CONTINUOUS MEASUREMENTS OF AEROSOLS AND WATER VAPOR IN THE AMAZON

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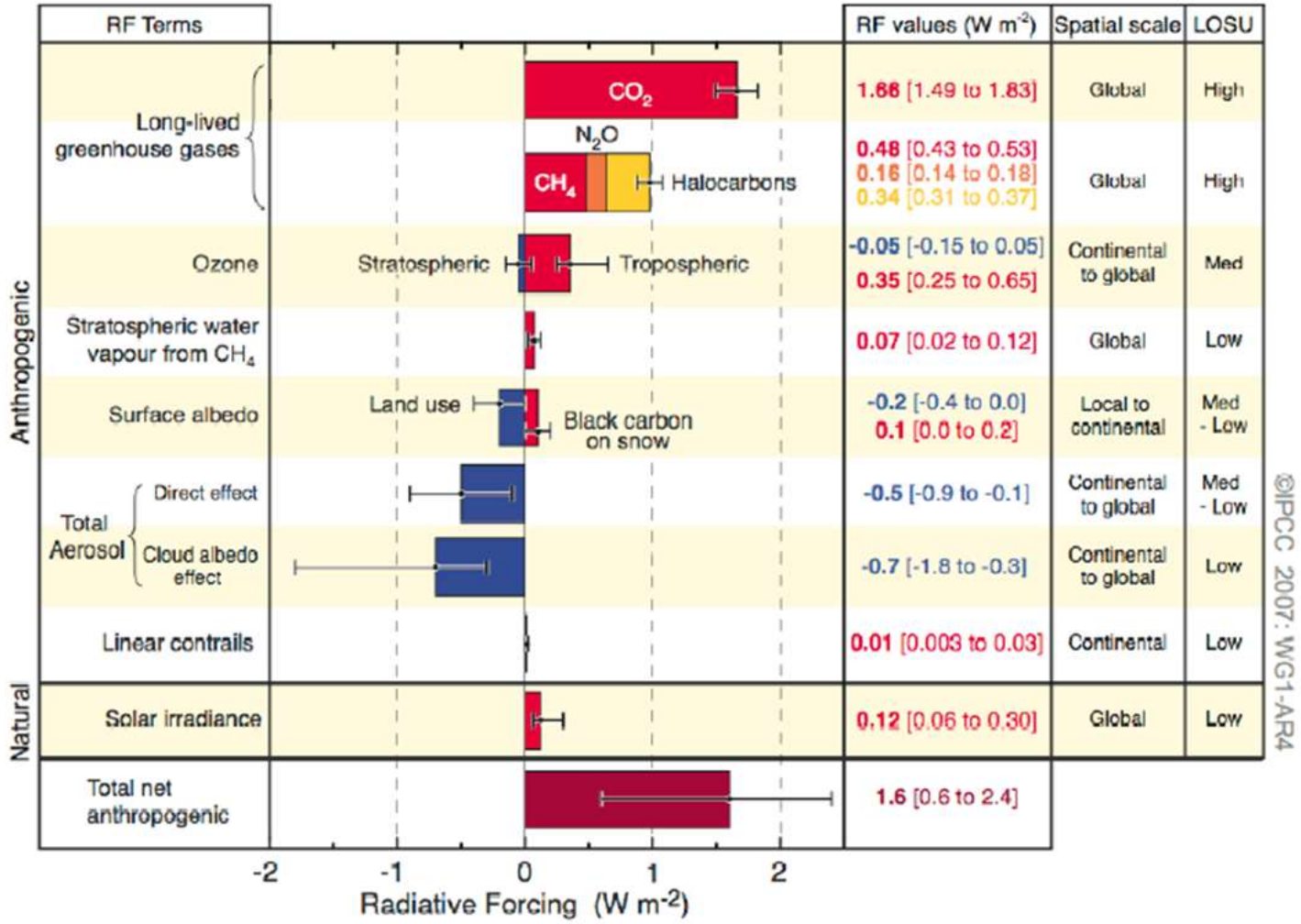
VI WLMLA – 2011 – La Paz

What I hope to tell you...

- AEROCLIMA project
  - Our Raman-Lidar
    - The instrument characteristics
    - A new site in the Amazon
    - Calibration of water vapor profiles
- ACONVEX - Convection and Microphysics
  - Instrumentation
  - First intensive campaign
    - A few preliminary snapshoots
- Other projects being planned

AEROCLIMA: reducing an error bar



AEROCLIMA Sites

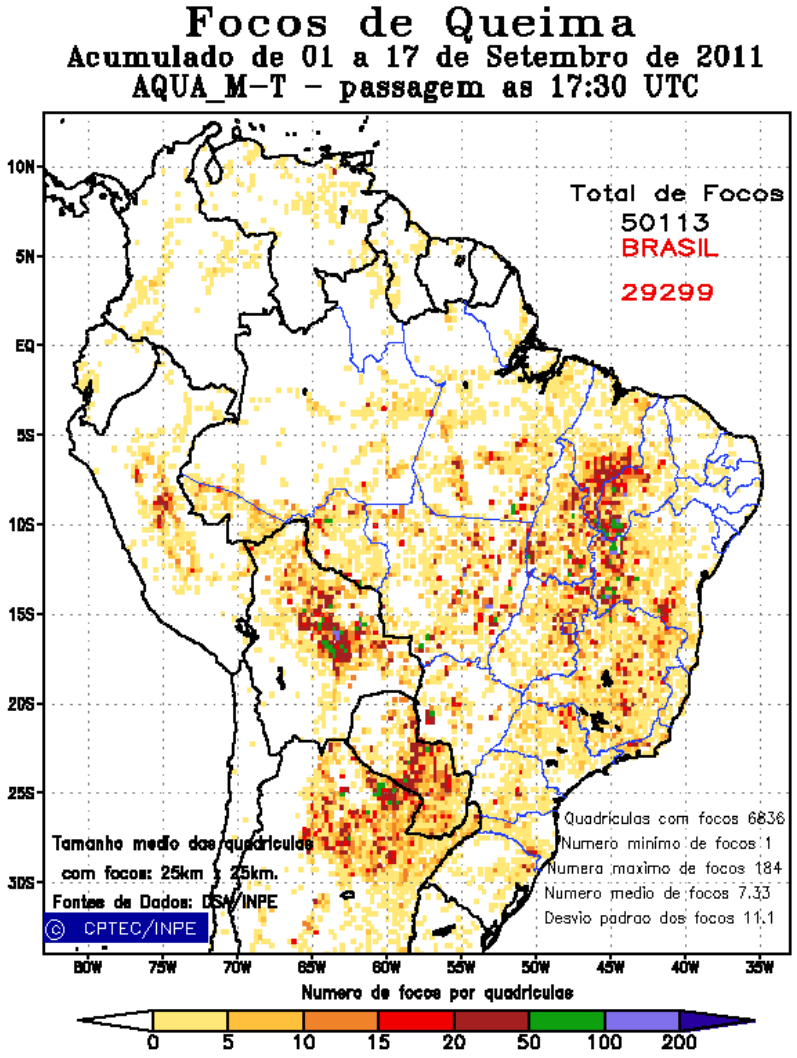
Aerosol Properties relevant to Climate

Properties	Climate	Most Popular Technique
Number and Size	✔	SMPS / OPC
Chemical Composition	✔	Off Line / On Line
Vertical Distribution	✔ ✔	Lidar
Scattering and back-scattering coefficients	✔ ✔	Nephelometer
Absorption Coefficient Black Carbon	✔ ✔	Absorption spectrometer
Aerosol Optical Depth	✔ ✔	Sun Photometer
RH-dependency	✔ ✔	Cloud Condensation nucleous counter (CCN)

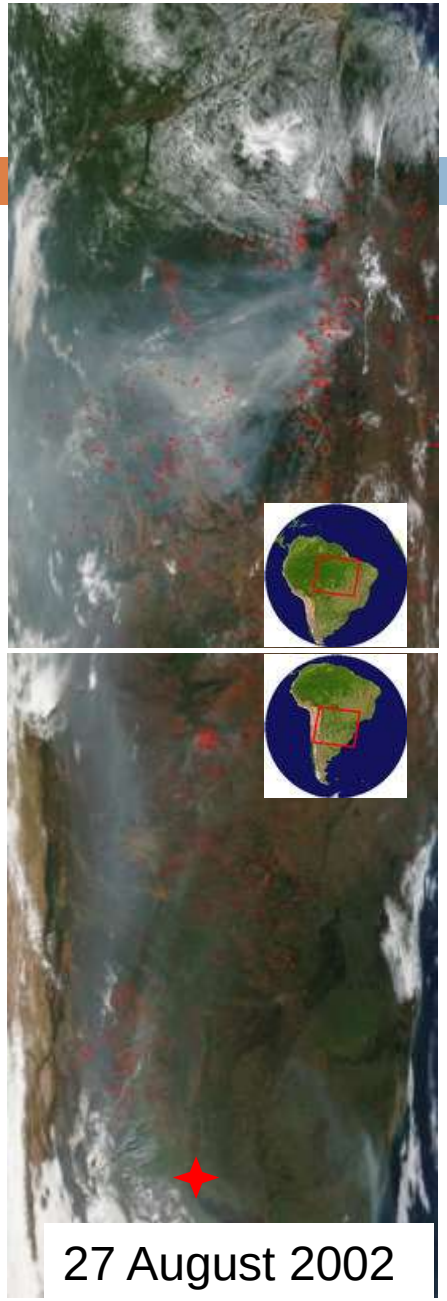
Paolo's talk

ZF2 (Manaus) - Site

Why bother with vertical distribution?



Long range transport of smoke!



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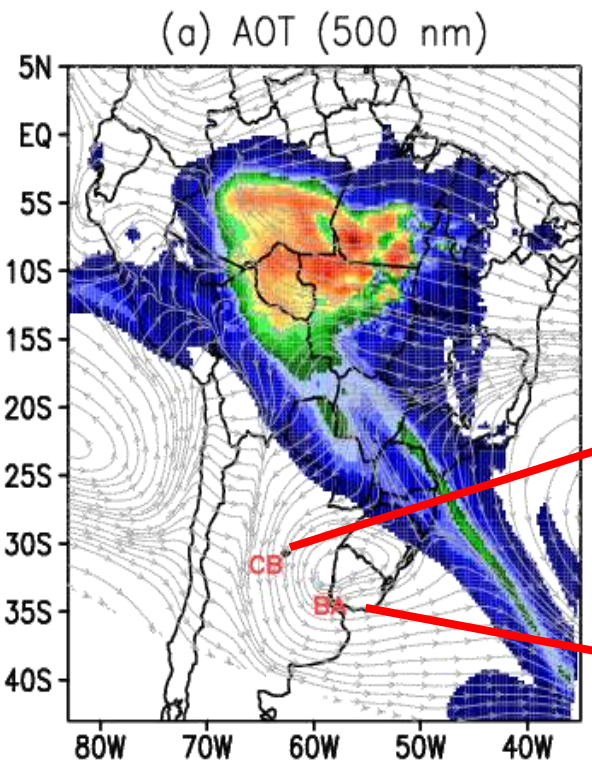
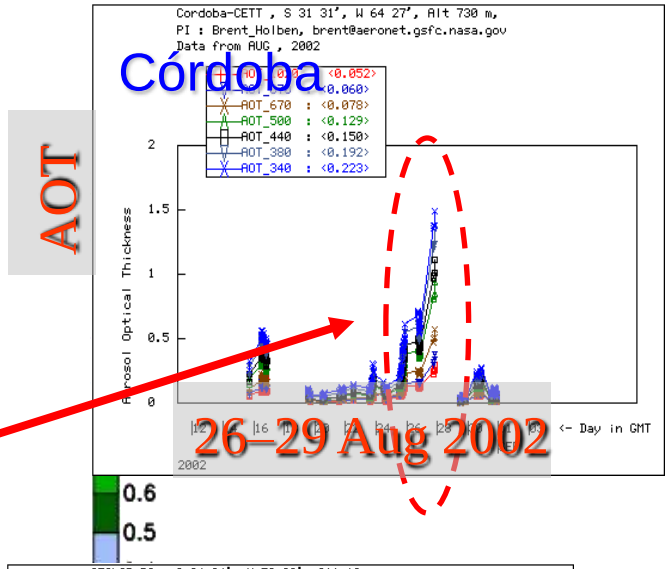
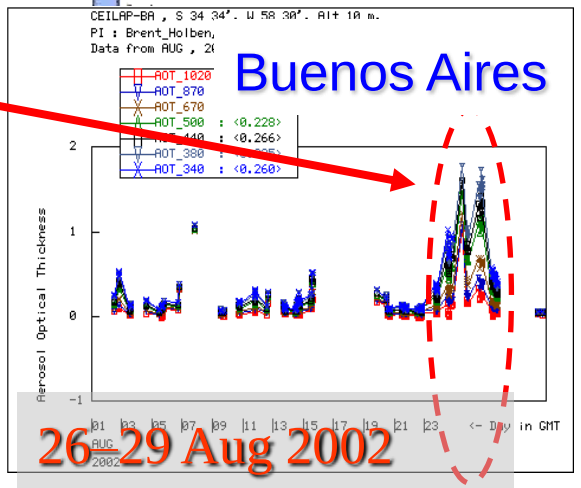


AOT



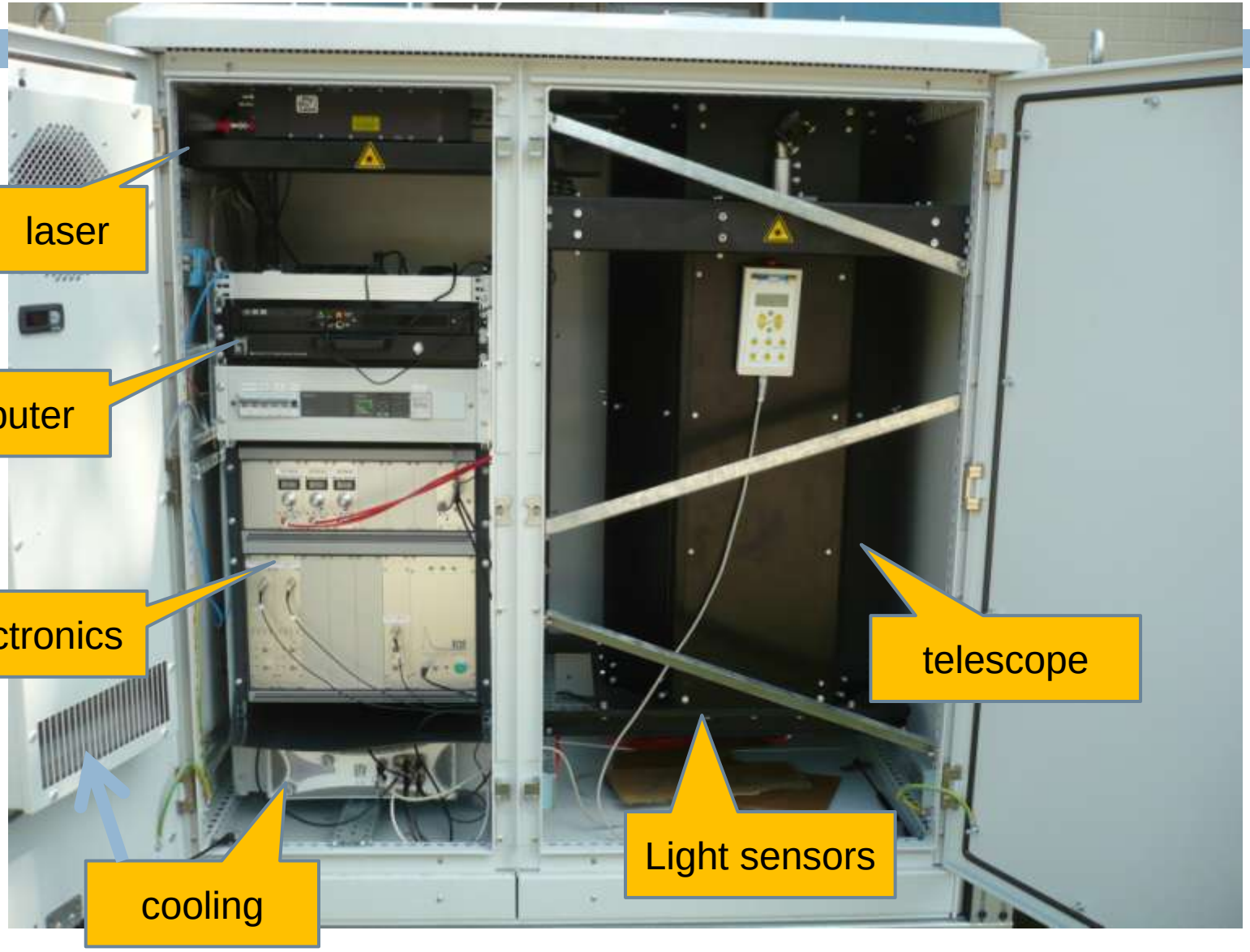


From Dr. Saulo Freitas – INPE – BR

The instrument

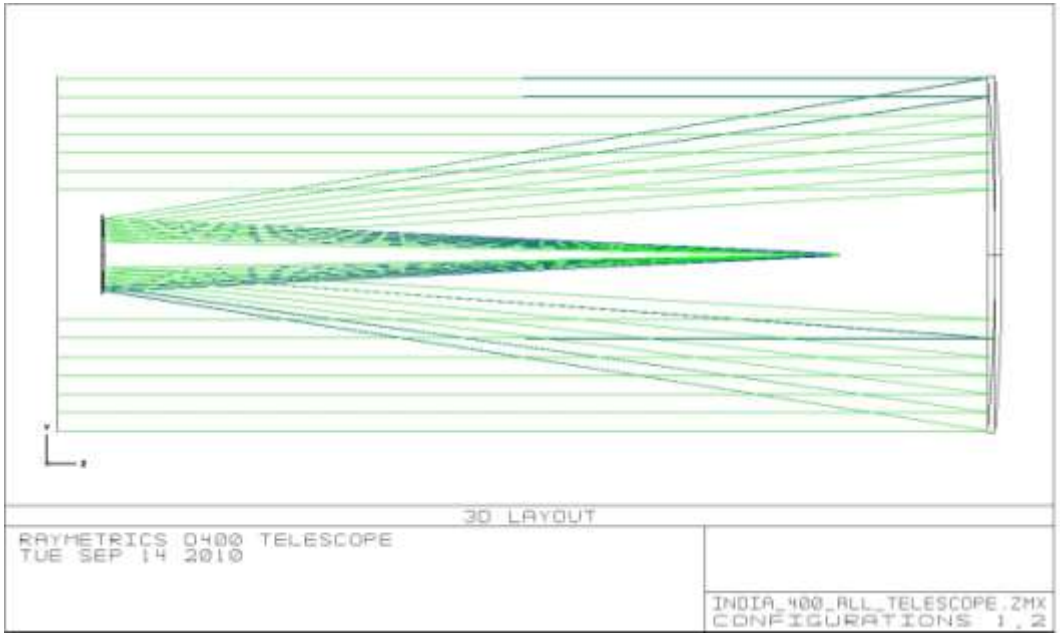
- Dimensions
  - 2 x 1.5 x 0.9 m
  - 700kg
- Electric energy
  - min= 500kva
  - max= 3000kva
  - Tension: 220V ± 10%
  - Frequency: 60hz ± 15%
- Internet
  - Online
  - Remotely operated

The Instrument



Telescope

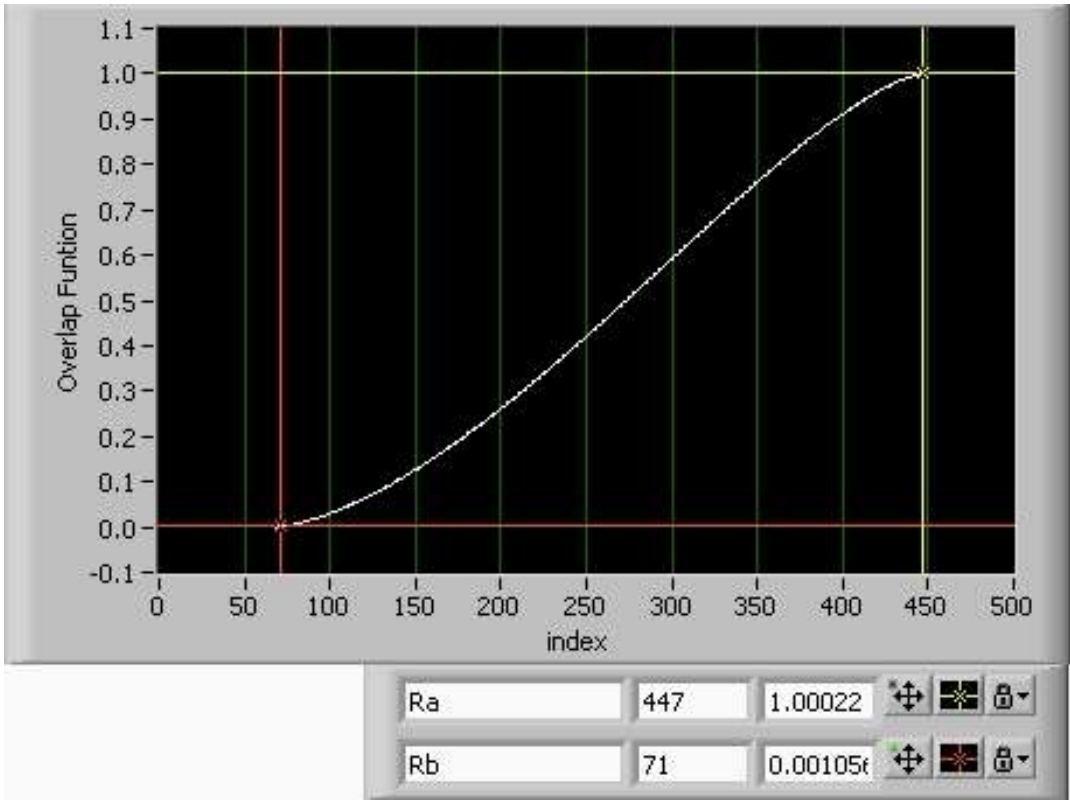
- The primary Φ = 400 mm
- The secondary Φ = 90 mm
  - Both coated with a durable high reflective coating suitable for the 350-1100 nm and very low thermal expansion coefficient
- Cassegrainian F/10
  - Focal length = 4000 mm
  - FOV = 1.75 mrad



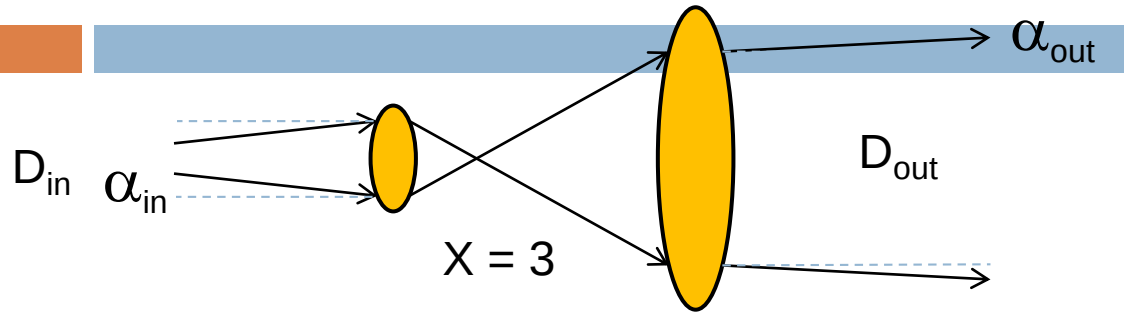
Telescope overlap

- *Default configuration with a laser beam divergence of 0.4 mrad, telescope FOV 1.75 mrad and inclination angle between axis of about 0.4 mrad.*

$\mathcal{O}(z<70m) = 0$
$\mathcal{O}(x>450m) = 1$

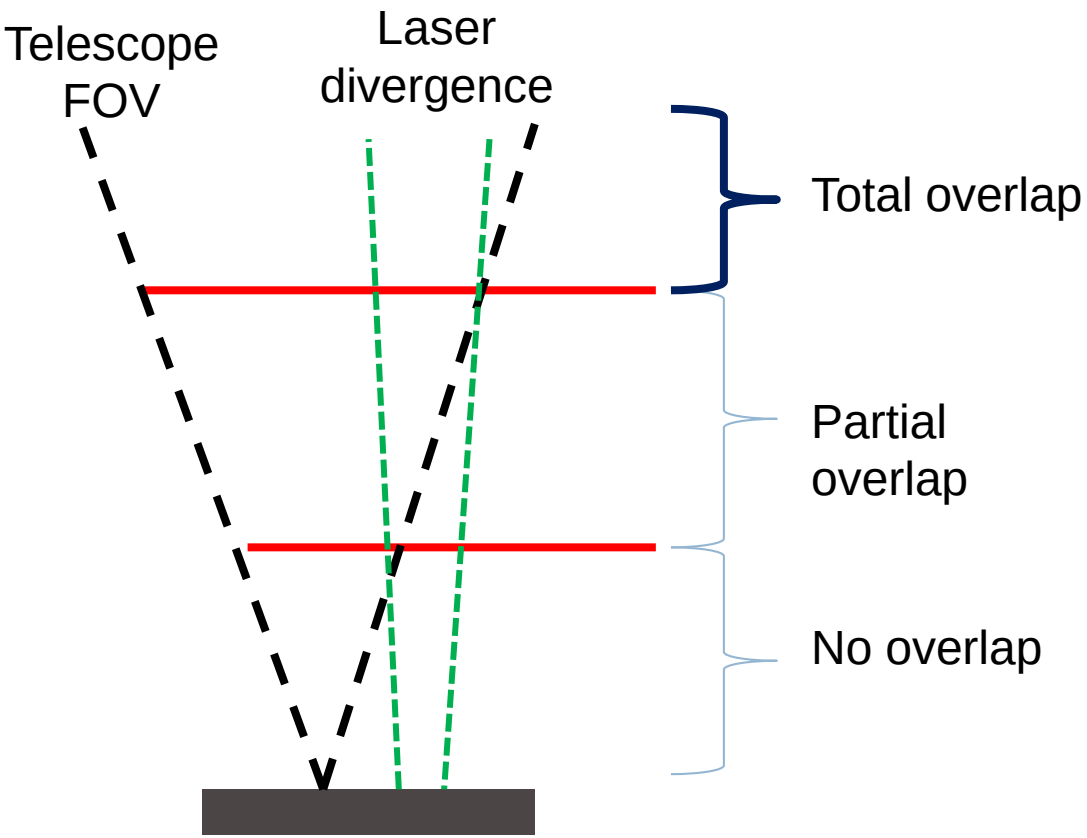


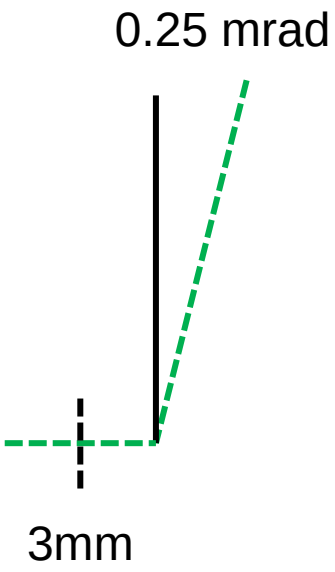
Optical layout



$$D_{out} = x \cdot D_{in} = 3 \cdot 1mm = 3mm$$

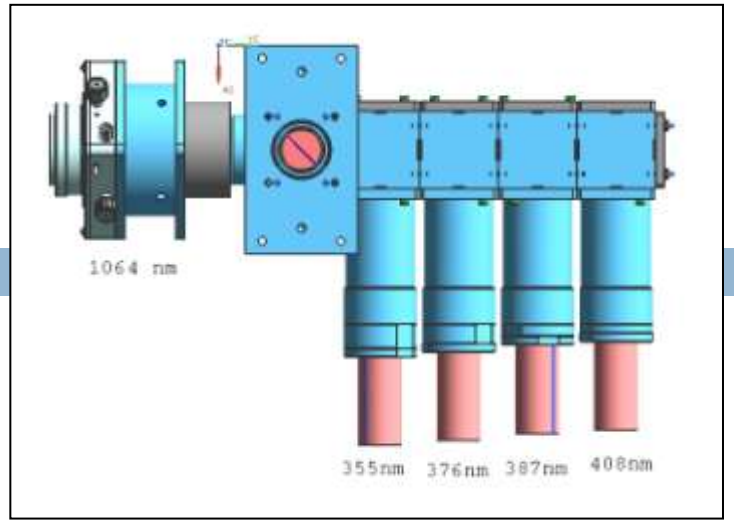
$$\alpha_{out} = \frac{\alpha_{in}}{x} = \frac{0.7mrad}{3} \cong 0.25mrad$$





Bi - axial

Optical layout



2nd mirror

Field stop (iris)

1st mirror

R355, 387, 408

R355

T408

R408

T1064, 607, 532

T387, 408

R387

Dicroic mirrors

IFF

20mm

8mm

PMT

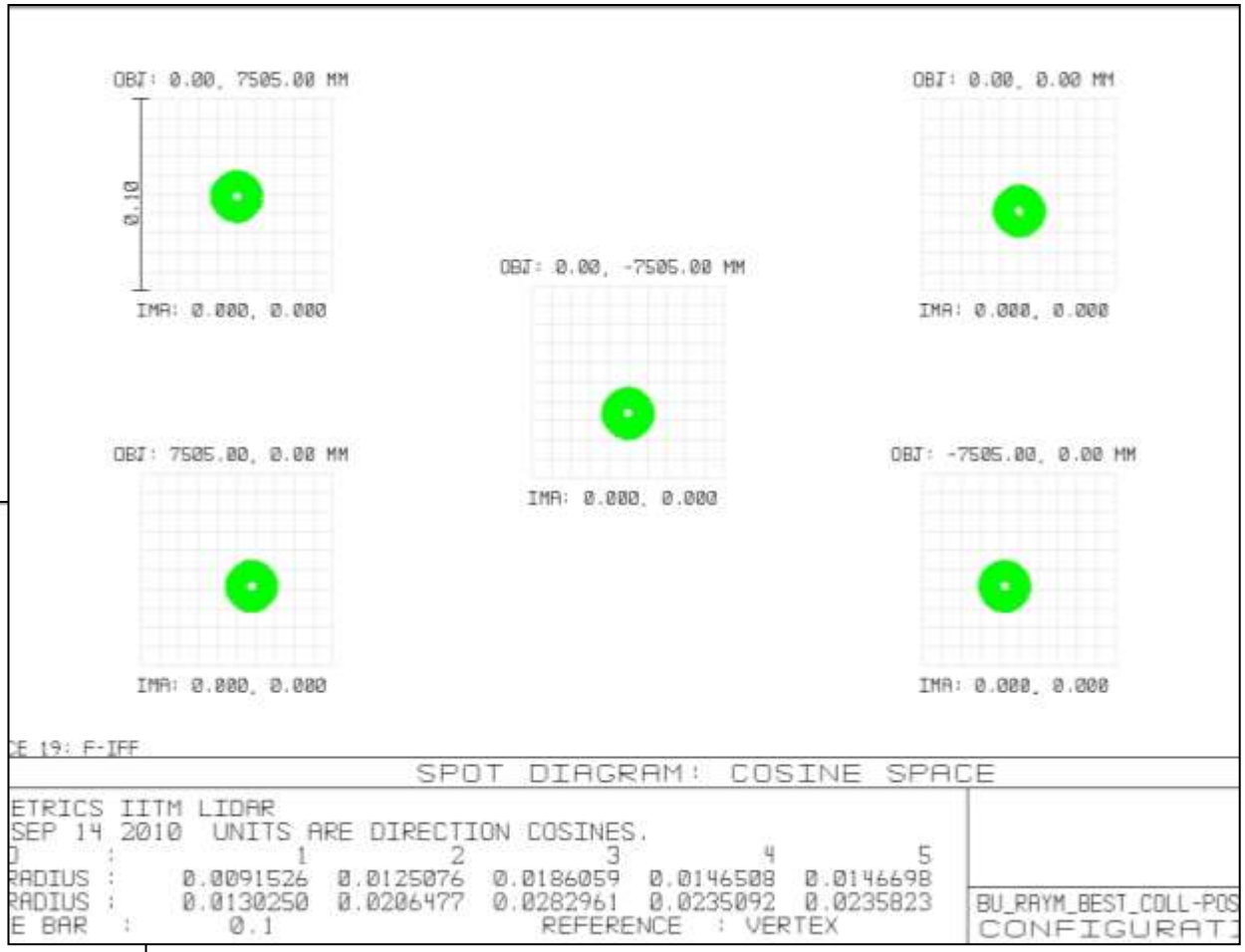
ND

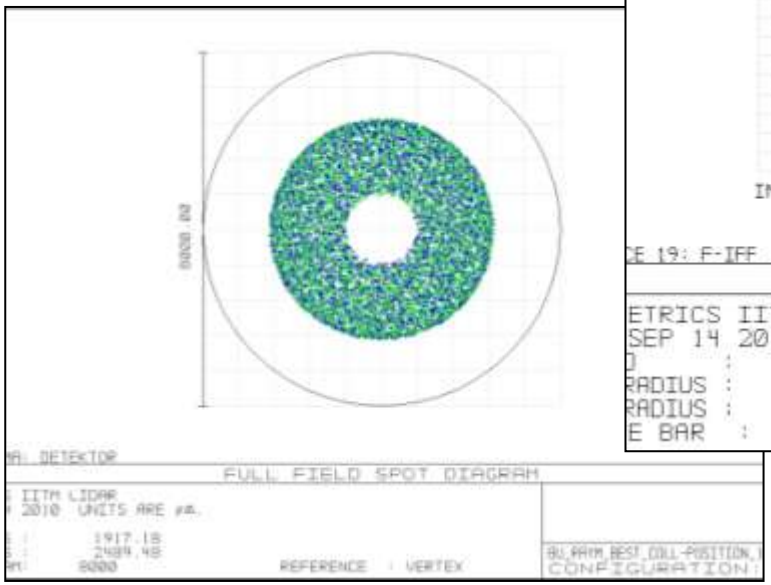
IFF 387

1nm FWHM

387nm

Image at cathode





PMTs + ADC

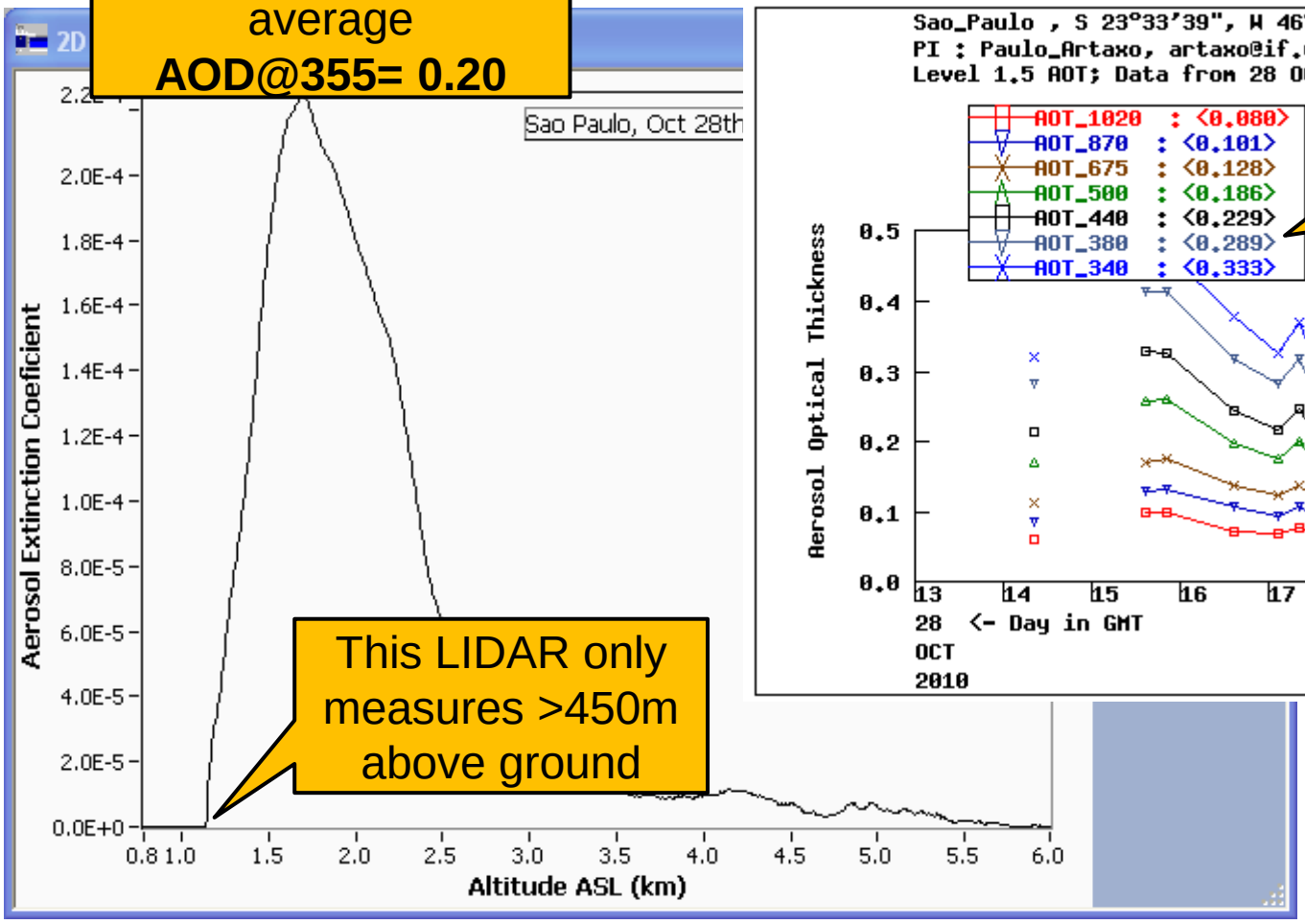
- Licel APD
  - TR20-160 355nm An+PC
  - TR20-160 387nm An+PC
  - PR20-160P 408nm PC
- Hamamatsu R9880U-10
  - High voltage 0-1000V
    - Linear 900-1000V

Laser

- Nd:Yag - Quantel CFR
- 95 mJ @ 355 nm
- Pulse: 5.04 ns
- Rate: 10 Hz
- Divergence: < 0.3 mrad

Sun Photometer vs Lidar
AOD - Sao Paulo, Oct 28th 2010

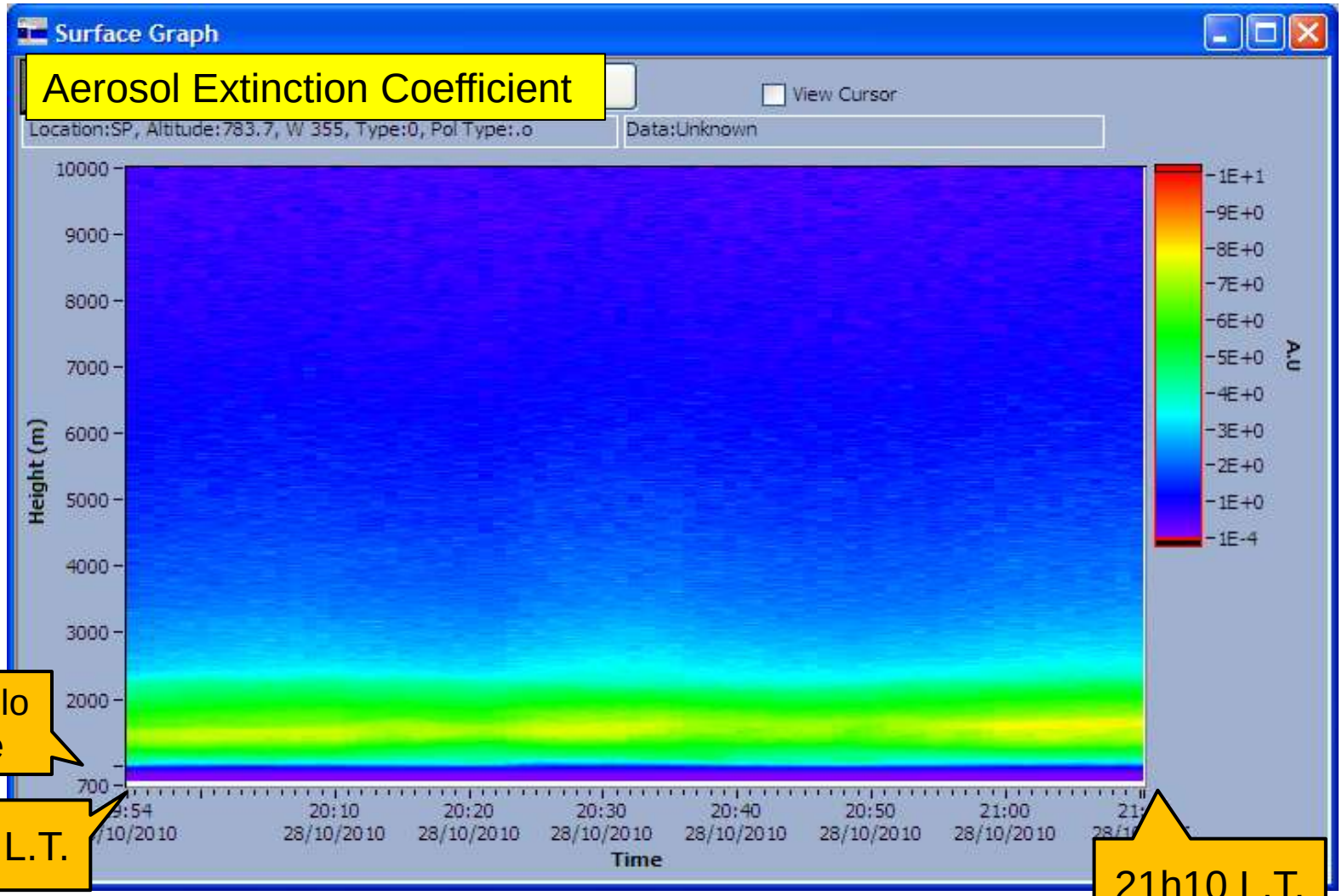
19h55-21h10
average
AOD@355= 0.20



This LIDAR only measures >450m above ground

AERONET
@380= 0.289
@340= 0.333

Pollution Plume over Sao Paulo
Sao Paulo, Oct 28th 2010



São Paulo altitude

19h54 L.T.

21h10 L.T.

Amazon


Port-of-Spain
Trinidad and Tobago
Caracas
Venezuela
Georgetown
Guyana
Bogota
Colombia
Quito
Ecuador
We moved the lidar here!
Map
Photos
Brazil
Brasilia
La Paz
Bolivia
© 2011 MapLink/Tele Atlas
US Dept of State Geographer
© 2011 Google
© 2011 Europa Technologies
©2010 Google
Terms of Use

Manaus Area


N
Map
Photos
Manaus
AM-070
Manacapuru
BR 319
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Image © 2011 TerraMetrics
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Image © 2011 DigitalGlobe
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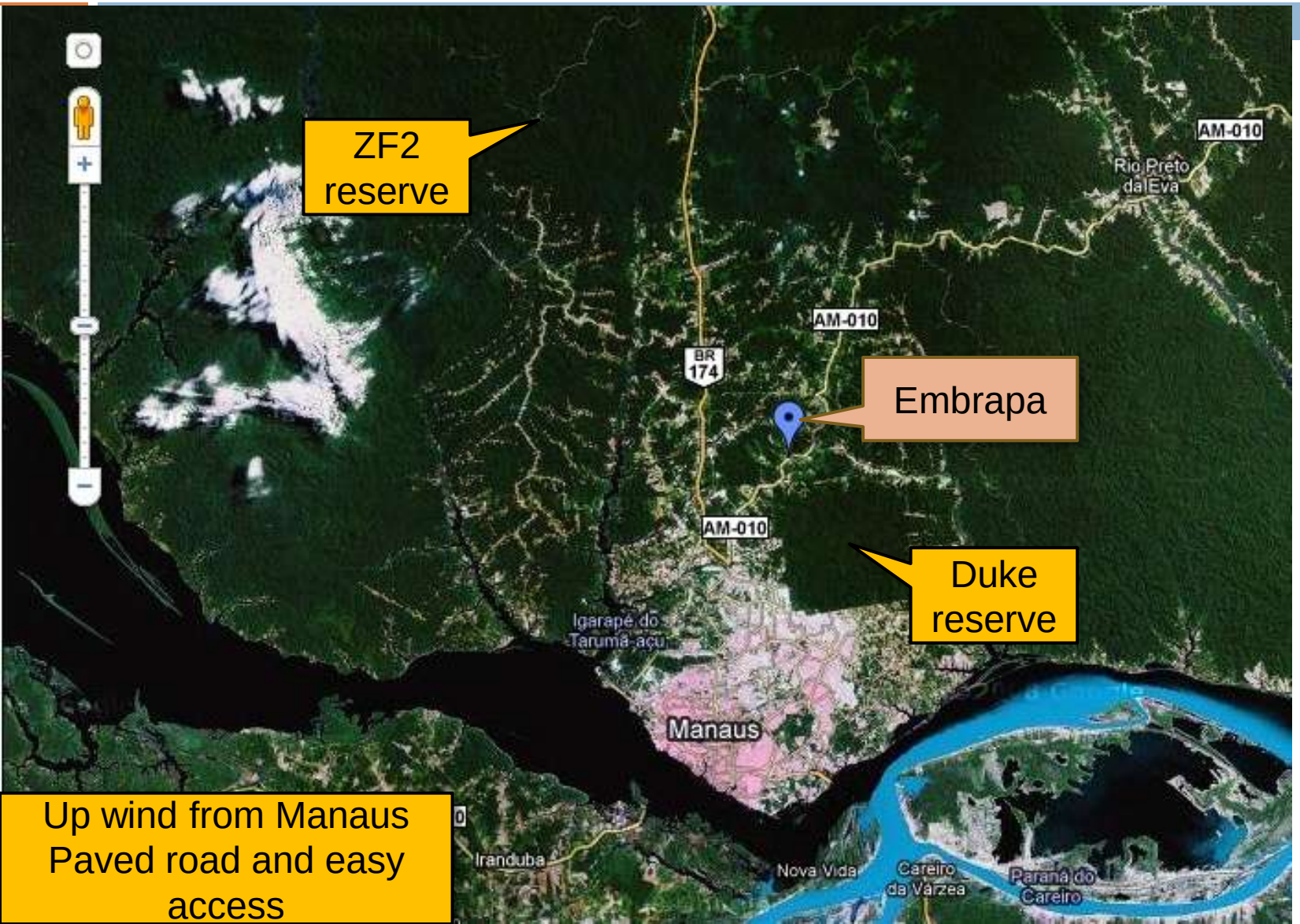
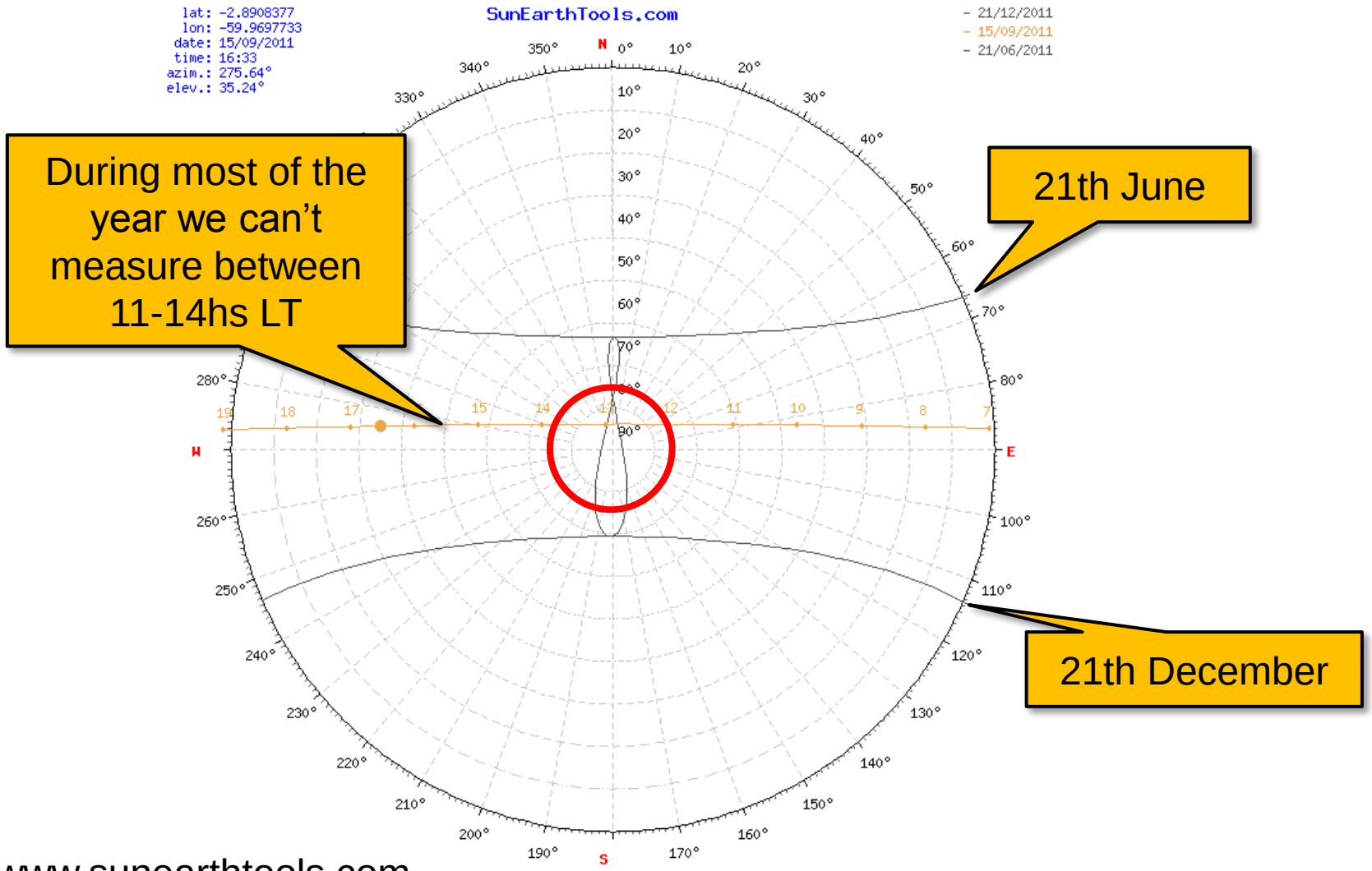
Embrapa Site – km30 AM-010



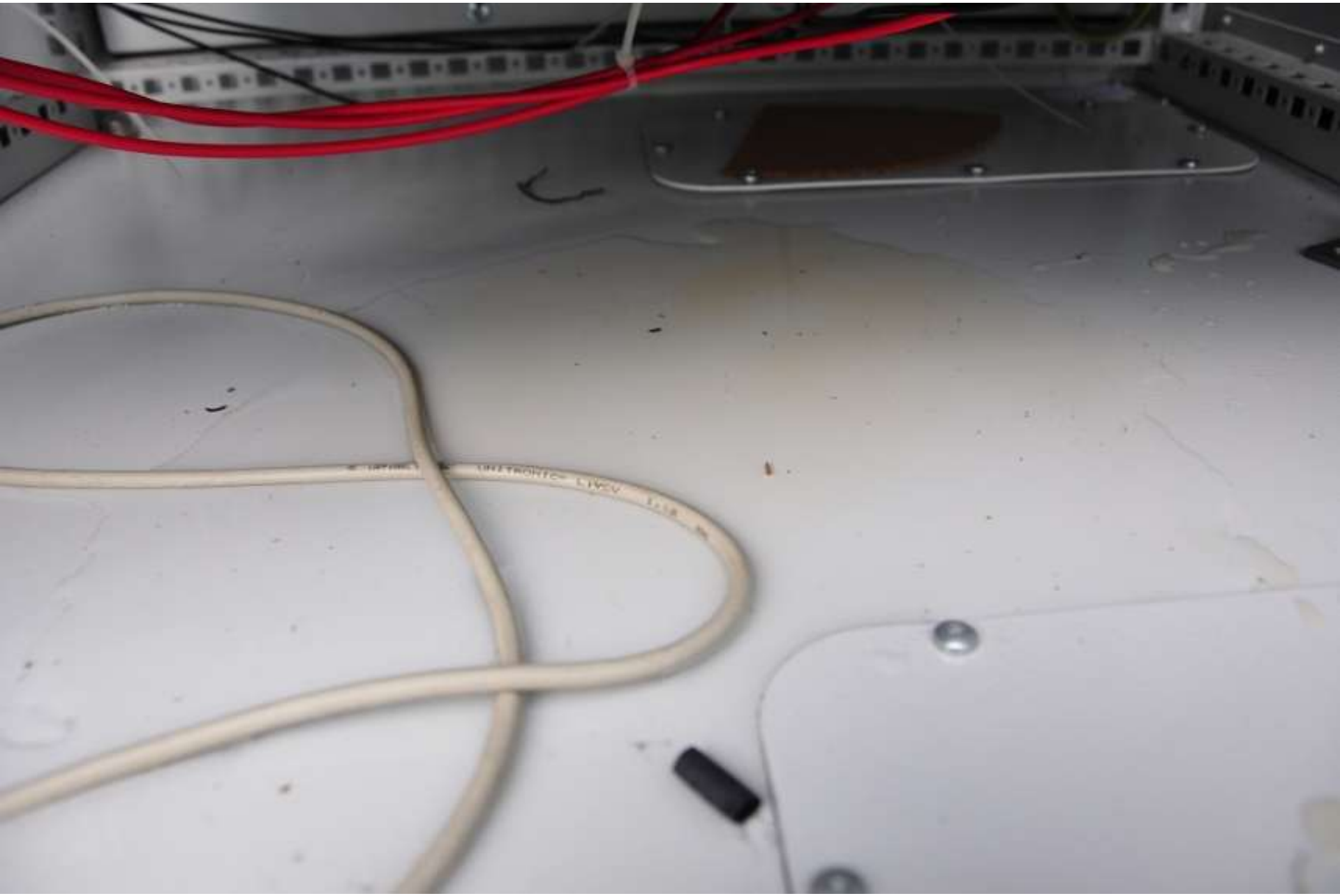
Up wind from Manaus
Paved road and easy access

Embrapa Site - Closeup

Embrapa Site – Sun Chart 2.891ºS 59.970ºW



www.sunearthtools.com



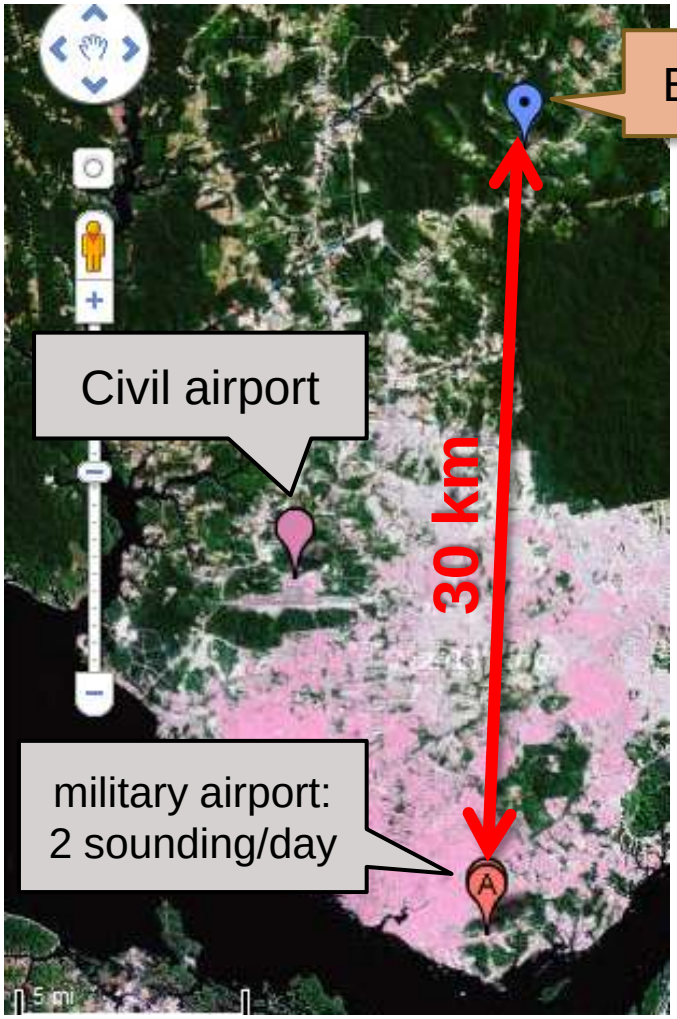
Problems

- Rital Container
  - Super-hyper-extra water proof
    - Did not survive the first rain
- IP-67 water proof position switches
  - First survived 1 week
  - Second survived 1 month

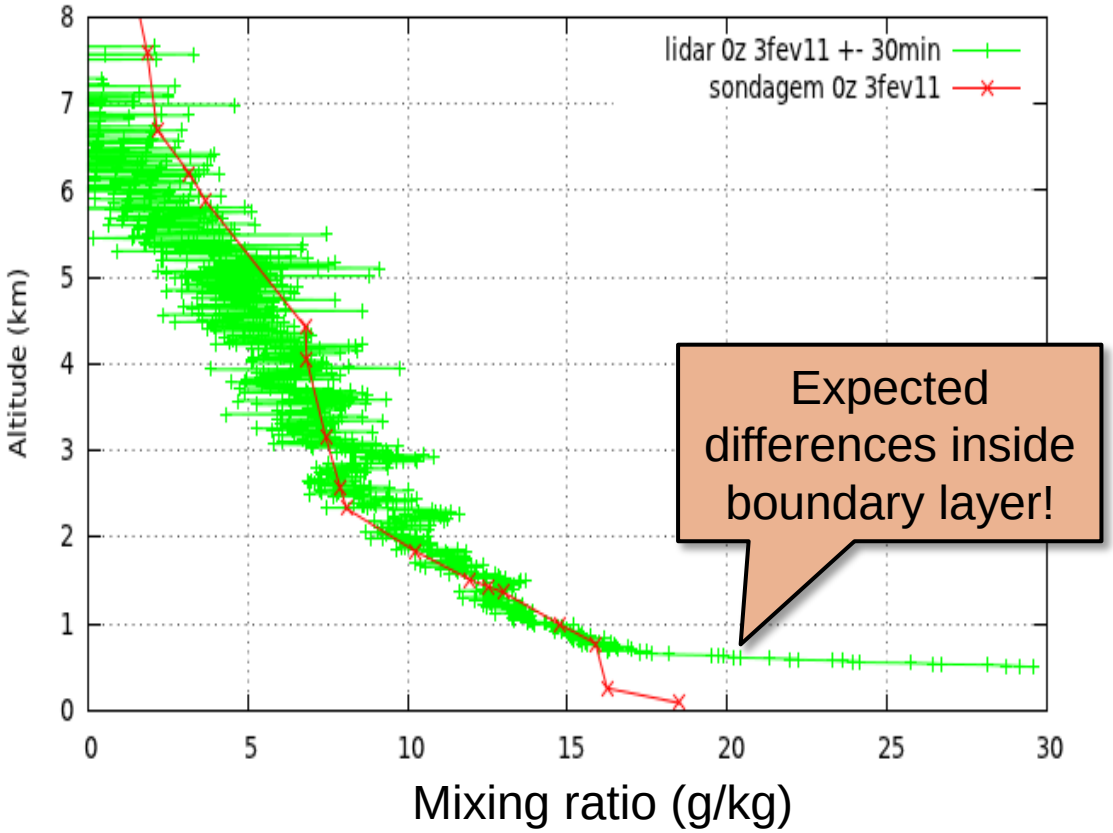
Problems

- Rital Container
  - Super-hyper-extra wat
    - Did not survive the first
- IP-67 water proof posi
  - First survived 1 week
  - Second survived 1 mo
- Unwanted visitors

Example: Water Vapor Profiles



Lidar: 23h30 feb 2nd – 0h30 feb 3rd
Sounding: 00 Z feb 3rd



Expected differences inside boundary layer!

From Pablo's lecture

- The H_2O to N_2 (O_2) Raman Signals

$$\frac{p^{\lambda_0 \to \lambda_{H_2O}}(z)}{p^{\lambda_0 \to \lambda_{N_2}}(z)} = \left(\frac{N^{H_2O}(z)}{N^{N_2}(z)}\right) \times \left(\frac{K_{H_2O}}{K_{N_2}} \times \frac{\sigma_{Raman}^{\lambda_{H_2O}}}{\sigma_{Raman}^{\lambda_{N_2}}}\right) \times \cdots$$

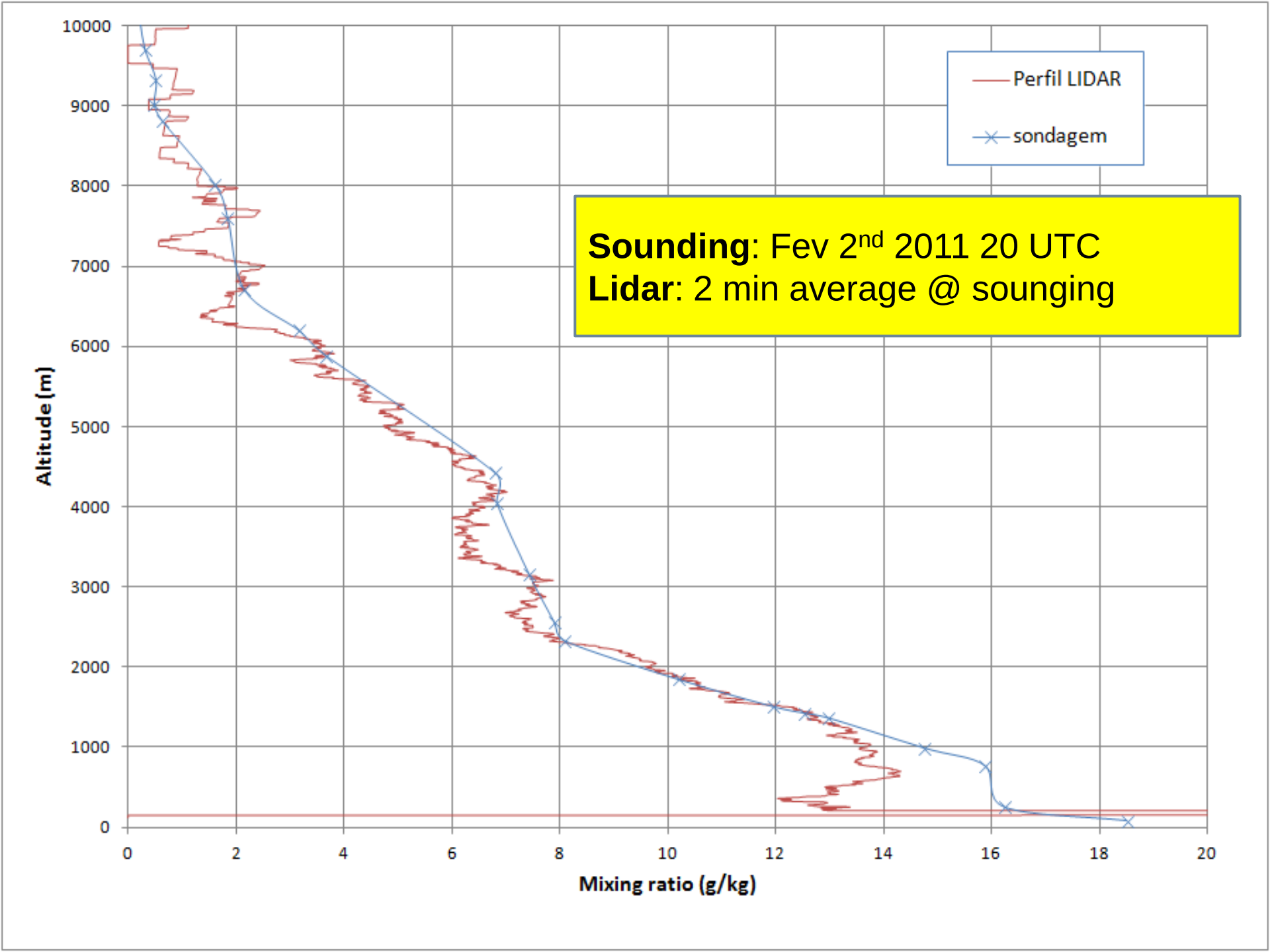
$$\cdots \times \exp\left(-\int_0^z \left(\alpha_{mol}^{\lambda_{H_2O}}(\zeta)\left(1-\left(\frac{\lambda_{H_2O}}{\lambda_{N_2}}\right)^4\right) + \alpha_{aer}^{\lambda_0}(\zeta)\left(1-\left(\frac{\lambda_{H_2O}}{\lambda_{N_2}}\right)^{\text{Å}}\right)\right) d\zeta\right)$$

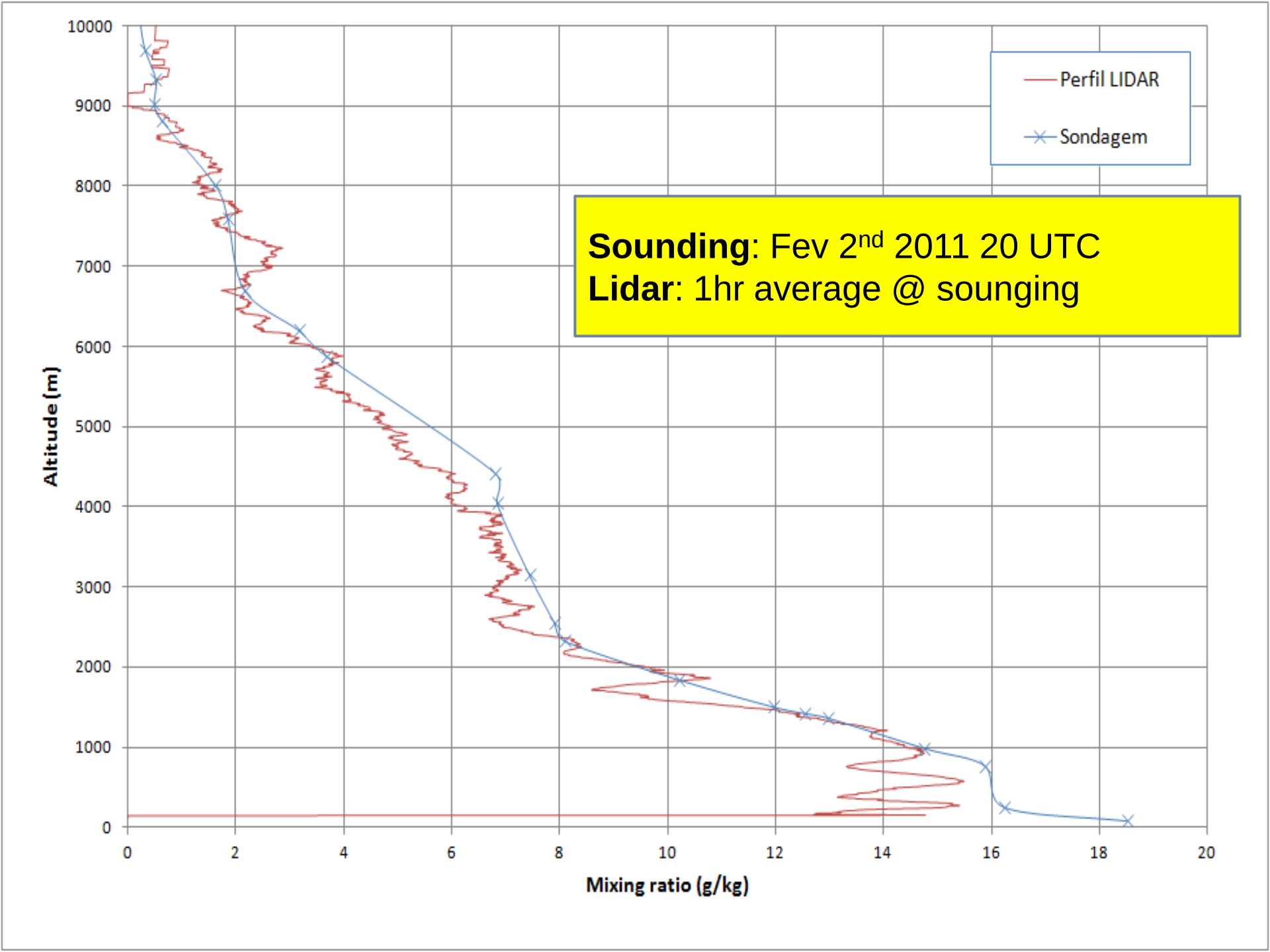
- Modeling molecular extinction, assuming low aerosol load

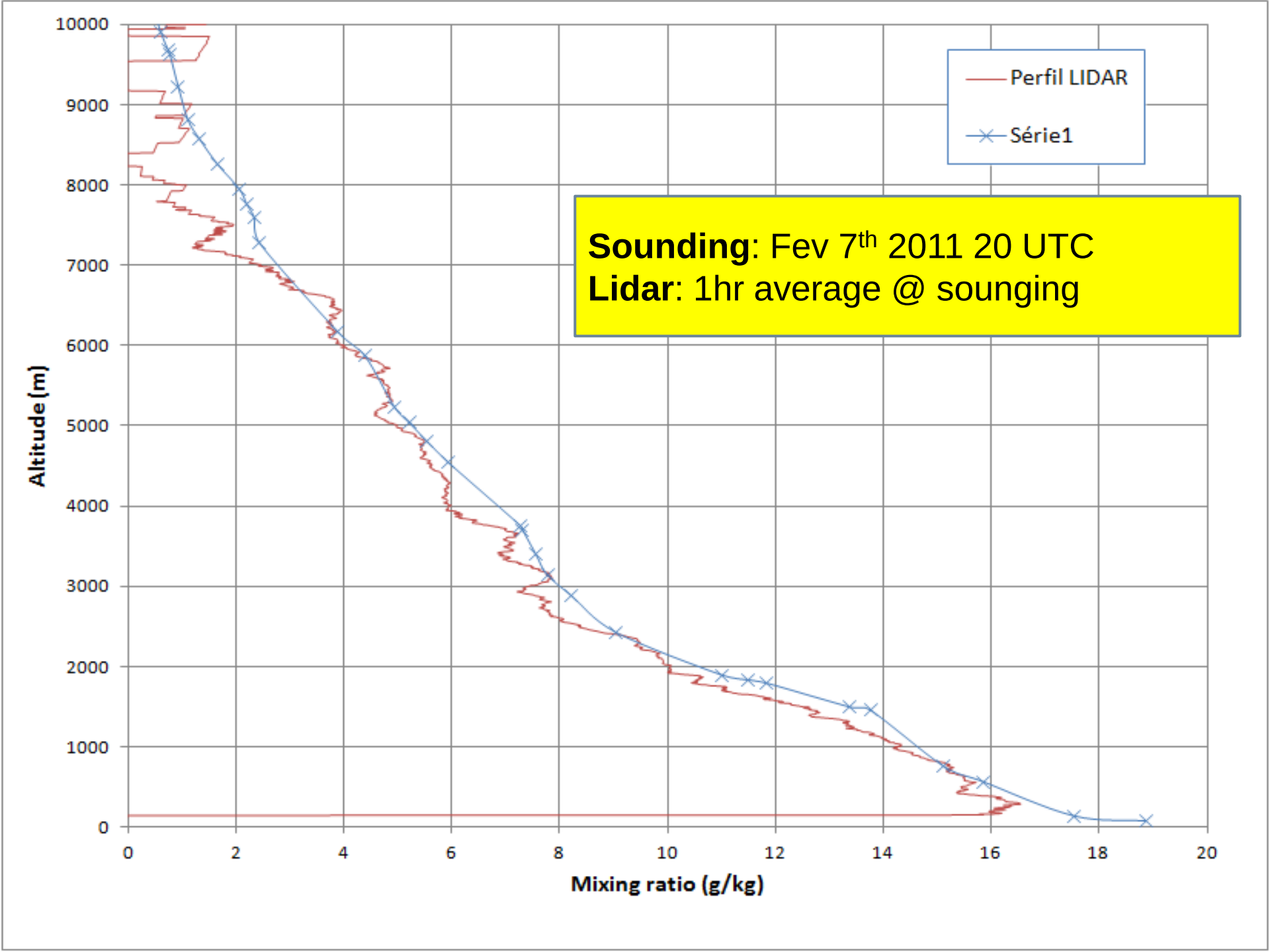
$$\left(\frac{N^{H_2O}(z)}{N^{Air}(z)}\right) = \underbrace{0.78 \times \left(\frac{K_{N_2}}{K_{H_2O}} \times \frac{\sigma_{Raman}^{\lambda_{N_2}}}{\sigma_{Raman}^{\lambda_{H_2O}}}\right)}_{Calibration} \times \underbrace{\left(\frac{p^{\lambda_0 \to \lambda_{H_2O}}(z)}{p^{\lambda_0 \to \lambda_{N_2}}(z)}\right)}_{Signal} \times \underbrace{\exp\left(\int_0^z \left(\alpha_{mol}^{\lambda_{H_2O}}(\zeta)\left(1-\left(\frac{\lambda_{H_2O}}{\lambda_{N_2}}\right)^4\right)\right) d\zeta\right)}_{Model\ or\ Measurement}$$

Water Vapor Raman Lidar: No Corrections

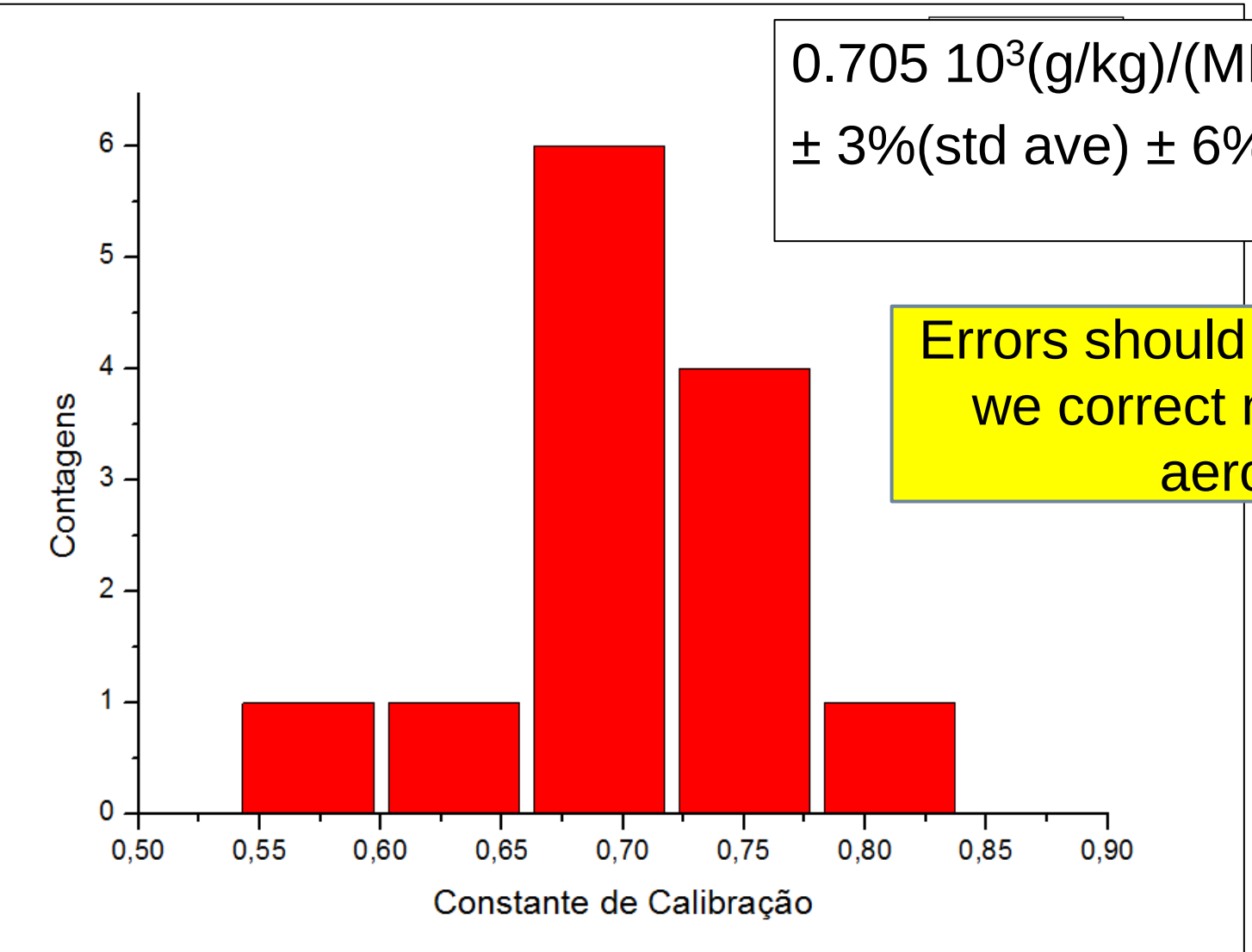
Our callibration constant


Perfil LIDAR
sondagem
Sounding: Fev 2nd 2011 20 UTC
Lidar: 2 min average @ sounging
Altitude (m)
Mixing ratio (g/kg)
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
0
2
4
6
8
10
12
14
16
18
20


Perfil LIDAR
Sondagem
Sounding: Fev 2nd 2011 20 UTC
Lidar: 1hr average @ sounging
Altitude (m)
Mixing ratio (g/kg)
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
0
2
4
6
8
10
12
14
16
18
20


Perfil LIDAR
Série1
Sounding: Fev 7th 2011 20 UTC
Lidar: 1hr average @ sounging
Altitude (m)
Mixing ratio (g/kg)
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
0
2
4
6
8
10
12
14
16
18
20

Calibration (13 soundings)



0.705 10^3(g/kg)/(MHz/MHz)

± 3%(std ave) ± 6% (ave fit err)

Errors should be reduced if we correct molecular + aerosol

ACONVEX
Aerosol, Clouds, cONVection EXperiment in the Amazon

Intensive Campaign, Aug-Sep ‘11

ADAMS, BARBOSA & PAULIQUEVIS

New experimental site @ KM30 AM-010

PWVCA - Team

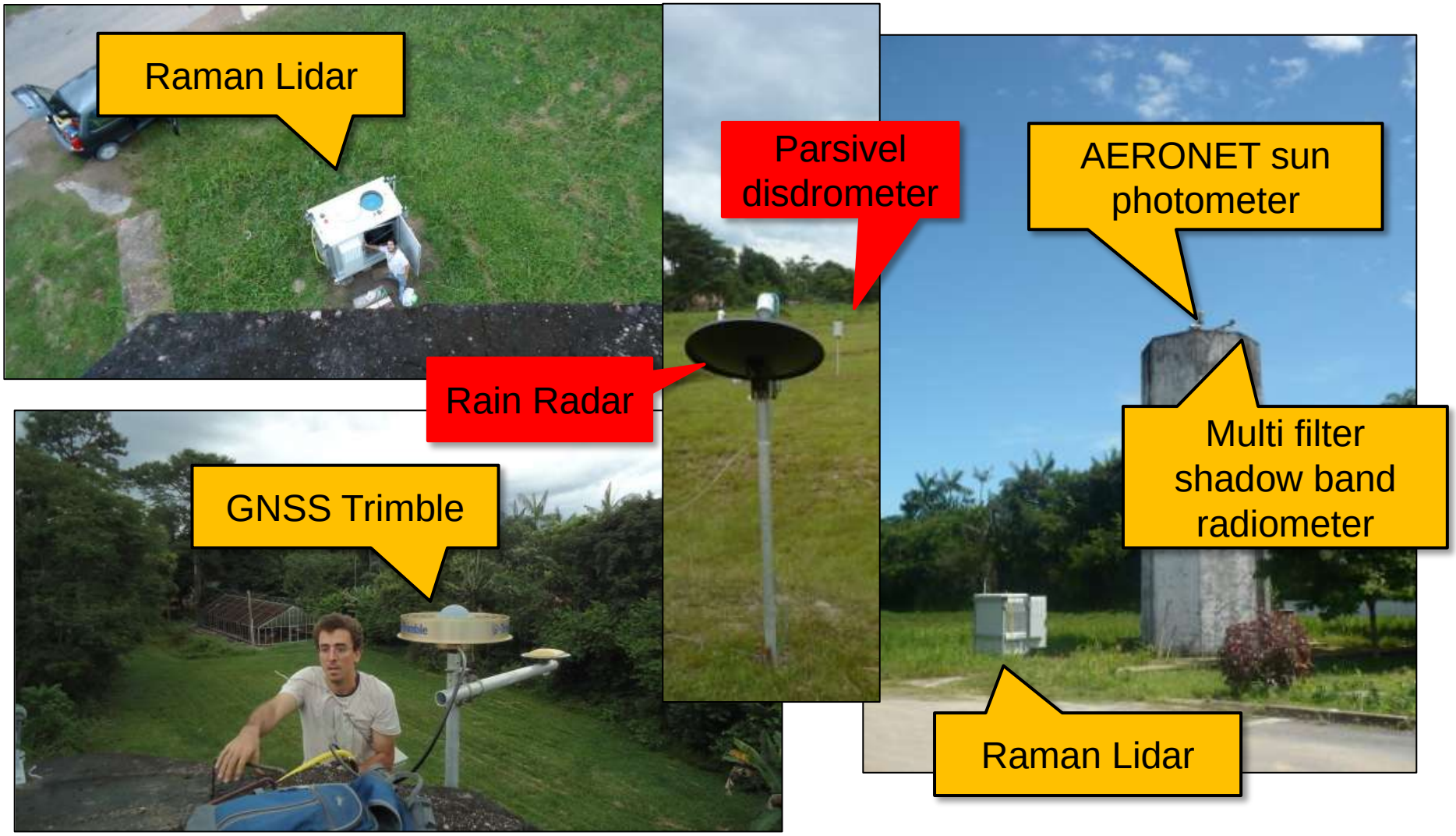
- Principal investigators:
  - Prof. David Adams - UEA
  - Prof. Henrique Barbosa - USP
  - Prof. Theotônio Pauliquevis - UNIFESP

- Collaborators
  - Prof. Paulo Artaxo – USP
  - Profa. Maria Assunção – USP
  - Prof. Luiz Augusto – INPE
  - Prof. Gilberto Fish – CTA
  - Profa. Betânia Oliveira – UEA
  - Profa. Rosa dos Santos – UEA
  - Prof. Rodrigo Souza – UEA
  - Prof. Júlio Tota – UEA

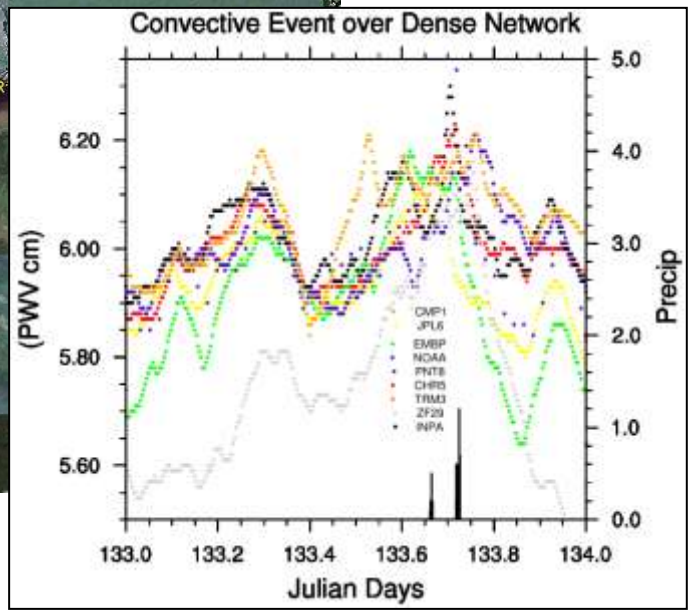
- Students
  - Glauber Cirino
  - Albert Daviet
  - Ludimila Silva
  - Diego Souza
  - Theomar Trindade

- Tech/Admin
  - Ruth Araujo – LBA
  - Fernando Morais – USP
  - Simara Oliveira – USP
  - Roberta Souza – LBA
  - Victor Souza – Embrapa

Embrapa Site - Instruments

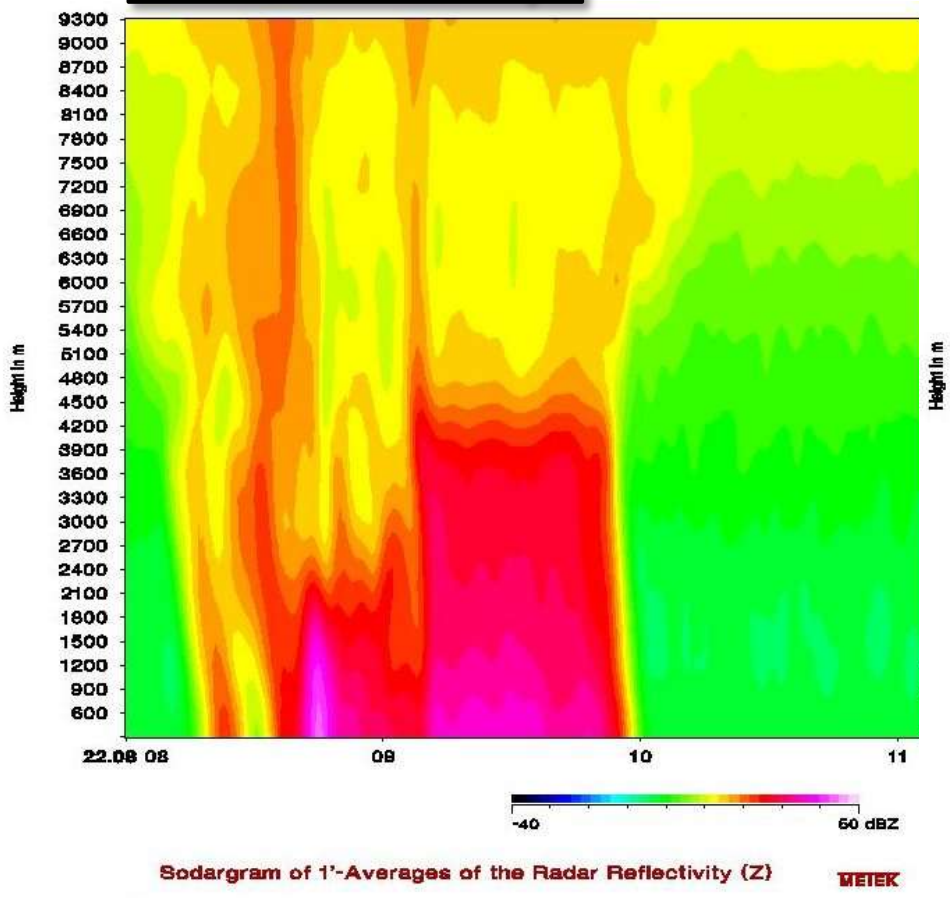


GNSS Network
Precipitable Water Vapor

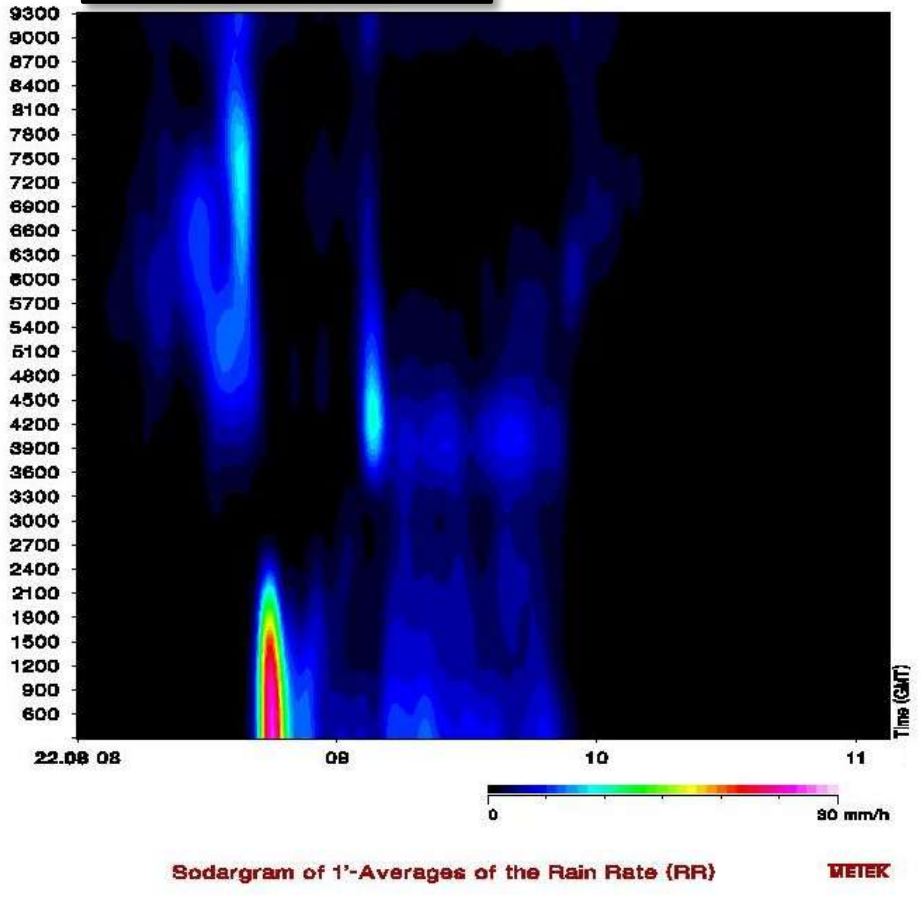


Vertical Pointing Radar (MRR) Embrapa - 22nd August 2011

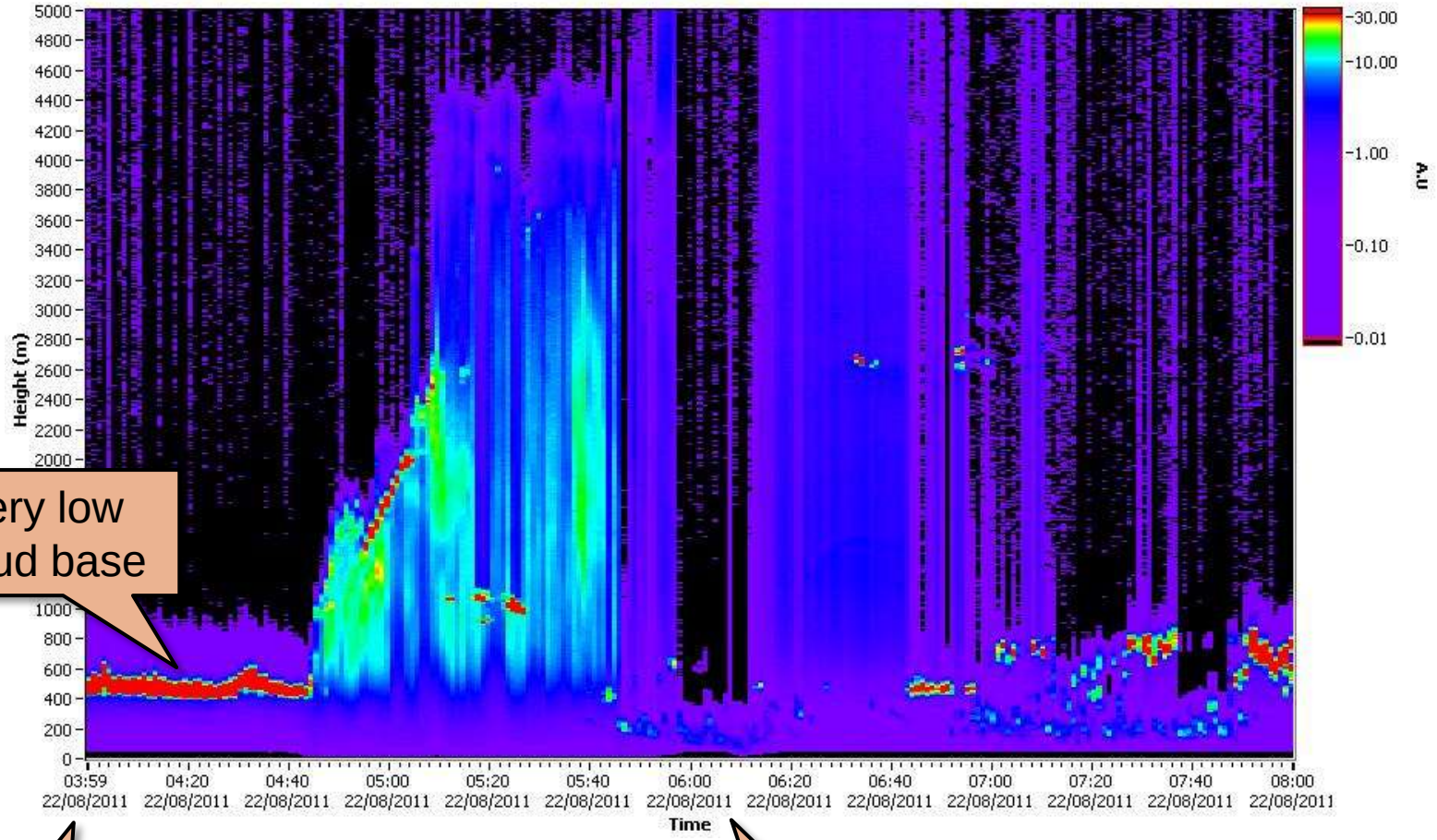
Radar Reflectivity



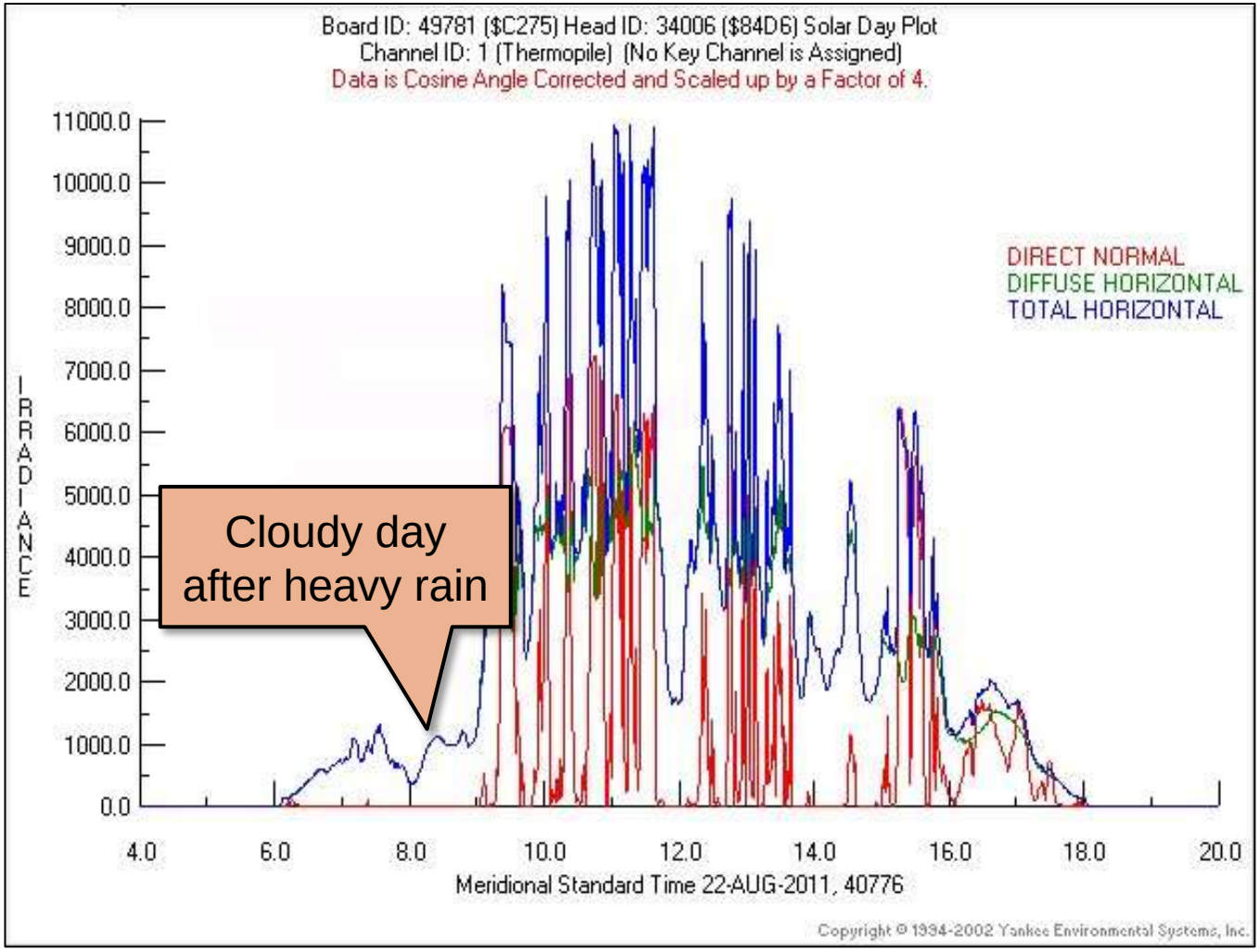
Rain Rate



Lidar Extinction Coefficient Embrapa - 22nd August 2011

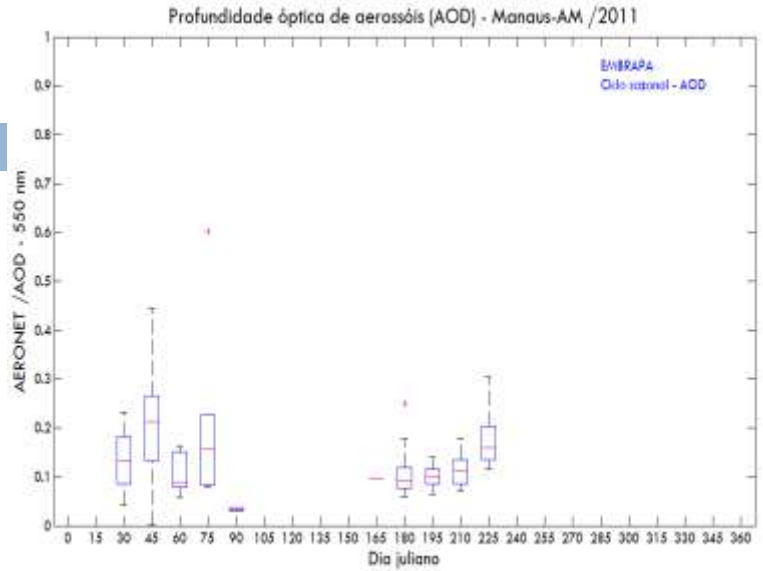


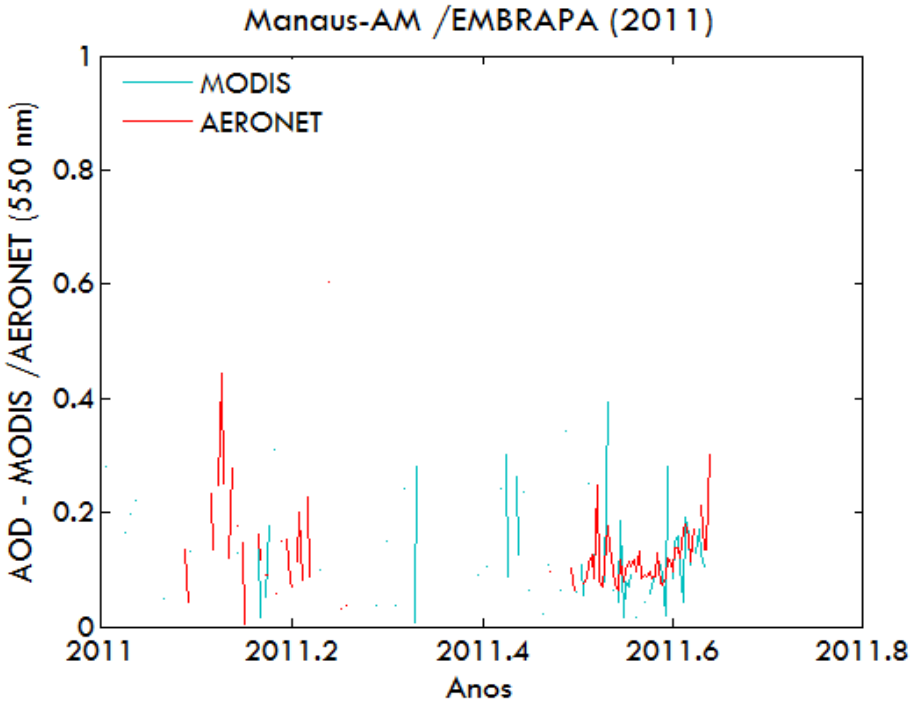
Multifilter Shadow Band Radiometer Embrapa - 22nd August 2011

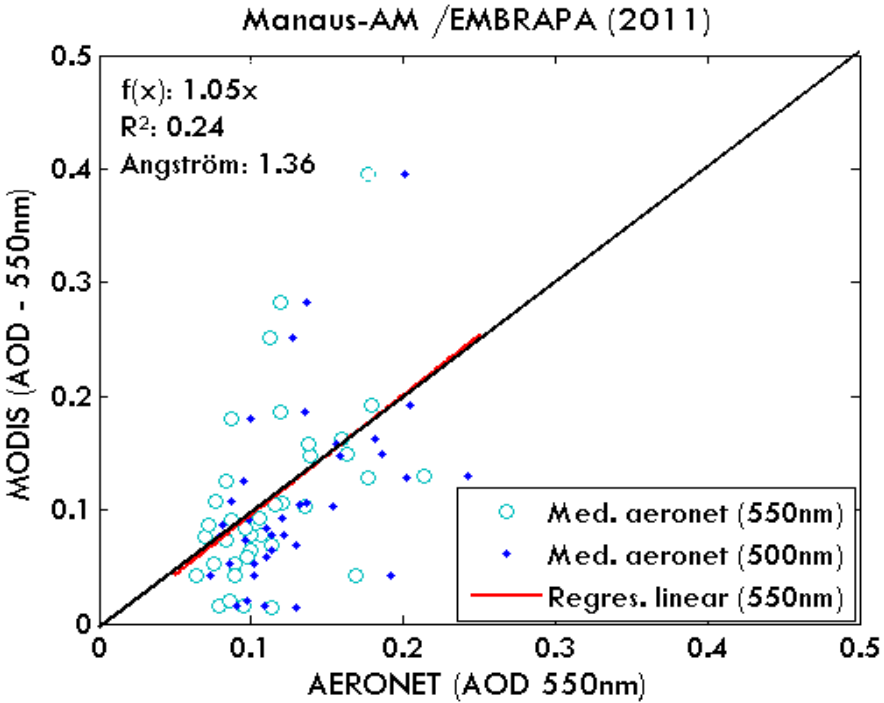


AOD Modis x Aeronet Embrapa - 2011

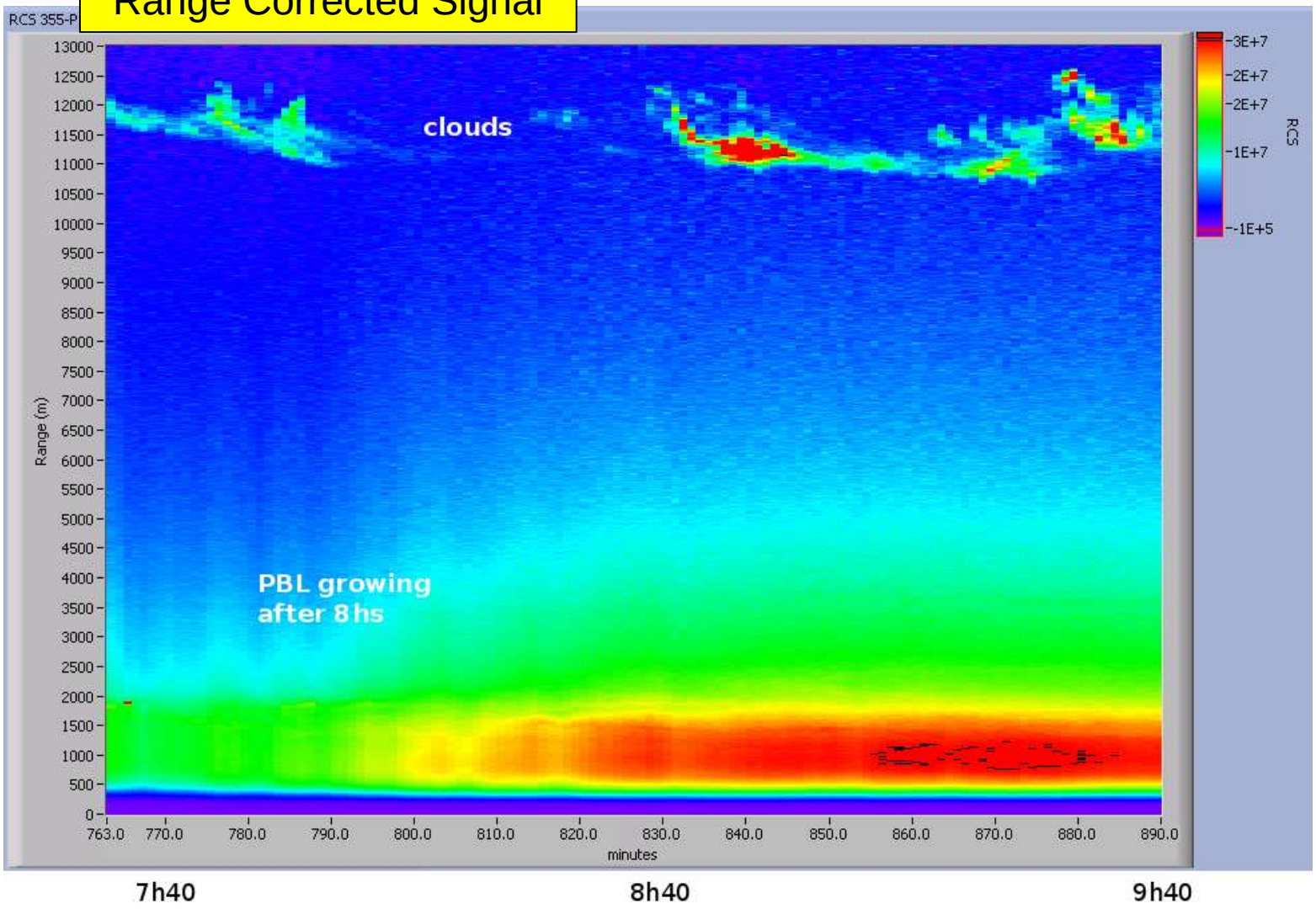
I am working on the inversion algorithms to compare both to the lidar data





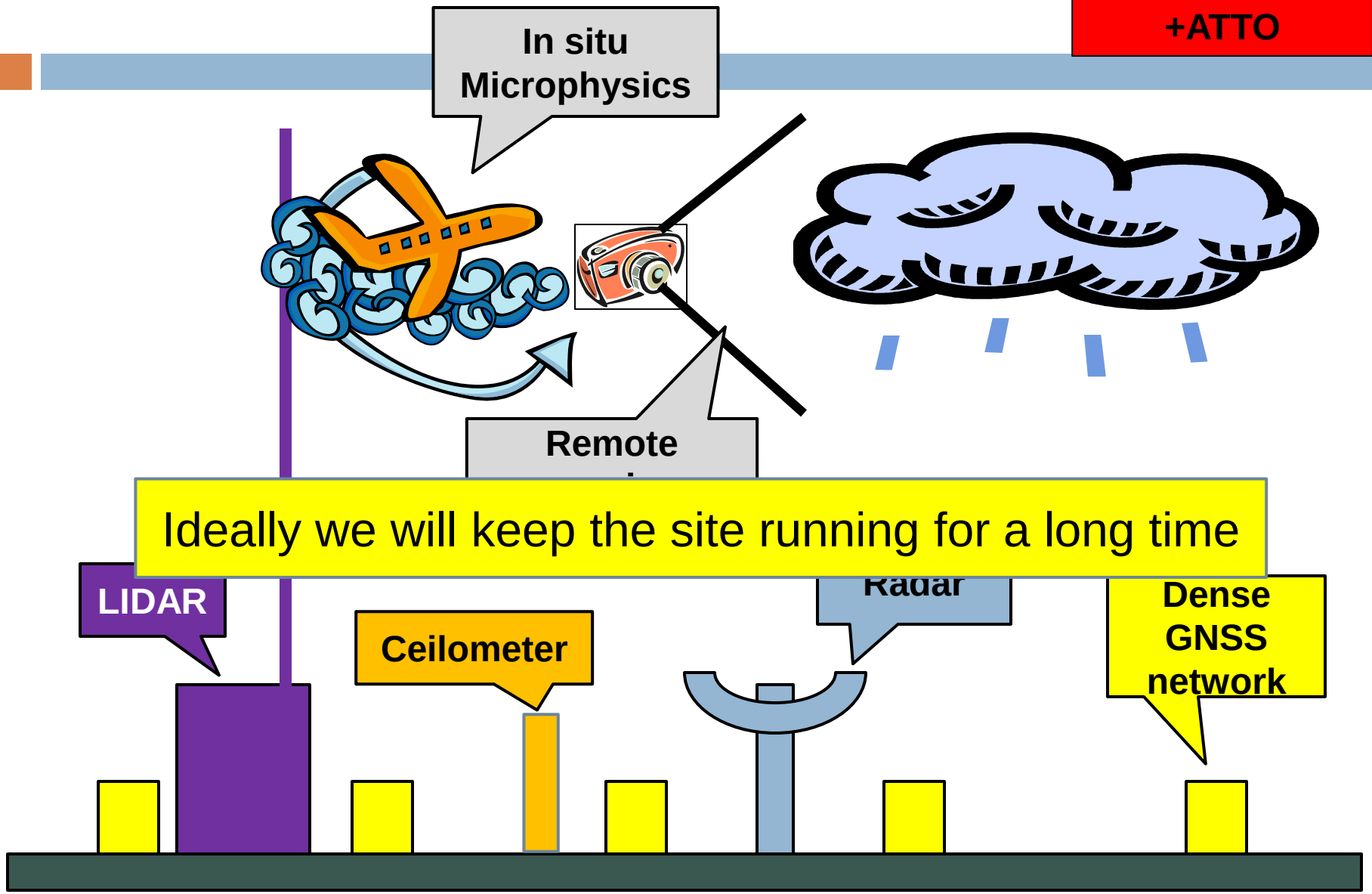


PBL Growth and Clouds Embrapa, July 28th 2011



Future Perspectives

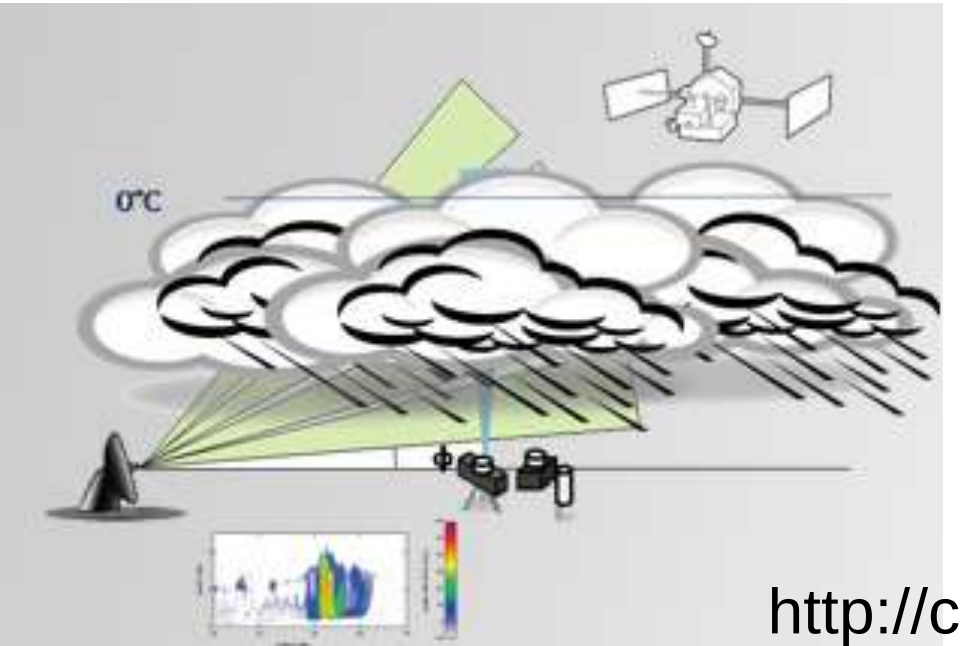
+ CHUVA
+GoAmazon
+ATTO



OTHER PROJECTS INTENSIVE CAMPAING

CHUVA Project

PI: Luiz Machado – INPE/Brasil



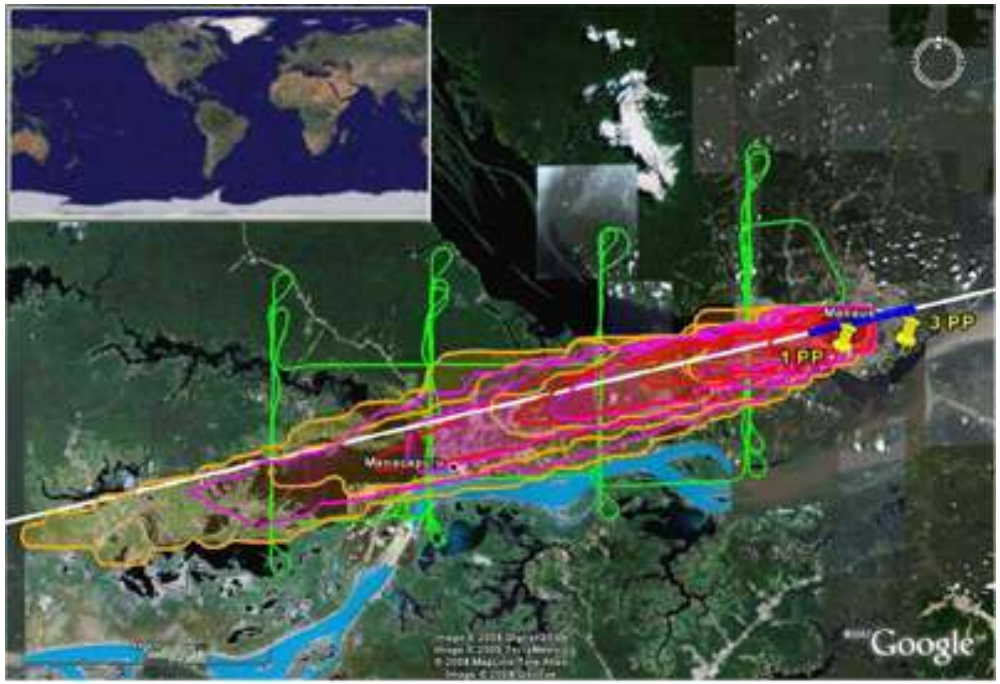
http://chuvaproject.cptec.inpe.br/portal

GoAmazon2014

PI: Scot Martin – Harvard/USA

- **The ARM Climate Research Facility in the Amazon Basin**. Led by Scot Martin, are seeking to understand aerosol and cloud life cycles, particularly the effect of aerosols on cloud formation and precipitation.

- To support their research, ARM will deploy its ARM Mobile Facility (AMF), ARM Aerial Facility's Gulfstream-1, and the Mobile Aerosol Observing System within the Amazon Basin from January through December 2014.



http://www.seas.harvard.edu/environmental-chemistry/GoAmazon2014/

ATTO - Amazonian Tall Tower Observatory

Germany/Brazil partnership

O.125.0.html

4 smal
1 tall to

gracias!

Complicated logistics...

but very interesting physics!
Students and colaborations are wellcome!!
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