GROUND-BASED AIR QUALITY OBSERVATIONS

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WMO Training Course on Seamless Prediction of Air Pollution in Africa - Online sessions (Sep 17, 2024)

@ ICOS-ERIC

Outline

I. Air Quality

II. In-Situ Air Quality Measurements

III. Remote Sensing Air Quality Measurements

IV. Status of Air Quality Observations over Africa

1. Air Quality

I. Air Quality

II. Air Quality Monitoring (AQM)

III. Instrumentation in AQM

IV. International Standard Guidelines for AQM

V. Criteria Pollutants

VI. Measurement Networks

What is air pollution?

- According to WHO, air pollution is a complex mixture of solid particles, liquid droplets, as well as gases. It can come from many sources: household fuel burning, industrial chimneys, traffic exhausts, power generation, open burning of waste, agricultural practices, desert dust and others.
- Different sources can lead to different mixtures of air pollution.
- Our concern is specifically to define those pollutants that have been shown to have harmful effects on human health and to effectively develop our capabilities to monitor these atmospheric components.
- These pollutants fall into two broad categories:

Gases and Aerosols

Air Quality (AQ) Monitoring

Routine monitoring of specific air pollutants, also known as “Criteria Air Pollutants”, defined at National level in National Ambient Air Quality Standards (NAAQS) or by International Organizations.

Essential characteristics of an effective monitoring system (UNEP, Clear Air Asia, 2016):

1. Well-planned network according to monitoring objectives, representative of the AQ conditions at the country and compliance with ambient air quality standards
2. Proper implementation of quality assurance (QA) and quality control (QC) procedures
3. Sustainable operation
4. Effective communication to the public/policymakers
5. Strong commitment from authorities in terms of financial and human resource suppport.

Economic benefits (implementation and operation):

Health BUT
National Wealth & Equality

- Benefits far outweigh the costs of implementing control measures.
- Cost-benefit analysis (USEPA’s 2006 NAAQS for PM alone): €42-€136 billion for 2020.
- Health benefits for every EU citizen is estimated between 6 and 19 times (average annual costs of €94-€301) exceed costs (average annual costs of €15) (Holland, et al., 2005).

Instrumentation in AQ Monitoring (AQM)

Traditionally, government networks use **Reference-Grade air quality Monitors (RGM)** that comply with very strict standards (AQ Regulations).

Key features of RGM are:

1. Continuous, long-term use with minimal drift in their measurements over time
2. High accuracy (strict regulatory standards suitable to be used for regulatory purposes)
3. Calibration to standards (traceability)
4. Sustainable operation
5. High level of standarization
6. Audits and maintenance according to established Standard Operational Procedures (SOPs)
7. Hybrid Monitoring Network: RGM (**10.000 - 100.000 USD**) + Low-Cost Sensors (LCS, **100 - 2.000 USD**)
   - ✓ Complement tradicional AQM
   - ✓ Reach uncovered areas
   - ✓ Research and public awareness purposes
   - × Interpreted with caution and often validation against reference instruments

Evaluation of Emerging Air Sensor Performance

International Standards Guidelines for AQM

According to UNEP, there exist three internationally accepted guidelines for AQM networks or programs:

(Clear Air Asia, 2016)

Organization	Title/Link to Guidelines
WHO	Monitoring Ambient Air Quality for Health Impacts Assessment http://www.euro.who.int/__data/assets/pdf_file/0010/119674/E67902.pdf
USEPA	Air Planning and Standards http://www.epa.gov/airquality/montring.html Guidance for Network Design and Optimum Site Exposure for $PM_{2.5}$ And PM_{10} http://www.epa.gov/ttn/amtic/files/ambient/pm25/network/r-99-022.pdf Guidance for Using Continuous Monitors in $PM_{2.5}$ Monitoring Networks http://www.epa.gov/ttn/amtic/files/ambient/pm25/r-98-012.pdf
EU	Directives for Monitoring Atmospheric Pollution (Directive 2008/50/EC) http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32008L0050&from=EN

These guidelines introduce:

- Ambient AQ standards (limit and exposure period) based on <u>extensive scientific evidence</u> relating main criteria pollutants to their adverse impacts on public health.
- Reference instrumentation/techniques
- Procedures: QA/QC

Reference Method (RM)

Equivalent Method (EM)

Scientifically developed to provide quantification for AQ regulations (NAAQS)

Criteria Air Pollutants

Most of the countries defined as ‘criteria pollutants’, stablishing air quality limits for all of them, to the following atmospheric species:

Sulfur Dioxide (SO_2)

Carbon Monoxide (CO)

Nitrogen dioxide (NO_2)

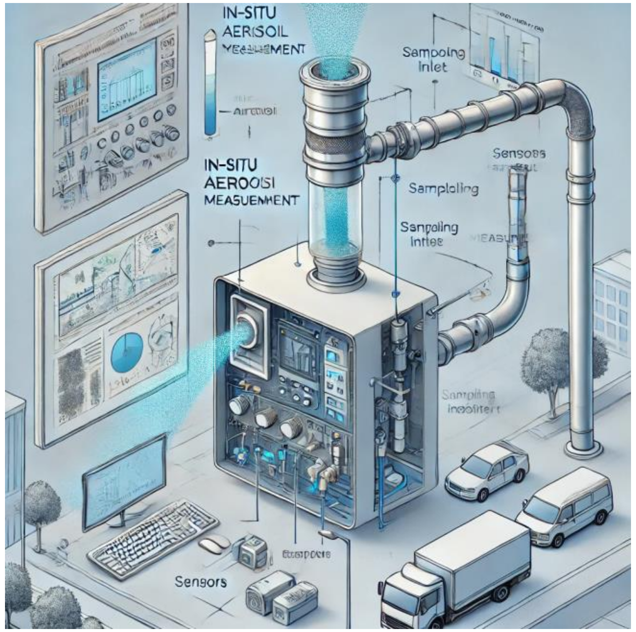
Particulate matter

Ozone (O_3)

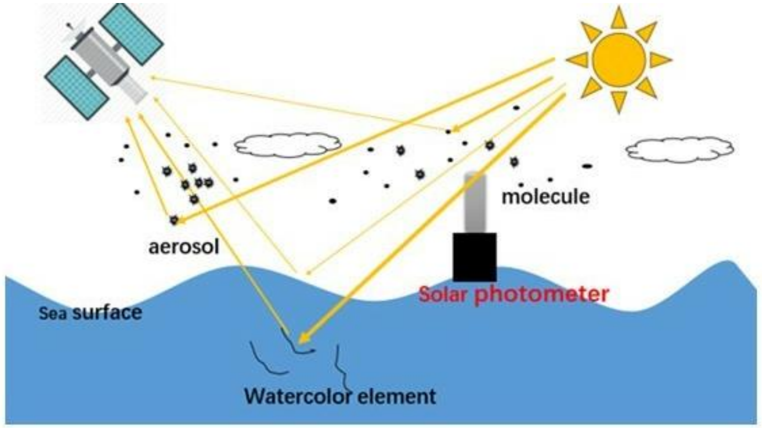
Measurement Techniques

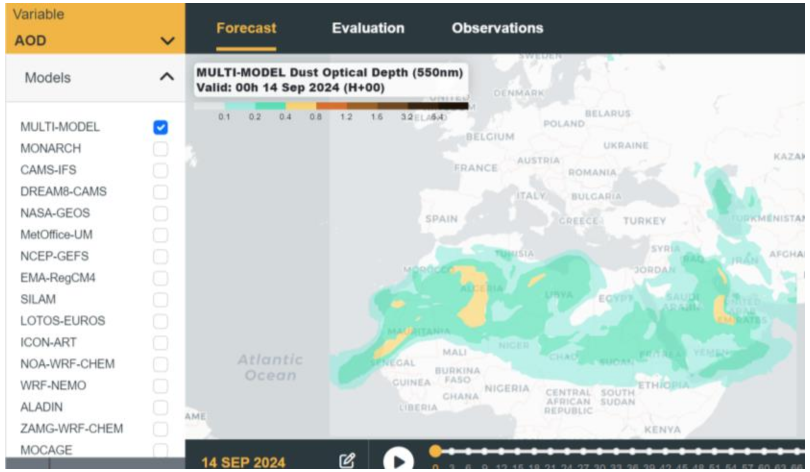
To monitor the presence and evolution of gases and aerosols in the atmosphere (Criteria Pollutants), we need to look at the **content in the air** using different monitoring techniques:

In-Situ



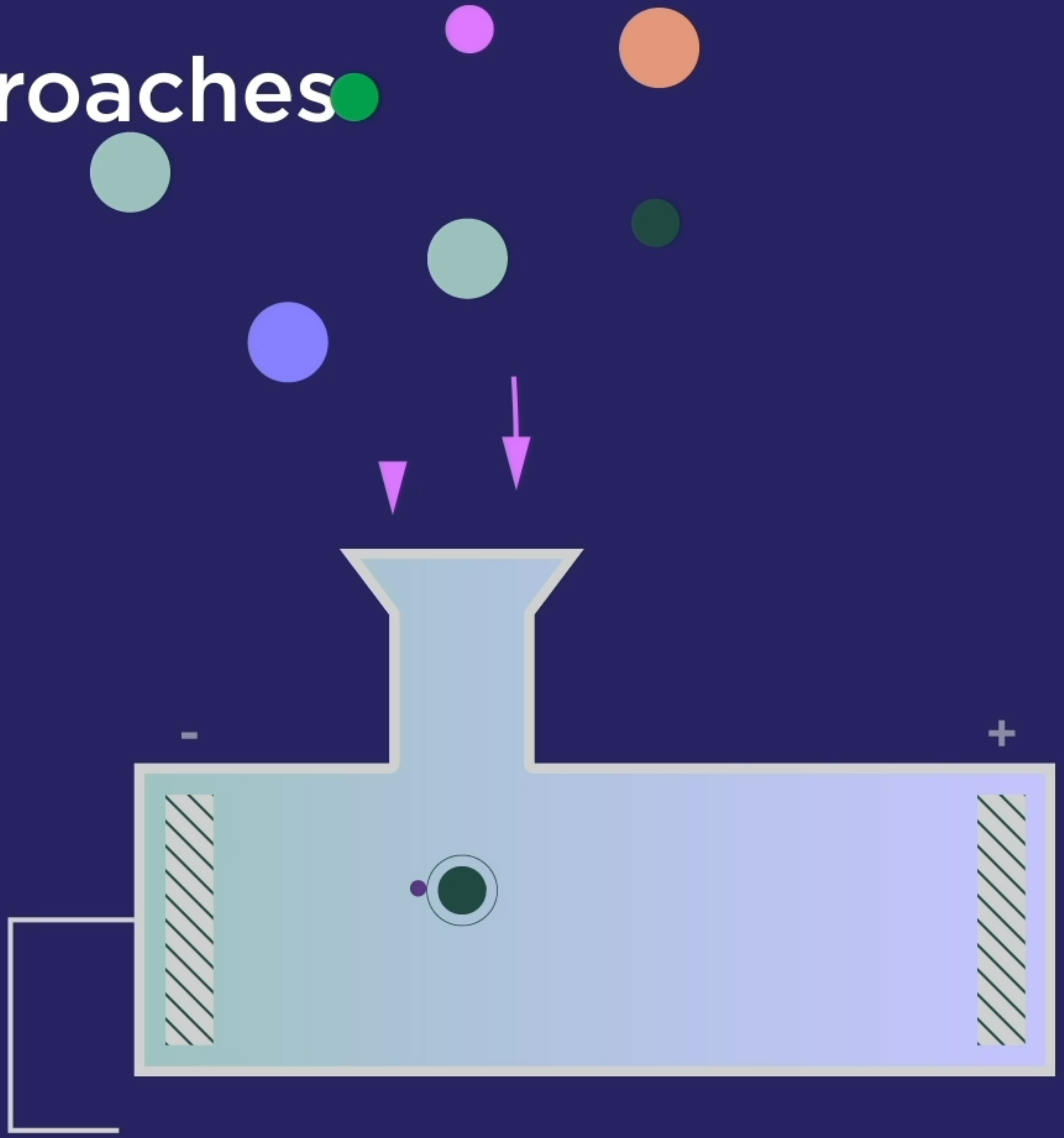
Remote Sensing





Numerical Models

in situ approaches



2.

In-Situ AQ Measurements

Criteria Air Pollutants

Sulfur Dioxide (SO_2)

Reference Method (RM): Pararosaniline Metho

Equivalent Method (EM): U.V. Fluorescen

- Highly reactive gas with a important health effect, basically on the respiratory system (irritation and lung effect)
- Secondary product: H_2SO_4 (soluble)
- Important influence in gas-to-particle formation
- Natural sources: volcanoes or geothermal
- Anthropogenic sources: combustion of fossil fuels containing sulphur (urban areas)
- Significant regional and seasonal differences as well as short-term episodes depending on the dominant sources and their spatial distribution

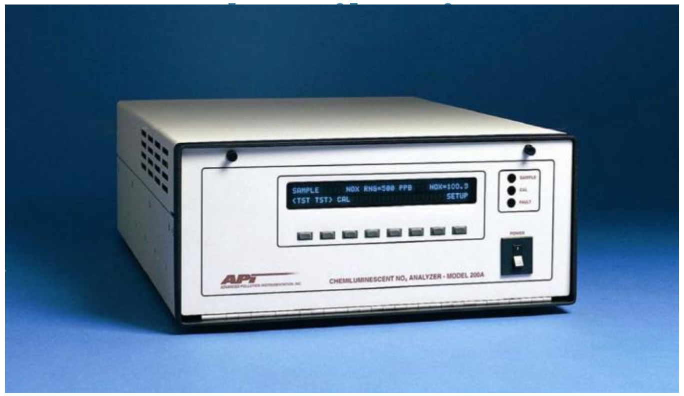
SO_2 Analyzer

Criteria Air Pollutants

Nitrogen dioxide (NO_2)

- Oxidizing agent that may damage cell membranes and proteins produced in combustion processes (about half of total emissions throughout Europe come from road traffic)
- Short-term exposure may predispose towards an increased risk of respiratory diseases
- Both acute and chronic effects, especially in susceptible population subgroups such as people with asthma.

Reference Method (RM): Gas Phase



NO_x Analyzer

Equivalent Methods (EM): Sodium Arsenite (SA) Method, Differential Optical Absorption Spectrometry (DOAS), U.V. Photolytic Conversion, Cavity Attenuated Phase Shift Spectroscopy (CAPS)

Criteria Air Pollutants

Ozone (O_3)

Reference Method (RM): Ethylene Chemiluminescence (ISO 10313)

Equivalent Method (EM): U.V. Photometry (ISO 13964), Differential Optical Absorption Spectroscopy (DOAS)

O_3 Analyzer

- O_3 is a secondary photochemical pollutant formed from the precursors volatile organic compounds, NO_x and CO in the presence of short wavelength solar radiation
- O_3 concentrations tend to peak some distance from the emission sources of ozone precursors being quite complex and dependent on various effects
- Ozone can enter the body through inhalation and can reach the respiratory system because it is not very soluble in water
- Ozone exposure has also been associated with increased numbers of hospital admissions from respiratory diseases, including asthma

Criteria Air Pollutants

Carbon Monoxide (CO)

- Reduces the capacity of blood to carry oxygen, affecting organs, such as the brain, cardiovascular system or muscles
- At very high concentrations, well above normal ambient levels, CO causes death
- The most important source is road traffic
- CO emissions peak when traffic movement is restricted: in crossroads with traffic lights and in traffic jams

Reference Method (RM): Non-Dispersive Infrared Photometry (NDIR)

CO Analyzer

Equivalent Method (EM): U.V. Photometry (ISO 13964)

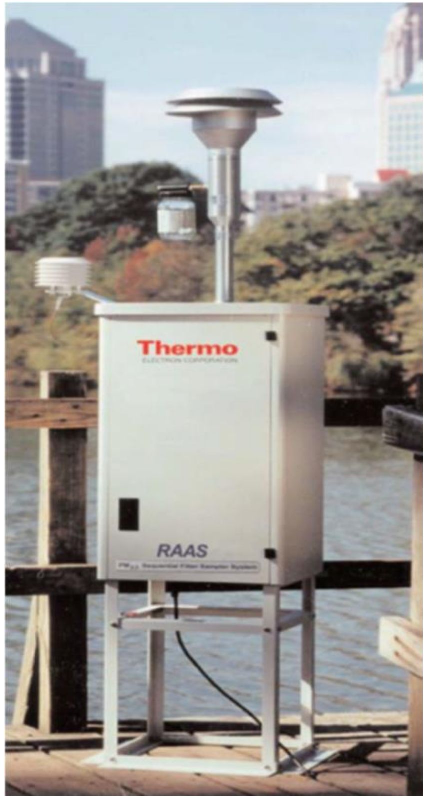
Criteria Air Pollutants

Particulate matter (PM_x)

- Airborne particulate matter represents a complex mixture of organic and inorganic substances
- Designated with the different aerodynamic diameter: PM_{10} (coarse) and $PM_{2.5}$ (fine)
- Day-to-day variation in particulate matter concentrations
- Important health effects (mortality, respiratory and cardiovascular diseases) even at low concentration levels (especially for fine particulate matter and depending on chemical composition)
- Long-term exposure to particulate matter is associated with reduced survival and prevalence rates of respiratory and cardiovascular diseases

Reference Method (RM): In-Stack Particulate Filtration

PM_x sampler



Equivalent Method (EM): Beta-Attenuation Monitoring, Tapered Element Oscillating Microbalance (TEOM®), Laser Aerosol Spectrometry, Dichotomous Air Sampler

Beta attenuator PM_x monitor

International Standards Guidelines for AQM (in-situ)

- WHO recommends values for limiting air pollutant concentrations and exposure at levels at which the risk for health effects is low.
- AQG based on purely epidemiological and toxicological evidence
- AQGs are intended for **worldwide** use to achieve a safe AQ for public health: <u>local circumstances</u> (level of development, AQM capability, socioeconomic - political conditions, cultural and traditional issues, etc).

NAAQS

Table 0.1. Recommended AQG levels and interim targets

Pollutant	Averaging time	Interim target				AQG level
		1	2	3	4	
$PM_{2.5}$, µg/m³	Annual	35	25	15	10	5
	24-hour[a]	75	50	37.5	25	15
PM_{10}, µg/m³	Annual	70	50	30	20	15
	24-hour[a]	150	100	75	50	45
O_3, µg/m³	Peak season[b]	100	70	–	–	60
	8-hour[a]	160	120	–	–	100
NO_2, µg/m³	Annual	40	30	20	–	10
	24-hour[a]	120	50	–	–	25
SO_2, µg/m³	24-hour[a]	125	50	–	–	40
CO, mg/m³	24-hour[a]	7	–	–	–	4

[a] 99th percentile (i.e. 3–4 exceedance days per year).
[b] Average of daily maximum 8-hour mean O_3 concentration in the six consecutive months with the highest six-month running-average O_3 concentration.

International Standards Guidelines for AQM (in-situ)

Adoption of AQ Standard in different regions

WHO region	Countries in the region (*n*)	Countries with standards for at least one pollutant and averaging time		Countries without standards		Countries with no information	
		n	%	*n*	%	*n*	%
African Region	47	17	36	21	45	9	19
Region of the Americas	35	20	57	13	37	2	6
South-East Asian Region	11	7	64	3	27	1	9
European Region	53	50	94	2	4	1	2
Eastern Mediterranean Region	21	11	52	1	5	9	43
Western Pacific Region	27	12	44	13	48	2	7
Total	194	117	60	53	27	24	12

Source: Kutlar Joss et al. (2017).

- WHO AQG are adopted in many countries (at least for one pollutant)
- Many countries without any standard (or information is lacking)
- Gap between WHO AQG and National Regulations

Air Quality Monitoring networks

※ Monitoring at fixed-location sites for most commonly monitores pollutants

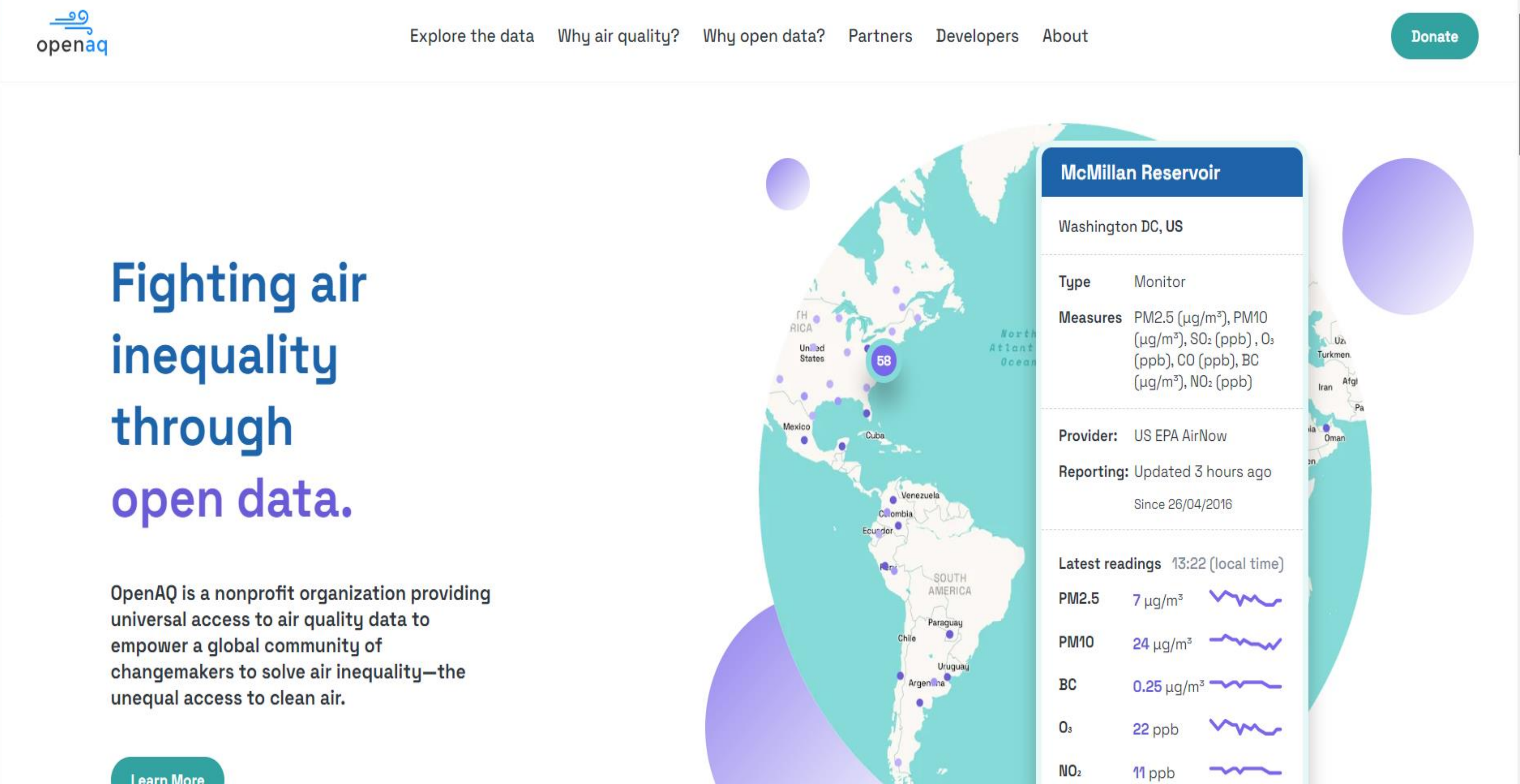
※ Inadequate spatial coverage: mainly centered on major cities and important lack of information on rural areas

※ Impact on spatial and temporal resolution of AQM – protection of the population

Current databases (ground-based):

⁂ Several regional databases of AQM

⁂ Only 2 global databases to track global AQ concentrations and trends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Type Monitor
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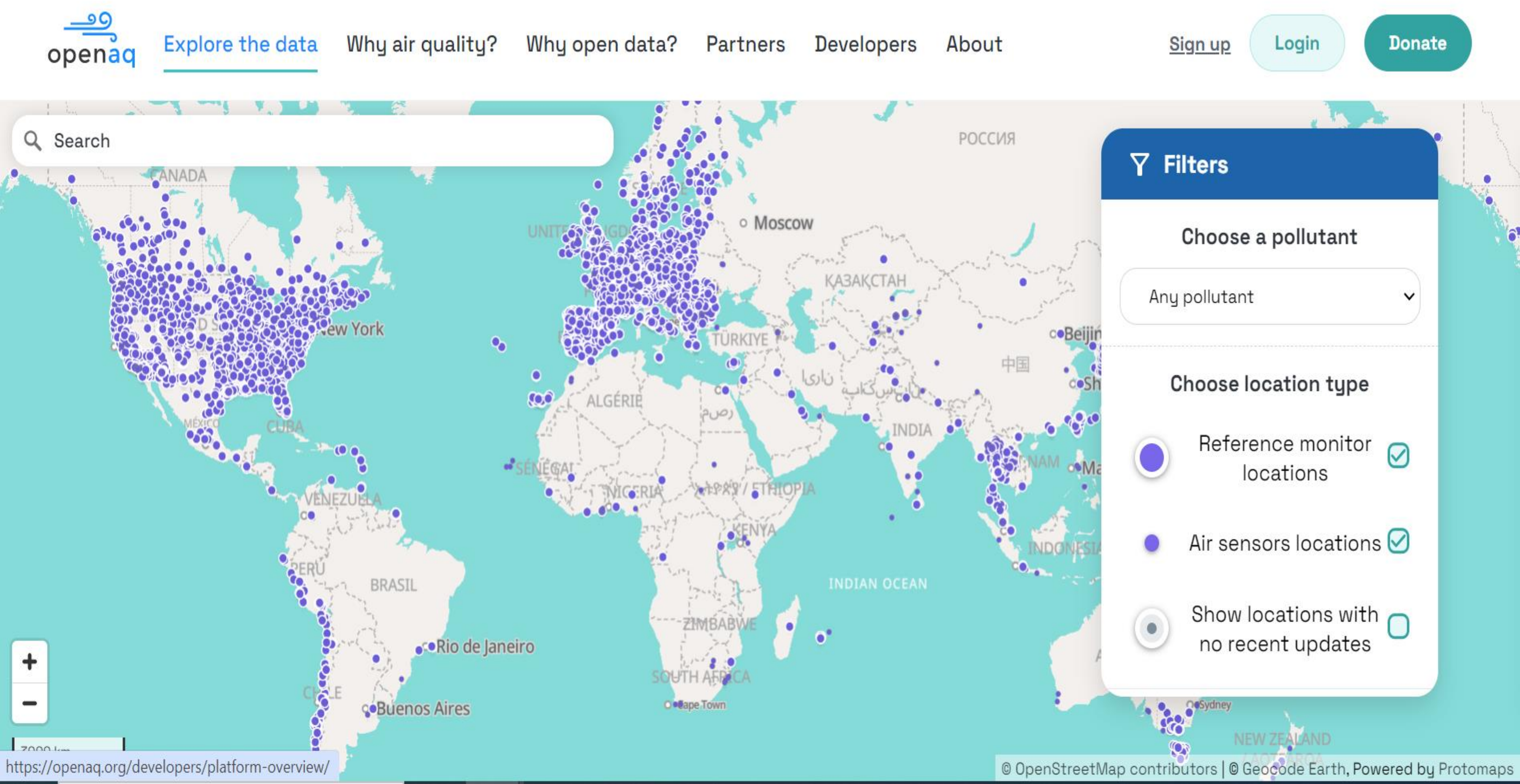
Provider: US EPA AirNow
Reporting: Updated 3 hours ago
Since 26/04/2016
Latest readings 13:22 (local time)
PM2.5 7 µg/m³
PM10 24 µg/m³
BC 0.25 µg/m³
O₃ 22 ppb
NO₂ 11 ppb
58
Mexico
Cuba
Venezuela
Paraguay
Chile
Uruguay
SOUTH AMERICA
Iran
Oman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World Health Organization Ambient Air Quality Database Application

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Pollutant

- $PM_{2.5}$ (Particulate matter of less than 2.5 µm diameter)
- PM_{10} (Particulate matter of less than 10 µm diameter)
- NO_2 (Nitrogen dioxide)

Year

2010 – 2022

2010 2012 2014 2016 2018 2020 2022

Annual mean concentration of particulate matter of less than 10 microns of diameter (PM_{10}) [µg/m³] and of less than 2.5 microns ($PM_{2.5}$) [µg/m³] and of Nitrogen Dioxide (NO_2) [µg/m³] in cities and localities.

WMO

GAW

GAW World Data Centres

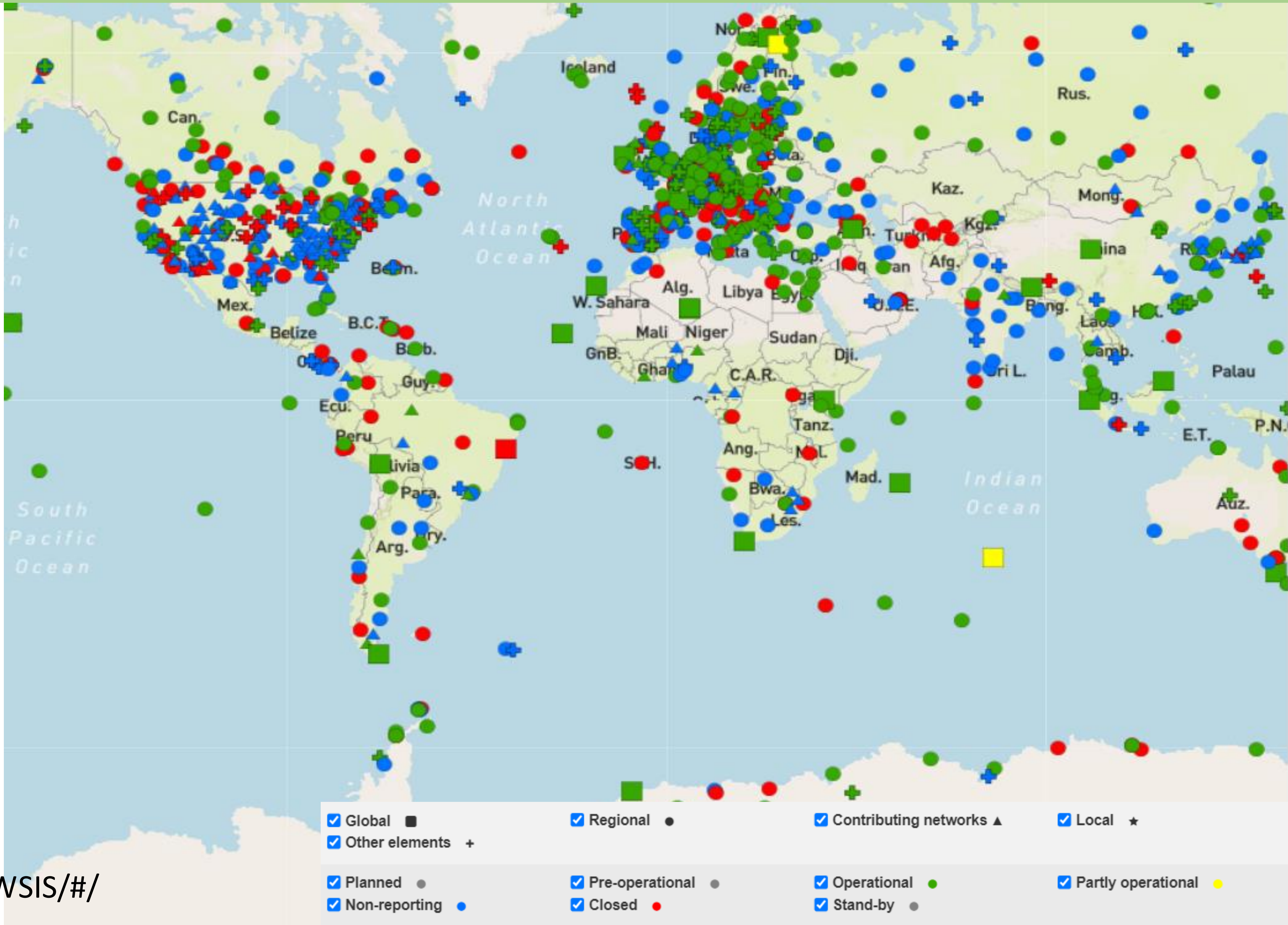
- WDC-RSAT (World Data Center for Remote Sensing of the Atmosphere)
- WDCA (World Data Centre for Aerosols)
- WDCGG (World Data Centre for Greenhouse Gases)
- WDCRG (World Data Centre for Reactive Gases)
- WOUDC (World Ozone and UV Data Centre)
- WRDC (World Radiation Data Centre)

Contributing networks data archives

- CASTNET (Clean Air Status and Trends Network)
- IMPROVE (IMPROVE Optical Aerosol)
- INDAAF (International Network to study Deposition and Atmospheric chemistry in AFrica)
- NADP (National Atmospheric Deposition Program)
- TCCON (Total Carbon Column Observing Network)

Other relevant data archives

- EMEP (EMEP)
- NDACC (NDACC Data Center)



https://gawsis.meteoswiss.ch/GAWSIS/#/

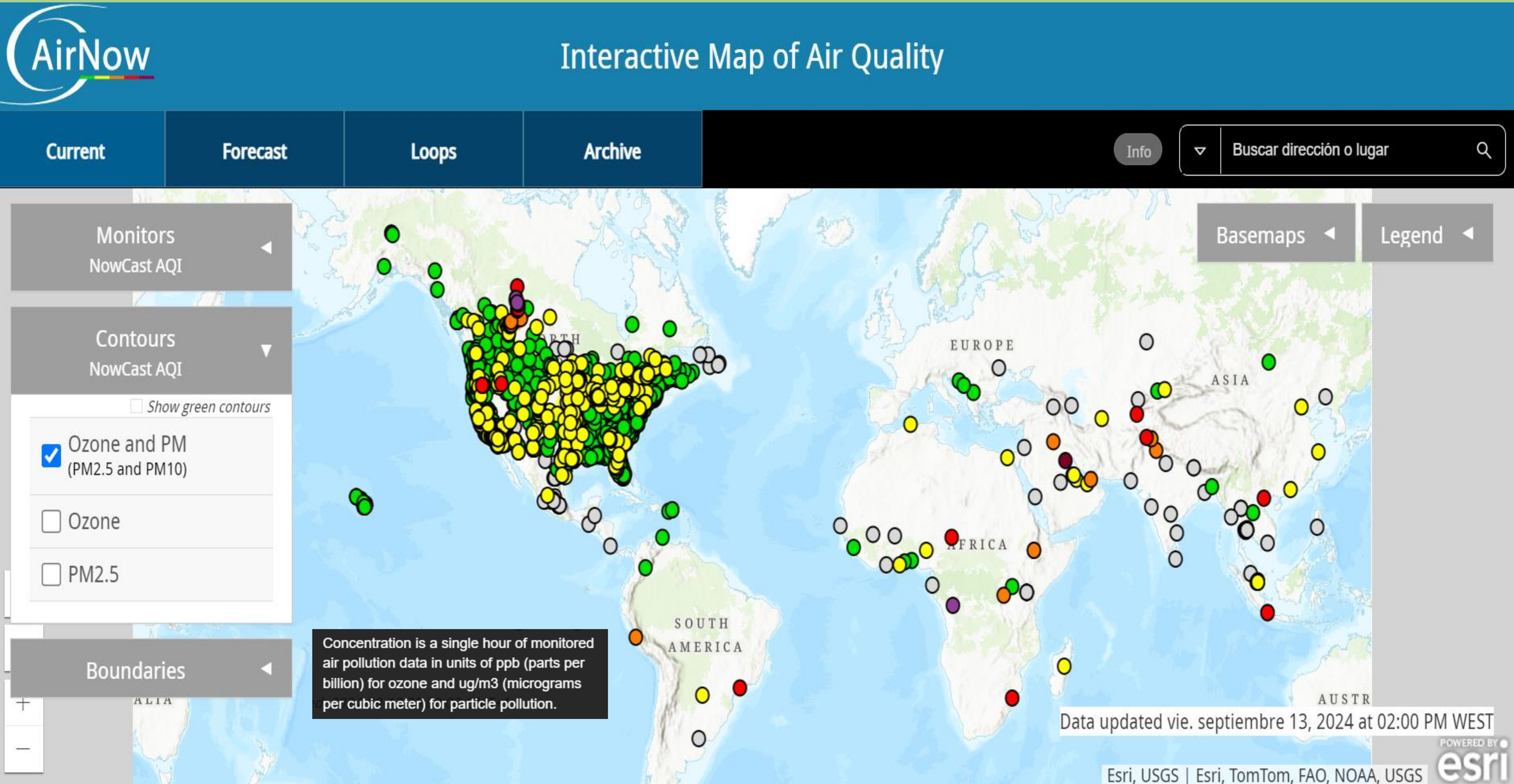
Air Quality Index (AQI)

- An effective tool for informing the public about exposure and risks involved.
- Governments worldwide develop and implement air quality standards which set official exposure limits to help and assess air quality levels.
- These standards are usually in line with the WHO or US EPA guidelines.

AQI Basics for Ozone and Particle Pollution

Daily AQI Color	Levels of Concern	Values of Index	Description of Air Quality
Green	Good	0 to 50	Air quality is satisfactory, and air pollution poses little or no risk.
Yellow	Moderate	51 to 100	Air quality is acceptable. However, there may be a risk for some people, particularly those who are unusually sensitive to air pollution.
Orange	Unhealthy for Sensitive Groups	101 to 150	Members of sensitive groups may experience health effects. The general public is less likely to be affected.
Red	Unhealthy	151 to 200	Some members of the general public may experience health effects; members of sensitive groups may experience more serious health effects.
Purple	Very Unhealthy	201 to 300	Health alert: The risk of health effects is increased for everyone.
Maroon	Hazardous	301 and higher	Health warning of emergency conditions: everyone is more likely to be affected.

AQI from US EPA


AirNow
Interactive Map of Air Quality
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Forecast
Loops
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Buscar dirección o lugar
Monitors
NowCast AQI
Contours
NowCast AQI
Show green contours
Ozone and PM
(PM2.5 and PM10)
Ozone
PM2.5
Boundaries
Basemaps
Legend
EUROPE
ASIA
AFRICA
SOUTH AMERICA
AUSTR
Concentration is a single hour of monitored air pollution data in units of ppb (parts per billion) for ozone and ug/m3 (micrograms per cubic meter) for particle pollution.
Data updated vie. septiembre 13, 2024 at 02:00 PM WEST
Esri, USGS | Esri, TomTom, FAO, NOAA, USGS
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3.

Remote Sensing AQ Measurements

I. Criteria pollutants

  a) Aerosol Optical Depth (AOD)

II. Monitoring Networks

Criteria Air Pollutants

- Columnar aerosol content as measured with Remote Sensing instrumentation

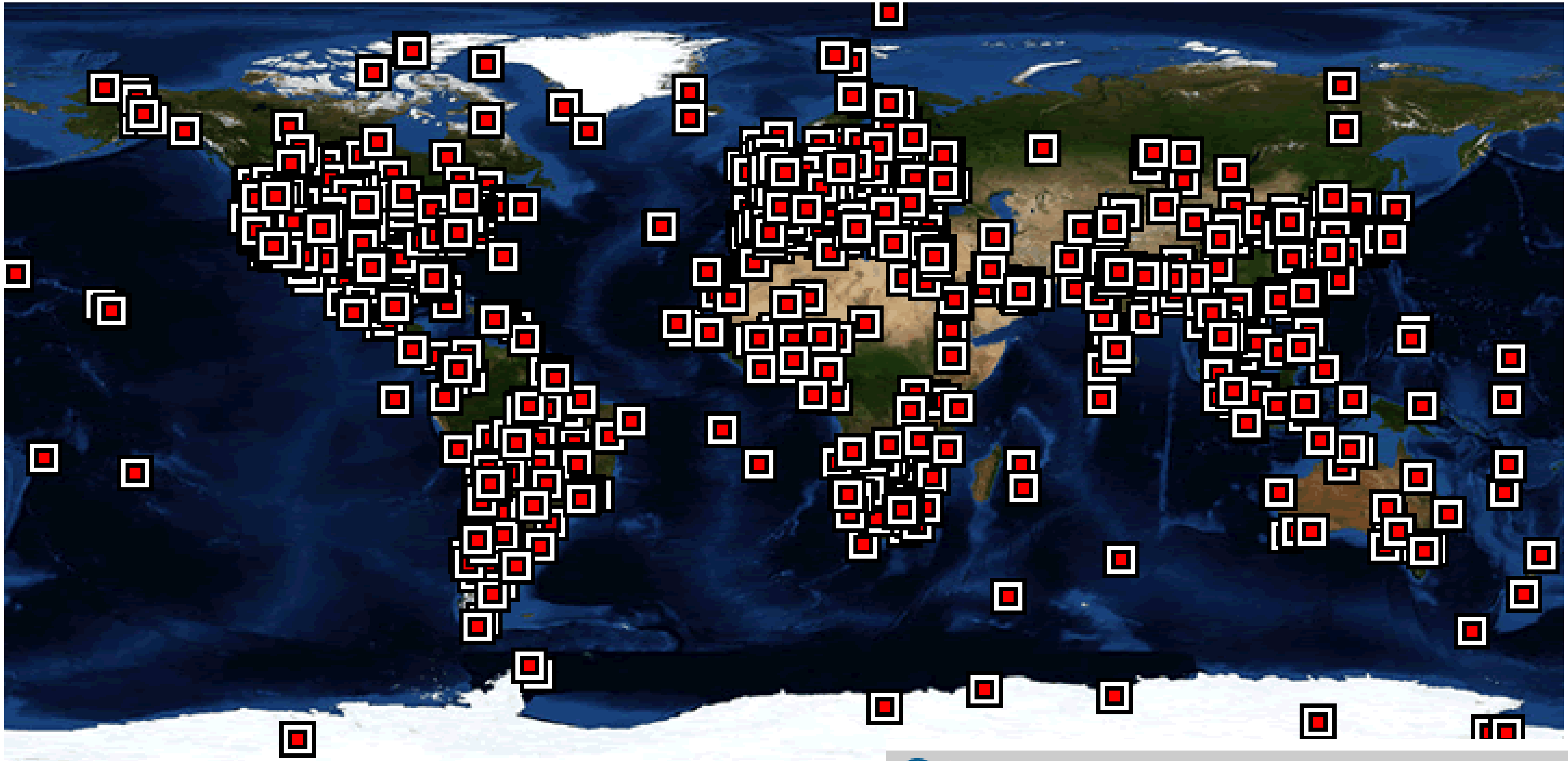
Particulate matter (AOD)

Reference Method (RM): Sun – Lunar – Stellar photometry

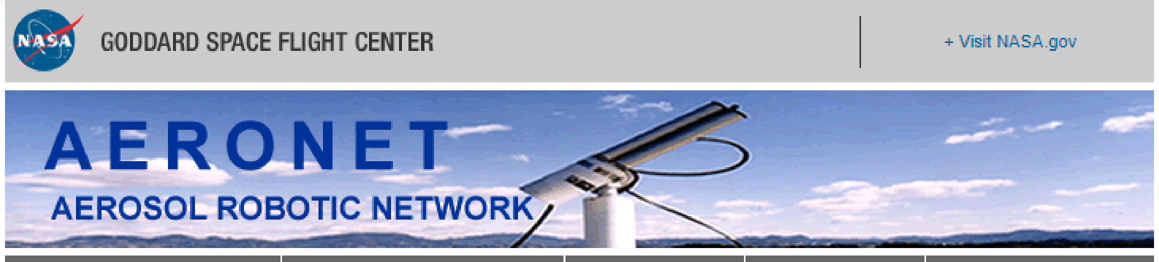
Aerosol Optical Depth AOD

AERONET

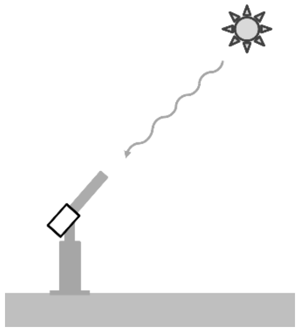
https://aeronet.gsfc.nasa.gov



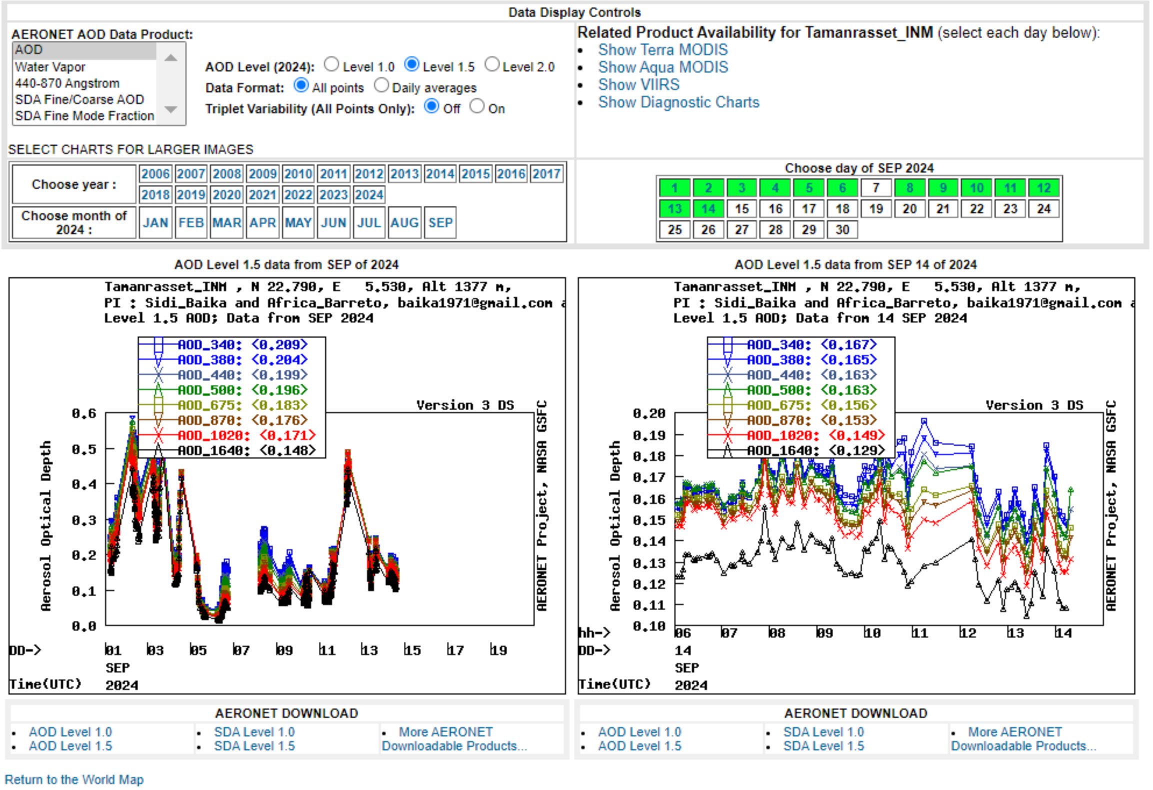
- Aerosol monitoring at global scales + satellite validation
- Over 500 stations over the world (sun + moon measurements)
- Highly standarized: instrumentation and processing

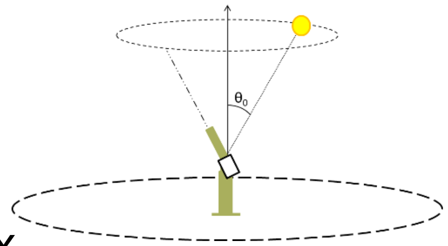


AERONET Products

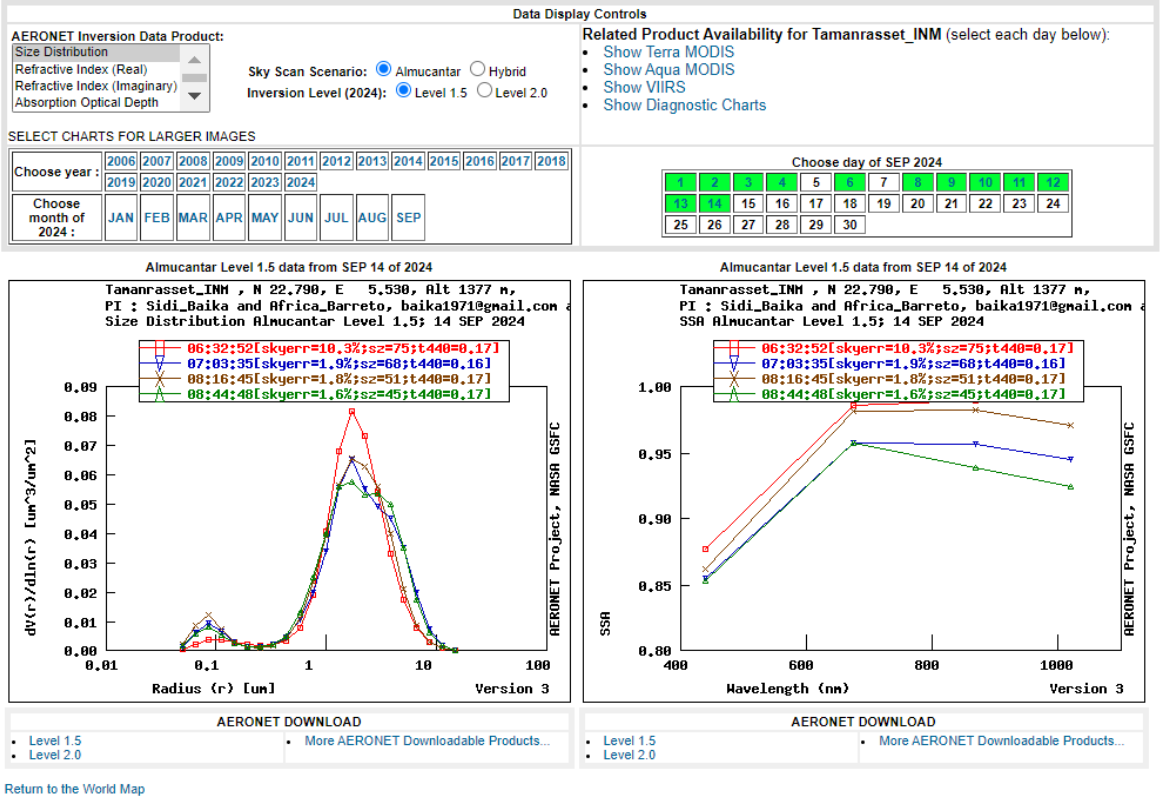


Direct SUN-MOON: AOD, AE, PWV

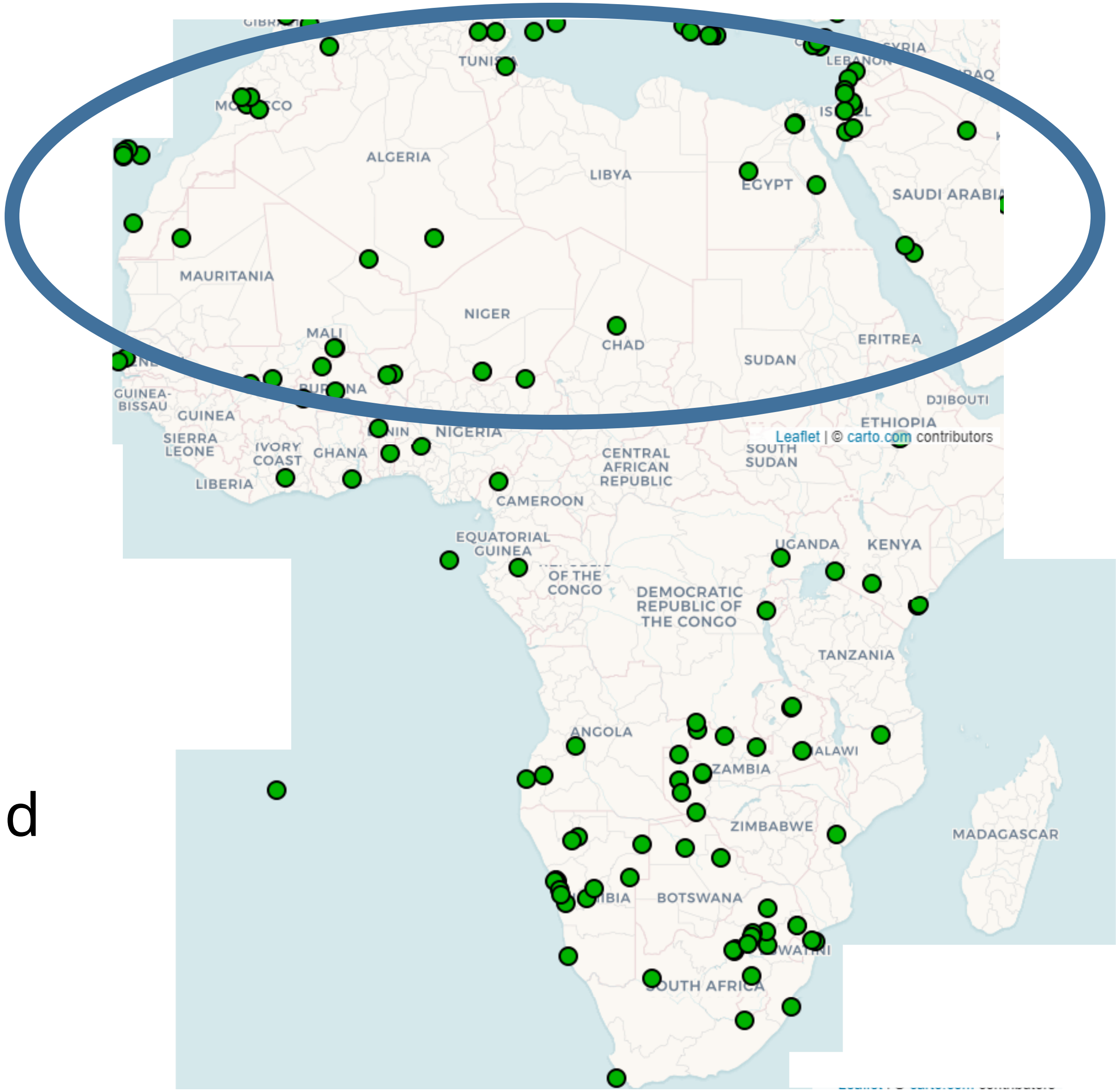




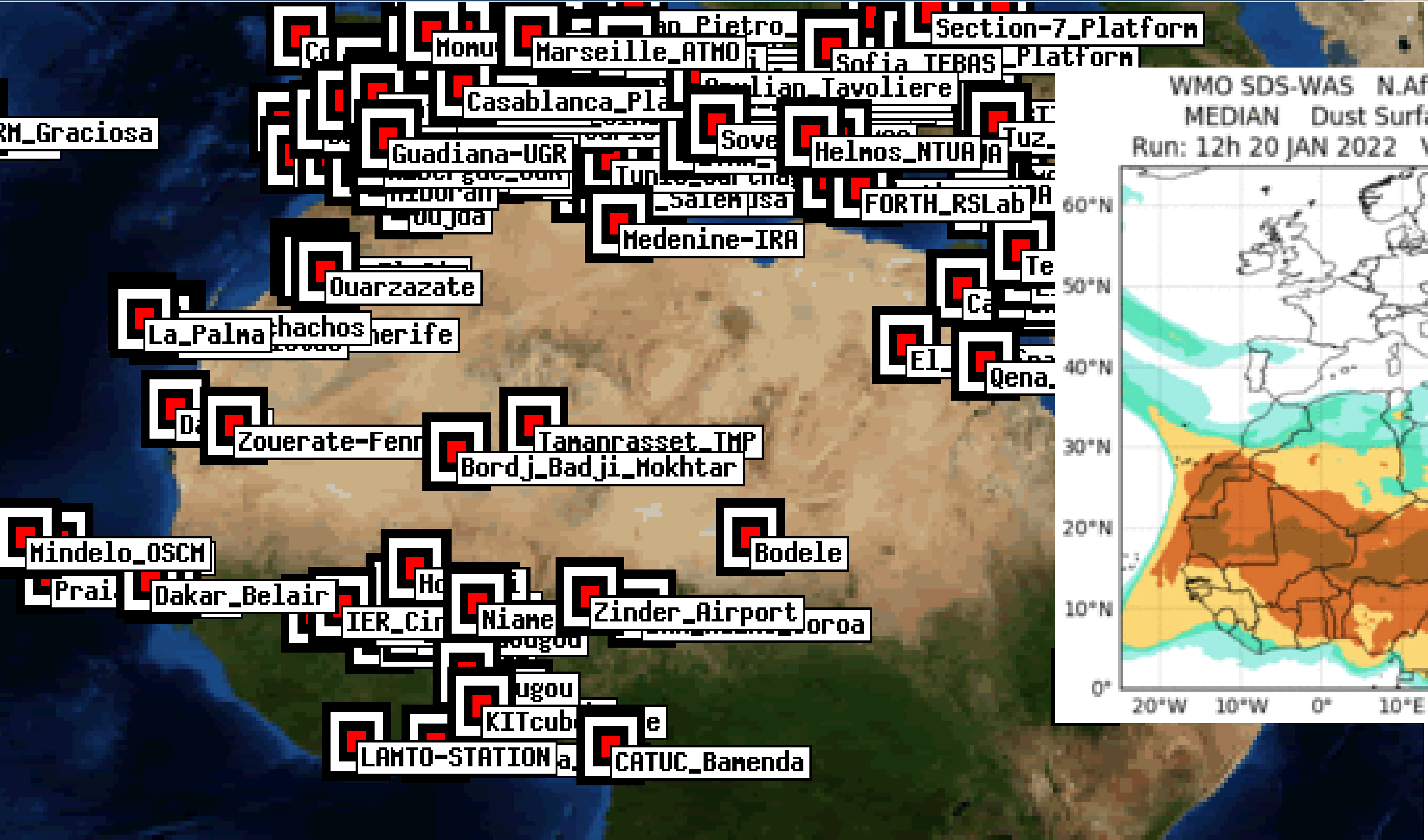
Inversion SUN-SKY: Aerosol Size Distribution, SSA, Refractive Index, ….

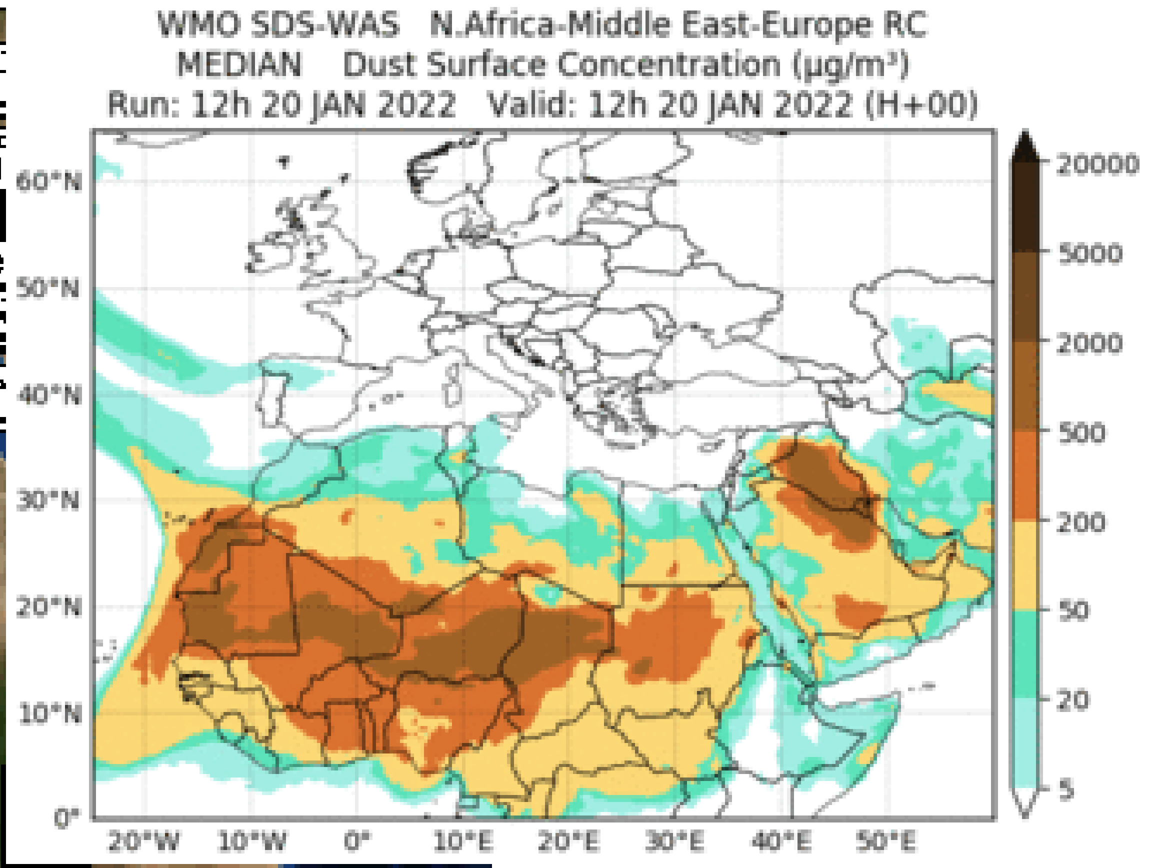


AERONET over Africa



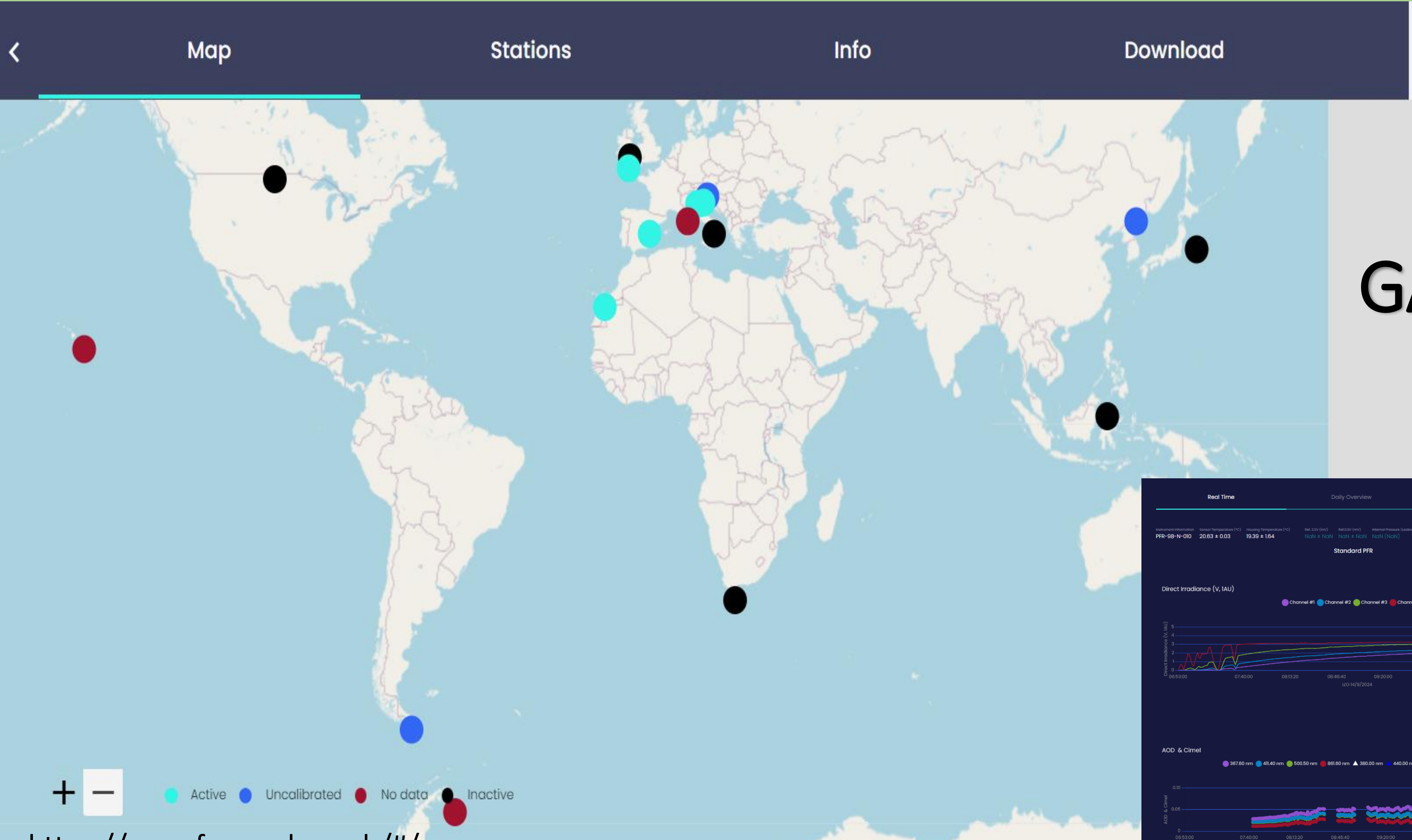
- 100 stations over the continent
- Important gaps over the most important dust source
- Actives: Algeria, Morocco, Tunisia and Egypt





Barcelona Dust Regional Center

GAW-PFR



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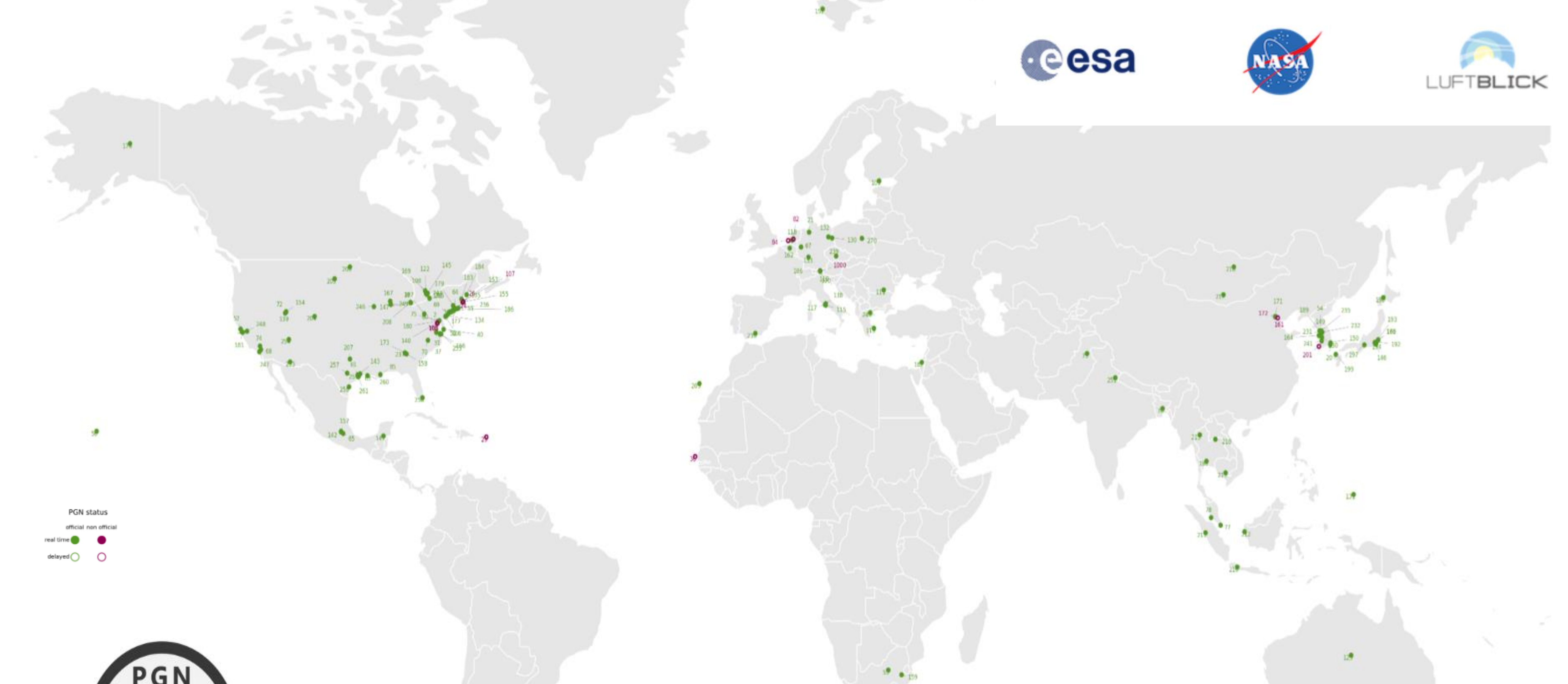

PANDONIA GLOBAL NETWORK

Reference Measurements of Atmospheric Composition

Network for the Detection of Atmospheric Composition Change

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- Campaign

Instrument

- Brewer
- Dobson
- FTIR Spectrometer
- Lidar
- Microwave Radiometer
- Sonde
- UV/Visible Spectrometer
- UV Spectroradiometer

AERONET - *updated September 2021*
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4.

Status of Air Quality Observations over Africa

Air Quality Monitoring over África

Key facts: rapid urbanization, population growth and social inequity.

⁂ In Africa, AQ it is a major contributor to premature deaths and other health problems.

⁂ Africa is currently the least urbanized continent, but is the region experiencing the fastest rate of urbanisation in the world (inequalities and “urbanisation of poverty”)

⁂ Persistent poverty and air pollution are closely connected (social inequity - environmental degradation)

⁂ AQ status dependent economic development stage: **lower economies** (lack of AQM capability), **lower-middle economies** (Senegal, Kenya, Ghana, Nigeria, Zimbabwe, Tanzania or Mozambique with partial monitoring, coverage and reliability) to **emerging economies** (Egypt or South Africa with a relatively comprehensive air quality data monitoring system)

Air Quality Monitoring over África

Table 1.3: Synopsis of country AQM capability

Country	Key pollutants	Sulphur content of diesel [ppm]†	Inspection & maintenance for mobile sources	Emissions inventory	Routine monitoring	Health impact assessment	Projects or plans with AQ benefit ongoing	Estimated stage of air quality management
Benin	SO_2, NO_x, NO_2, O_3, CO, HCs, PM.	5,000	No	No	No	Two studies	Yes	Early*
Botswana	SO_2,NOx, NO_2, O_3, CO, HCs	500	No	Yes, but incomplete	Yes	Few qualitative studies	No	Intermediate**
Burkina Faso	PM, SO_2, HCs, NOx, SO_2	5,000	No	Yes, but elementary	No	No	Yes	Early*
Burundi	Pesticides, Persistent Organic Pollutants, Pb	5,000	No	No	No	No	No	Absent[#]
Cameroon	PM, CO, HCs, NOx, SO_2.	5,000	Yes	No	No	No	No	Initial[ǂ]
Congo-Brazzaville	PM, CO, HCs, NO_x	10,000	No	No	No	No	No	Absent[#]
Congo-Kinshasa	PM, SO_2, NO_2, CO, HCs	3,500	No	No	No	No	Yes	Initial[ǂ]
Ethiopia	PM_{10}, CO, SO_2, O_3	10,000	No	No, but source apportionment for PM_{10}	No, only campaign	No	No	Early*
Gabon	PM, CO, HCs, NOx, SO_2	8,000	No	No	No	No	No	Absent[#]
Ghana	SO_2, NO_2, O_3, CO, PM_{10}, manganese	5,000	In progress	No	Yes	Three studies	Yes	Advanced[+]
Guinea	PM_{10}, $PM_{2.5}$, NO_2, SO_2, formaldehyde, benzene	5,000	No	No	No	No	No	Absent[#]
Kenya	PM, CO, HCs, NOx, SO_2	10,000	No	No	No	No	Yes	Initial[ǂ]
Liberia	PM, CO, NOx, SO_2.	5,000	No	No	No	No	No	Absent[#]
Madagascar	PM, CO, HCs, NOx, SO_2	5,000	Yes, mobile sources	No	Yes	No	Yes	Intermediate**
Malawi	PM, SO_2, CO, NOx, HCs	5,000	No	No	No	No	No	Absent[#]
Mali	PM, NOx, CO, HC, VOC, SO_2, Pb	5,000	No	Yes, for transport	No	No	No	Initial[ǂ]
Mauritius	PM, NOx, CO, SO_2	2,500	No	No	No	No	Yes	Initial[ǂ]
Mozambique	PM_{10}, $PM_{2.5}$, Black Carbon, SO_2, NOx, CO_2, O_3.	5,500	No	Being developed	No	No	Yes	Early*
Nigeria	CO_2, CO, NO_X, O_3, SO_2, TSP, PM_{10}	5,000	No	Yes, of 1990	No, one non operational station	No	Yes	Early*
Rwanda	Not identified	5,000	No	No	No	No	No	Absent[#]
Senegal	PM_{10}, $PM_{2.5}$, CO	5,000	No	No	Being initialised	No	Yes	Initial[ǂ]
South Africa	PM_{10}, $PM_{2.5}$, NOx, SO_2, O_3, CO,Pb	500	Yes	Yes	Yes	Yes	Yes	Comprehensive[++]
Swaziland	Not identified	500	No	Qualitative	No	No	Yes	Early*
Tanzania	PM, CO, NO_2, SO_2, O_3, Pb	5,000	No	No	Yes	No	Yes	Early*
Togo	Not identified	5,000	No	Yes, initial	No	No	No	Initial[ǂ]
Uganda	PM, CH_4, H_2S, NH_3, dioxins and furans, HCs, NO_x, SO_x, re-suspended dust	5,000	No	No	No	No	Yes	Initial[ǂ]
Zambia	SO_2, NO_2, PM, black smoke, dust, CO, CO_2 and odours	7,500	No	Yes, initial, in copper belt	Yes	No	Yes	Intermediate**
Zimbabwe	SO_2, NO_2, PM, CO, VOCs	5,000	Yes, for stationary sources	No	Yes	Anecdotal evidence	No	Intermediate**

† Source: PCFV (2007); [#] Absent = None of the topics addressed; [ǂ] Initial Any one topic addressed; * Early = Any two topics addressed; ** Intermediate = Any three topics addressed; [+] Advanced = Any four topics addressed; [++] Comprehensive = All topics addressed.

Air Quality Monitoring over Sub-Saharan Countries

Table 1.4: Tools that can be applied in SSA countries to enhance AQM capability

Country	Air quality standard setting	Initial Emissions inventory*	Routine monitoring**	Health impact assessment†
Benin	WHO guidelines	Rapid inventory assessment (RIA)	Hybrid network	More studies needed using REA
Botswana	National standards exist	Completion and update by RIA	Is being performed	Rapid epidemiological assessment (REA)
Burkina Faso		Completion and update by RIA	Hybrid network	
Burundi	WHO guidelines	Rapid inventory assessment		
Cameroon				
Congo-Brazzaville				
Congo-Kinshasa				
Ethiopia				
Gabon				
Ghana	National standards exist		Is being performed	More studies needed
Guinea	WHO guidelines		Hybrid network	Rapid epidemiological assessment
Kenya	Exist			
Liberia	WHO guidelines			
Madagascar			Is being performed	
Malawi			Hybrid network	
Mali		Completion and update by RIA		
Mauritius	National standards proposed	Rapid inventory assessment		
Mozambique	WHO guidelines	Completion and update by RIA		

* RIA = Rapid Inventory Assessment; ** HN = Hybrid Network; † REA = Rapid Epidemiological Assessment

Table 1.4 (continued): Recommendation to enhance AQM capability

Country	Air quality standard setting	Initial Emissions inventory*	Routine monitoring**	Health impact assessment†
Nigeria	WHO guidelines	To be updated and amended by RIA	Hybrid network	Rapid epidemiological assessment
Rwanda		Rapid inventory assessment		
Senegal			Is being initialised	
Swaziland			Hybrid network	
Tanzania			Is being performed	More studies needed
Togo		To be enhanced by RIA	Hybrid network	Rapid epidemiological assessment
Uganda		Rapid inventory assessment		
Zambia		To be amended for vehicles	Revamping or hybrid network	
Zimbabwe		Rapid inventory assessment	Is being performed	

* RIA = Rapid Inventory Assessment; ** HN = Hybrid Network; † REA = Rapid Epidemiological Assessment

Air Quality Monitoring in South Africa

- South Africa has its own guidelines and standards for air quality (comprehensive and stringent), which are adapted to its local conditions and specific needs (in line with many international recommendations, including WHO)

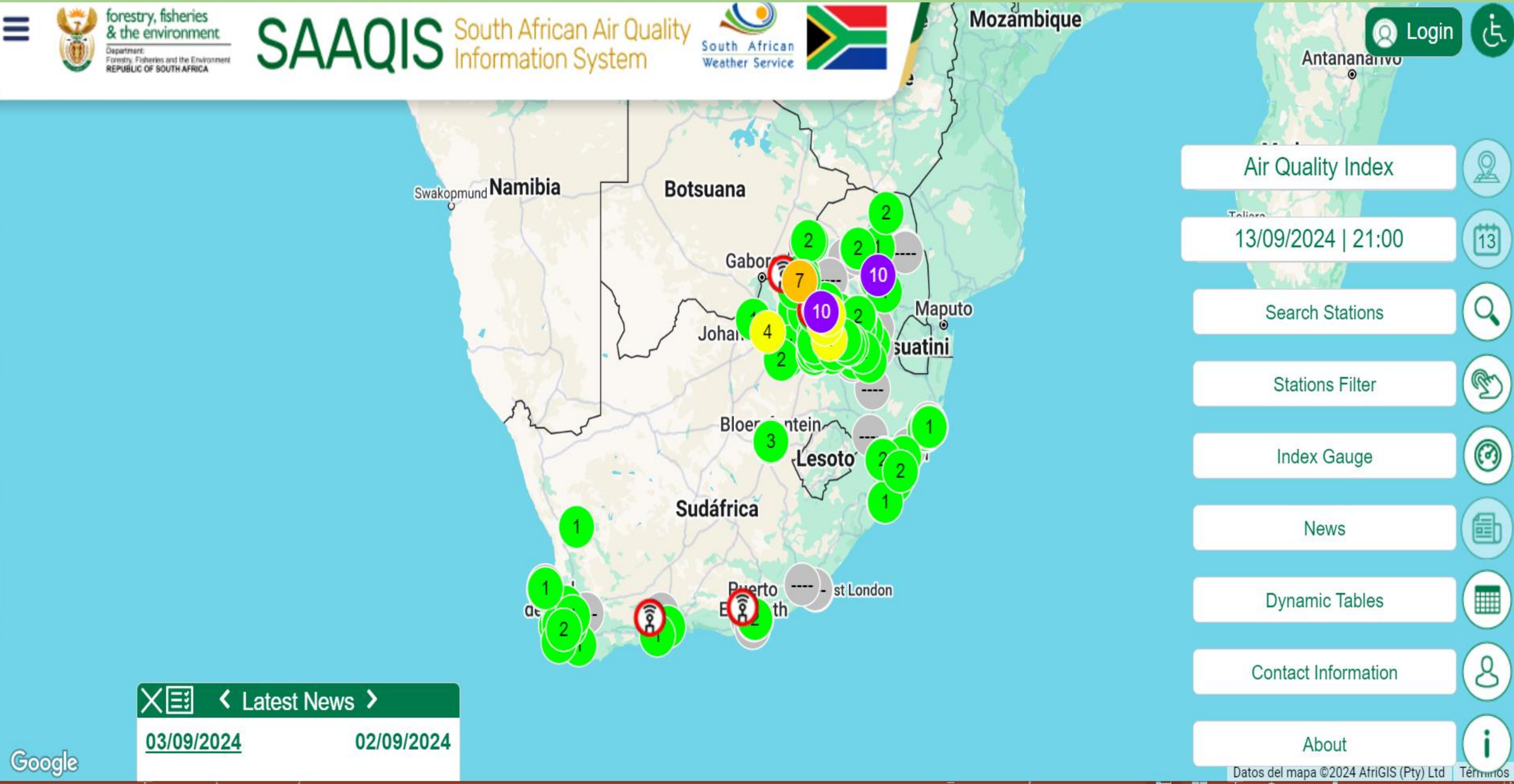
- The air quality guidelines in South Africa are primarily defined by the **National Ambient Air Quality Standards (NAAQS)**

- Use of reference sensors and low-cost sensors in a hybrid AQM Network

- **SAAQIS (South African Air Quality Information System)** ensures that all instruments are calibrated and maintained according to international standards to guarantee the quality of air quality information in South Africa

- SAAQIS is exemplary at disseminating air pollution information to the public (near-real time visualized and downloaded at https://saaqis.environment.gov. za)

- To facilitate the interpretation of air quality data, SAAQIS produces an aggregated air quality index (1 to 10) associated to different categories: good, moderate, unhealthy, very unhealthy and hazardous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South African Air Quality Information System
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SAAQIS South African Air Quality Information System

South African Weather Service

Mozambique Antananarivo Login

Dynamic Tables - Dynamic Table

Station Name	Time	PM10 µg/m3	PM2.5 µg/m3	NO2 ppb	NOX ppb	NO ppb	SO2 ppb	O3 ppb	CO ppm	Benzene ppb	H2S ppb
Secunda	13/09/2024 21:00	67.107	23.151	12.37	14.062	1.692	3.385	32.166	0.35		6.213
Diepkloof-NAQI	13/09/2024 21:00										
PTA West	13/09/2024 21:00	70.43	45.109	0	0.011	0.04	7.634		3.426		
Delmas MP	13/09/2024 21:00	0.523		0	0	0		3.259	0.869		
Hendrina - SAWS	13/09/2024 21:00	75.21	5.224	31.539	35.729	4.19	3.586	24.231	0.532		
Karoo-NAQI	13/09/2024 21:00	1.065	1.002						0.033		
Kliprivier	13/09/2024 21:00			20.253	26.515	6.262	3.09	13.462	0.51		
Lephalale-NAQI	13/09/2024 21:00	96.602	40.359	37.031	90.407	53.376	3.792		0.897		
Middelburg SAWS-NAQI	13/09/2024 21:00	57.305	51.073	49.459	97.24	47.781	3.357	1.441	1.185		
Middelburg MP	13/09/2024 21:00	106.833	26.167	28.166	32.698	4.537		30.222	0.946	1.005	
Mokopane	04/09/2024 16:00	43.117	6.059	4.618	6.492	1.874	0.628	41.169			
Rosslyn-NAQI	13/09/2024 21:00	426.393	144.265				4.462				
Sebokeng	13/09/2024 21:00	65.5	31.859	10.86	11.063	0.417	2.951	39.798	0.299		

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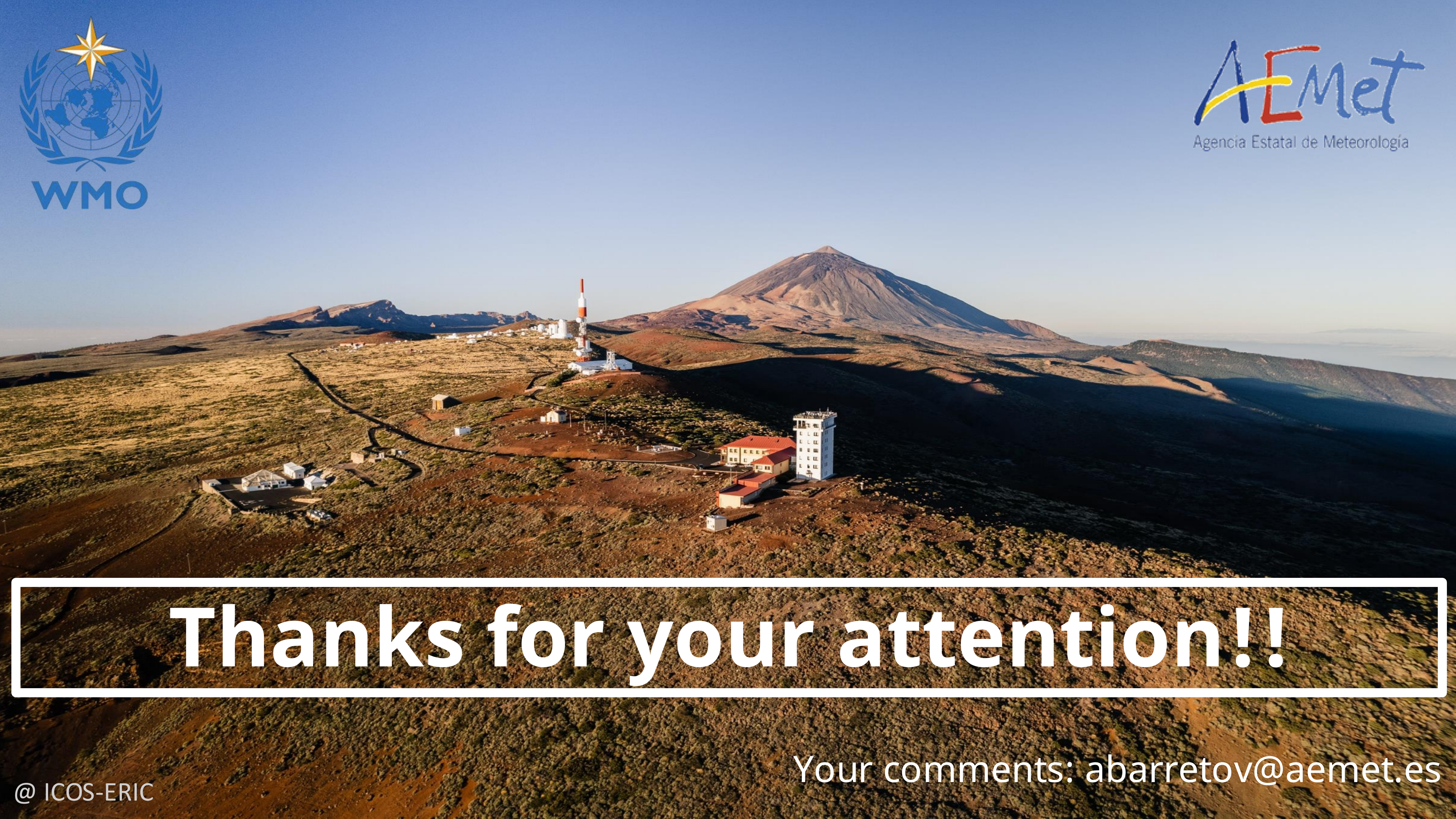
- Open access to a vast repository (2 million records of raw and calibrated real-time, historical, and forecast air quality data)
- Increased access to air quality data evidence to help them tackle urban air quality and achieve cleaner air objectives.

REFLECTIONS



Thanks for your attention!!
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