Early Evolution of the Hunga-Tonga Aerosol Stratospheric Plume from Lidar Observations at La Réunion (21° S, 55° E)

GRUAN IMC-14

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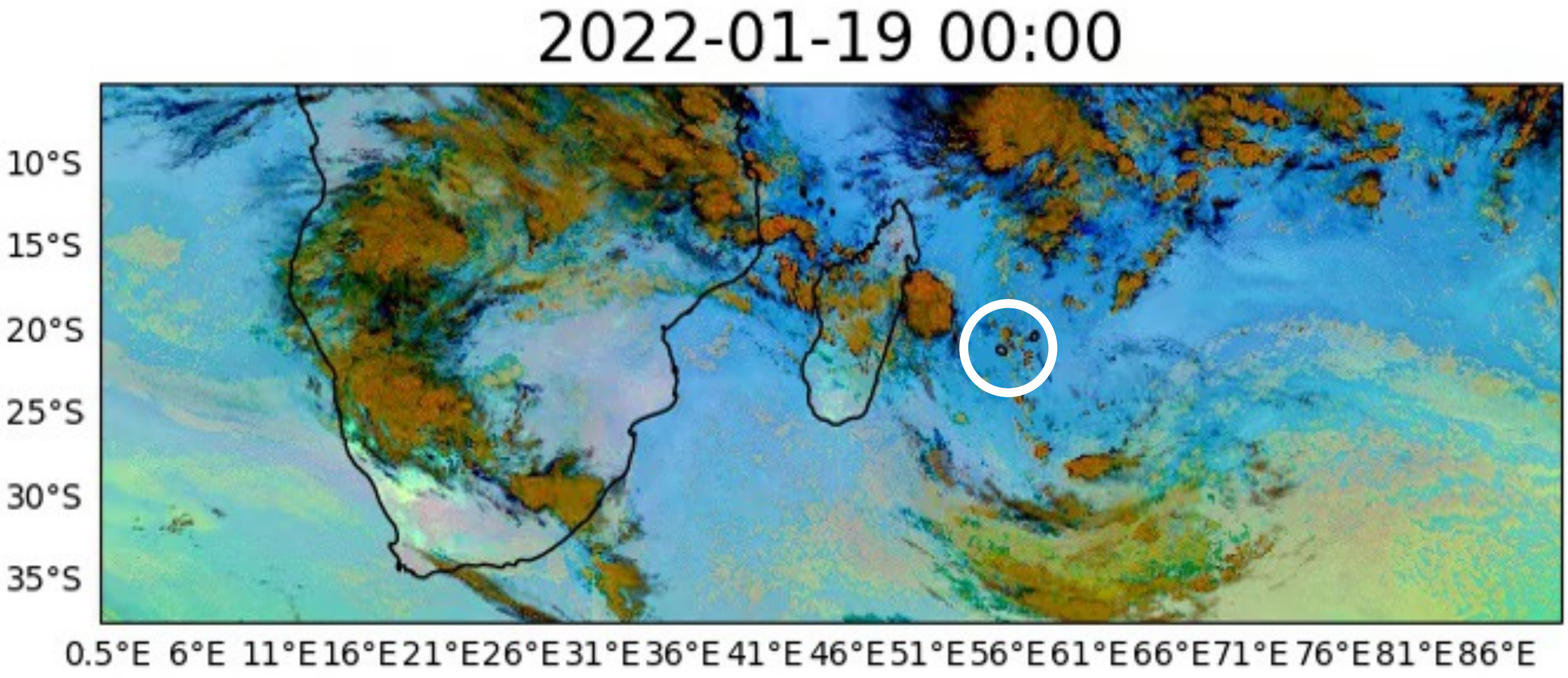
A. Baron[1], P.Chazette[2], S.Khaykin[3], G. Payen[4], N. Marquestaut[4], N. Bègue[1] and V. Duflot[1]

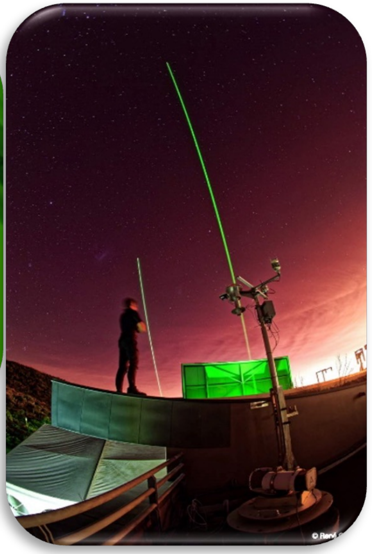
Transport toward La Réunion



Hunga – Tonga Intensive Campaign at Maïdo

Two main instruments for aerosols profiling

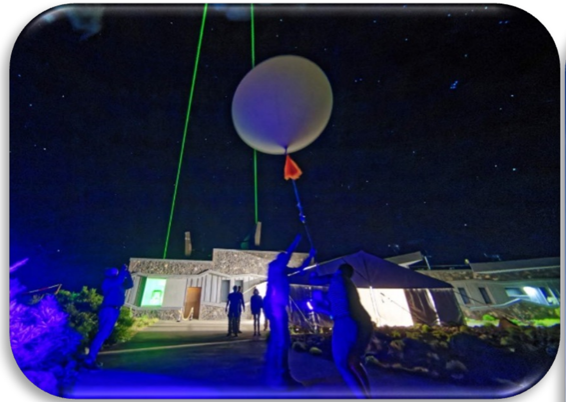
- **Li1200 operating at 355 nm (UV)**
- **LiO_3T operating at 532 nm (Visible)**



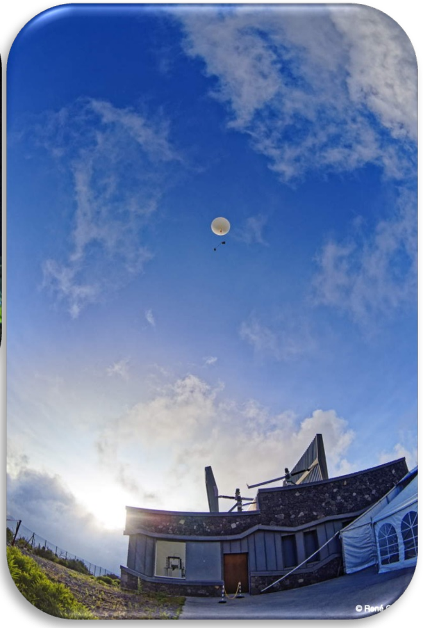
Large size lidar systems at Maïdo © CNRS

Up to **24 nights** of measurements between **19 Jan. and the end of February** (end of the intensive lidar measurements)
→ **372 hours of lidar obs.** cumulated with these two systems

TR²Ex campaign



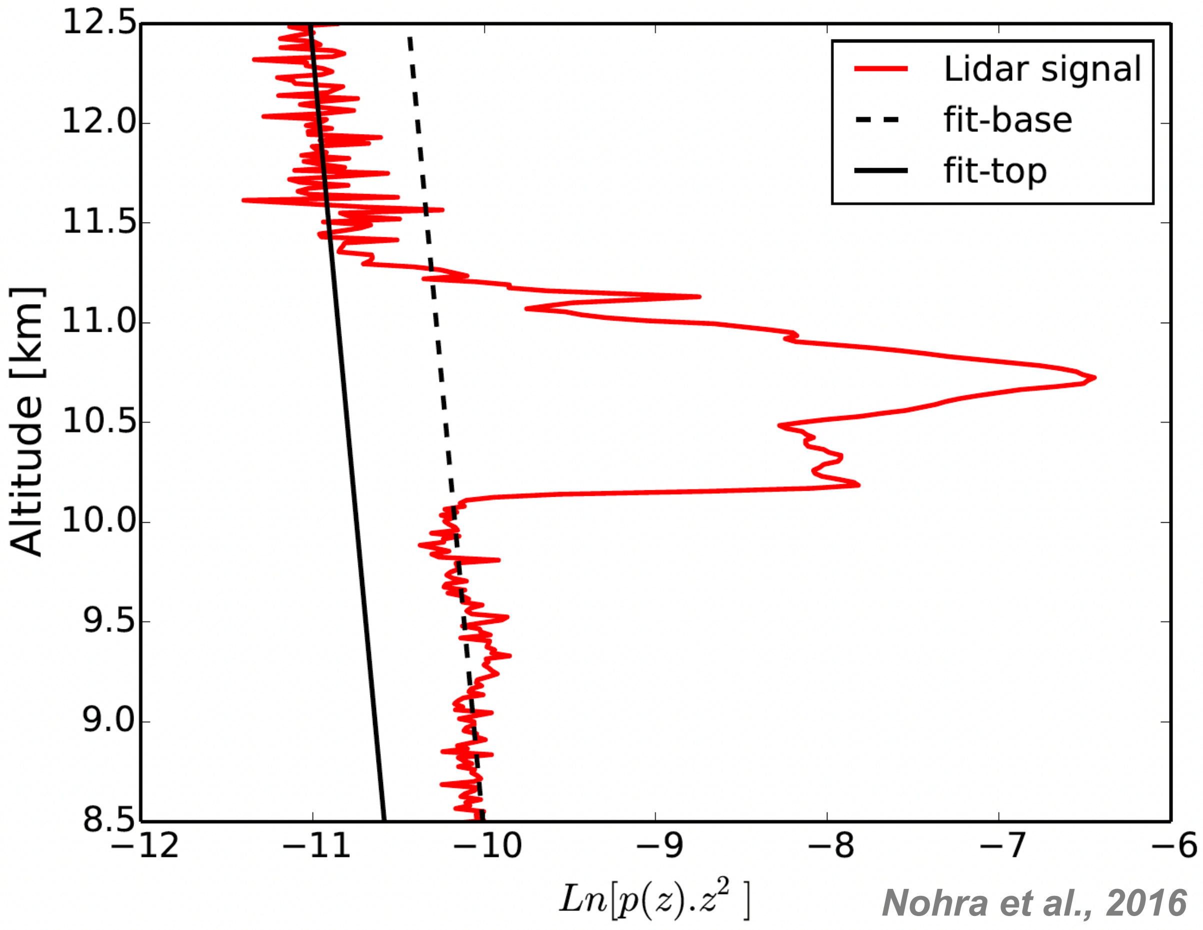
Balloon-born in-situ measurements during the intensive campaign at Maïdo



More than 15 balloons launches involving **ECC ozone** measurements, **POPS, COBALD** aerosols measurements, **SO2** sondes, **LOAC** sondes and **CFH** water vapor sondes

Methodology

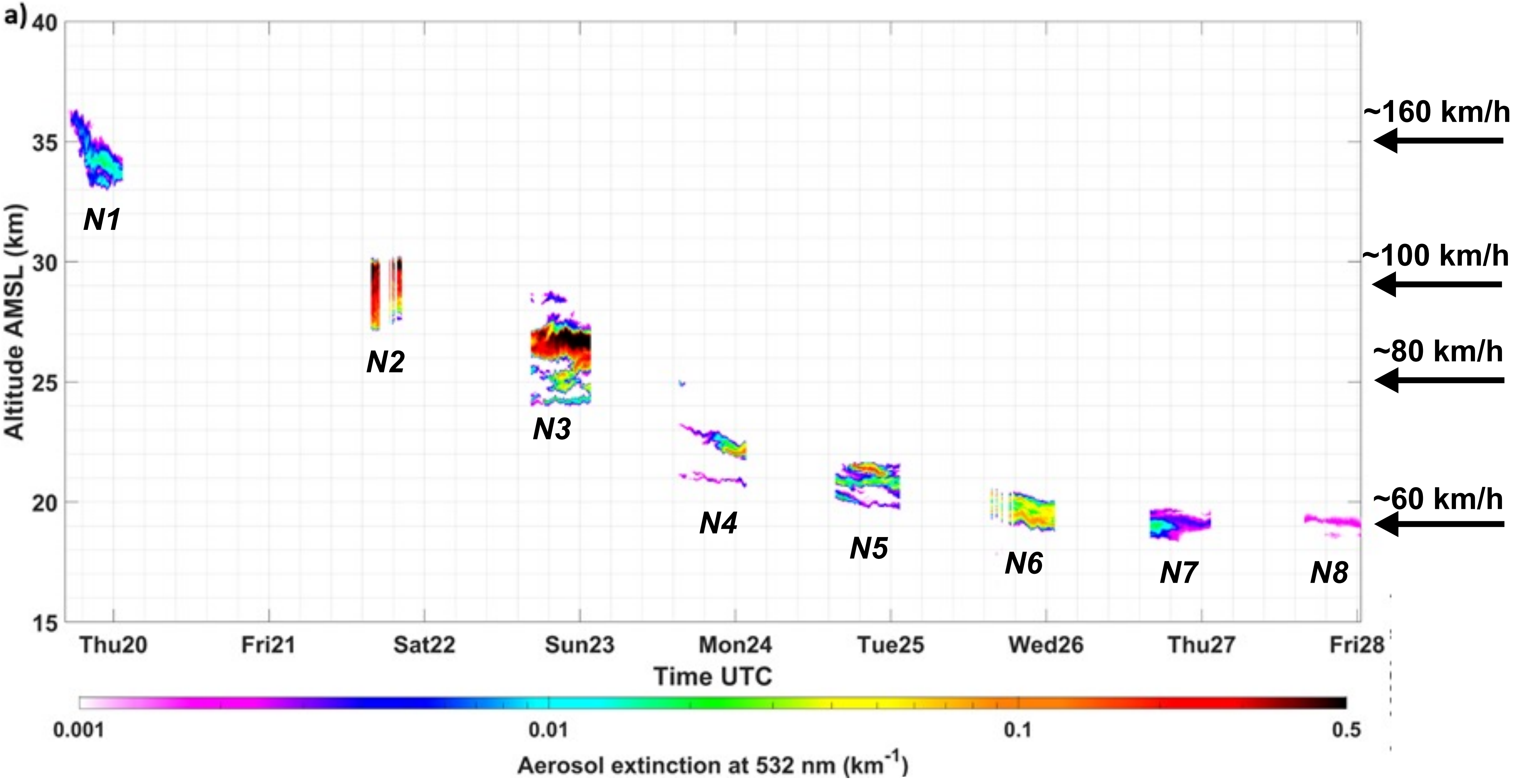
Aerosol layer sandwiched between stratospheric clean layers
=> “Transmittance” or “Rayleigh slope” method (used for cirrus clouds optical depth)



Nohra et al., 2016

OPAR Lidar observations – January 2022

Baron et al., GRL, in review



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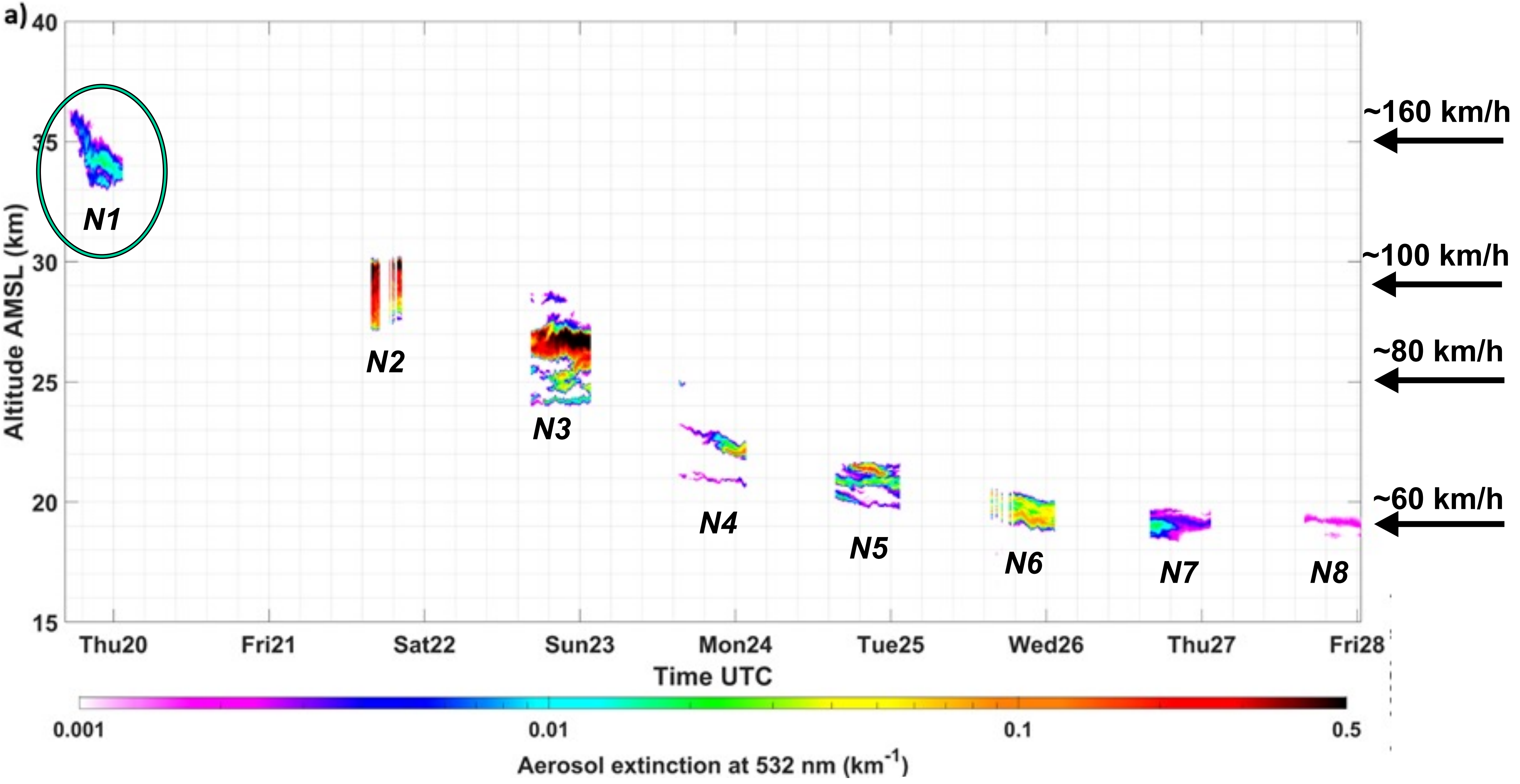
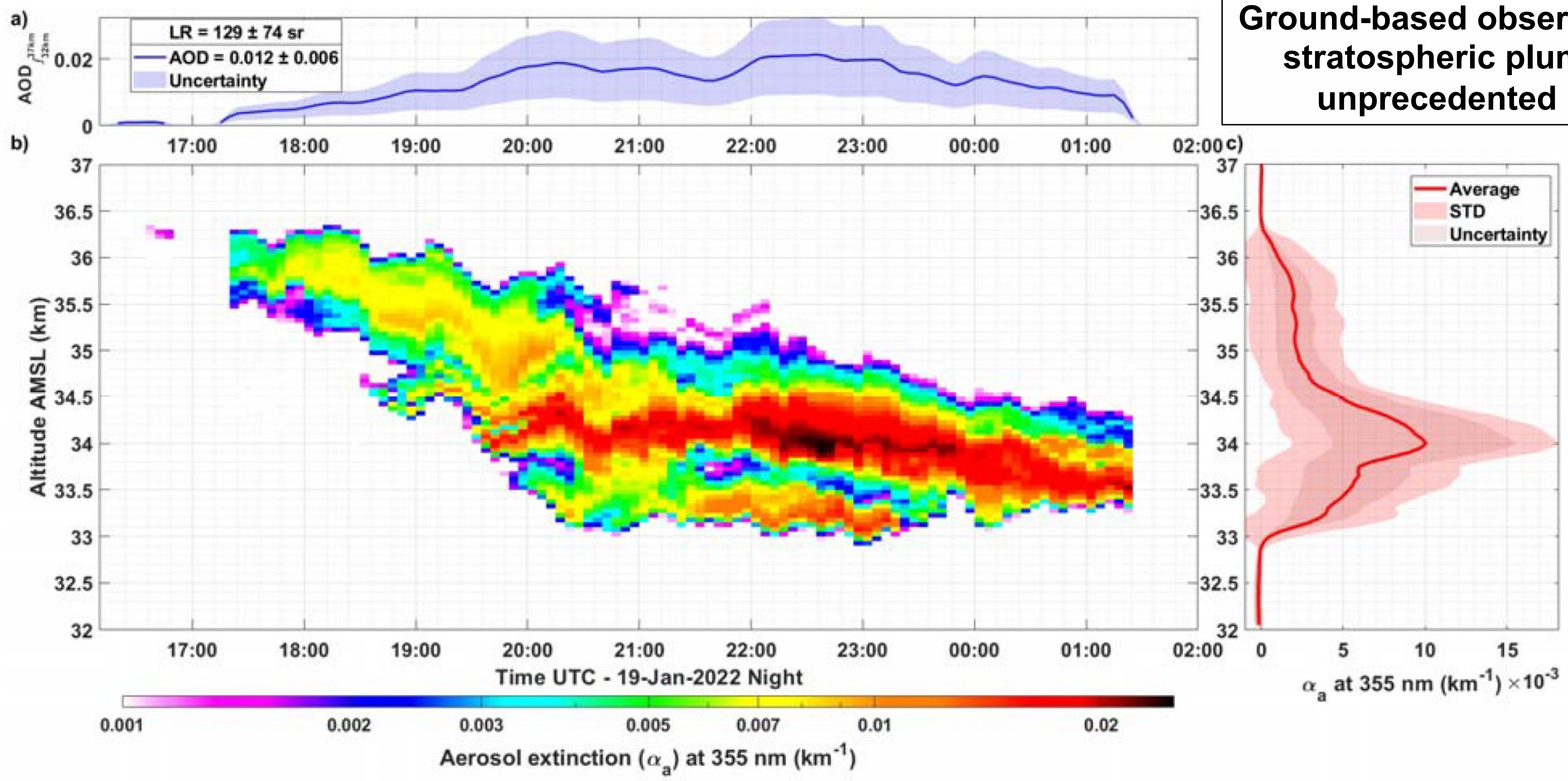


19 January – Li1200

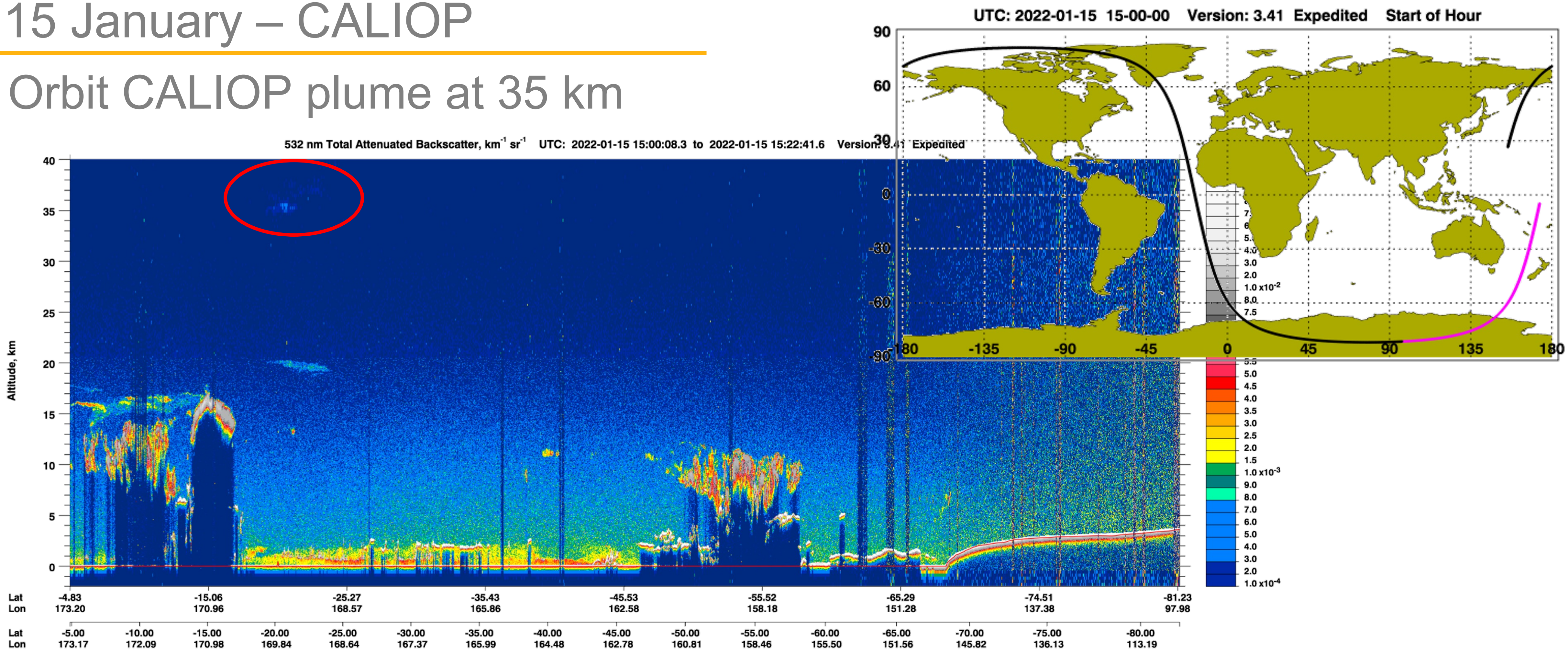
Baron et al., GRL, in review

Ground-based observation of a stratospheric plume at an unprecedented height



15 January – CALIOP

Orbit CALIOP plume at 35 km

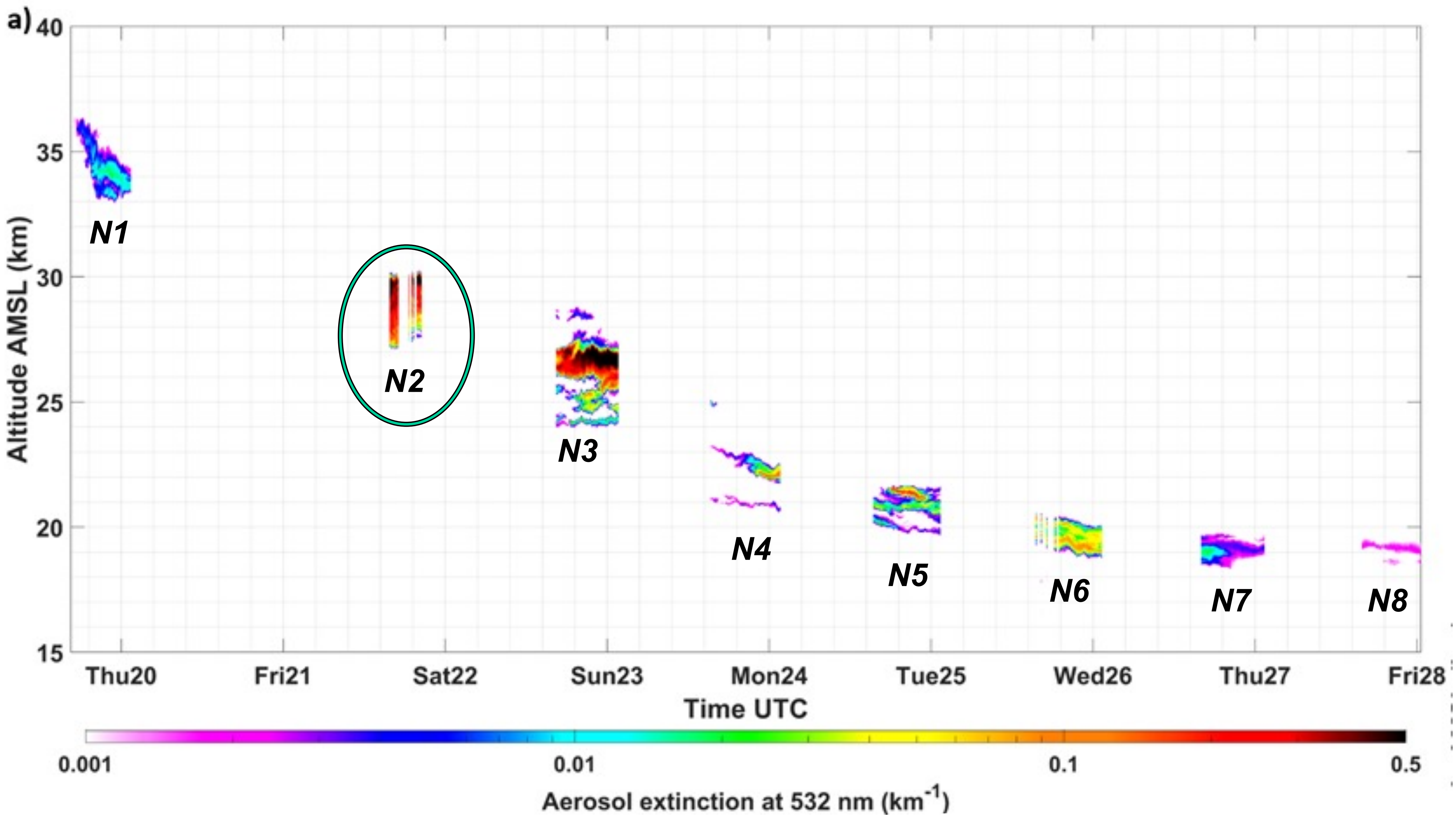


High Lidar Ratio$_{355}$ (129 sr)
High uncertainty (± 74 sr)
30% CALIOP linear depol ratio

Inhomogeneous plume & aerosol mixture: fine ash, sulfates, sea salts ?

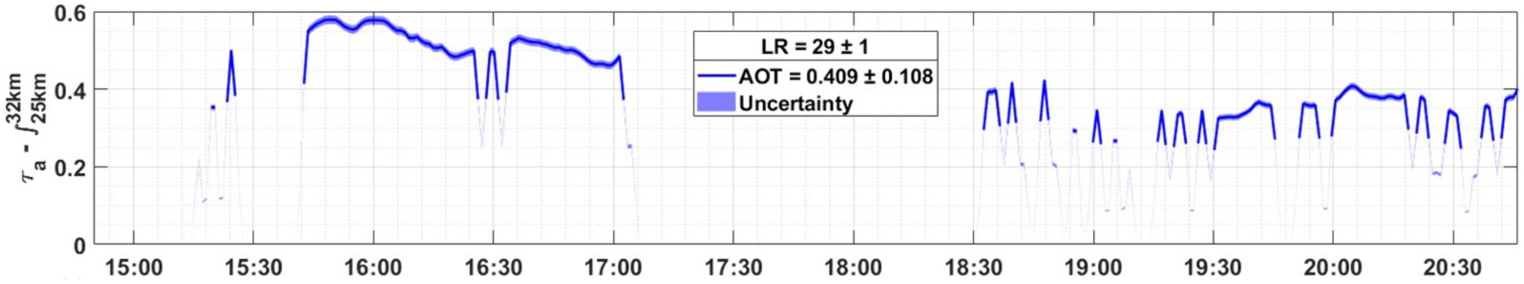
OPAR Lidar observations – January 2022

Baron et al., GRL, in review

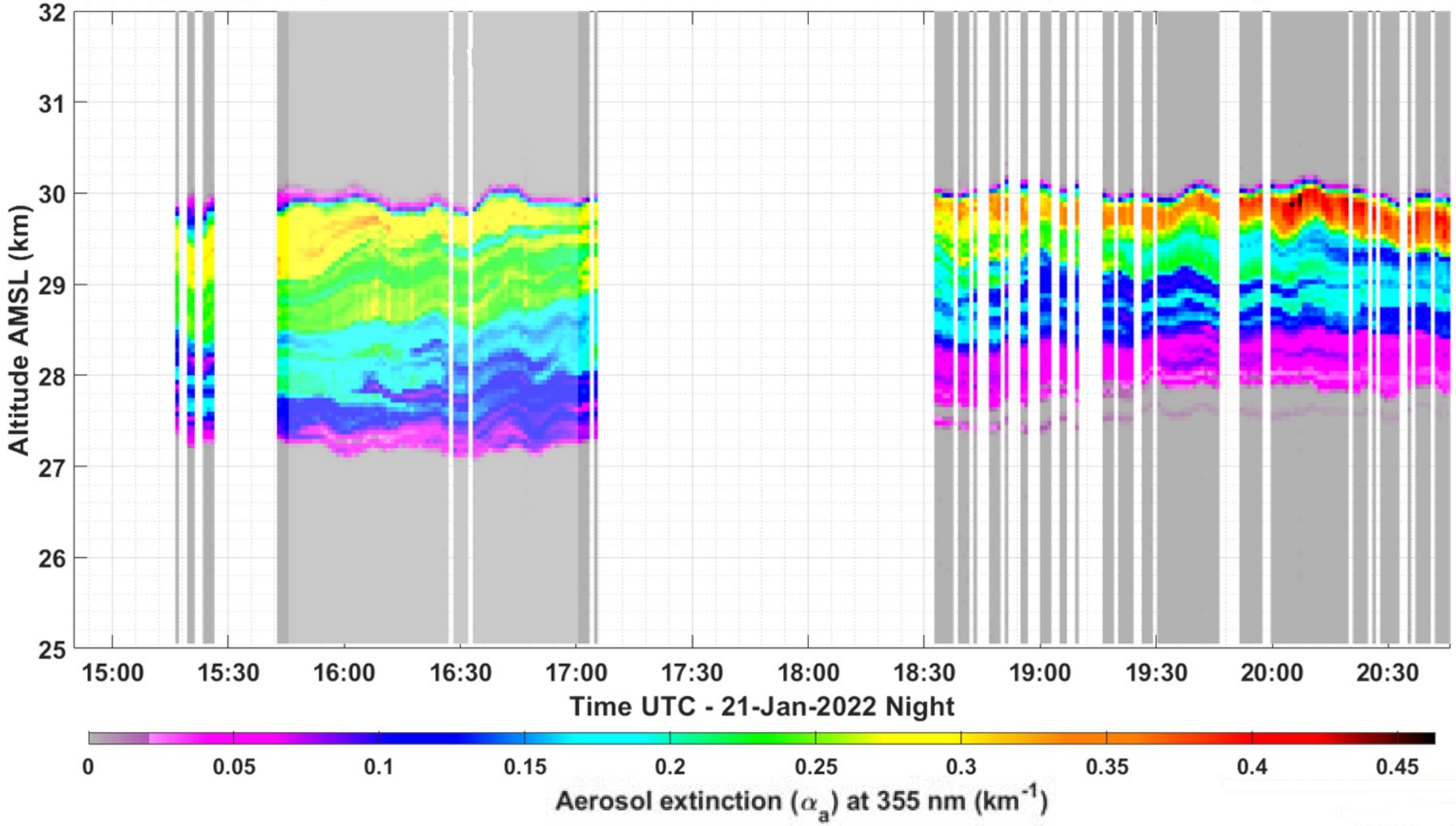


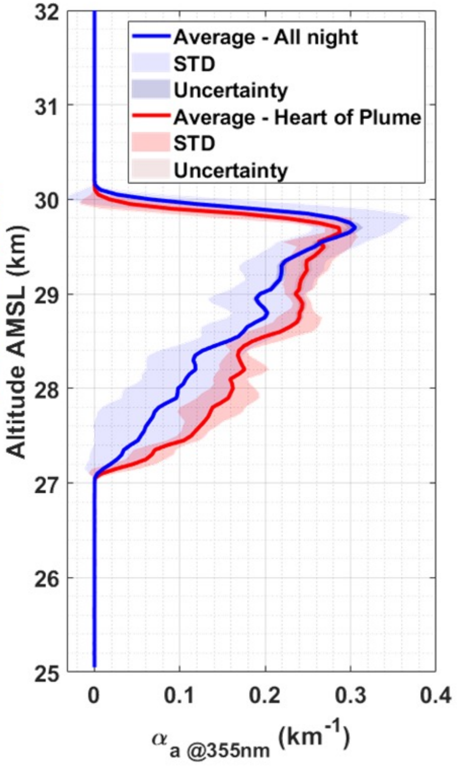
21 January – Li1200

Baron et al., GRL, in review



Unprecedented AOD of a stratospheric plume: 0.84 at 532nm





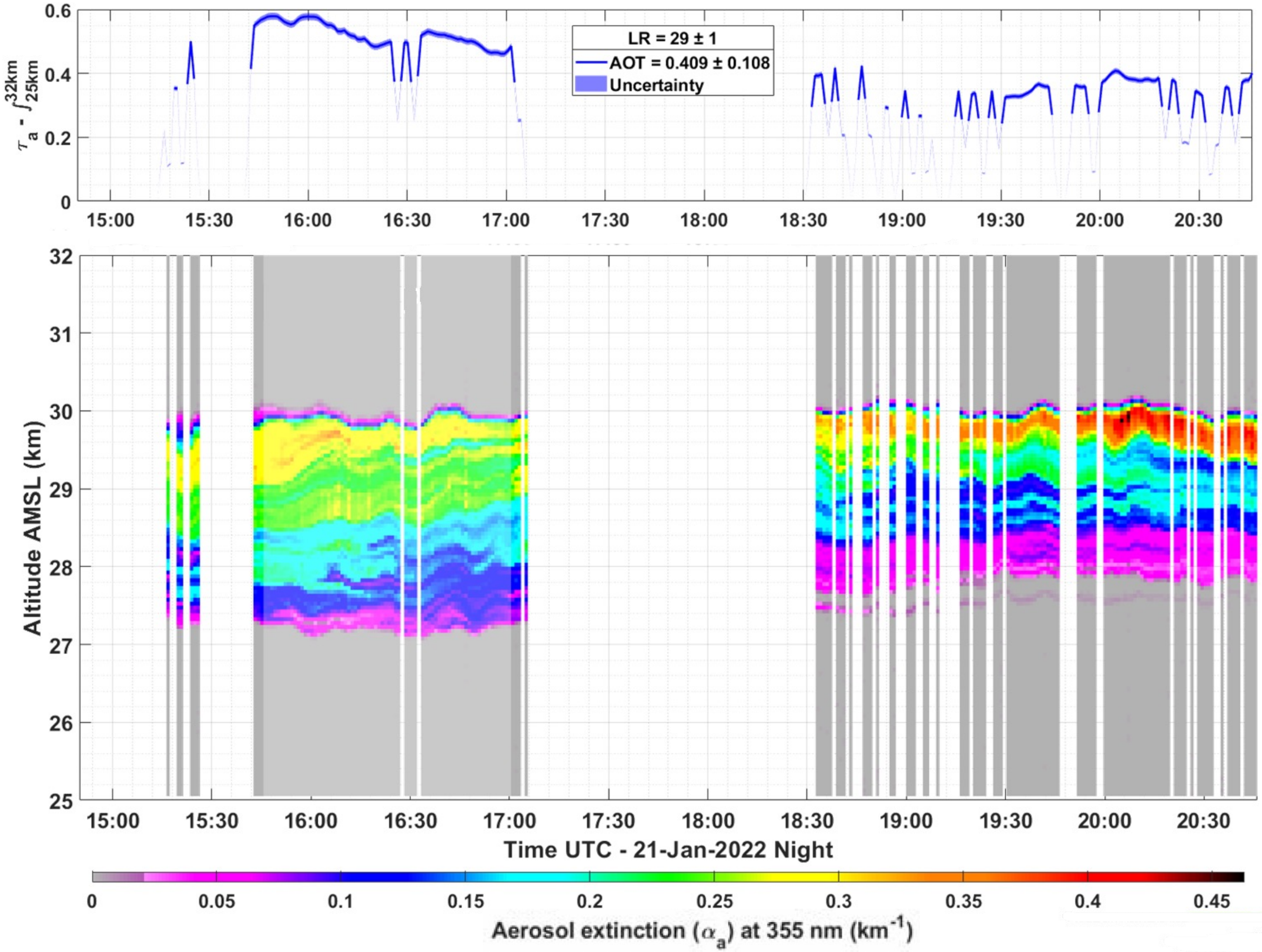
Mean AOT_{355}=0.41 ± 0.10
Mean AOT_{532}=0.60 ± 0.15

LR_{355}=29 ± 1 sr
LR_{532}=69 ± 11 sr

AE=-0.8 ± 0.8

21 January – Li1200

Baron et al., GRL, in review



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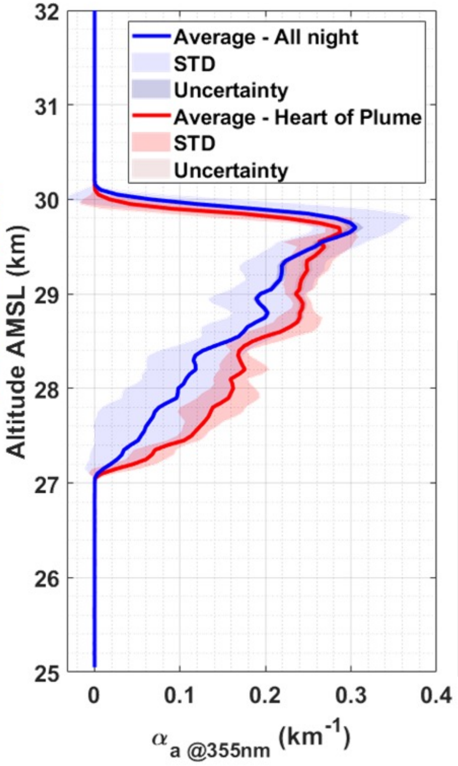

Mean AOT_{355}=0.44 ± 0.10
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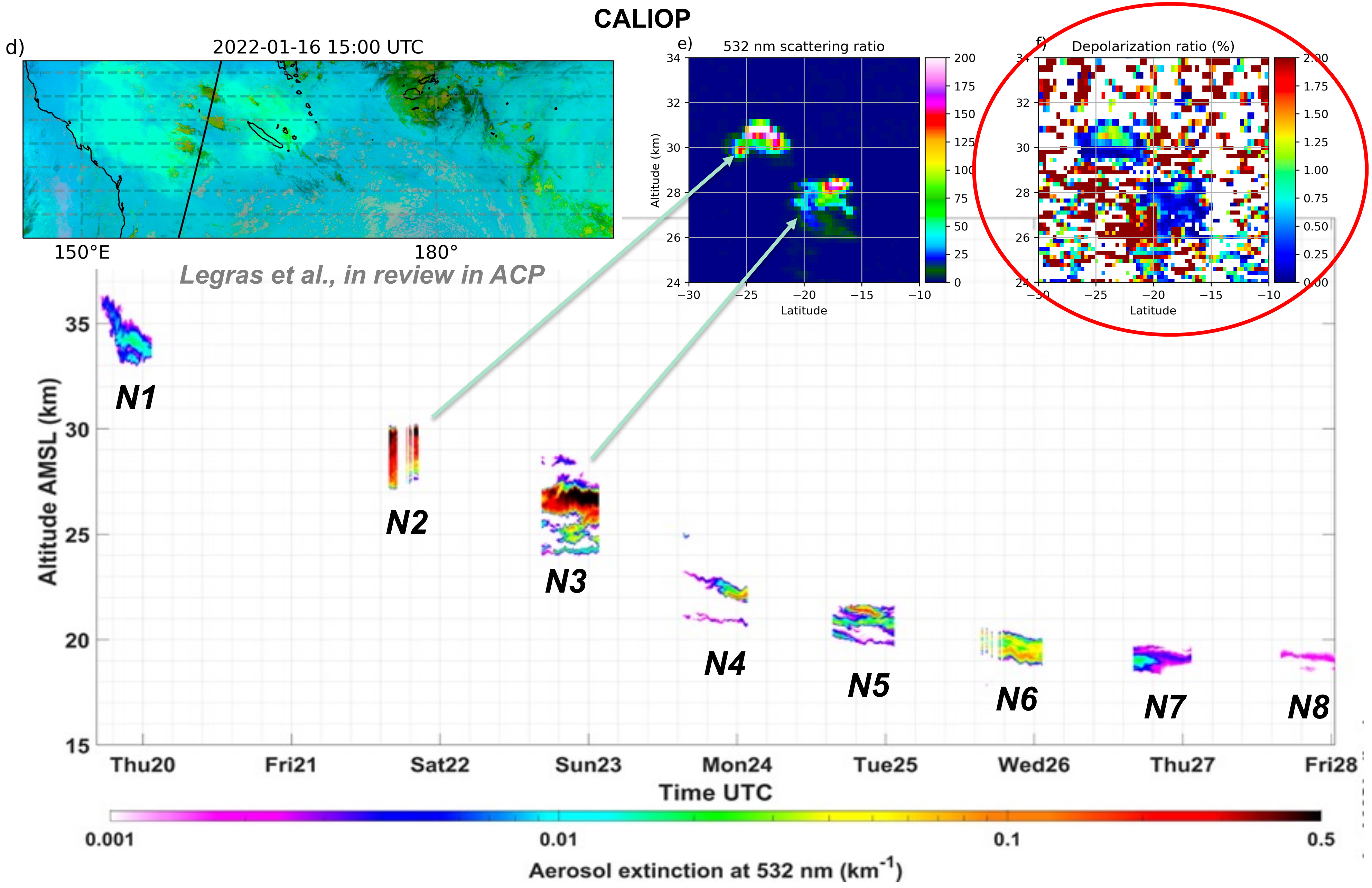
Typical for volcanic aerosol driven by sulfates presence

OPAR Lidar observations – January 2022

Baron et al., GRL, in review



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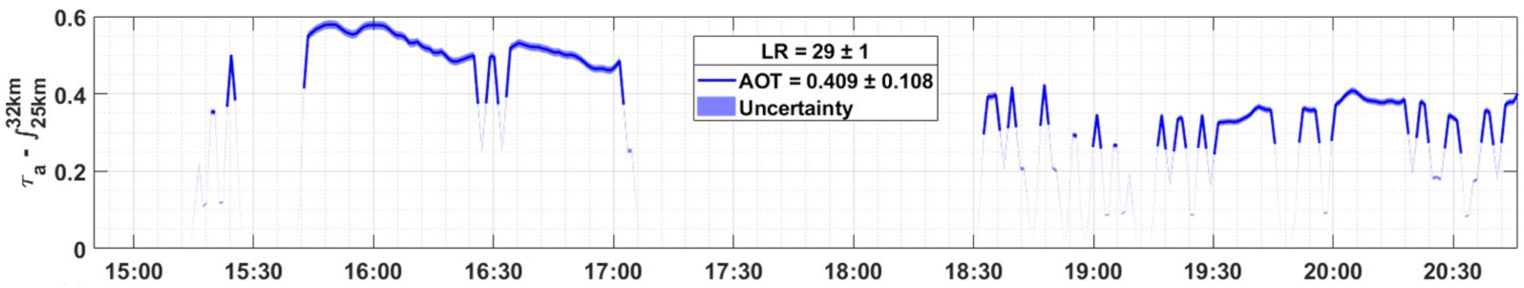

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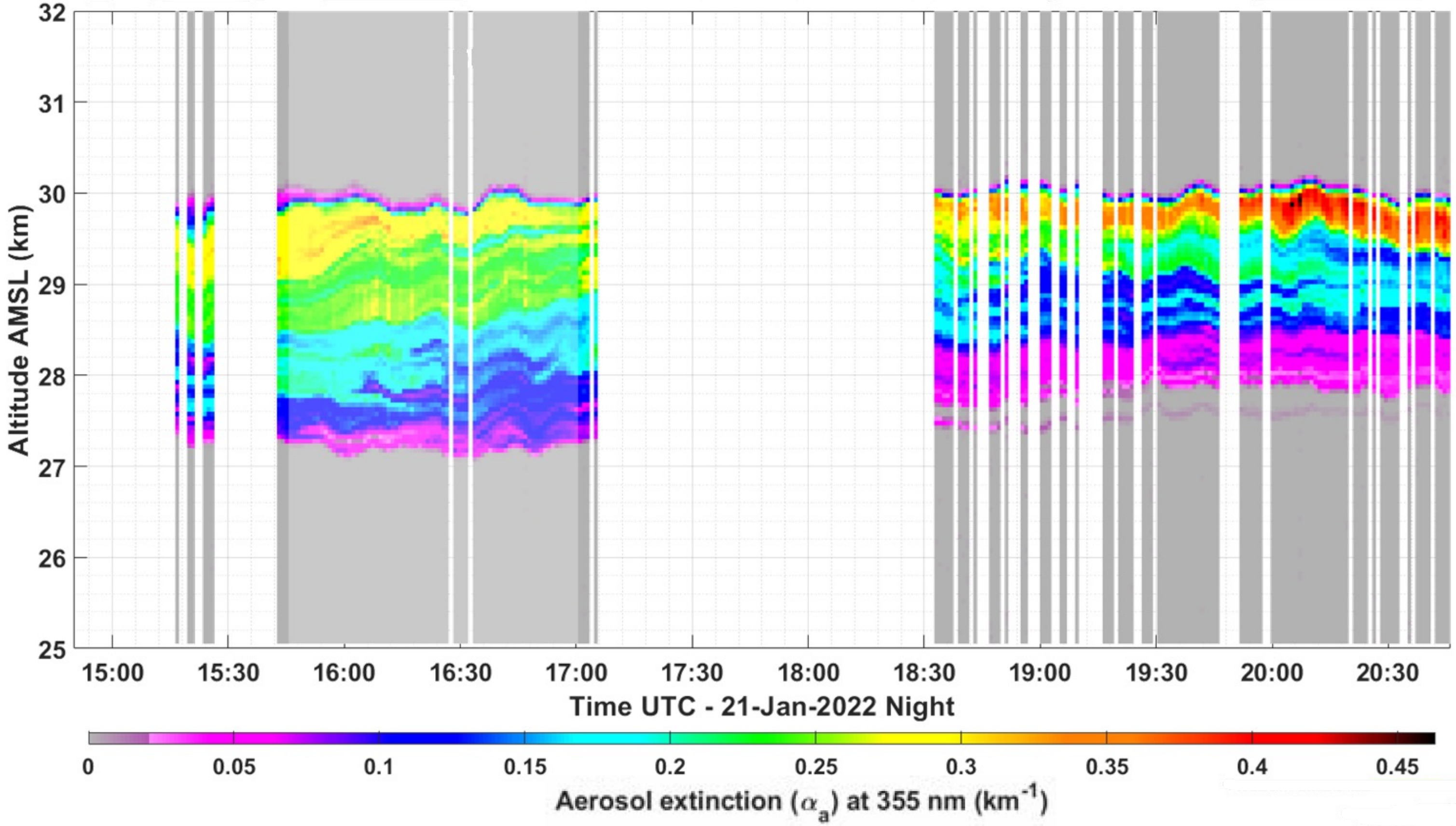

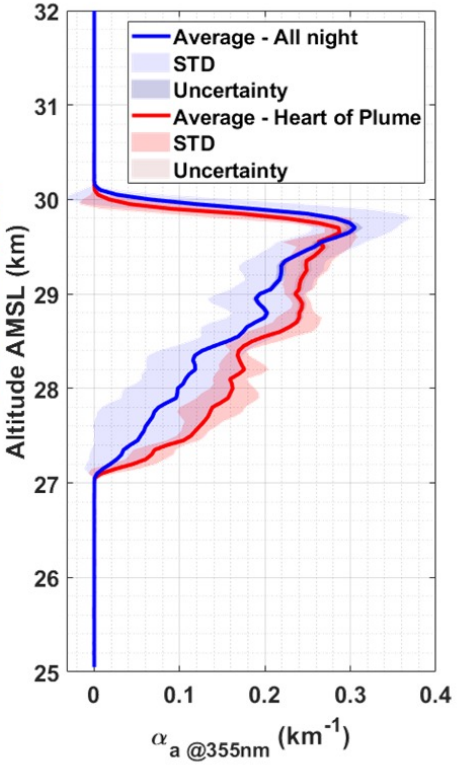

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Supported by depolarization ratio ~0% (CALIOP)

21 January – Li1200

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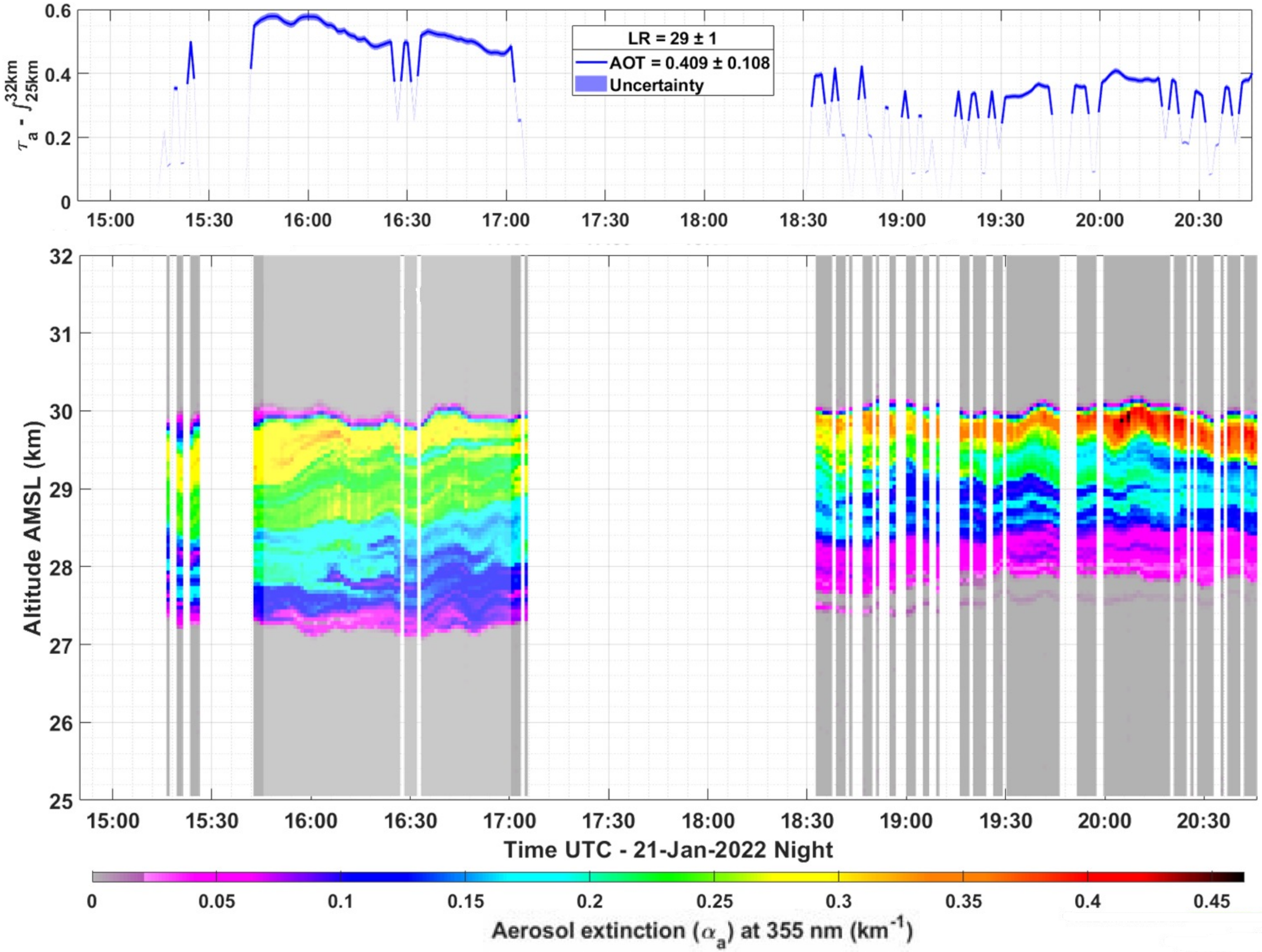

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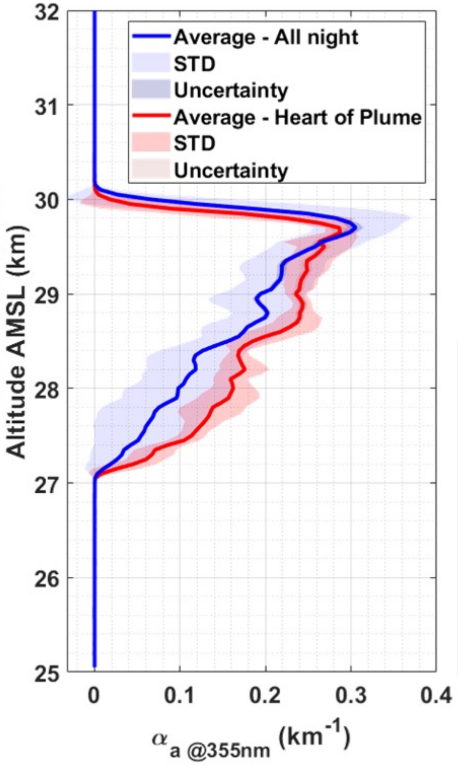

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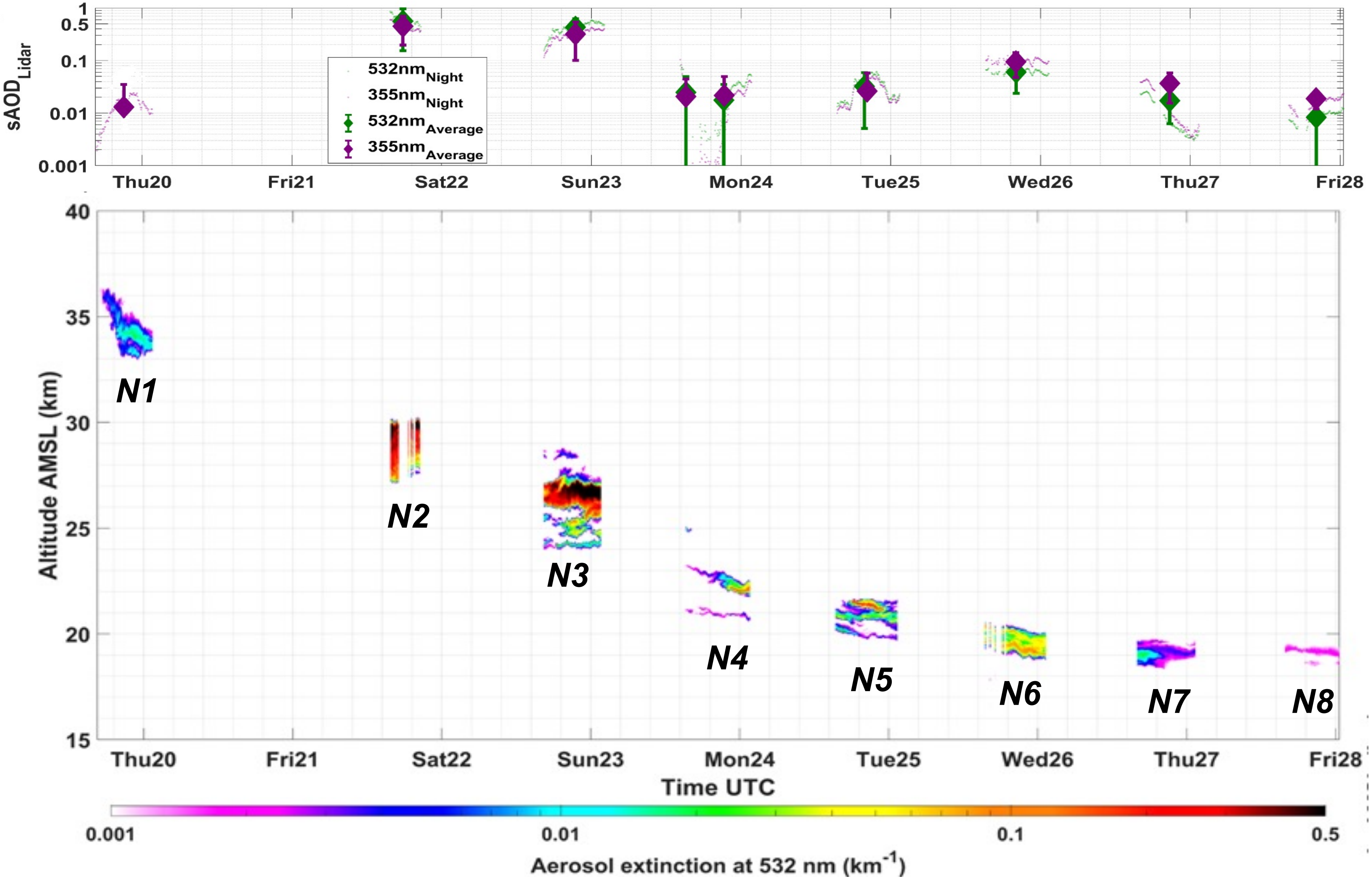

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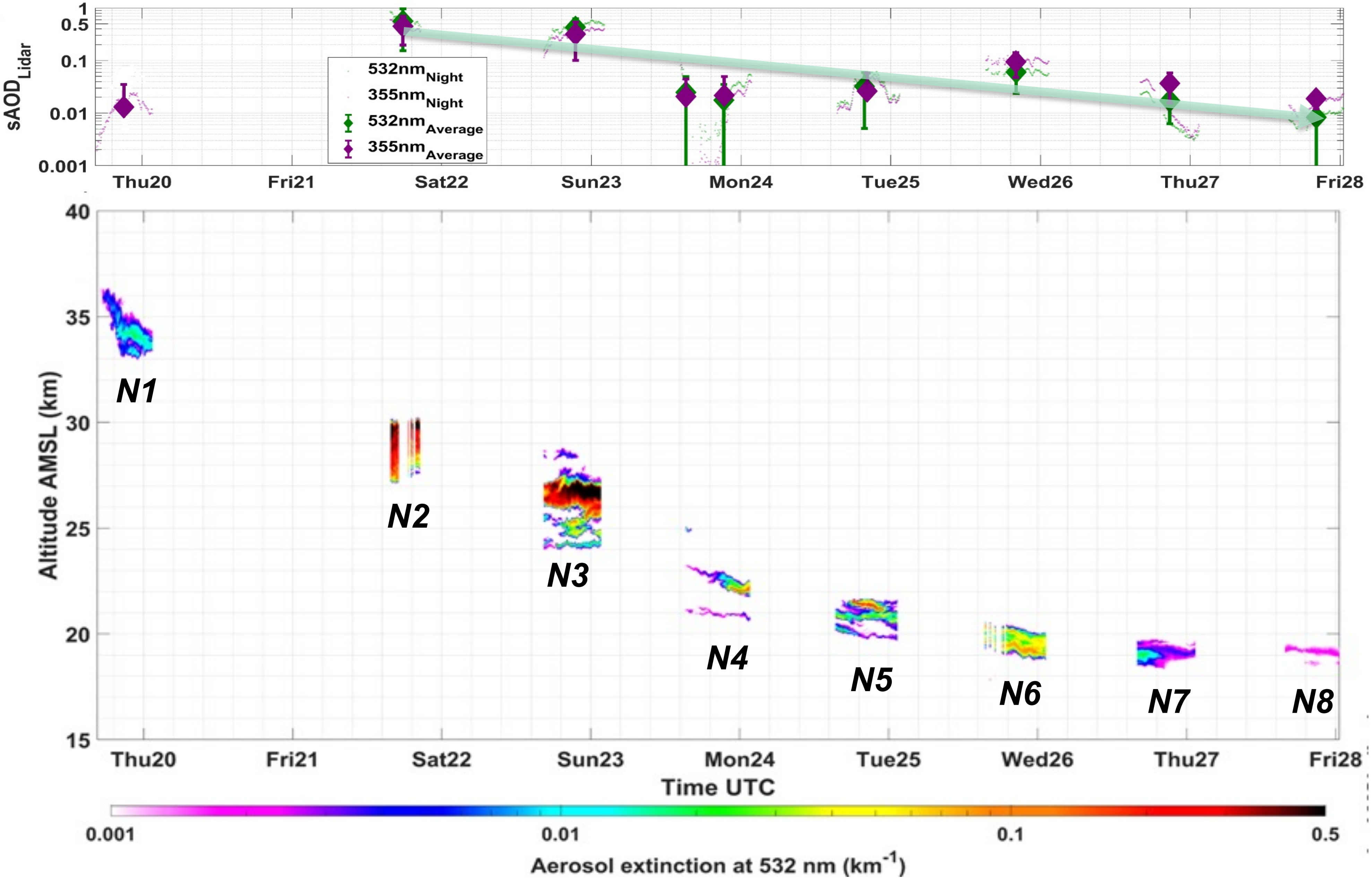

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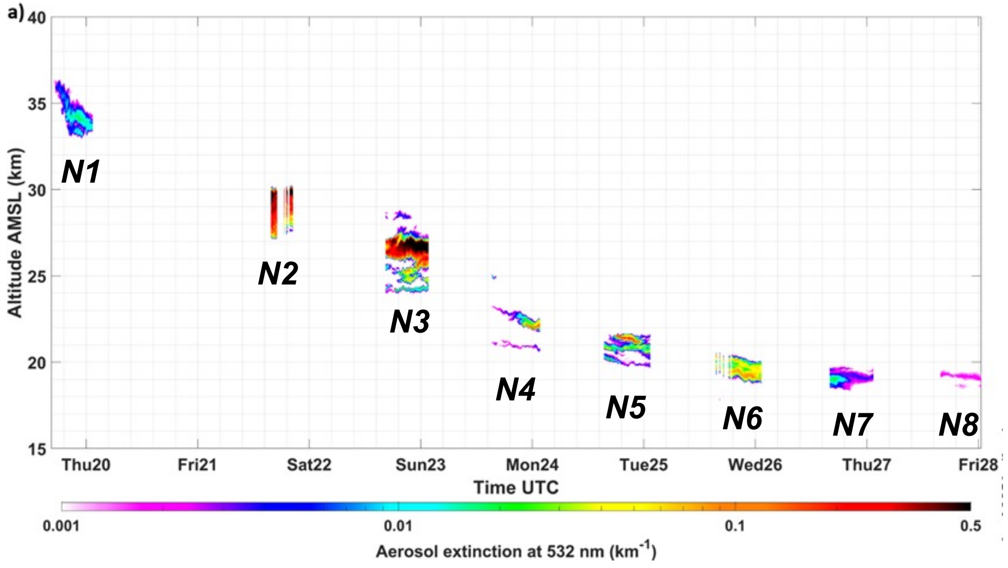

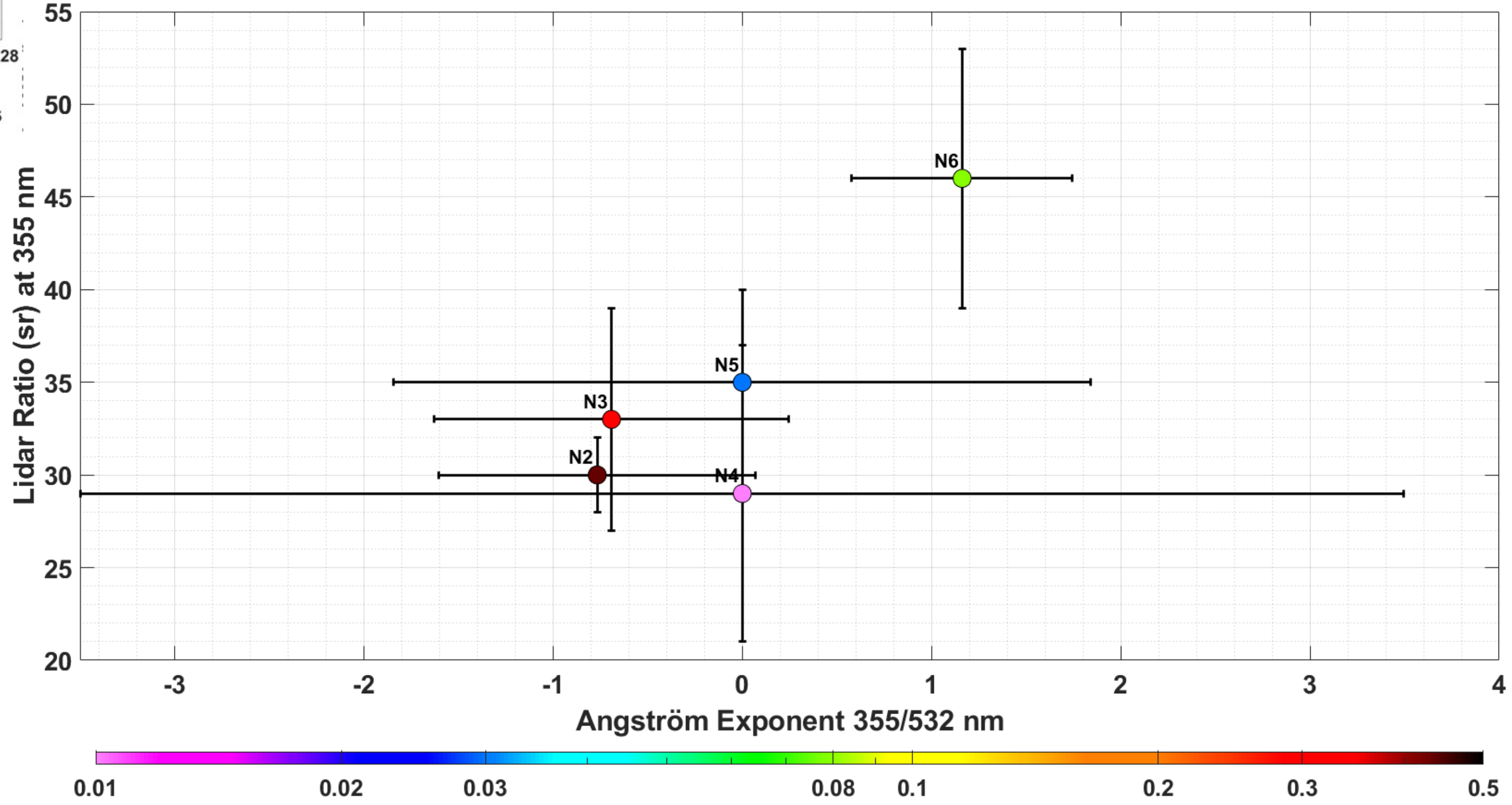

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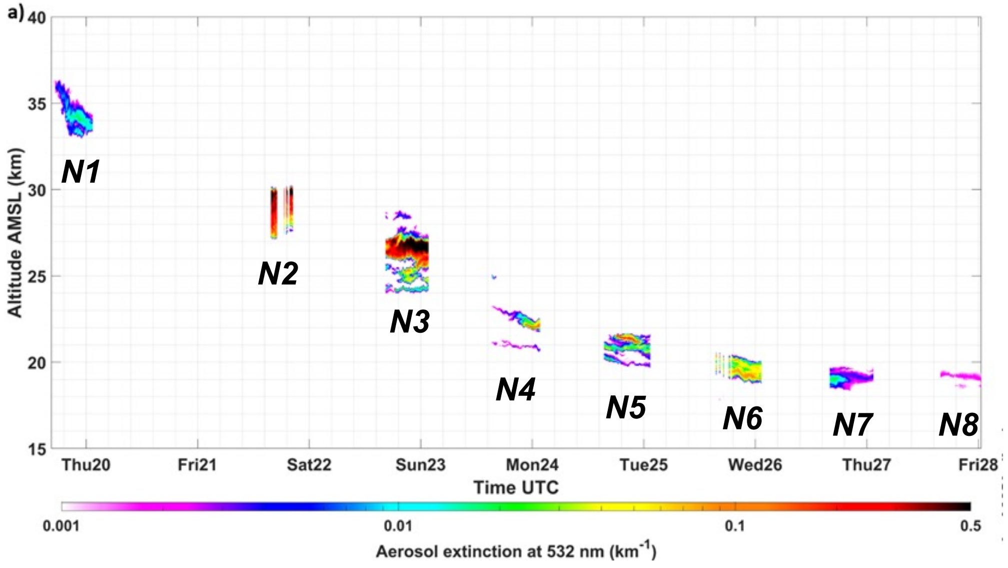

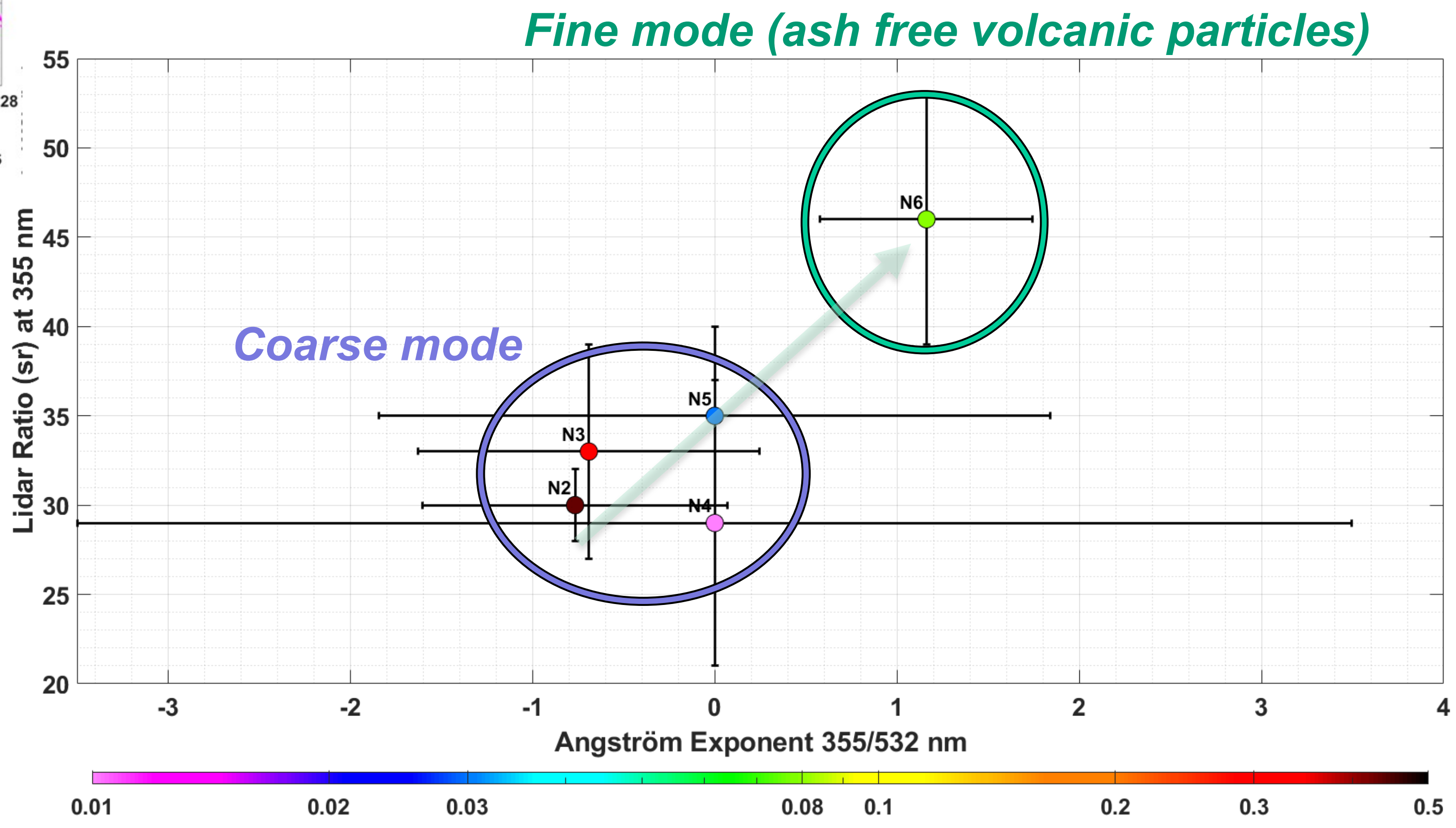

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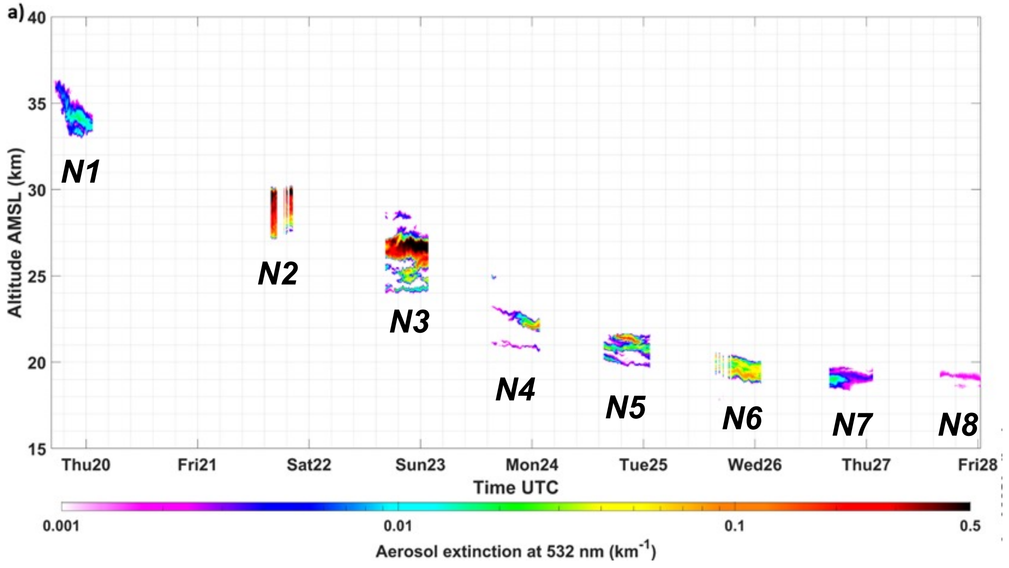

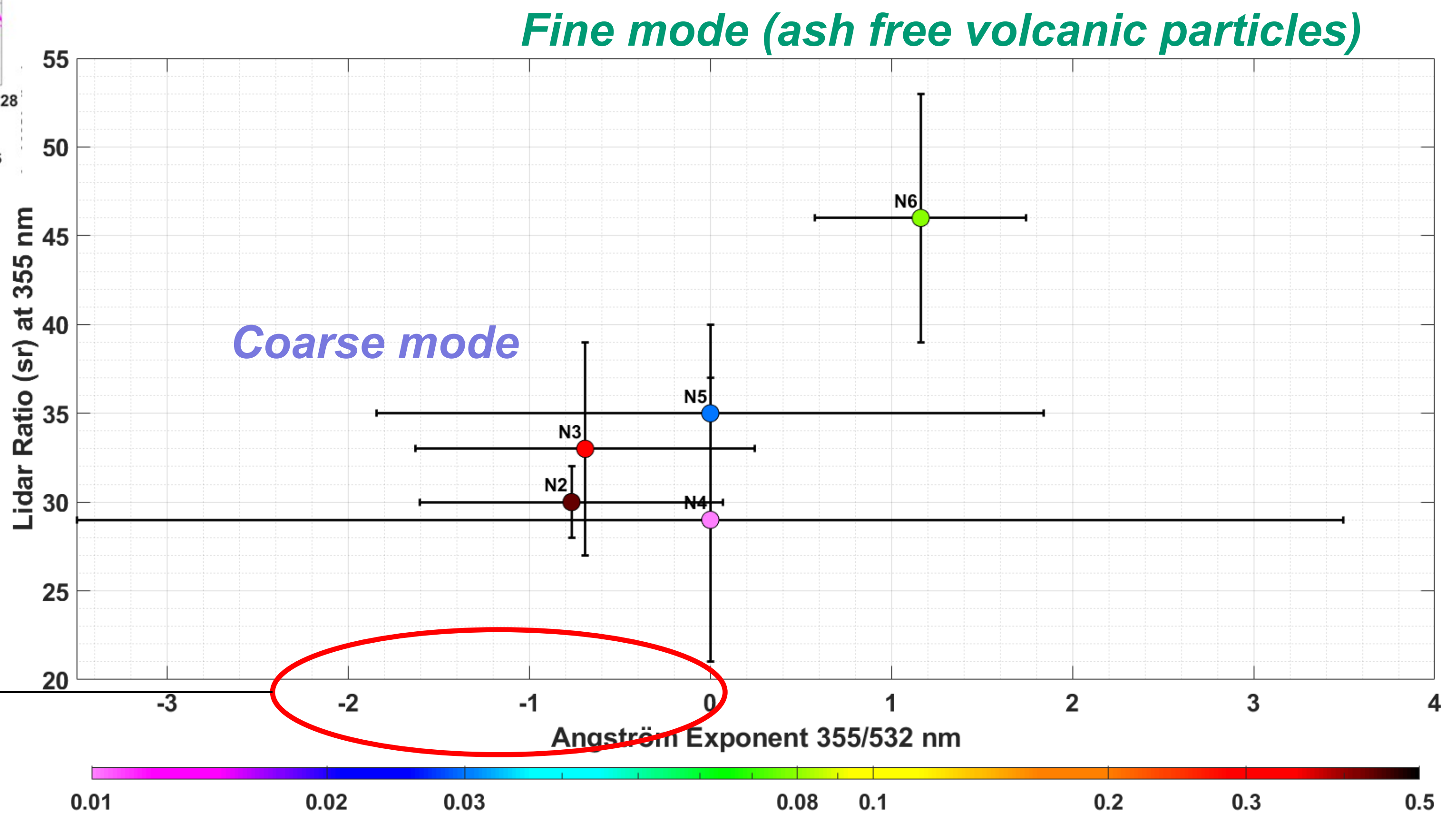

Can it be explained ?

Mie Code

Baron et al., GRL, in review

Hypothesis:

- **Spherical particles (OK for sulphates, NOK for ash)**
- **Monomodal lognormal size distribution (supported by previous in situ observations on stratospheric balloons)**
- **Aerosol mixture with the properties of sulfate particles (supported by mean LR_{532}=66 ± 7 sr)**

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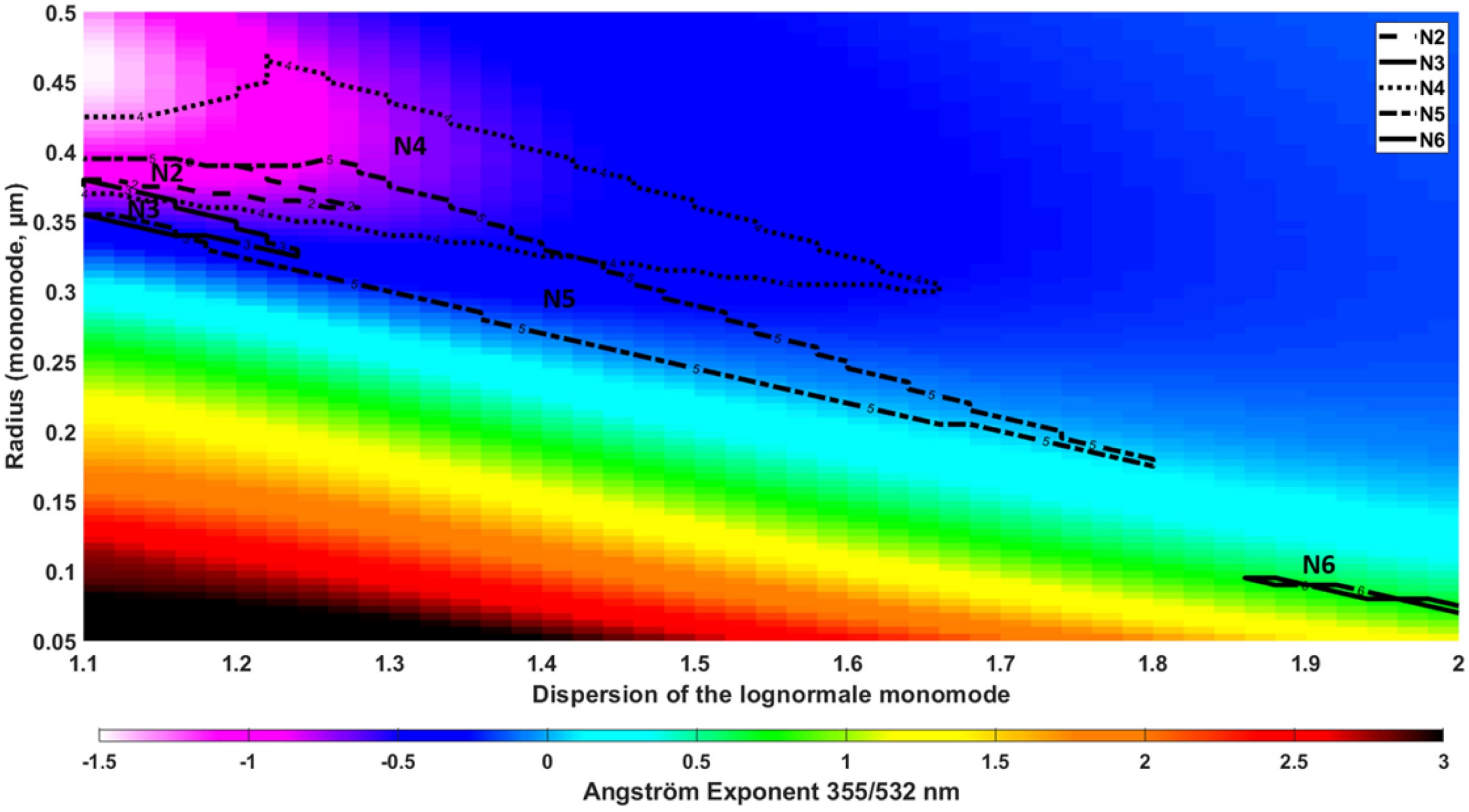

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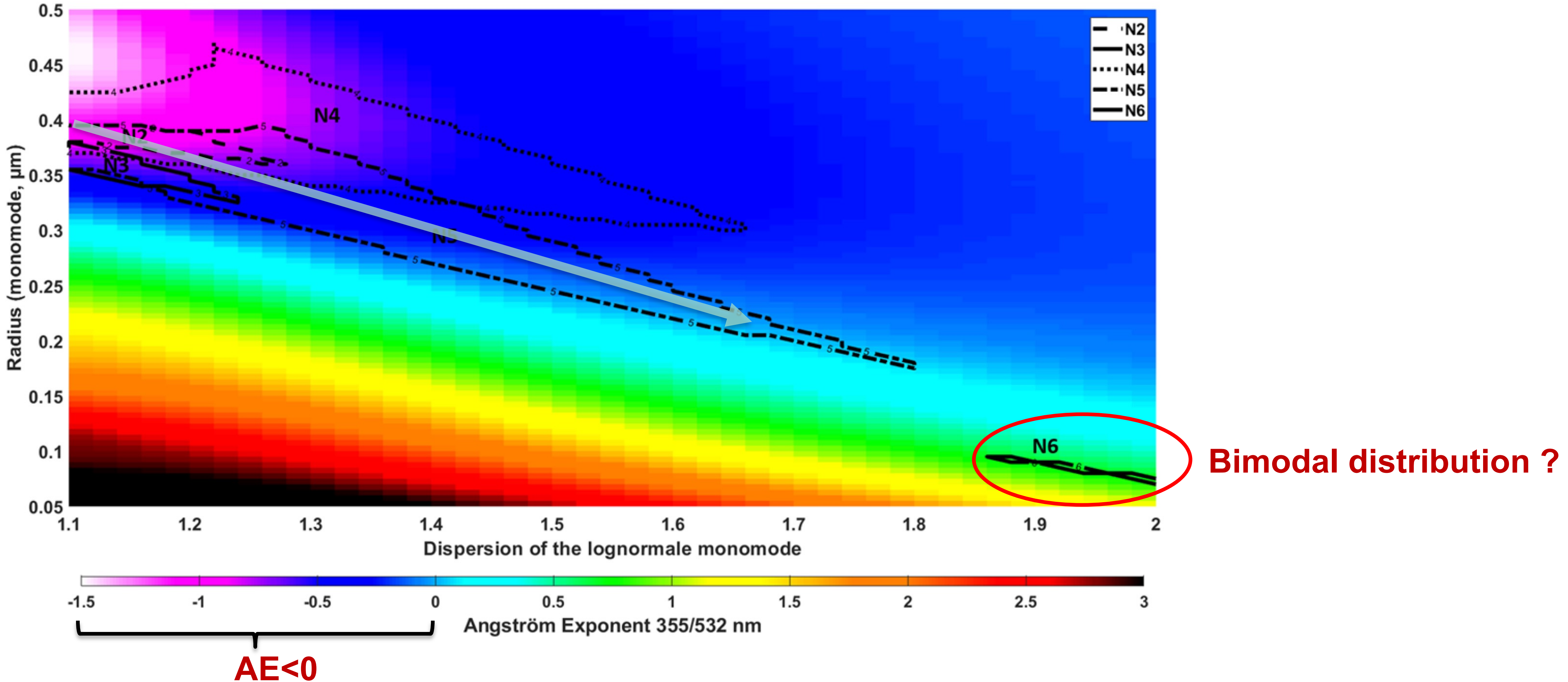
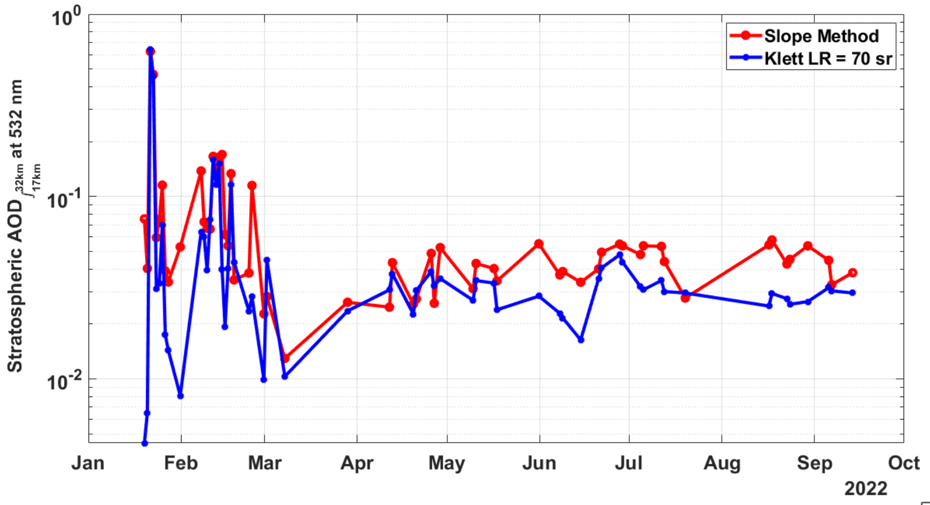


Conclusion, Synergies and Outlook

- **OPAR RS measurements**
  - Unprecedented ground-based lidar observations of aerosol volcanic plume at these altitudes
  - Highly variable plume structure shaped by stratospheric dynamics
  - Heterogeneous optical properties and aerosol load between the different injection altitudes

Conclusion, Synergies and Outlook



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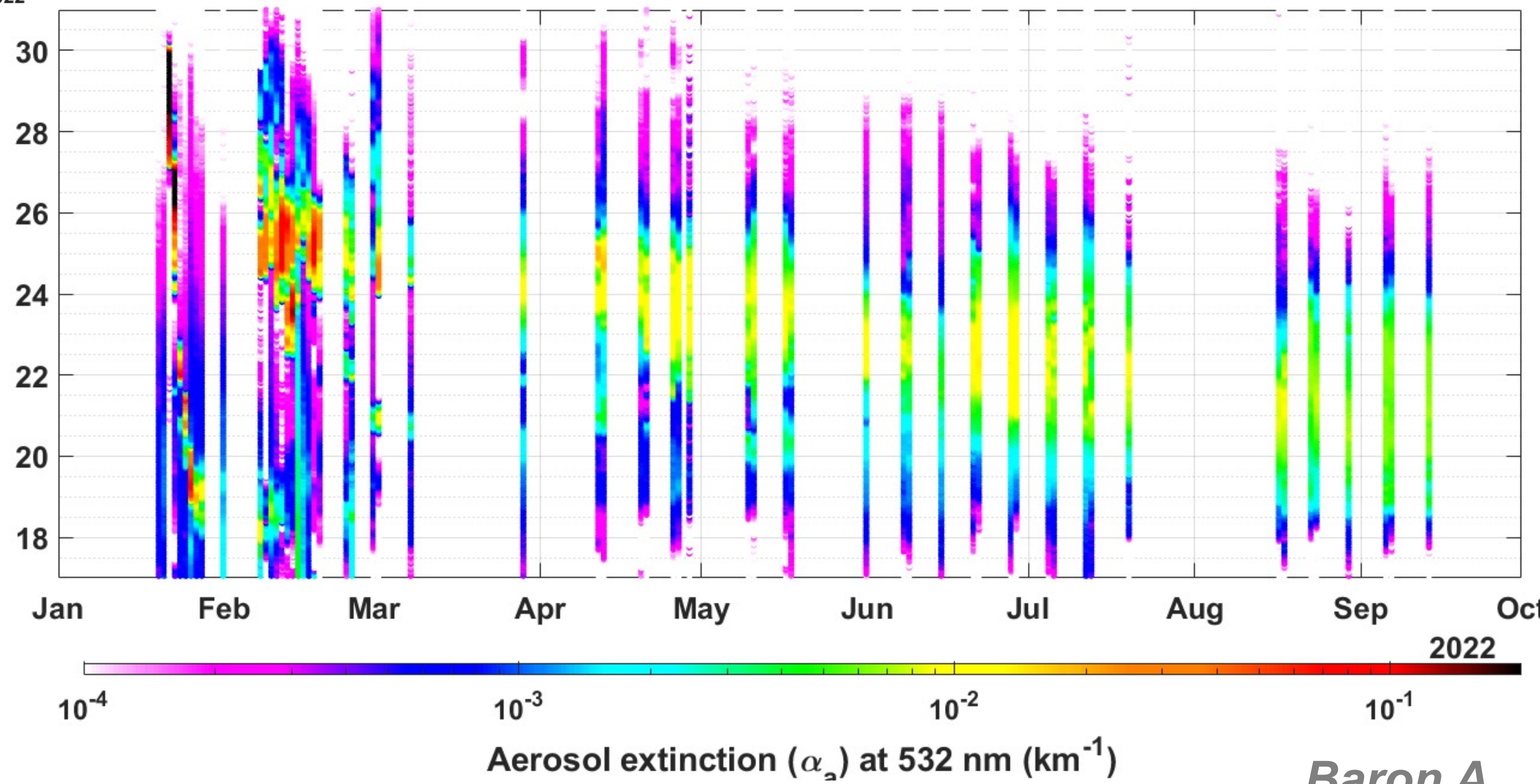
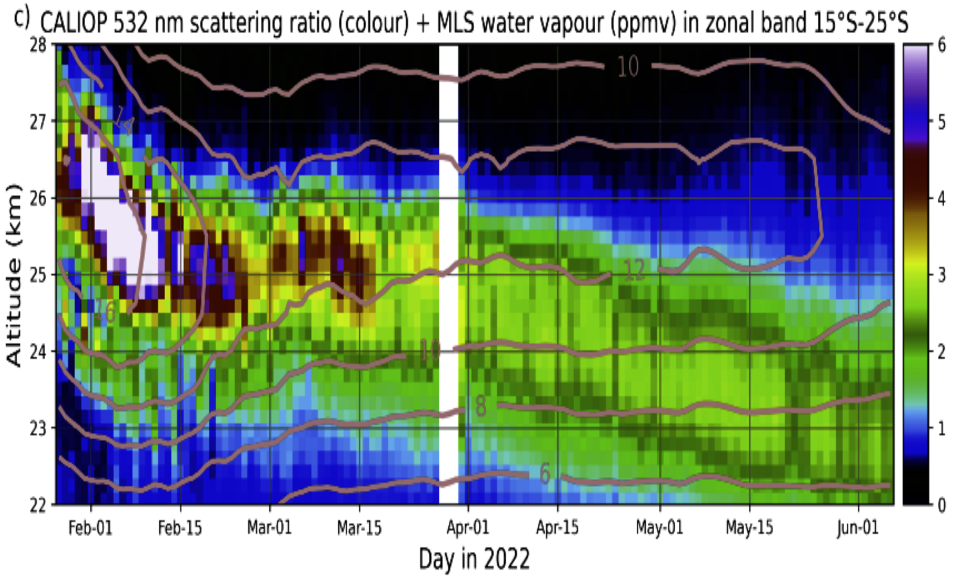


Baron A.

Conclusion, Synergies and Outlook

Upcoming comparison with spaceborne measurements



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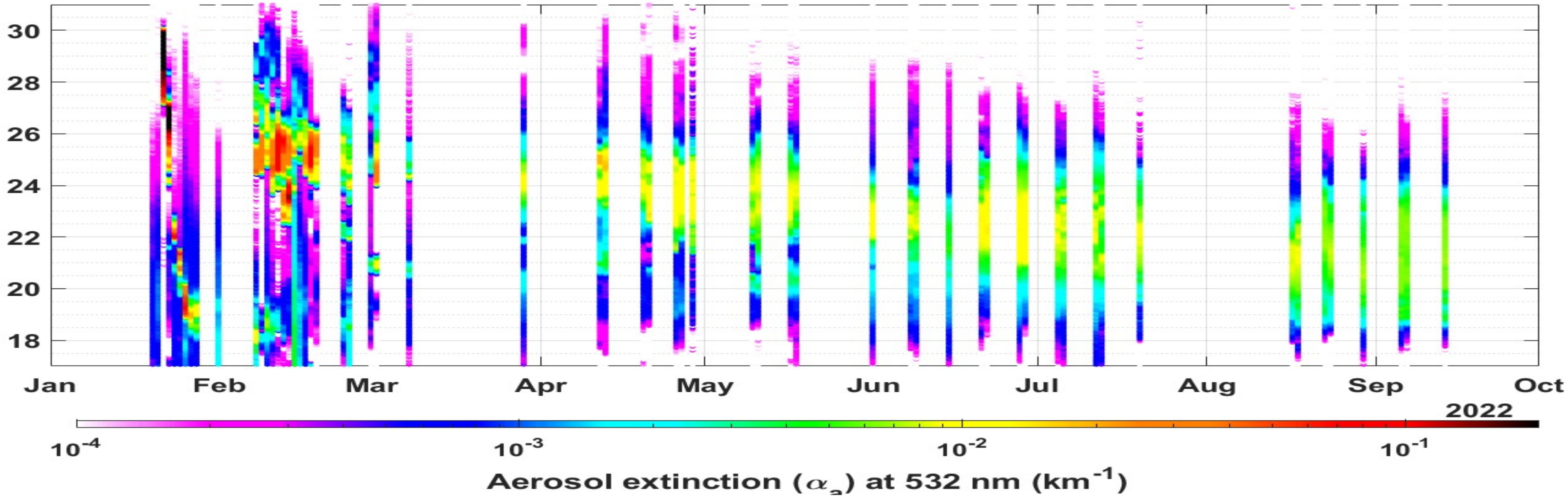
Legras et al., in review in ACP



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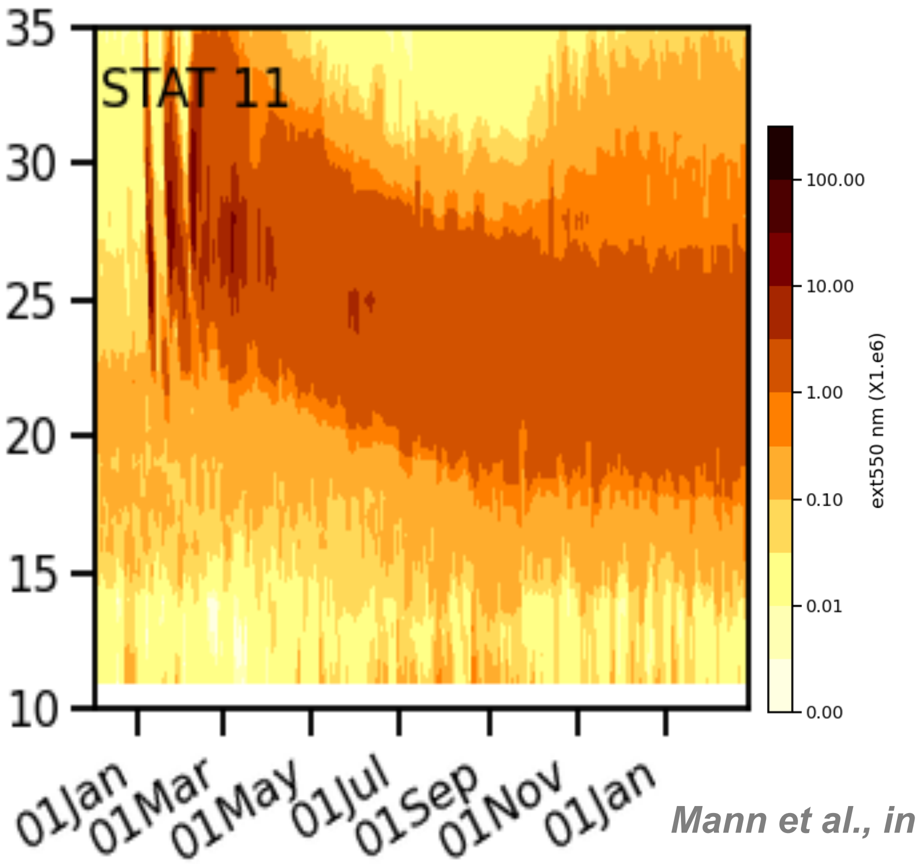
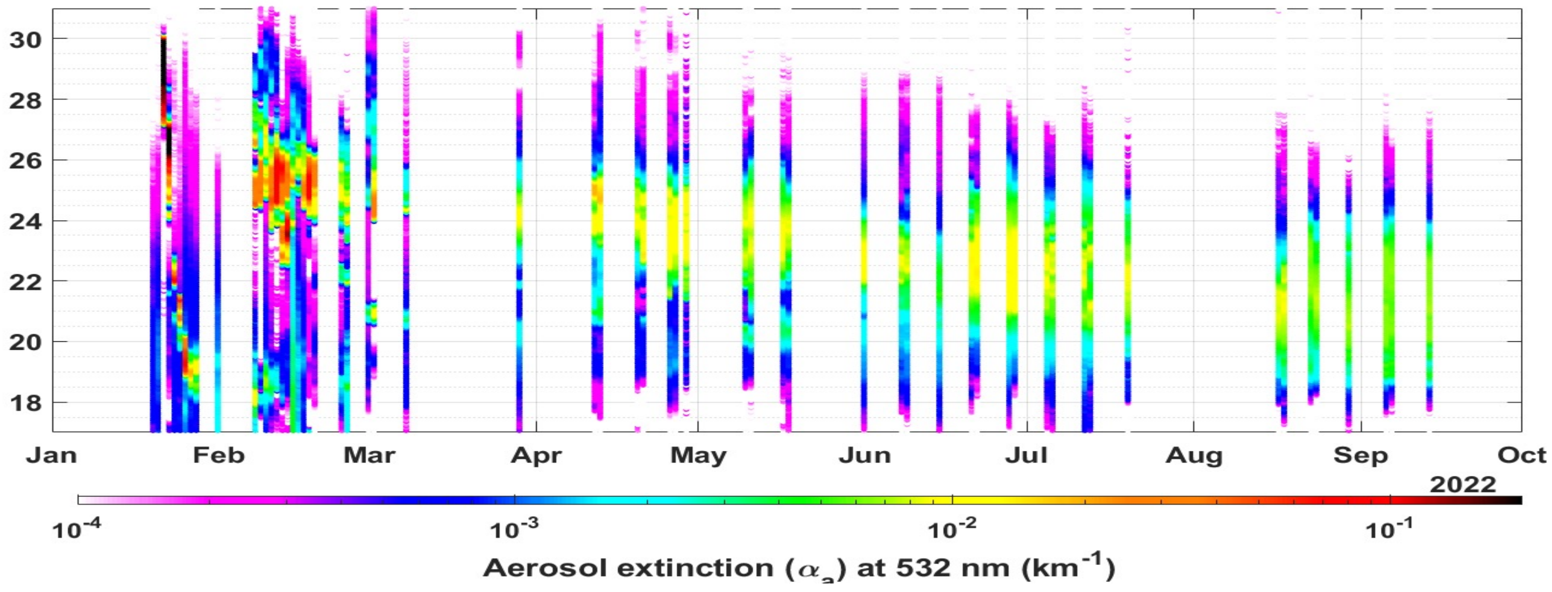
Upcoming comparison with model outputs

GLOMAP-mode global aerosol microphysics model



Mann et al., in prep.



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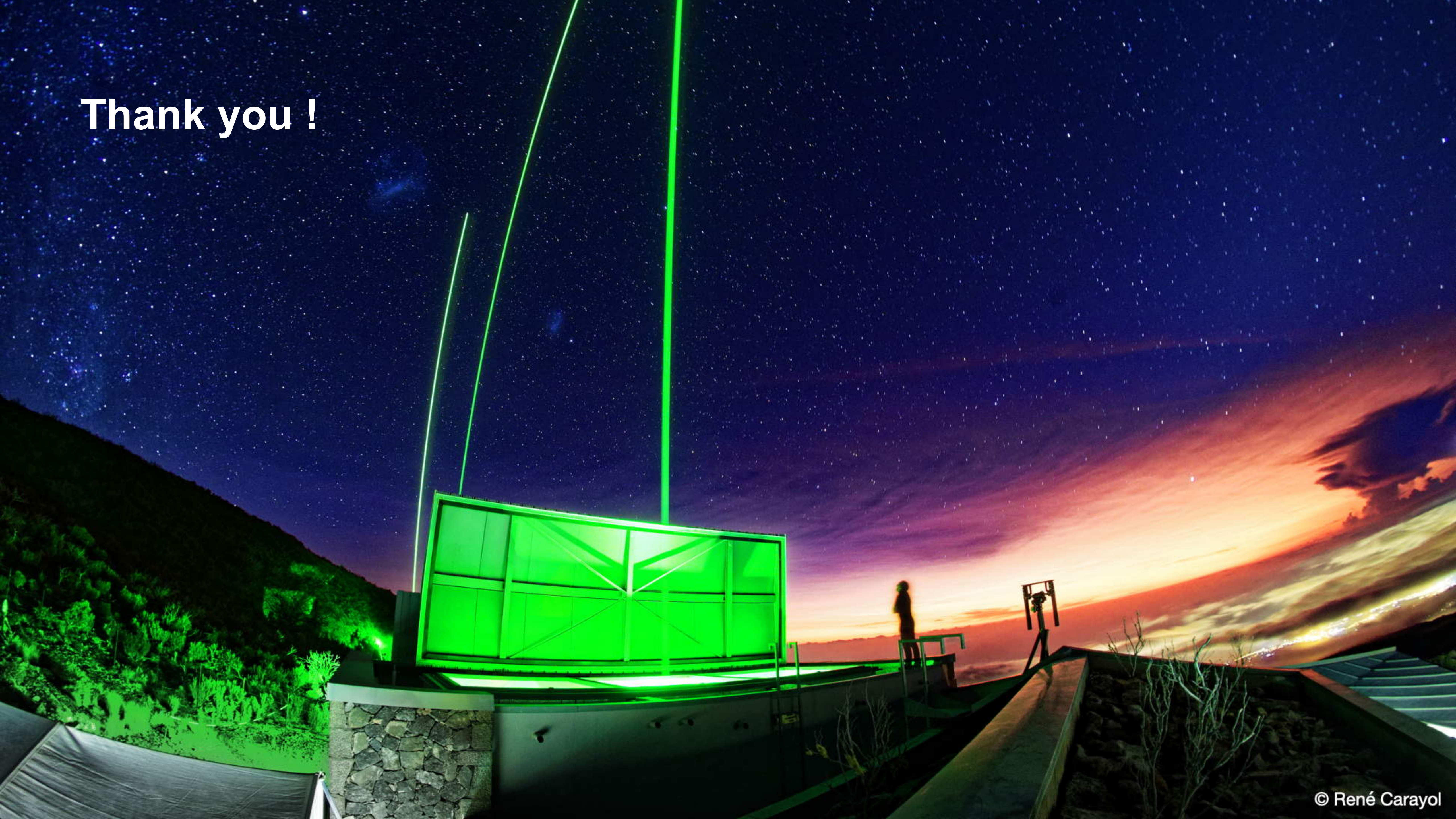
- **In situ & Lidar synergies**
  - POPS x Lidar: aerosol extinction cross section → time height cross section of aerosol mass/surface concentration in the plume
  - POPS + CFH x Lidar: aerosol hygroscopic properties, aerosol ageing and associated optical properties


Thank you !
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