Co-ordinated by ECMWF

CO_2 Human Emissions

WP2 – LIBRARY OF EMISSIONS AND SIMULATIONS

Joint General Assembly of CHE and VERIFY

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This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 776186.

WP Objectives

Overall objective of WP2

- Generate a library of realistic "nature" simulations of CO_2 from global to point-source scale serving as basis for studying the requirements for an operational fossil fuel CO_2 emissions monitoring system and adequately dimensioning a future space mission

Specific objectives for year 1:

- Define and prepare all simulations (model setups, domains, input/output requirements) D2.1
- Conduct a first global “Tier 1” simulation with ECMWF’s CAMS system D2.2
- Generate emission data sets and biospheric CO_2 fluxes for 2015 (and 2030) for different model domains (global, European, Berlin area) D2.3

All delivered and available

Task Overview

- **Task 2.1 Specification of model simulations and input data sets**
  Completed (EMPA, TNO, ECMWF, MPG)
- **Task 2.2 Emission scenarios and biospheric fluxes for use in nature runs**
  completed (TNO, JRC, MPG, EMPA, ECMWF)
- **Task 2.3 Nature runs**
  Activities ongoing (ECWMF, EMPA, TNO, MPG)
- **Task 2.4 Synthetic satellite observations**
  Recently started (DLR, EMPA)
- **Task 2.5 Role of aerosols in detecting city plumes**
  Recently started (SRON, EMPA)
- **Task 2.6 Simulating and quantifying power plant emission plumes**
  Not active yet (SPASCIA)

LIBRARY OF EMISSIONS

Task 2.2 and 4.1
Lead TNO

CO_2 HUMAN EMISSIONS

Task 2.2 Emission scenarios and biospheric fluxes for use in nature runs (Lead: TNO, M1-M12)

- Task Objectives
  - Generate global, European and regional emissions and biospheric fluxes:
    1) Biogenic fluxes for Europe (MPG); 2) Global anthropogenic CO_2 2015 and 2030 EDGAR (JRC) 3) Emission inventory Senat Berlin (EMPA) 4) European anthropogenic CO_2, CO, NO_x (TNO)
  - Emissions should represent present day (2015) and two future (2030) scenarios for Europe with incrementally reduced CO_2 emissions. Biospheric fluxes only for a present day scenario.
  - Nested higher resolution inventory for a domain centered on city of Berlin to support T2.3 and T2.5
- Progress
  - All available for model support / input
- Impact
  - Combined datasets (biogenic & anthropogenic / global, regional, urban / present, future) essential for nature runs as well as further testing of the use of observations to verify emissions (also e.g. VERIFY)
  - Products may help cities or regions with high-resolution GHG emission data

Task 2.2 Anthropogenic CO_2 emissions for 2015 – Some details

TNO GHGco inventory

- Anthropogenic CO_2 from fossil fuels & biofuels separately
- Co-emitted species NO_x and CO (CO also split in ff and bf)
- Point sources at exact location - major improvements compared to previous products
- Available for 2015
- Resolution 0.1° x km)
- G-NFR (IPCC) cla before
- Default temporal a

Inventories openly shared with other projects
e.g. VERIFY, ESA projects, national projects

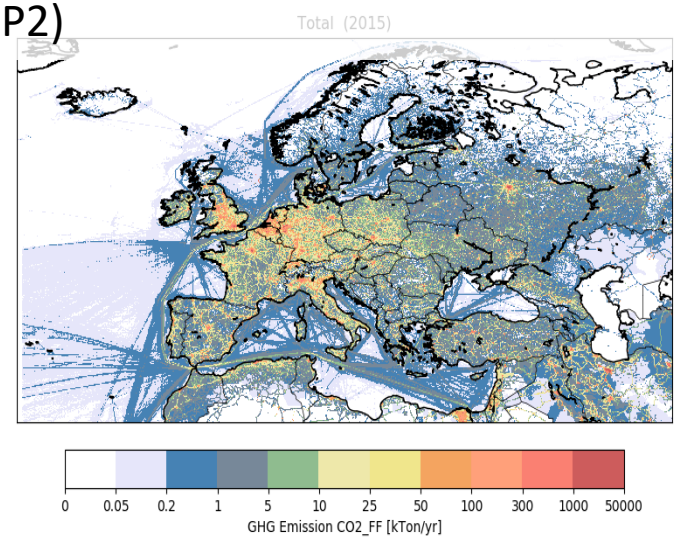
Connects to CHE WP3 & WP4

Berlin inventory

- Very detailed inventory obtained from the city of Berlin
- Mapped to same G-NFR classes and resolution as TNO-GHGco zoom
- CO_2 , CO, NO_x, CH_4 and many other species

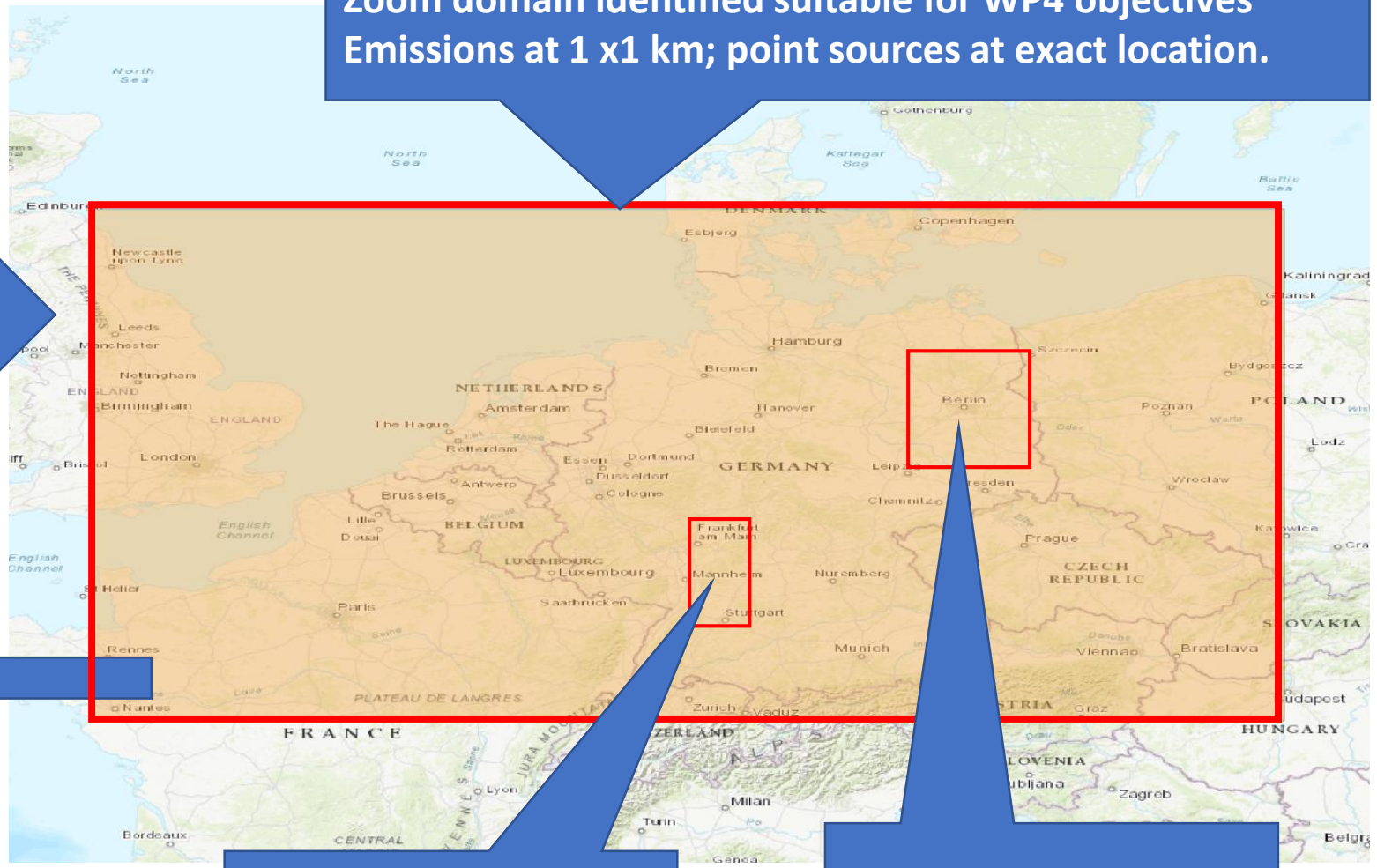
Task 2.2 & 4.1 (lead TNO)

TNO anthr. CO_2 emission at 6x6 km2 (WP2)



New proxy maps developed for road transport, population, land use, industrial areas, wood use to downscale from the 6 x6 km maps

Zoom domain identified suitable for WP4 objectives
Emissions at 1 x1 km; point sources at exact location.

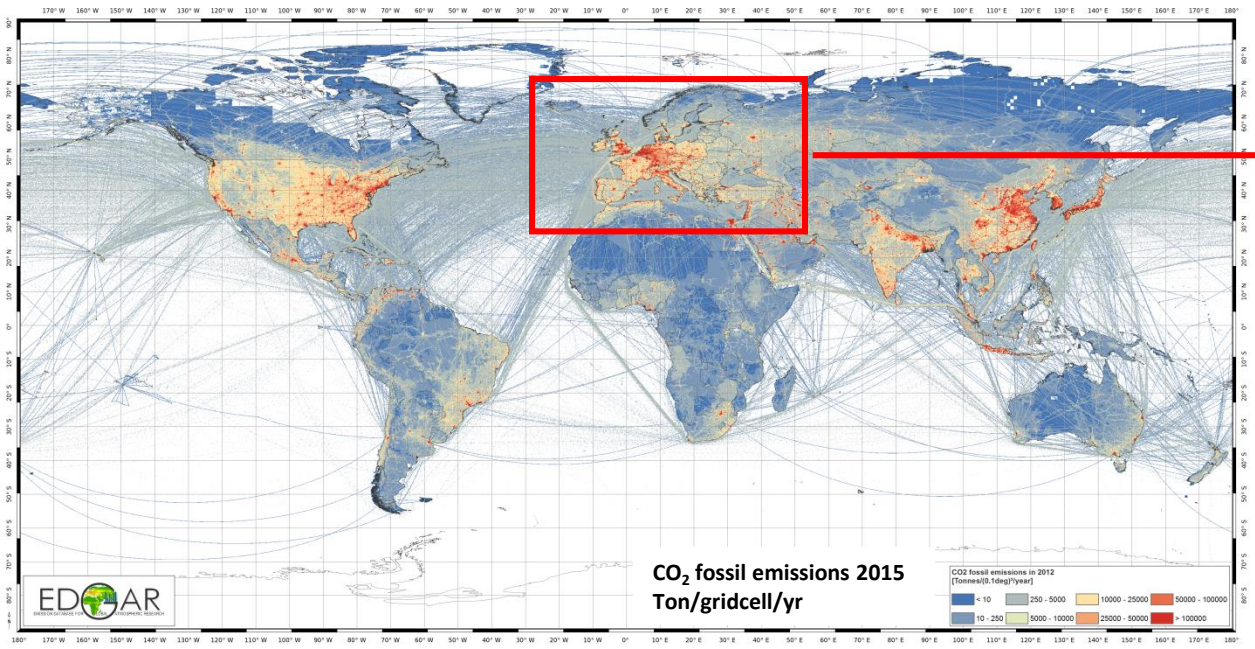


H2020 VERIFY
Rhine Valley case study

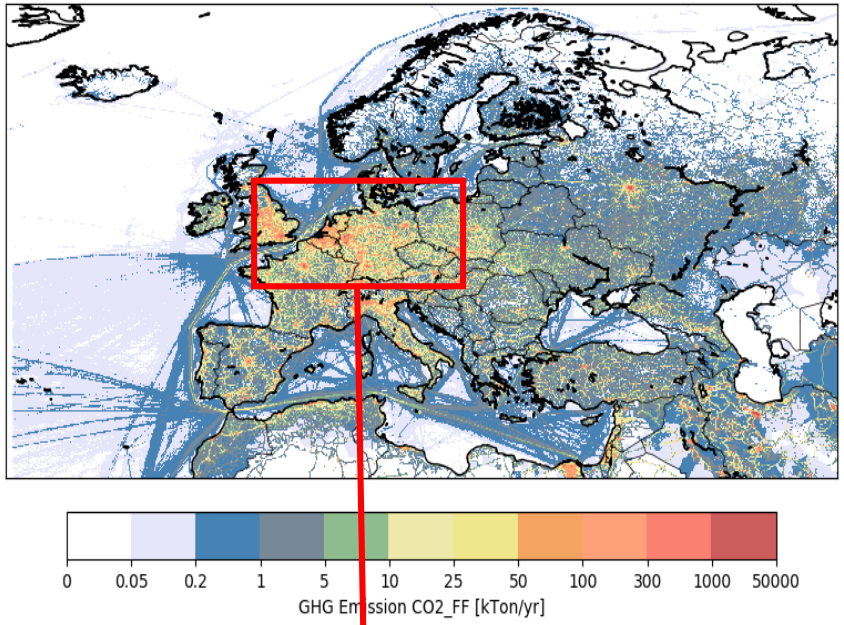
Berlin case study for WP2

Task 2.2 Anthropogenic CO_2 emissions for 2015 – scales

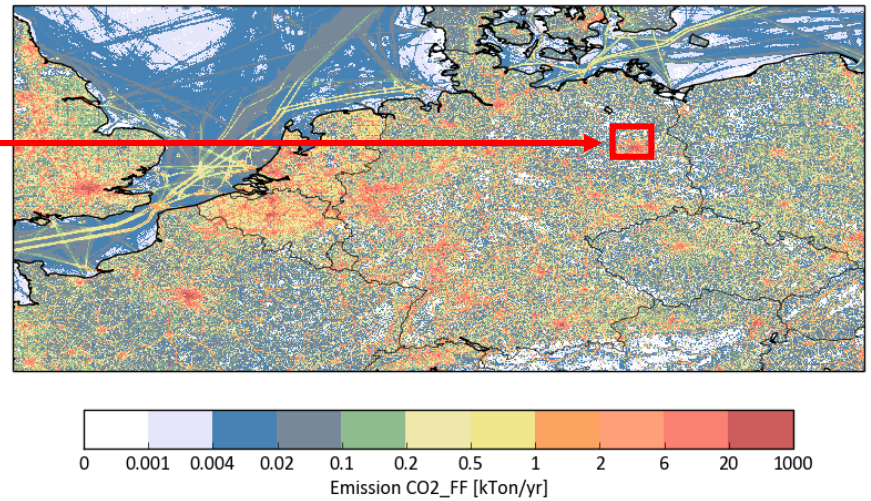
EDGARv4.3.2 Global 0.1° x 0.1°



TNO-GHGco Europe, approx. 6 km x 6 km

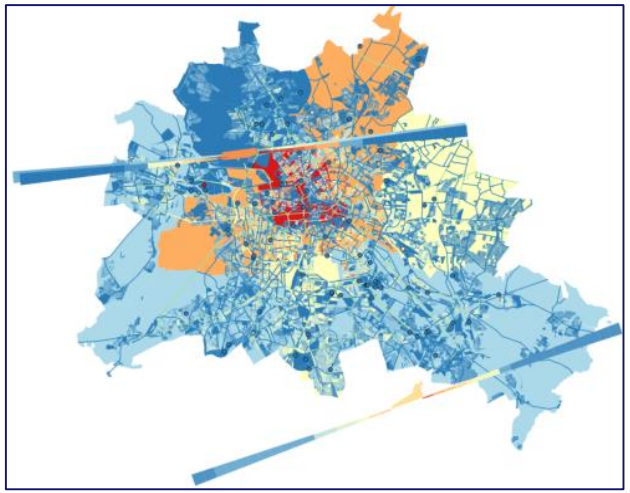


TNO-GHGco zoom: approx. 1 km x 1 km

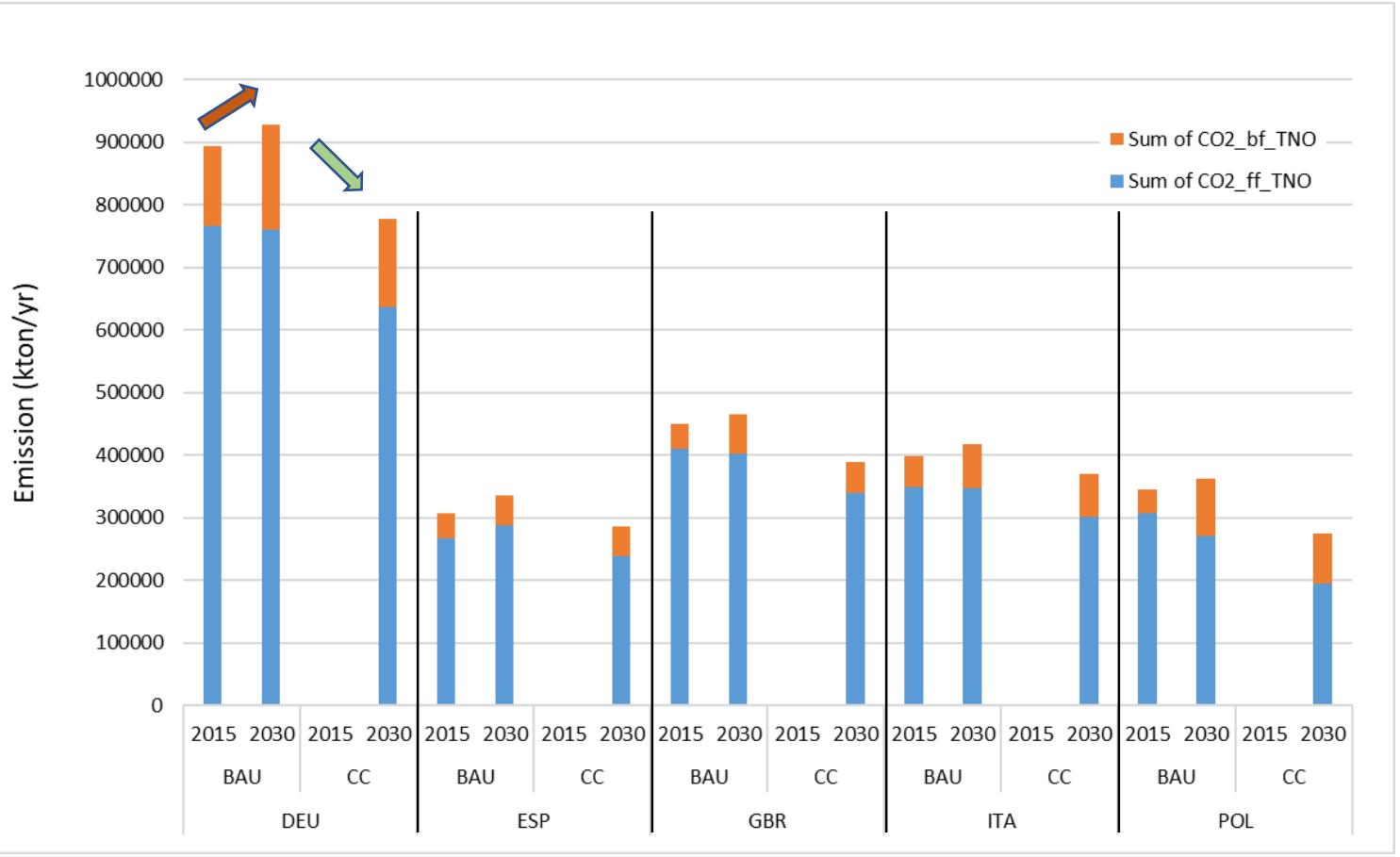


Senate of Berlin

point, area + line sources
Nested into TNO GHGco zoom
at 1 km x 1 km



2030 emissions available from TNO (Europe) and EDGAR (Global)
example Selected countries



Change 2015 – 2030 BAU

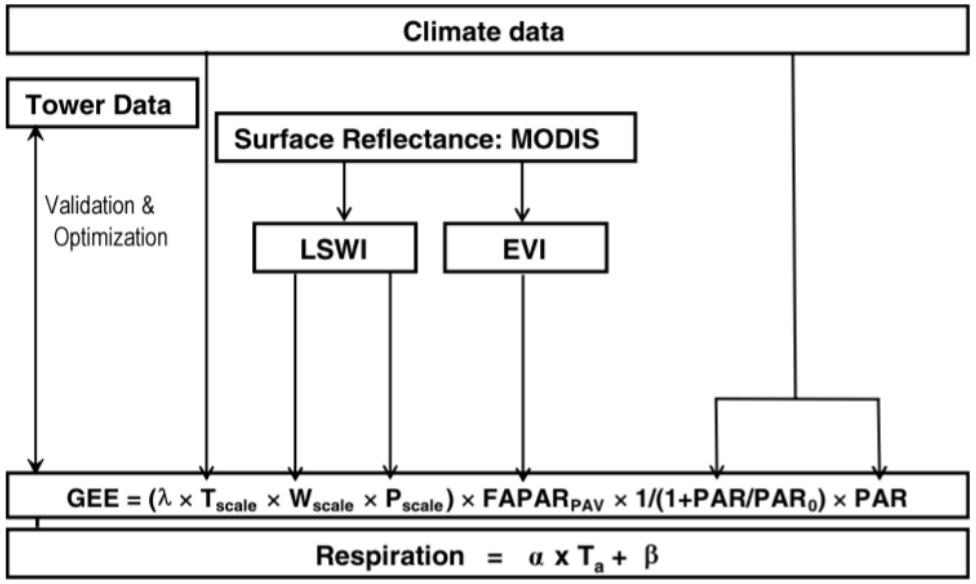
Change 2030 BAU - CC

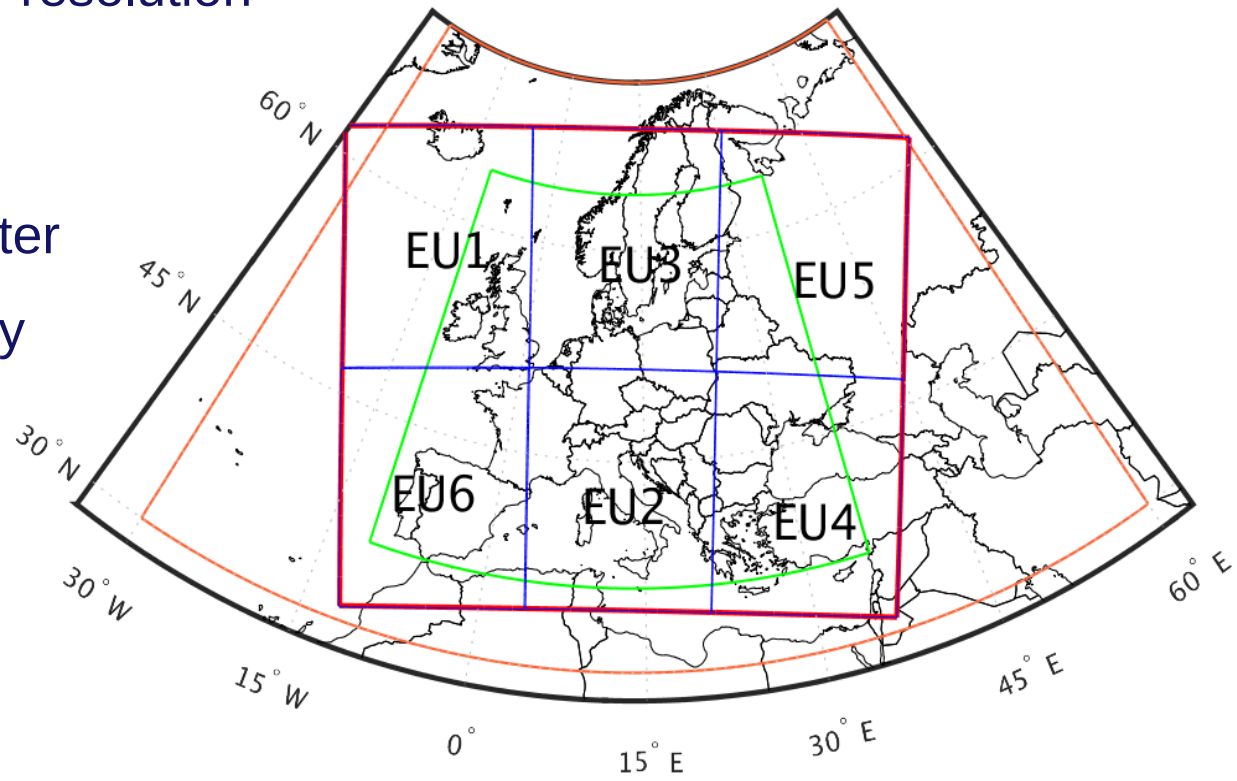
BAU = Business as usual
CC = Climate change measure scenario

Task 2.2 Biospheric fluxes (MPI Jena)

- Vegetation, Photosynthesis and Respiration Model (VPRM)
- GPP, respiration and NEE at **1 km x 1 km hourly** resolution for all of Europe for year 2015
- Meteo input from ECMWF's Tier 1 simulation
- MODIS reflectances for vegetation and inland water
- Broken down into 6 tiles for calculation, 10 Gb/day

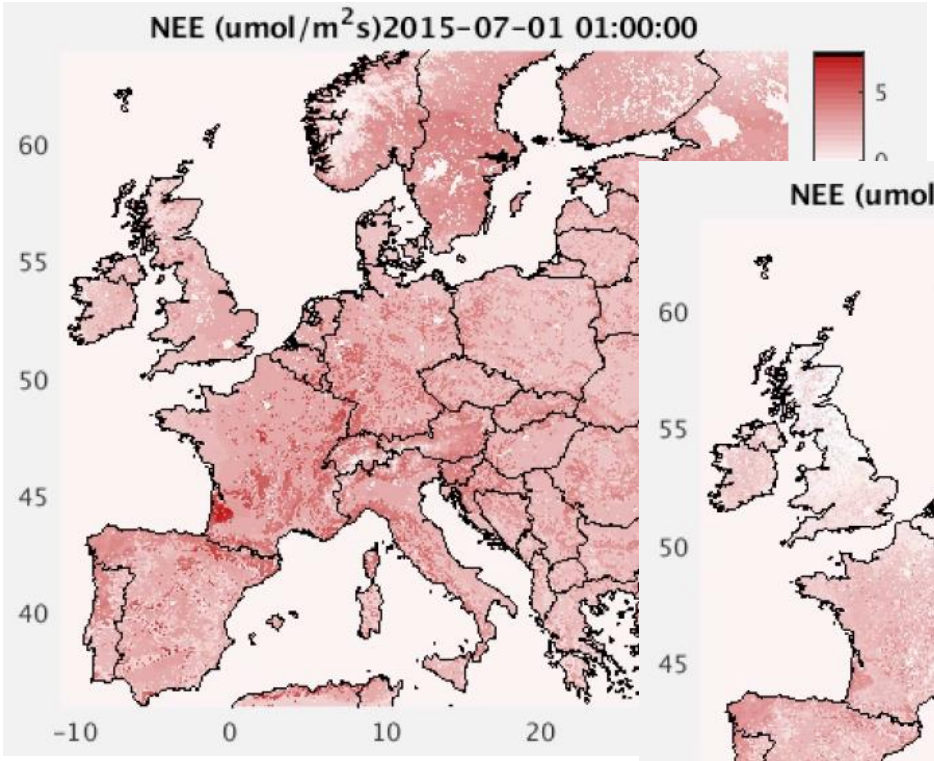
VPRM approach



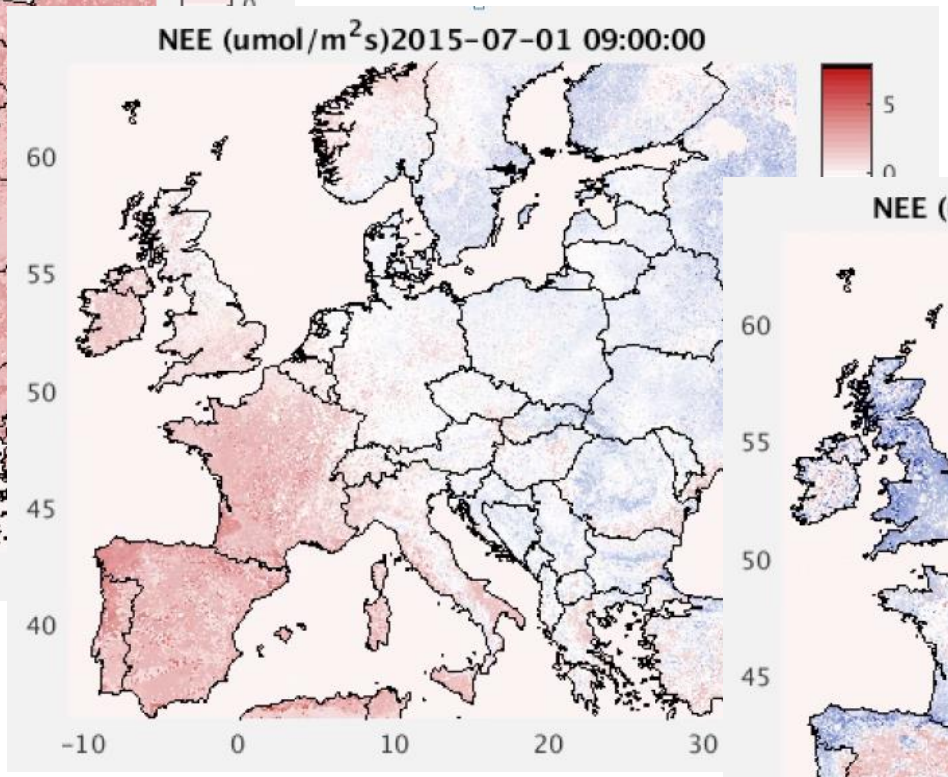


Minimum domain from D2.1
Domain for TNO anthropogenic emissions
WRF-GHG 5-km EU domain
Six sub-domains for VPRM calculation

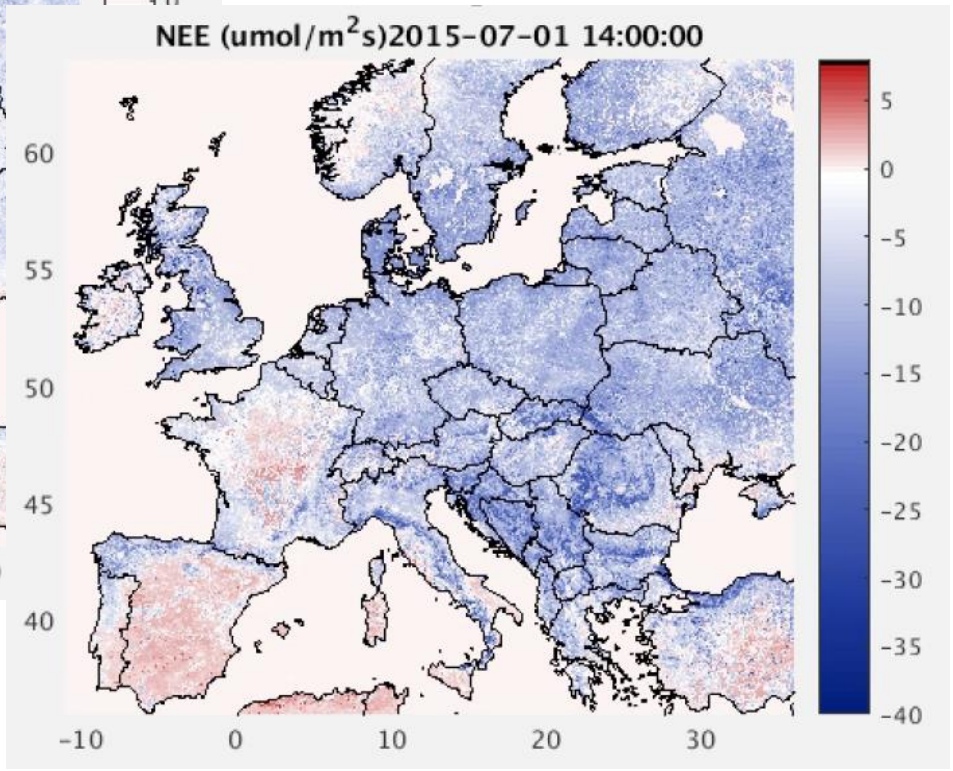
Task 2.2 Biospheric fluxes (MPI Jena)



midnight



early morning



afternoon

LIBRARY OF SIMULATIONS

Tasks 2.1, **2.3** (and 4.2)
Lead Empa

CO_2 HUMAN EMISSIONS

Task 2.3 Nature runs

- Task Objectives
  - Produce ensemble of high-resolution nature runs from the global to the regional scale to provide CO_2 fields with realistic variability and representation of sources and sinks
  - Provide basis for defining requirements for future Sentinel CO_2 satellites
- Progress
  - Global Tier 1 simulation conducted and evaluated (**Deliverable D2.2**)
  - Regional simulations for European domain prepared, first test simulations conducted
- Impact
  - Nature runs provide realistic reference for CO_2, CO, CH_4 variability and source signatures at different scales; essential input for Observing System Simulation Experiments and similar
  - Single and multi-model ensembles provide essential information on transport uncertainties
  - Full chemistry run with LOTOS-EUROS provides unique information on co-emitted species (NO_x, CO)

Task 2.1 Specification of model simulations – D2.1

Global
CAMS-IFS

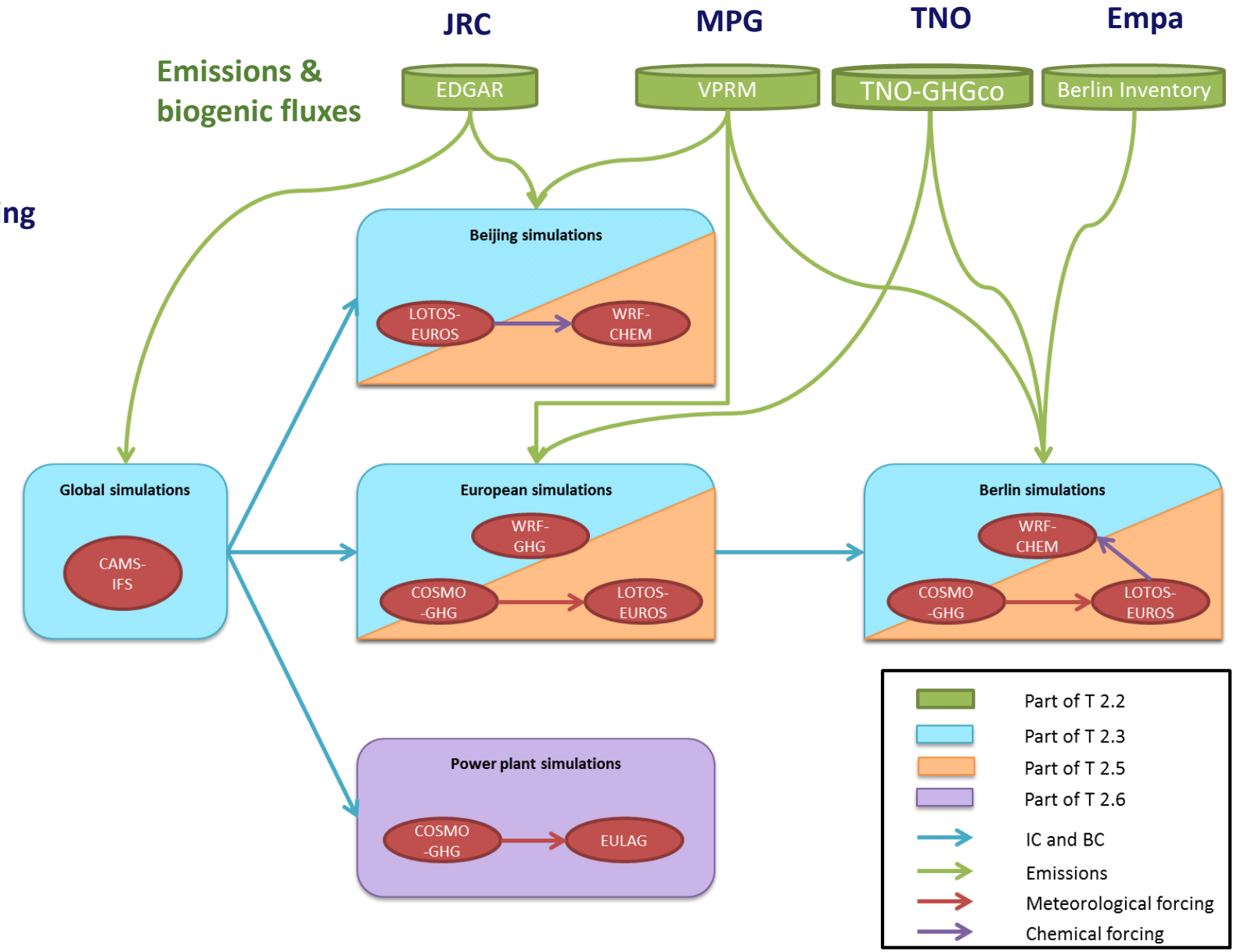
Europe, Berlin, Beijing
LOTOS-EUROS

Europe
WRF-GHG

Europe, Berlin
COSMO-GHG

Berlin, Beijing
WRF-Chem

Power plants
EULAG (LES)



Task 2.1 Specification of model simulations – D2.1

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CAMS-IFS

Europe, Berlin, Beijing
LOTOS-EUROS

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Berlin, Beijing
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Power plants
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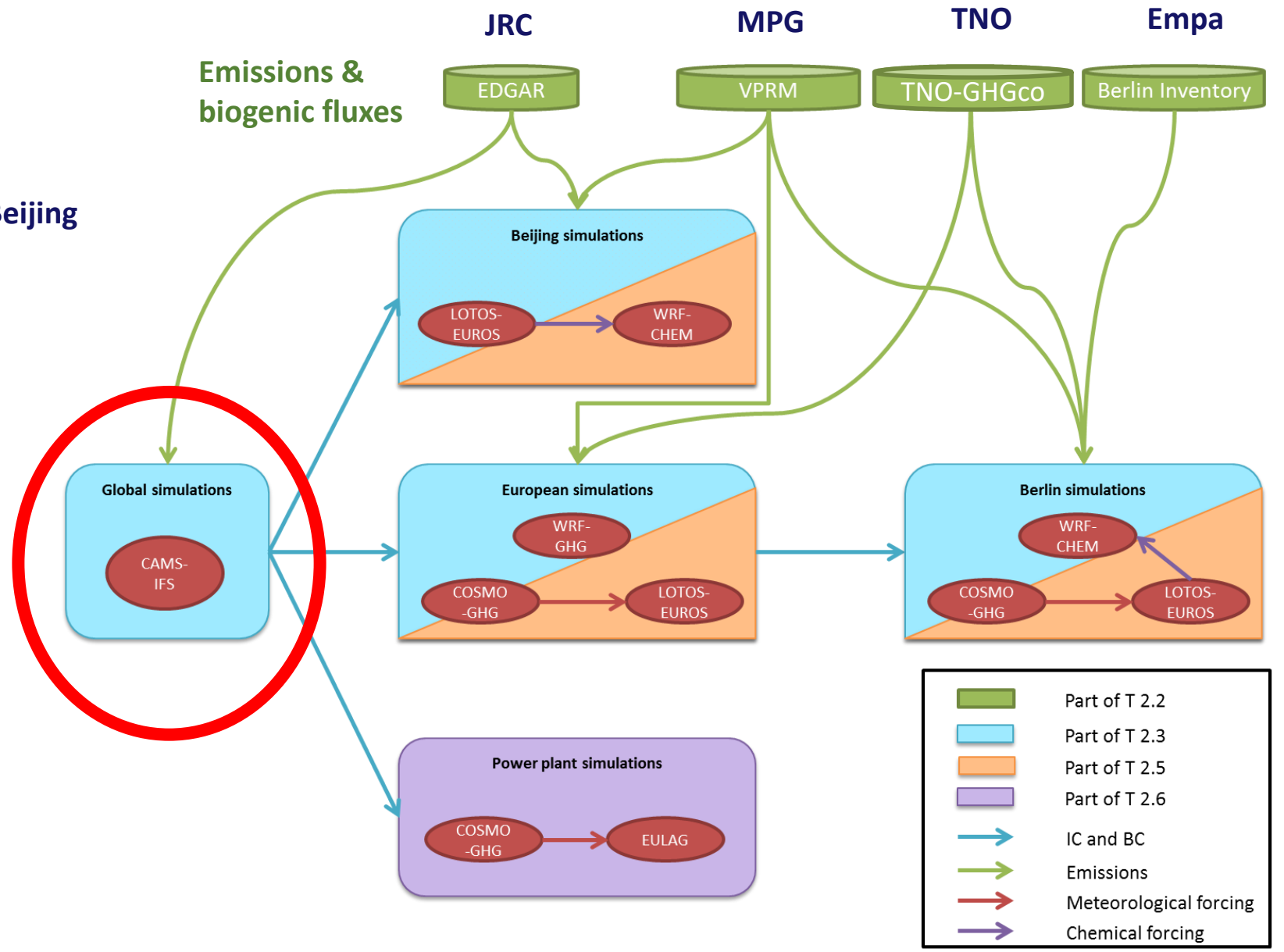


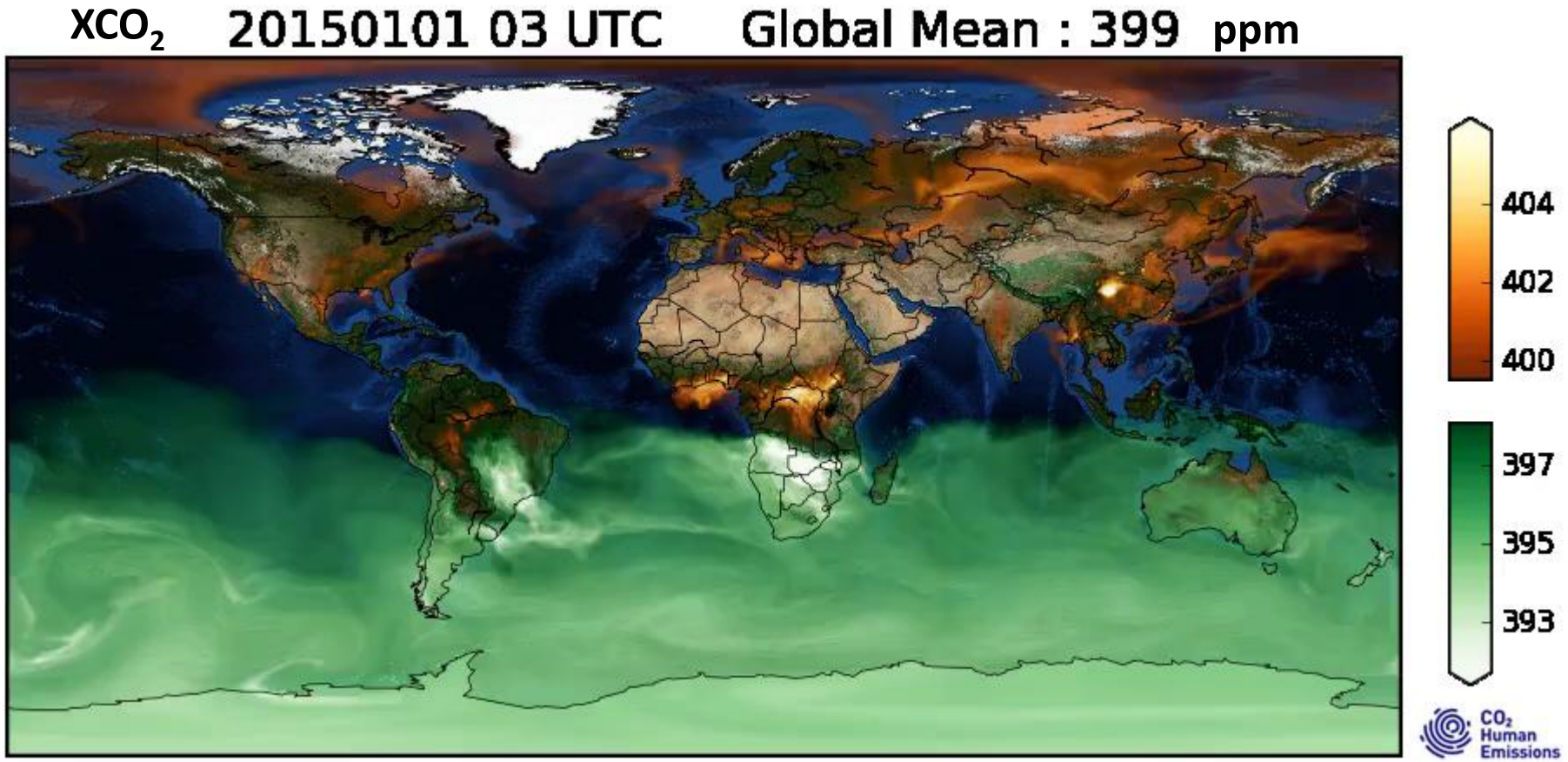
Global nature runs – D2.2

Tier 1 global nature run for 2015 using the CAMS system at ECMWF

IFS model (ECMWF):

- 9km horizontal resolution
- 137 vertical levels
- Meteo: ECMWF analysis
- Fluxes: Online NEE with bias correction, EDGARv4.1FT2010, Takahashi et al. (2009) ocean fluxes, GFAS fire emissions

- Tracers: CO_2, CH_4, CO
- 3-hourly tracer and NWP fields



Tier 2 Global nature runs – D2.6

Tier 2 global ensemble of simulations using the CAMS system at ECMWF

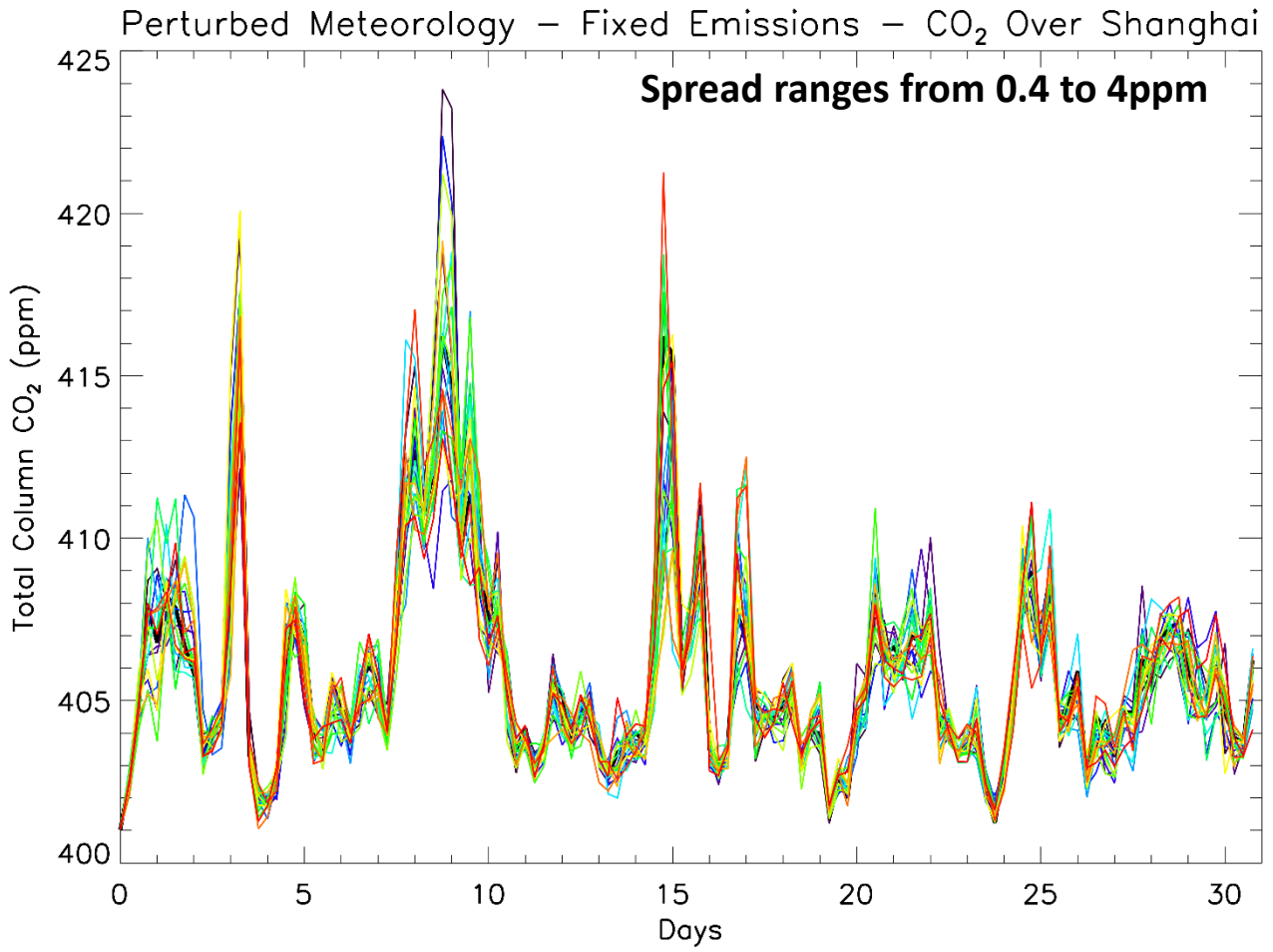
- ❑ 9km simulation with improved transport model and emissions
- ❑ ~25km ensemble of simulations

Initial testing with three configurations:

- **Perturbed Meteorology and Fixed Emissions**.
- Perturbed Emissions and Fixed Meteorology.
- Perturbed Emissions and Meteorology.

Ensemble simulations will be used to:

- derive **model transport error**
- develop ensemble-adjoint hybrid inversion system.



Task 2.1 Specification of model simulations – D2.1

Global
CAMS-IFS

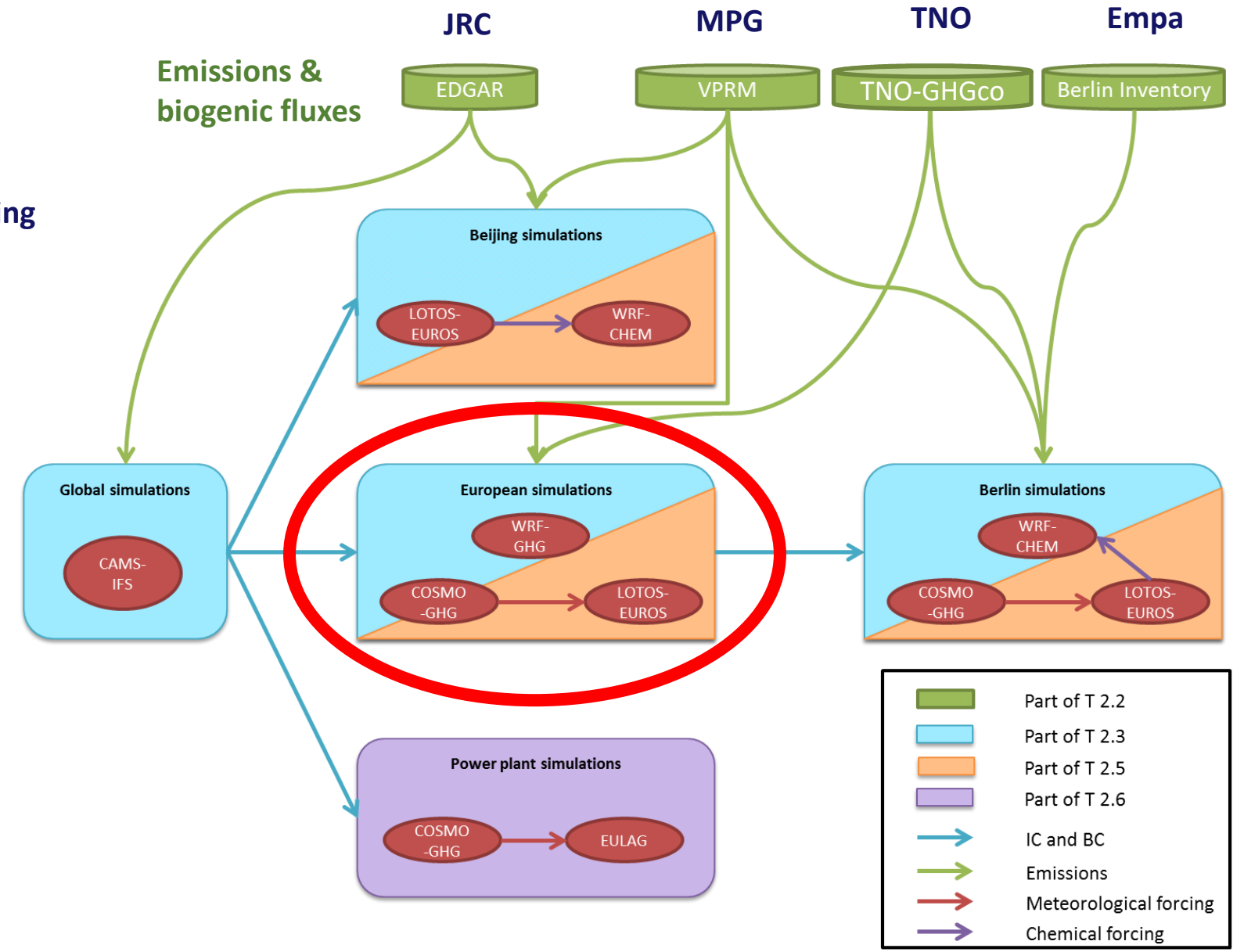
Europe, Berlin, Beijing
LOTOS-EUROS

Europe
WRF-GHG

Europe, Berlin
COSMO-GHG

Berlin, Beijing
WRF-Chem

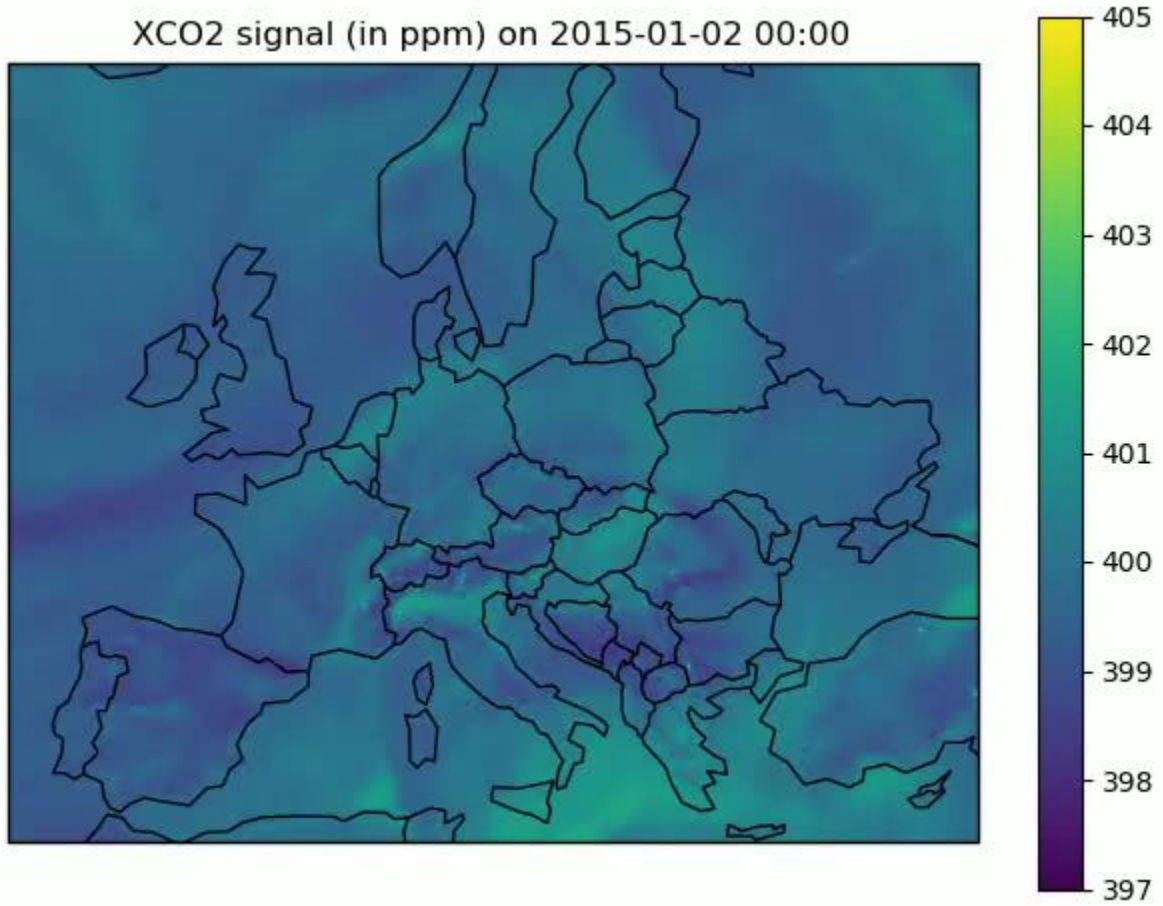
Power plants
EULAG (LES)



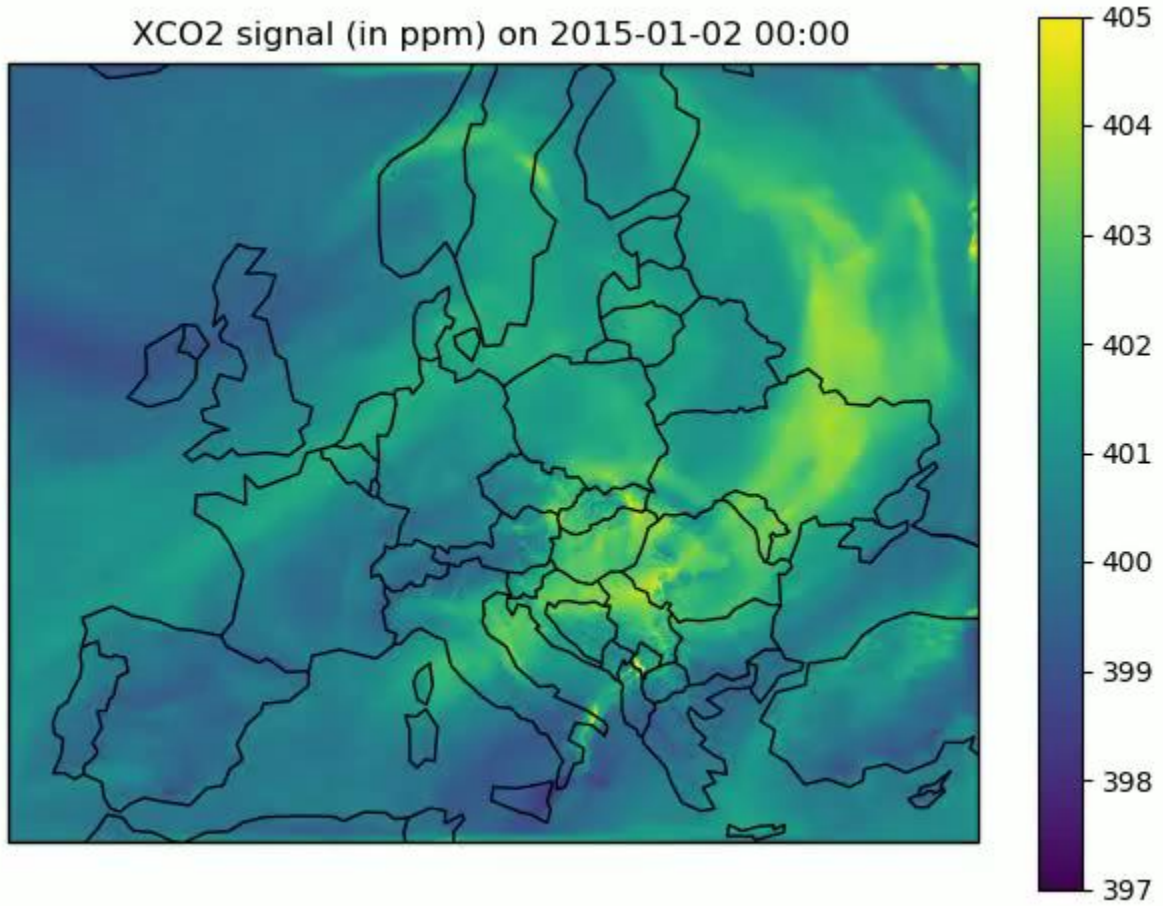
COSMO-GHG European simulations

First comparison of CAMS versus COSMO-GHG for total column CO_2

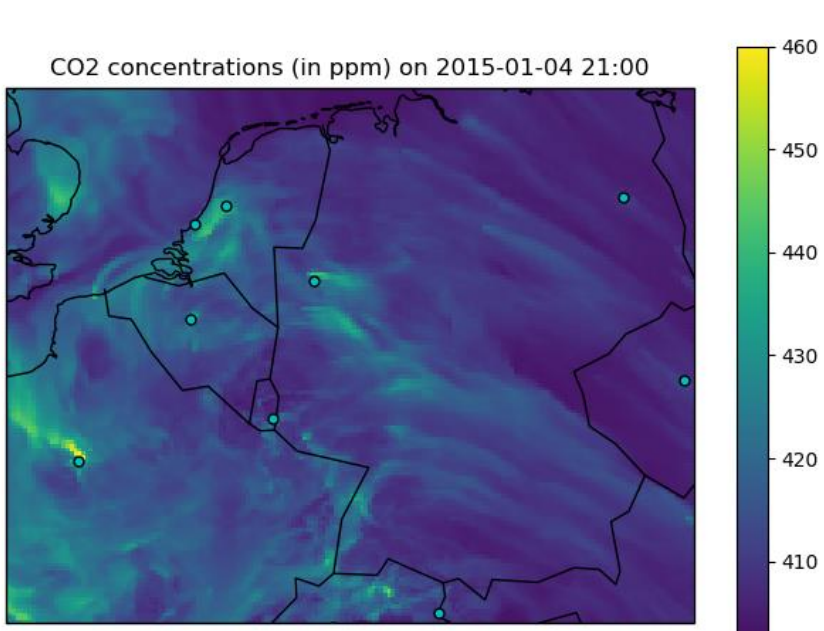
CAMS-IFS



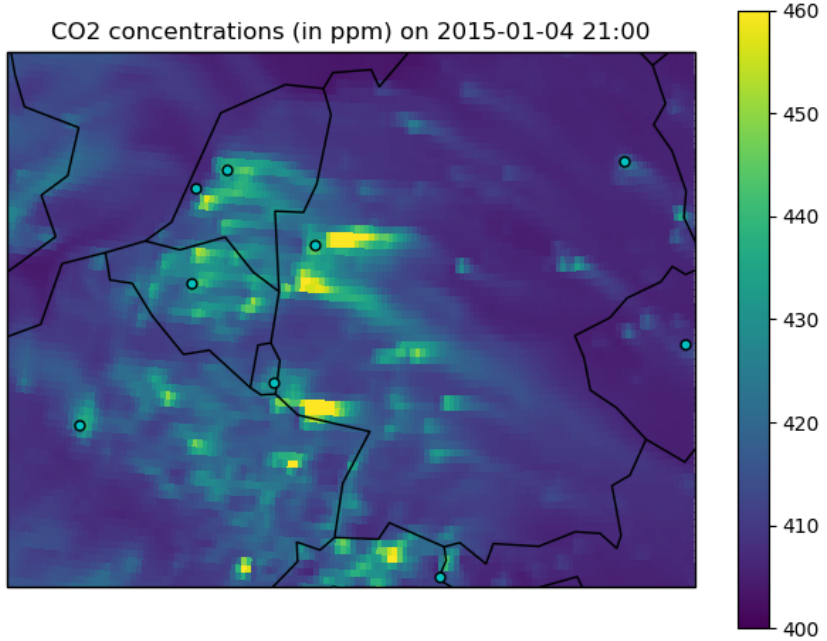
COSMO-GHG



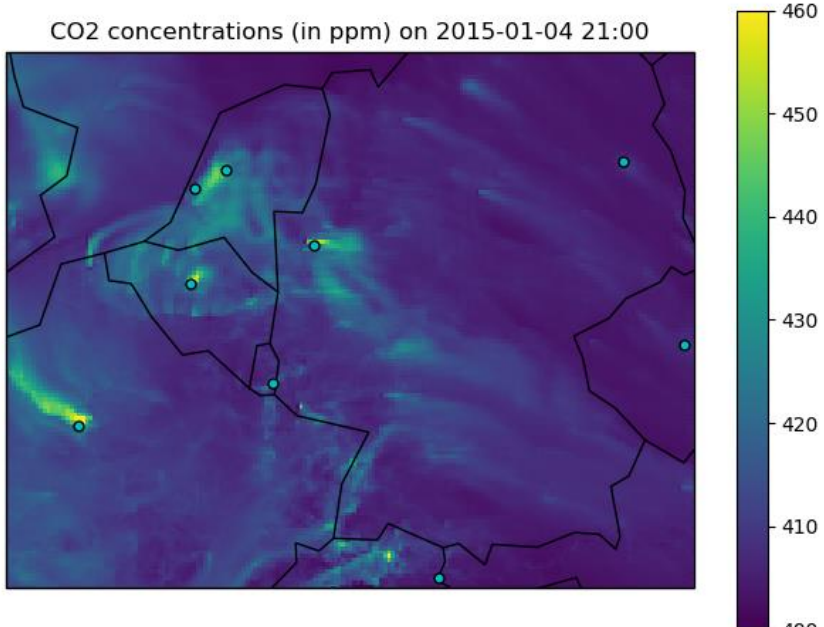
Surface concentrations of CO_2



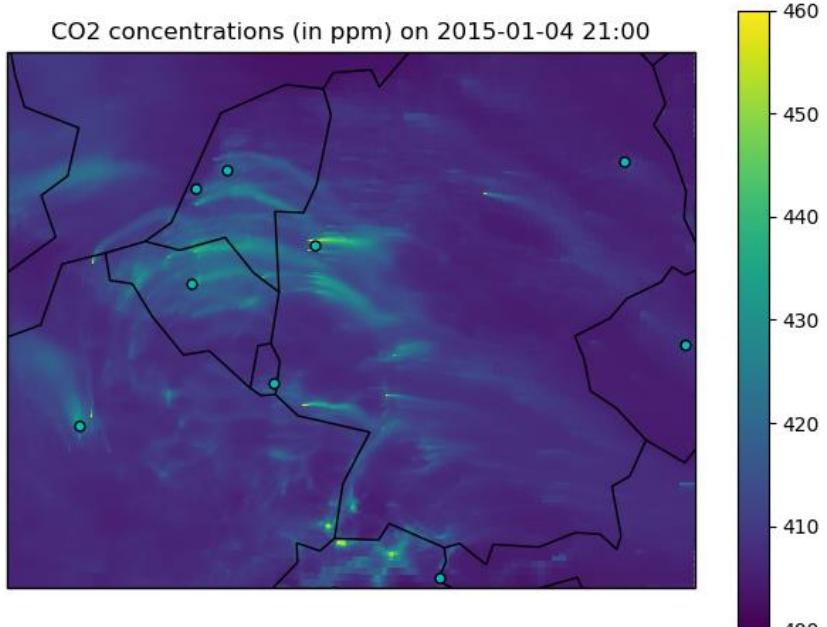
LOTOS-EUROS



CAMS



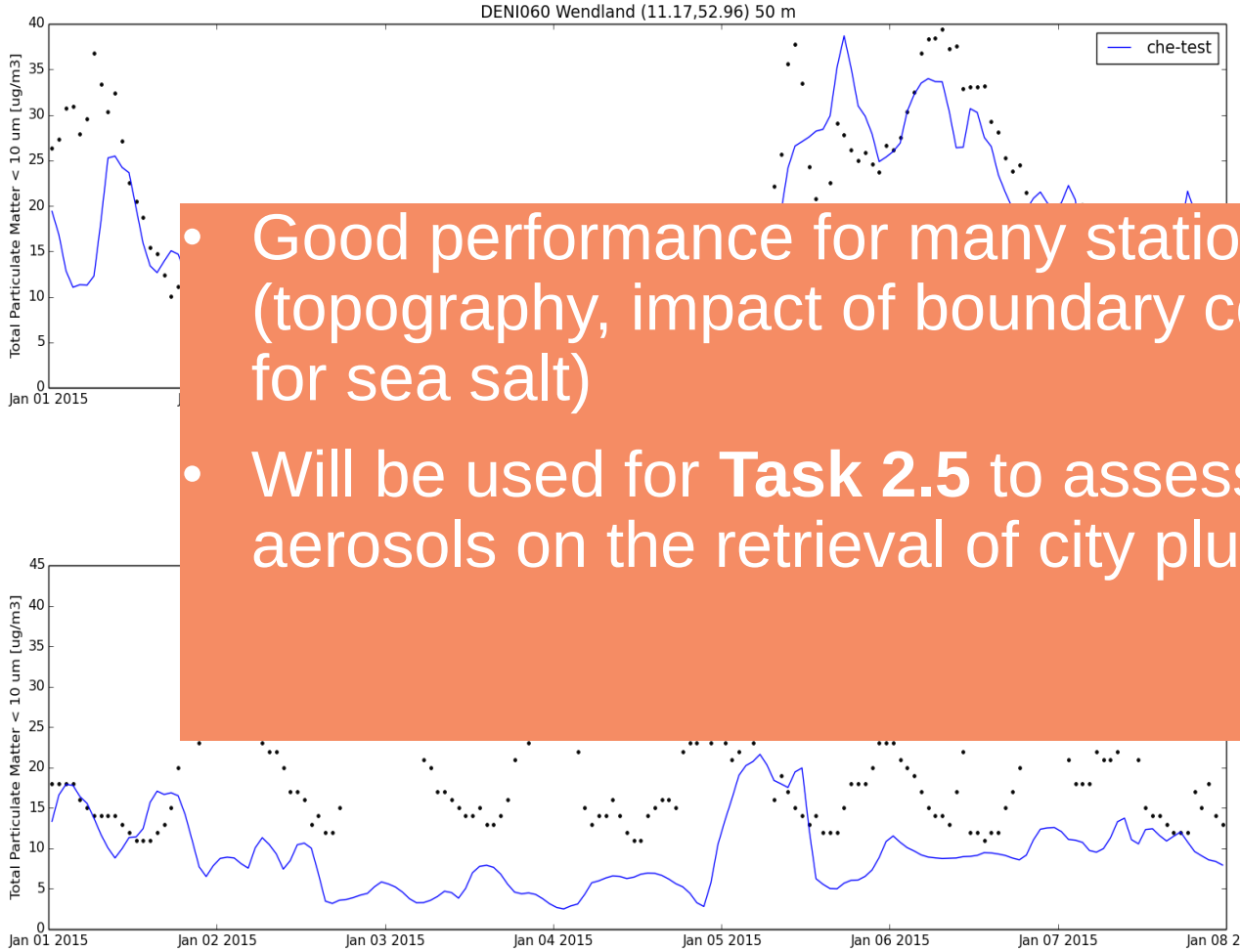
COSMO

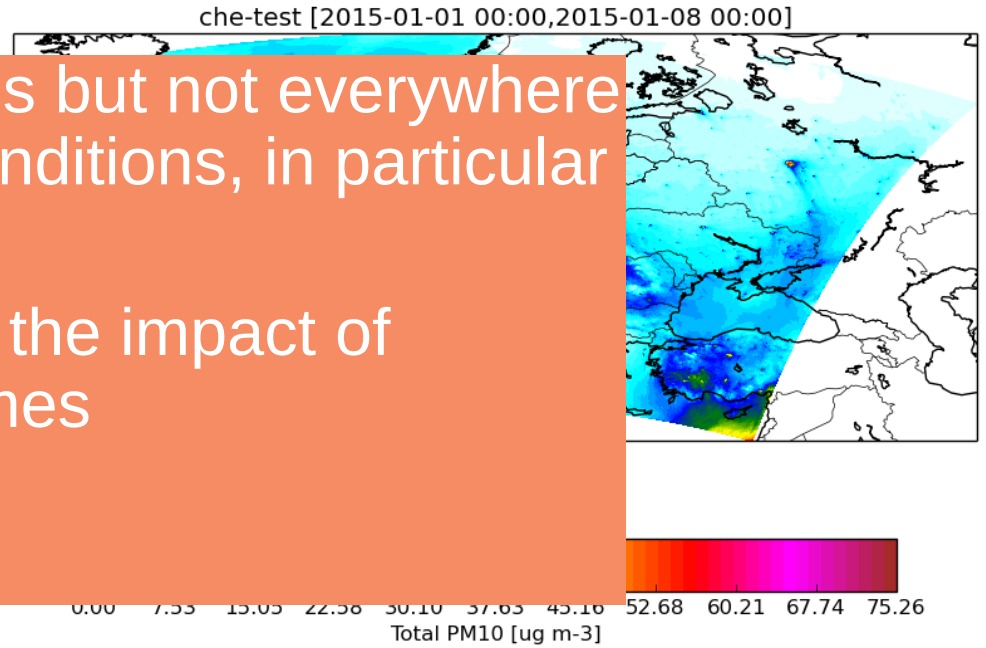


CHIMERE (WP4)

Aerosol simulations (LOTOS-EUROS)

- Germany





- Good performance for many stations but not everywhere (topography, impact of boundary conditions, in particular for sea salt)
- Will be used for **Task 2.5** to assess the impact of aerosols on the retrieval of city plumes

Summary and future development

- Task 2.1 Specification of model simulations
  - Task completed, update to the deliverable necessary **(D2.1)**
- Task 2.2 Emissions and other input data
  - Task completed **(D2.3)**
- Task 2.3 Nature runs
  - Global Tier-1 run completed **(D2.2)**
  - First week of simulation and comparison
- Task 2.3 Nature runs
  - Complete simulations for European and regional (Berlin, Beijing) domains **(D2.4, M21)**
  - Run global Tier 2 simulation **(D2.6, M27)**
- Task 2.4 Synthetic satellite observations
  - Start producing synthetic satellite observations from European runs **(D2.5, M27)**
- Task 2.5 Role of aerosols in detecting city plumes
  - Prepare simulations (Berlin, Beijing) to investigate effect of urban aerosols on satellite observations **(D2.7, M39)**
- Task 2.6
  - Start preparing LES simulations for power plant plumes **(D2.8, M33)**

CO_2 Human Emissions

THANK YOU

Jean-Matthieu Haussaire &
Hugo Denier van der Gon