The Copernicus Atmosphere Monitoring Service: overview

Zak Kipling

With thanks to the rest of the CAMS team, and especially Vincent-Henri Peuch *(ECMWF) and* Samuel Rémy *(IPSL/CNRS) for many of the slides.*

inDust workshop, CNR, Rome, 11 March 2019
"Desert Dust impacts on Air Quality in Europe",

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The Copernicus Sentinels

		Key Features
 SENTINEL-1: 4-40m resolution, 3 day revisit at equator	*S1A and 1B in orbit*	Polar-orbiting, all-weather, day-and-night radar imaging
 SENTINEL-2: 10-60m resolution, 5 days revisit time	*S2A and 2B in orbit*	Polar-orbiting, multispectral optical, high-resolution imaging
 SENTINEL-3: 300-1200m resolution, <2 days revisit	*S3A and S3B in orbit*	Optical and altimeter mission monitoring sea and land parameters
 SENTINEL-4: 8km resolution, 60 min revisit time	*1st Launch 2022*	Payload for atmospheric chemistry monitoring on MTG-S
 SENTINEL-5p: 7-68km resolution, 1 day revisit	*S5P in orbit*	Mission to reduce data gaps between ENVISAT and Sentinel 5
 SENTINEL-5: 7.5-50km resolution, 1 day revisit	*1st Launch 2023*	Payload for atmospheric chemistry monitoring on MetOp 2nd Gen
 SENTINEL-6: 10 day revisit time	*1st Launch 2020*	Radar altimeter to measure sea surface height globally

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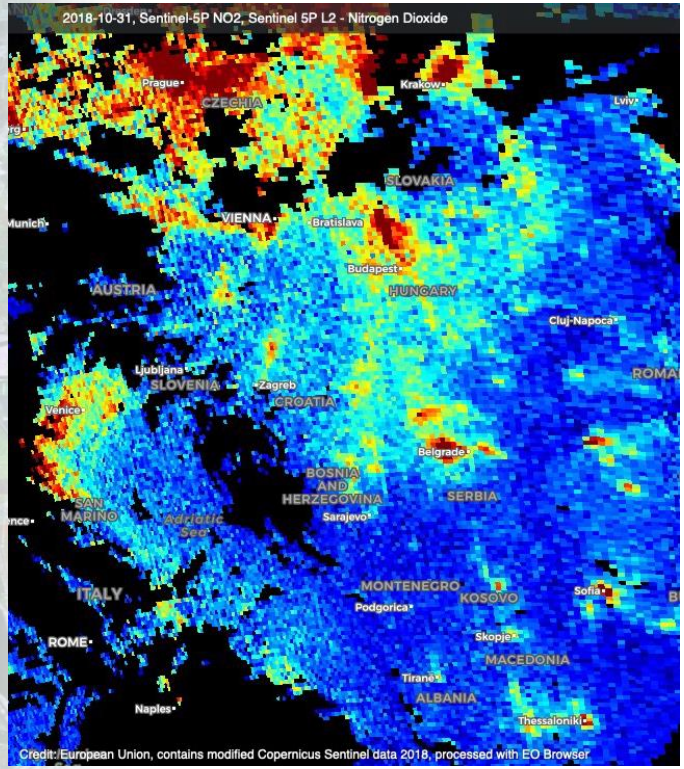
Why are information services needed?



Example: NO_2 tropospheric column from Copernicus Sentinel-5P (31/10/2018)

Observations are essential, but **direct use** is generally **limited**:

- gaps in space and time
- observed quantities may not be directly relevant (vertical column vs nose-level concentration)
- Complex and numerous

What services do:

- blend observations (satellite and non satellite) with model to provide a consistent “picture”
- forecasts, some days ahead
- reanalyses over past years, decades

6 Copernicus Thematic Services

Monitoring the State of the Earth System Environment ...

... Six cross-cutting Thematic Services

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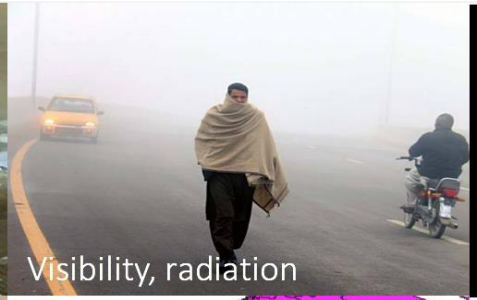
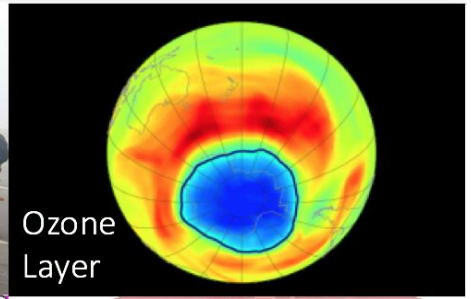
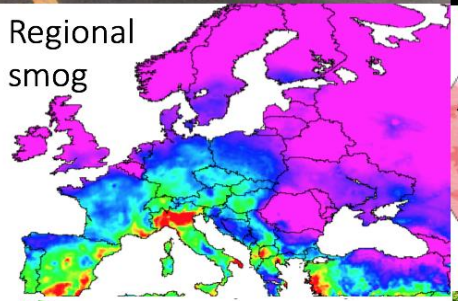
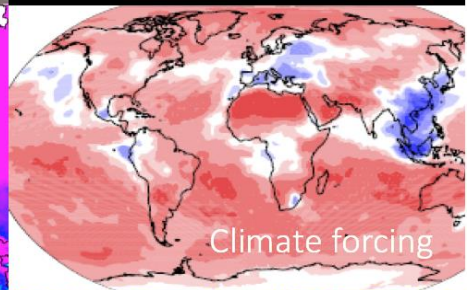
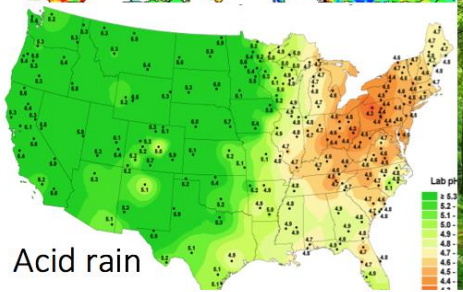
Why monitor atmospheric composition?

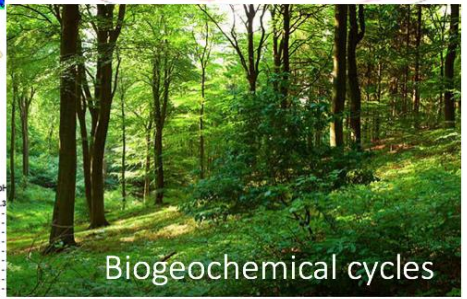












Local < 100km | Regional 100-1000km | Global > 1000km

from D. Jacob

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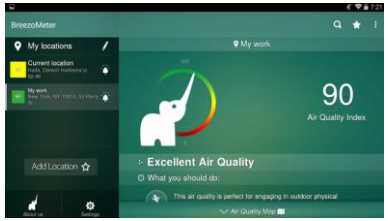
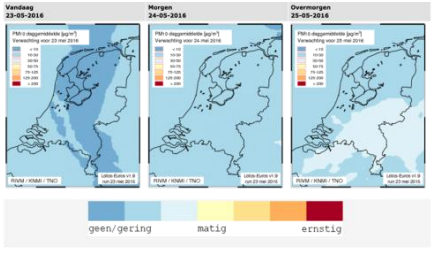
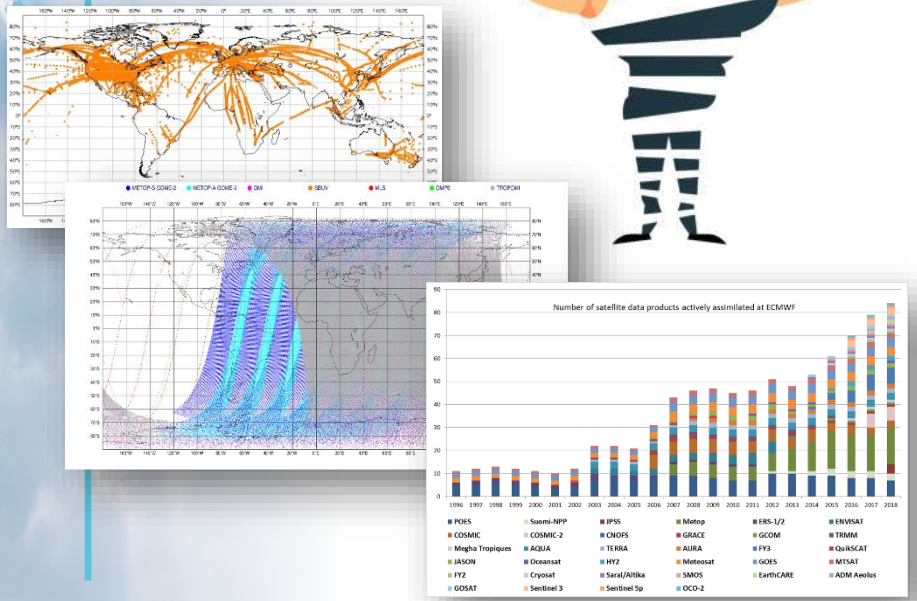
Let CAMS do the heavy lifting…







…and public/commercial users run the last mile

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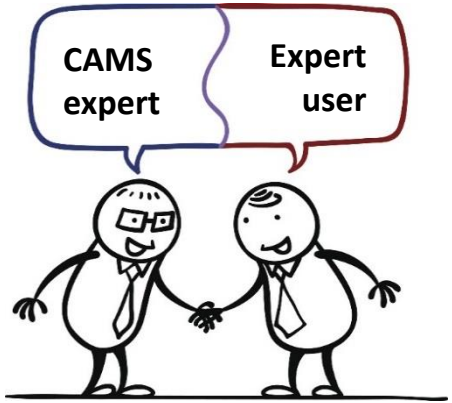
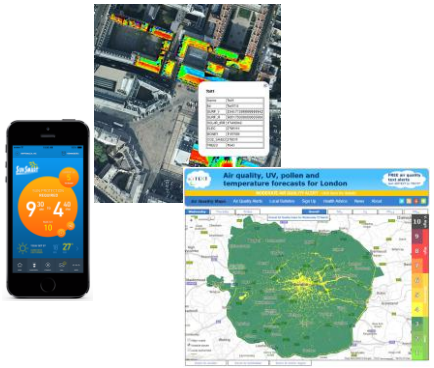
CAMS: Big Data for local applications

CAMS provides big data with the corresponding technical and scientific expertise to support expert users.
In doing so, we allow the CAMS information to reach millions of users in and outside Europe.





Downstream applications

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The CAMS product chain

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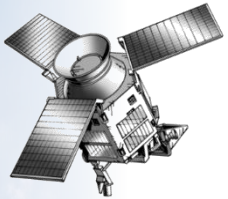
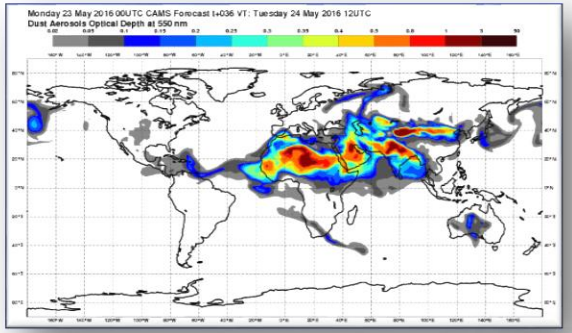
Space Agencies

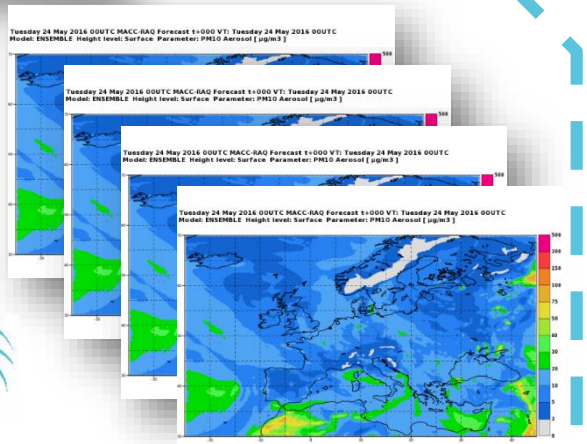




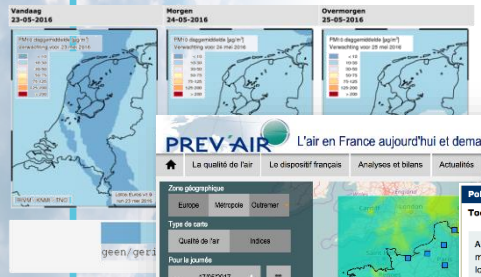
ECMWF/IFS

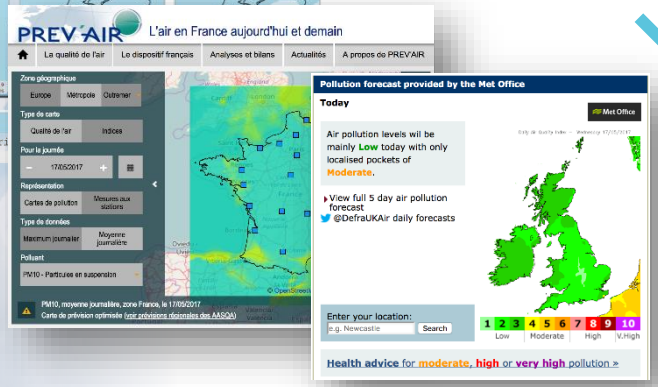
In-situ observations

7+2 regional CTMs



National scale





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Becoming a mainstream source

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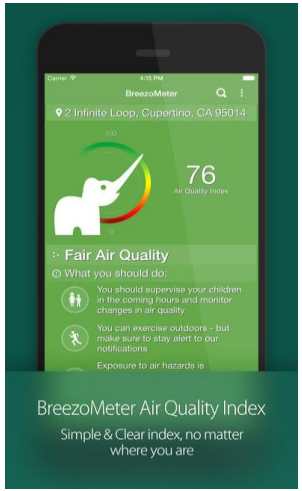
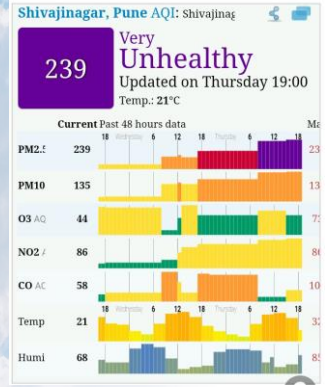
Plumelabs



Breezometer

Euronews



aqcin

Apple iOS 12 Weather app

The Weather Channel

TWC web and app

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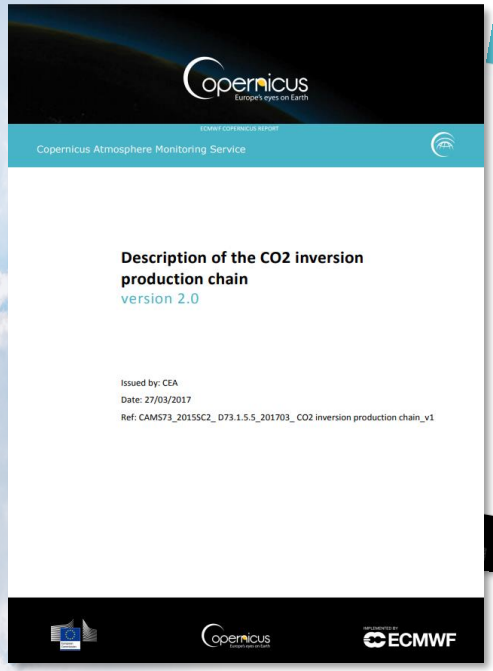
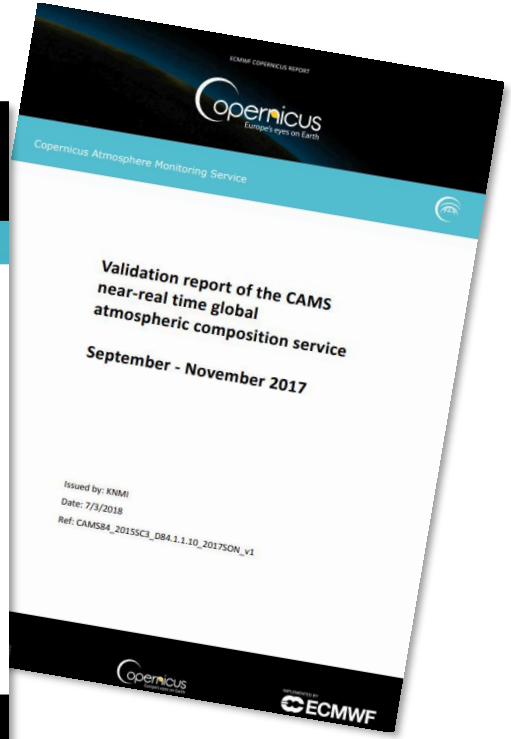
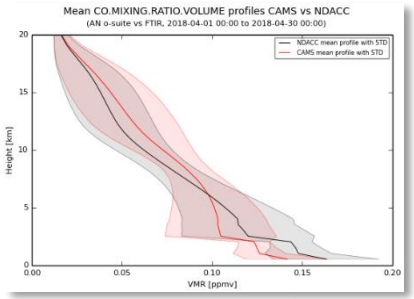
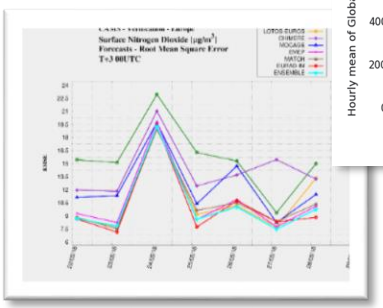
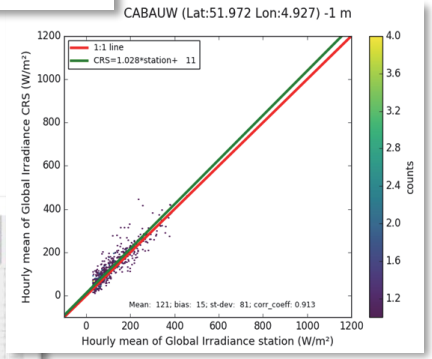
Documentation and Quality Control











CAMS provides detailed information about how its products are produced and what the quality is

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CAMS global products

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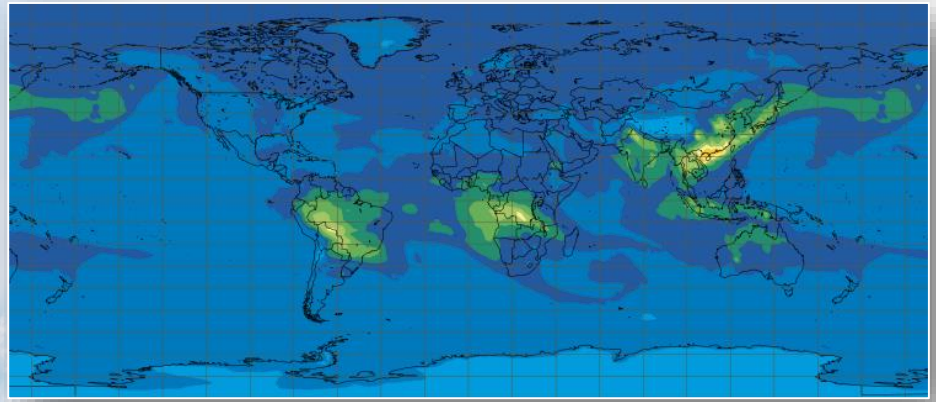
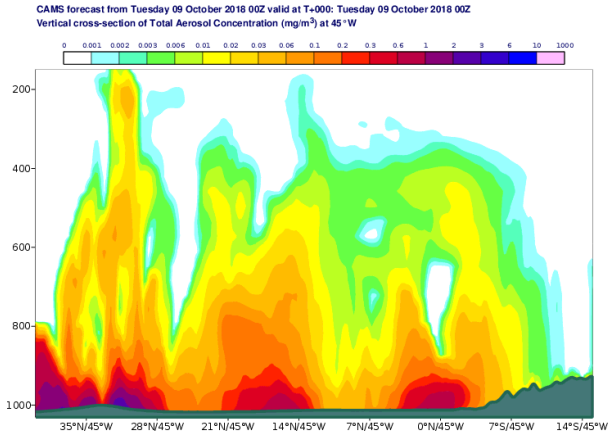
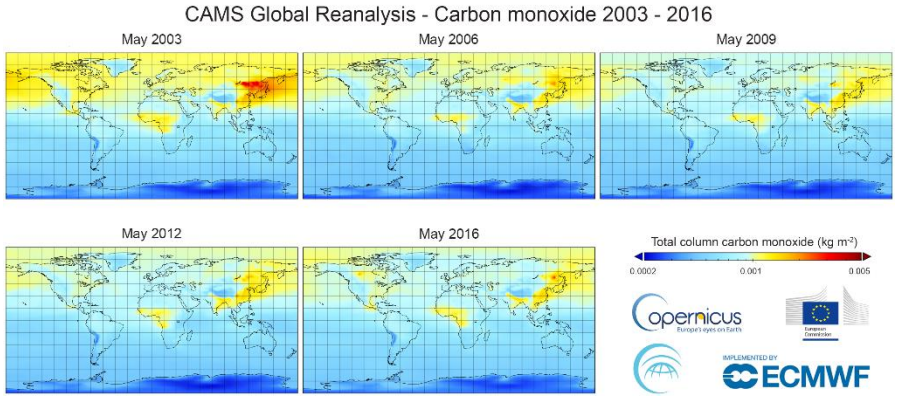




- Real-time analyses and 5-day forecasts at ~40km resolution
- Reanalysis 2003– at ~80km resolution
- Dedicated forecasts (e.g. field campaign support, special events)



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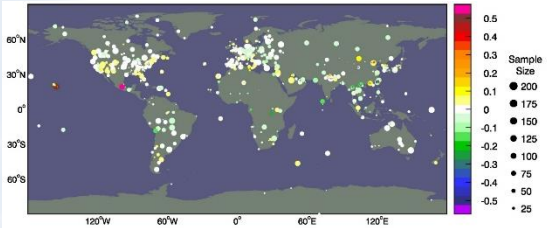
The CAMS global reanalysis of atmospheric composition

The dataset covering the period 2003 to end 2016 was released in September. This **reanalysis** is a marked improvement over our previous datasets (**MACC reanalysis** and **CAMS interim reanalysis**).

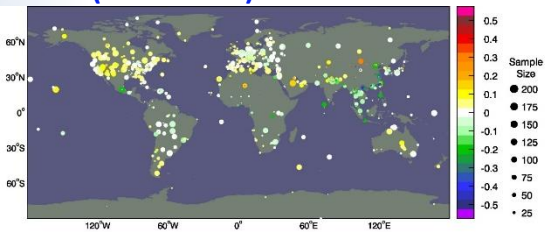
Evaluation of Aerosol Optical Depth

AERONET

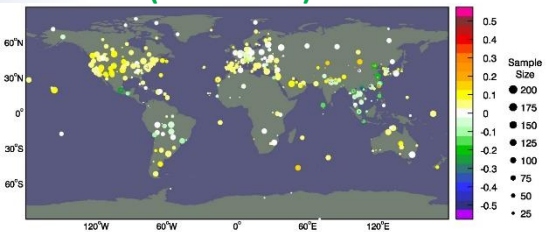
CAMSRA (2003-2016)



CIRA (2003-2016)

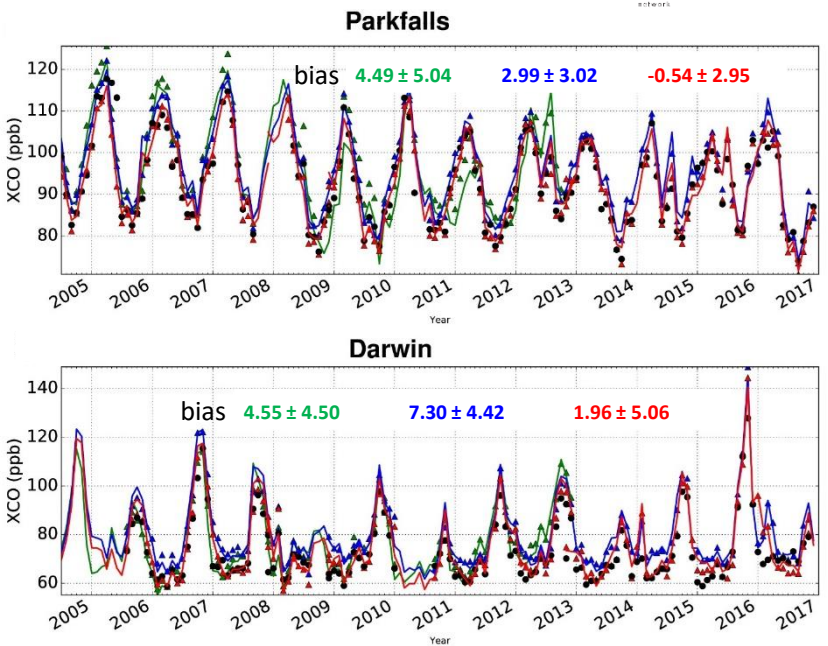


MACCRA (2003-2012)



Evaluation of total column CO

TCCON total carbon column observing network



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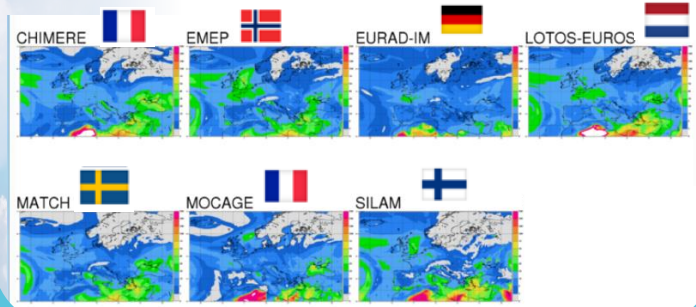
CAMS European Air Quality Portfolio

Based on a multi-model approach (same boundary conditions, same emissions, same meteorology, assimilation of 1000+ surface observations for key species)

Individual operational AQ models



DEHM (AARHUS University)

GEM-AQ (IEP)

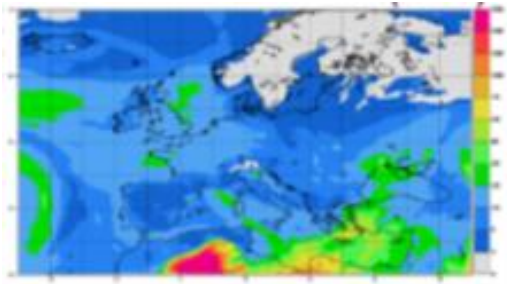
MINNI (ENEA)

MONARCH (BSC)

http://regional.atmosphere.copernicus.eu

Operational AQ ensemble

(incl. spread/uncertainty)



- Once-daily 4-day forecasts
- Regulated pollutants and pollens
- Annual reanalyses
- ~10km resolution

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NO_2

High quality products at European scale

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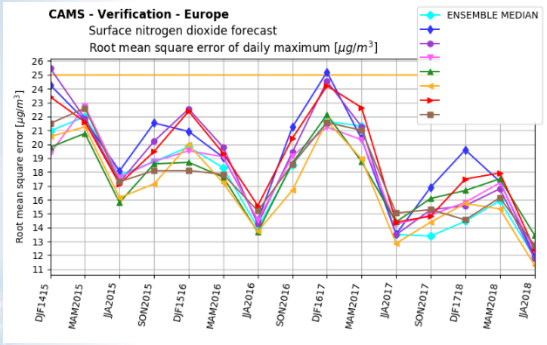
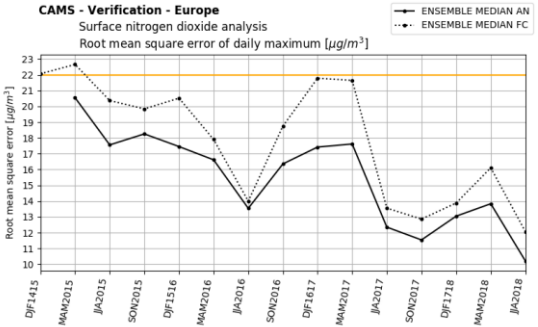
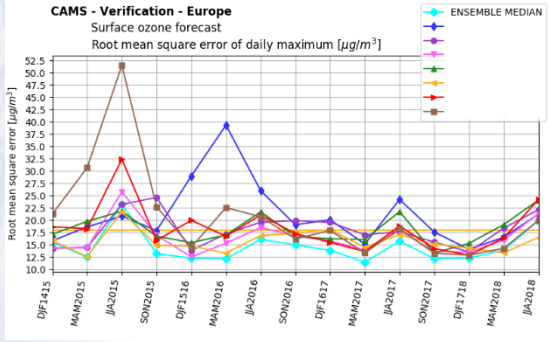
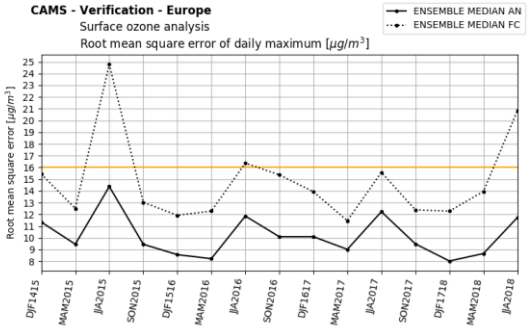
NO_2

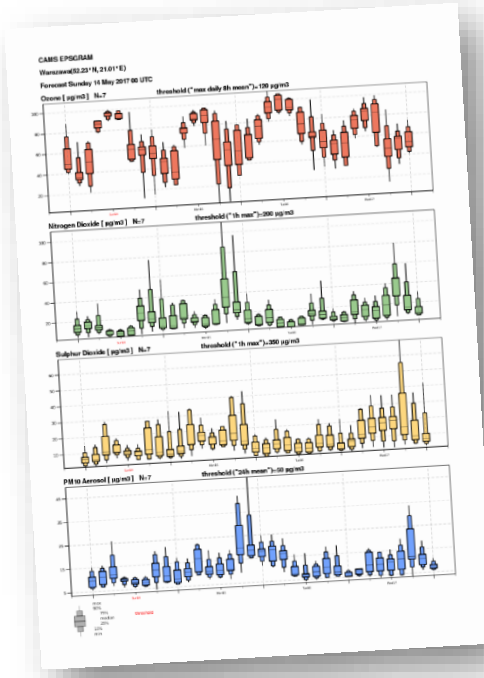
Ozone











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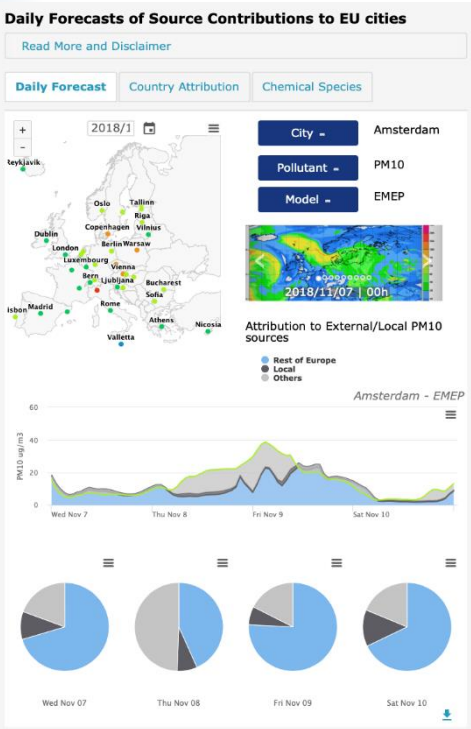
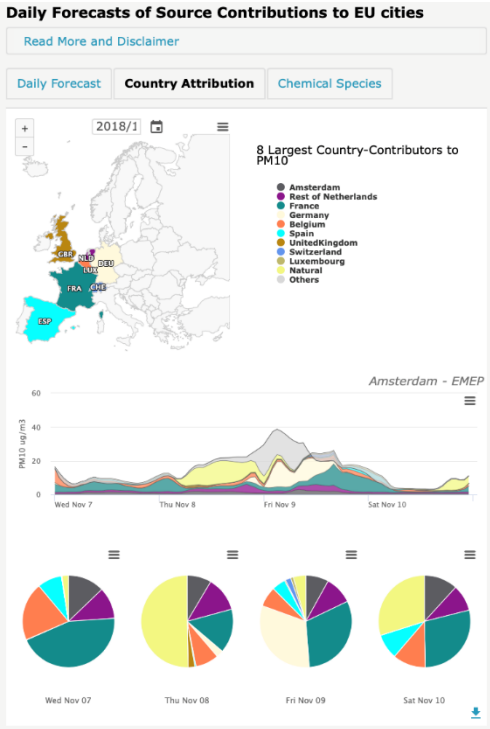
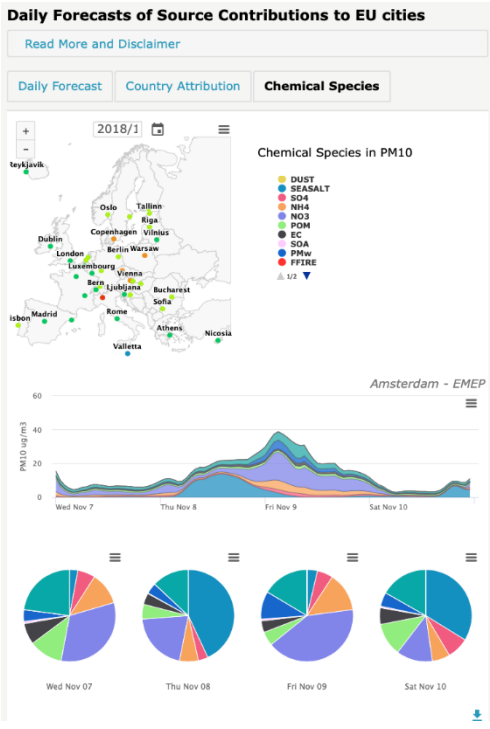
Products in support of policy users

Experimental: local vs imported, geographical origin, chemical speciation







http://policy.atmosphere.copernicus.eu/DailySourceAllocation.html

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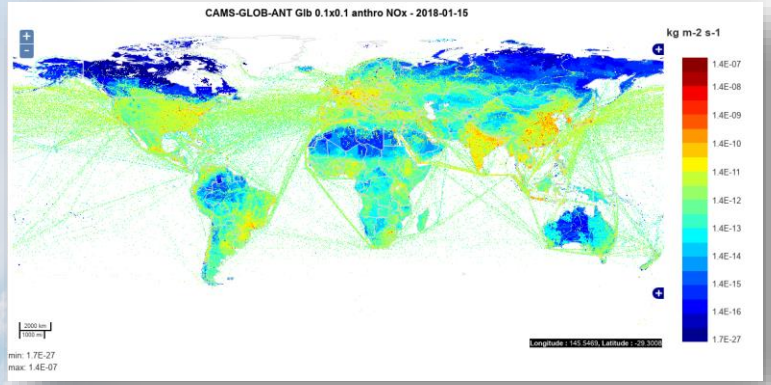
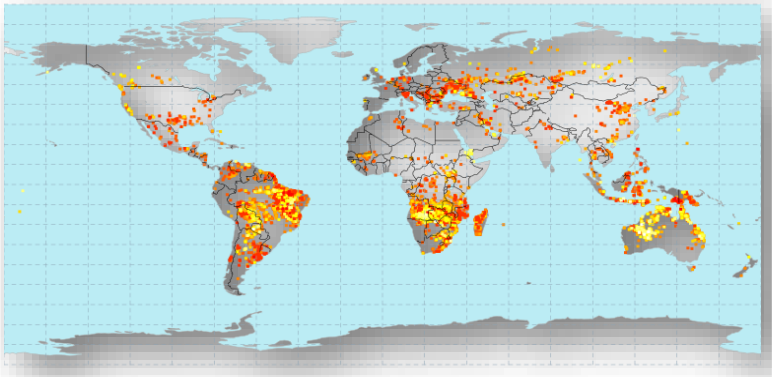
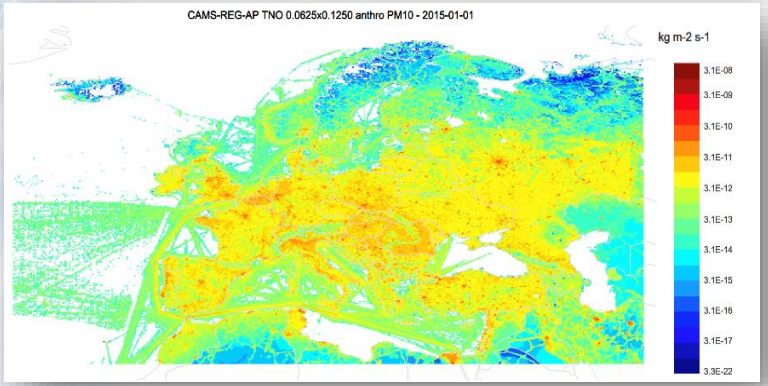
CAMS emission products







- Fire emissions (GFAS)
- Global anthropogenic emissions
- Regional anthropogenic emissions
- Natural emissions

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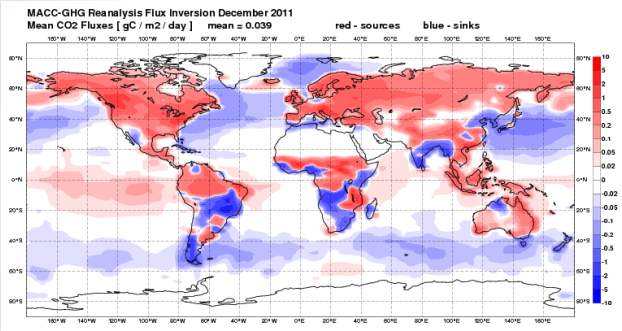
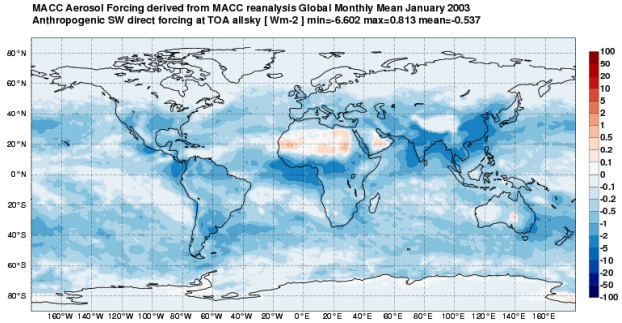
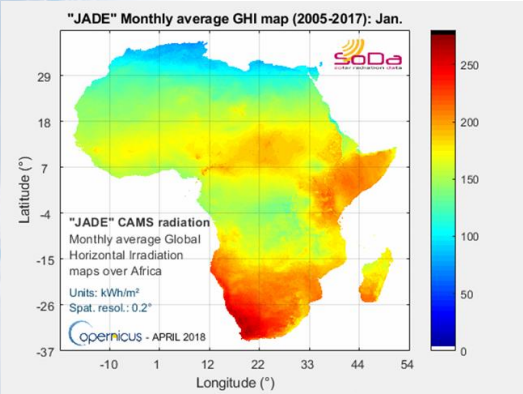
Supplementary products

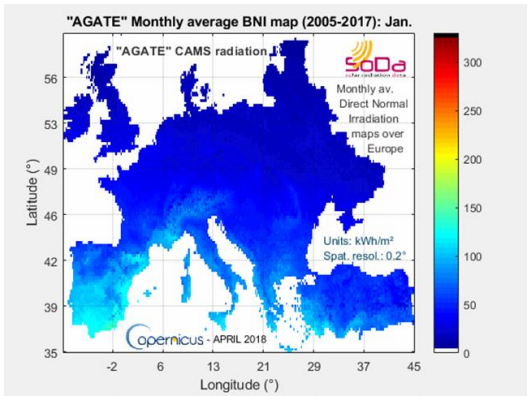


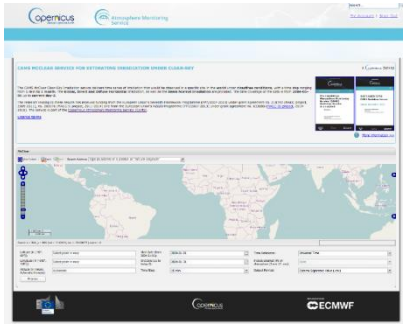


Greenhouse gas fluxes (CO_2, CH_4, N_2O)

Climate forcings







Solar radiation

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Dust entrainment: the Ophelia case

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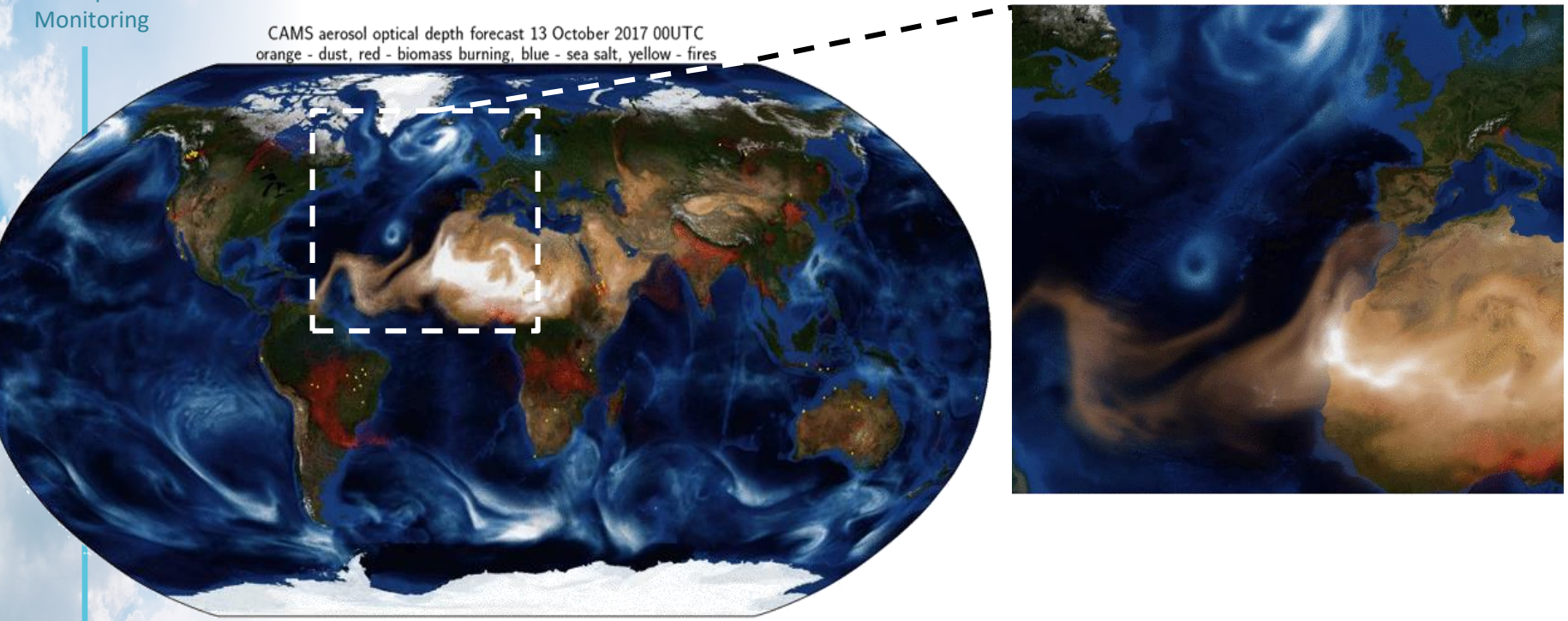

CAMS aerosol forecasts initialized on 13 October 2017. Storm Ophelia transported a mixture of smoke, dust and sea salt aerosol across Europe leading to the sun appearing red and to yellow skies.

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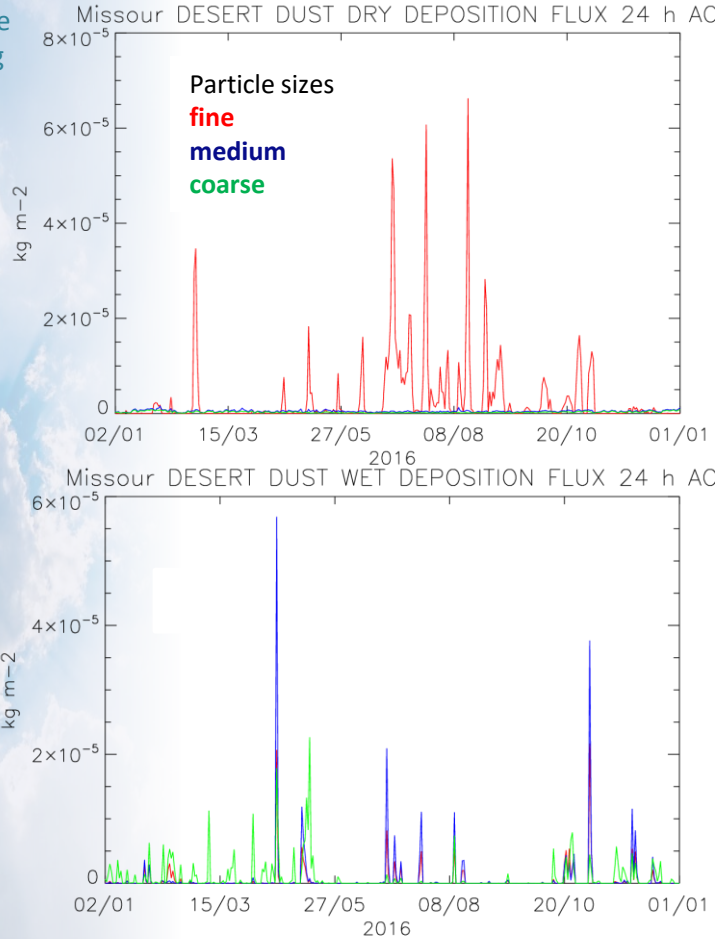
Dust deposition on solar panels

Atmosphere Monitoring



CAMS is continually carrying out new/experimental developments. Often, co-design of products with users.

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A new dust scheme for Cycle 46r1 (later this year): Nabat et al. (2015)

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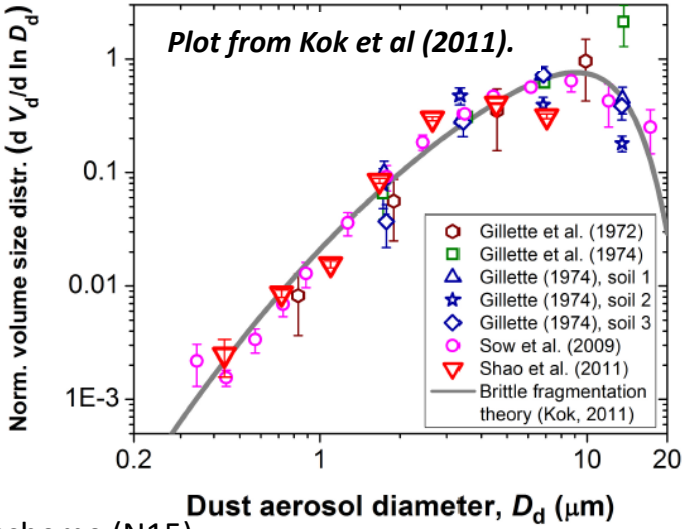
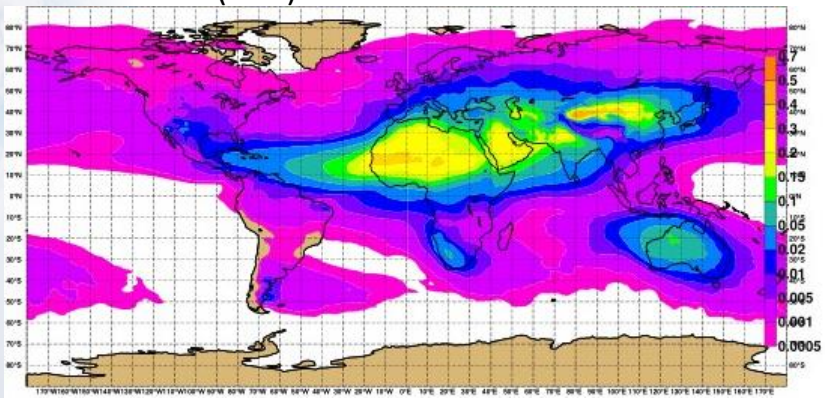
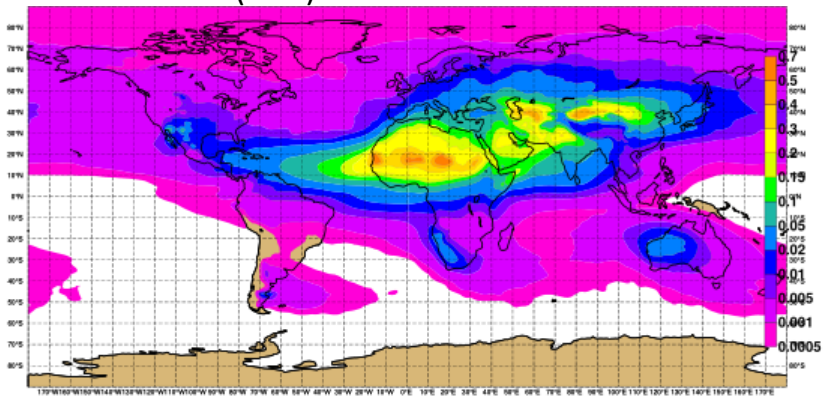
- Replaces older Ginoux et al. (2001).
- Marticorena and Bergametti (1995) saltation
- Kok et al. (2011) size distribution at emission
- Sand and clay fraction from SURFEX (Météo-Fr)
- 4-fold increase in super-coarse particles
- Greater total emissions



Old scheme (G01)



New scheme (N15)



A new Dust Source Function (in 46r1) and larger size bins (experimental)

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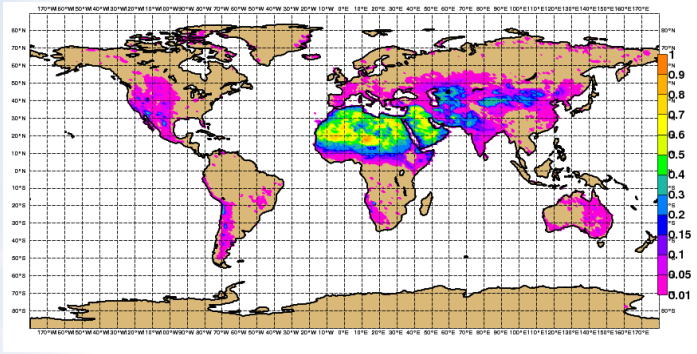
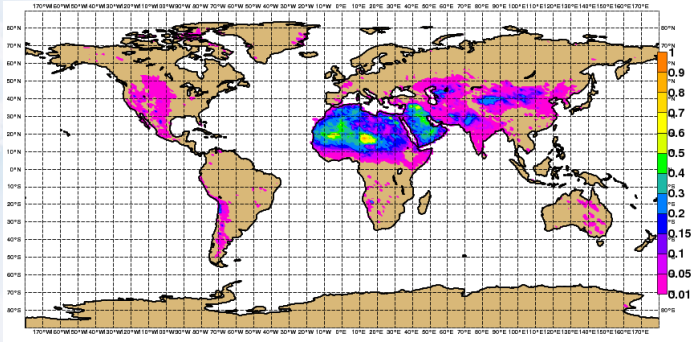
Freq (DOD > 0.2)



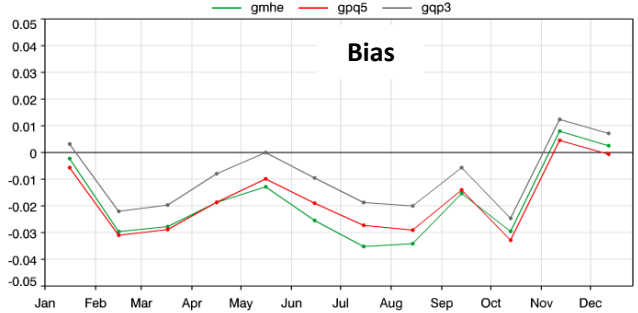
Freq (DOD > 0.4)



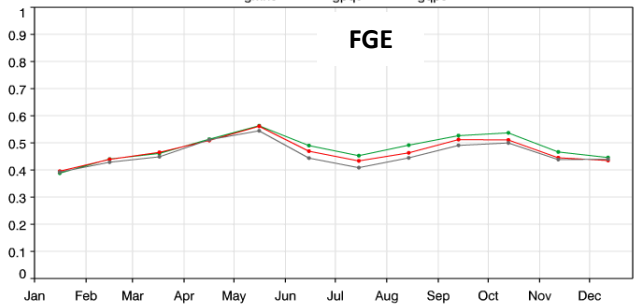
DSF based on AquaMODIS DOD 2003–14 (P. Ginoux) to replace empirical local dust emission criteria

— Ref (43r1, G01) — N15+DSF — N15+DSF+largebins

FC-OBS bias. Model against L2.0 Aeronet AOT at 500nm.
327 Voronoi-weighted sites globally (r_{max}=1276km).
1 Jan - 26 Dec 2014. FC start hrs=00Z. T+6 to 24.



Fractional Gross Error. Model against L2.0 Aeronet AOT at 500nm.
327 Voronoi-weighted sites globally (r_{max}=1276km).
1 Jan - 26 Dec 2014. FC start hrs=00Z. T+6 to 24.



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Resuspension of deposited aerosols (Kim et al., 2010, 2016)

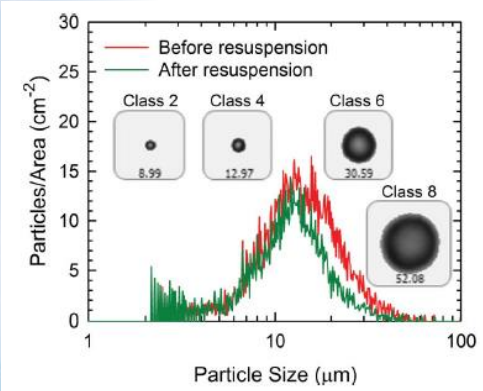
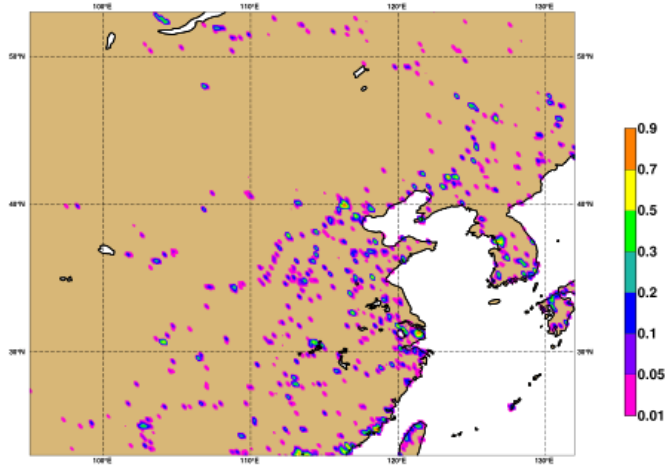
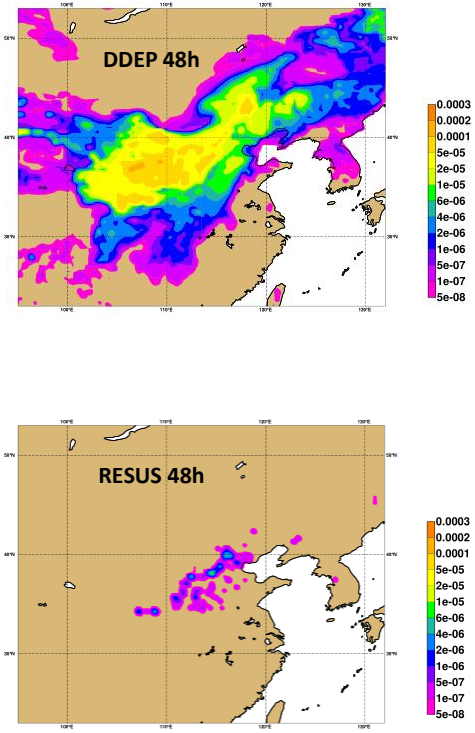


Figure 3. The particle size distribution of the PE spheres on a glass surface before and after a resuspension experiment. The images correspond to typical Classes 2, 4, 6, and 8 PE particles.

(Kim et al., 2016)



Urban fraction over China (USGS data)



- Resuspension significant for coarse particles over concrete surfaces with short roughness length.
- In urban areas, resuspended fraction parameterised empirically based on particle size, friction velocity and relative humidity.
- Generally small except during extreme events, more impact expected at very high resolutions

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CAMS: a truly European effort
133 entities from 28 EU/ECMWF countries
48 contracts
> 10-year heritage (GEMS, MACC/MACC-II/MACC-III…)