Cirrus clouds observation in Santa Maria, Rio Grade do Sul during the experiment CHUVA – SUL.

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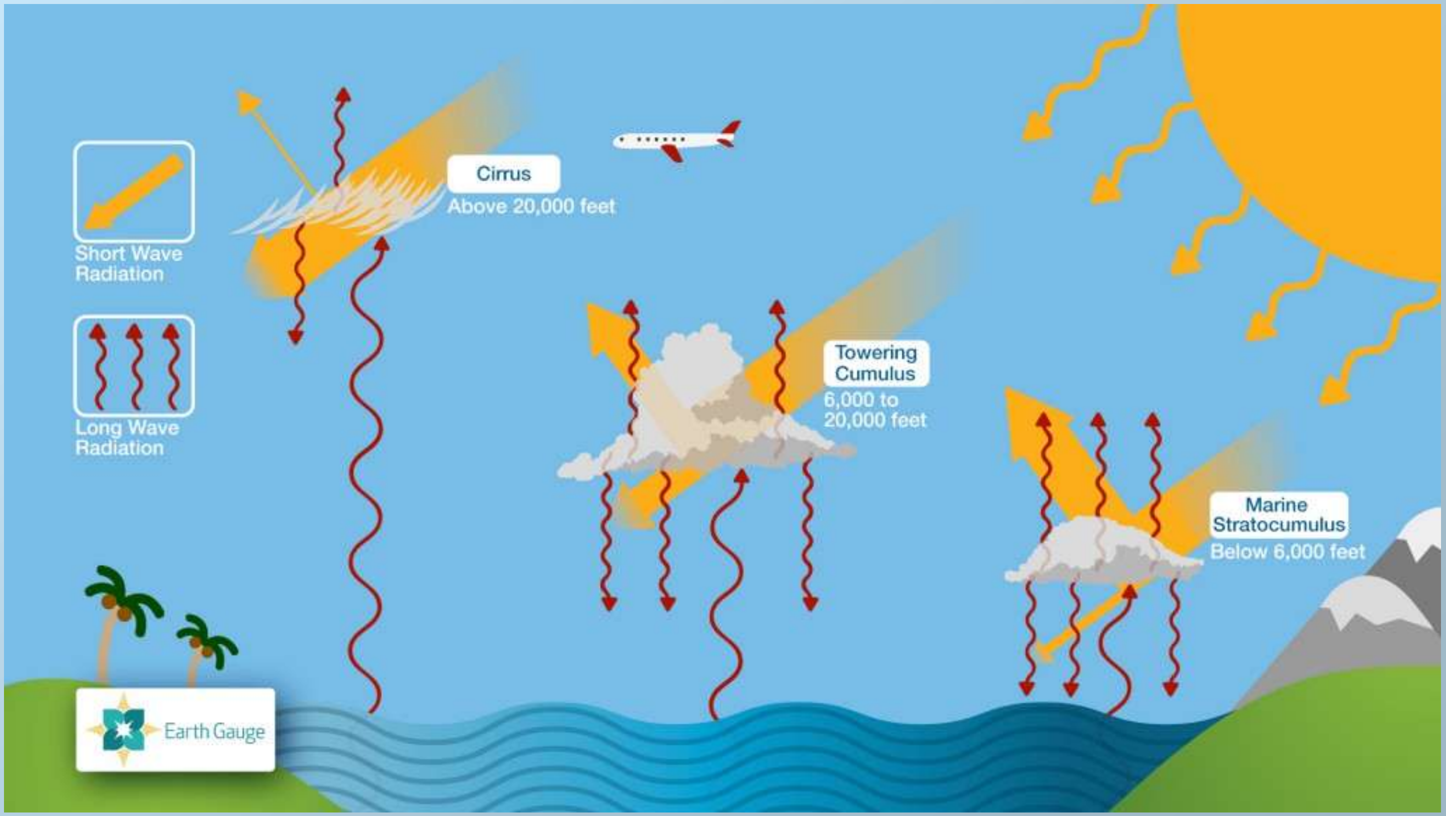
Motivation

1. Cirrus can affect the atmospheric radiation budget by reflecting the incoming solar radiation and absorbing the outgoing terrestrial radiation

2. Cirrus are involved in the dehydration of the upper troposphere and lower stratosphere.



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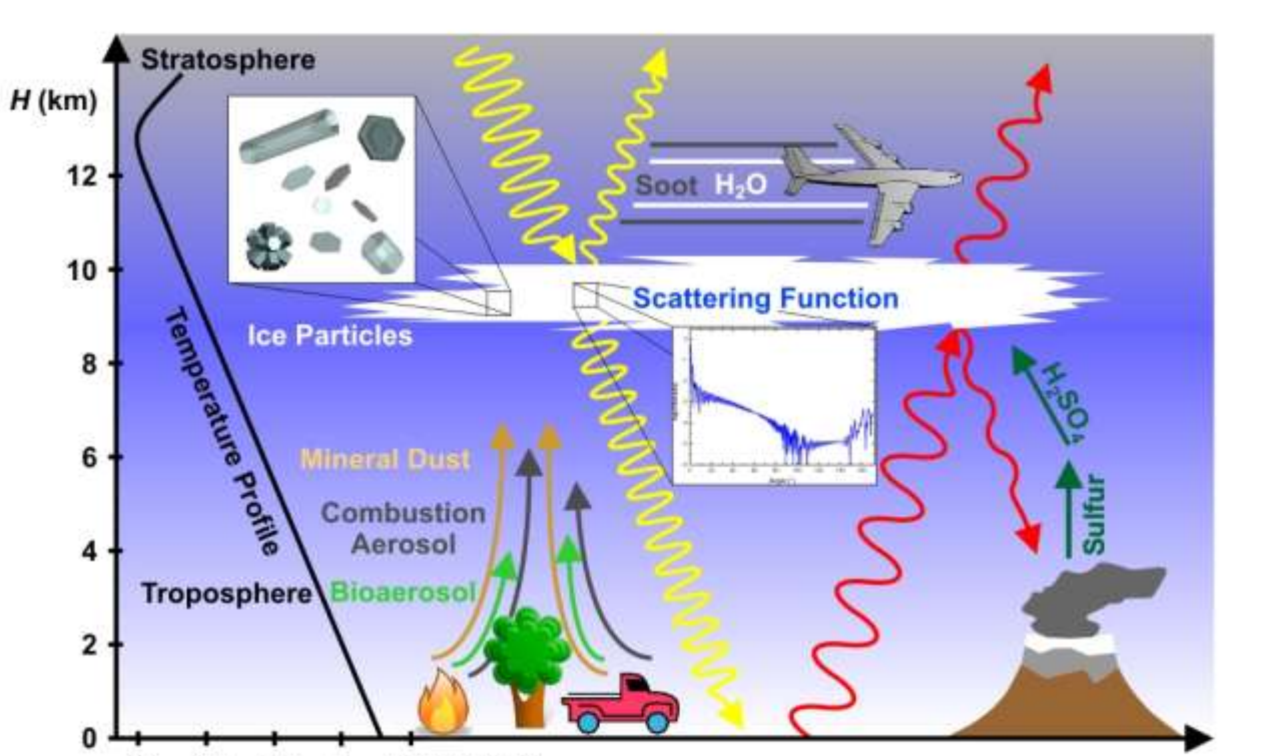


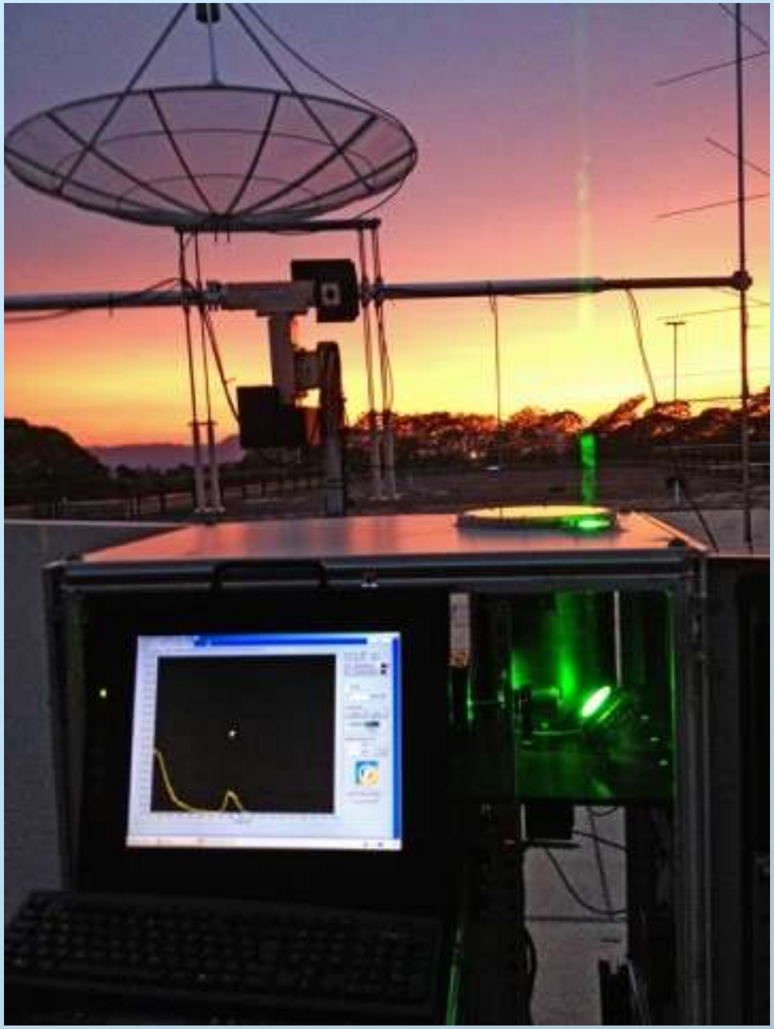
http://www.imk-aaf.kit.edu/348.php

Data and measurement Site

CHUVA- SUL. Many instruments were located in different sites

- Lidar measurements were conducted in the Santa Maria site (29.8 °S; 53.7 °W, 100 m asl).
- Four days of lidar cirrus clouds measurements were selected: 7, 8, 19 and 28 of November 2012
- Cirrus cloud optical depth was analyzed during these days

Instrument



Elastic-backscatter lidar:

Nd:Yag - Quantel CFR 200

20 mJ @ 532 nm

Pulse: 8 ns, Rate: 10 Hz

Divergence: 0.5 mrad

Newtonian telescope of 20 cm diameter and focal length of 1 m.

Narrowband interference filter (0.5 nm FWHM).

Photomultiplier tube (PMT) and an electronic transient recorder operating in photo-counting and in analog mode.

Algorithm for base and top altitude

z, nfotons

↓

Find ALL minimums maximums

↓

Sliding average and local fitting

↓

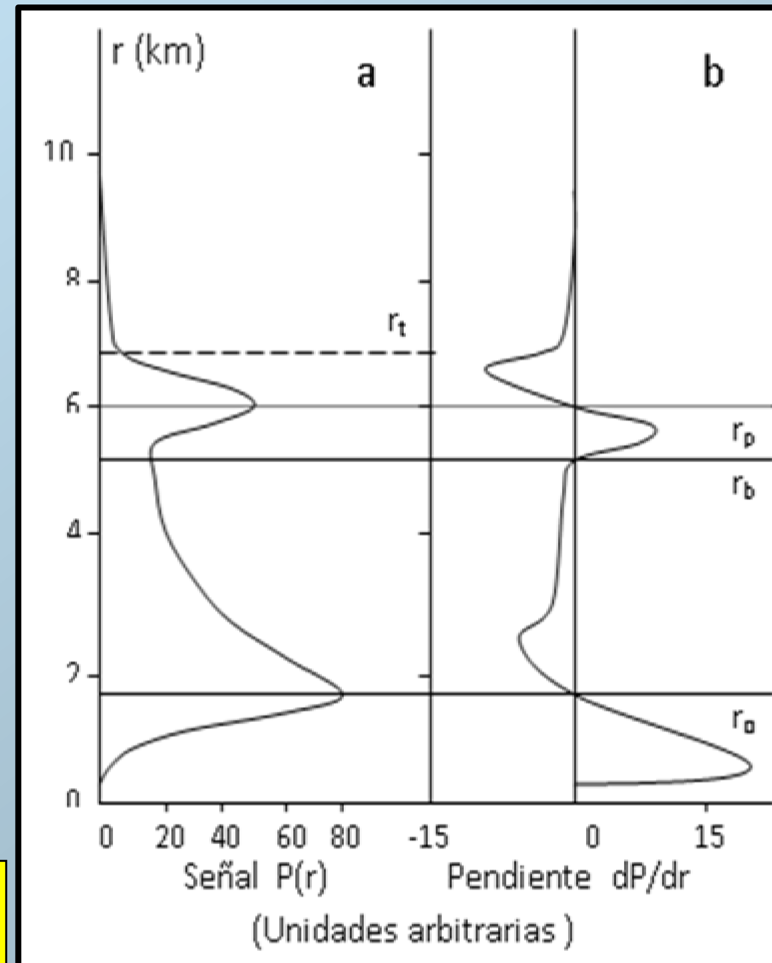
Peak height / noise to select real peaks or valleys

↓

Select molecular region => aerosol backscatter

⇒

Decide if it is a cloud or an aerosol layer



Method

- **Cirrus clouds backscattering coefficients profile was calculated from the raw photon number signal using the Klett method, the normalization altitude was selected after the top altitude.**

- **Molecular backscattering coefficient was obtained from the radio sounding launched in the measurement site during the days of campaigns.**

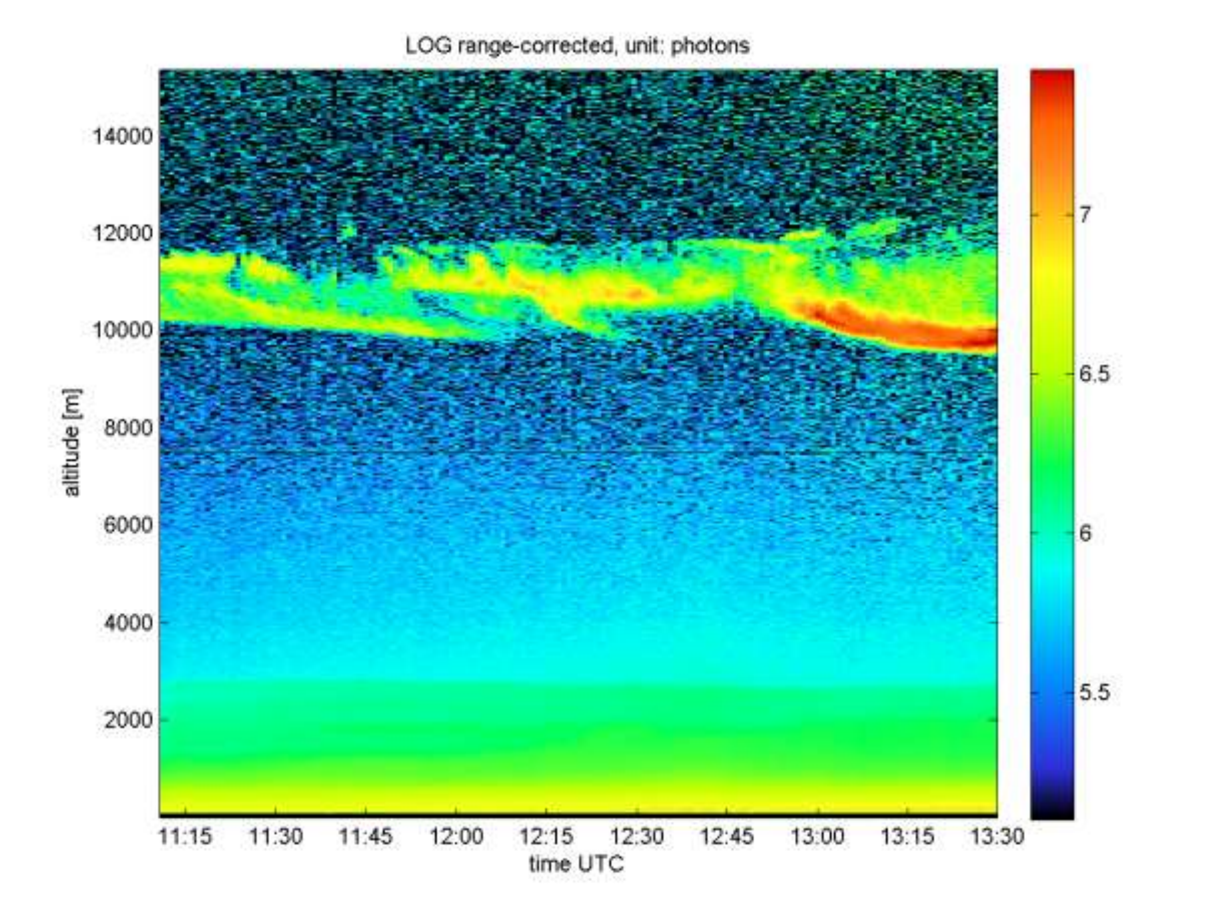
- **Using a threshold criteria from the backscattering coefficient new values of base and top altitudes were selected.** The sum of the average value and twice the standard deviation of backscattering coefficient between 19 and 20 km of altitude.

- **Lidar Ratio: 18 sr, was assumed from the literature to obtain the extinction coefficient profile.**

- **Cirrus cloud optical depth is the integration of the extinction coefficient between the cirrus cloud base and top altitudes.**

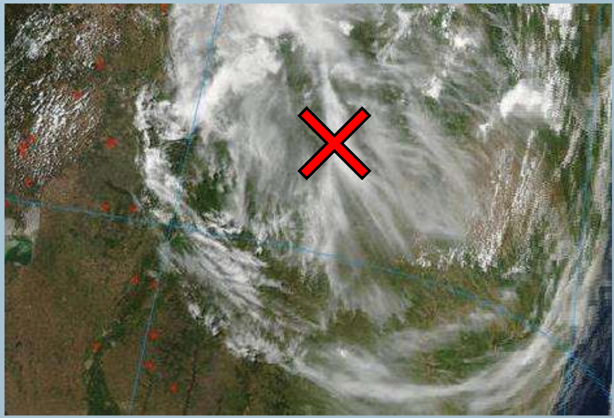
RESULTS

November 7, 2013.



MODIS TERRA 13:35 UTC.

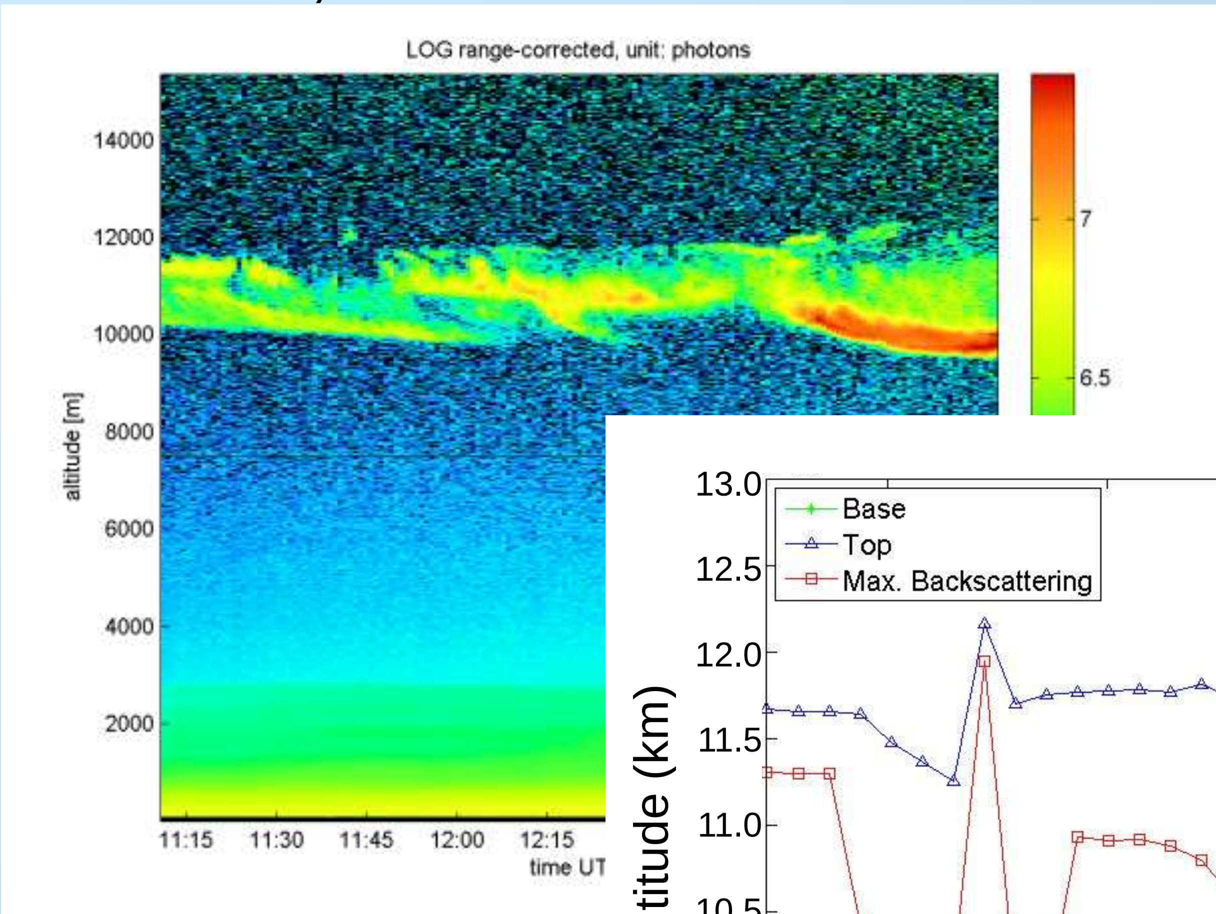
MODIS AQUA 17:50 UTC.

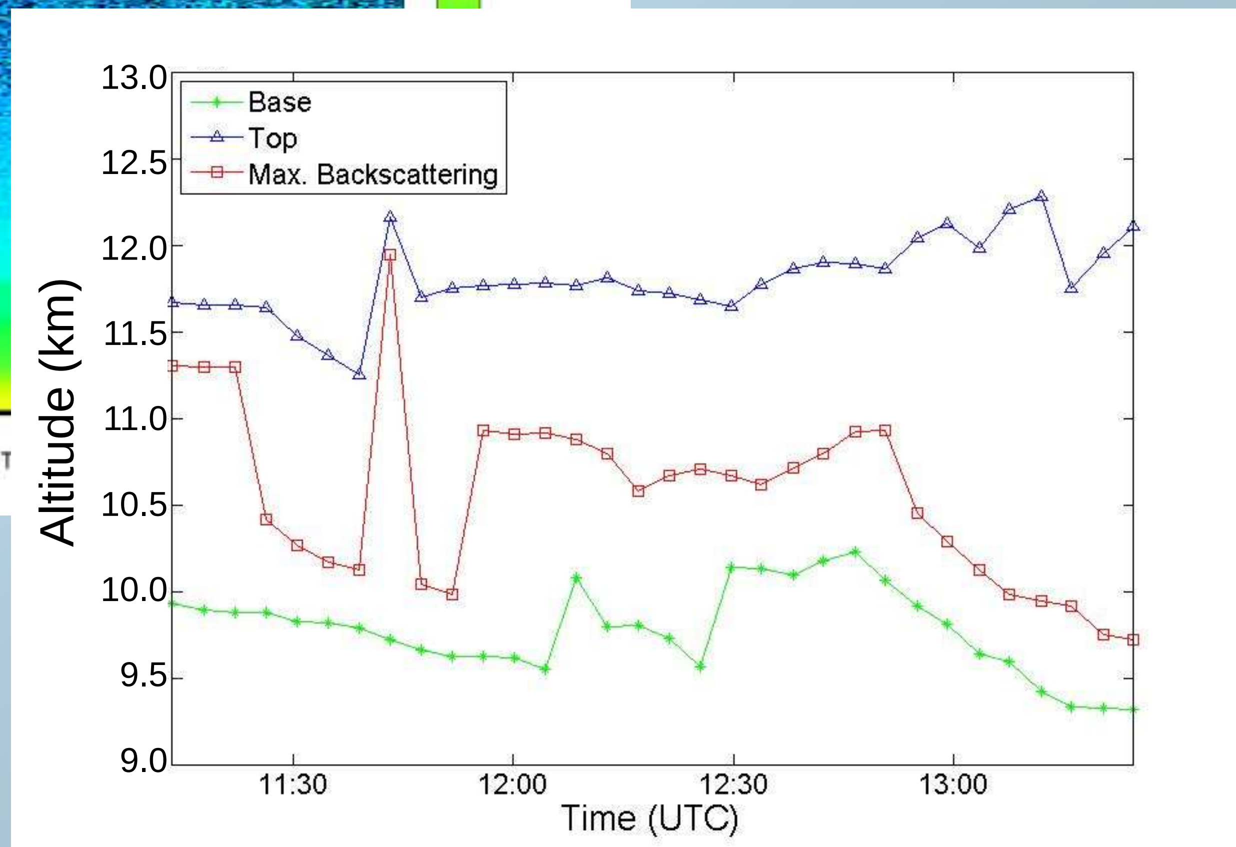


Region with occurrence of high clouds and cirrus clouds

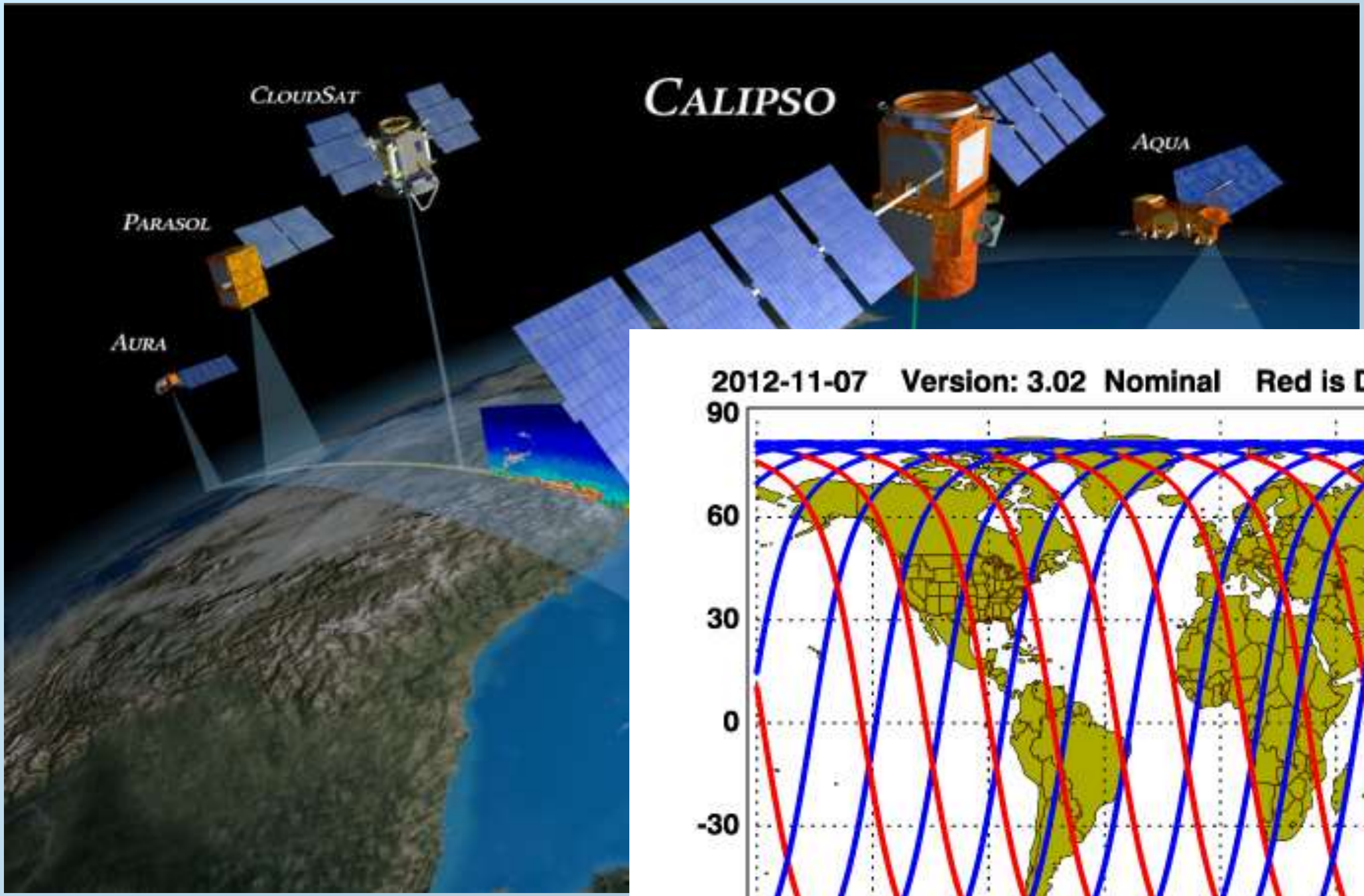
RESULTS

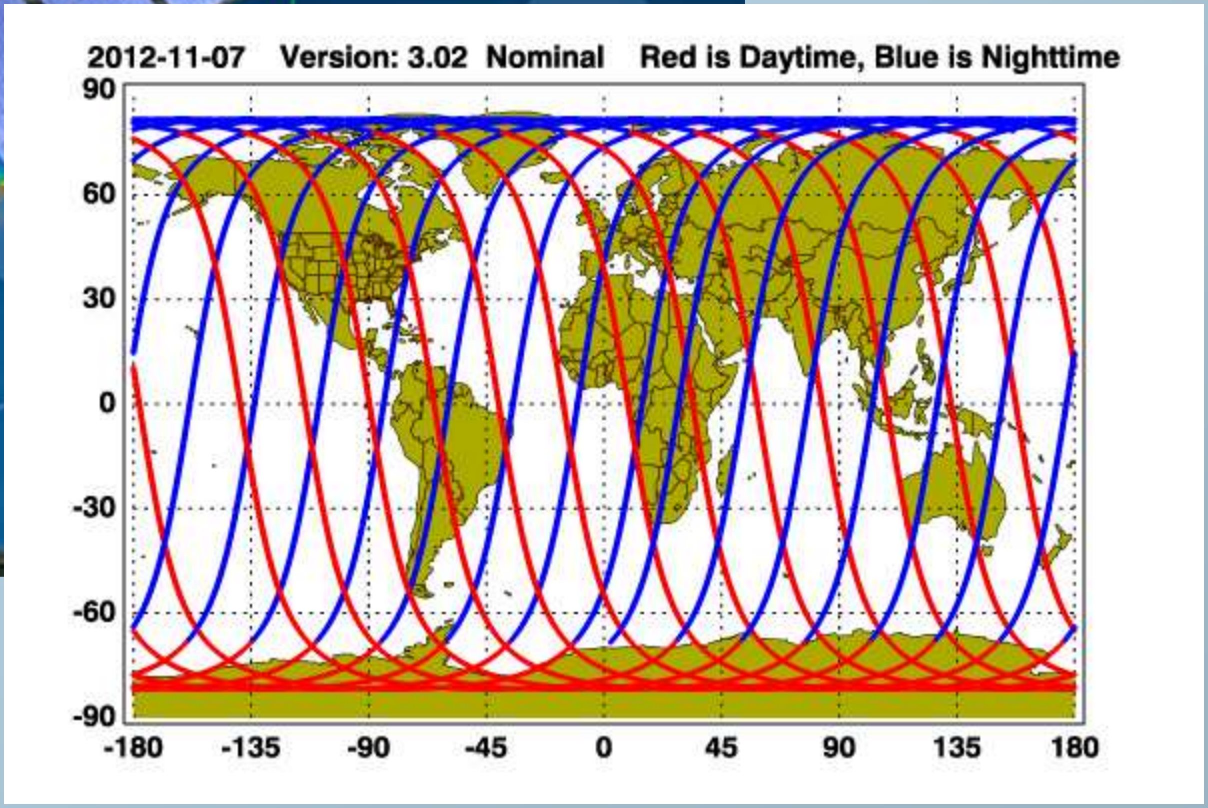
November 7, 2013.



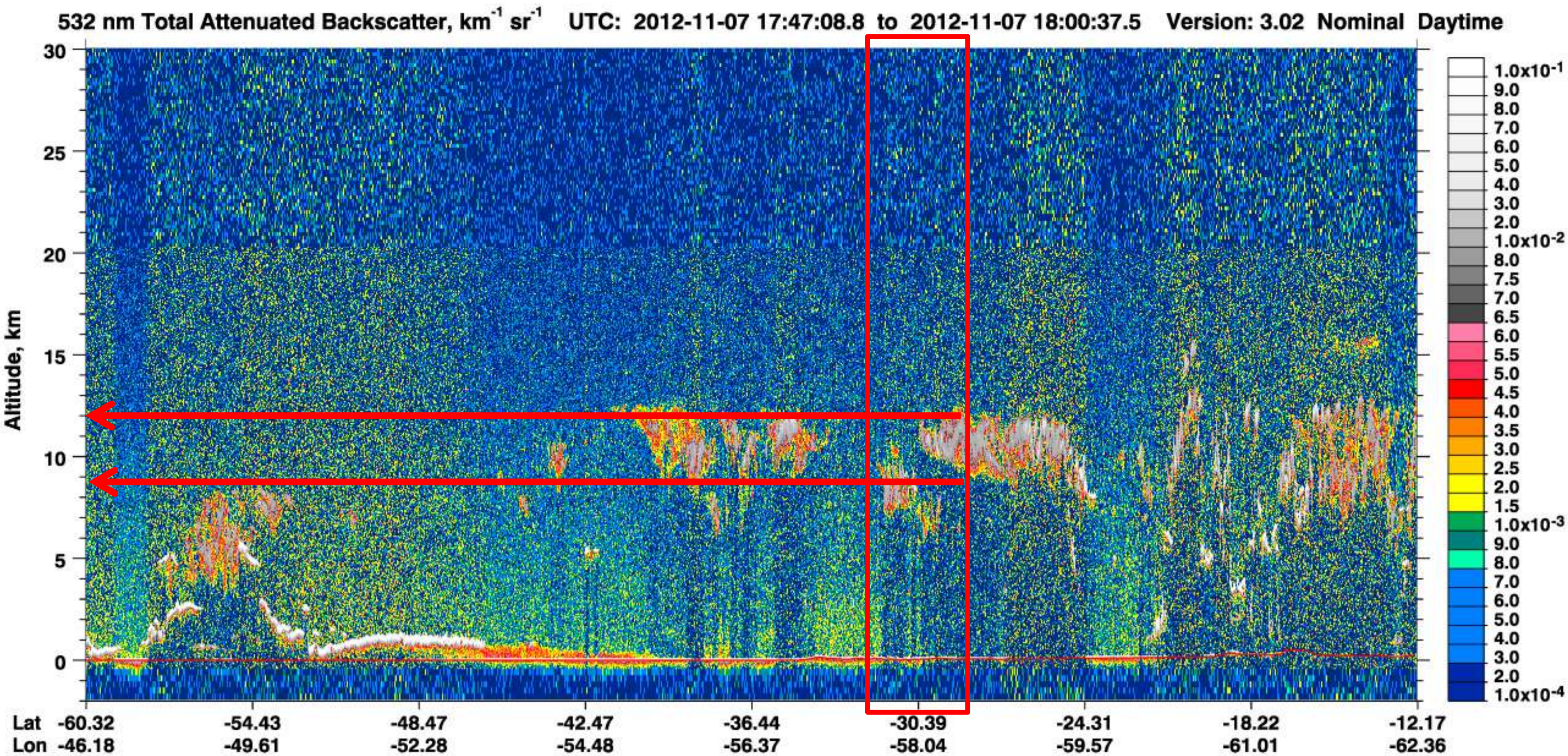


CALIPSO


CLOUDSAT
CALIPSO
AQUA
PARASOL
AURA

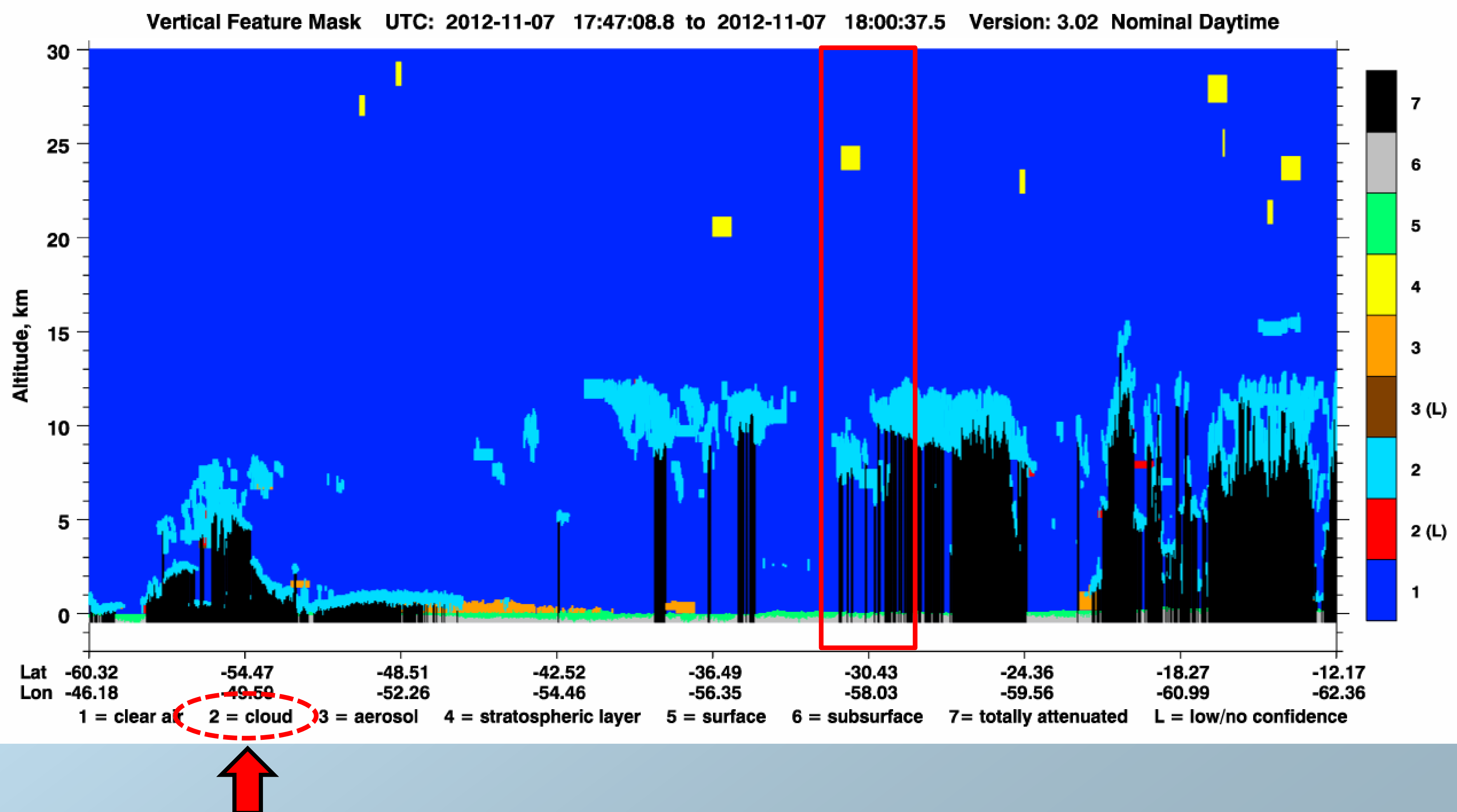

2012-11-07 Version: 3.02 Nominal Red is Daytime, Blue is Nighttime
90
60
30
0
-30
-60
-90
-180
-135
-90
-45
0
45
90
135
180

CALIPSO



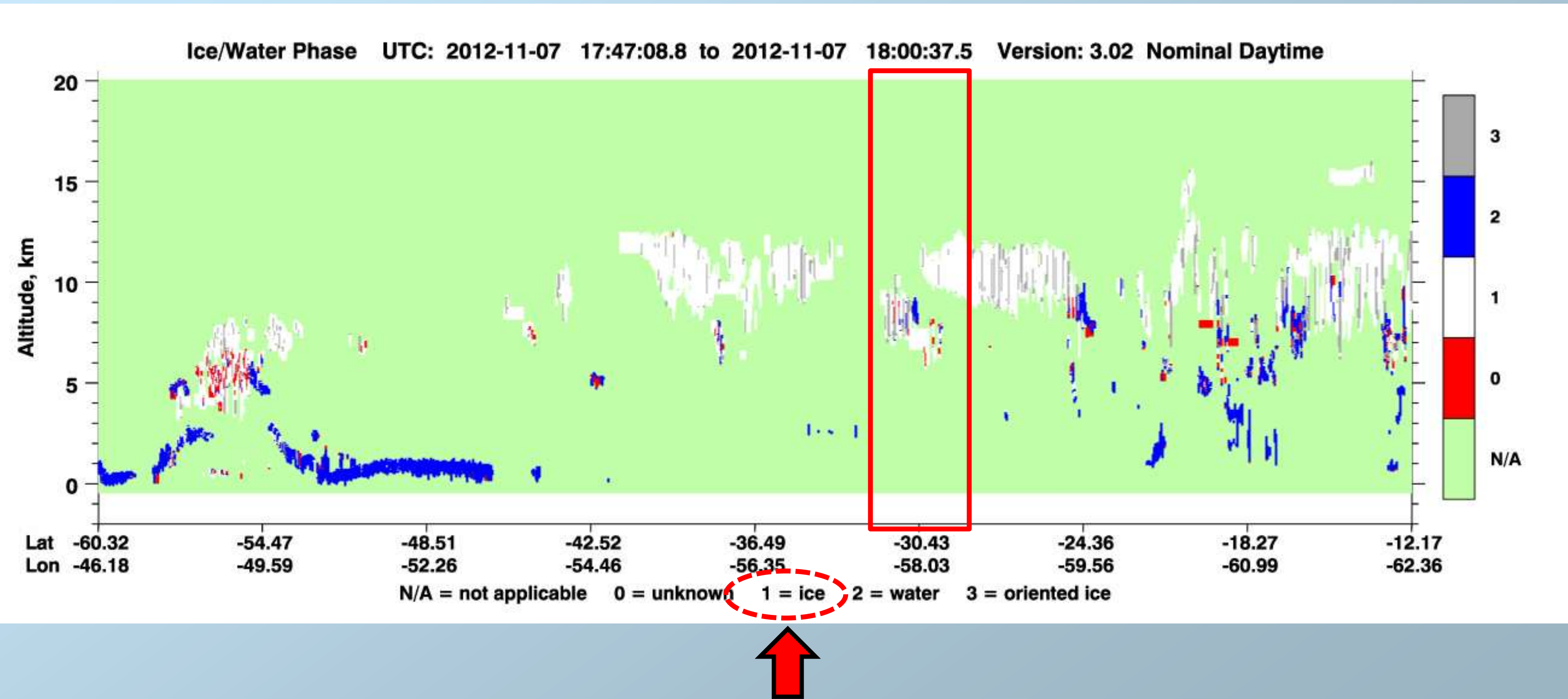
532 nm Total Attenuated Backscatter, km^{-1} sr^{-1} UTC: 2012-11-07 17:47:08.8 to 2012-11-07 18:00:37.5 Version: 3.02 Nominal Daytime
Altitude, km
30
25
20
15
10
5
0
Lat -60.32 -54.43 -48.47 -42.47 -36.44 -30.39 -24.31 -18.22 -12.17
Lon -46.18 -49.61 -52.28 -54.48 -56.37 -58.04 -59.57 -61.01 -62.36
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}

CALIPSO



Vertical Feature Mask UTC: 2012-11-07 17:47:08.8 to 2012-11-07 18:00:37.5 Version: 3.02 Nominal Daytime
Altitude, km
30
25
20
15
10
5
0
7
6
5
4
3
3 (L)
2
2 (L)
1
Lat -60.32 -54.47 -48.51 -42.52 -36.49 -30.43 -24.36 -18.27 -12.17
Lon -46.18 -52.26 -54.46 -56.35 -58.03 -59.56 -60.99 -62.36
1 = clear air 2 = cloud 3 = aerosol 4 = stratospheric layer 5 = surface 6 = subsurface 7= totally attenuated L = low/no confidence

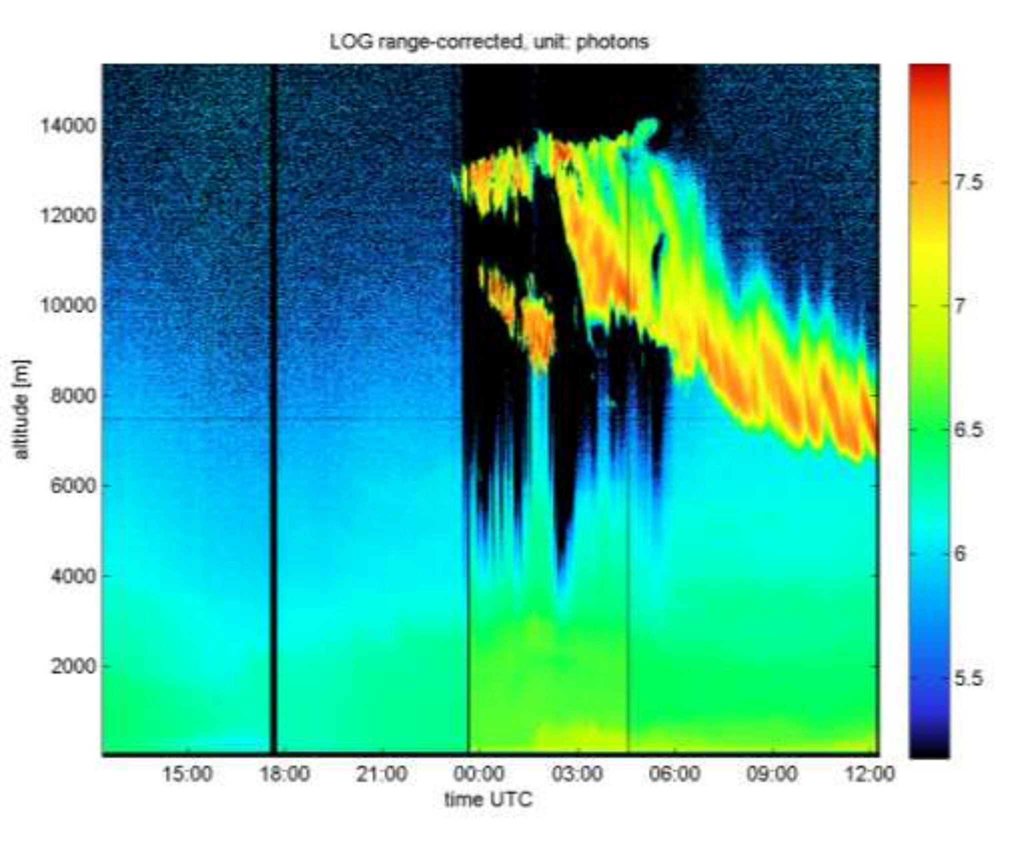
CALIPSO



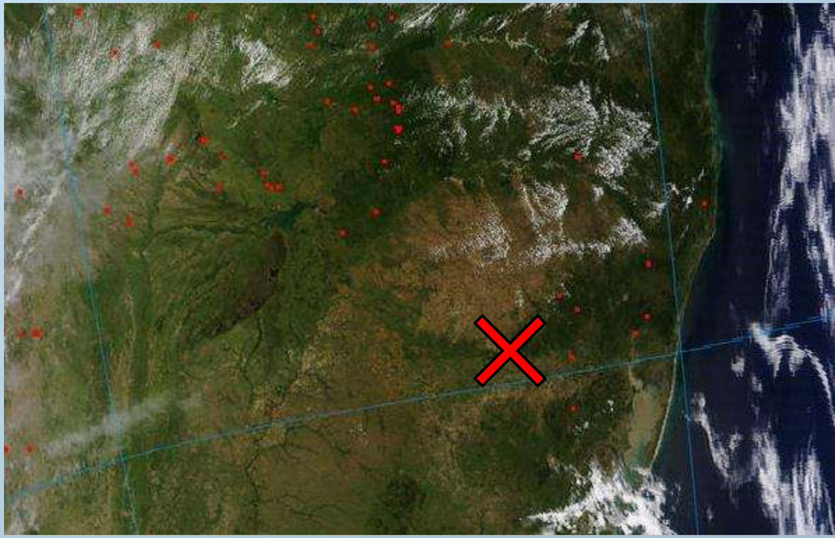
Ice/Water Phase UTC: 2012-11-07 17:47:08.8 to 2012-11-07 18:00:37.5 Version: 3.02 Nominal Daytime
Altitude, km
20
15
10
5
0
3
2
1
0
N/A
Lat -60.32 -54.47 -48.51 -42.52 -36.49 -30.43 -24.36 -18.27 -12.17
Lon -46.18 -49.59 -52.26 -54.46 -56.35 -58.03 -59.56 -60.99 -62.36
N/A = not applicable 0 = unknown 1 = ice 2 = water 3 = oriented ice

RESULTS

November 28-29, 2013.



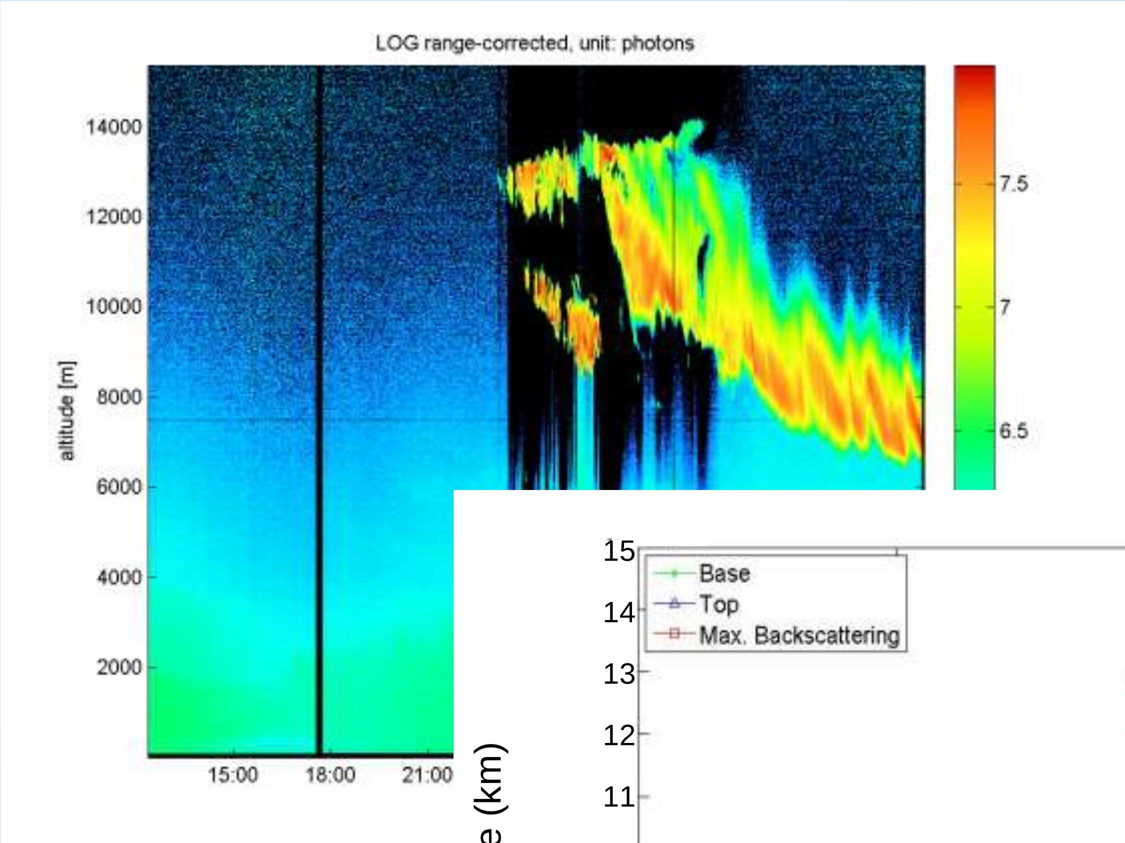
MODIS TERRA, Nov. 28, 13:50 UTC.

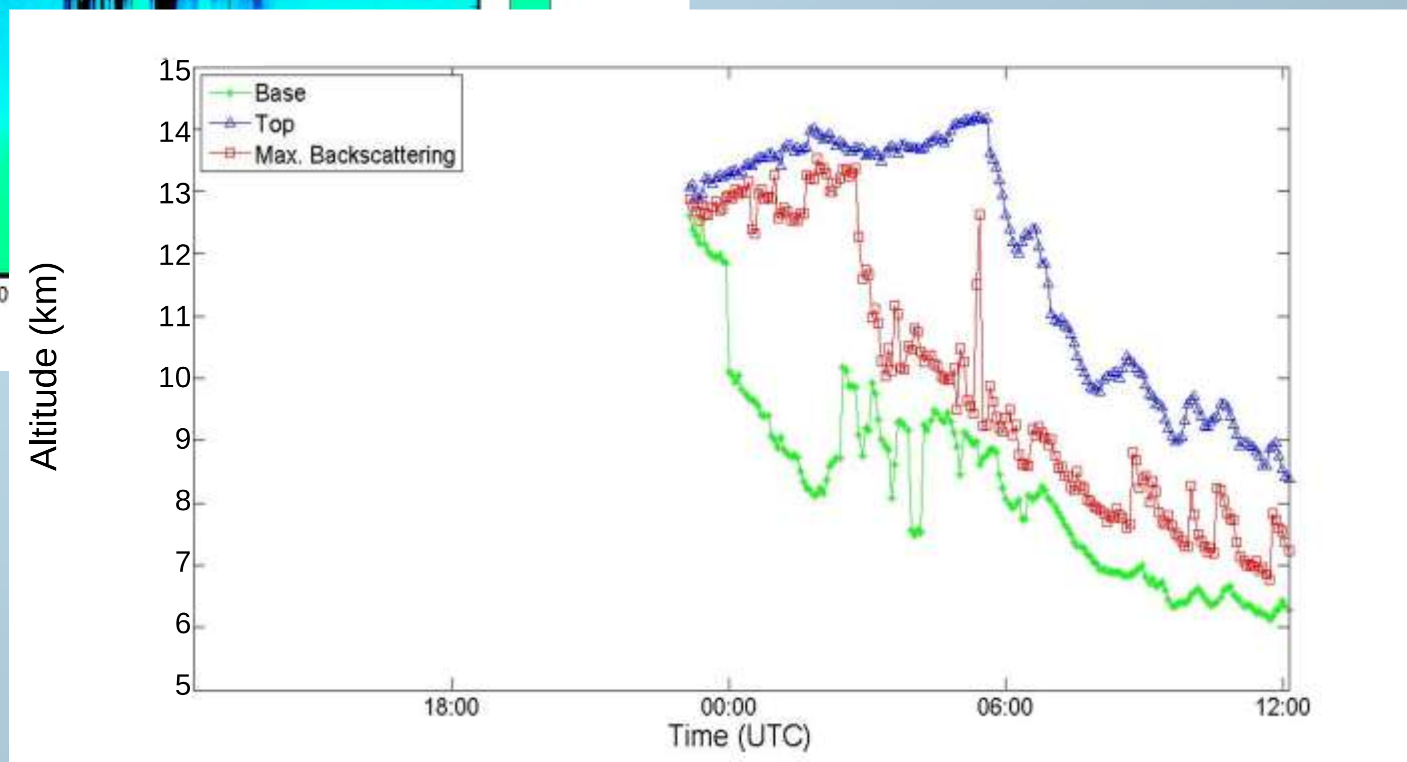


MODIS TERRA, Nov. 29, 13:00 UTC.

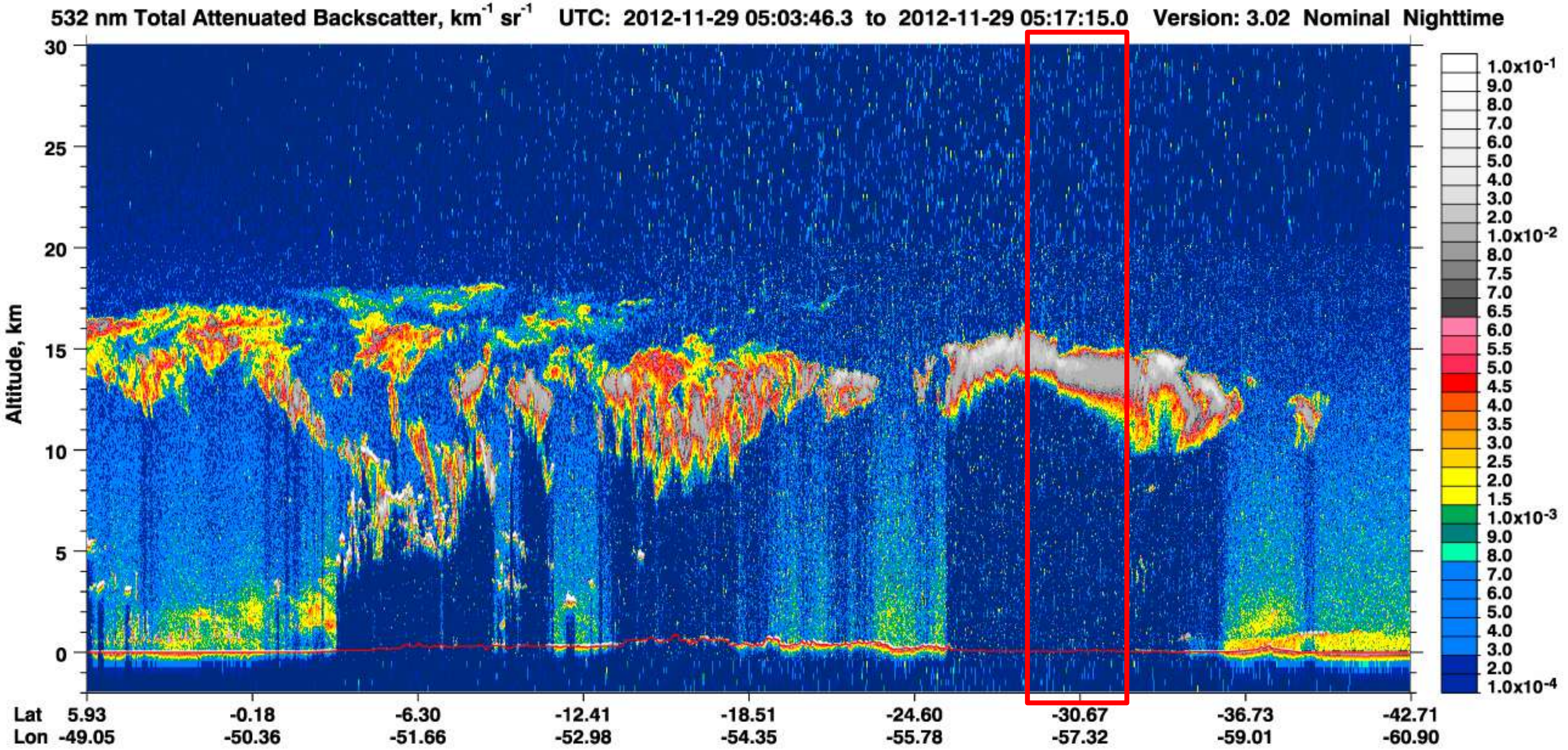
RESULTS

November 28-29, 2013.





CALIPSO



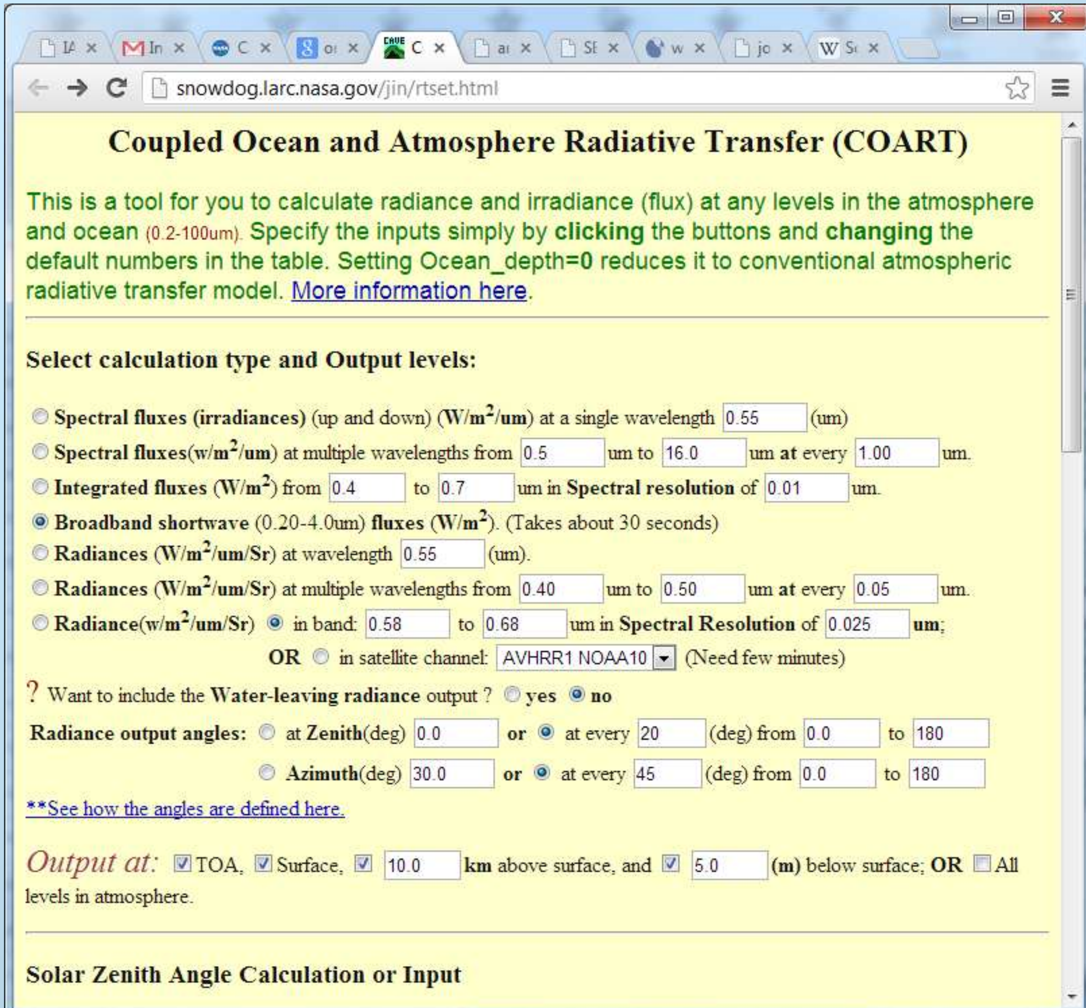
532 nm Total Attenuated Backscatter, km^{-1} sr^{-1} UTC: 2012-11-29 05:03:46.3 to 2012-11-29 05:17:15.0 Version: 3.02 Nominal Nighttime
Altitude, km
Lat 5.93 -0.18 -6.30 -12.41 -18.51 -24.60 -30.67 -36.73 -42.71
Lon -49.05 -50.36 -51.66 -52.98 -54.35 -55.78 -57.32 -59.01 -60.90
1.0x10^{-1} 9.0 8.0 7.0 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}

RESULTS

	Nov. 07	Nov. 08	Nov. 19	Nov. 28
Occurrence (%)	100	82	92	56
Base (m)	9780	6830	8387	8232
Top (m)	11805	8555	10488	11918
Max. Backscattering (m)	10563	7914	9078	9954
Optical Depth	1.23	1.94	1.95	0.84

How important are these optical depths for the radiative balance?

Preliminary (last night)



snowdog.larc.nasa.gov/jin/rtset.html

Coupled Ocean and Atmosphere Radiative Transfer (COART)

This is a tool for you to calculate radiance and irradiance (flux) at any levels in the atmosphere and ocean (0.2-100um). Specify the inputs simply by **clicking** the buttons and **changing** the default numbers in the table. Setting Ocean_depth=0 reduces it to conventional atmospheric radiative transfer model. More information here.

Select calculation type and Output levels:

- **Spectral fluxes (irradiances)** (up and down) (**W/m^2/um**) at a single wavelength 0.55 (um)
- **Spectral fluxes**(**w/m^2/um**) at multiple wavelengths from 0.5 um to 16.0 um **at** every 1.00 um.
- **Integrated fluxes** (**W/m^2**) from 0.4 to 0.7 um in **Spectral resolution** of 0.01 um.
- **Broadband shortwave** (0.20-4.0um) **fluxes** (**W/m^2**). (Takes about 30 seconds)
- **Radiances** (**W/m^2/um/Sr**) at wavelength 0.55 (um).
- **Radiances** (**W/m^2/um/Sr**) at multiple wavelengths from 0.40 um to 0.50 um **at** every 0.05 um.
- **Radiance**(**w/m^2/um/Sr**) in band: 0.58 to 0.68 um in **Spectral Resolution** of 0.025 **um**; **OR** in satellite channel: AVHRR1 NOAA10 (Need few minutes)

? Want to include the **Water-leaving radiance** output ? **yes** **no**

Radiance output angles: at **Zenith**(deg) 0.0 **or** at every 20 (deg) from 0.0 to 180

Azimuth(deg) 30.0 **or** at every 45 (deg) from 0.0 to 180

**See how the angles are defined here.

Output at: TOA, Surface, 10.0 **km** above surface, and 5.0 **(m)** below surface; **OR** All levels in atmosphere.

Solar Zenith Angle Calculation or Input

- Case 1

Base=9.78km

Top=11.8km

AOD=1.23

~ 12 UTC

- BUT ALSO:

Ref=70µm, spherical ice

Tsfc=32^{o}C

Mid-lat summer

Albedo=0.18

PWV=4cm

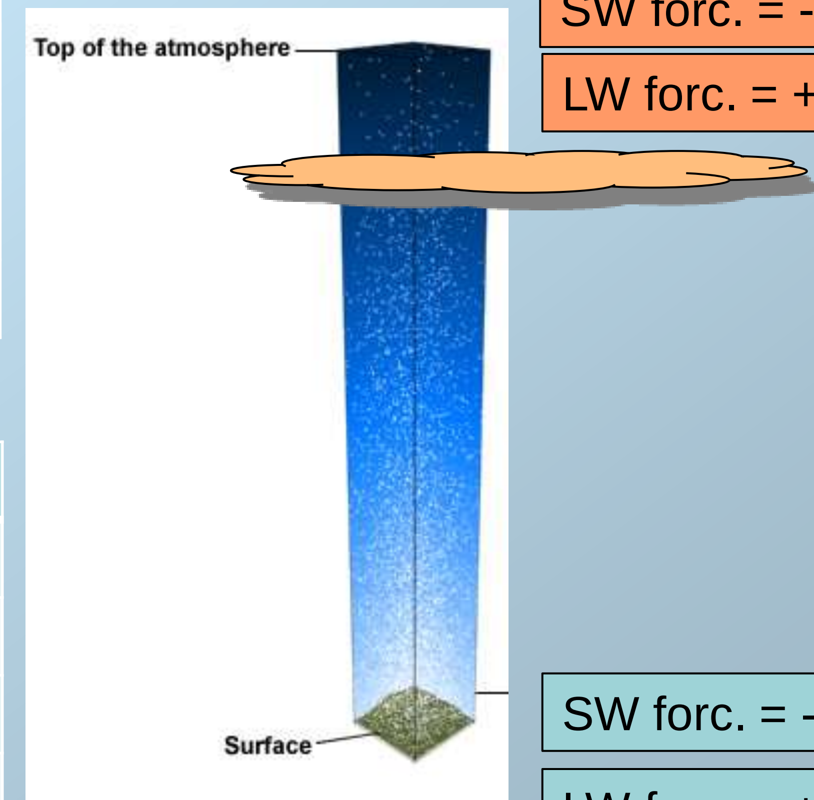
http://snowdog.larc.nasa.gov/jin/rtset.html

http://arm.mrcsb.com/sbdart/

Preliminary (last night)

			W/m²
NET SW	Top	Clear	779.5
		Cloudy	737.2
	Sfc	Clear	565.1
		Cloudy	511.6

			W/m²
NET LW	Top	Clear	-263.6
		Cloudy	-183.2
	Sfc	Clear	-133.5
		Cloudy	-124.9



SW forc. = -42.3 W/m^2

LW forc. = +80.4 W/m^2

SW forc. = -53.5 W/m^2

LW forc. = +8.6 W/m^2

Conclusions

- Cirrus clouds was detected with lidar during for days during CHUVA-SUL measurement campaign.
- It was demonstrated the applicability of the methods for the determination of the cloud base, top and maximum backscattering altitude.
- Also was obtained the values of cirrus cloud optical depth.

Perspectives

- Analysis of the measurements in other campaigns.
- Synergy between lidar measurements and other instruments.