

Atmospheric Aerosol Characterization with SPEXone: Data Products and Applications

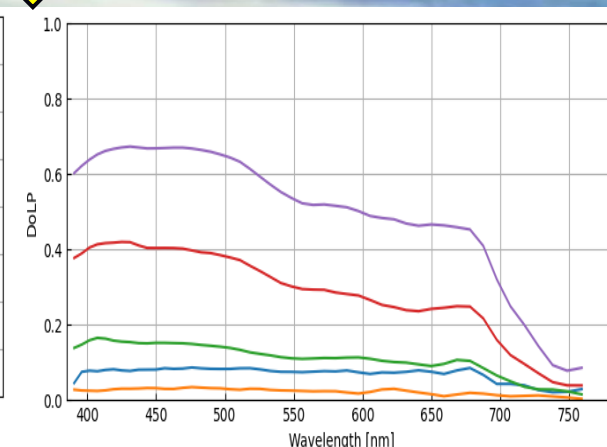
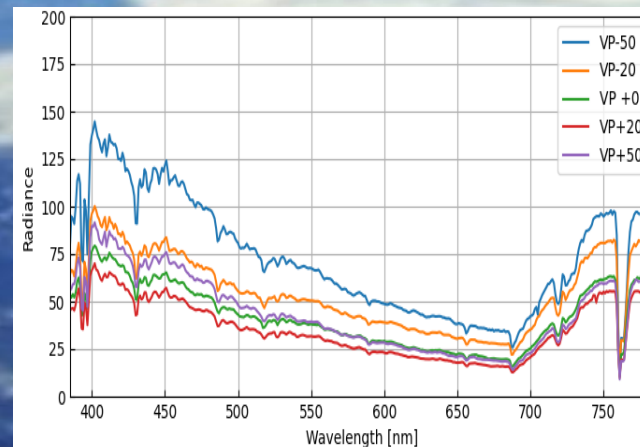
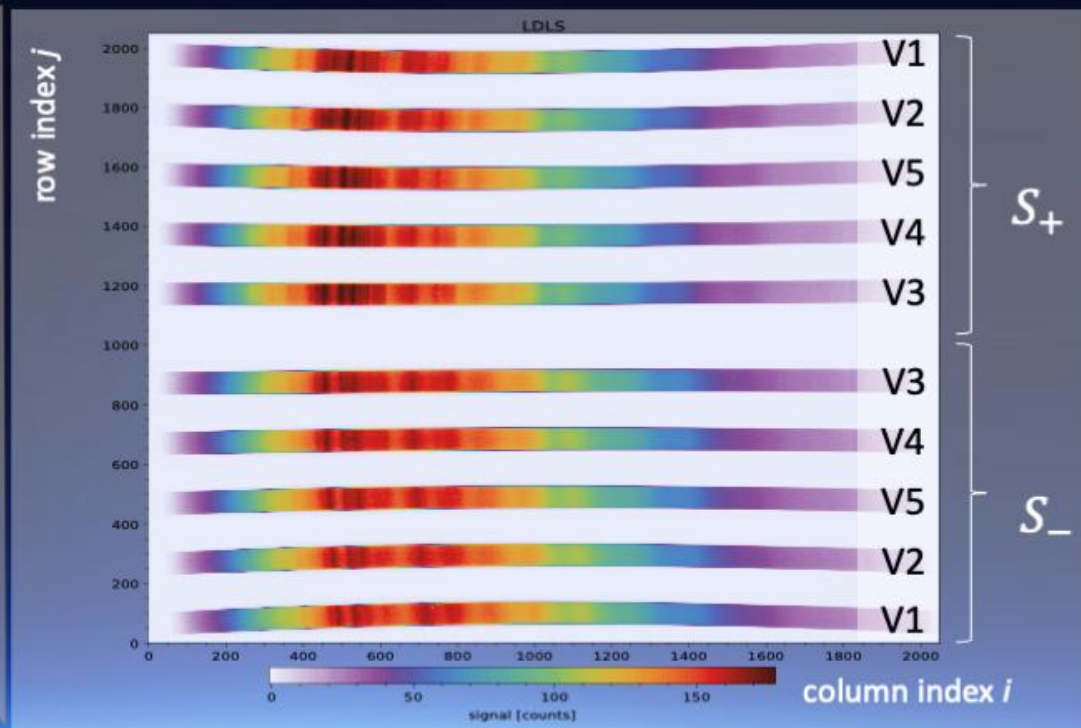
Otto Hasekamp on behalf of the SPEXone Team

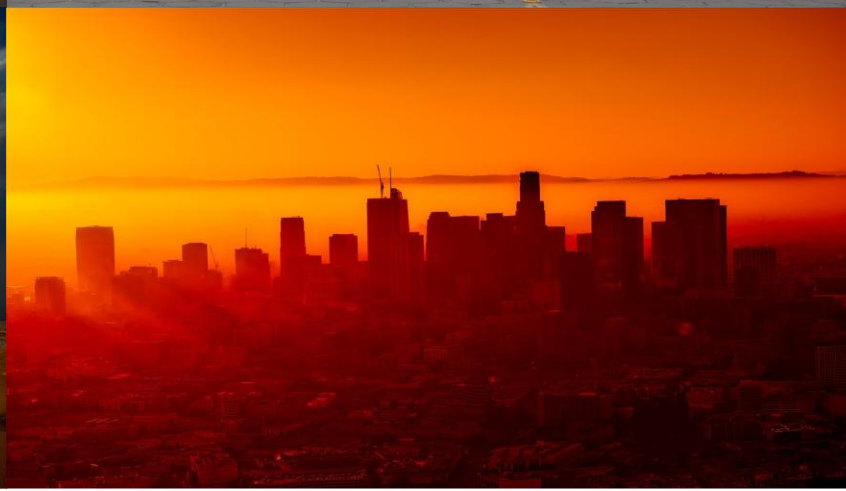
SRON

SPACE
RESEARCH
ORGANISATION
NETHERLANDS

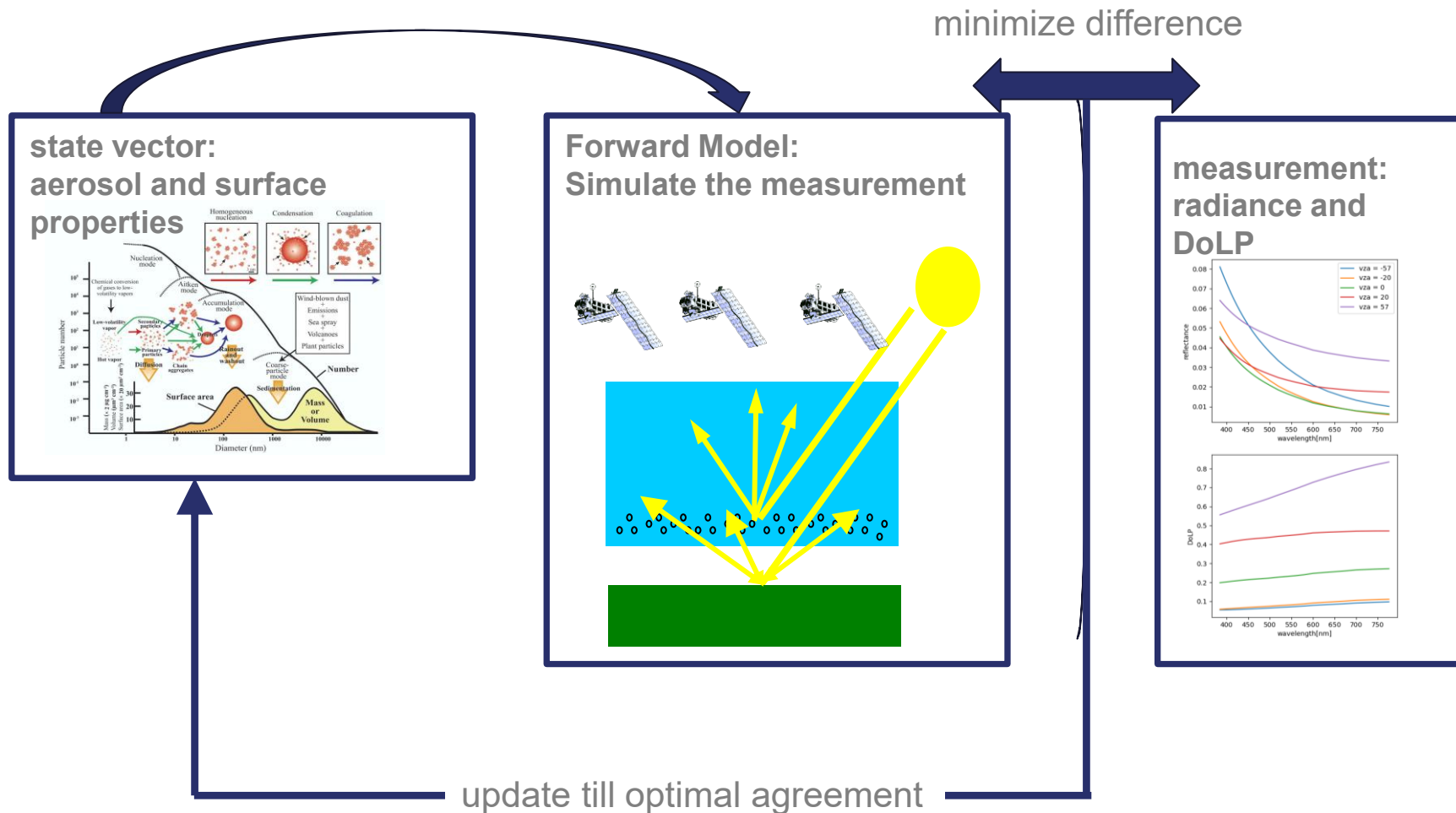
Parameter	Specification
Spatial resolution	5X5 km ²
Swath	100 km
Spectral resolution (radiance)	400 bands, 2nm FWHM
Spectral resolution (polarization)	50 bands 10-30 nm FWHM
Accuracy	2% (radiometric), 0.003 (polarimetric)

Launched:
February 2024





Retrieving Aerosol Properties: The RemoTAP algorithm



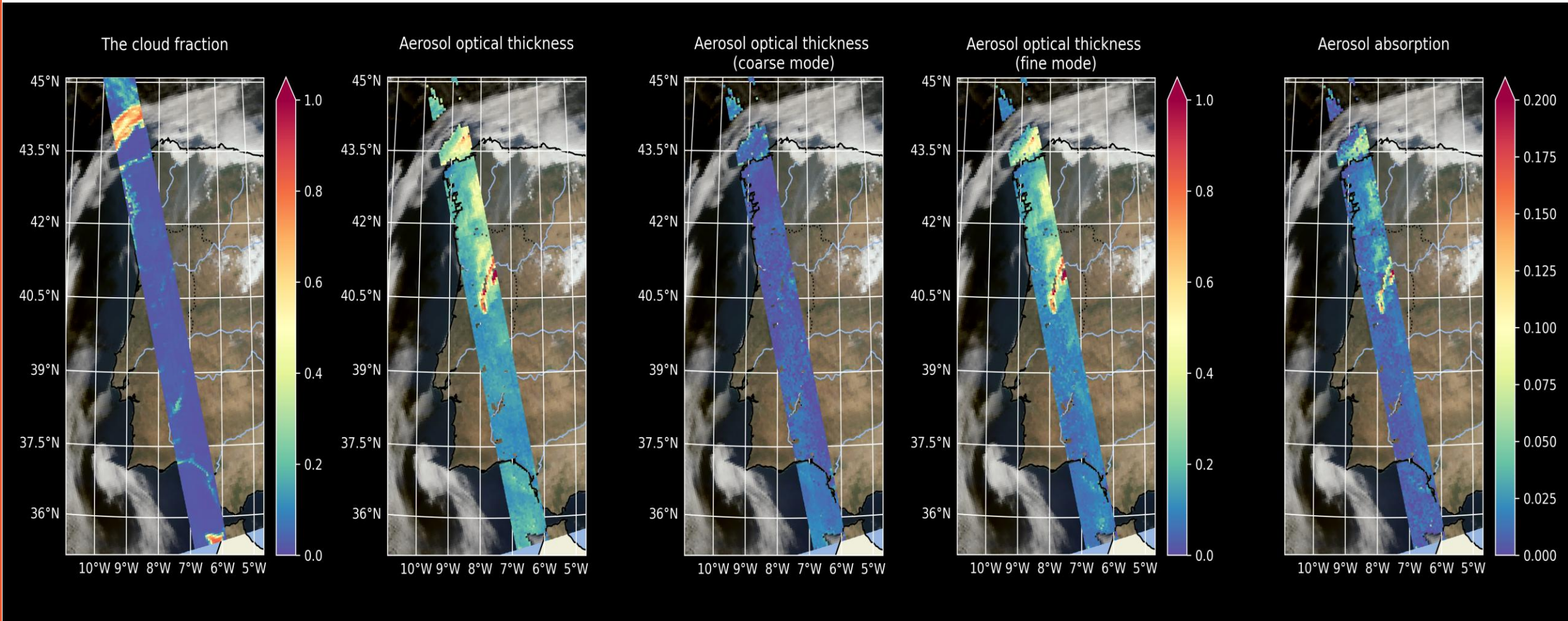
References:

Fu et al, GRL, 2025
Hasekamp et al., AMT, 2024
Lu et al., Frontiers Rem. Sens., 2022
Fu et al., AMT, 2018; 2022
Fan et al., Rem. Sens., 2019
Hasekamp et al., JGR, 2011

RemoTAP: REMOte sensing of Trace gas and Aerosol Products

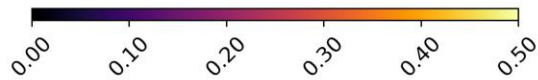
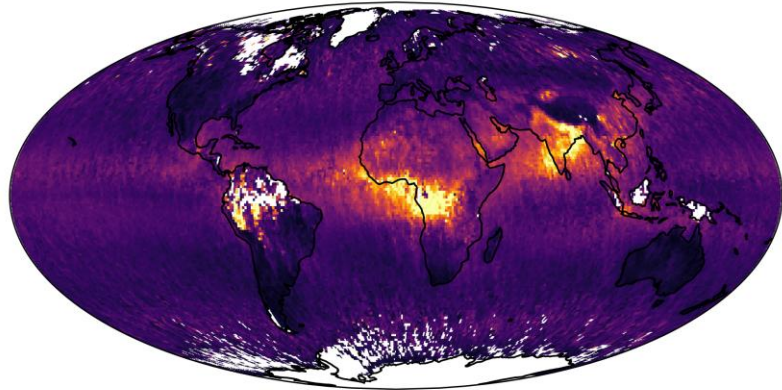
Products: optical properties, size distribution, chemical composition

Fires over Portugal (August 2025)

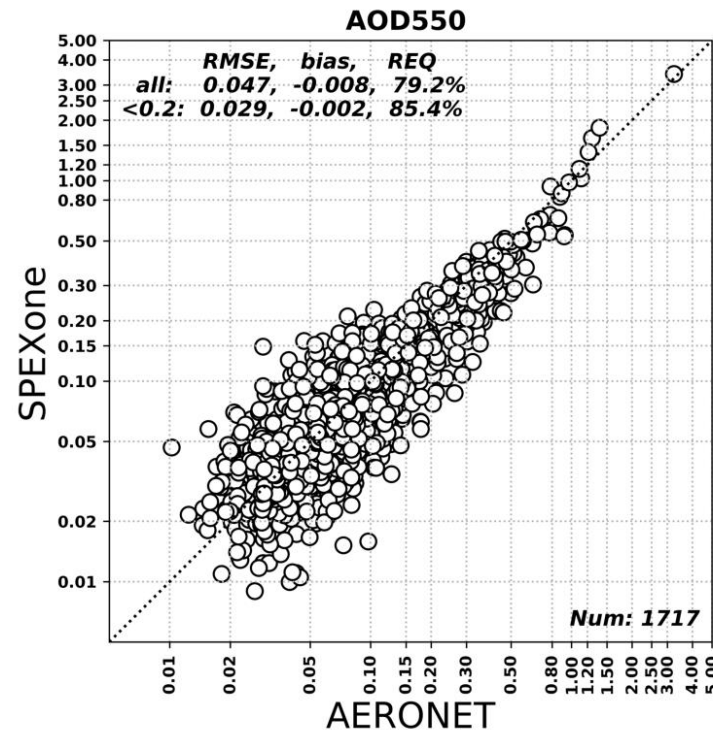
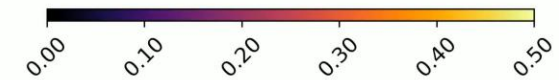
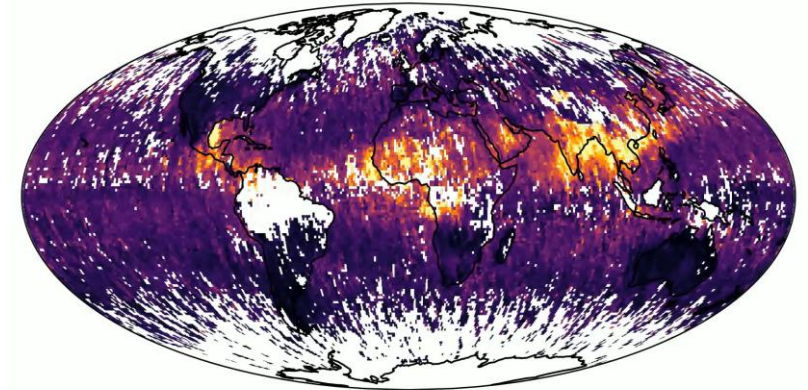


Two Years of Aerosol Optical Depth (AOD)

aot_two-year_march2024_feb2026



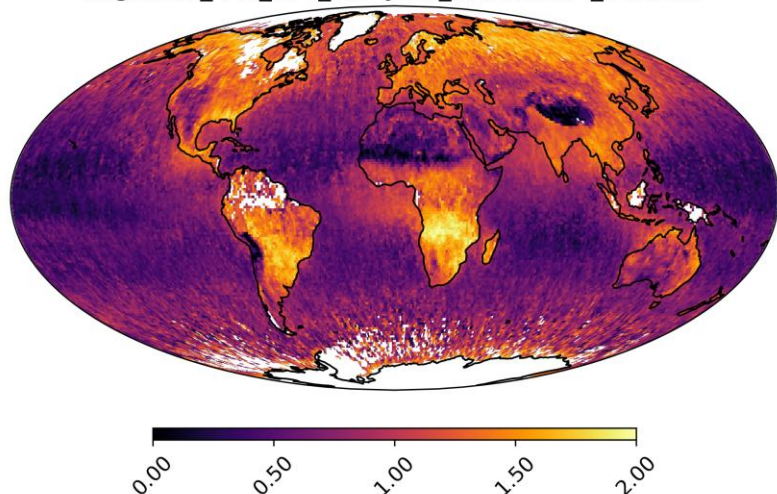
aot_april2024



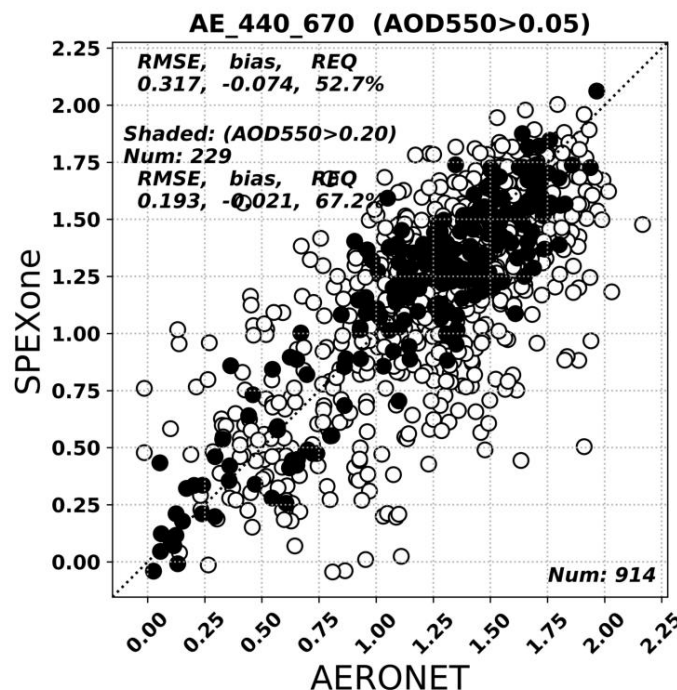
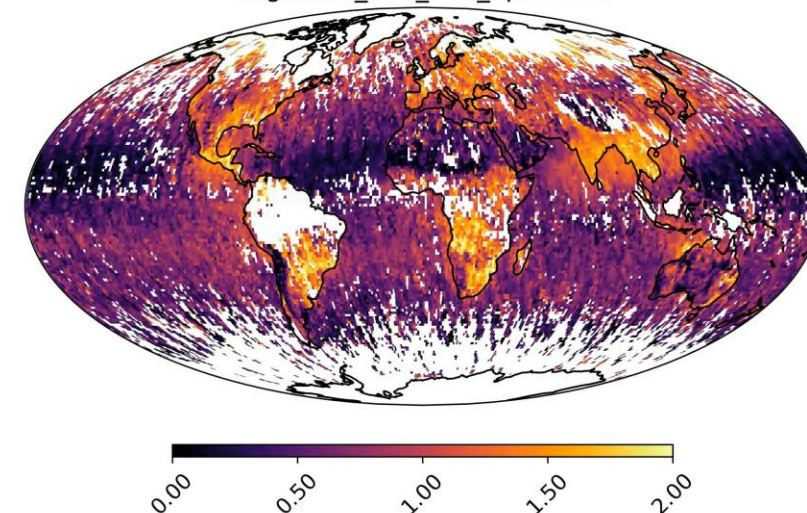
- Largest overall AOD for biomass burning and Ganges valley, followed by Dust and industrial pollution.
- Much stronger Amazon fire in 2024 than 2025
- Unprecedented agreement with AERONET

Two Years of Angstrom Exponent (Size)

angstrom_440_670_two-year_march2024_feb2026



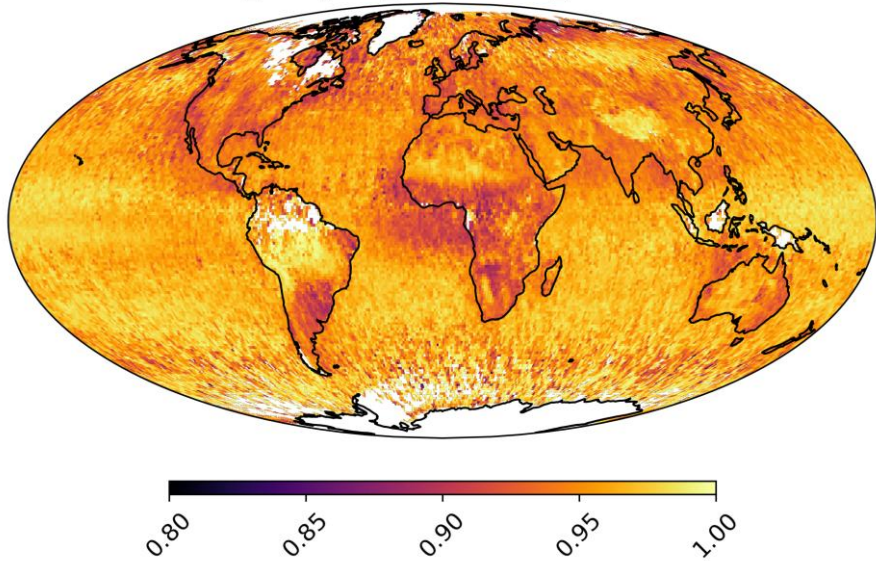
angstrom_440_670_april2024



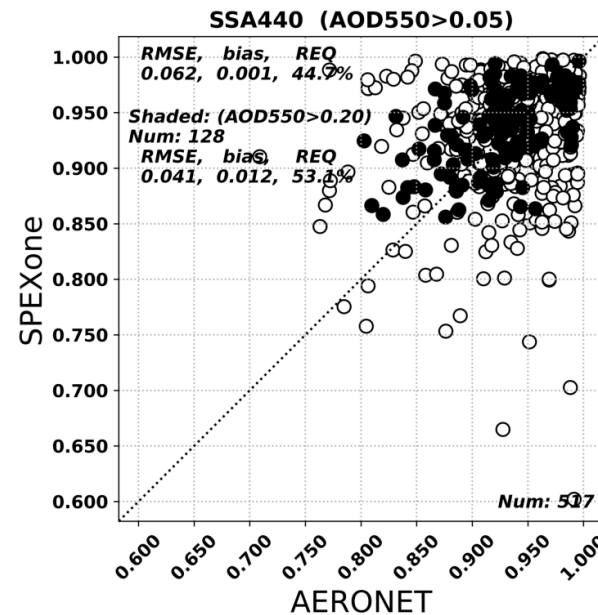
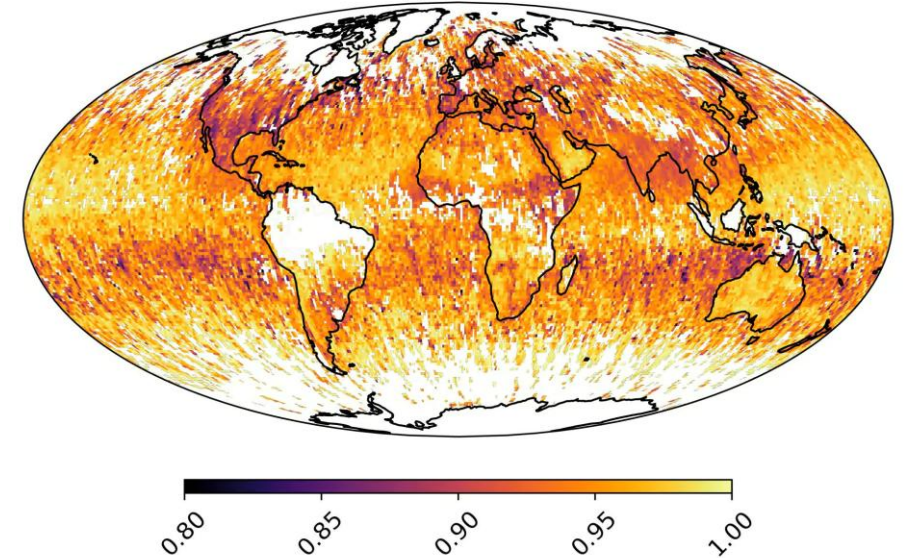
- Smallest particles (large Angstrom Exp) for smoke – with clear seasonal pattern on each hemisphere. Outflow affect oceans globally
- Small particles over southern ocean in Austral Spring and Summer.
- Unprecedented agreement with AERONET

Two years of Single Scattering Albedo (absorption)

ssa_two-year_march2024_feb2026



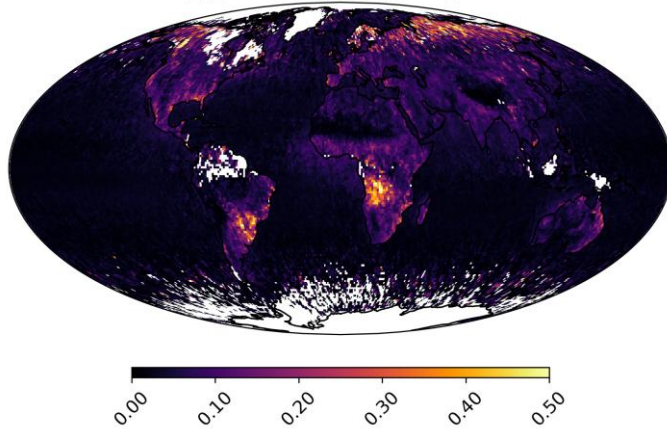
ssa_april2024



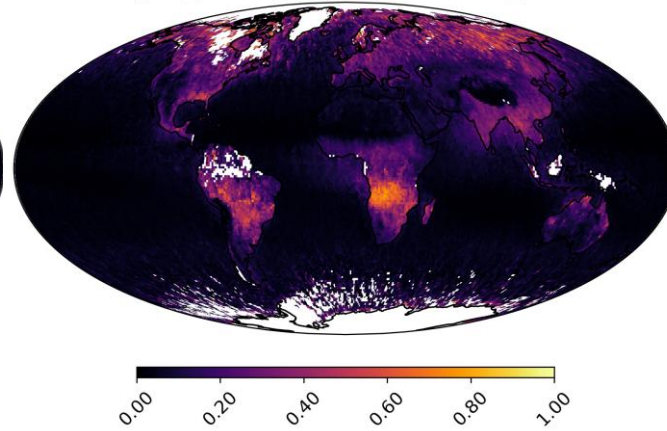
- Strongest absorption for African smoke. Amazon smoke less absorbing
- Outflow affects absorption over ocean globally
- Reaching limits of AERONET accuracy

Aerosol Chemical Composition (Volume Fractions)

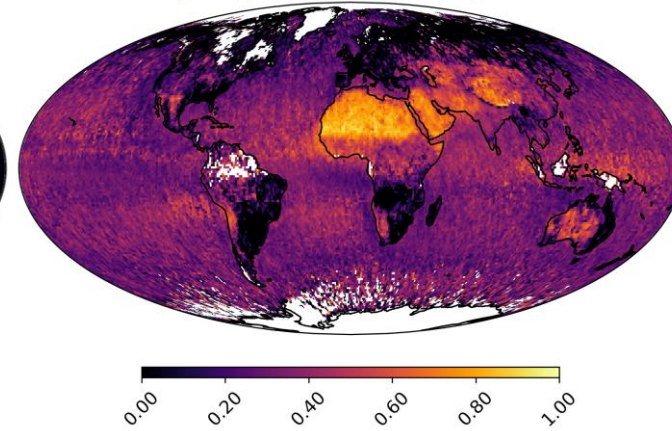
Black+ Brown Carbon



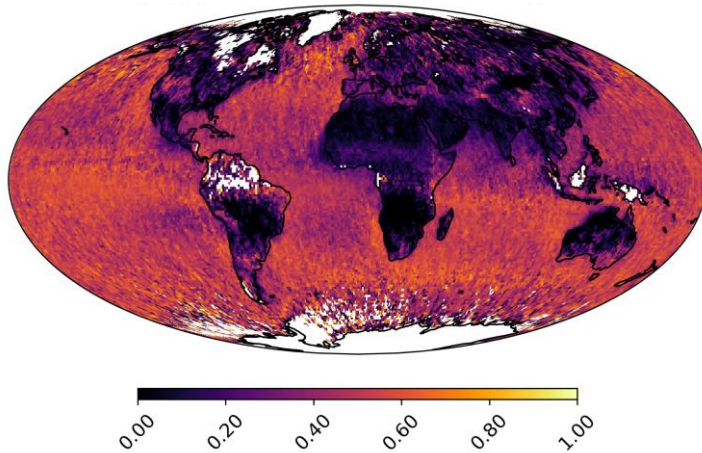
fine secondary aerosol



Dust



Hydrated Sea Salt

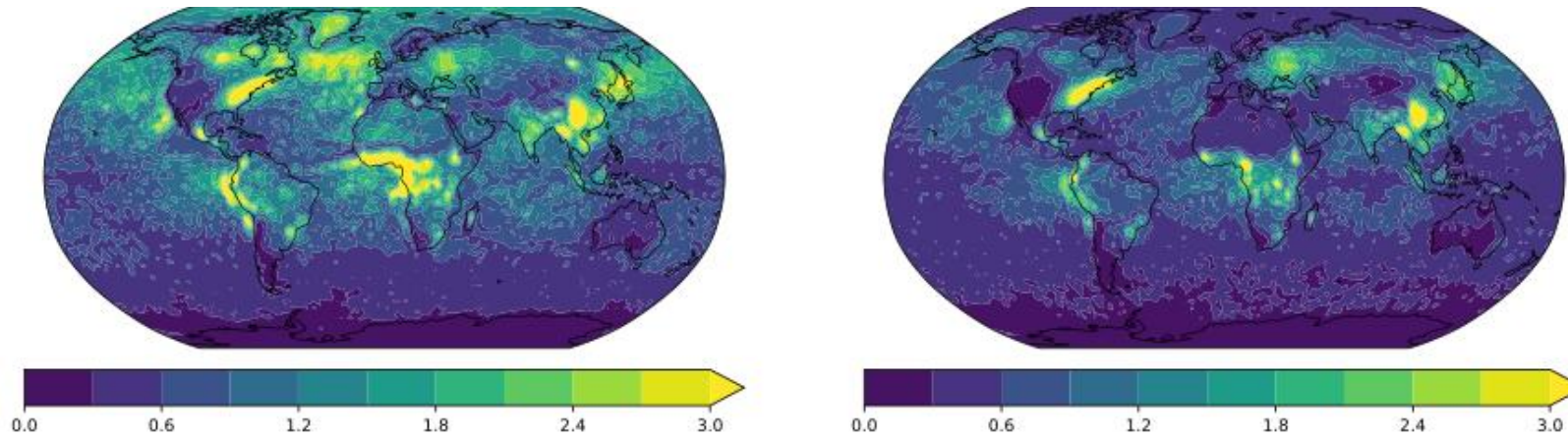


- Black and Brown Carbon over equatorial Africa, Patagonia, Boreal regions (smoke)
- Fine secondary aerosol over industrial regions and biomass burning
- Dust dominated close to desert (Sahara, Namibia, Gobi, Australia) and outflow
- Sea salt over the ocean

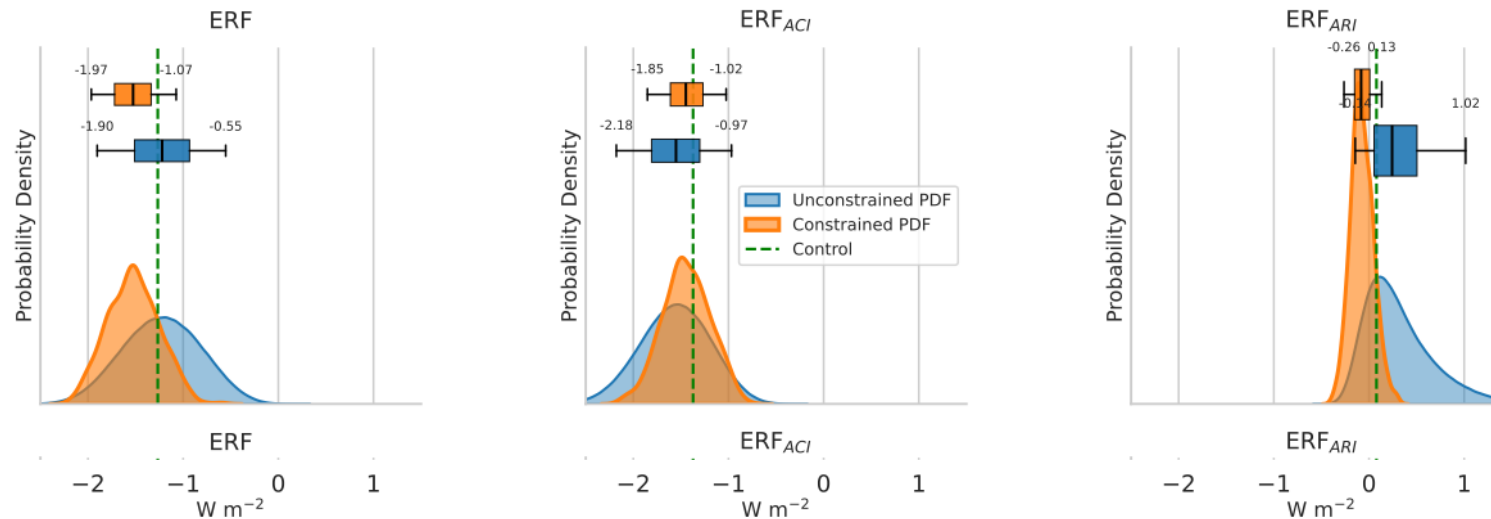
Constraining Aerosol Climate Model Simulations (ECHAM-HAM) using PACE and Earthcare



aerosol Effective Radiative Forcing (ERF) uncertainty
before constraint after constraint



- Using ATLID (Earthcare) vertical profile information (fraction of extinction < 2 km).
- Using PACE aerosol amount, size, absorption (SPeXone) and CDNC (OCI).
- ATLID provides unique constraint on aerosol processes (e.g. Sulfate chemistry, wet deposition)



Preliminary maps of PM_{2.5} from space (SPeXone)

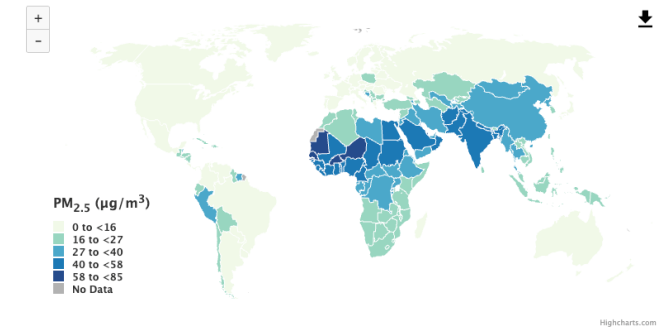
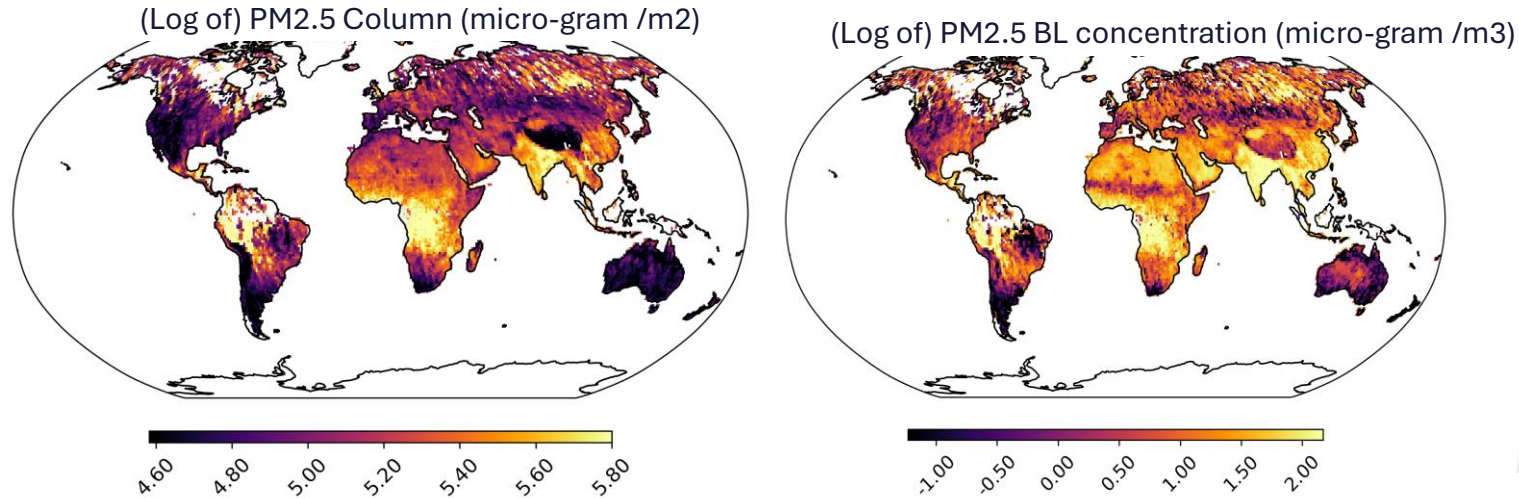


Figure B. Population-weighted annual average PM_{2.5} concentrations in 2019. Hover or tap to explore the data.

- PM_{2.5} Mass concentration aerosols with a dry diameter < 2.5 micron. For AQ purpose, concentration in planetary boundary layer (PBL is relevant).
- Can be computed from size distribution, component fractions (including water), and aerosol layer height (ALH).
- There are many caveats (ALH uncertainty, assumptions on components, etc) but there is clear potential (much more information than from previous satellites)

STATE OF GLOBAL AIR

Pollution and Its Sources ▾ Health Impacts of Air Pollution ▾ Explore the Data ▾ Reports and Resources ▾

PM_{2.5} Exposure

Fine-particle outdoor air pollution remains high across much of the world.

Typical ranges PM_{2.5} surface concentration:

- **Clean background / remote regions:**
~1–5 µg/m³
- **Rural / suburban areas:**
~5–15 µg/m³
- **Urban background in developed countries:**
~10–30 µg/m³
- **Highly polluted urban/industrial regions:**
50–200+ µg/m³
- **Extreme episodes (wildfires, dust storms):**
can exceed 500 µg/m³ locally.

Take-Home Messages

- SPEXone provides novel and/or improved information about aerosol: **Amount** (Aerosol Optical Depth), **Size** (angstrom Exponent, fine mode fraction, effective radius), **absorption** (Single Scattering Albedo) and **composition** (Brown/black Carbon, Secondary aerosol, Dust, Sea Salt).
- Data have shown important value for data assimilation (emissions), climate model calibration, process studies and have potential for air quality applications (PM2.5)

Data Links

SPEXone L2:

NASA: <https://search.earthdata.nasa.gov/search?q=10.5067/PACE/SPEXone/L2>

SRON: <https://public.spider.surfsara.nl/project/spexone/RemoTAP-SPEXone/> (includes 'soft' radiometric calibration)

SPEXone L3 (GRIDDED):

NASA: <https://search.earthdata.nasa.gov/search?q=10.5067/PACE/SPEXone/L3>

SRON: <https://public.spider.surfsara.nl/project/spexone/RemoTAP-SPEXone-GRIDDED/>