Stratospheric Aerosol and Cloud lidar at the French Antarctic station Dumont d'Urville

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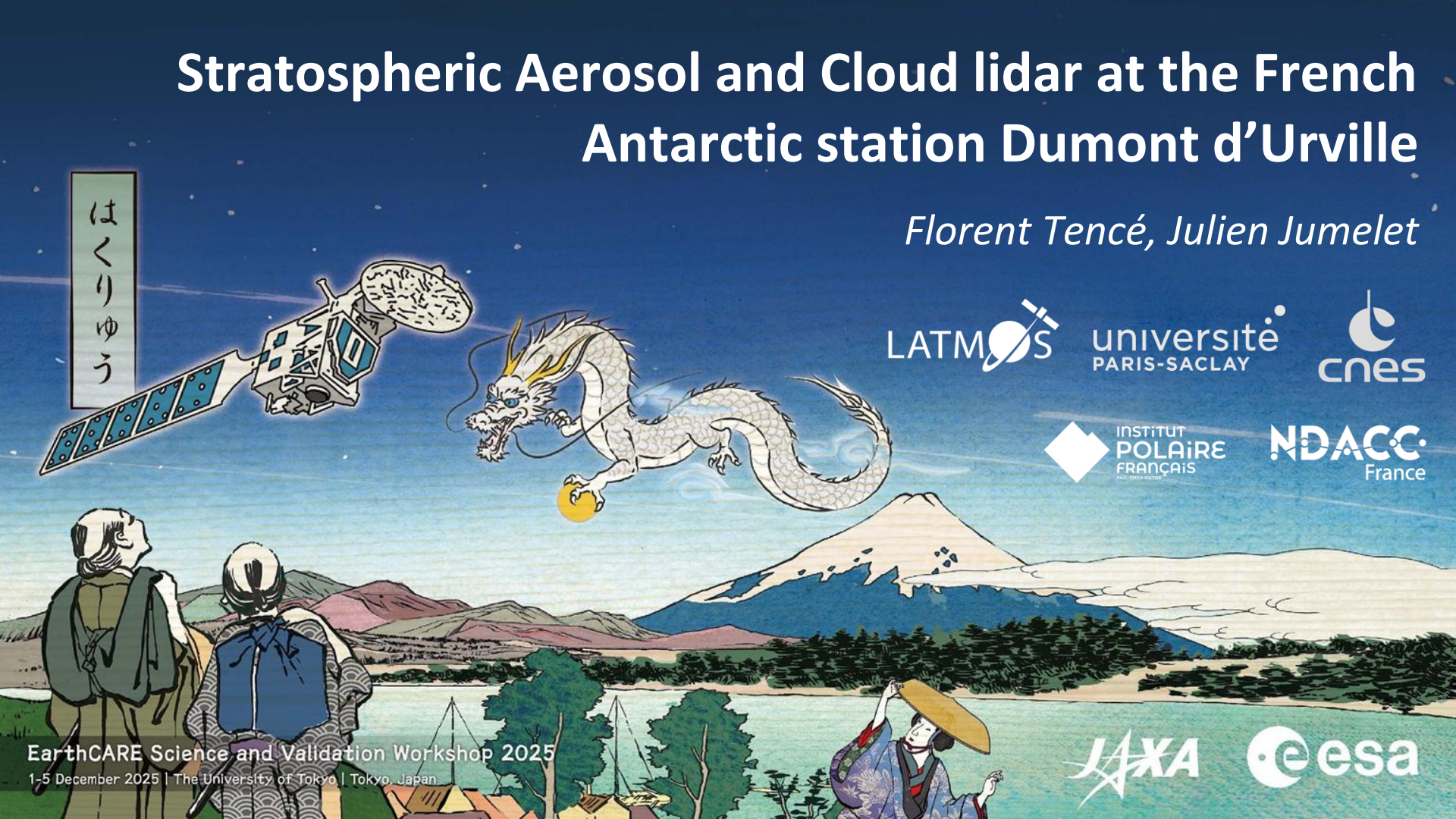

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EarthCARE Science and Validation Workshop 2025

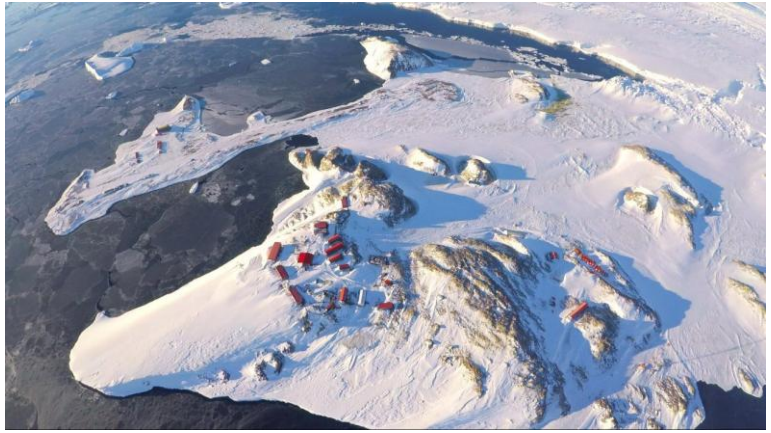
1-5 December 2025 | The University of Tokyo | Tokyo, Japan

JAXA esa

Dumont d'Urville Lidar

- Aerosol and cloud stratospheric lidar at Dumont d'Urville French Antarctic station since **1989**
- Main objectives: study of **PSC**, and stratospheric perturbation events (**volcanism**, **wildfires**, sudden stratospheric warming, etc)

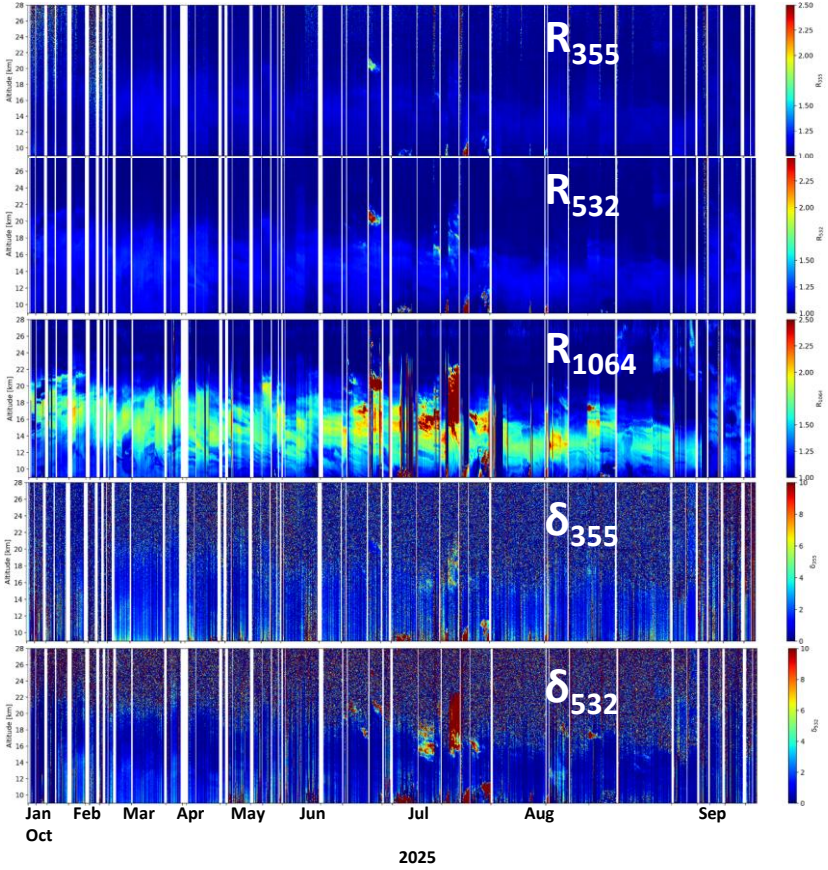
LiDAR Dumont d'Urville



- Instrumental setup upgraded between 2022 and 2025:
  - **Laser source** (Qsmart 850, 355 + 532 + 1064 nm emission)
  - **UV polychromator**: Polarization and 387 nm Raman
  - Renewal of most **detectors** (PM and APD)

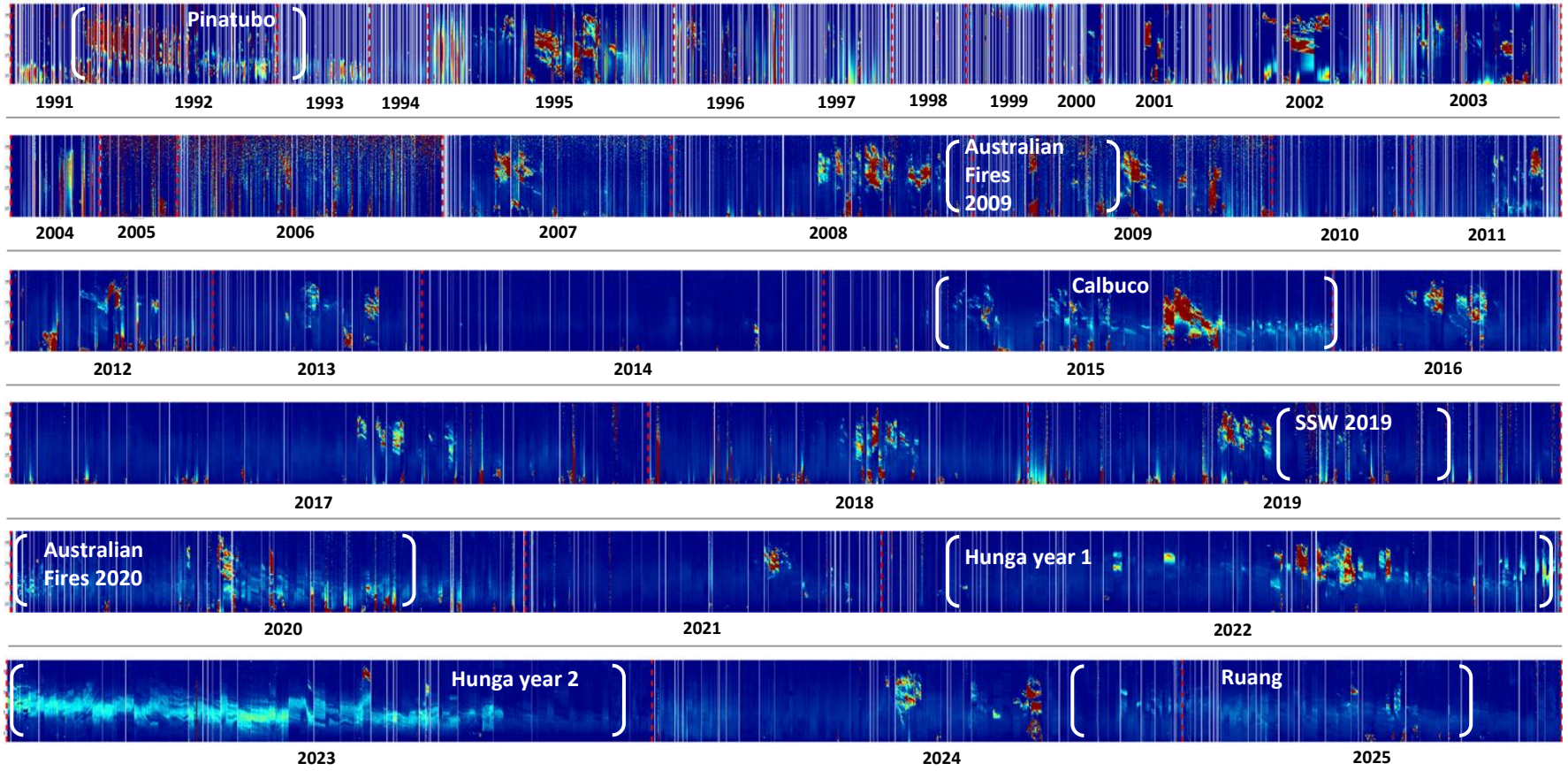
R_{355}, δ_{355}, R_{532}, δ_{532}, R_{1064}

2025 First multispectral series at DDU



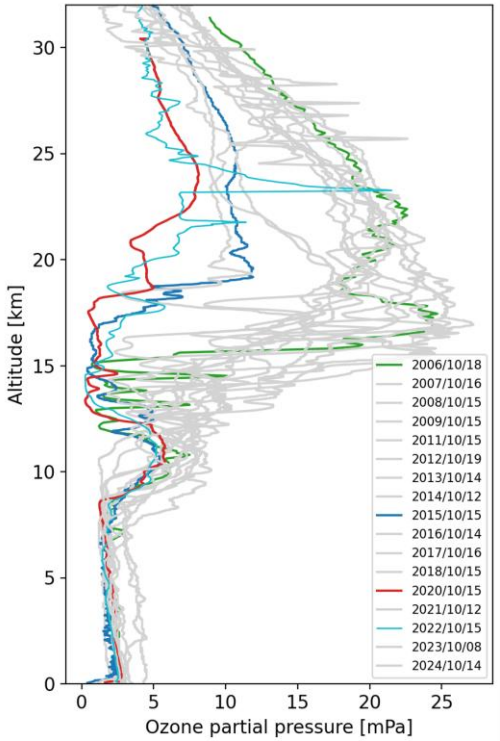
- New configuration provides a more complete observation of stratospheric aerosols and clouds
- Estimation of **aerosol size distribution** (semi-direct nonlinear approach combining optical calculations from chemically equilibrated lookup tables and lidar measurements)
- **Direct comparisons with ATLID** now possible
- Raman N_2 algorithms in development

Advanced Klett algorithm - Full database reprocessing



PSC / aerosols interactions: an active topic

- Significant aerosols plumes reaching the polar vortex could **impact PSC related processes** → ozone
- Ozone is closely monitored with radiosondes in DDU, especially during depletion season
- **ATLID** could play a key role in observing interactions of **fine stratospheric aerosol and cloud**. Updates from CALIOP: fine sensitivity, lidar ratio, particle radius



October ozone sondes DDU 2006 - 2024

Recent articles about PSC / aerosol and ozone

Chlorine activation and enhanced ozone depletion induced by wildfire aerosol (**Solomon** et al, Nature **2023**) → impact of wildfire stratospheric aerosol on ozone chemistry

Antarctic Polar Stratospheric Cloud Analysis of ACE-FTS Data from 2005 to 2023 (**Lecours** et al, JGR **2024**) → volcanic and wildfire stratospheric aerosols impact PSC season (in quantity and types)

Australian bushfire emissions result in enhanced polar stratospheric clouds (**Prasanth** et al, ACP **2025**)

Australian Black Summer smoke observed by lidar at the French Antarctic Station Dumont d'Urville (**Tencé** et al, **2022**);

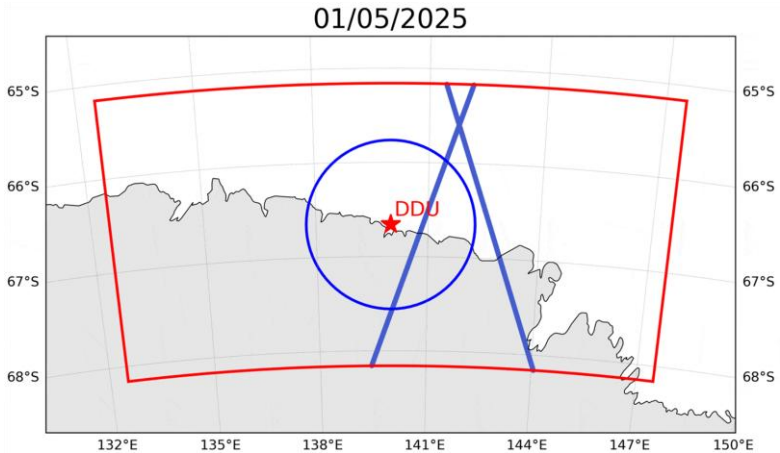
14 years of lidar measurements of polar stratospheric clouds at the French Antarctic station Dumont d'Urville (**Tencé** et al **2023**)

ATLID extraction - methodology

- **Small window** : **< 100 km** to the station
- **~ 7 to 9 / month**

- **Large window** : ± 1,5° lat ; ± 7.5° lon (**max 360 km**)
- **~ 25 / month**
- Justified by stratospheric aerosol and clouds stability and horizontal extent

DDU
66,66° S
140° E



NOM_1B

- Baseline BA
- Attenuated backscatter (Rayleigh, Mie copolar, Mie crosspolar)
- Variables smoothed and vertically regridded
- Scattering Ratio R

$$\frac{\beta_{ray,att} + \beta_{mie\_copolar,att} + \beta_{mie\_crosspolar,att}}{\beta_{ray,att}}$$

EBD_2A

- Baseline BA
- Particle backscatter and rayleigh model
- Variables vertically regridded
- Scattering Ratio R

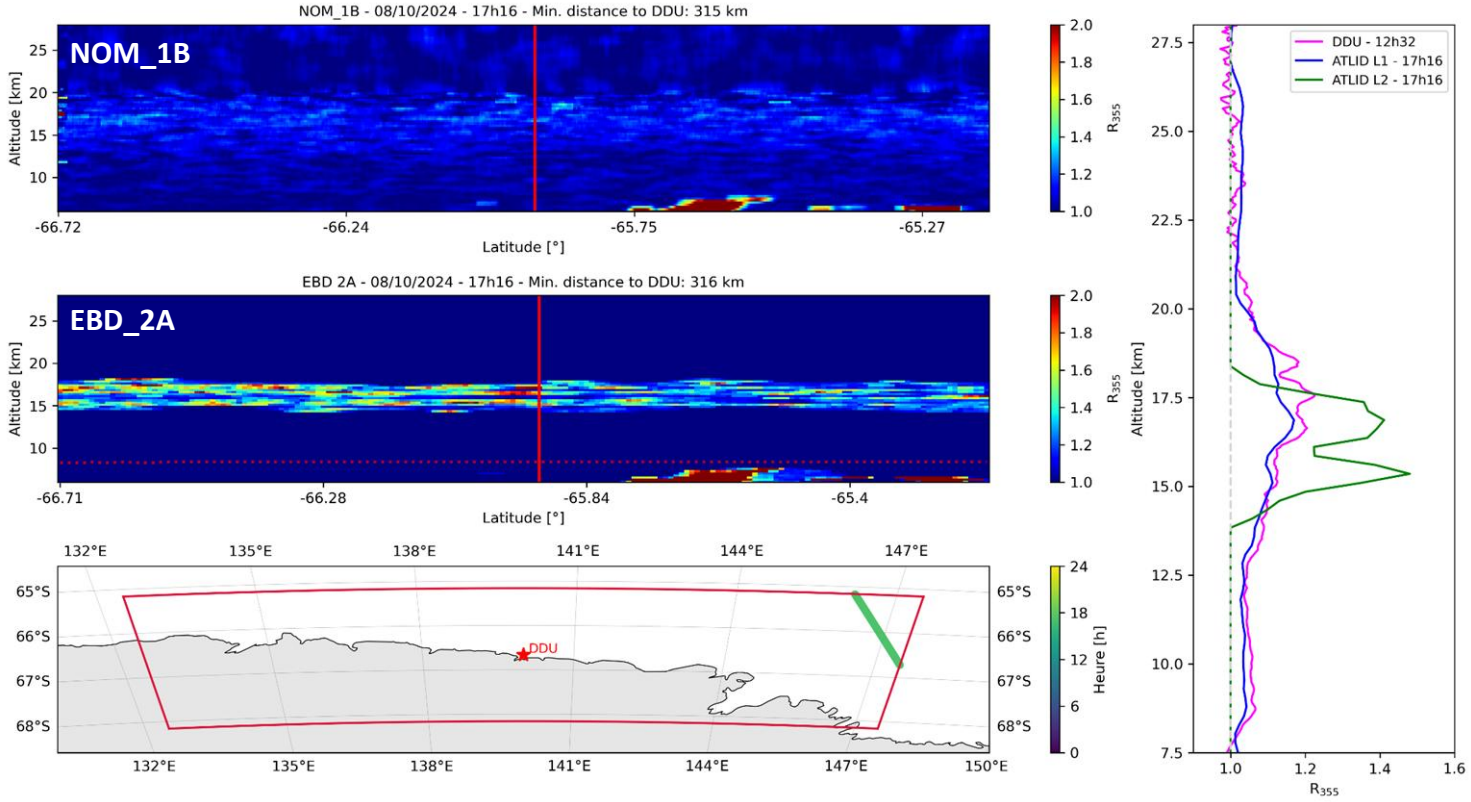
$$\frac{\beta_{ray,model} + \beta_{particle}}{\beta_{ray,model}}$$

08/10/2024: Ruang aerosols, nighttime

Night

315 km

5 h

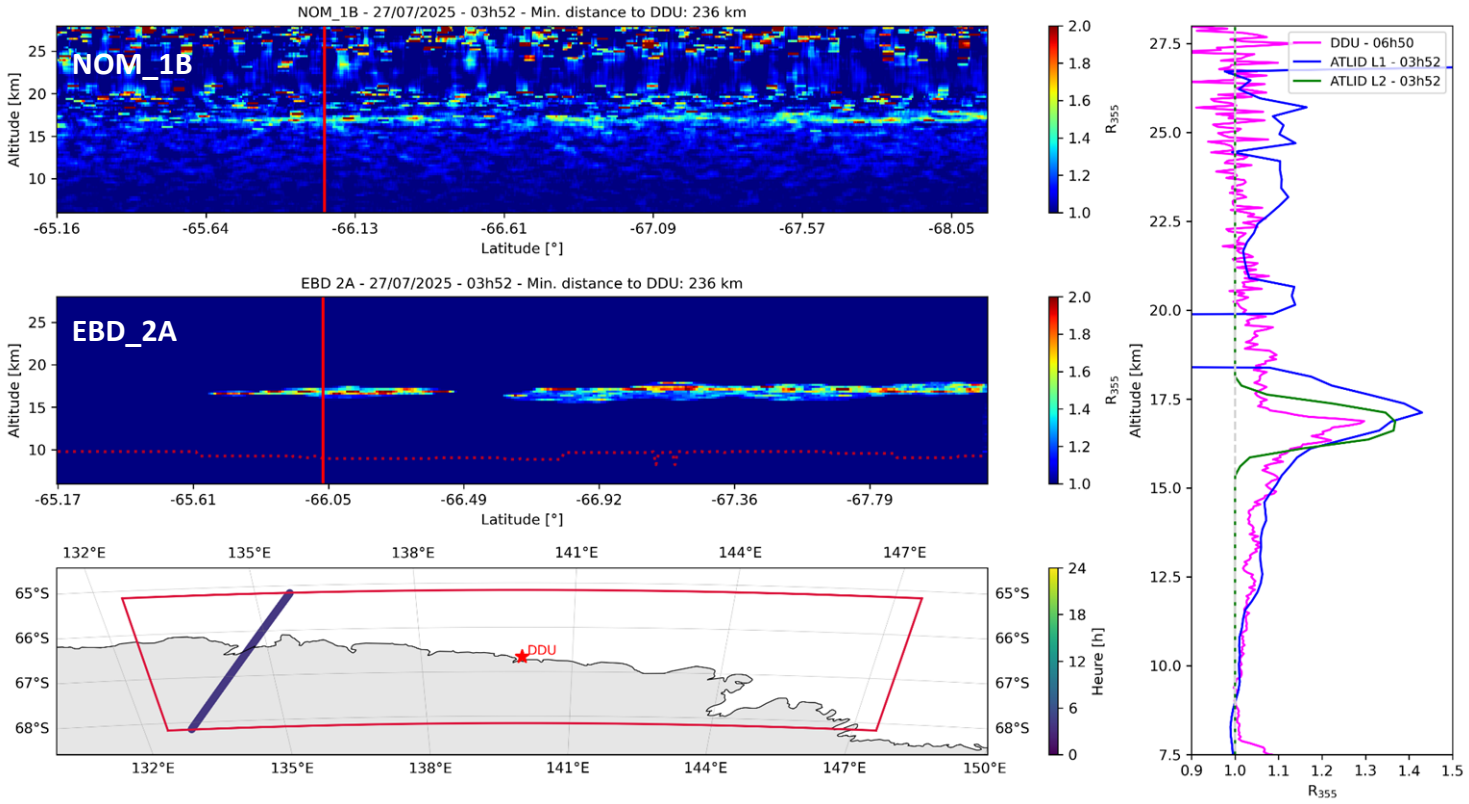


27/07/2025: PSC, daytime

Day

236 km

3 h

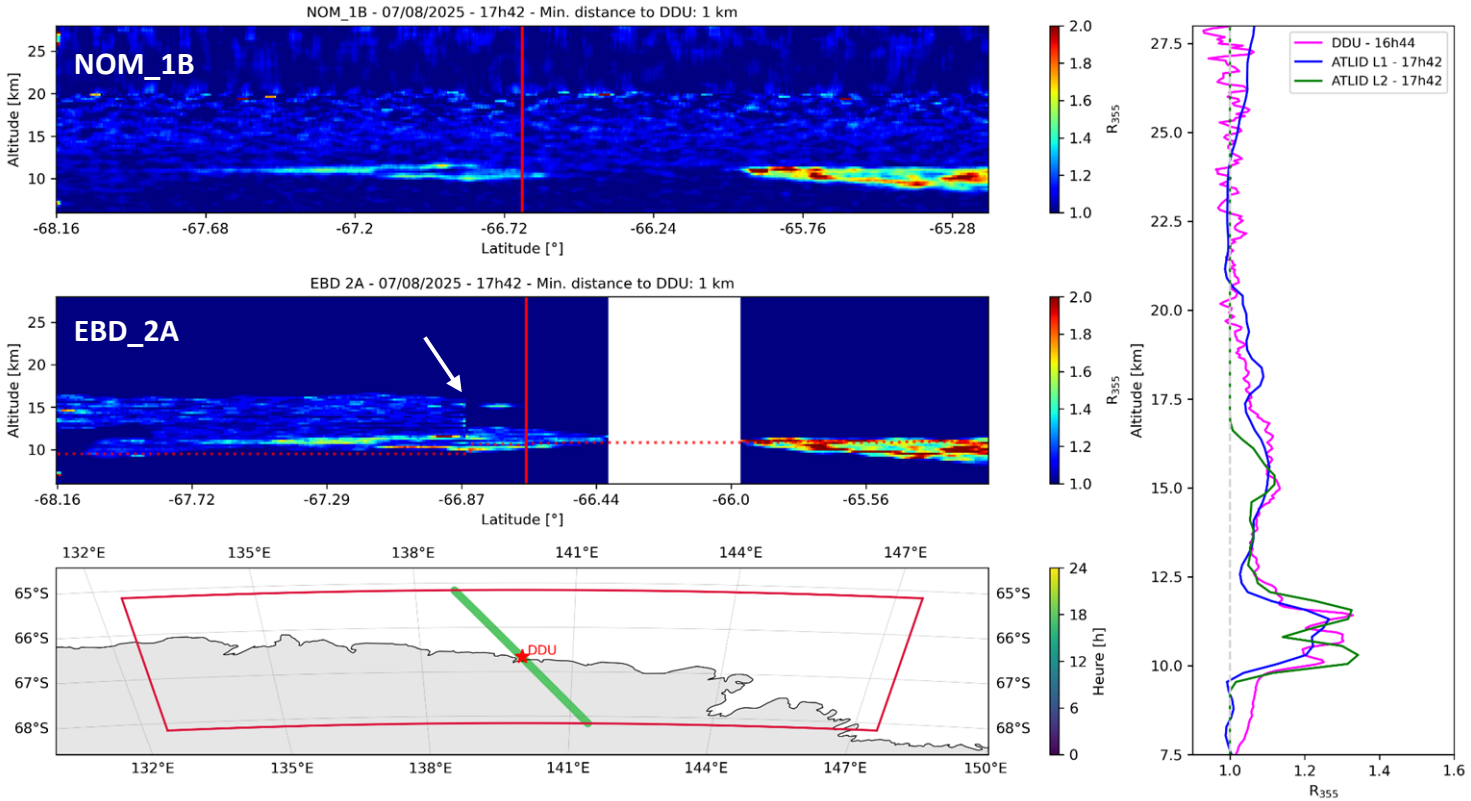


07/08/2025: Cirrus + aerosols, nighttime

Night

0 km

0 h

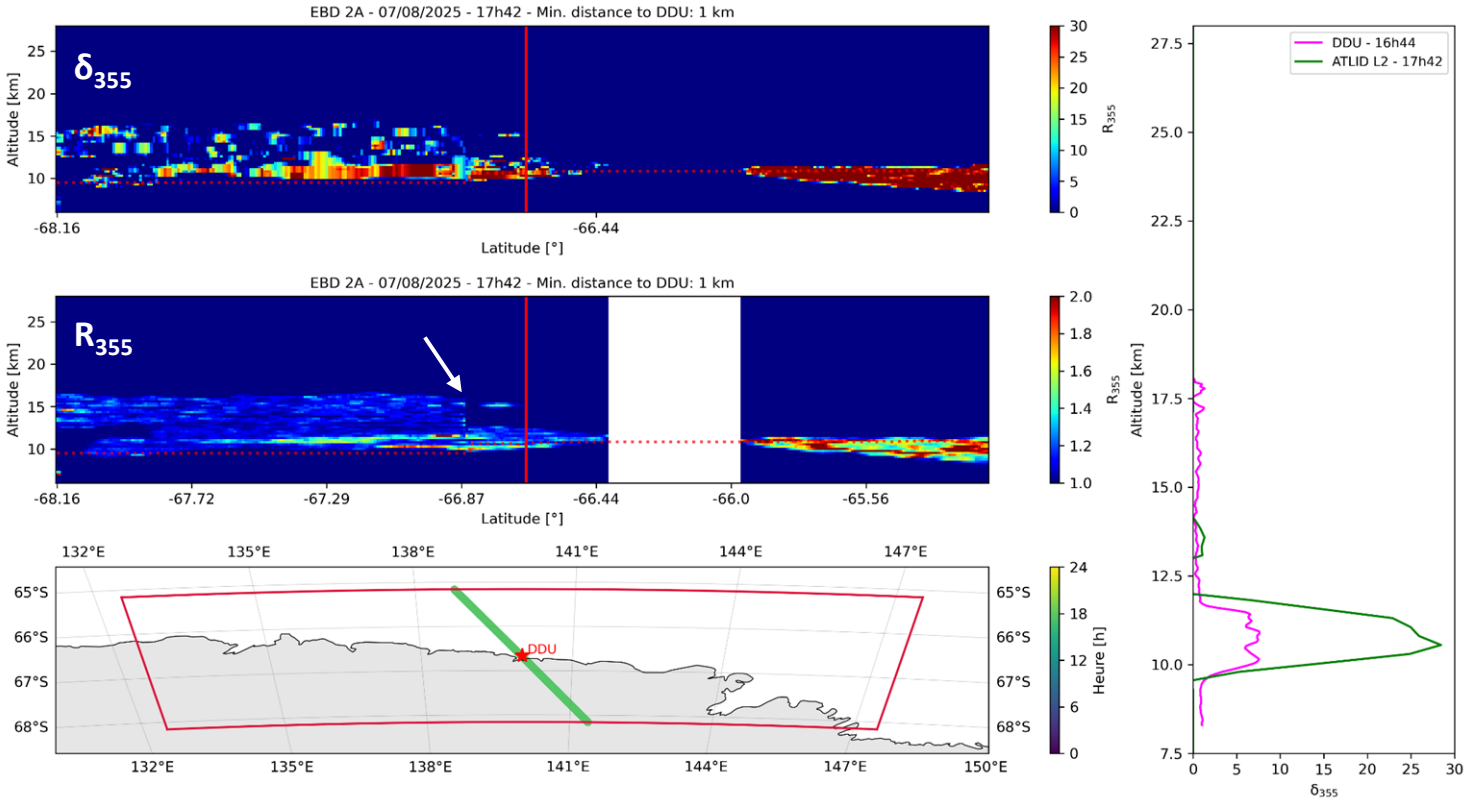


07/08/2025: Depolarization

Night

0 km

0 h

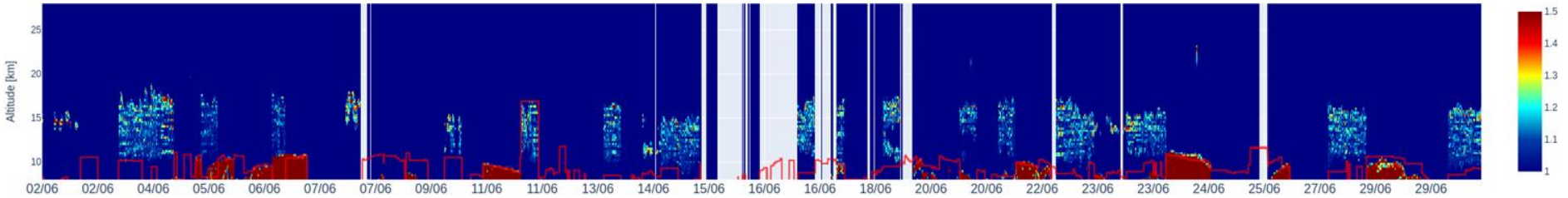


EBD stratospheric layer detection

- Unstable stratospheric aerosol layer detection

- Cirrus presence? File limits? Unadapted thresholds?

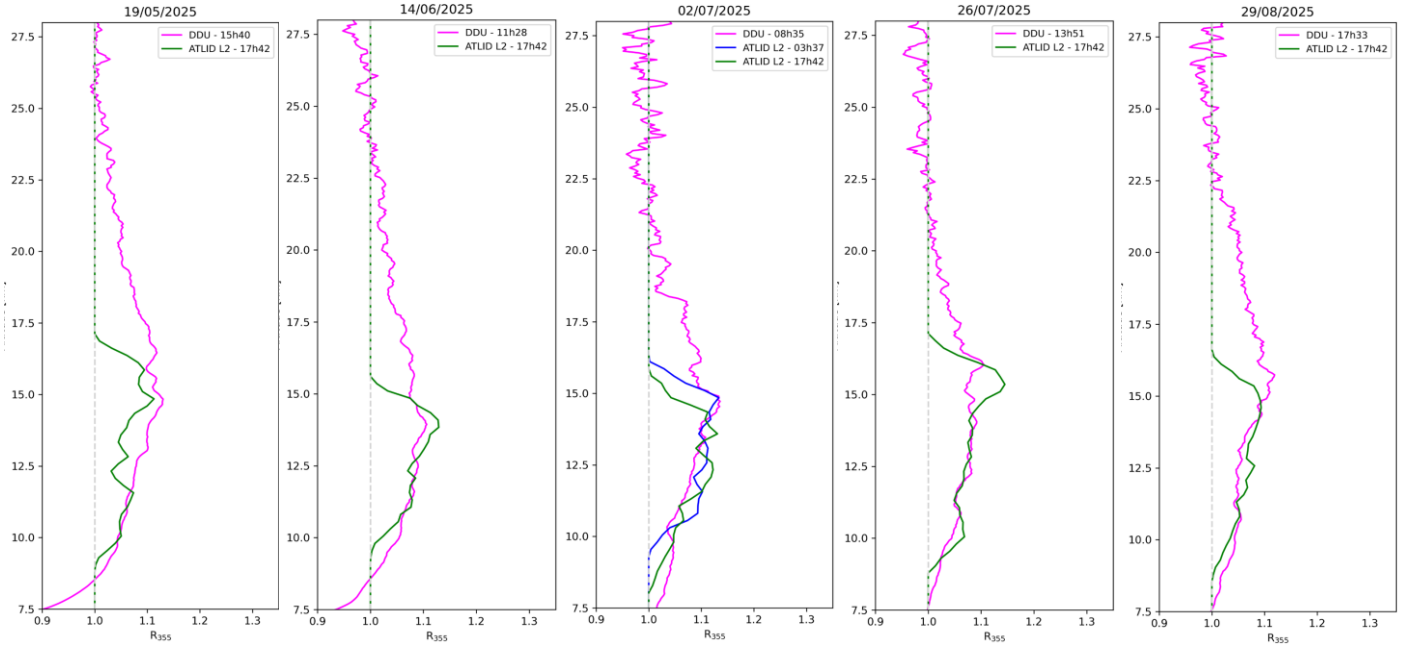
June 2025



R 355 nm

EBD stratospheric layer detection

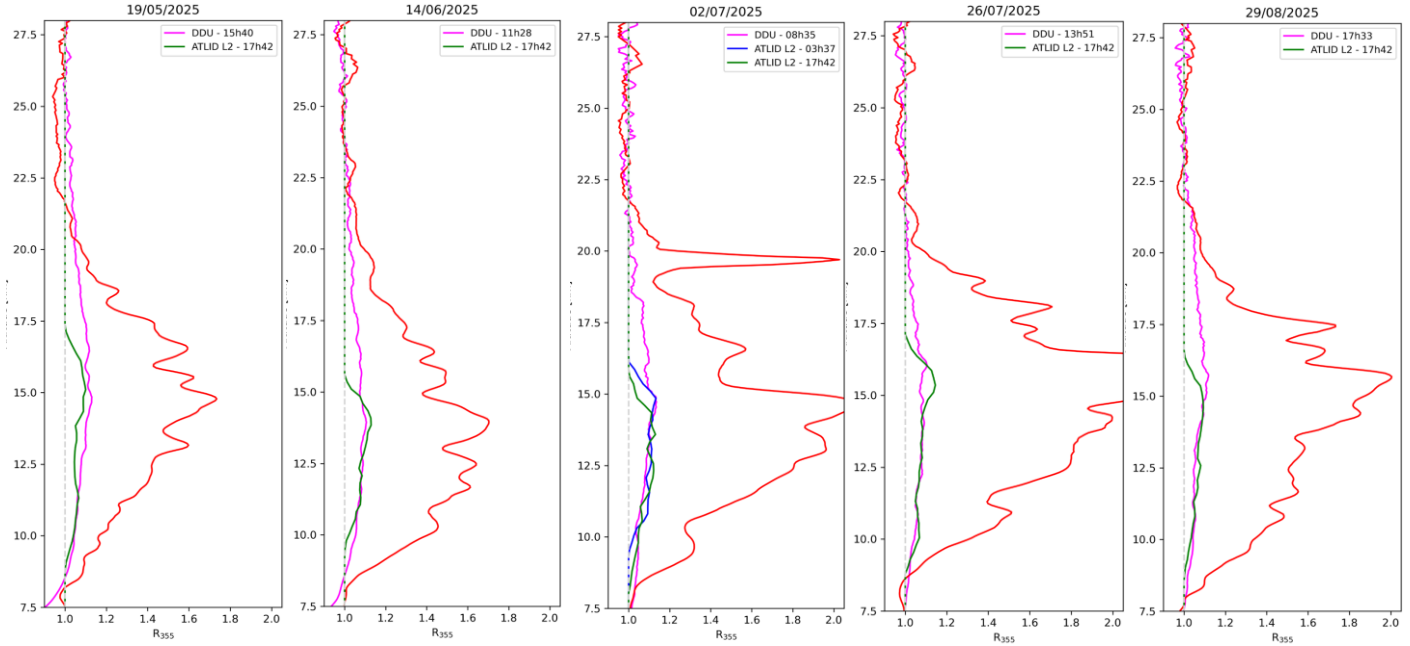
- Stratospheric aerosol layer: **not fully resolved in altitude?**



R 355 nm

EBD stratospheric layer detection

- Stratospheric aerosol layer: **not fully resolved in altitude?** → See 1064 nm channel for aerosol detection



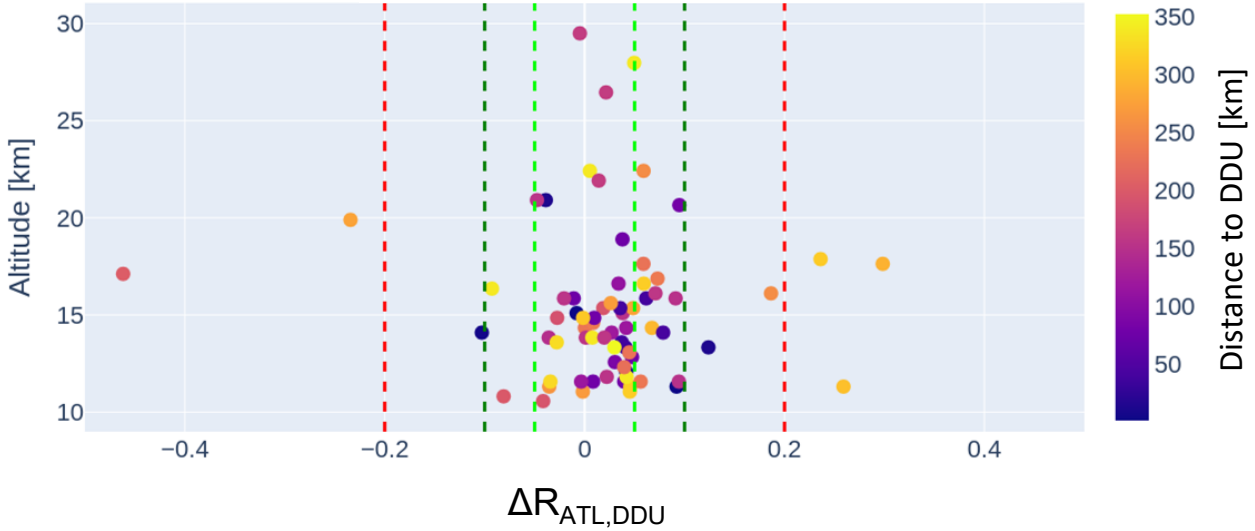
R 355 nm

ATLID vs DDU volume comparison

- For each **stratospheric layer (cirrus filtered out)** detected by ATLID, we compute the bias of the **mean** and **maximum in R_{355}** between ATLID and DDU

$$\Delta R_{ATL,DDU} = 100 * \frac{R_{ATL,355} - R_{DDU,355}}{R_{ATL,355}}$$

$\Delta R_{ATL,DDU}$	$R_{355,max}$	$R_{355,mean}$
< 5%	50%	71%
< 10%	79%	89%
< 20%	89%	93%

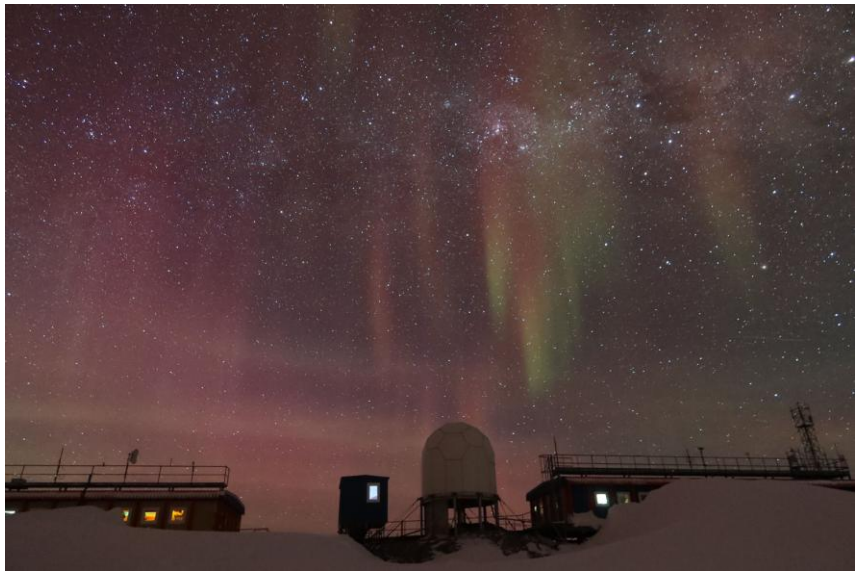


Total: 60 dates, **72** stratospheric layers

Only accounts for layers detected by ATLID!

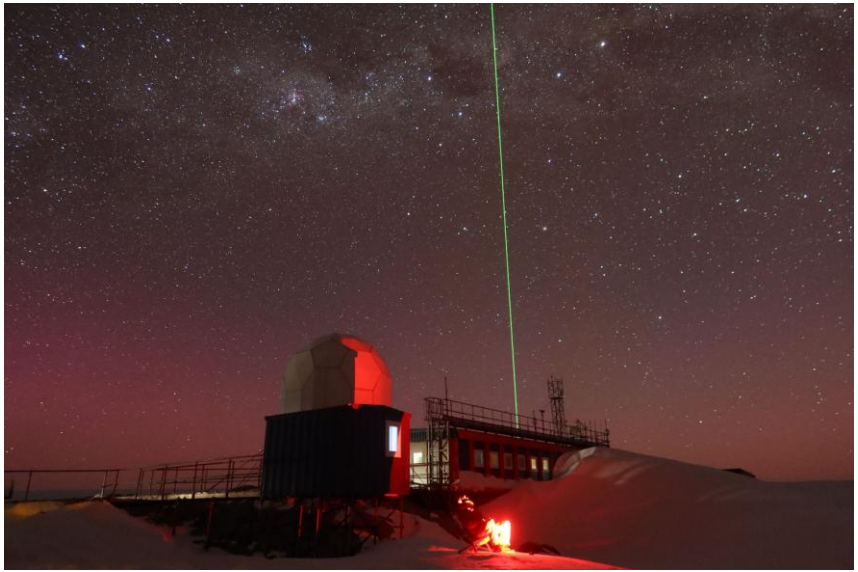
Main conclusions on NOM_1B & EBD_2A

- **NOM_1B** attenuated backscatter; very good agreement with DDU lidar, though low SNR in day mode
- **EBD_2A** very good in scattering ratio, but issues on layer detections
- **File borders** inconsistencies in L2 data
- **EBD_2A**: more work to do on depolarization (noisy, overestimation)



- Better **thin layer detection** should be considered to study fine stratospheric aerosols processes (thresholds, cirrus disturbance, horizontal averaging…)

Conclusion



- **New UV-Vis-IR stratospheric lidar set-up in DDU, Antarctica**

- DDU NOAA/NDACC data archive **open** to use: https://www-air.larc.nasa.gov/missions/ndacc/data.html?station=dumont.d.urville/ames/lidar/

- Contact us for more information, question or collaboration at florent.tence@latmos.ipsl.fr or julien.jumelet@latmos.ipsl.fr

Thank you!