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# Applying remote sensing techniques to investigate the trajectory of smoke plumes during biomass burning events

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## INTRODUCTION & AIM

Mato Grosso do Sul, Mato Grosso, and Pará (Figure 1) recorded, respectively, 4,648 (6.8% of the entire country), 14,617 (21.3% of the entire country), and 13,803 (20.1% of the entire country) fire outbreaks in August 2024. These numbers represent increases of 1,845%, 457%, and 105% compared to August 2023.

**Table 1.** Values and percentages of fire hotspots in Corumbá and São Félix do Xingu

| | Corumbá - MS | São Félix do Xingu - PA |
|---|---|---|
| Fire Outbreaks | 1268 | 2908 |
| In Relation to the Country | 8st place with 4.1% | 1st place with 9.3% |
| In Relation to the State | 1st place with 27.29% | 1st place with 21,07% |

The cities with the highest number of fire outbreaks in each state are presented in Table 1.

Objective:

The main objective is to identify the presence (or effect) of smoke plumes from wildfires that occurred in other regions of Brazil on the city of São Paulo.


**Figure 1.** Geographical map of Brazil indicating the location of the municipalities of São Paulo-SP, Corumbá-MS, and São Félix do Xingu-PA.

## METHOD

Demonstration of how data acquisition is performed MSP-LIDAR I (Figure 2) and ATLID (Figure 3).

**Level 0** $$P(r) = P_O \frac{c\tau}{2} A\eta \frac{O(r)}{r^2} \beta_{aer}(r) + \beta_{mol}(r)\, e^{\left[-2\int_0^r \alpha_{aer}(r) + \alpha_{mol}(r)\, dr\right]}$$

**LIDAR - Level 1** $$RCS(z) = (P(r) - DC(r) - BG)\, z^2$$

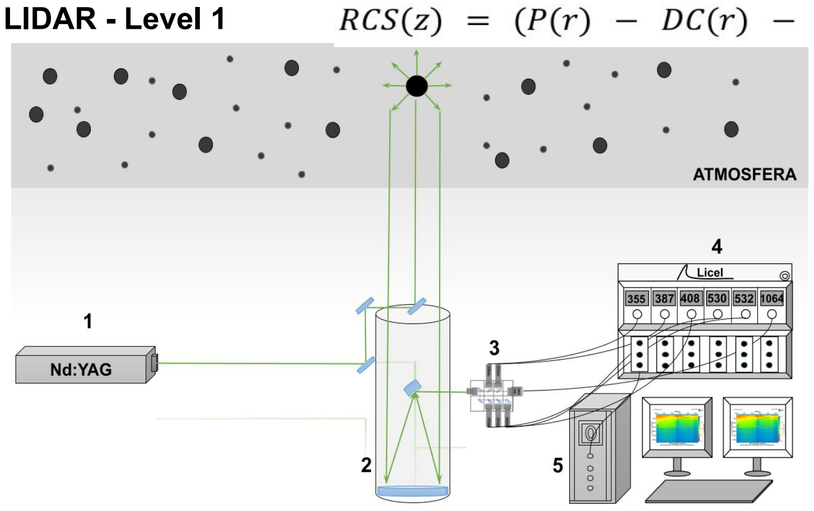


**Figure 2.** MSP-Lidar I Raman multi-channel Lidar system. Operated by the Laser Environmental Applications Laboratory at the Center for Lasers and Applications of IPEN.

**ATLID - Level 1 (A-NOM)**

Total Attenuated backscatter (Mie+Rayleigh) $P(r, \lambda)\, T_{atm}\, r^2$

Is the signal attenuated due to the transmittance of the atmosphere $T^2$ * Range Corrected Signal

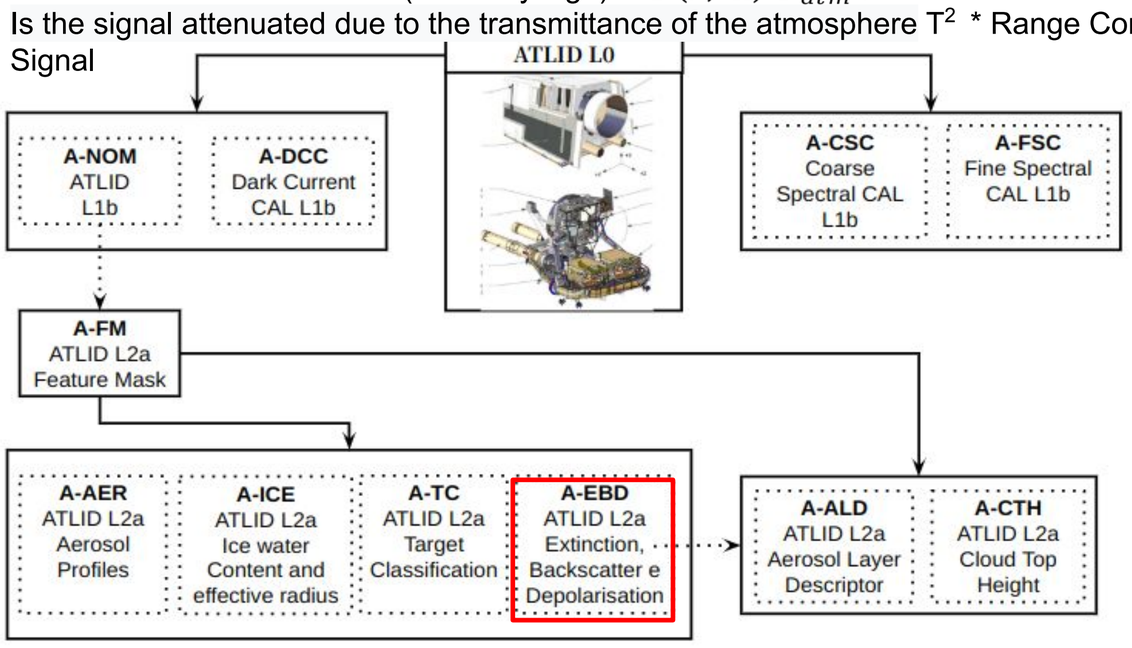


**Figure 3.** Flowchart of the processing of ATmospheric LIDar products onboard the EarthCARE satellite.

After processing the data, an analysis was conducted to identify the days with a high number of fire hotspots in the cities under study. Based on this, satellite overpasses from EarthCARE (Tabela 2) were plotted using the Earth Observation Swath and Orbit Visualisation program.

**Table 2**. EarthCARE overpasses in Corumbá and São Félix do Xingu

| | Corumbá - MS | São Félix do Xingu - PA | São Paulo - SP |
|---|---|---|---|
| Start Orbit | 1412 | 1443 | 1497 |
| Start Sec | 3054 | 2865 | 5187 |
| Start Date | 2024-08-27 | 2024-08-29 | 2024-09-02 |
| Start UTC | ~T17:43:03 | ~T17:28:33 | ~T05:24:15 |

## RESULTS & DISCUSSION

The HYSPLIT model was used to determine possible trajectories of aerosol plumes on days with the highest number of fire hotspots. Once the source locations were identified, their correspondence with burn areas was verified. After confirming the correlation, the satellite overpasses for these regions were analyzed in figure 4.

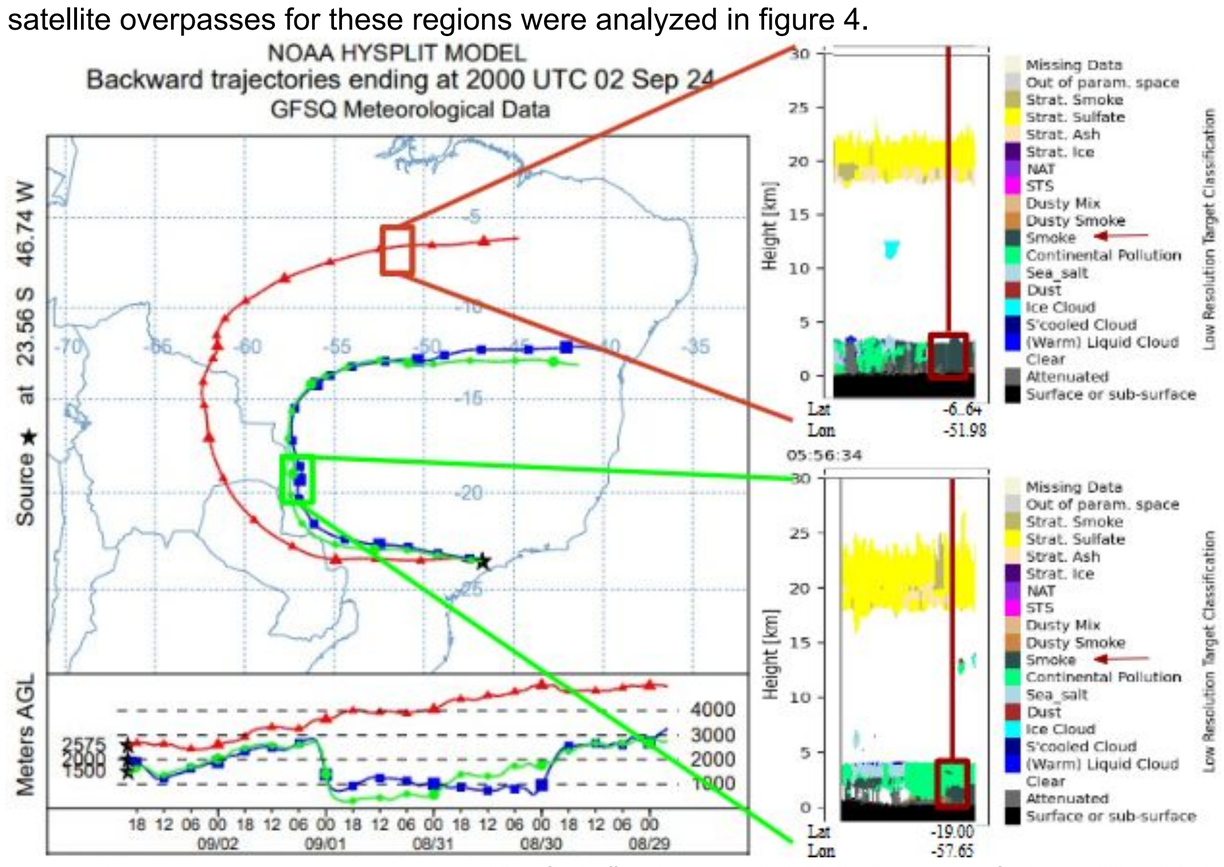


**Figure 4.** Five-day backward trajectories ending at 20 UTC, at different levels 1500, 2000, 2575 m a.g.l.) on September 02th 2024 at MSP-Lidar II measurement site and EarthCARE products ATL_TC_2A (Target Classification).

Next, back-trajectory analyses were combined with profiles generated by EarthCARE and photometer data in the São Paulo region to map the occurrence of biomass burning events. Finally, the photometer data were analyzed to infer aerosol properties based on AOD values and the Ångström Exponent in Figure 5.

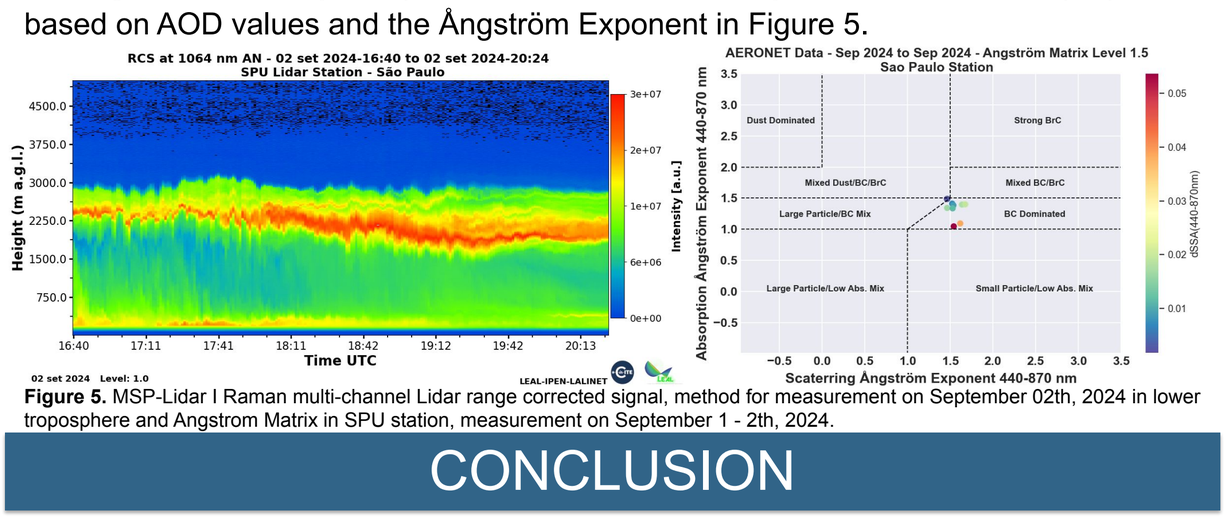


**Figure 5.** MSP-Lidar I Raman multi-channel Lidar range corrected signal, method for measurement on September 02th, 2024 in lower troposphere and Angstrom Matrix in SPU station, measurement on September 1 - 2th, 2024.

## CONCLUSION

The satellite products of backscatter, extinction, lidar ratio, and AOD were analyzed for these cities. Elevated values of lidar ratio and AOD were observed between 1 and 3 km in altitude—coinciding with the air mass trajectory analyzed by HYSPLIT that passed over Corumbá-MS. Photometer data analysis indicated a significant presence of black carbon in São Paulo between September 1st and 2nd. The results identified three trajectories overlapping with fire hotspots, suggesting that biomass burning in Corumbá-MS and São Félix do Xingu-PA may have been the primary sources of the aerosol plumes observed over São Paulo.

## FUTURE WORK / REFERENCES

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