



Atmosphere Monitoring

Using EMEP model in CAMS analysis of pollution episodes in European cities

Cooperation between EMEP and CAMS

Presented by Svetlana Tsyro



PROGRAMME OF
THE EUROPEAN UNION



IMPLEMENTED BY



Norwegian
Meteorological
Institute

TFMM 24-th meeting
Warsaw, May 10-12, 2023





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CAMS Policy Support:

Implemented by ECMWF as part of the Copernicus Programme

News Events Press Tenders Help & Support

Data About us What we do

<https://policy.atmosphere.copernicus.eu/>

CAMS Policy Support

Air pollution at target cities

4-day forecast (EMEP model)

PM10 PM2.5 O3

Oslo

Max. concentration

11.5

For more information and additional results (past results, comparisons with observations and source tagging with the LOTOS-EUROS model), check out the [daily air pollution forecasts](#) page: [local/remote](#) allocation, [country](#) allocation/contributions, and the [PM₁₀ chemical speciation](#).

Our services

CAMS policy support provides a number of products and results that aim at supporting decision and policy making in the management of **air pollution episodes** and reporting under European Directives. Policy services are based on the air quality regional services capacities to elaborate added value products describing the evolution of air quality in Europe and the influence of the main anthropogenic sources, helping in designing appropriate and efficient policy responses to episode situations.

The EMEP model is one of the members of the CAMS multi-model ensemble used for CAMS regional services, e.g. operational daily analyses and 4-day forecasts of air quality, and reanalysis.

Also, it contributes within CAMS Policy Support Service.

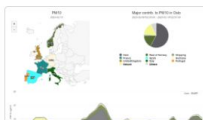
... provides a number of products and results that aim at supporting decision and policy making in the management of **air pollution episodes** and reporting under European Directives



Air Control Toolbox

The CAMS Air Control Toolbox offers a flexible framework to explore the benefit of **emission reduction** strategies.

[Data Access](#)



Air Pollution Forecasts

Daily forecasts of **local/long-range** allocation, allocation from **countries** of PM₁₀, PM_{2.5} and O₃ in European cities, and **chemical speciation** of PM₁₀.

[Data Access](#)



Air Quality Reports

Find reports on major **air pollution episodes** in Europe (fine particles, ozone, forest fires, ...), as well as **annual assessment** reports.

[Reports Access](#)





CAMS Policy Products: source allocation for PM and ozone

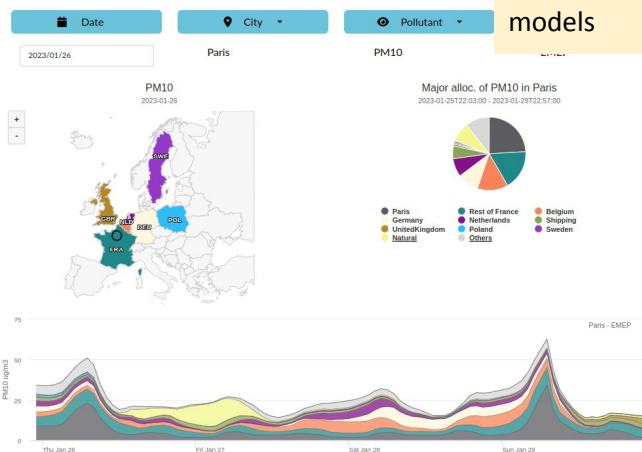
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<https://policy.atmosphere.copernicus.eu/>

Source Contribution to EU Cities

Country Source Apportionment

EMEP &
LOTOS-EUROS
models



CAMS ACT: Air Control Toolbox

[Read More](#)

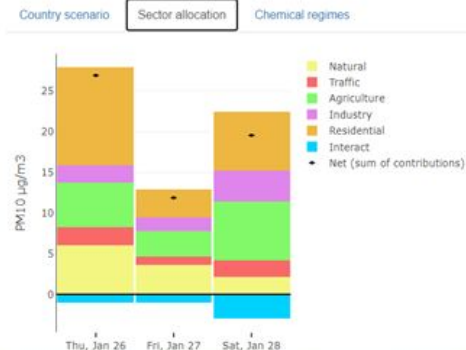
CHIMERE (& EMEP)

[Air pollution scenarios](#)

[Forecasts at target cities](#)

Pollutant: PM10
Forecast Base Time: 2023-01-26
Valid Time: 2023-01-26

Target city: Paris



Use of the Policy Products:

- understand origin of episodes
- understand impact of mitigation measures (policy planning)
- identify sources
- compliance checking
- support communication towards the public

In addition, modelled PM10 country allocation and chemical composition and comparison PM10 with observations from 2019 onwards

In addition: country scenarios, chemical regimes





EMEP model setup for the operational runs of SR forecasts

Simulation domain: 0.25°x0.125° lon-lat

Emissions: CAMS-REG-AP_v5.1 (including condensables from Residential combustion)

Meteorology and Boundary conditions: IFS forecast (ECMWF)

Cities: 80 (popul > 500 000), defined as 3x3 grids (appr. 42x42 km)

Daily 4-day forecasts, starting at 3:30 UTC: 75 runs in total

1 Base run

40 city reductions (2 cities in each run)

31 country reductions

1 Shipping reduction, 1 BCs reduction, 1 all domain reduction

15 % reduction of all emissions for the source region:

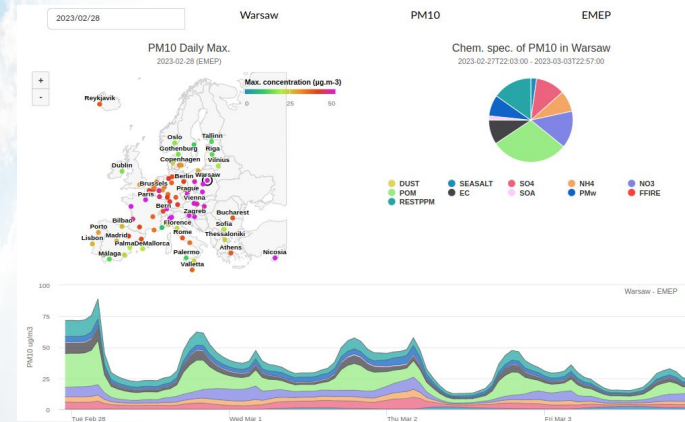
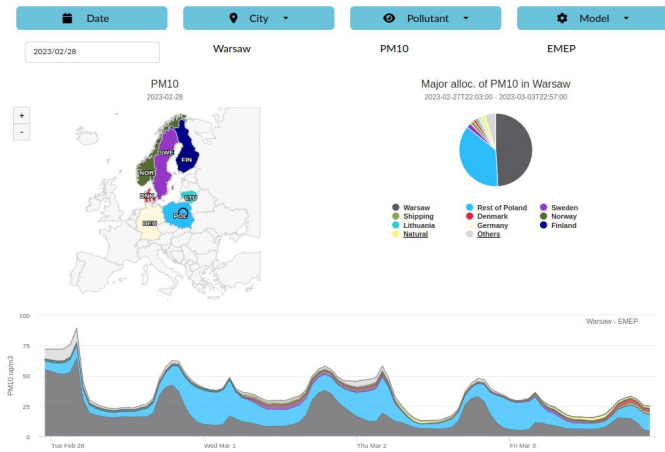
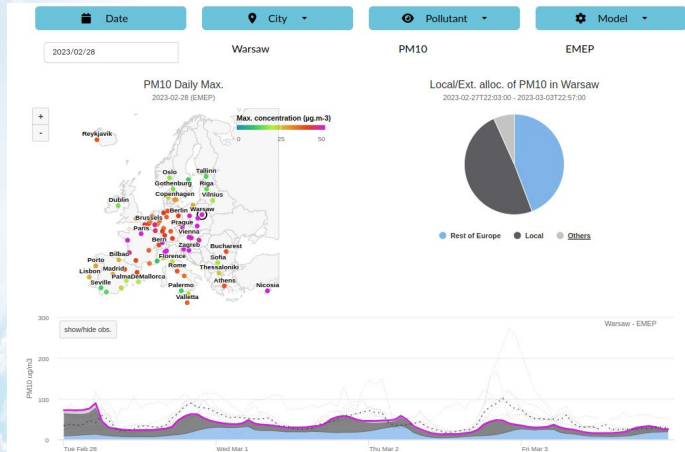
For each city, **hourly timeseries** are produced for **PM₁₀**, **PM_{2.5}**, **ozone**, Including source allocation

The results are visualized on the **web interface CAMS Policy Support:**

<https://policy.atmosphere.copernicus.eu/>



EMEP forecast for Warsaw (28 Febr - 3 March 2023)



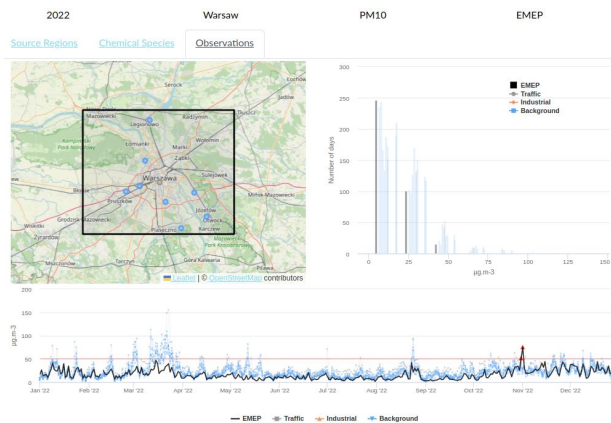
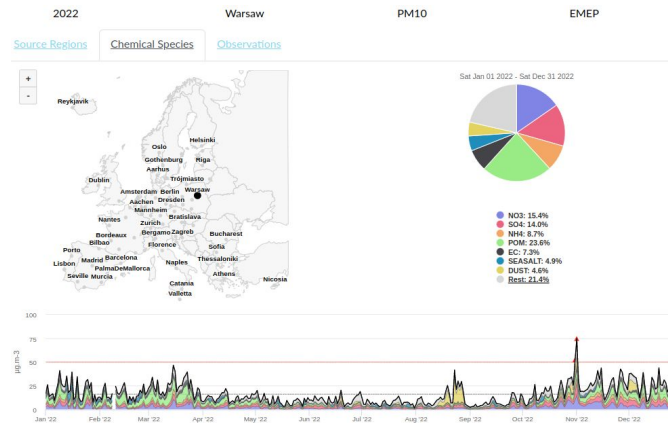
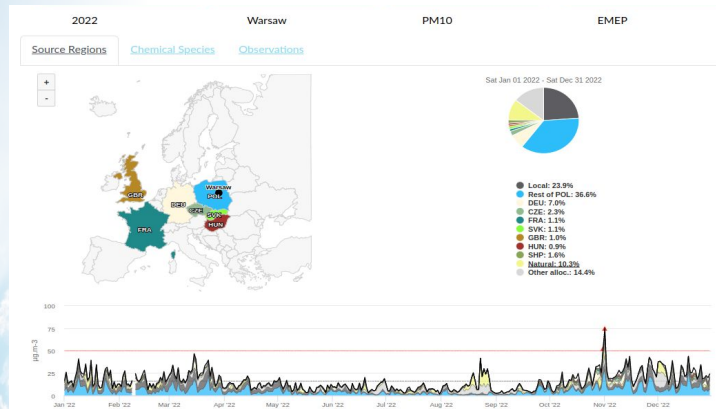
Hourly timeseries for PM_{10} , $PM_{2.5}$, ozone:

- Local (city) and long-range contributions
- Top 10 sources-contributors
- Chemical speciation for PM
- EEA observations (for PM_{10} currently)



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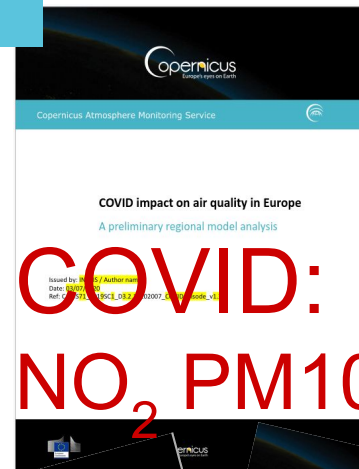
Yearly Air Pollution Analysis: daily timeseries PM10 (Warsaw, 2022)





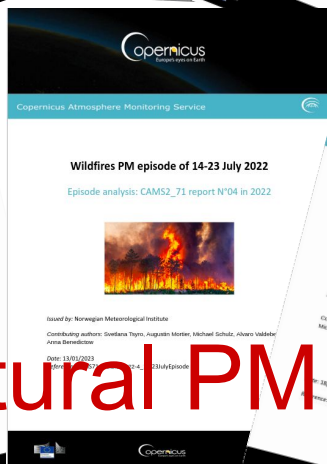
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Episode Reports

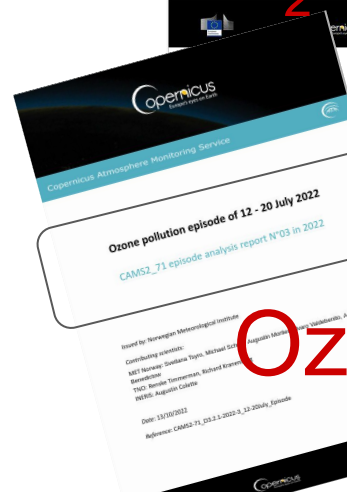


PM10

COVID:
NO₂ PM10



Natural PM10



Ozone





PM10 episode 20-27 March 2022

Practically all capitals in central/western Europe experienced several days with daily PM10 above $50 \mu\text{g}/\text{m}^3$

March 21

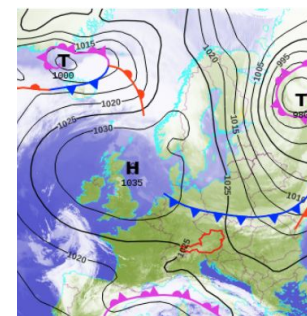
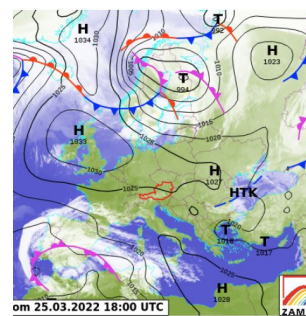
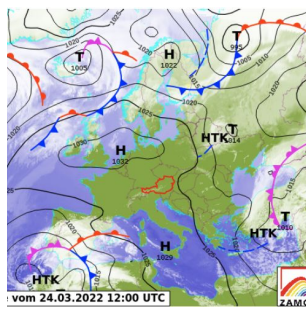
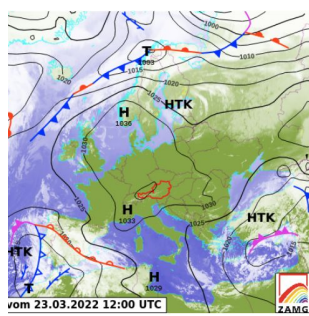
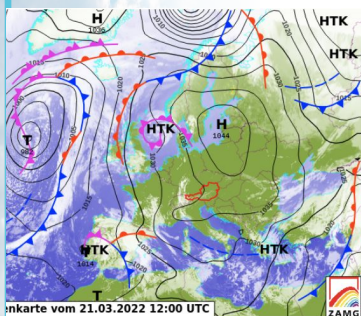
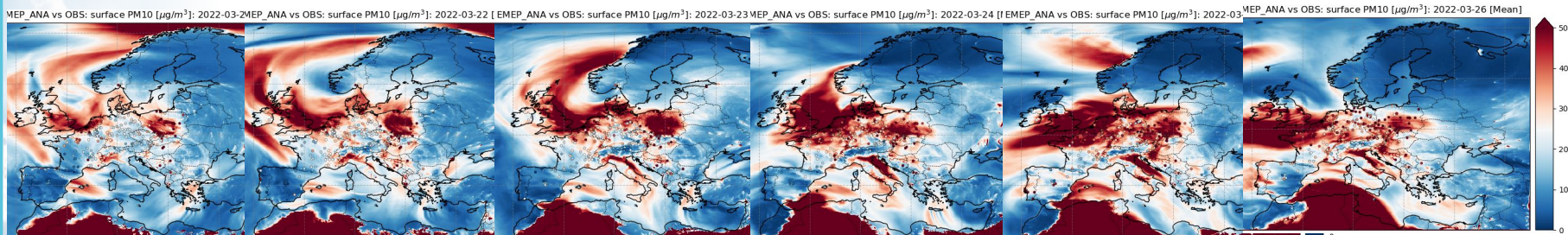
March 22

March 23

March 24

March 25

March 26

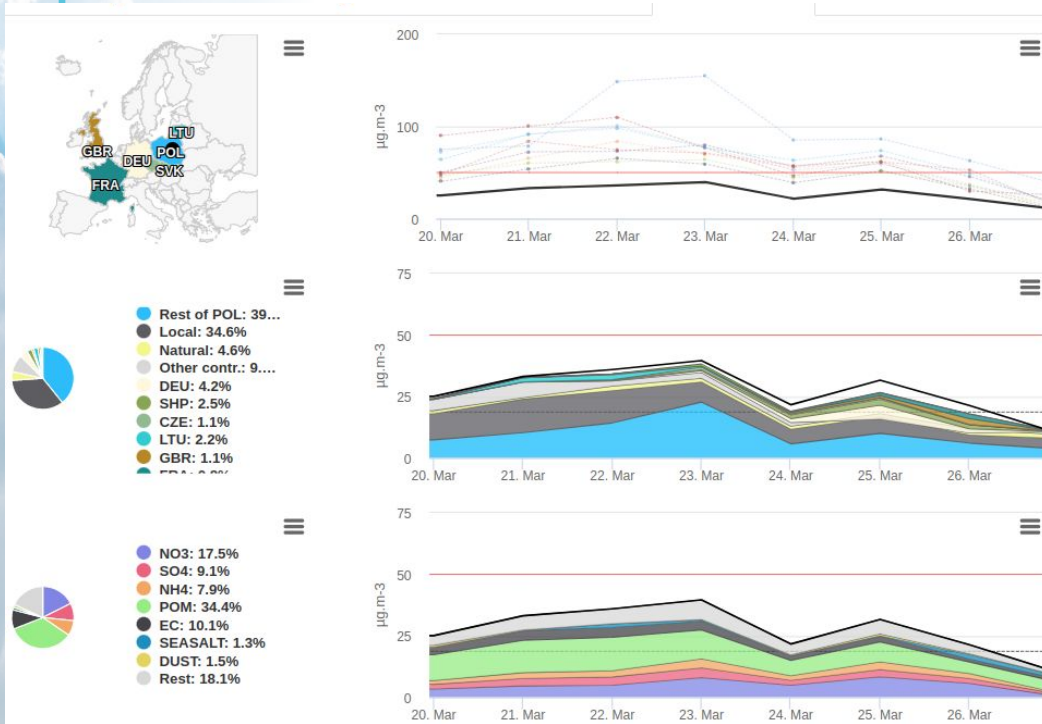




PM10 episode 20-27 March 2022: analysis for Warsaw

Daily time-series of PM₁₀ concentrations, source allocation and chemical composition for Warsaw during the PM₁₀ episode from EMEP model simulations.

<https://policy.atmosphere.copernicus.eu/YearlyStatistics.php>



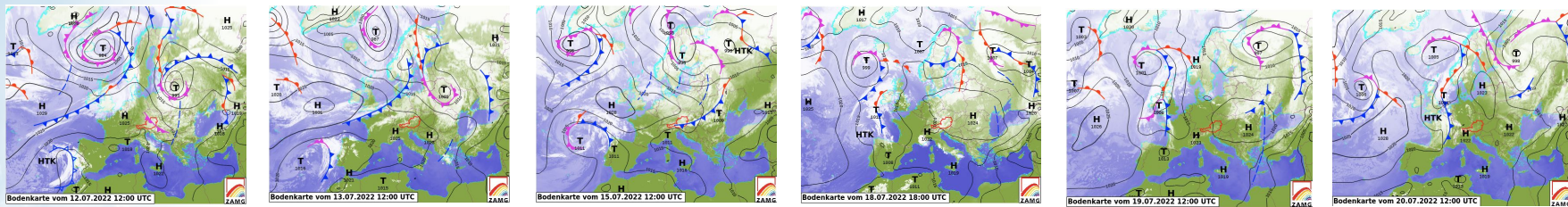
- One of the most affected cities (4-7 exceedance days observed)
- The major sources of PM₁₀ - domestic emissions from Poland (74%): with contributions from the city itself 35% and the rest of Poland 39%.
- The main PM components: primary organic matter (POM) and nitrate (NO₃⁻), which contributed during the most polluted days with around 40% and 15% respectively.
- EMEP model reproduced the development of the PM episode, but observed PM₁₀ are underestimated (coarse model resolution; uncertainties regarding condensables in primary PM emissions, not accounting for temperature dependence of residential PM and ammonia emissions)



Ozone episode 12-20 July 2022:

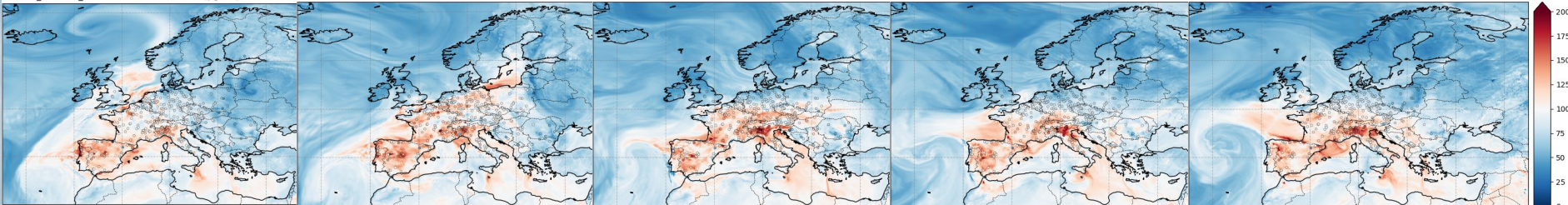
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CAMS forecast support to the activation of EMEP Ozone IMP

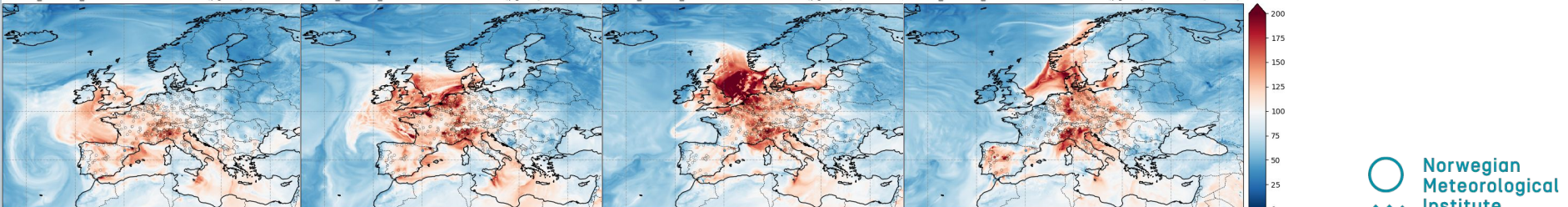


Analysis of the ozone episode: CAMS71 report 3 in 2022

CAMS2_40 EMEP_ANA vs OBS: surface ozone [$\mu\text{g}/\text{m}^3$]: 2022-07-12 | CAMS2_40 EMEP_ANA vs OBS: surface ozone [$\mu\text{g}/\text{m}^3$]: 2022-07-13 | CAMS2_40 EMEP_ANA vs OBS: surface ozone [$\mu\text{g}/\text{m}^3$]: 2022-07-14 | CAMS2_40 EMEP_ANA vs OBS: surface ozone [$\mu\text{g}/\text{m}^3$]: 2022-07-15 | CAMS2_40 EMEP_ANA vs OBS: surface ozone [$\mu\text{g}/\text{m}^3$]: 2022-07-16 [18UTC]



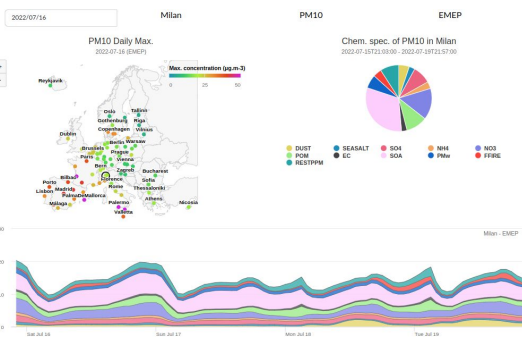
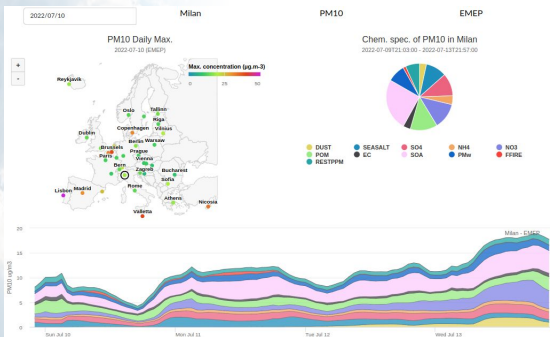
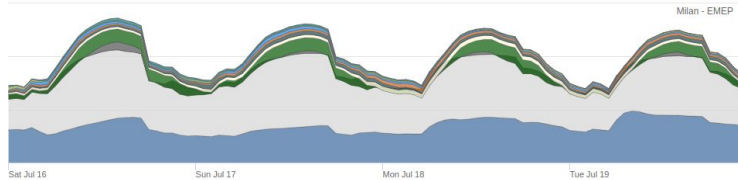
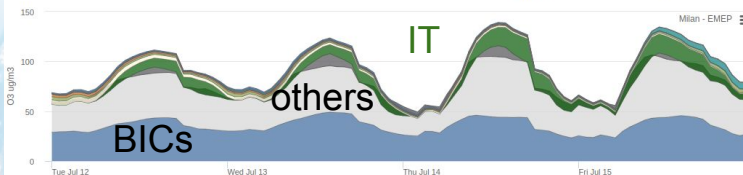
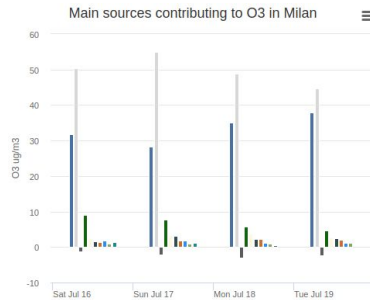
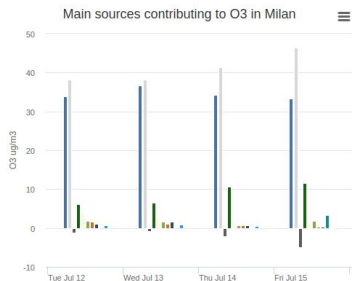
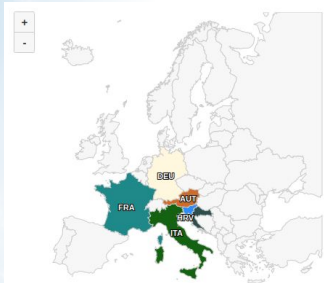
CAMS2_40 EMEP_ANA vs OBS: surface ozone [$\mu\text{g}/\text{m}^3$]: 2022-07-17 | CAMS2_40 EMEP_ANA vs OBS: surface ozone [$\mu\text{g}/\text{m}^3$]: 2022-07-18 | CAMS2_40 EMEP_ANA vs OBS: surface ozone [$\mu\text{g}/\text{m}^3$]: 2022-07-19 | CAMS2_40 EMEP_ANA vs OBS: surface ozone [$\mu\text{g}/\text{m}^3$]: 2022-07-20 [18UTC]





Ozone episode 12-20 July 2022:

Milan



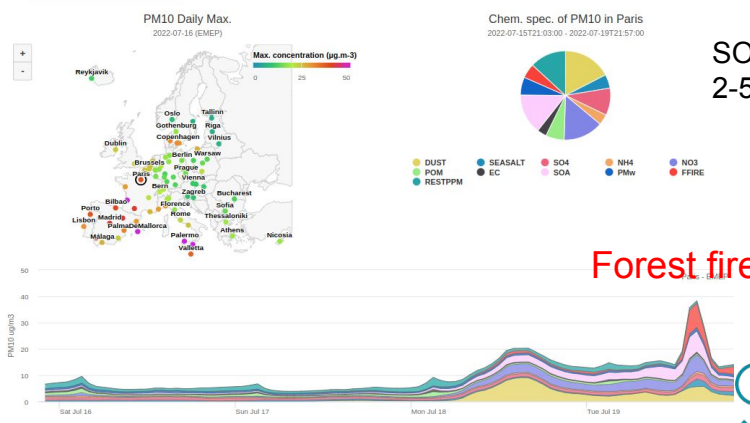
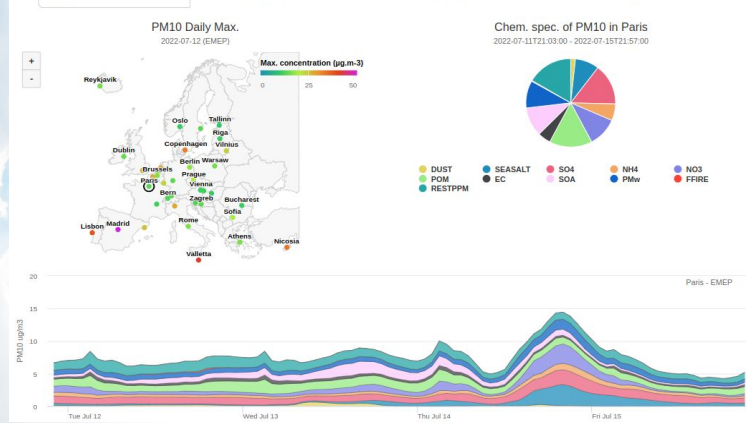
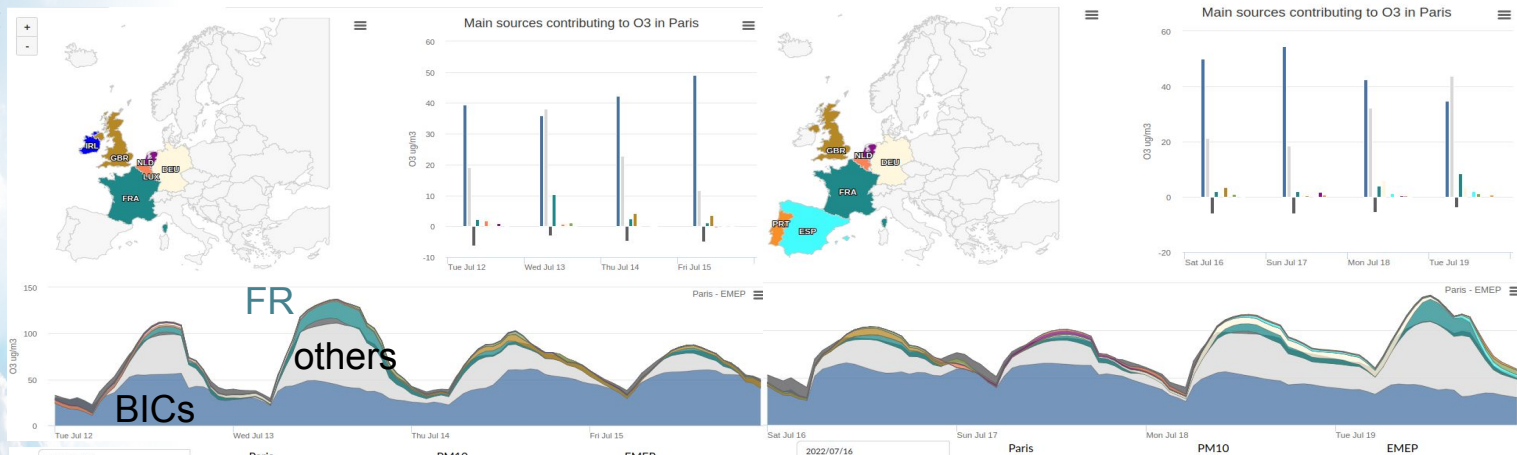
On the days with higher ozone concentrations, the contribution from BICs decreased wrt that from European sources within the CAMS domain, whereas the effect of domestic emissions increases (city emissions typically titrate ozone).

SOA portion in PM10 increases from 15% to >30% from the days before and during the episode, indicating increased VOC (biogenic, forest fires)



Ozone episode 12-20 July 2022:

Paris



SOA in PM10:
2-5% to 20-25%

Forest fires



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PM10 episodes due to natural sources

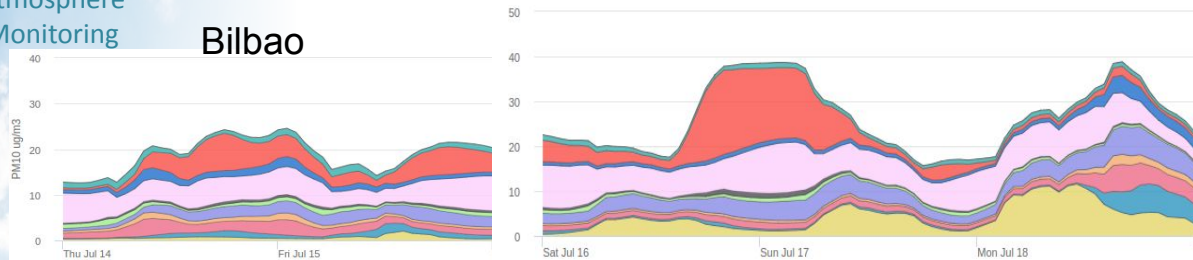
Natural aerosol episodes happen on a regular basis and may impact local air quality and cause/contribute to exceedances of critical levels



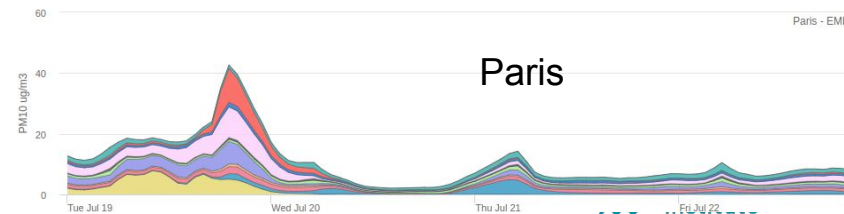
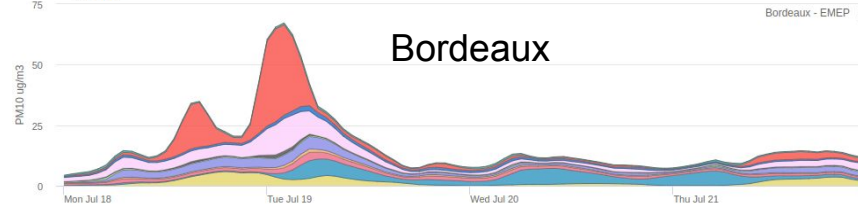
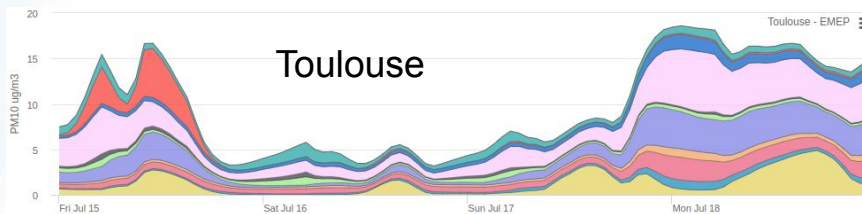
Forest fires episode 14-23 July 2022

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Bilbao



Hourly time-series of PM₁₀ concentrations and chemical composition from the 4-day EMEP forecasts



<https://policy.atmosphere.copernicus.eu/DailySourceAllocation>

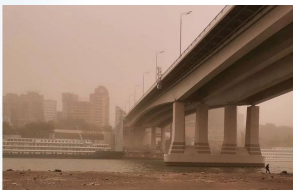


Dust & Forest fires episode: 27 Sept - 4 Oct 2020

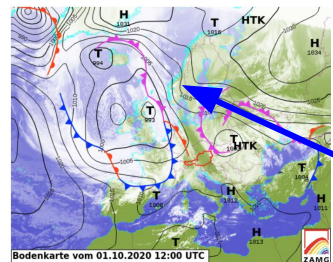
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Pollution origin: southern Russia and eastern Ukraine

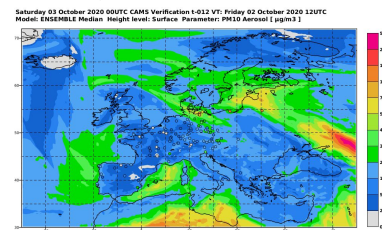
- very hot and dry summer resulted in dry bare soils and dried vegetation
- severe wind storm end of September gave rise to large dust storms and grassland and forest fires



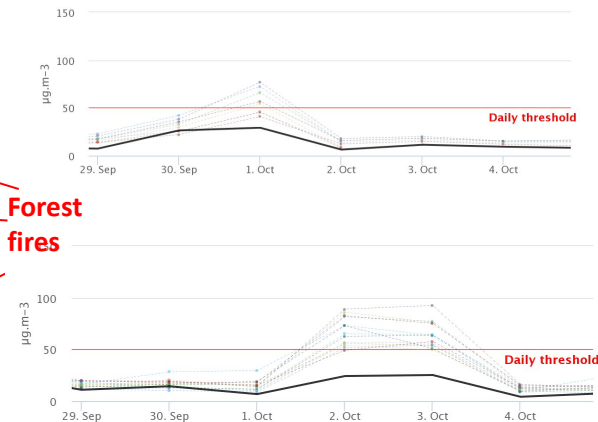
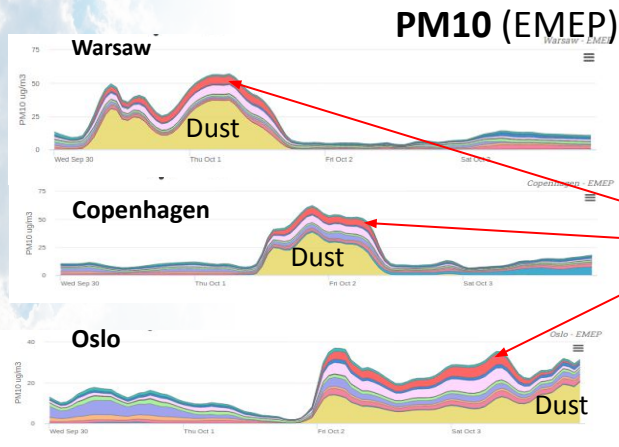
The combination of high pressure over Russia and the lows over E/SE and Western Europe created a kind of channel, where the air could stream from the south of Russia across eastern Europe towards Scandinavia



PM10 (CAMS Ensemble forecast)



Large amounts of smoke and soil dust were transported by strong winds over Poland, northern Germany, Denmark, Sweden, southern Finland and then onwards through most of Norway.



Hazy air in Western Norway.
Foto: Michael Schulz.



Saharan dust episode: 13-18 March 2022

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<https://regional.atmosphere.copernicus.eu/>

MARCH 14

MARCH 15

MARCH 16

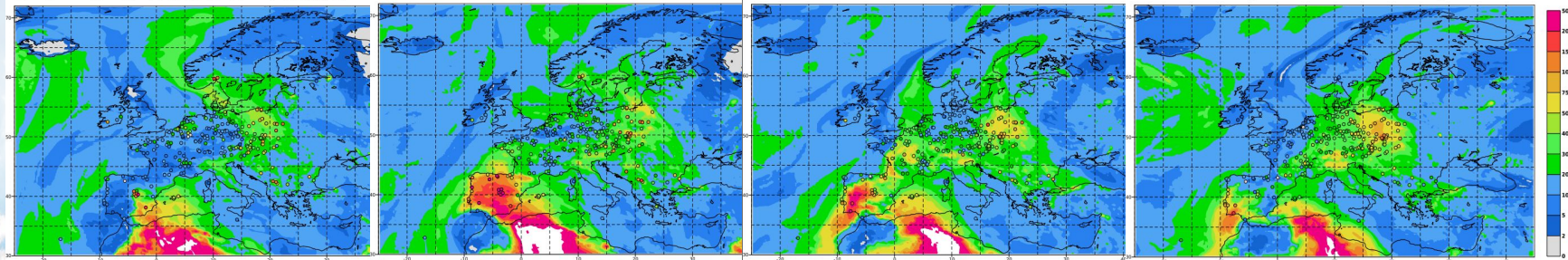
MARCH 17

Tuesday 15 March 2022 00UTC CAMS Verification t-006 VT: Monday 14 March 2022 18UTC
Model: ENSEMBLE Median Height level: Surface Parameter: PM10 Aerosol [$\mu\text{g}/\text{m}^3$]

Wednesday 16 March 2022 00UTC CAMS Verification t-006 VT: Tuesday 15 March 2022 18UTC
Model: ENSEMBLE Median Height level: Surface Parameter: PM10 Aerosol [$\mu\text{g}/\text{m}^3$]

Thursday 17 March 2022 00UTC CAMS Verification t-006 VT: Wednesday 16 March 2022 18UTC
Model: ENSEMBLE Median Height level: Surface Parameter: PM10 Aerosol [$\mu\text{g}/\text{m}^3$]

Friday 18 March 2022 00UTC CAMS Verification t-018 VT: Thursday 17 March 2022 06UTC
Model: ENSEMBLE Median Height level: Surface Parameter: PM10 Aerosol [$\mu\text{g}/\text{m}^3$]



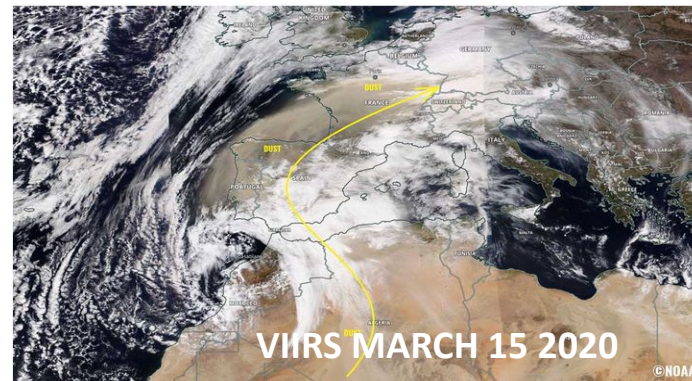
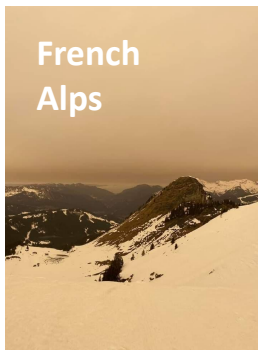
Sierra Nevada



Pyrenees



French Alps

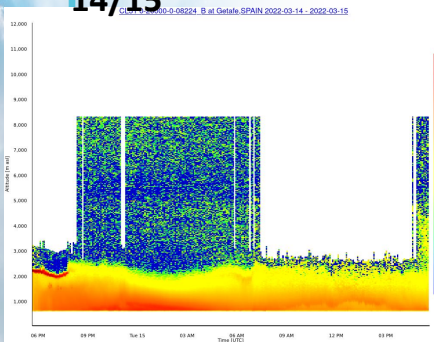




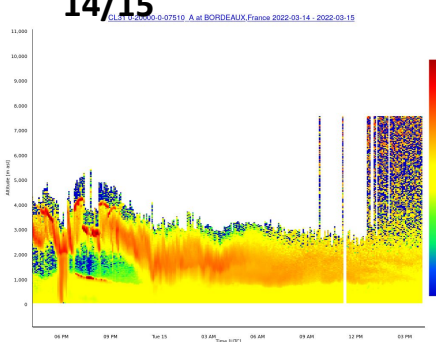
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Aerosol backscatter profiles from ceilometer network give indication of the height of dust layer

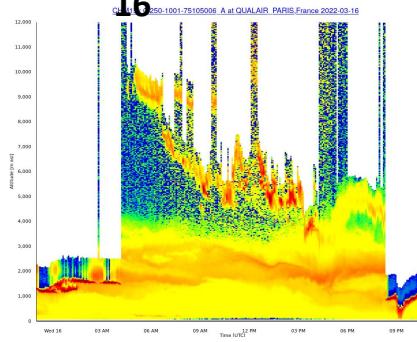
**Madrid MARCH
14/15**



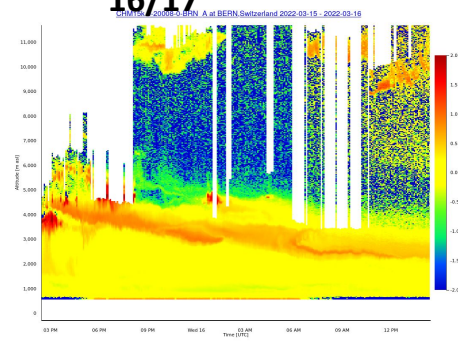
**Bordeaux MARCH
14/15**



**Paris MARCH
16**



**Bern MARCH
16/17**

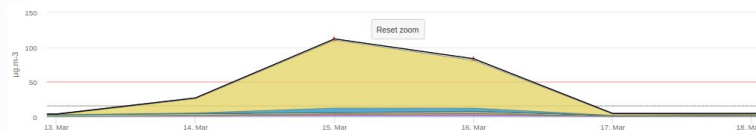
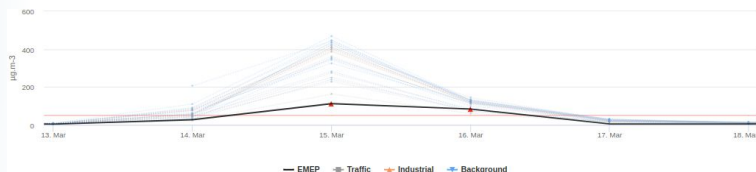


Source: EUMETNET (e-profile.eu)

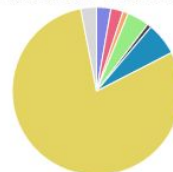


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Saharan dust episode: 13-18 March 2022



Sat Mar 12 2022 - Fri Mar 18 2022

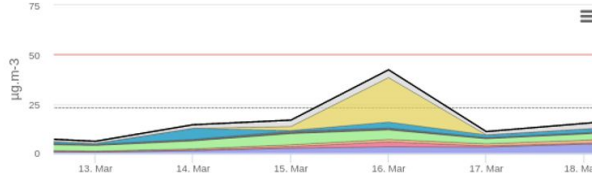
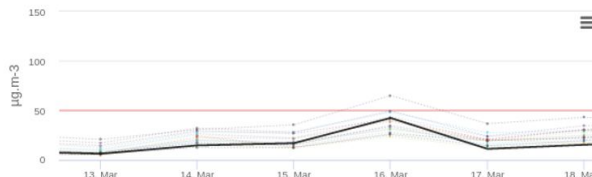


- NO3: 2.7%
- SO4: 2.3%
- NH4: 1.0%
- POM: 4.2%
- EC: 0.8%
- SEASALT: 6.3%
- DUST: 79.6%
- Rest: 3.0%

PM10 Madrid



- NO3: 12.6%
- SO4: 5.1%
- NH4: 4.6%
- POM: 22.9%
- EC: 4.2%
- SEASALT: 12.9%
- DUST: 24.8%
- Rest: 13.0%



PM10 Paris

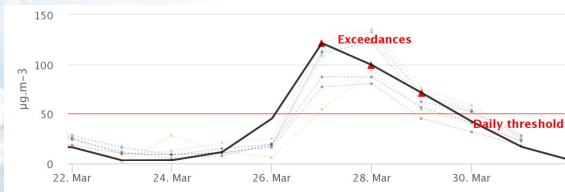


Dust episode 26-29 March 2020

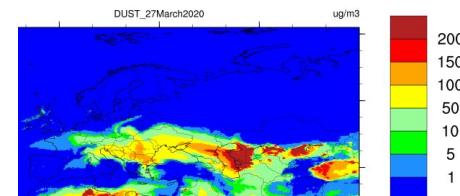
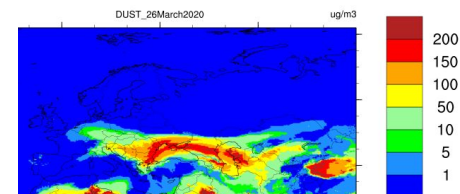
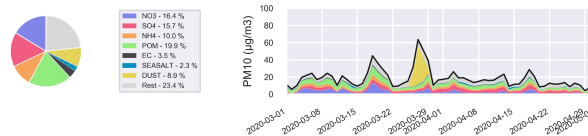
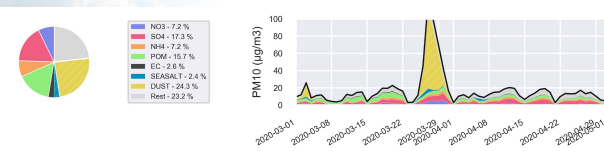
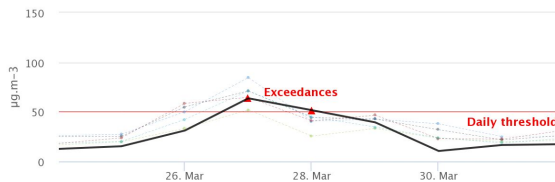
The severe pollution episode on 26-29 March in parts of SE and Central Europe was caused by dust originating in the Aralkum Desert.



PM10: Sofia



Budapest



Source: EMEP model, CAMS71 source-receptor forecast



Summary and concluding remarks

- ❑ The EMEP model contributes to CAMS forecasting of air quality and pollution source allocation
- ❑ Operational 4-day source-receptor forecasts are performed daily
- ❑ Hourly time series of source allocation (SA) are provided for PM_{10} , $PM_{2.5}$ and ozone (and chemical speciation for PM_{10} and $PM_{2.5}$) for 80 EU cities
- ❑ The results are used in the analysis of pollution episodes, documented in CAMS Episode reports - one of the CAMS policy support products: examples of ozone, PM (from anthropogenic and natural sources) episodes
- ❑ LOTOS-EUROS is the other model contributing to CAMS SA for cities.

The results from EMEP and L-E differ due to differences in model formulations and setup (resolution, city definition) and SA methodology - to be thoroughly investigated within CAMEO project



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Thanks to my colleagues at MSC-W and CAMS team

Thank you for your attention



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PM10 Surface concentrations two models