30º SIICUSP

LIDAR MEASUREMENTS OF FOG OCCURRENCE AT THE ATTO TOWER

Gabriel Dorneles da Silva Barreiros

Henrique Barbosa

University of São Paulo

gabriel.barreiros@usp.br

Objectives

The main objective of this scientific initiation project was to use the data from the ceilometer (Lufft, 2016) installed by the LAP (Laboratory of Atmospheric Physics) at Campina/ATTO to determine the occurrence of fog during the dawn and verify how this affects shallow cloud cover in the morning, from Sep-2021 to Aug-2022.

Methods and Procedures

The data provided by the ceilometer had the NetCDF (Network Common Data Form) format, so the first step was to create a routine capable of reading these files and extracting the relevant variables for the analysis. The variables used were those related to the height of the cloud base, the corrected and normalized signal recorded by the instrument and the time at which the measurements were performed. Data were organized into daily files, which needed to be read and processed individually. Thus, we created routines to access and organize the data contained in these variables, that allowed the analysis of all data simultaneously. Due to problems with the instrument's operation in the Amazon forest, we observed that the signal recorded by the ceilometer was negative at some points. As the number of photons collected by the instrument must be positive, a routine was created to calculate the average of the signal recorded by the instrument for each of the 24 hours of the day; if at any time the signal became negative, then that dataset (1 day) was discarded. Finally, an algorithm was created capable of detecting whether there was fog formation during the night on that specific day. The criteria used for the occurrence of fog were: clouds up to 200m in height; at least 240 clouds detected during the dawn (which correspond to an hour of fog as the data is obtained every 15s); period considered (dawn) was from 00:00 to 09:00 UTC. Lastly, the data were classified into days with and without fog, and a histogram was created by joining all the corresponding days.

Results

Below are some results obtained during the development of the project. Figure 1 shows an example of quality control, for a day that was dropped from the analysis.

Figure 1: Signal recorded by the ceilometer over the course of a day for a dataset that was discarded from the analysis (negative sign).

Figures 2 and 3 present the function created for fog detection and the result generated by it, respectively. Note that it is possible to change the minimum amount of clouds detected to take into account the occurrence of fog and the start and end times. The last two columns of the function's output indicate the presence of fog (True/False) and the amount of clouds detected in the time range of interest.

```python
def fog(datas, nuvens, hi1=0, hf1=9, altmin=200, Nmin=240):

    ti1 = datetime.time(hi1,0,0)
    tf1 = datetime.time(hf1,0,0)

    t = np.array([adate.time() for adate in datas])

    mask = ((ti1 <= t) & (t <= tf1))

    selecao = nuvens[mask, :]

    bases = selecao[:, 0] < altmin

    N = np.nansum(bases)

    return N>=Nmin, N
```

Figure 2: Algorithm created for fog detection in the files generated by the instrument.

```
0 20220526_ATTO_CHM160146_000.nc False 0
1 20211101_ATTO_CHM160146.nc False 0
2 20220124_ATTO_CHM160146_000.nc False 60
3 20211218_ATTO_CHM160146.nc True 826
4 20220425_ATTO_CHM160146_000.nc False 216
5 20220218_ATTO_CHM160146_000.nc True 818
6 20211230_ATTO_CHM160146.nc True 1035
7 20220530_ATTO_CHM160146_000.nc True 1111
8 20210919_ATTO_CHM160146.nc False 0
9 20220321_ATTO_CHM160146_000.nc True 1130
10 20220620_ATTO_CHM160146_000.nc True 764
11 20211006_ATTO_CHM160146_000.nc False 0
12 20220222_ATTO_CHM160146_000.nc False 31
13 20220409_ATTO_CHM160146_000.nc False 48
14 20211010_ATTO_CHM160146_000.nc False 0
15 20220108_ATTO_CHM160146_000.nc False 0
16 20220305_ATTO_CHM160146_000.nc True 1671
17 20220604_ATTO_CHM160146_000.nc False 184
18 20220206_ATTO_CHM160146_000.nc False 1
19 20211022_ATTO_CHM160146_000.nc False 0
20 20220210_ATTO_CHM160146_000.nc True 292
```

Figure 3: Values returned by the algorithm.

From the analysis of 329 days of measurements, 159 were discarded due to instrumental problems, 120 were classified as days with fog, and 50 as days without fog (considering the rainy and dry periods).

Figures 4 and 5 below present the histograms obtained for the rainy season (Dec-May) for each of the datasets: days with and without fog, obtained after the filters (whose criteria were described in the previous section). We can see that cloudy days present persistent cloudiness below 200 m, which does not even allow the instrument to detect any clouds in the higher layers (Gouveia, 2014).

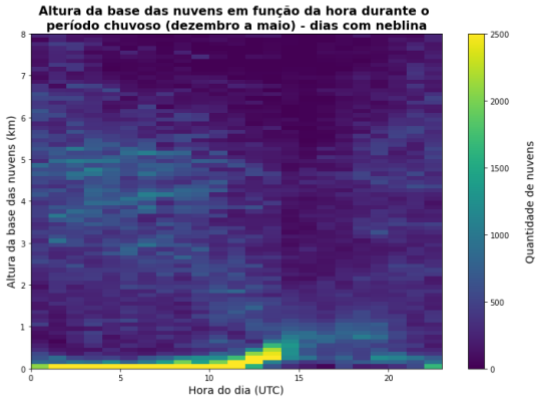

Figure 4: Histogram generated for the days when the algorithm detected fog at dawn during the rainy season.

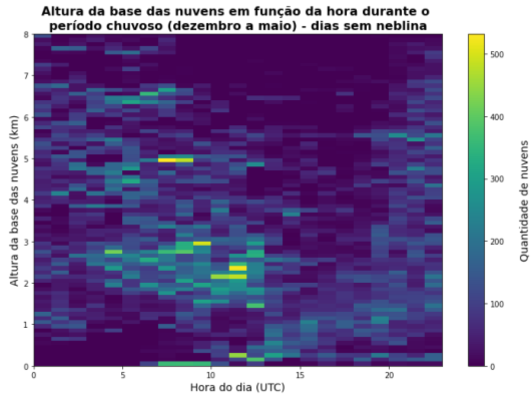

Figure 4: Histogram generated for the days when the algorithm did not detect fog at dawn during the rainy season.

Conclusions

During the development of the project, it became clear that just running the analyzes for the entire dataset would not be enough, as inconsistencies were observed in a few days. Creating an algorithm capable of classifying them was important to obtain results more consistent with the reality of the observed phenomenon. Furthermore, automating the fog detection process and creating a single histogram joining all similar data was relevant to characterize both scenarios (days with and without fog).

Bibliographic References

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.

Manual Ceilometer CHM 15k „NIMBUS“, Lufft. 2016.