Vertical distribution of clouds in central Amazon from the measurements of a ceilometer

Amanda V. dos Santos(1), Diego A. Gouveia(1), Henrique M. J. Barbosa(1), Eduardo Landulfo(2)

(1)Instituto de Física, Universidade de São Paulo, São Paulo, Brazil

(2)Centro de Lasers e Aplicações, Instituto de Pesquisas Energéticas e Nucleares, São Paulo, Brazil

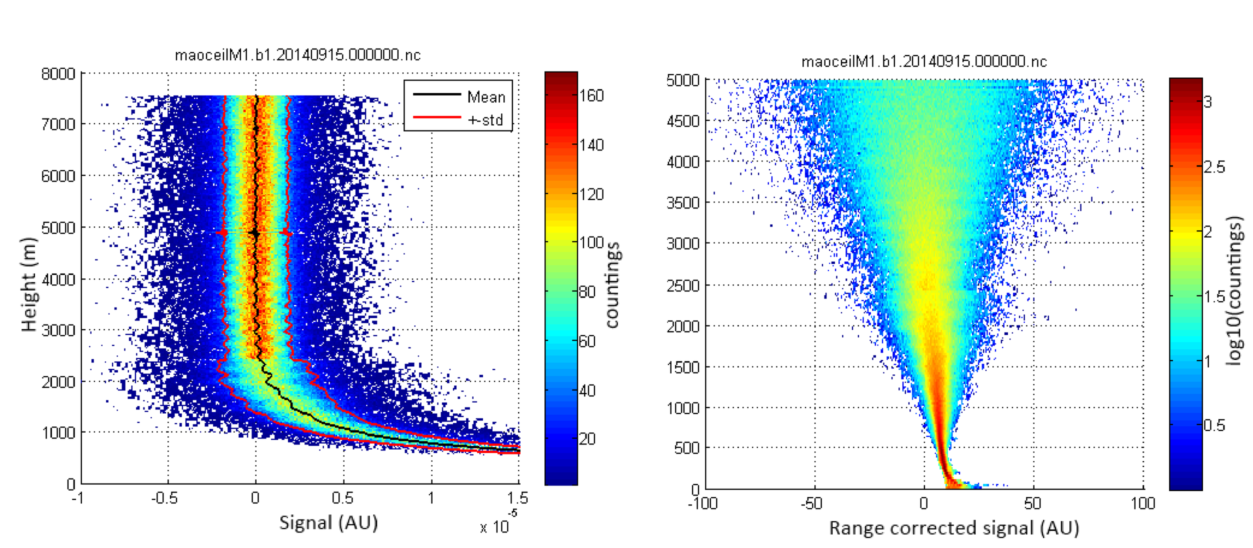
Email: amanda.vieira.santos@usp.br

Introduction

Clouds are important for the global climate system and they can significantly alter Earth's energy balance, in time scales ranging from minutes to climate change. Despite their importance, physical processes governing clouds are still not fully known, partially because of the lack of observations. The recent GoAmazon2014/15 and CHUVA experiments finally provided the missing continuous observations with high temporal and spatial resolution to solve the physical processes that control clouds, at least over the Amazon rainforest.

Our main goal was to use this database to investigate the diurnal cycle of cloud coverage in central Amazon, for the dry and wet seasons. Data from the ceilometer located on the T3-Manacapuru site from Jan/2014 to Dec/2015 was used. Clouds were detected using an automatic algorithm developed in our laboratory (Gouveia et al, 2014). Applying a different algorithm was necessary because the manufacturer only provides the first three cloud base heights. There is no information about the thickness of the detected layers, neither about the signal attenuation. With our adapted detection algorithm, we found cloud base and top heights for the two years of the GoAmazon dataset. We then derived the thickness of each cloud layer, which allowed the calculation of the vertical frequency of occurrence, for both the dry and wet seasons. We compared our results with co-located radiosonde data, and with already published papers discussing cloud formation during the GoAmazon2014/15 campaign.

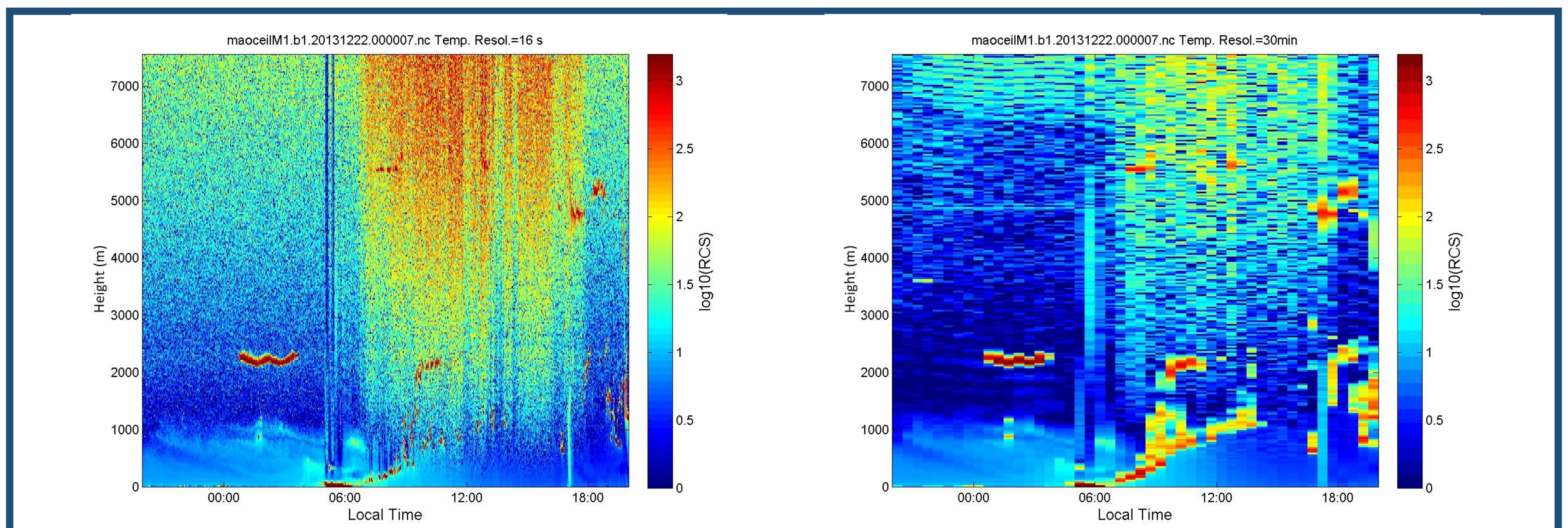
Adapting the detection algorithm

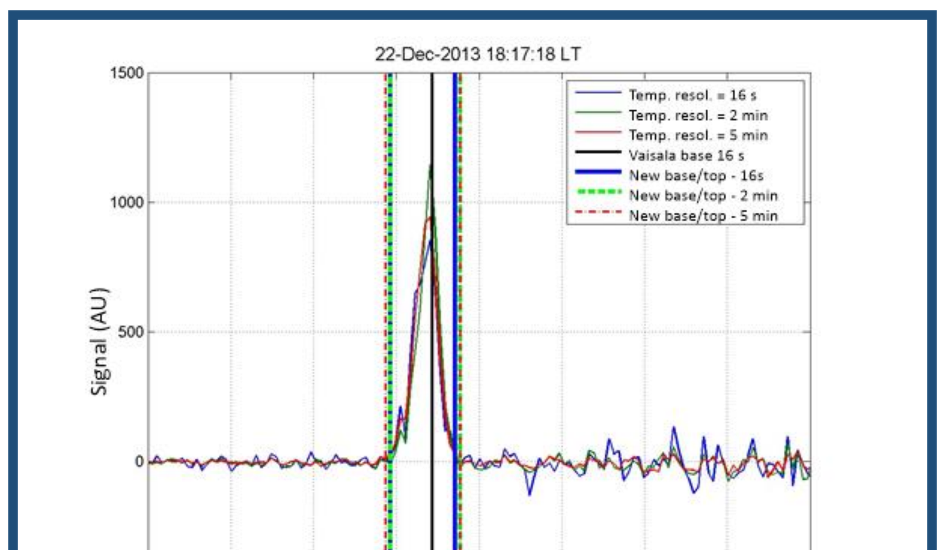


The analysis of the ceilometer signal needs to be done carefully.

According to Kotthaus et al. (2016), the sampled signal is averaged by the instrument's software, which causes the step change at 2400 m that can be seen in both images to the left.

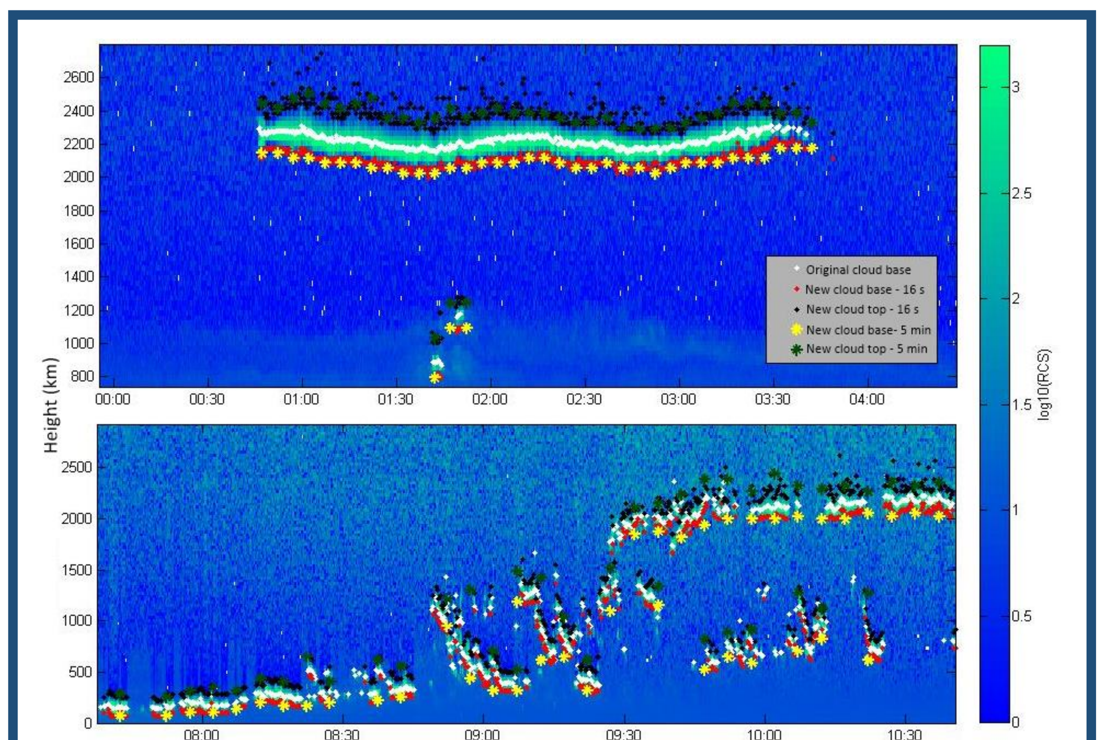
For the CL31 Ceilometer used here, for range gates above 2400 m the reporting interval is 16 s but the internal averaging interval is 30 s.





While the manufacturer only provides three cloud base heights, the algorithm is able to find base and top heights.

In order to choose the best temporal resolution, we tested the algorithm by using different time averages. It is easier to detect clouds with higher temporal resolutions, because it improves the signal-noise ratio.



With the values of cloud base and top height we can derive the thickness of a cloud layer.

Due to limitations of the instrument, we can only measure the thickness of very thin clouds.

Conclusion

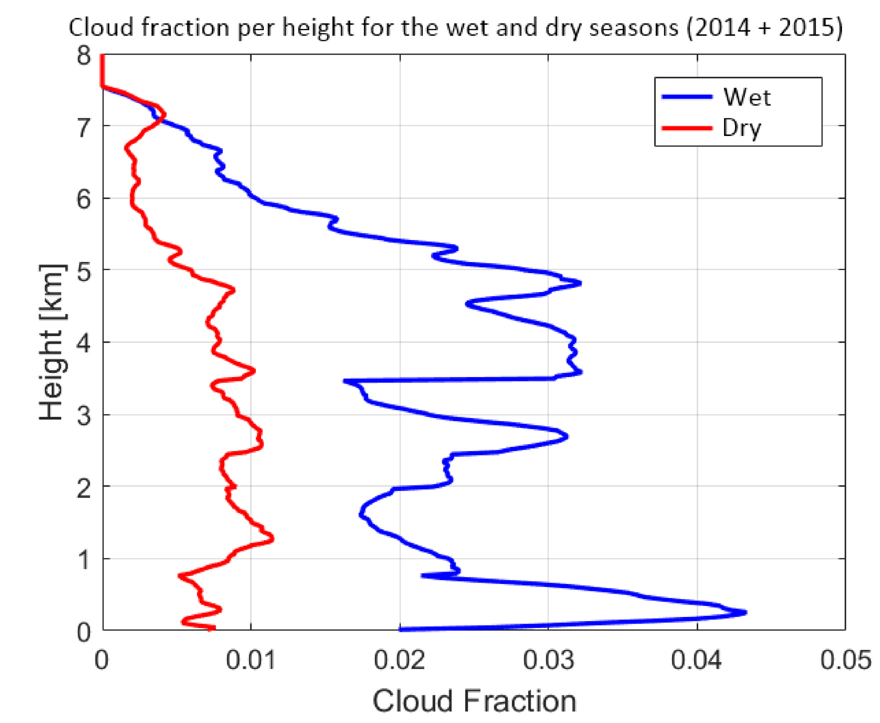
With the adapted detection algorithm, we were able to find cloud base and top heights for the two years of data, and we derived the thickness of each cloud layer, the diurnal cycle, the vertical frequency of occurence and the backscatter inside the clouds.

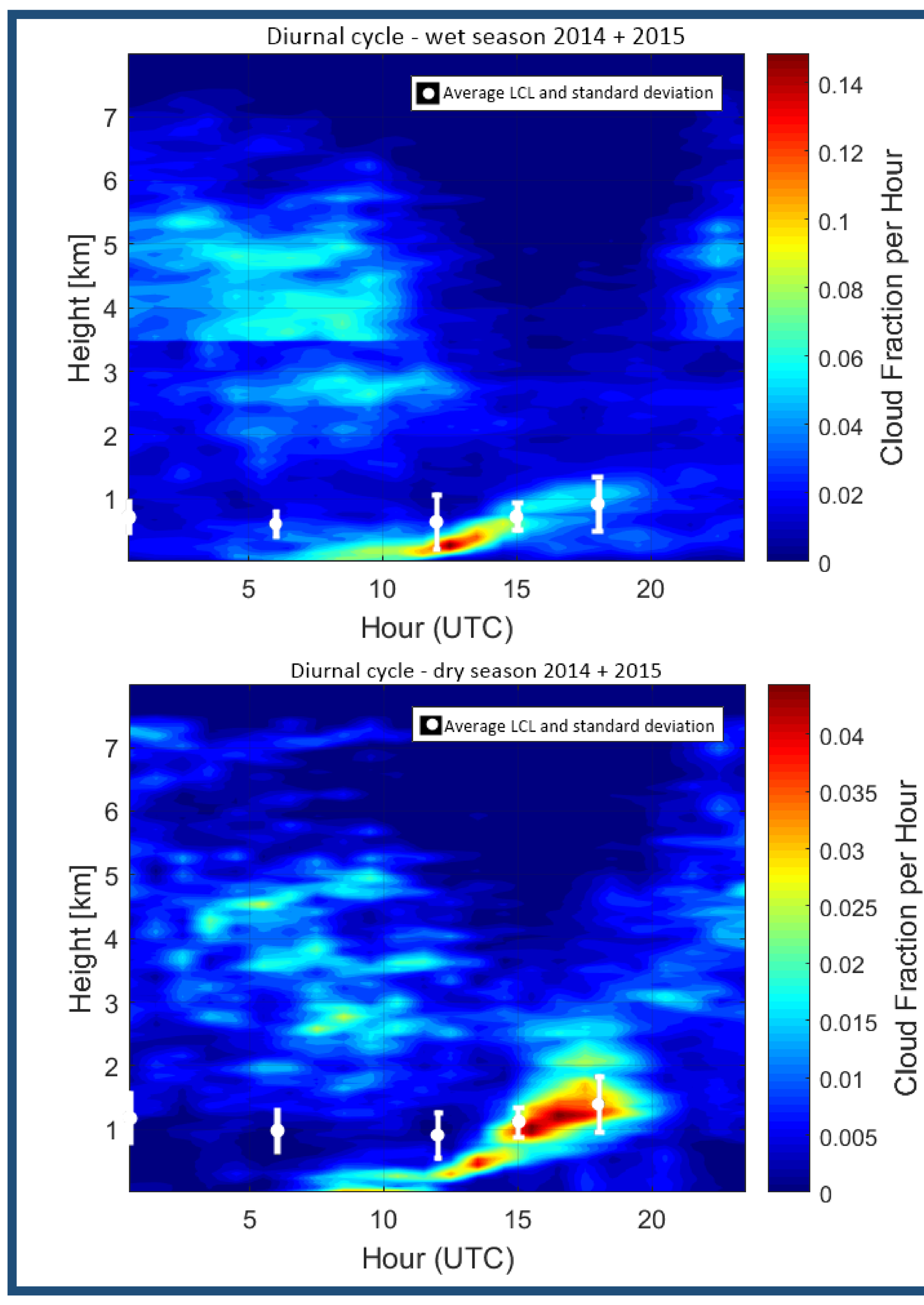
Vaisala CL31 Laser Ceilometer

- Maximum vertical range: 7700 m
- Vertical resolution: 10 m
- Reporting interval: 10 m
- Wavelength: 910 nm at 25 °C

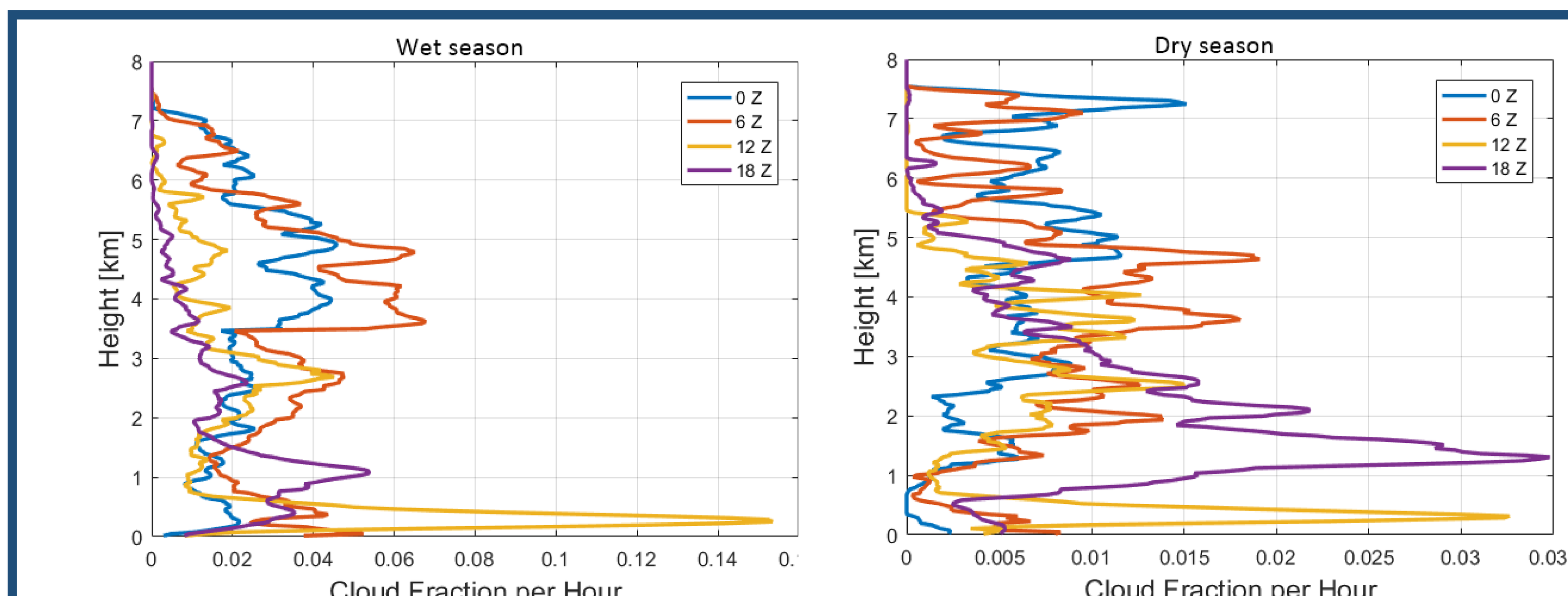
Diurnal cycle of the vertical distribution of clouds

More clouds were detected during the wet season, which is in accordance to the discussions in Collow et al. (2016). The maximum single-altitude cloud fraction was around 4.3% for low-level clouds detected at around 0.5 km.





The figures to the left show the diurnal cycle of clouds and the average lifted condensation level (LCL) obtained by the radiosonde data, for five different times of the day. We see that the LCL for the wet season is lower compared to the dry season, which matches the pattern of formation of clouds at lower heights and higher cloud fraction that was detected by our algorithm. During the dry season, we see a rise in cloud base height throughout the day, coinciding with the rise of LCL values, but the LCL values are systematically higher.



During the wet season, the highest cloud coverage occurs at around 12h00 UTC (Z), when the highest cloud coverage is of approximately 15%. During the dry season, the highest cloud coverage happens at around 18h00 UTC (Z), wihen the highest cloud coverage is of almost 3.5%.

These results are consistent with what we saw for the diurnal cycle: there is higher fog formation at night during the wet season than on the dry season.

References

1. Gouveia, D. A.: Caracterização de nuvens cirrus na região da Amazônia central utilizando um lidar em solo, 96 pp, Dissertação de Mestrado, Universidade de São Paulo, 2014.
2. Kotthaus et al., 2016: Recommendations for processing atmospheric attenuated backscatter profiles from Vaisala CL31 ceilometers. Atmos. Meas. Tech., 9, 3769-3791, doi: 10.5194/amt-9-3769-2016.
3. Collow, A. B. M., M. A. Miller, and L. C. Trabachino (2016), Cloudiness over the Amazon rainforest: Meteorology and thermodynamics, J. Geophys. Atmos., 121, 7990-8005, doi:10.1002/2016JD024848.

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