Synergy of remote sensing within ACTRIS

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Synergy of remote sensing within ACTRIS

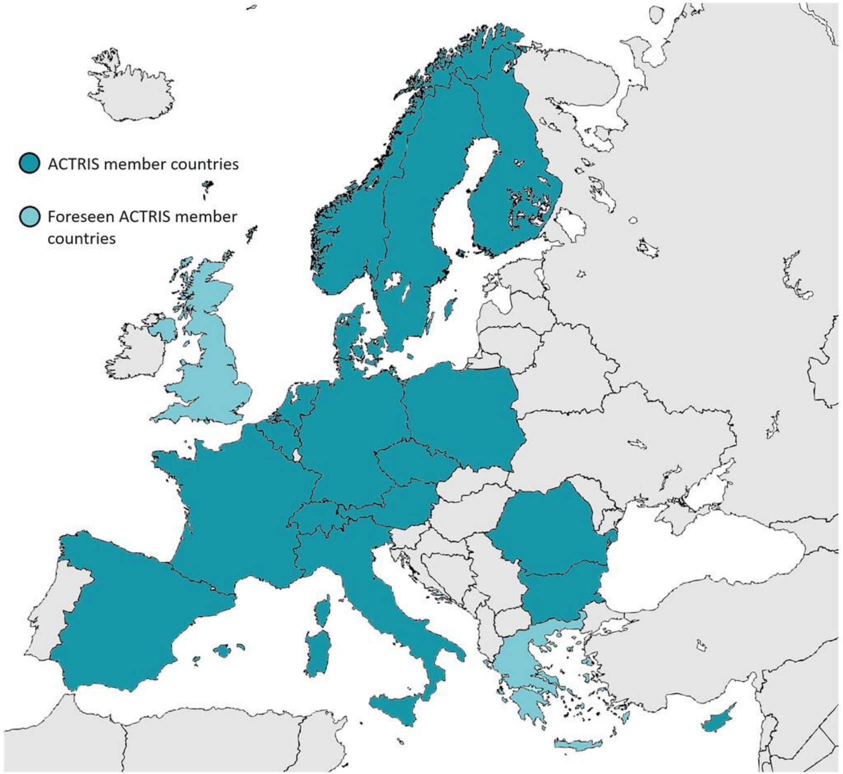
aerosols, clouds, trace gases

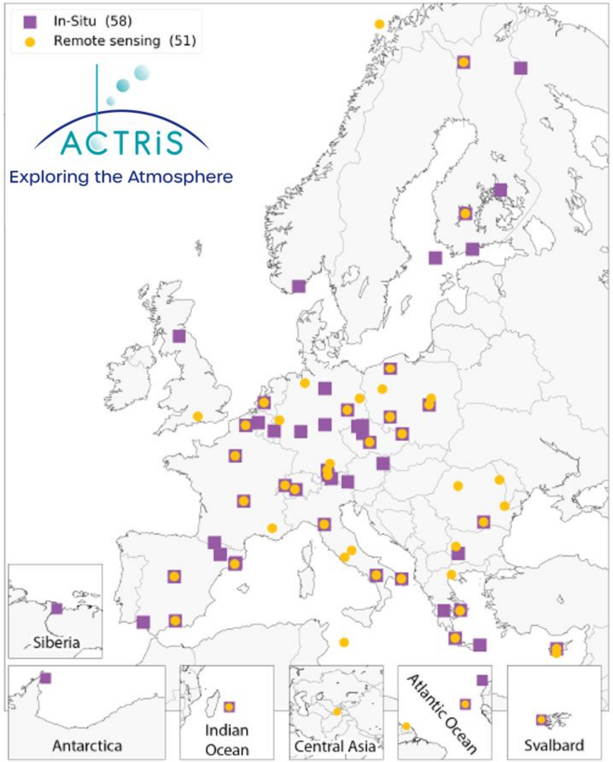
instruments overview

spectrometers, photometers, lidars

networks: PGN, AERONET, EARLINET

ACTRIS – The Aerosol, Clouds and Trace Gases Research Infrastructure

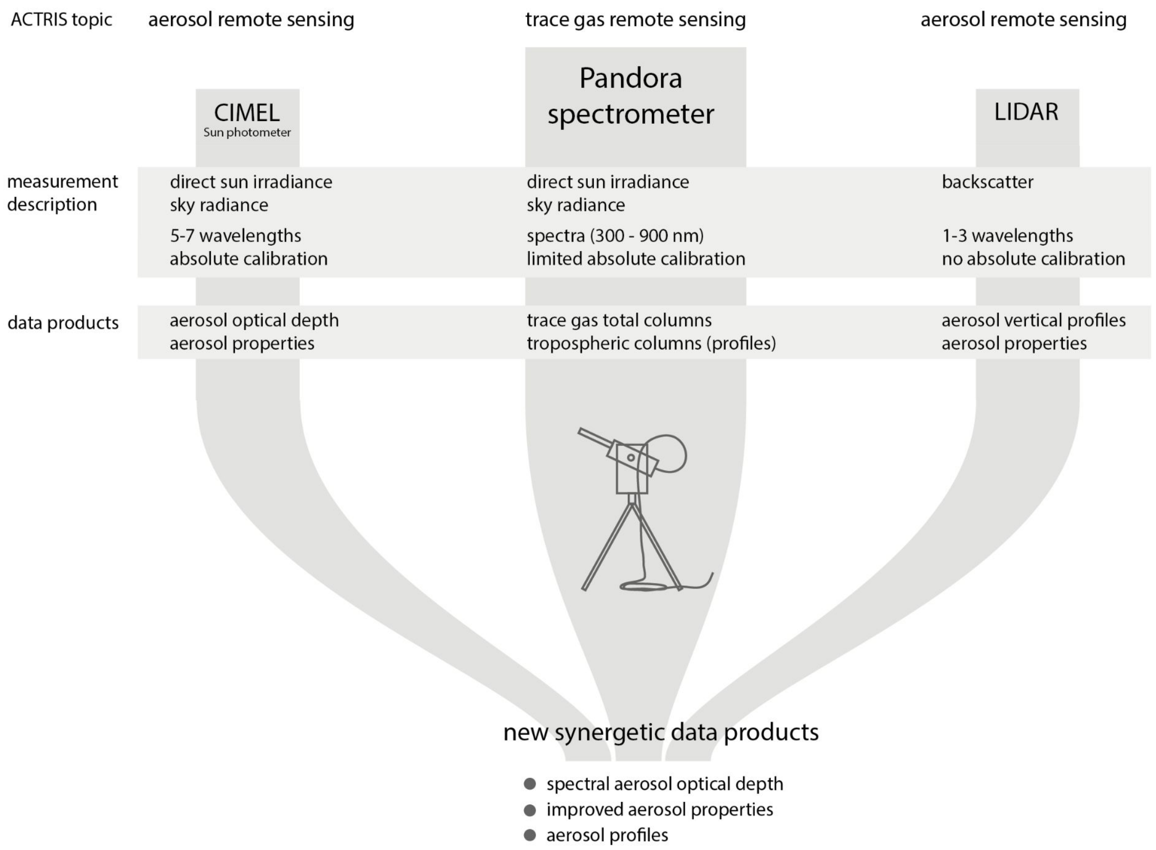




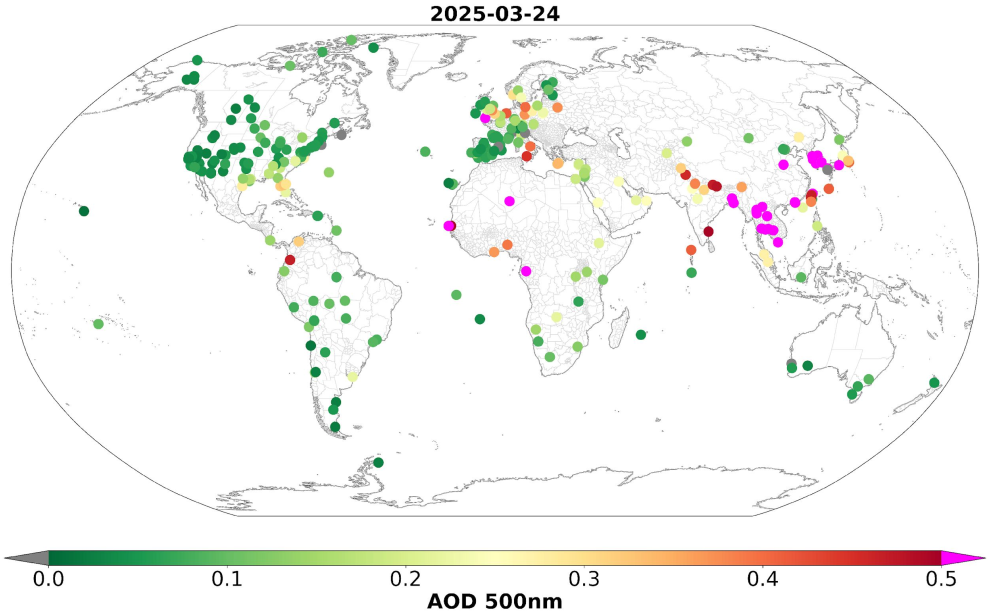
AEROPAN project:
Synergetic aerosol remote sensing of Pandora within ACTRIS

Collaboration between
Medical University Innsbruck and
University of Warsaw

AEROPAN overview



Cimel Spectrometer & Aeronet Network



Aerosol products

Aerosol Product	Description
Aerosol Optical Depth (AOD)	Spectral measurement of light extinction by aerosols at each wavelength (380–1640 nm)
Angstrom Exponent (α)	Parameter derived from the wavelength dependence of AOD, indicating the dominant particle size
Fine Mode Fraction (FMF)	The proportion of the total AOD attributable to fine (submicron) aerosol particles
Aerosol Volume Size Distribution	Inversion-derived distribution of aerosol particle sizes, separating fine and coarse modes
Effective Radius	The average aerosol particle size, obtained through inversion algorithms using the full spectral dataset
Complex Refractive Index	Both real and imaginary components, crucial for characterizing aerosol scattering and absorption properties
Single Scattering Albedo (SSA)	The ratio of scattering to total extinction, essential for estimating aerosol radiative effects

PollyXT Lidar products

- **3 β** (backscattering coefficient)
- **2 α** (extinction coefficient)
- **2 δ** (depolarization ratio)
- **wv** (water vapour mixing ratio)

- **lidar ratio**
- **Angström exponent**
- **AOD**

δ – depolarization ratio as a selection criterion for the spherical os aspherical mathematical model

3 *β* + 2 *α* – optimal input for the microphysical parameters mathematical inversion

Böckmann, 2001

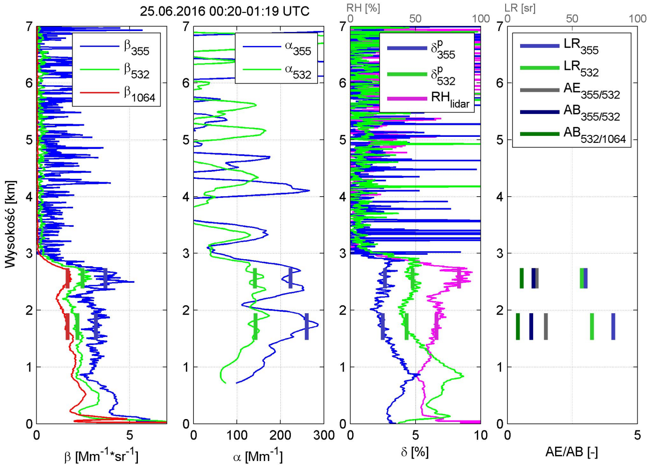
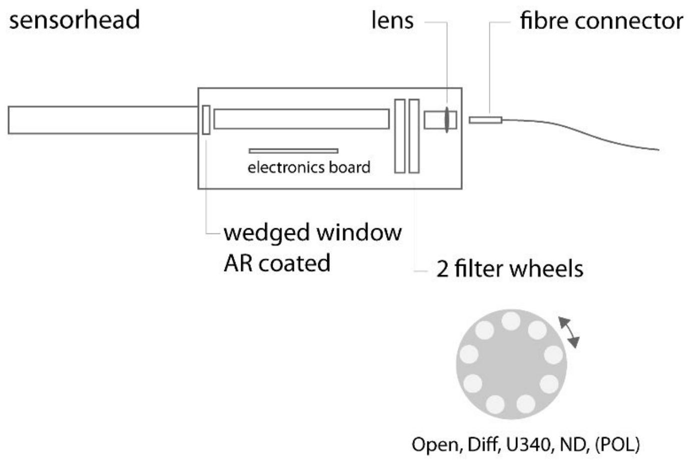


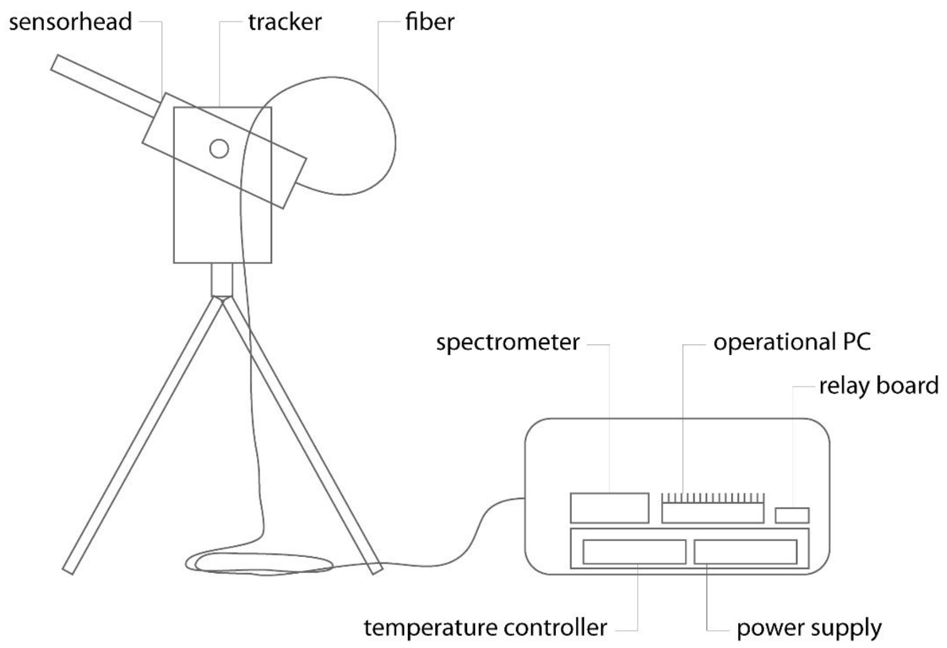
Fig. Example set of lidar profiles with chosen layers marked.

Pandora Spectrometer System

Instrument design

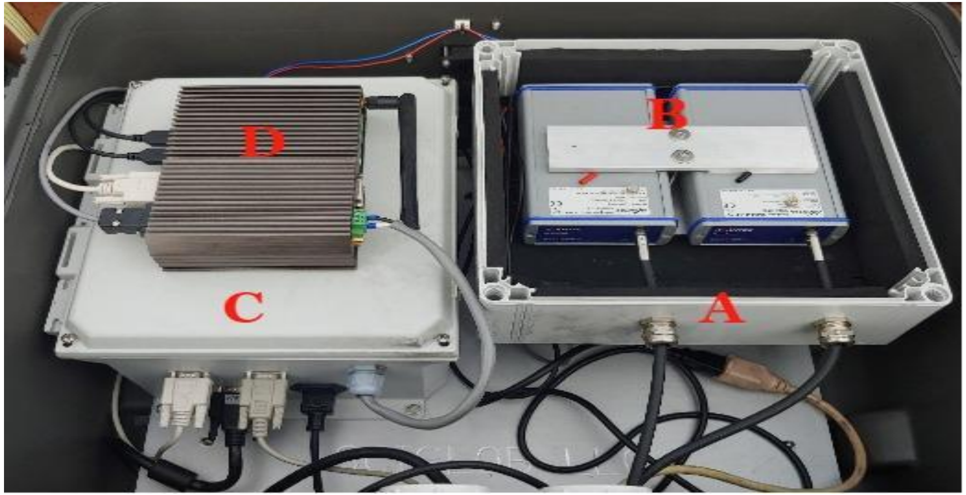
for sun, moon and sky observations





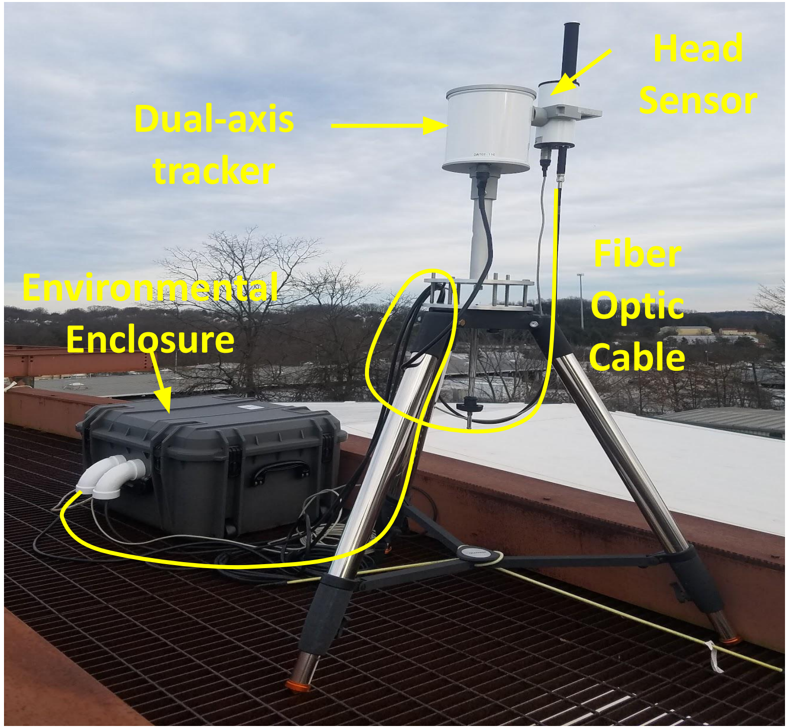
Pandora Description

PANDORA ENCLOSURE - INTERNAL SYSTEMS



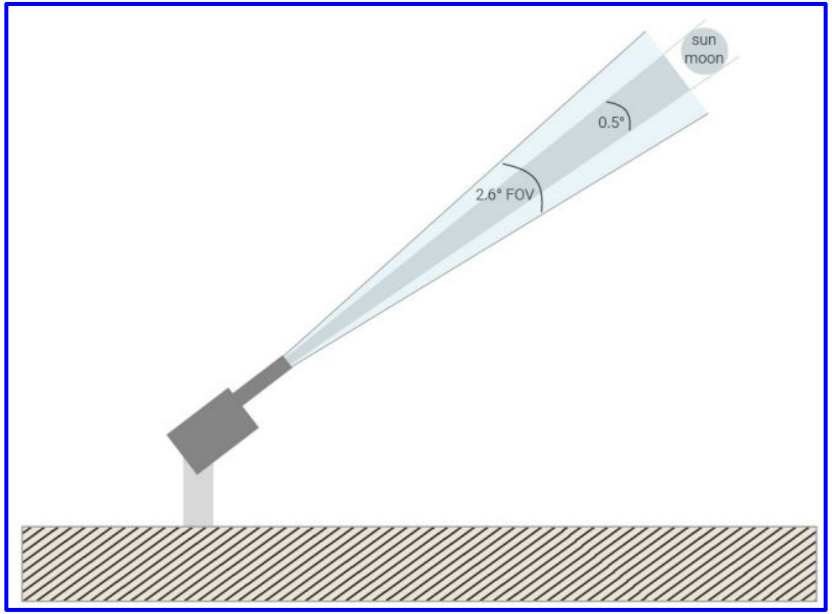
A - Spectrometer box (maintains spectrometer temperature)
B - Spectrometer(s) (measure spectra)
C - Electronics box (power and electronics)
D - Control computer (runs control software)

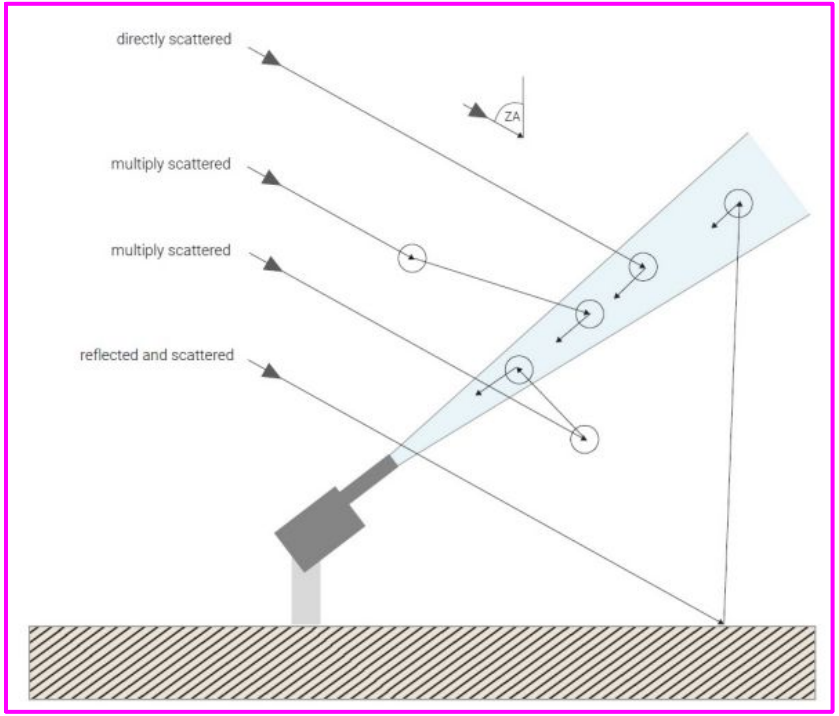
PANDORA SUN & SKY SPECTROMETER SYSTEM



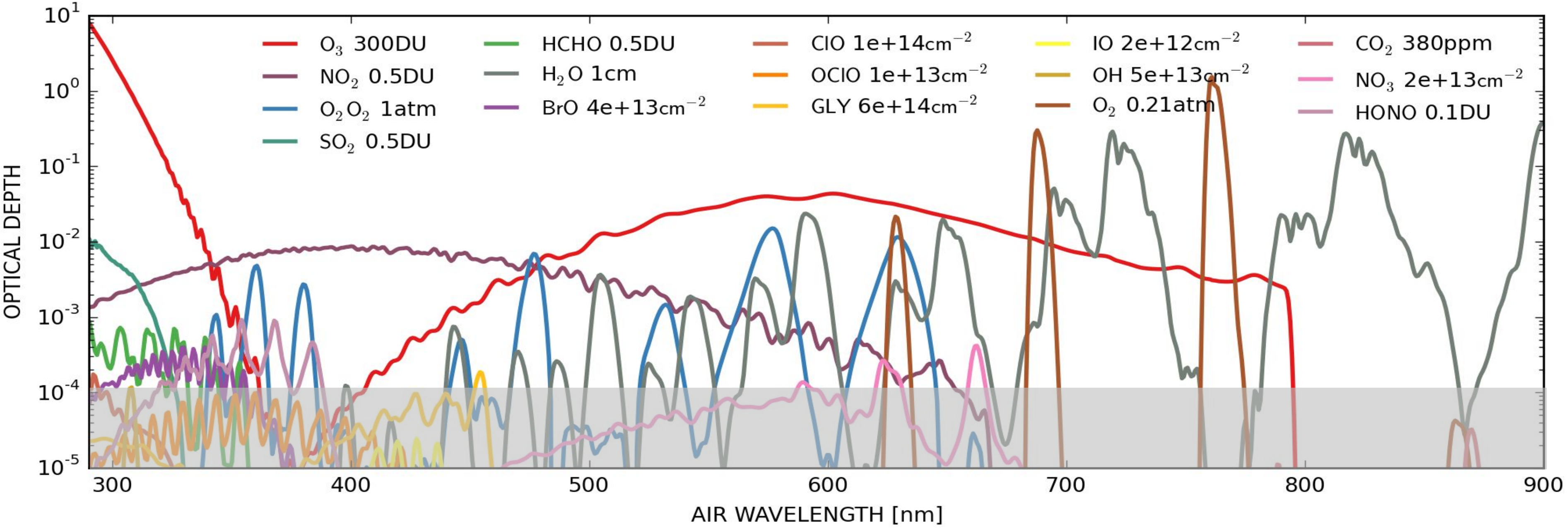
Pandora observation modes

Direct sun or moon → Total columns
MAXDOAS → Tropospheric columns, surface concentrations and vertical profiles





Pandora wavelength range



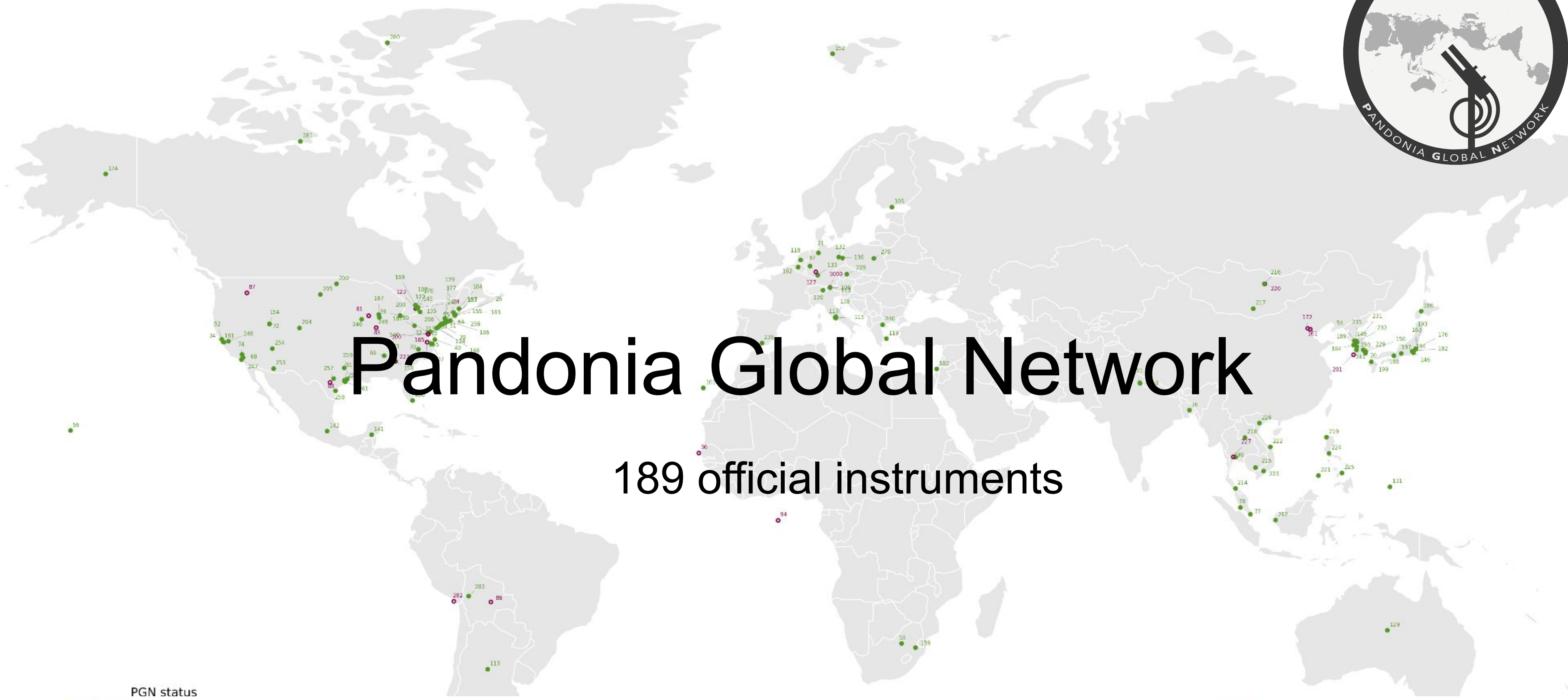
Spectrometer 1, 270 to 530 nm
0.12 nm step, 0.6 nm resolution

Spectrometer 2, 400 to 900 nm
0.24 nm step, 1.1 nm resolution

AEROPAN overview

Pandonia Global Network

189 official instruments



funding

funding

PGN: A global network for air quality monitoring and satellite validation<<

MANUFACTURING

- N. Abuhassan
- O. Abuhassan
- E. Krimchansky
- W. Lo
- C. Rader
- B. Padfield
- J. Gallegos
- M. Mahmud
- A. Joshi
- R. Sanjaykumar
- R. Abuhassan
- A. Soliman

INSTRUMENTATION & OPERATION

- T. Hanisco
- L. Valin
- E. Baumann
- D. Santana
- M. Roca
- N. Lombel
- K. Zecarias
- D. Williams
- D. Kim
- Ser. Kim
- Seo. Kim
- H. Cho
- J. Robinson

CALIBRATION & PRODUCTION

- A. Cede
- M. Tiefengraber
- M. Gebetsberger
- A. Kreuter
- L. Haunold
- C. Waldauf
- S. Morhenn
- R. Rajagopalan
- B. Place
- A. Pandey
- H. Rohringer
- M. Kilian
- B. Eder
- J. Park

MANAGEMENT

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- A. Dehn
- S. Casadio
- H. Hong
- J. Szykman

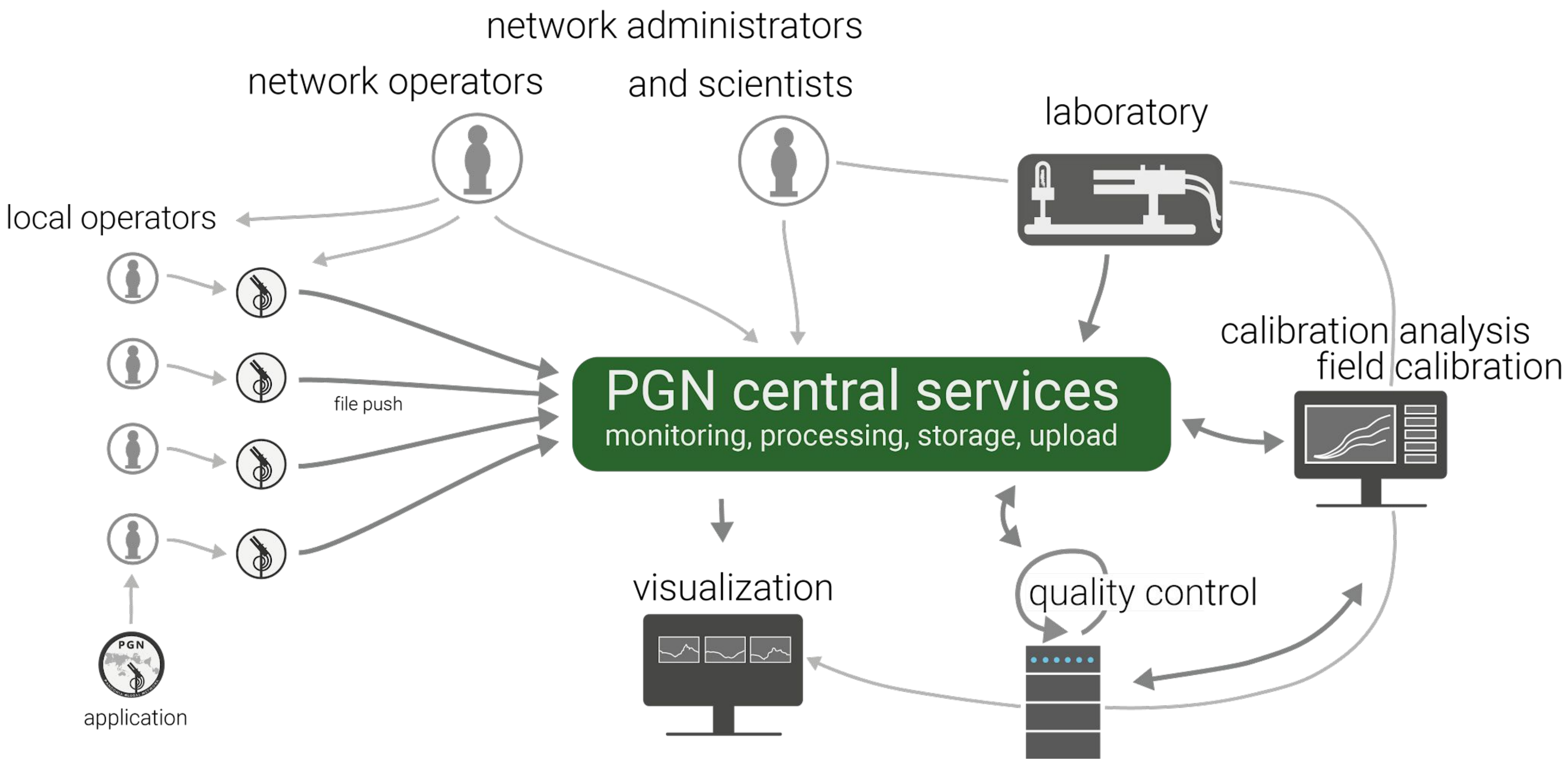
Members of PGN-AG in Red

SCIENTIFIC ADVISORS

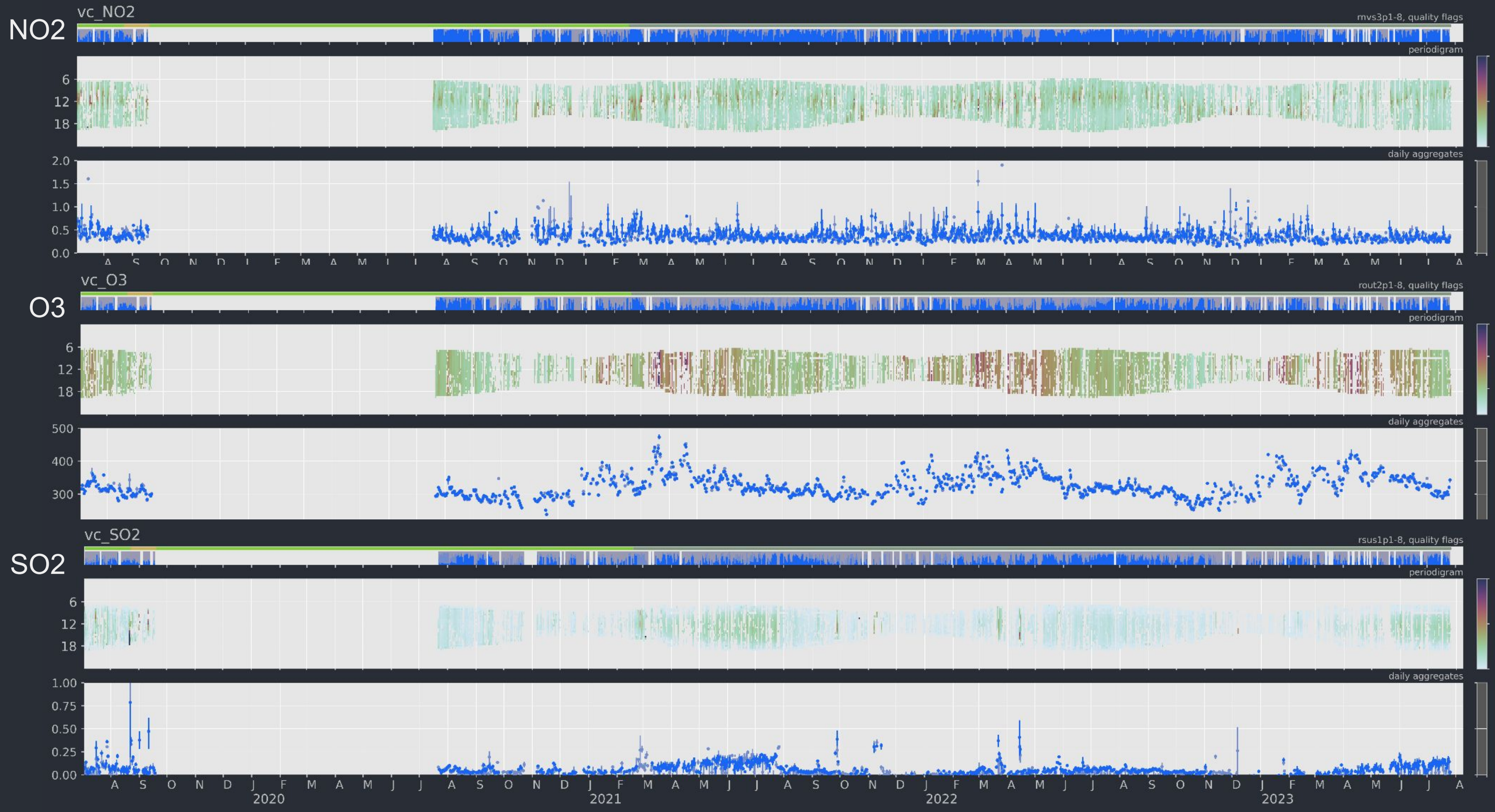
- M. v. Roozendael
- A. Redondas
- E. Spinei Lind

NASA funding SciGlob · EPA · 국립환경과학원 National Institute of Environmental Research · LUFTBLICK funding EUMETSAT esa

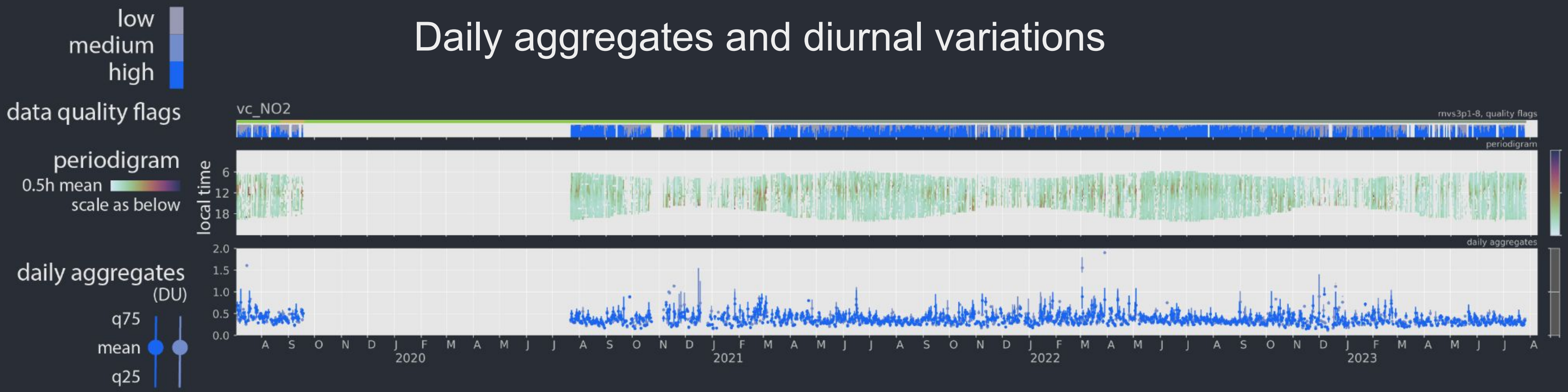
Data flow and management



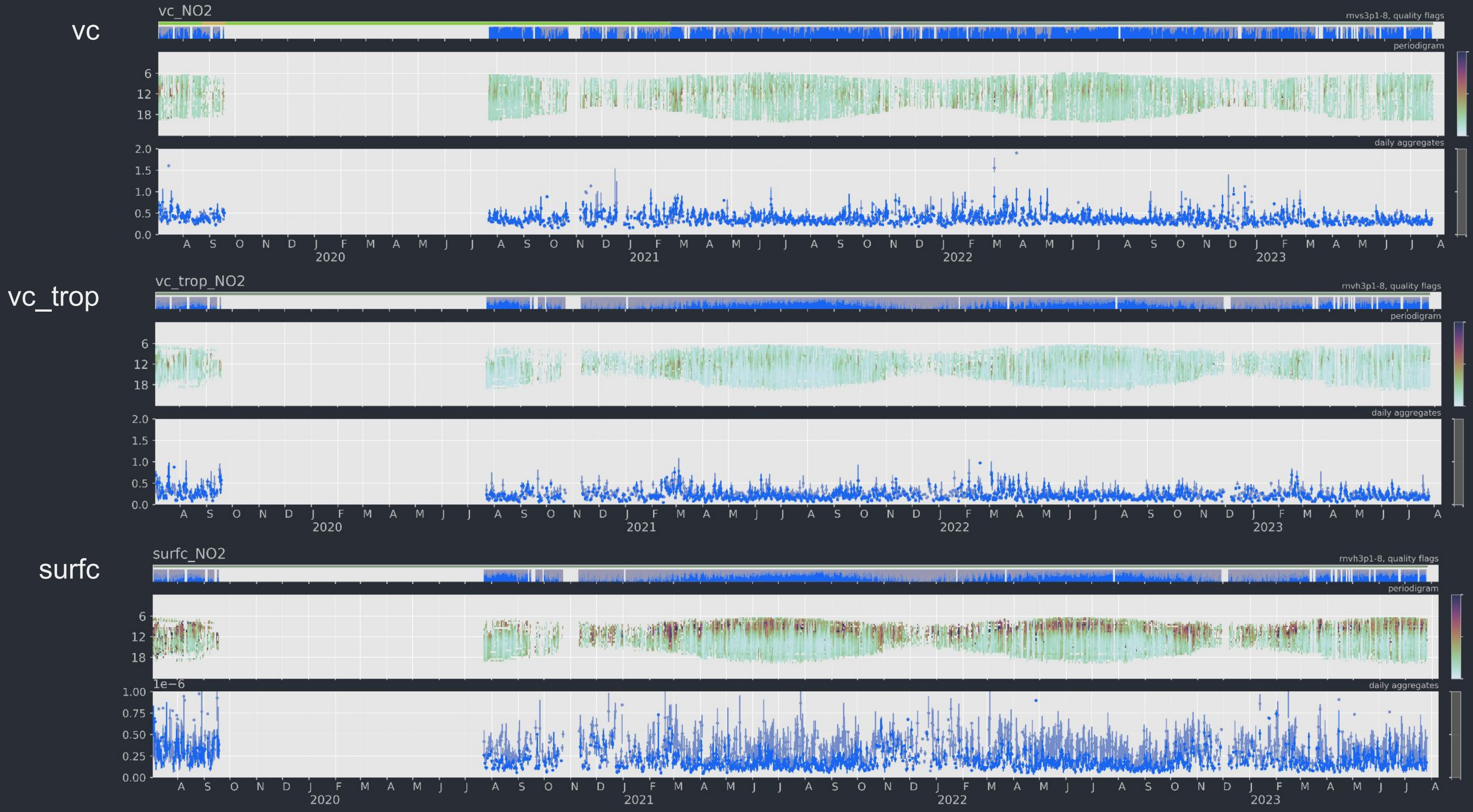
Vertical columns, Pan 117 Rome-SAP PI: Casadio



PGN data timelines - legend

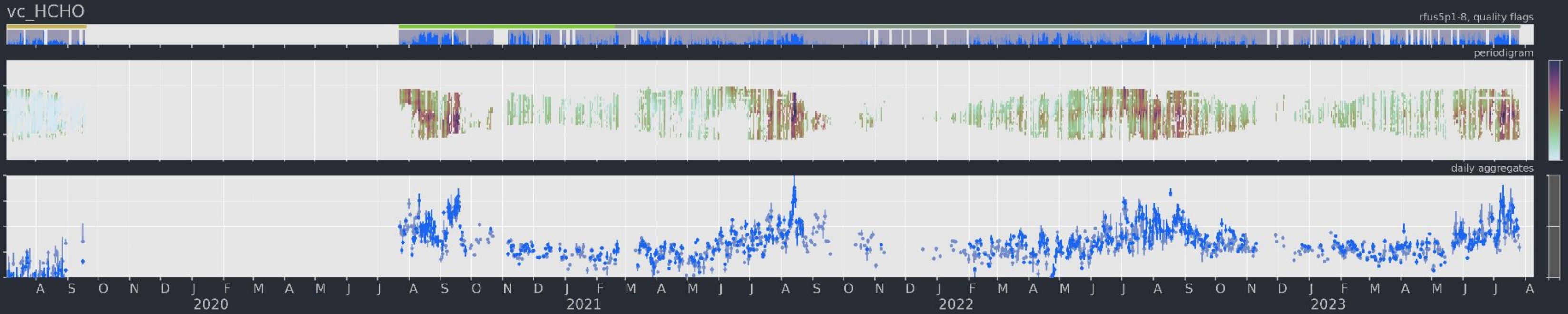


NO2 data products, Pan 117 Rome-SAP

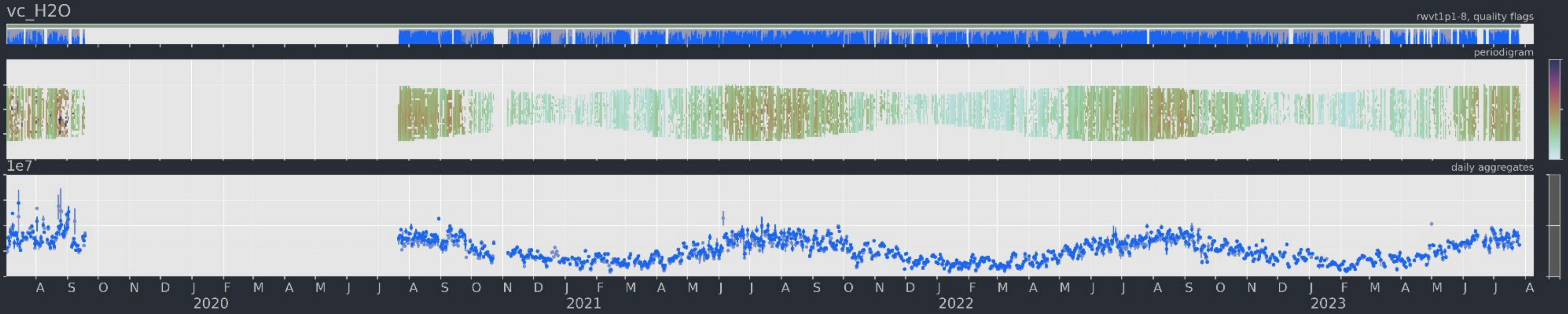


Vertical columns, Pan 117 Rome-SAP

HCHO

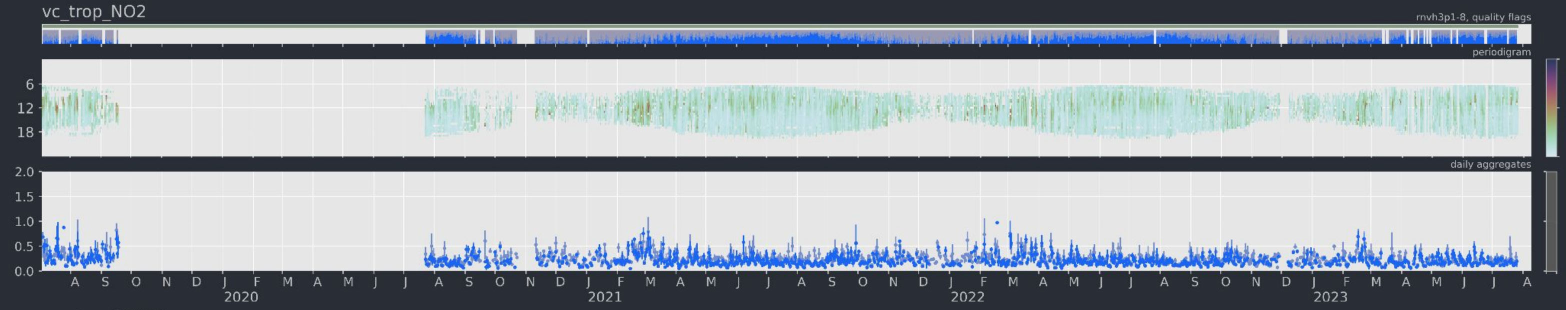


H2O



Tropospheric columns, Pan 117 Rome-SAP

NO2



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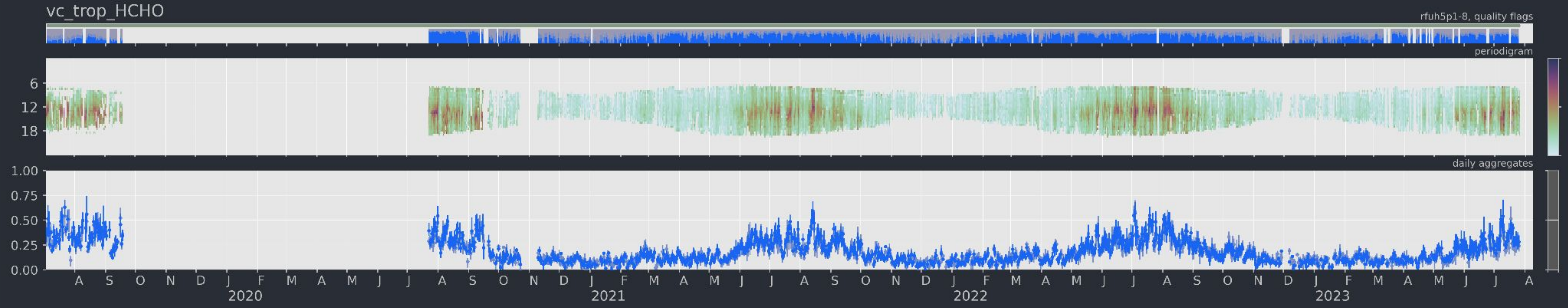

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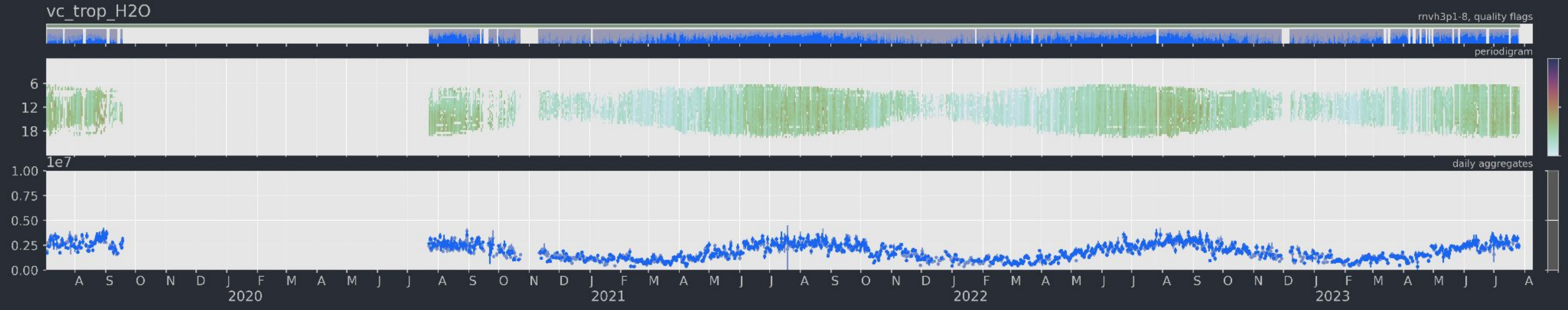
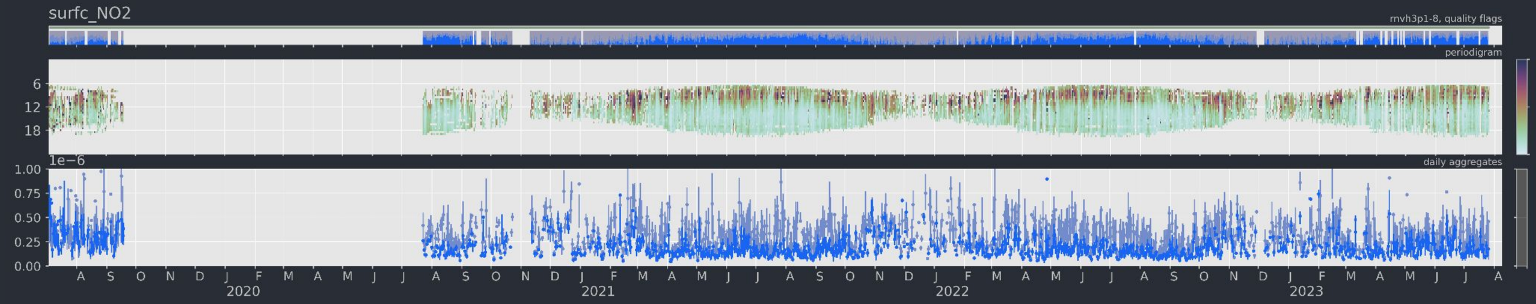


Surface concentrations, Pan 117 Rome-SAP

NO2



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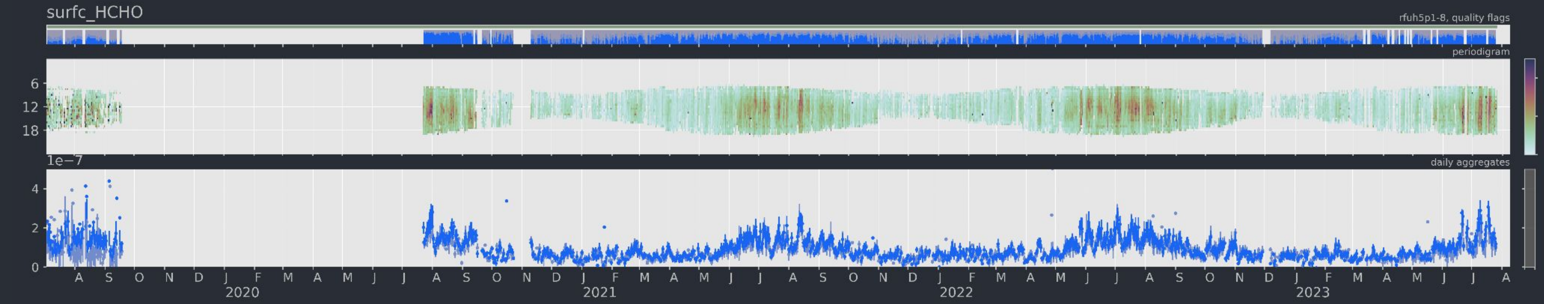
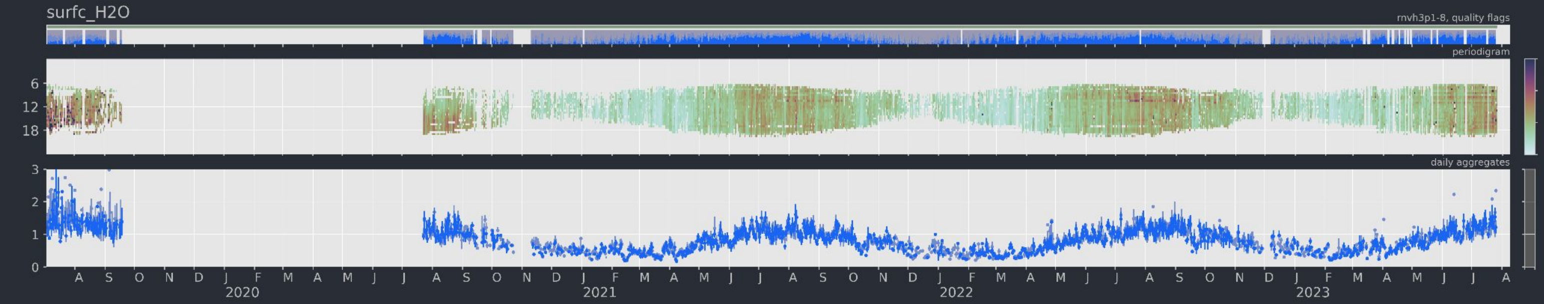


H2O

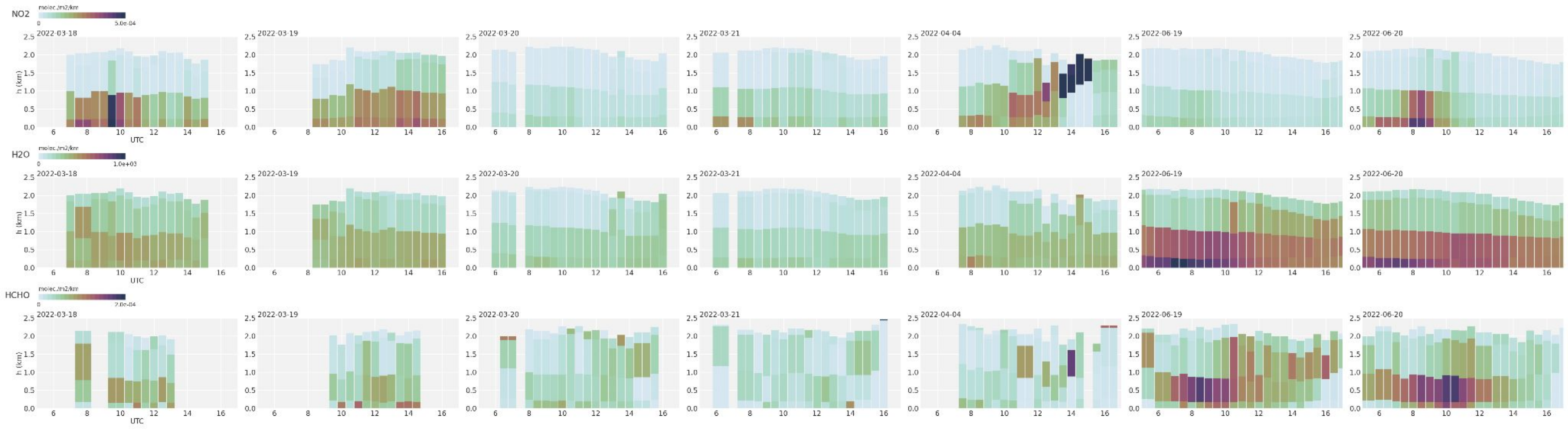


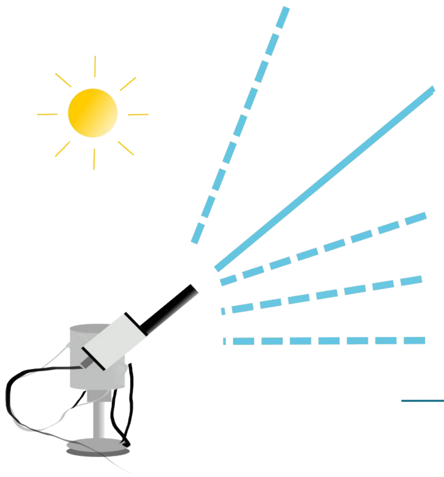
Profiles, Pan 117 Rome-SAP

NO2

H2O

HCHO





Aerosol Profiles

25th of march 2025, MS
At university of warsaw

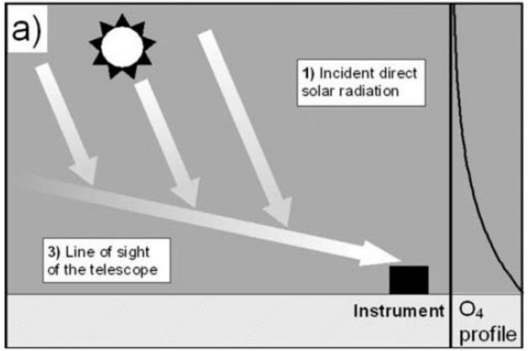
Principle idea how to get from Pandora data to Aerosol Profiles

- Data from Pandora is (differential) O2O2 absorption slant column density (L2Fit)
- O2O2 absorption: 343nm, 360nm, 380nm, 447nm, 477nm, 530nm

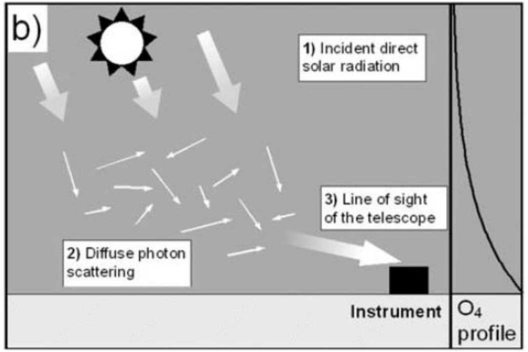
- O2O2 absorption profile in the atmosphere is known
- Measured SCD depends on length of line of sight of Pandora
- Which is affected by Aerosols
- -> we use O2O2 as a proxy for Aerosols

- Different measurement elevation angles have their highest sensitivity to different altitudes in the atmosphere
- -> we can get profile information

no/little aerosol scattering



more aerosol scattering



MAX-DOAS O_4 measurements: A new technique to derive information on atmospheric aerosols—Principles and information content

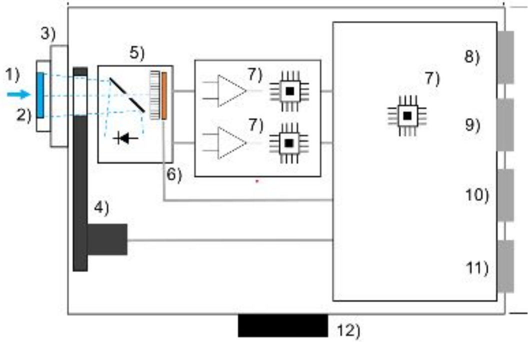
T. Wagner, B. Dix, C. v. Friedeburg, U. Frieß, S. Sanghavi, R. Sinreich, and U. Platt
Institut für Umweltphysik, University of Heidelberg, Heidelberg, Germany

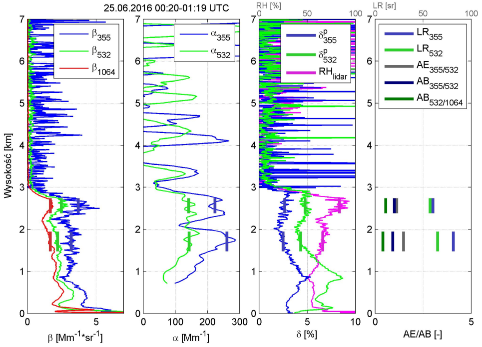
Received 14 April 2004; revised 25 July 2004; accepted 3 August 2004; published 24 November 2004.

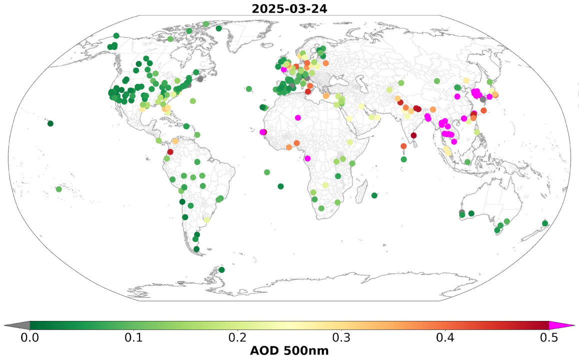
BTS2048-UV-S-WP

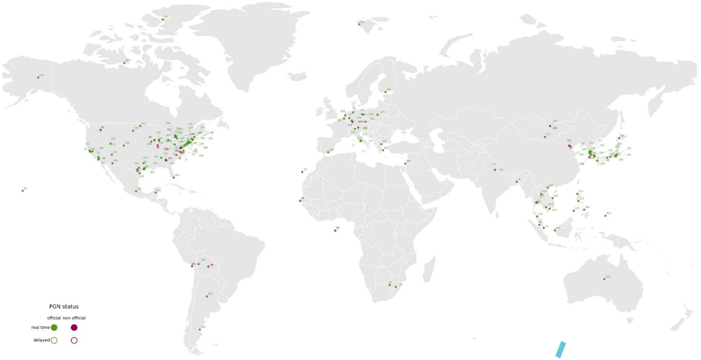
Spectroradiometer **B**i**T**ec **S**ensor for high-quality outdoor UV measurements from Gigahertz-Optik

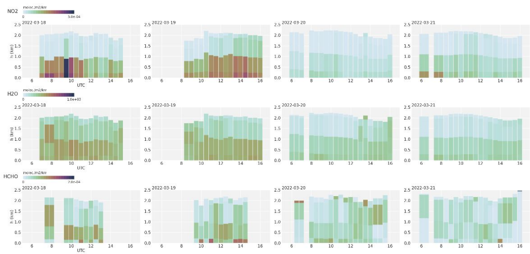
- Spectral+integral detector
- Optimized measuring routine for direct sun measurements using combination of 3 BP filters
- Sensitivity not high enough for sky measurements
- λ: 190-430 nm; FWHM ~0.8 nm
- Data since January 2024
- Co-located with CIMEL, Pandora in Innsbruck
- Integrated within Blick Operational software
- Data products same as for Pandora, but continuous development work on calibration and retrieval improvement:
  - total columns of O_3,NO_2,SO_2,HCHO,BrO

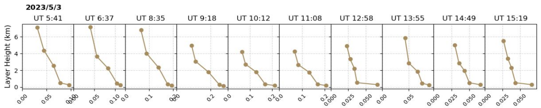



25.06.2016 00:20-01:19 UTC
Wysokość [km]
β [Mm⁻¹*sr⁻¹]
α [Mm⁻¹]
RH [%]
δ [%]
LR [sr]
AE/AB [-]
RH_lidar


2025-03-24
AOD 500nm


PGN status


NO2
H2O
HCHO
2022-03-18
2022-03-19
2022-03-20
2022-03-21
UTC


2023/5/3
Layer Height (km)
UT 5:41
UT 6:37
UT 8:35
UT 9:18
UT 10:12
UT 11:08
UT 12:58
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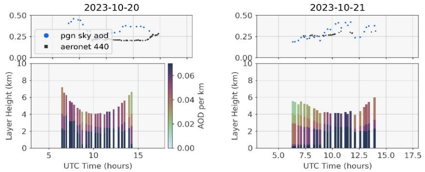
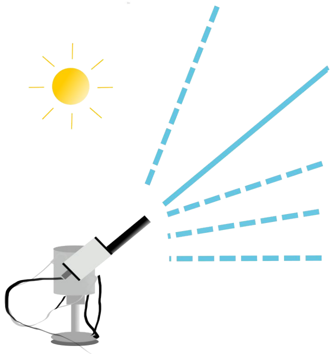
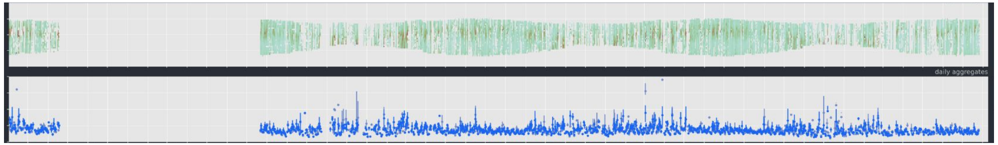
UT 14:49
UT 15:19

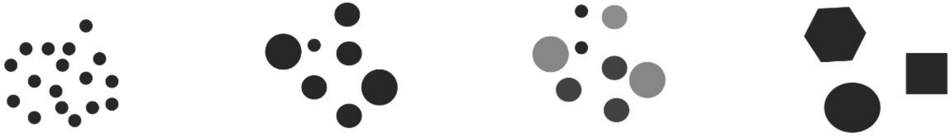

2023-10-20
2023-10-21
pgn sky aod
aeronet 440
Layer Height (km)
AOD per km
UTC Time (hours)




daily aggregates

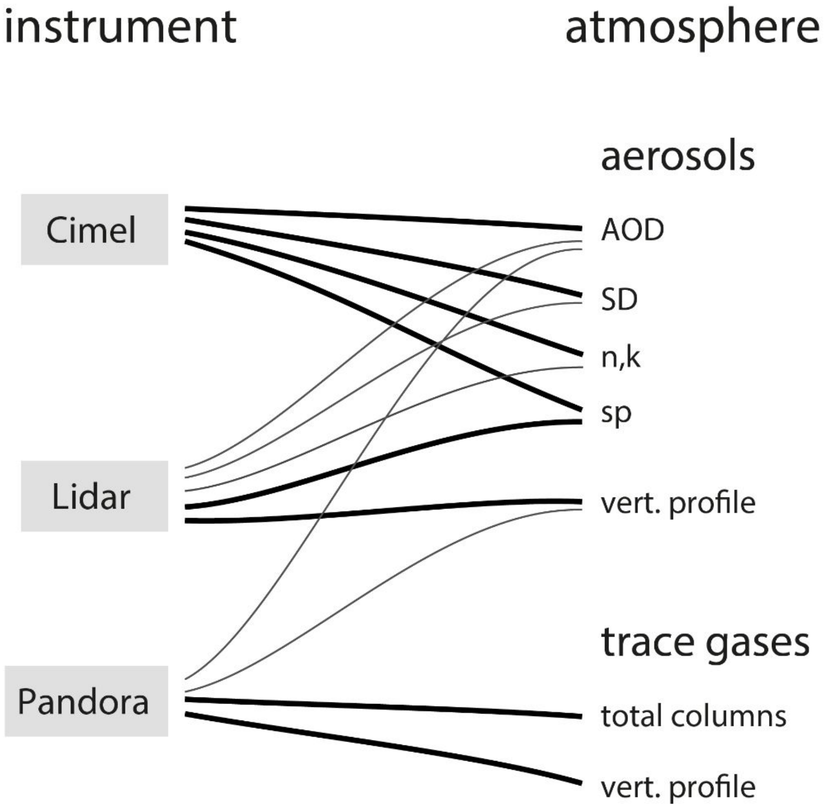
synergy?!

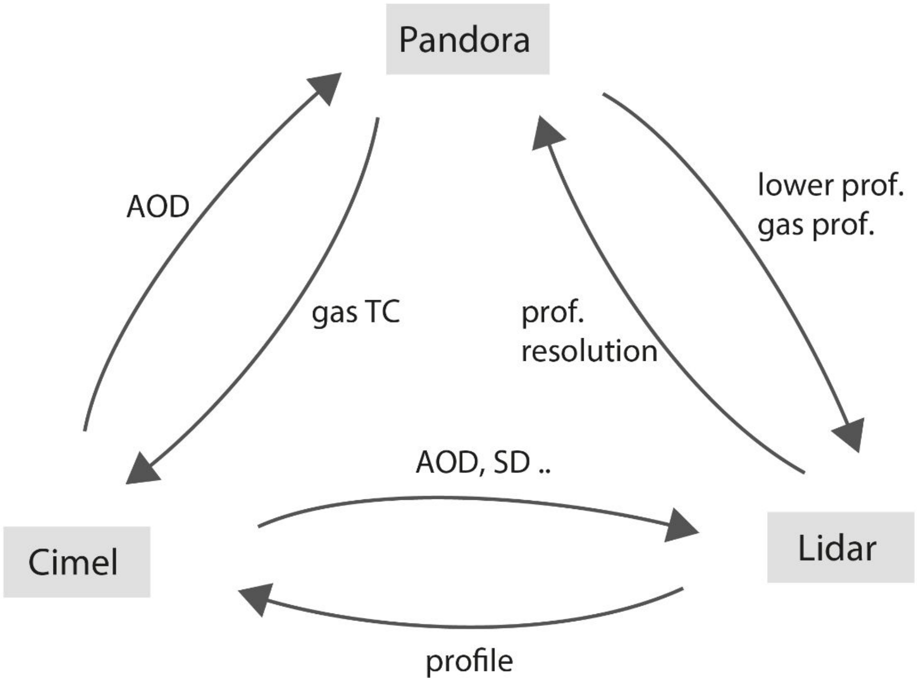
aerosol properties

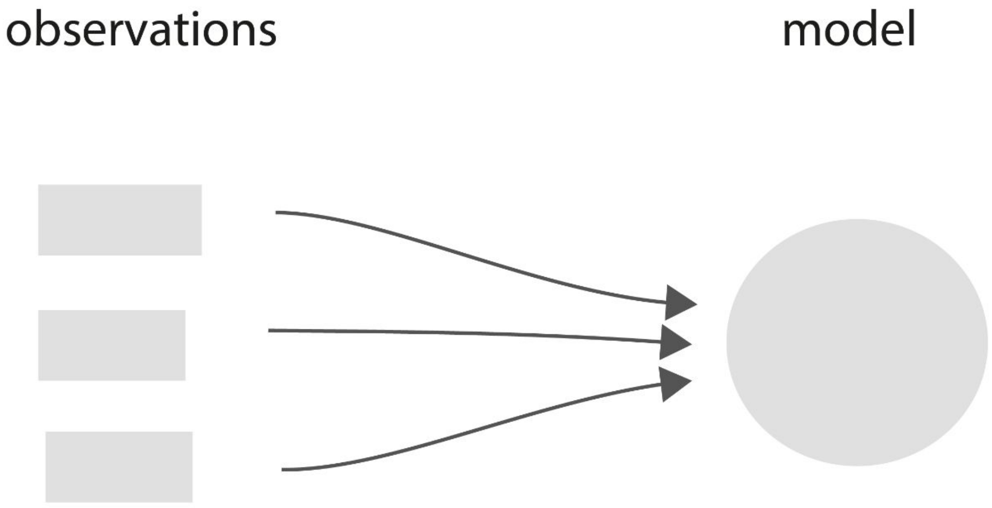


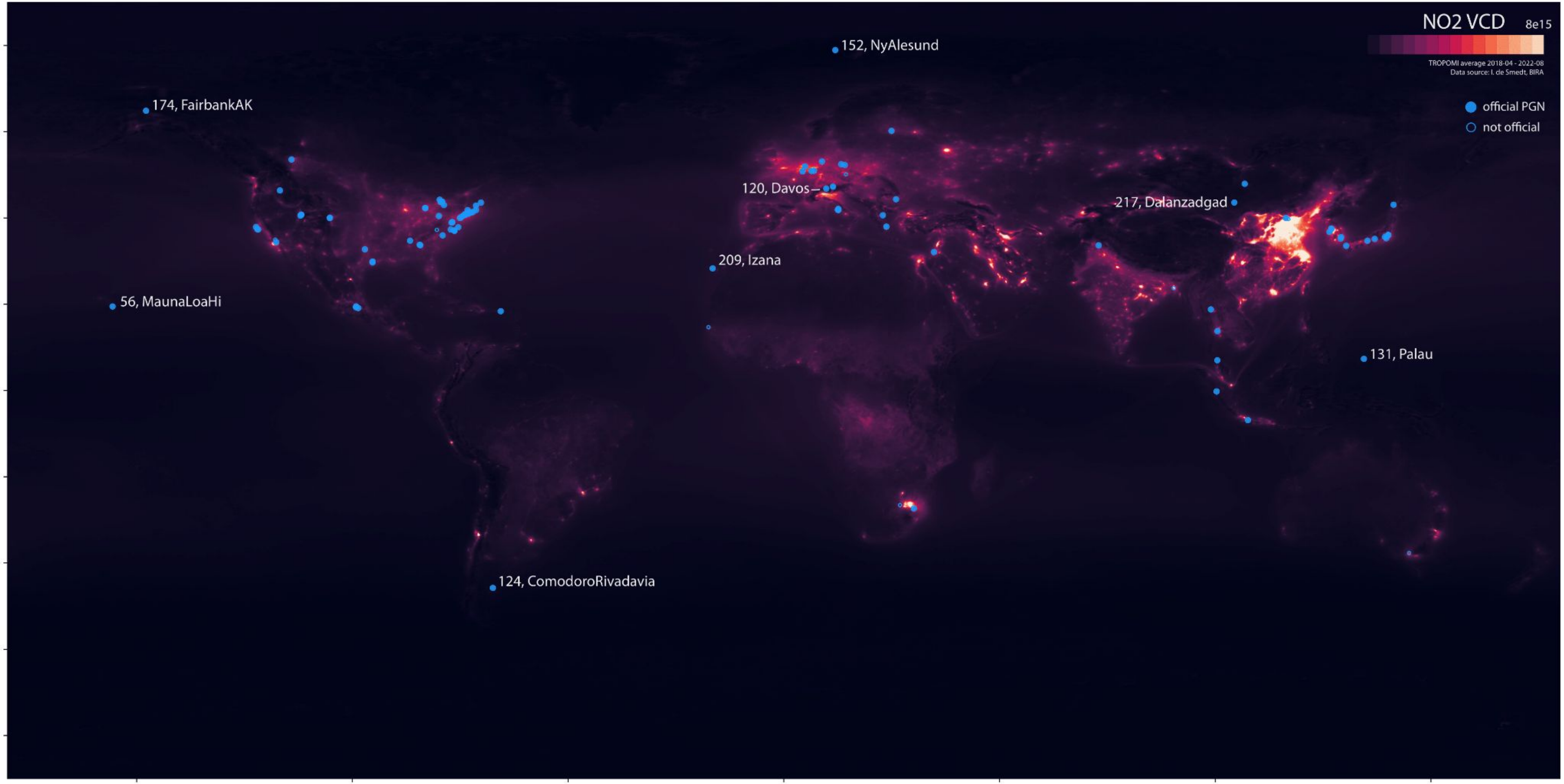
concentration — size — optical properties — shape — distribution

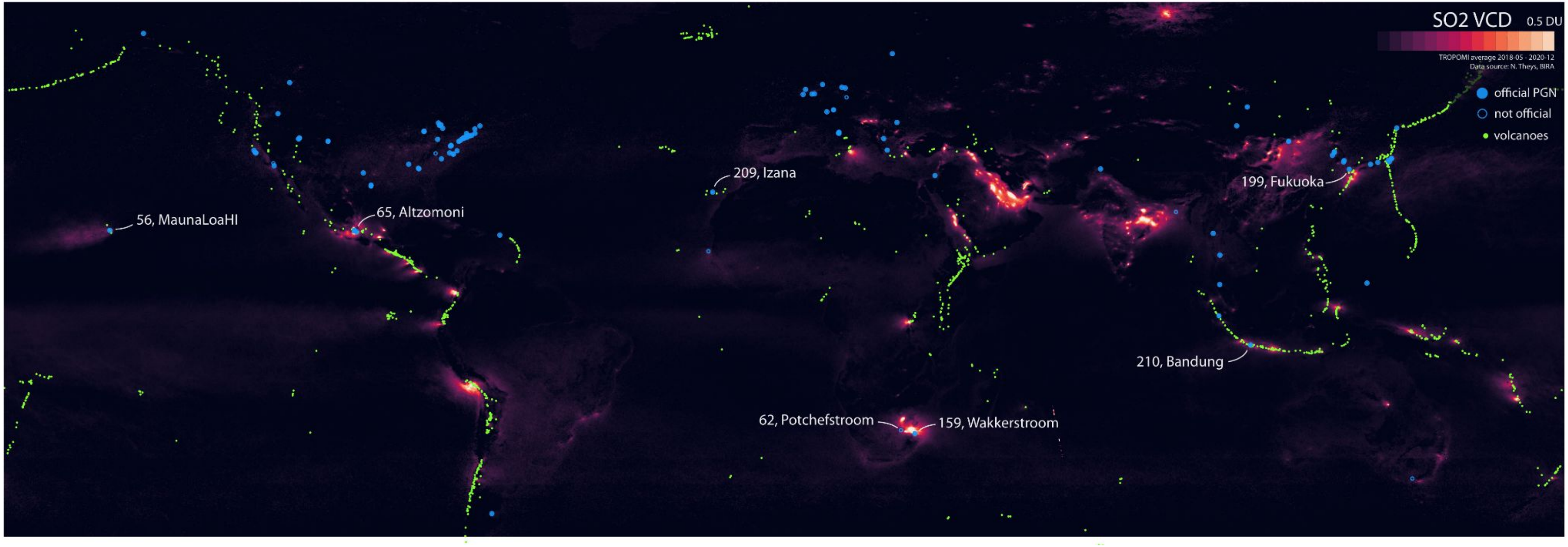
aerosol optical depth — size distribution — index of refraction — sphericity — profile

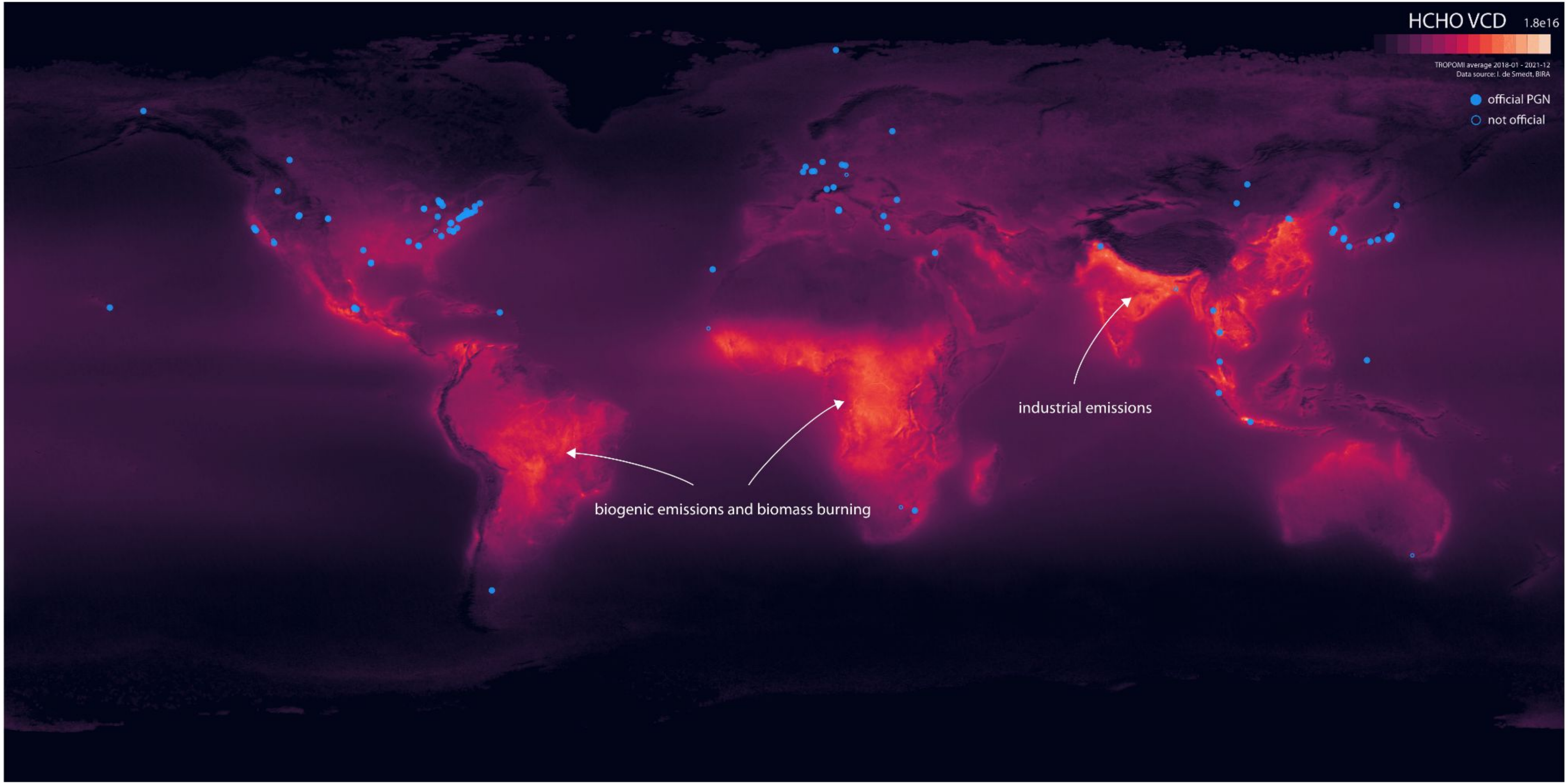

instrument
atmosphere
aerosols
Cimel
AOD
SD
n,k
sp
Lidar
vert. profile
trace gases
Pandora
total columns
vert. profile

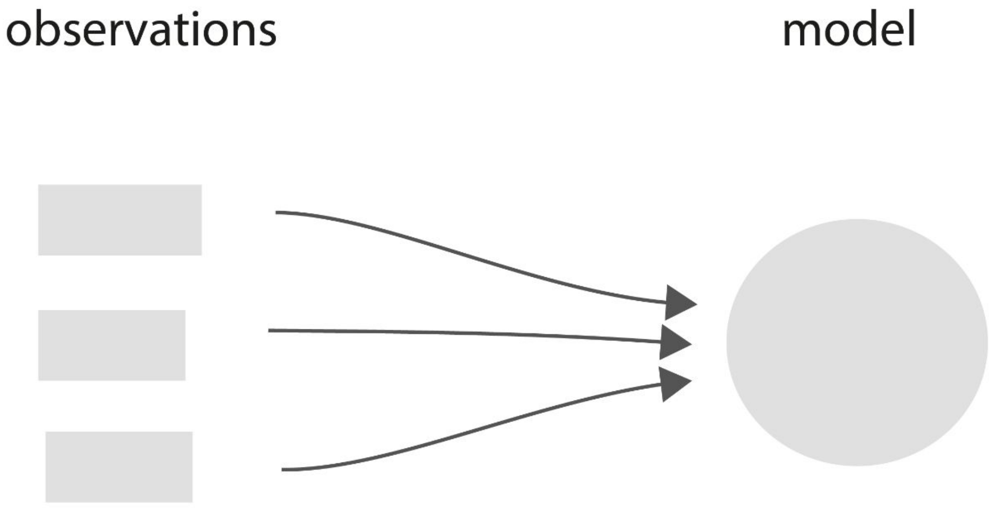

Pandora
AOD
gas TC
lower prof.
gas prof.
prof.
resolution
AOD, SD ..
Cimel
Lidar
profile

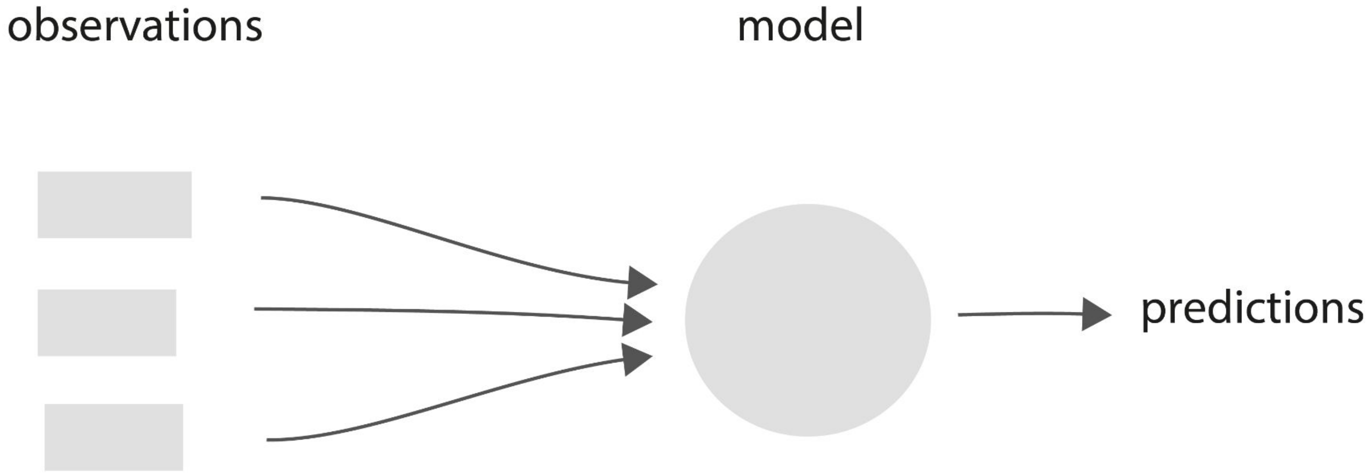

observations
model


NO2 VCD
8e15
TROPOMI average 2018-04 - 2022-08
Data source: I. de Smedt, BIRA
official PGN
not official
152, NyAlesund
174, FairbankAK
120, Davos
217, Dalanzadgad
209, Izana
56, MaunaLoaHi
131, Palau
124, ComodoroRivadavia


SO2 VCD
0.5 DU
TROPOMI average 2018-05 - 2020-12
Data source: N. Theys, BIRA
official PGN
not official
volcanoes
56, MaunaLoaHI
65, Altzomoni
209, Izana
62, Potchefstroom
159, Wakkerstroom
199, Fukuoka
210, Bandung


HCHO VCD
1.8e16
TROPOMI average 2018-01 - 2021-12
Data source: I. de Smedt, BIRA
official PGN
not official
industrial emissions
biogenic emissions and biomass burning


observations
model


observations
model
predictions

Synergy of remote sensing within ACTRIS

Thank you!

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