Study Cases of Cirrus Cloud Radiative Effect in Manaus Region during September – October 2014.

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Diego Alves Gouveia, Jorge Almeida

Mar/2016

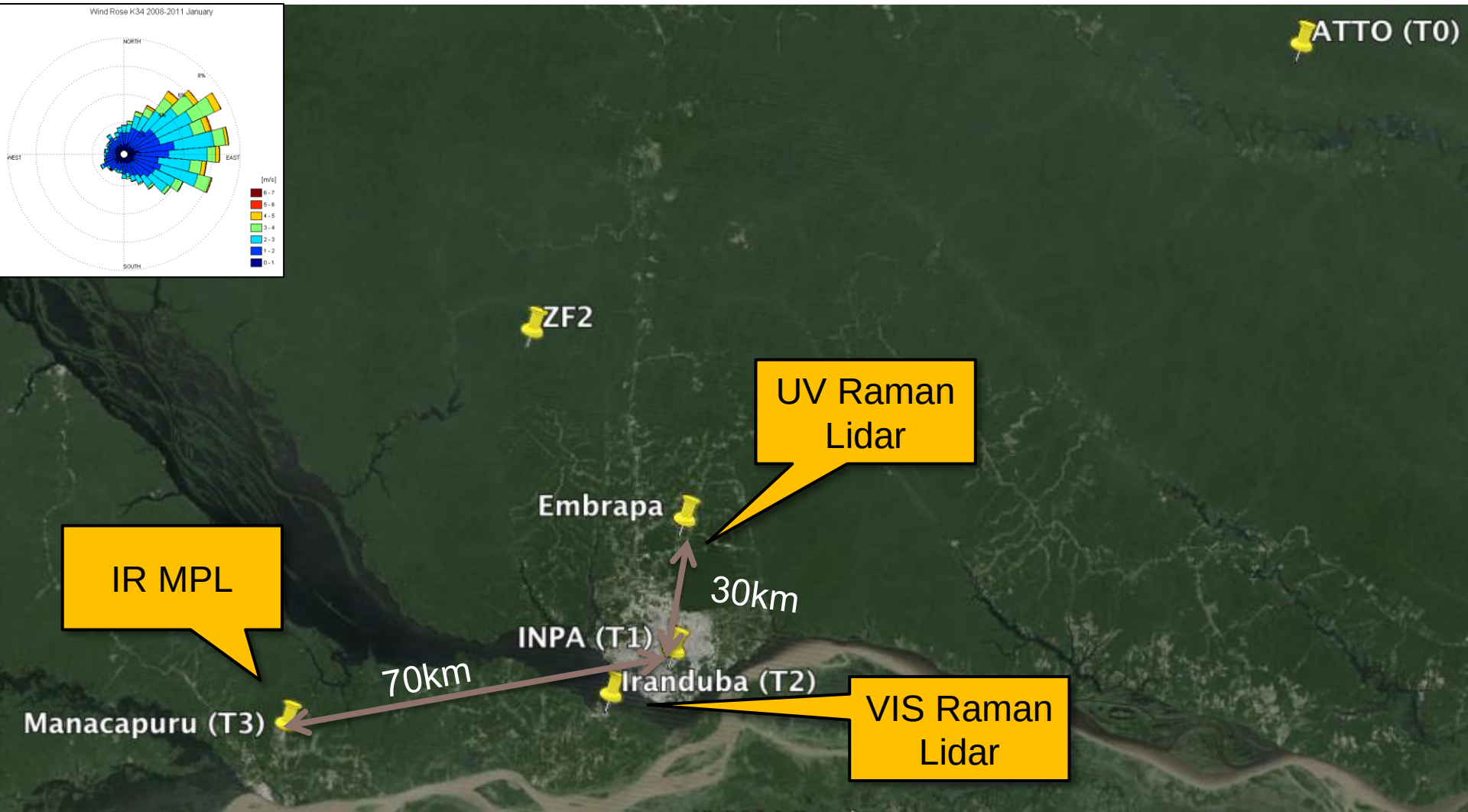
Outline

IOP2 Lidar Network

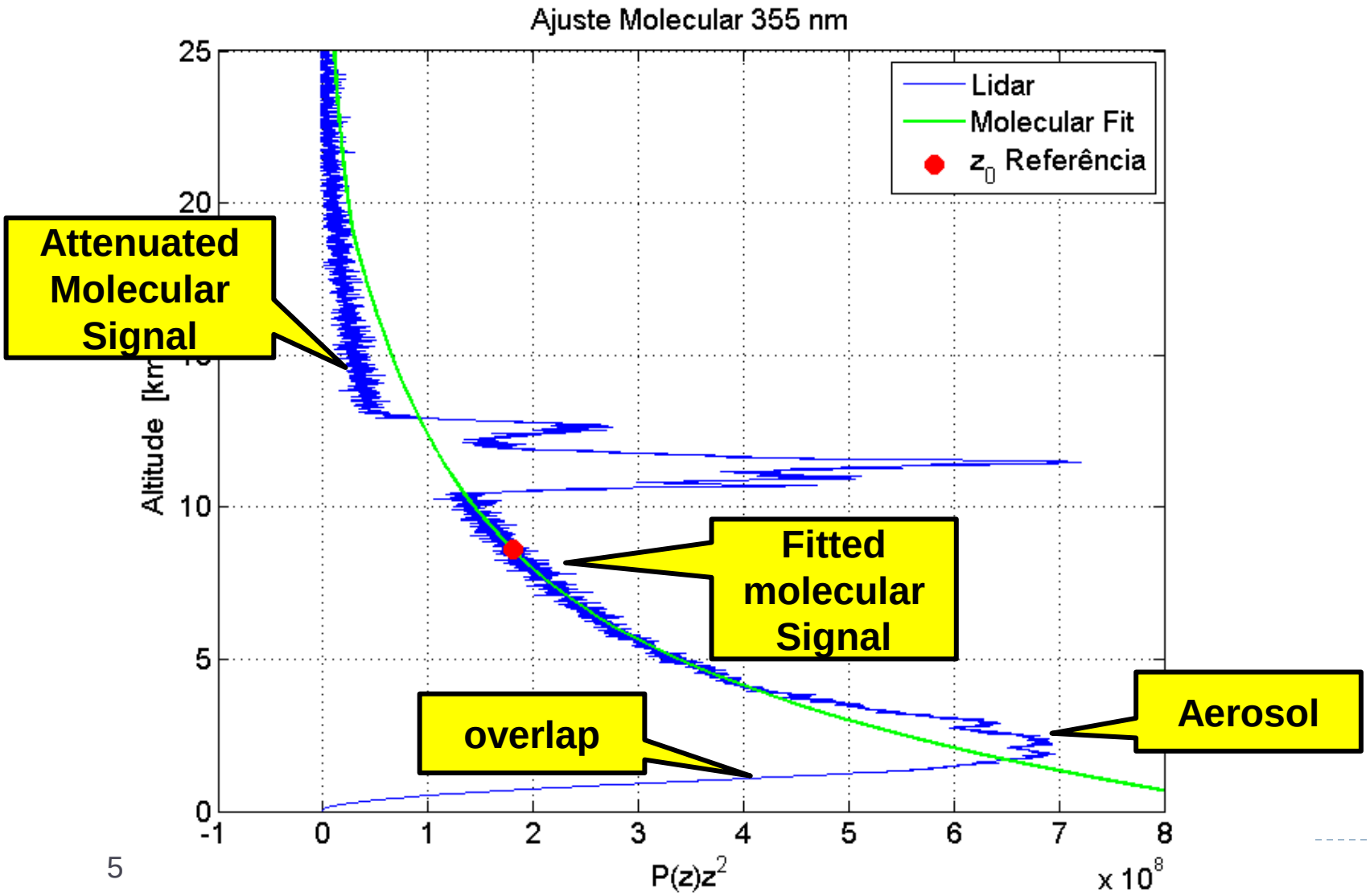
- Lidar Setup and Experimental Site
- Side-by-Side Intercomparison
- Cirrus Clouds Measurements
- Cirrus Clouds Radiative Effects

The GoAmazon 2014/15 project

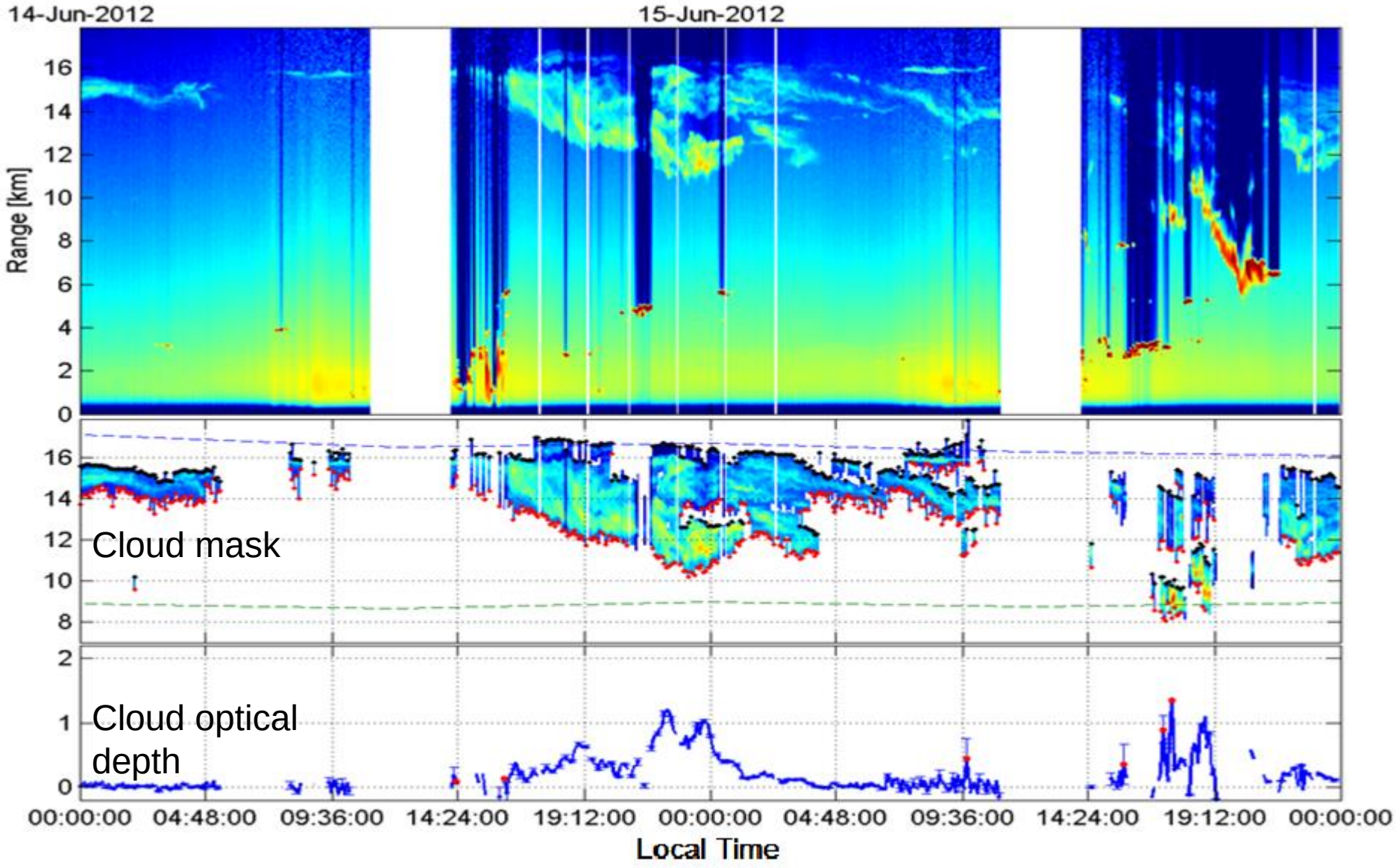
Experimental Sites



Lidar Signal



Method for cloud base/top
Gouveia et al, Opt. Pura y Ap. (2014)



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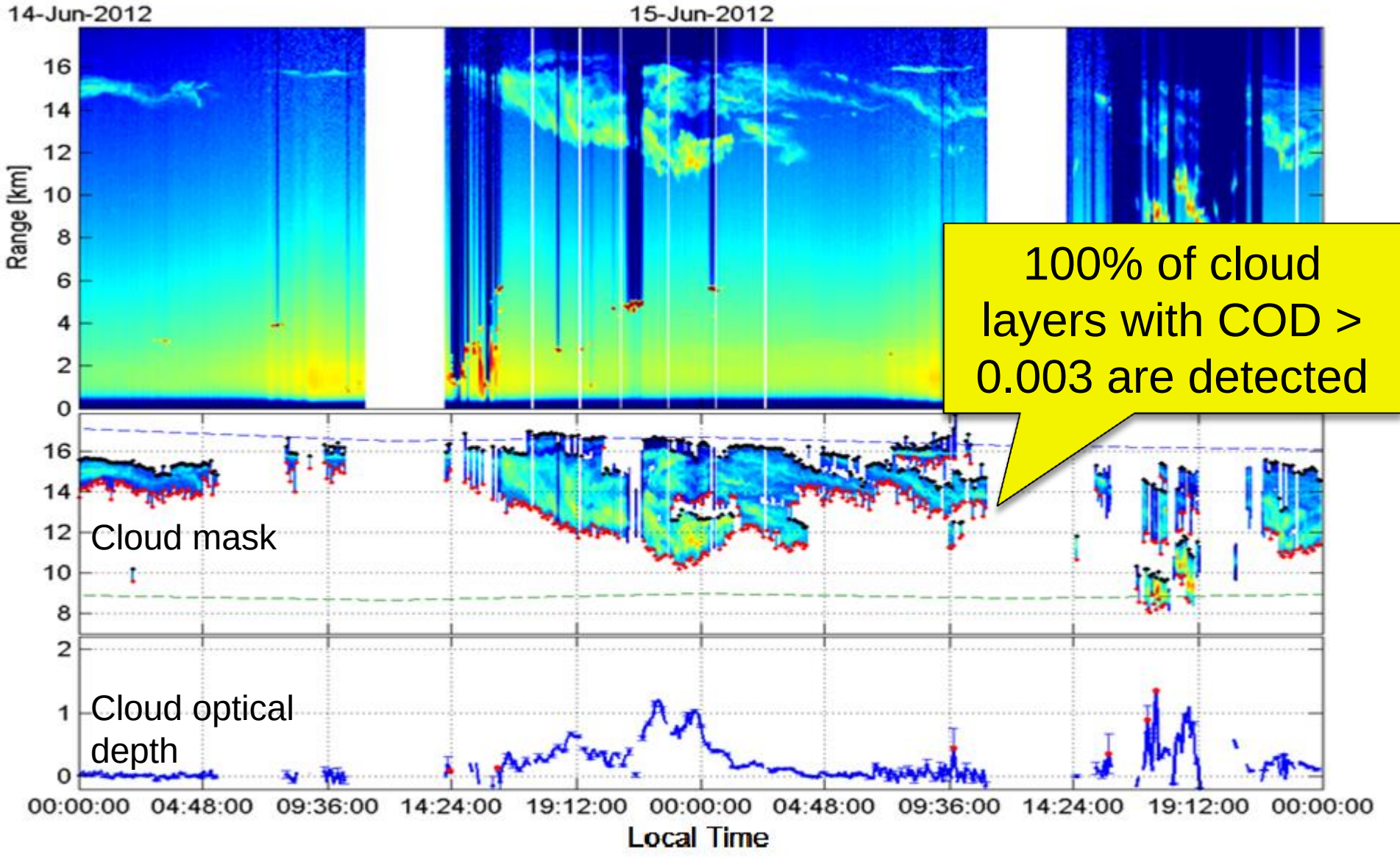

Lidar Systems

	UV Raman Lidar LFA (T0)	VIS Raman Lidar IPEN (T2)	IR MPL ARM mobile facil
Manufactor	Raymetrics	Raymetrics	Sigma Space
Laser	Nd-YAG	Nd-YAG	Nd-YLF
Wavelangth	355 nm	532 nm	532 nm
Vertical Resolution	7.5 m	7.5 m	15 m
Detection	355 nm (elastic), 387nm (N2) and 408nm (H20)	532 nm (elastic) and 608 nm (N2)	Co and Cross Pol

Lidar Systems

GOUVEIA, D. A at al. 2012

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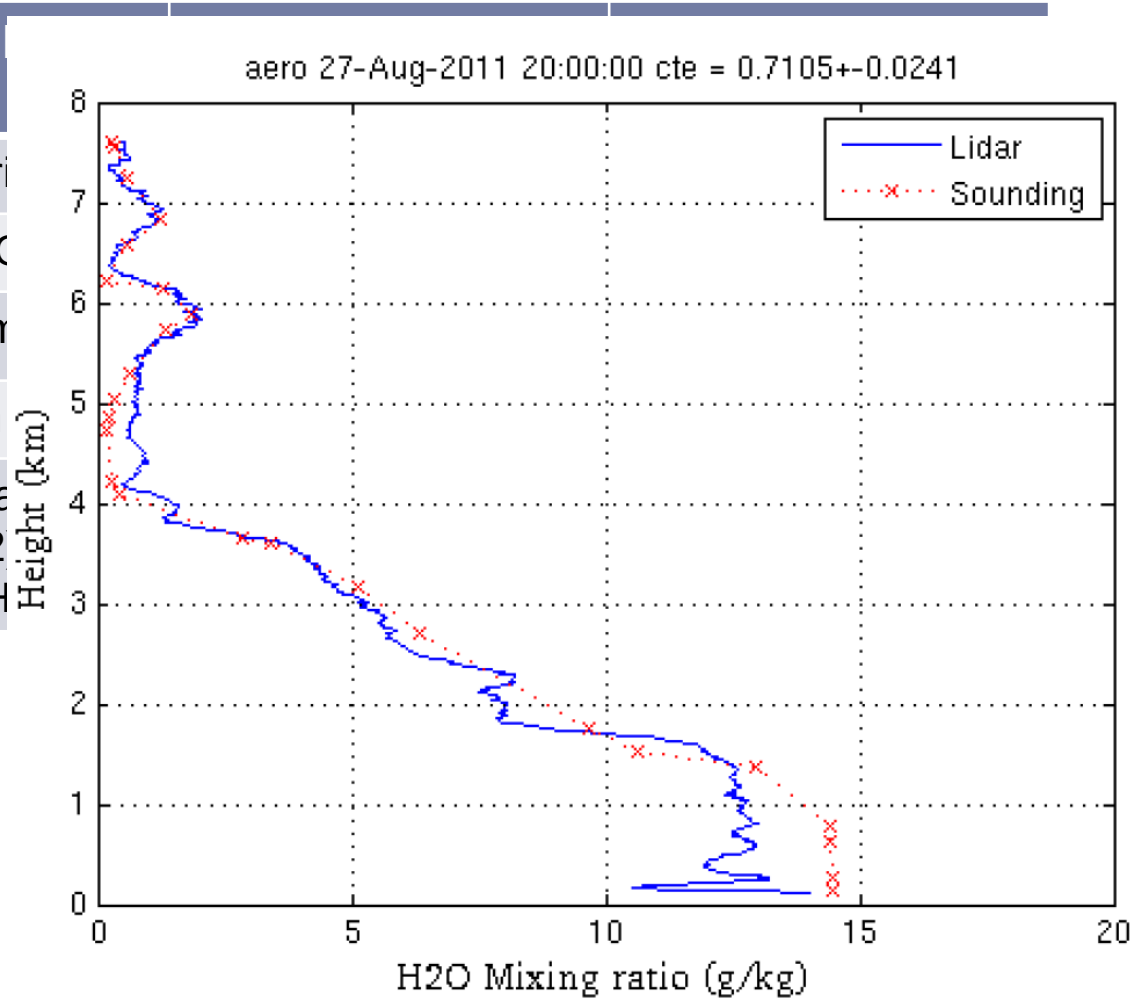

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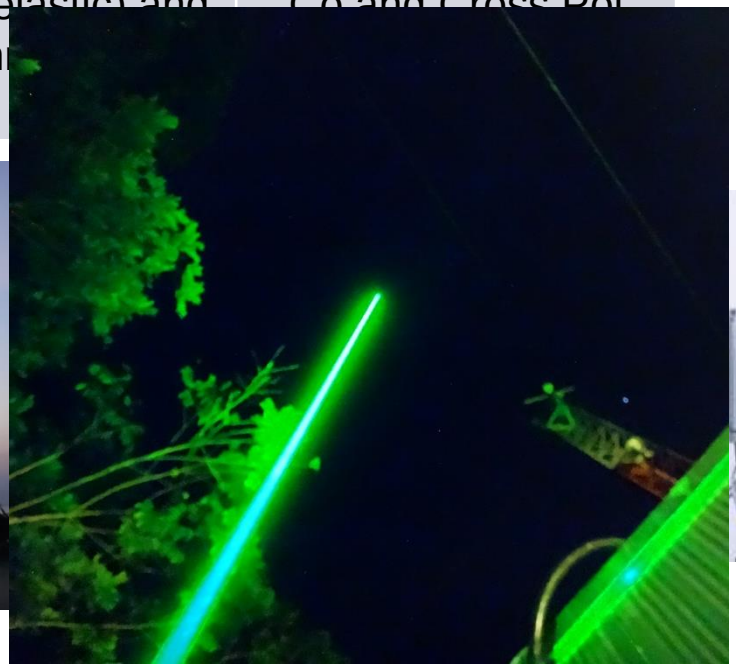

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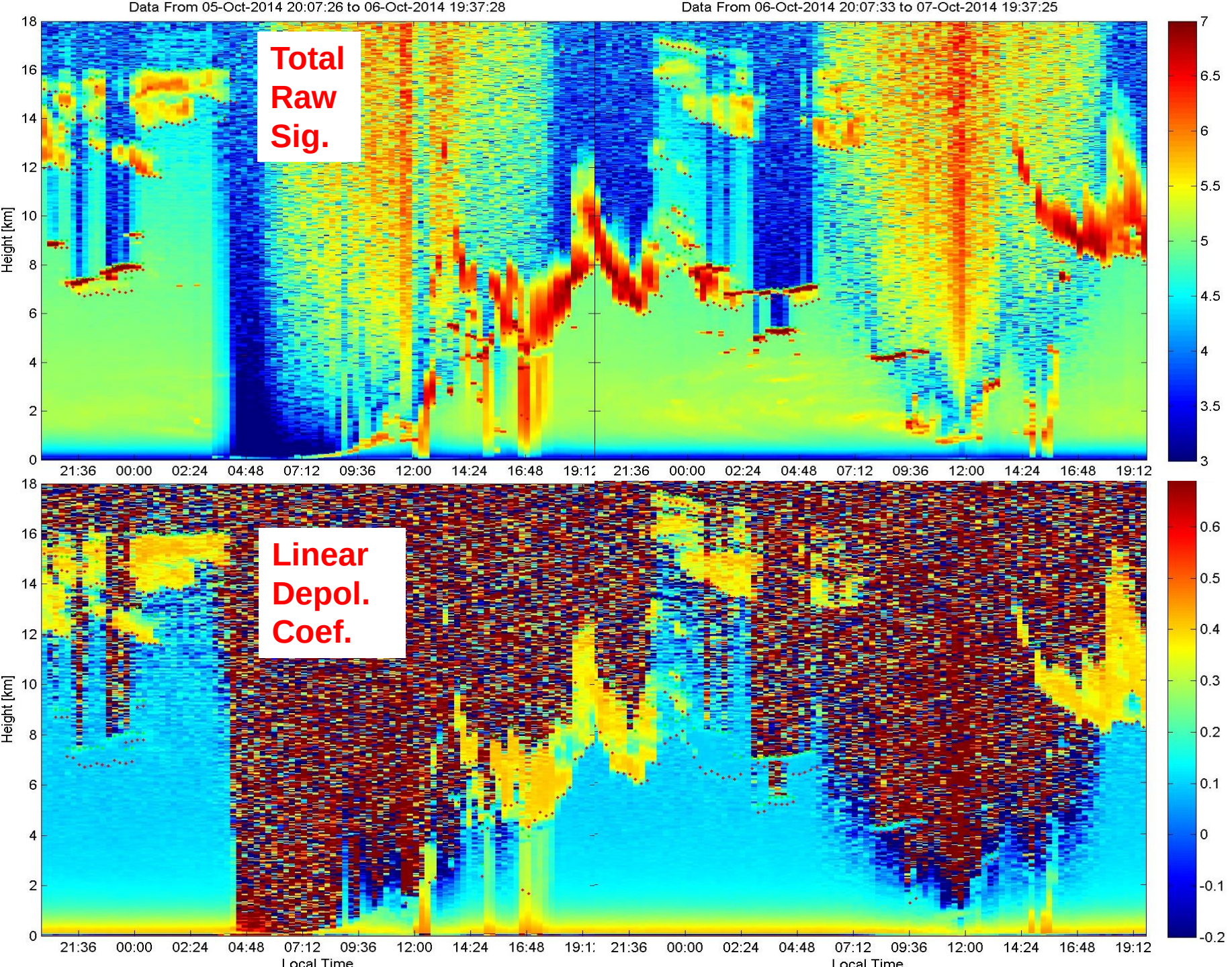
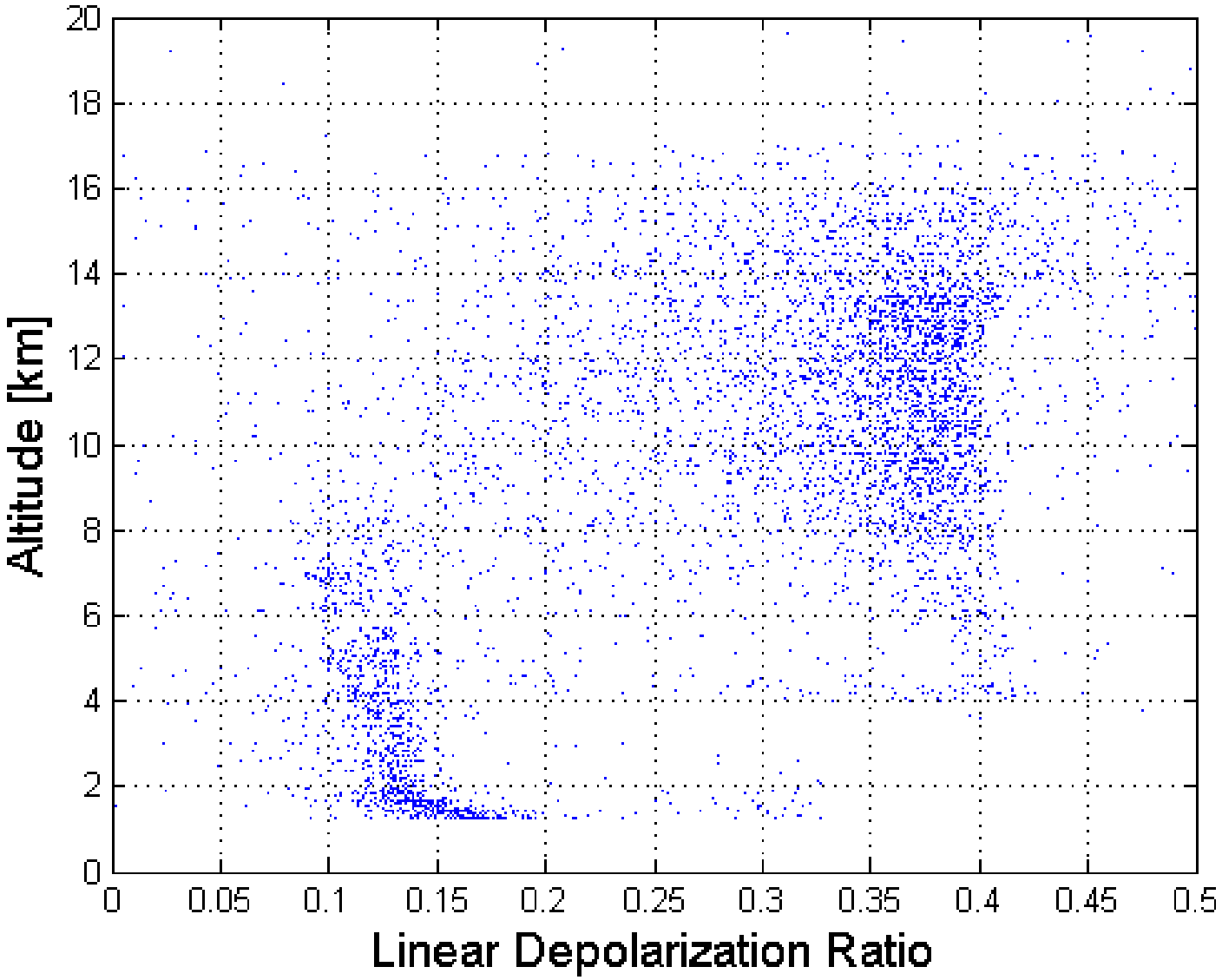
MPL System – Depolarization


Data From 05-Oct-2014 20:07:26 to 06-Oct-2014 19:37:28
Data From 06-Oct-2014 20:07:33 to 07-Oct-2014 19:37:25
Total Raw Sig.
Linear Depol. Coef.
Height [km]
0
2
4
6
8
10
12
14
16
18
21:36
00:00
02:24
04:48
07:12
09:36
12:00
14:24
16:48
19:12
Local Time
7
6.5
6
5.5
5
4.5
4
3.5
3
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2

MPL System – Depolarization



Side-by-Side Intercomparison

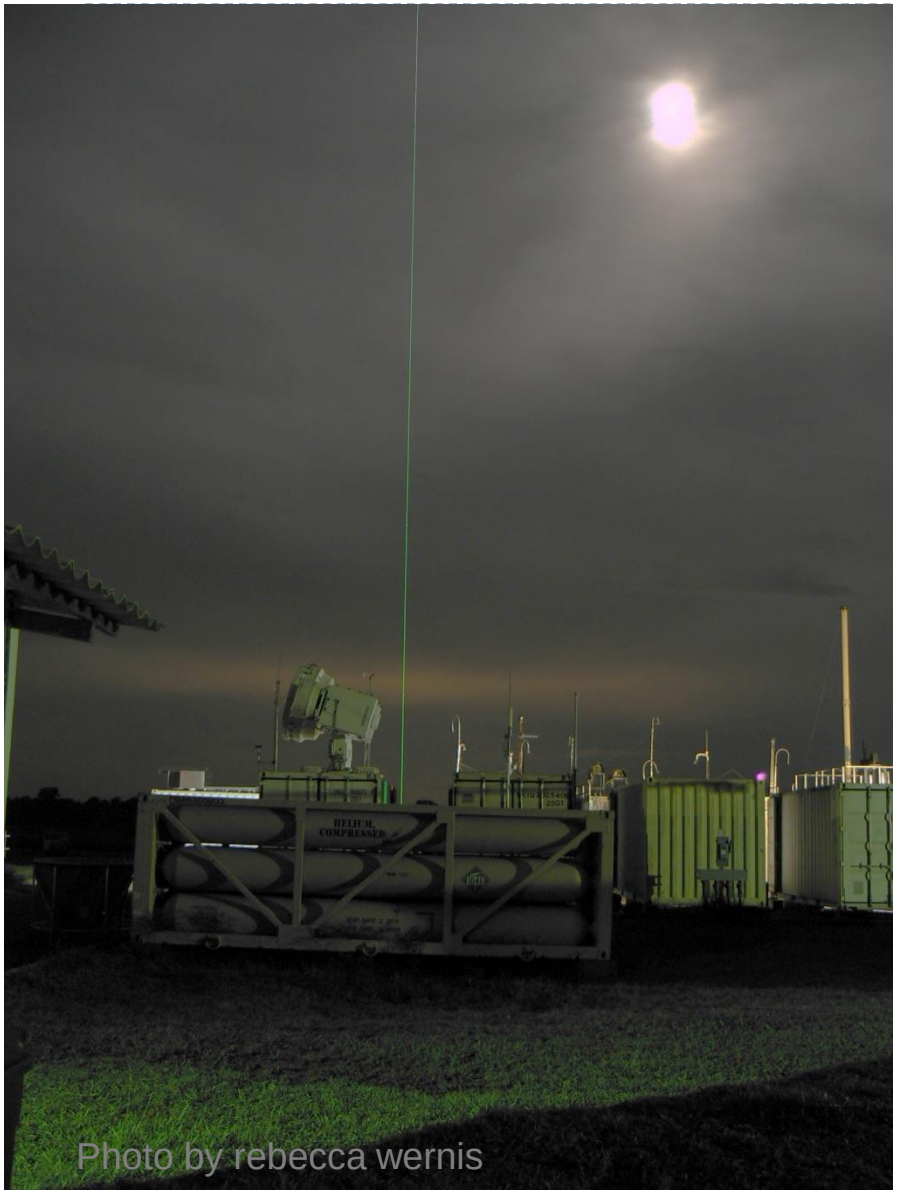
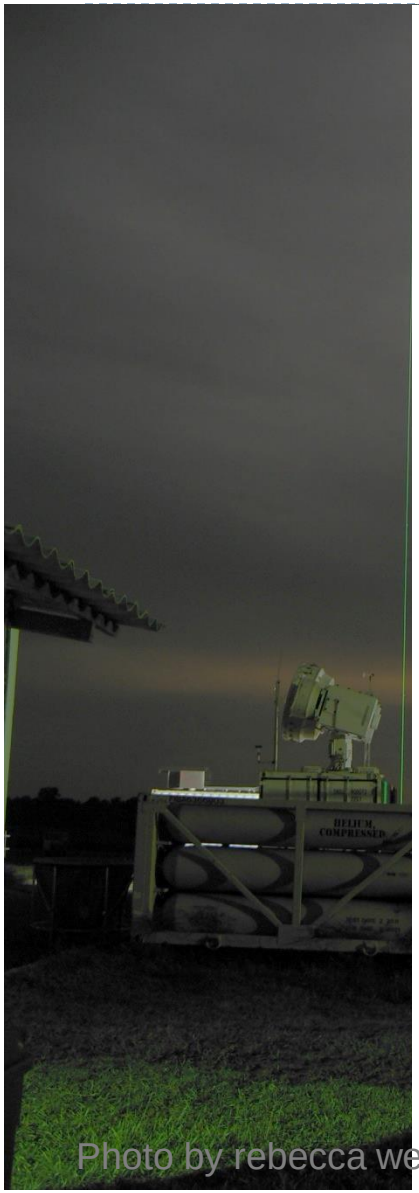
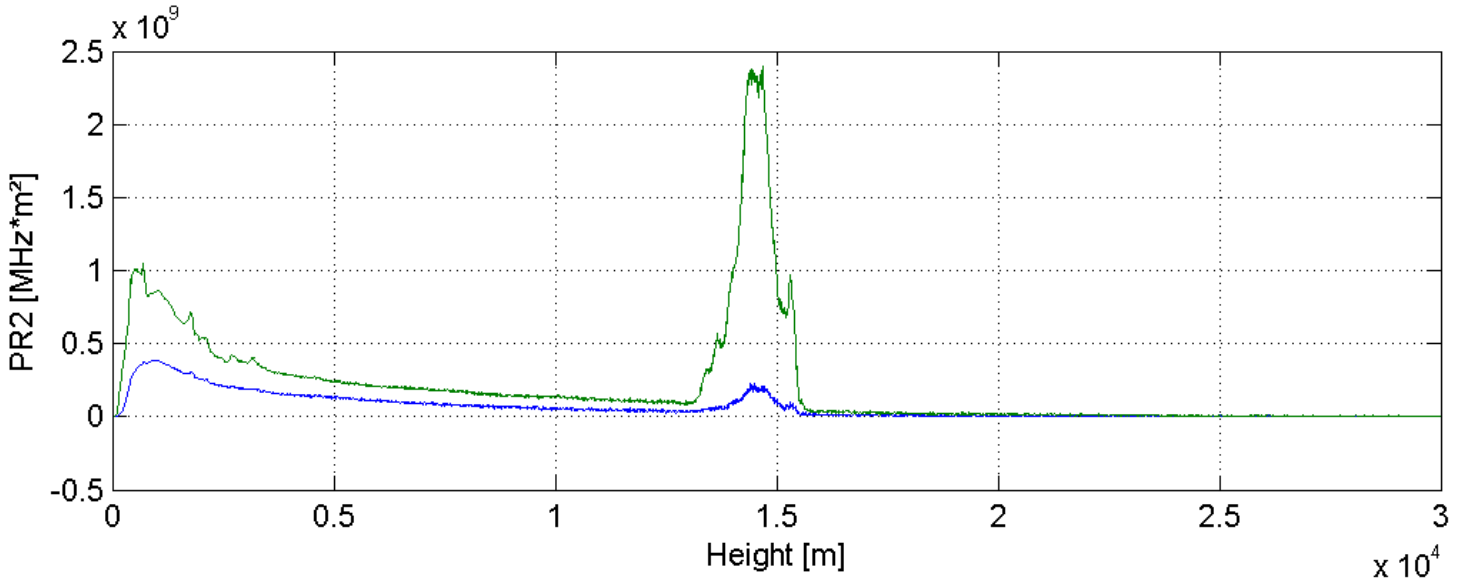
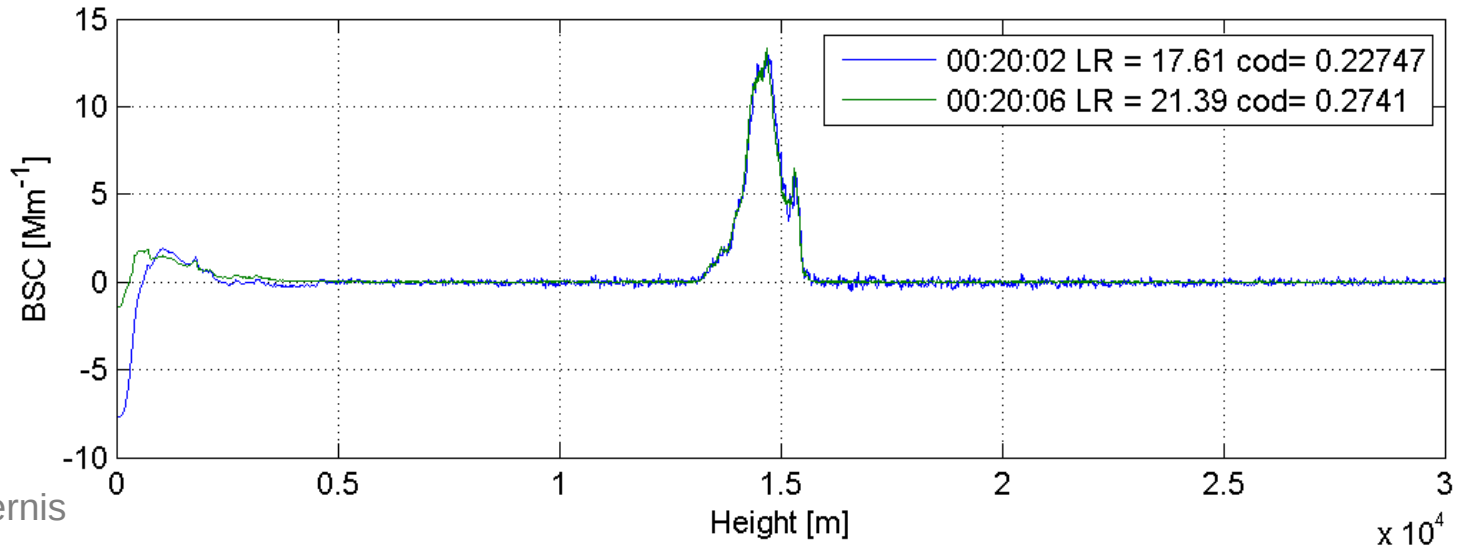


Photo by rebecca wernis

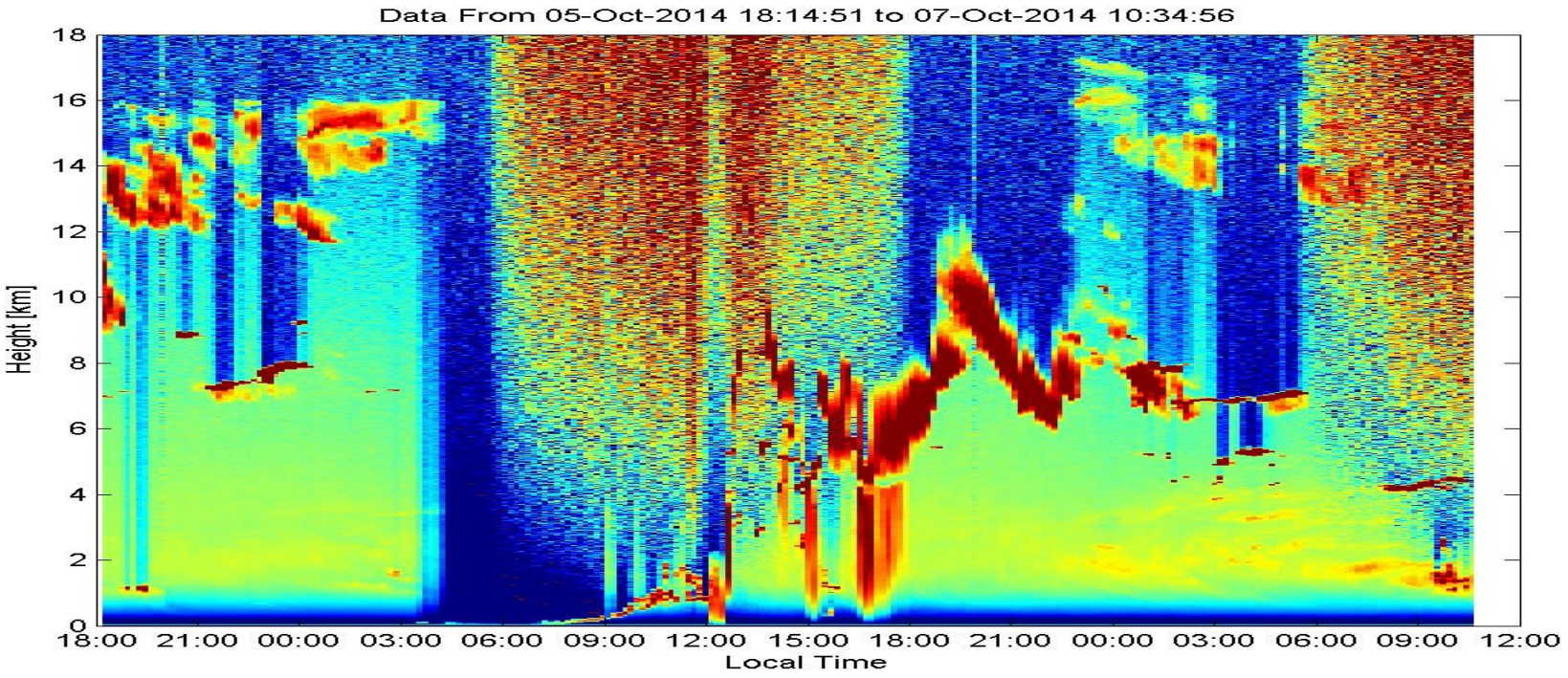
Side-by-Side Intercomparison



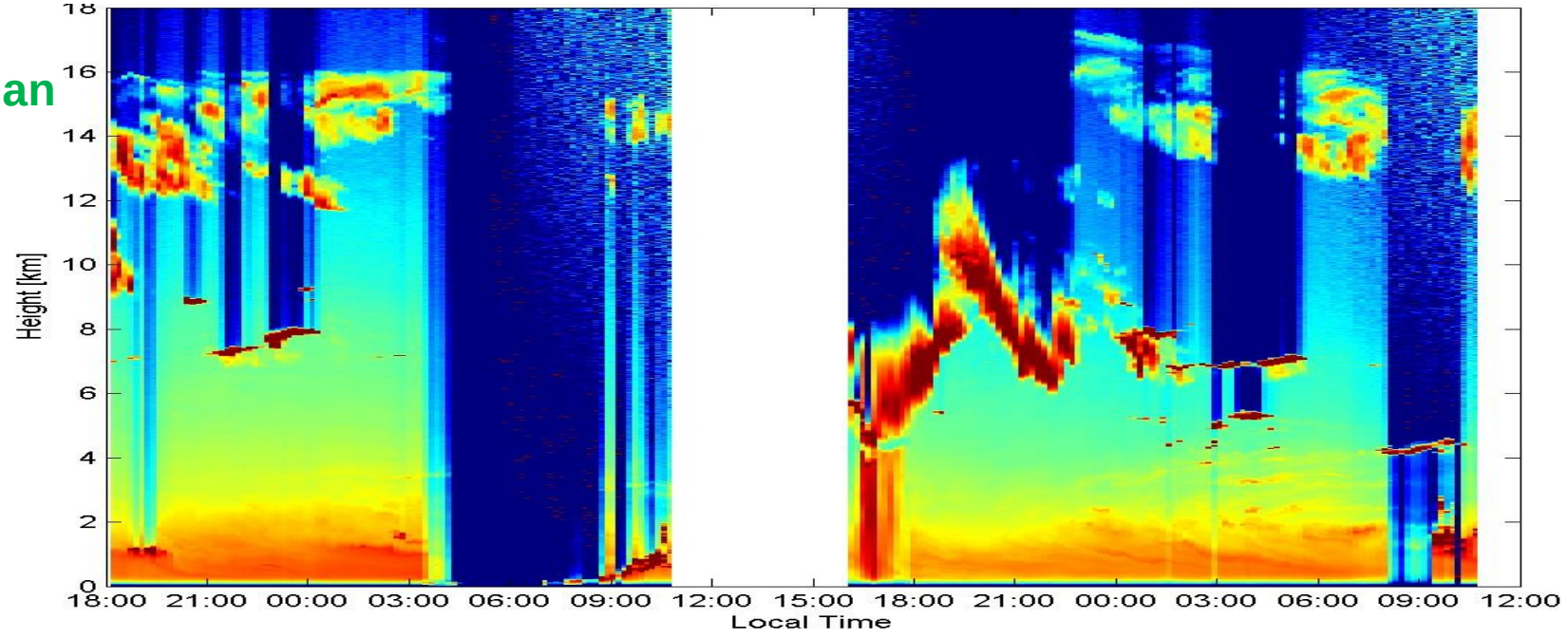




MPL



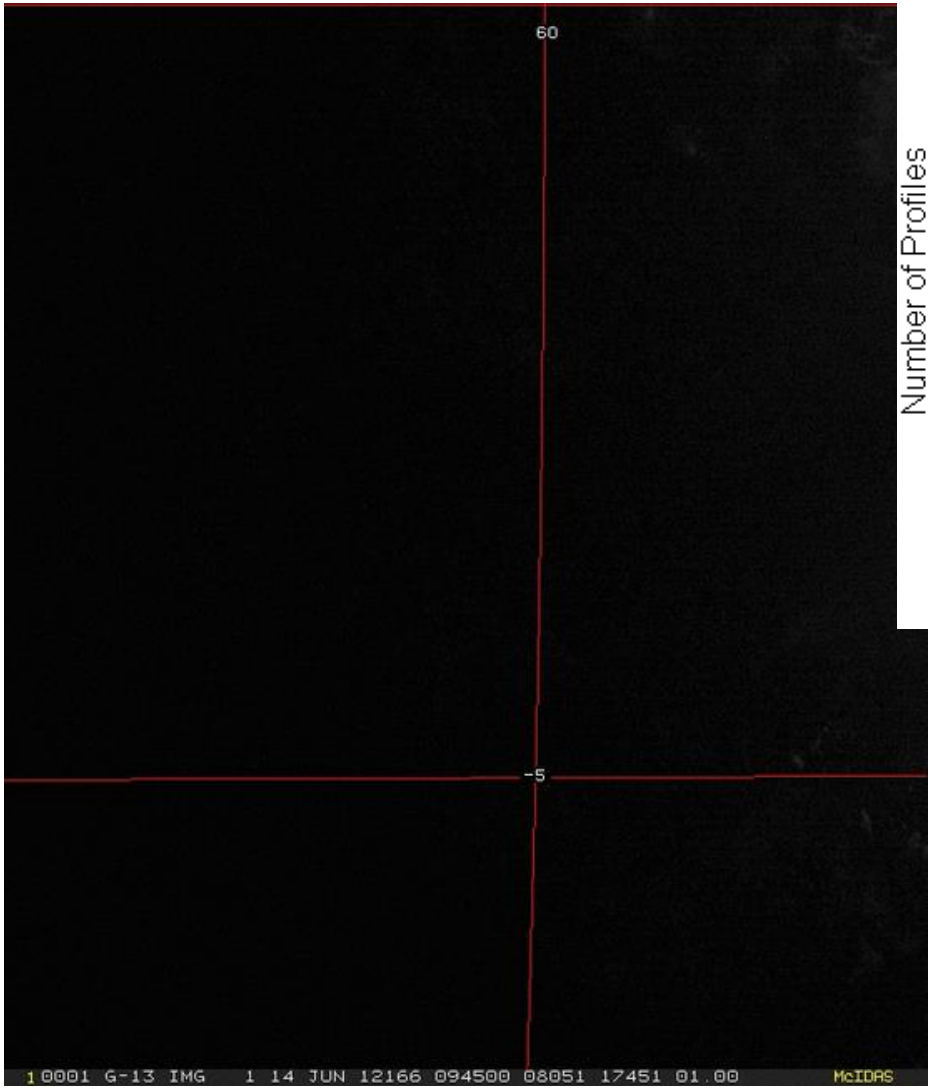
Vis Raman

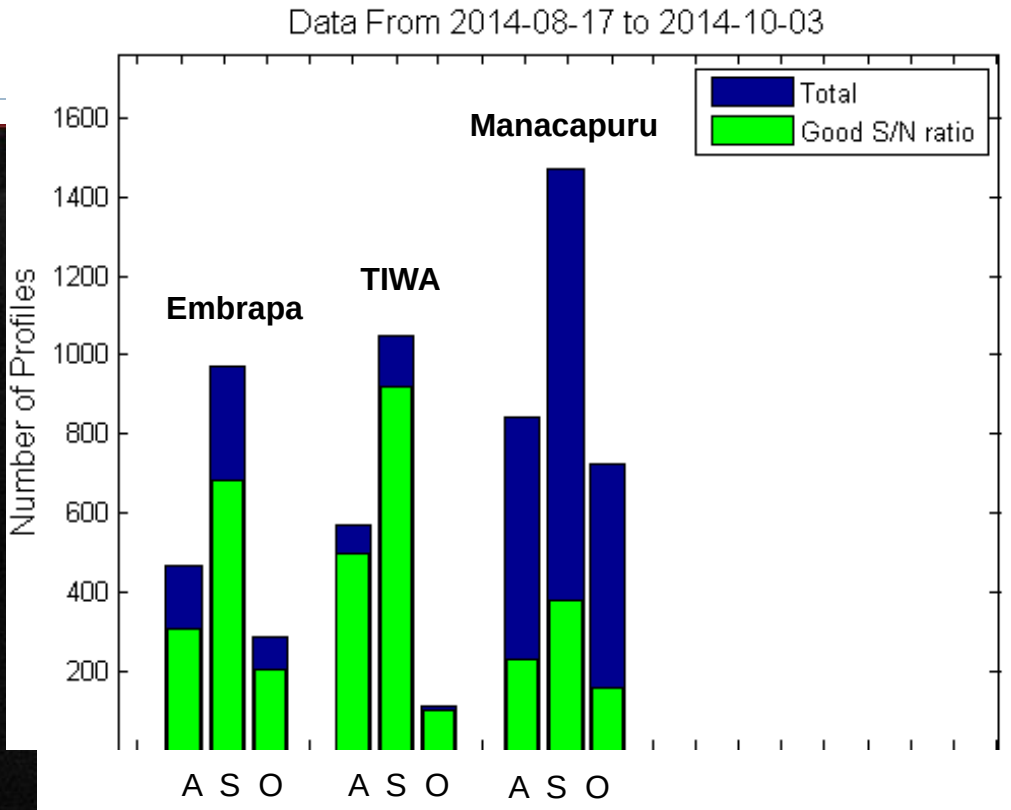


Results

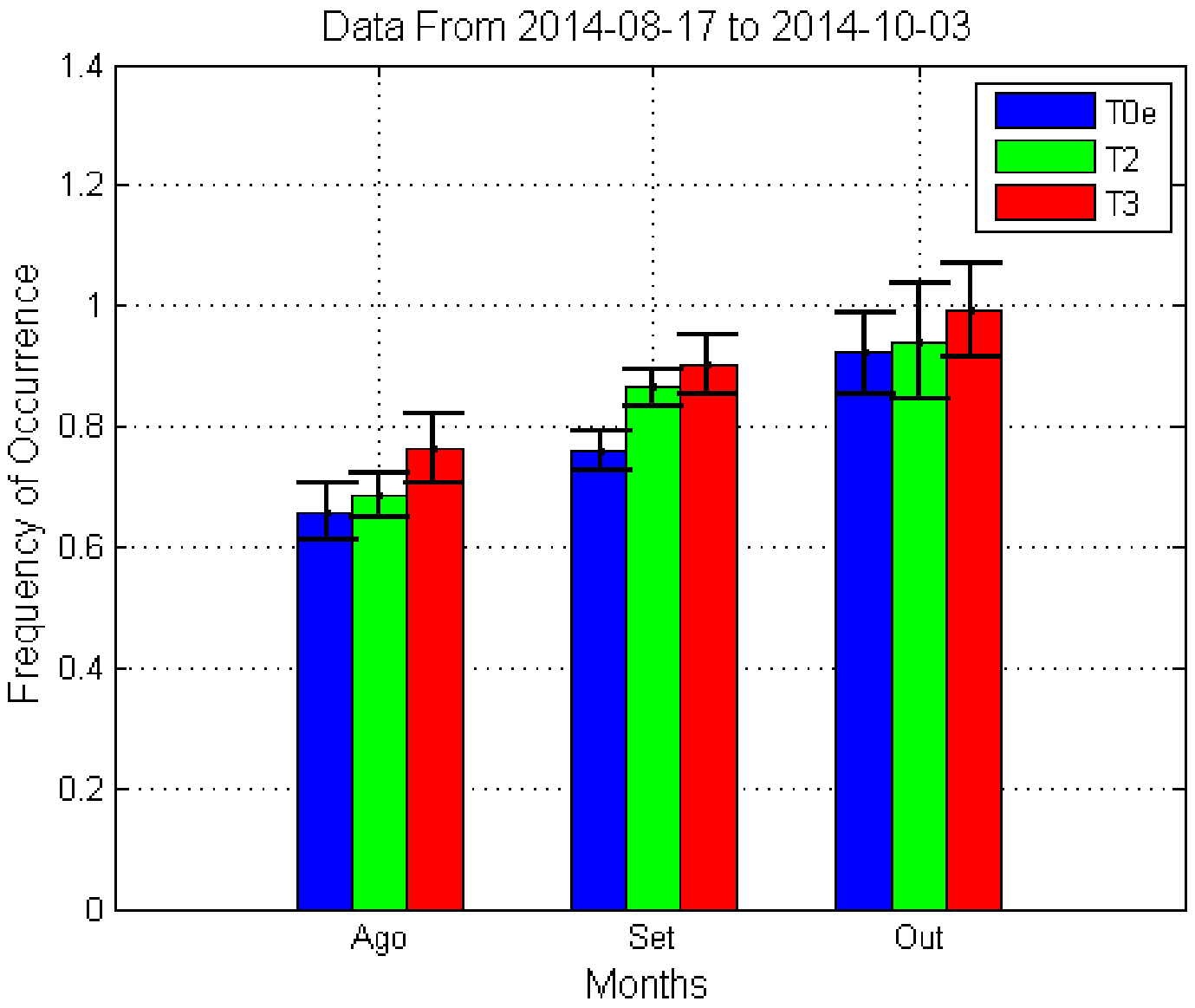
- Frequency of Occurrence
- Macrophysical Properties
- Optical Properties
- Microphysical Properties

Data Base

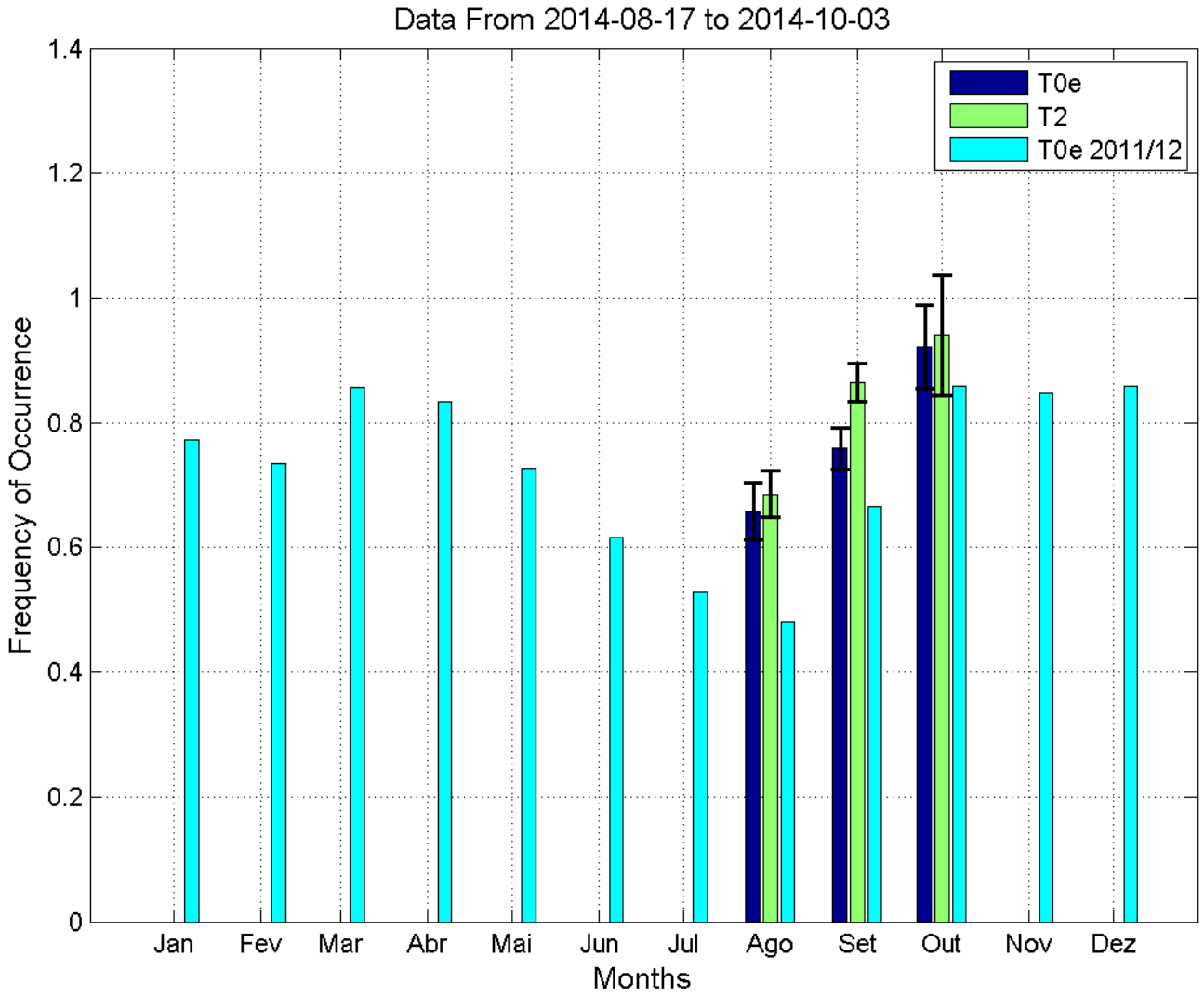

60
-5
1 0001 G-13 IMG 1 14 JUN 12166 094500 08051 17451 01.00
McIDAS


Data From 2014-08-17 to 2014-10-03
Total
Good S/N ratio
Number of Profiles
1600
1400
1200
1000
800
600
400
200
Embrapa
TIWA
Manacapuru
A S O
A S O
A S O

Frequency of Occurrence



Frequency of Occurrence: Annual Cycle

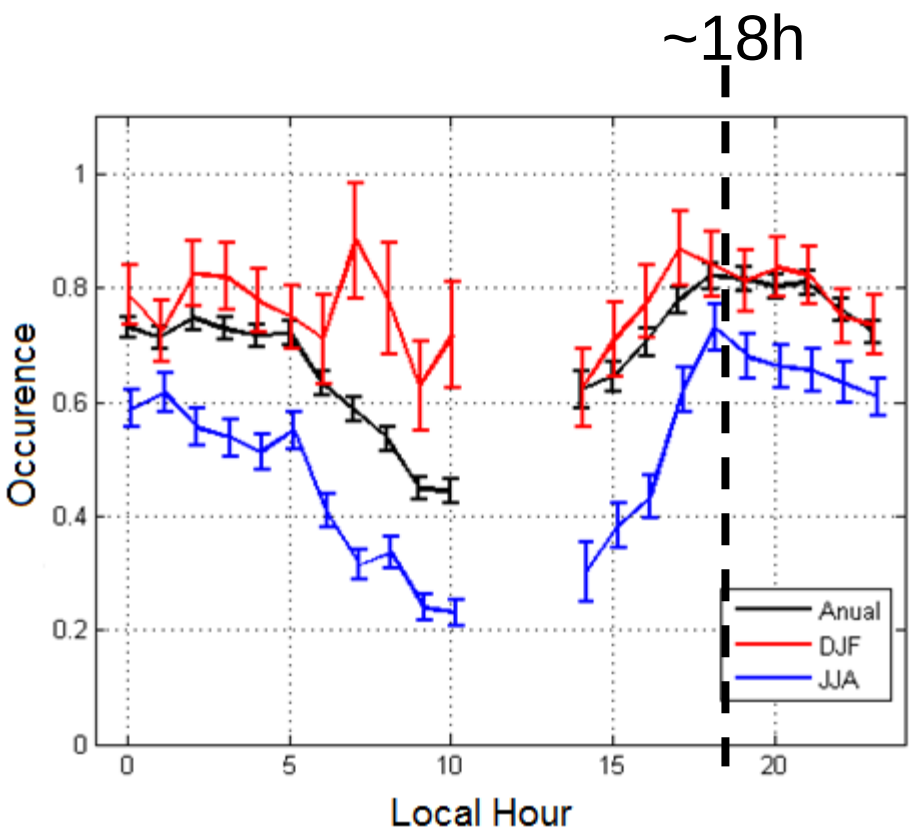


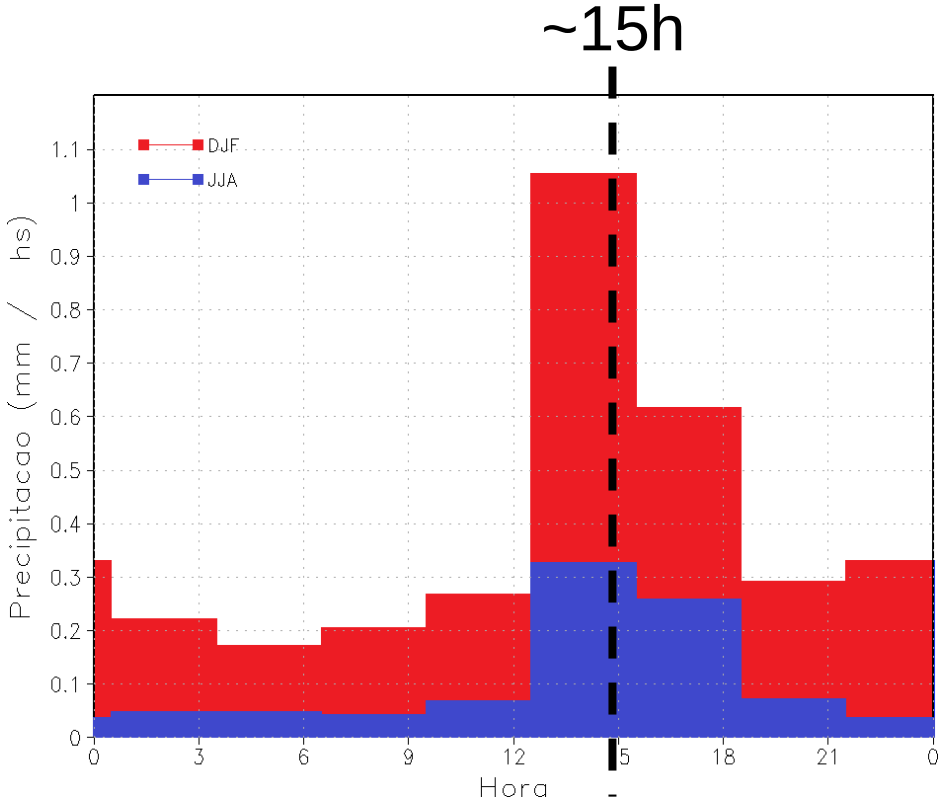
Mean:
T0e 2011/12: %
IOP2: 81%

Frequency of Occurrence

Local	Measurement year	Total	Wet Months	Dry Months
Manaus	**2011-12**	**71%**	**78%**	**52%**
Manaus (Calipso) NAZARYAN, 2008, JGR	2006-7	60-65%		
Maldivas (4.1°N, 73.3°E) SEIFERT et al. , 2007, JGR	1999-00	43%	64%	35%
Ilha Nauru (0.5 °S, 166 °E) JM et al. , 2002, JGRD	1999	55%		
Mahé, Seychelles (4.4 °S, 55.3 °E) PACE et al. , 2003, JGR	2003	54%		
Sul da França (43.9◦ N–5.7◦ E) HOAREAU et al., 2013, ACPD	1996-07	37%		

Frequency of Occurrence: Daily Cycle





The cirrus clouds cycle does not follow exactly the rainfall cycle

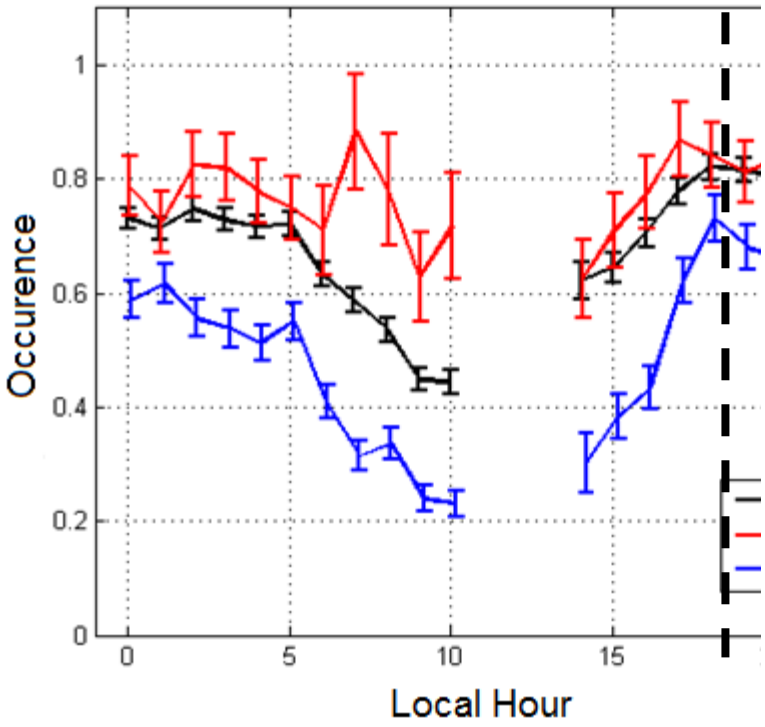
Cirrus has a large residence time

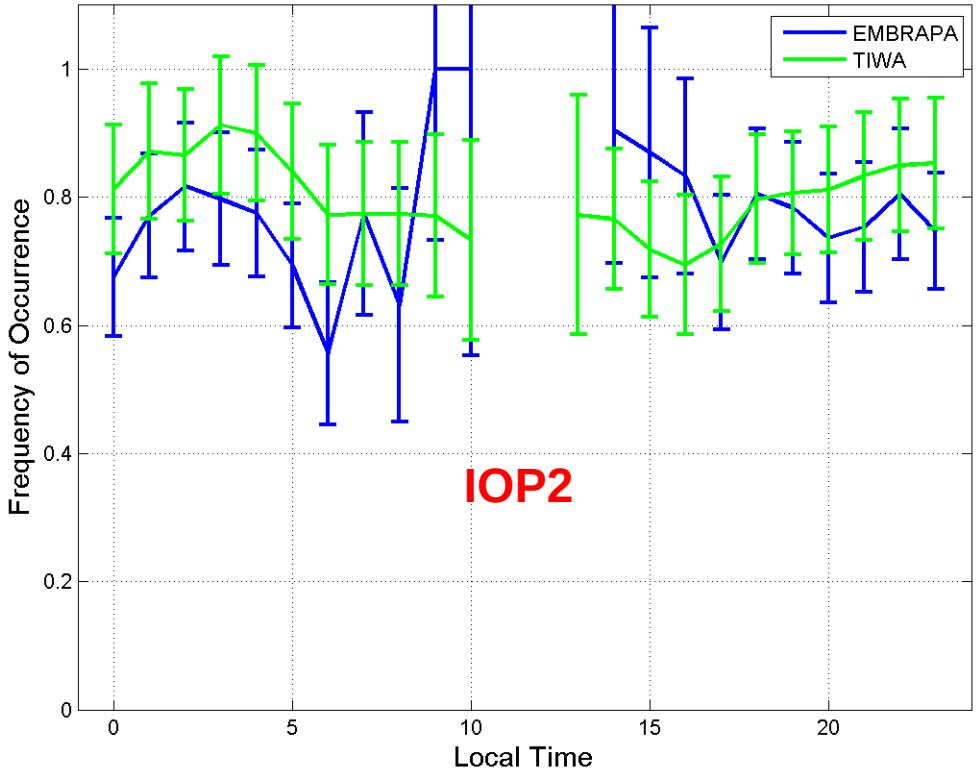
Preciptation TRMMv7 (mm/hs) in a 2°× 2° area centered on site

Frequency of Occurrence: Daily Cycle

~18h

~15h





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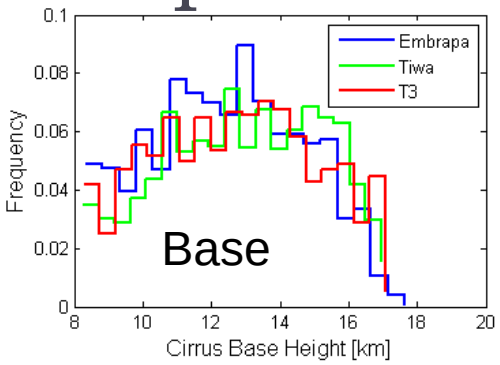
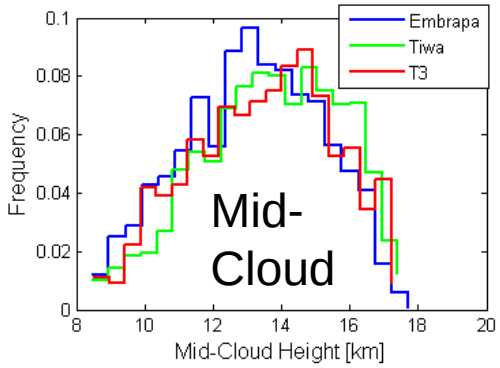
Results

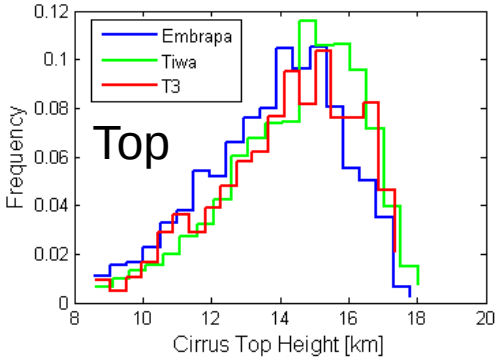
- Frequency of Occurrence
- Macrophysical Properties
- Optical Properties
- Microphysical Properties

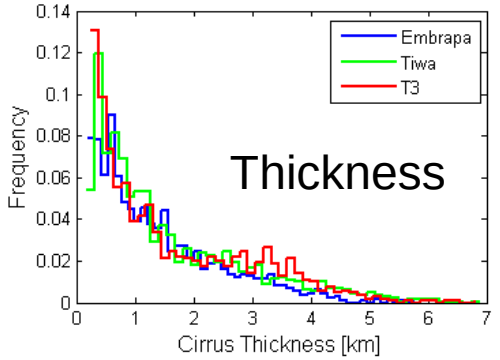
Macrophysical Properties

- Occurrence range 8-19 km
- Thickness up to 7-8 km
- Apparent difference between Embrapa and Tiwa sites









	Base (km)	Mid (km)	Top (km)	Thickness	Temperature
Manaus	**12.5 ± 2.4**	**13.4 ± 2.1**	**14.3 ± 2.2**	**1.82 ± 1.53**	**-57 ± 15 °C**
Maldivas SEIFERT et al 2007 JGR	11.9 ± 1.6	12.8 ± 1.4	13.7± 1.4	1.8 ± 1.0	-58 ± 11 °C
Zonal Tropical SASSEN 2008 JGR	13.0		14.8		
Zonal Tropical NAZARYAN 2008 JGR	12.5		15		

Results

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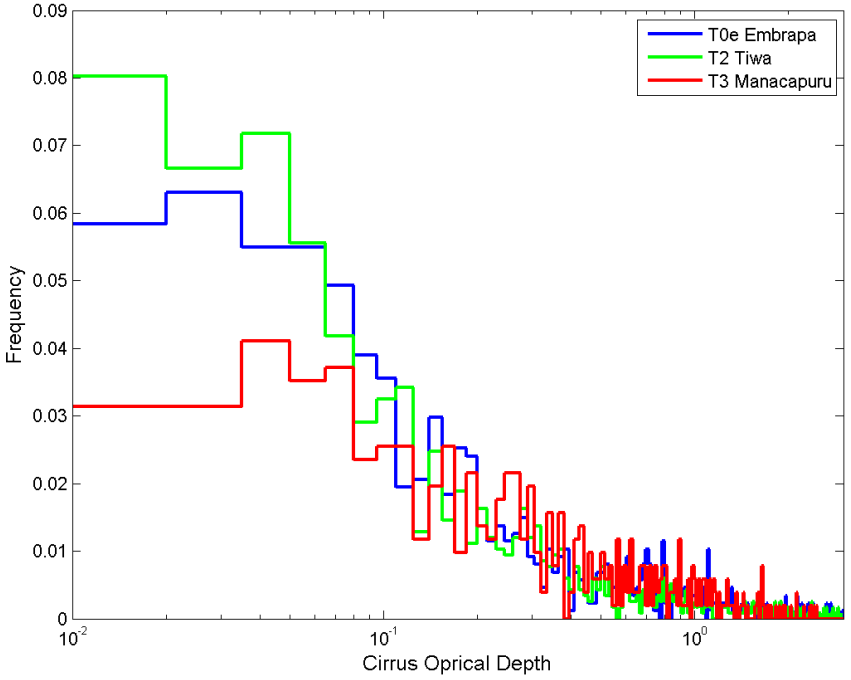
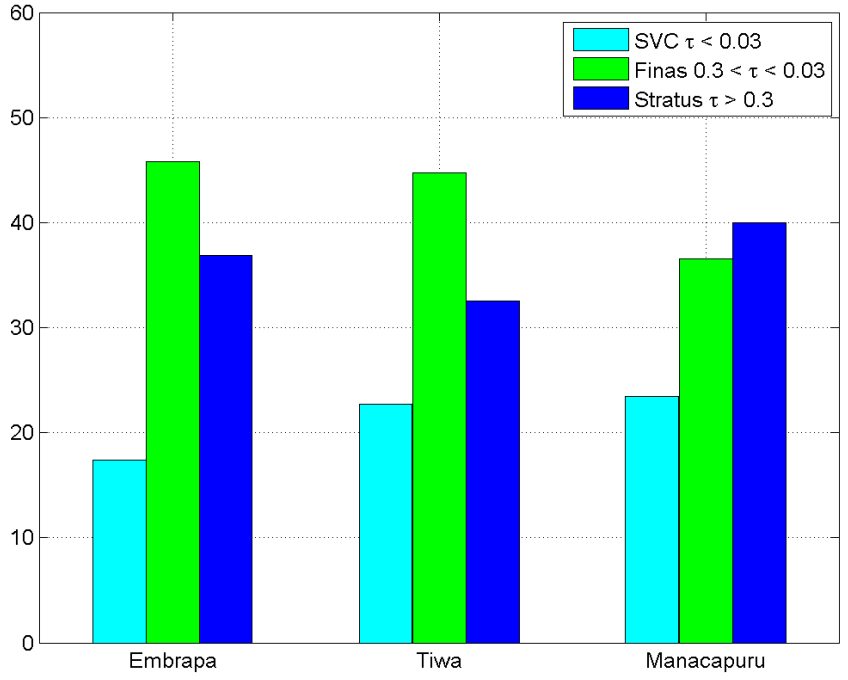
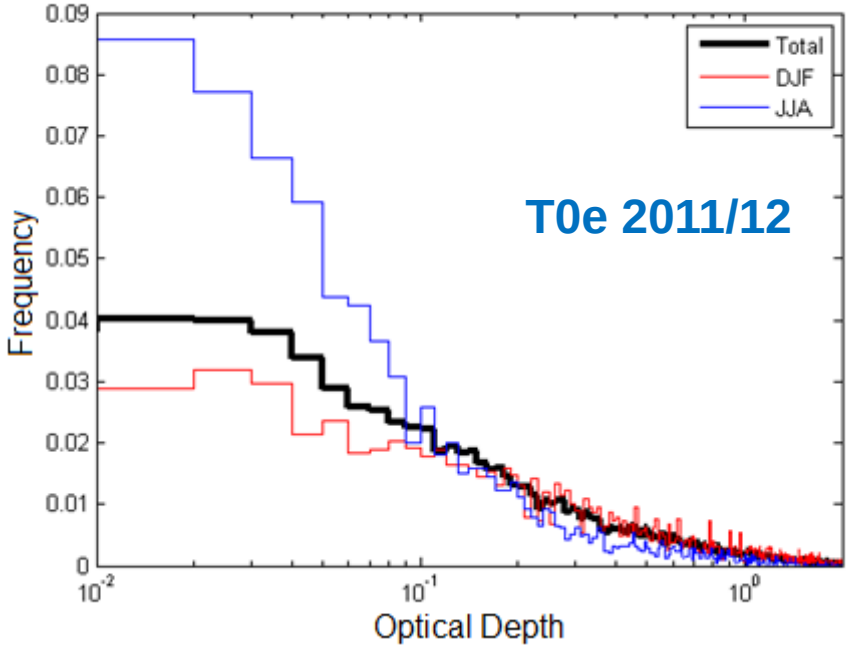
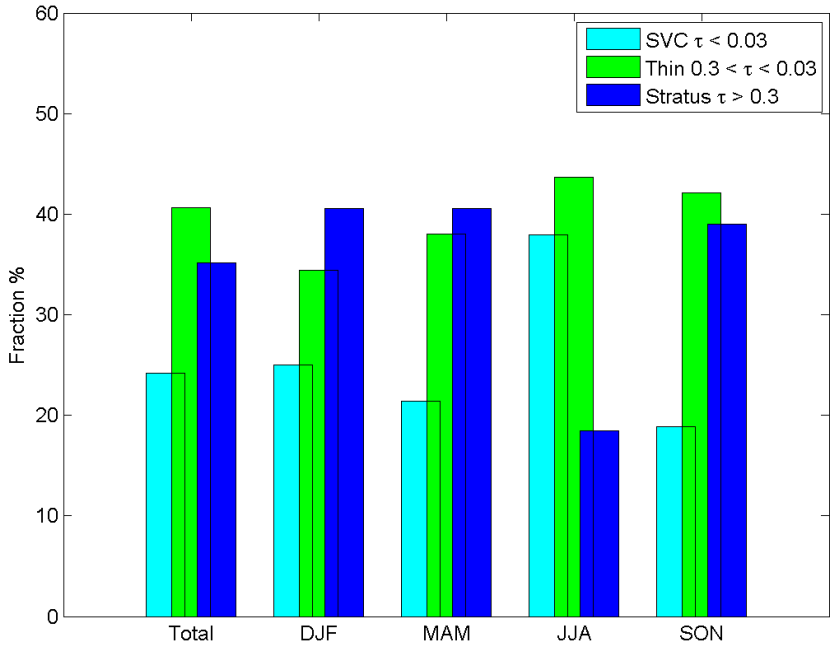
Optical Properties

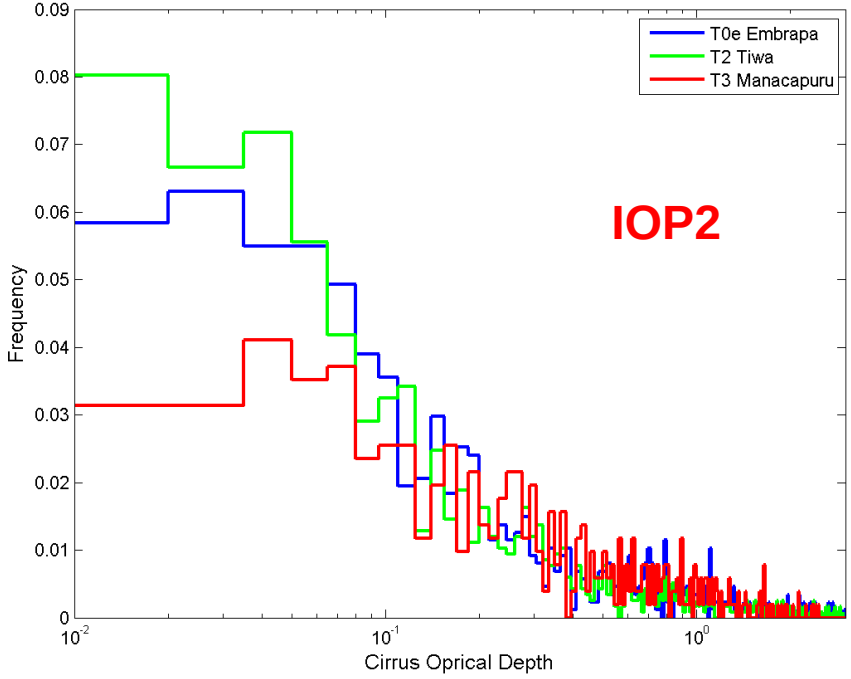
- Subvisuais (τ<0.03)
- Thin cirrus (0.03 < τ < 0.3)
- Cirrustratus (τ > 0.3)

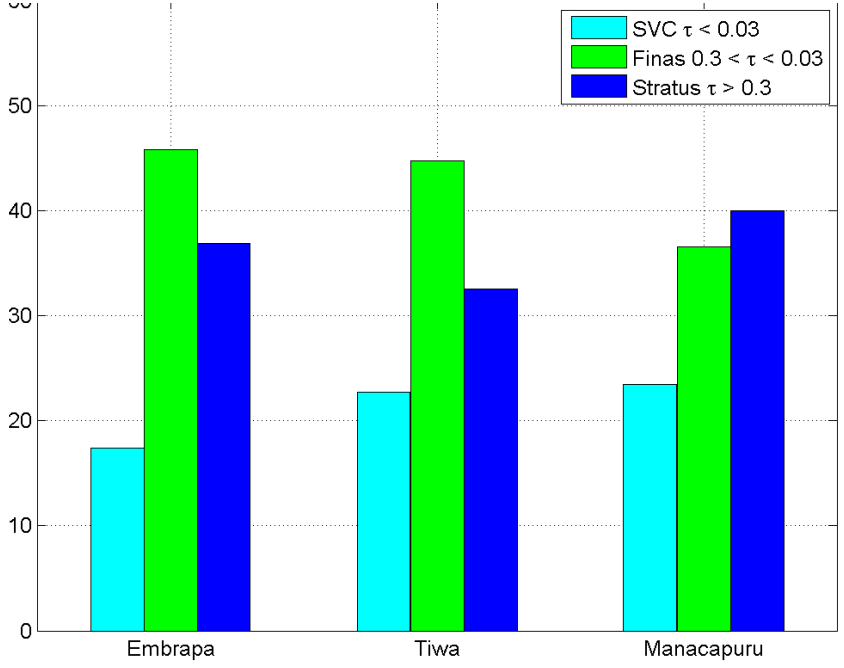





Total
DJF
JJA
T0e 2011/12
Frequency
Optical Depth


SVC τ < 0.03
Thin 0.3 < τ < 0.03
Stratus τ > 0.3
Fraction %
Total
DJF
MAM
JJA
SON


T0e Embrapa
T2 Tiwa
T3 Manacapuru
IOP2
Frequency
Cirrus Oprical Depth


SVC τ < 0.03
Finas 0.3 < τ < 0.03
Stratus τ > 0.3
Embrapa
Tiwa
Manacapuru

Results

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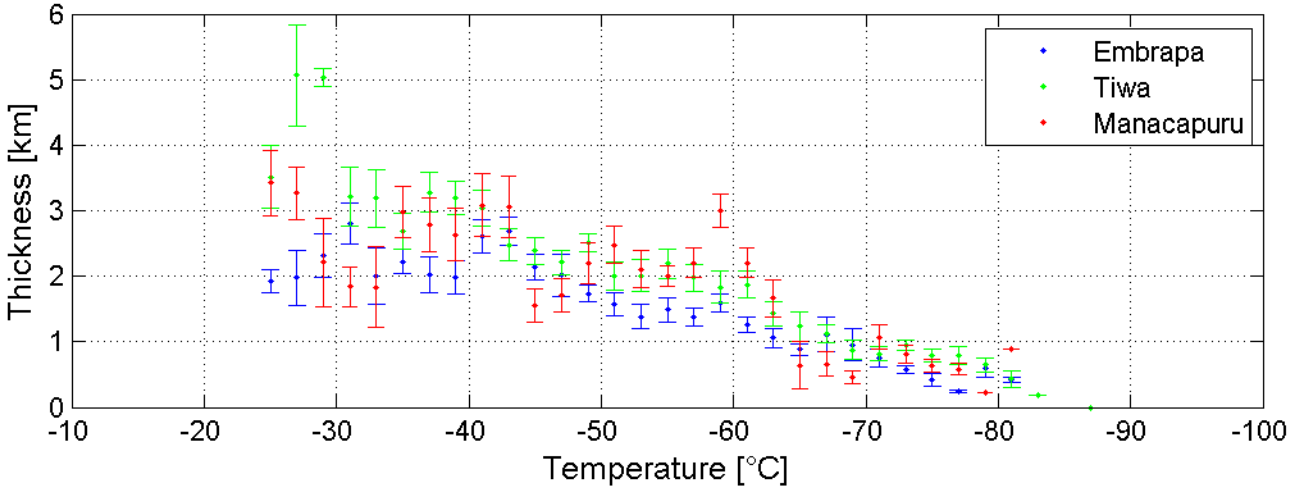
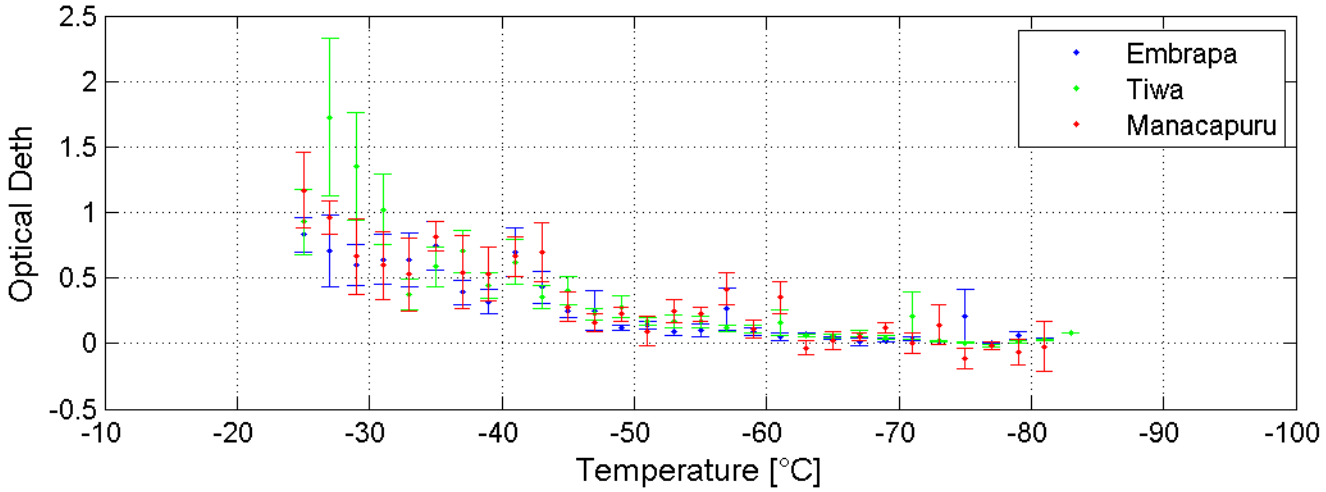
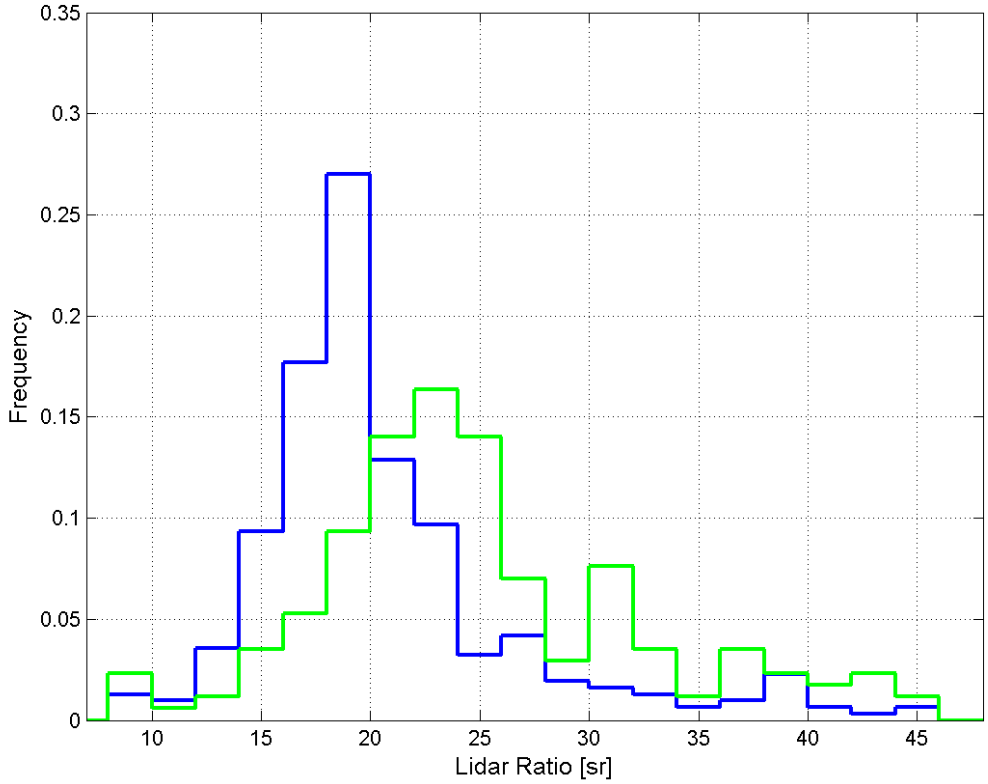
Microphysical Properties



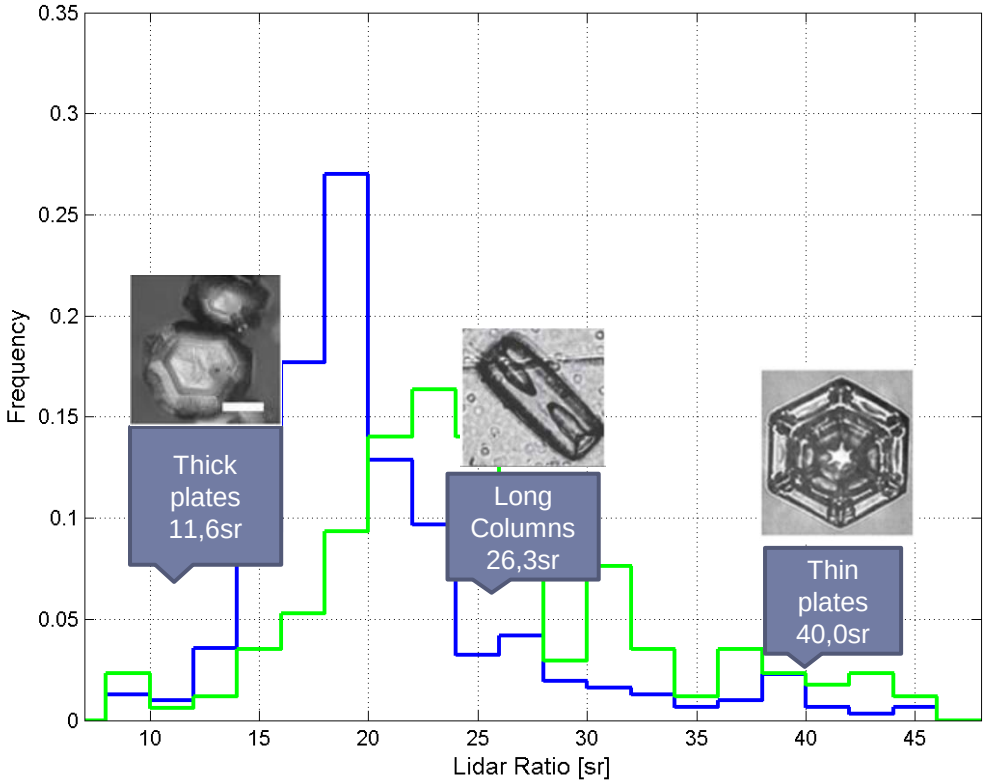


Microphysical Properties



	LR (sr)
Manaus	**20,6 ± 6,8**
Mahé, Seuchells.	19,6
Maldivas	30 ± 10 33 ± 10
Aspendale (Platt; Diley , 1984,AO)	18,2sr ± 20%
Sul da França (Giannakaki et al. 2007 ACP)	28 ± 17
Salt Lake City, Utah (Sassen; Comstock, 2001,JAS)	24 ± 38
São Paulo **(Larrosa, PhD, 2011)**	26 ± 12

Microphysical Properties



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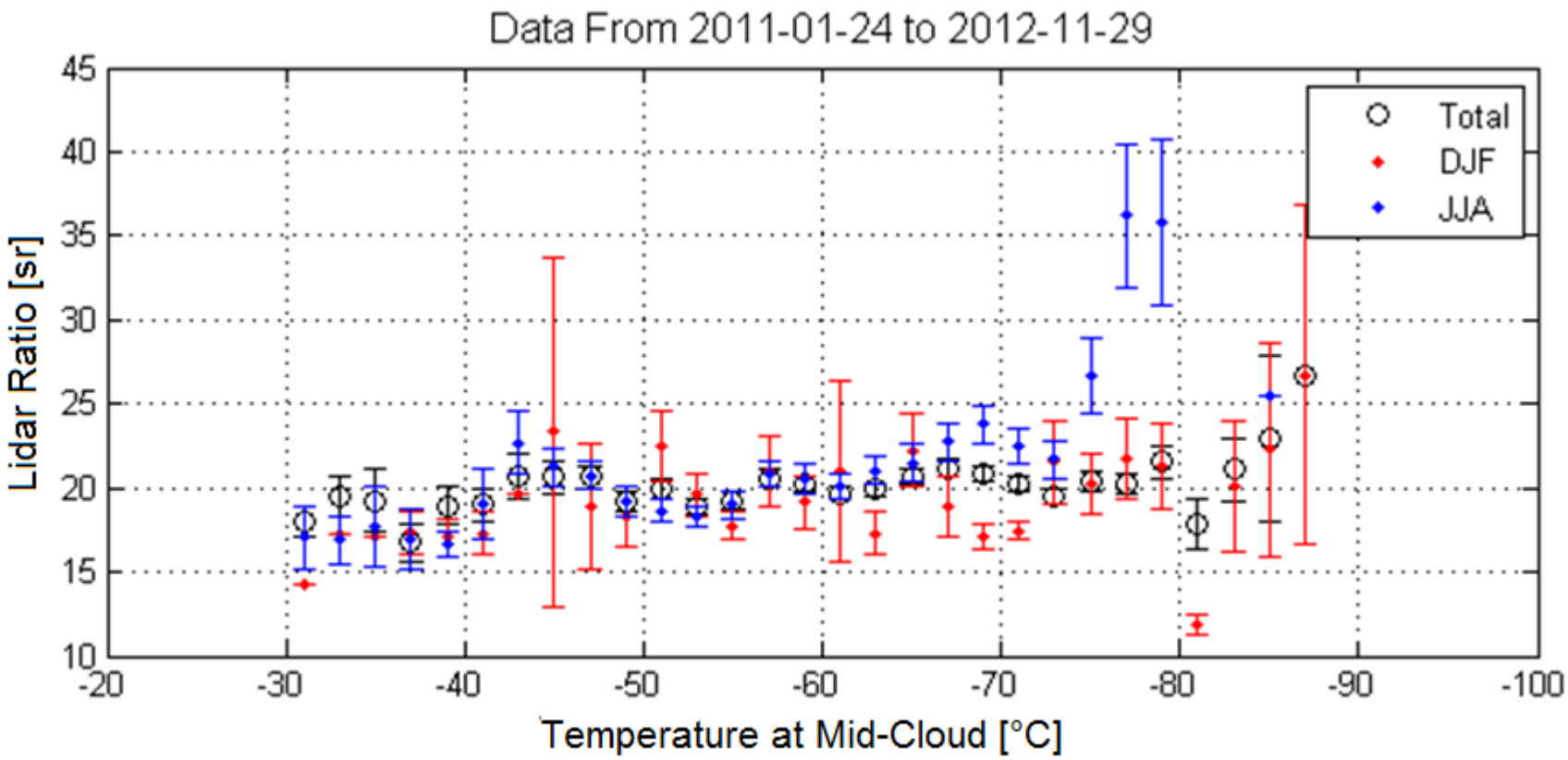
Microphysical Properties



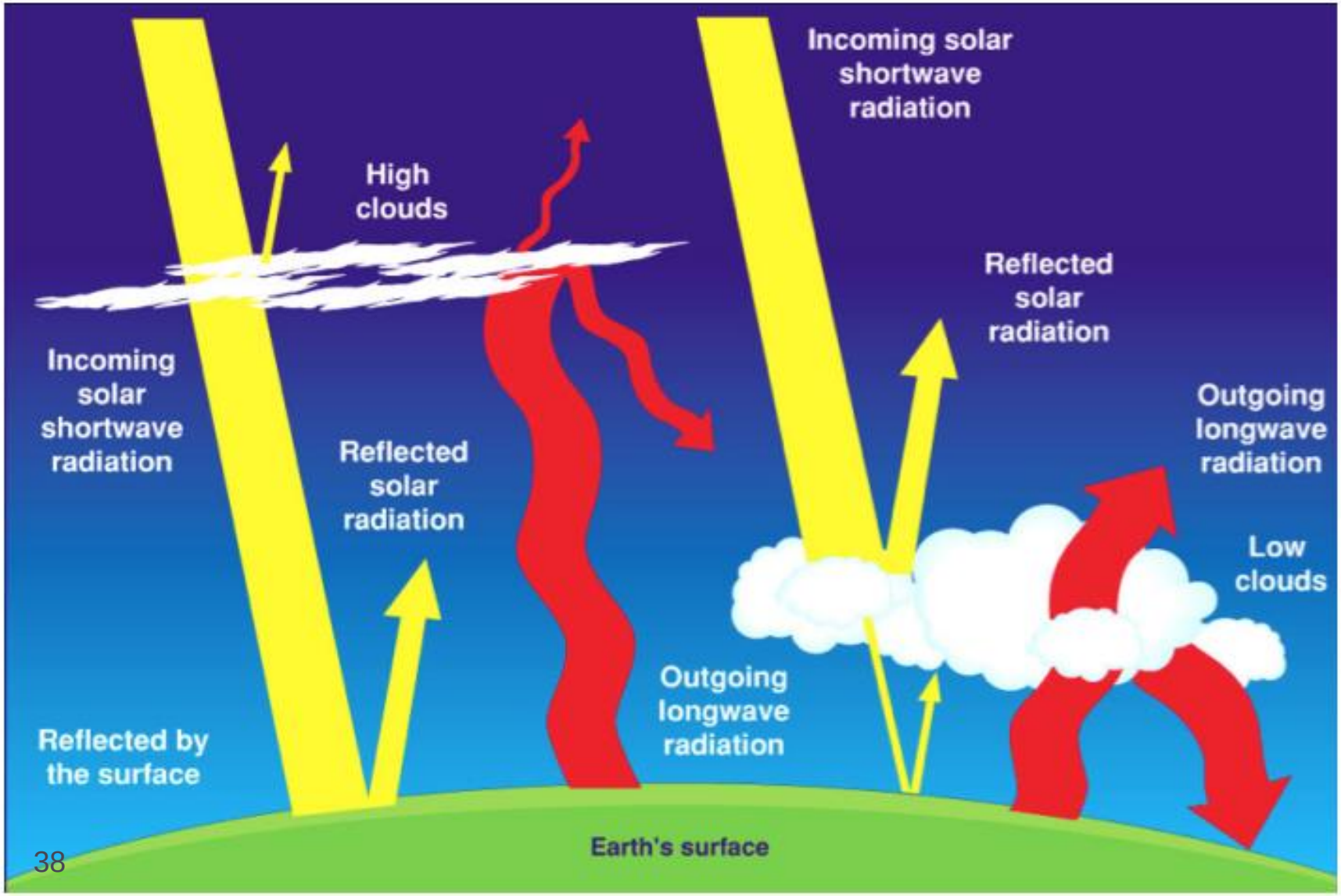
Conclusions Observations – Long term

- Well defined annual cycle occurring in 50% to 85% of the time.
- Macrophysical properties, rainfall and wind direction patterns indicate deep convection and the transport from other regions as its main source
- 24% of the clouds are subvisual, 42% are optically thin and 35% of them are cirrus stratus, with a change only in JJA, showing more aged clouds

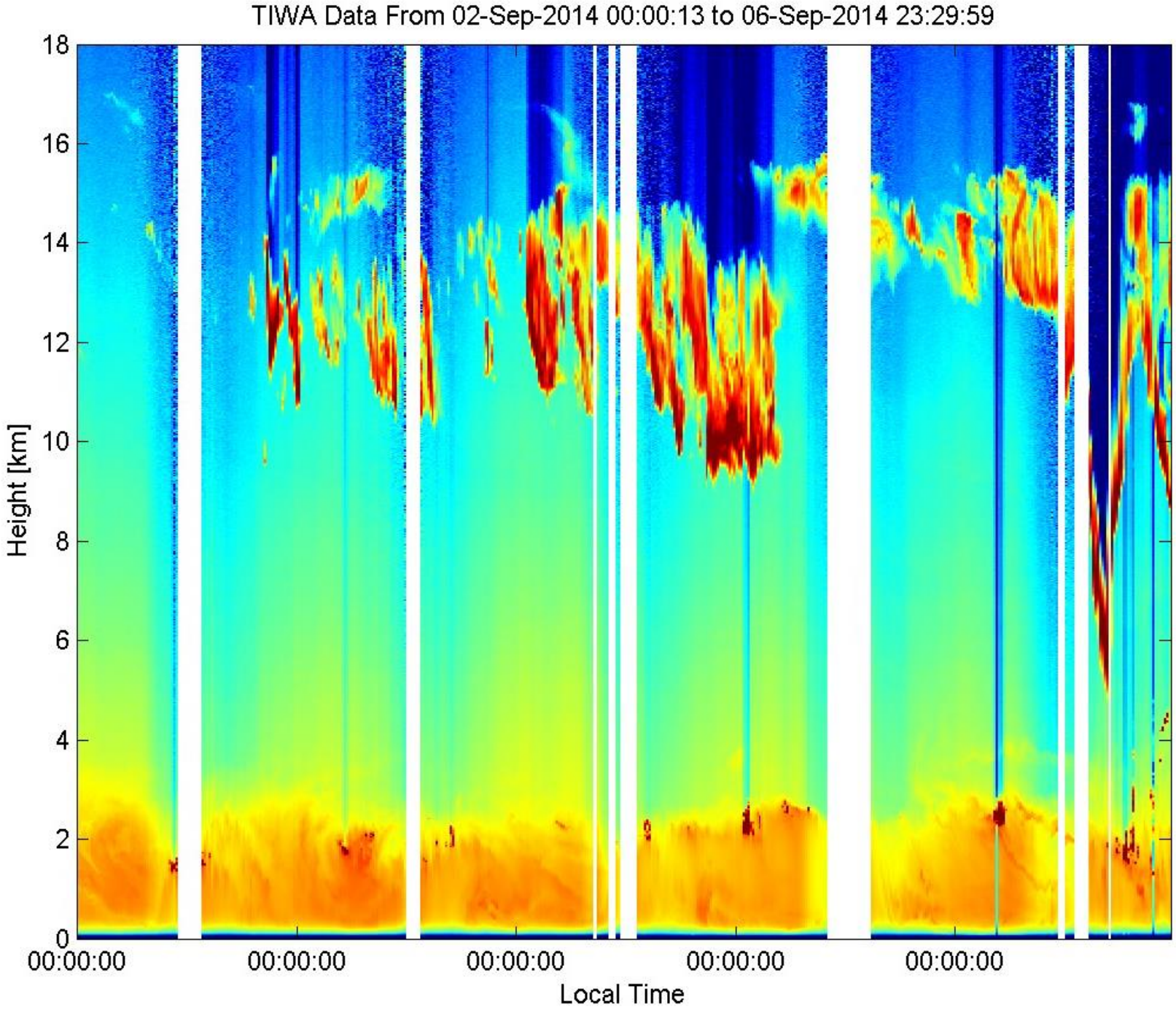
Conclusions Observations – IOP2

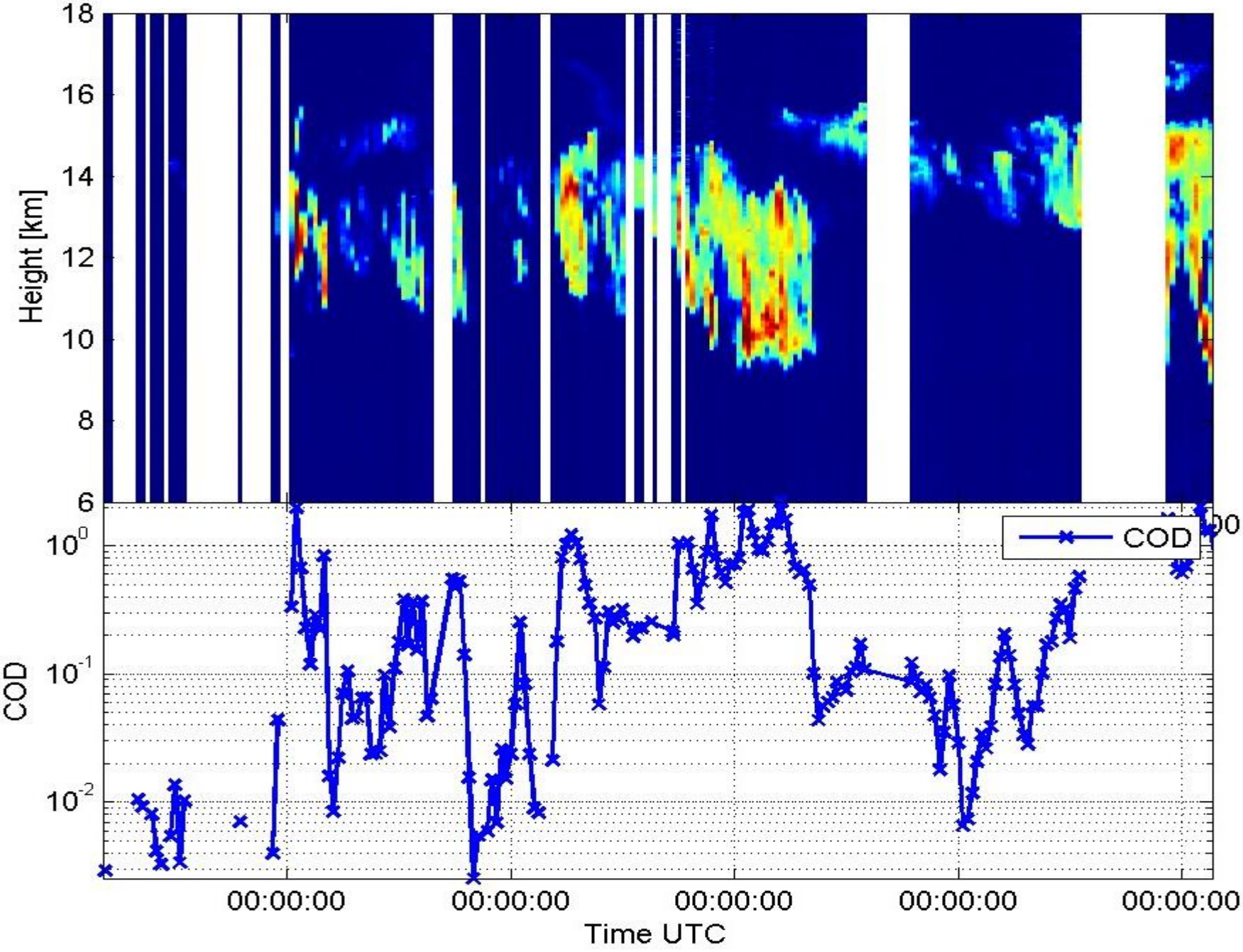
- Higher occurrence of clouds compared to 2011/12.
- Apparent difference in the macrophysical properties between Embrapa and Tiwa sites.
- approximately the same optiacal depth for T0e and T2, with about 65% considered as thin clouds. T3 results needs further validations.
- The distribution of lidar ratio showed a wide range of values indicating thick plaques and long columns as the main composition of ice crystal. However, the behavior with temperature needs further investigation

Cirrus Radiation Balance

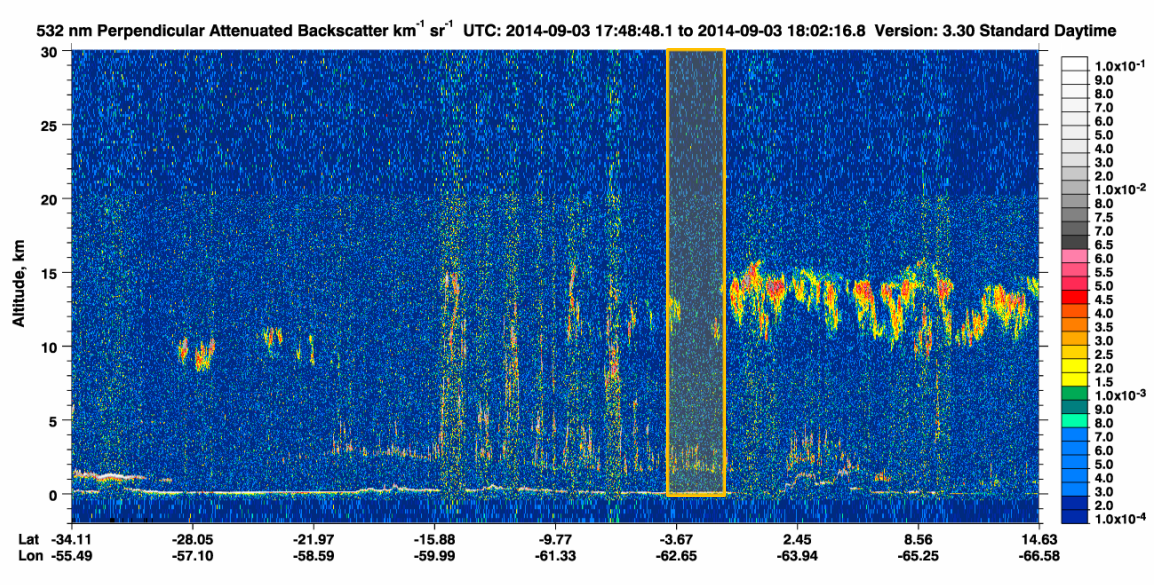


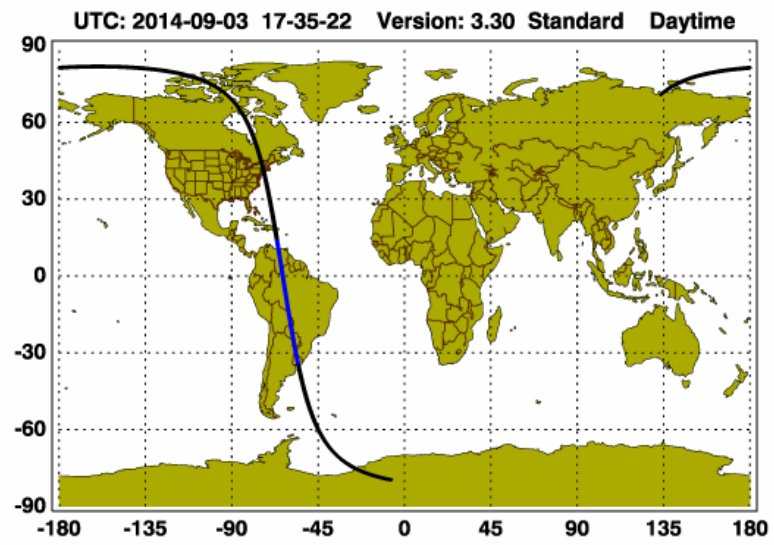
Cirrus Cases


TIWA Data From 02-Sep-2014 00:00:13 to 06-Sep-2014 23:29:59
Height [km]
18
16
14
12
10
8
6
4
2
0
00:00:00
00:00:00
00:00:00
00:00:00
00:00:00
Local Time

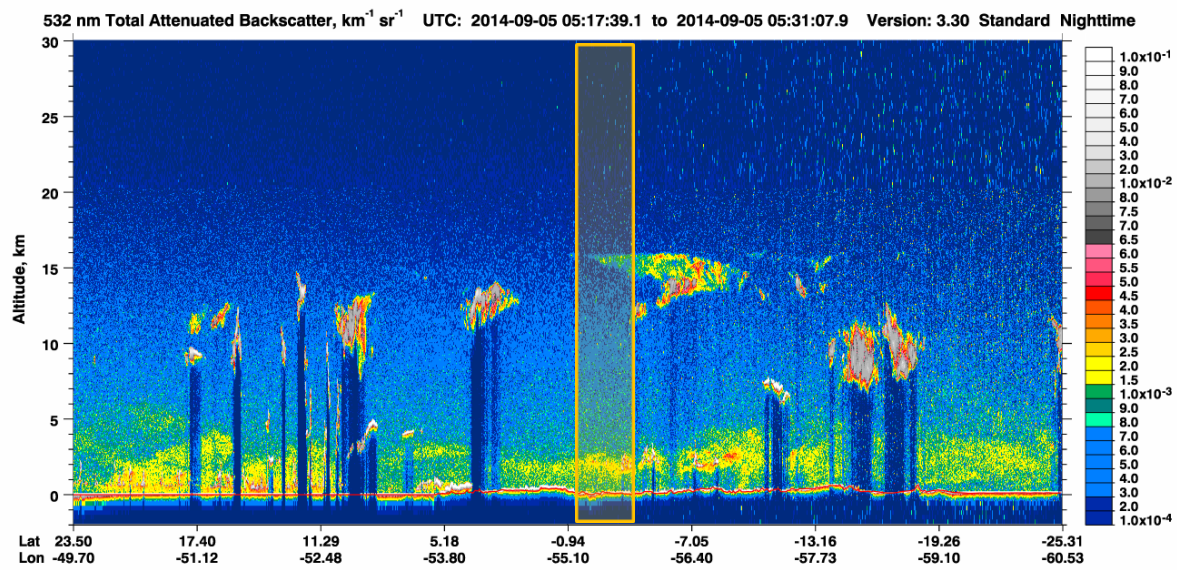

532 nm total particulate Extinction coefficient [km-1] from the day 02-Sep-2014 lidar Manaus
Height [km]
18
16
14
12
10
8
6
> 0
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
COD
10^{0}
10^{-1}
10^{-2}
00:00:00
00:00:00
00:00:00
00:00:00
00:00:00
Time UTC

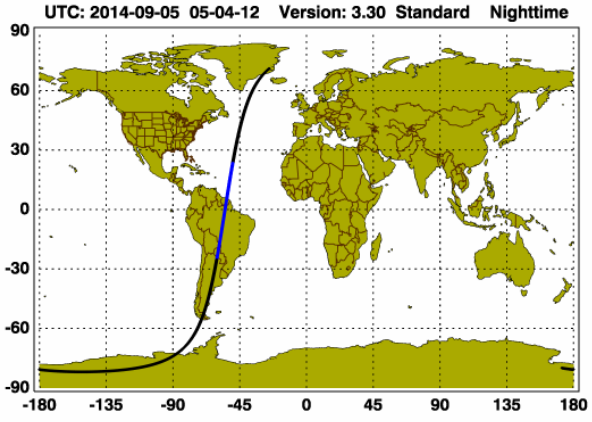
Calipso 2014-09-03

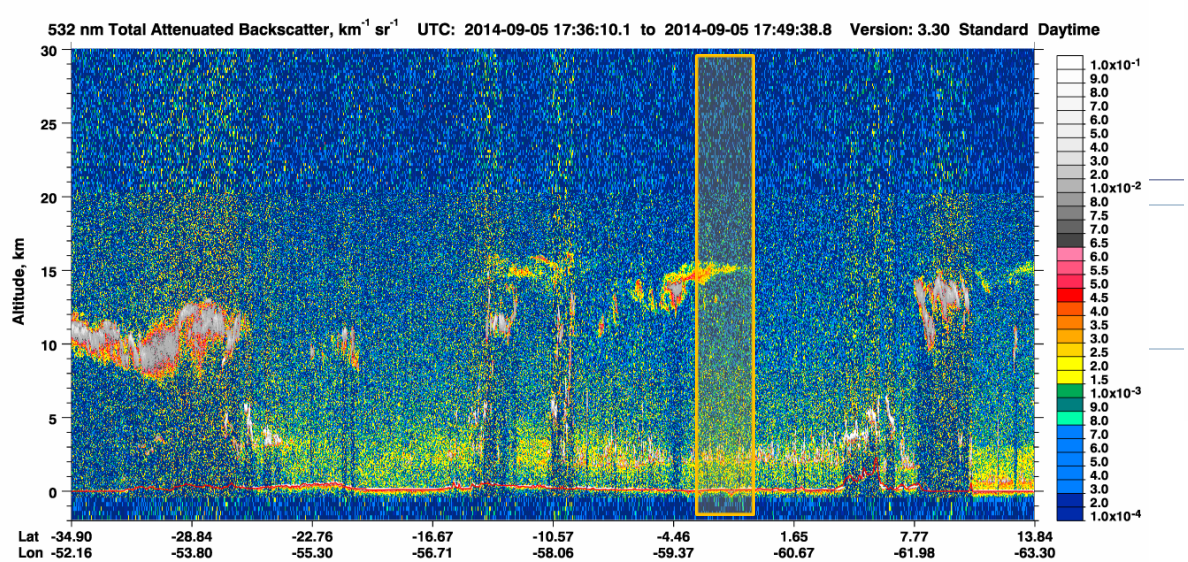


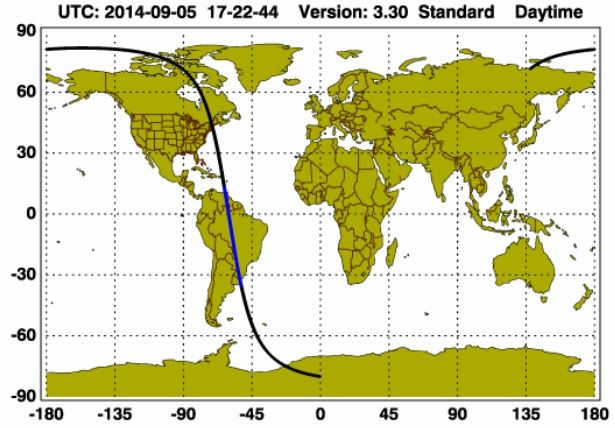


Calipso 2014-09-05

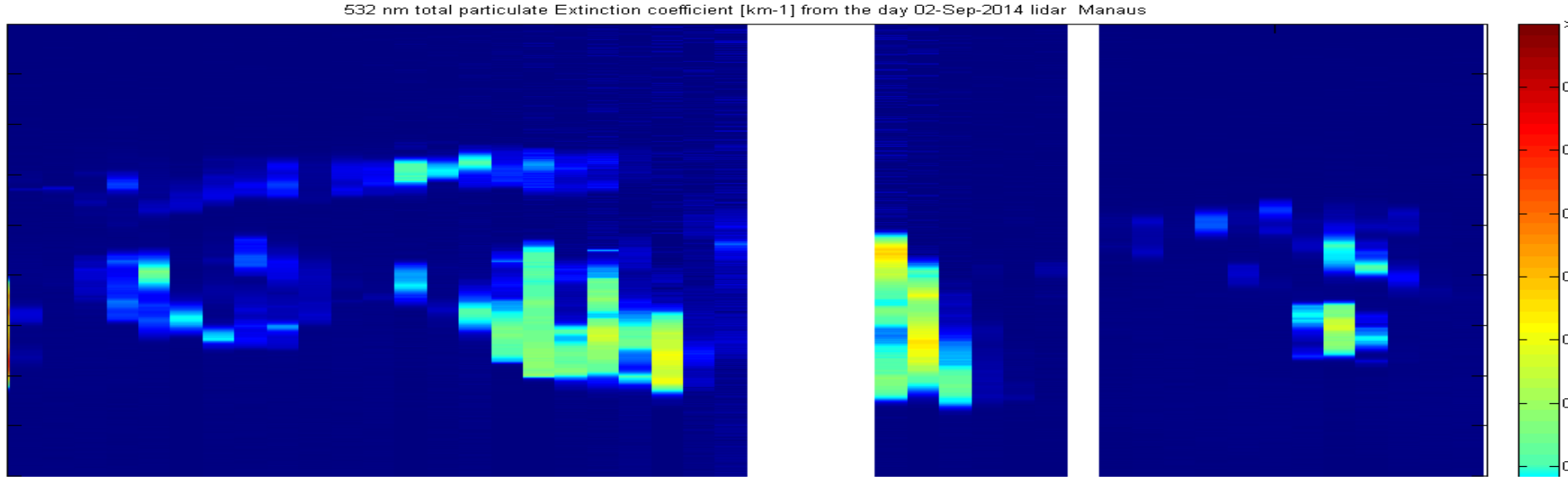


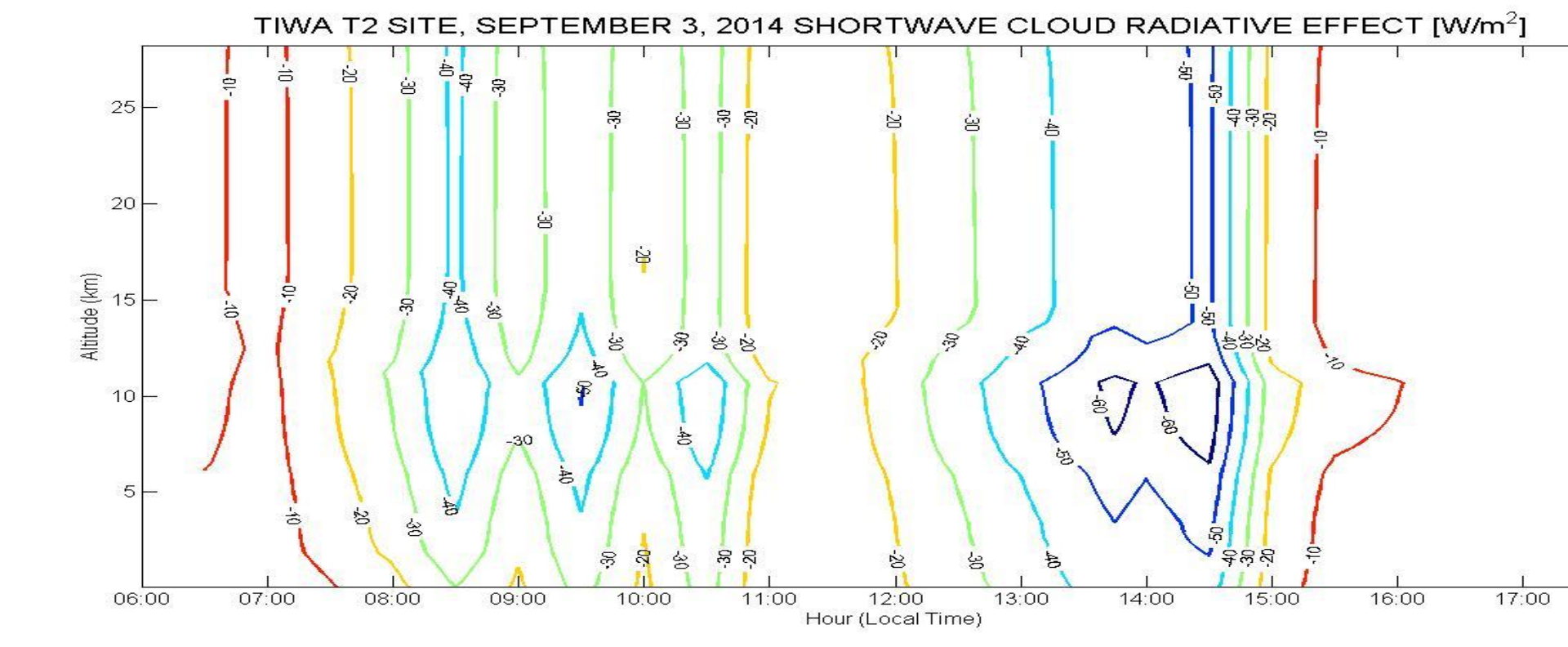


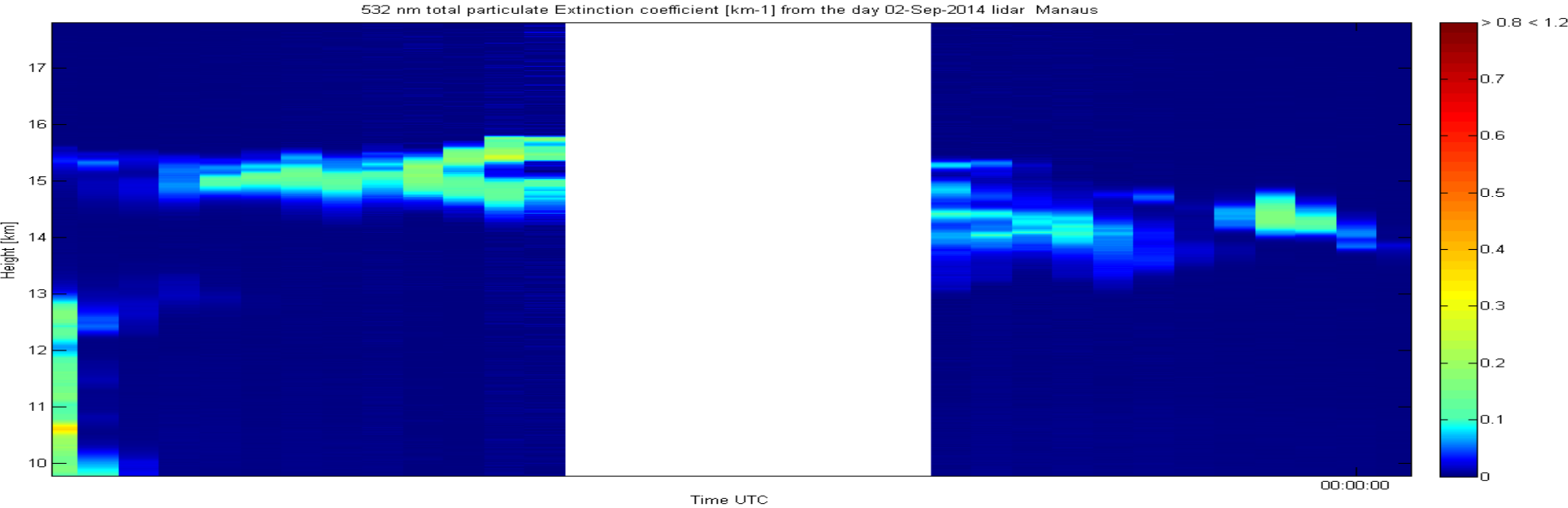


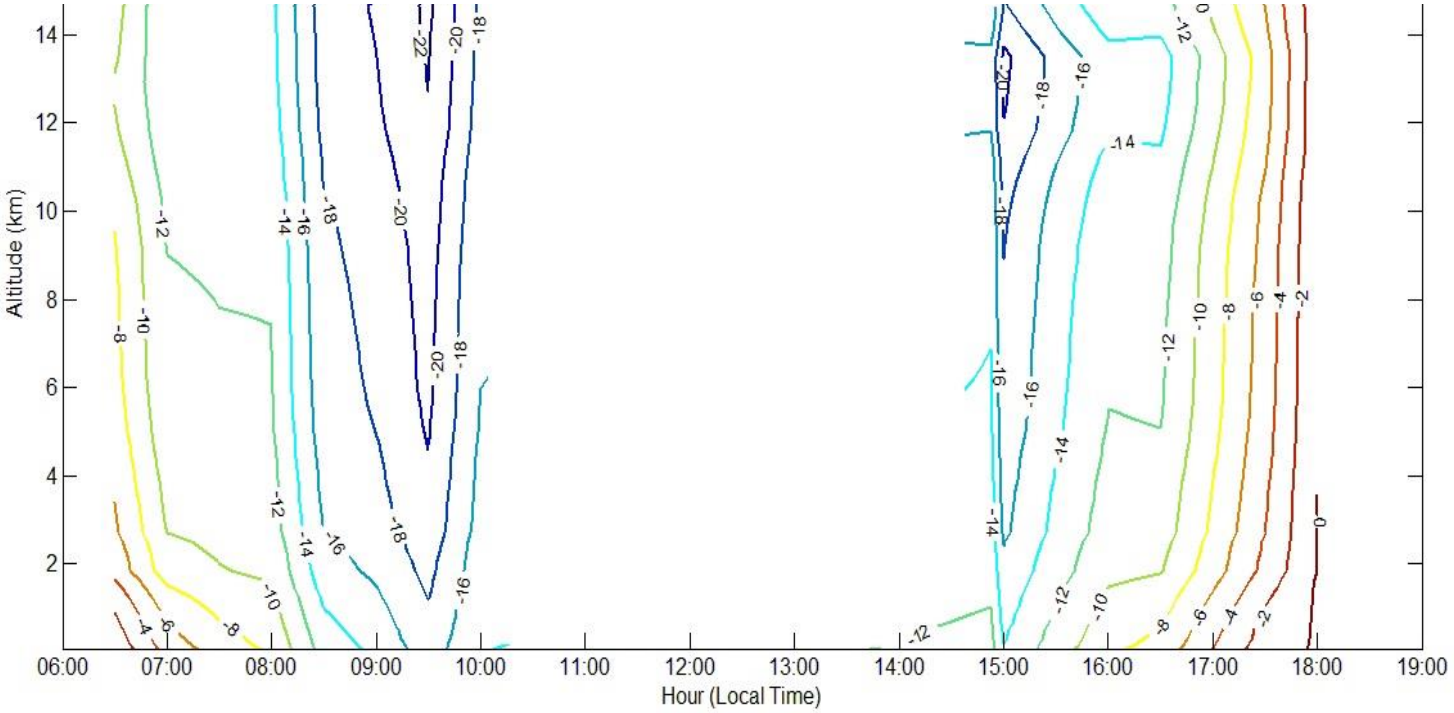


Results

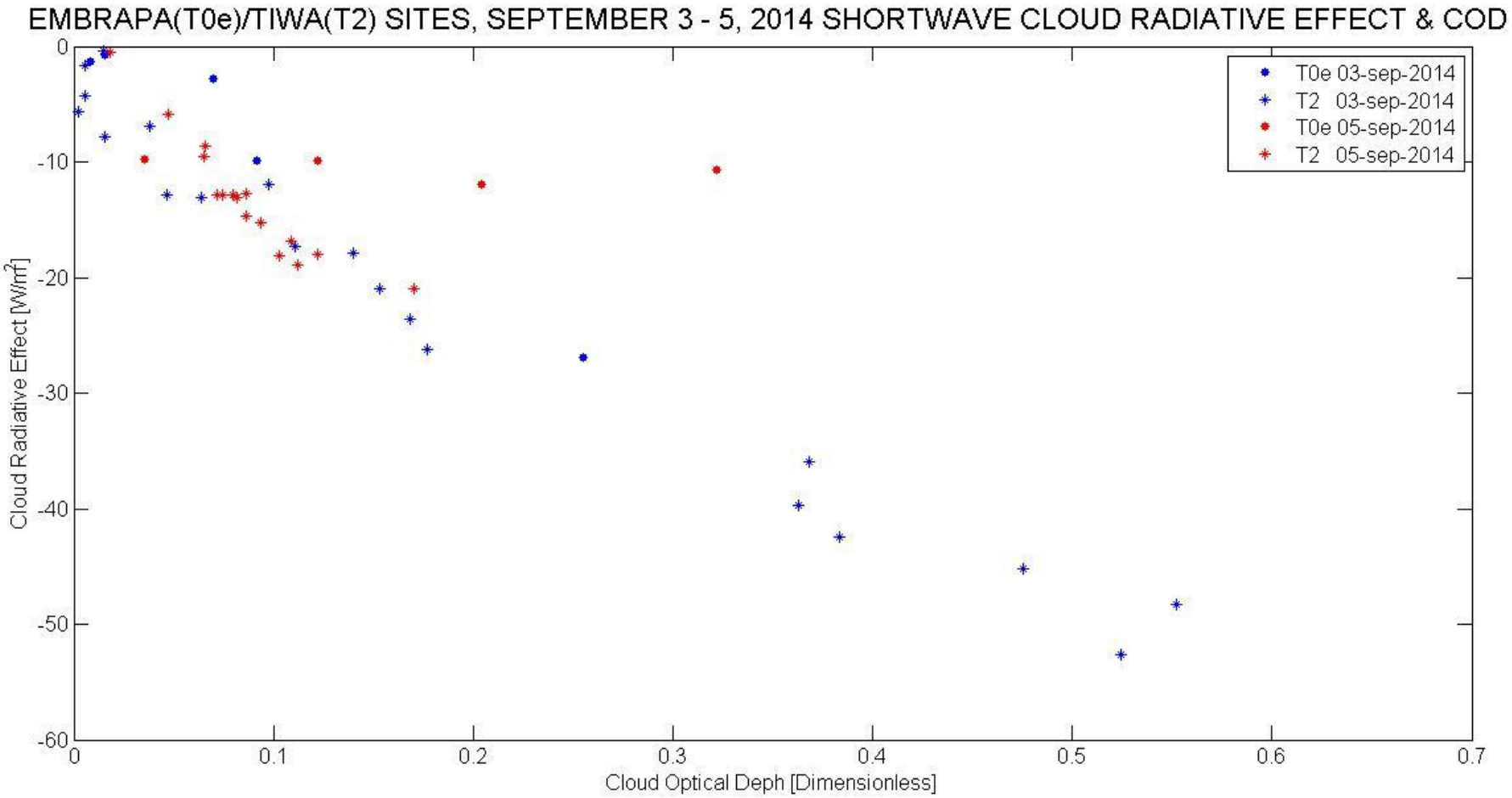

532 nm total particulate Extinction coefficient [km-1] from the day 02-Sep-2014 lidar Manaus


TIWA T2 SITE, SEPTEMBER 3, 2014 SHORTWAVE CLOUD RADIATIVE EFFECT [W/m2]
Altitude (km)
Hour (Local Time)
06:00
07:00
08:00
09:00
10:00
11:00
12:00
13:00
14:00
15:00
16:00
17:00
5
10
15
20
25

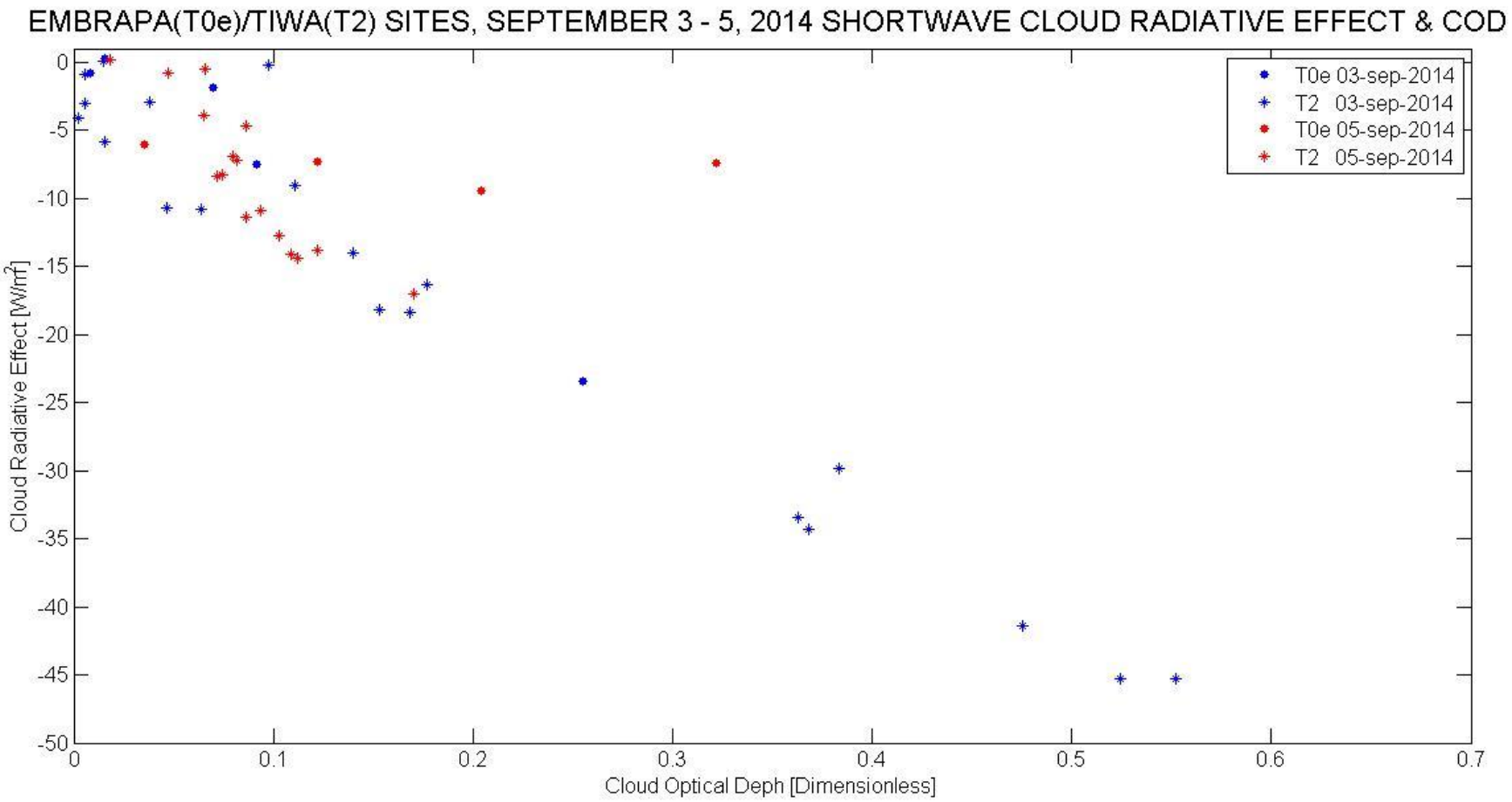

532 nm total particulate Extinction coefficient [km-1] from the day 02-Sep-2014 lidar Manaus
Height [km]
17
16
15
14
13
12
11
10
00:00:00
Time UTC
> 0.8 < 1.2
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0


Altitude (km)
14
12
10
8
6
4
2
06:00
07:00
08:00
09:00
10:00
11:00
12:00
13:00
14:00
15:00
16:00
17:00
18:00
19:00
Hour (Local Time)

Results – CRF TOA



Results – CRF Surface



Obrigado!