1. ENSEMBLE factsheet

1.1 Assimilation and forecast system: synthesis of the main characteristics

ENSEMBLE forecasts and analyses	
Horizontal resolution	0.1° regular lat-lon grid
Domain	25°W-45°E, 30°N-72°N
ENSEMBLE method	Median model: for each grid-cell, the value corresponds to the median of the different model values
Individual models	CHIMERE, EMEP, EURAD-IM, LOTOS-EUROS, MATCH, MOCAGE, SILAM Since Oct. 2019: DEHM, GEM-AQ

1.2 ENSEMBLE background information

Based on a sample of individual model members, the ensemble approach is useful and relevant for air quality monitoring (Galmarini et al, 2004). The ensemble products, indeed, generally yield better performance than the individual model products. Besides, the spread between the different members may be used to provide some information about the uncertainty of the ensemble products. Consequently, the forecasts, analyses and re-analyses delivered as part of the CAMS Regional production are based on an ensemble approach.

1.2.1 Method

The ENSEMBLE is currently based upon a median value approach (Marécal et al, 2015).

For each time step of the daily forecasts, the different individual model fields (see 1.2.2) are interpolated on a common regular 0.1°x0.1° grid over the European domain (25°W-45°E, 30°N-72°N) used for the CAMS Regional production. For each point of this grid, the ENSEMBLE model value is simply defined as the median value of all the individual models' forecasts on this point. The median is defined as the value having 50% of individual models with higher values and 50% with lower values.

This method provides an optimal estimate in the statistical sense (Riccio et al, 2007) and is rather insensitive to outliers in the forecasts, which is a useful property for the quality and for the reliability of the CAMS Regional production. The method is also little sensitive if a particular model forecast is occasionally missing.

1.2.2 Individual models

The ENSEMBLE production is based on the 9 individual models listed in Table 1.

Table 1. Individual models contributing to the ENSEMBLE

Model names	Institutes
CHIMERE	INERIS (France)
EMEP	MET Norway (Norway)
EURAD-IM	FZJ-IEK8 (Germany)
LOTOS-EUROS	KNMI, TNO (The Netherlands)
MATCH	SMHI (Sweden)
MOCAGE	Meteo-France (France)
SILAM	FMI (Finland)
DEHM	AARHUS UNIVERSITY (Denmark)
GEM-AQ	IEP-NRI (Poland)

DEHM and GEM-AQ take part in operational production since the U1.2 upgrade of 16/10/2019. In addition, 2 candidate models will be evaluated over the course of CAMS_50.II for a possible future integration in the ENSEMBLE: MINNI (ENEA, Italy) and MONARCH (BSC, Spain).

The main characteristics of the individual models are outlined in half-yearly development reports, as well as in the present document that is regularly updated and available from the CAMS website[1]. The latter also provides access to quarterly NRT production reports[2] comprising, per model, a description of the daily analysis and forecast activities undertaken by the models and a performance review.

1.2.3 Common input forcing

All the regional chemistry-transport models share common inputs regarding meteorology, boundary conditions and emissions. Some specificities in the implementation of individual model are highlighted in the following sections.

Using common anthropogenic emission is a very strong requirement in the CAMS_50 setup. As of U2, the reference emission dataset is CAMS-REG-AP_v3.1/2016 provided by CAMS_81. We also implemented two new PM tracers helping in the identification of anthropogenic activities leading to air quality episodes. Those tracers correspond to Elemental Carbon in the $PM_{2.5}$ fraction, depending on the emission source: fossil fuel (EC_ff) or wood burning (EC_wb).

[1] https://atmosphere.copernicus.eu/documentation-regional-systems
[2] https://atmosphere.copernicus.eu/validation-regional-systems

The emissions of EC_ff and EC_wb are estimated using information for each country and activity provided by CAMS_81: (i) the share of biomass in total $PM_{2.5}$ emissions, and the composition of $PM_{2.5}$ (in particular EC/OC share). These factors are then applied to the total $PM_{2.5}$ emissions by gridpoint for each model to derive EC_ff and EC_wb emissions.

A major issue lies however in the fact that wood burning emission reporting is far from being harmonised in the official EMEP inventories underlying the national totals in CAMS-REG-AP_v3.1. This is due to a different interpretation of EMEP States Parties on whether only the filterable fraction should be reported, or if the condensable part should also be accounted for. The issue has been documented in (Denier van der Gon et al., 2015) and it is also a focus on intense recent development under the CLRTAP convention (TFEIP/TFMM, 2018;EMEP, 2019). CAMS_50 will be following closely these developments to improve the reliability of EC_wb modelling.

Using common wildfire emission is also a strong requirement. At present we use hourly GFAS provided by ECMWF in pre-operational stream. Injection heights information is not available in these hourly emission (whereas it was provided in the daily operational stream). As of U2, we implemented a new aerosol tracer (PM_wilffire) corresponding to the species tpmfire in the GFAS emissions.

1.2.4 Air quality NRT EPSgrams

Daily, “EPSgrams” for 67 major European cities and urban areas are produced and displayed on the CAMS website for Regional Air Quality. Such graphics are common for presenting ensemble meteorological forecast products but, to our knowledge, this is the first experimental implementation worldwide in the field of Air Quality, which started within the GEMS project.

Figure 1 presents an example of AQ EPSgram. For the 4 main pollutants (ozone, NO_2, SO_2 and PM_{10}) forecasts are plotted every 3 hours as bars, which indicate the range of forecasts of individual ensemble members (minimum, maximum and percentiles 10, 25, 50, 75 and 90). This presentation allows users to assess the dispersion within the ensemble for each species and each 3-hourly forecast horizon at the given location of the EPSgram.

The 67 selected sites include the 41 European capitals and 26 urban areas that are among the most populated ones and where pollution episodes are common. The forecasts are based upon models that have resolutions of ~10km to 25km, which is too coarse to account for very local and urban effects (high primary pollutants, titration of ozone, etc.). The AQ EPSgrams presented have thus to be taken with caution; the forecast does not correspond to city centre values, but rather to values representative of the background in the urban area around the city.

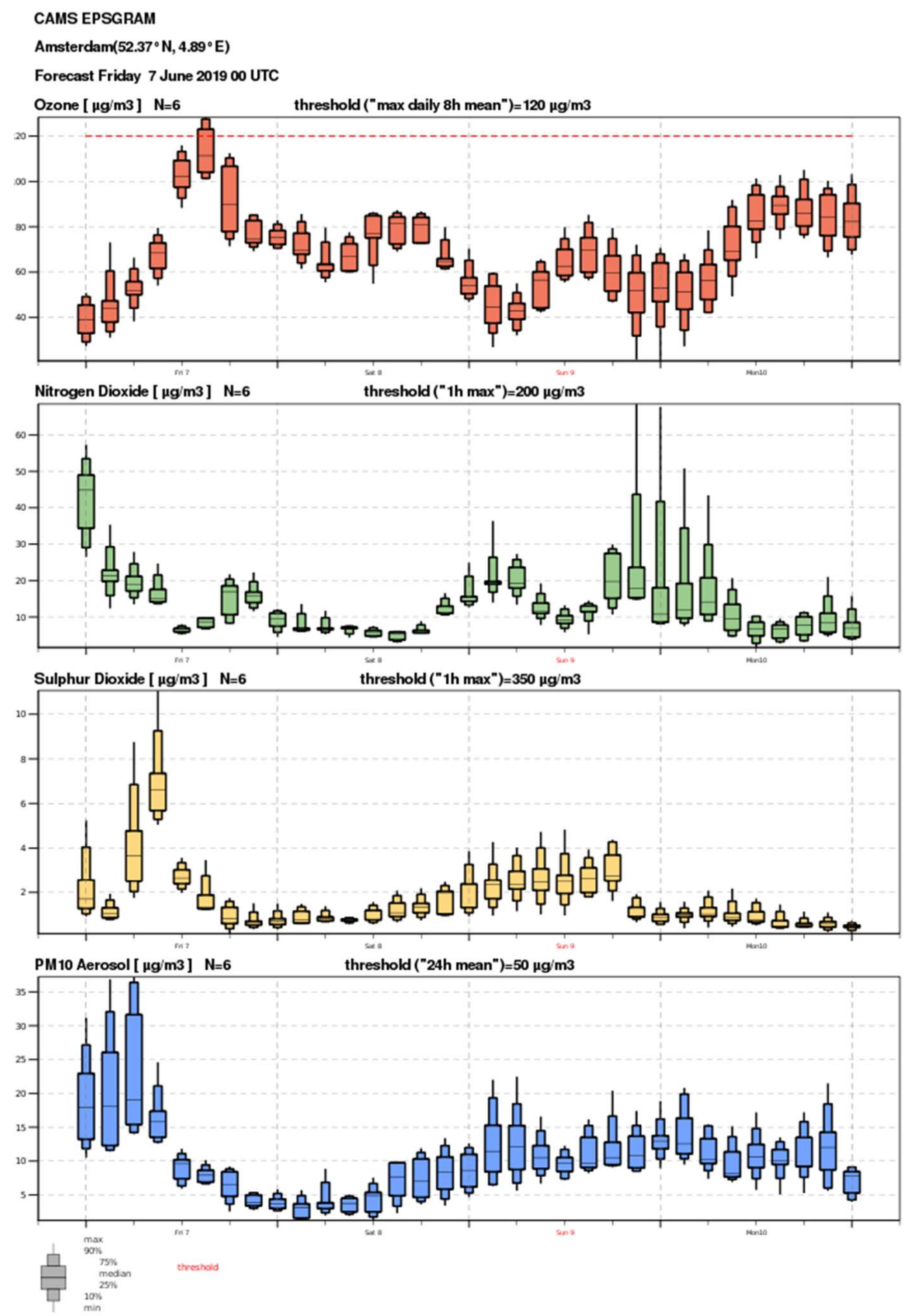

Figure 1 - Example of air quality EPSgram at the location of the city of Amsterdam (the Netherlands), concerning June 7th, 2019.