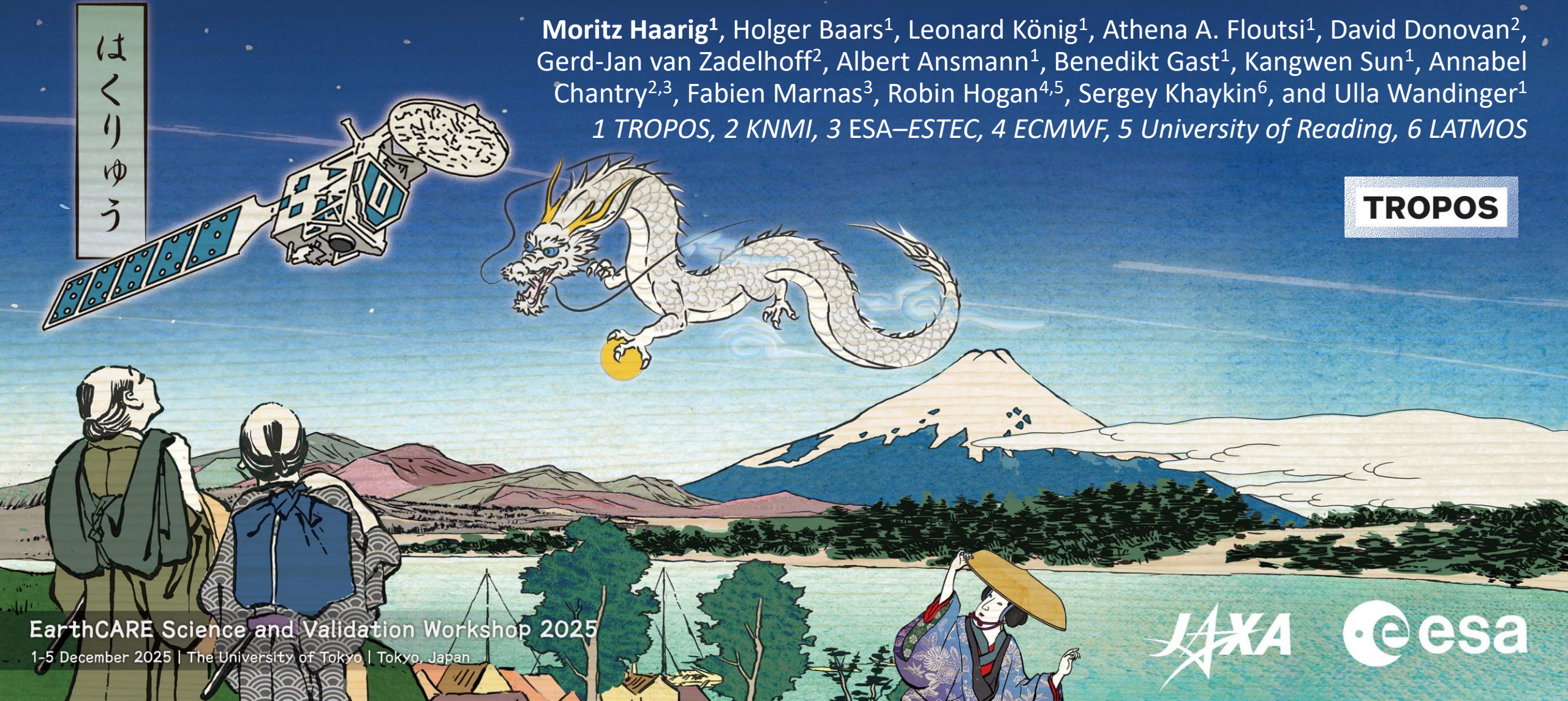


EarthCARE tracks a stratospheric smoke plume from Canada to Europe or “The life cycle of a stratospheric smoke plume”

Moritz Haarig¹, Holger Baars¹, Leonard König¹, Athena A. Floutsi¹, David Donovan², Gerd-Jan van Zadelhoff², Albert Ansmann¹, Benedikt Gast¹, Kangwen Sun¹, Annabel Chantry^{2,3}, Fabien Marnas³, Robin Hogan^{4,5}, Sergey Khaykin⁶, and Ulla Wandinger¹

1 TROPOS, 2 KNMI, 3 ESA-ESTEC, 4 ECMWF, 5 University of Reading, 6 LATMOS

TROPOS



EarthCARE Science and Validation Workshop 2025

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



Pyrocumulonimbus produce stratospheric smoke



Fire-triggered thunderstorm – **Pyrocumulonimbus**



**Fire smoke
in the
thunderstorm**



Intense wildfires in
Canada
(~28 May ~ 3 June 2025)

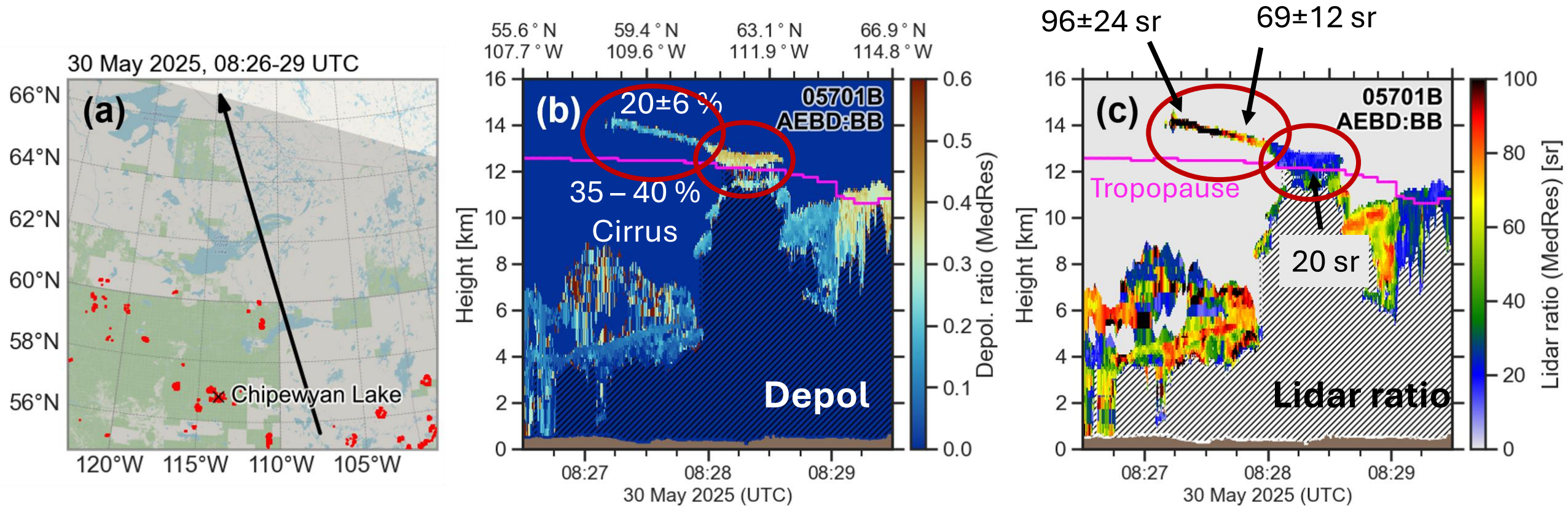
Lifting of smoke
to the Upper Troposphere
/ Lower Stratosphere
(UTLS)

≈ 10 – 12 km height
e.g. Fromm et al., BAMS 2010

Comparable to volcanic
eruptions
Observed with EarthCARE

© Kyle Brittain, May 2025

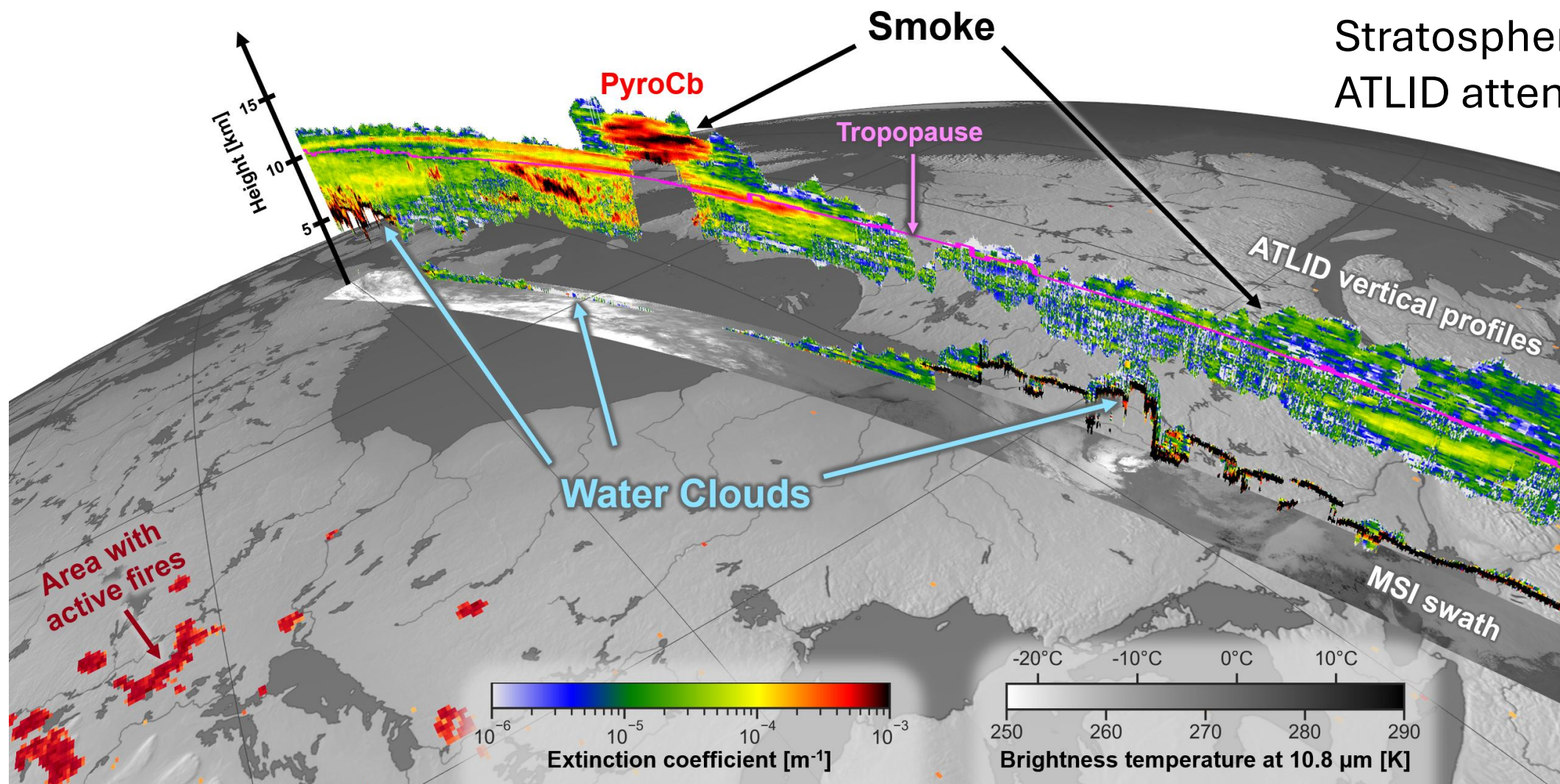
Fresh stratospheric smoke a source



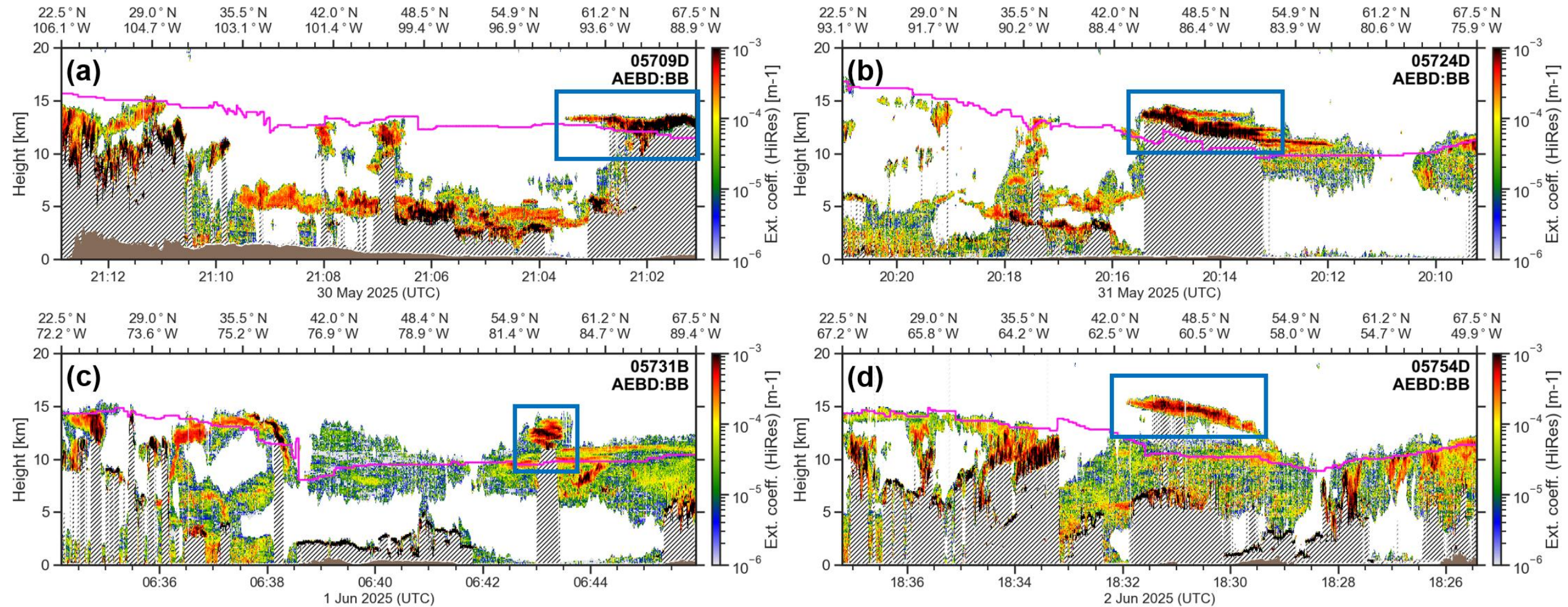
EarthCARE (5701B)
on 30 May 2025

- Smoke filament attached to ice cloud – overshoot of tropopause
- Strong decay of lidar ratio with the filament
- Enhanced depolarization ratio → non-spherical particles (Haarig et al., ACP 2018)

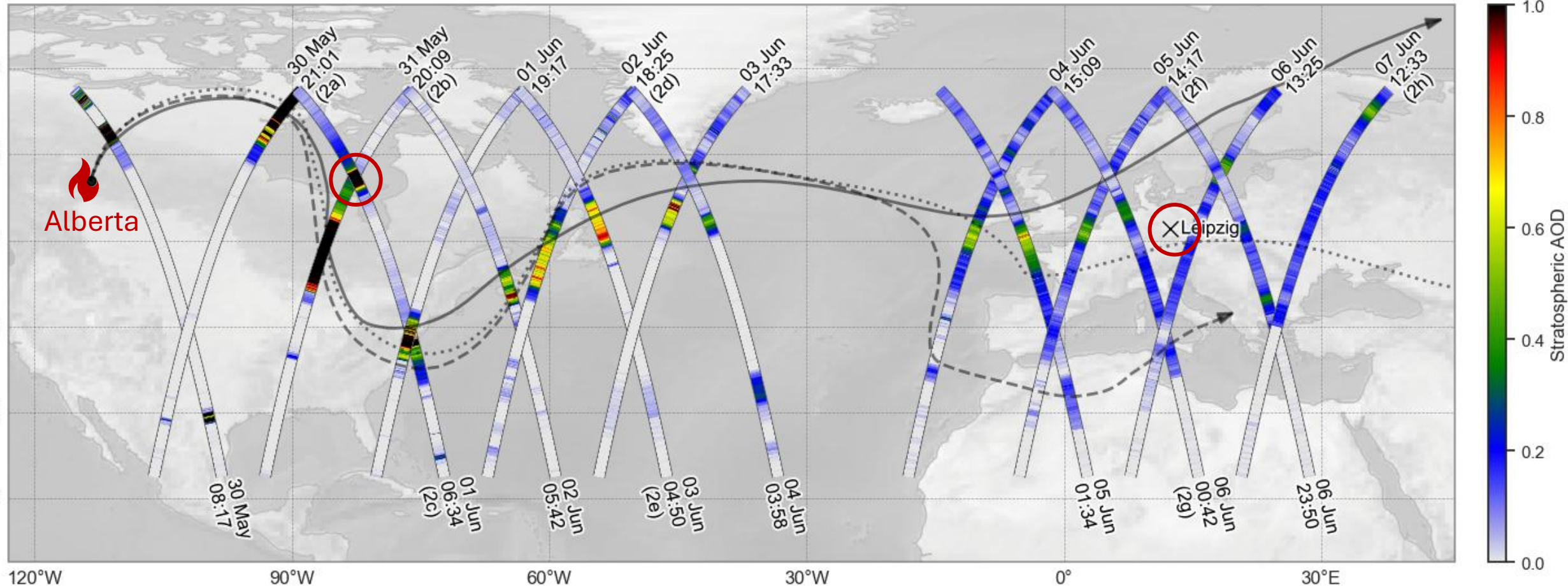
Mature stratospheric smoke plume



EarthCARE observes the intense smoke plume



Tracking of the smoke plume towards Europe

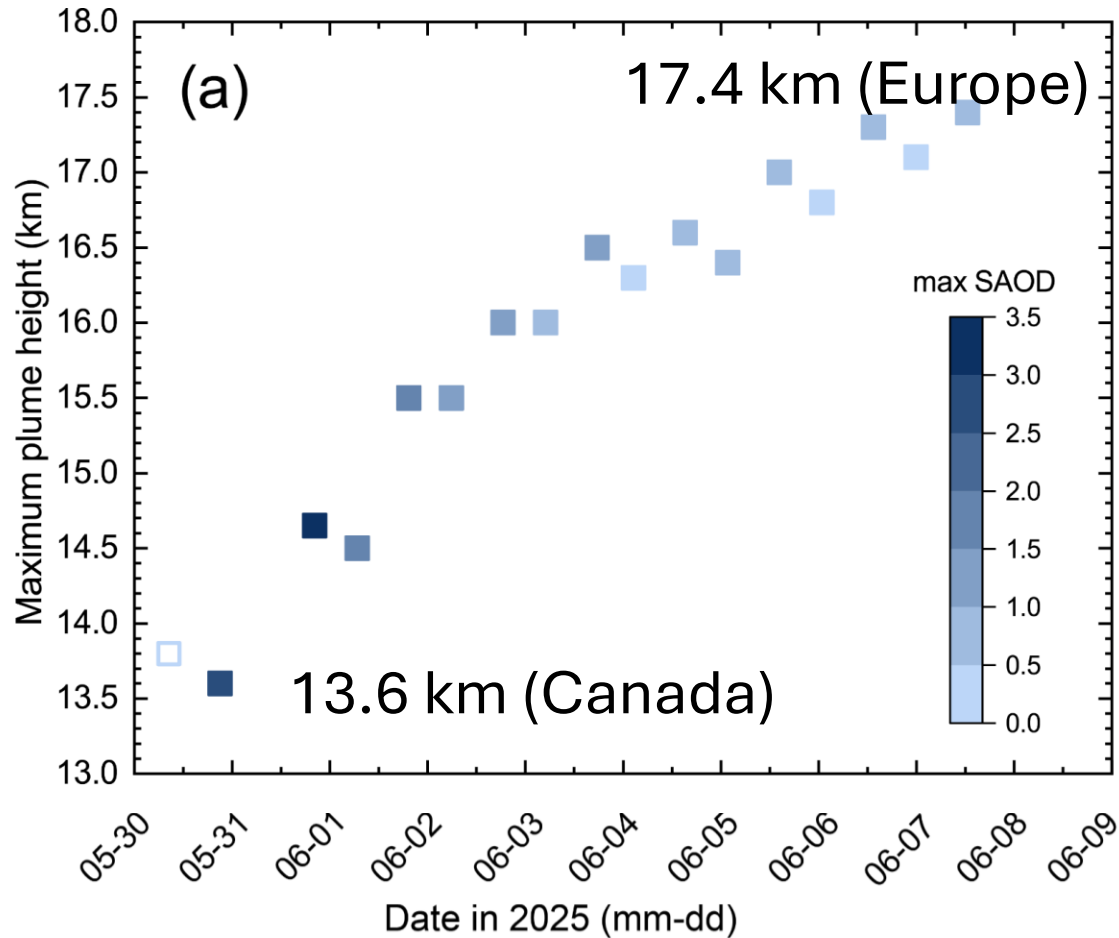


HYSPLIT + ATLID used to track stratospheric smoke plume

SAOD up to **3.2** (!) above Canada, decreasing during transport

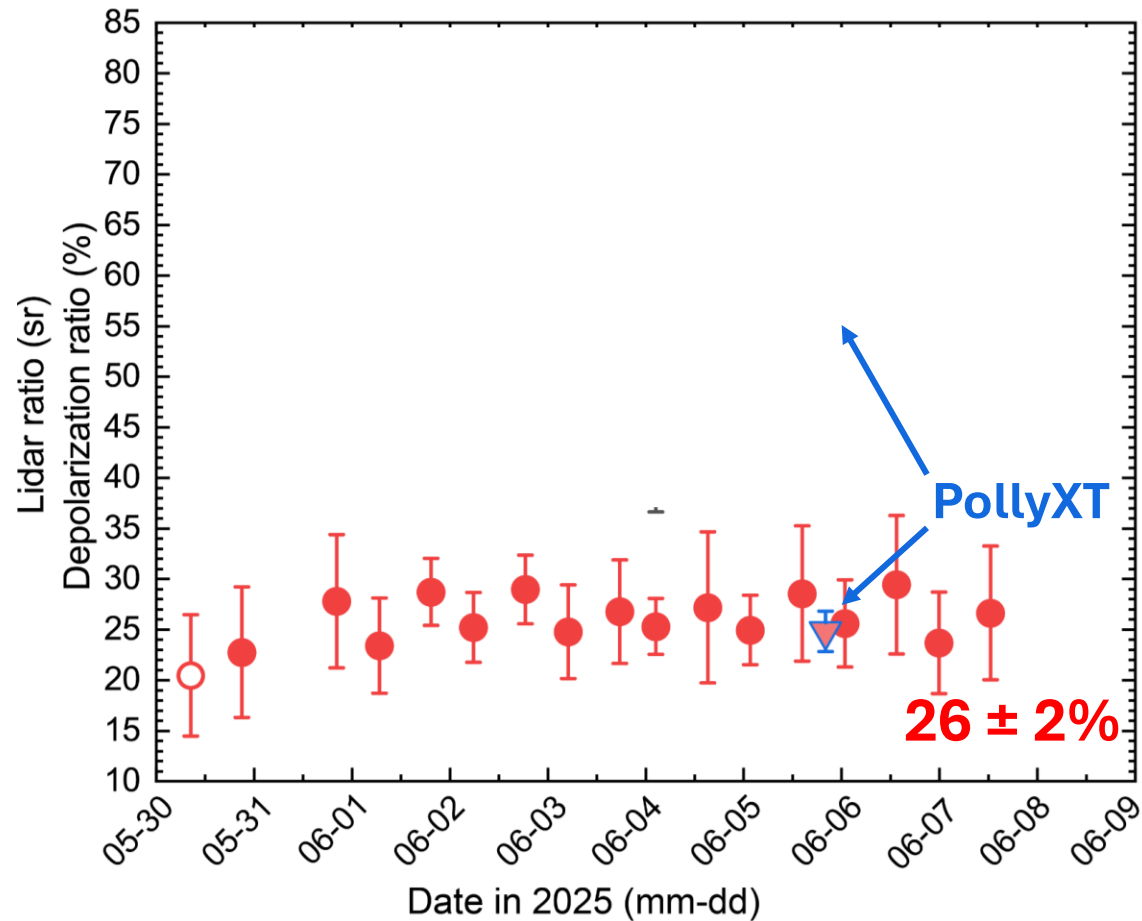
Haarig et al., submitted to GRL 2025 6

Evolution of the maximum plume height



- **Self-lofting** because of heat absorption
(not well captured in aerosol transport models)
- Lofting is strongest for high AOD
- ATLID perfectly suited to detect maximum layer height

Evolution of the optical properties



Validation at Leipzig with PollyXT on 5 June

Decay of lidar ratio in the first days
→ Over Europe approx. 50 sr

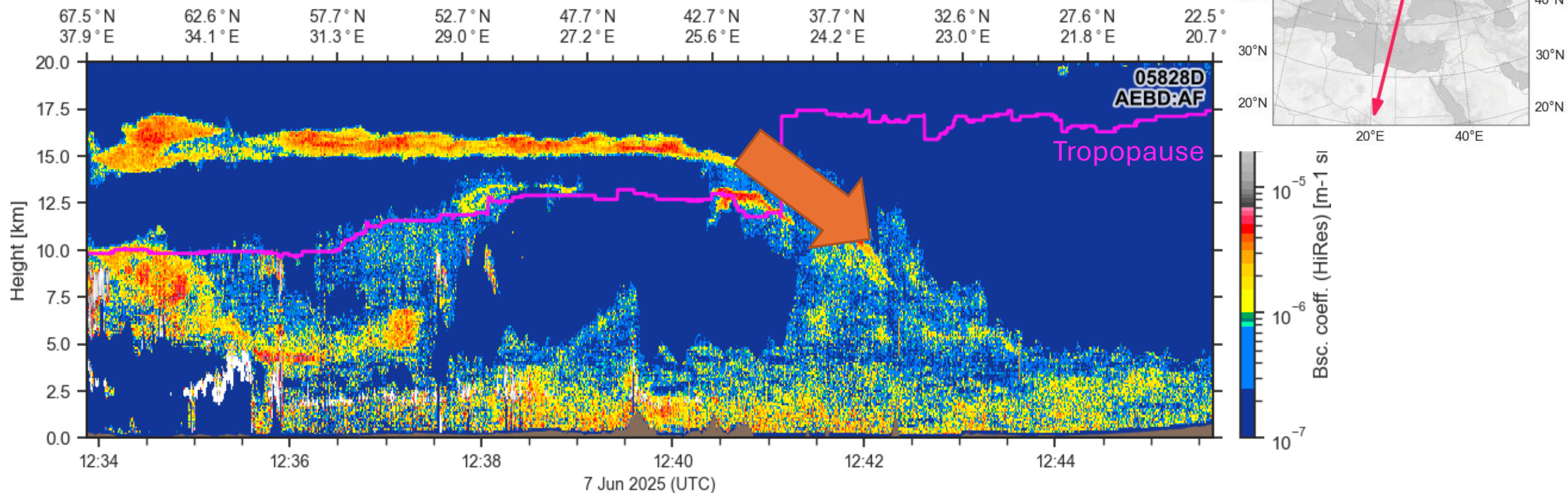
Enhanced depolarization
→ **non-spherical particles**

see also Haarig et al., ACP 2018

Hu et al., ACP 2019

Side Note:
Daytime values are higher than nighttime values
→ not physical
→ ATLID issue

Removal of stratospheric smoke



Downmixing to the troposphere at **tropopause fold** → Removal of stratospheric smoke



- **Source**

- Smoke from pyroCb detected in stratosphere
- High aerosol load in stratosphere (SAOD up to 3.2)

- **Transport**

- EarthCARE used to track the stratospheric smoke plume towards Europe
- Self-lofting characterized with ATLID
- Decay of lidar ratio during early transport
(ATLID is first space lidar to measure the lidar ratio at 355 nm)

- **Removal**

- Tropopause folds over Mediterranean and North Africa identified as removal mechanism

- **Great potential of ATLID for stratospheric observations**