SPECIAL PROJECT PROGRESS REPORT

Reporting year 2019/2020

Project Title: Copernicus Atmospheric Monitoring Service – Air Quality and Composition – Regional Component (CAMS_50)

Computer Project Account: SP DEFRIU

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Name of ECMWF scientist(s) collaborating to the project (if applicable) Vincent Henry Peuch

Start date of the project: January 2018

Expected end date: December 2020

Computer resources allocated/used for the current year and the previous one (if applicable)
Please answer for all project resources

		Previous year		Current year	
		Allocated	Used	Allocated	Used
High Performance Computing Facility	(units)	5,650,000	5,600,000	5,800,000	5,650,000
Data storage capacity	(Gbytes)	9,000	8,700	10,000	7,500

Summary of project objectives

Copernicus Atmosphere Monitoring Service (CAMS, atmosphere.copernicus.eu) is establishing the core global and regional atmospheric environmental service delivered as a component of Europe's Copernicus program. The service provides continuous data and information on atmospheric composition. The service describes the current situation, forecasts the situation a few days ahead, and analyses consistently retrospective data records for recent years. CAMS has been developed to support policymakers, business and citizens with enhanced atmospheric environmental information. These services, which achieved an operational status in 2015, are the result of more than ten years of pilot and active research projects (PROMOTE, GEMS, MACC (I-III)). The Rhenish Institute for Environmental Research at the University of Cologne (RIUUK) plays an active role in sub-project CAMS_50, which is the regional air quality component of CAMS.

Summary of problems encountered

With the regular update of the CAMS_50 operational service in November 2018 the horizontal resolution of the EURAD_IM regional air quality forecast as well as air quality analysis has been increased from 15 km to 9 km. More computing time than expected at the time of application for this special project is needed for the daily model simulations with increased resolution.
Further computing time has been consumed by simulations of the impact of the COVID-19 shutdown on air quality in Europe from March to May 2020.

Summary of plans for the continuation of the project

Within the framework of CAMS_81 a new set of emission temporal profiles (monthly, weekly/daily, hourly) has been developed to be used with the CAMS-REG_AP emission inventory. The dataset consists of gridded and spatially invariant temporal weight factors separately for each sector and pollutant. The CAMS_81 temporal profiles will be tested in a sensitivity study.
Based on information provided by FMI an emission mechanism Alder pollen will be added to the EURAD-IM pollen module.

List of publications/reports from the project with complete references

C. Gama, I. Ribeiro, A.C. Lange, A. Vogel, A. Ascenso, V. Seixas, H. Elbern, C. Borrego, E. Friese, A. Monteiro, Performance assessment of CHIMERE and EURAD-IM' dust modules, Atmospheric Pollution Research, in press, 2019, https://doi.org/10.1016/j.apr.2019.03.005.

Summary of results

The delivery of the European-scale air quality data within CAMS_50 is based upon a geographically distributed ensemble of currently 9 individual models under the lead of Meteo France. RIUUK provides a member of this ensemble with its comprehensive chemistry transport model EURAD-IM (Elbern et al., 2007). Three data streams are provided:

- on a daily basis, hourly analyses for the previous day and forecasts up to + 96 h;
- with a delay of a few weeks (in order to maximise the number of observations) interim re-analyses are produced daily;
- with a delay of up to 2 years (due to the delay in getting fully validated data), re-analyses are processed.

An additional important component of CAMS 50 is the further development of the individual air quality forecast models and data assimilation systems. Subject of this progress report are activities in the frame of CAMS_50 during the reporting period from July 2019 to June 2020.

1. Anthropogenic CAMS-REG-AP_v3 (2016) emissions

Yearly emission data from the CAMS-REG-AP_v3 inventory have been disaggregated using the GIS based EURAD-IM emission data pre-processor. The data has been aggregated on the EURAD-IM model domains used for CAMS_50 with 45km and 9km horizontal resolution. For the regular CAMS_50 service upgrade in November 2019 profiles from the CAMS-REG-AP_v3 inventory have been used for the PM/VOC splits, the temporal variation, and the injection height of area sources. A sensitivity study performed in the previous reporting period has shown that EURAD-IM surface concentrations especially for SO_2 and PM_{10} are overestimated, if the CAMS-REG-AP injection height profile is used for point sources. Therefore modified injection heights for point sources from the GNFR sectors A (public power stations) and B (industry) from the EURAD-IM emission model (EEM) have been introduced. More weight is assigned to higher altitudes for point source emissions (see Table 1). With the modified injection height the locally strong over estimation of PM and the general over estimation of SO_2 is prevented.

Table 1. Emission injection height for area sources and point sources

	GNFR	20m	92m	184m	324m	522m	781m	1106m
Area sources	Public power	0	0	0.25	51	45.3	3.25	0.2
	Industry	6	16	75	3	0	0	0
Point sources	Public power	0	0	0	8	46	29	17
	Industry	0	4	19	41	30	6	0

2. New aerosol species: wildfires, ECff, ECwb

2.1 Wildfire tracers

Three new aerosol species have been introduced in the EURAD-IM for the treatment of aerosols from wildfires:

PMWFi: Aitken mode aerosol from wildfires
PMWFj: Accumulation mode aerosol from wildfires
PMWFc: Coarse aerosol from wildfires

GFAS emission data is assigned to these species as follows:

$$PMWFi = 0.15 * GFAS_{2.5}$$
$$PMWFj = 0.85 * GFAS_{2.5}$$
$$PMWFc = GFAS_{tpm} - GFAS_{2.5},$$

where $GFAS_{2.5}$ is the wildfire flux of $PM_{2.5}$ (GRIB code 87.210) and $GFAS_{tpm}$ is the wildfire flux of total particulate matter (GRIB code 88.210) derived from GFAS data. The newly introduced species are considered to be chemically inert but there concentration is altered by aerosol dynamic processes treated in MADE. A tracer for aerosol with diameter lower than 10 μm from wildfires ($PMWF_{10}$) is calculated via integration over particle diameter under the assumption, that aerosols from wild fires have the same log-normal size distribution as the internally mixed aerosol species in MADE.
The development has been tested in a hindcast air quality simulation for December 2017 to February 2018. Daily GFAS data from experiment g9zk including injection height has been used for this study. $PMWF_{10}$ data has been delivered to Meteo France for validation purposes.

The former approach for the treatment of GFAS data was the following: The wildfire flux of black carbon (GRIB code 91.210) was assigned to the EURAD-IM aerosol species *anthropogenic elemental carbon (EC)*, and the wildfire flux of organic carbon (GRIB code 90.210) was assigned to the aerosol species *anthropogenic primary organic carbon (OC)*:

$$ECi = ECi + 0.15 * GFAS_{BC}$$
$$ECj = ECj + 0.85 * GFAS_{BC}$$
$$OCi = OCi + 0.15 * GFAS_{OC}$$
$$OCj = OCj + 0.85 * GFAS_{OC}$$

Aerosol species in EURAD-IM are internally mixed. Since the assignment of wildfire emissions to aerosol species has been changed, an impact on the overall PM performance is expected. Because the wildfire flux of total particulate matter was not considered in the former approach, a slight increase of the total PM concentration is expected.

2.2 ECff, ECwb

The EURAD-IM aerosol species *anthropogenic elemental carbon (EC)* has been replaced by the species *elemental carbon from fossil fuel (ECFF)* and *elemental carbon from wood burning (ECWB)*. EC emissions from GNFR sector C (other stationary combustion) are split in ECff and ECwb according to a country dependent factor provided with the CAMS-REG-AP_v3 inventory. EC emissions from other GNFR sectors are assigned to ECff. Elemental carbon emissions are distributed between the two log-normal fine aerosol modes treated in MADE as follows:

$$ECFFi = 0.05 * ECff$$
$$ECFFj = 0.95 * ECff$$
$$ECWBi = 0.05 * ECwb$$
$$ECWBj = 0.95 * ECwb.$$

The newly introduced species are considered to be chemically inert but there concentration is altered by aerosol dynamic processes treated in MADE. Elemental carbon concentrations in the $PM_{2.5}$ fraction are calculated via integration over particle diameter under the assumption, that elemental carbon has the same log-normal size distribution as the internally mixed aerosol in MADE.
The development has been tested in a hindcast air quality simulation for December 2017 to February 2018. ECff data and ECwb data have been delivered to Meteo France for validation purposes.

2.3 Data assimilation

The introduced aerosol species particulate matter from wildfires, elemental carbon from fossil fuel, and elemental carbon from wood burning are part of the internally mixed log-normal aerosol size distribution used in EURAD-IM. Consistency with assimilated PM_{10} is ensured due to the adjoint PM_{10} observation operator applied with the EURAD-IM 3d-var assimilation method.

3. Validated assessment of air quality in Europe

Within CAMS_50 the state and the evolution of background concentrations of air pollutants in Europe are described in yearly produced air quality assessment reports for Europe. Validated observation and modelling data are combined in re-analysed maps and numerical fields, to propose the best available representation of air pollutant concentration fields for a spatial resolution of 0.1 deg. During the accounting period the 2017 air quality re-analysis has been completed. The observation data assimilated in the 2017 re-analysis consists of surface in situ data for the pollutants O_3, NO_2, SO_2, CO, PM_{10}, and $PM_{2.5}$, the troposhperic NO_2 column content retrieved from the OMI and GOME-2 instruments, CO profile data retrieved from the MOPITT and IASI, and aircraft in situ data from IAGOS. Intermittent 3d-var data assimilation has been applied. 30% of surface in situ background stations were held back from assimilation to allow for an independent validation of the assimilation results.

4. Voluntary contribution to the Eurodelta-Carb model intercomparison

The Eurodelta-Carb reference run (EXP A) based on CAMS-REG-AP_v2.2.1 emissions and a sensitivity run (EXP B) based on CAMS-REG-AP_v2.2.1 emissions including the condensable fraction in PM emissions have been performed with the EURAD-IM version developed for the treatment of elemental carbon from fossil fuel and from wood burning as described in Section 2. Results in CAMS GRIB format have been delivered to INERIS.