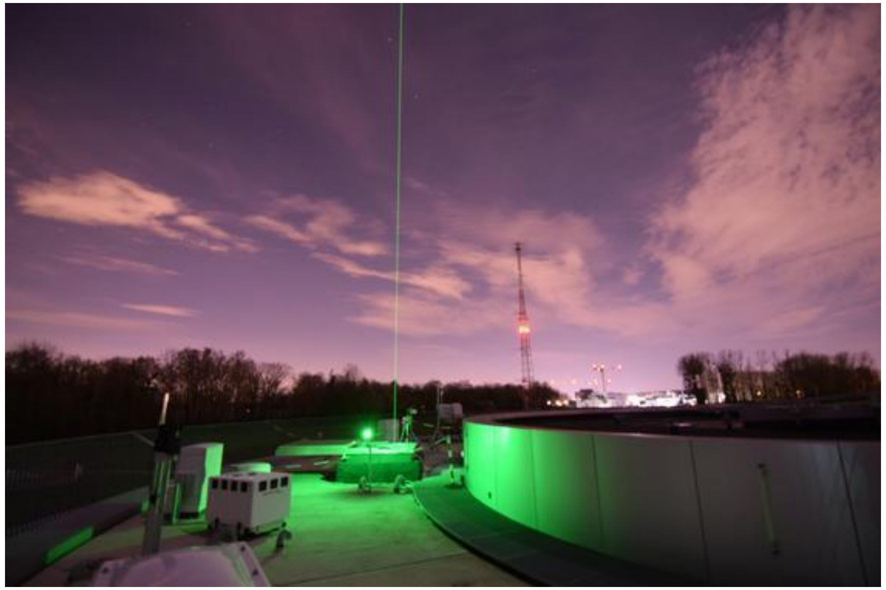
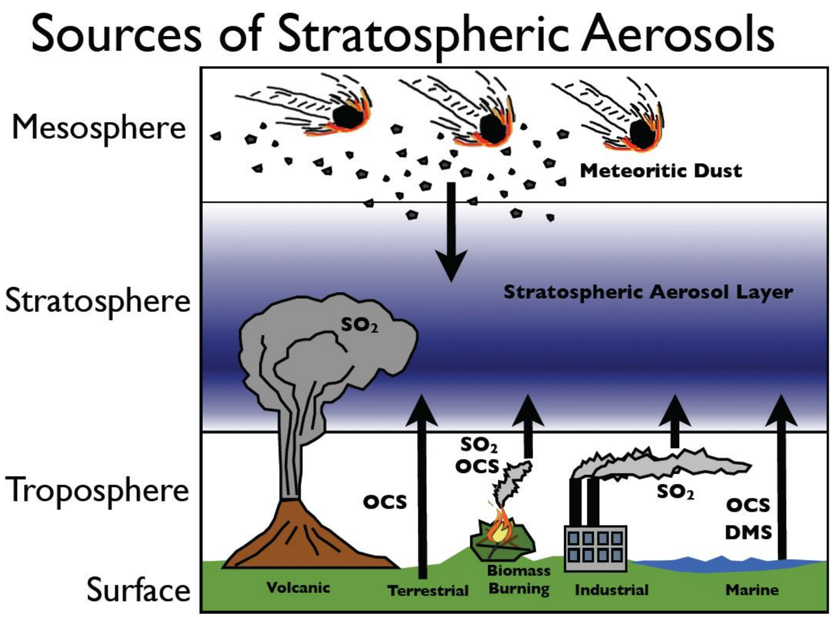
Variabilité des aérosols stratosphériques à partir de 10 ans d'observations Lidar IPRAL

Sergey Khaykin, IPRAL-SIRTA team, PyroStrat team

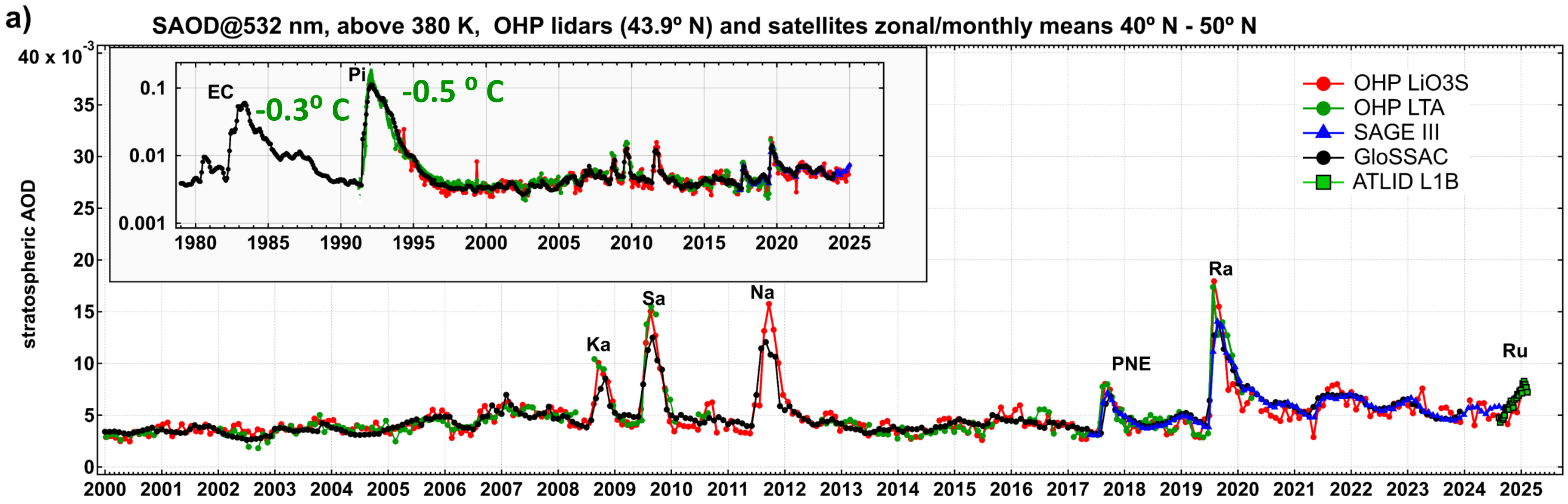


Journée Scientifique SIRTA / ICEO 24 juin 2025

Stratospheric aerosols in the climate system



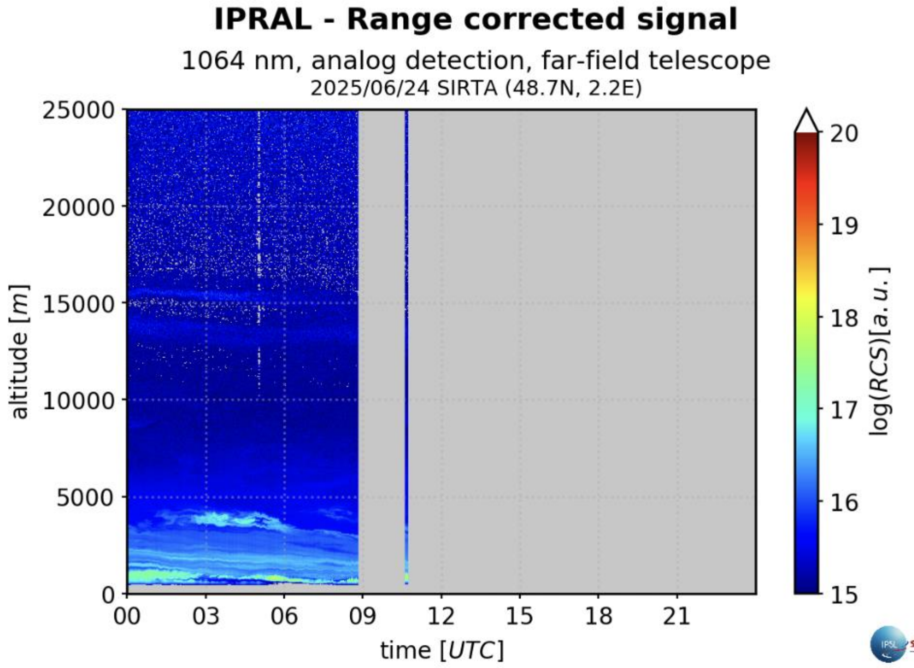
- Stratospheric aerosol is one of the key components of the climate system
- Stratospheric aerosols cool the surface and warm the lower stratosphere
- Impact on atmospheric circulation and ozone chemistry
- Central to geoengineering considerations, particularly SRM
- Observed increase in SA loading and changes to its composition due to natural and anthropogenic emissions
- Wildfires and pyroCb – an emerging source of stratospheric aerosols
- Long residence time of stratospheric aerosols (months to years) compared to that of tropospheric aerosols (days to weeks)



Stratospheric aerosol retrieval from IPRAL measurements

IPRAL : IPSL Hi-Performance multi-wavelength **RA**man **L**idar for Cloud Aerosol Water Vapor Research

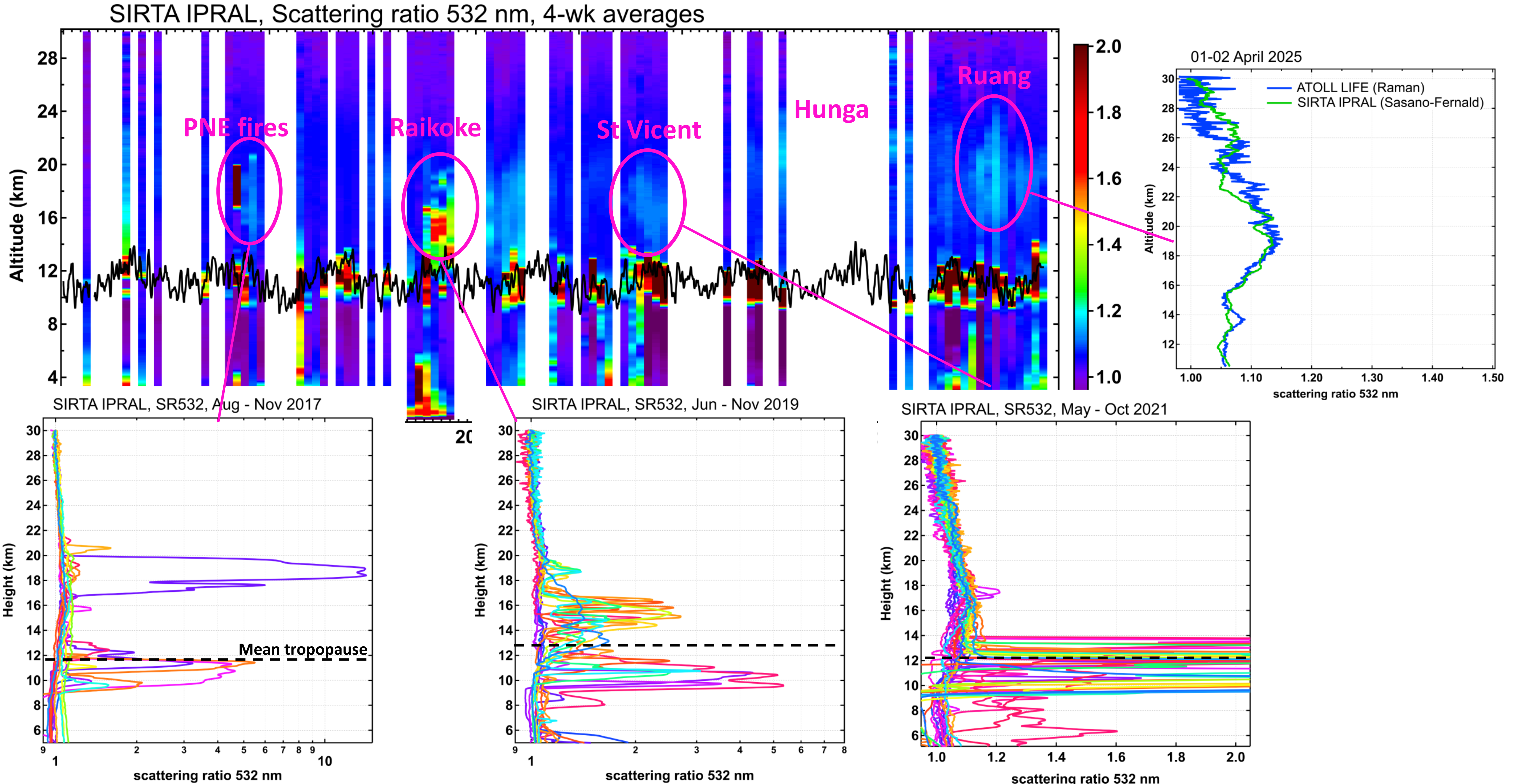
- 3 elastic channels (355, 532 and 1064 nm)
- 3 Raman (387, 407 and 607 nm) channels
- 1 depolarization channel (355 nm)
- Near fields (20 cm) and far field (60 cm) telescopes
- Analog and photocounting channels (total of 18 ch)
- (semi) Automatic day/night operation



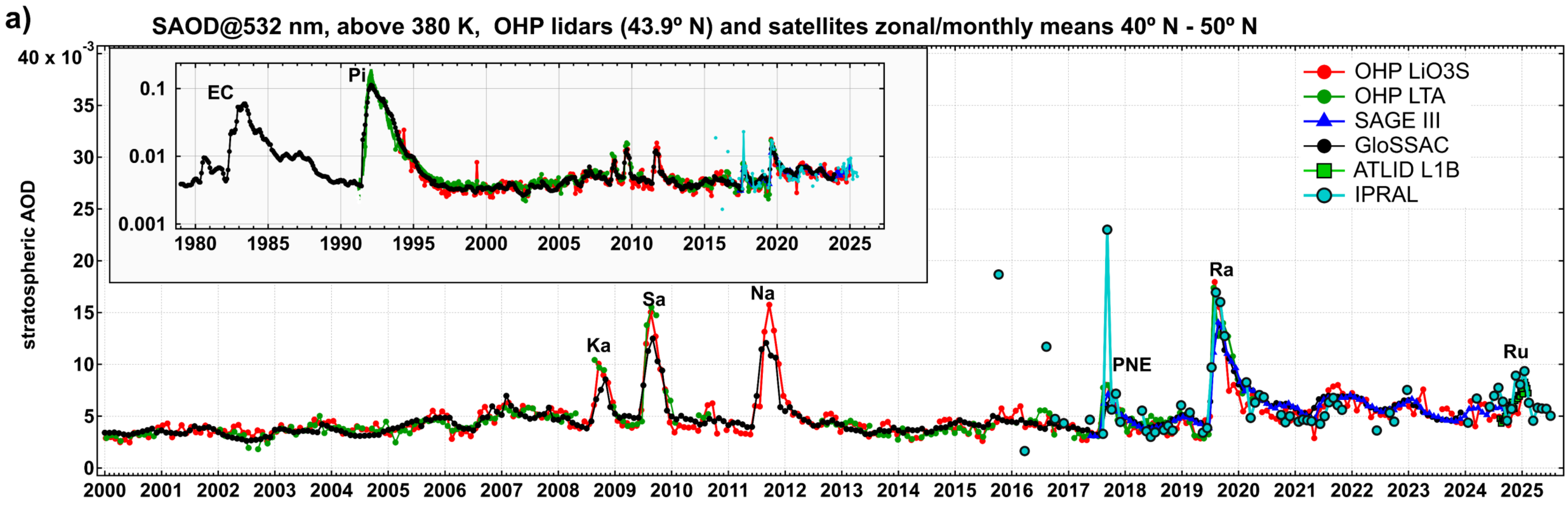
Data processing and inversion

- L1a (30 s resolution) => L1b (hourly integration, nighttime only (background-screened), low-level cloud-filtered using ceilometer (CBH< 9 km)
- Subtraction of sky background (55 – 60 km) and range correction
- Gluing of far-range analog and photocounting 532 and 355 channels
- Sasano-Fernald inversion (variable LR) with normalization at 30 – 32 km and molecular density from Trappes RS
- Output: nightly-mean profiles of backscatter coefficient, scattering ratio and extinction (310 nights since 2015/09)

Stratospheric aerosol variability from IPRAL measurements



Stratospheric aerosol variability from IPRAL measurements

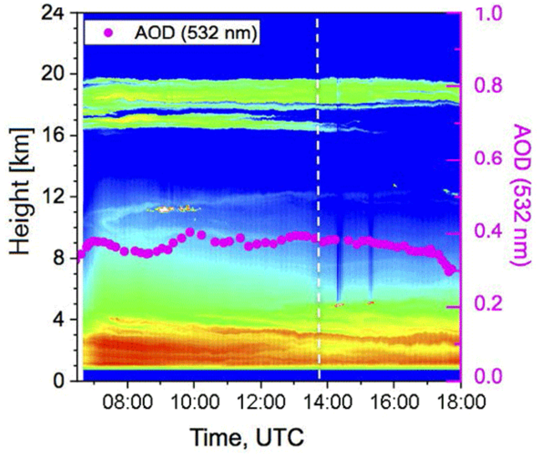


- Excellent agreement of IPRAL $SAOD_{532}$ time series with reference data sets
- IPRAL can be qualified for NDACC

PNE smoke-charged vortices above Europe

Hu et al., ACP 2018

SIRTA



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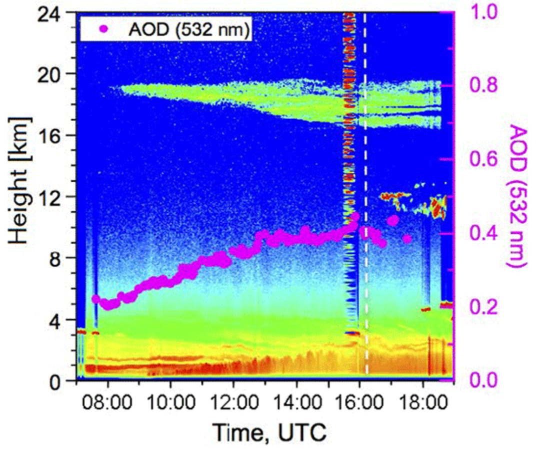
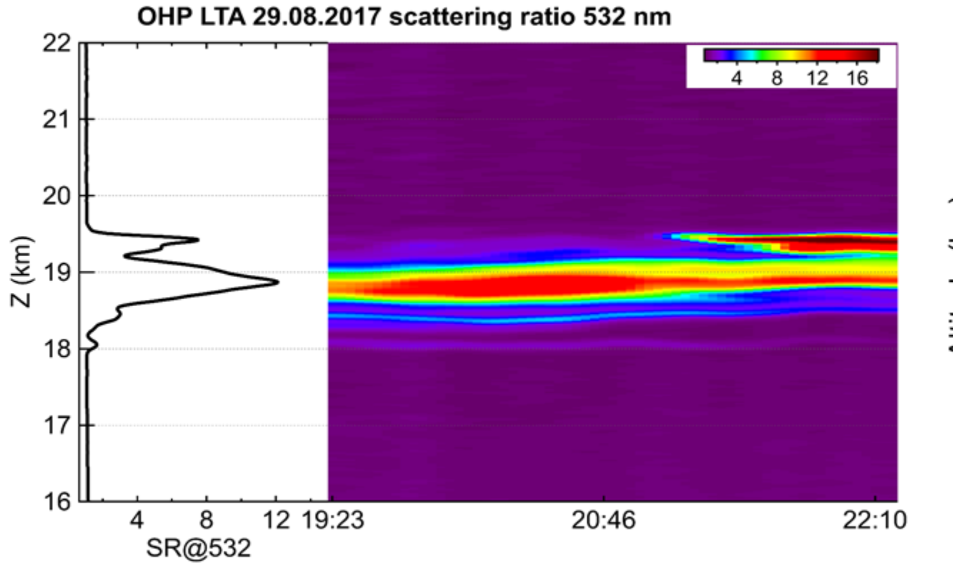
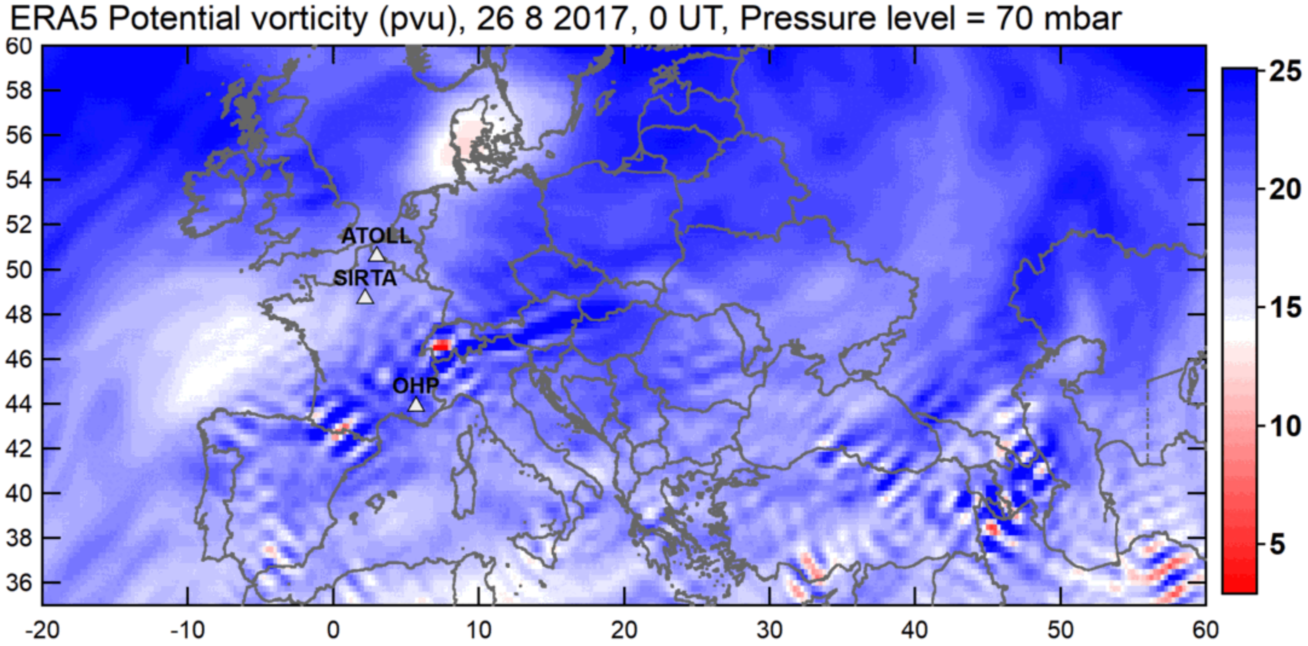


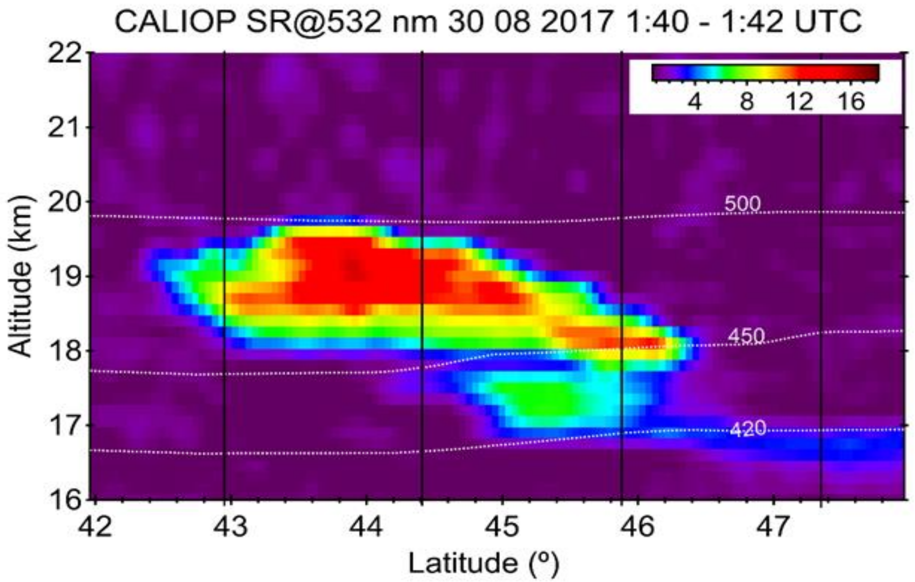
OHP



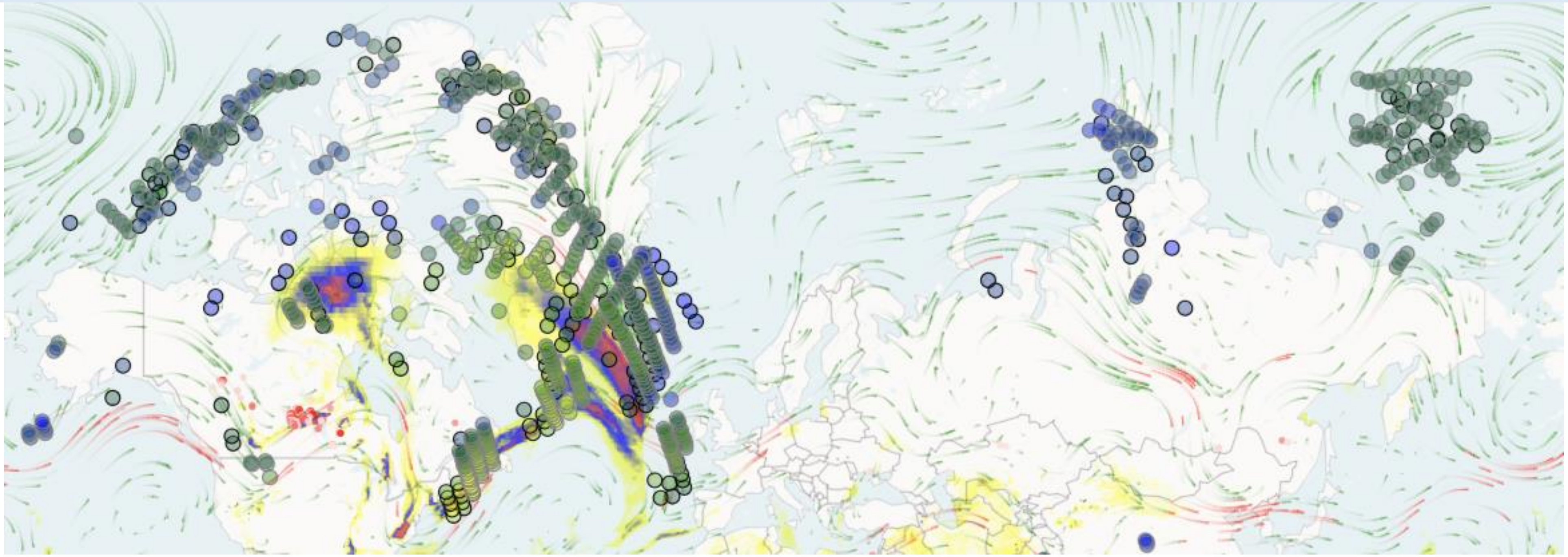


Khaykin et al., GRL, 2018

CALIOP



Panboreal Wildfire Outbreak (PWO) May-June 2025



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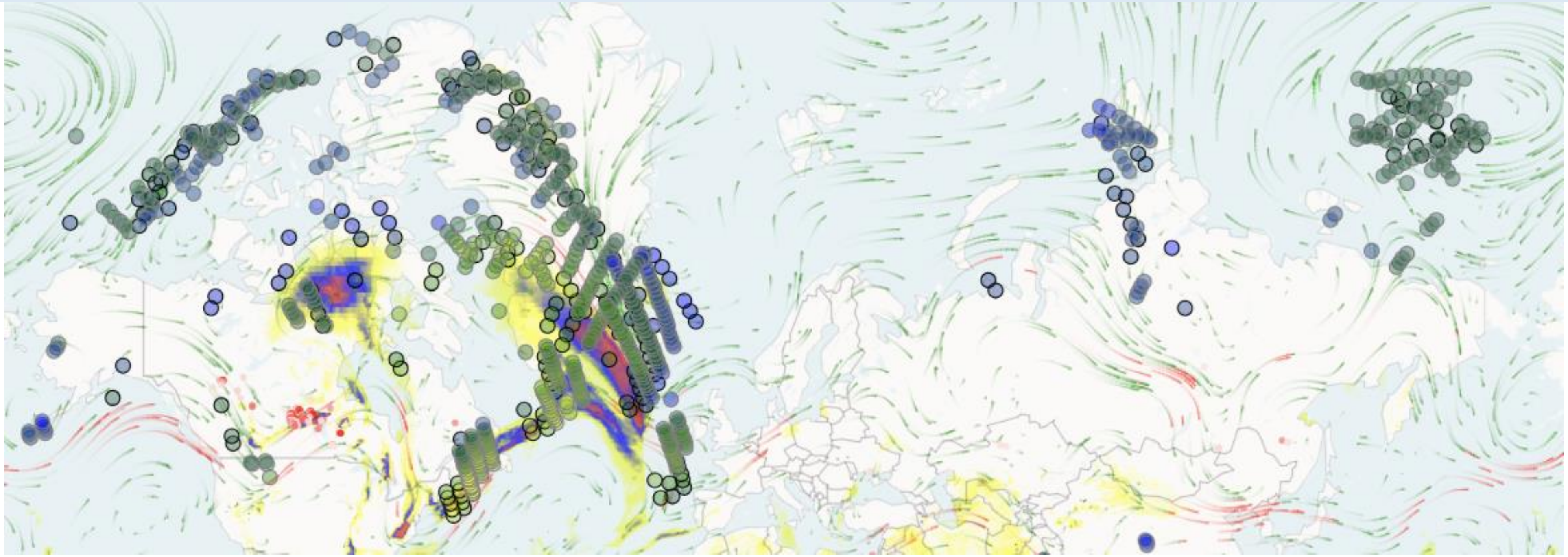
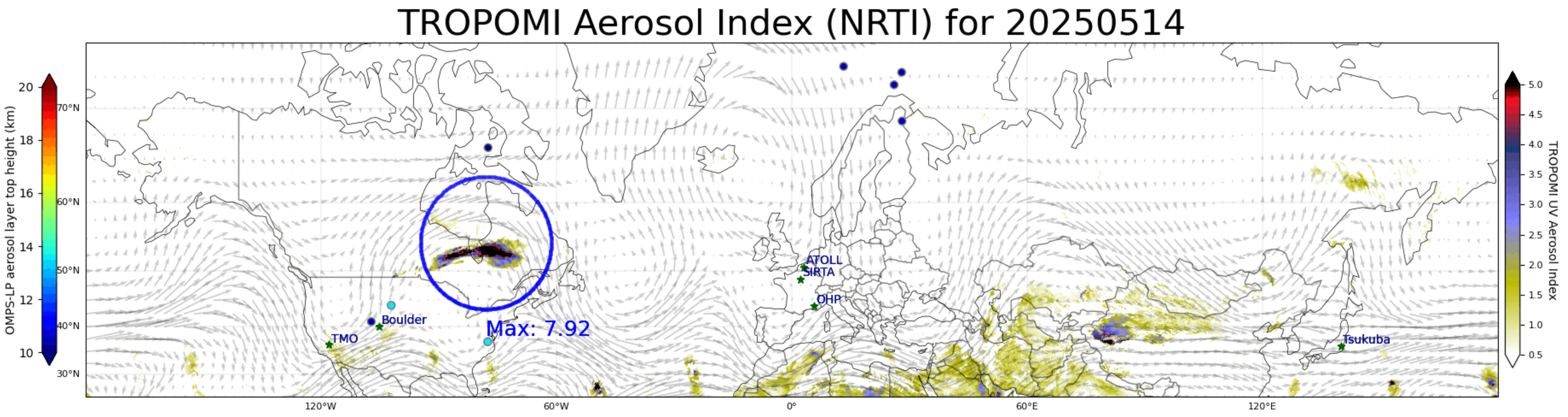
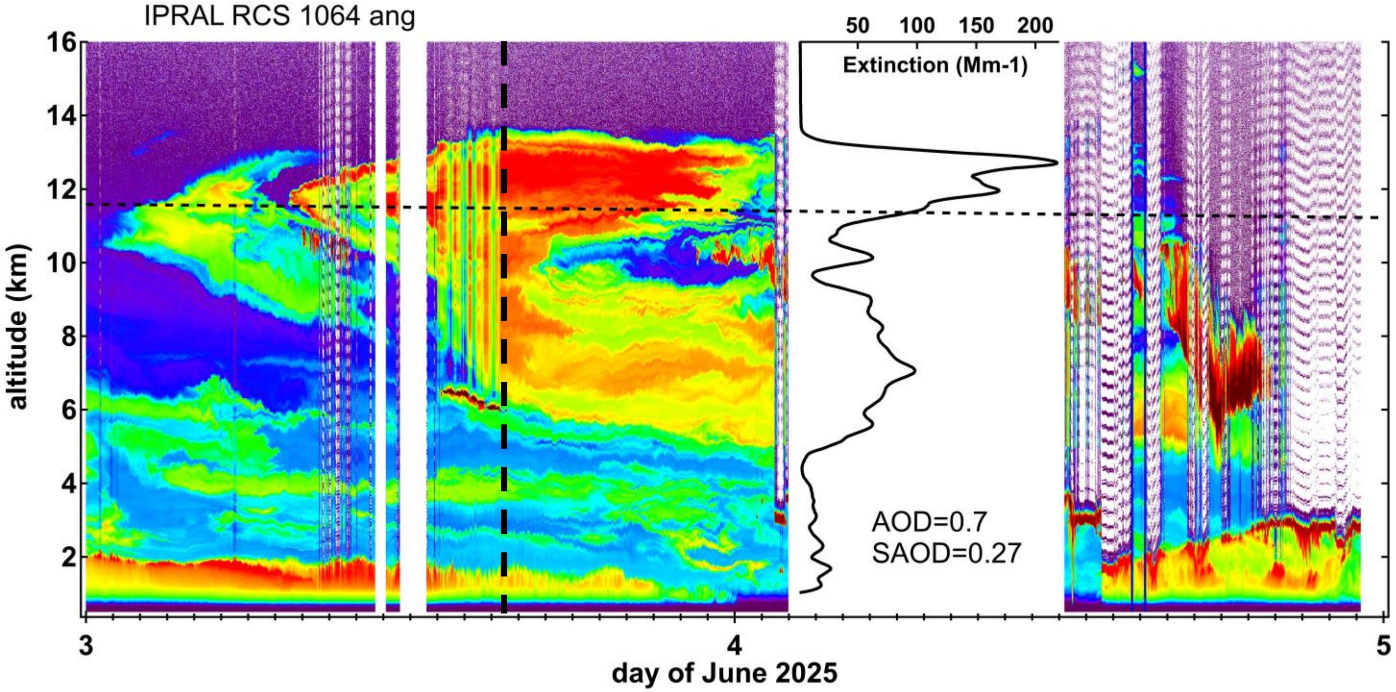
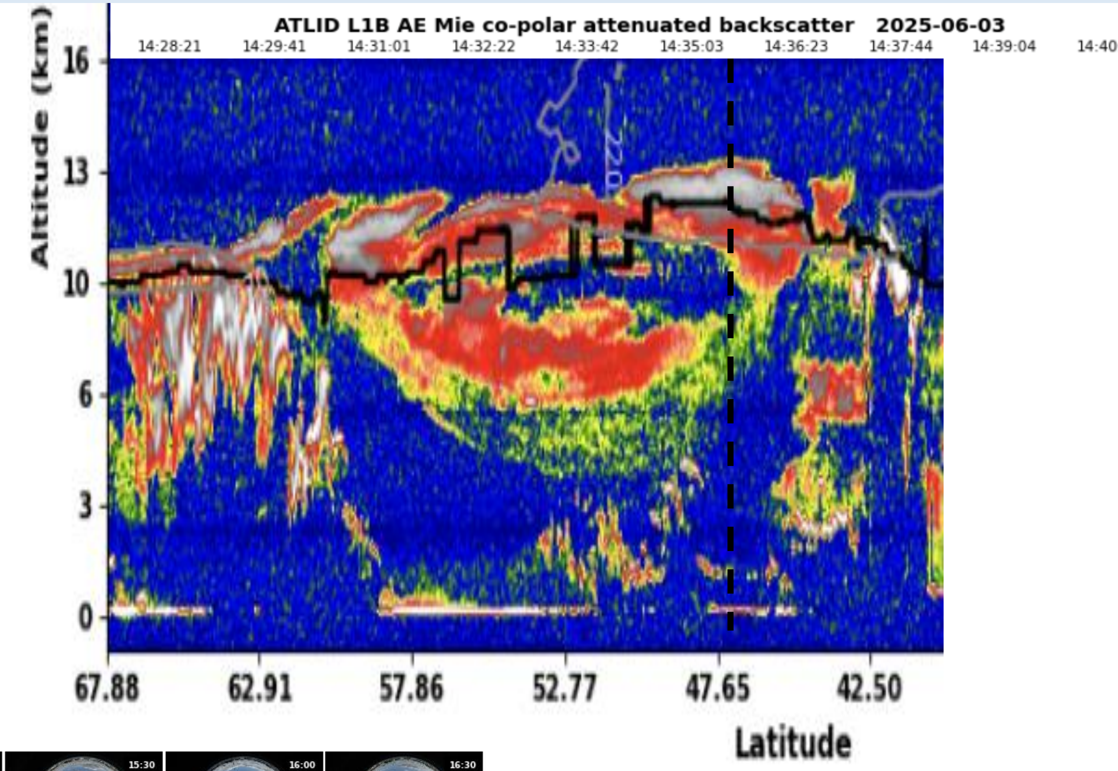
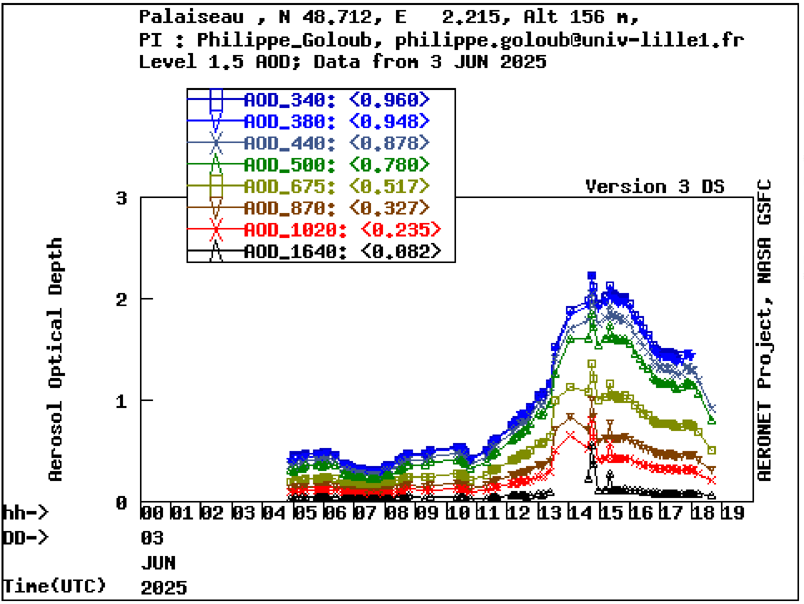




PWO observations by IPRAL and ATLID







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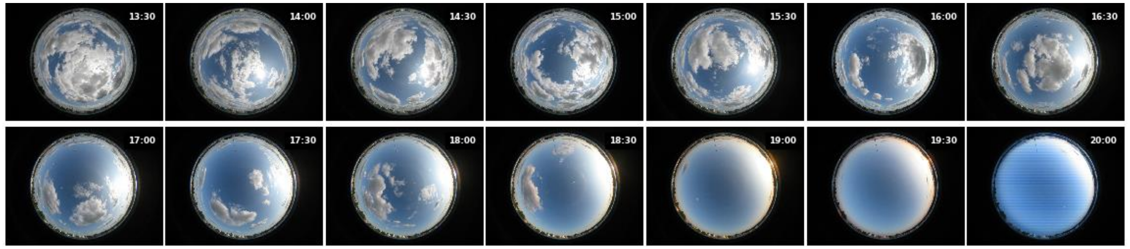

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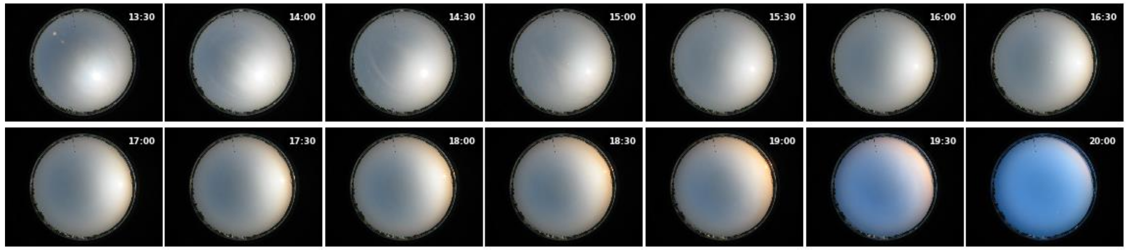
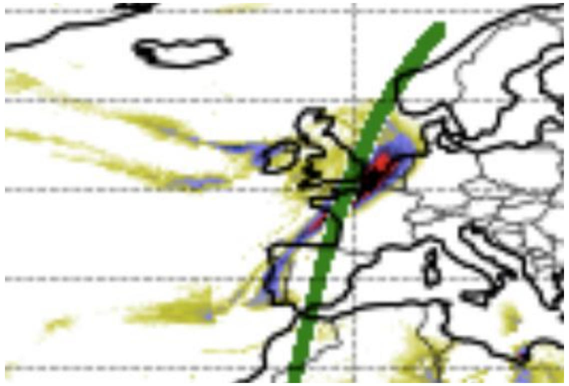
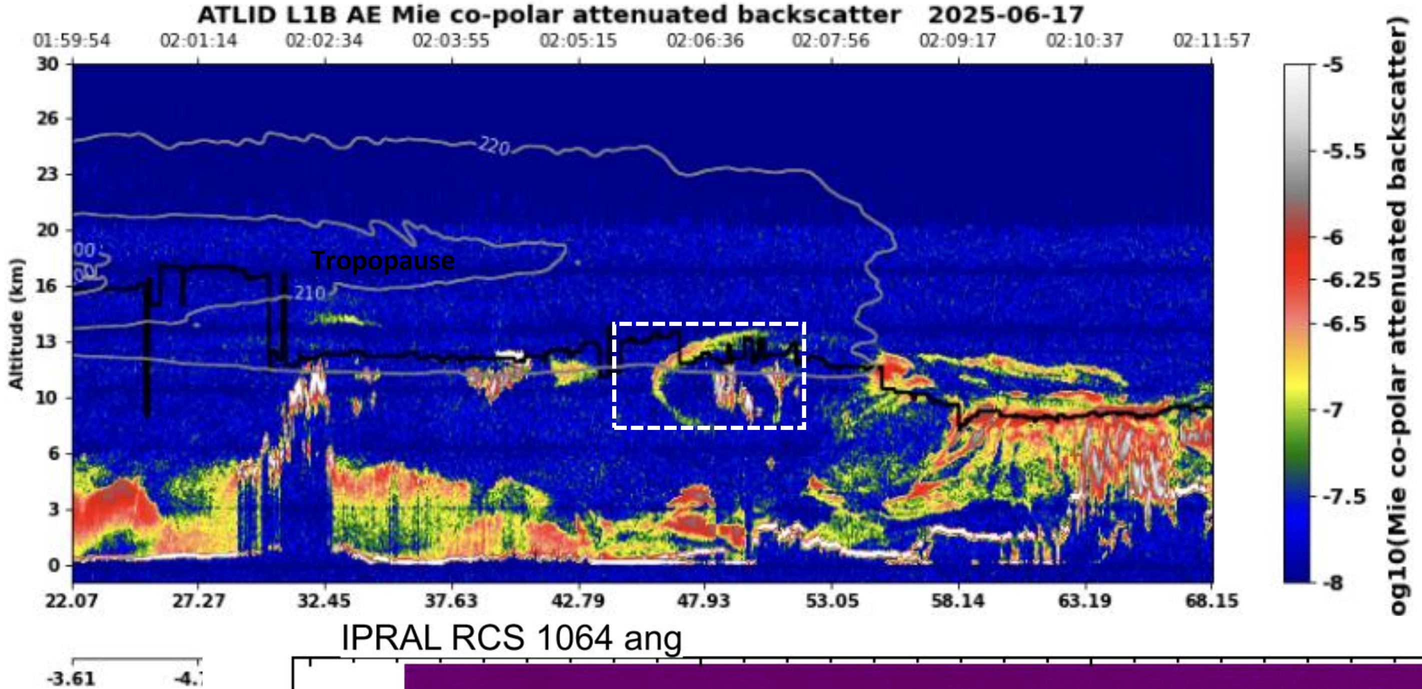
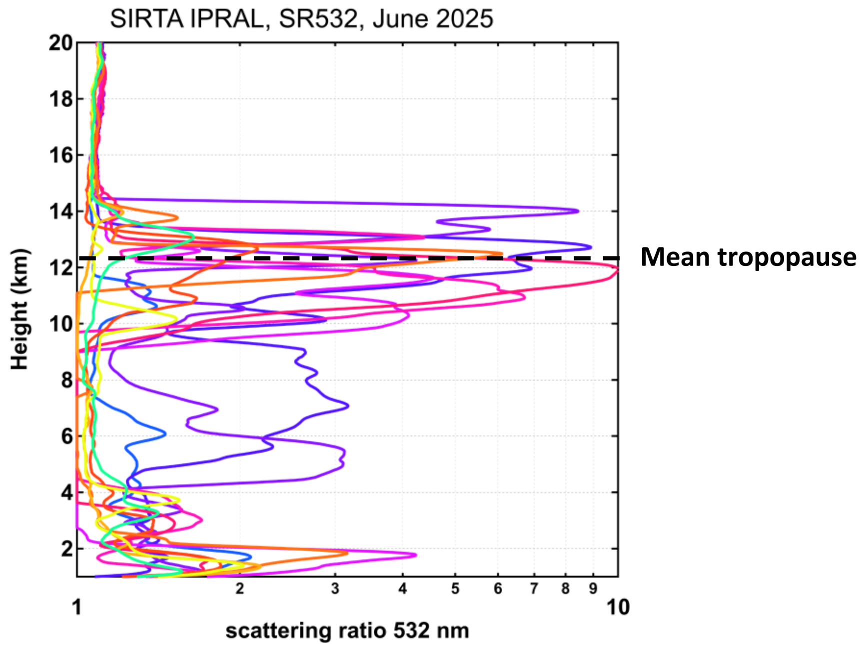
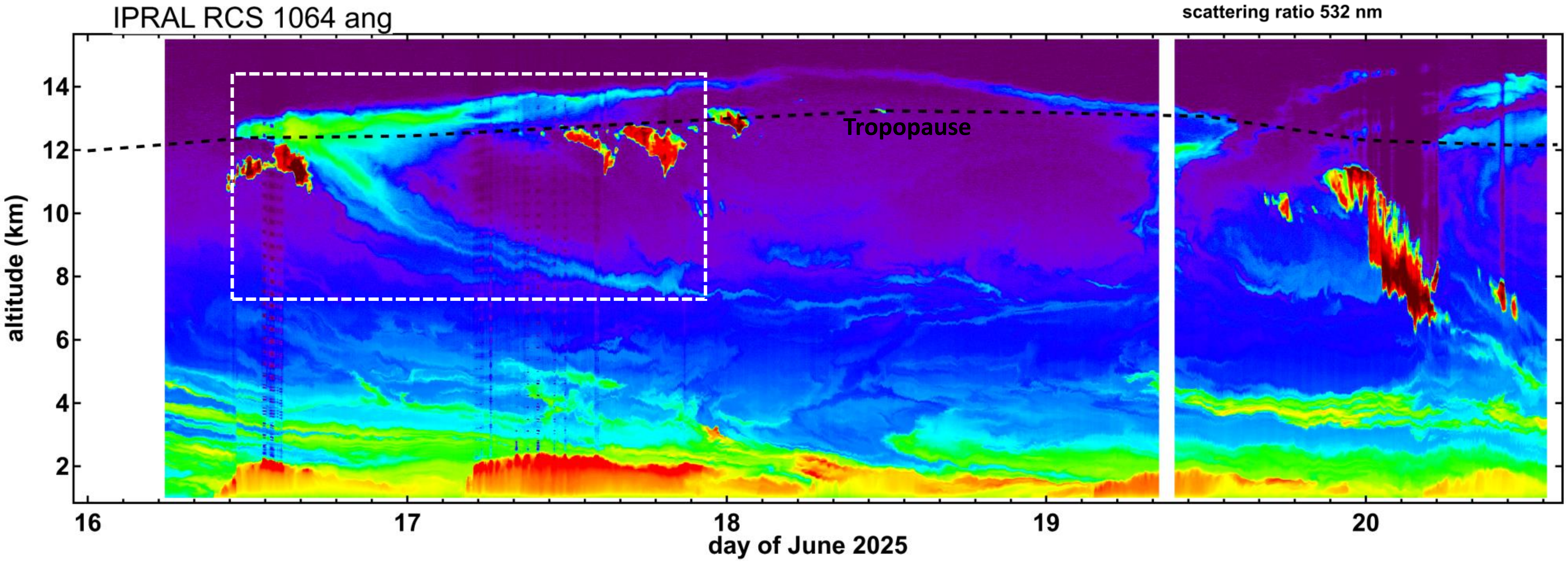




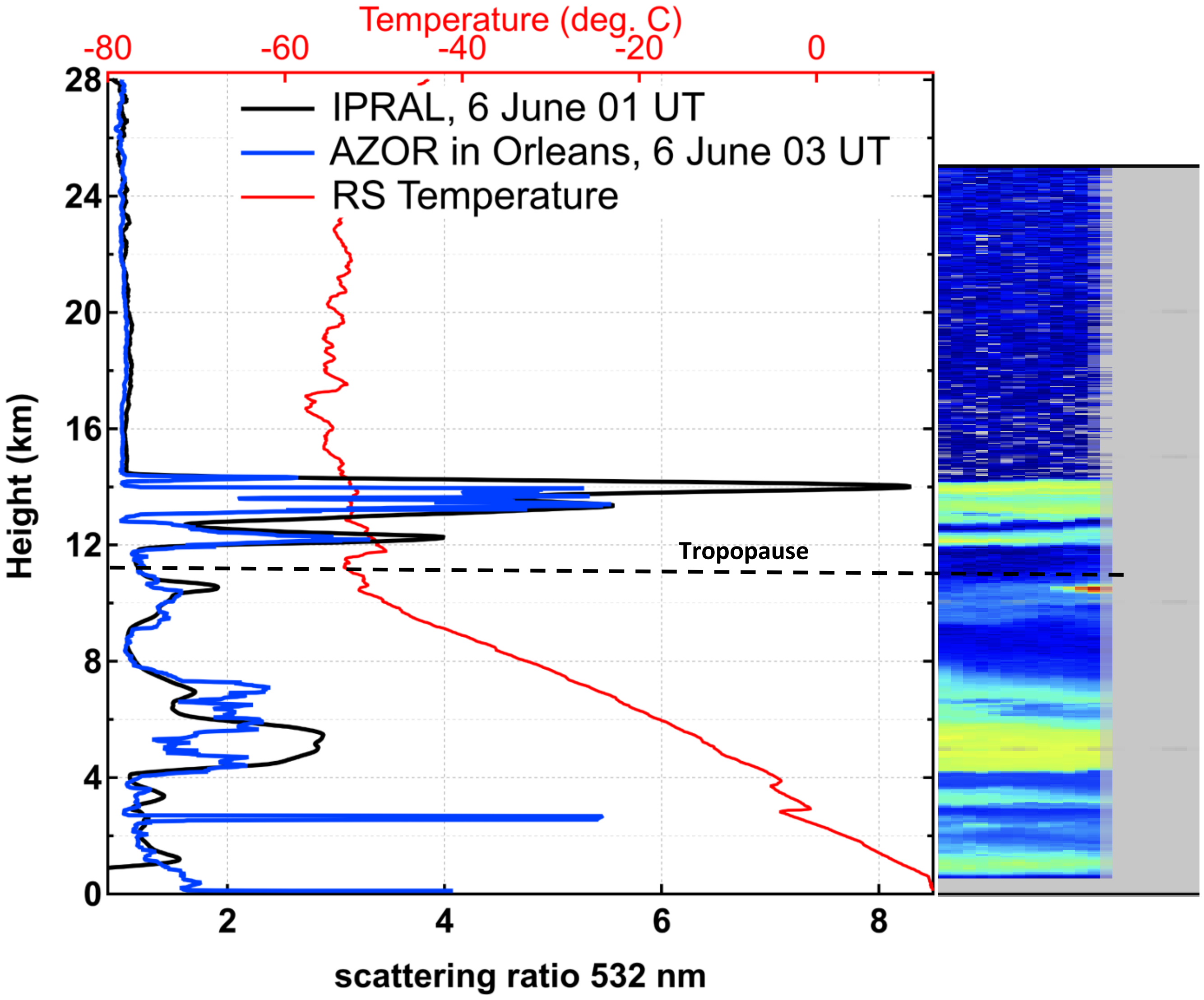
PWO observations by IPRAL and ATLID



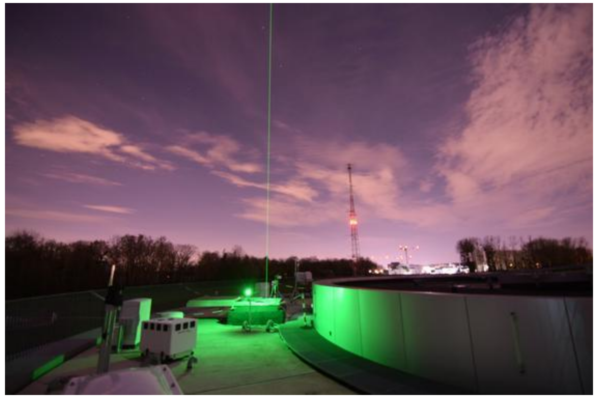




PWO observations by IPRAL and AZOR



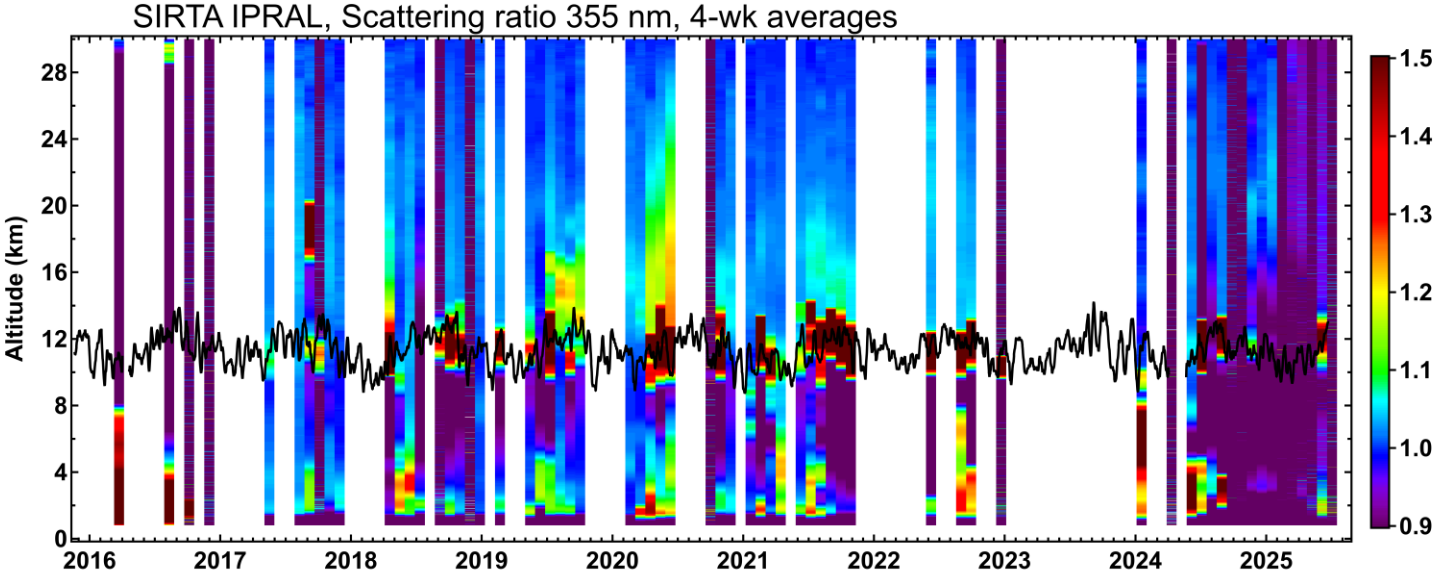
- **AZOR** is a 2-lambda balloon-borne backscatter sonde (528 and 940 nm)
- Wavelength conversion using BAE derived from the two channels

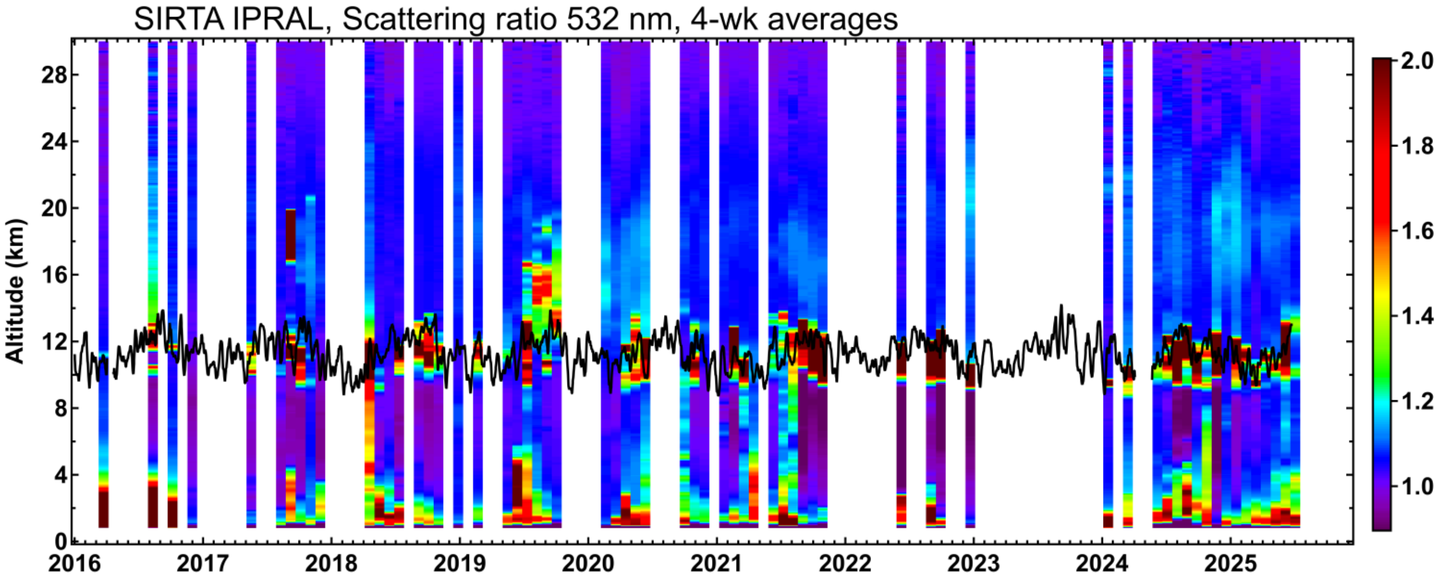


Summary

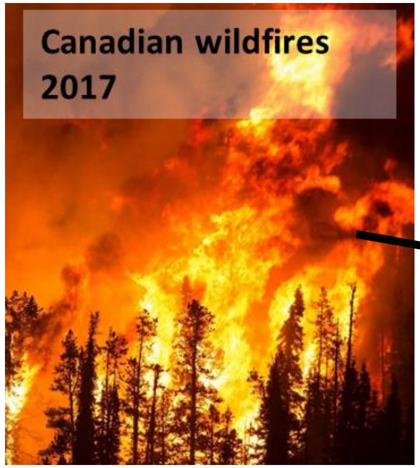
- Stratospheric aerosol loading and composition are important climatic variables
- Wildfires and pyroCb – an emerging source of stratospheric aerosols with peculiar properties
- Understanding the dynamics and lifecycle of stratospheric aerosols is crucial to assess the potential effects and risks of stratospheric geoengineering
- IPRAL is capable of stratospheric aerosol profiling after appropriate data pre-processing
- IPRAL has witnessed several remarkable events, such as major wildfire outbreaks and volcanic eruptions providing valuable material for study of aerosol properties
- IPRAL NRT curtains
  https://aerosolstrato.projet.latmos.ipsl.fr/o/data/SIRTA_quicklooks/SIRTA_quicklooks.html
- GSAW (Global Stratospheric Aerosol Watch) portal
  https://aerosolstrato.projet.latmos.ipsl.fr/

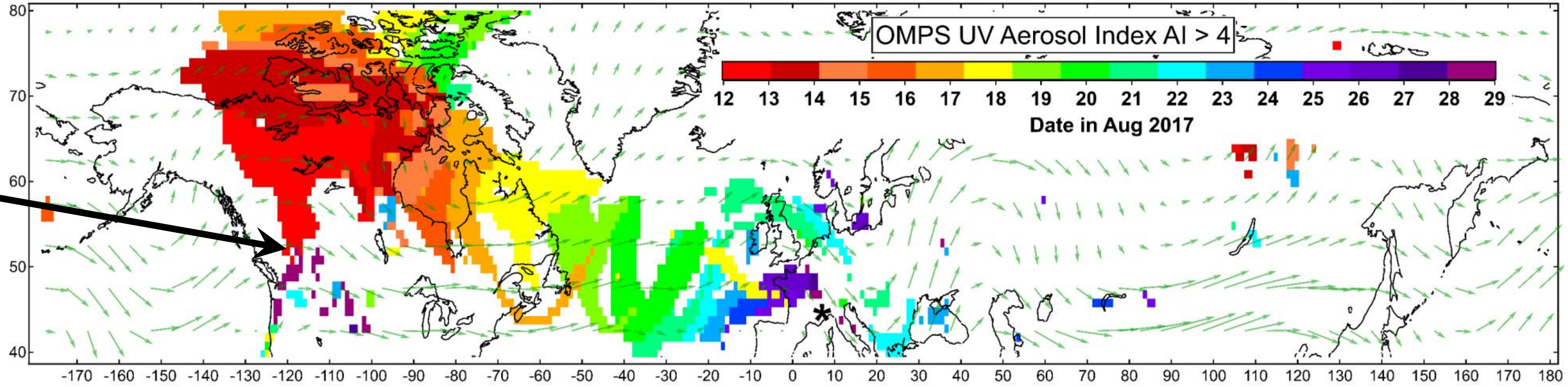
Stratospheric aerosol variability from IPRAL measurements

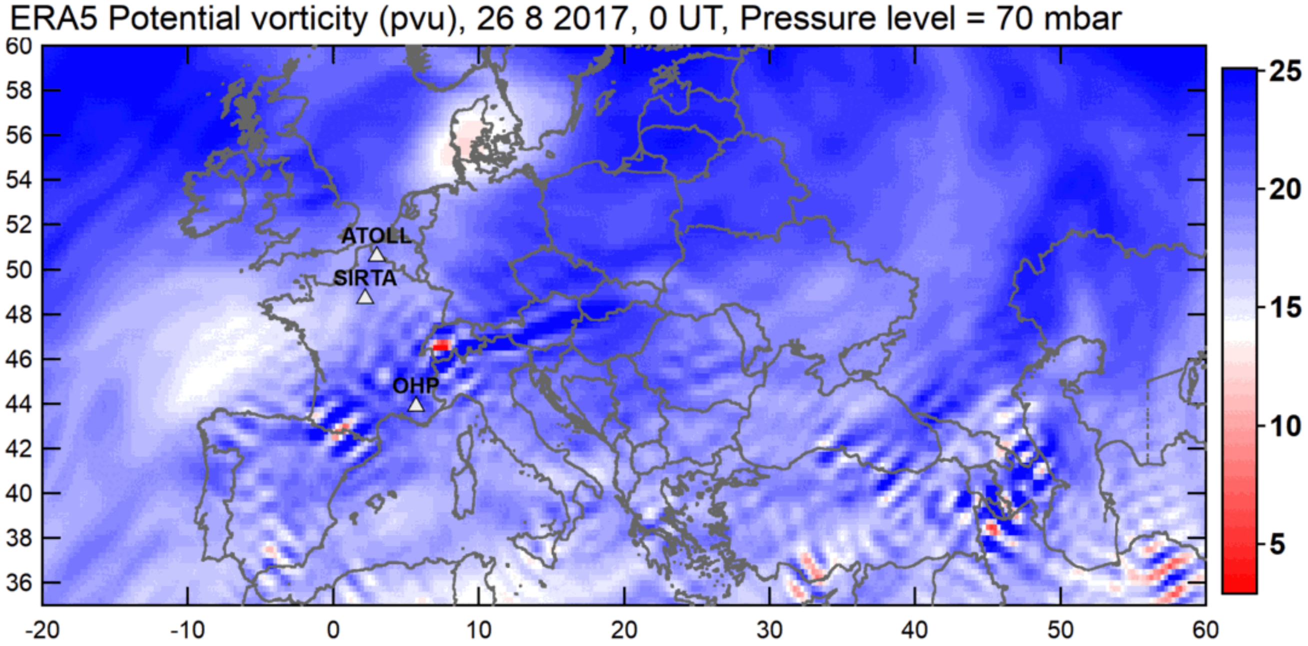




British Columbia wildfires (PNE outbreak) 13 August 2017







PNE smoke-charged vortices above Europe

Hu et al., ACP 2018

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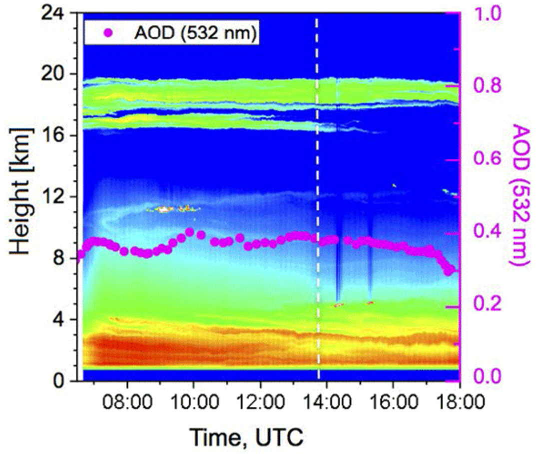

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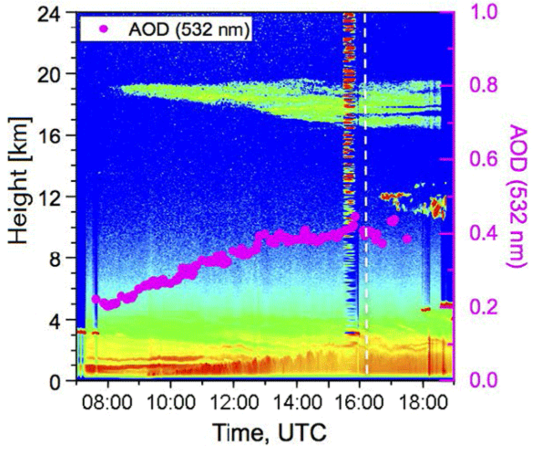

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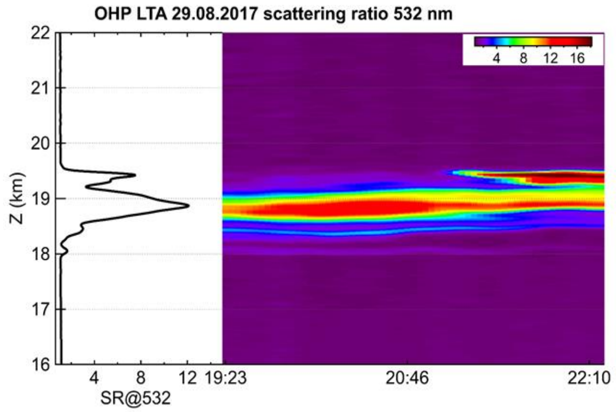
Khaykin et al., GRL, 2018



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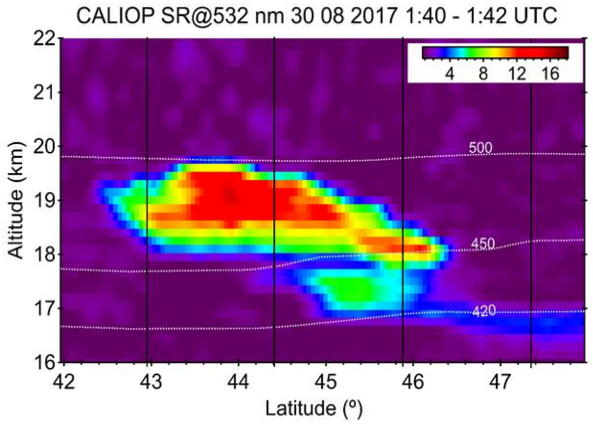

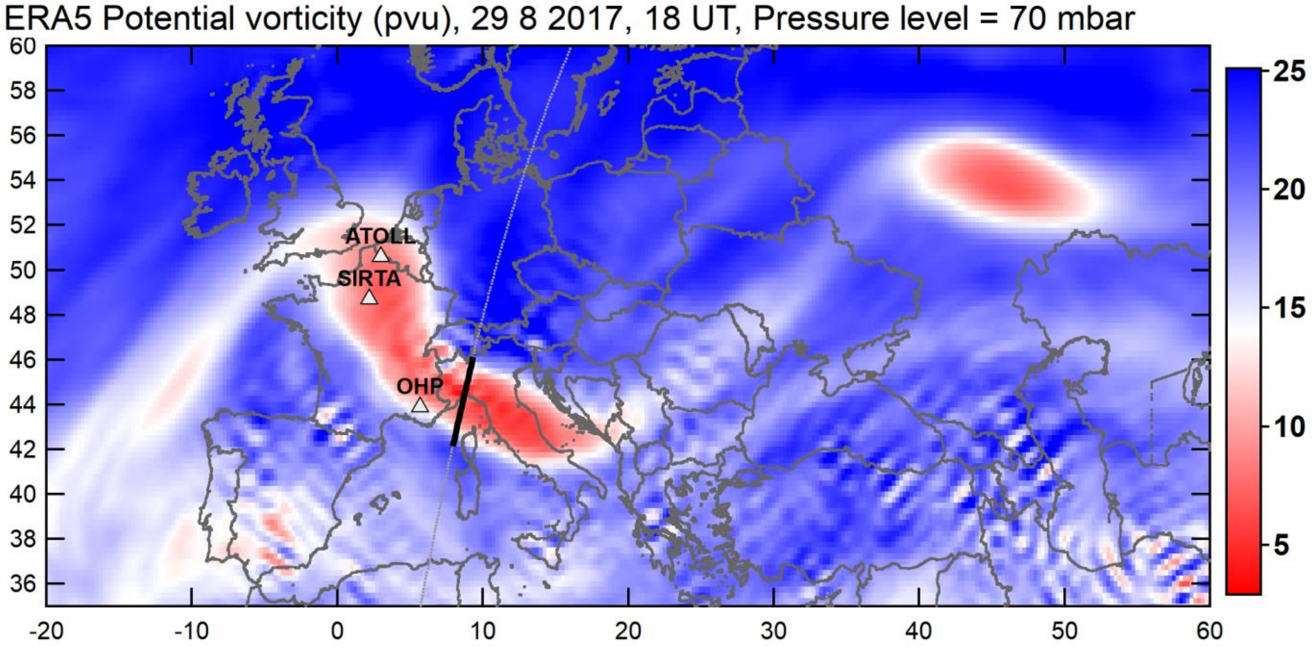

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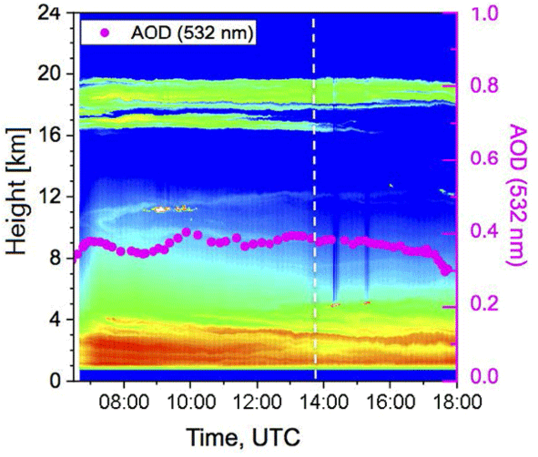

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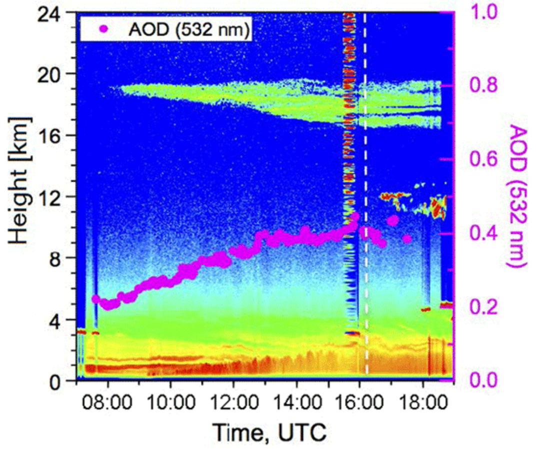

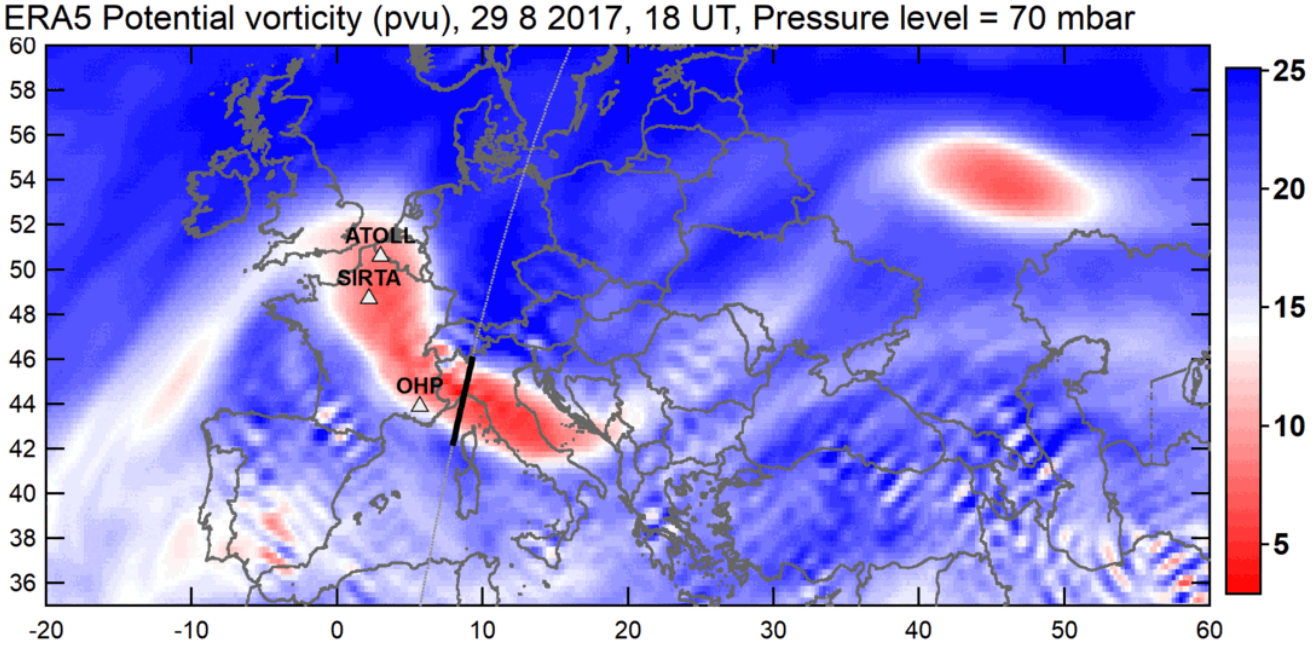

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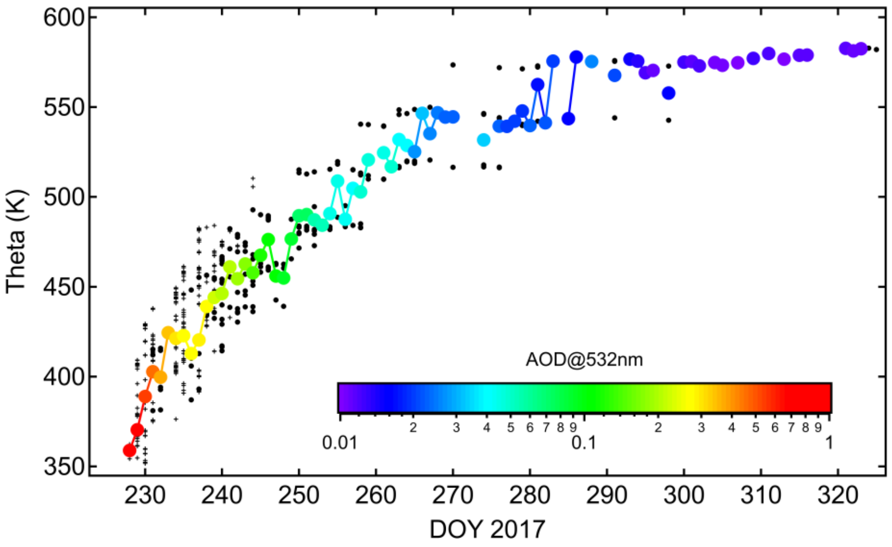
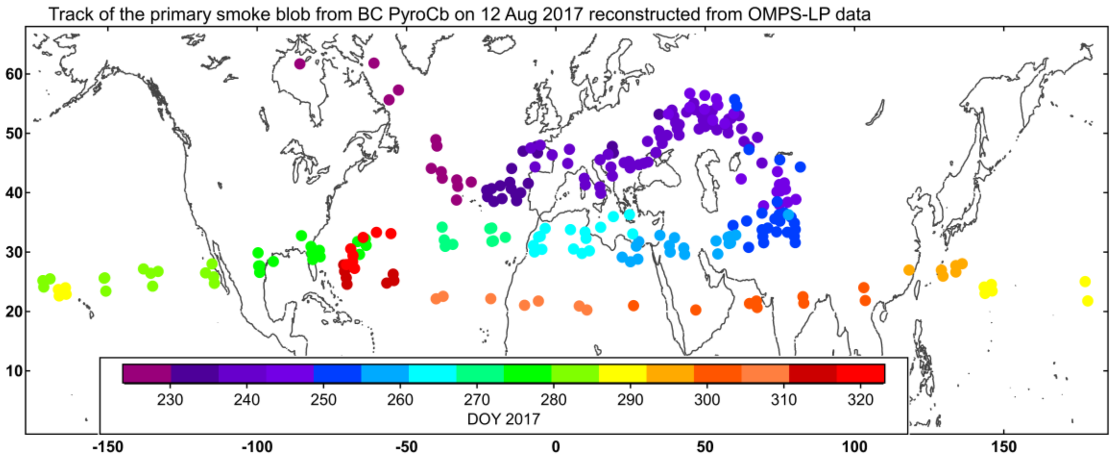
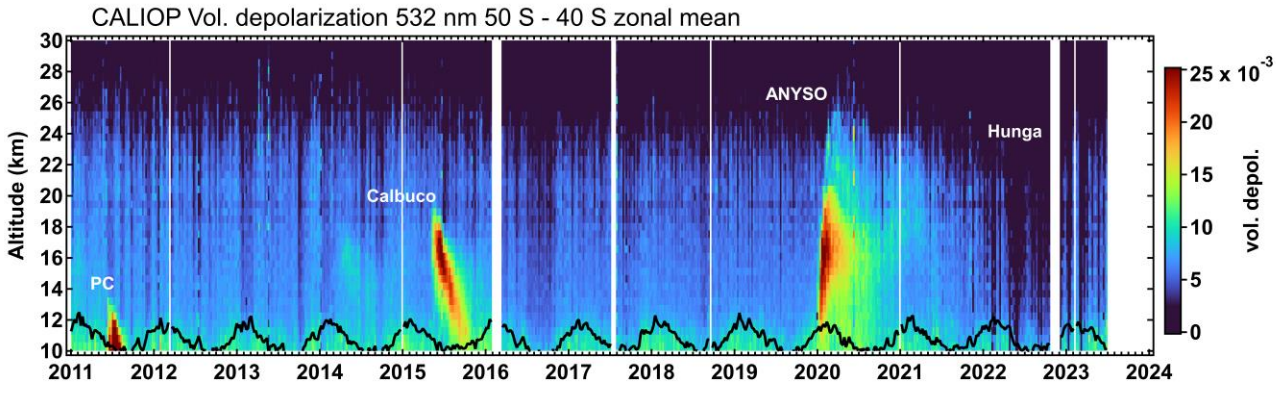
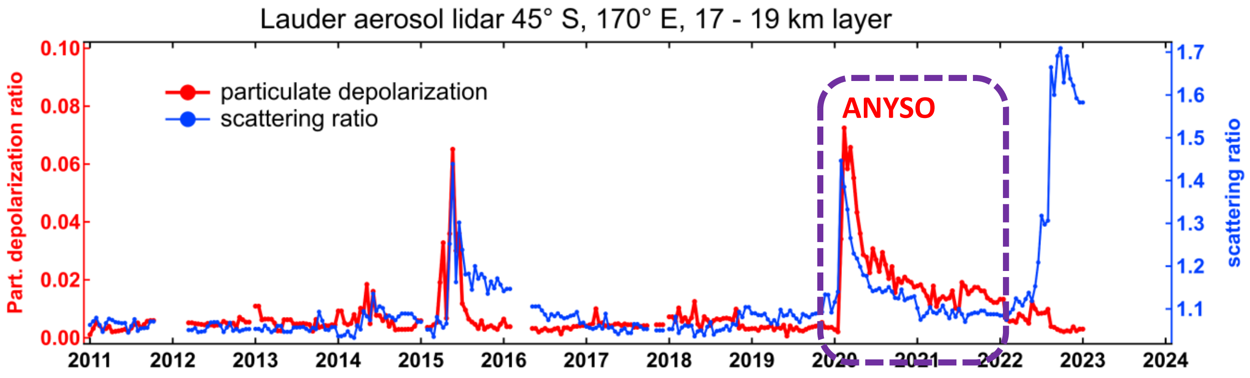




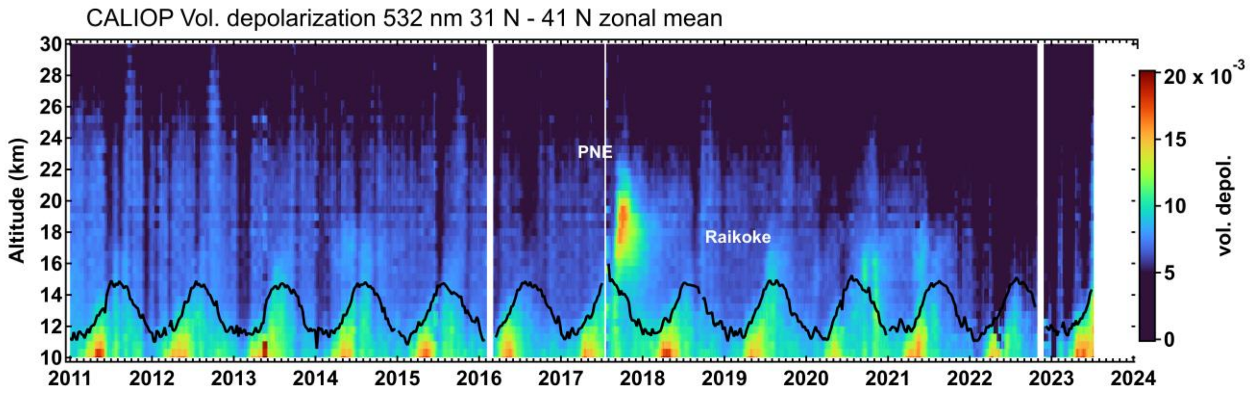
Longevity of smoke particles in the stratosphere

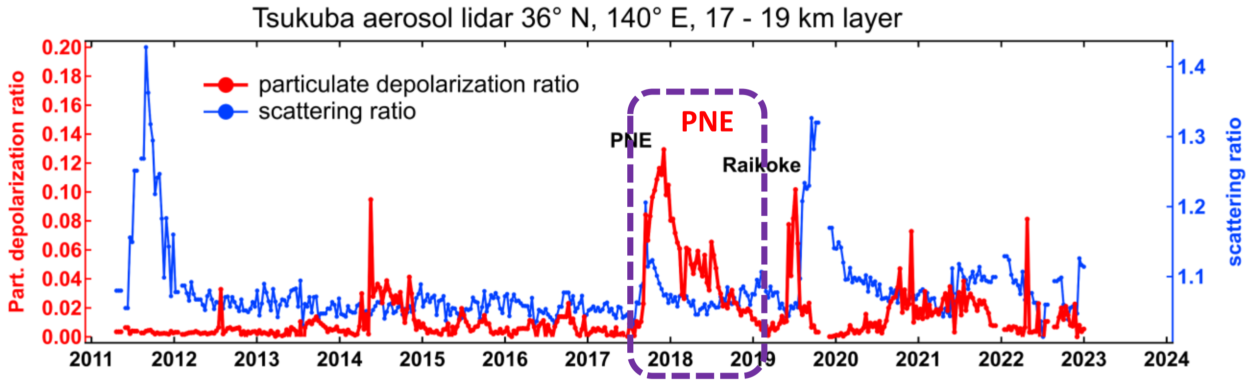
Sothern midlatitudes





Northern midlatitudes





Prolonged decay of stratospheric smoke (2 yr+) from particle depolarization

Long-term evolution of stratospheric aerosol budget