

The WMO Global Atmosphere Watch (GAW) programme
**Supporting Atmospheric Composition Services:
Data integration – Low cost sensors**

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The WMO Global Atmosphere Watch (GAW) Programme



Advance and enhance science, services and infrastructure related to atmospheric composition, and support policies for society through applied research aimed at improving the understanding of the roles of aerosols, reactive gases, stratospheric ozone and greenhouse gases and their interactions in the Earth System

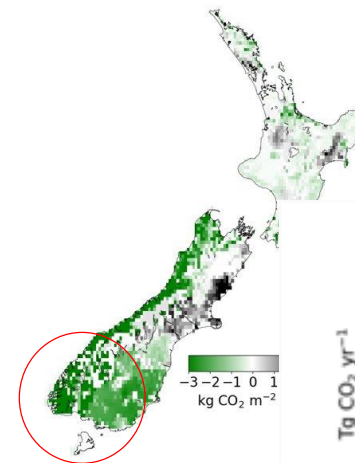
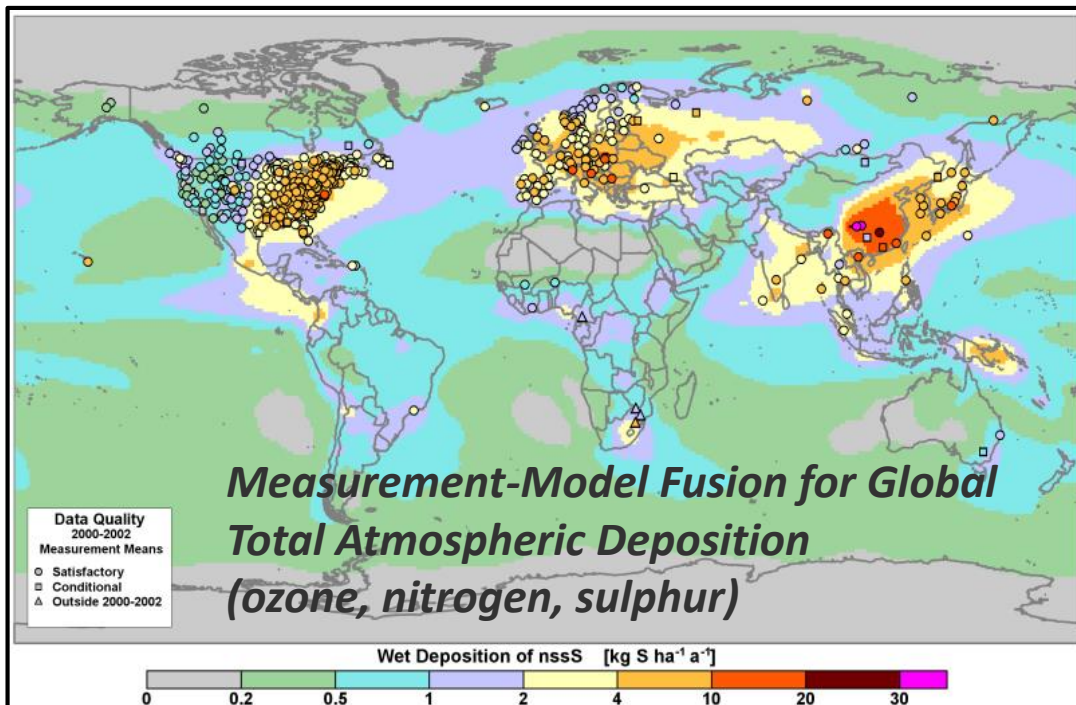




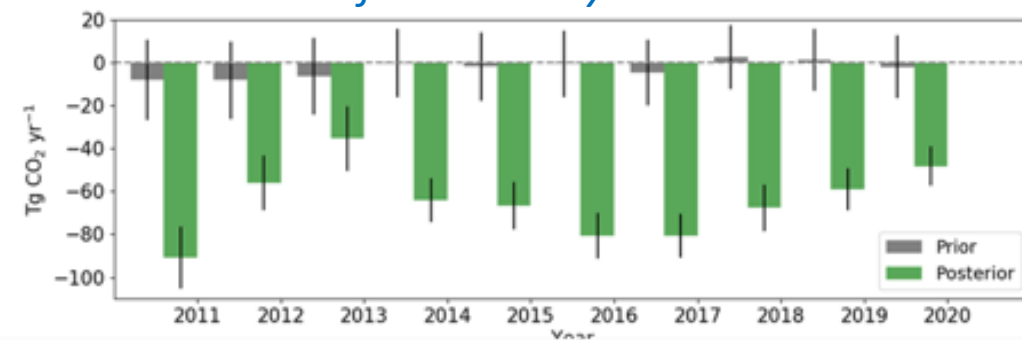
Science for Services

*Advance the application of atmospheric composition information in support of policies and conventions, and expand **societal services** related to air quality, human and ecosystem health, **climate change** and food production.*

Deposition to ecosystems and crops + climate action



Integrated Global Greenhouse Gas Information System



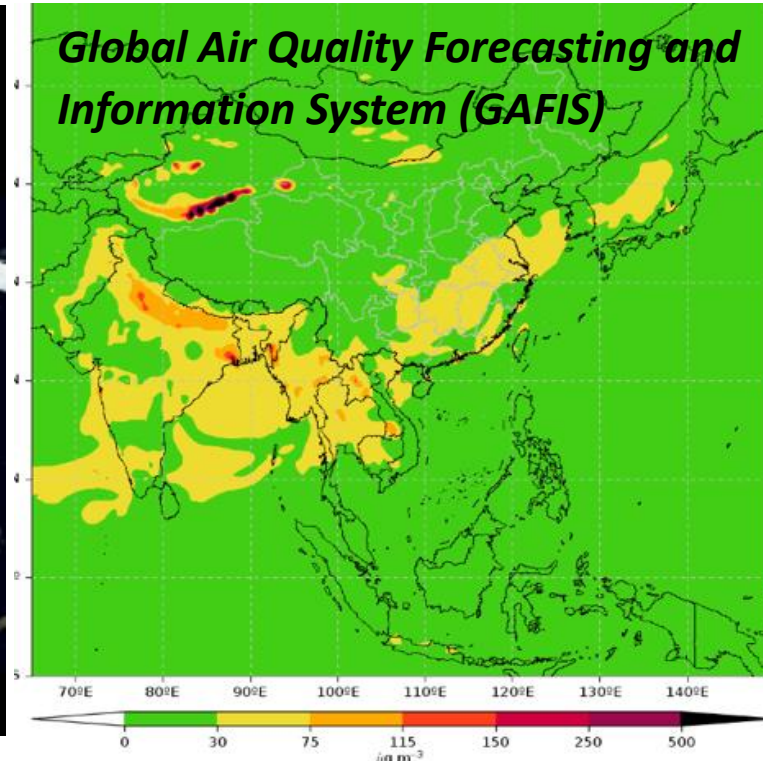
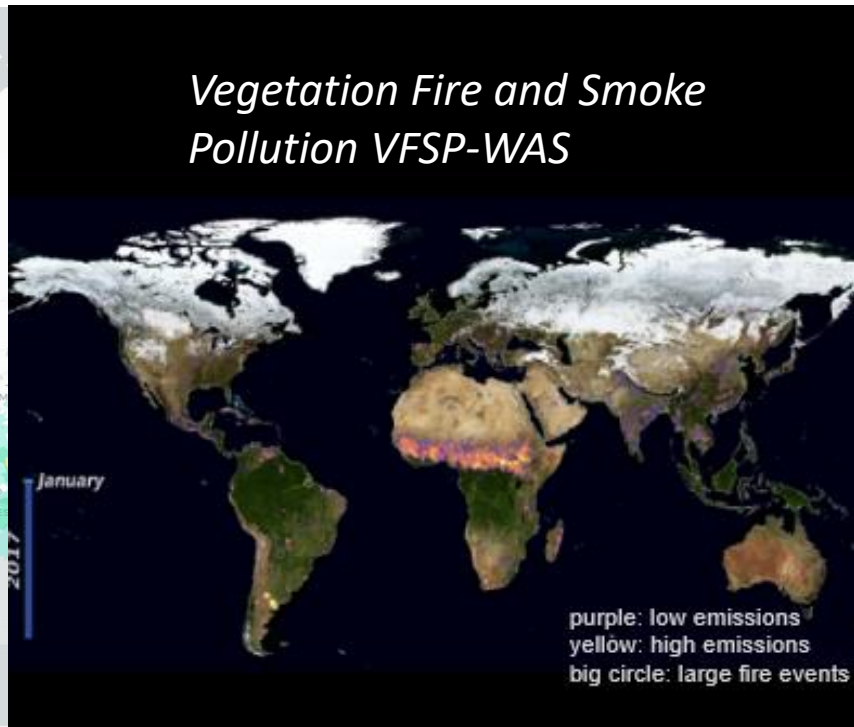
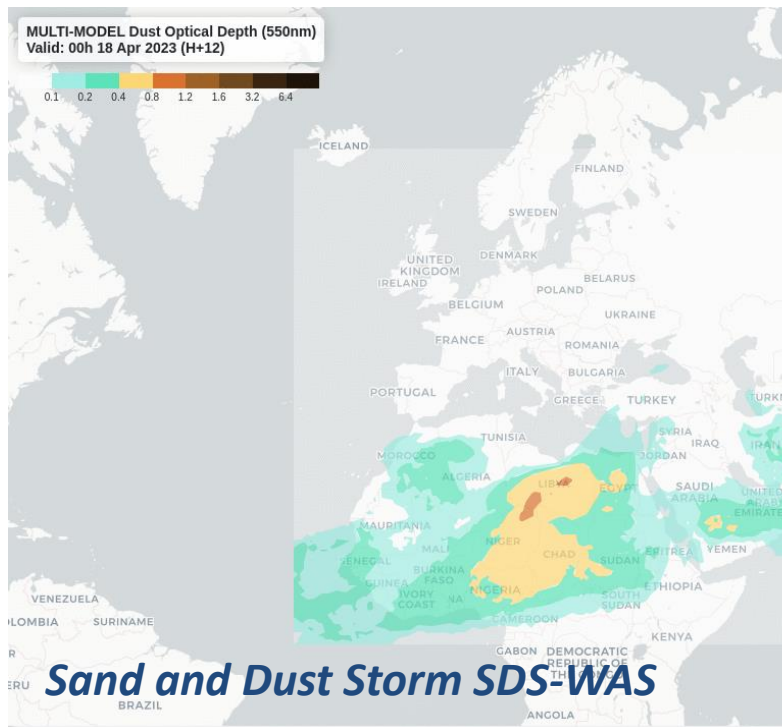
Aotearoa New Zealand's terrestrial carbon uptake



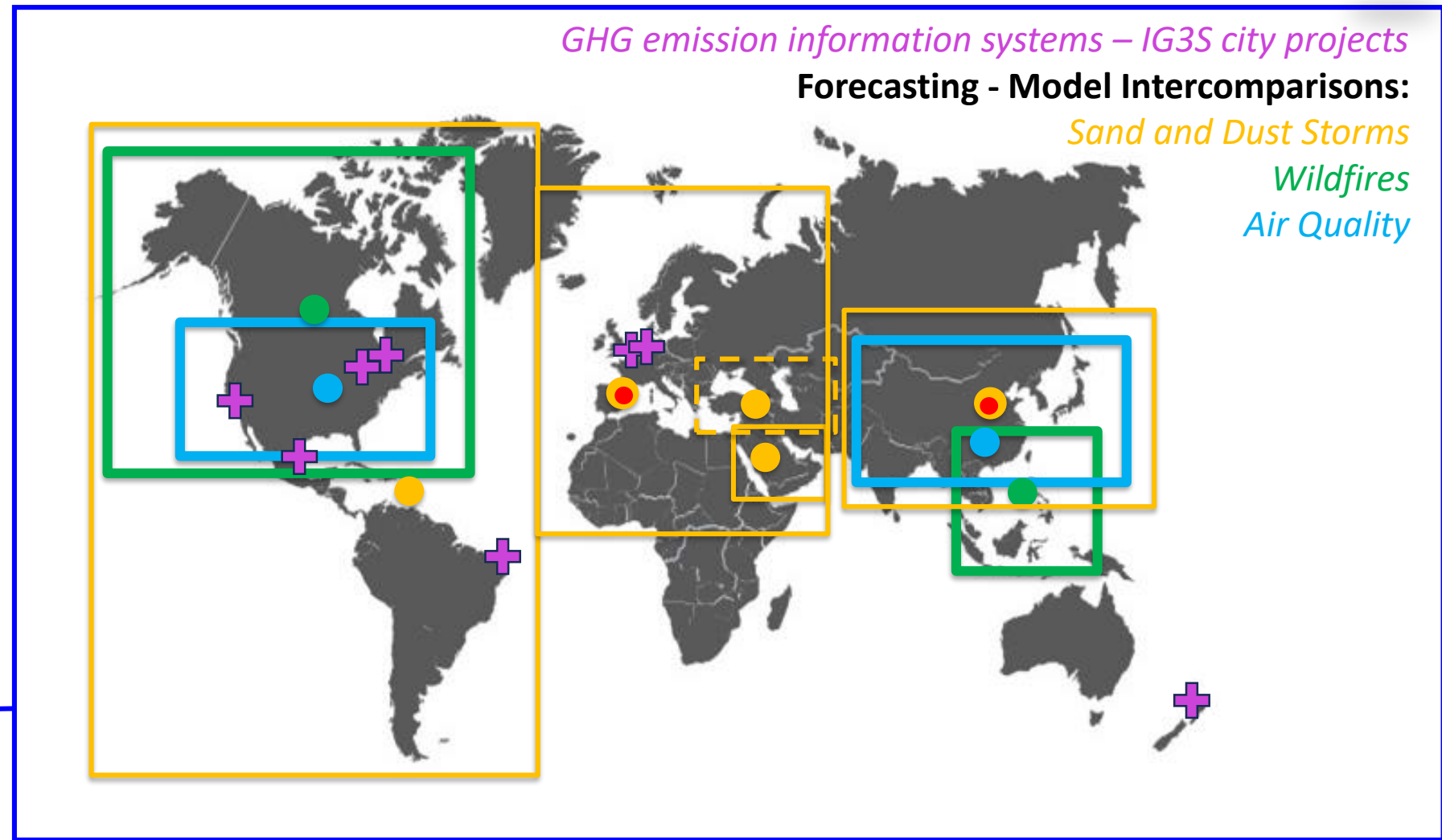
Science for Services

*Advance the application of atmospheric composition information in support of policies and conventions, and expand **societal services** related to air quality, human and ecosystem health, climate change and food production.*

Warnings and Forecasting Services Model intercomparisons



Infrastructure for the development of services



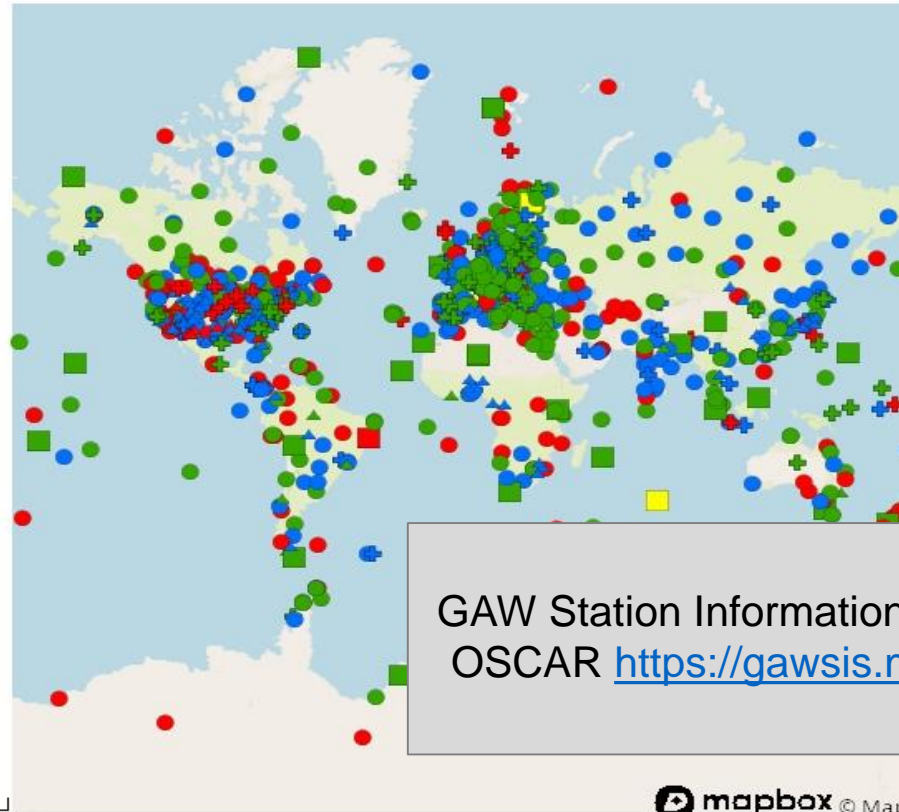


Observational (research) Infrastructure

Strengthen the atmospheric composition measurement and data infrastructure and contribute to **understanding trends and variability and extremes.**

- More than 200 parameters
- Intercomparisons
- Measurement guidelines
- World Data Centers

Open access with emphasis in QA and QC



Integration!
Filling gaps: **Modelling, LCS and satellites, but also National AQ networks**

GAW Station Information System (**GAWSIS**) part of OSCAR <https://gawsis.meteoswiss.ch/GAWSIS/#/>

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Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

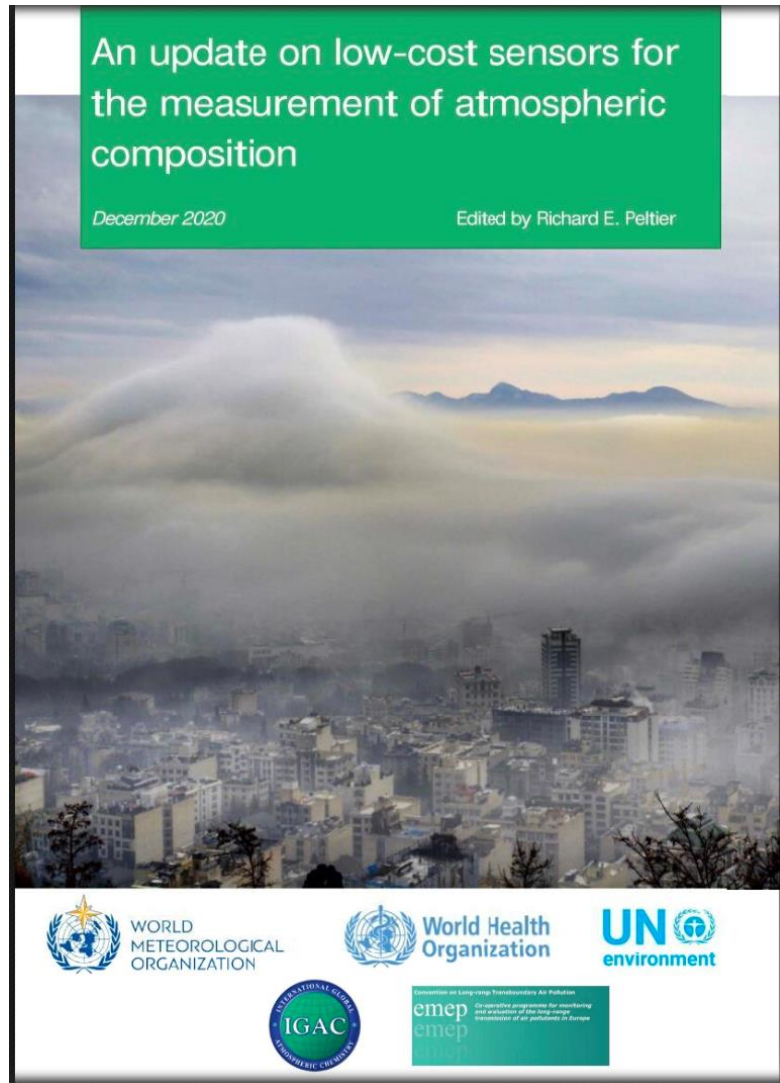
Swiss Confederation

Federal Department of Home Affairs FDHA
Federal Office of Meteorology and Climatology MeteoSwiss

- | | | |
|-----------------------|--------------------|---|
| Global | Operational | ● |
| Regional | Partly operational | ● |
| Contributing networks | Non-reporting | ▲ |
| Local | Closed | ★ |
| Other networks | Planned | + |
| | Pre-operational | ● |
| | Stand-by | ● |



Integrating other sources of information



The report reflects on the state of the art in terms of **accuracy, reliability and reproducibility** of different sensors used for the measurements of atmospheric composition along with the key analytical principles and what has been learned so far about low-cost sensors from both laboratory studies and real-world tests.

The document considers specifically sensors that are designed for the measurements of atmospheric composition at ambient concentrations of the following constituents:

- Air pollution gases including NO, NO₂, O₃, CO, SO₂, and an operational metric defined as ‘total VOC’.
- Long-lived greenhouse gases: CO₂ and CH₄.
- Airborne particulate matter (PM) in various size classes (e.g. PM₁, PM_{2.5} and PM₁₀).

WMO, WHO, UNEP, IGAC and EMEP (2020)
<https://library.wmo.int/idurl/4/37465>



Integrating other sources of information: LCS

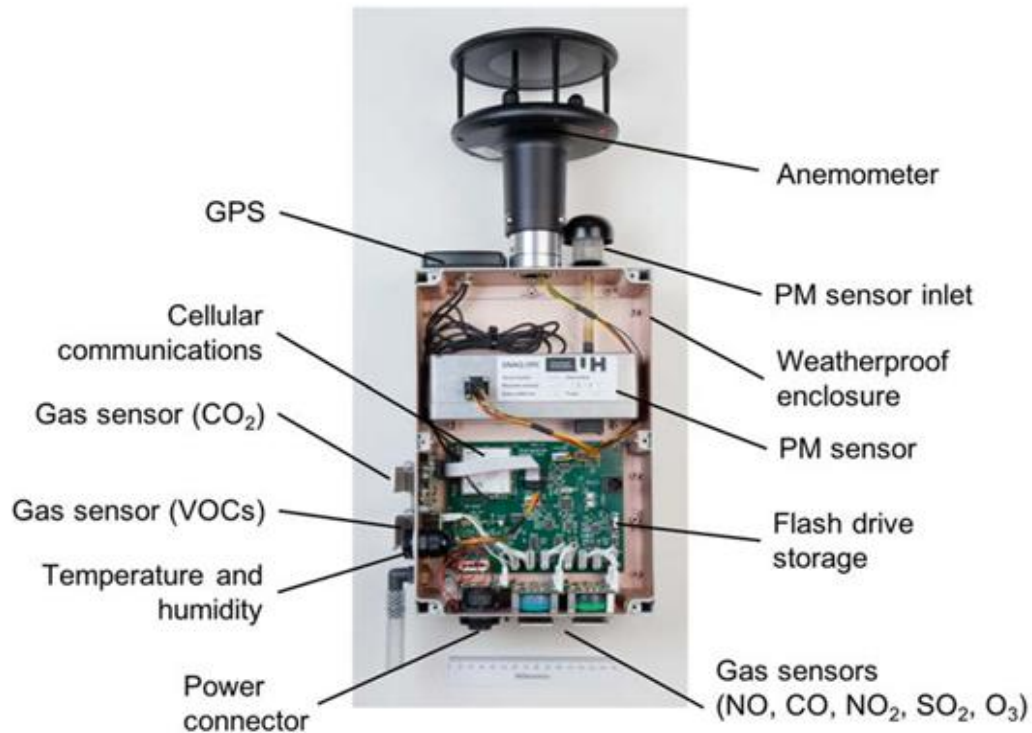


Figure 1: An example of a low-cost sensing system that is comprised of many different components. Photo Courtesy of R Jones, Cambridge University, UK

Core components of **low-cost sensor systems** (LCS) are:

- the sensing/analytical elements used for detection
- and components that acquire, process, and output data as:
 - sampling capability (e.g. pump),
 - power system (e.g. batteries),
 - sensor signal processing (e.g. signal amplification),
 - local data storage,
 - data transmission capability (e.g. WiFi, 4G),
 - housing and weatherproofing



Integrating other sources of information: LCS

Low-Cost Air Sensors										
		1	5	10	25	50	100	250	500	1000
	Price	OpEx	OpEx	OpEx	OpEx	OpEx	OpEx	OpEx	OpEx	OpEx
Hardware										
PM2.5 & NO2	\$ 1,000	\$ 1,000	\$ 1,000	\$ 10,000	\$ 15,000	\$ 10,000	\$ 100,000	\$ 150,000	\$ 100,000	\$ 1,000,000
Shelter										
Calibrator										
Supplies										
Supporting H/W	\$ 10	\$ 150	\$ 150	\$ 1,500	\$ 1,750	\$ 1,500	\$ 15,000	\$ 17,500	\$ 15,000	\$ 150,000
Annual Maintenance	\$ 158	\$ 173	\$ 163	\$ 1,725	\$ 1,313	\$ 1,625	\$ 17,250	\$ 13,125	\$ 16,250	\$ 172,500
Discount (%)		0%	0%	0%	0%	5%	10%	10%	10%	25%
Discount (amt.)		\$ 1	\$ 1	\$ 1	\$ 1	-\$ 1,306	-\$ 13,225	-\$ 13,063	-\$ 16,125	-\$ 130,625
Subtotal		\$ 1,323	\$ 1,613	\$ 13,225	\$ 13,063	\$ 12,819	\$ 119,025	\$ 197,563	\$ 195,125	\$ 191,875
Software										
Data Mgmt.	100	\$ 100	\$ 100	\$ 1,000	\$ 1,500	\$ 1,000	\$ 10,000	\$ 15,000	\$ 10,000	\$ 100,000
Discount (%)		0%	0%	0%	0%	10%	15%	15%	15%	25%
Discount (amt.)		\$ 1	\$ 1	\$ 1	\$ 1	-\$ 100	-\$ 1,500	-\$ 1,750	-\$ 1,500	-\$ 15,000

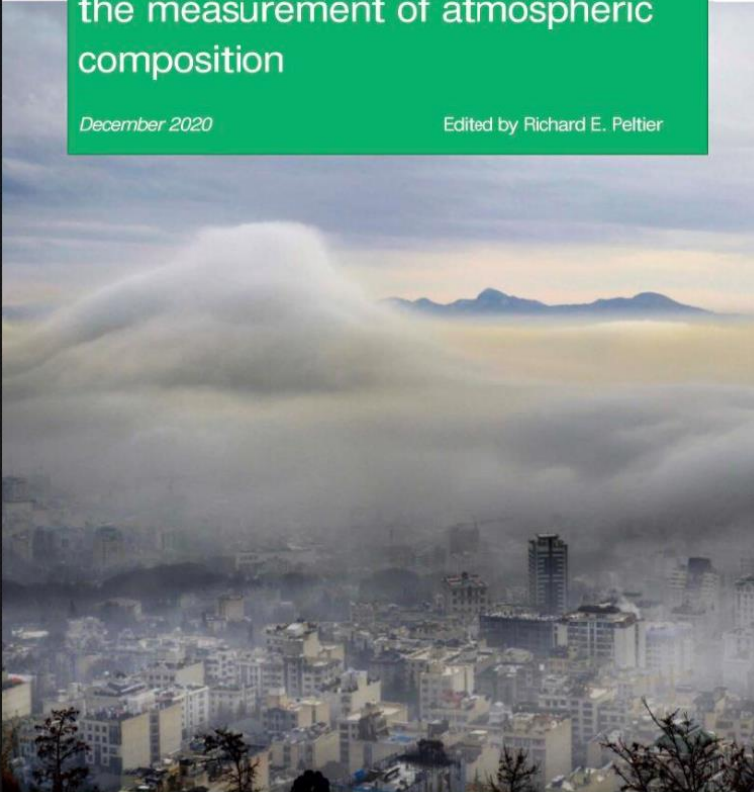
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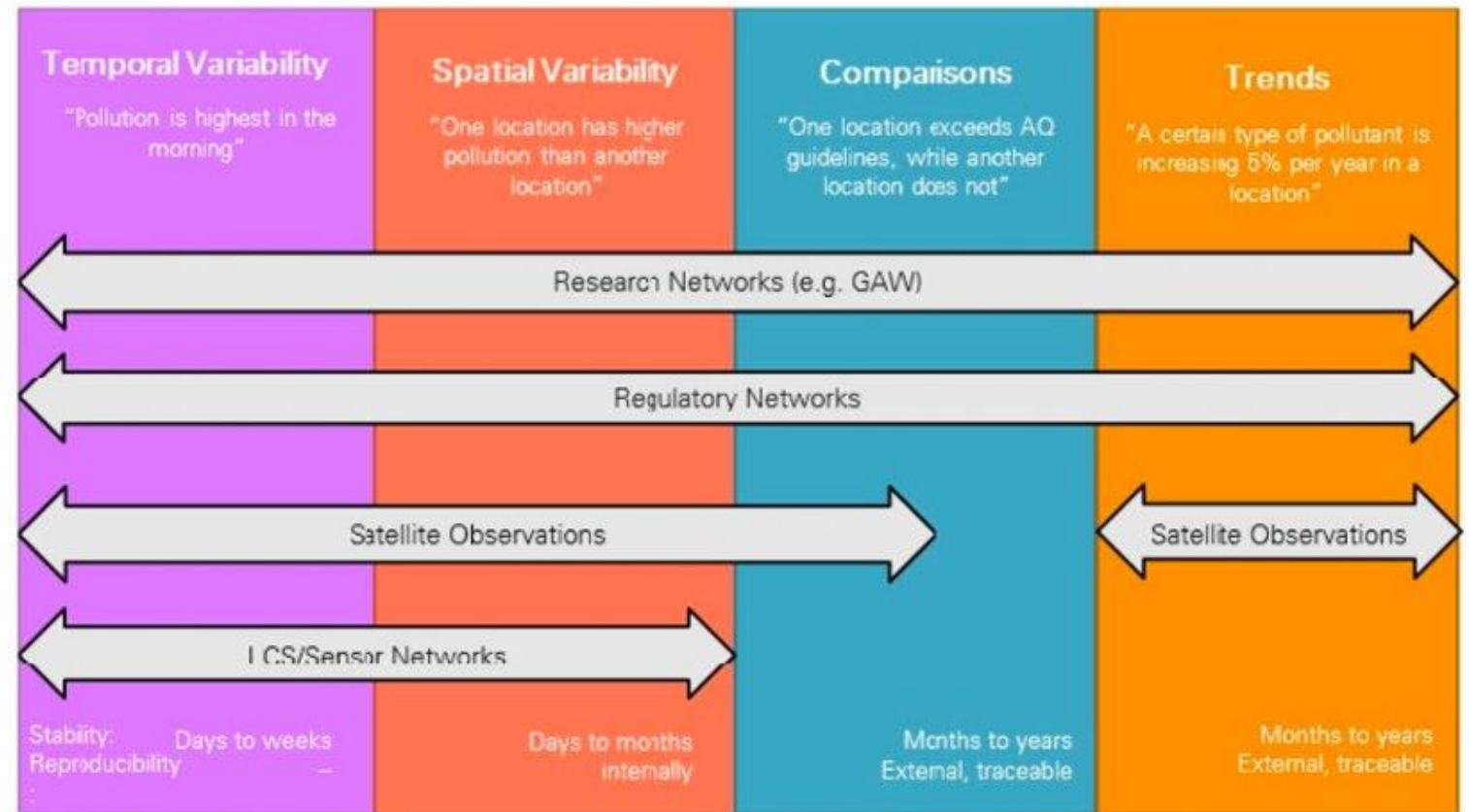
Integrating other sources of information: LCS

An update on low-cost sensors for the measurement of atmospheric composition

December 2020 Edited by Richard E. Peltier



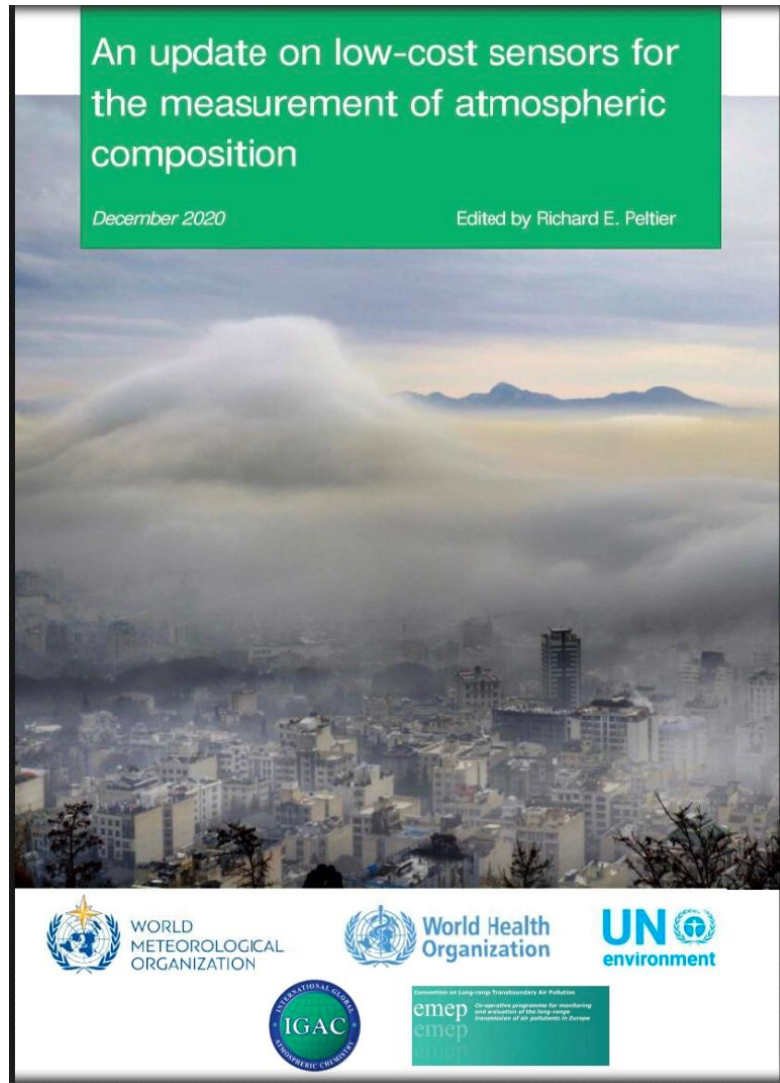
WORLD METEOROLOGICAL ORGANIZATION | World Health Organization | UN environment | IGAC | emep



WMO, WHO, UNEP, IGAC and EMEP (2020)
<https://library.wmo.int/idurl/4/37465>



Integrating other sources of information: LCS



Benefits and Limitations of Low-cost Sensors

Benefits

- Low cost production
- Portable and small
- Uses low amounts of power
- Rapidly advancing technology
- Low power consumption

Limitations

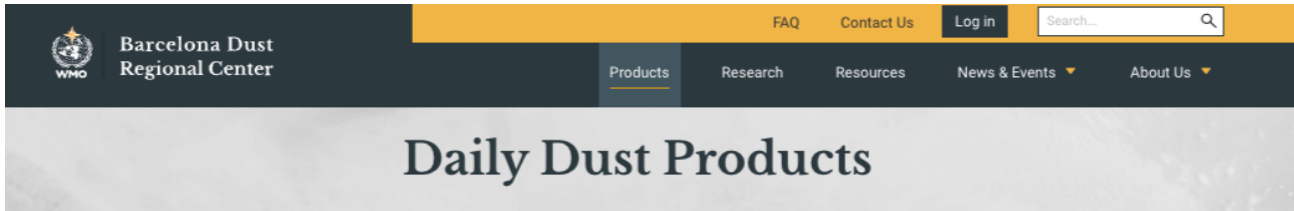
- High cost for their maintenance
- Low measurement precision
- Prone to large measurement errors
- Difficult to calibrate
- Limited lifetime

Recommendations for manufacturers:

"More information on sensor lifetimes and degradation over extended periods of time is needed. Most research evaluations of sensor performance are limited to weeks or months and there is a lack of information on changes over the annual timescale and longer. "

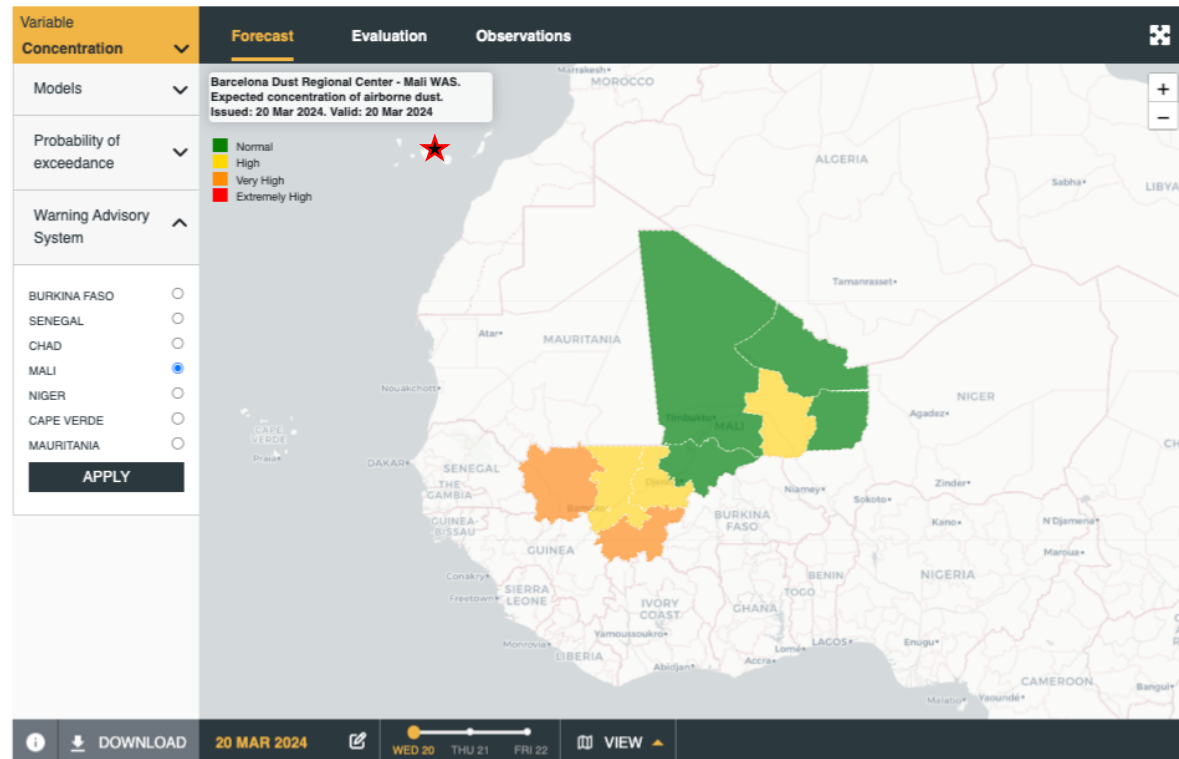
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Integrating other sources of information: LCS



< BACK TO PRODUCTS

This interactive visualisation tool allows you to access dust forecasts from different [numerical models](#) and dust-related observational products. To find out how to interact with it, please watch the [Video Tutorial](#) or download the [User Guide](#) and read the [Documentation](#). The Warning Advisory System has been developed thanks to the co-funding support of [FEDER INTERREG MAC](#) program and [WMO-CREWS](#) initiative.



For PM forecast evaluation, the Izaña Atmospheric Research Center (IARC-AEMET) conducted an intercomparison of different low-cost sensor in **Tenerife, Canary Islands** ★



Sensirion SPS30 – DUST010



Nova SDS011 – DUST011

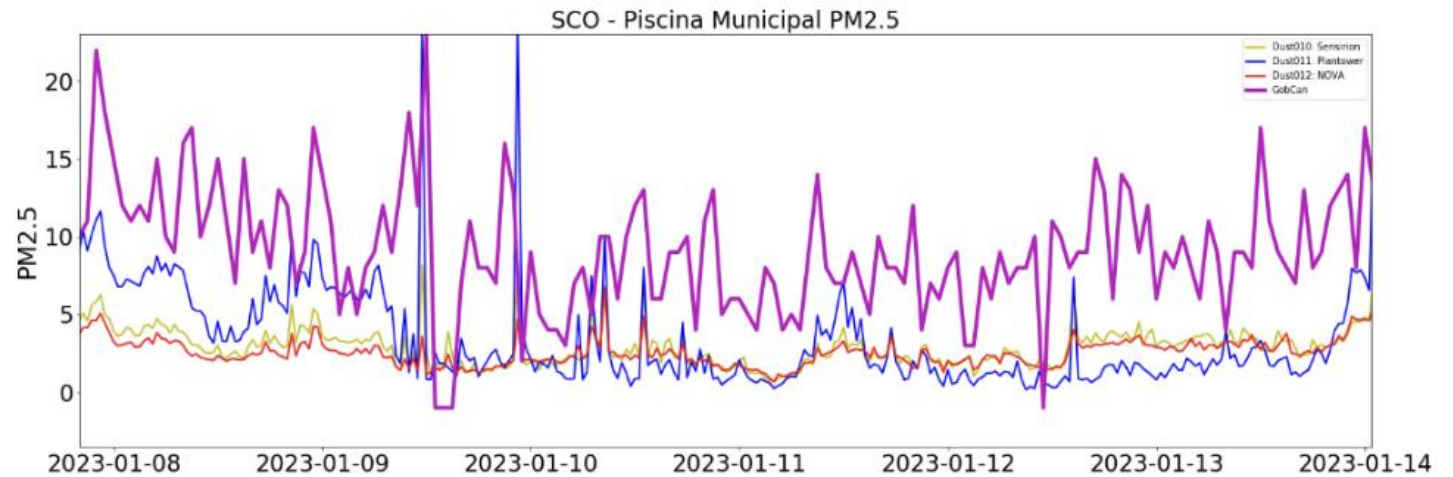
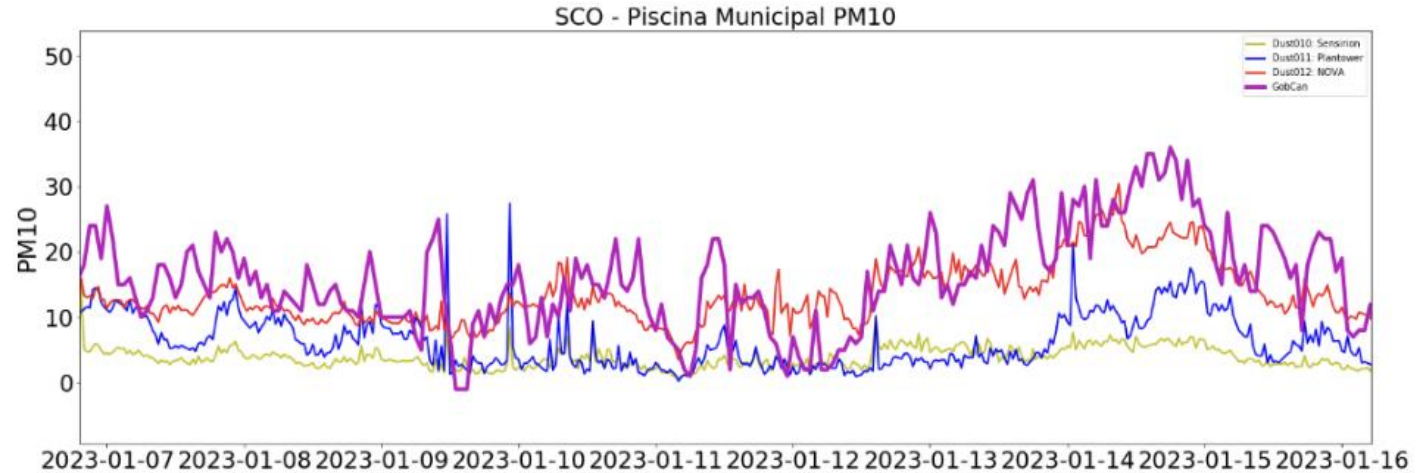


Plantower PMS5003 – DUST012



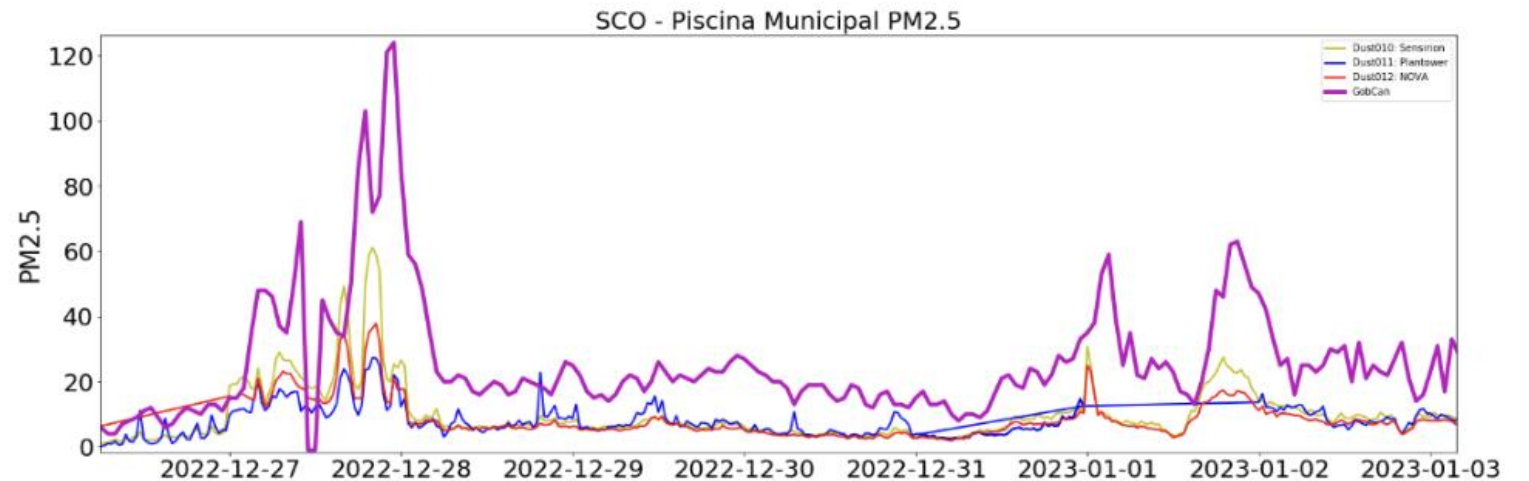
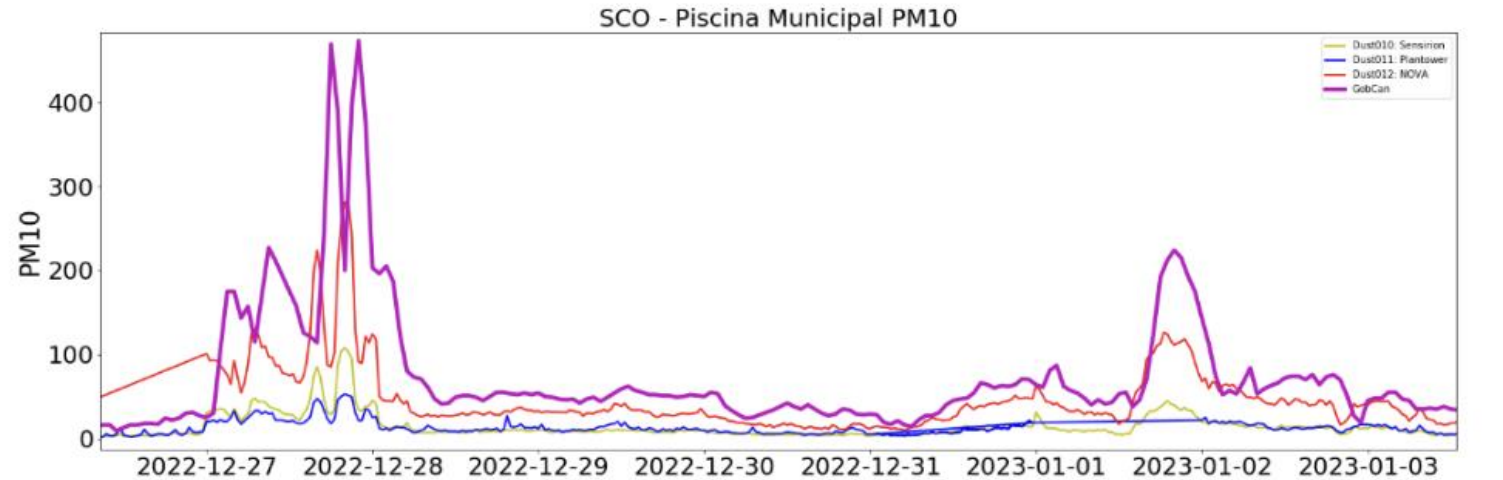
Integrating other sources of information: LCS

Comparison for low concentration events

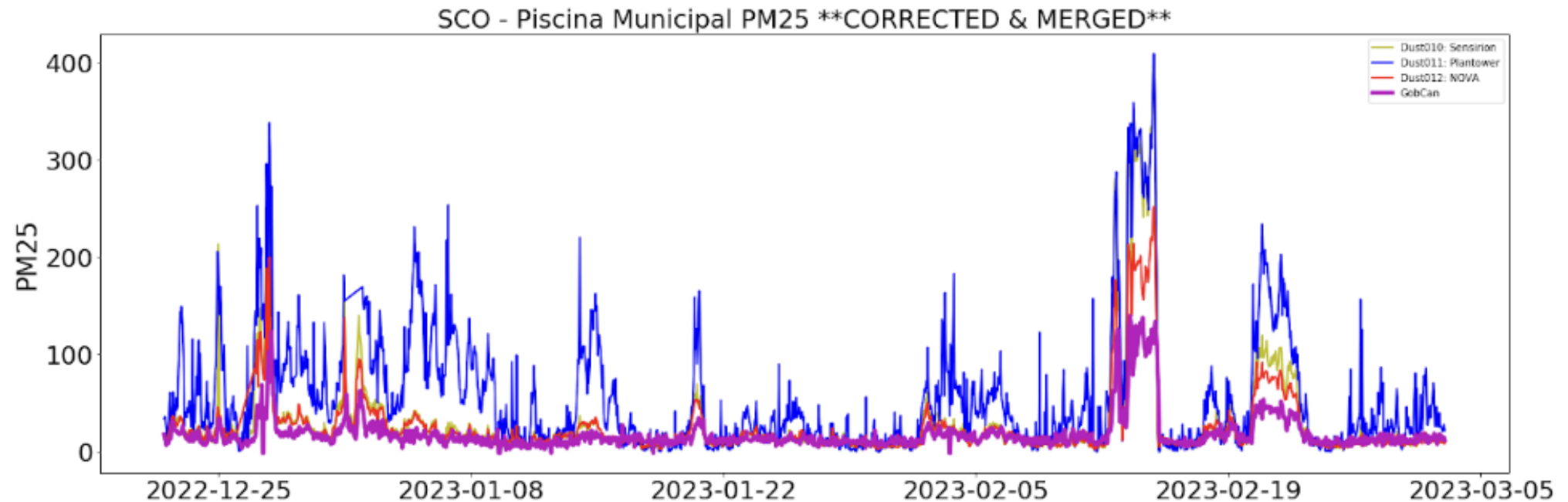


Integrating other sources of information: LCS

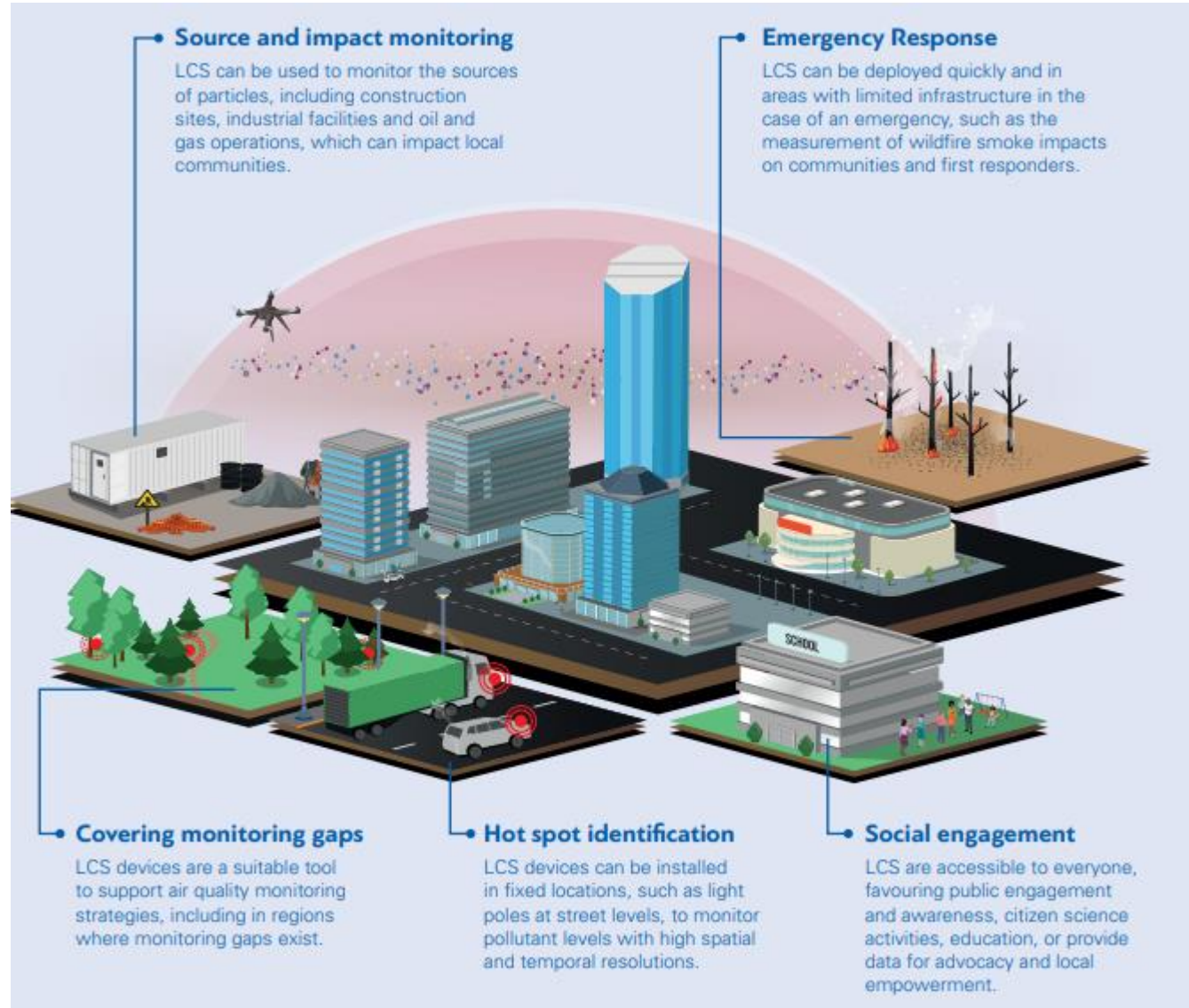
Comparison for high concentration events



Integrating other sources of information: LCS



Integrating other sources of information: LCS



New complementary report focusing on Air Quality Management applications to be **launched in June 2024**

Extended discussion on network design and implementation

Thank you.



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<https://community.wmo.int/en/activity-areas/gaw>

