

A new WMO-GAW initiative Global Air Quality Forecasting and Information Systems GAFIS

Johannes Flemming (ECMWF), Lu Ren (WMO), Okasna Tarasova (WMO)
Alexnader Baklanov(WMO), and Greg Carmichael (UoI) &

GAFIS Steering Committee (29.4.2020 first meeting)





The high-level objective of GAFIS

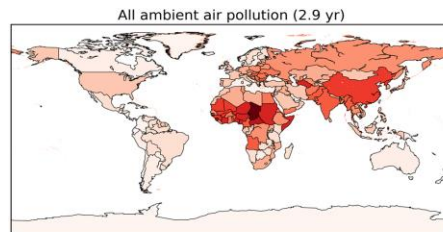
“... to enable and provide air quality forecasting and information services in a globally harmonized and standardized way tailored to the needs of society ...”

Role within WMO-GAW:

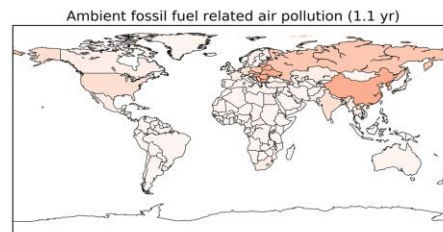
... help the transition of science to services

Mean global and country-level loss of life expectancy from different causes...

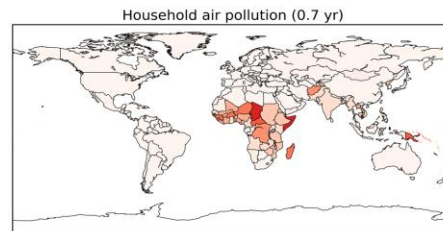
All Ambient
Air Pollution



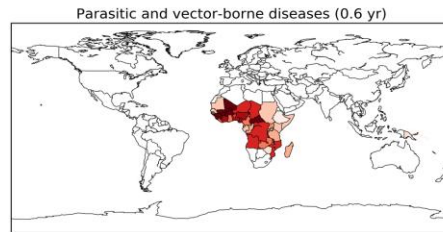
Ambient
Fossil Fuel
Air Pollution



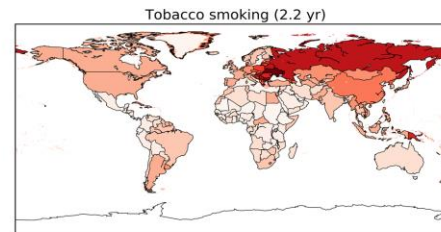
Indoor
Air Pollution



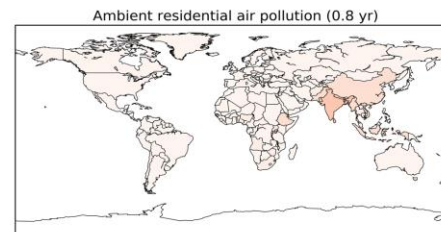
Parasitic and
Vector-borne
Diseases



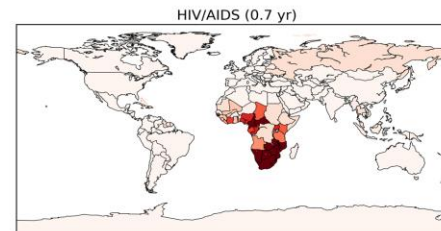
Tobacco
Smoking



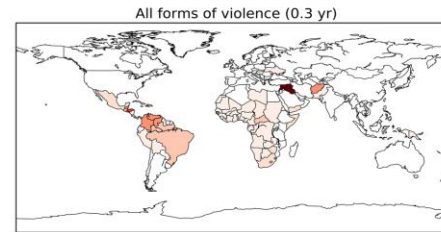
Ambient
Residential



HIV/AIDS



Violence/
Conflict



Mean global and country-level loss of life expectancy from different causes of death referring to the year 2015. Household air pollution is from the indoor use of solid biofuels. Ambient residential air pollution is mostly from household sources and can include fossil and biofuel use. Parasitic and vector-borne diseases include malaria, leishmaniasis, rabies, dengue, yellow fever, and others. Violence includes interpersonal, collective conflict, and armed intervention.

Air pollution because of PM2.5 and Ozone

Cardiovascular Research, , <https://doi.org/10.1093/cvr/cvaa025>

The content of this slide may be subject to copyright: please see the slide notes for details.

Objectives and Goals of GAFIS

- Build **network** for the development of good practices utilizing diverse approaches for air quality forecasting and monitoring
- **Survey** of regional and global air quality forecasting and information systems
- **Capacity** building in areas missing air quality forecasting systems
- Develop, promote and implement **best practises for AQ forecasting**
- Improve access to and quality assurance of **air quality observations**
- Enhance science and operational applications **of atmospheric composition feedbacks in Numerical Weather Prediction**
- User interaction and collecting user requirements

Building a Network of Air Quality Service Providers and Users

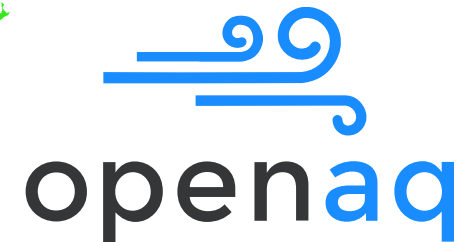
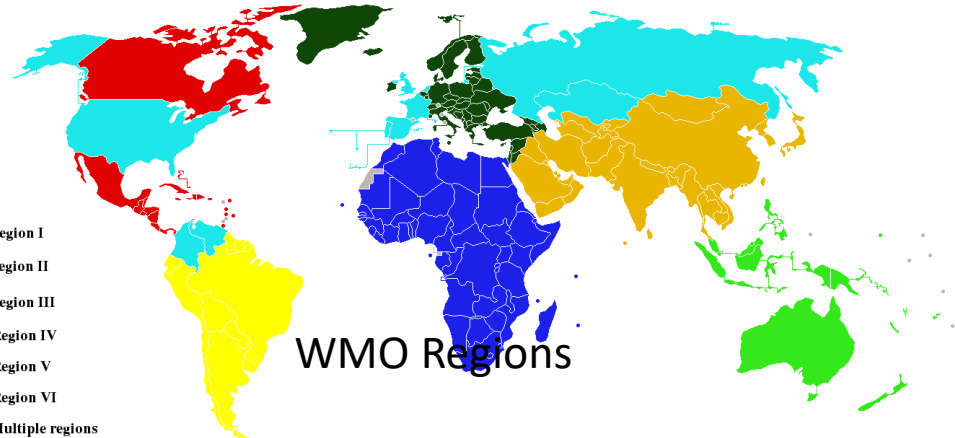


SDS-WAS

GAFIS



- Region I
- Region II
- Region III
- Region IV
- Region V
- Region VI
- Multiple regions



GAFIS thematic topics (examples)

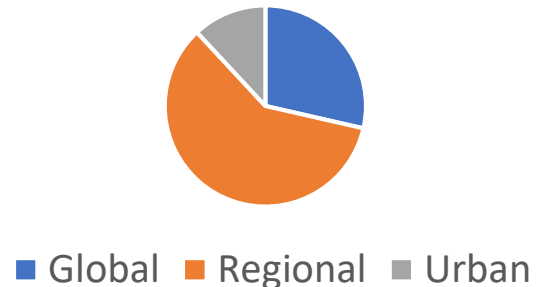
- Survey of air quality information systems
- Operational evaluation of multiple AQ forecasts
- Air quality observations
- Atmospheric composition and NWP
- COVID-19 AQ response

Survey of Air Quality Information Systems

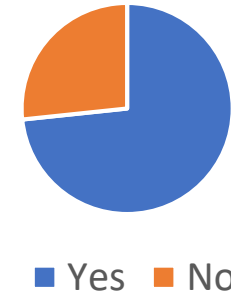


Spatial Domain

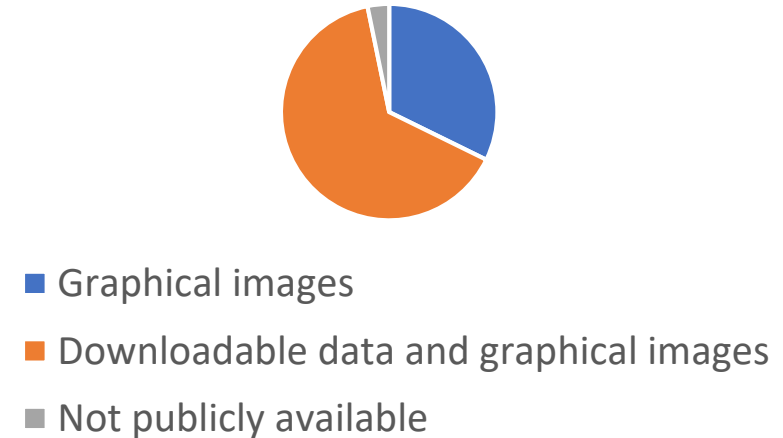
31 entries (so far)
-ALL interested in GAFIS



Retrospective Air Quality Information



Forecast Presentation



Air quality forecast inter-comparison

Environment and
Changement climatique Canada

AQ MULTI-MODEL VERIFICATION FOR NORTH AMERICA

September-November 2019

Patrick M. Manseau,
Michael D. Moran,
and Si Jun Peng (ECCC)



2020-02-10

Multi-model Performance Analysis

Domain: NAQFC–RAQDPS intersection
(Southern Canada and continental USA)

Sept.	O ₃	NO ₂	PM _{2.5}
CAMS-ECMWF	86	60	59
NAQFC-NOAA	92	-	56
RAQDPS-ECCC	90	72	62
FireWork-ECCC	90	72	67
Oct.	O ₃	NO ₂	PM _{2.5}
CAMS-ECMWF	89	71	60
NAQFC-NOAA	92	-	54
RAQDPS-ECCC	91	79	60
FireWork-ECCC	91	79	64
Nov.	O ₃	NO ₂	PM _{2.5}
CAMS-ECMWF	85	72	62
NAQFC-NOAA	90	-	61
RAQDPS-ECCC	87	78	65
FireWork-ECCC	87	78	67

Legend	AQPI (%)
Excellent	[90,100]
Very good	[80,90]
Good	[70,80]
Acceptable	[60,70]
Poor	[50,60]
Very poor	<50

- O₃ : All systems have a very good or excellent performance. **NAQFC** has the best performance.
- NO₂ : **RAQDPS** has the best performance.
- PM_{2.5} : **FireWork** has the best performance.

$$AQPI[O_3, NO_2, PM_{2.5}] = 100 * AVG [FAC2, R, (1 - ABS(MFB/2))]$$

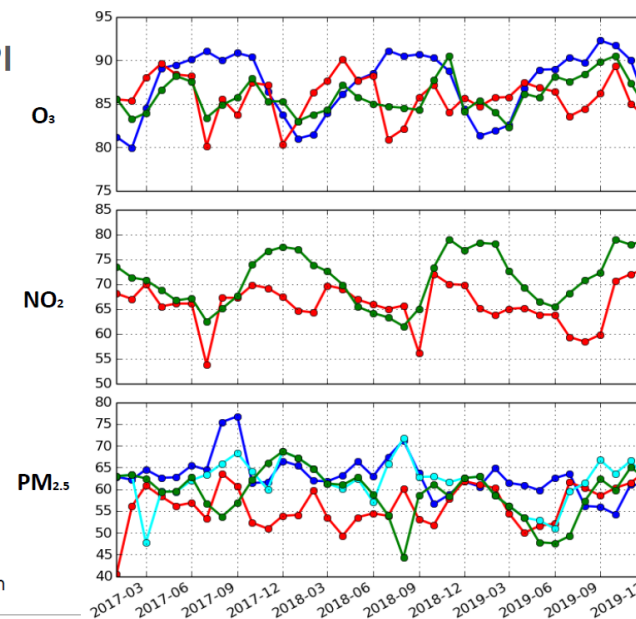
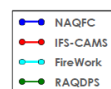
3

AQ Modelling Systems

System	Model	Origin	Type	Grid Size (km)	Pollutants	Wildfire Emissions	Chemical Data Assimilation	Forecast Availability
RAQDPS	GEM-MACH	Canada (ECCC)	Regional	10	O ₃ PM _{2.5} NO ₂	No	No	Hourly
FireWork	GEM-MACH	Canada (ECCC)	Regional	10	PM _{2.5}	Yes	No	Hourly
NAQFC	CMAQ	U.S.A. (NOAA)	Regional	12	O ₃ PM _{2.5}	Yes	No	Hourly
IFS	CAMS	Europe (ECMWF)	Global	40	O ₃ PM _{2.5} NO ₂	Yes	Yes	3-Hourly

The integrations starting at 12 UTC are the only common ground for the comparison of these 4 systems.

Monthly AQPI 2017-01 to 2019-12



Domain: NAQFC–
RAQDPS intersection

$$AQPI[O_3, NO_2, PM_{2.5}] = 100 * AVG [FAC2, R, (1 - ABS(MFB/2))]$$

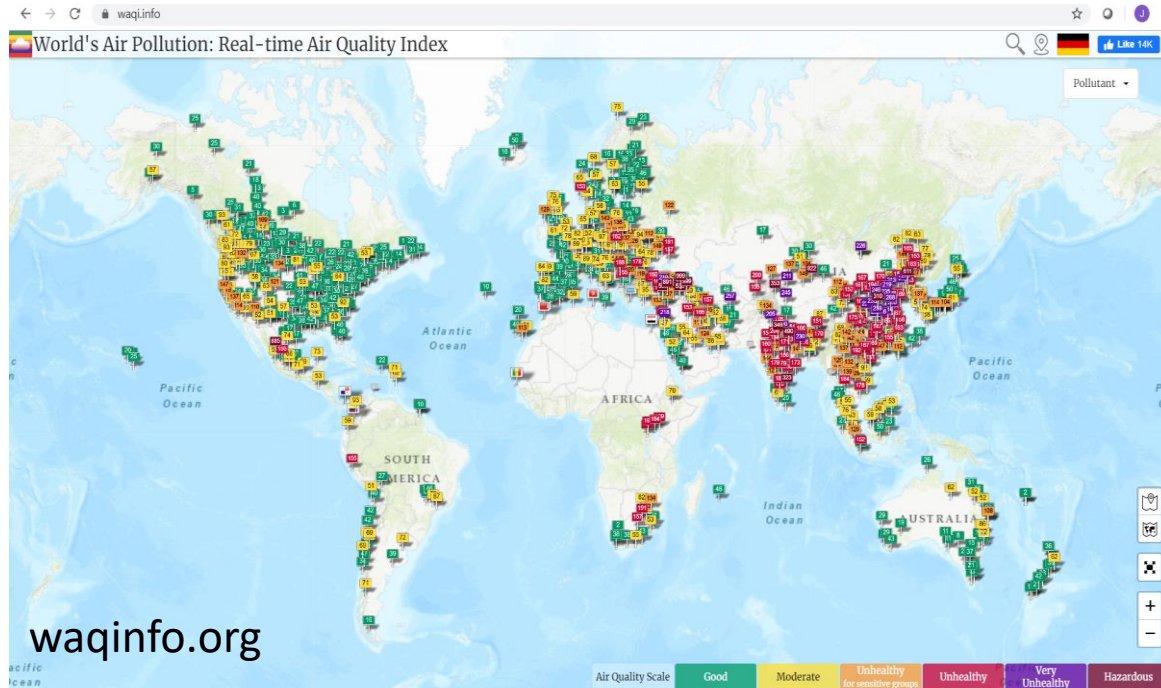
Long-term
Close to NRT
Same evaluation
procedure

Radenko Pavlovic
Michael D. Moran
Patrick M Manseau
Si Jun Peng
(ECCCCanada)

Air Quality Observations

In situ air quality observations are available for many parts of the world but:

- quality control can be missing
- access can be delayed and fragmented
- Provision can be sporadic only
- Important areas with high air pollution have no data



waqinfo.org



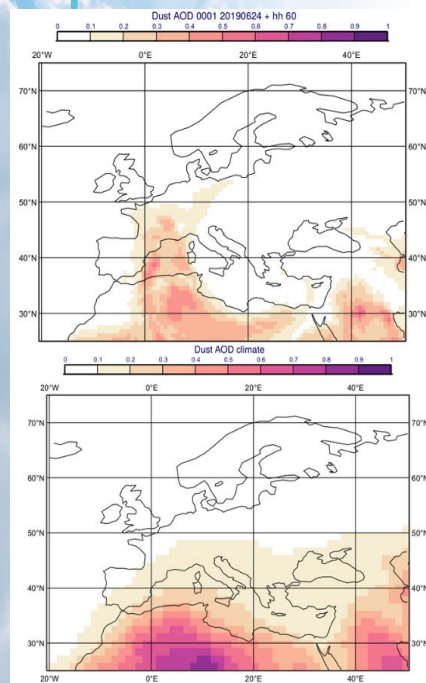
4 proposals to use ML to classify openAQ observations



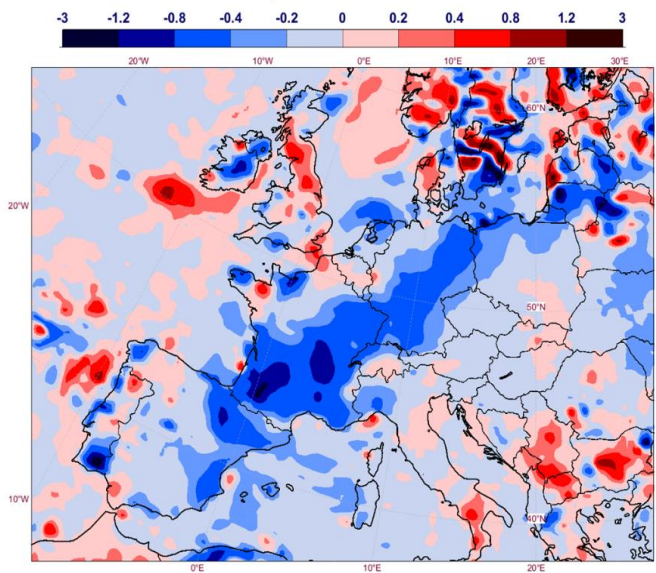
Atmosphere
Monitoring

Composition and Weather Forecasting (CAMS at ECMWF)

Up to 1 K cooling of 2m Temperature
because of Dust Transport in Europe (June
2019)

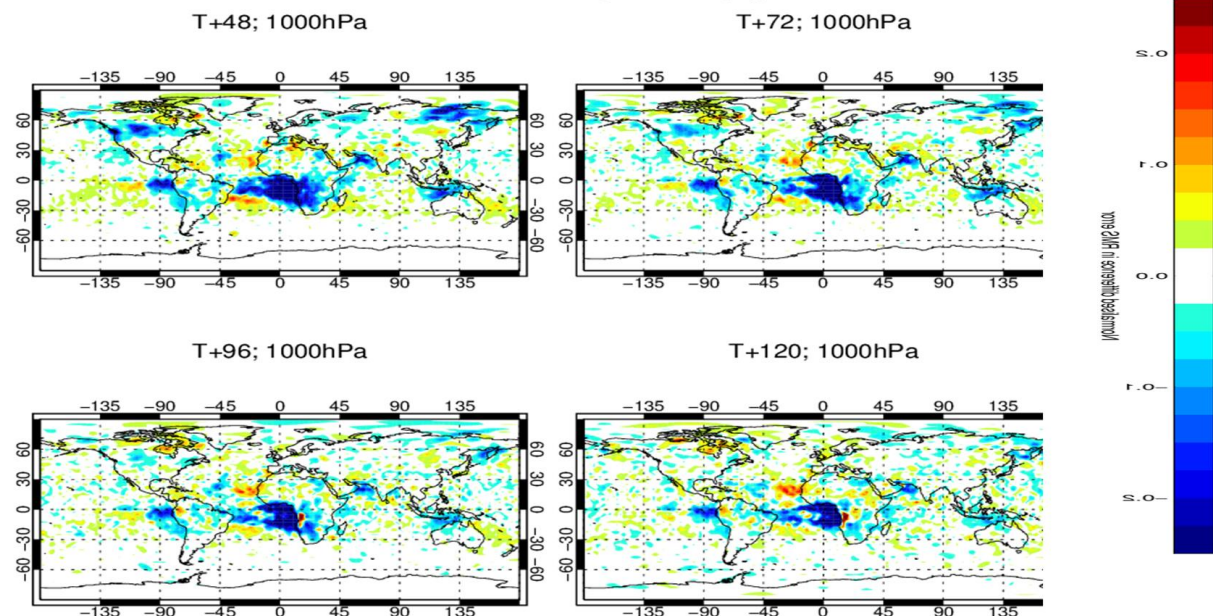


CAMS operational – CAMS climatological aerosol
Param: 2-metre temperature
FC+60h; VT: 26/06/19 12 UTC



Difference in RMSE of temperature at 1000 hPa
against analysis between prognostic and
climatological aerosol and ozone. Blue areas
indicate an improvement with prognostic
aerosols and ozone.

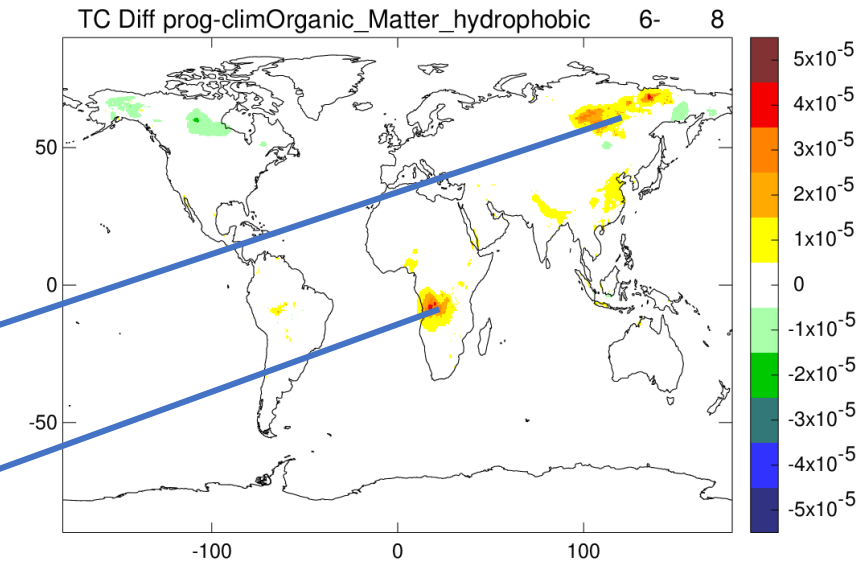
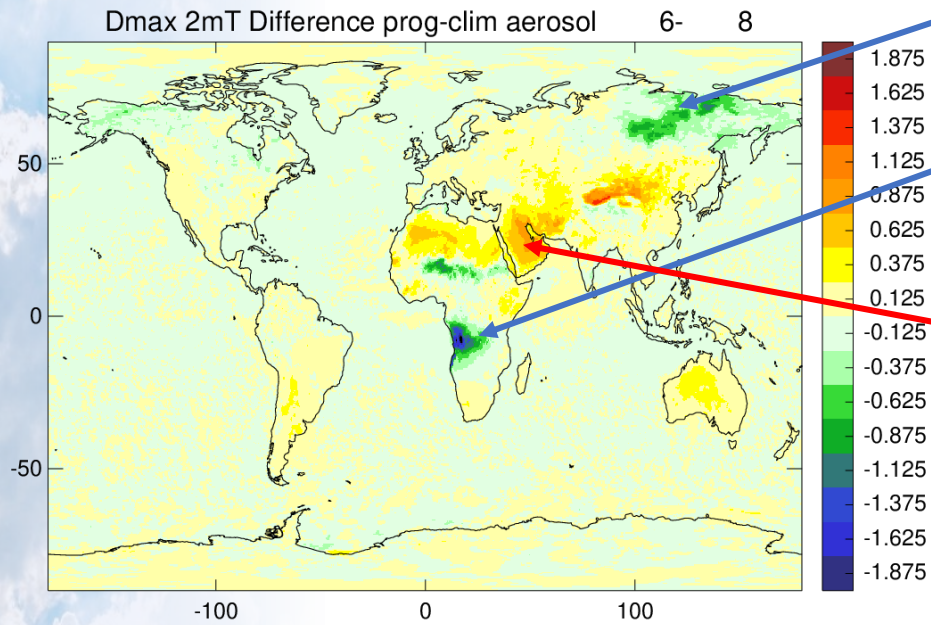
Change in RMS error in T (prog_DA – clim)
1-Jul-2018 to 30-Sep-2018 from 87 to 92 samples. Verified against 0001.
No statistical significance testing applied



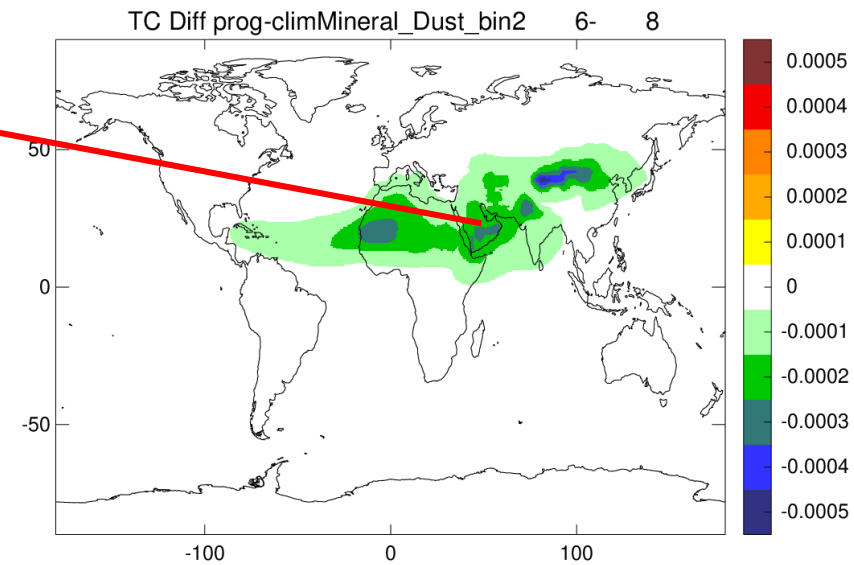


Aerosol anomalies vs 2m T anomalies

PROG aerosol – CLIM aerosol
JJA 2019



OM->
BB anomaly
-> T decrease

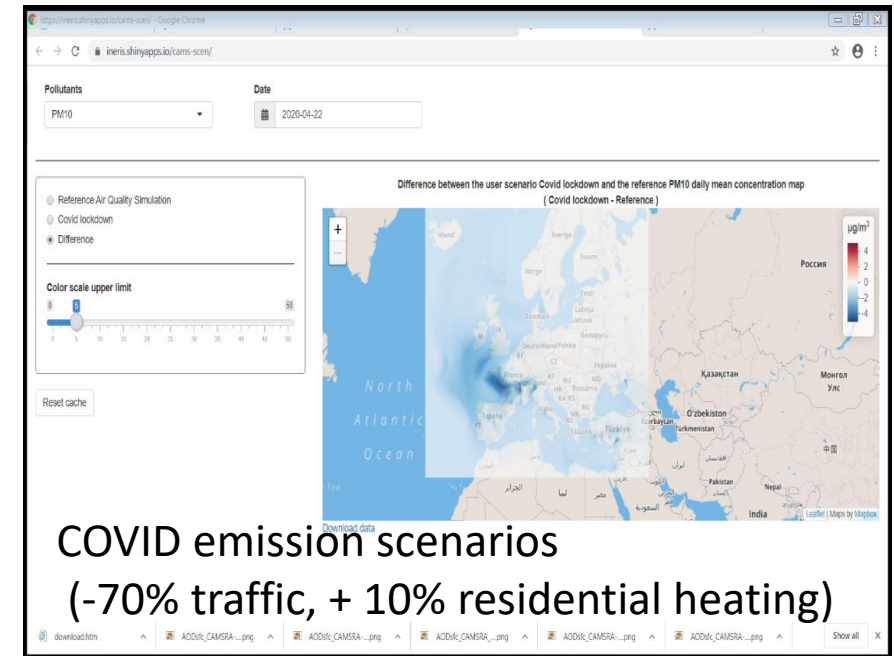
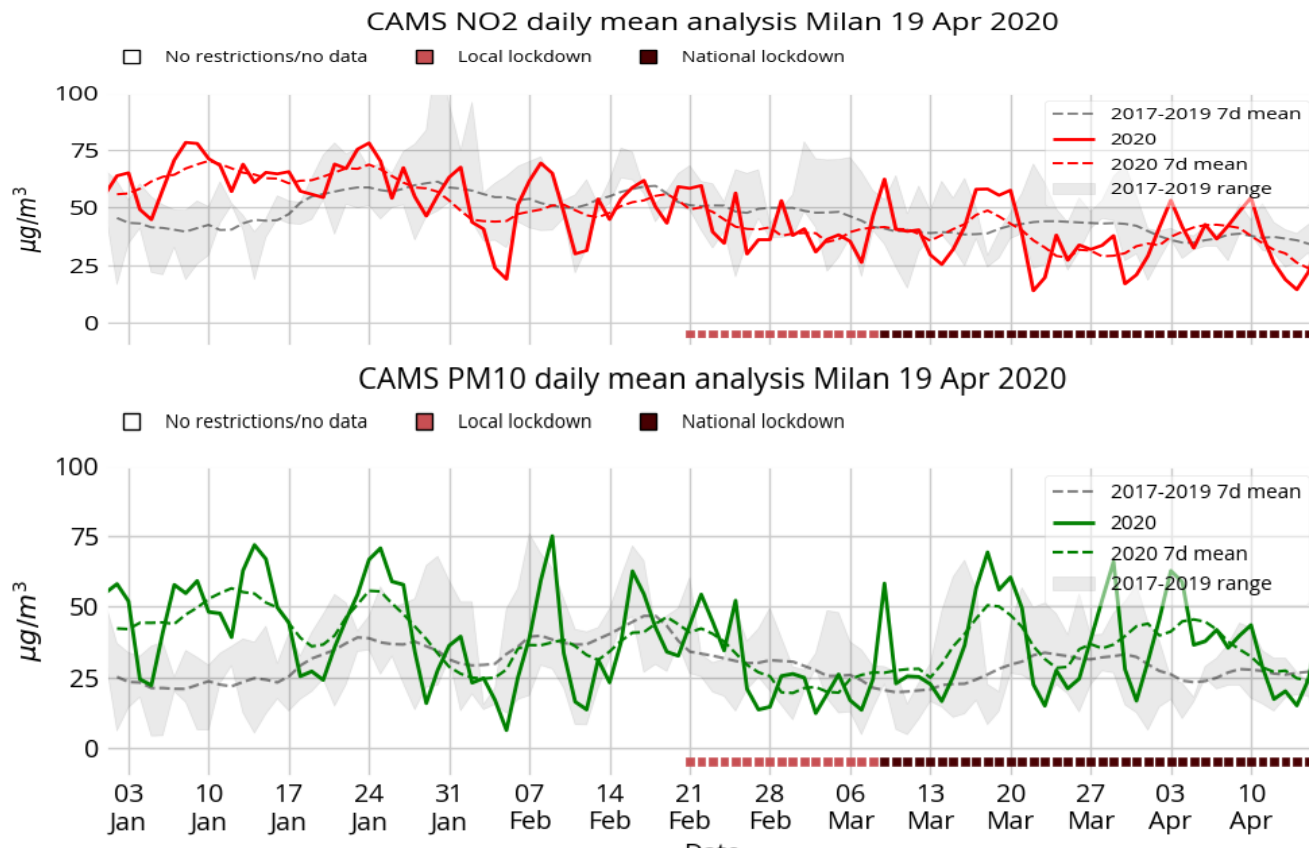


DD2->
DD bias
-> T increase



CAMS products for COVID response in Europe

- <https://atmosphere.copernicus.eu/european-air-quality-information-support-covid-19-crisis>
- Maps and time series of European Air Quality (regional analysis)
- Online emission scenarios as policy support





Atmosphere
Monitoring

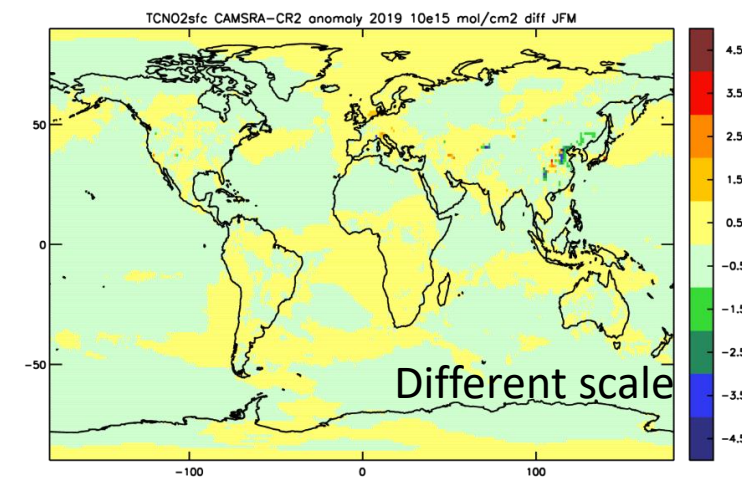
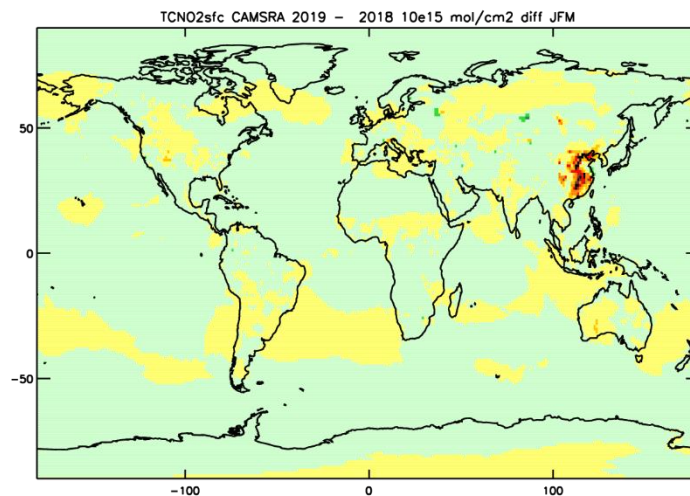
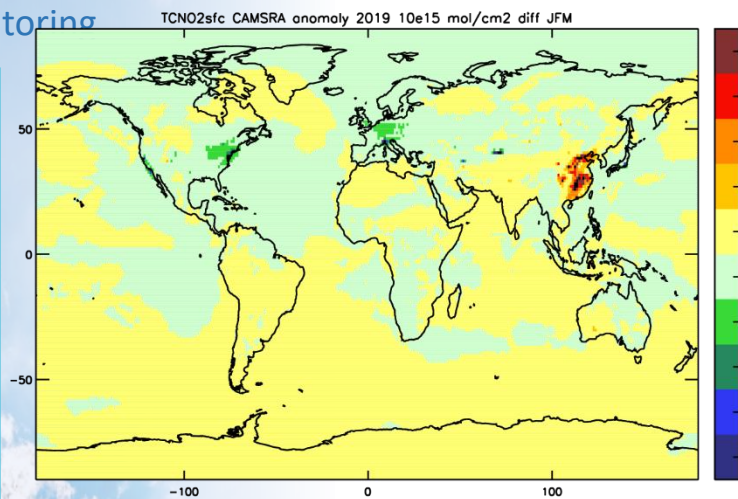
TCNO₂ JFM 2020 anomaly

CAMS RA ano w.r.t 2003-2019

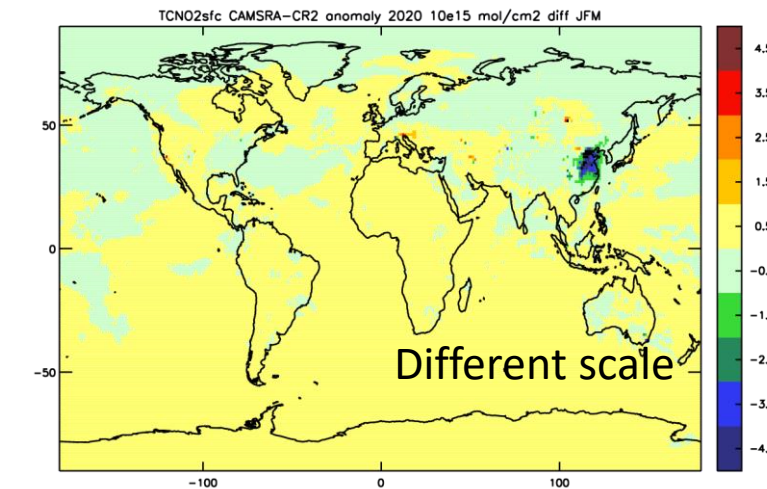
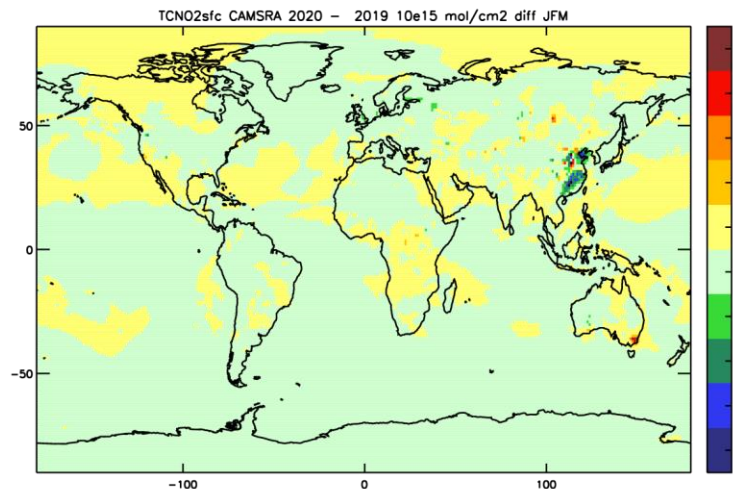
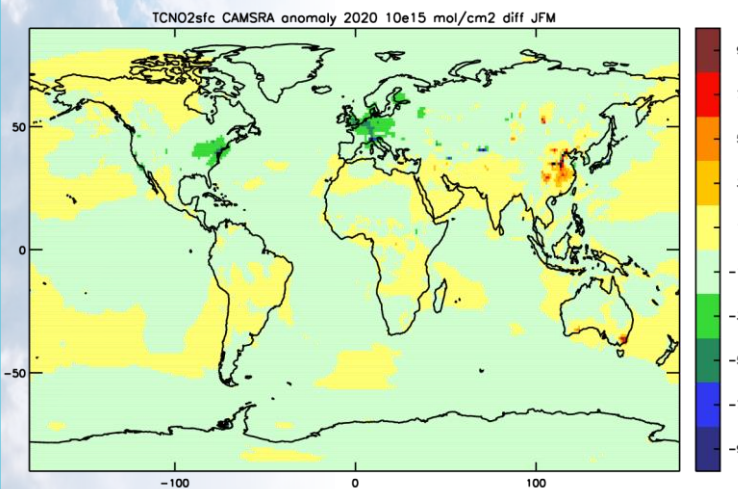
CAMSRA w.r.t previous year

CAMSRA-CR ano w.r.t 2003-2019

2019



2020



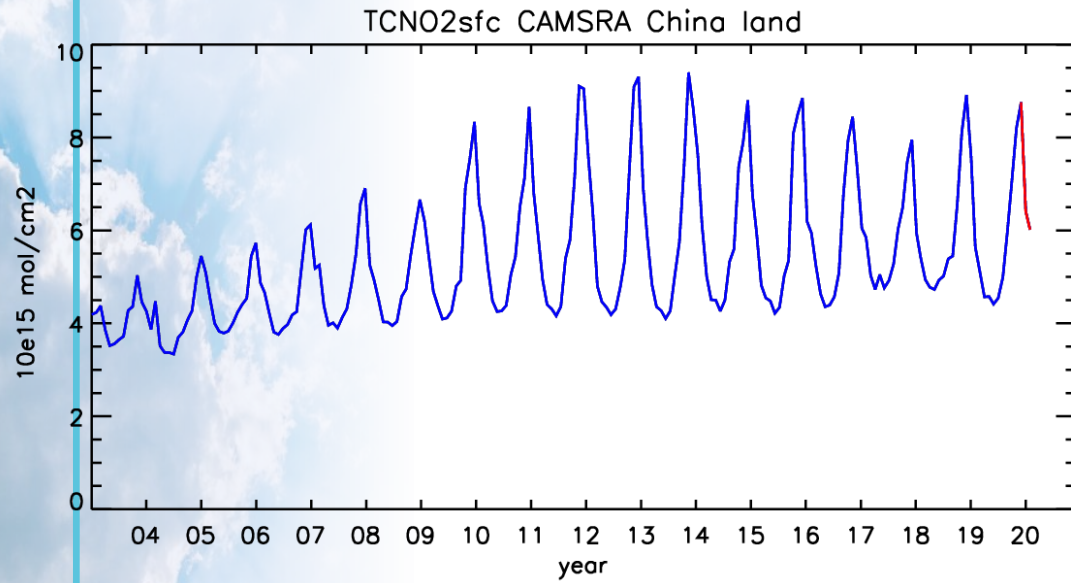
OMI and GOME-2 assimilated



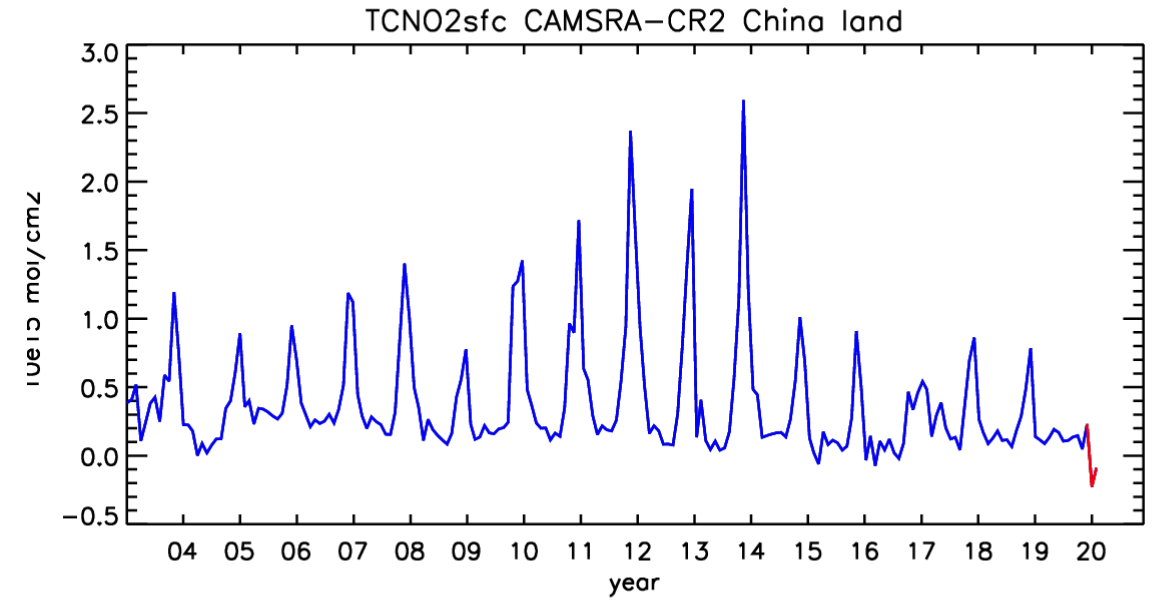
Atmosphere
Monitoring

JFM 2020 Total Column NO₂ over China

CAMS RA



CAMS RA – CR



If you are interested ...

- **GAFIS Survey of air quality forecasting systems:**

<https://forms.office.com/Pages/ResponsePage.aspx?id=VL6m6odGxECYJ8BEvY6NPOEUPVxZj4VPuHkwEB6oPDFUQ0c5UIhVU1o1U1BRQVpCUUZDVUk1VlINQy4u>

- **GAFIS website:** <https://community.wmo.int/activity-areas/gaw/science-for-services/gafis>

- **contact:**

- Johannes Flemming (at) ecmwf.int
- Lren (at) wmo.int