Project: **1260**

Project title: **Megacity Aerosol Composition by Satellite: A tool to study anthropogenic Emissions, Climate change and human Health**

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Report period: **2021-11-01 to 2022-10-31**

The resources allocated for have been employed to analyze the two EMeRGe aircraft campaigns which took place in Europe during the period 11 – 28 July 2017 based in Munich (Germany), and in East Asia during the period 8 March – 9 April 2018 based in Taipei (Taiwan). From the large set of instruments, we selected for this study the following variables of meteorology, trace gases and aerosol concentrations (*Details are given in Andrés Hernández et al., 2022; 10.5194/acp-2021-500; cf. Table 2)*:

- **Meteorological variables** (from the standard HALO core instrumentation):
  - Temperature, wind, relative humidity, water mass mixing ratio
- **Trace gases:**
  - **CO** and **O3** (AMTEX instrument using UV-photo/fluorimetry),
  - **NO2** and **HCHO** (mini-DOAS instrument using Differential Optical Absorption Spectrometry),
  - NO and NOy (AENEAS instrument using chemiluminescence),
  - **SO2** (CI-ITMS: Chemical Ionisation Ion Trap Mass Spectrometry),
  - RO2* (PeRCA: Peroxy Radical Chemical Amplification),
  - VOC (GC-C-IRMS: Gas Chromatography Combustion Isotope Ratio Mass Spectrometry)
- **Aerosol concentrations:**
  - **BC** (SP2: Single Particle Soot Photometry),
  - **OC**, sulfate, nitrate and ammonium (CTOF-AMS: Time of Flight- Aerosol Mass Spectrometry)

The payload of the aircraft being the same for the two campaigns, this makes it possible to carry out the same analyzes for the two regions, and to interpret the similarities and the differences.

In order to analyze the measurements of the aircraft, a model ensemble is used which aims to represent the state-of-the-art of atmospheric modeling (Table 1). Indeed, WRFchem is used with two meteorological input datasets: (i) the final operational global analysis (dataset ds083.3; 10.5065/D65Q4T4Z) provided by NCEP, and (ii) the ERA5 reanalysis (dataset: 10.24381/cds.bd0915c6) provided by ECMWF.

Table 1: Main configuration setting (Domain, Emissions, Gas and aerosol and meteorology) of the model ensemble composed of two global models (CAMchem and CAMS) and the versions of the WRFchem regional model run at DKRZ with two meteorologies.

	WRFchem ERAv1	**WRFchem GFSv1**	**WRFchem ERAv2**	**WRFchem GFSv2**	CAMchem NCAR	CAMS ECMWF
Domain	----------	----------	----------	----------	----------	----------
Horizontal resolution	10 km	10 km	10 km	10 km	~100 km (0.9 x 1.25°)	~ 40 km (0.4 x 0.4°)
Vertical levels	40 (up to 50 hPa)	40 (up to 50 hPa)	40 (up to 50 hPa)	40 (up to 50 hPa)	56	137
Output frequency	1h	1h	1h	1h	6h	3h
Emissions	----------	----------	----------	----------	----------	----------
Anthropogenic emissions	CAMS	CAMS	CAMS	CAMS	CMIP6-SSP5-85	CAMS
Biogenic	MEGAN	MEGAN	MEGAN	MEGAN	MEGAN	CAMS
Mineral dust / Sea salt	GOCART (on-line)	GOCART (on-line)	GOCART (on-line)	GOCART (on-line)	GOCART (on-line)	on-line
Fires	FINN	FINN	FINN v2	FINN v2	GFED-FINN	GFAS
Gas and aerosol	----------	----------	----------	----------	----------	----------
Chemical	MOZART-T1	MOZART-T1	MOZART-T1	MOZART-T1	MOZART-T1	CAMS

mechanism						
Aerosol scheme	GOCART	GOCART	GOCART	GOCART	MAM	CAMS
Boundary conditions	CAMchem	CAMchem	CAMchem	CAMchem	Global Model	Global Model
Meteorology	----------	----------	----------	----------	----------	----------
Boundary conditions	**ERA5 reanalysis**	**GFS**	**ERA5 reanalysis**	**GFS**	**MERRA2 reanalysis**	**IFS-ECMWF**
Data assimilation	none	none	none	none	none	yes

Comparison of aircraft measurements and modelling outputs

In order to compare the measurements of the HALO aircraft with each model ensemble, the measurements are averaged over a time step of 1 min. Since the aircraft is traveling at a horizontal speed of approximately 600 km/h (10 km/min) and the horizontal resolution of the regional model grid is 10 km, this time step allows each crossed grid-mesh to be used. To reproduce a modeled variability of the concentration, the outputs of the models are interpolated in time and in space according to the trajectory of the aircraft. In other words, the modeled concentrations are interpolated along the flight positions with a triple interpolation (bilinear horizontally, linear vertically and linear between two time steps).
For the two regions studied, 8 MPCs are considered for their locations with respect to the different flight trajectories and their anthropogenic emission magnitude (Figure 1).

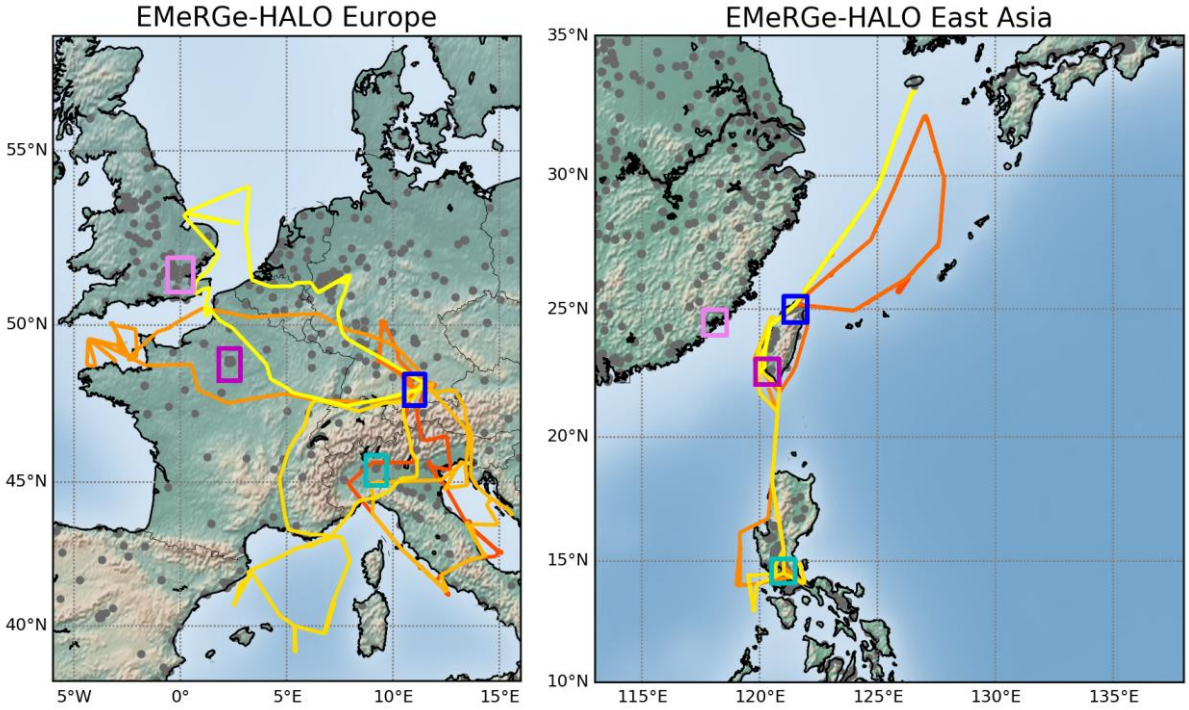

Figure 1: Map of the studied domains with the trajectories of the HALO research aircraft during the EMeRGe aircraft campaigns in Europe and East Asia. The gray dots represent cities with more than 100,000 inhabitants. The colored squares are the MPC studied, for Europe: Munich (Germany) in dark blue, Milan (Italy) in light blue, London (UK) in pink, Paris (France) in purple; for East Asia: Taipei (Taiwan) in dark blue, Kaohsiung (Taiwan) in purple, Manila (Indonesia) in light blue, Xiamen (China) in pink.

The results of the statistical investigation have been recently presented at the International Global Atmospheric Chemistry (IGAC) Project (https://www.icacgp-igac-2022.org/scientific-program/) with the title ***Linking the composition of carbonaceous aerosols and trace gases: Insight from the EMeRGe aircraft campaigns in Europe and East-Asia***, and an article is in preparation.