

Global Atmosphere Watch (GAW) Programme



Sara Basart

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Greg Carmichael

Chair of the GAW programme

Daniel Tong, Mikhail Sofiev and Judd Welton

GAW experts

WMO OMM

World Meteorological Organization

Organisation météorologique mondiale

World Meteorological Organization (WMO)

- UN specialized agency on weather, climate and water.
- It's supported by 193 Members and the headquarters is in Geneva (Switzerland).
- Coordinates work of > 300,000 national experts from meteorological and hydrological services, academia and private sector.
- Co-Founder and host agency of IPCC.



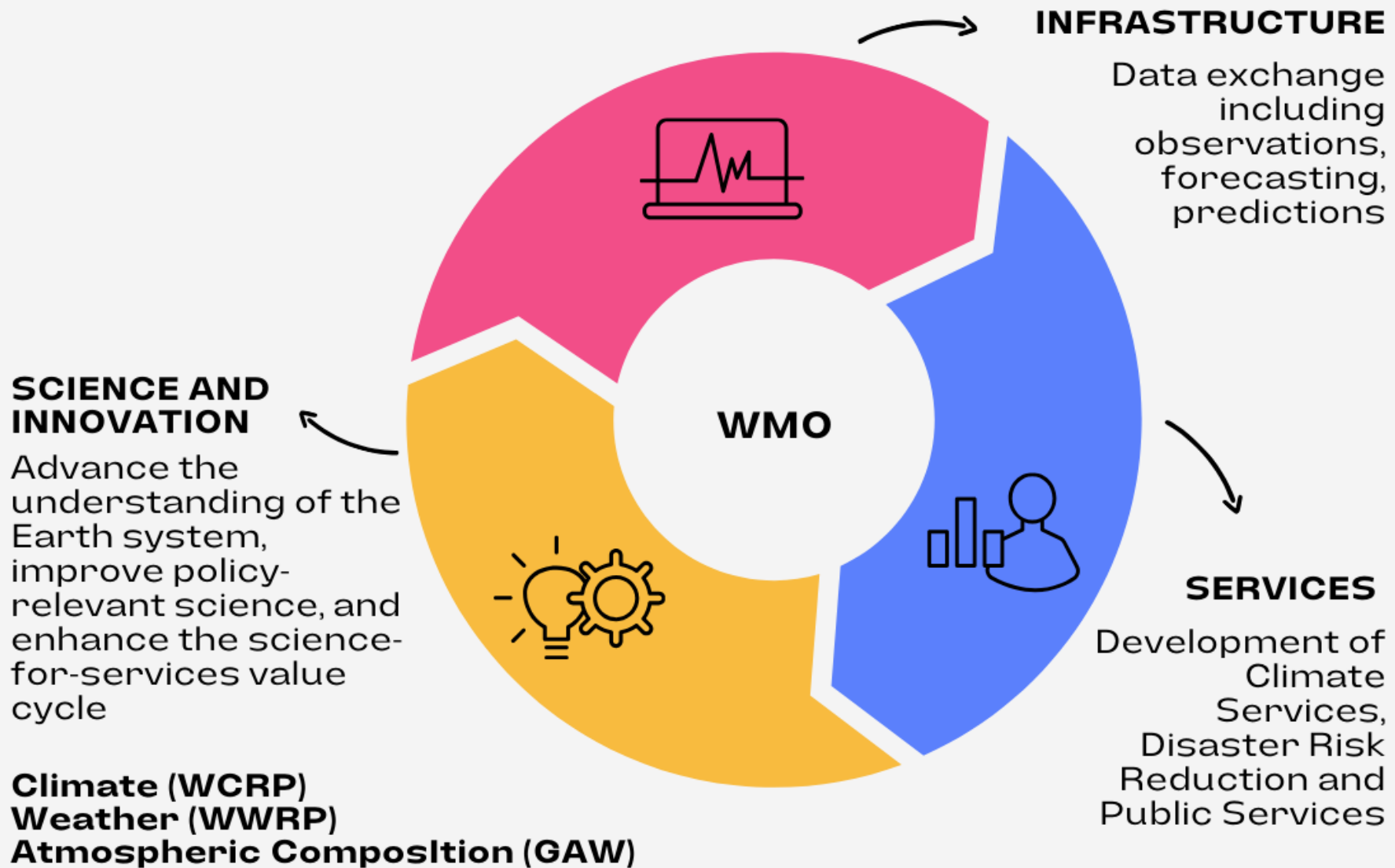
WMO OMM



Prof. Celeste Saulo, WMO Secretary-General elect (left), and Dr Al Mandous, newly elected President of WMO (right) (1 June 2023)

WMO

WMO Departments





WMO Research - Global Atmosphere Watch (GAW)

Research Enabling Atmospheric Composition Services

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.

Drivers: Global societal needs



WMO OMM

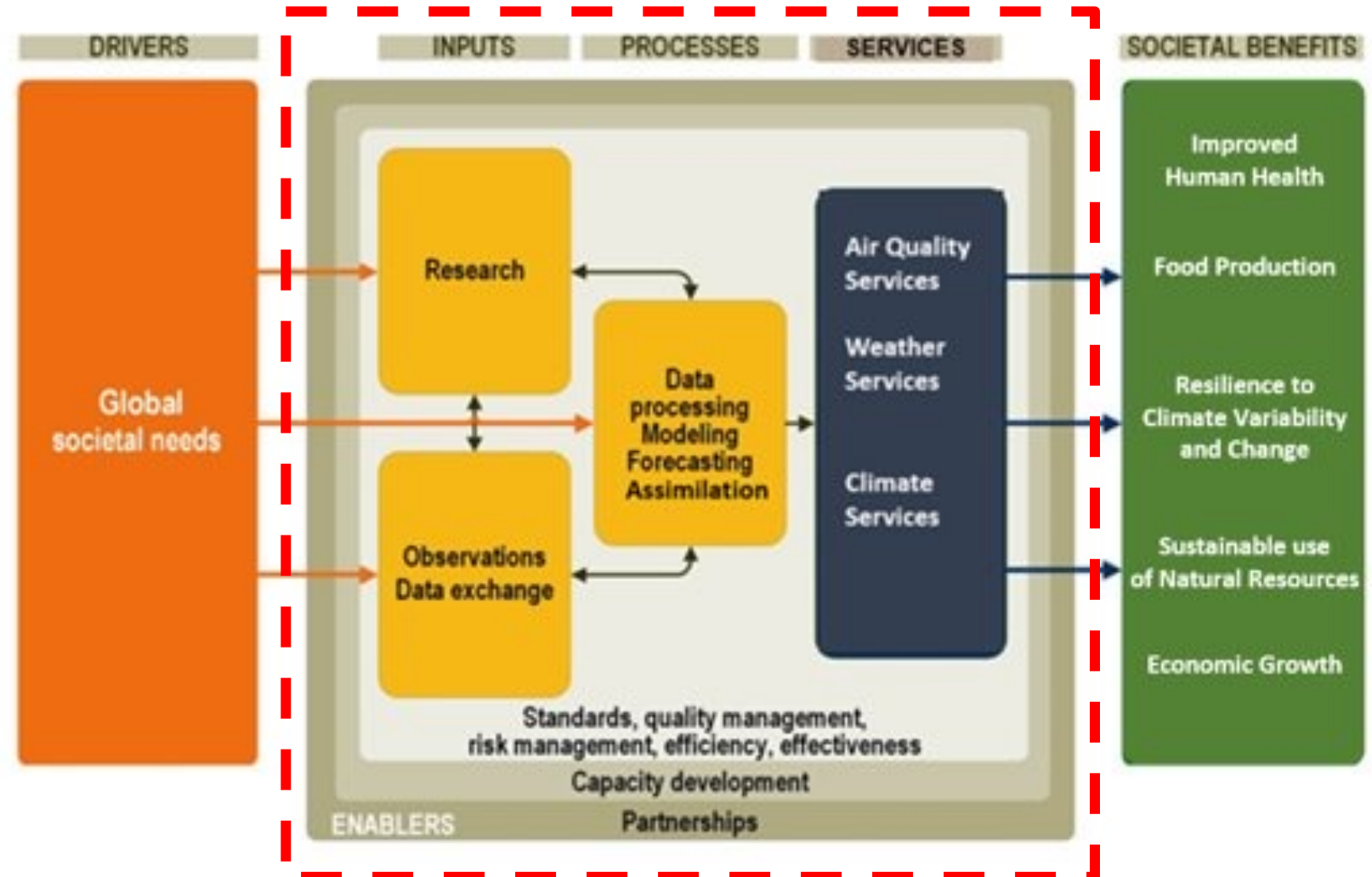




Global Atmosphere Watch (GAW)

Achieving a comprehensive atmospheric composition observing and analysis infrastructure by closely linking operations and research

20 GAW expert groups that considers more than 300 expert sfrom different disciplines including monitoring, modelling and data management

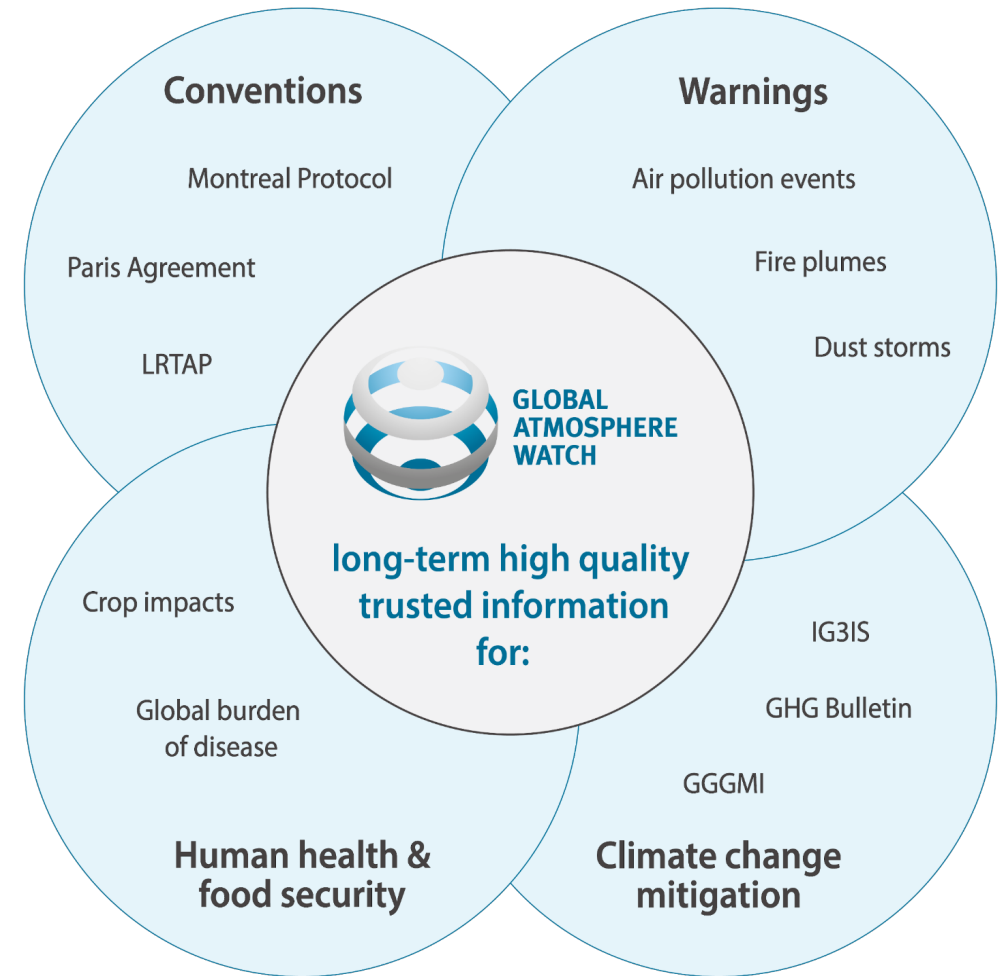


WMO



Global Atmosphere Watch (GAW)

- *Based on partnerships involving contributors from **100 countries** (including many contributions from research community)*
- *Maintains and applies **long-term systematic** observations of the chemical composition and related physical characteristics of the atmosphere*
 - Emphasizes **quality assurance and quality control**
- *Delivers integrated products and services of relevance to society.*





GAW Achievements

Atmos. Chem. Phys., 22, 4615–4703, 2022
https://doi.org/10.5194/acp-22-4615-2022
© Author(s) 2022. This work is distributed under
the Creative Commons Attribution 4.0 License.

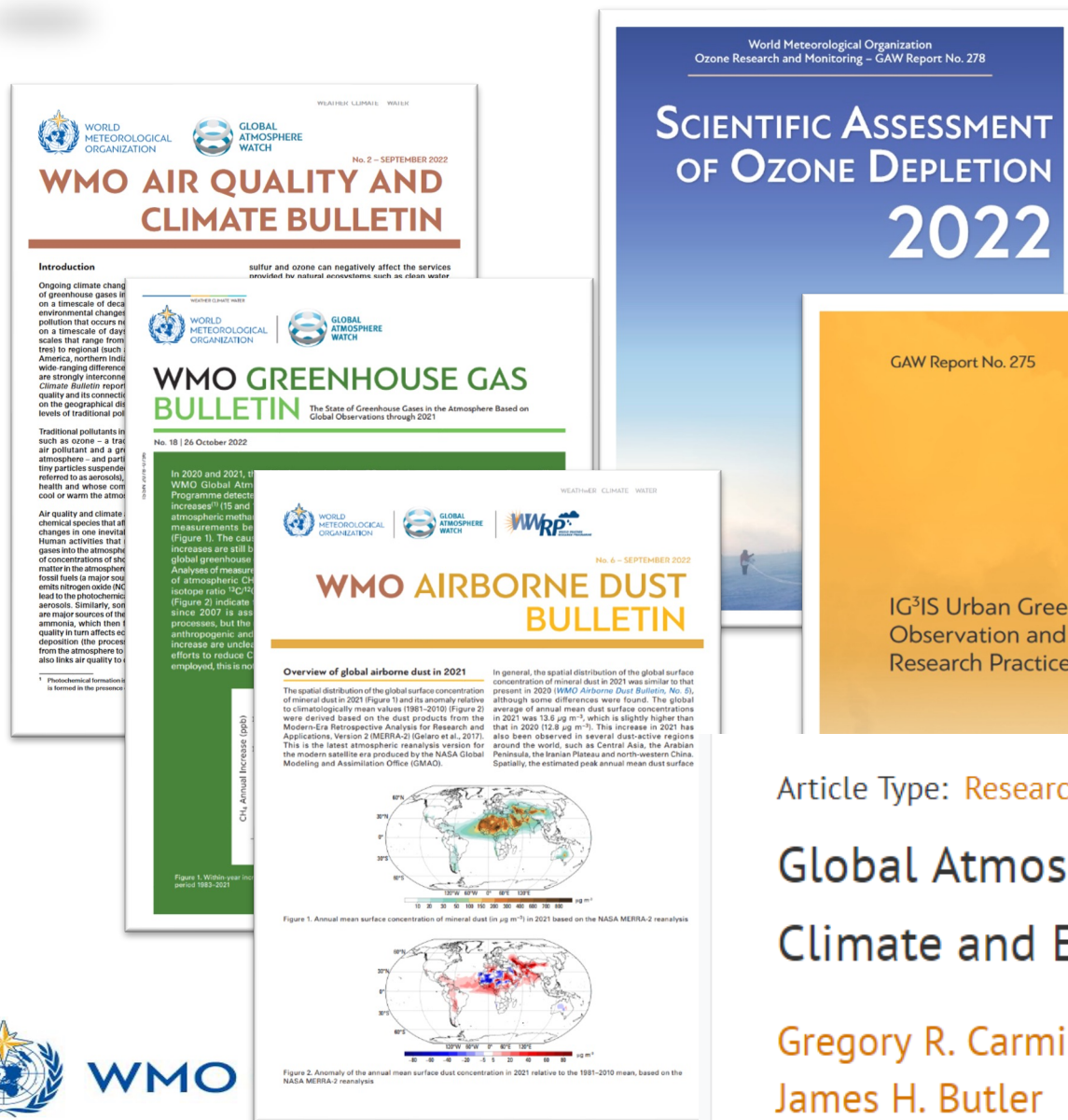


Atmospheric
Chemistry
and Physics
Open Access
EGU

Review article

Advances in air quality research – current and emerging challenges

Ranjeet S. Sokhi¹, Nicolas Moussiopoulos², Alexander Baklanov³, John Bartzis⁴, Isabelle Coll⁵, Sandro Finardi⁶, Rainer Friedrich⁷, Camilla Geels⁸, Tiia Grönholm⁹, Tomas Halenka¹⁰, Matthias Ketzel⁸, Androniki Maragkidou⁹, Volker Matthias¹¹, Jana Moldanova¹², Leonidas Ntziachristos², Klaus Schäfer¹³, Peter Suppan¹⁴, George Tsegas², Greg Carmichael¹⁵, Françoise Franco¹⁶, Steve Hanna¹⁷, Jukka-Pekka Jalkanen⁹, Guus J. M. Velders^{18,19}, and Jaakko Kukkonen^{9,1}



Environmental
Science & Technology

pubs.acs.org/est



Perspective

Improving Estimates of Sulfur, Nitrogen, and Ozone Total Deposition through Multi-Model and Measurement-Model Fusion Approaches

Joshua S. Fu,* Gregory R. Carmichael,* Frank Dentener,* Wenche Aas, Camilla Andersson, Leonard A. Barrie, Amanda Cole, Corinne Galy-Lacaux, Jeffrey Geddes, Syuichi Itahashi, Maria Kanakidou, Lorenzo Labrador, Fabien Paulot, Donna Schwede, Jiani Tan, and Robert Vet

Cite This: *Environ. Sci. Technol.* 2022, 56, 2134–2142

Read Online

ACCESS |

Full Text |

Article Recommendations

Supporting Information

Article Type: Research Article

Global Atmospheric Composition Observations: The Heart of Vital Climate and Environmental Action

Gregory R. Carmichael, Oksana Tarasova, Øystein Hov, Leonard Barrie, and James H. Butler

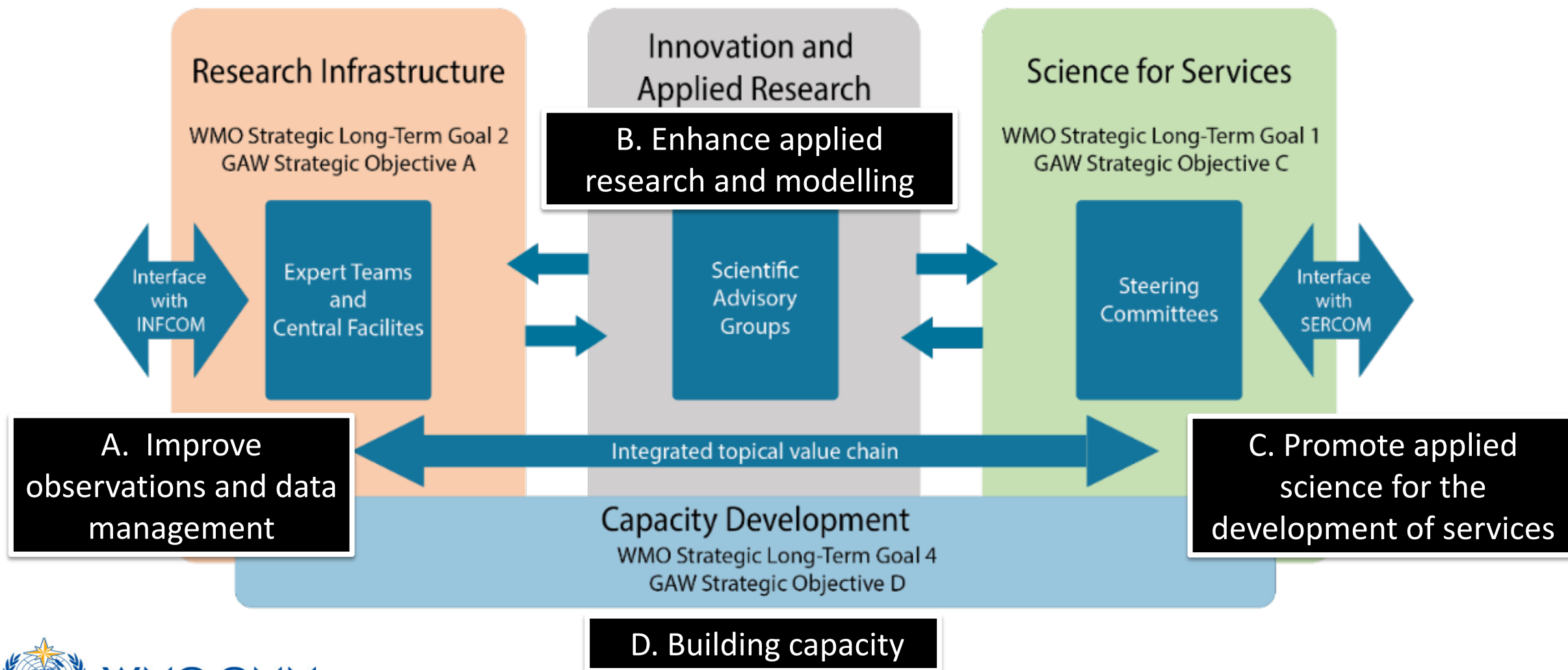


https://doi.org/10.5194/acp-22-4615-2022
within precipitation, or dry deposition on vegetation, soil, crop production. Current global scale maps of atmospheric deposition are mainly based on chemical transport model



GAW SIP 2024-2027 Strategic Objectives

Aligned explicitly with new WMO strategic plan



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GAW: 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*



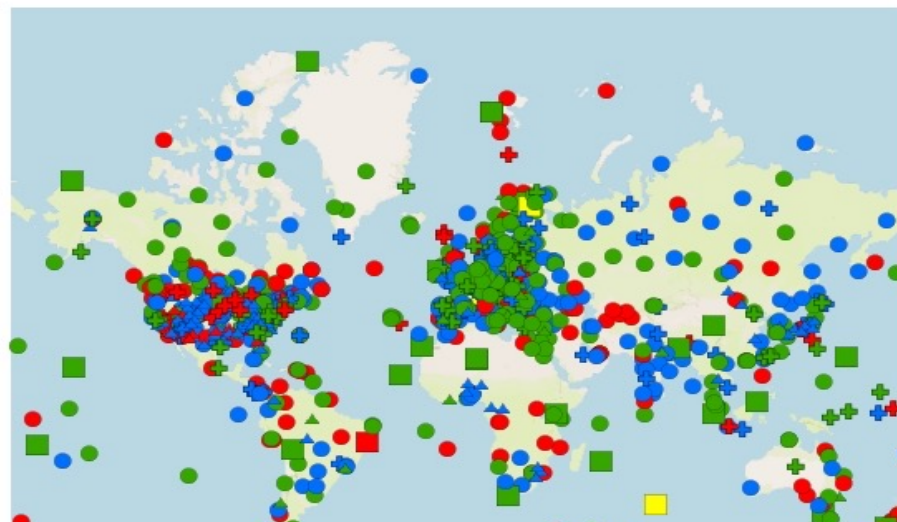
WMO OMM



Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Confederation

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



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

GAW Station Information System
(**GAWSIS**, <https://gawsis.meteoswiss.ch/GAWSIS/#/>) part of
WMO Integrated Global Observation Systems (**WIGOS**)

mapbox © Mapbox © WMO © OpenStreetMap

Global
Regional
Contributing networks
Local
Other networks

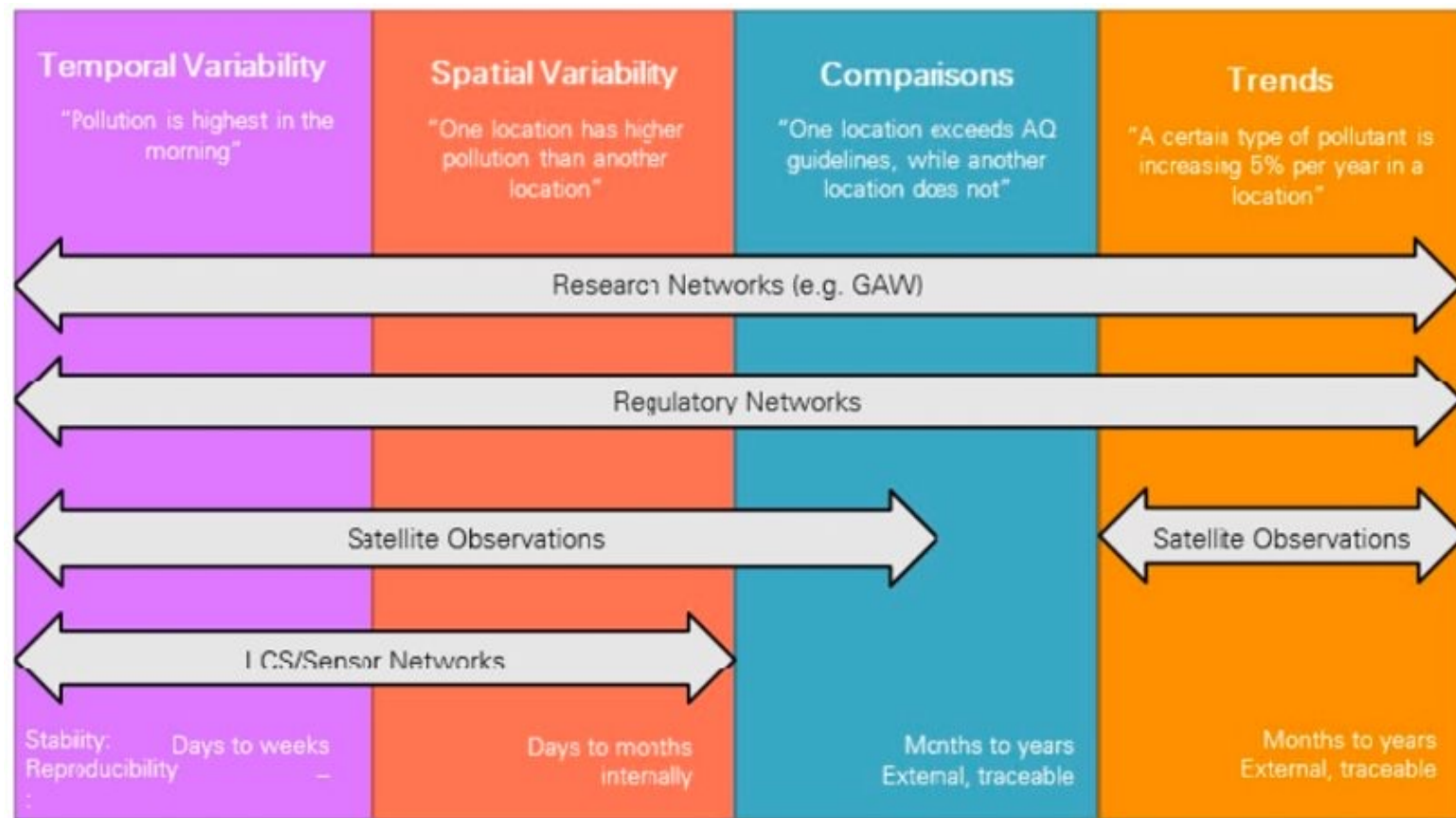
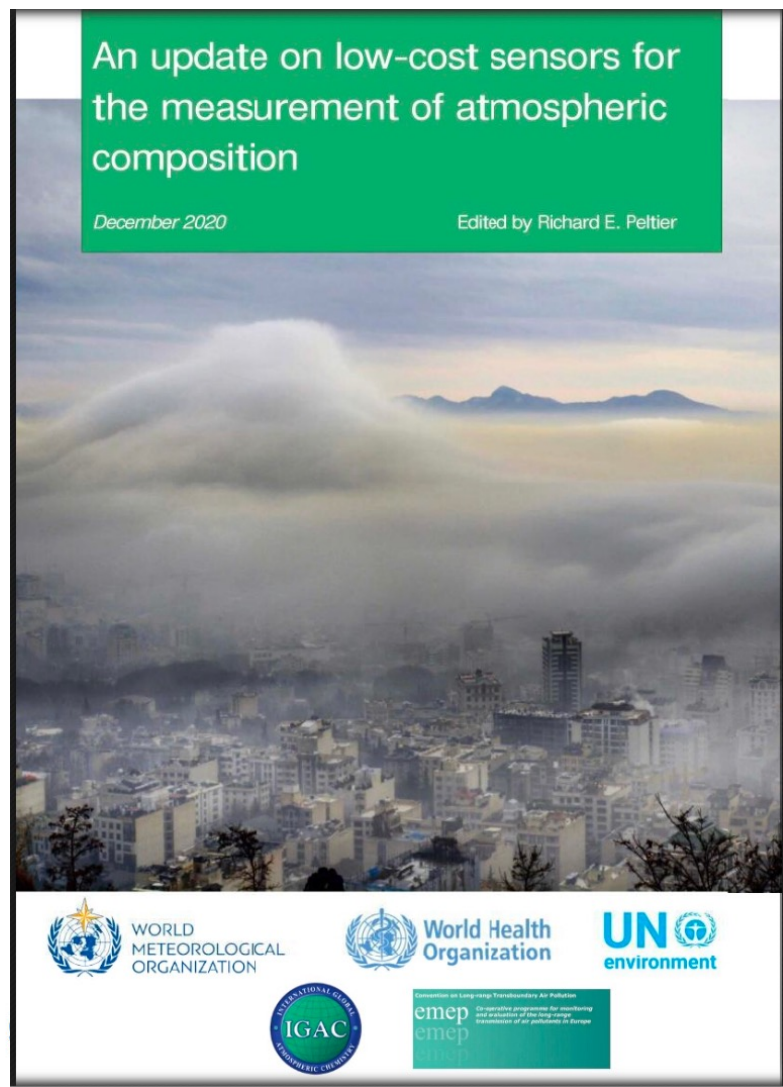
Operational
Partly operational
Non-reporting
Closed
Planned
Pre-operational
Stand-by





GAW: Observational (research) Infrastructure

Integrating other sources of Air Quality information: Low-Cost Sensors



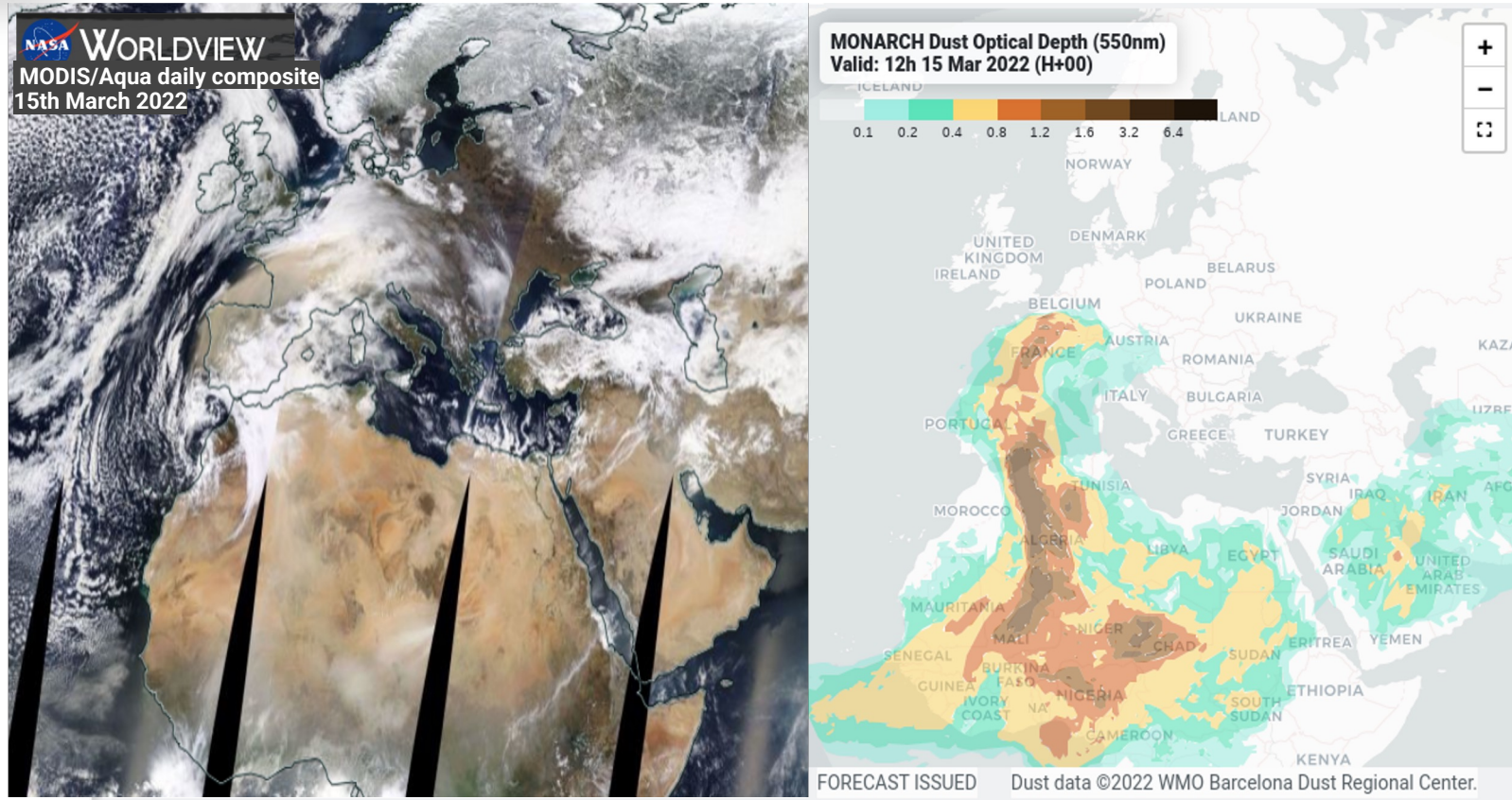
New report ongoing for 2024!

Extracted from (WMO, 2020)



Global Atmosphere Watch (GAW)

Integrating available information



Assessing the model uncertainty
and identifying missing processes
thanks to model **evaluation**

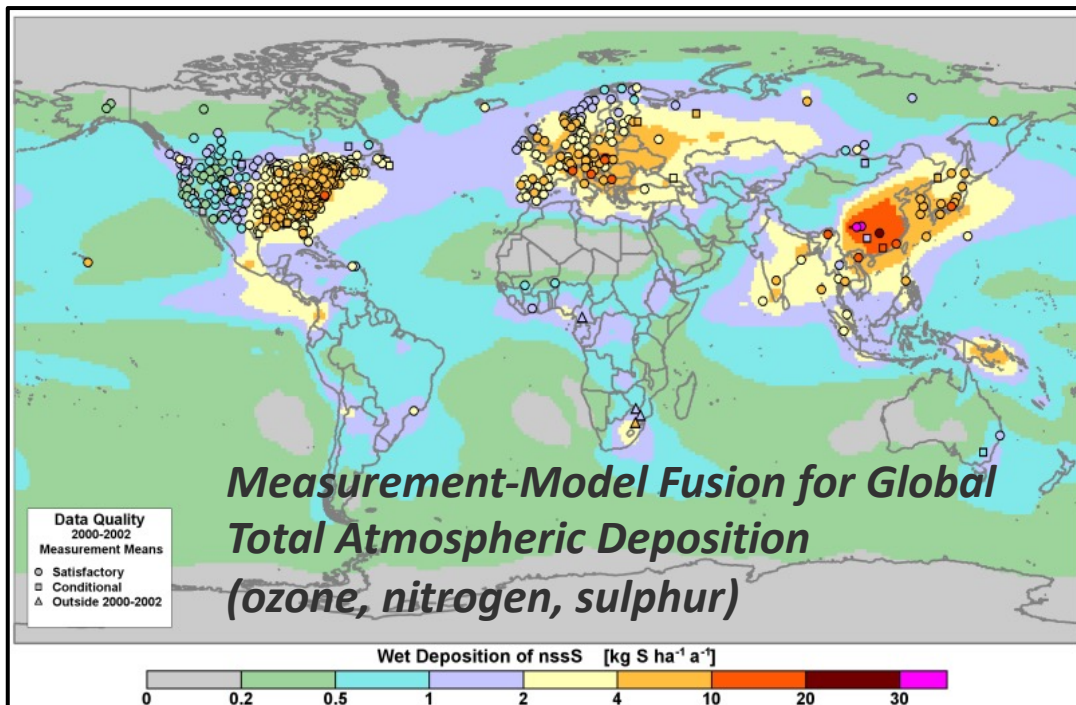
Improved dust and aerosol forecasting
products through the **assimilation** of
satellite retrievals



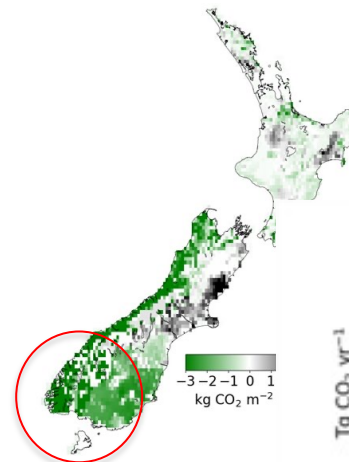
GAW: Science for Services

*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.*

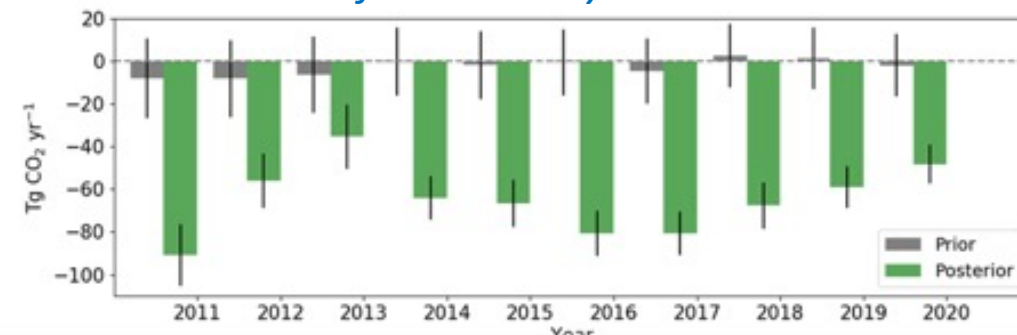
Deposition to ecosystems and crops + climate action



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Integrated Global Greenhouse Gas Information System



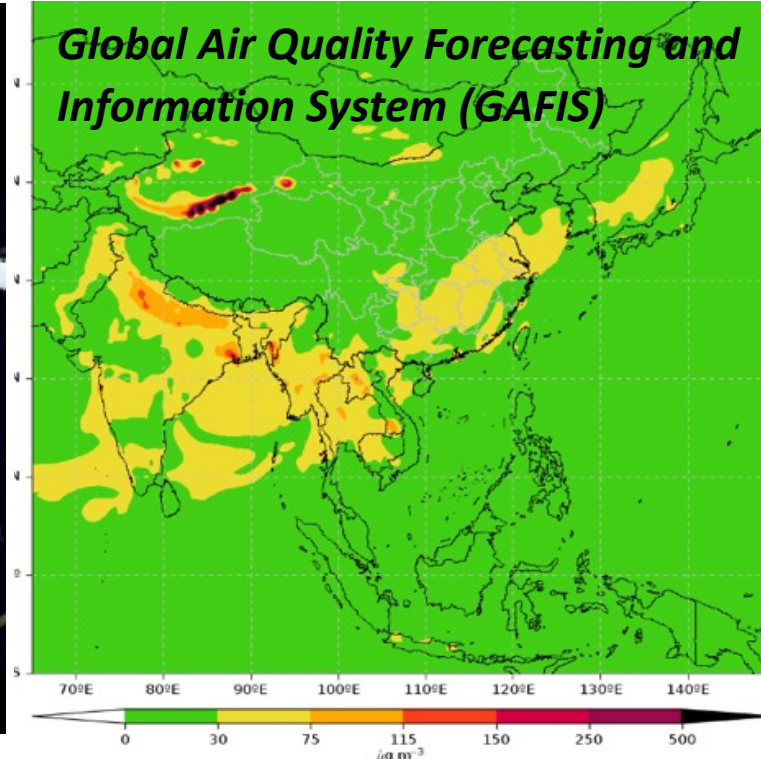
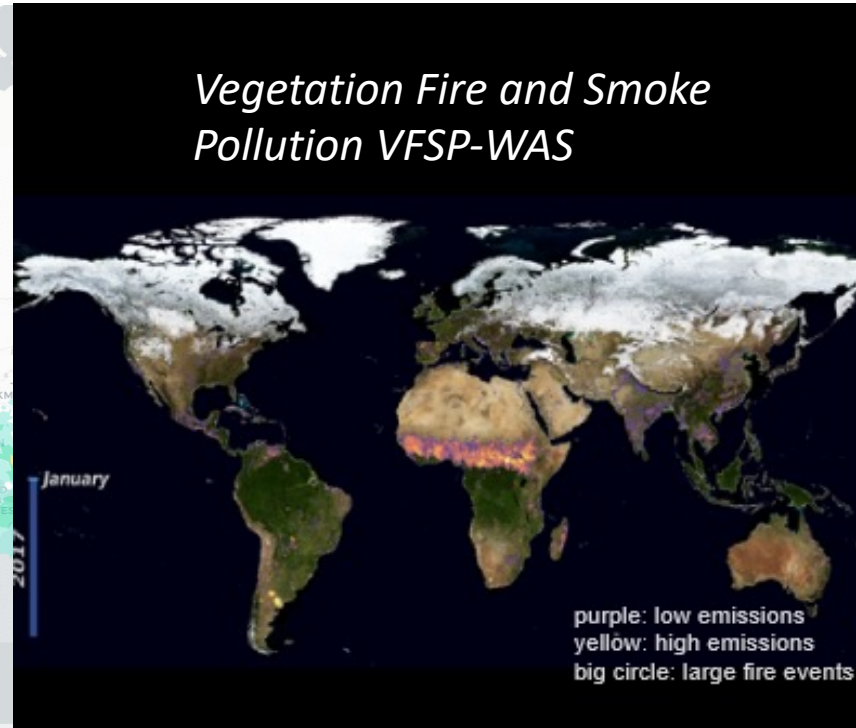
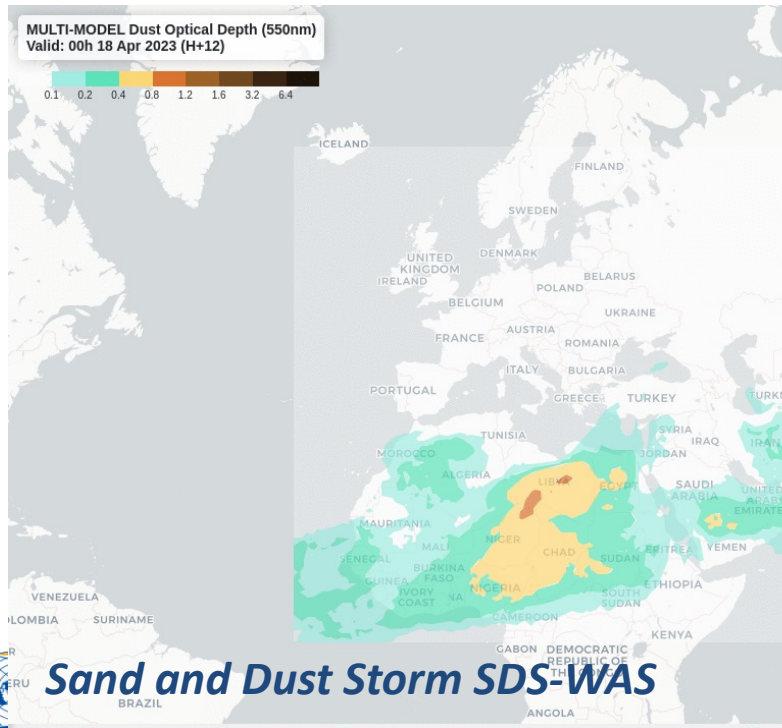
Aotearoa New Zealand's terrestrial carbon uptake



GAW: 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



Sand and Dust Storm SDS-WAS



GAW: Science for Services

"Research" Infrastructure for building Services

Monitoring

746 active
global/regional/urban/
stations in 112 countries

Central Facilities

13 countries are hosting
GAW central facilities

Forecasting

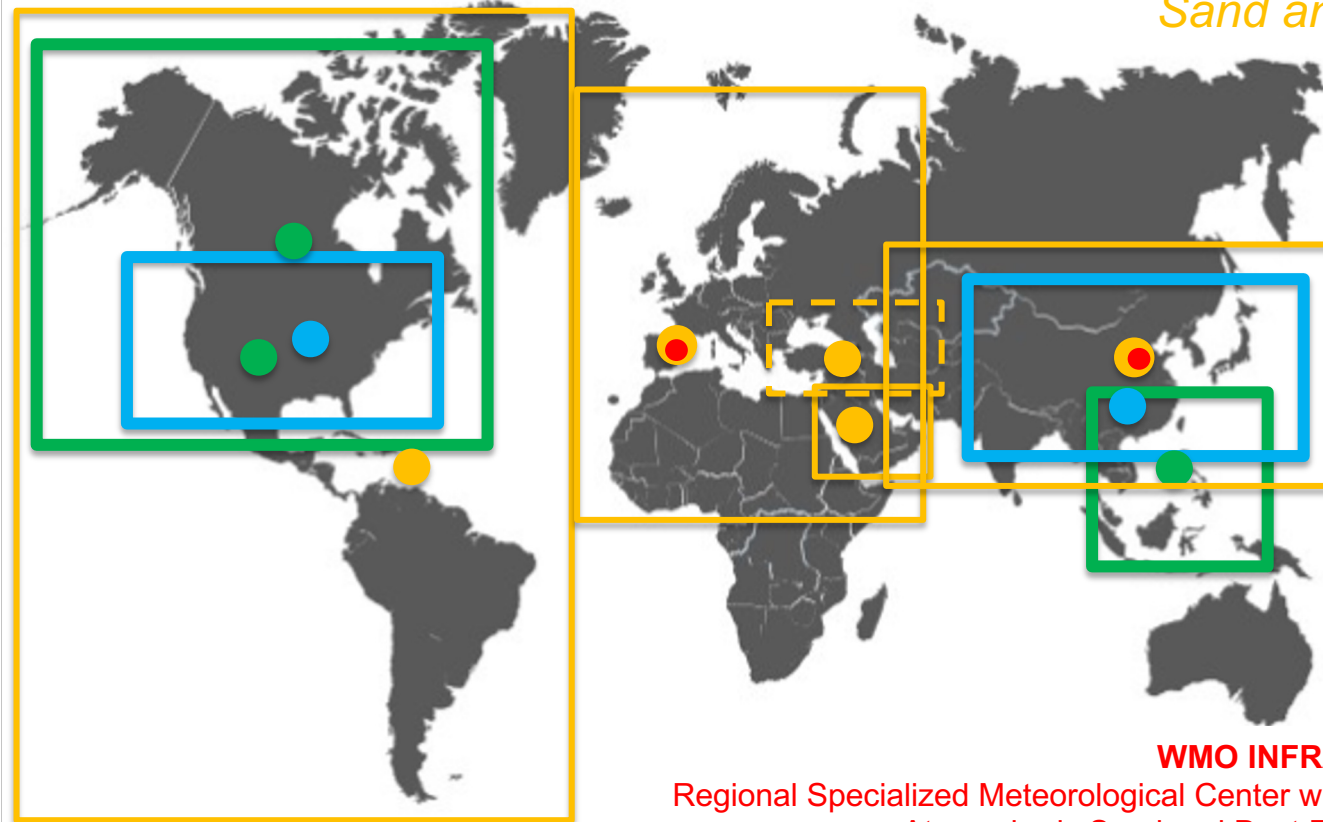
21 countries providing daily
forecasts

Forecasting - Model Intercomparisons:

Sand and Dust Storms

Wildfires

Air Quality



WMO INFRASTRUCTURE - WIIPS

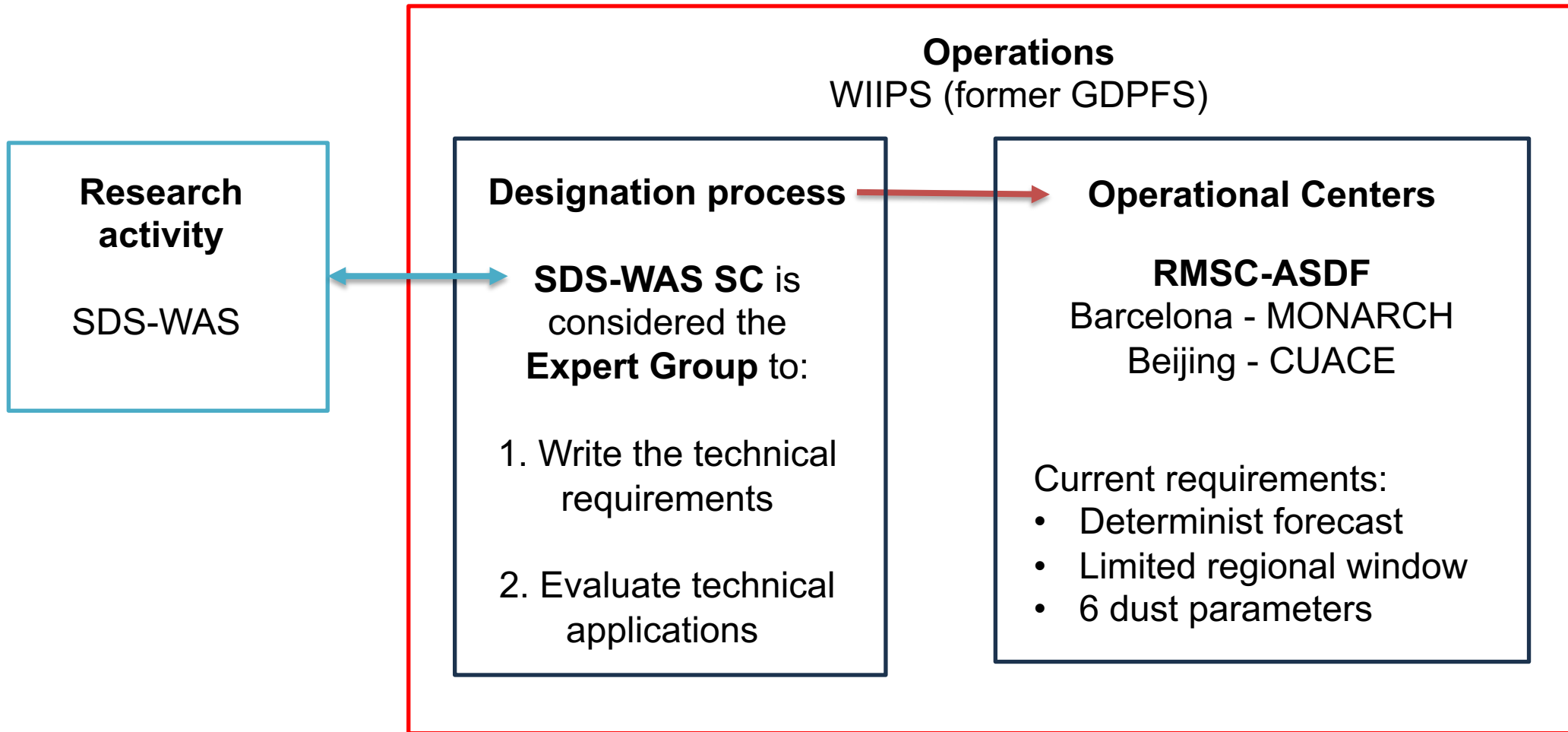
Regional Specialized Meteorological Center with activity specialization
on Atmospheric Sand and Dust Forecast (RSMC-ASDF)



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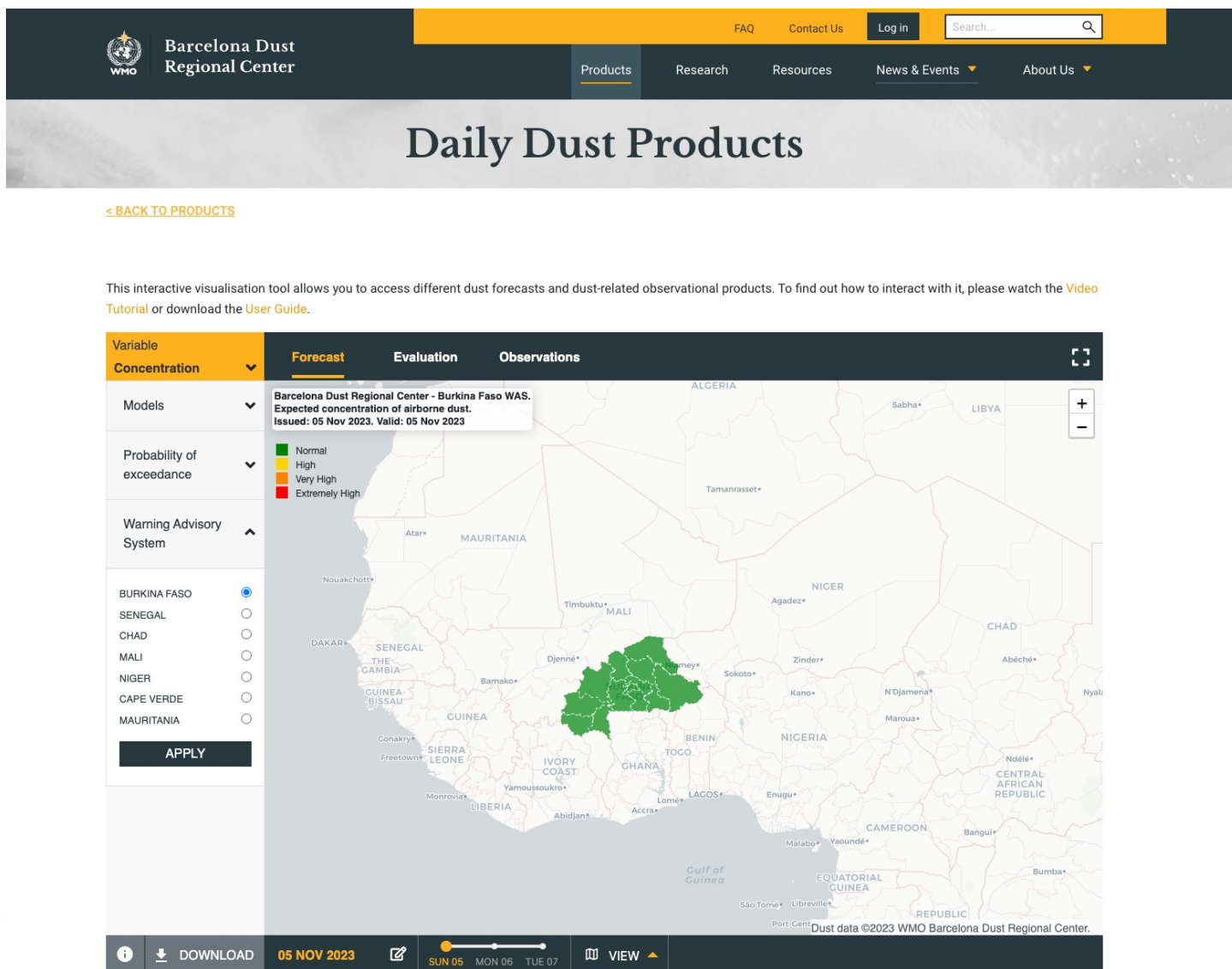
From Research to Operations

WMO Integrated Processing and Prediction System (WIIPS)



RSMC-ASDF should evolve

From Research to Operations | Next, the WARNING

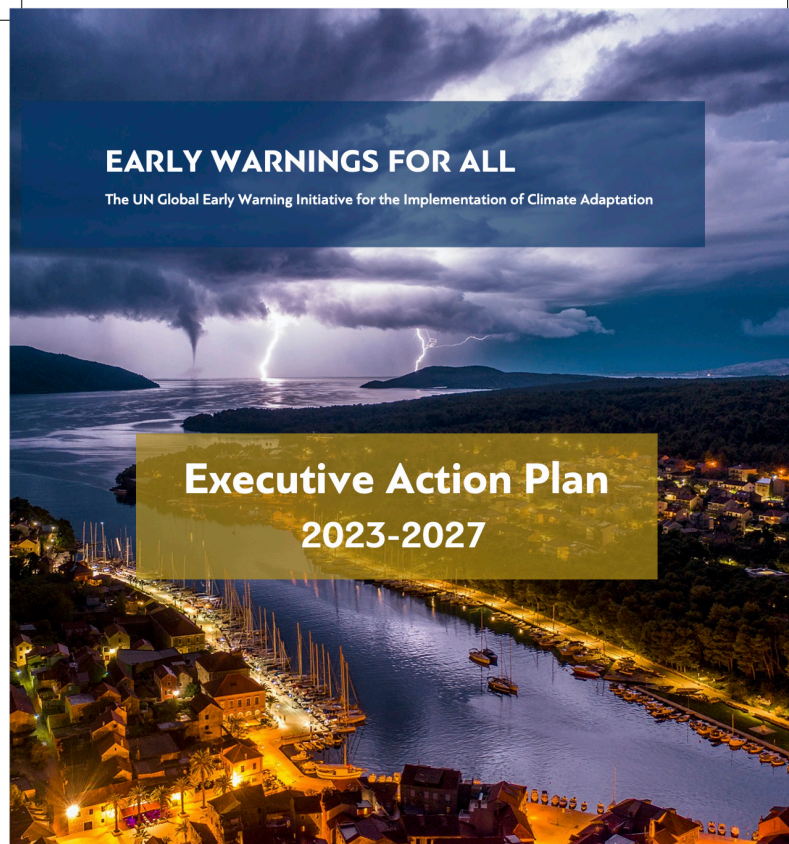


CREWS (Climate Risk and Early Warning Systems) is a unique and specialized fund for climate action that saves lives and livelihoods in Least Developed Countries (LDCs) and Small Island Developing States (SIDS).



GAW Report on assessment methodologies, final draft in November 2023 (lead author S. Nickovic)

UN Early Warning for All | EW4All



“The facts are clear. Early warnings save lives and deliver vast financial benefits. I urge all governments, financial institutions and civil society to support this effort.” – UN Secretary-General António Guterres



WORLD
METEOROLOGICAL
ORGANIZATION



UNDRR
UN Office for Disaster Risk Reduction

+C IFRC



Strategy build in 4 pillars:

1. Disaster risk knowledge and management (UNDRR)
2. Detection, observation, monitoring, analysis, and forecasting (WMO)
3. Warning dissemination and communication (ITU)
4. Preparedness and response capabilities (IFRC)



WORLD
METEOROLOGICAL
ORGANIZATION



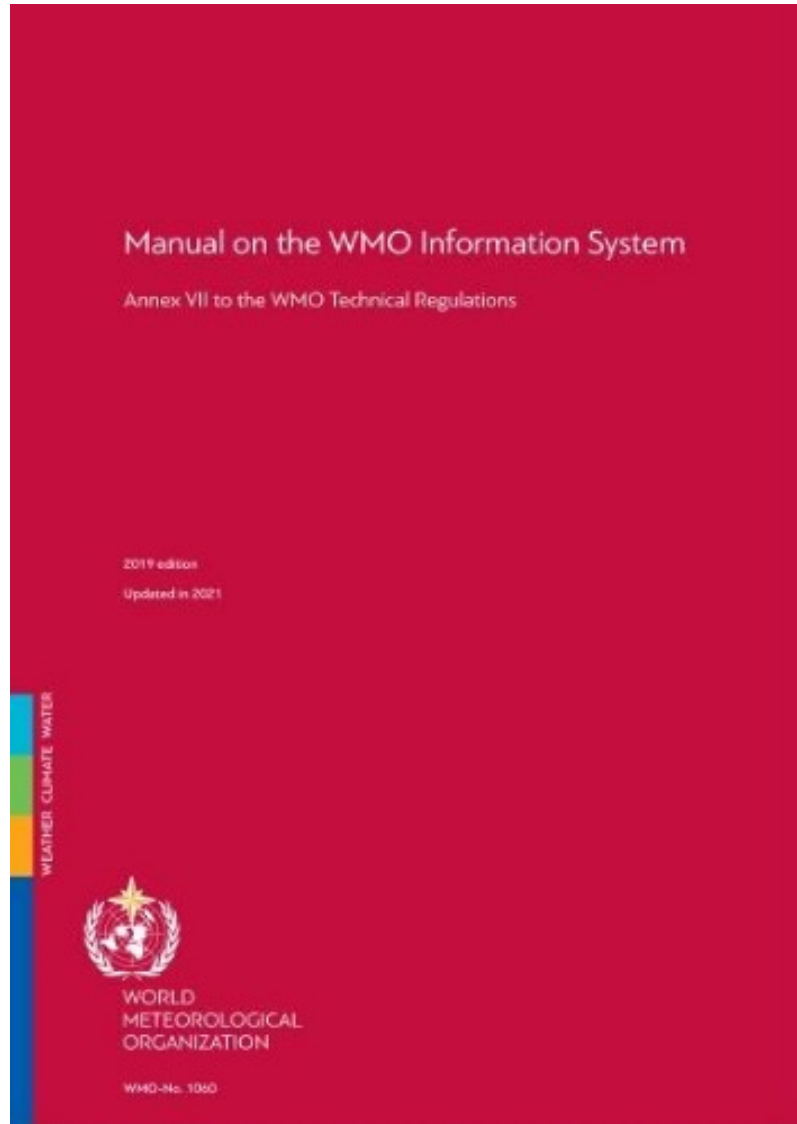
WEATHER CLIMATE WATER



<https://library.wmo.int/>

**50% of the countries are not protected by Early Warnings
In the list of hazards is considered SDS and wildfires**

From Research to Operations | The data exchange WMO Information System (WIS)



The **WMO Information System (WIS)** which provides a coordinated network of systems for sharing authoritative data on weather, climate, water, and related **observations (WIGOS)**, **forecasting/predictions (WIPPS)** and **warnings**.

This requires strict conventions definition for the exchange of products

- *Daniel Tong and Mikhail Sofiev (SDS-WAS and VFSP-WAS): SDS and Wildfires **forecasting** products – Definition of products to be provided*
- *Judd Welton (GALION) : Identification of issues on data exchange for **atmospheric composition observations***

From Science to Services

Sand and Dust Storms and Wildfires Forecasting



Mikhail Sofiev and Daniel Tong

GAW Experts – Chairs of the SDS-WAS and the VFSP-WAS

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World Meteorological Organization

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GAW: Science for Services

"Research" Infrastructure for building Services

Forecasting

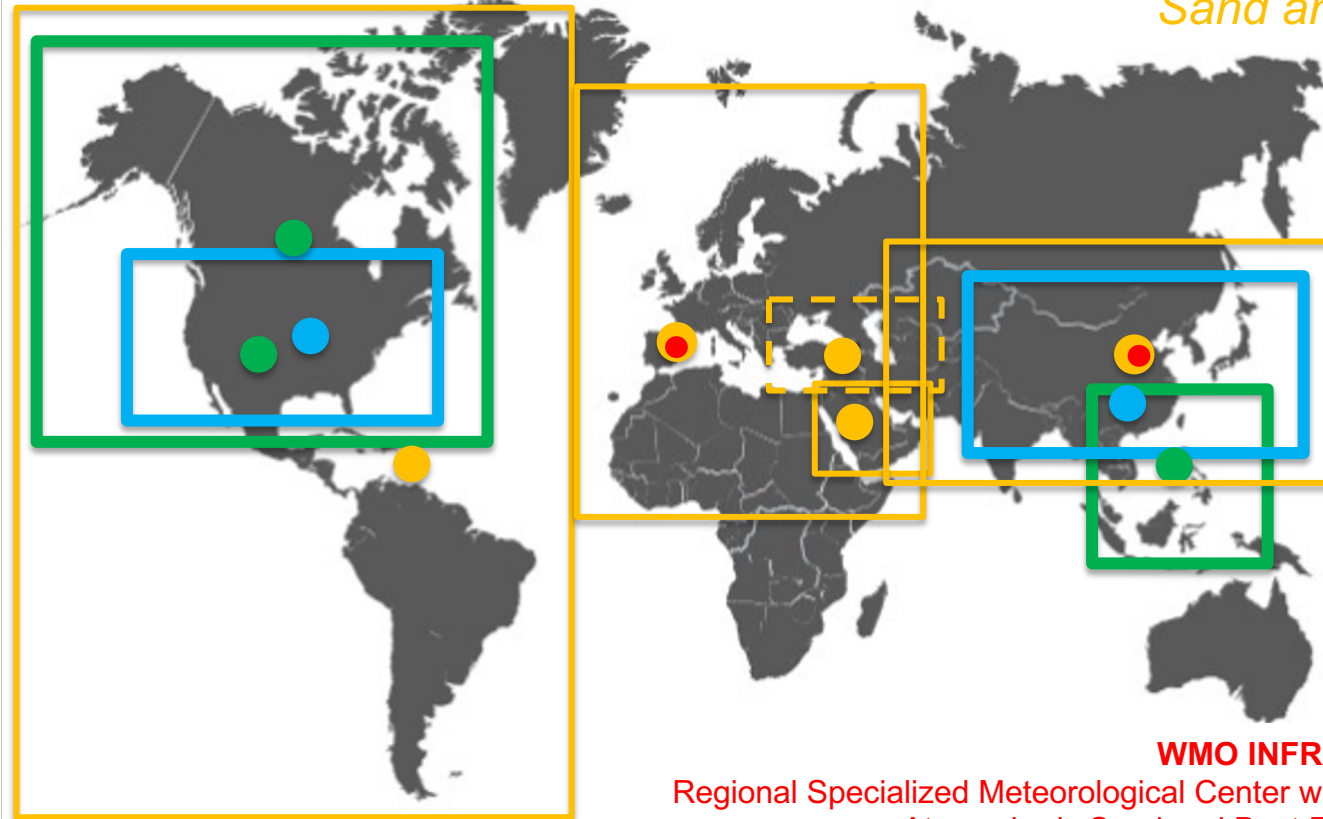
21 countries providing daily forecasts

Forecasting - Model Intercomparisons:

Sand and Dust Storms

Wildfires

Air Quality



WMO INFRASTRUCTURE - WIIPS

Regional Specialized Meteorological Center with activity specialization on Atmospheric Sand and Dust Forecast (RSMC-ASDF)



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From Research to Operations

Vegetation Fires and Smoke Pollution (VFSP)

- Started recently but catching up
- North-American and Asian regional centres in research mode
- Global coordination VFSP-WAS centre is being established
 - ToR
 - Technical requirements to operational centres
- Possible ICAP community contribution:
 - Scientific expertise and scrutiny
 - Contribution to research/operational activities of regional centres: forecasts, DA technology and products, evaluation



WMO Sand and Dust Storms Warning Advisory & Assessment System (SDS-WAS): 2022 -2023



Daniel Tong (Email: qtong@gmu.edu)

Chair of the SDS-WAS Global Steering Committee (GSC)

Members: Ana Vuković, Andrea Sealy, Barry Baker, Hyunsuk Kang, Jumaan Saad Alqahtani, Melanie Ades, Peng Xian, Slobodan Nickovic, Takashi Maki, Xiaoye Zhang, Ernest Werner

Sara Basart (sbasart@wmo.int)

Scientific Officer, WMO Science and Innovation Department

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World Meteorological Organization

Organisation météorologique mondiale

What is WMO SDS-WAS?

SDS-WAS is a coordinated global network of SDS research & forecasting centers:

Mission: To enhance the ability of countries to deliver timely and quality SDS forecasts, observations, information and knowledge to users through an international partnership of research and operational communities;

- International coordination of SDS research
- Assessment of SDS impacts
- Promoting use of available SDS products
- Building capacity and facilitate access to the available services
- Dissemination and awareness

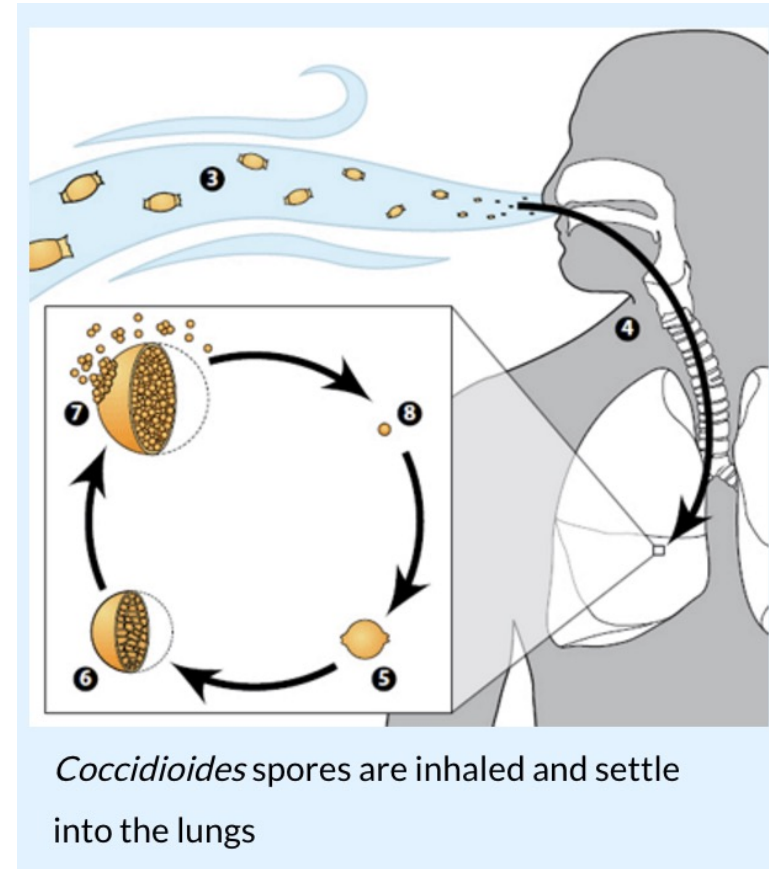


What is inside a “dust” storm?

“Whatever is of the right size, in the right place, at the right time, can be part of the ‘dust’ available to be inhaled by someone” -- William Sprigg, 2017



Dust Storms in Sacaton, Arizona (July 5, 2011). Photo by NOAA/NWS/Grace Watson

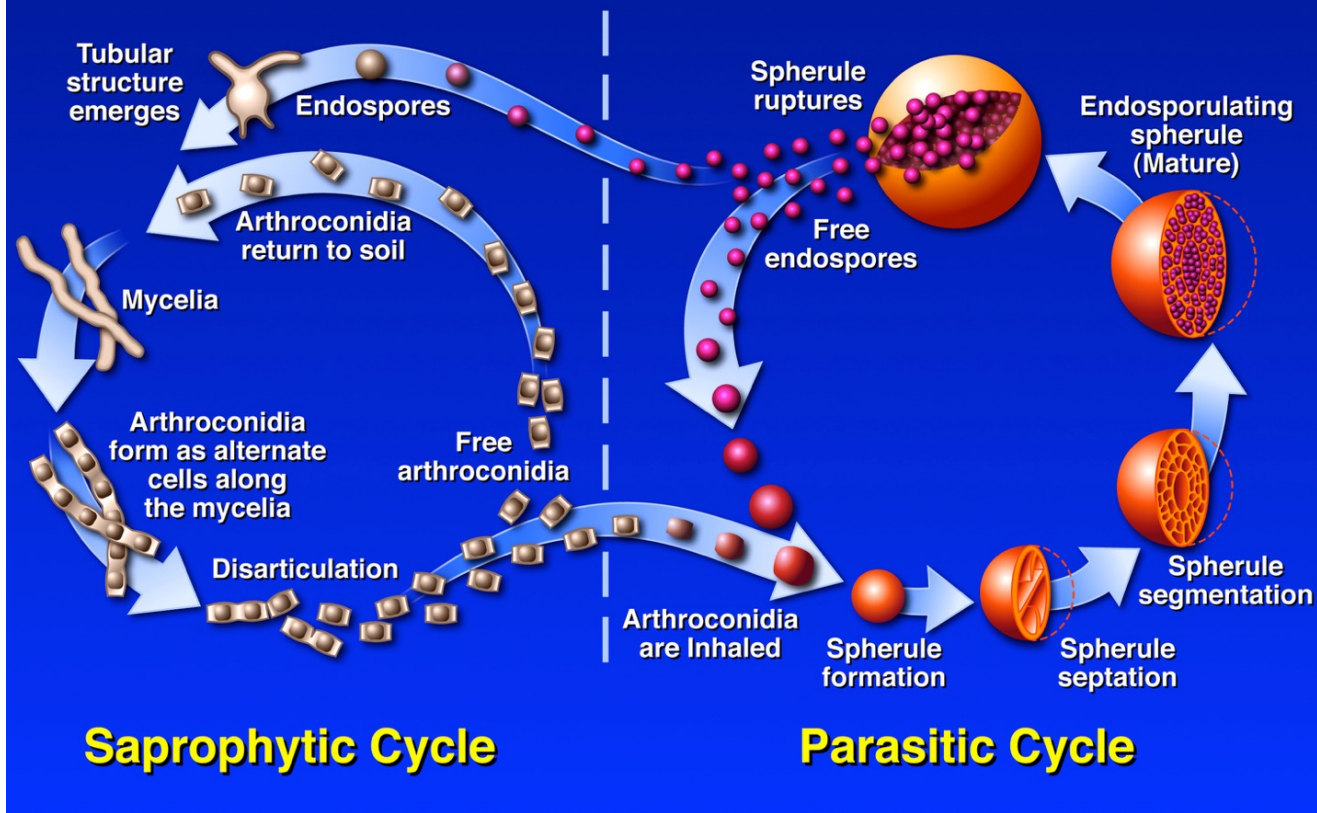


(<http://nmindepth.com>)

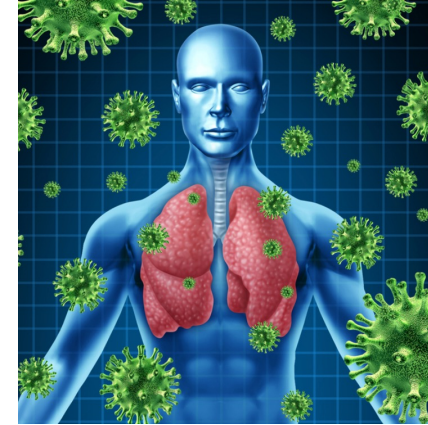
Valley Fever (Coccidioidomycosis)

Infection caused by inhaling the *Coccidioides* fungi living in the soils in Pan-America

The Morphology of *Coccidioides*



Coccidioidomycosis: Lung infection;



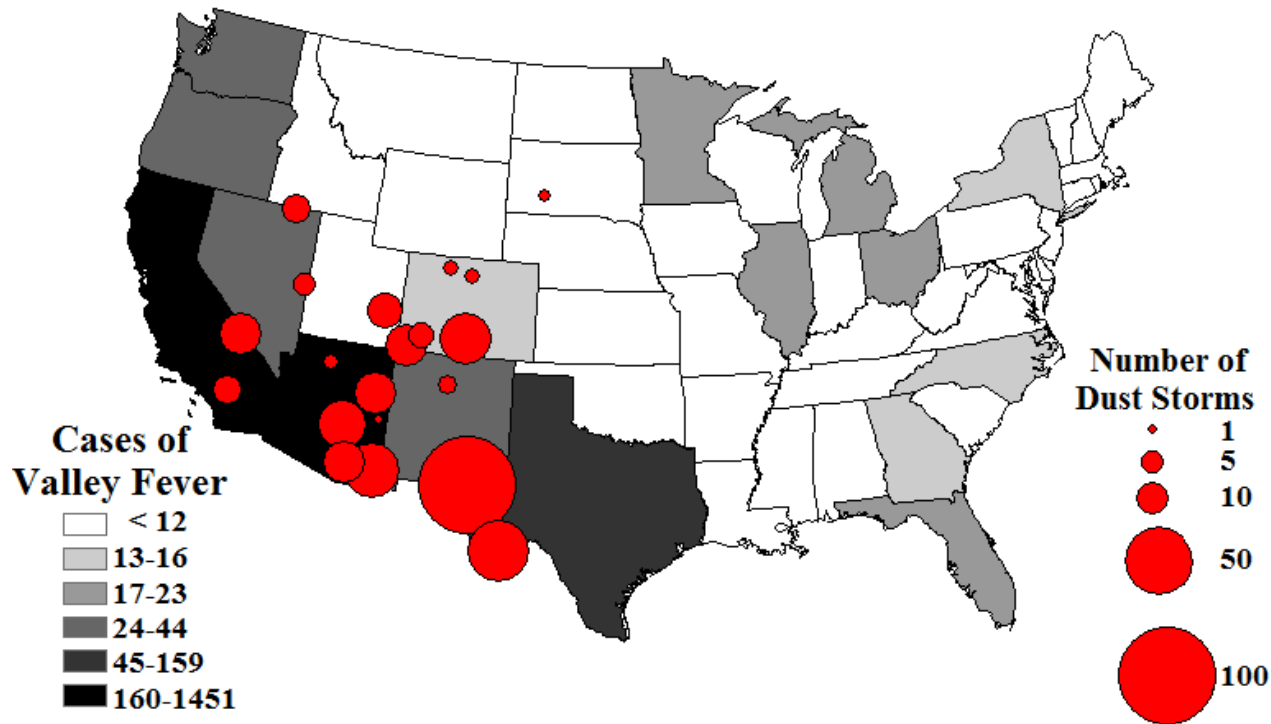
Disseminated Coccidioidomycosis: Bloodstream transport to Skin, Brain, Nerve etc



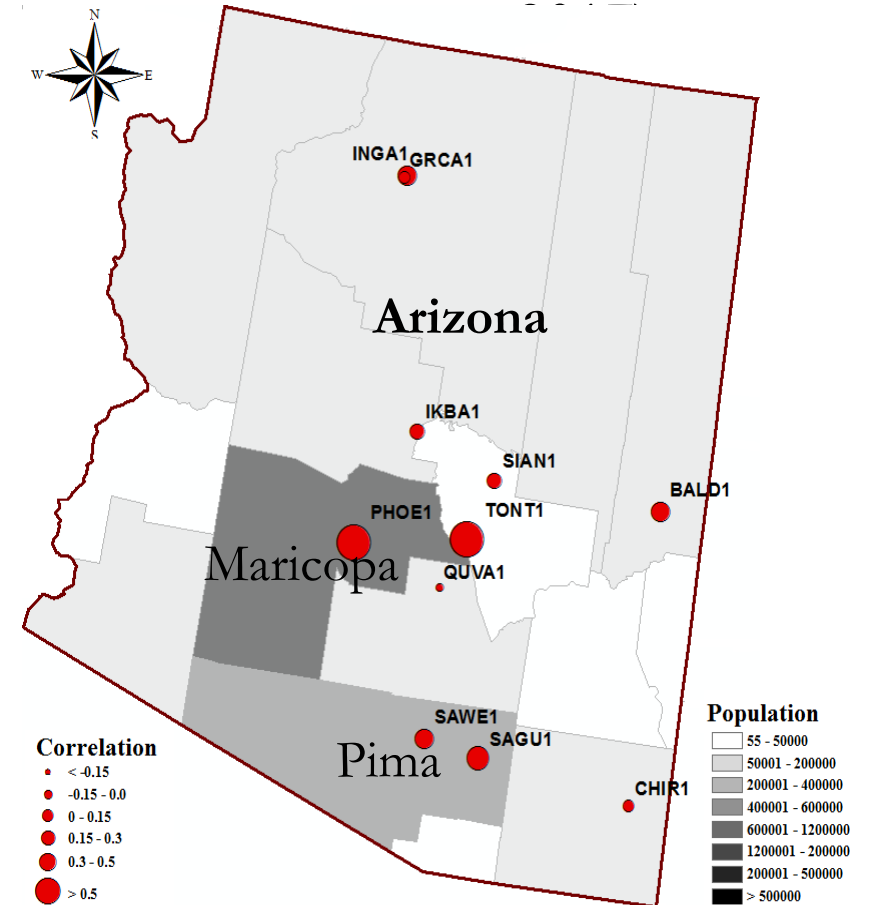
(Source: thinklink.com)

Collocation of Dust Storms and Valley Fever

(Tong et al.,



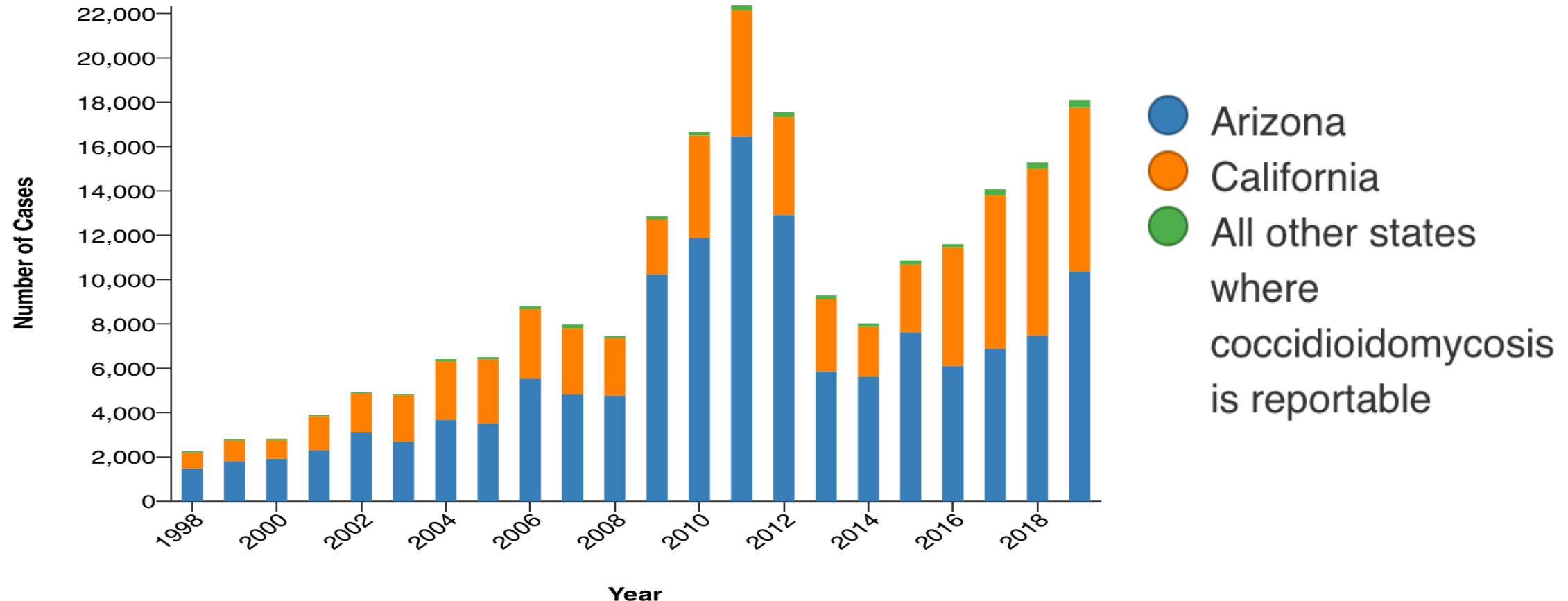
High infection rate of Valley fever in states frequented by dust storms.



Only near-city dust storms are strongly correlated to Valley Fever;

Health Burden of Valley Fever

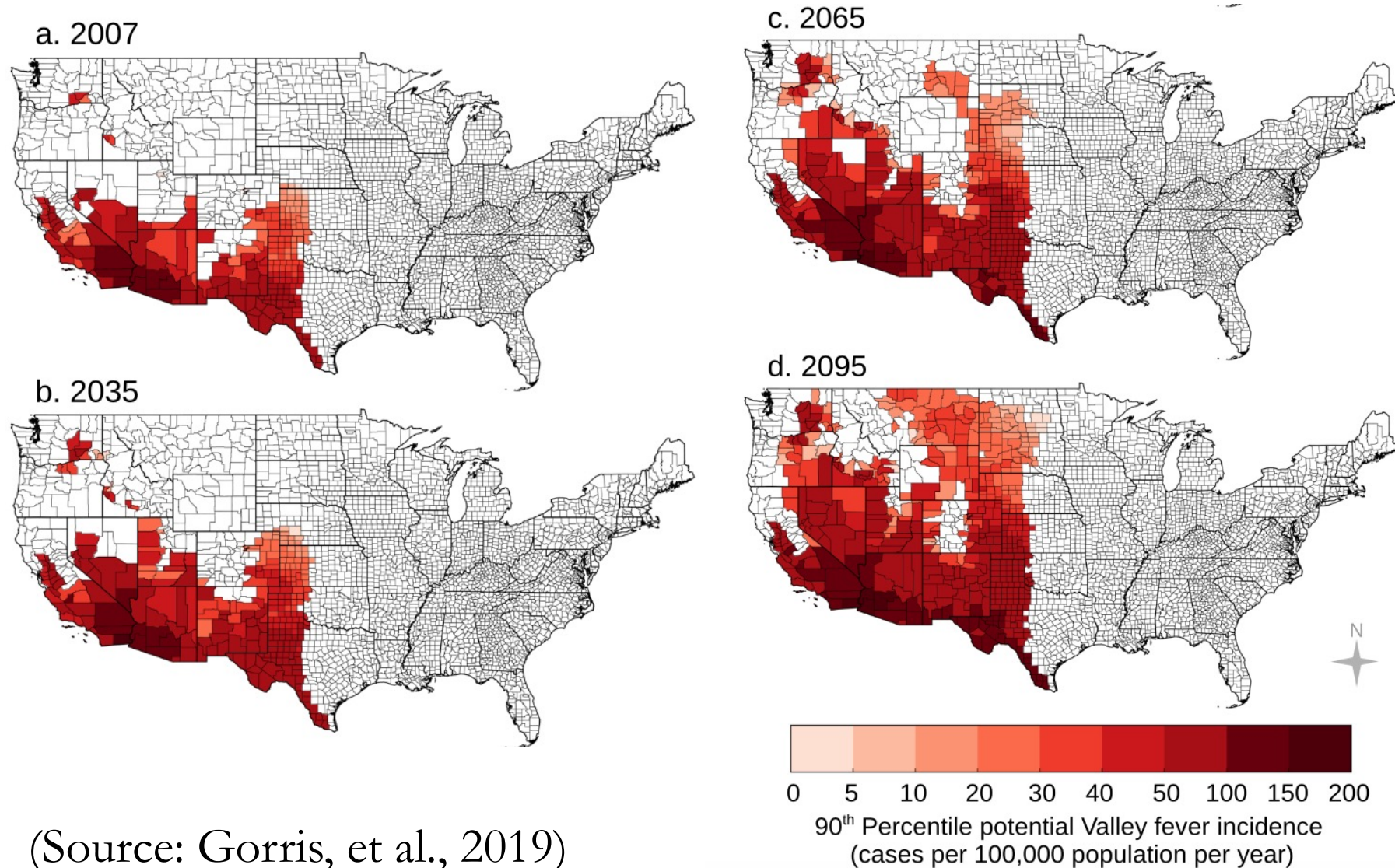
- ~10,000-20,000 cases reported to public health annually
- 200 deaths each year (mostly in Arizona and California)



(Source: CDC)

>4,000 deaths in the United States

Expansion of Valley Fever Endemic Zone in Response to Climate Change



(Source: Gorris, et al., 2019)

Dust Storms and Highway Safety



(Source: Giphy)



How Many People Were Killed by Windblown Dust Events?

A Myth of Two Tales

6 killed in 25-vehicle pileup at New Mexico-Arizona line

UPDATED ON: JUNE 20, 2017 / 6:51 AM / AP



LORDSBURG, N.M. -- Authorities in New Mexico say six people are dead after a 25-vehicle pileup on I-10 was caused by sudden blowing dust in New Mexico near the Arizona state line.

“..six people dead after a 25-vehicle pileup”

(Source: CBS News June 2017)



Summary of Natural Hazard Statistics for 2017 in the United States



This National Weather Service (NWS) report summarizes fatalities, injuries and damages caused by severe weather in 2017. The NWS Office of Climate, Water and Weather Services and the National Climatic Data Center compiled this Summary of U.S. Natural Hazard Statistics from Storm Data, a report comprising statistics from NWS forecast offices in the 50 states, Puerto Rico, Guam, and the Virgin Islands.

Summary of 2017 Weather Events, Fatalities, Injuries, and Damage Costs

Weather Event	Fatalities	Injuries	Property Damage (million \$)	Crop Damage (million \$)	Total Damage (million \$)
Other					
Drought	0	0	0.05	0.31	0.36
Dust Storm	0	0	0.35	0.00	0.35
Dust Devil	0	0	0.06	0.00	0.06

Source: <https://www.nws.noaa.gov/om/hazstats/sum17.pdf>

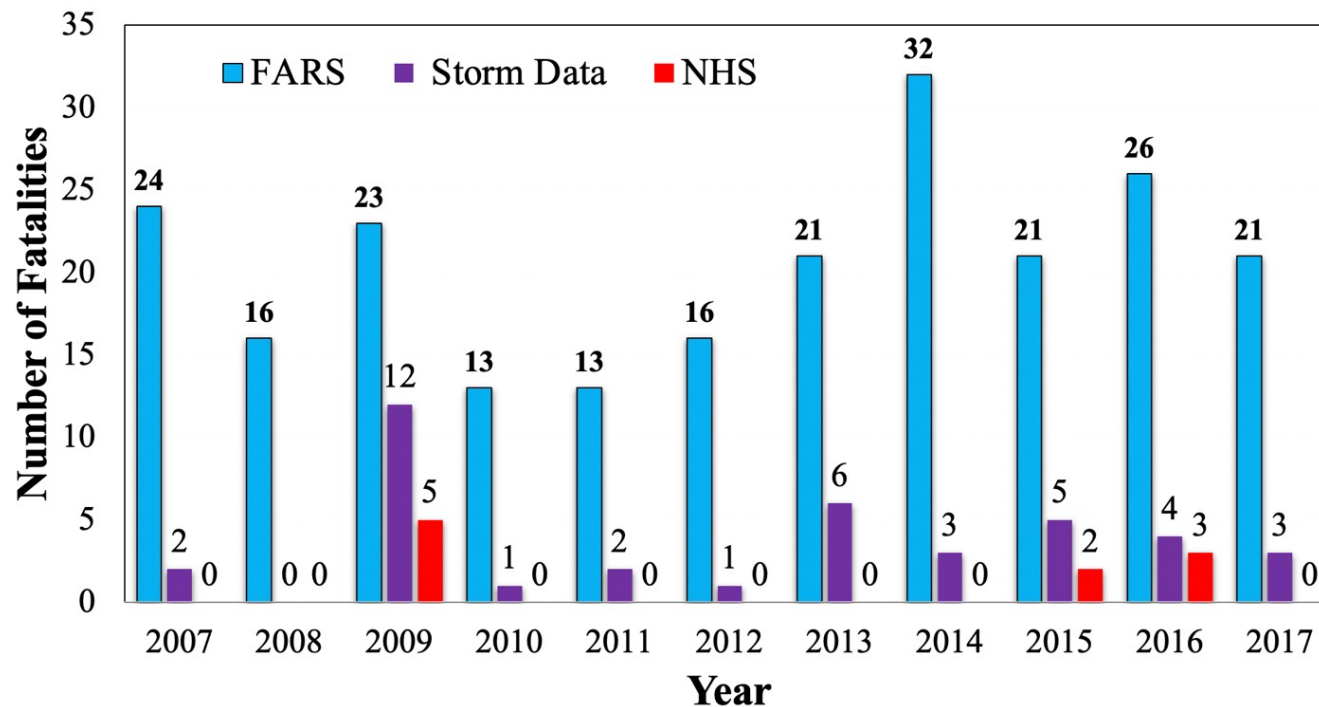
0-5 deaths, on average 1 death per year

Debunk the Myth

Comparison of three datasets:

(Tong et al., BAMS, 2023)

- NOAA Natural Hazard Statistics (NHS)
- NOAA Storm Events Dataset (Storm Data)
- DOT Fatality Analysis Report System (FARS) (Police Accident Reports)



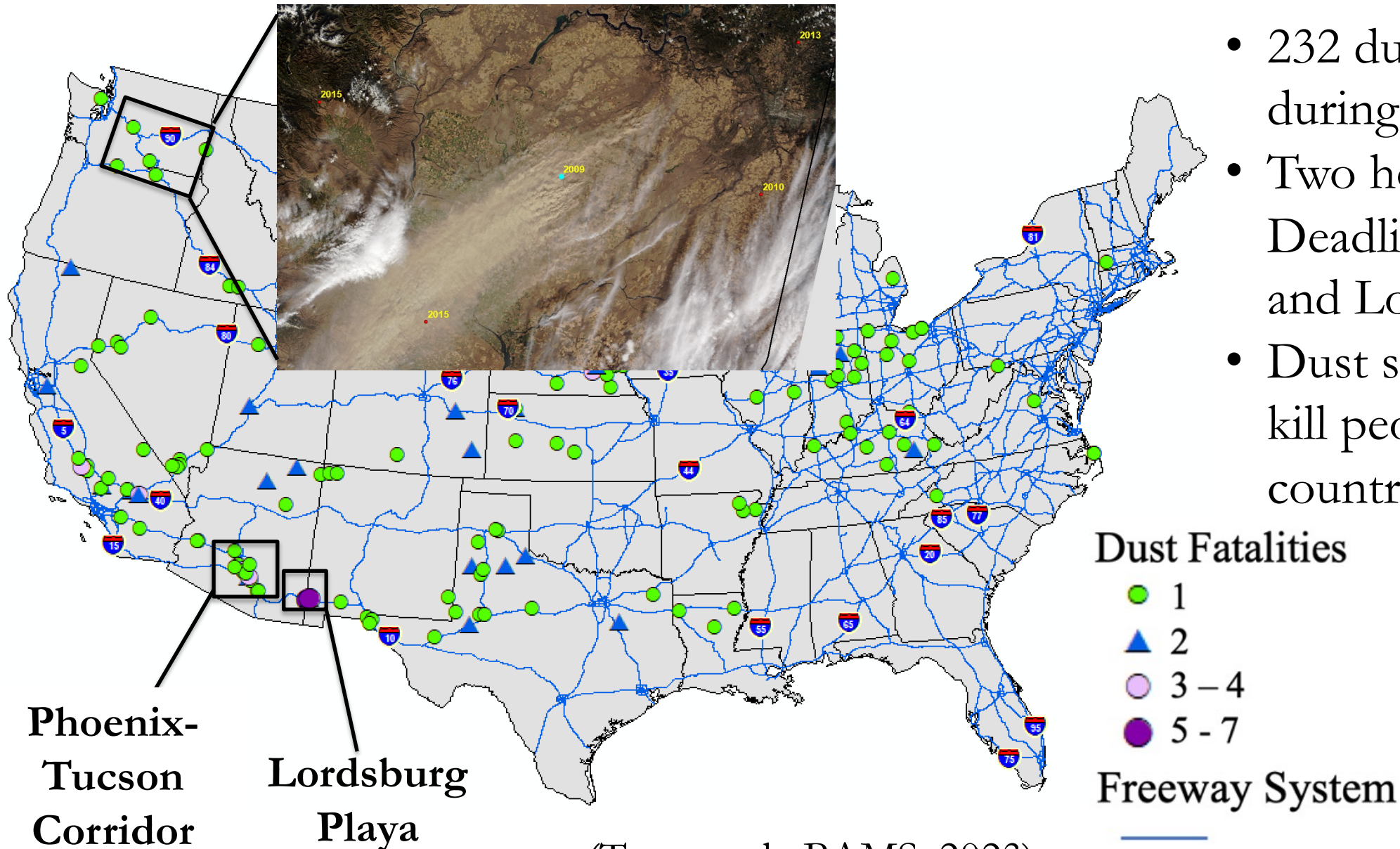
How did NHS go wrong?

- 1) Incomplete reporting;
- 2) Categorized as high winds;

Dust events are different from high wind events:

- 1) Soil particles added to the air;
- 2) Reduced visibility;
- 3) Lower traction at road surface;

Where Did Fatal Accidents Occur?



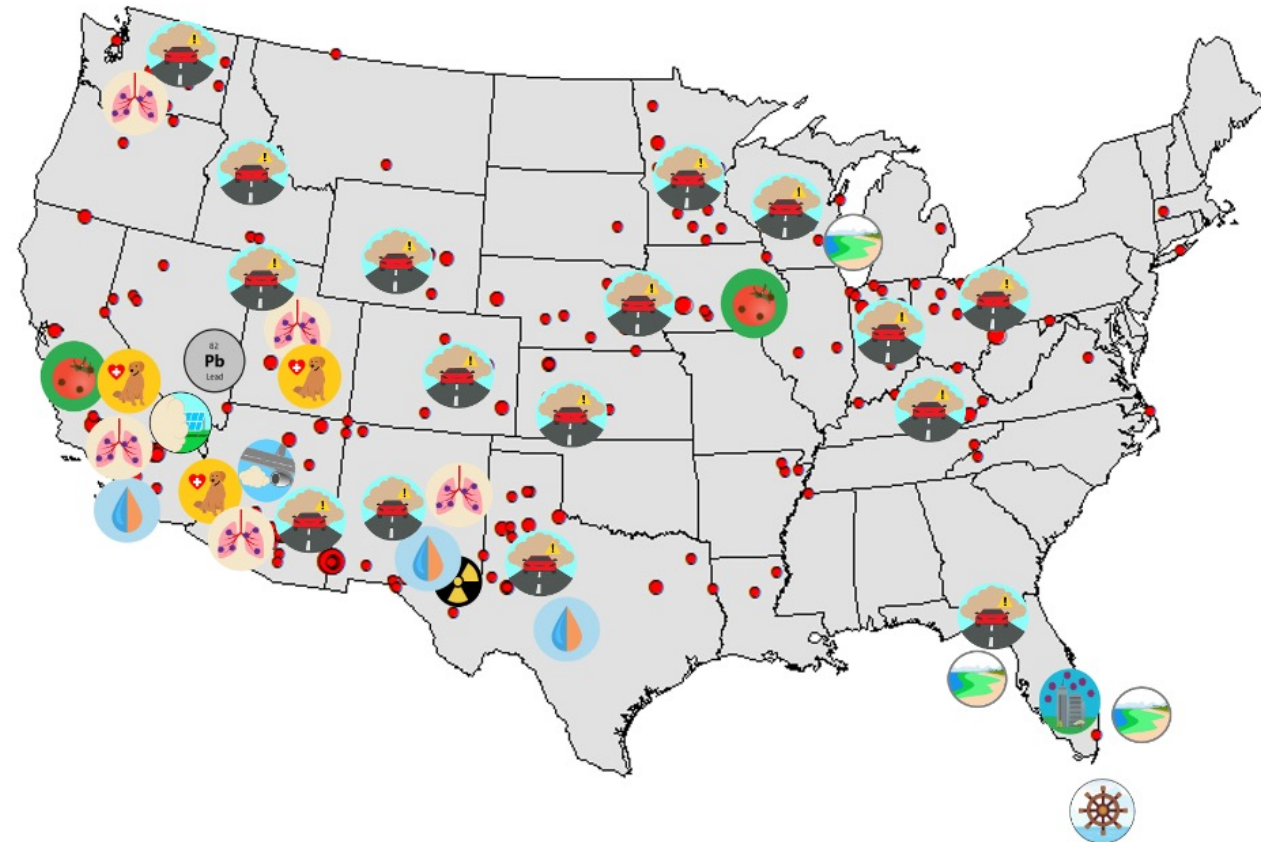
- 232 dust fatalities during 2007-2017.
- Two hotspots: Deadliest Ten Miles and Lordsburg Playa
- Dust storms/events kill people across the country.

(Tong et al., BAMS, 2023)

Dust Effects on Health and Safety

Daniel Q. Tong¹, Thomas E. Gill², William A. Sprigg³, Robert Scott Van Pelt⁴, Alexander A. Baklanov⁵, Bridget Marie Barker⁶, Jesse E. Bell⁷, Juan Castillo⁸, Santiago Gassó⁹, Cassandra J. Gaston¹⁰, Dale W. Griffin¹¹, Nicolas Huneus¹², Ralph A. Kahn¹³, Arunas P. Kuciauskas¹⁴, Luis A. Ladino¹⁵, Junran Li¹⁶, Olga L. Mayol-Bracero¹⁷, Orion Z. McCotter¹⁸, Pablo A. Méndez-Lázaro¹⁹, Pierpaolo Mudu²⁰, Slobodan Nickovic²¹, Damian Oyarzun²², Joseph Prospero¹⁰, Graciela B. Raga¹⁵, Amit U. Raysoni²³, Ling Ren¹, Nikias Sarafoglou¹, Andrea Sealy²⁴, Ziheng Sun¹, Ana Vukovic Vimic²⁵

(Tong et al., Review
of Geophysics, 2023)

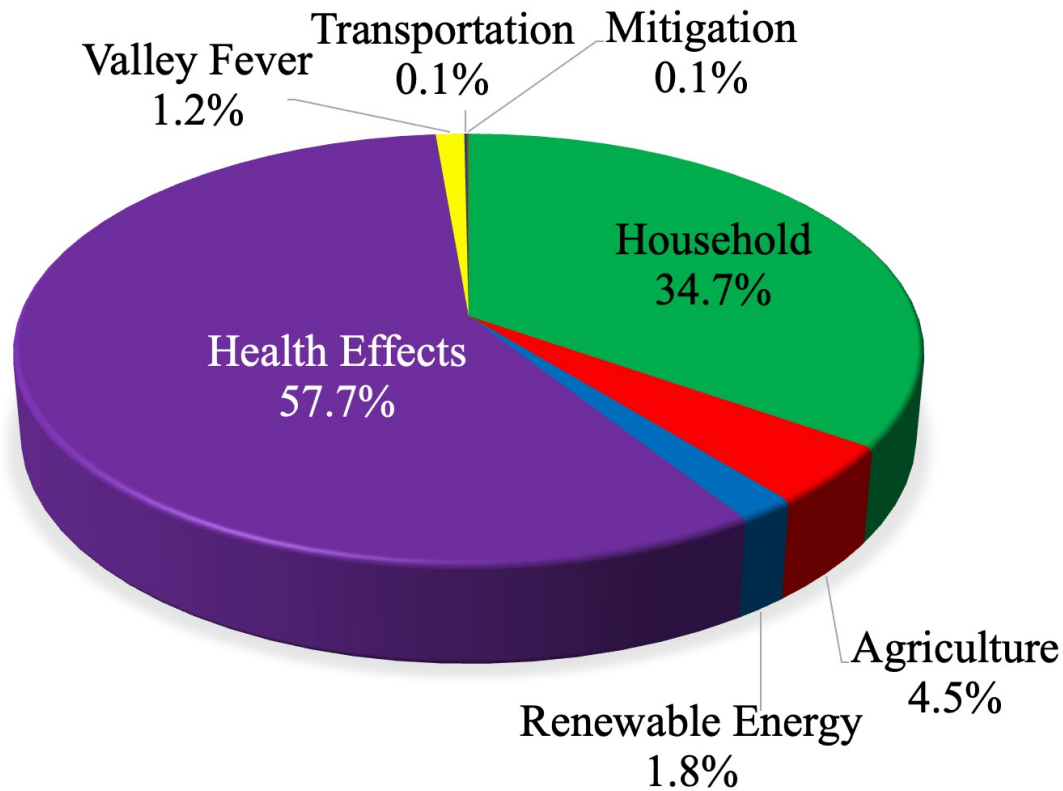


Red Dots – Fatal crashes caused by dust

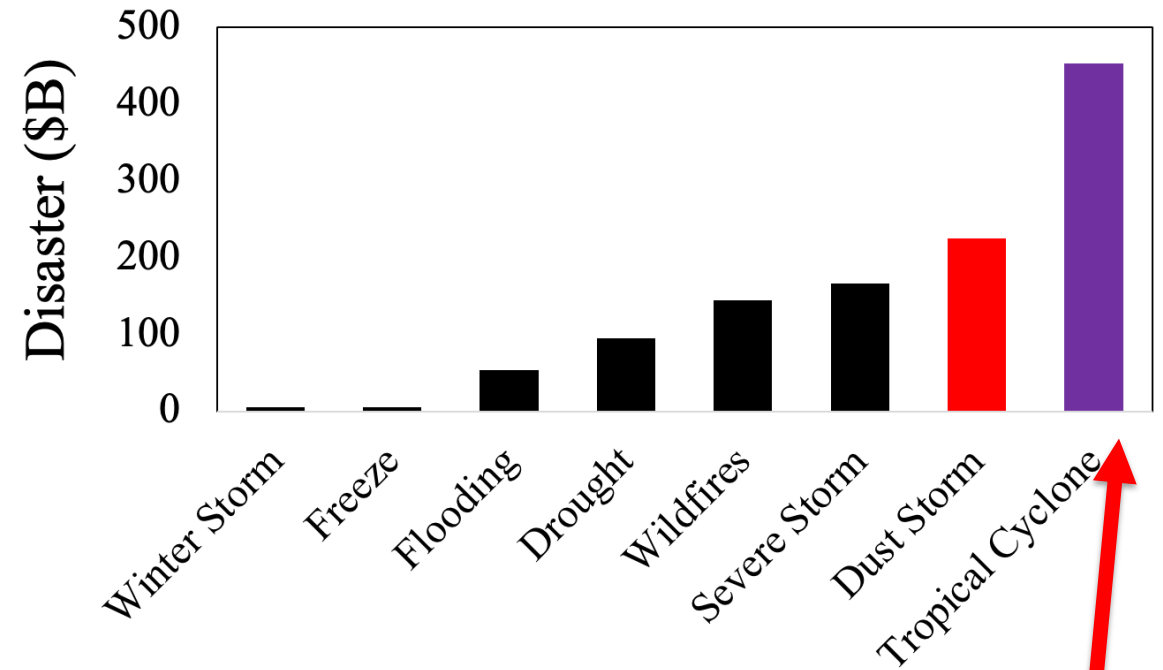
Economic Cost of Dust Impacts in US (2017)

(Feng et al., in preparation)

Total Annual Cost: \$225B



Comparison with \$B Disasters

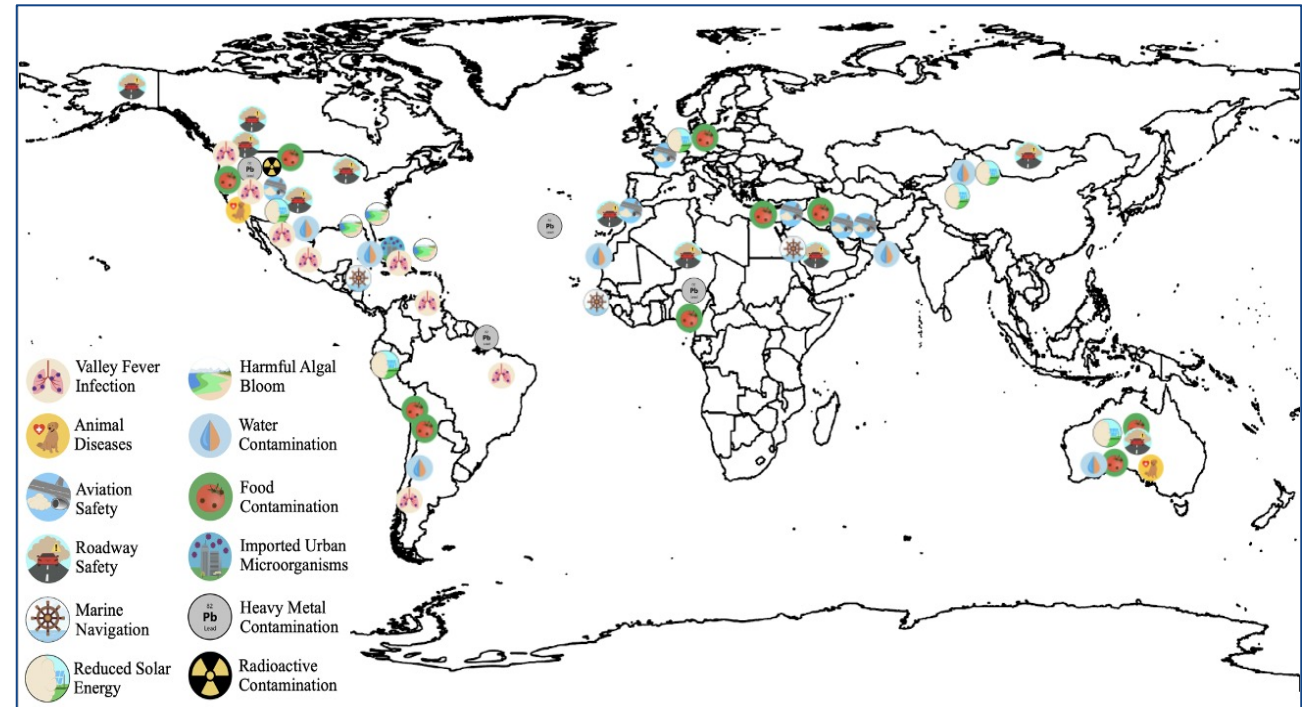
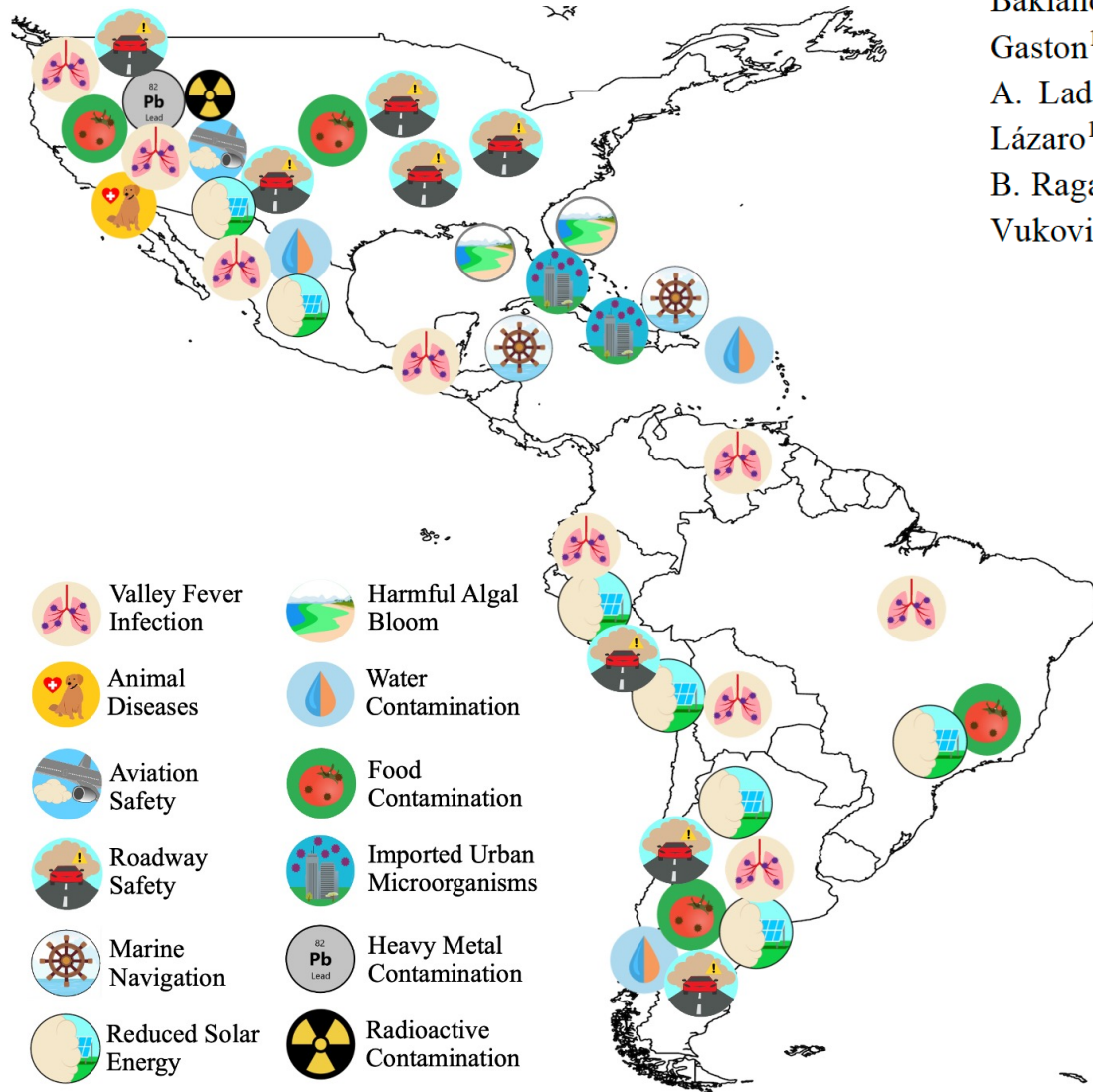


There were 17 tropical storms, including hurricanes Harvey, Irma, and Maria, in 2017.

(Unpublished data – Do not cite or post)

Mapping Global Dust Vulnerabilities

Daniel Q. Tong¹, Thomas E. Gill², William A. Sprigg³, Robert Scott Van Pelt⁴, Alexander A. Baklanov⁵, Bridget Marie Barker⁶, Jesse E. Bell⁷, Juan Castillo⁸, Santiago Gassó⁹, Cassandra J. Gaston¹⁰, Dale W. Griffin¹¹, Nicolas Huneeus¹², Ralph A. Kahn¹³, Arunas P. Kuciauskas¹⁴, Luis A. Ladino¹⁵, Junran Li¹⁶, Olga L. Mayol-Bracero¹⁷, Orion Z. McCotter¹⁸, Pablo A. Méndez-Lázaro¹⁹, Pierpaolo Mudu²⁰, Slobodan Nickovic²¹, Damian Oyarzun²², Joseph Prospero¹⁰, Graciela B. Raga¹⁵, Amit U. Raysoni²³, Ling Ren¹, Nikias Sarafoglou¹, Andrea Sealy²⁴, Ziheng Sun¹, Ana Vukovic Vimic²⁵



(Nickovic et al., WMO Book, In Review)

(Tong et al., Review of Geophysics, 2023)

Global Dust Reanalysis Ensemble

(SDS-WAS Reanalysis Working Group)

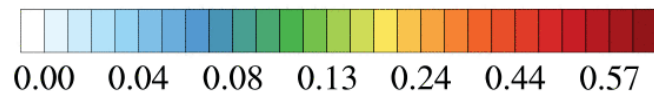
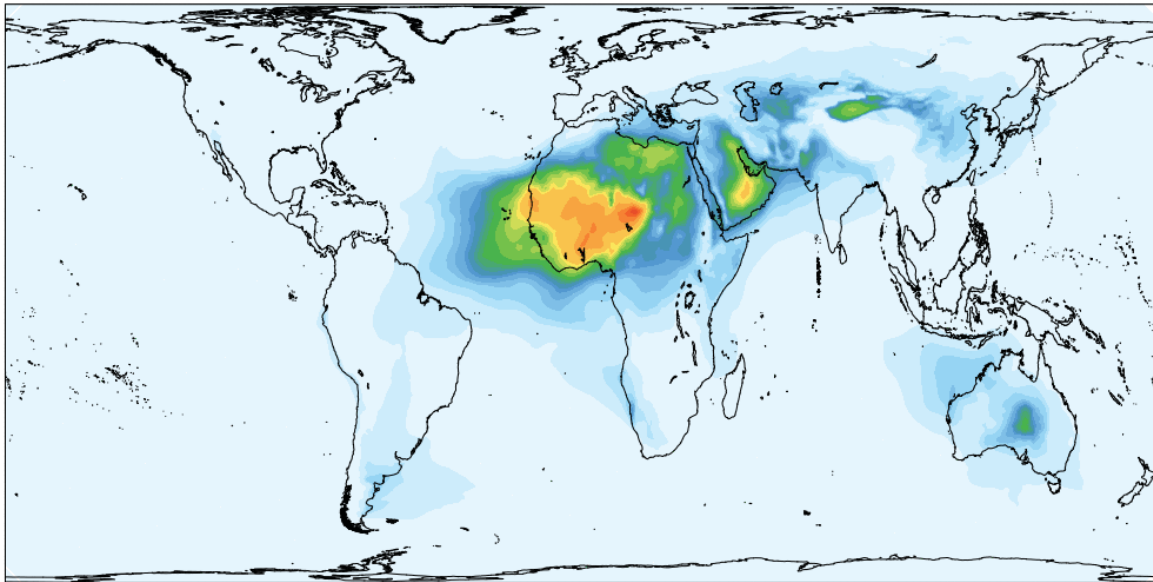
Objectives:

- Building consensus of global dust budget (2003-pres, 0.1degree)
- Developing tailored SDS products/services

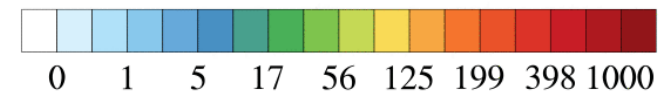
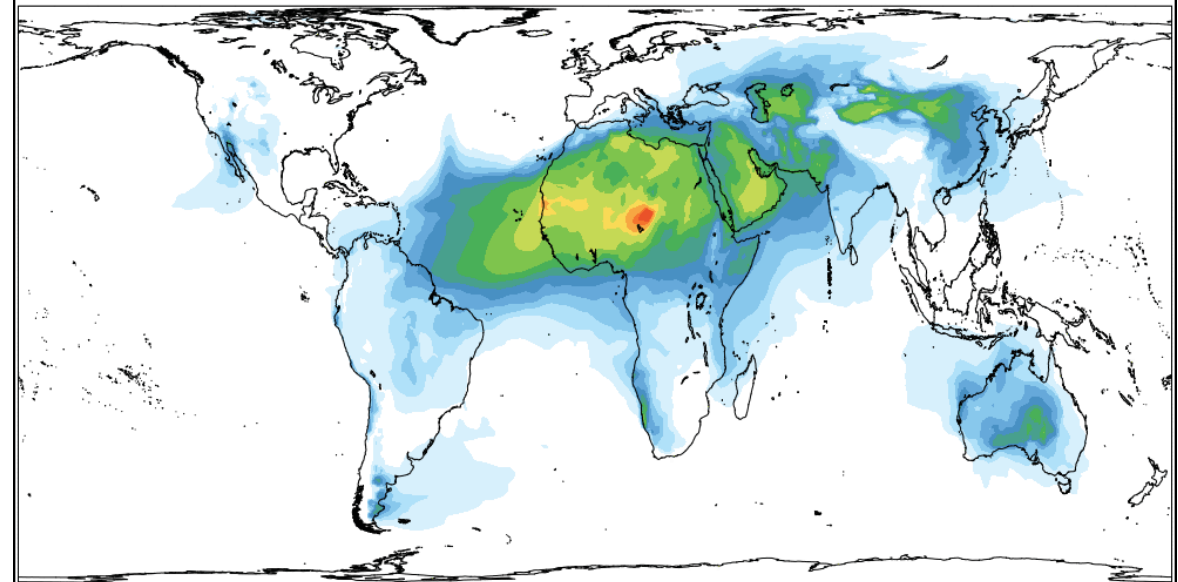
Phase I: Selected global datasets (NASA, ECMWF, NRL and FMI)

Phase II: More global + regional reanalysis datasets

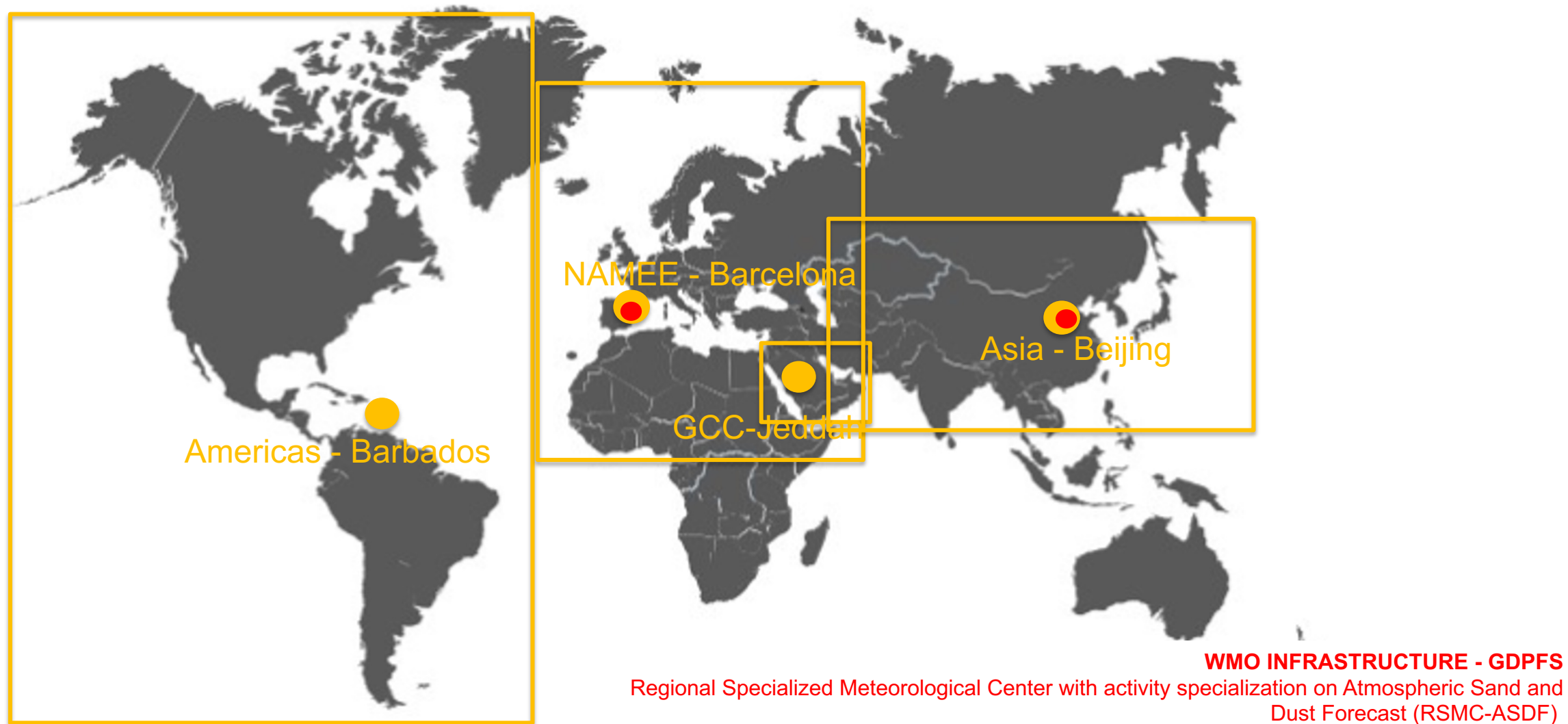
Dust AOD median 200301



Dust PM_{2.5} median 200301



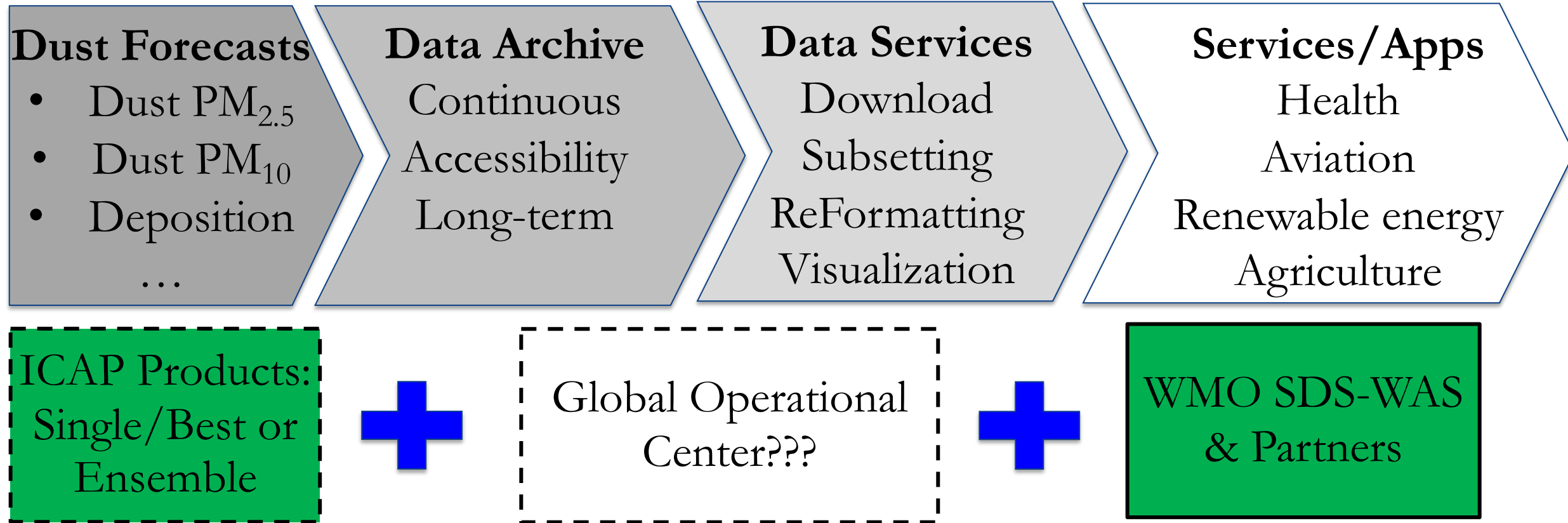
Current WMO SDS-WAS Forecasting Capability



Early Warning Needs:

- 1) Regions without operational centers;
- 2) Global Backbone Forecast(s)

From Dust Forecasts to Services



Join hands to deliver dust early warning services to impacted and often underserved communities?

From Science to Services Monitoring - Aerosol observations



Judd Welton

GAW Expert – co-Chair of GALION

WMO OMM

World Meteorological Organization

Organisation météorologique mondiale

<https://community.wmo.int/en/activity-areas/gaw>
Sara Basart (sbasart@wmo.int)



Thank you
Merci

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World Meteorological Organization

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