EarthCARE observations of smoke

Gerd-Jan van Zadelhoff (KNMI)

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

EarthCARE Mission and Goals

- To improve our understanding of **cloud, aerosol and precipitation processes and** their **radiative** impact
- **Use synergy of active and passive instruments** to provide the most accurate profiles of cloud, aerosol and precip.
- To perform **radiative closure** as part of the core mission
- To provide near-real-time observations for **assimilation** into weather forecast models

Cloud Profiling Radar (CPR) - JAXA

94 GHz Doppler, 2.5 m dish

Atmospheric Lidar (ATLID)

High-Spectral Resolution Lidar (HSRL), λ=355nm.

Multi-Spectral Imager (MSI)

pushbroom, 4 solar + 3 TIR channels

Broad-Band Radiometer (BBR)

2 Channels: Solar + Thermal; 3 fixed FoV

EarthCARE NRT radiative closure

Jonathan Flunger, Alex Hoffmann
and the ESA visualization team

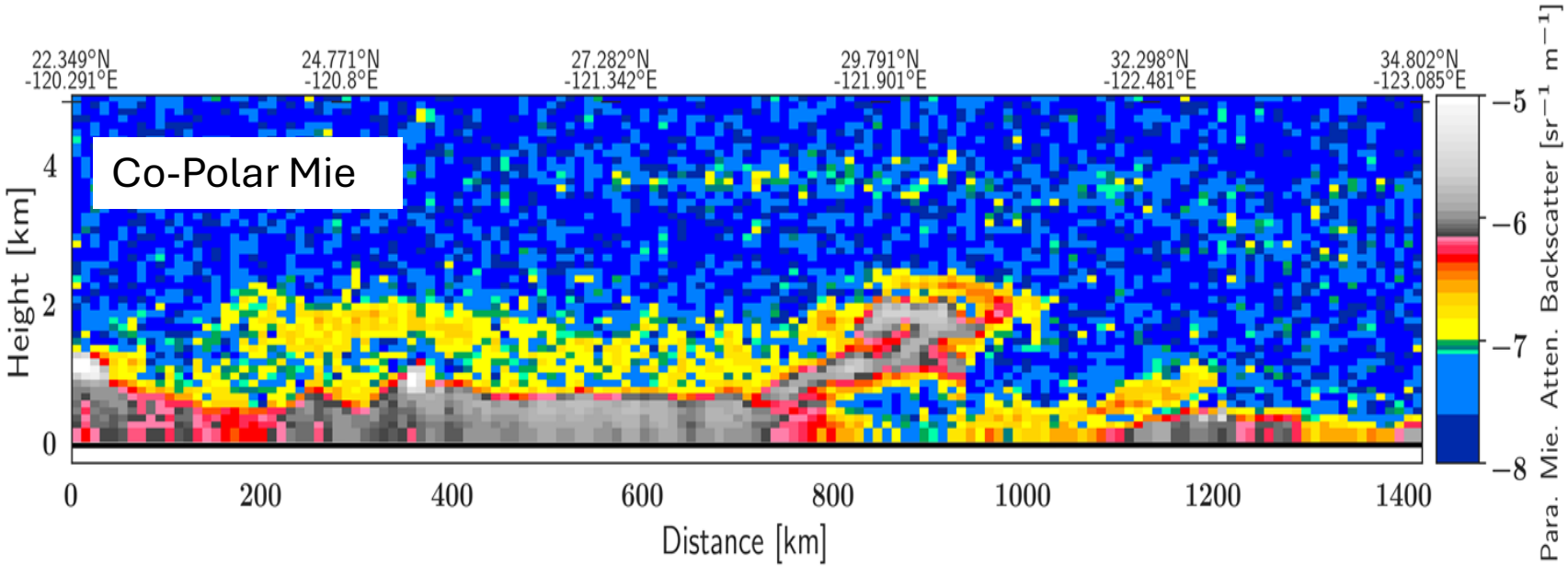
3. 1D & 3D radiative transfer (ACM-RT, ACM-RAD)

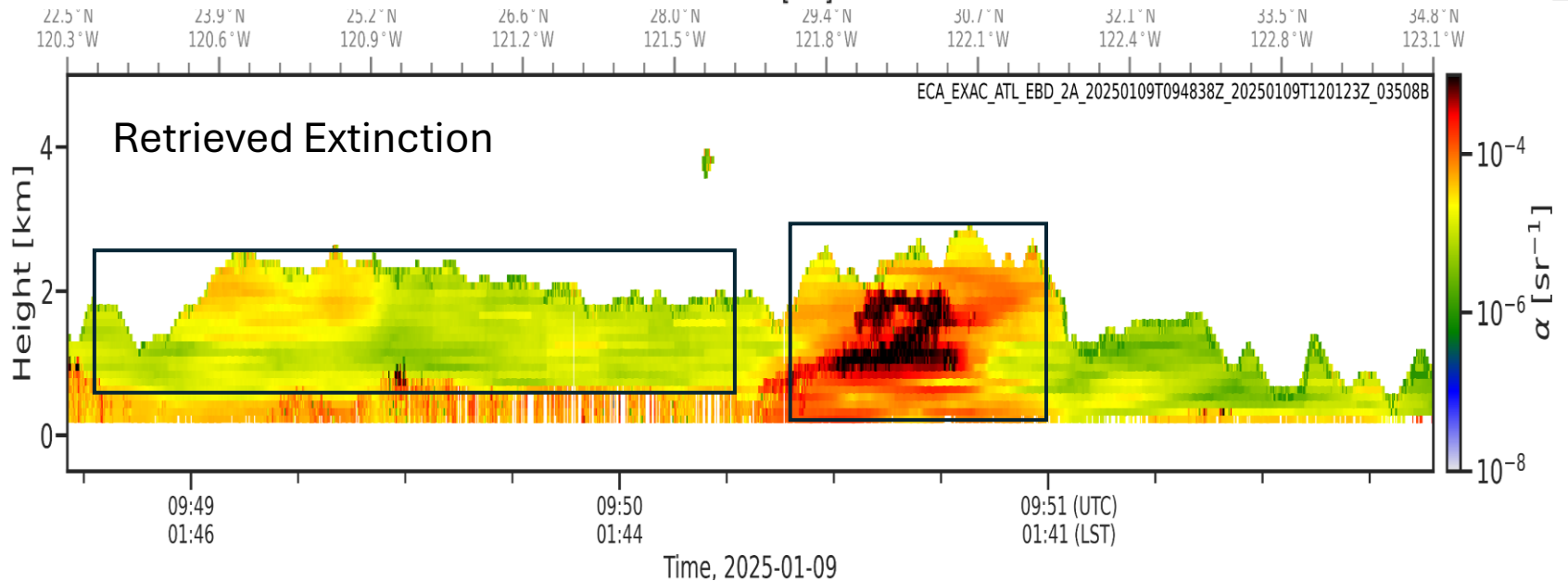
4. Compare to BBR measurements (BMA-FLX): computed, observed

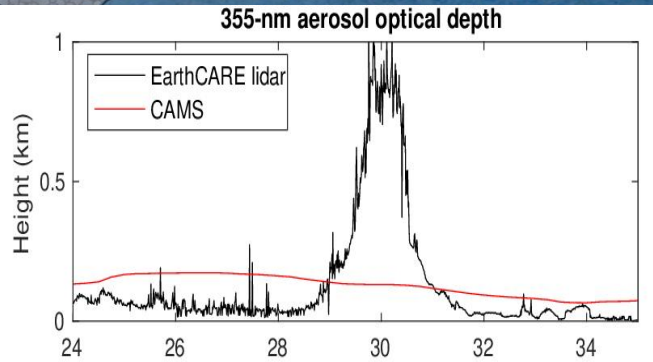
2. Off-track 3D construction (ACM-3D)

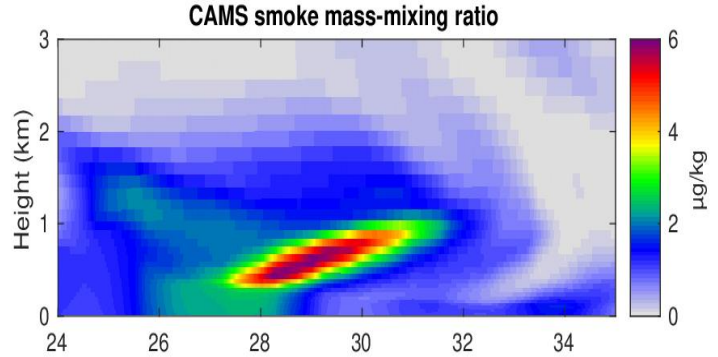
1. Retrieve cloud properties from synergy of radar, lidar & imager (ACM-CAP, ACM-CLP)

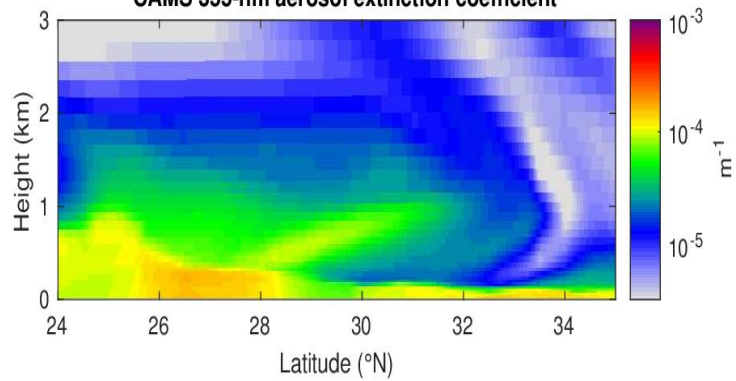
Detecting smoke with the ATLID lidar
California fires: 9 January 2025







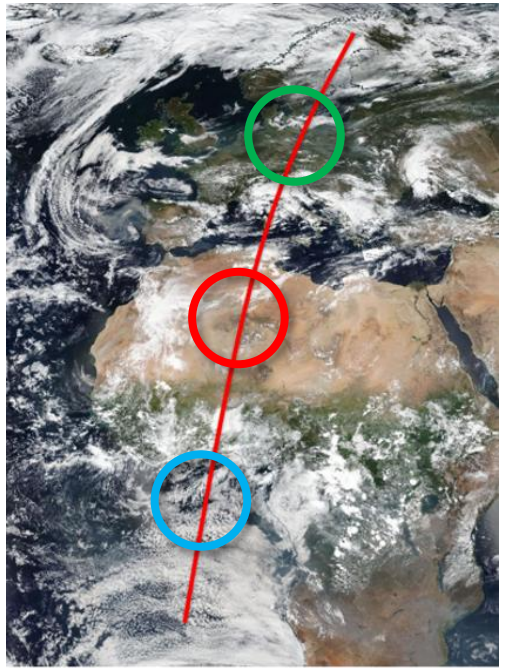


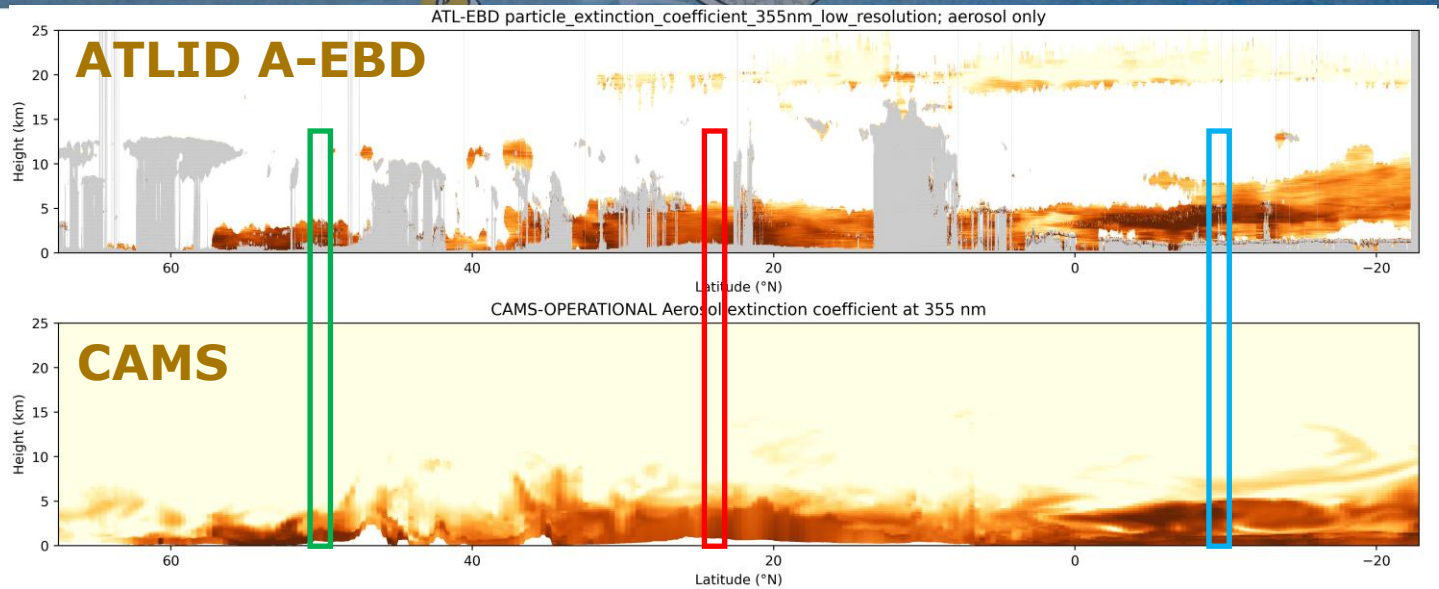


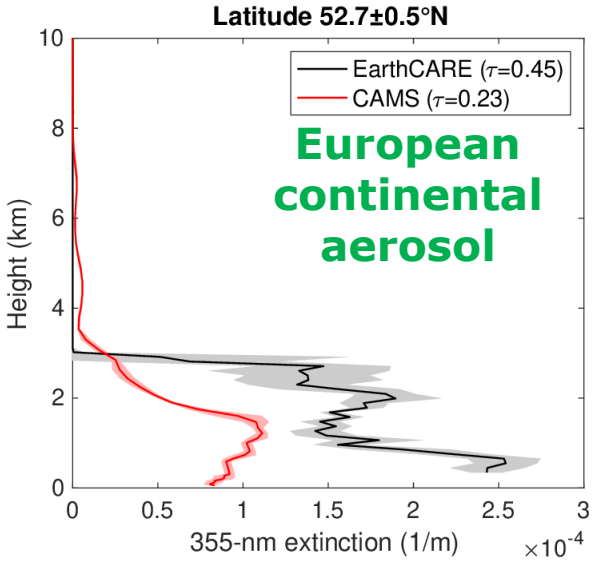
Retrieving and comparing ATLID aerosol properties

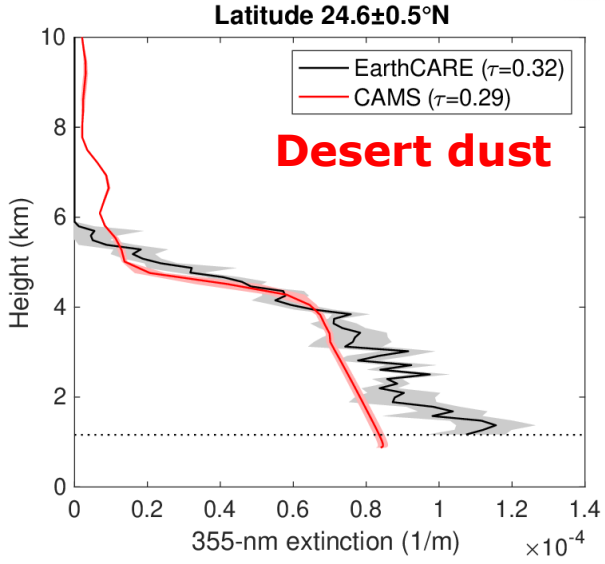
Peter Hill, Robin Hogan, David Donovan

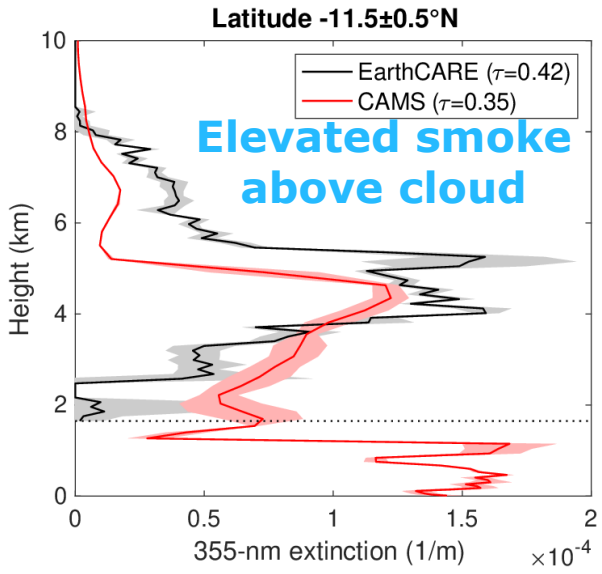
- ATLID retrieves 355-nm extinction coefficient, the classification uses measured depolarization and lidar-ratio (extinction-to-backscatter ratio)
- CAMS: ECMWF's air quality forecast including 15 prognostic aerosol variables
- *"Have never before been able to evaluate aerosol profiles globally with such resolution & accuracy."*



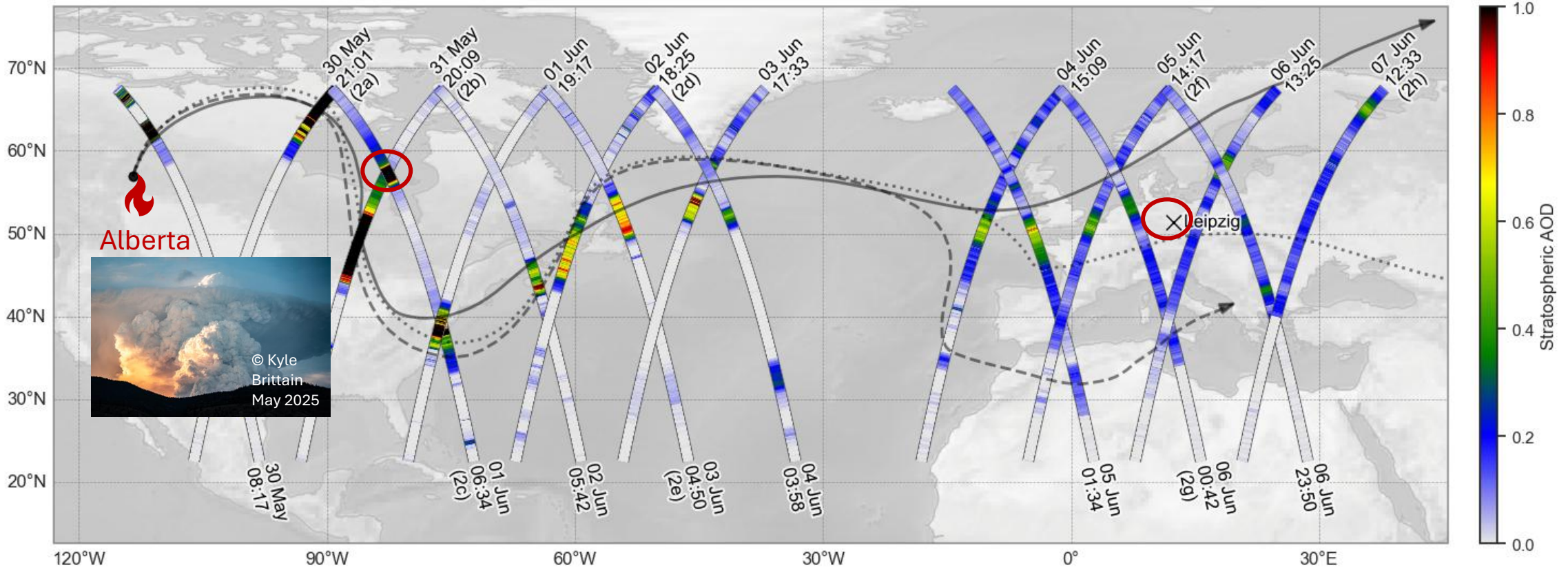








Tracking of the smoke plume towards Europe



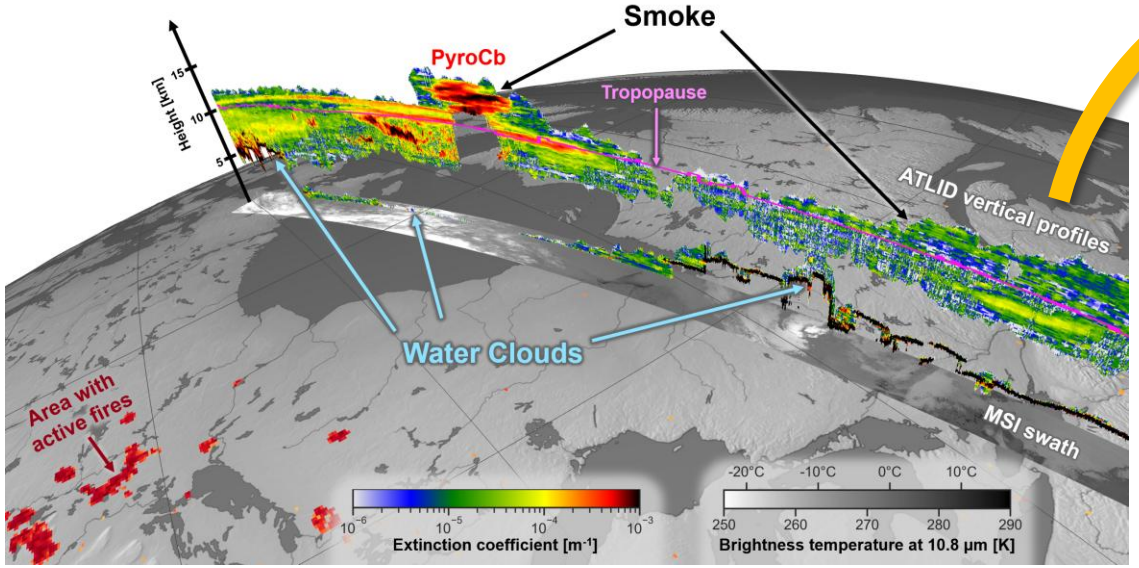
- Intense wildfires in Canada (~28 May ~ 3 June 2025) lead to Pyrocumulonimbus
- Lifting smoke to the Upper Troposphere / Lower Stratosphere (UTLS) ≈ 10 – 12 km height
- Used both HYSPLIT + ATLID to track stratospheric smoke plume
- SAOD up to 3.2 above Canada, decreasing during transport!!

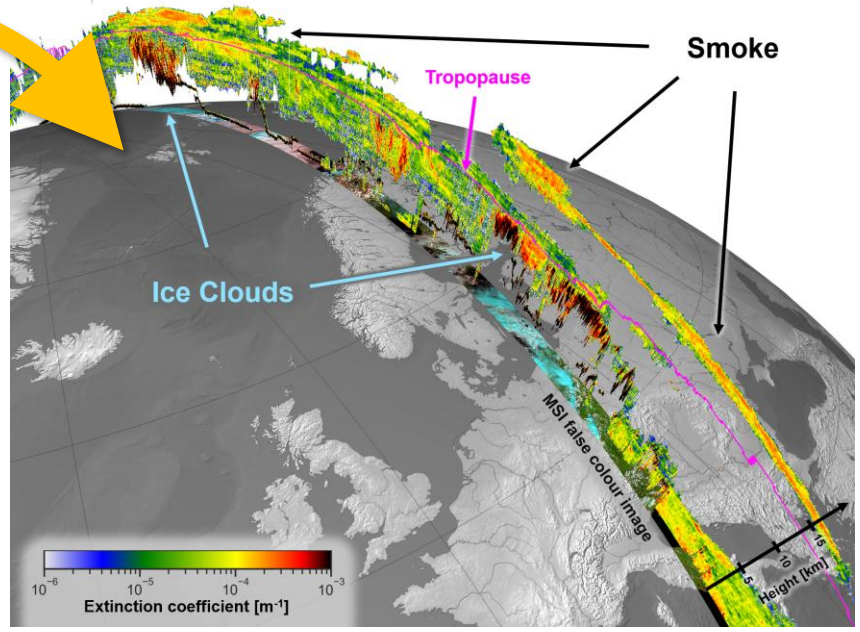
Haarig et al. (GRL 2025)

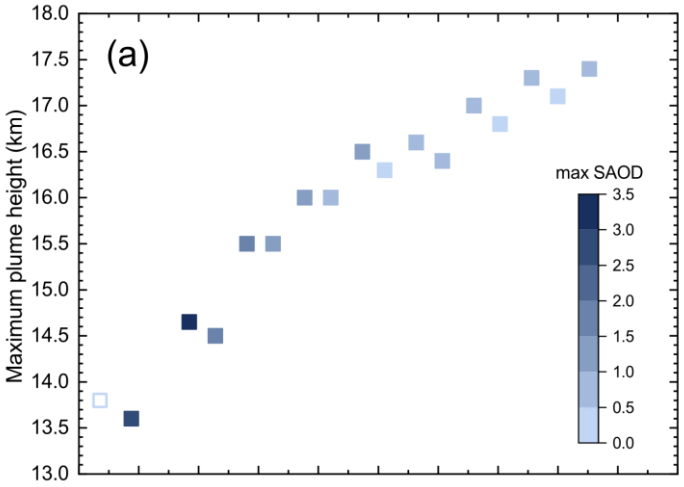
Tracking smoke from Canadian wildfires

Moritz Haarig
(TROPOS)

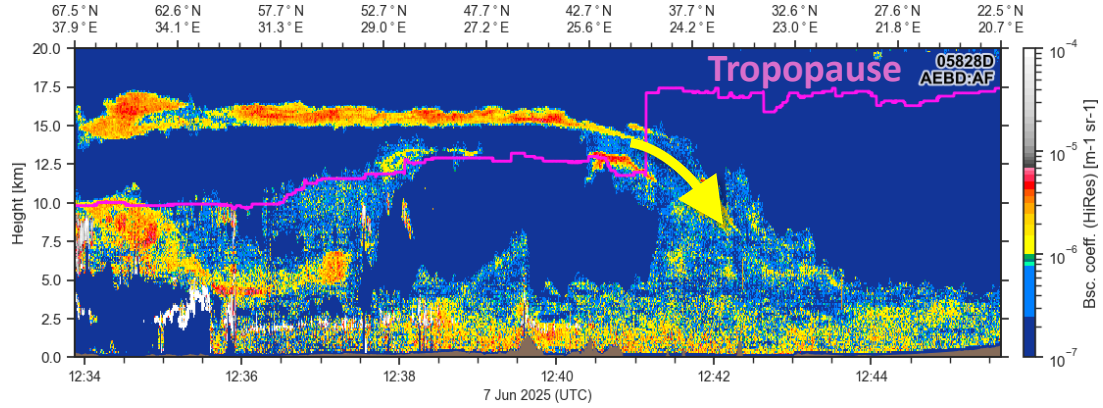
Aerosol carried from Canada (1 June) to Europe (6 June)





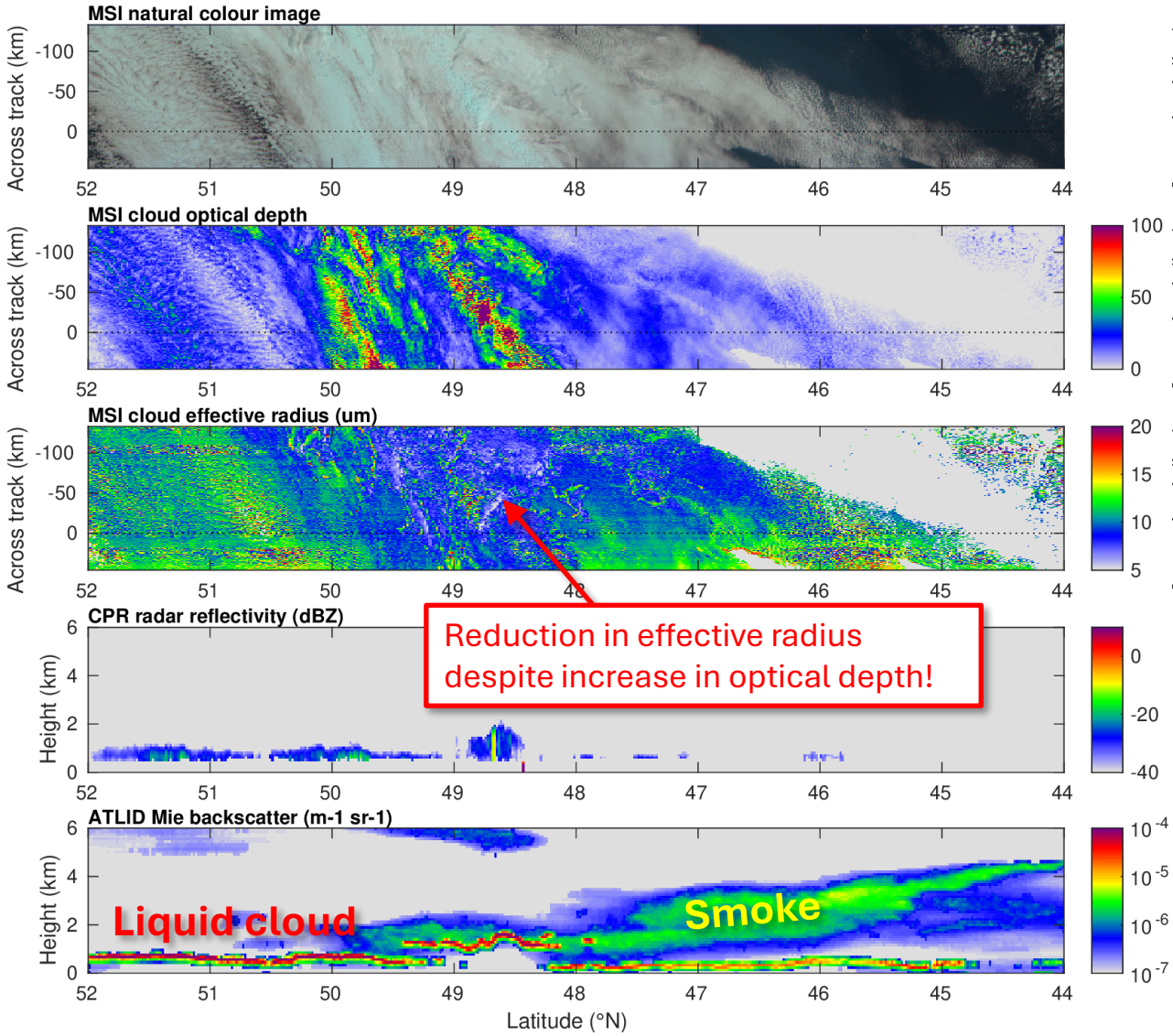


- ATLID revealed that the plume rose 3.6 km in 9 days: 400 m per day (Haarig et al. 2025)
- Smoke lingers above tropopause and mixes back into troposphere by tropopause folds

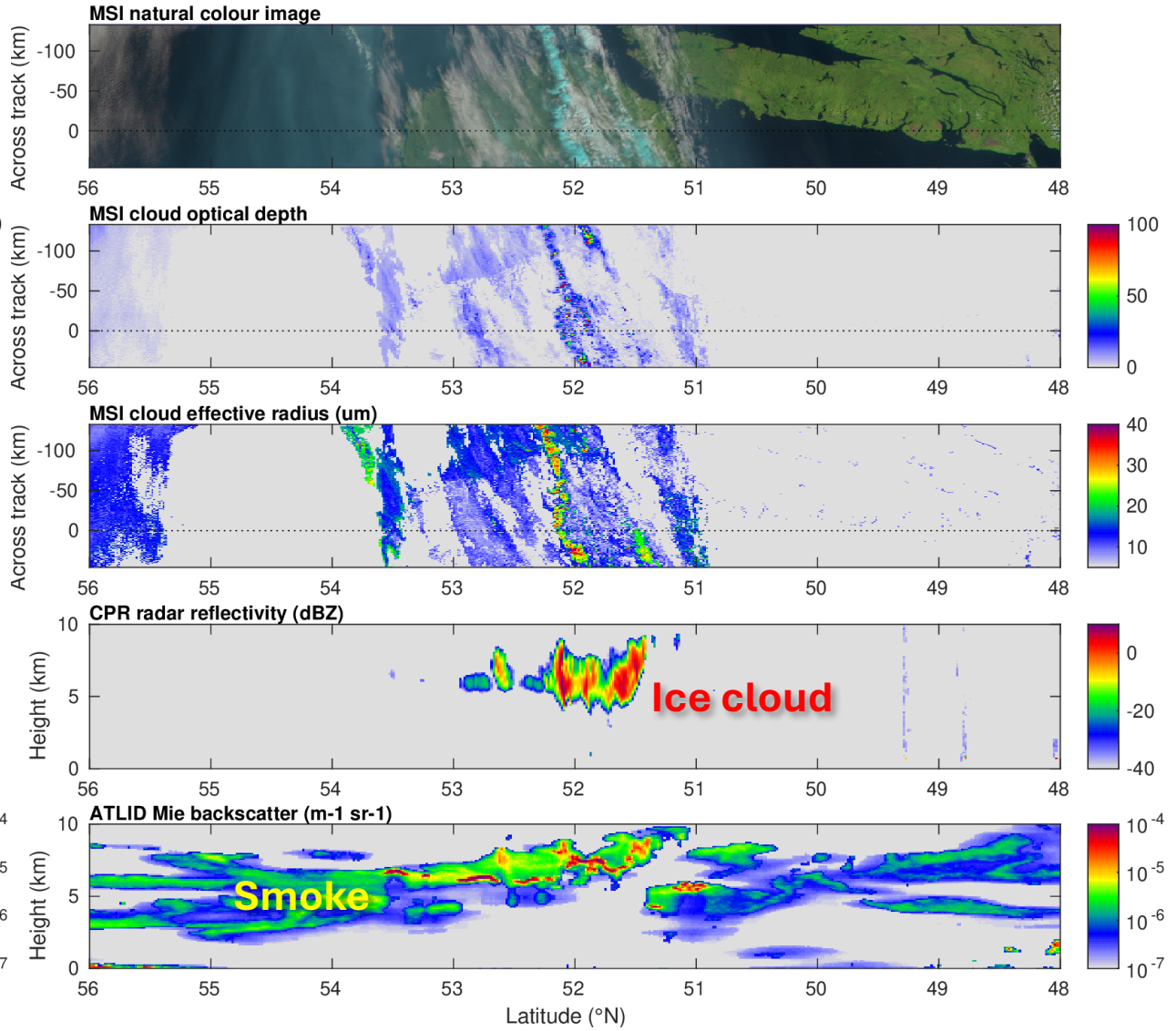


What can EarthCARE tell us about aerosol-cloud interactions, e.g. Canadian smoke August 2024?

01272D: Clear impact of smoke on liquid clouds!



01226D: Is there an impact on ice clouds?



What is the climate impact of Canadian smoke?

npj | clean air

Article

https://doi.org/10.1038/s44407-025-00022-9

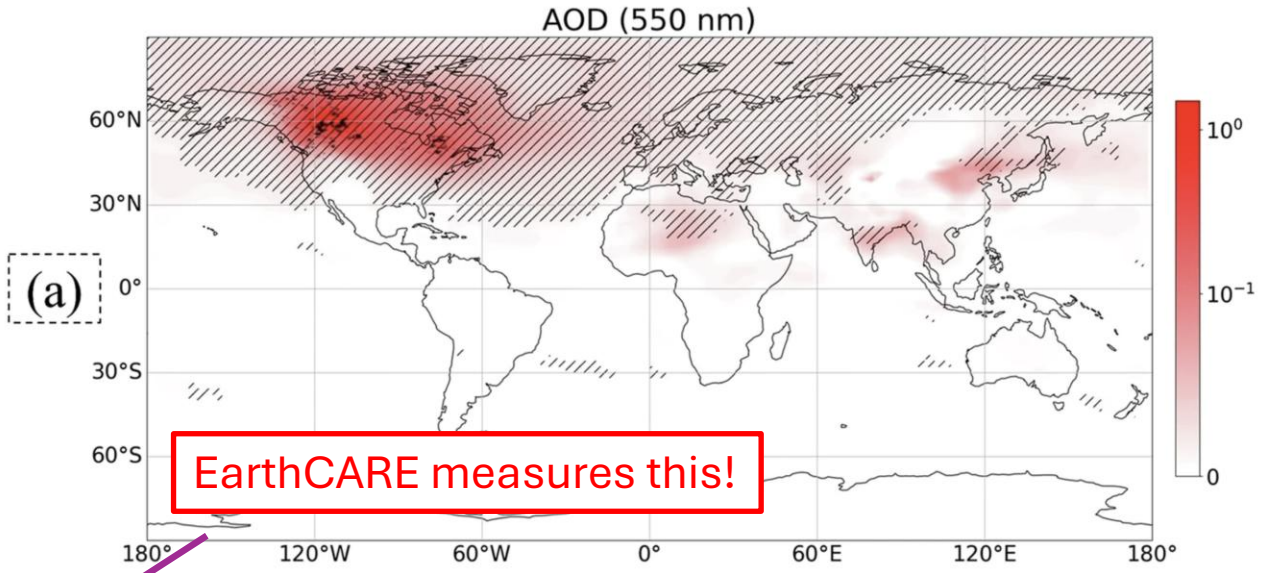
Large-scale impacts of the 2023 Canadian wildfires on the Northern Hemisphere atmosphere

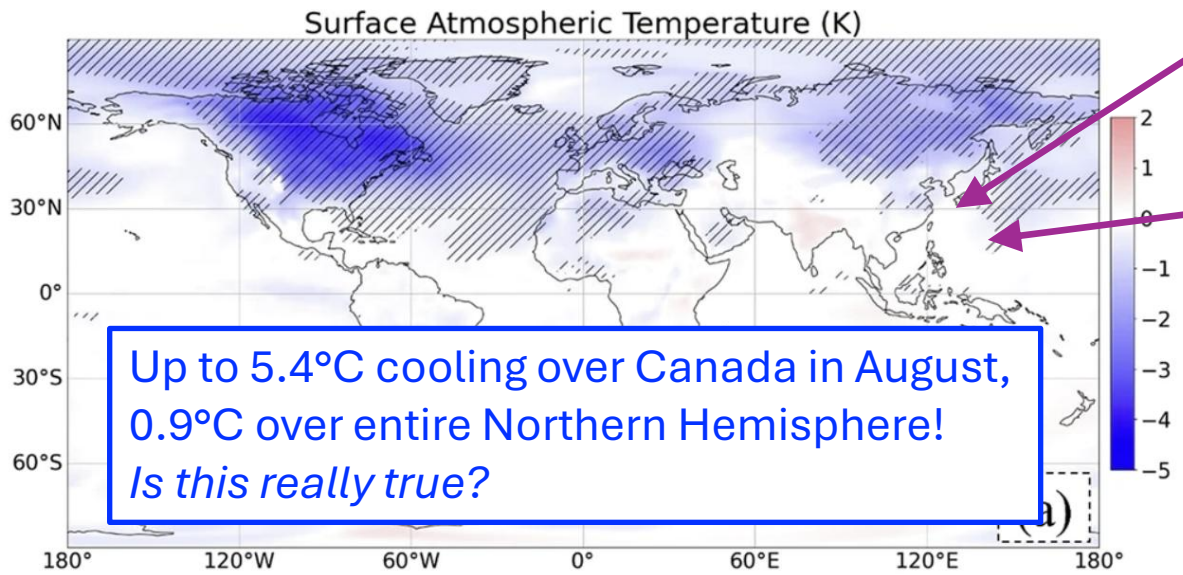
Check for updates

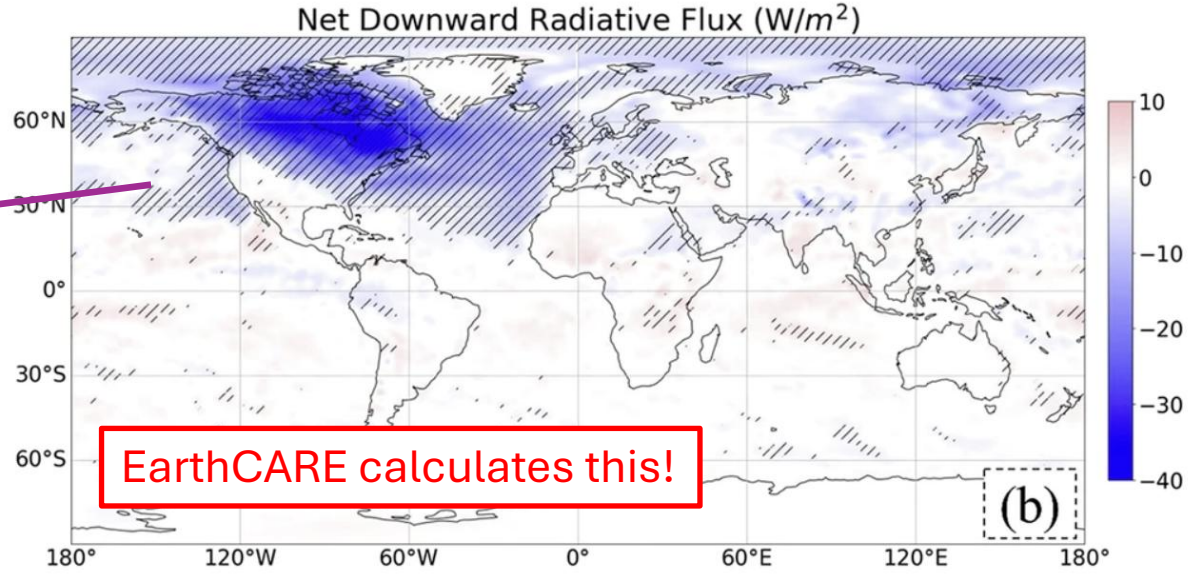
Iulian-Alin Roșu[1,2] ✉, Rafaila-Nikola Mourgela[1,2], Matthew Kasoar[2,3], Eirini Boleti[1,2], Mark Parrington[4] & Apostolos Voulgarakis[1,2,3]

Climate change projections are expected to increase wildfire activity in many world regions in the coming decades because of rising mean temperatures and hydrological changes. This increase is

- Uses MODIS fires, GFAS emissions, EC-Earth simulations







Outlook

- The first years of EarthCARE data has gone extremely well, with all L1 & L2 data publicly available since December 2025.
- EarthCARE lidar ATLID data provides vertical profiles of aerosols and clouds incl. extinction. We type these as, e.g. smoke, using the linear depolarization and lidar ratio.
- The mission has been extended from original 3 years to a minimum of 10 years
- EarthCARE lidar & radar data will be assimilated at ECMWF starting June 2026
- We can use EarthCARE data to:
  - Improve our understanding of **cloud microphysics** (synergy retrievals and Doppler)
  - Improve representation of **radiative effects of clouds in models** (radiative closure) incl. profiles of heating/cooling rates
  - Understand the dynamics of **convective clouds** (Doppler)
  - Improve **aerosol models** for air-quality forecasts & climate (HSRL extinction retrievals)
  - Get the greatest impact on forecasts through **data assimilation** (near real time)
  - Pin down **cloud-aerosol interactions** (synergy)
  - Narrow uncertainty in **cloud feedbacks** (trends from a long mission)
- Visit www.earthcarescience.net & https://earth.esa.int/eogateway/missions/earthcare for further information