MÉTHODES D'OBSERVATION DE LA PUSSIÈRE

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WMO SDS-WAS CREWS Training Course for Africa: Chad (Online, Oct 16 2024)

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Outline

I. Why measuring mineral dust

II. Air Quality Aspects

III. In-Situ Measurements

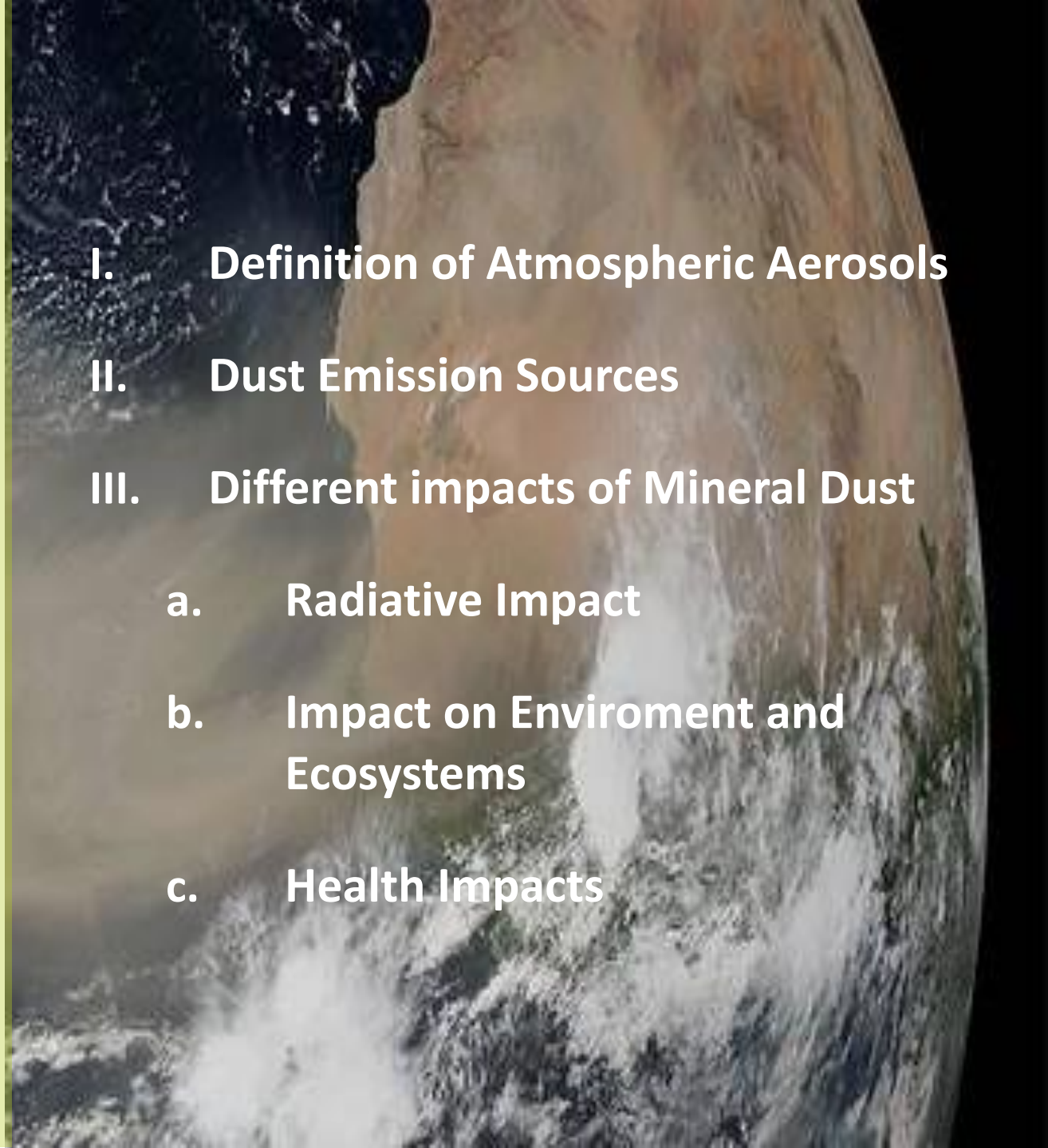
IV. Remote Sensing Measurements

V. Status of Air Quality Observations over Africa

IV. Status of Dust Observations over Africa

1.

Why Measuring Mineral Dust?



I. Definition of Atmospheric Aerosols

II. Dust Emission Sources

III. Different impacts of Mineral Dust

   a. Radiative Impact

   b. Impact on Enviroment and Ecosystems

   c. Health Impacts

DEFINITION OF ATMOSPHERIC AEROSOLS

Atmospheric Aerosols

"Solid or liquid particles in suspension in the air"

Natural and Anthropogenic

Sea salt, mineral dust, volcanic aerosols, bacteria, virus, pollen

Industrial emissions, vehicle exhaust, biomass/forestal burning – carbonaceous, sulphates, nitrates or other organic compounds-

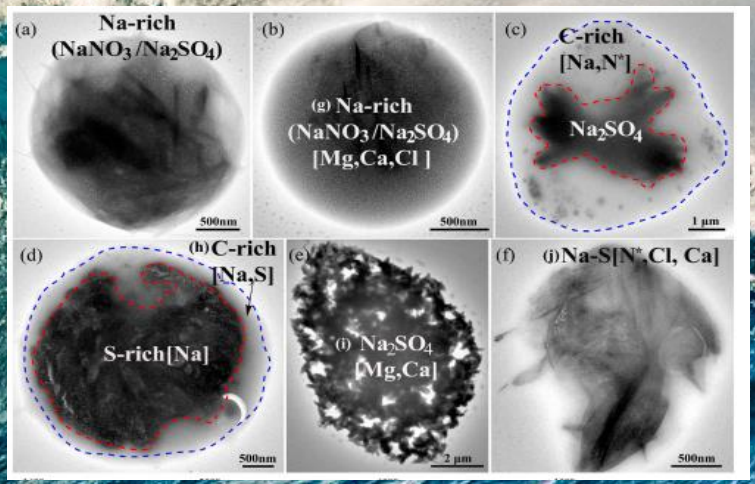
DEFINITION OF ATMOSPHERIC AEROSOLS

Natural – Mineral dust

- Emission governed by mechanical processes (wind)
- Importance of mineralogy (changeable from sources)
- Irregular shape: effect in light polarización
- Dominance of coarse mode
- Important radiative effect

Natural – Sea Salt

Chi et al. (2015)

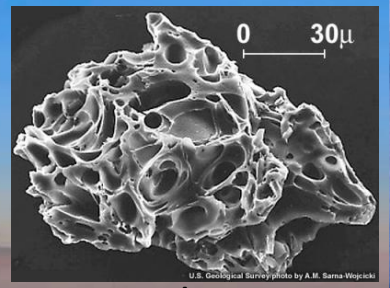


- Composition: NaCl, sulfates & org/inor soluble compounds
- Highly hygroscopic – spherical shape
- MBL
- Important radiative effect

DEFINITION OF ATMOSPHERIC AEROSOLS

Natural – Volcanic Aerosols

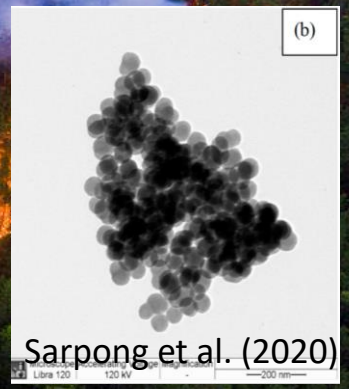
- Ash (Si, Al, Fe oxides), gases (SO2, H2S, CO2…) & WV
- Important radiative effect
- Size distribution bimodal (sulfates & ash).



Ash

Natural/Anthropogenic – Biomass Burning

- Carbonaceous (BC + POA/SOA), sulfates, nitrates & volatile compounds
- BC: important radiative effect

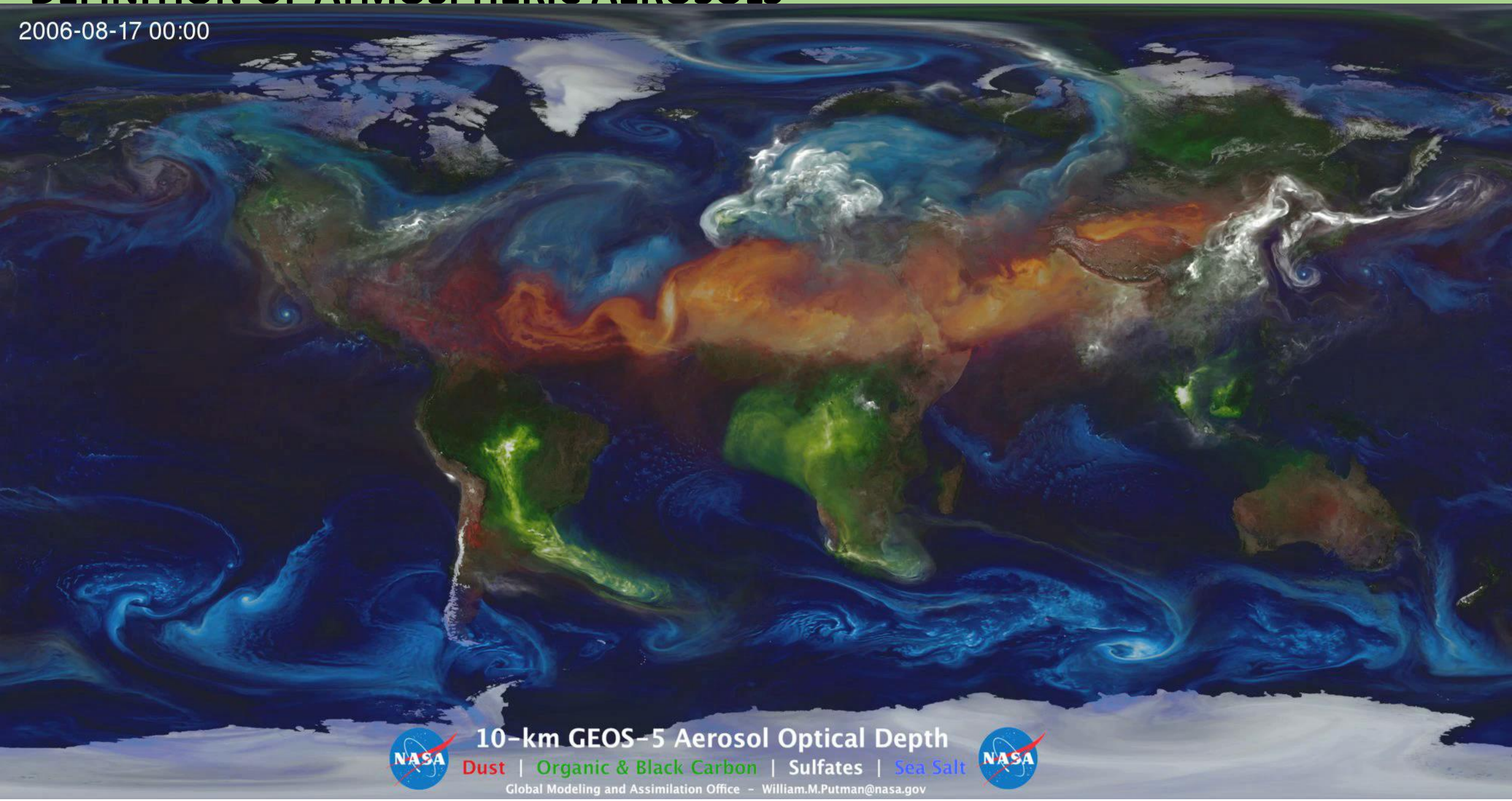


Sarpong et al. (2020)

Anthropogenic – Industrial & traffic

- Different sources: coal mining or combustion of fossil fuels
- Fine mode: sulfates, nitrates and carbonaceous

DEFINITION OF ATMOSPHERIC AEROSOLS



DUST EMISSION SOURCES IN NORTH AFRICA: SAHARA AND SAHEL

Edited from Vandenbussche et al. (2020)

Hot spots for dust emission in the Sahara Region: PALEOLAKES

1. Bodelé Depression (≈44.5%)
2. Central Sahara (Adrar des Ifhogas and the Aïr Mountains)
3. Central Algeria (north of the Hoggar mountains and south-east towards the Libya / Niger / Chad border)
4. Central-east of Sudan, in the Nile River Basin

Hot spots for dust emission in the Sahel Region: ALLUVIAL DEPOSITS

1. Mali-Niger border
2. Southern Mauritania
3. Mali east of the Mauritanian border

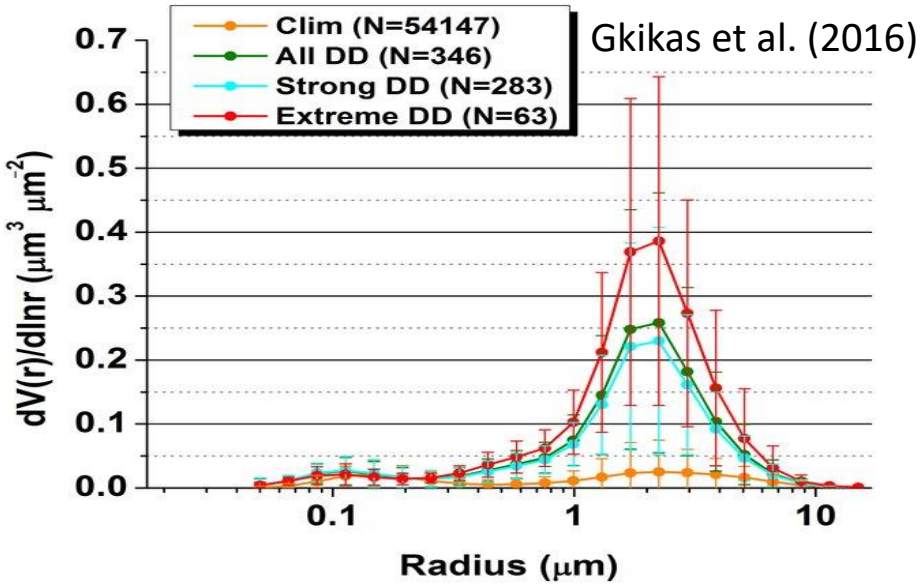
DIFFERENT IMPACTS OF MINERAL DUST

Typical ranges in the size of mineral dust particles

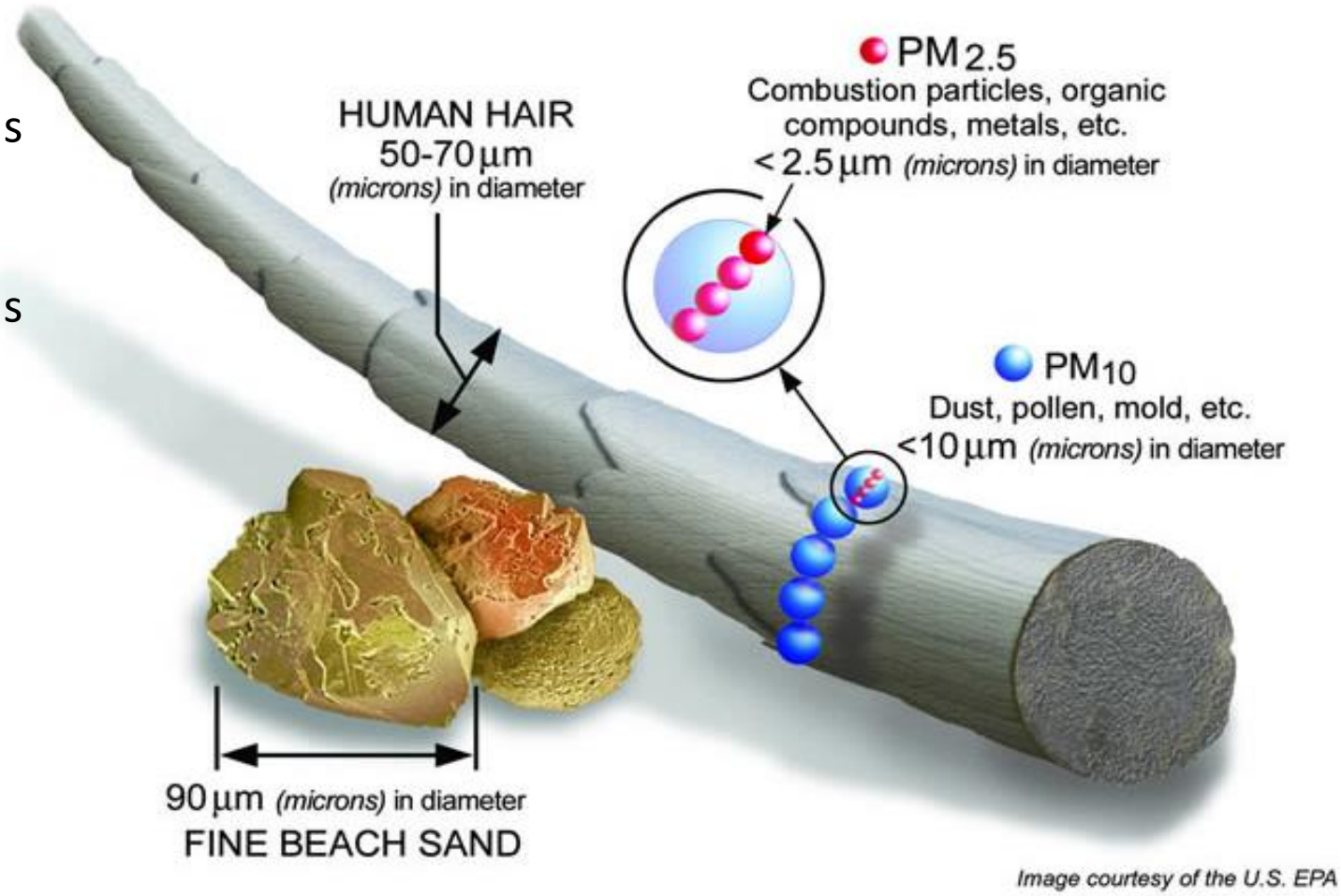
In terms of Air Quality: Particulate Matter PM

PM_{10} mass concentration (µg/m³) of all aerosols smaller than 10 µm (particles with Ø < 10 µm)

$PM_{2.5}$ mass concentration (µg/m³) of all aerosols smaller than 2,5 µm (particles with Ø < 2,5 µm)

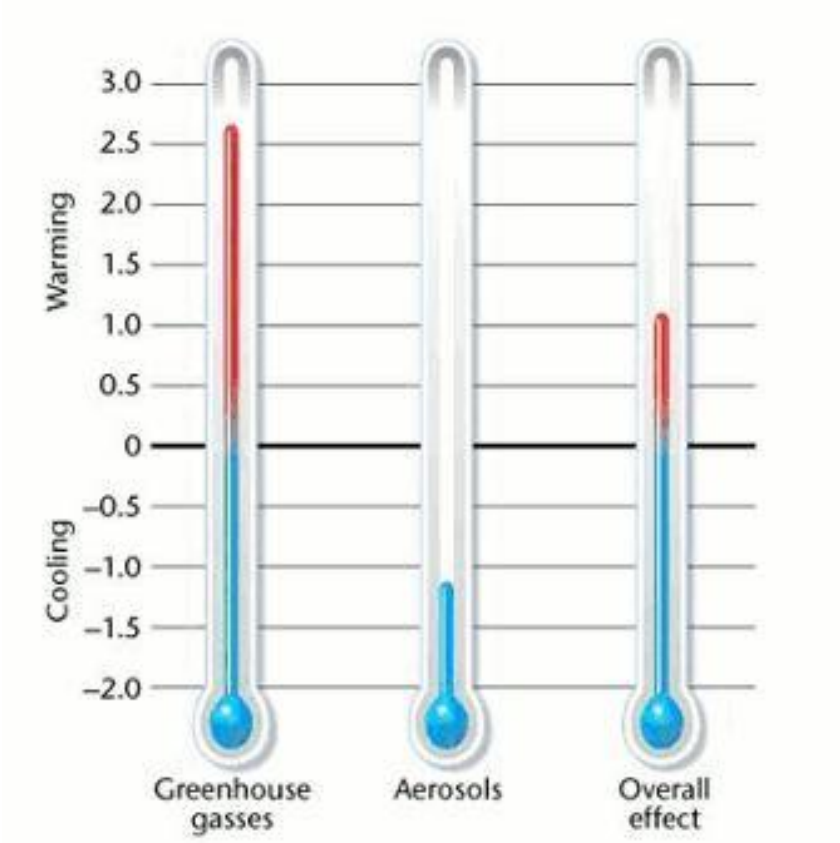


Gkikas et al. (2016)



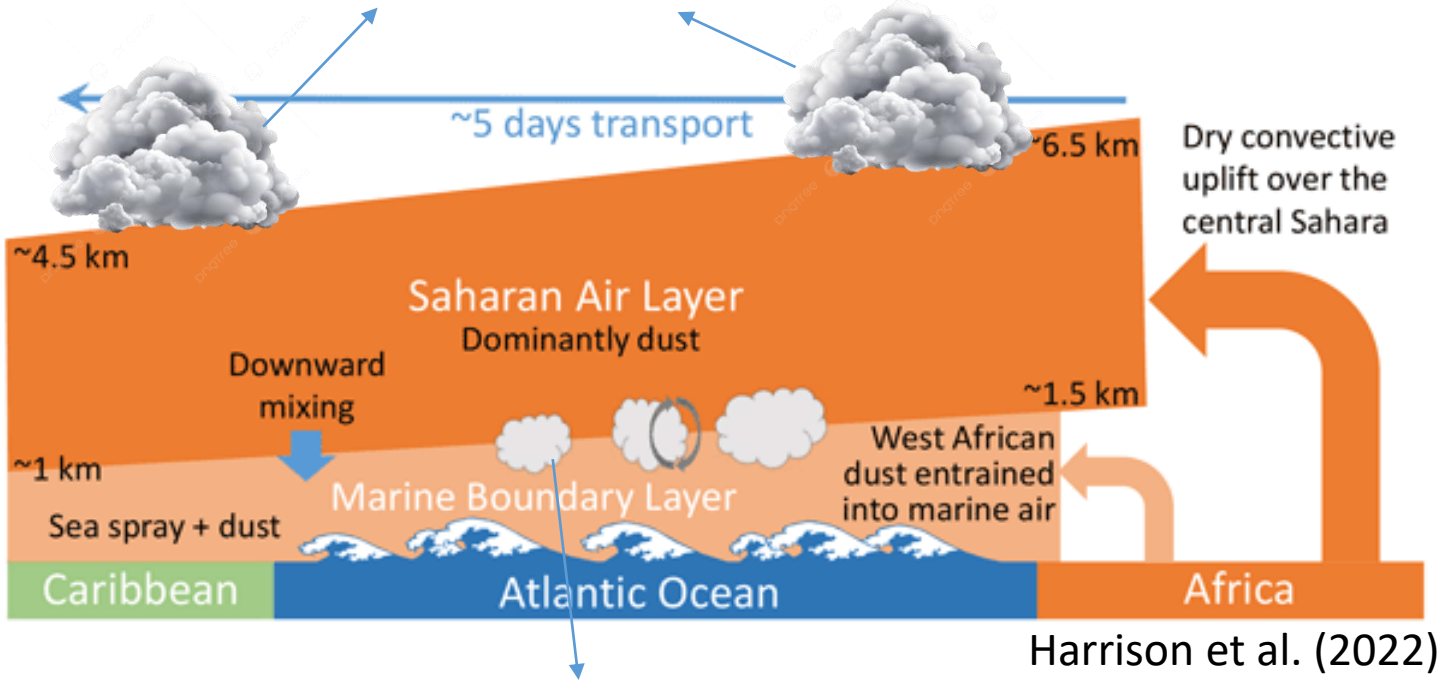
DIFFERENT IMPACTS OF MINERAL DUST

Radiative impact (direct) + Efect on cloud formation (indirect)



The overal effect of mineral dust is cooling the system

Mid-level clouds can form in the upper part of the SAL where the dust may promote primary ice formation



Harrison et al. (2022)

Relatively shallow clouds tend to form at the top of the MBL

DIFFERENT IMPACTS OF MINERAL DUST

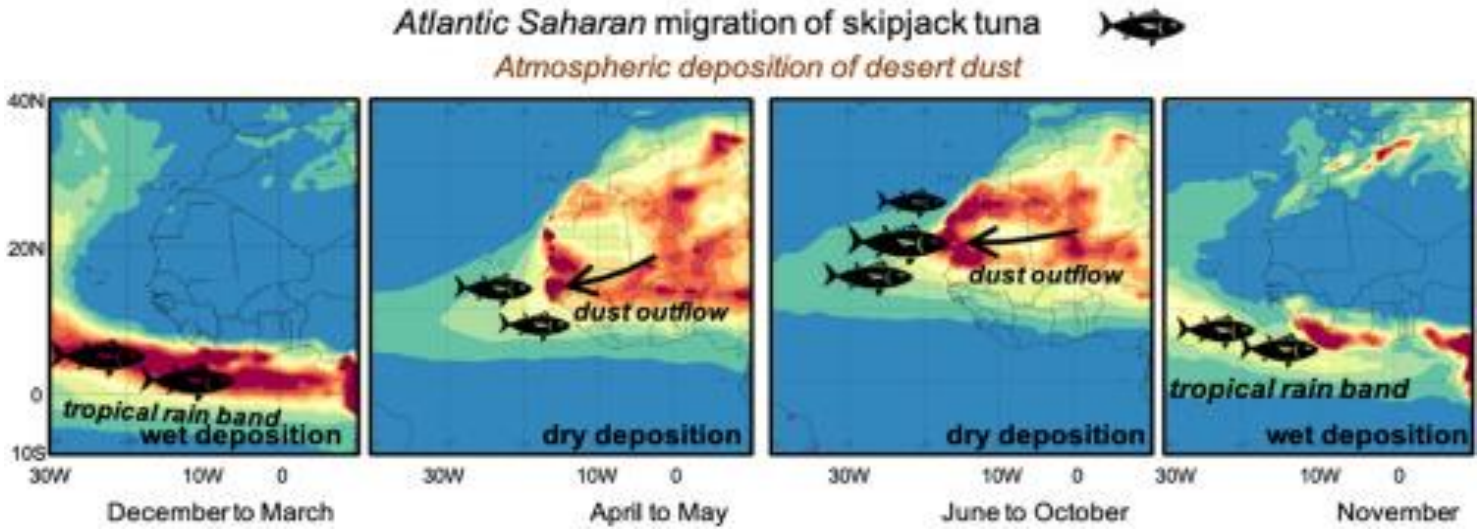
Environment and Ecosystems Impacts

Dust is able to:

- ❖ Provide essential nutrients such as iron, phosphorus and nitrogen into surface waters
- ❖ Long-range transport of these components
- ❖ Increase iron solubility – bio-availability

Phosphorus – Amazon Rainforest fertilization

Fe, P and N into Surface waters – Impact on migration patterns



Rodríguez et al. (2023)

DIFFERENT IMPACTS OF MINERAL DUST

Aerosols and Health

- Particles suspended in the air enter our body when we breathe
- Associated hazard depend on chemical composition and where they deposit within the respiratory system
- These effects include **infectious diseases** (meningitis and valley fever), **respiratory problems** or **cardiovascular diseases**, sometimes even leading to cancer
- Inflamatory response – Oxidative stress – DNA damage – Cell death

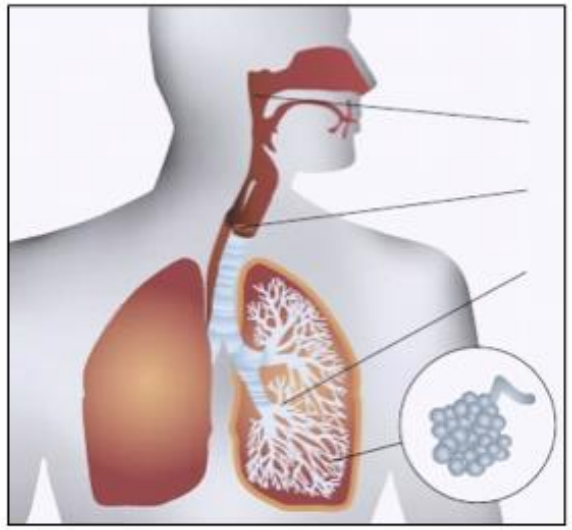
5-10 µm

3-5 µm

2-3 µm

1-2 µm

0.1-1 µm

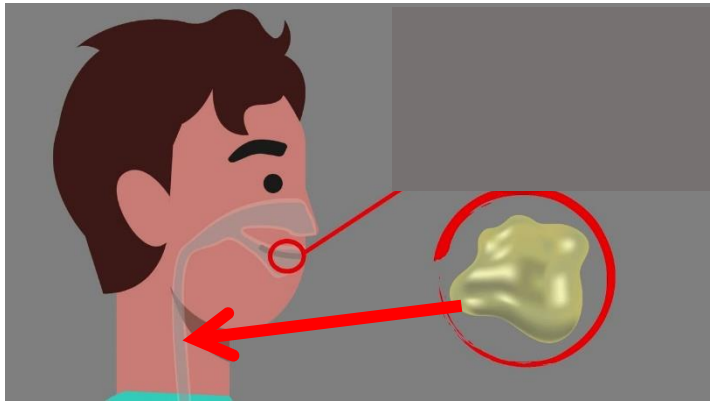


$PM_{2.5}$ + UFP (<1µm)

DIFFERENT IMPACTS OF MINERAL DUST

Some epidemiological evidence

Desert dust and cardiovascular diseases



Domínguez-Rodríguez et al. (2020, 2021)

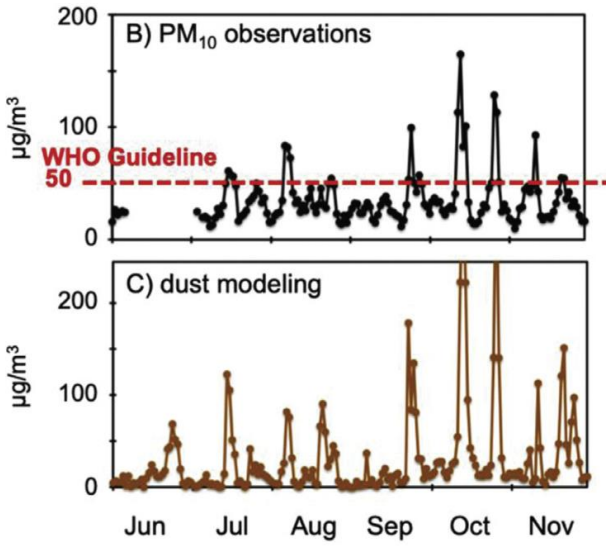
1 Each +1μg/m^3 of dust in PM_{10} is associated with an increase of: molecules biomarkers of inflammatory processes in the sputum of patients

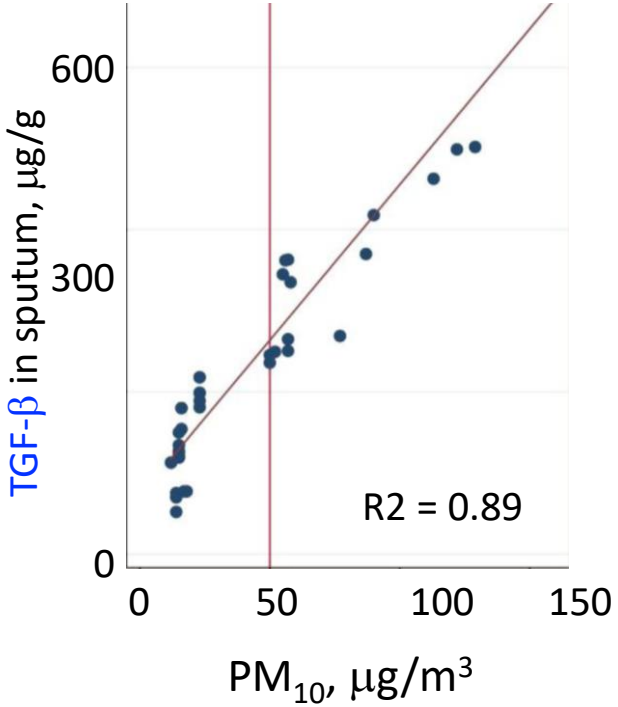
2 Each +10 μg/m^3 of dust in PM_{10} is associated with an increase of 2% in the risk of cardiovascular mortality

Health effects of dust worse when increasing dust concentration

3 2014-2017: 86% of in-hospital hearth failure mortality occurred in patients admitted during severe (> 50 μg/m^3) dust events

Inhalation of Saharan dust from the ambient air causes inflammation of the respiratory airways



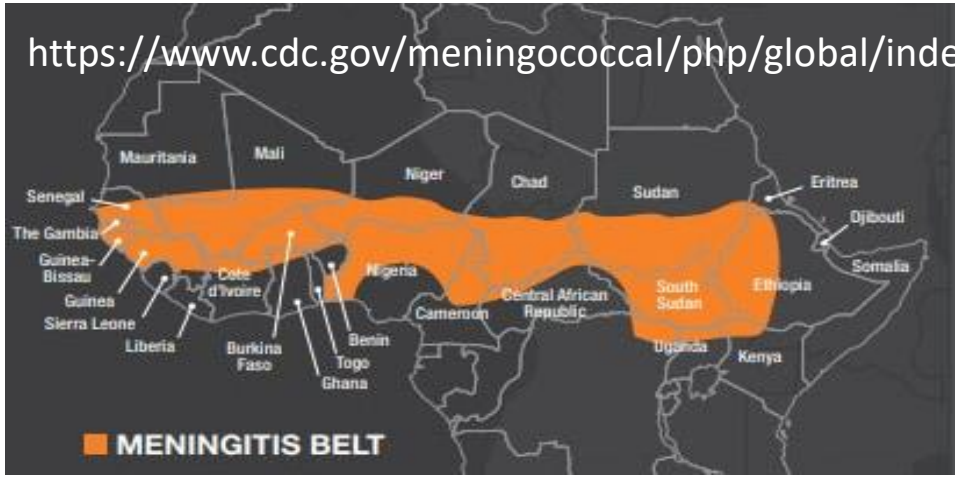


DIFFERENT IMPACTS OF MINERAL DUST

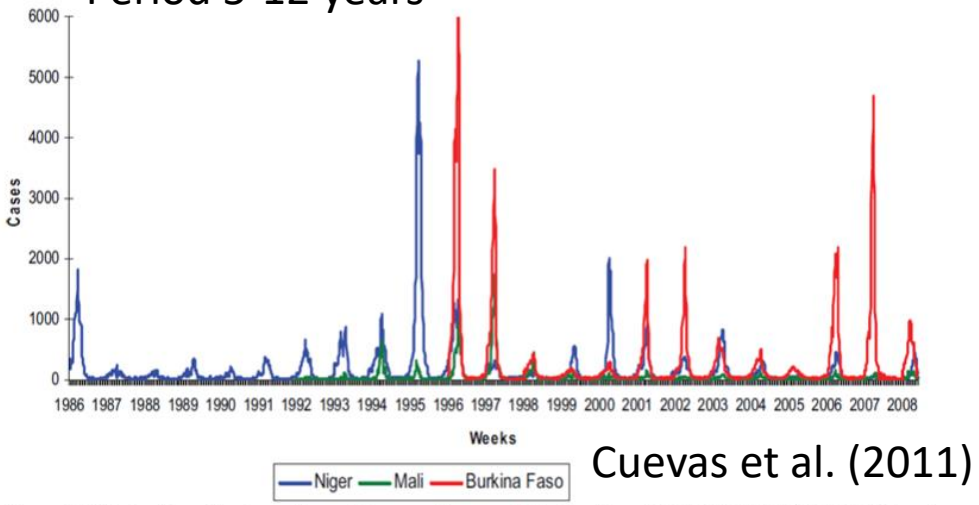
Some epidemiological evidence

Desert dust and meningitis belt

Meningococcal disease with the highest incidence in the 'meningitis belt' of sub-Saharan Africa under “favourable” conditions: dry, dusty conditions during the dry season (December to June).



Period 5-12 years

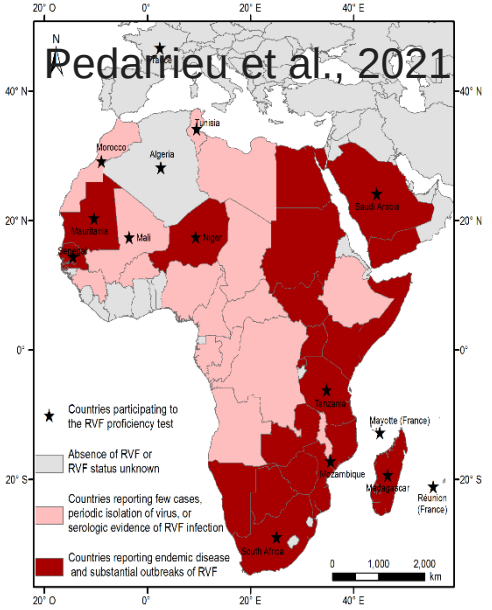


Cuevas et al. (2011)

Figure 6.1; Meningitis epidemic weekly evolution over the years in Burkina Faso (1997–2008), Mali (1992–2008), and Niger (1986–2008) (Djingarey et al., 2008).

Desert dust and Valley Fever occurrence

Fungal infection caused by fungi's spores commonly found in soil in specific regions stirred into the air by mechanical processes (farming, construction or dust patterns)



2.

Air Quality Aspects

I. Air Quality

II. International Standard Guidelines for AQM

III. Measurement Techniques

AIR QUALITY

What is air pollution?

- According to the World Health Organization (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

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)

Ozone (O_3)

Particulate matter

INTERNATIONAL STANDARDS GUIDELINES FOR AQ MONITORING

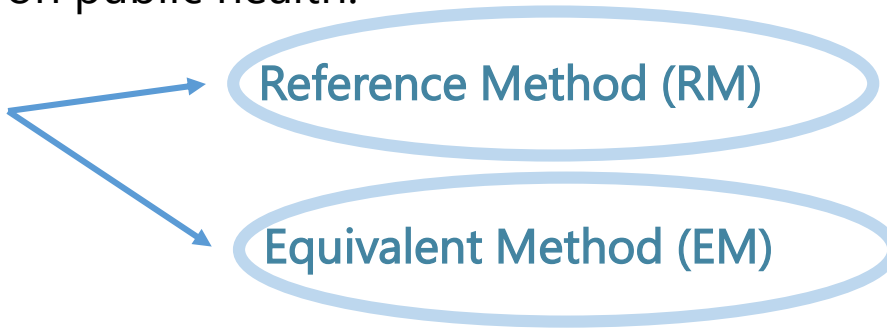
According to UNEP, there exist three internationally accepted guidelines for AQM networks or programs:

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

(Clear Air Asia, 2016)

These guidelines introduce:

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

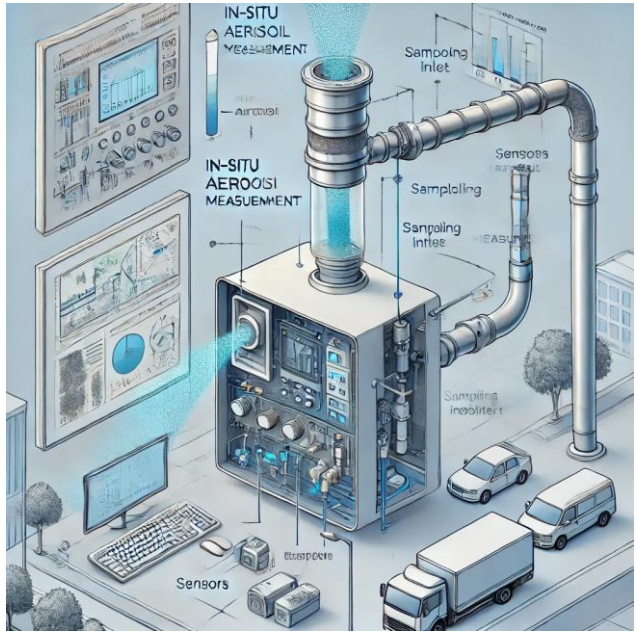


Scientifically developed to provide quantification for AQ regulations (NAAQS)

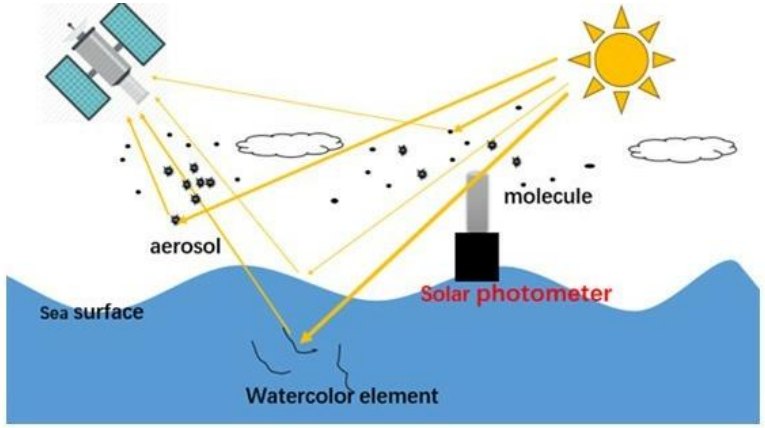
MEASUREMENT TECHNIQUES

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:

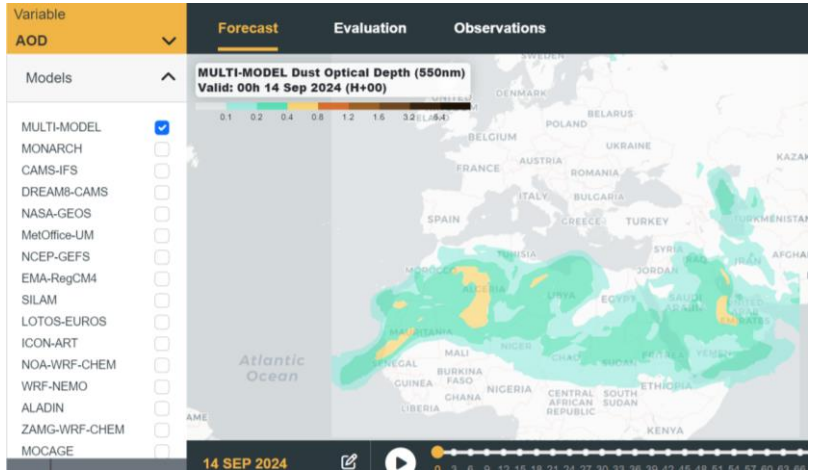
In-Situ



Remote Sensing

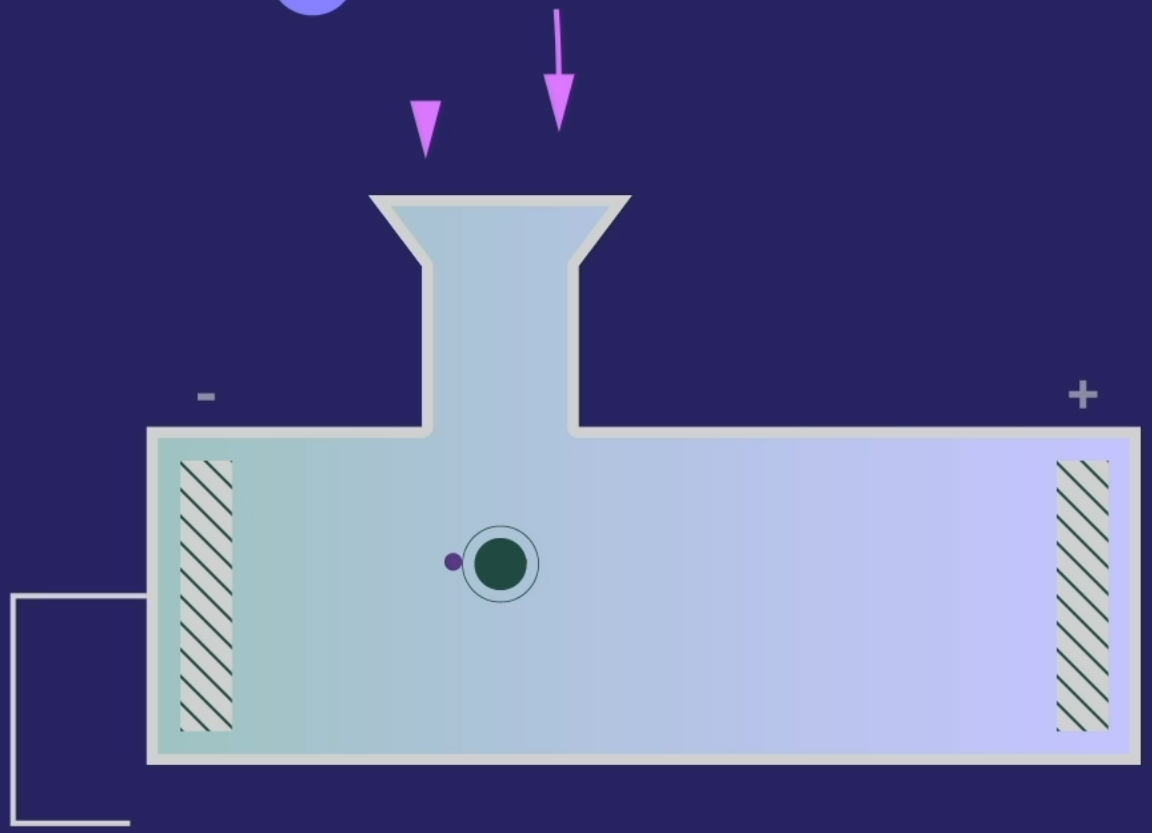


Numerical Models



MEASUREMENT TECHNIQUES

in situ approaches



3.

In-Situ Measurements

I. Criteria Pollutants

II. Principe of Operation of PM Measurements

III. International Standards Guidelines for AQM

IV. Monitoring Networks (Global)

V. AQ Index

CRITERIA AIR POLLUTANTS

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Ozone (O_3)

Particulate matter

Criteria Air Pollutants

- 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
- Important role of low-cost sensors (LCS)

Particulate matter (PM_x)

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

PRINCIPLE OF OPERATION OF PM MEASUREMENTS*

Optical Particle Counter (OPC)

This principle is based on **light scattering**.

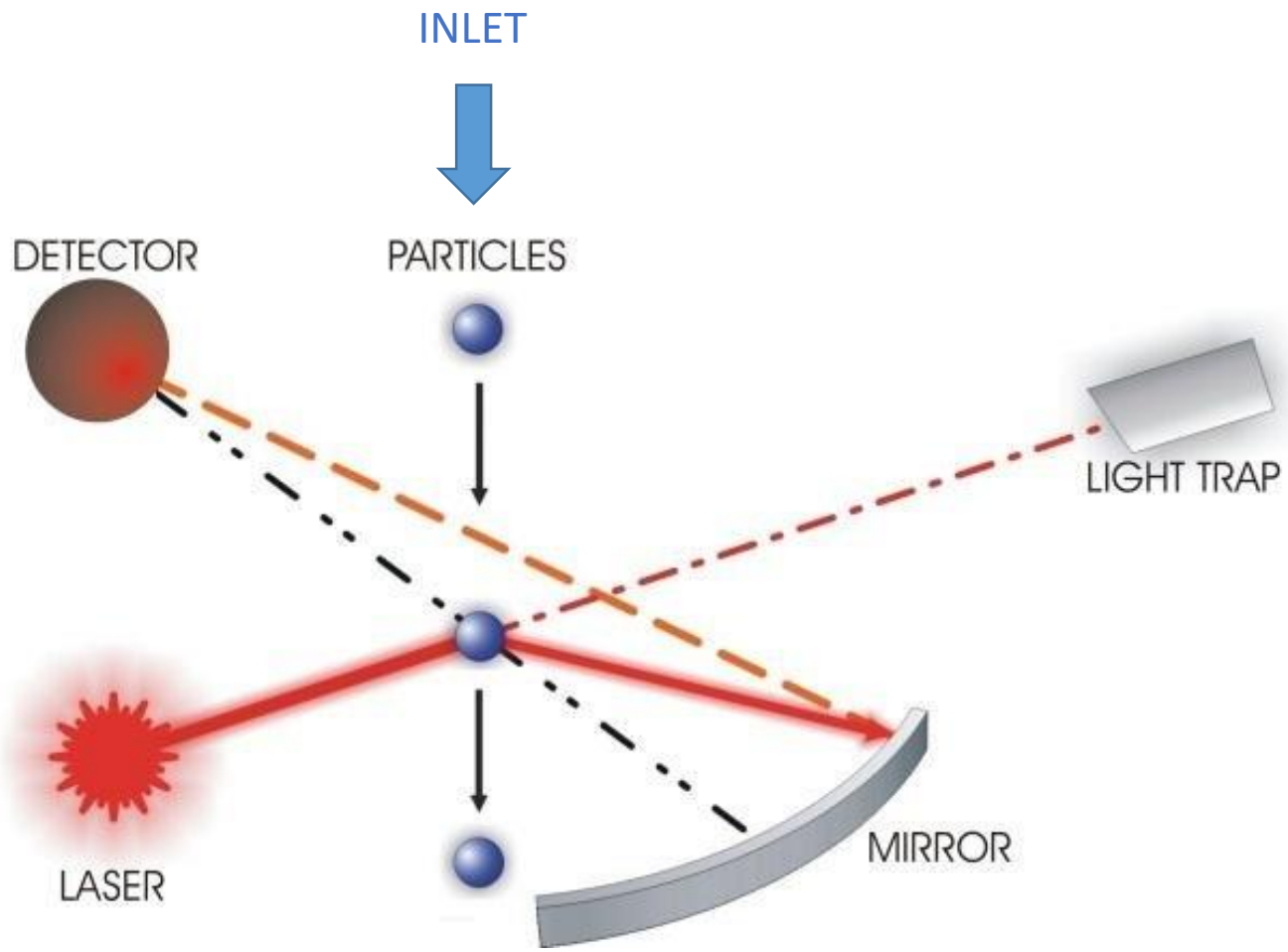
1. Air intake: The sensor uses a small fan or pump to draw air into the measurement chamber.

2. Light source: Inside the chamber, there is a light source, typically a laser diode or infrared LED, that illuminates the particles suspended in the air.

3. Light scattering: As particles ($PM_{2.5}$ or PM_{10}) pass through the light beam, they scatter the light in different directions.

4. Light detector: A photodetector or optical sensor measures the scattered light. The amount of scattered light is proportional to the size and number of particles present in the air.

5. Signal processing: The data from the detector are processed to calculate the concentration of particles in the air, expressed in micrograms per cubic meter ($\mu g/m^3$).



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: local circumstances (level of development, AQM capability, socioeconomic - political conditions, cultural and traditional issues, etc).

National Ambient Air Quality Standards (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

AQ MONITORING NETWORKS (Global)

openaq

Explore the data | Why air quality? | Why open data? | Partners | Developers | About | Donate

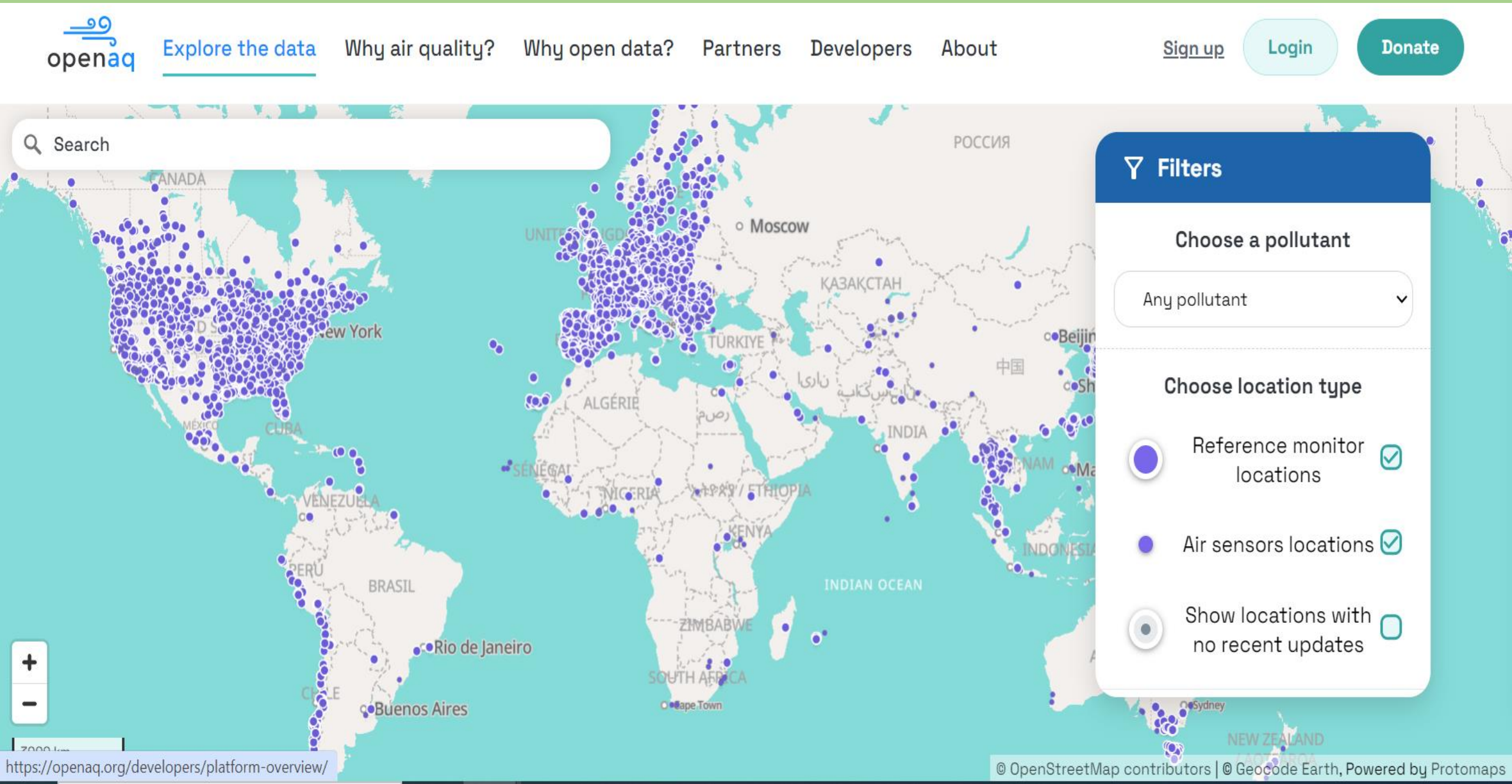
RGM + low-cost sensors (LCS)

Fighting air inequality through open data.

OpenAQ is a nonprofit organization providing universal access to air quality data to empower a global community of changemakers to solve air inequality—the unequal access to clean air.

Learn More

AQ MONITORING NETWORKS (Global)



AQ MONITORING NETWORKS (Global)

GAW

WMO

GAW World Data Centres

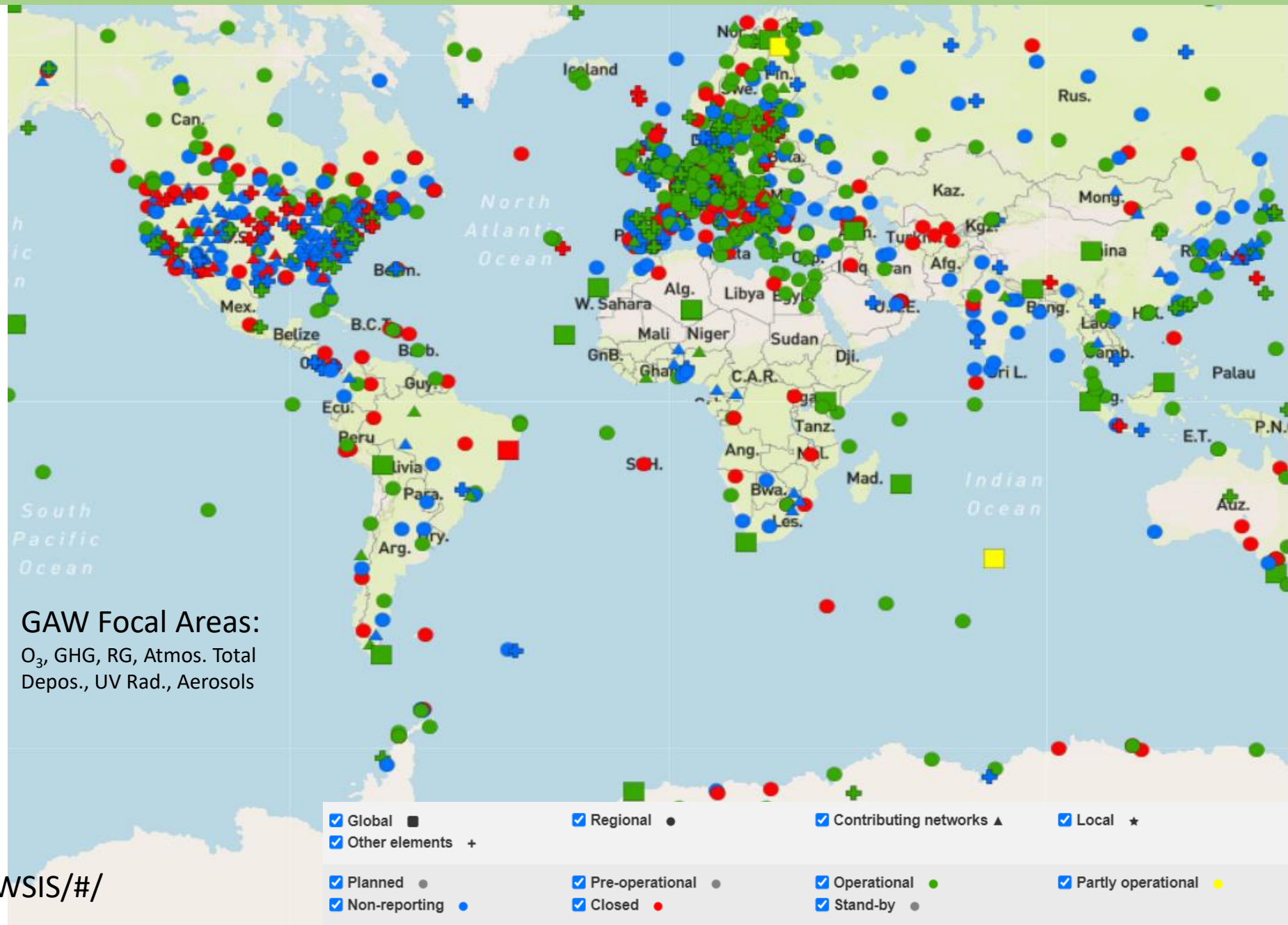
- WDC-RSAT (World Data Center for Remote Sensing of the Atmosphere)
- WDCA (World Data Centre for Aerosols)
- WDCGG (World Data Centre for Greenhouse Gases)
- WDCRG (World Data Centre for Reactive Gases)
- WOUDC (World Ozone and UV Data Centre)
- WRDC (World Radiation Data Centre)

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)



GAW Focal Areas:

O_3, GHG, RG, Atmos. Total Depos., UV Rad., Aerosols

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

AQ MONITORING NETWORKS: AQI

Air Quality Index (AQI)

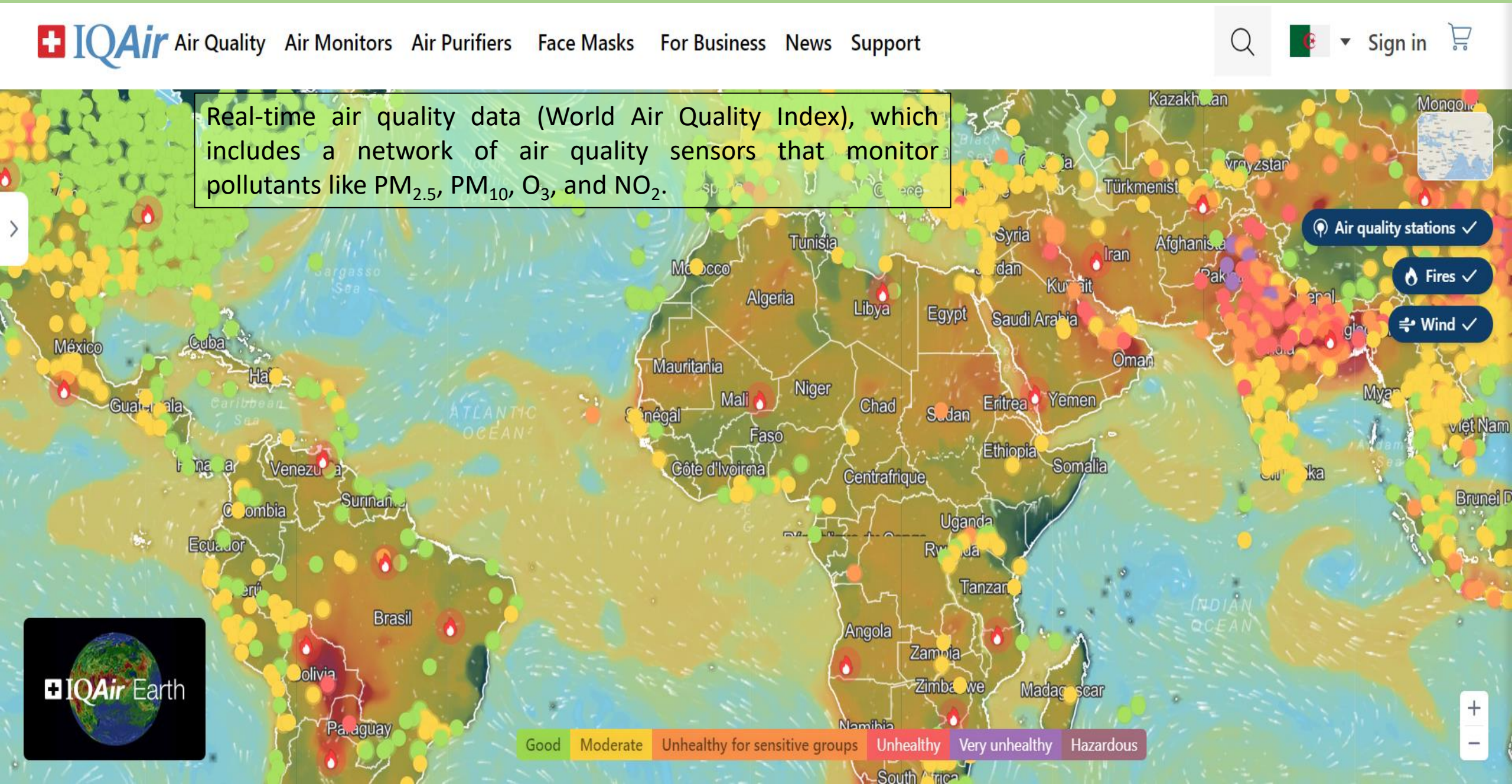
- An effective tool for informing the public about exposure and risks involved.
- Governments worldwide develop and implement air quality standards which set official exposure limits to help and assess air quality levels.
- These standards are usually in line with the WHO or US EPA guidelines.

AQI Basics for Ozone and Particle Pollution

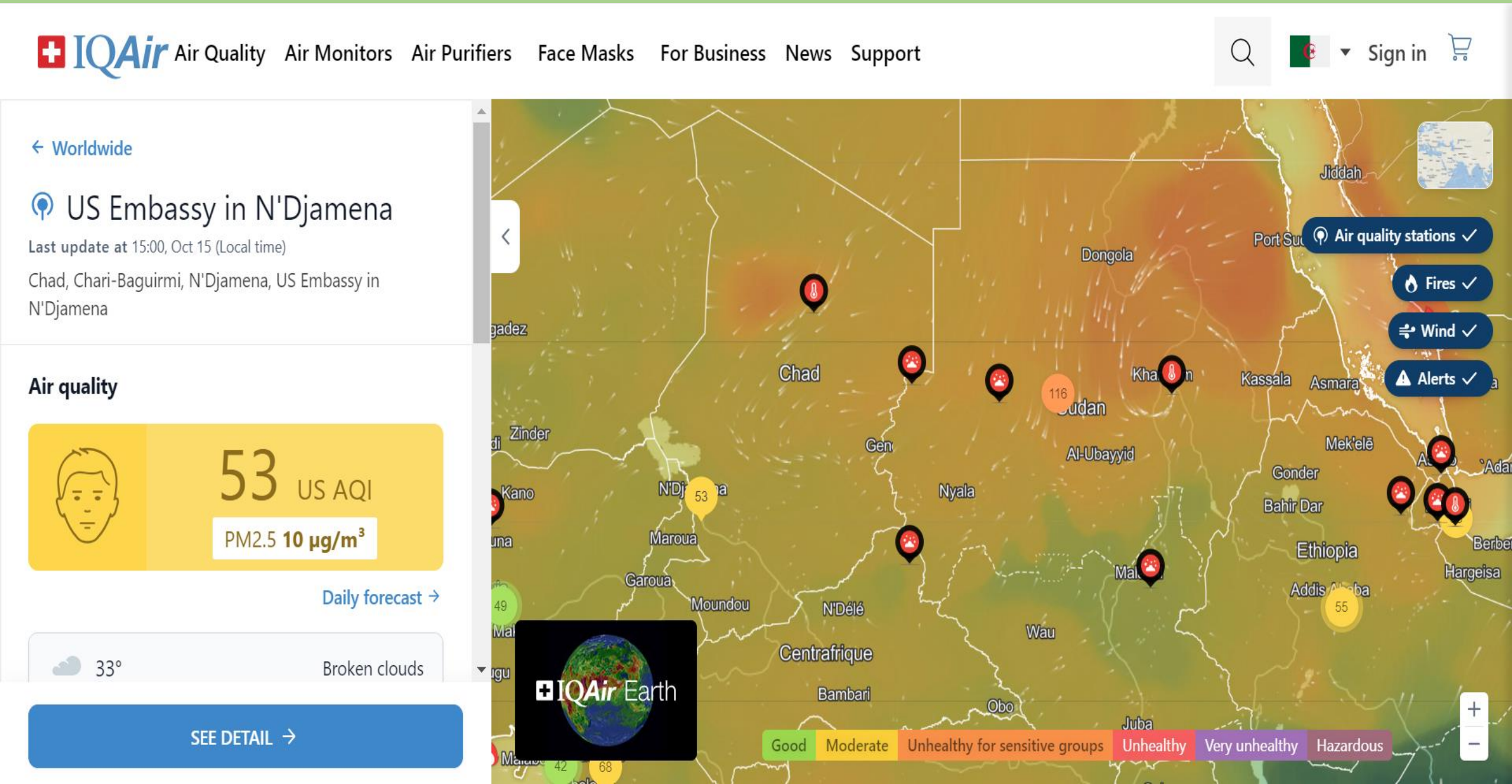
Daily AQI Color	Levels of Concern	Values of Index	Description of Air Quality
Green	Good	0 to 50	Air quality is satisfactory, and air pollution poses little or no risk.
Yellow	Moderate	51 to 100	Air quality is acceptable. However, there may be a risk for some people, particularly those who are unusually 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

AQ MONITORING NETWORKS: AQI



AQ MONITORING NETWORKS: AQI



4.

Remote Sensing Measurements

I. Criteria pollutants

   a) Aerosol Optical Depth (AOD)

II. Monitoring Networks (Global)

III. Low-Cost Sensors

IV. Principle of Operation of a Sunphotometer

CRITERIA AIR POLLUTANTS: AOD

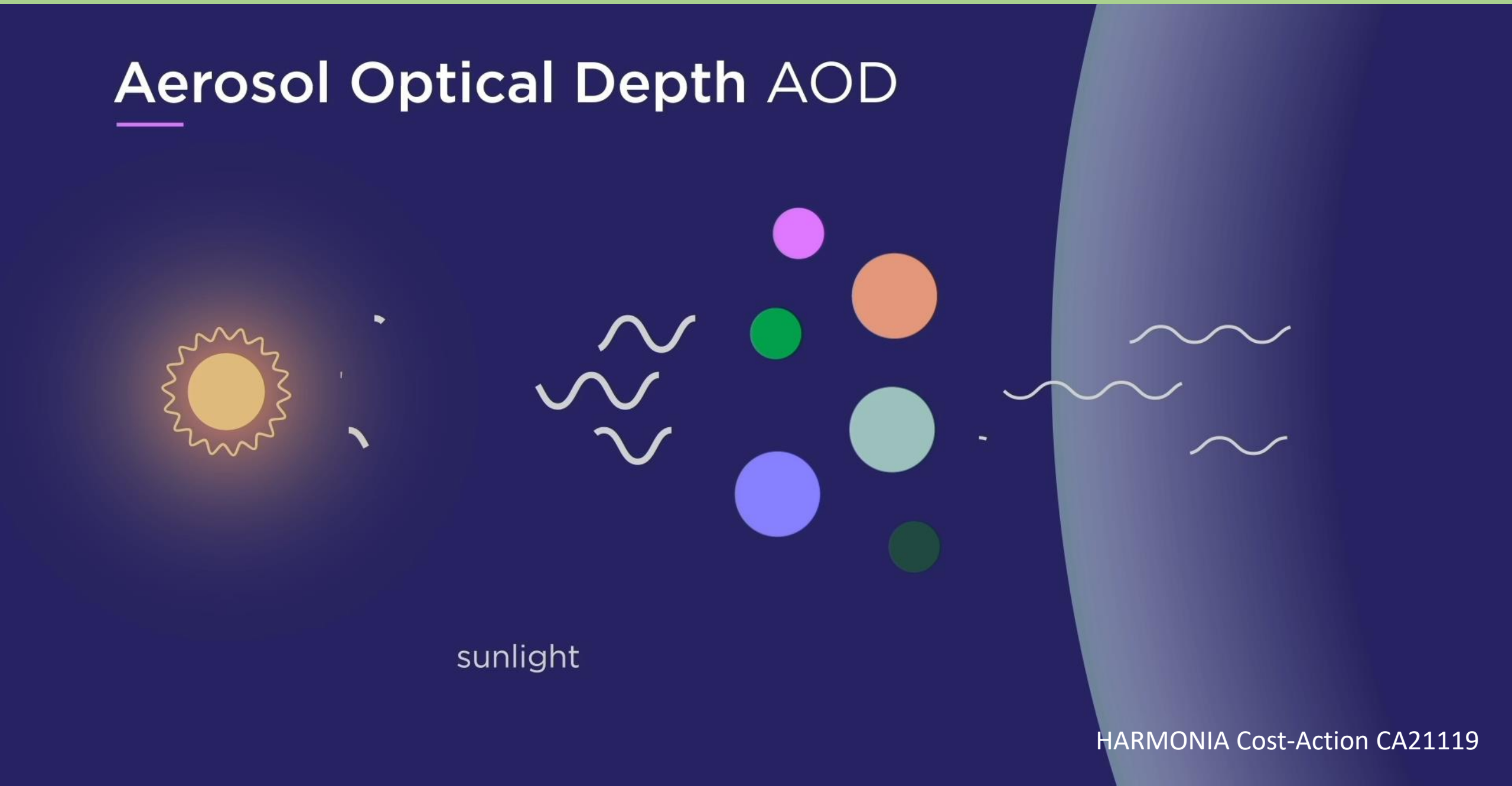
Columnar aerosol content as measured with Remote Sensing instrumentation

Particulate matter (AOD)

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

Important role of low-cost sensors: Calitoo

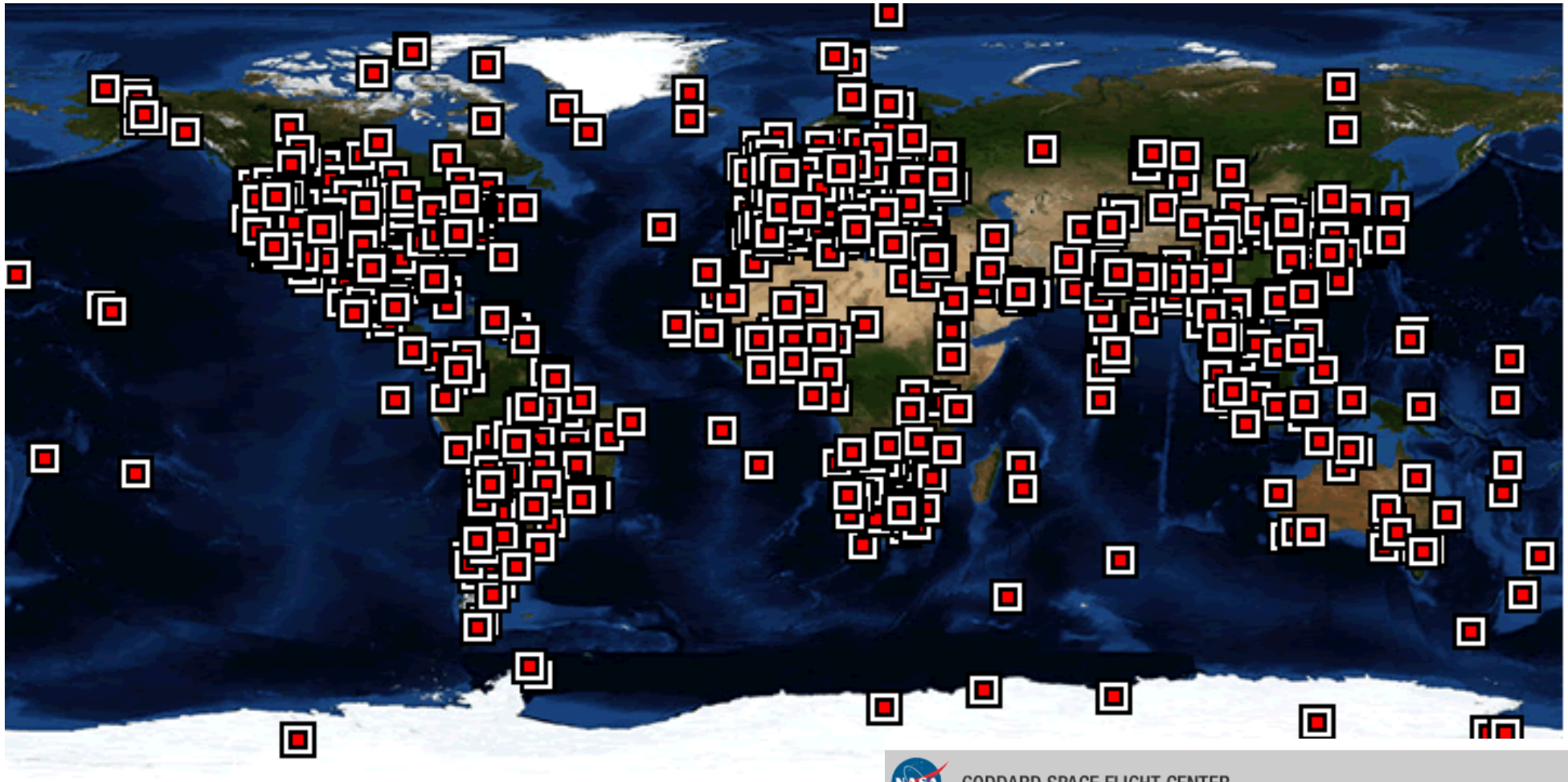
CRITERIA AIR POLLUTANTS: AOD



MONITORING NETWORKS (Global)

AERONET

https://aeronet.gsfc.nasa.gov

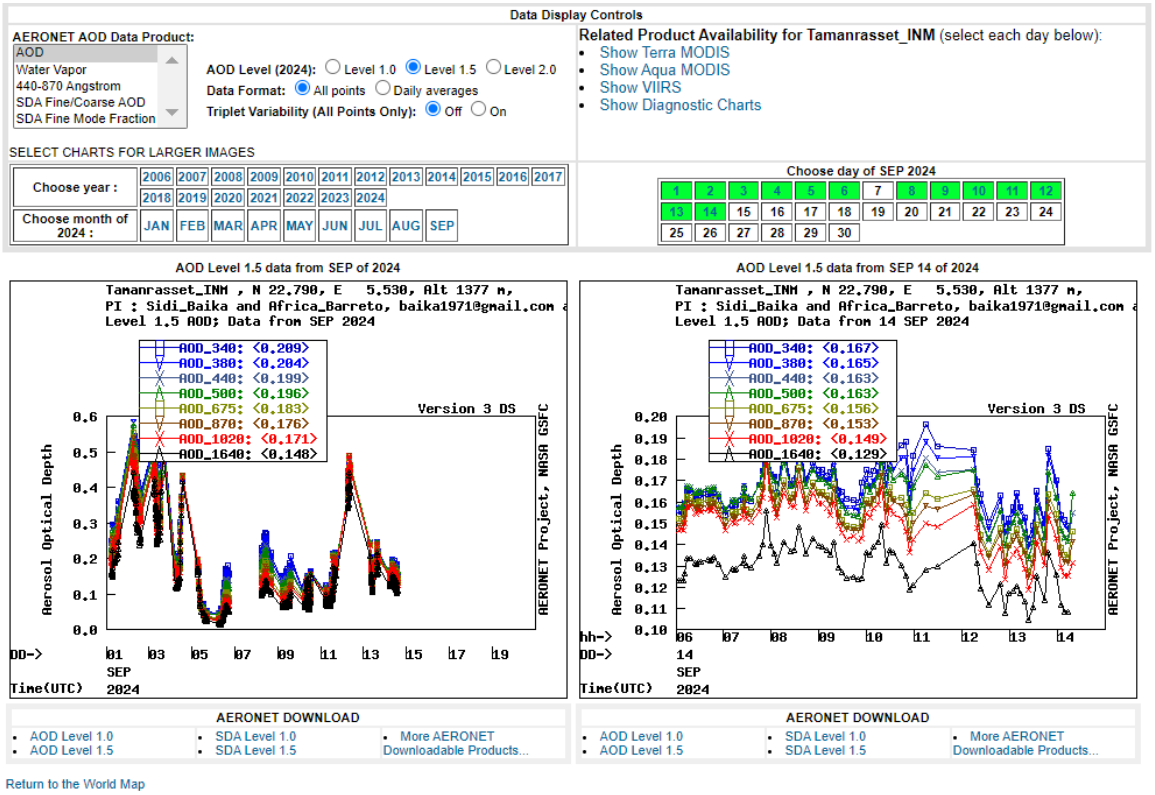


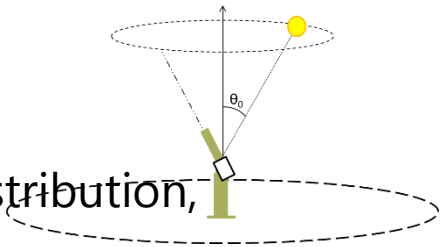
- Aerosol monitoring at global scales + satellite validation
- Over 500 stations over the world (sun + moon measurements)
- Highly standarized: instrumentation and processing

MONITORING NETWORKS (Global)

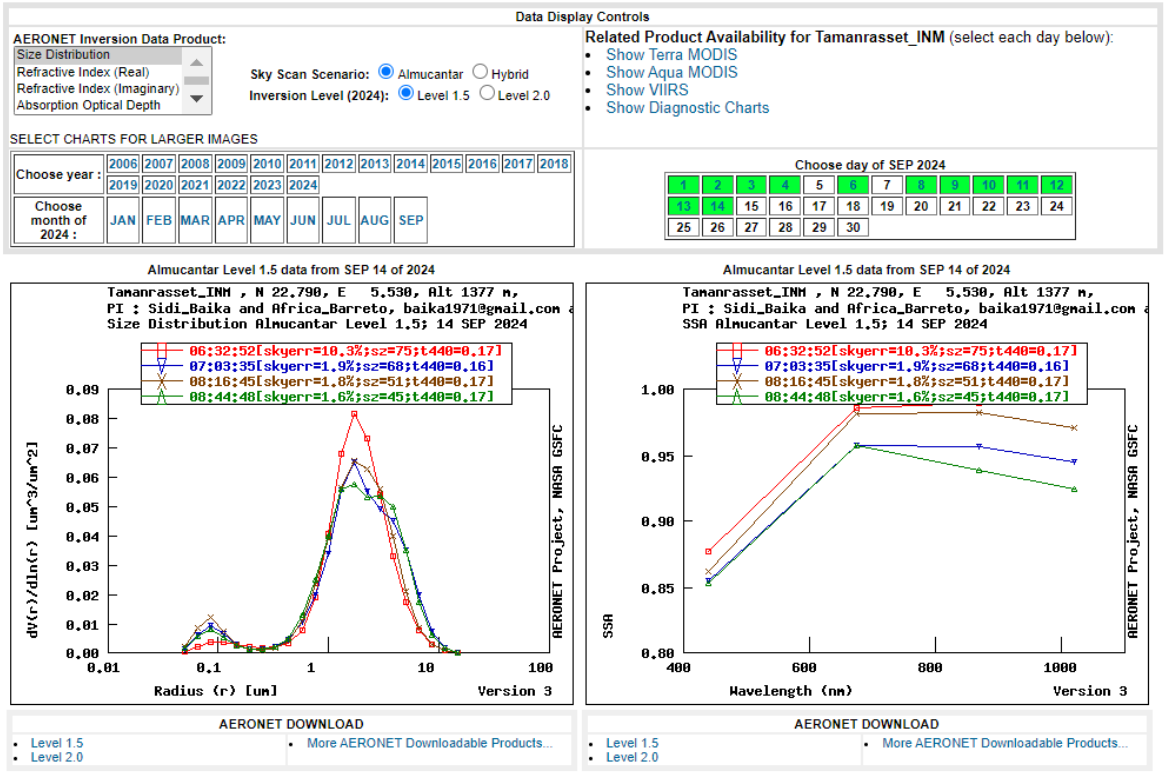
AERONET Products

Direct SUN-MOON: AOD, AE, PWV





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



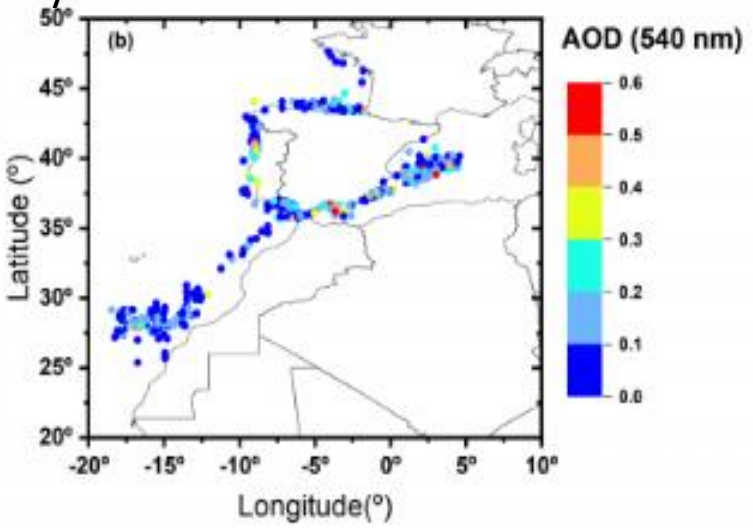
LOW-COST SENSORS: Calitoo & Microtops hand-held photometers

Aerosol retrievals derived from a low-cost Calitoo sun-photometer taken on board a research vessel*

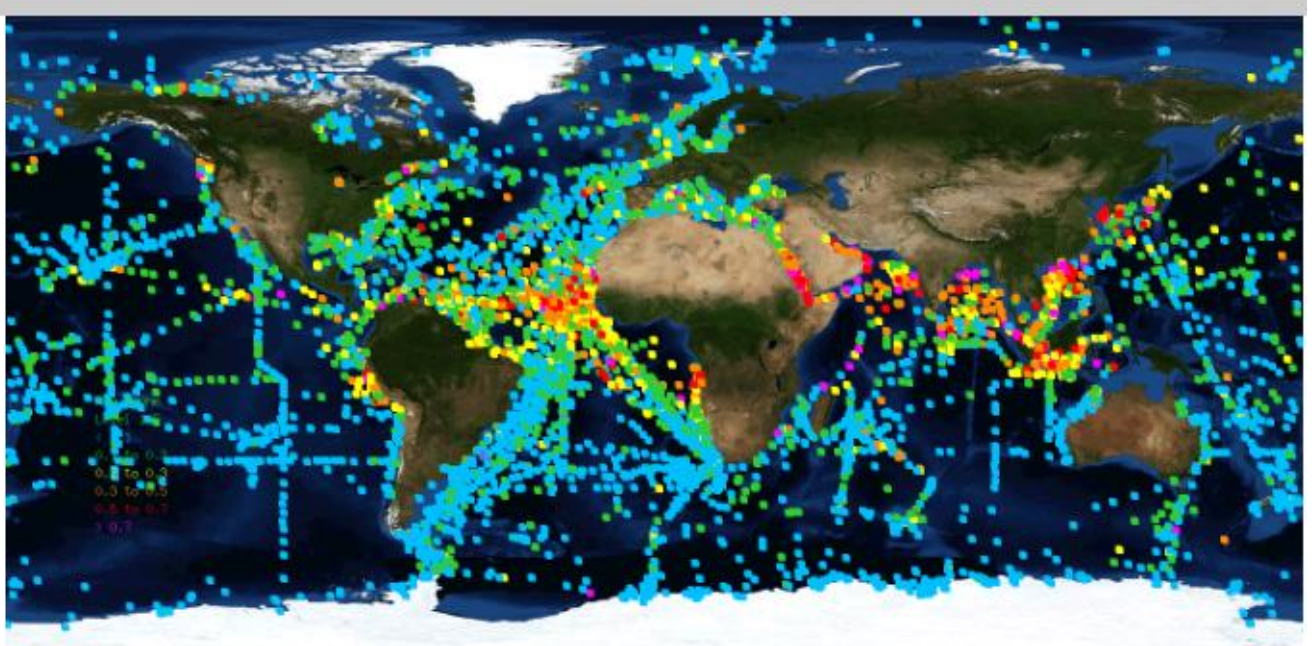
Rosa D. García[a,b], África Barreto[b,c,*,1], Celia Rey[b], Eugenio Fraile-Nuez[d], Alba González-Vega[d], Sergio F. León-Luis[a,b], Antonio Alcantara[b], A. Fernando Almansa[e,b], Carmen Guirado-Fuentes[b,c,f], Pablo González-Sicilia[b], Victoria E. Cachorro[c] and Frederic Bouchar[g]

*Submitted Atmos. Environ, (2024)

6 years of AOD over the ocean



CRUISES



AOD Observations at your site: Sun Photometry

Beer's Law

$$I_\lambda = I_{0,\lambda} \cdot e^{-\tau_\lambda \cdot m}$$

$$(I_\lambda < I_{0,\lambda})$$

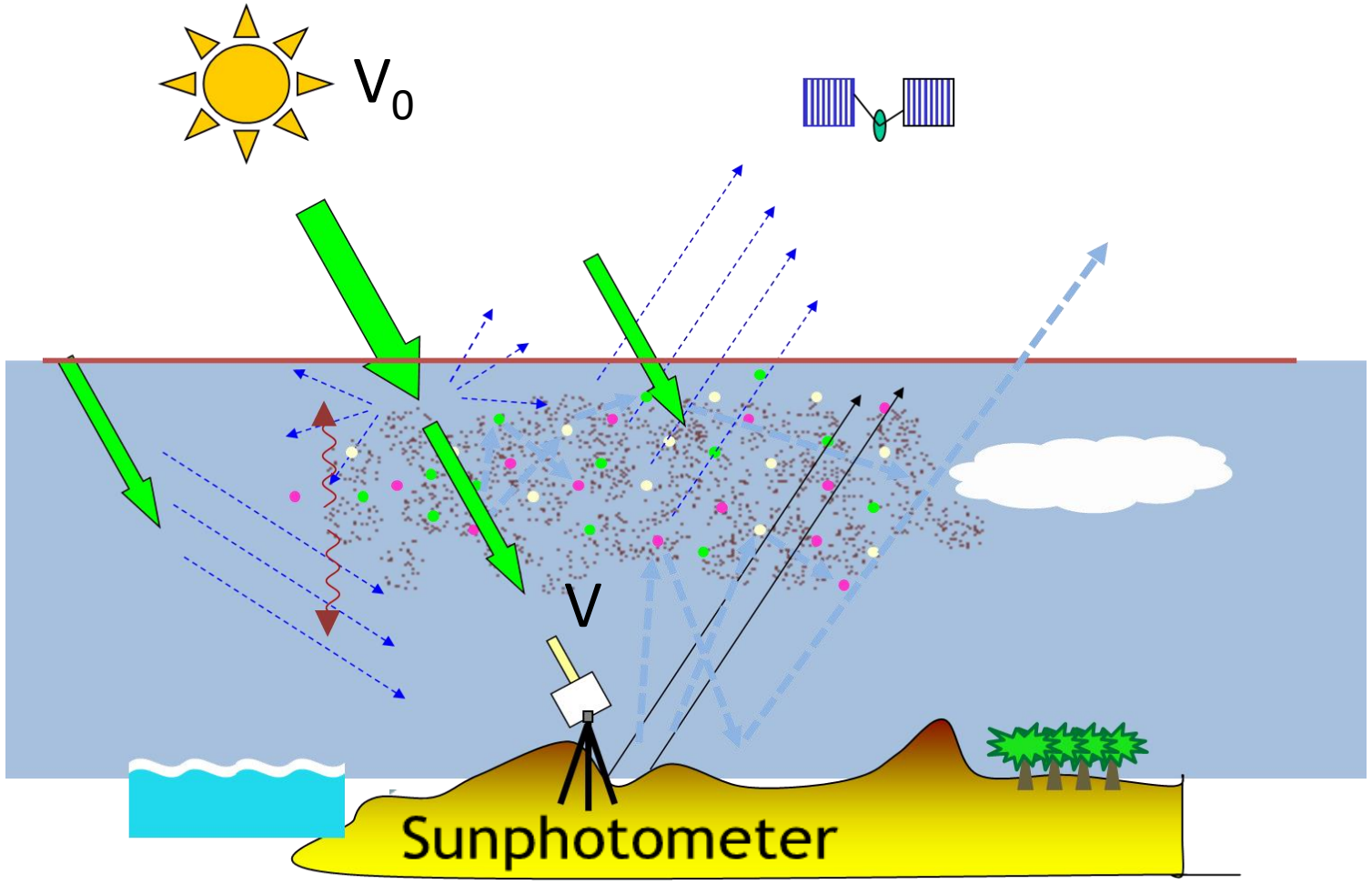
$$\tau_\lambda = AOD_\lambda$$

Angstrom Eq.

$$\tau_\lambda = \beta \cdot \lambda^{-\alpha}$$

$\alpha =$ Angstrom Exponent

α↓ large particles
α↑ fine particles



PRINCIPLE OF OPERATION OF A SUN PHOTOMETER

More aerosols in the atmosphere cause more extinction and less energy transmitted to the surface. AOD is the degree to which aerosols prevent the transmission of light.

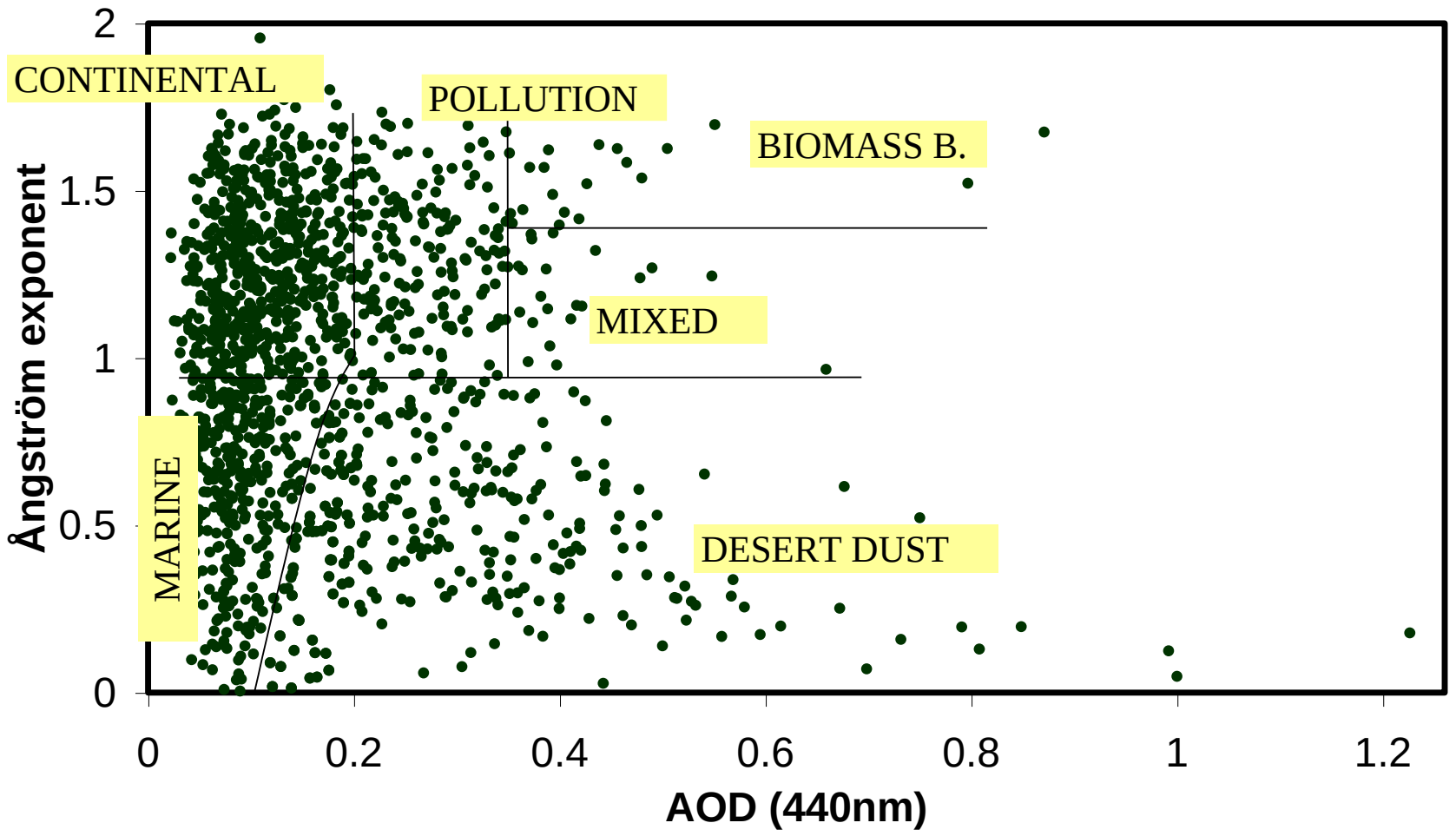
Typical AOD ranges

Sky conditions	500 nm	870 nm
Extremely clear (pristine)	0.03 - 0.05	0.02 - 0.03
Clear	0.05 - 0.10	0.03 - 0.07
Somewaht hazy	0.10 - 0.25	0.07 - 0.20
Hazy	0.25 - 0.5	0.20 - 0.40
Extremly hazy	> 0.5	> 0.4

Note that red AOD values are typically less than green AOD values. This is due to the fact that typical aerosols scatter green light more efficiently than red light.

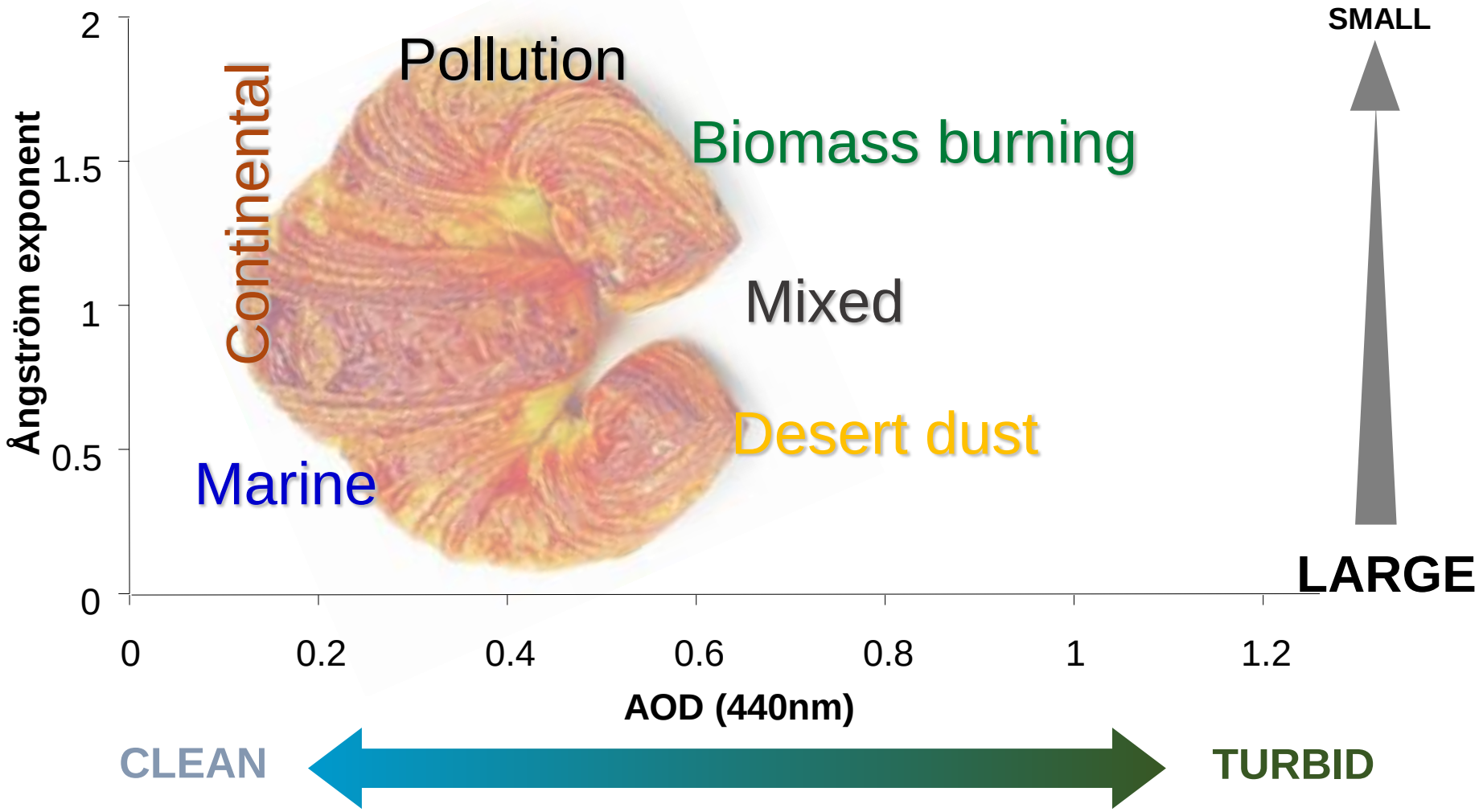
PRINCIPLE OF OPERATION OF A SUN PHOTOMETER

Aerosol Type with diagram AOD-α



PRINCIPLE OF OPERATION OF A SUN PHOTOMETER

Aerosol Type with diagram AOD-α



5.

Status of AQ Observations over Africa

STATUS OF AQ 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)

STATUS OF AQ OBSERVATIONS OVER AFRICA

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†
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†
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†
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†
Mauritius	PM, NOx, CO, SO_2	2,500	No	No	No	No	Yes	Initial†
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†
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†
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†
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; † Initial Any one topic addressed; * Early = Any two topics addressed; ** Intermediate = Any three topics addressed; + Advanced = Any four topics addressed; ++ Comprehensive = All topics addressed.

STATUS OF AQ OBSERVATIONS OVER AFRICA: Sub-Sahara

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		Is being performed	
Madagascar				
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

STATUS OF AQ OBSERVATIONS OVER AFRICA

Community engagement using LCS

160+ Air quality monitors installed in 8 major African cities

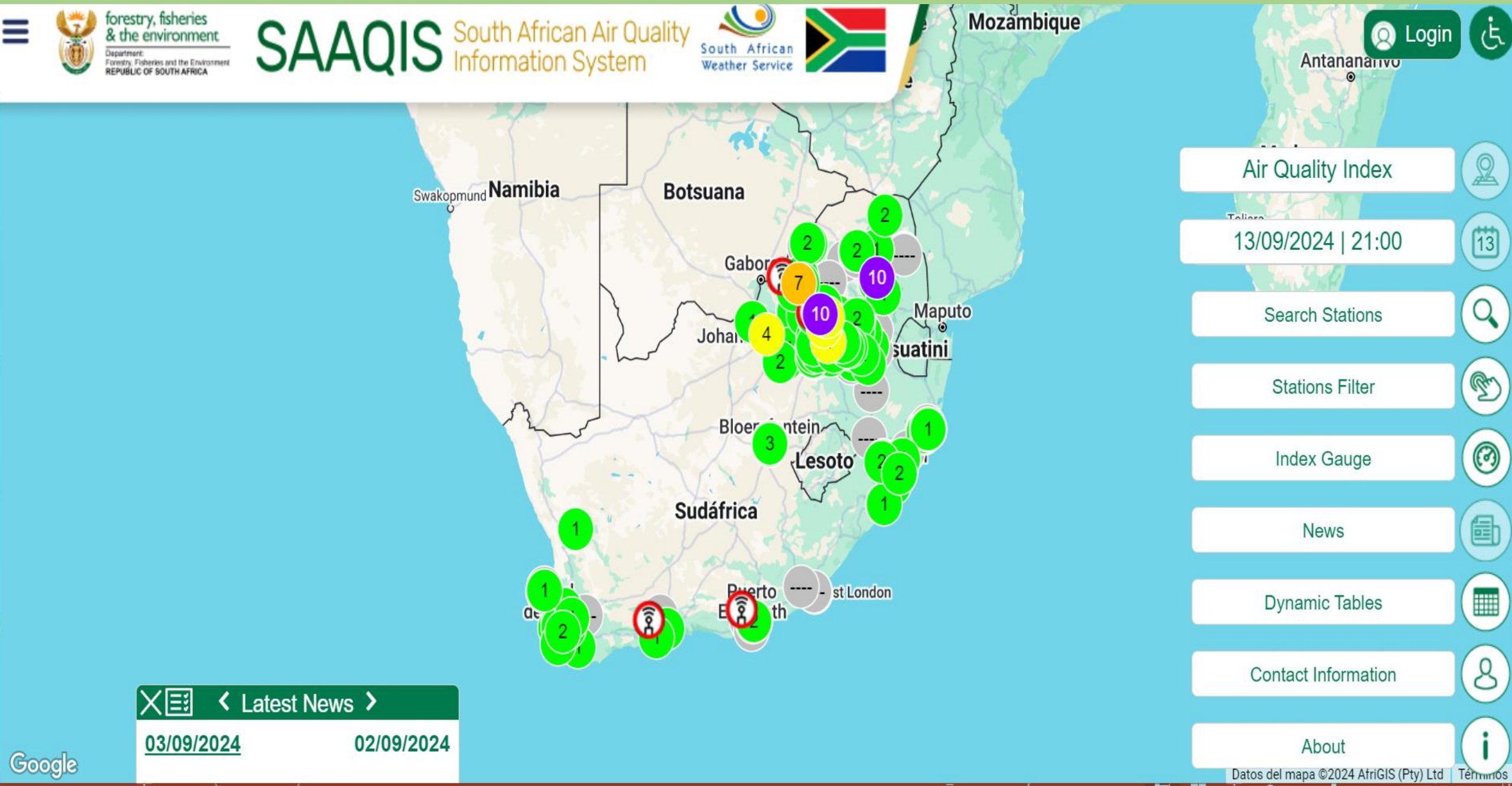
To effectively tackle air pollution, access to data and contextual evidence is important to show the scale and magnitude of air pollution.

We're providing an end-end air quality solution in major African Cities leveraging the locally built low-cost monitors and existing expertise to advance air quality management and, implicitly, air quality improvement in these African cities.

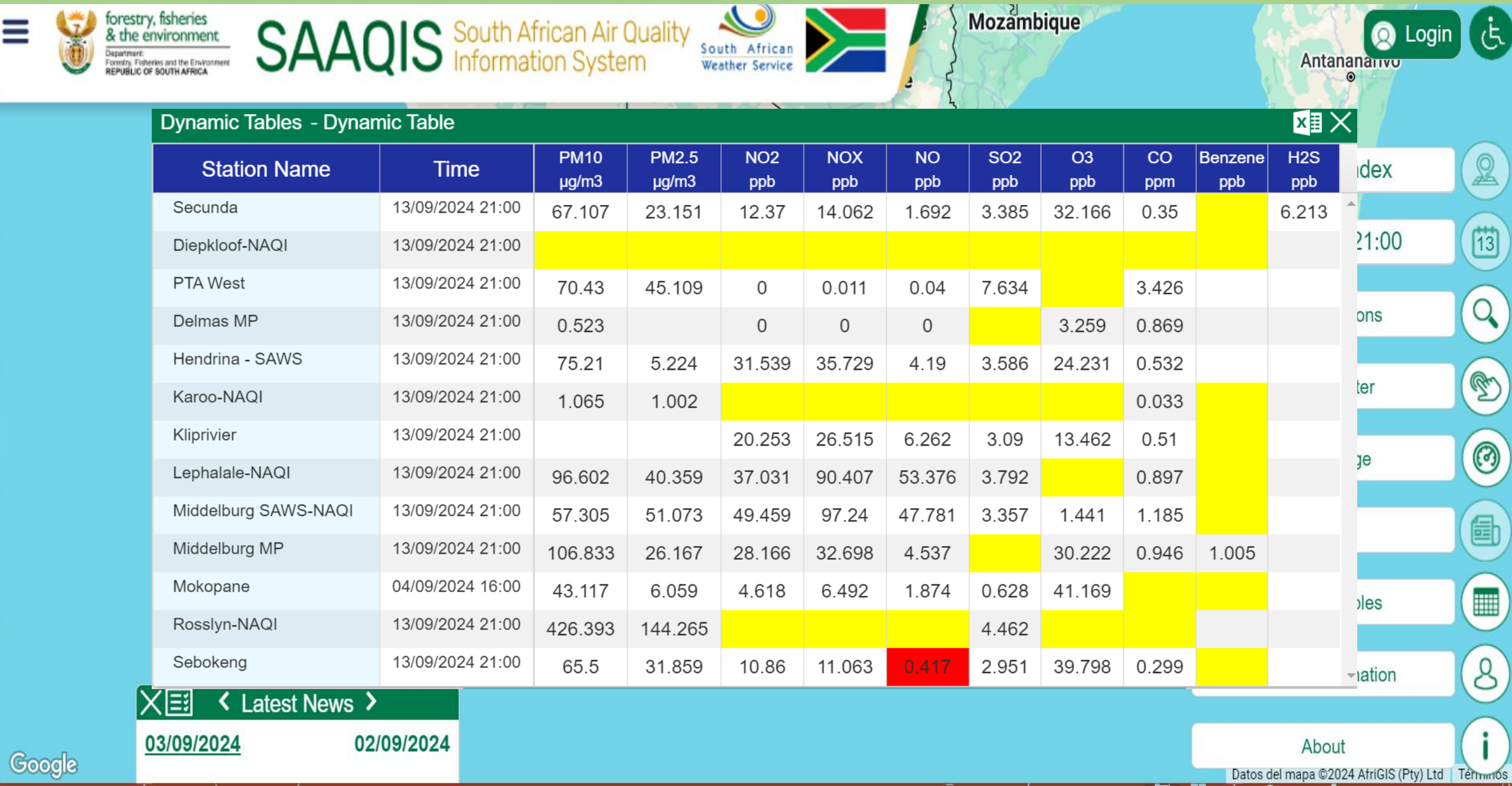
Makerere University (Uganda)

- Hyperlocal air quality dataset collected from spatially distributed LCS
- 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.

STATUS OF AQ OBSERVATIONS OVER AFRICA: South-Africa



STATUS OF AQ OBSERVATIONS OVER AFRICA: South-Africa



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		

STATUS OF AQ OBSERVATIONS OVER AFRICA: Chad

Chad Air Quality Policies

This document is based on research that UNEP conducted in 2015, in response to Resolution 7 of the UNEA 1. It describes country-level policies that impact air quality. Triple question marks (???) indicate that information for the section couldn't be found.

Please review the information, and provide feedback. A Word version of the template can be provided upon request. Corrections and comments can be emailed to Vered.Ehsani@unep.org and George.Mwaniki@unep.org.

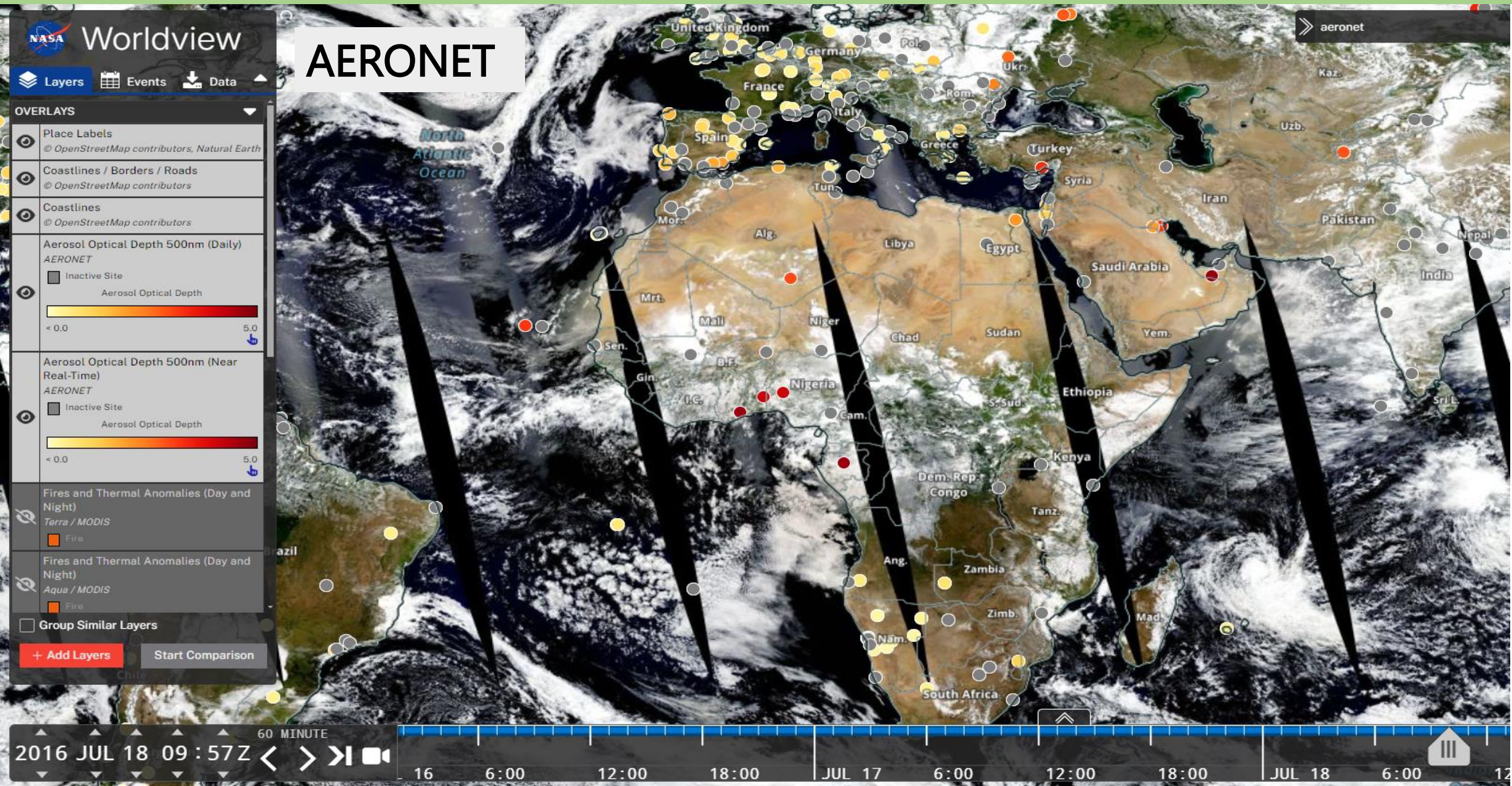
Chad Air Quality Policy Matrix		
Goals	**Status**	**Current Policies & Programmes**
GENERAL OVERVIEW	**Overall situation with respect to air quality in the country, including key air quality challenges**: ??? **Air quality monitoring system**: ???	**National Ambient air quality standards**: ??? **National Air Quality Policy**: ??? **Air Quality legislation / programmes**: ??? **Other**:???
REDUCE EMISSIONS FROM INDUSTRIES	**Industries that have the potential to impact air quality**: • The most important industries are; oil, cotton textiles, meatpacking, brewing, natron (sodium carbonate), soap, cigarettes and construction materials production among others **GDP of country**: USD 13.59B in 2013[1] **Industries' share of GDP**: 9.9% • **Electricity sources**: • 100% of the installed electricity generating capacity (31,000 KW in 2010) is generated from fossil fuel **Others** • PM SO_2, and NO_X are some of the most important air pollutant from Industrial	**Emission regulations for industries**: ??? **Small installation's emissions regulated**: *(Yes/No)* ??? **Renewable energy investment promoted**: ??? **Energy efficiency incentives:** *(ex: Subsidies, labelling, rebates etc)* ??? **Incentives for clean production and installation of pollution prevention technologies**: ??? **Actions to ensure compliance with regulations:** *(monitoring, enforcement, fines etc)* ??? **Other actions at national, sub-national and / or local level to reduce industrial emissions**: *(can include incentives to move industries to less populated areas here)* ???
	sources in the country	
REDUCE EMISSIONS FROM TRANSPORT	**Key transport-related air quality challenges**: *(ex: vehicle growth, old fleet, dirty fuel, poor public transport etc)* • Vehicle emissions are a major source of PM, NO_2 and CO • Freight and passenger transport is usually provided by private companies or individuals. • Private car ownership is low with 6 cars per 1000 individuals in 2006	**Vehicle emission limit**: *(Euro rating)* ??? **Fuel Sulphur content**: *(in ppm)* ??? **Fuel Lead content:** Unleaded gasoline restrictions since 2004 **Restriction on used car importation**: National standards are 2000 ppm for diesel and 500 ppm for petrol[2] • All new vehicles being imported into Chad are subject to tax and duty based on the value of the vehicle • All used vehicles are exempt from duty, except vehicles more than three years old which are prohibited from being imported • Import tax on new vehicles is subject to the make, model, year and value of the vehicle • Pre-importation inspection is required for road worthiness **Actions to expand, improve and promote public transport and mass transit**: ??? **Actions to promote non-motorized transport**: *(ex: include sidewalks and bike lanes in new road projects, car-free areas etc)* ???
REDUCE EMISSIONS FROM OPEN BURNING OF WASTE (OUTDOOR)	**Outdoor, open burning**: *(ex: is it commonly done? burning what kinds of wastes? etc)* • Uncontrolled waste burning, which is a common practice, is one of the practices that contributes to deteriorating air quality in urban centres • Agricultural waste burning can also impact air quality in the rural areas. • Due to the waste composition (plastics, waste tires, and other organic/inorganic materials) unregulated waste burning can be a source of health impairing emissions such as dioxins and furans • Waste management activities exist to a	**Legal framework**: *(ex: is burning banned?)* ??? **Actions to prevent open burning of municipal waste and / or agricultural waste**: ???
	streams such as municipal solid waste (MSW) are addressed by policies and institutions; others such as e-waste are not given attention at all.	

REDUCE EMISSIONS FROM BIOMASS BURNING (INDOORS)	**Dominant fuels used for cooking and space heating**:
	• Wood and charcoal provide 90% of the energy consumed in Chad, and natural gas consumption is on the rise, growing from 69 metric tons in 1999 to 367 metric tons in 2004.
	• 2.2% of households use electricity, with only 12% having access in the capital and 1% in provincial areas
	Impact:
	• Air pollution from indoor sources is the single largest contributor to the negative health effects of air pollution in Chad.
	• Indoor air pollution causes an estimated 9,600 premature deaths every year[3]
		Indoor air pollution regulated: *(Yes / No)* ???
		Promotion of non-grid / grid electrification:
		• The National Poverty Reduction Strategy places special significance on strategies to ensure strong and sustainable growth that helps to reduce poverty, in particular by:
		  • developing infrastructure to support power generation,
		  • making electricity available to users at a more reasonable cost, and
		  • promoting alternative sources of energy (solar, wind, etc.) to limit the cutting of firewood, which is exacerbating desertification.
		Promotion of cleaner cooking fuels and clean cook stoves: ???
		Other actions to reduce indoor biomass burning, or to reduce its emissions: ???

6.

Status of Dust Observations over Africa

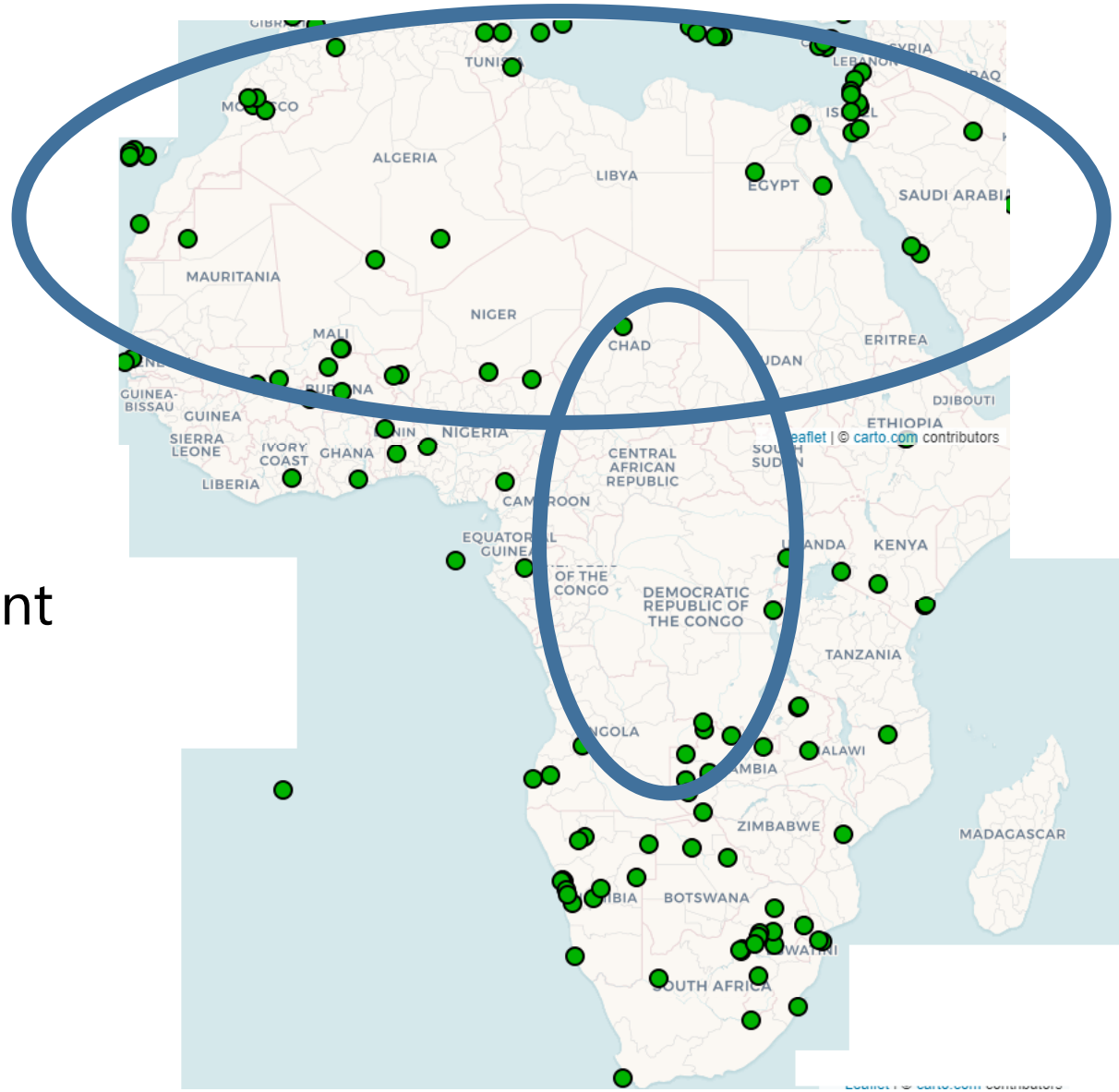
STATUS OF DUST OBSERVATIONS OVER AFRICA



STATUS OF DUST OBSERVATIONS OVER AFRICA

AERONET over Africa

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



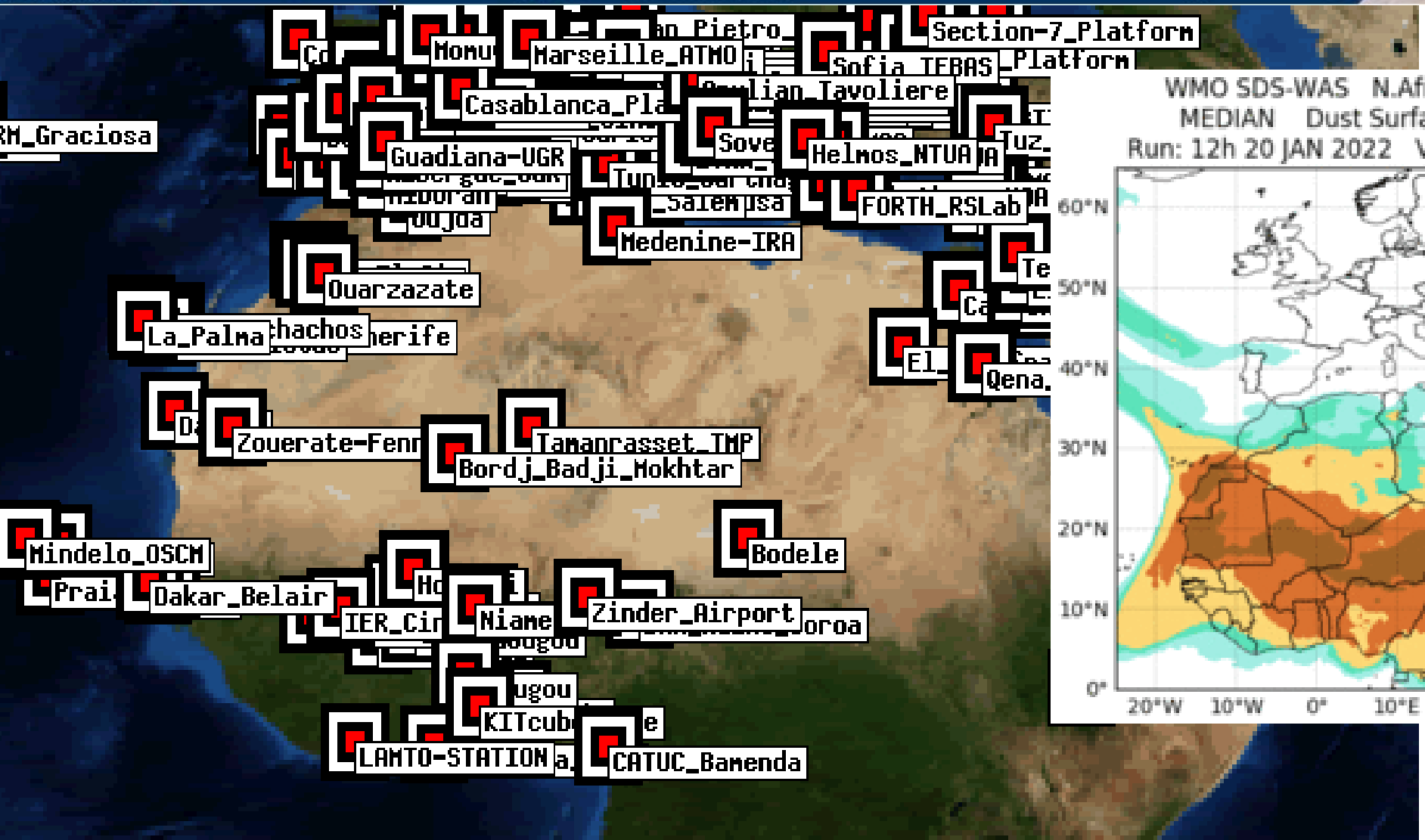
STATUS OF DUST OBSERVATIONS OVER AFRICA

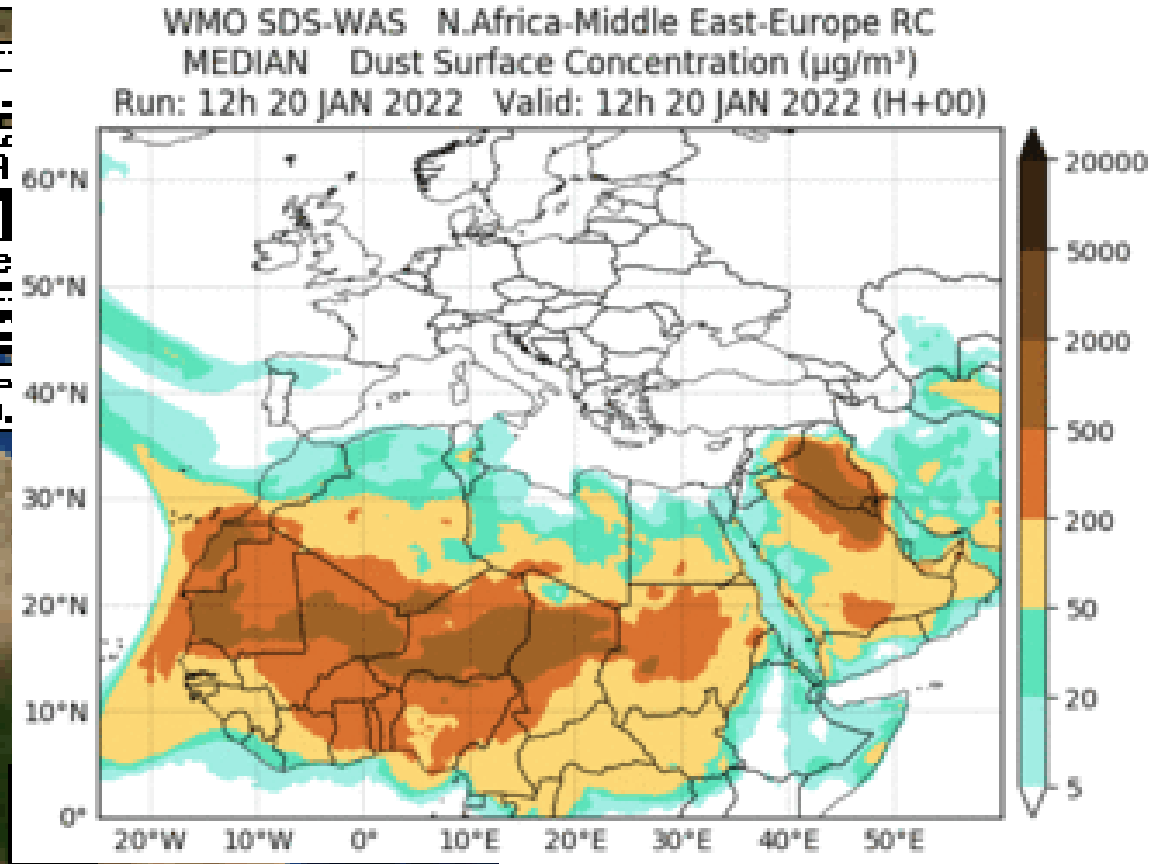
NORTHERN AFRICA-MIDDLE EAST-EUROPE (NA-ME-E) REGIONAL CENTER

WMO Sand and Dust Storm Warning Advisory and Assessment System (SDS-WAS)

World Meteorological Organization

WMO SDS WAS || Asia Regional Center || America Regional Center

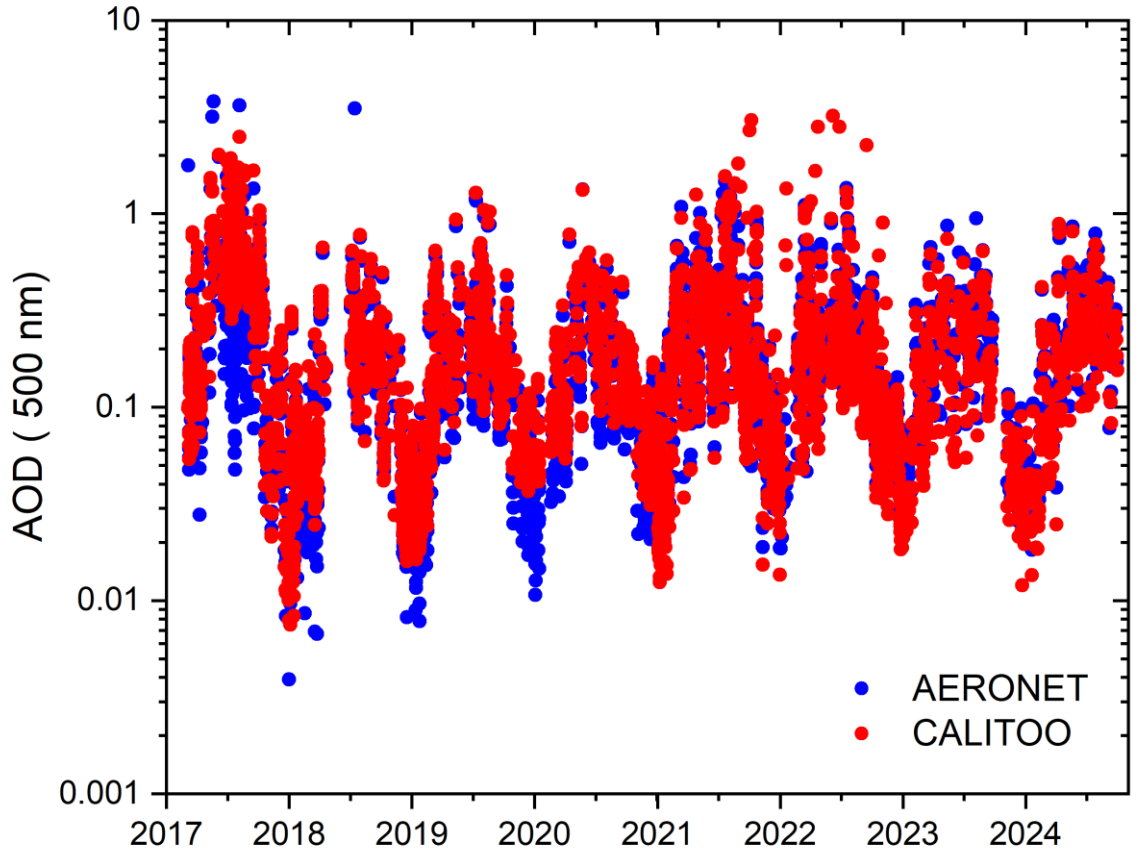




Barcelona Dust Regional Center

STATUS OF DUST OBSERVATIONS OVER AFRICA

Tamanrasset (Algeria) GAW Global Station



RGM versus LCS!!

STATUS OF DUST OBSERVATIONS OVER AFRICA

Tunis (Carthage), Egypt (Cairo, ?), Morocco (Ouazarzate, Atlas), Lybia (TBD), Chad??

As AERONET calibration Center we currently offer to African sites and operators:

- Training
- Calibration
- Support
- Open to cover gaps in Africa!!

STATUS OF DUST OBSERVATIONS OVER AFRICA

MACCLIMA Interreg
Fondo Europeo de Desarrollo Regional
EUROPEAN UNION

CREWS CLIMATE RISK & EARLY WARNING SYSTEMS
WORLD METEOROLOGICAL ORGANIZATION

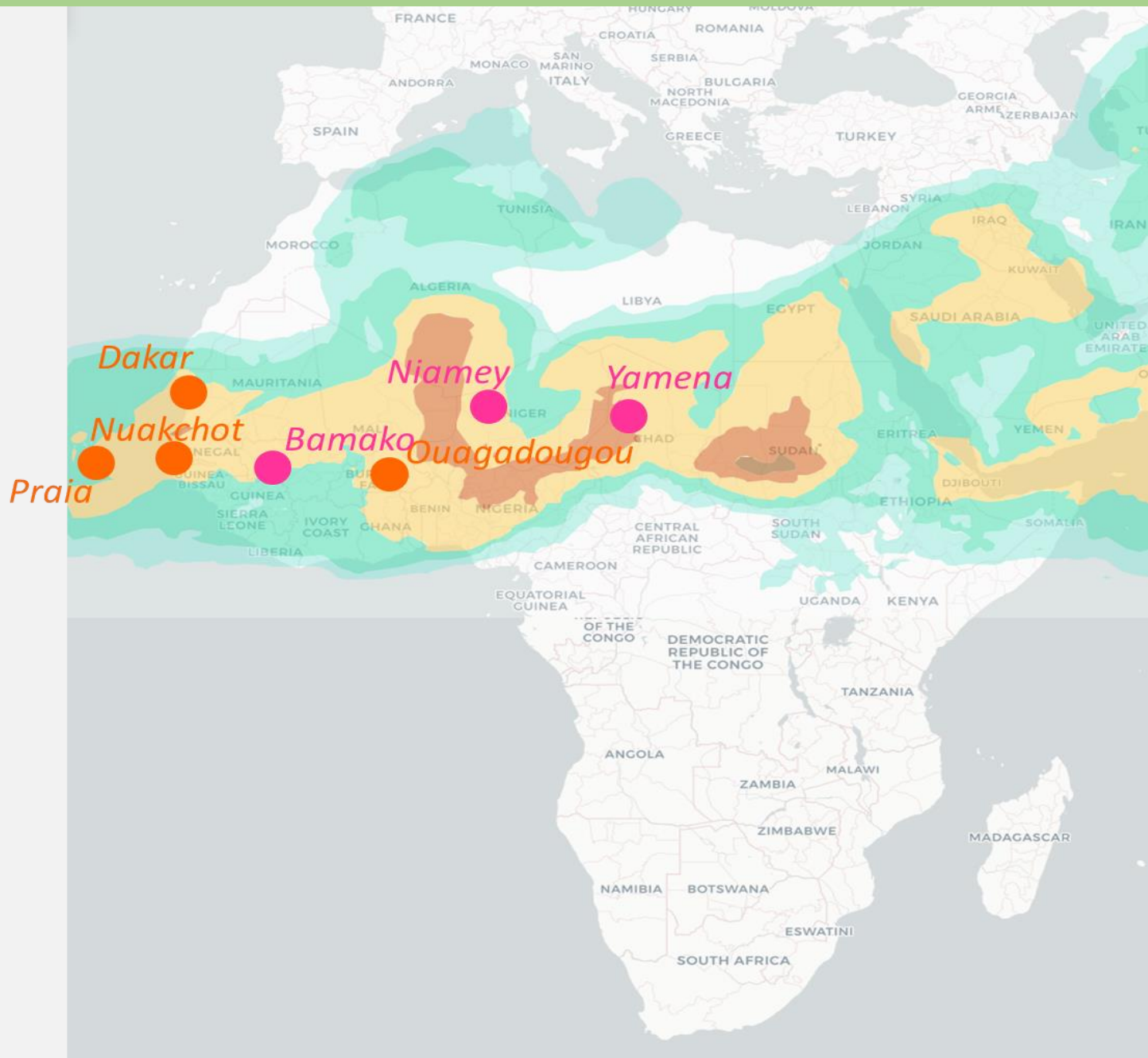
CREWS CLIMATE RISK & EARLY WARNING SYSTEMS
MACCLIMA

Aerosol Measurements

Hand-Held Photometer Calitoo

+

PM LCS



CREWS & MAC-CLIMA Projects: Training of personnel, development of new instrumentation and installation of climate monitoring systems in North Africa.

STATUS OF DUST OBSERVATIONS OVER AFRICA

DO NOT FORGET THE IMPORTANT ROLE OF LCS IN THE DUST/AEROSOL MONITORING OVER AFRICA

clarity

NASA

airqo

PurpleAir

IQAir


WMO
CREWS
CLIMATE RISK & EARLY WARNING SYSTEMS
AEMet
Agencia Estatal de Meteorología
Thanks for your attention!!
Your comments: abarretov@aemet.es
@ ICOS-ERIC

AQ MONITORING NETWORKS (Global)

Air Quality Monitoring networks

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

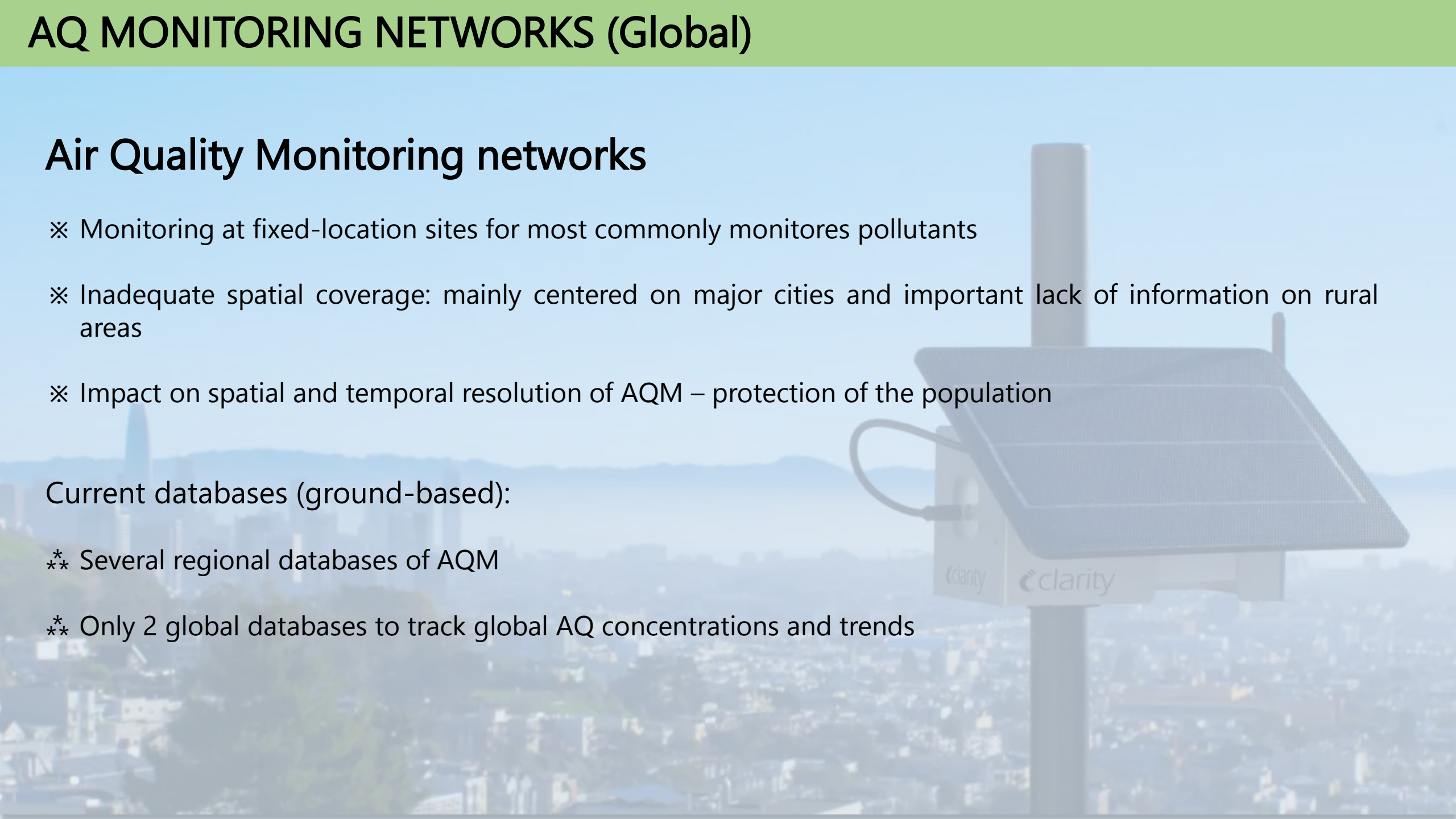
※ Inadequate spatial coverage: mainly centered on major cities and important lack of information on rural areas

※ 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



STATUS OF AQ OBSERVATIONS OVER AFRICA: South-Africa

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

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