Observations of SO_2, O_3, and Aerosols with the Langley Mobile Ozone Lidar

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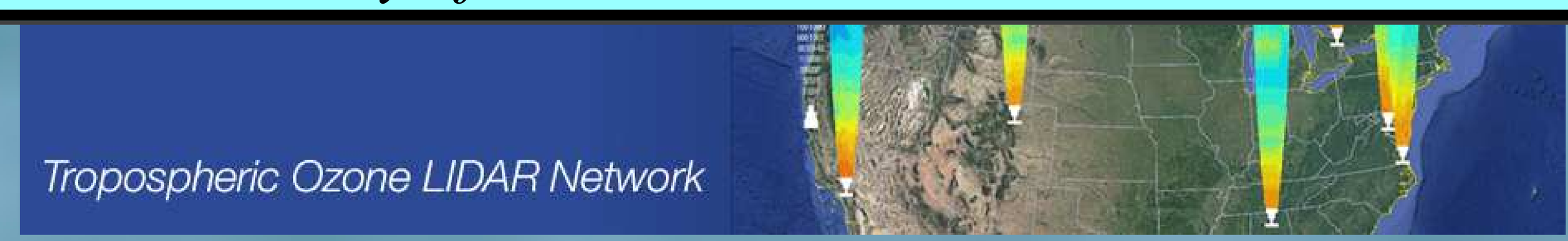
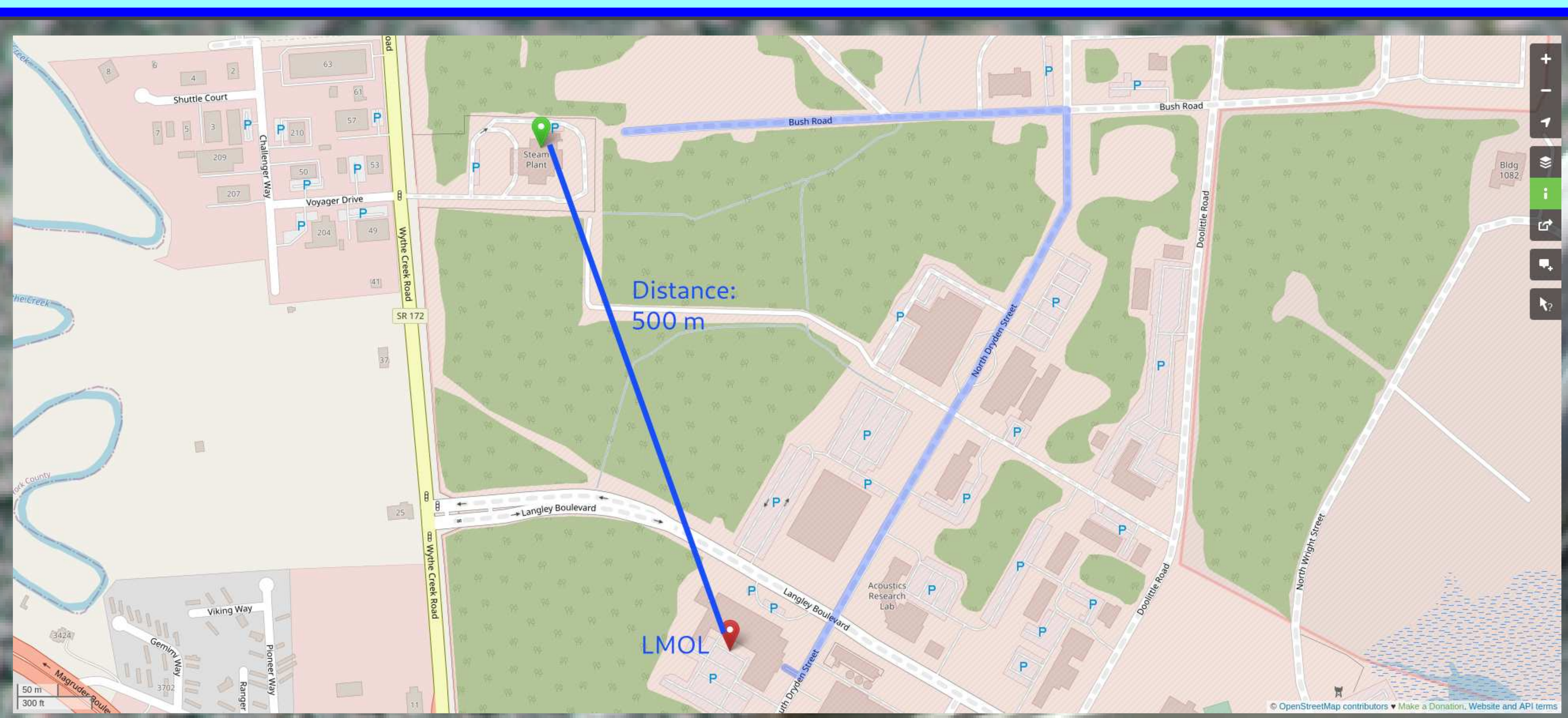


Abstract

LMOL, the NASA Langley Mobile Ozone Lidar, is located near NASA's LaRC steam plant when not deployed in campaigns. The steam plant is an incinerator, and when SO_2 was in the plume, it would affect the LMOL O_3 measurements at the plume altitudes of 100m-200m.
In 2022, we modified LMOL to observe four wavelengths simultaneously to distinguish between and measure both O3 and SO2. With an optimized selection of wavelengths, based on an analysis of the cross-sections, it is possible to retrieve both O_3 and SO_2 densities from three wavelengths. Adding a fourth wavelength enables better constrains the aerosol's backscatter and extinction. In this work, we present the dual observations of SO_2 and O_3 with the new channels of LMOL, and we present the advances in constraining the aerosol parameters from these multiple wavelengths. We highlight the SO_2 and Ozone Water-Land Environmental Transition Study (SOWLETS) campaign in preparation for the validation of the new system.

I - The SOWLETS Campaign

- SO_2 and Ozone Water-Land Environmental Transition Study (SOWLETS): campaign at NASA LaRC to study SO_2 and validate measurements
- Motivation: monitoring the tropospheric Air Quality (AQ)
- TEMPO, to be launched around 2020 will monitor AQ, needs support for validation and data product retrieval in complex regions.
- SO_2 from a nearby incinerator will be observed with LMOL, sondes, and Pandora
- Known outputs of the incinerator will enable a correct estimation of the plume SO_2 density
- The plume has already been observed and characterized by LMOL



II - The LaRC/Langly Mobile O_3 Lidar

LMOL, the Langley Mobile Ozone Lidar [1] is a part of the Tropospheric Ozone Lidar Network (TOLNET). It has been deployed for the OWLETS campaign [4] and LISTOS campaign, for the 2014 DISCOVER-AQ [5] and SCOOP (Southern California Ozone Observation Project) campaign. It is able to observe from 100 m altitude to up to 10 km with varying vertical resolution [3]

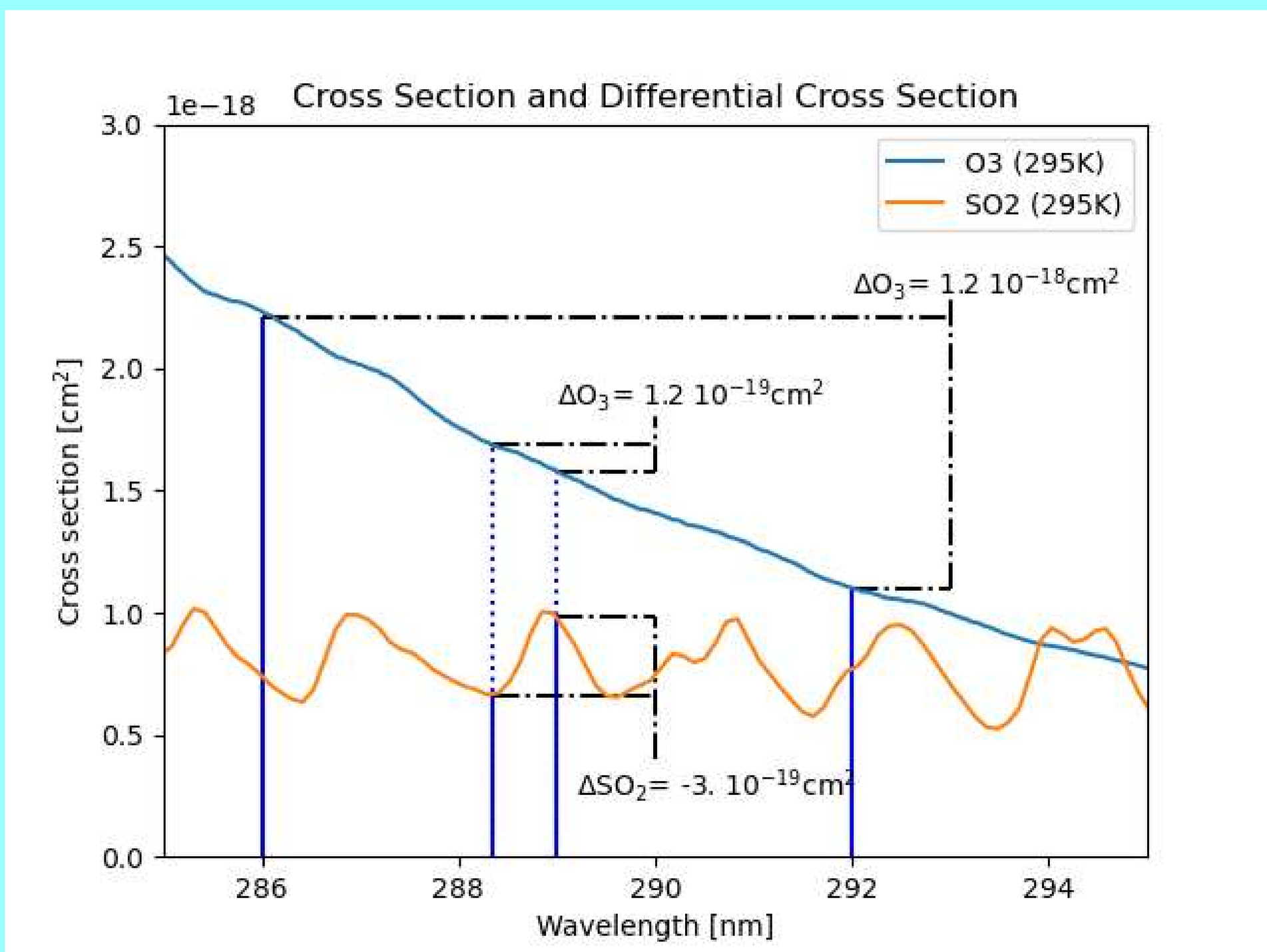
III - Aerosol and SO_2 modifications

Hardware modifications

- 4-channels licel cards
- Arbitrary signal generator and pulse generators for wavlength selections
- Improvements of the tunable laser cavity for power optimisation

Operational modifications

- 2-wavelengths operations have been demonstrated for both O_3 and SO_2
- 3-wavelengths is the minimum when both densities varies
- 4-wavelengths allow to reduce the uncertainties on aerosols
- Cross-sections have to be selected carefully



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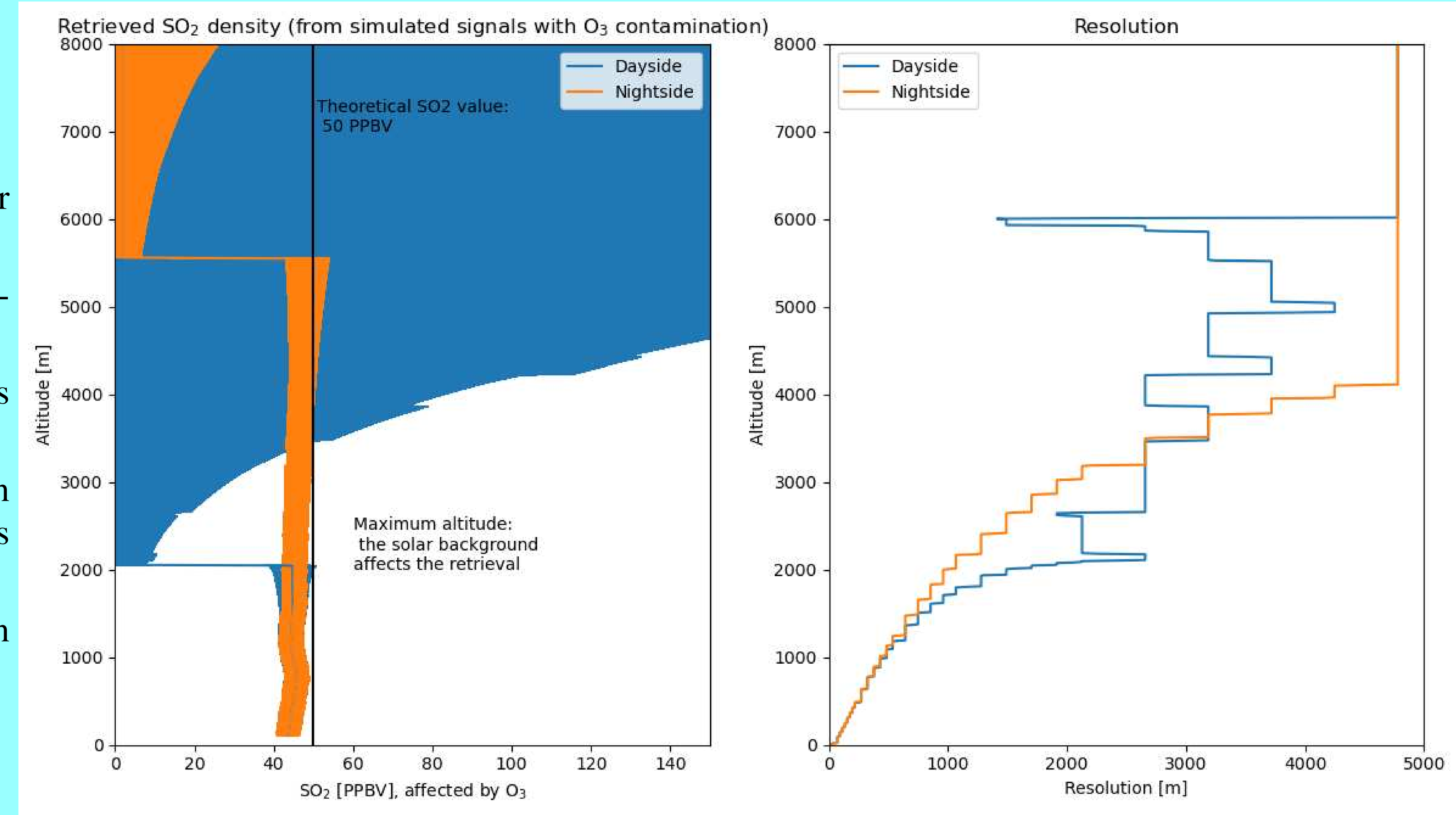
IV - Observation of a SO_2 plume

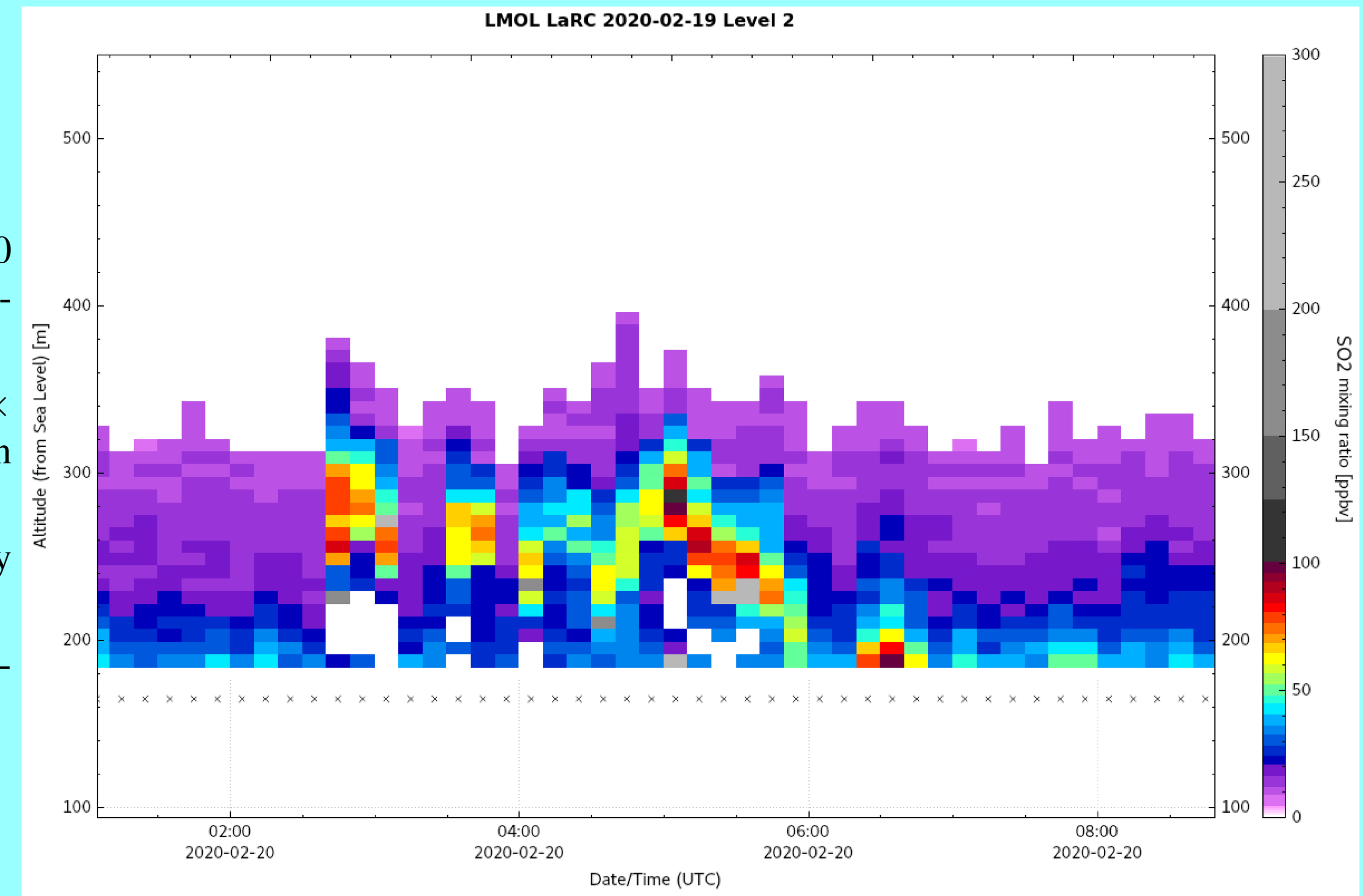
Validation of the retrieval system

- LibRadtran [2] was used to simulate LMOL signals for O_3 and SO_2 operations.
- The simulation first allowed to discover a loss of sensitivity of the PMT in 2019 on pure O_3 operations
- The processing of the simulations for O_3 reproduces real observations
- Simulated SO_2 can be retrieved up to 2km altitude on the dayside and 5 km in the nightside for 5 minutes integration
- The resolution of the retrieval for 5 minutes integration is also analyzed



Observation of a SO_2 plume on 2020-02-19

- Wind blowing from the north at 0.5 m/s; observations of 80-100 PPBV of SO_2 on a vertical range of 50m at around 250 - 300m altitude
- A plume of the power plant with a cross-section of 2500m^2 (50m × 50m) will have an average density of 90 PPBV for a yearly emission of 10 tons
- Plant emissions varies highly (43 tons in 2019, 93 in 2017). They also vary hourly.
- The system is able to measure realistic plume, but the additional observations provided by SOWLETS are needed



Conclusions

- The SOWLETS campaign is a multi-instrument observation of O_3 and SO_2
- The main target is the plume from the incinerator plant of NASA LaRC
- LMOL is able to observe SO_2 in addition to O_3
- Hardware and software development enable the future observation of both O_3 and SO_2 along with Aerosols

References

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