Comparison of AMV Cloud Top Pressure derived from MSG with space based lidar observations

G. Sèze, S. Marchand, J. Pelon, and R. Borde

Laboratoire de Météorologie Dynamique (LMD), SA, IPSL/CNRS,EUMETSAT

Context

Study funded by EUMETSAT in the framework of CGMS Rec.34-14.

Recommendation 34.14: Comparison of standard methods for the height assignment of AMVs with the new measurements from instruments on the A-Train (e.g. with the cloud lidar)

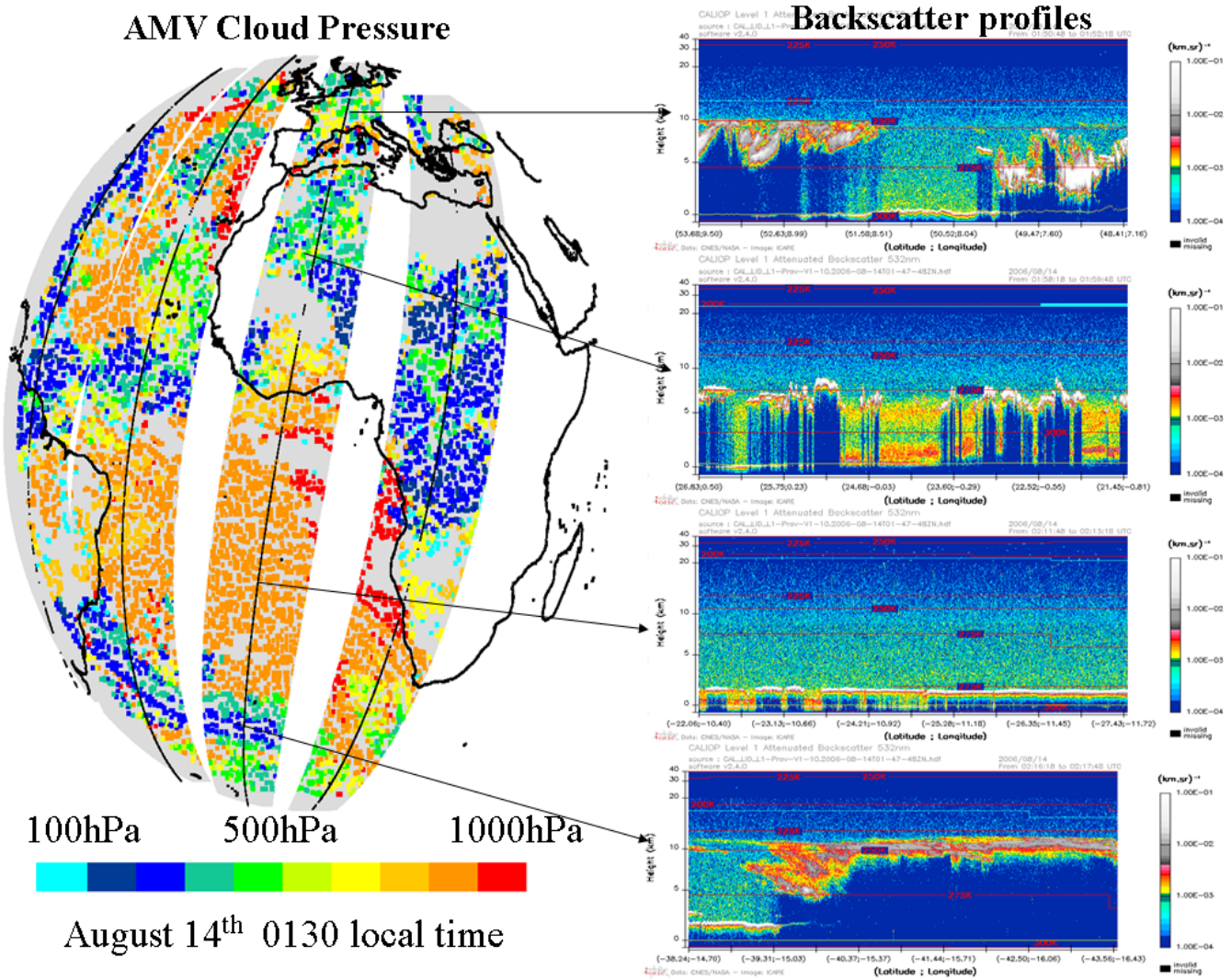
Sciences de l'environnement

Institut Pierre Simon Laplace

PERIOD and DATA set used (1)

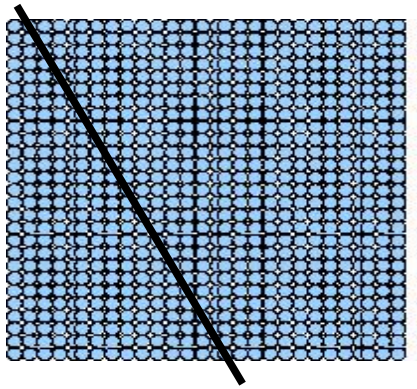
21 days during the 2007 February 23 to March 19 period. 192 CALIOP half orbits. SEVIRI AMV for the same periode with a repeat cycle of 15'.

24966 AMV located close from the CALIOP track and in +/- 7.5' of the CALIOP ovepass have been analysed.



PERIOD and DATA set used (2)

For each AMV, a 27x27 SEVIRI pixel box centred on the AMV location is defined.
Box representative of the target box used to estimate the AMV speed, direction and CTH. Box size close from 80kmx80km at sub-satellite point.

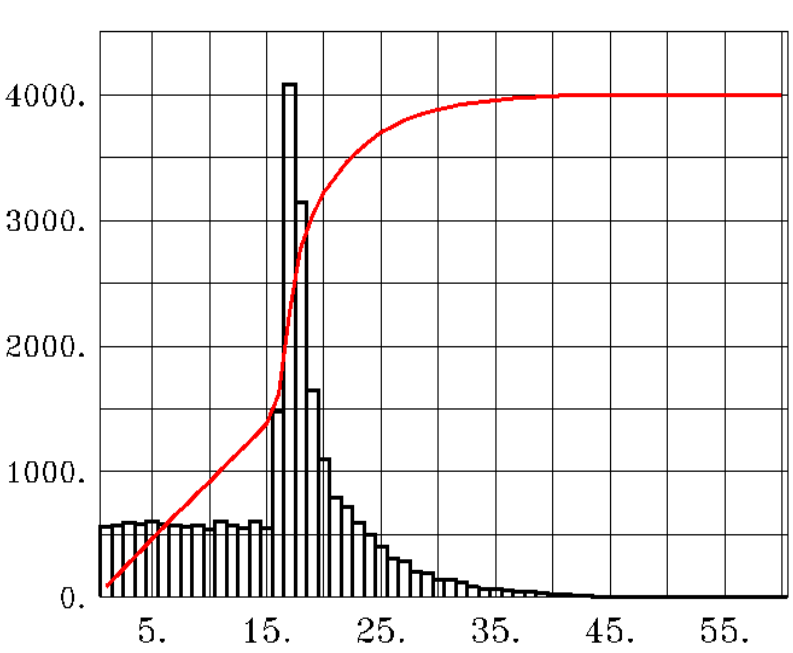


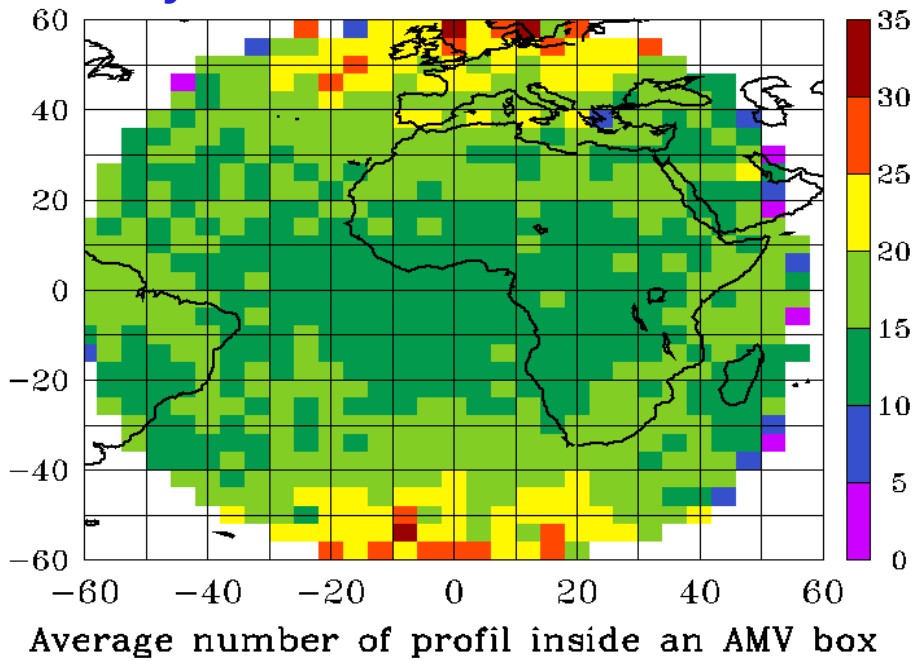
For that box are retained:

- the top and bottom pressure of the cloud layers of each CALIOP profils falling in the box,
- the SEVIRI CTP of each pixel
- the operationnal AMV CTP and the xx other CTP

among which the operationnal value has been choosen.

Number of CALIOP profils by AMV box:

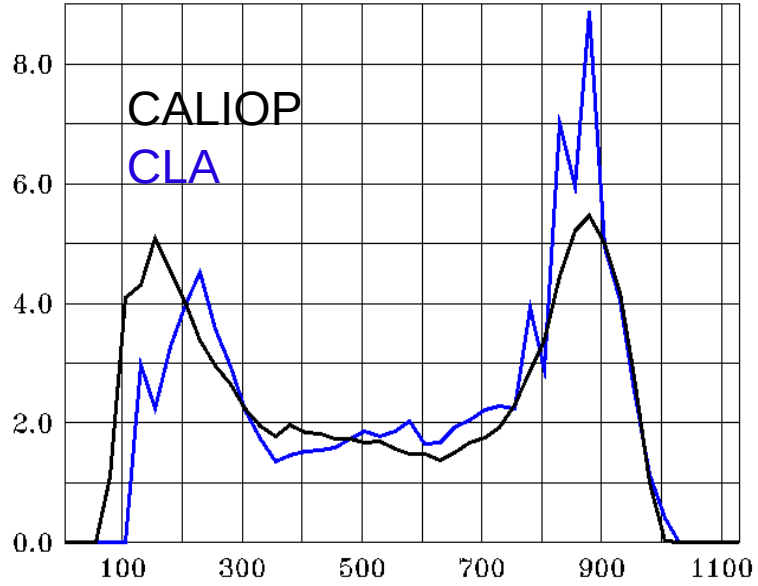




Only AMV with a minimum number of 3 profils are retained

REPRESENTATIVITY OF CALIOP OBSERVATIONS UNDER THE TRACK WITH RESPECT TO THE AMV BOX

CALIOP all cloud layer CTP
CLA CTP distributions



Classification in three main types according to the level of the highest cloud top in the BOX or under the track

Occurrence frequency in percent

	High	Mid.	Low	Clear
Box	54	17	29	0
CALIOP	53	13	30	5
Both	47	8	23	0

Effect of the under track sampling of the CALIOP observations

CLA : larger % of high-Low due to large spatial domain,

CALIOP: larger % of only high cloud due to the sensitivity of the lidar instrument

AMV analysis Principle

1 : Choice of representative pixels (operational vs alternative methods : Variable number of Cold pixels)

2 : estimation of CTP using the selected pixels

Dense clouds
From EBBT method

High semi-transparent clouds
From CO2 or IR/WV methods

Correction Methods for low clouds

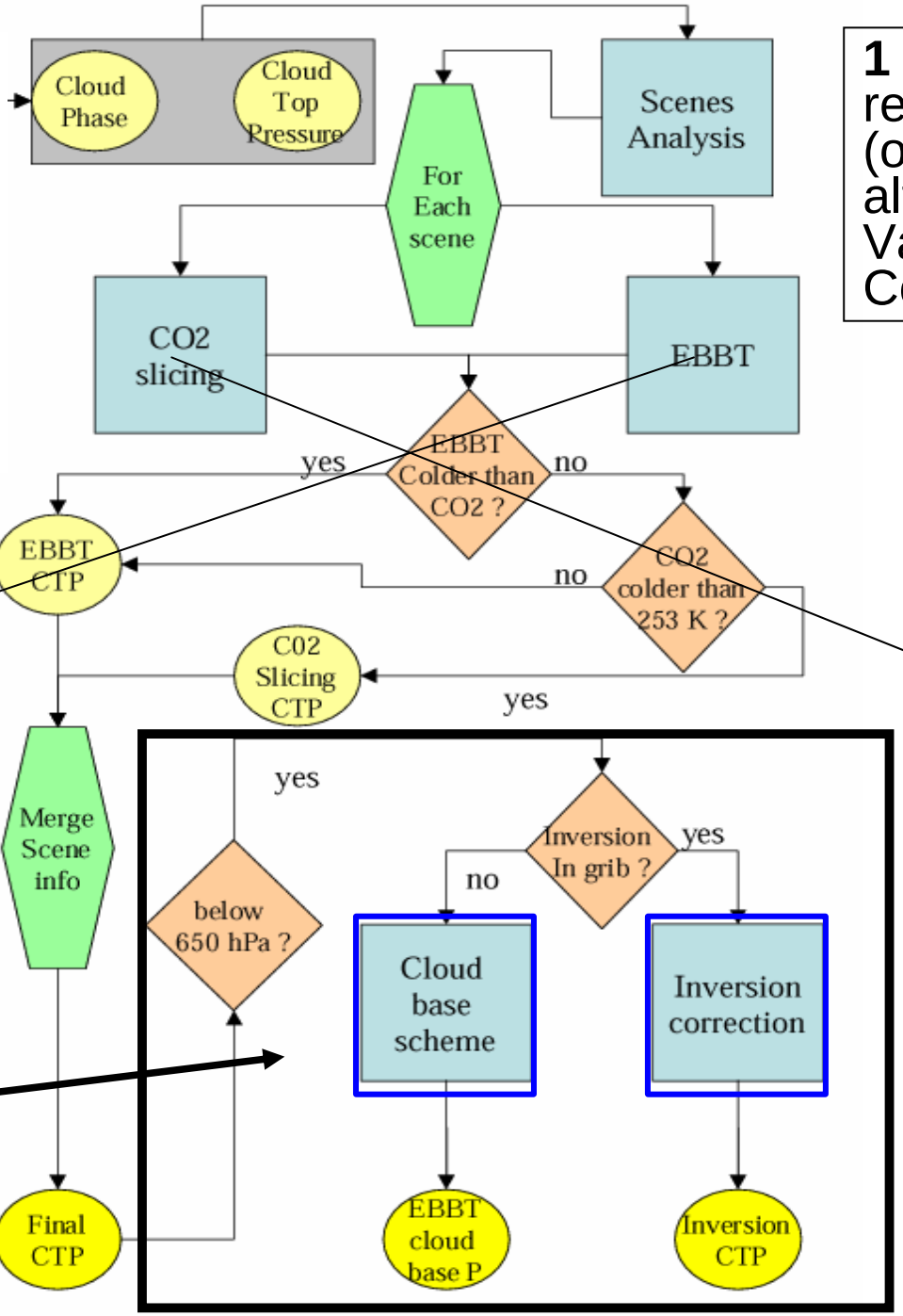


Figure 1 Flow chart of the height assignment process.
(CTP: Cloud Top Presure)

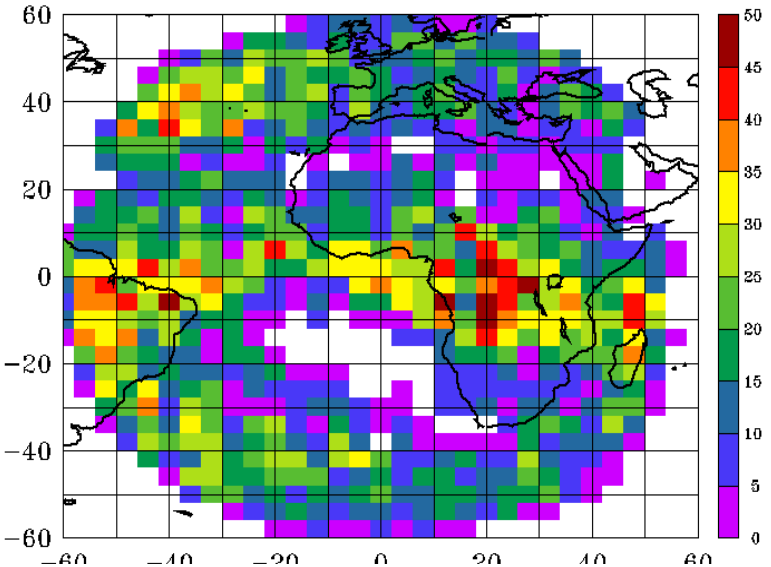
3 AMV analysis configurations:

Total number of AMV boxes : 24404/23912

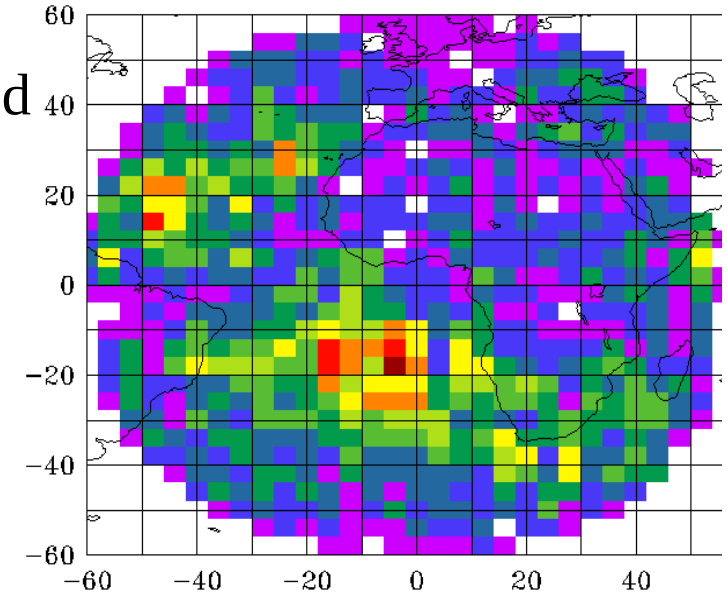
Case 1 : corrected for semi-transparency, STC AMV
10840 (CO2-IR12) + 574 (2.5% others)

Case 2 : EBBT < 253K AMV
(1080 cases)

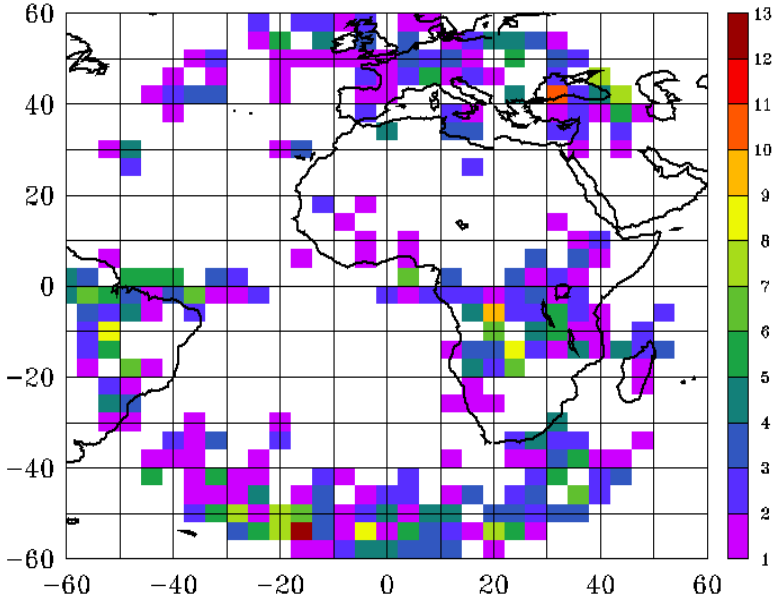
Case 3: EBBT > 253K AMV, low cloud cases, a correction method can be applied.
(11214 cases)



STC AMV



EBBT method for T>253K



EBBT method for T<253K

Case 1 and 2: STC and EBBT < 253K AMV

To compare with the AMV CTP how can a representative top pressure be determined from CALIOP observations ?

CALIOP allows to derive a high layer top altitude down to a low layer top altitude.

In between, the CTP distribution can be used to derive a representative altitude.

This is defined as the pressure value at a certain percentile of the distribution

- 0 % : equivalent of the highest cloud top in the AMV box.
- 20 %: allows some dispersion to be representative of spatial dispersion (preferably used).
- 100% : the lowest cloud top in the box

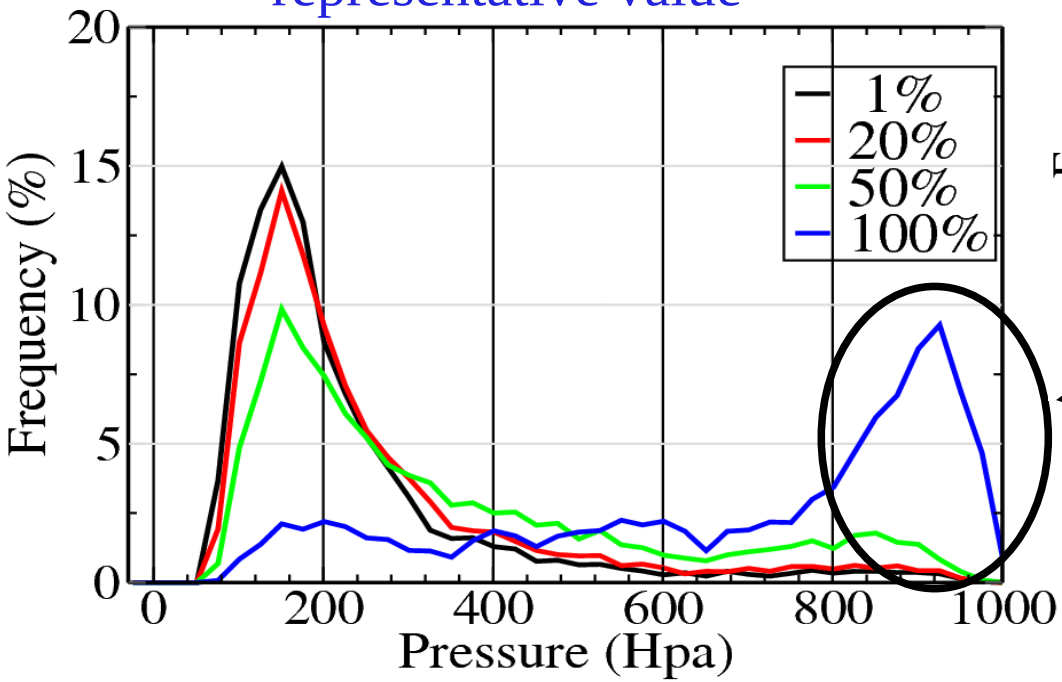
Two distributions can be used: the cloud top (TopTop) distributions and the cloud layer top distributions (AllTop). Here we use the AllTop distribution.

1. STC AMV, cases corrected for semi-transparency

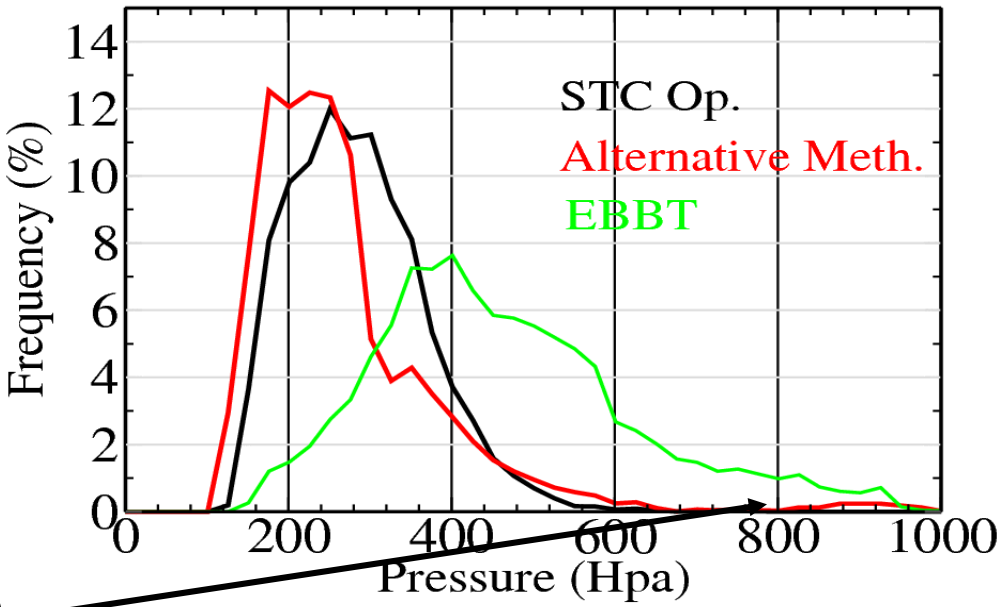
Correction with alternate method more important than with the operational method.

A large fraction of the CO2 AMV corresponds well to high cloud top. cases.

Distribution of CALIOP CTP representative value



AMV CTP distribution

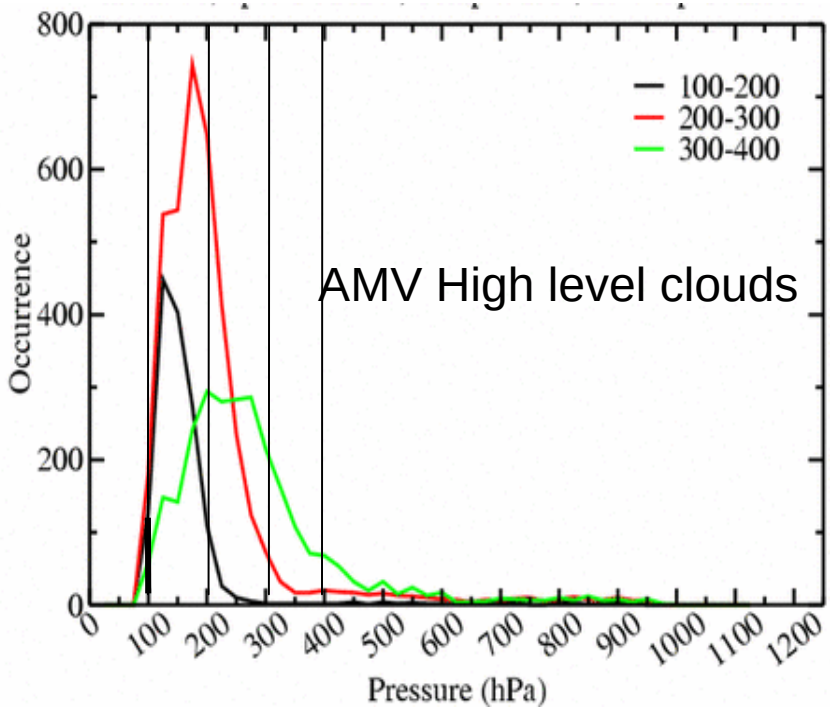


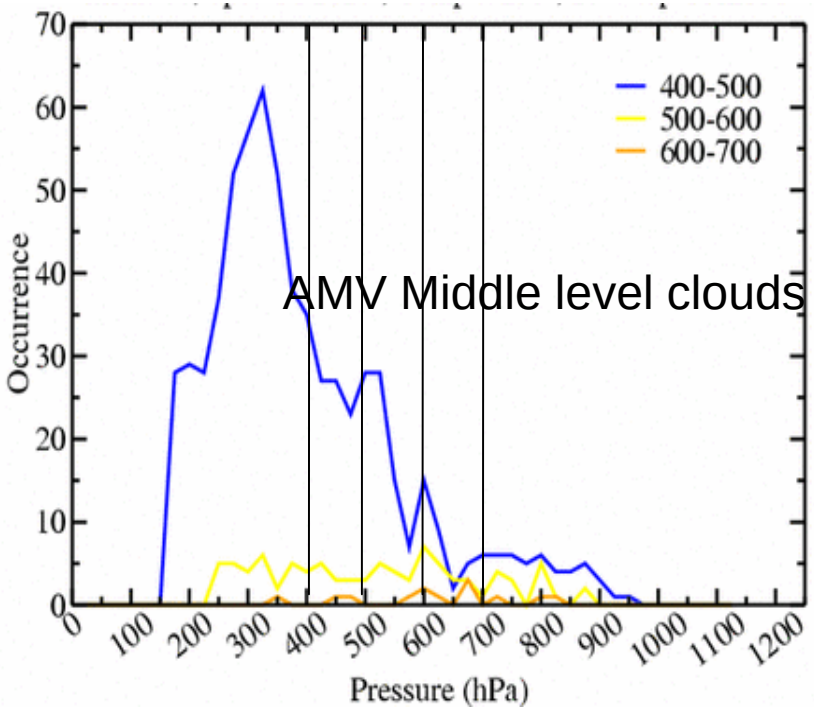
A non negligible fraction corresponds to multi-layered situations with at least one low cloud layer.

CALIOP, the AMV alternative method height (AMV AH) and the AMV operational height (AMV OH), peak of occurrence respectively close to 150, 200 and 250 hPa.

AMV cases corrected for semi-transparency: CALIOP CTP as a function of AMV pressure

:





- Recognition by CALIOP of the AMV higher levels : no bias only at 150 hPa
- AMV middle level cloud: frequent observation of high cloud top by CALIOP

CALIOP CTP: value at the percentile 20 of the distribution

Statistics as a function of CALIOP cloud type

Choice of the STC correction method, choice of representative pixels

→ High clouds:

Method → Best agreement obtained with the IR/WV 6.2 ratio method.
Bias/RMS 28/86hPa – Operational method 73/112hPa

→ CALIOP and lowest CLA CTP value: same bias than CALIOP IR/WV6.2 ratio Operational method but larger RMS.

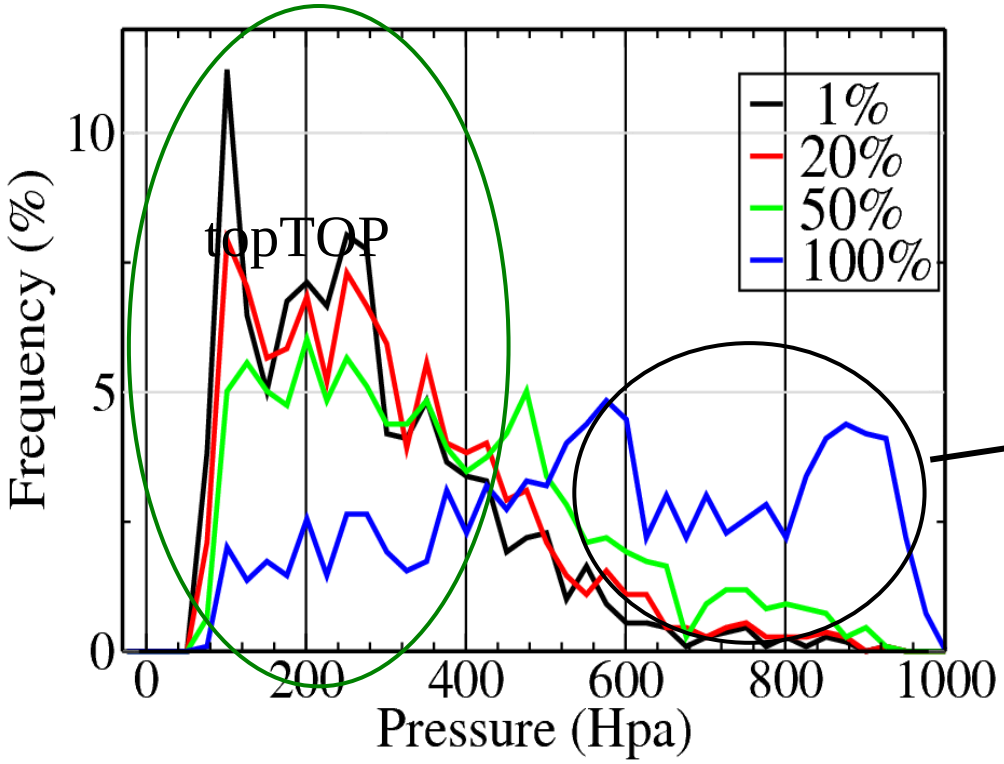
Pixel choice → Lowest bias (18hPa) with the 10% coldest cloudy pixels

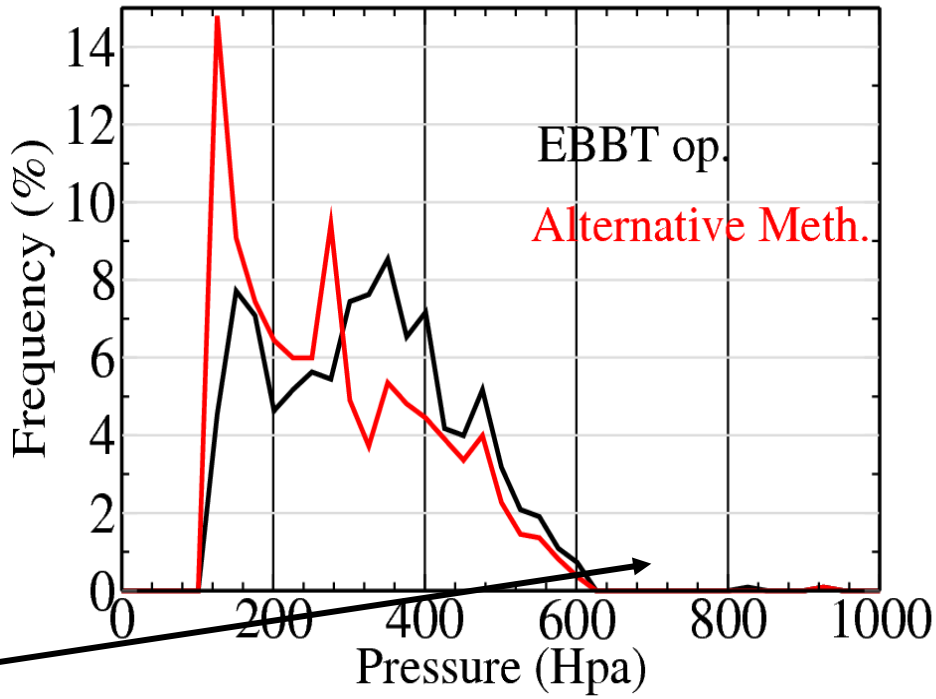
Threshold on CALIOP layer OD: bias decrease but RMS increase

→ High above low clouds: smaller bias but larger RMS than for high cloud alone. increase bias between the CO2 and IR-WV6.2 ratio CTP differences

→ Mid level clouds: a large negative bias (AMV above CALIOP) is obtained when using CO2 method. Smaller bias with the CLA CTP. BOX to track sampling problem?

2. EBBT T<253K: Thick clouds



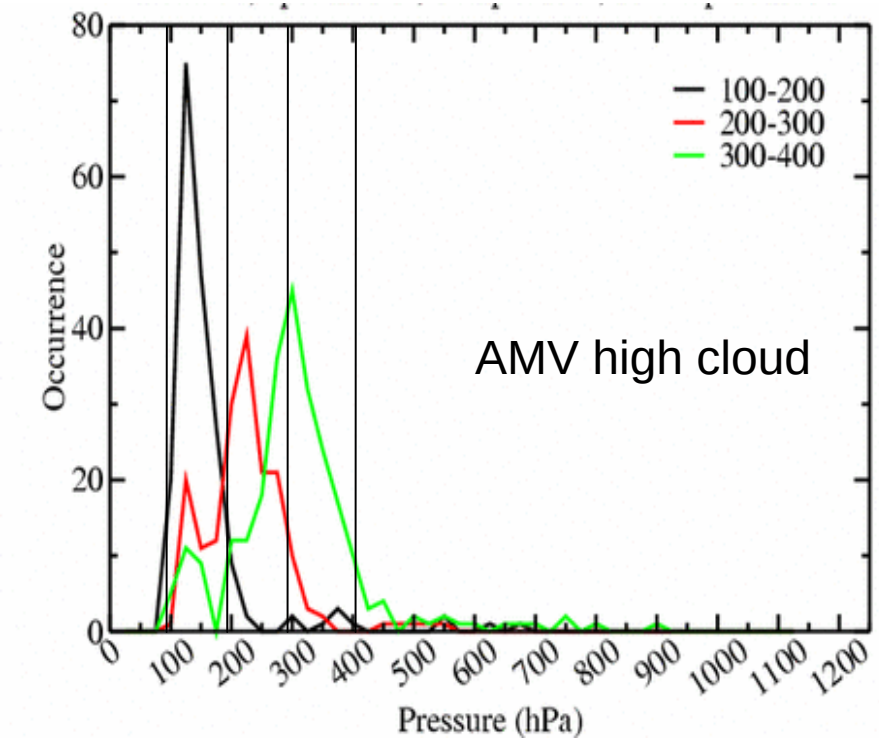


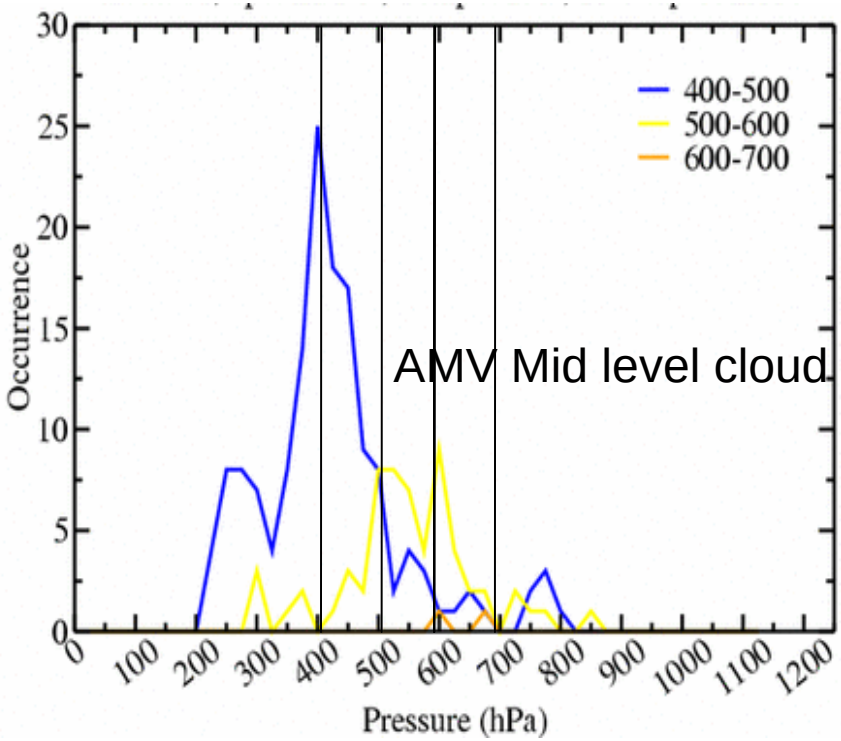
A large fraction of the EBBT AMV corresponds well to high cloud top cases.

A non negligible fraction corresponds to multi-layered situations with at least one low cloud layer.

Different shape from those of the thin cloud AMV (case 1). Peak at low pressure and then a constant decrease toward larger pressures.

EBBT < 253K AMV cases:
CALIOP CTP as a function of AMV pressure





Compared to the STC AMV cases:

➔ Better agreement CALIOP and AMV higher levels (bias < 50 hPa)
Smaller bias when using the IR/WV channels correction method.

➔ Smaller decrease of the bias after application of an OD threshold on CALIOP layers

➔ AMV middle level cloud: less frequent observation of high cloud top by CALIOP

3. EBBT T >253K:

AMV low cloud top height correction methods

Height inversion

Cloud base correction

Low level scene merging

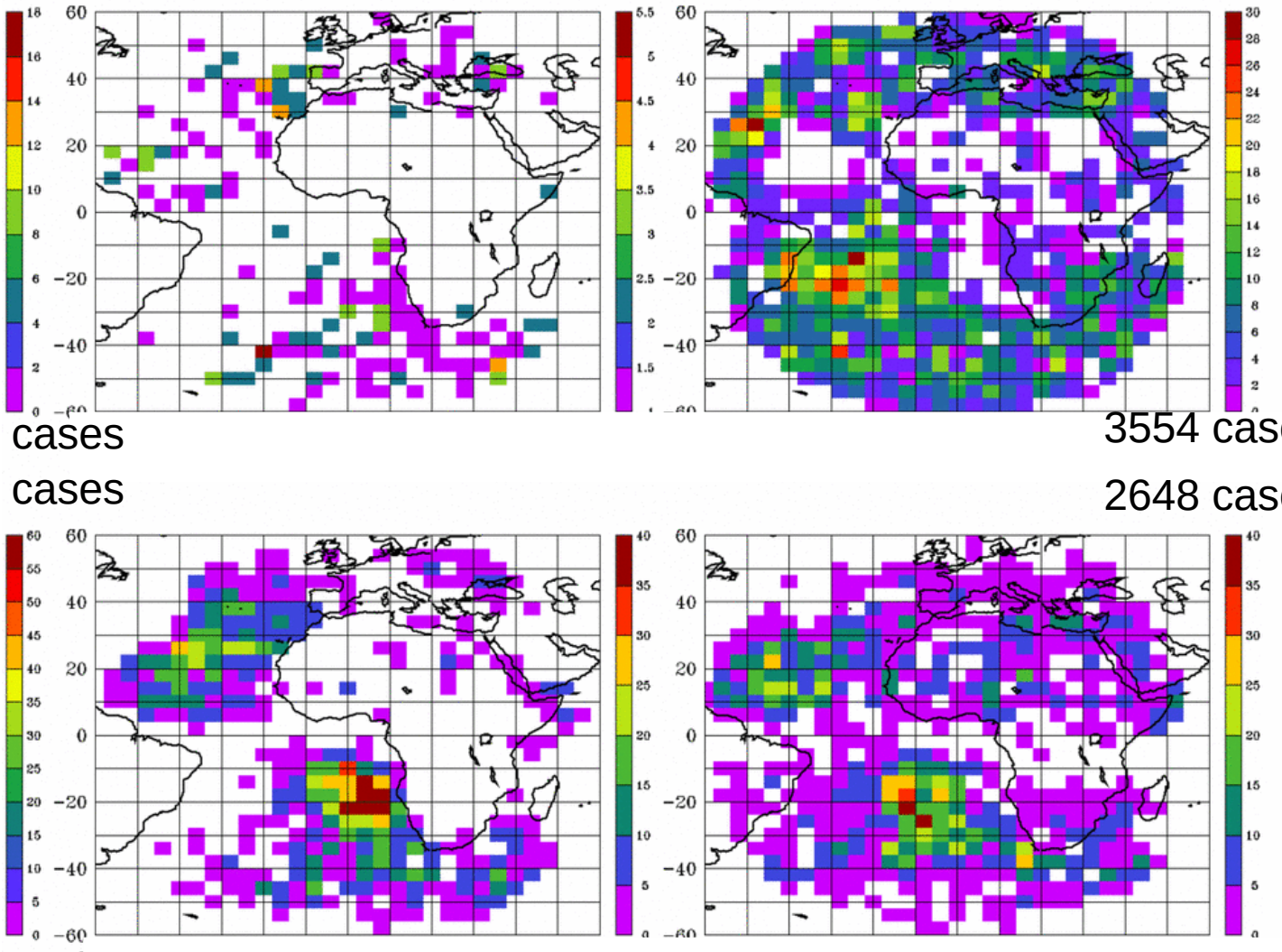
213 cases

2241 cases

3554 cases

2648 cases

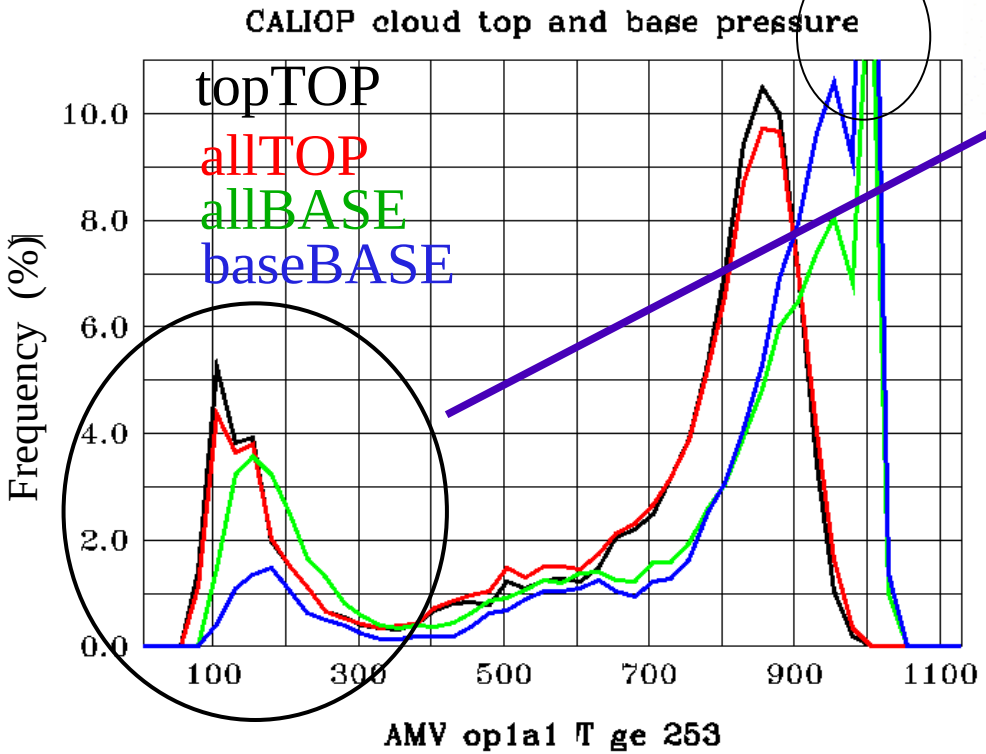
No low level scene merging

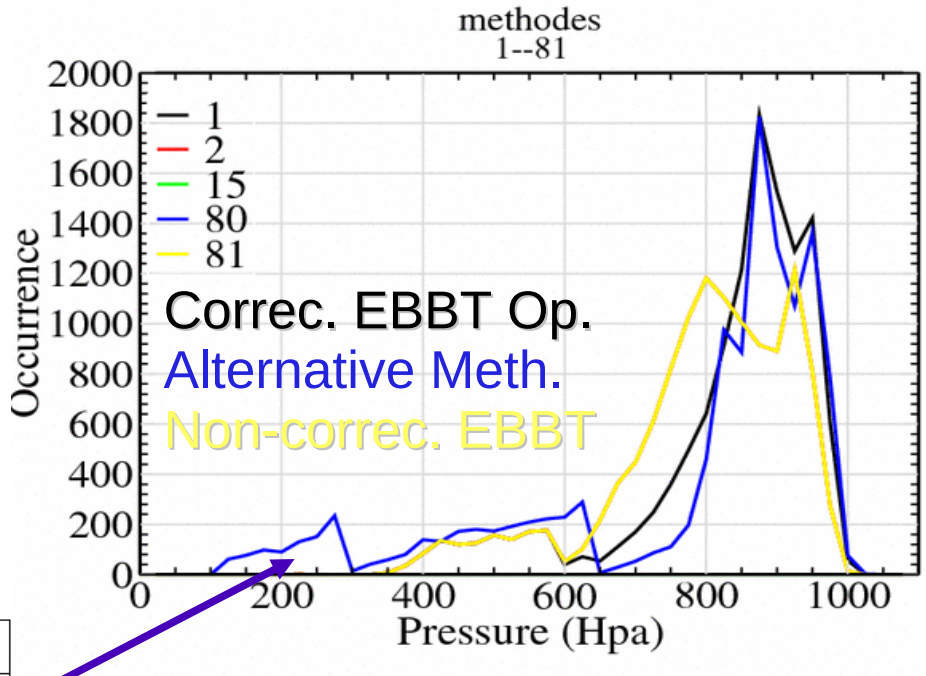


Spatial Distribution of low cloud cases with correction

3. EBBT T >253K: low clouds

For CALIOP 4 distributions:
topTOP: cloud top
all TOP : cloud layer top
all BASE: cloud layer base
base Base : cloud base





Peak of occurrence between 850 and 900hPa in the AMV and in the CALIOP top distributions.

Occurrence of high clouds for the lidar observations.

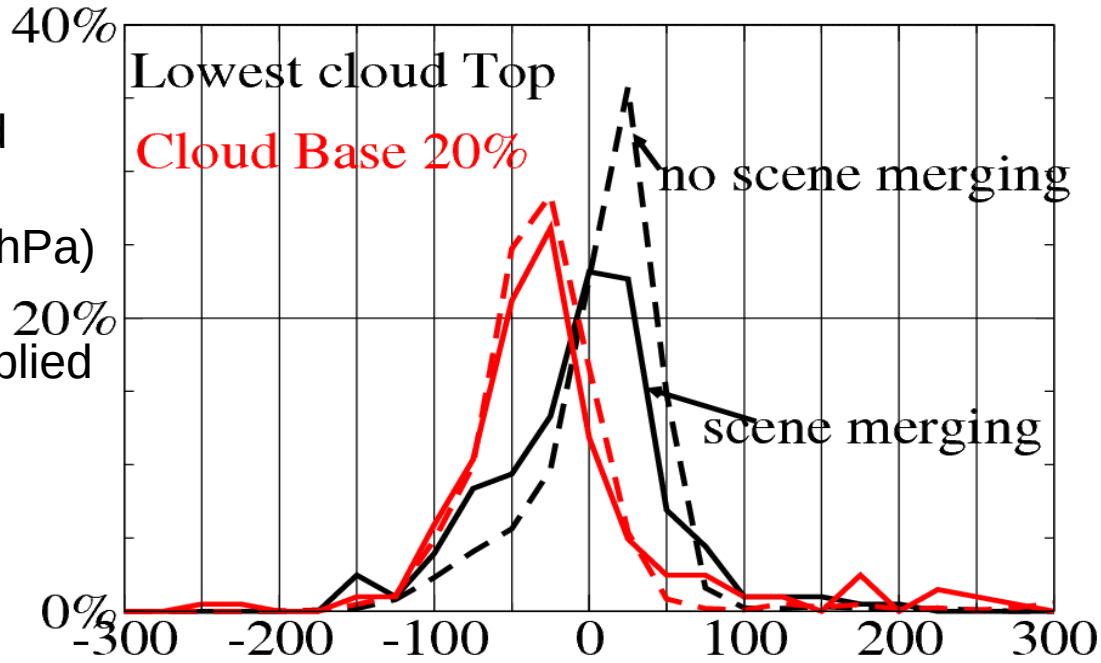
Histogramme of differences between AMV OP and CALIOP

AMV CTP compared to CALIOP lowest cloud layer top CTP:

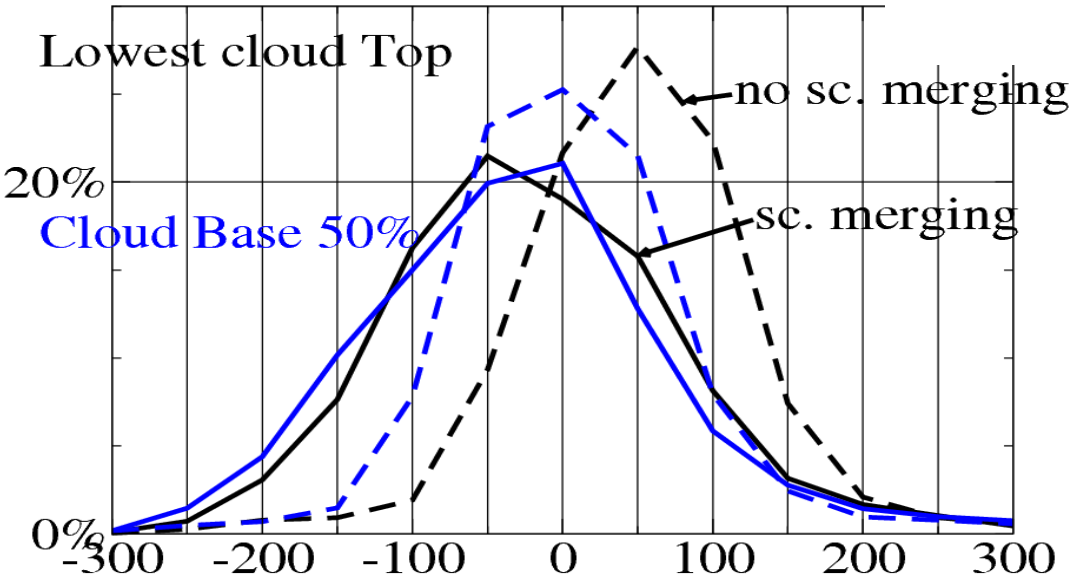
➔Smaller bias and RMS for corrected cases than uncorrected cases:
(cor. 24/120hPa, uncor. -34/206hPa)

➔No biais when scene merging is applied

Inversion height correction



Cloud base correction



Scene merging effect is the largest on the cloud base corrected cases.

RMS for the cloud base correction cases double from those inversion correction cases.

➔Larger heterogeneity of the cloud field.

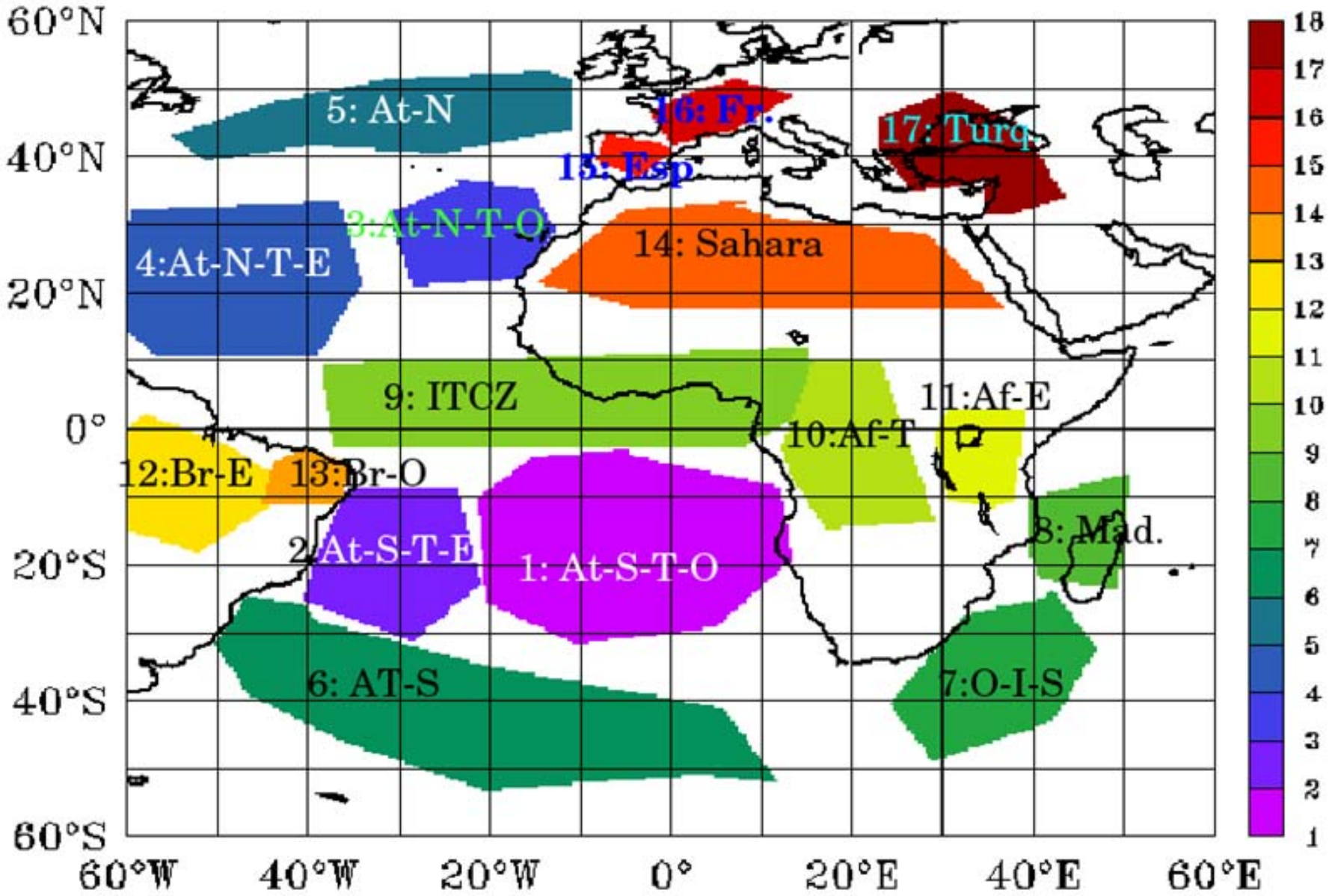
Conclusion of correction methods for AMV low clouds

→ The best agreement is obtained with the CALIOP lowest cloud top using the inversion methods (low bias and small RMSD)

For 34% of the cases, high or mid-level layer also observed in the box by CALIOP.

→Results from methods cloud base assignment are closer to CALIOP cloud base observations

→ Decrease of bias between AMV and CALIOP when scene merging is applied.


60°N
40°N
20°N
0°
20°S
40°S
60°S
60°W
40°W
20°W
0°
20°E
40°E
60°E
5: At-N
16: Fr.
17: Turq.
15: Esp
3:At-N-T-O
4:At-N-T-E
14: Sahara
9: ITCZ
11:Af-E
10:Af-T
12:Br-E
13:Br-O
8: Mad.
2:At-S-T-E
1: At-S-T-O
6: AT-S
7:O-I-S
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17 regions

STC AMV

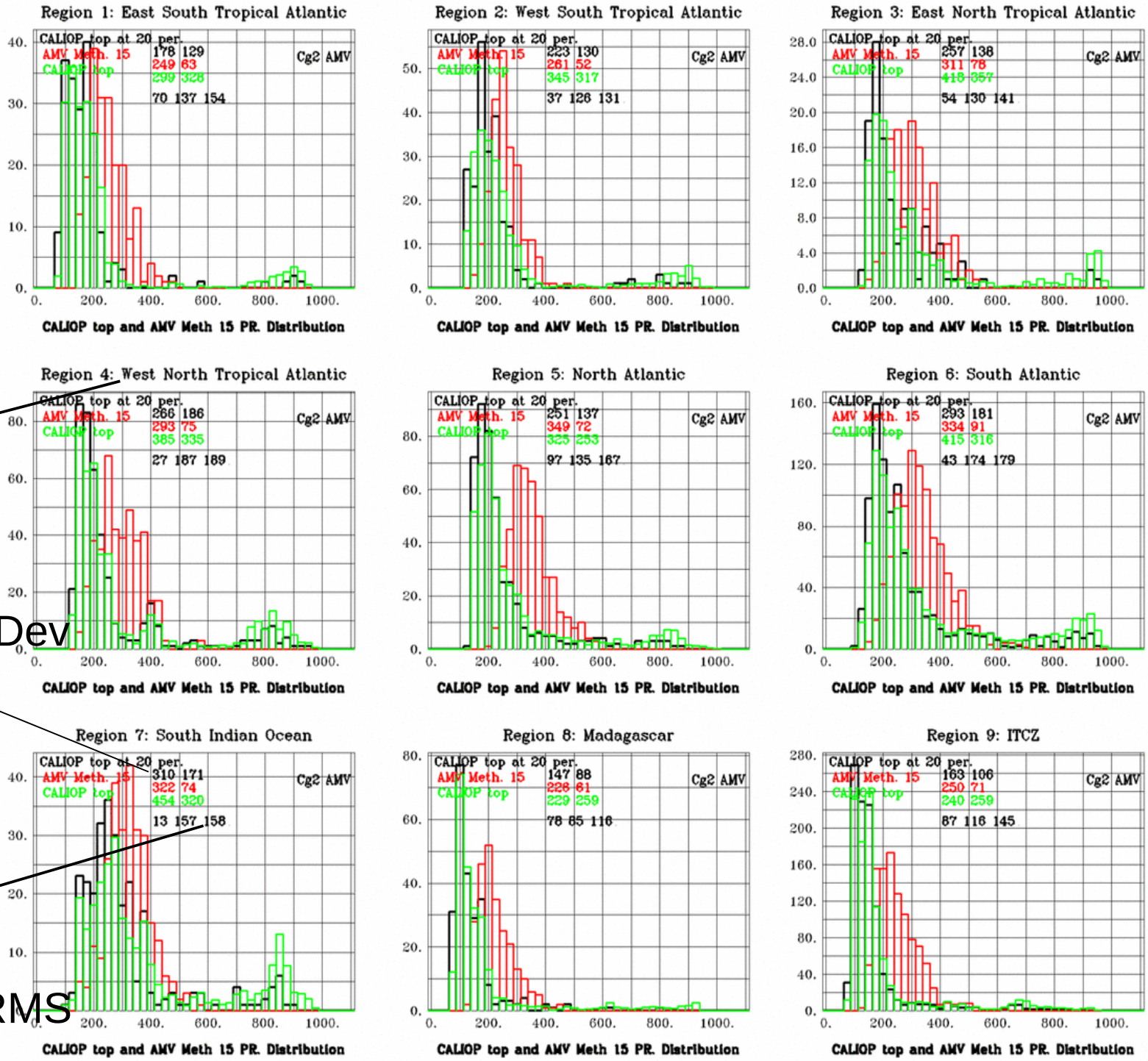
AMV Op. pressure

Ocean

Region name

Mean and StDev

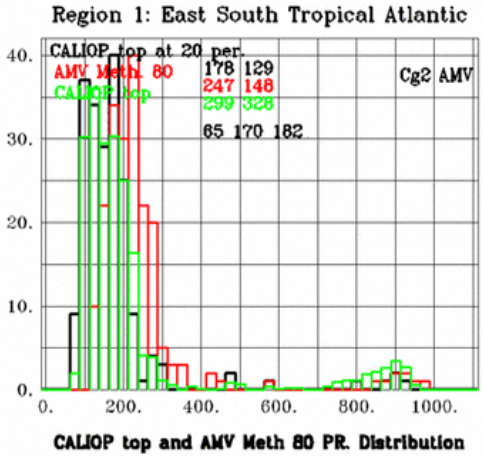
Diff. stats mean, SD, RMS

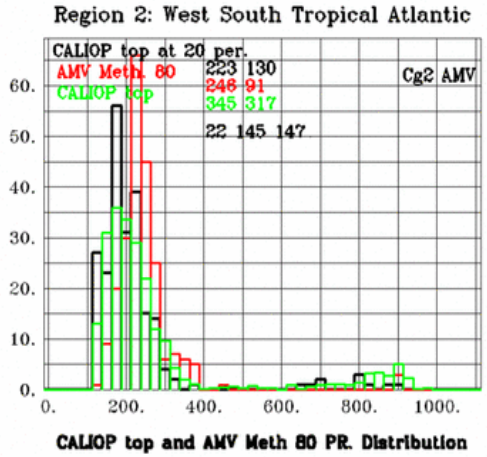


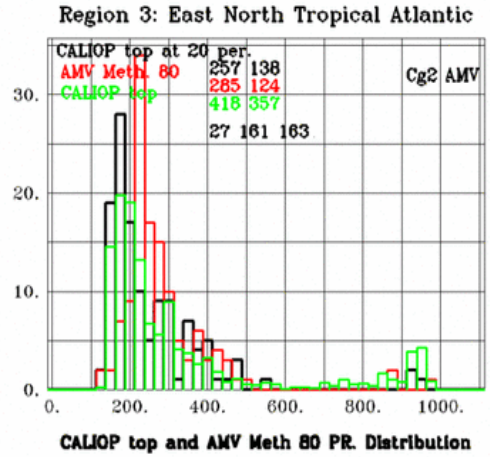
STC AMV

AMV Alt. pressure

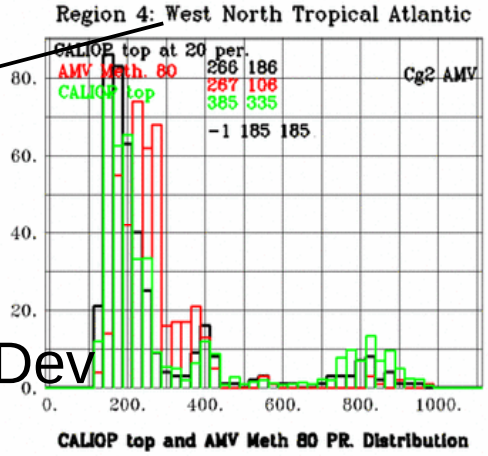
Ocean

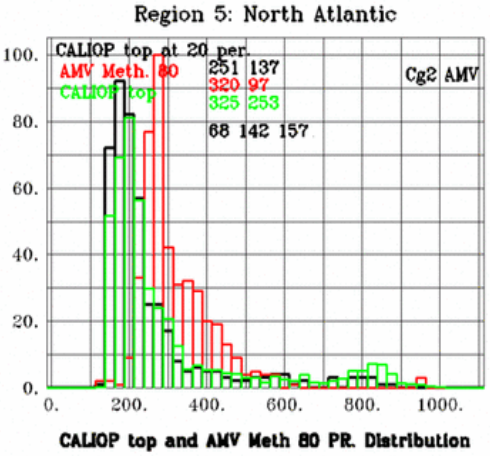


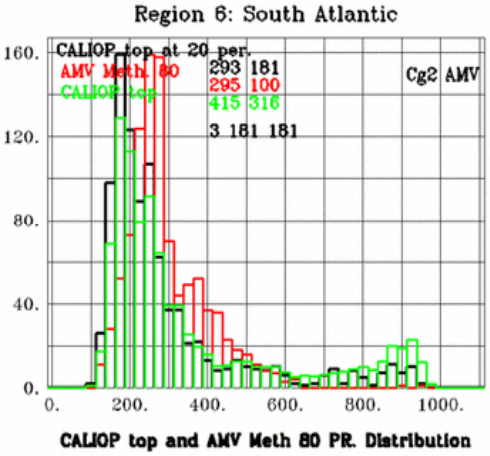




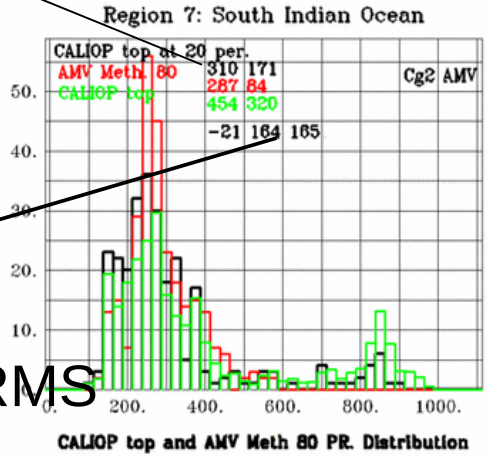
Region name

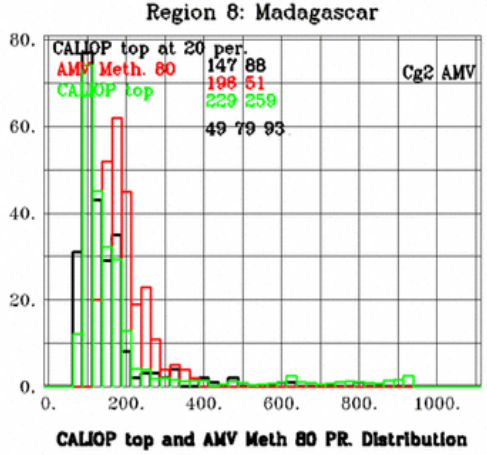


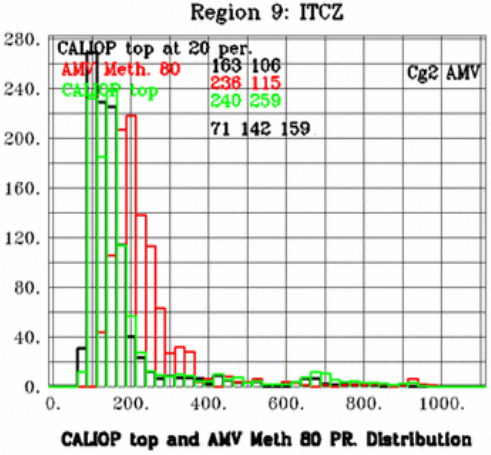




Mean and StDev







Diff. stats mean, SD, RMS

STC AMV

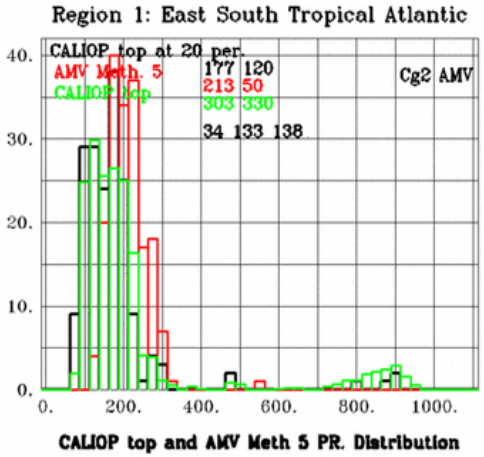
AMV OP.
IR/W6.2

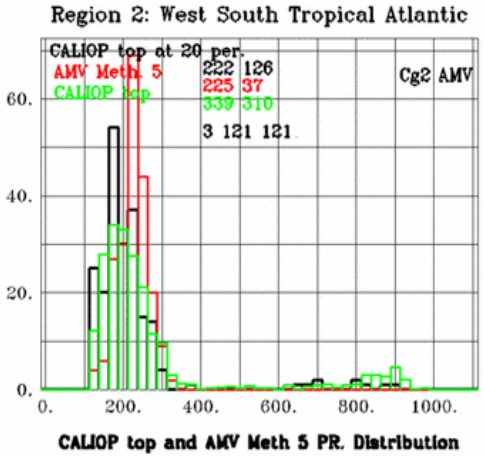
Ocean

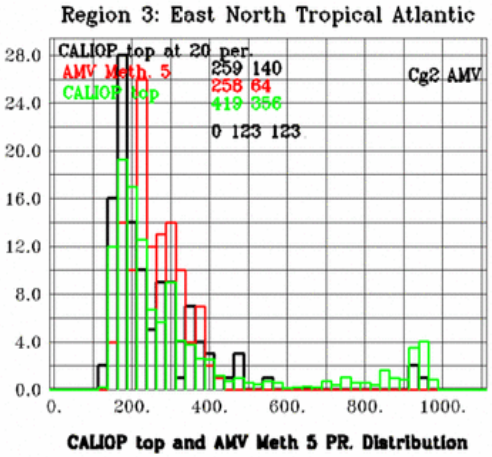
Region name

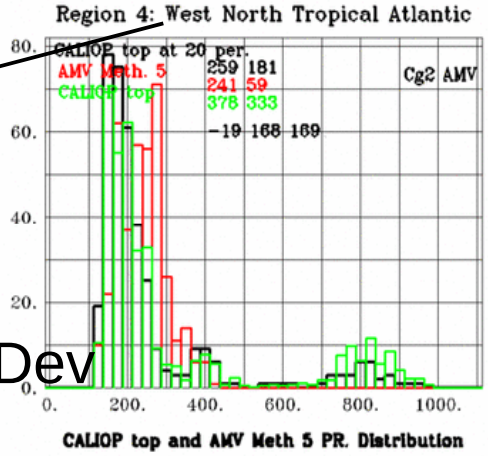
Mean and StDev

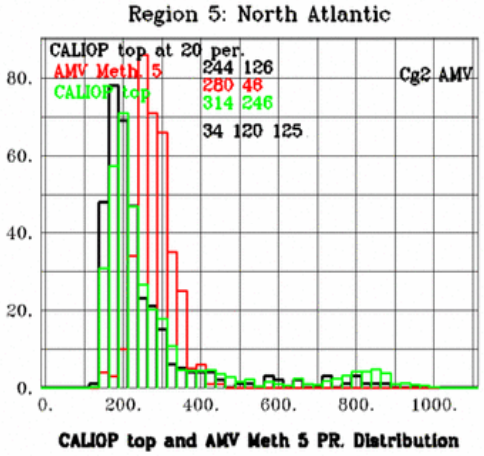
Diff. stats
mean, SD, RMS

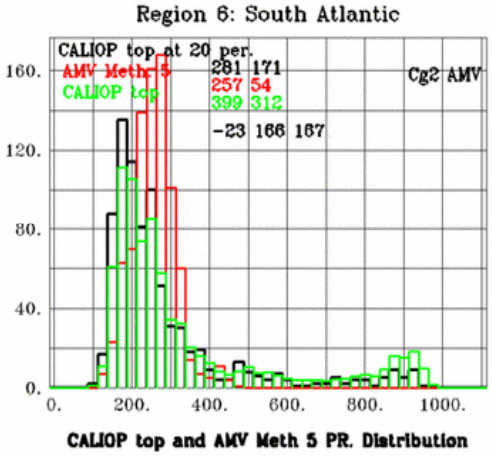


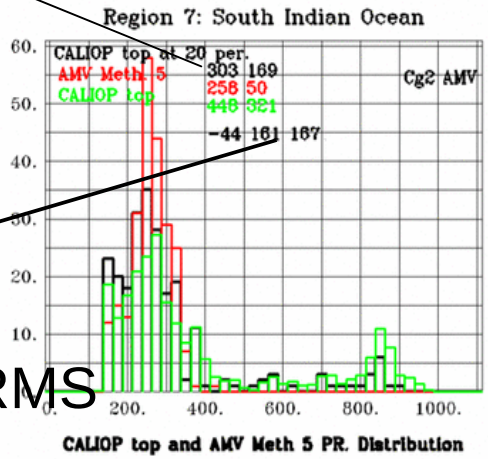


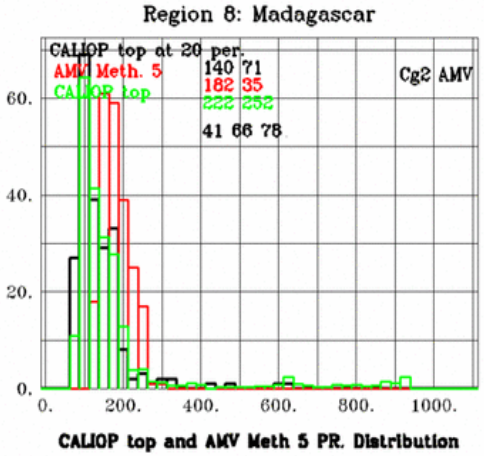


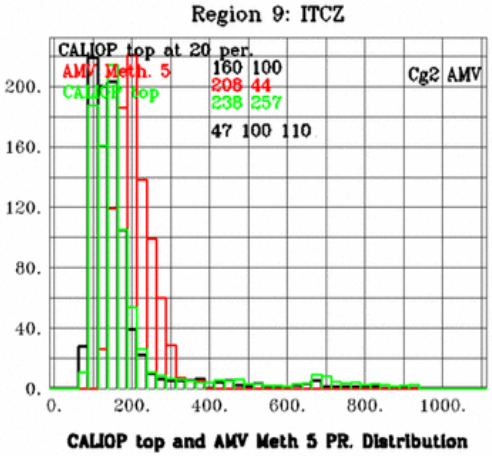












STC AMV

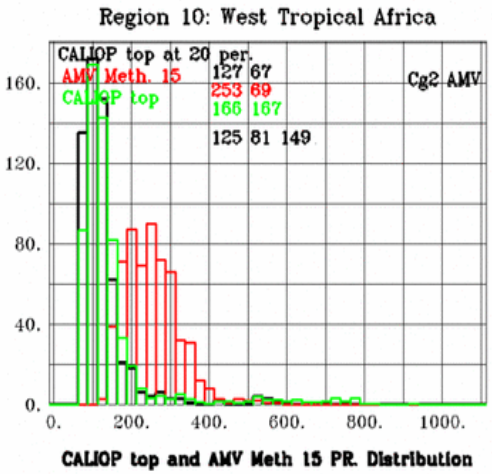
AMV Op. pressure

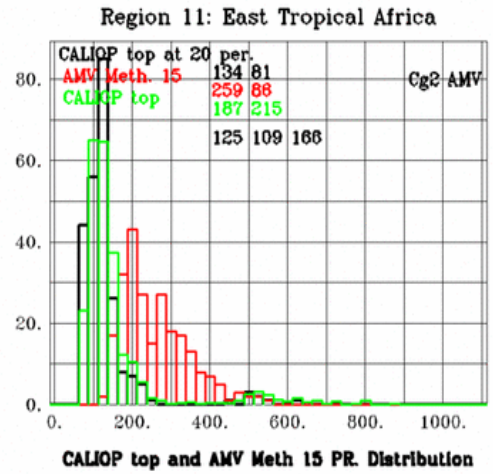
Land

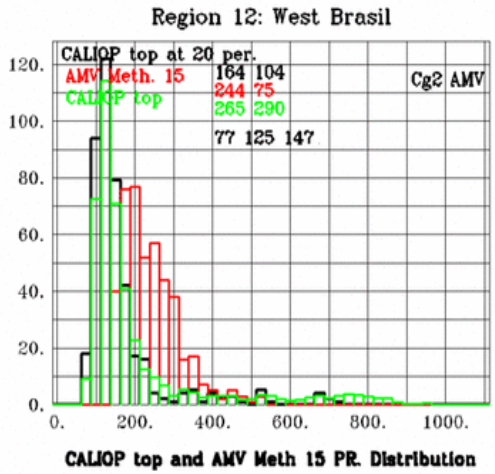
Region name

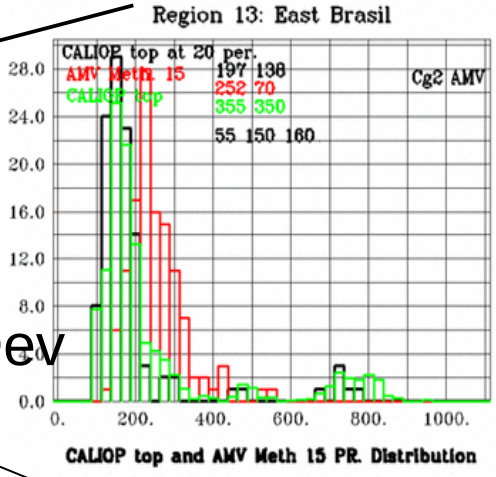
Mean and StDev

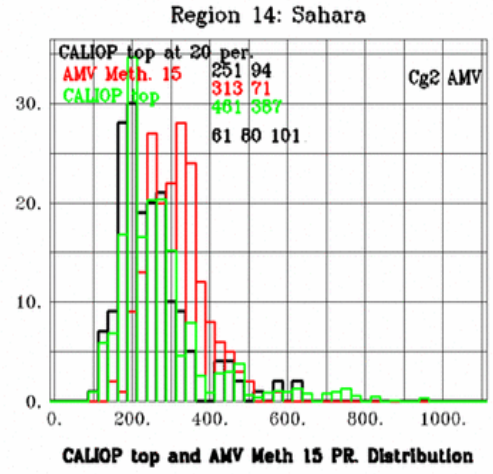
Diff. stats mean, SD, RMS

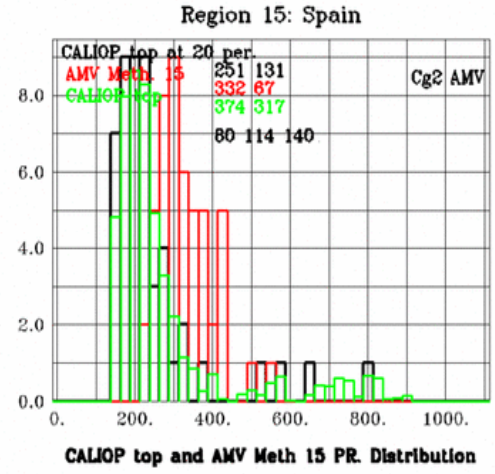


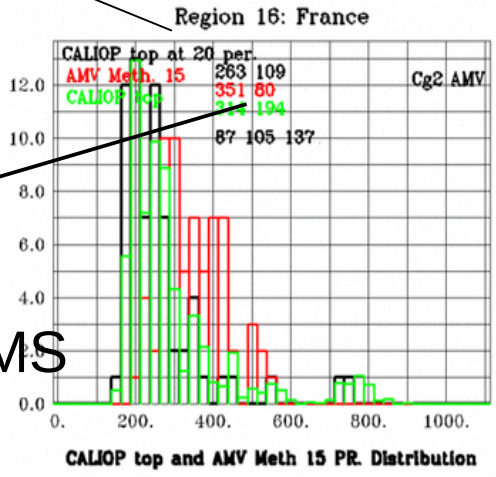


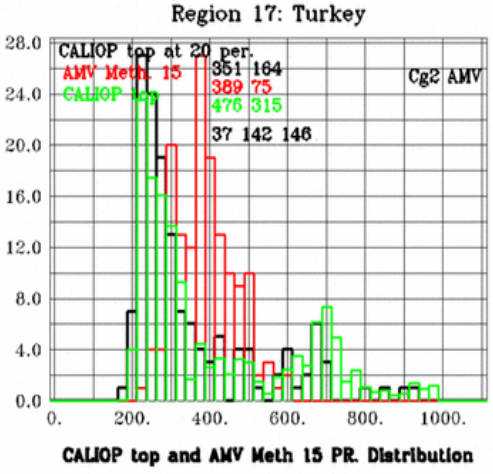












STC AMV

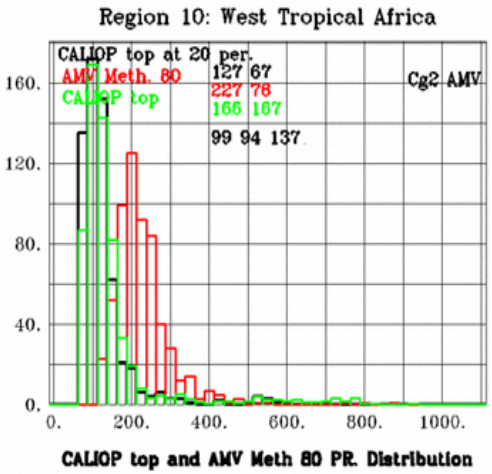
AMV Alt. pressure

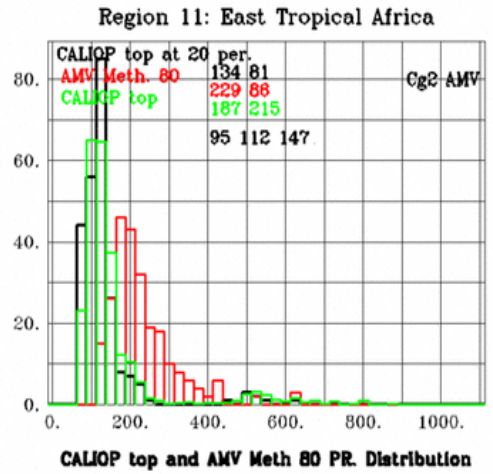
Land

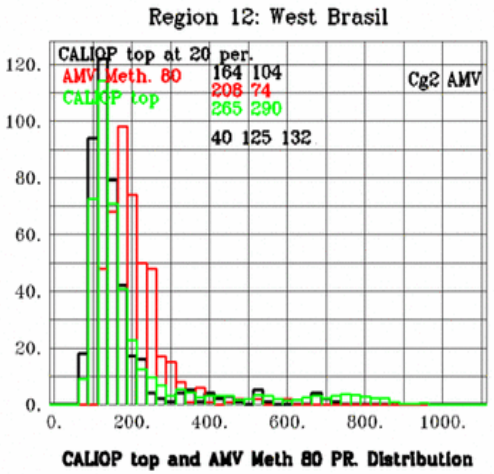
Region name

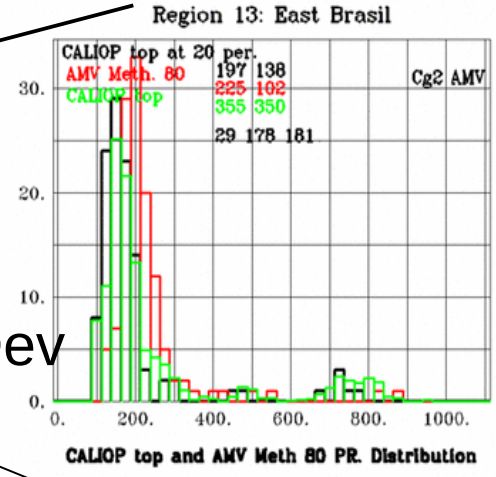
Mean and StDev

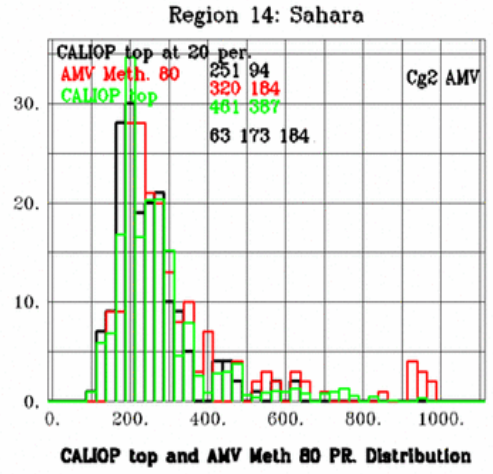
Diff. stats mean, SD, RMS

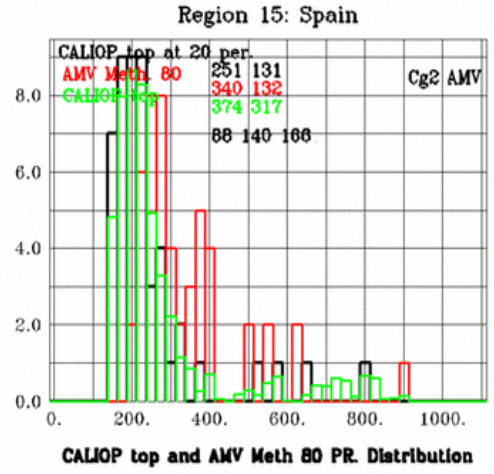


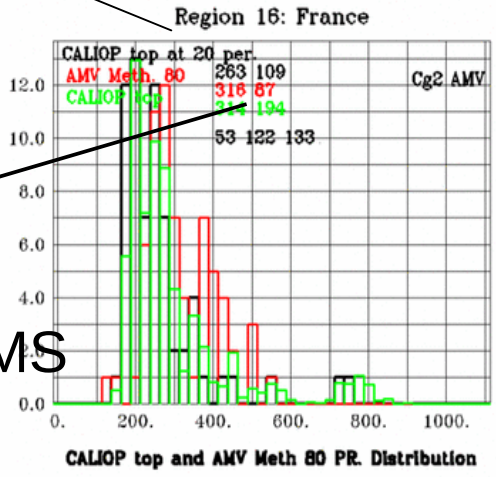


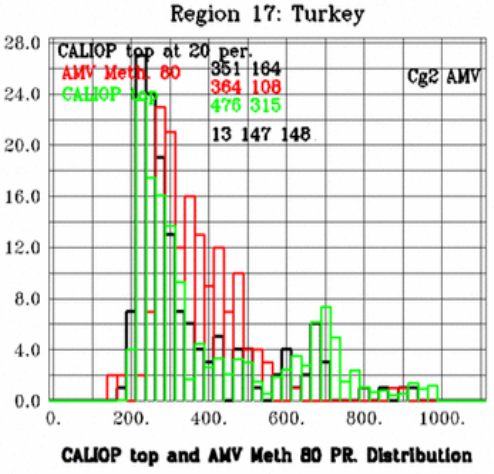












STC AMV

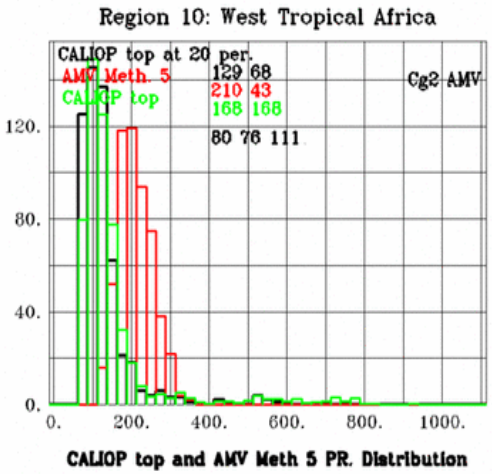
AMV OP
IR/WV 6.2

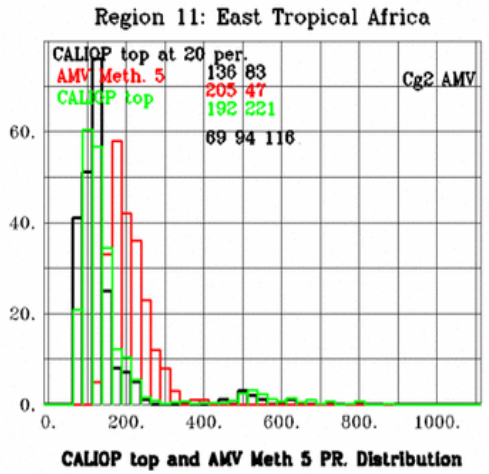
Land

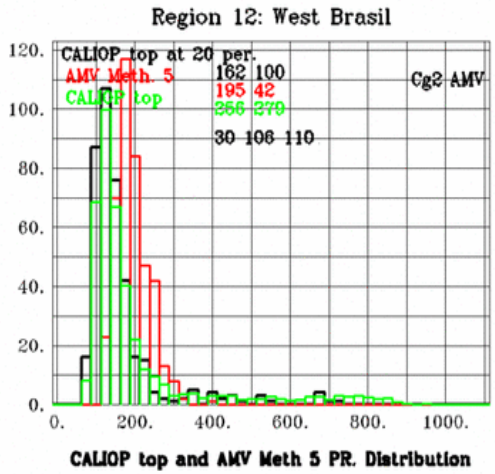
Region name

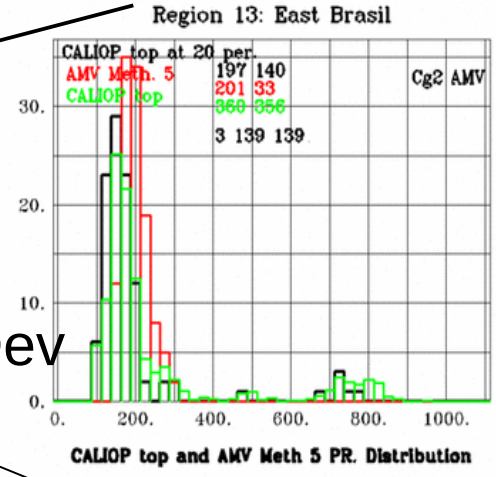
Mean and StDev

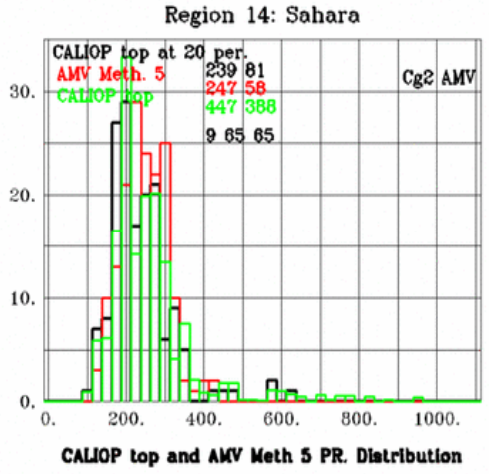
Diff. stats
mean, SD, RMS

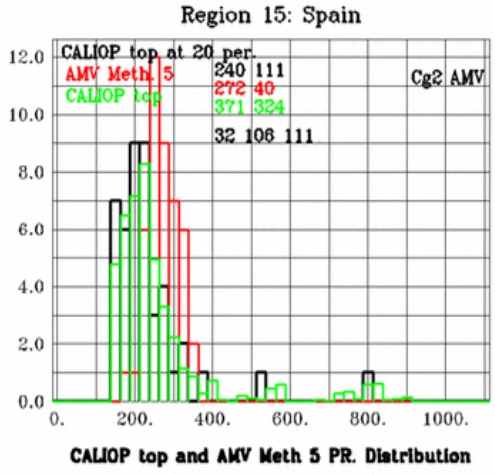


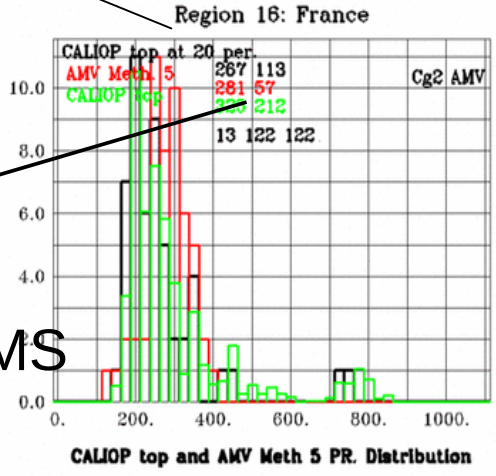


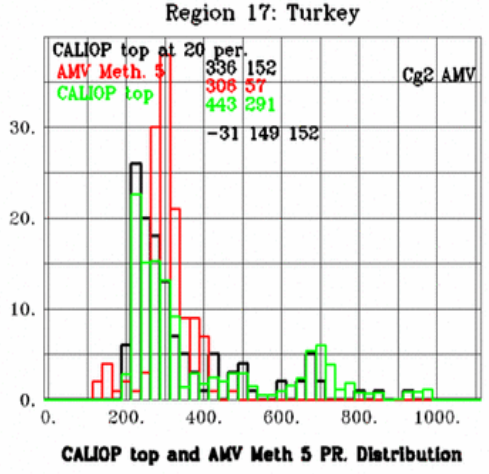












CONCLUSION

NO STRONG LIMITATION INDUCED BY TRACK OBSERVATIONS
WITH RESPECT TO AMV BOXES

SIGNIFICANT DIFFERENCES BETWEEN AMV AND CALIOP PRESSURE LEVELS FOR HIGH CLOUDS WITH CO2 METHOD

- The best agreement for uppest layer (100hPa),

BETTER AGREEMENT WITH ALTERNATIVE SCENE CHOICE AND IR/WV METHODS
BUT LIDAR MAY BIAS TOWARDS UPPER ALTITUDE (ONLY CLOUD TOP ALTITUDE USED)

MIDDLE CLOUDS : POOR AGREEMENT

LOW CLOUDS :

- Inversion correction methods give good agreement between AMVs and CALIOP lowest cloud top

- Results from cloud base assignment methods are closer to CALIOP cloud base observations

THANKS

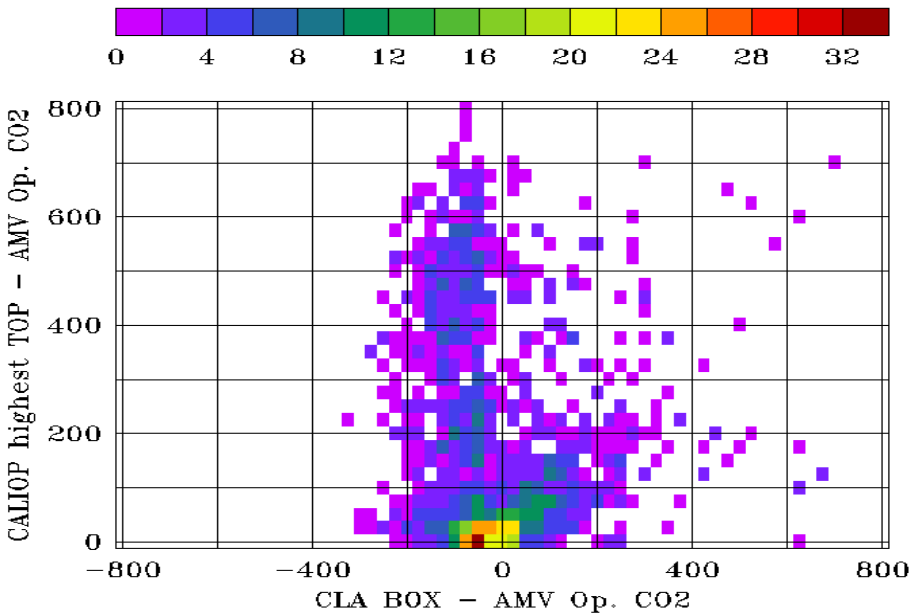
Aknowledgements:

MOD team for providing dataset and help during this study

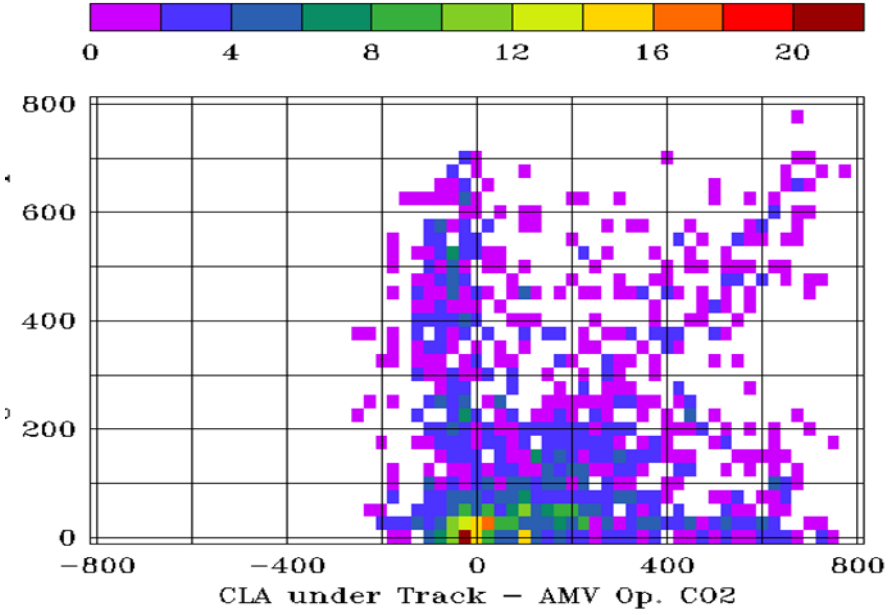
Upper layer detected by CALIOP is at a pressure larger than the one of the corresponding AMV one: CO2 AMV cases

Distribution of CLA BOX(Track)-AMV pressure differences versus CALIOP-AM differences

CLA BOX



CLA under Track



CALIOP pressure: cloud layer top lowest pressure
CLA pressure: cloud top lowest pressure in the target BOX or under CALIOP track

One part of the case but not all of them could be explained by the under track sampling.
Large viewing angle for SEVIRI?

Comparison of the AMV and CALIOP cloud pressure

Definition of the CALIOP cloud top/base pressure distribution :

Case 1 : Only CALIOP uppermost cloud top height from individual Profiles is considered (Toptop)

Case 2 : All CALIOP cloud layer tops from any profile are considered (Alltops)

Case 3 : Basebase same as Toptop for cloud base (lowest value)

Case 4 : AllBase same as for Alltops for cloud bases

CALIOP cloud top analysis :

→ Difficulty to define a single equivalent level

Conclusion on first comparisons for the 3 AMV configurations

- CO2 AMV (corrected for semi-transparency): for CALIOP, the AMV atlternative method height (AMV AH) and the AMV operational height (AMV OH), peak of occurrence respectively close to 150, 200 and 250hPa. Some cases with only low cloud top for CALIOP. A large percentage of multi-layered cases for CALIOP.

- EBBT < 253 K : Similar distribution shapes with two peaks at low pressure and then a constant decrease toward larger pressures. Non neglectable occurrence of warm cloud top for CALIOP.

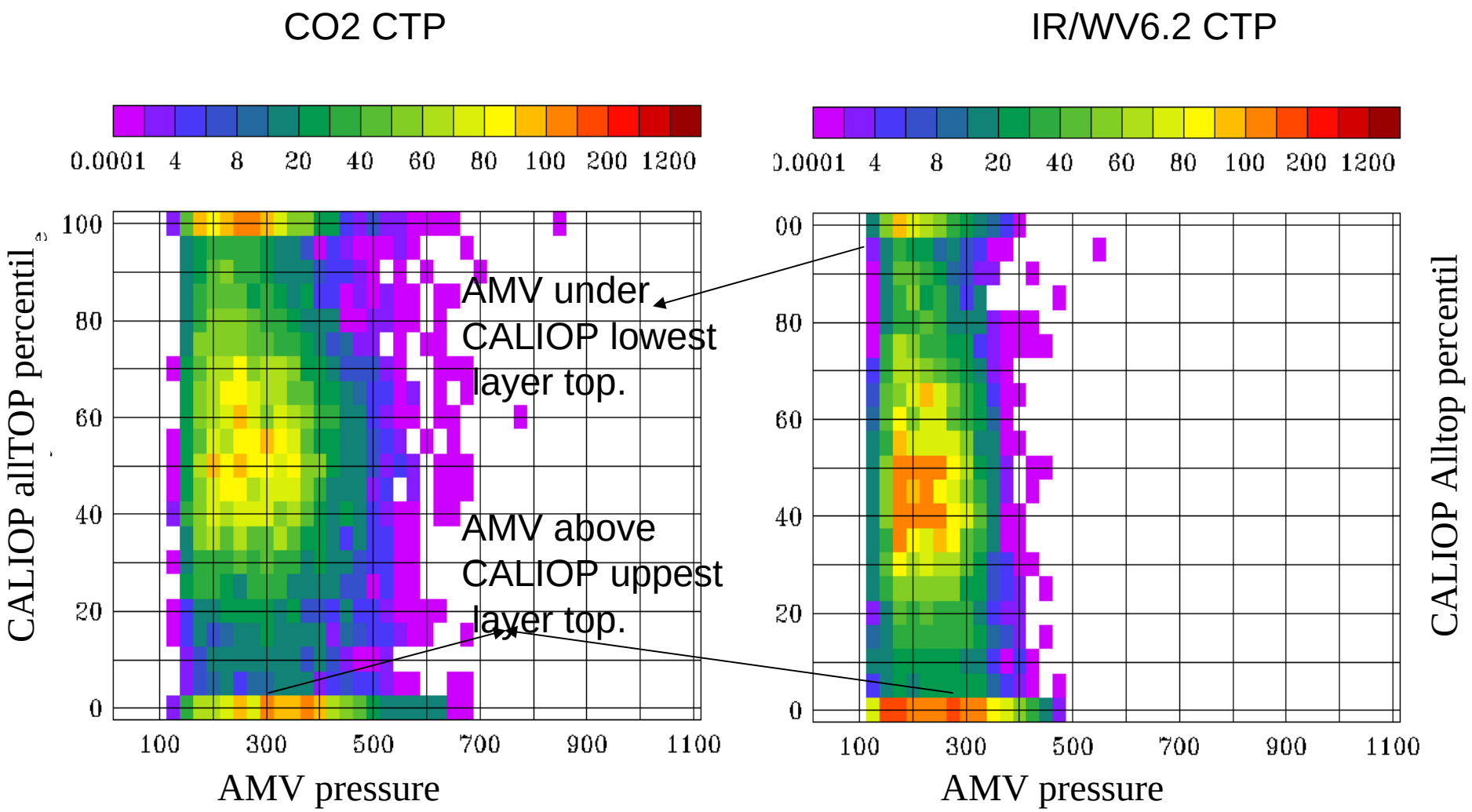
EBBT > 253 K: Well defined peak between 850 and 900hPa in the CALIOP cloud top and the AMV corrected height distributions. Occurrence of high clouds for lidar observations.

Methods are listed between 1 and 81

1= operational method
2= EBBT,
3= STC WV6.2
4= STC7.3,
5= IRWV6.2,
6= IRWV7.3
9= CO2IR10.8 Rep.Meth.,
10= CO2IR12.0 Rep.Meth.
12= CO2IR10.8 Samp. Meth.,
15= CO2IR12.0 Sam. meth.
81= operational method no correction
80 = alternative height assignment method

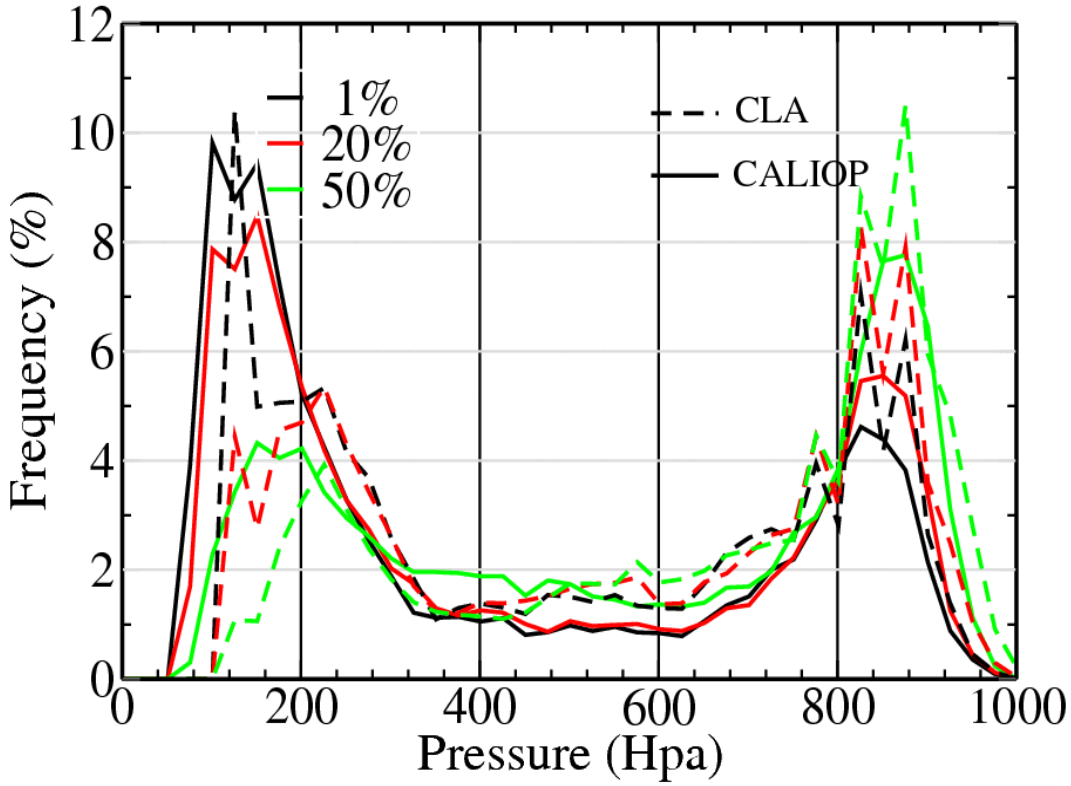
*The AMV ensemble is called « **ALL AMV** »,*
*The ensemble for which the atmospheric pressure level is obtained with a method other Than EBBT is called « **CO2 AMV** »,*
*The ensemble obtained with EBBT method is called « **EBBT AMV** »,*
*When in the ensemble « EBBT AMV » temperatures are larger than 253K the ensemble is called « **EBBT AMV T > 253K** »,*
*otherwise « **EBBT AMV T < 253K** »*

AMV cloud pressure and percentil value of the CALIOP pressure distribution: CALIOP all TOP distributions

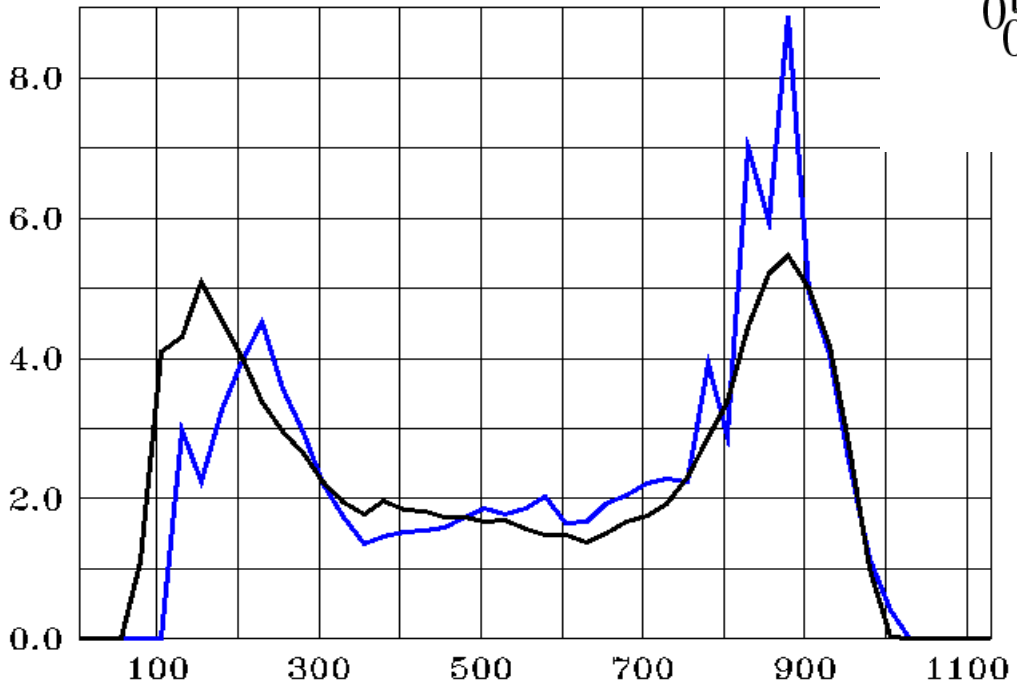


Il faudrait le faire par type de classe CALIOP

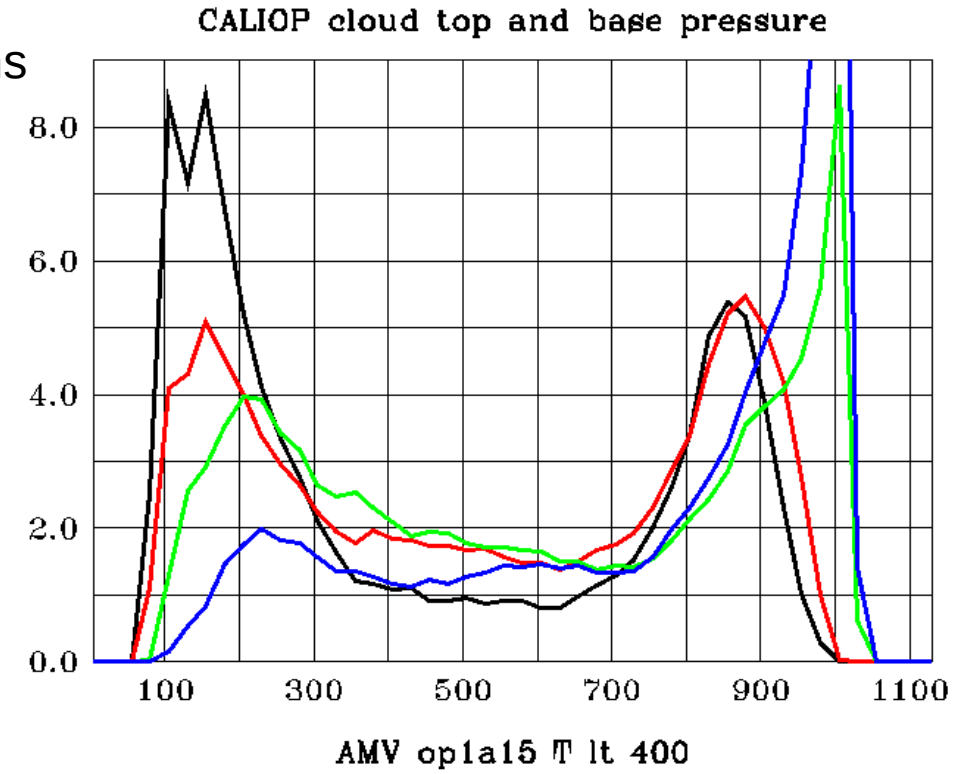
Distributions of the x percentil of the CALIOP ALL TOP CTP and CLA CTP distributions



CALIOP all Top and CLA CTP distributions

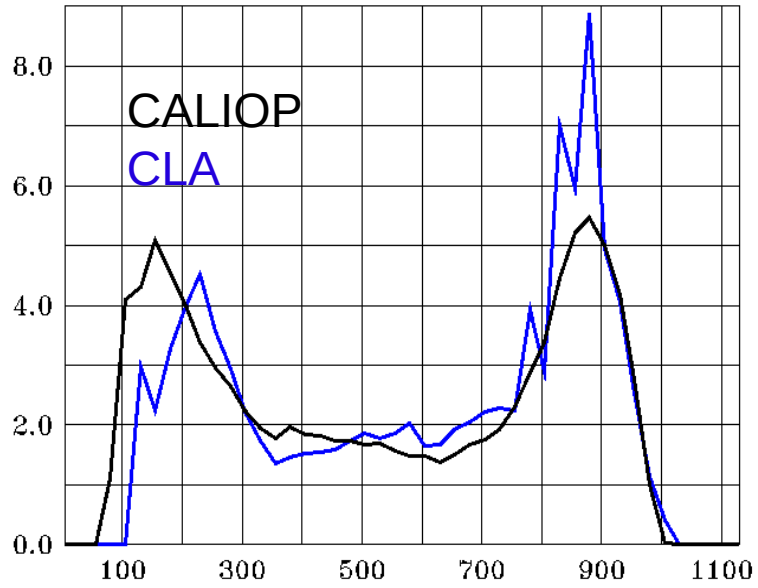


TopTOP, AllTOP,
All BASE and BaseBASE distributions



REPRESENTATIVITY OF CALIOP OBSERVATIONS UNDER THE TRACK WITH RESPECT TO THE AMV BOX

CALIOP all cloud layer CTP
CLA CTP distributions



Occurrence frequency in percent

		CLA	CALIO	Both
High	mono	0/7	8/8	0
	mult	1/3	3/3	0
	Mid	7/9	11/10	3
	Low	46/17	30/24	25
Mid	mono	0/4	3/4	0
	mult	0/2	1/1	0
	Low	16/11	9/10	5
Low	mono	16/30	21/25	11
	mult	13/8	8/9	4
Clear		0/10	5/6	0

CLA= Box/Track CAL Thr. OD=0/OD=2

Effect of the under track sampling of the CALIOP observations

CLA : larger % of high-Low,

CALIOP: larger % of only high cloud

→ under track CLA High+Low occurrence frequency is only of 17%

To not take intoaccount CALIOP very thin cloud layer (OD <0.2) decreases the High+Low occurence