

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

Florent Tencé, Julien Jumelet



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Dumont d'Urville Lidar



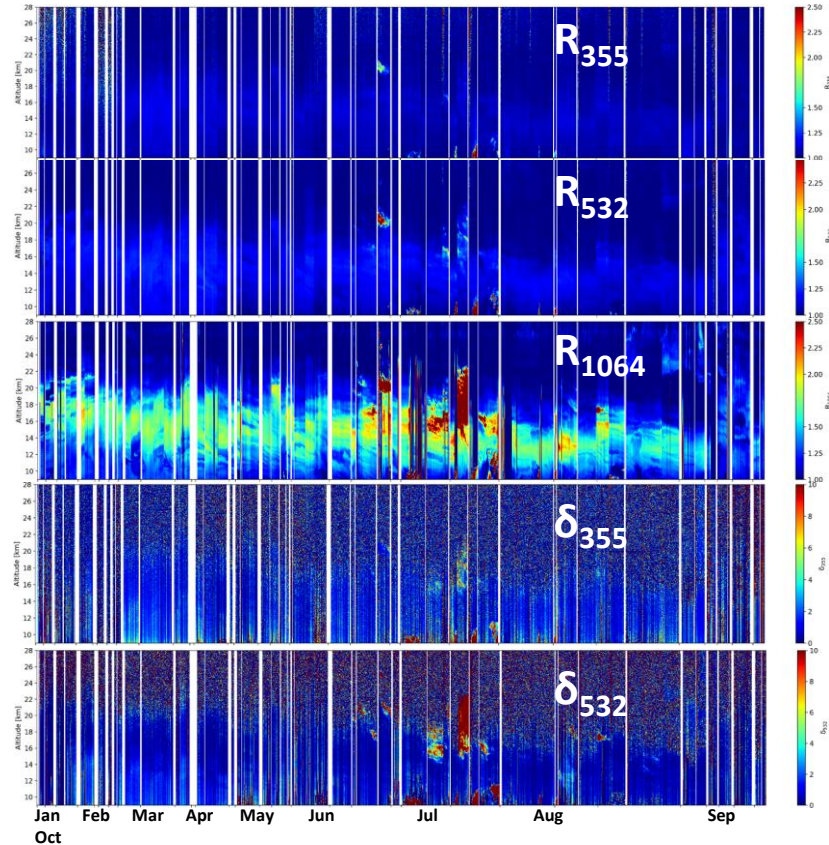
- Aerosol and cloud stratospheric lidar at Dumont d'Urville French Antarctic station since **1989**
- Main objectives: study of **PSC**, and stratospheric perturbation events (**volcanism, wildfires**, sudden stratospheric warming, etc)



- 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)

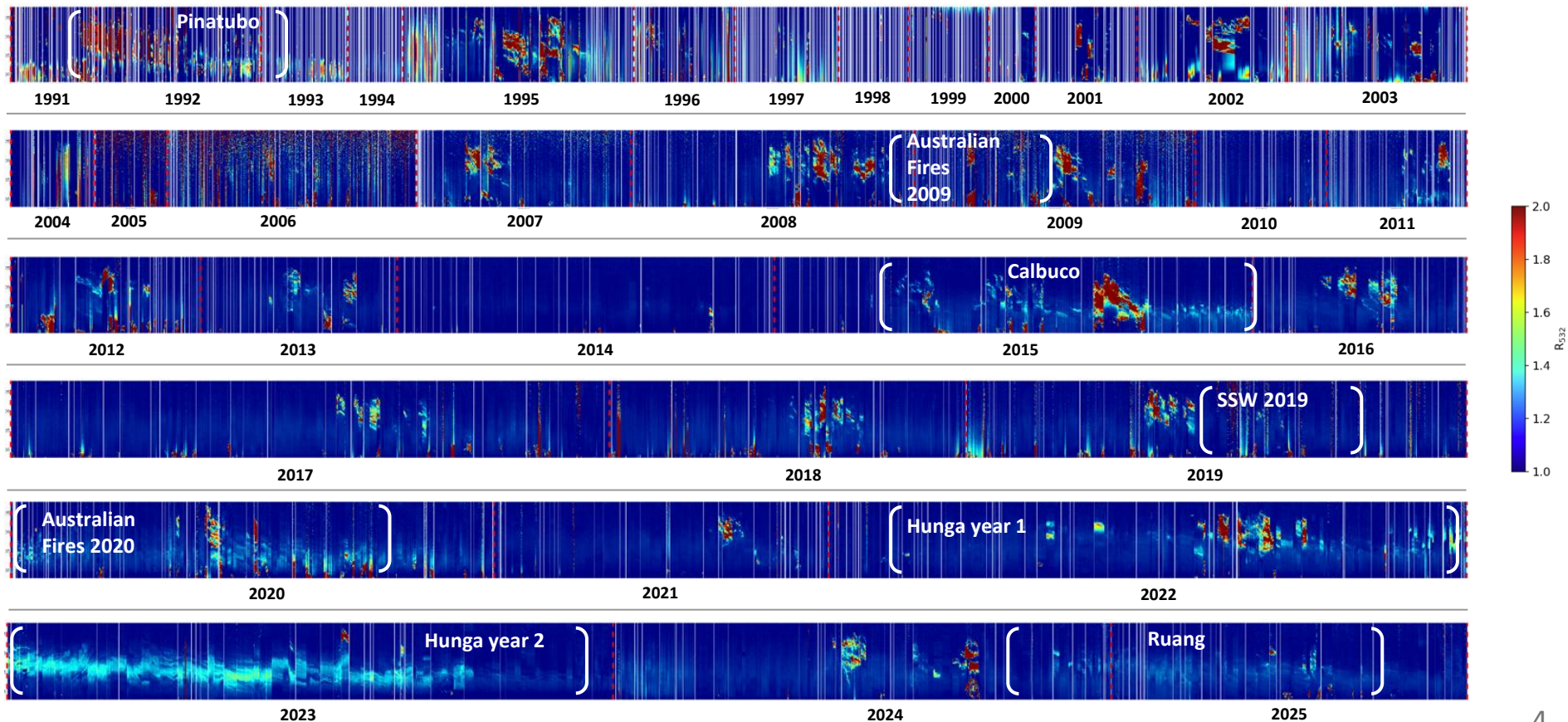
$R_{355}, \delta_{355}, R_{532}, \delta_{532}, R_{1064}$

2025 First multispectral series at DDU

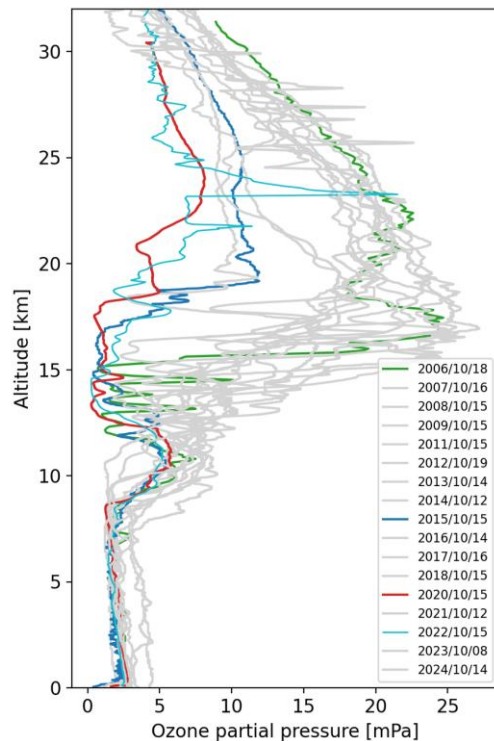


- New configuration provides a more complete observation of stratospheric aerosols and clouds
- Estimation of **aerosol size distribution** (semi-direct nonlinear approach combining optical calculations from chemically equilibrated lookup tables and lidar measurements)
- **Direct comparisons with ATLID** now possible
- Raman N₂ algorithms in development

Advanced Klett algorithm - Full database reprocessing



- 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

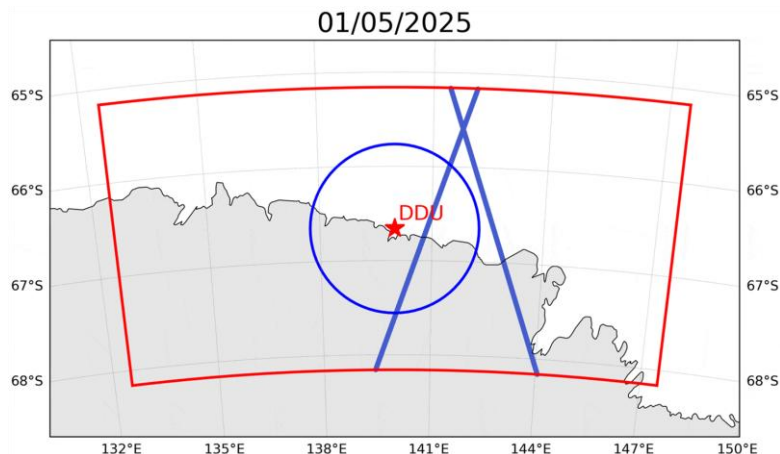


- **Small window** :
 < 100 km to the station
- ~ 7 to 9 / month

- **Large window** : $\pm 1,5^\circ$ lat ; $\pm 7.5^\circ$ 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

$$\frac{\beta_{\text{ray,att}} + \beta_{\text{mie_copolar,att}} + \beta_{\text{mie_crosspolar,att}}}{\beta_{\text{ray,att}}}$$

EBD_2A

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

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

08/10/2024: Ruang aerosols, nighttime



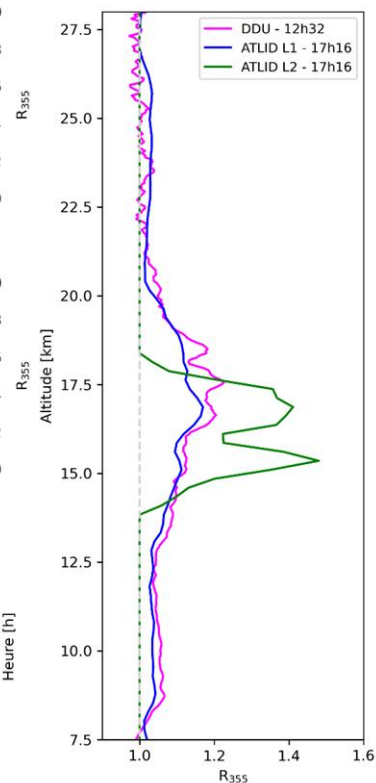
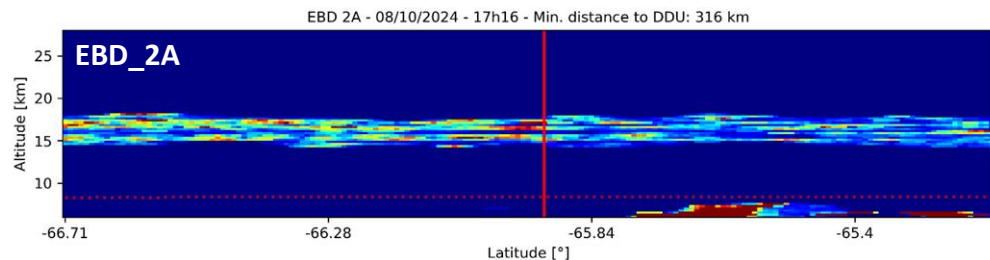
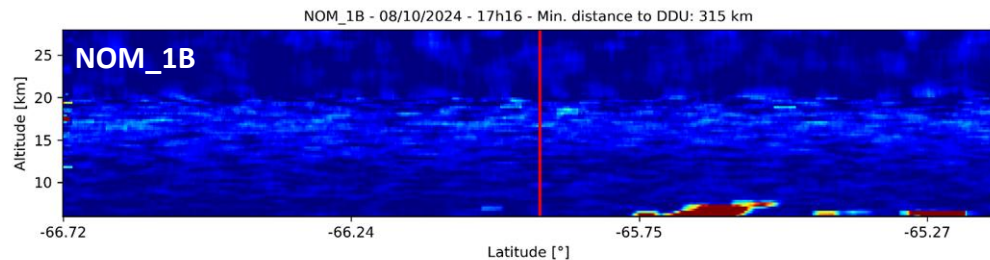
Night



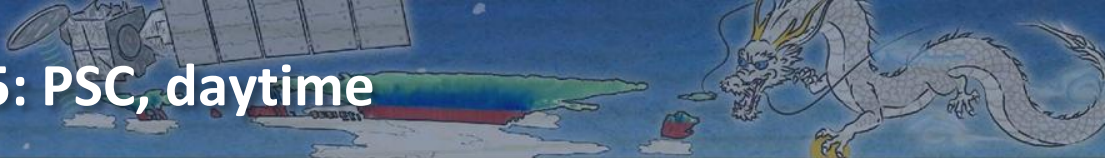
315 km



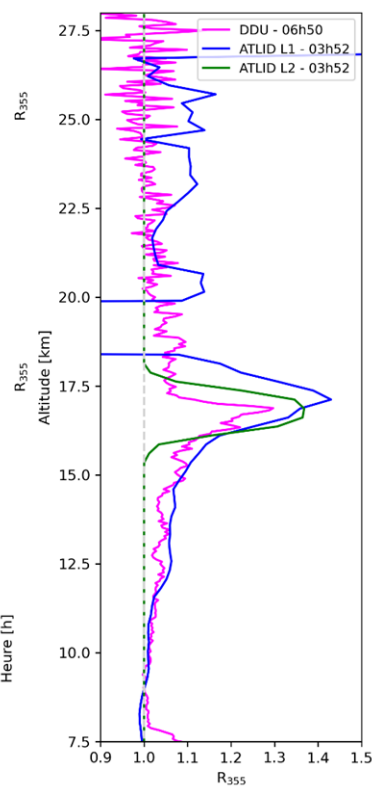
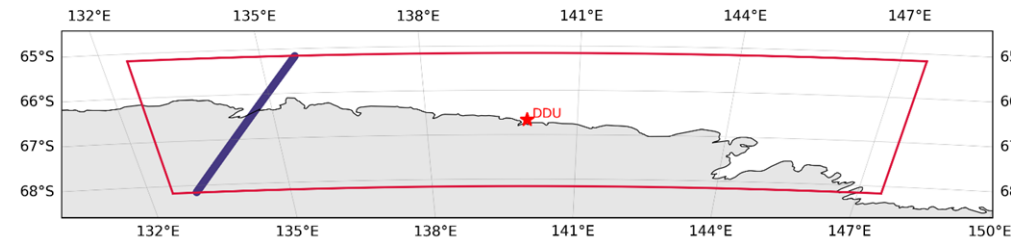
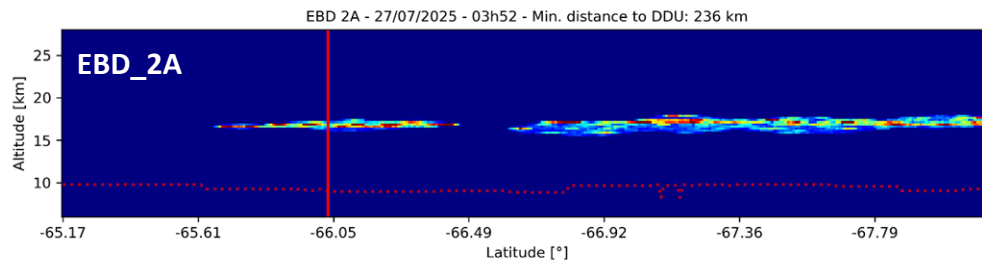
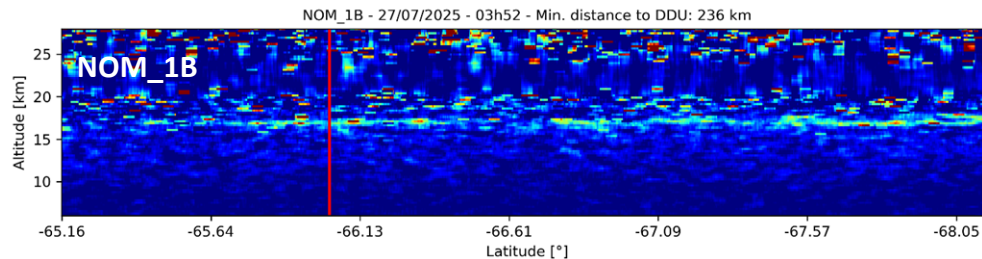
5 h



27/07/2025: PSC, daytime



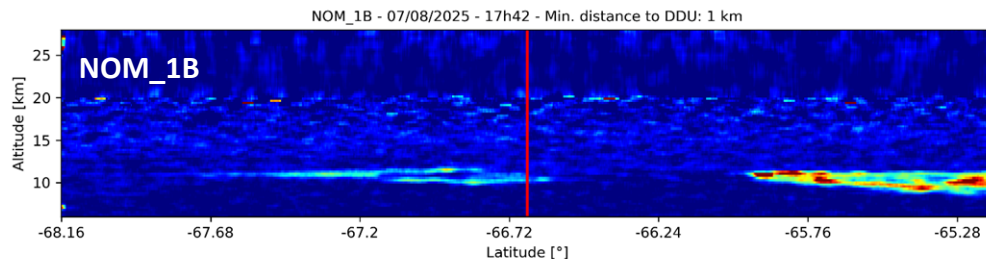
Day



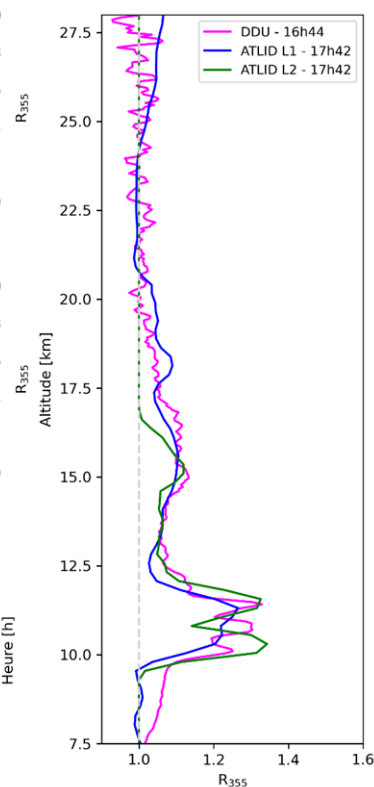
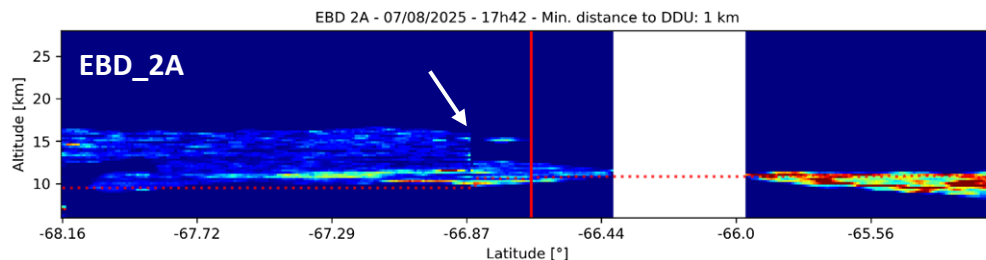
07/08/2025: Cirrus + aerosols, nighttime



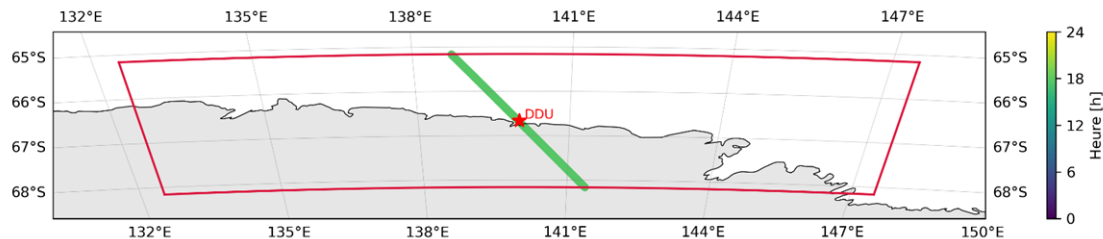
Night



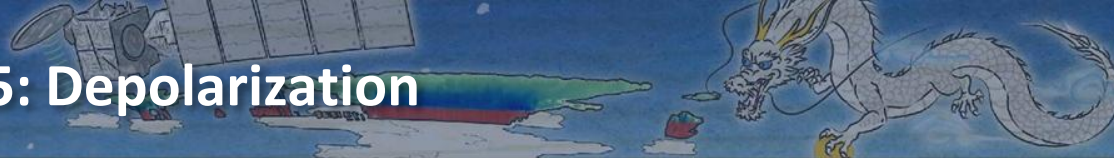
0 km



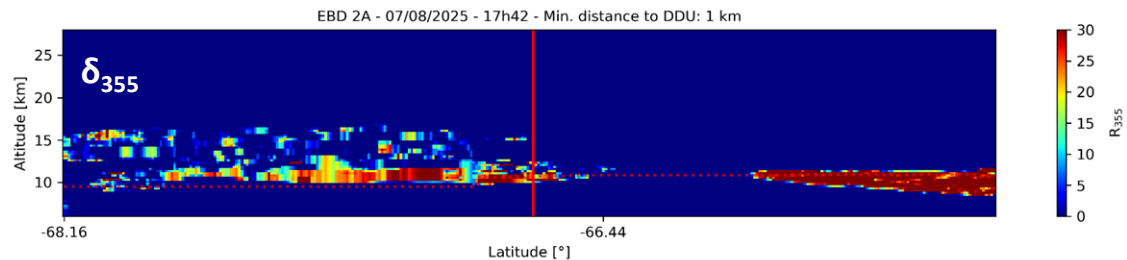
0 h



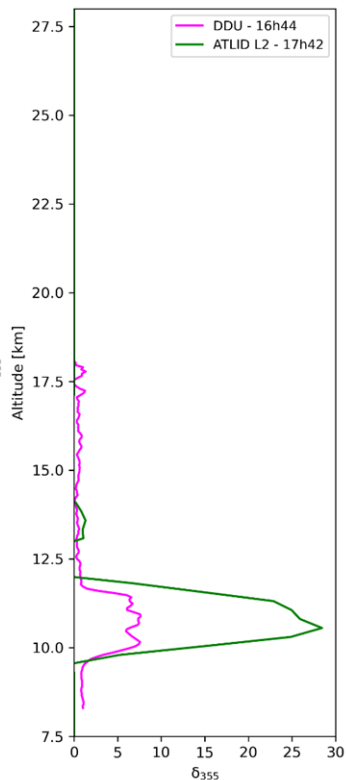
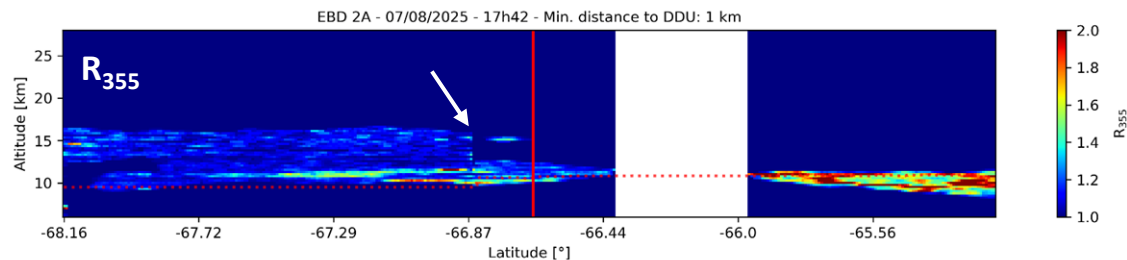
07/08/2025: Depolarization



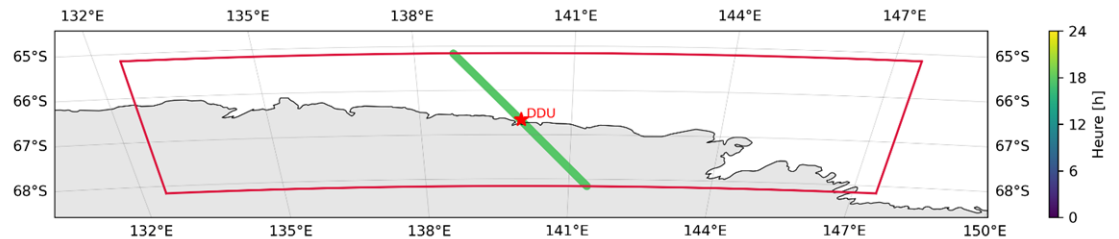
Night



0 km



0 h

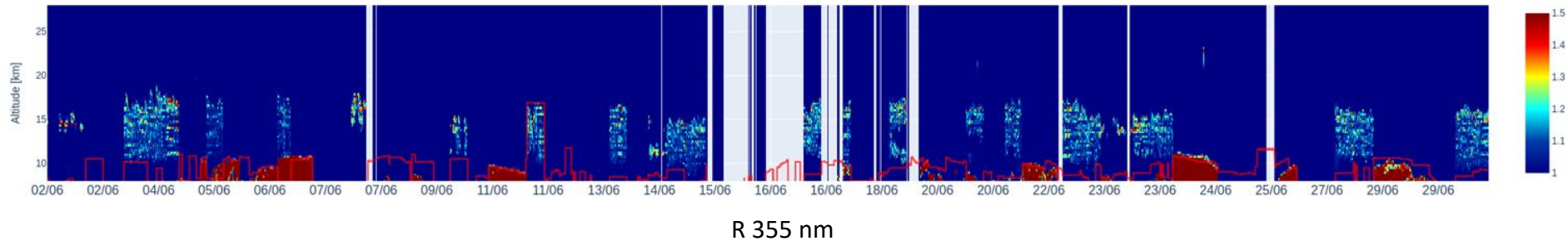


EBD stratospheric layer detection

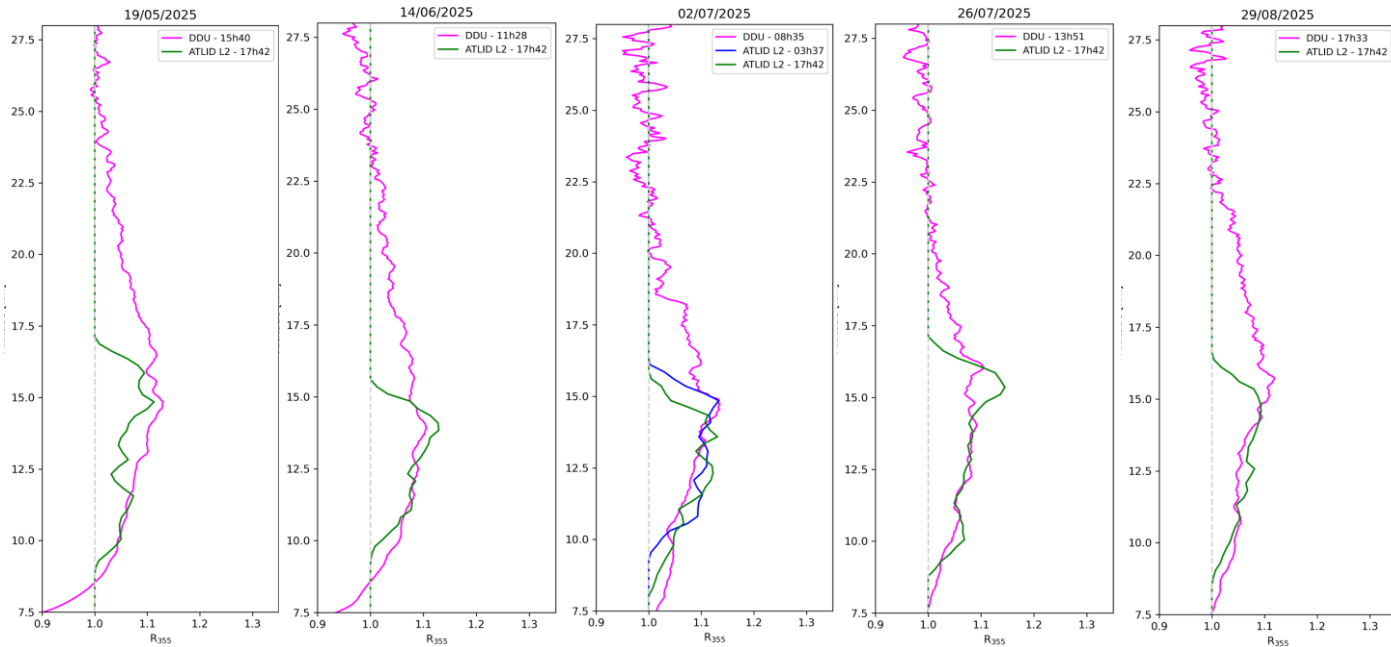


- Unstable stratospheric aerosol layer detection
- Cirrus presence? File limits? Unadapted thresholds?

June 2025

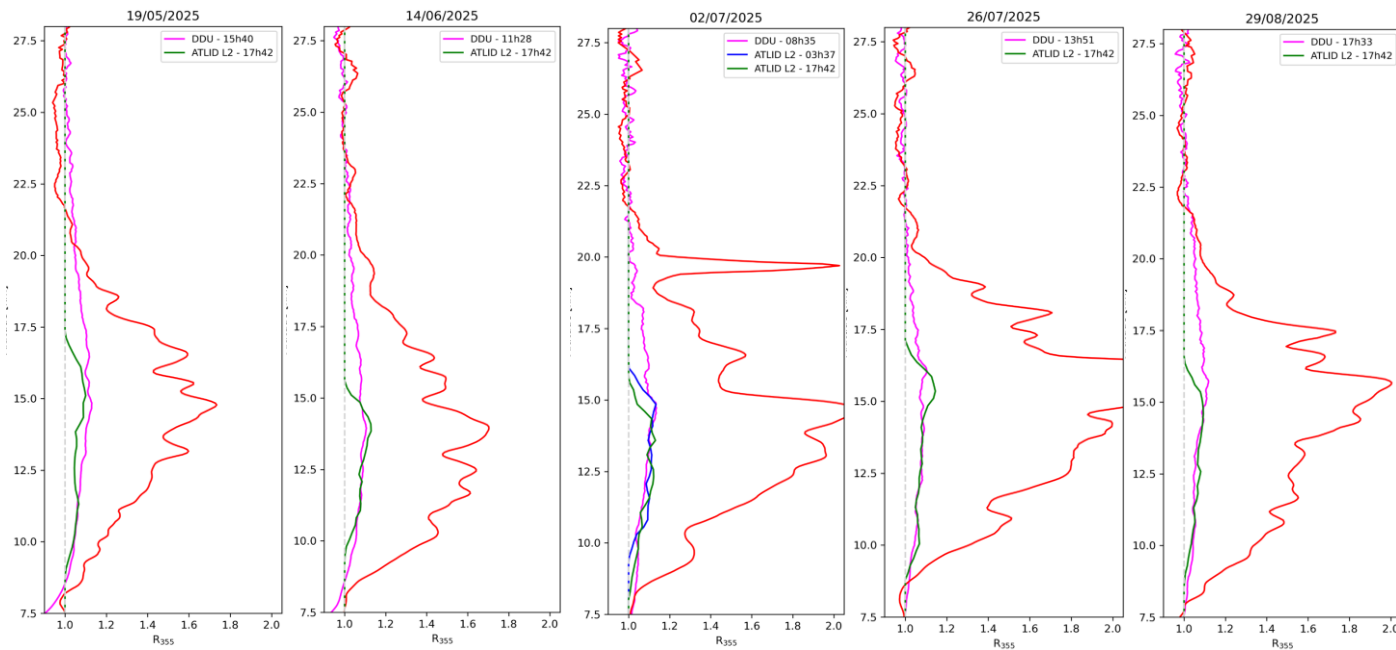


- Stratospheric aerosol layer: **not fully resolved in altitude?**



R 355 nm

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



R 355 nm

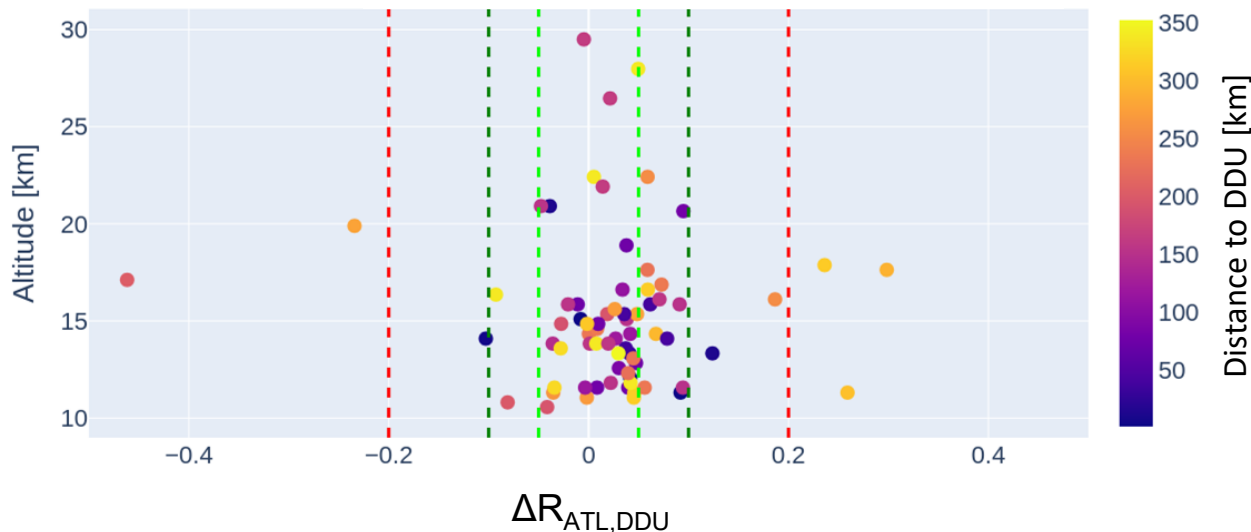
ATLID vs DDU volume comparison



- 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%



Only accounts for layers detected by ATLID!

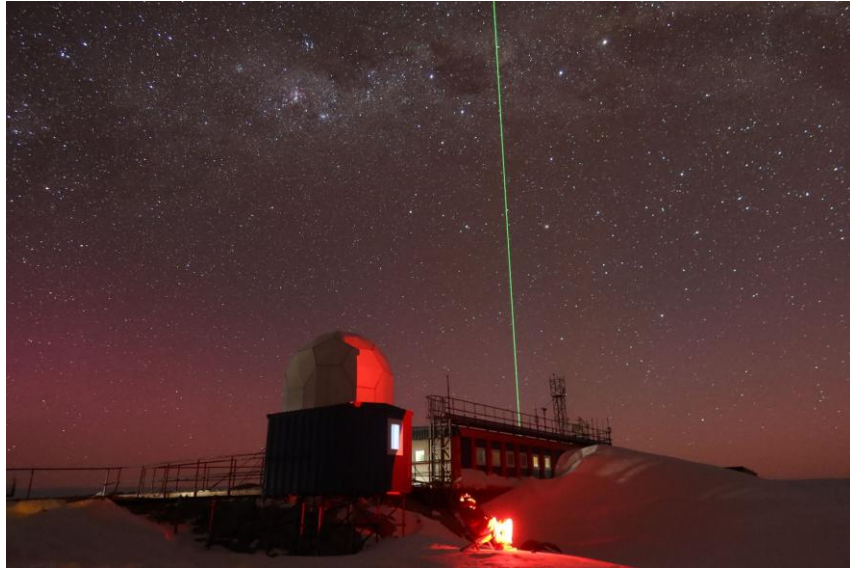
Total: 60 dates, **72** stratospheric layers

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...)





- 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