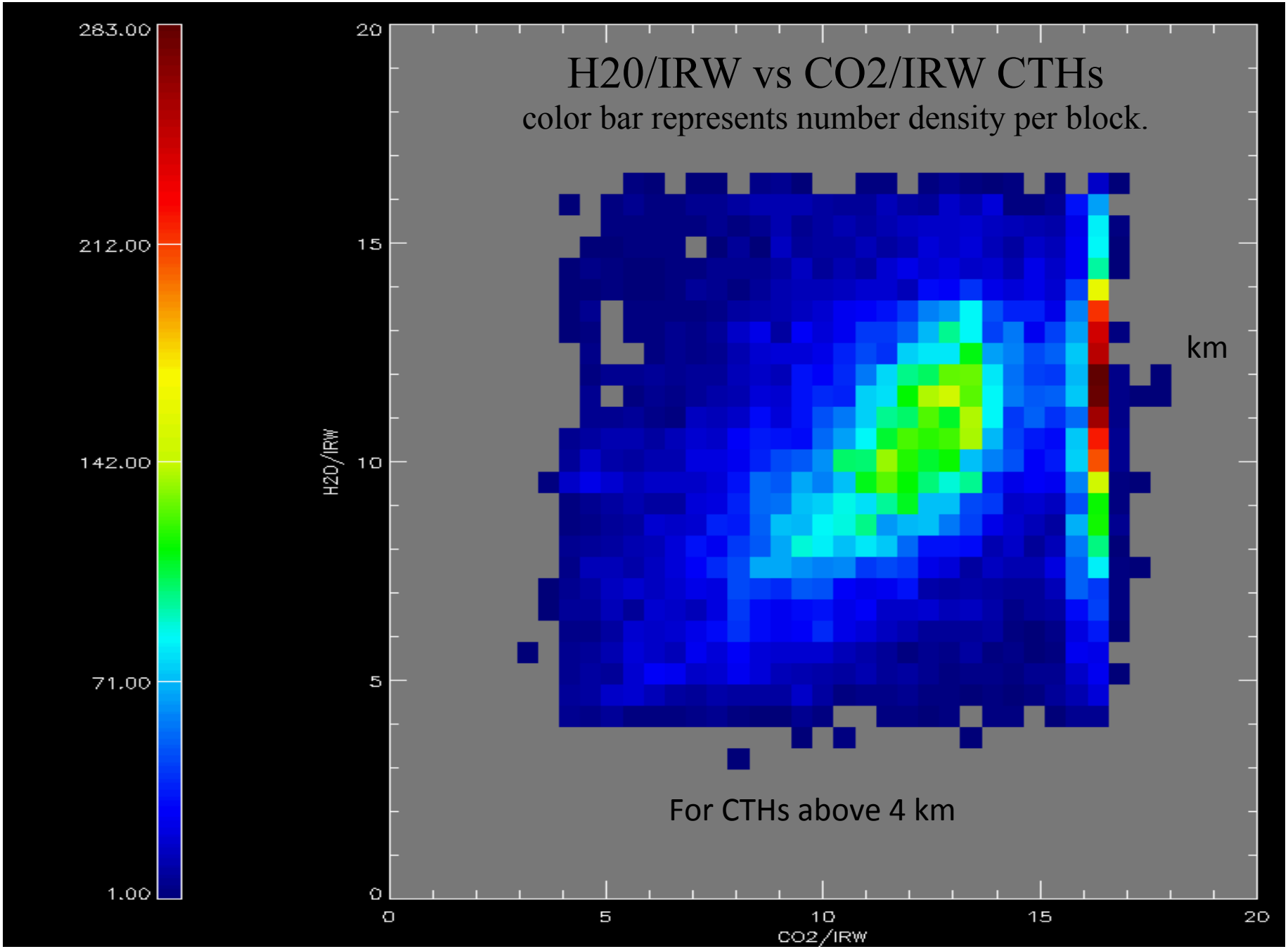
Cloud-top pressures were converted to heights using the Global Forecast System (GFS) and were compared to heights from analysis of Cloud-Aerosol Lidar with Orthogonal Polarization (CALIOP) 0.532-m backscatter data averaged to 1 km footprints.

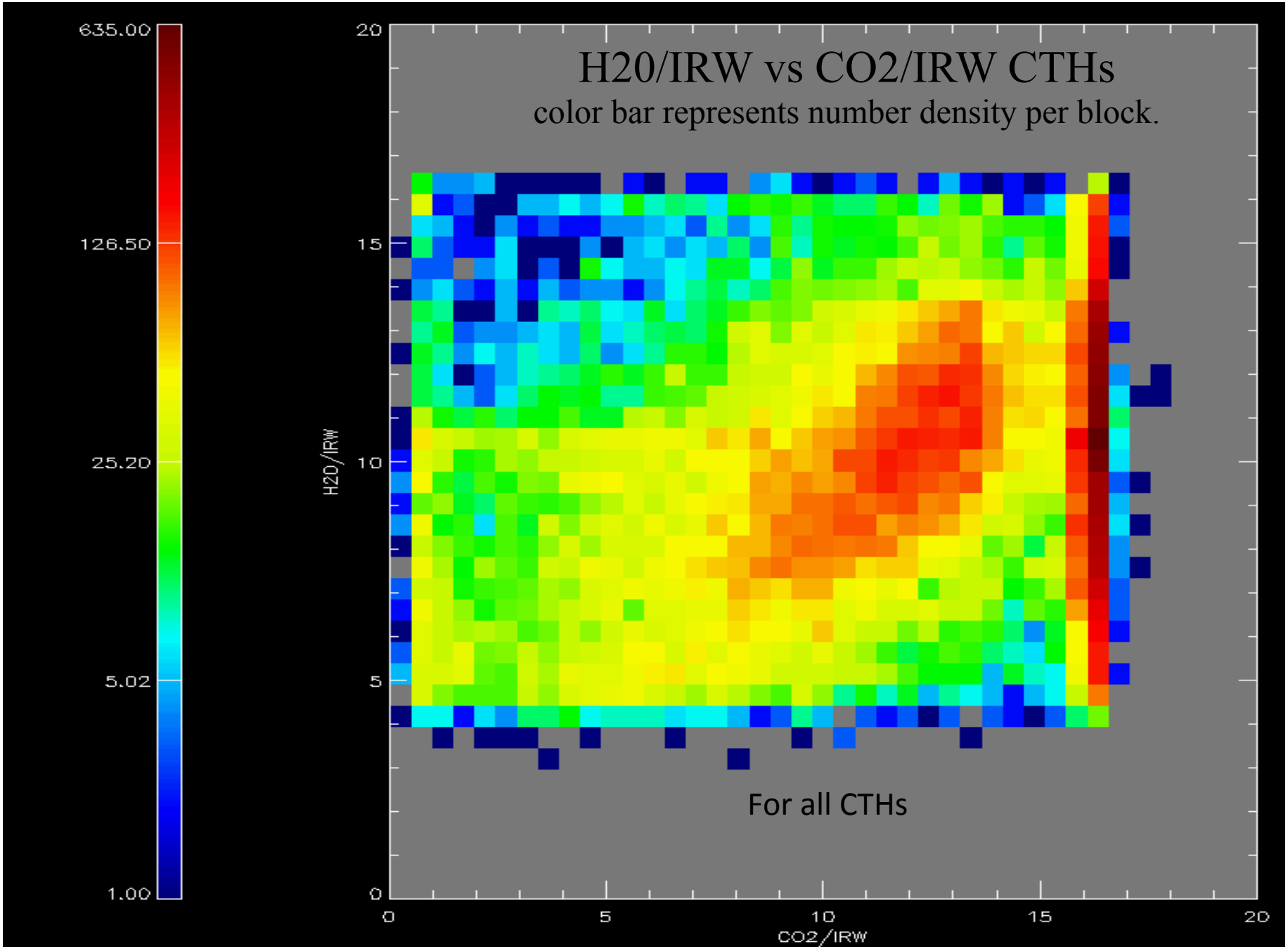

60
40
150
0
20
0
120
90
60
30
GOES-13 IMAGER LONG WAVE WINDOW 14 DEC 10 18:45UTC

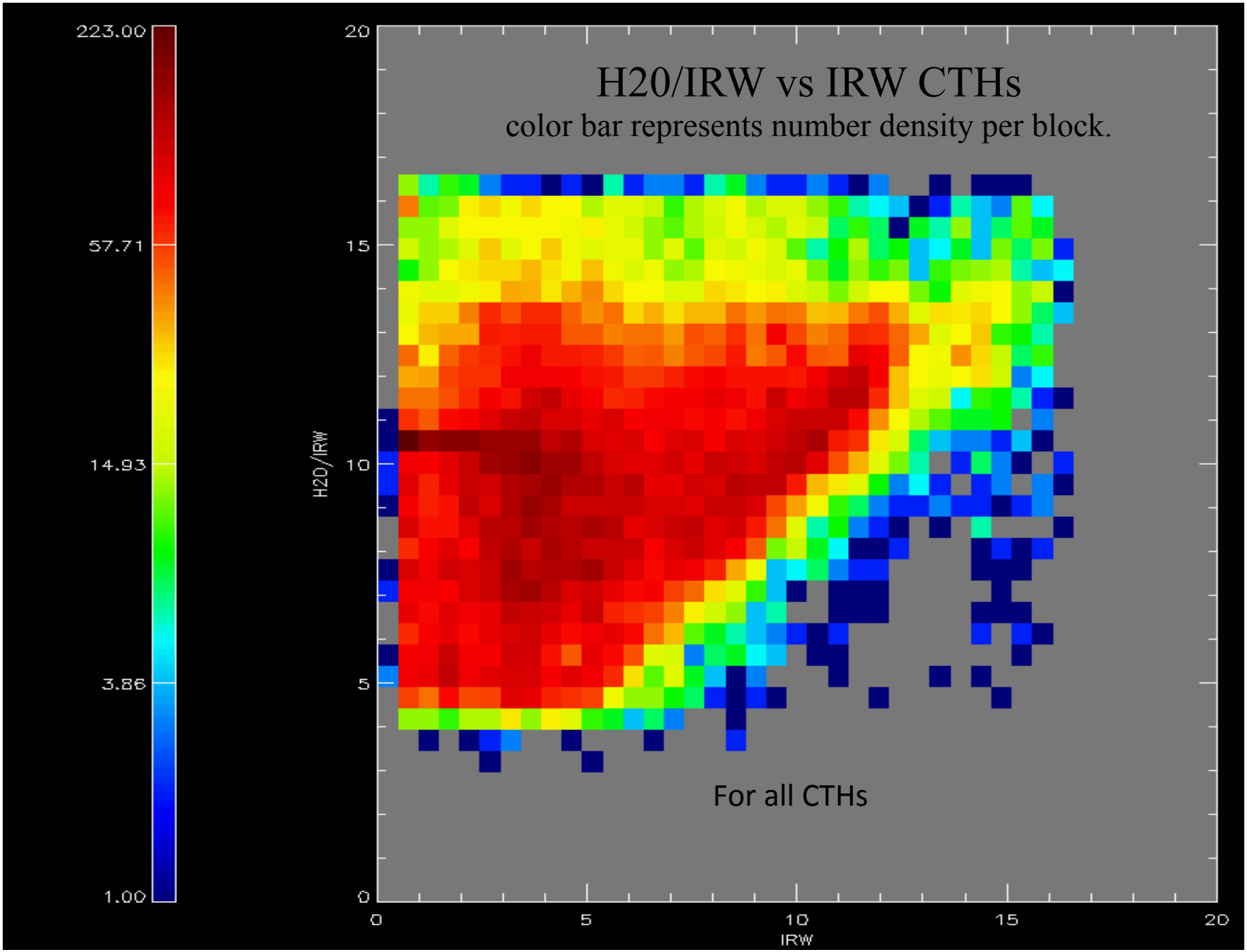

60
40
150
0
20
0
120
90
60
30
GOES-13 IMAGER VISIBLE 14 DEC 10 18:45UTC

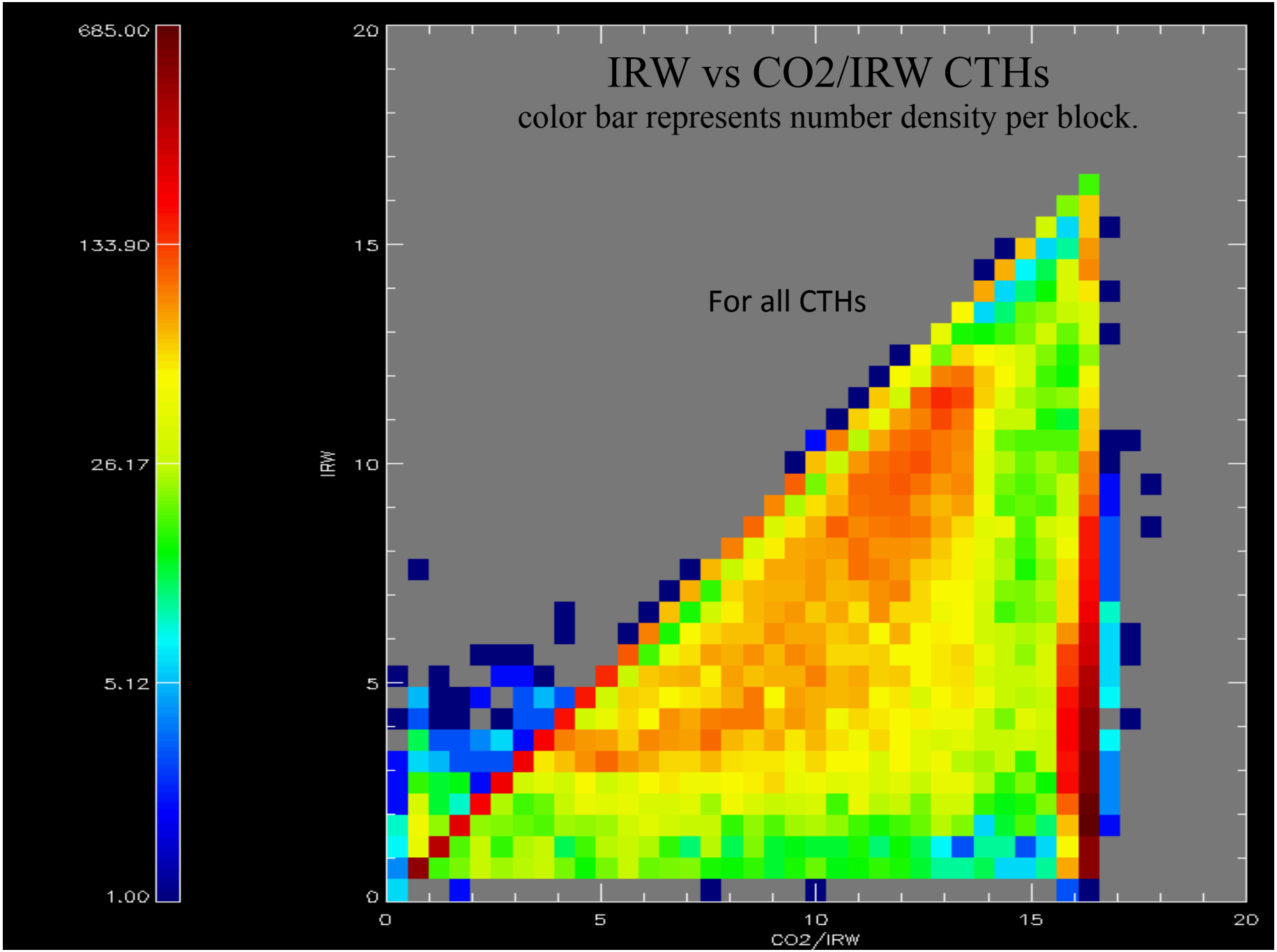

532 nm Perpendicular Attenuated Backscatter km-1 sr-1 UTC: 2010-12-14 18:36:14.3 to 2010-12-14 18:49:43.0 Version: 3.01 Nominal Daytime
Altitude, km
30
25
20
15
10
5
0
1.0x10-1
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0x10-2
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0x10-3
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0x10-4
Lat -19.55 -13.46 -7.35 -1.24 4.88 10.99 17.10 23.20 29.25
Lon -70.00 -71.37 -72.70 -74.01 -75.31 -76.62 -77.98 -79.40 -80.90


Schreiner CO2/IRW
Schreiner IRW
Schreiner H2O/IRW
Surface
CALIOP Tropo
Altitude (km)
Latitude (deg)
30
25
20
15
10
5
0
0
20
40
60


H20/IRW vs CO2/IRW CTHs
color bar represents number density per block.
283.00
212.00
142.00
71.00
1.00
km
H2O/IRW
CO2/IRW
0
5
10
15
20
For CTHs above 4 km

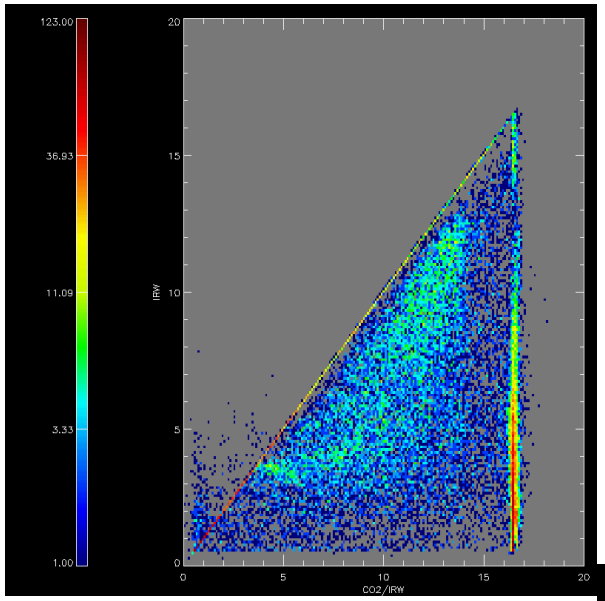

H20/IRW vs CO2/IRW CTHs
color bar represents number density per block.
635.00
126.50
25.20
5.02
1.00
20
15
10
5
0
H2O/IRW
0
5
10
15
20
CO2/IRW
For all CTHs


H20/IRW vs IRW CTHs
color bar represents number density per block.
223.00
57.71
14.93
3.86
1.00
H20/IRW
0
5
10
15
20
IRW
For all CTHs


IRW vs CO2/IRW CTHs
color bar represents number density per block.
For all CTHs
685.00
133.90
26.17
5.12
1.00
IRW
CO2/IRW
0
5
10
15
20

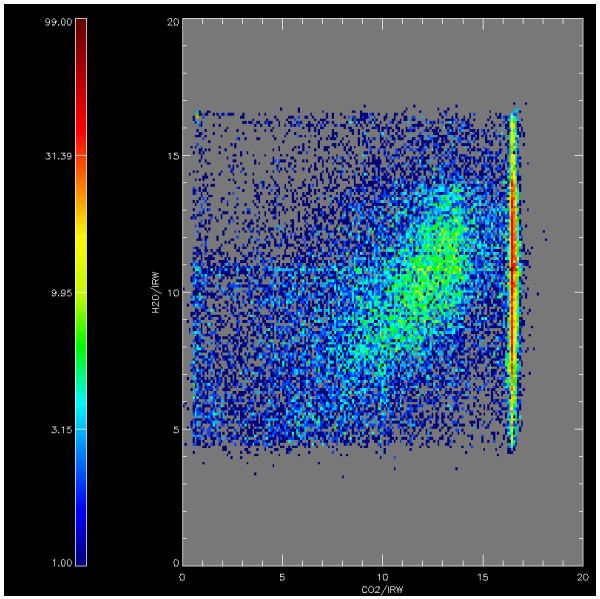
Algorithm comparisons

IRW



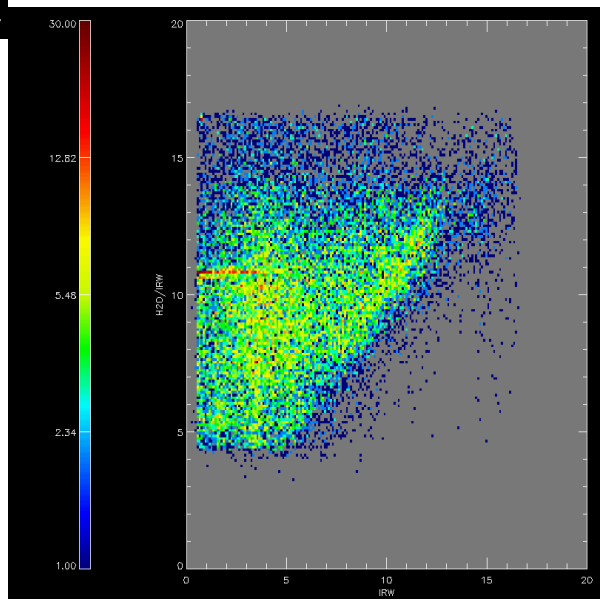
CO2

H2O

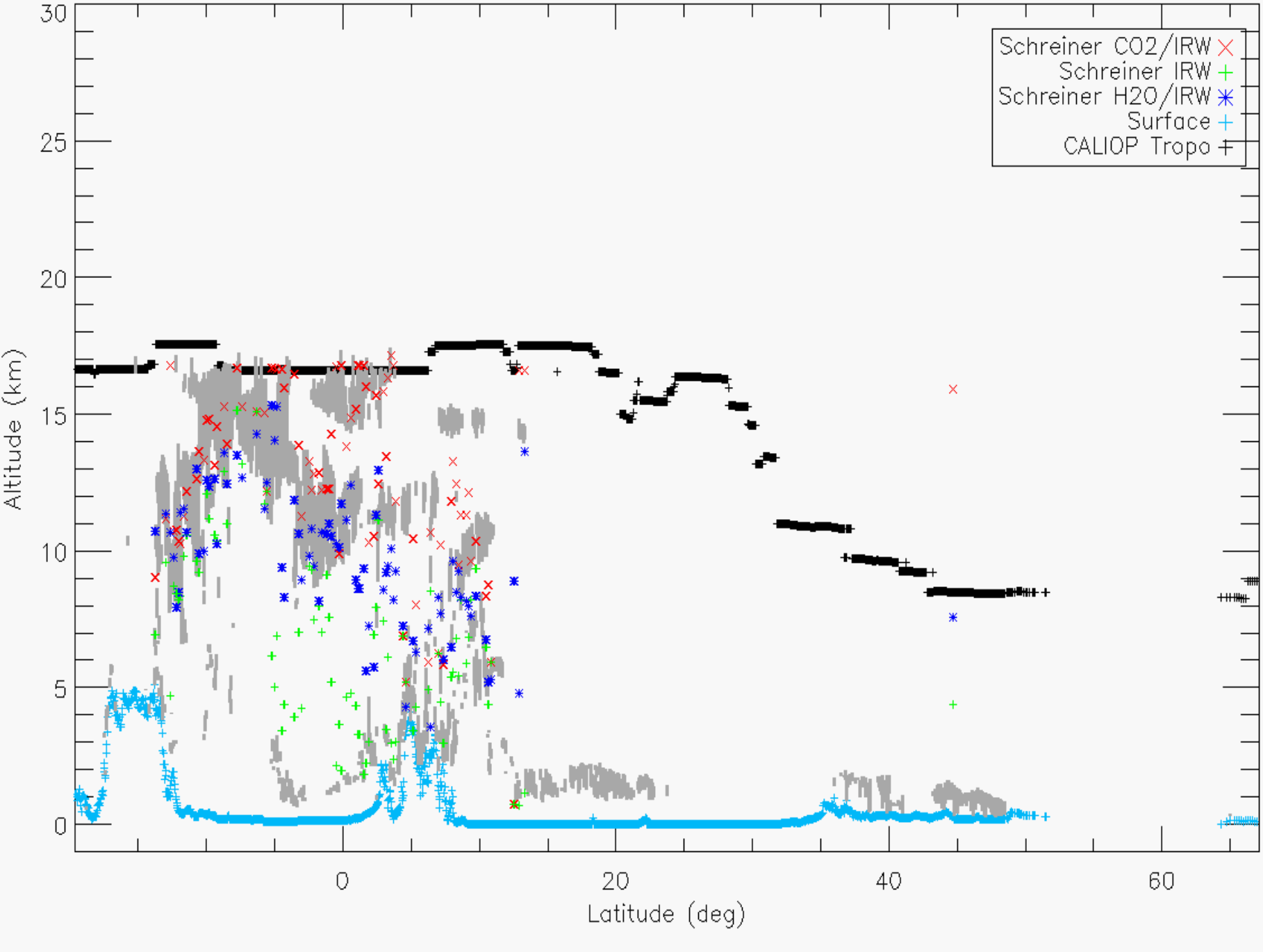


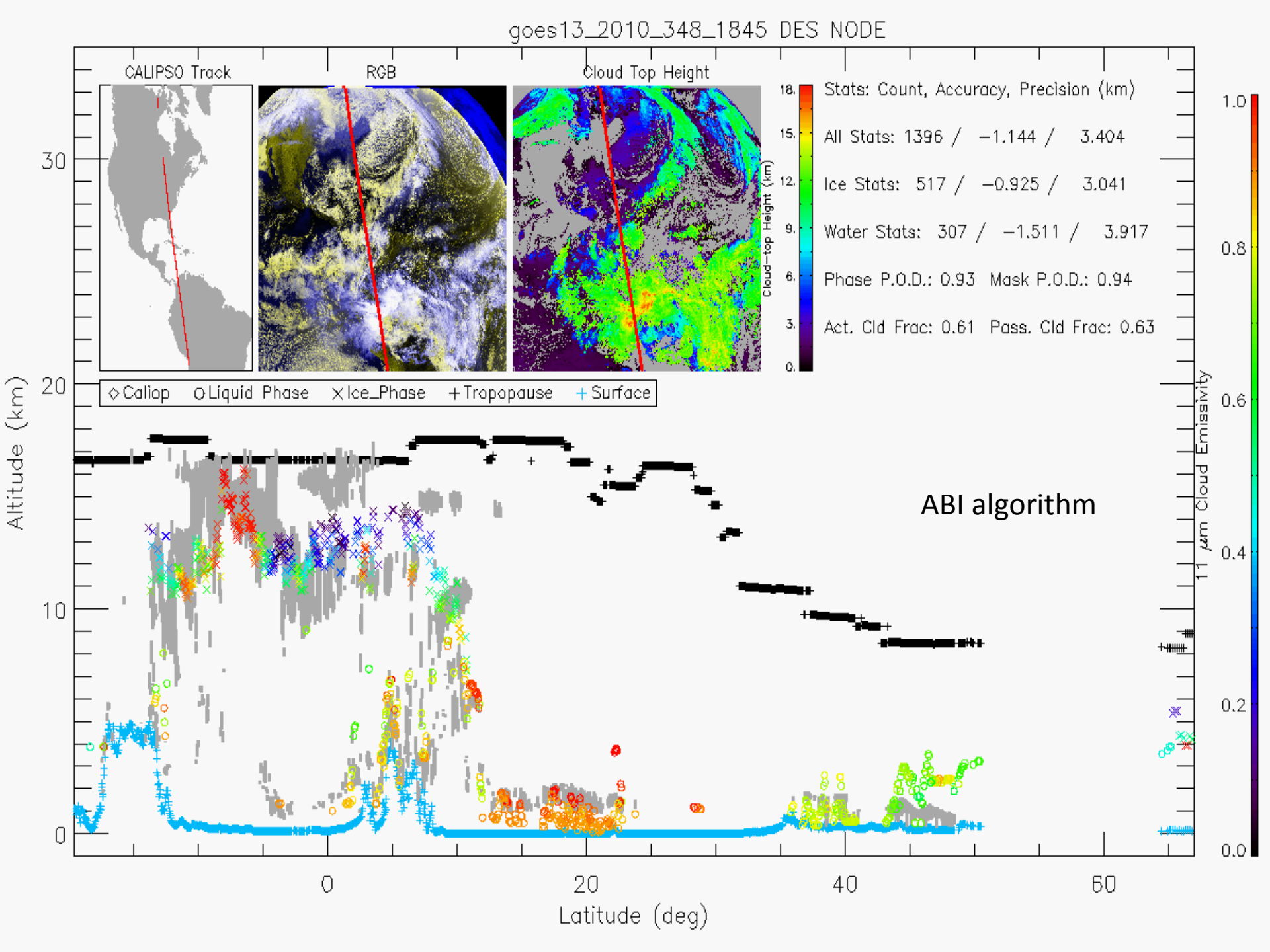
CO2

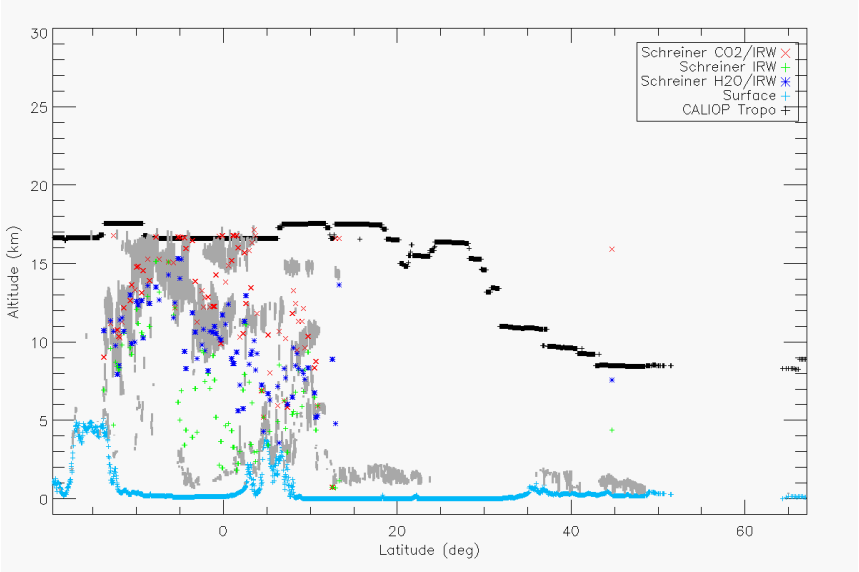
H2O



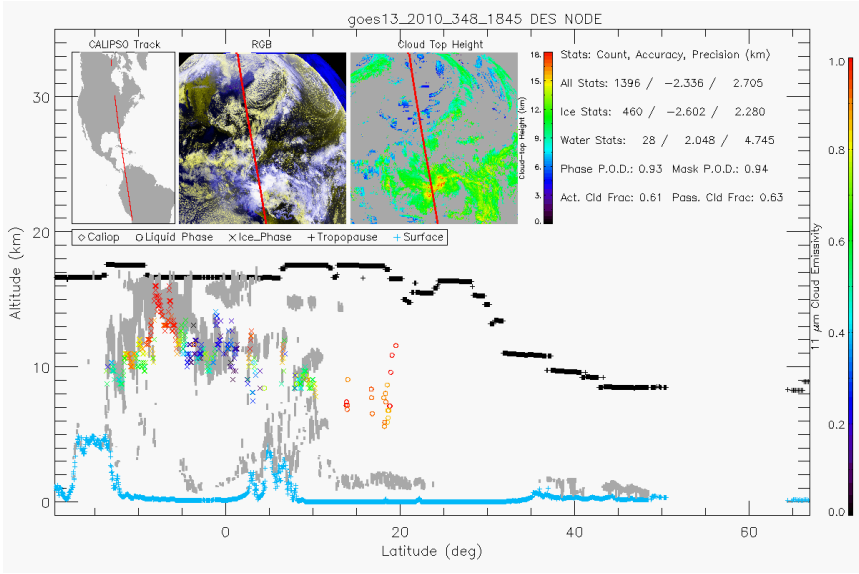
IRW


Schreiner CO2/IRW
Schreiner IRW
Schreiner H2O/IRW
Surface
CALIOP Tropo
Altitude (km)
Latitude (deg)
30
25
20
15
10
5
0
0
20
40
60

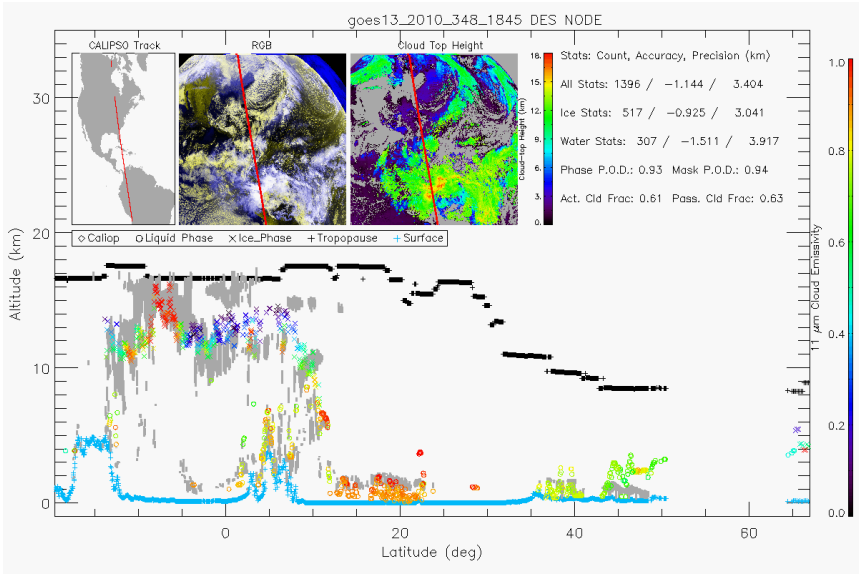

goes13_2010_348_1845 DES NODE
CALIPSO Track
RGB
Cloud Top Height
Cloud-top Height (km)
18.
15.
12.
9.
6.
3.
0.
Stats: Count, Accuracy, Precision (km)
All Stats: 1396 / −1.144 / 3.404
Ice Stats: 517 / −0.925 / 3.041
Water Stats: 307 / −1.511 / 3.917
Phase P.O.D.: 0.93 Mask P.O.D.: 0.94
Act. Cld Frac: 0.61 Pass. Cld Frac: 0.63
◇Caliop ○Liquid Phase ×Ice_Phase +Tropopause +Surface
ABI algorithm
Altitude (km)
30
20
10
0
0
20
40
60
Latitude (deg)
11 μm Cloud Emissivity
1.0
0.8
0.6
0.4
0.2
0.0



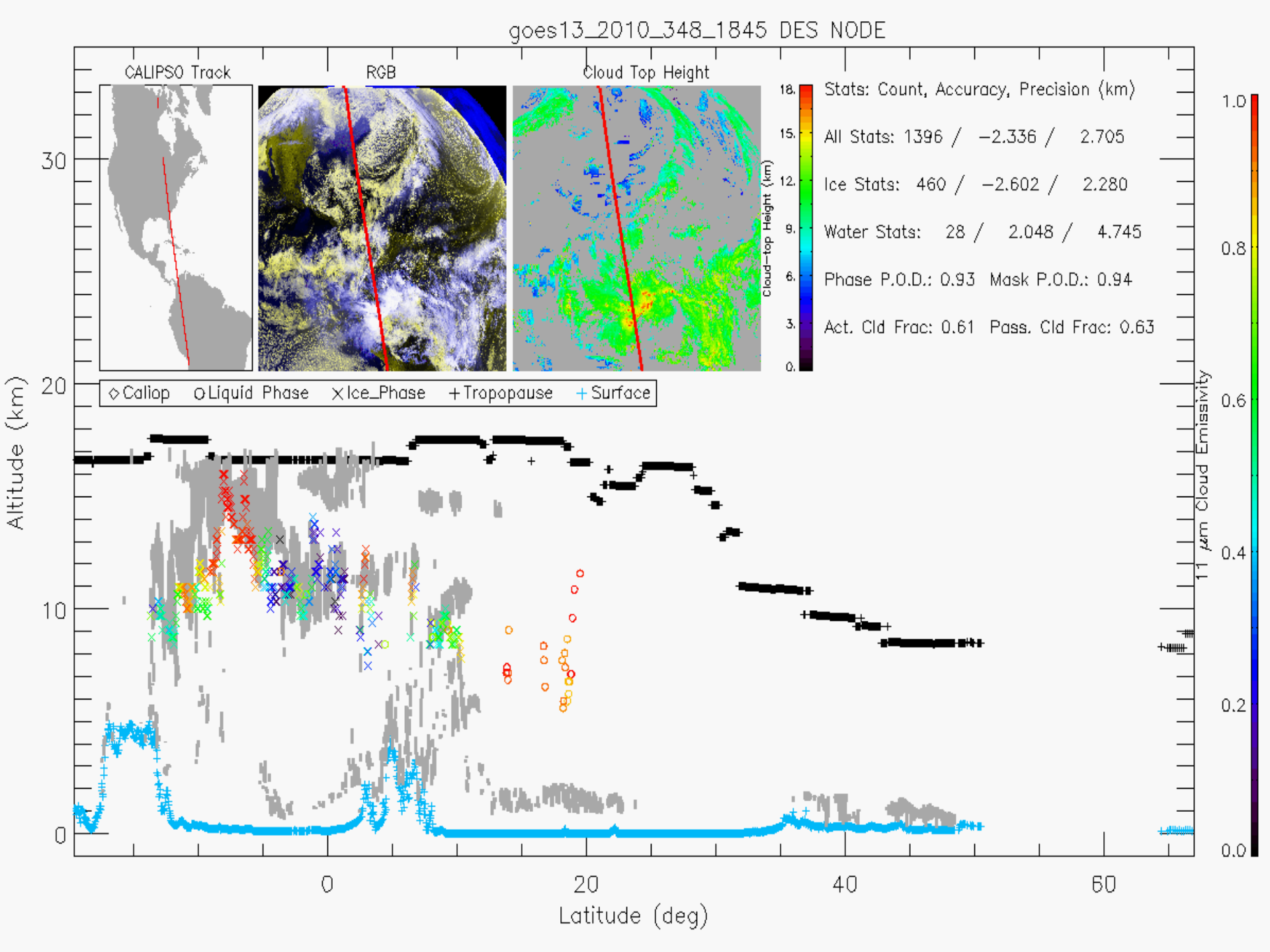
Schreiner algorithms



ACHA H20



ACHA


goes13_2010_348_1845 DES NODE
CALIPSO Track
RGB
Cloud Top Height
Cloud-top Height (km)
18.
15.
12.
9.
6.
3.
0.
Stats: Count, Accuracy, Precision (km)
All Stats: 1396 / −2.336 / 2.705
Ice Stats: 460 / −2.602 / 2.280
Water Stats: 28 / 2.048 / 4.745
Phase P.O.D.: 0.93 Mask P.O.D.: 0.94
Act. Cld Frac: 0.61 Pass. Cld Frac: 0.63
◇Caliop ○Liquid Phase ×Ice_Phase +Tropopause +Surface
Altitude (km)
30
20
10
0
0
20
40
60
Latitude (deg)
11 μm Cloud Emissivity
1.0
0.8
0.6
0.4
0.2
0.0

Conclusions

* H2O/IRW & CO2/IRW CTP determinations show modest correlation for AMV cloud tracers above 4 km
* H2O/IRW CTH estimates are about 1 km lower than CO2/IRW on average, for semi-transparent ice clouds this increases to 4 km
* CALIOP offers excellent opportunity for cal/val
* GOES-13 CO2/IRW CTH estimates are in better agreement with CALIOP
* ABI AMV CTH estimates are anticipated to be of better quality (better spatial resolution, spectral characterization, and radiometric calibration) with improved AMV tracer characterization (cloud phase, thickness, microphysics, …).