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CORSO
CO2MVS Research on Supplementary Observations

WP1: IMPROVED ESTIMATES OF EMISSION FACTORS/RATIOS AND THEIR UNCERTAINTIES

Kick-off Meeting

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23/01/2023

* WP1 includes colleagues from BSC, UT3, CEA, iLab, TNO, ULUND, UEDIN, EMPA

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WP1 partners: A strong pool of experts in bottom-up inventories, emission modelling and atmospheric inverse modelling

Barcelona Supercomputing Center (BSC)




Netherlands Organisation for Applied Scientific Research (TNO)

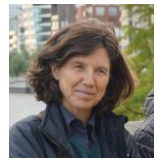



Commissariat à l'Énergie Atomique et aux Énergies Alternatives (CEA)

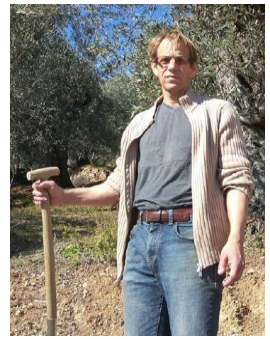

The University of Edinburgh (UEDIN)

Universite Paul Sabatier Toulouse III (UT3)



The Inversion Lab (iLab)

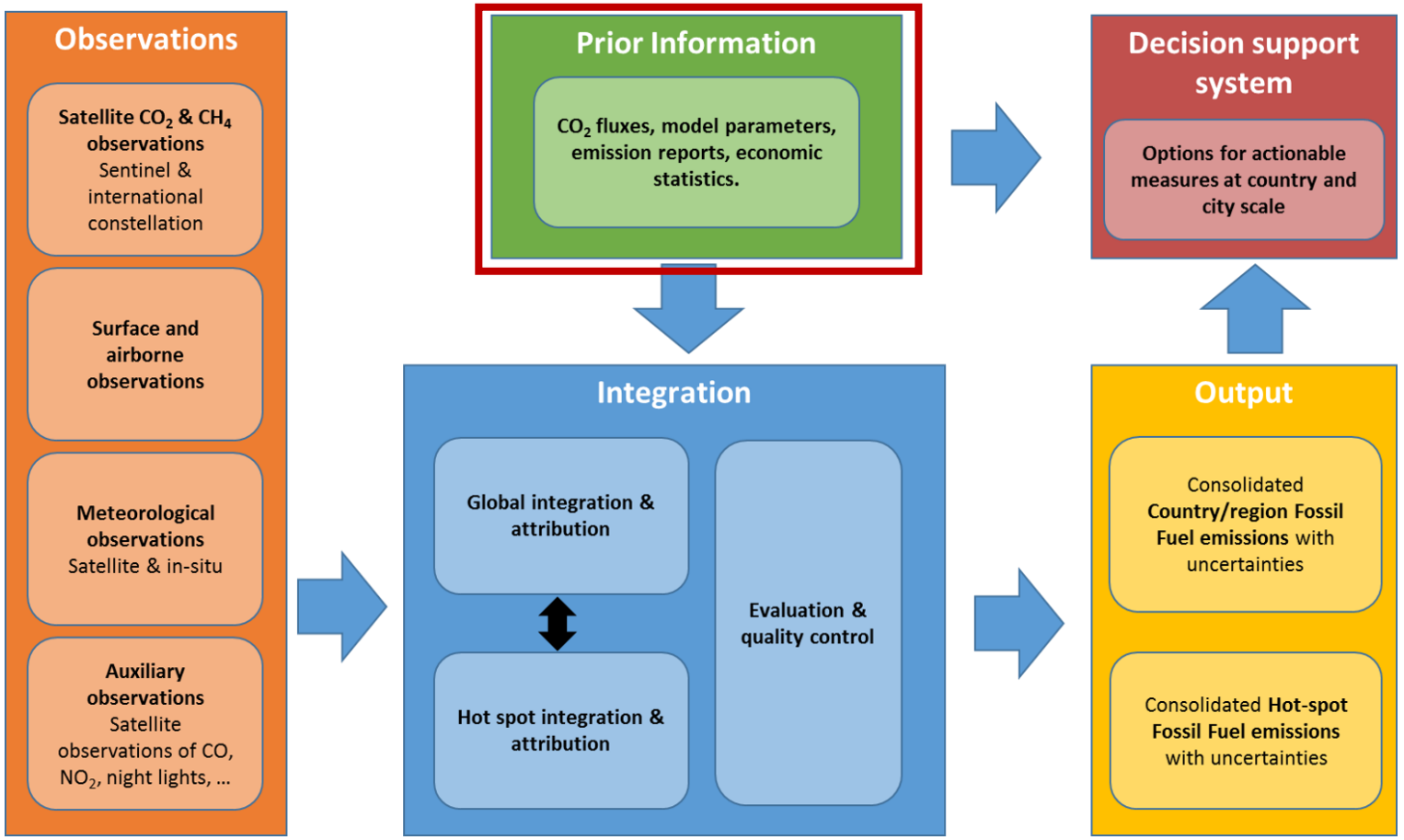



Lunds Universitet (ULUND)

Federal Laboratories for Materials Science and Technology (EMPA)



WP1 motivation, main objective and outcomes



High-level data flow of the CO2MVS

In CoCO2, the prior information block was mostly focussed on developing multiple prior emission inventory datasets, including 2018/2021 global/regional:

- Biogenic fluxes
- Ocean fluxes
- Anthropogenic fluxes

+ global lateral carbon fluxes (biofuel pro/cons)
+ global LULUCF fluxes
+ global anthropogenic mosaic based on state-of-the-art regional inventories for 2015
+ global point source database for 2018

WP1 motivation, main objective and outcomes

CO_2 Human Emissions

"Definition of the correlations between emissions of co-emitted species (CO2, NO2, CO) in support of CO2 fossil fuel emission estimation is complex and needs further improvement. "

Main objective: Improve our estimates of emission factors, ratios, and their uncertainties, including the spatial and temporal characterisation of hotspots

Start from existing information:

- CAMS/CoCO2 prior emission datasets
- Fossil fuel emission model & uncertainties
- …

Expanded and further refined!

Outcome: Uncertainty ranges for sectoral emissions to be used as prior uncertainties and error correlations in the global IFS-based CO2MVS prototype (WP2)

+ Better harmonization between emission estimates for CO2MVS and for air quality in CAMS + improve the estimates for individual species

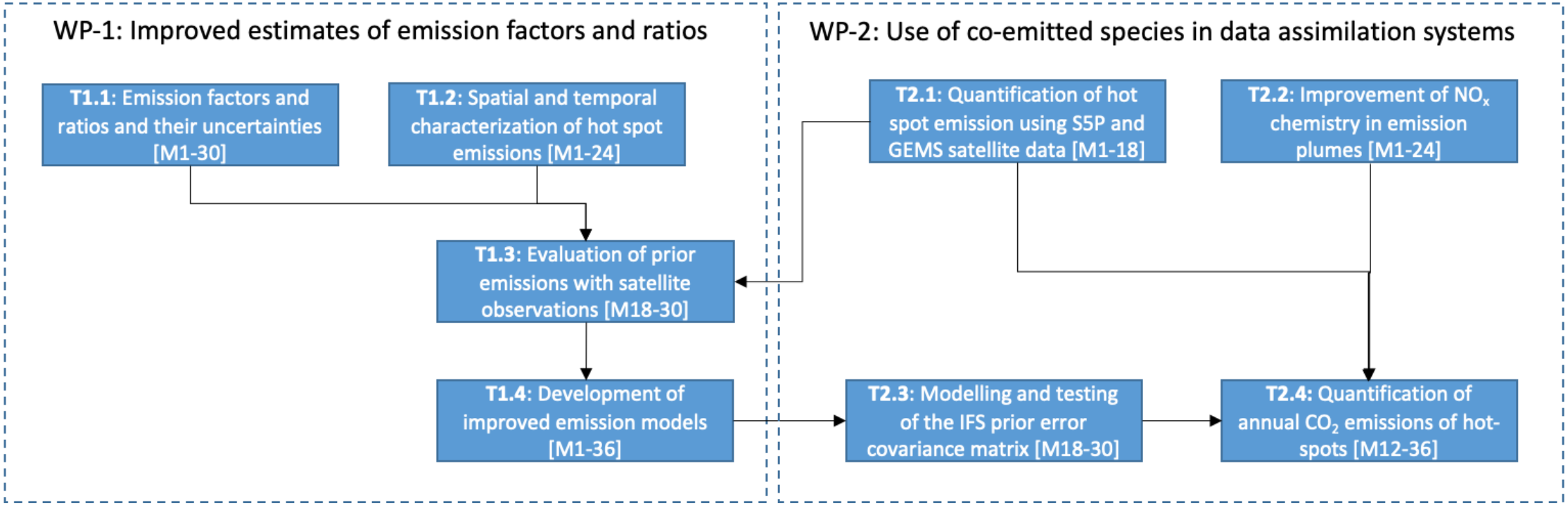
Atmosphere Monitoring

CoCO2 Prototype system for a Copernicus CO_2 service

CO_2 Human Emissions

WP1 tasks & interactions

- *Task 1.1 Uncertainties in emission factors and emission ratios CO2:NOx:CO* – M1-M30 **(UT3)**
- *Task 1.2 Improvement of the spatio-temporal characterisation of industrial and urban plumes and associated emission ratio uncertainties* – M1-M24 (**BSC**, CEA, TNO, UT3)
- *Task 1.3 Evaluation and validation of prior information with satellite-based emissions* – M18-M30 (**BSC**, **EMPA**, TNO, UT3)
- *Task 1.4 Emission models and uncertainties* – M1-M36 (**iLab**, ULUND, TNO, UEDIN, BSC)



Task 1.1: Uncertainties in emission factors/ratios CO2:NOx:CO

Objective: Construction of Emission Factor (EF) global maps and their uncertainties to be used as input to the global IFS-based CO2MVS for the construction of the prior emission error covariance (B matrix) in WP2

- T1.1.a: Compilation of CO2, CO and NOx emission factors and emission ratios (in 2023)
- T1.1.b: global maps of CO2, CO and NOx EFs and their uncertainties for the year 2021 (in 2024)

In 2023

→ Gather datasets on Emission Factors from databases, literature + involve the international community on emissions (GEIA) during the June 2023 GEIA conference

→ Calculate emission ratios for species/sectors for the past 20 years, from a large number of global and regional emission datasets (all available in the ECCAD emission database)

This work will require some harmonization of sectors. Such a harmonization has been done for the CAMS global and regional inventories, but not for the other datasets

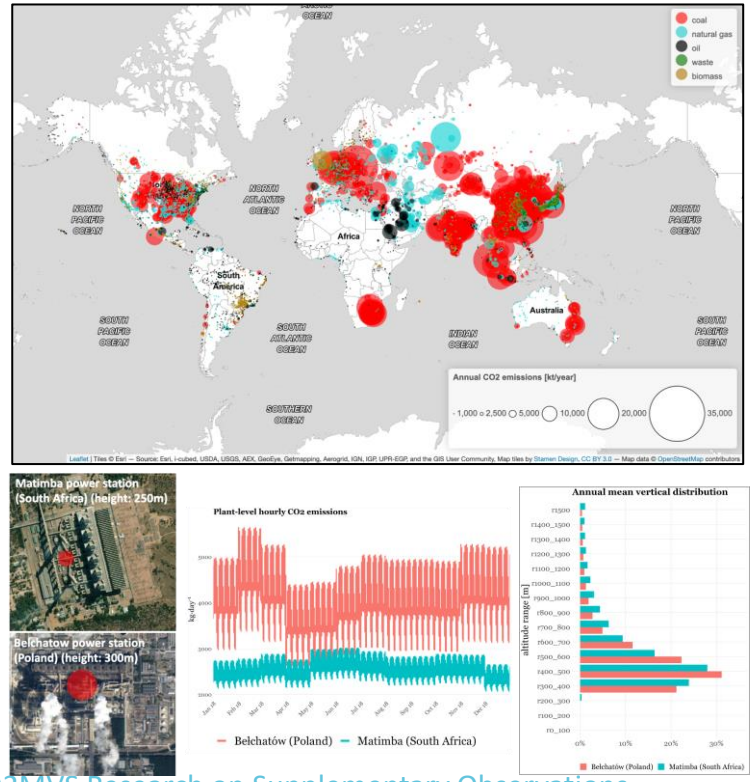
→ Quantify the evolution of emission factors using the collected data

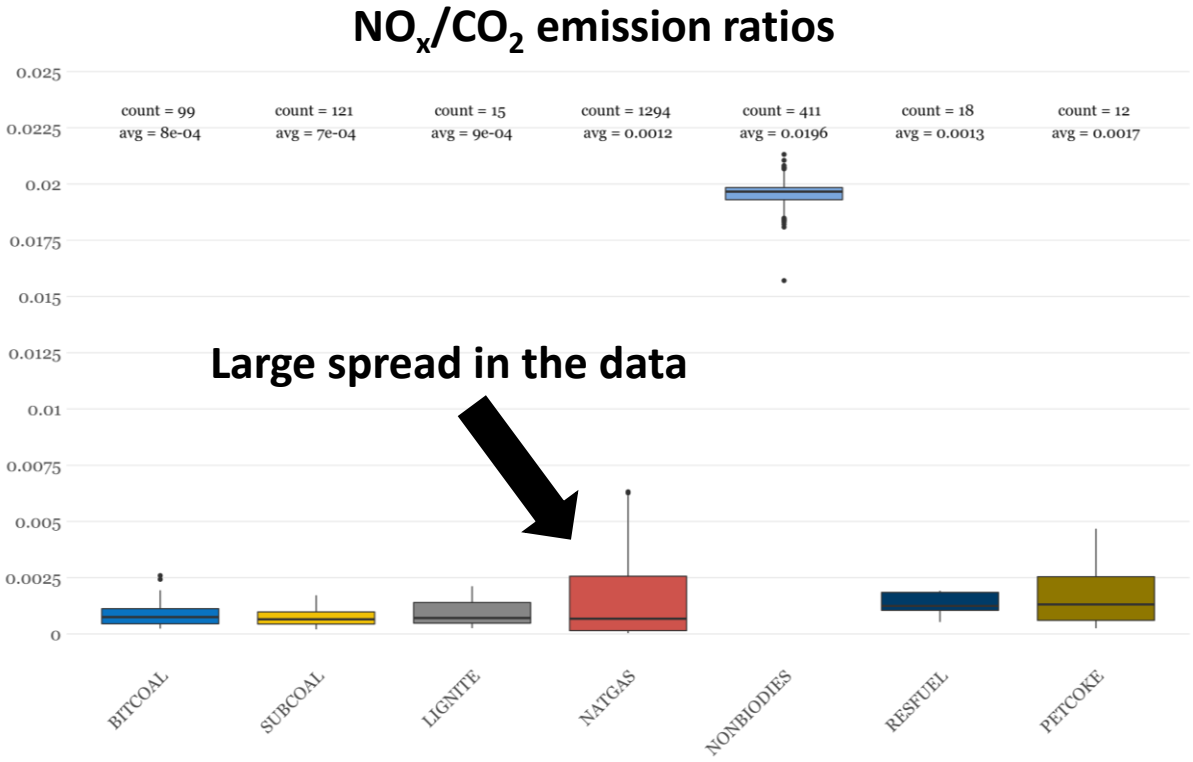
→ Start to build a publicly available database of EFs and emission ratios, which will include metadata

All these results will be used for the determination of uncertainties in 2024.

Task 1.2: Improving spatio-temporal characterization of industrial/urban plumes and associated emission ratio uncertainties

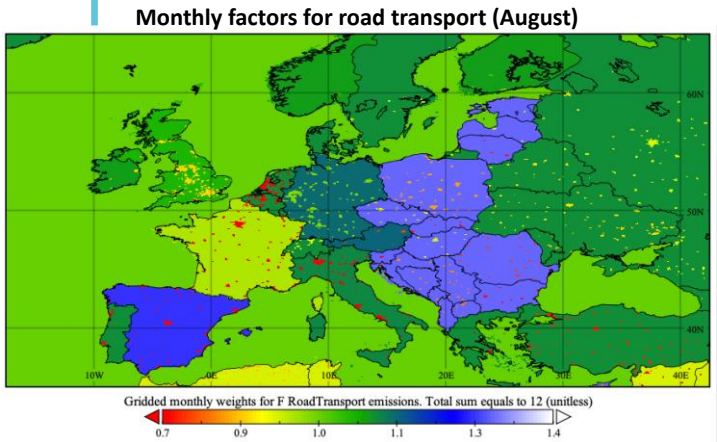
- <u>T1.2.a: Further develop the CoCO2 global point source dataset for CO2 and co-emitted species:</u>
  - Update database for 2018 to 2021 (e.g., power plants shut down in EU / new opened in China)
  - Inclusion of additional large CO2 industrial sources (cement and iron/steel plants)
  - Include information on NMVOC in support of activities in T2.2.
  - Estimation of uncertainties in the emission ratios (CO2:NOx:CO:SO2:CH4) and temporal profiles

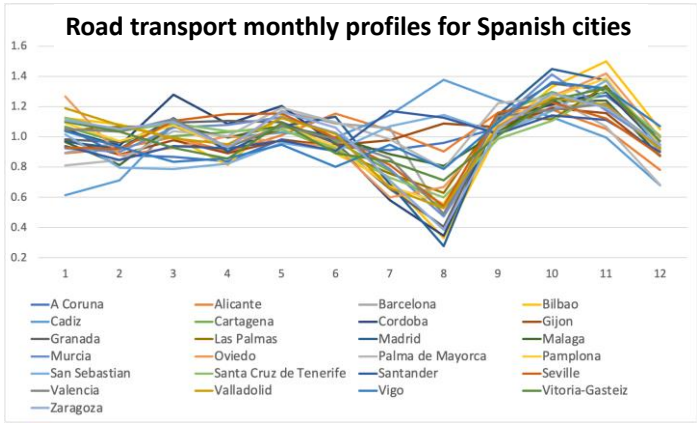


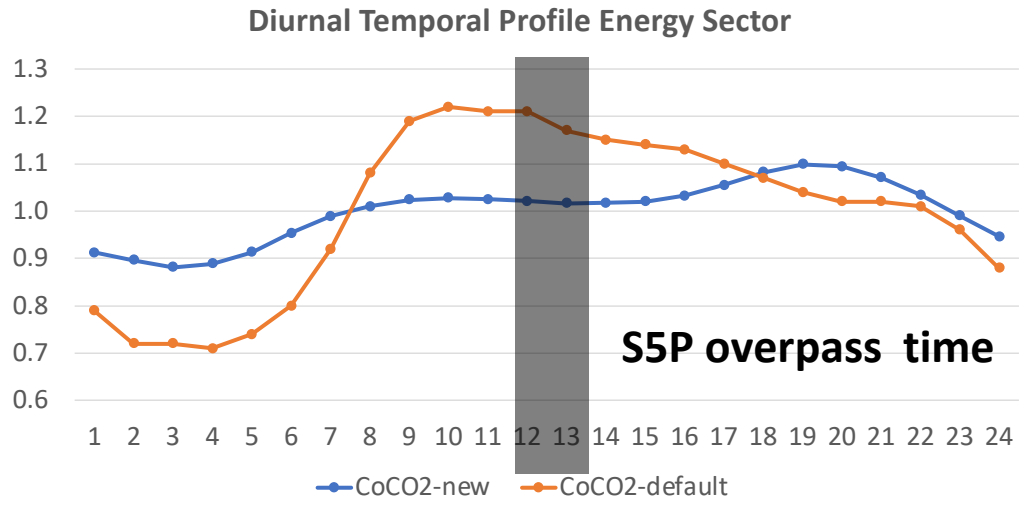


Task 1.2: Improving spatio-temporal characterization of industrial/urban plumes and associated emission ratio uncertainties

- T1.2.b: Emission temporal profiles with associated uncertainties
  - Construct temporal profiles (i.e., road transport, residential combustion, energy industry) using CAMS-TEMPO approach and comparison with Carbon Monitor
  - Quantify associated uncertainties by providing an ensemble of temporal profiles
  - Compute and analyse fluctuation of emissions ratios in hotspots (gridded emissions + profiles)
  - Resulting information will feed into:
    - T1.3 for comparison against satellite-based emissions
    - T2.1 to extrapolate emissions derived from satellite overpasses to annual mean estimates



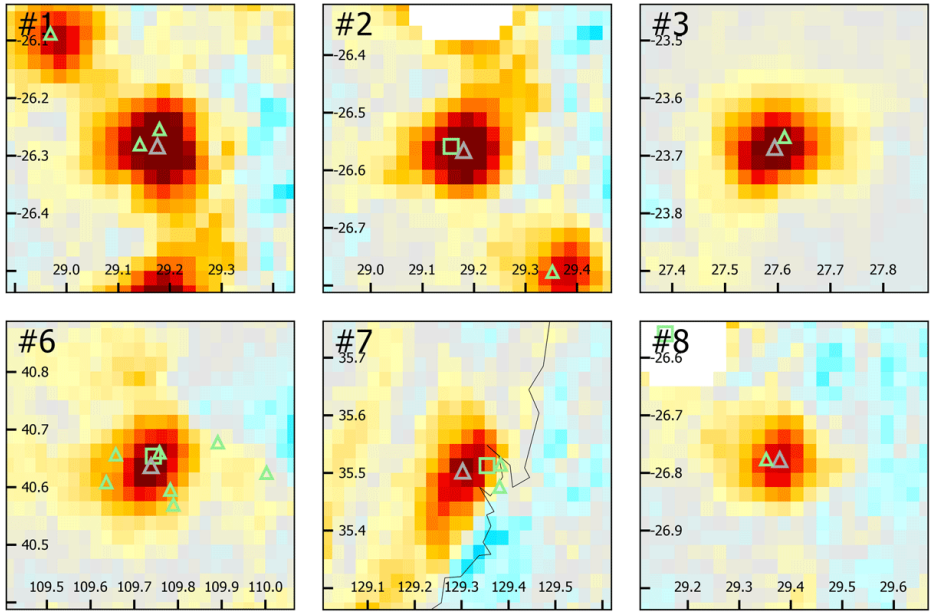




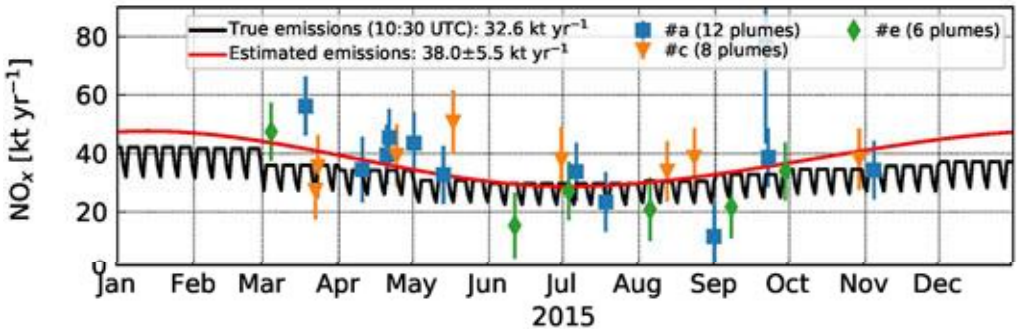
Task 1.3: Evaluation/validation of prior information with satellite-based emissions

- **Objective**: Validation of hot spot locations and temporal variability of emission ratios with satellite measurements from T2.1.
- Focus on Africa, Europe and SE Asia
  - <u>T1.3.a: Evaluate the spatial distribution of prior emissions</u>
    - Compare prior data with hot spots generated from S5P and GEMS NO2 observations (T2.1.a)
    - Analyse the spatial consistency between S5P and GEMS products
  - <u>T1.3.b: Evaluate the temporal distribution of CO and NOx emissions in urban/industrial hotspots</u>
    - Comparison between the bottom-up emission temporal distributions developed in T1.2 against satellite-based time series developed in T2.1.b
- **Outcome**: Provide evaluated/validated prior information as input for improved emissions model (T1.4)

NO_x point sources from TROPOMI (Beirle et al., ESSD, 2021)



Example of NO_x time series from CO2M (Kuhlmann et al. 2021)



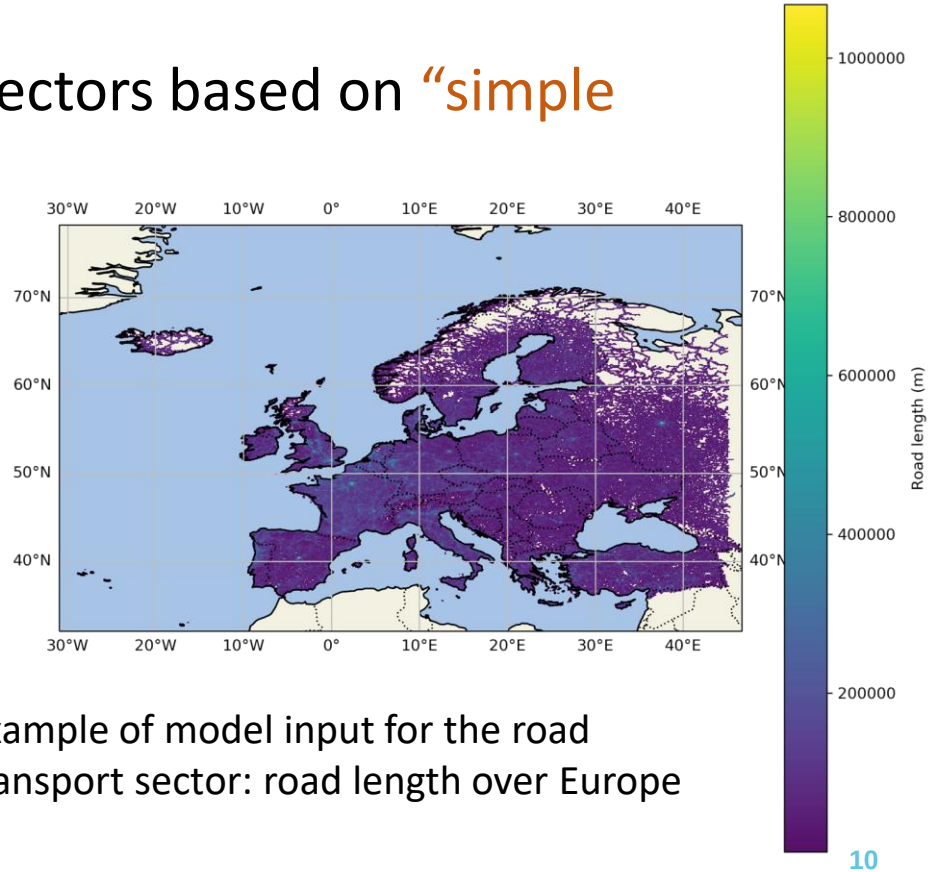
Task 1.4: Emission models and uncertainties

Objective: develop further the fossil fuel emission model from CoCO2 and apply it to derive uncertainty ranges for sectoral emissions that can be used as prior uncertainties in atmospheric transport inversions (link with WP2)

Starting point: Fossil fuel emission model with 4 sectors based on "simple equations"; sectors are:

- Energy Generation
- Residential Combustion
- Road Transport
- "Other sector" (Complement)

  Most uncertain sector of the model (e.g., spatial distribution using generic proxies such as nightlight intensity and population density



Example of model input for the road transport sector: road length over Europe

Task 1.4: Emission models and uncertainties

- Activities:
  - Refinement of existing sectoral representations, in terms of model formulation and accuracy of input data (link to T1.1)
  - Inclusion of additional sectors, to reduce the contribution of the (most uncertain) “other sector” and thus the overall uncertainty in the system
  - Test emission model in the Carbon Cycle Fossil Fuel Data Assimilation System (CCFFDAS) and explore developments in T 1.1 and T1.2 (e.g., effect of improved temporal profiles)
  - Provision of prior flux information for transport inversion (IFS) (link with WP2)
- Focus on CO2. Users can simulate emissions (e) of other tracers based on emission factor (f) ratios (provided by T1.1), e.g. for CO:

$$e_{CO} = e_{CO2} * f_{CO} / f_{CO2}$$

WP1 Deliverables and Milestones

No	Deliverable Name	Lead	Deadline
D1.1	Global maps of CO2, CO and NOx emission factors and their uncertainties per sector for the year	UT3	M24
D1.2	Improved global point source emission dataset	BSC	M24
D1.3	Validation of the spatio-temporal characterisation of prior emissions and recommendations for improvement	BSC	M30
D1.4	First version of uncertainty ranges in flux space derived by an ensemble of emission model runs	iLab	M24
D1.5	Results of CCFFDAS assessments with recommendations on the formulation/parameterisation of the MVS fossil emission model and on the observational constraints to be used for assimilation	iLab	M36

WP1 Deliverables and Milestones

No	Milestone	Means of verification	Deadline	Lead
M1	WP1-WP2 meeting to jointly discuss the comparison results, need for adjustments in products or timing, and feedbacks	Minutes of meeting	M6, M12, M18, M24, M30	BSC/EMPA
M2	Collection of pollutant-dependent emission temporal profiles and associated uncertainties	Data available to consortium partners	M12	BSC
M3	First version of the global maps of emission factors and their uncertainties available for consortium use	Data available to consortium partners	M18	UT3
M4	Fluctuations of emission ratios in urban plumes	Data available to consortium partners	M18	BSC
M5	Successful simulation experiment with draft emission model	Model output or log file available to consortium partners	M18	iLab
M6	Public database to access all compiled emission factors	Data available on portal	M30	UT3

WP1 breakout session

- Tour de table (presentation of teams + role in CORSO WP1)
- Overview of WP1 (tasks, interactions, deliverables, milestones)
- General points for discussion
- Task-specific points for discussion
- a.o.b.

If you want to know more about WP1 partners/tasks and participate in the discussion, join the WP1 breakout session of this afternoon!

THANK YOU

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