Co-ordinated by ECMWF

CO_2 Human Emissions

WP2 OVERVIEW

First General Assembly
Reading, UK, 5-7 Feb 2018

Dominik Brunner &
Empa, Switzerland

Hugo Denier van der Gon
TNO, The Netherlands

05/02/2018

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

WP2 Library of simulations for emissions and atmospheric transport

Generate library of realistic CO_2 forward simulations - “nature runs”

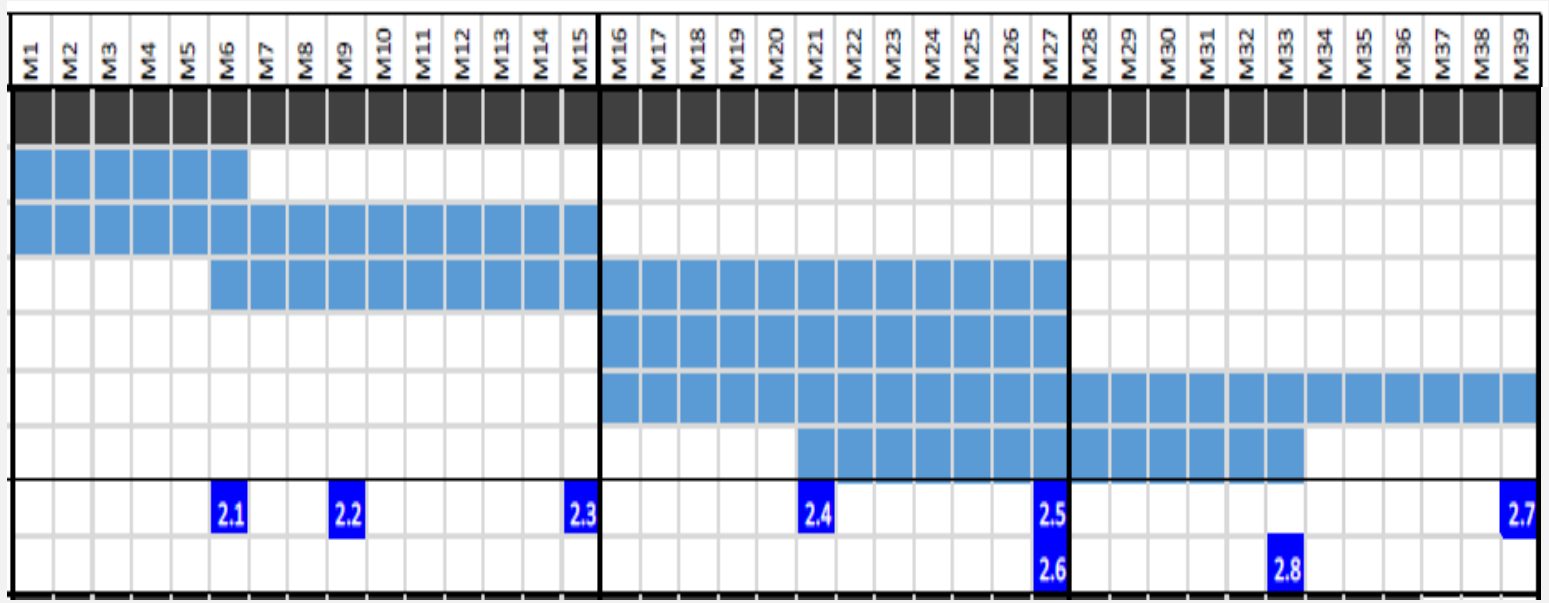
- Simulations for present-day and future emission scenarios
- From global to regional to point source scale
- Provide simulation input for other WPs and other projects

Support assessment of requirements for a future CO_2 space mission

- Generate collection of synthetic satellite observations with realistic error characteristics, by combining model output with orbit simulations
- Investigate influence of aerosols on CO_2 retrieval in urban plume
- Investigate influence of small-scale and fluctuating nature of power plant plumes on capability to detect and quantify such plumes

Tasks and Schedule

T2.1 Specification of model simulations
T2.2 Emission scenarios & biosph. fluxes
T2.3 Nature runs
T2.4 Synthetic satellite observations
T2.5 Role of aerosols in city plumes
T2.6 Simulation and quantification of power plant plumes



Deliverable	Resp.	Type
D2.1 Model systems and simulation config.	**Empa**	**Report**
D2.2 Global Run V1.1	**ECMWF**	**Simulation**
D2.3 Emissions and natural fluxes dataset	**TNO**	**Dataset**
D2.4 European and Regional Runs	MPG	Simulation

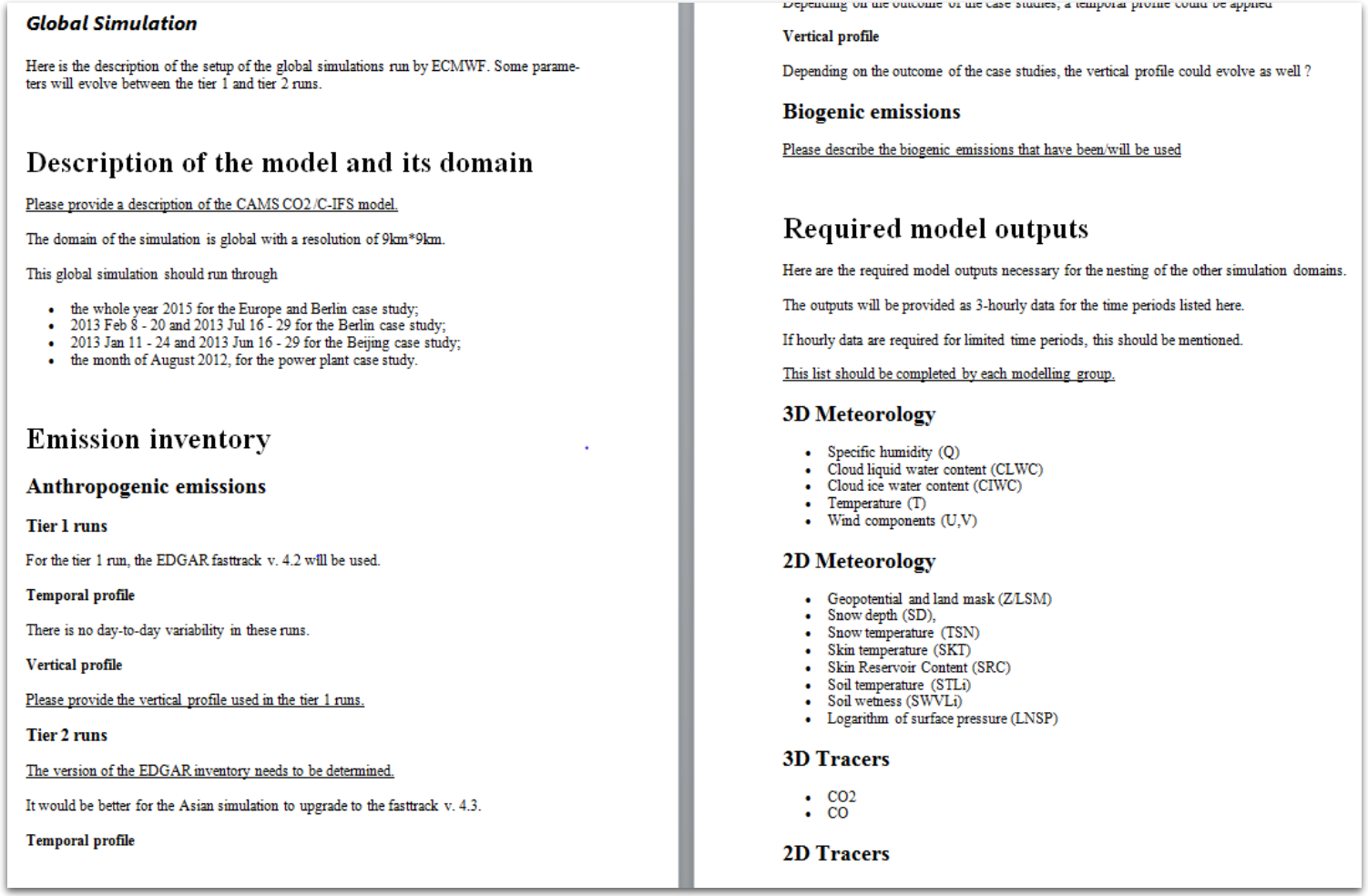
Deliverable	Resp.	Type
D2.5 Synthetic satellite datasets	DLR	Dataset
D2.6 Global Run V2.1	ECMWF	Simulation
D2.7 Impact of urban aerosols on CO_2	SRON	Report
D2.8 LES Simulation	SPASCIA	Report

Task 2.1 Specification of model simulations

Specifications

- Model descriptions
- Planned simulations (domains, periods, tracers)
- Emission data sets
- Other inputs and boundary conditions
- Required model outputs
- Appendices with further details (variable lists, data formats, etc.)

Draft for global simulations (example)



Global Simulation

Here is the description of the setup of the global simulations run by ECMWF. Some parameters will evolve between the tier 1 and tier 2 runs.

Description of the model and its domain

Please provide a description of the CAMS CO2 /C-IFS model.

The domain of the simulation is global with a resolution of 9km*9km.

This global simulation should run through

- the whole year 2015 for the Europe and Berlin case study;
- 2013 Feb 8 - 20 and 2013 Jul 16 - 29 for the Berlin case study;
- 2013 Jan 11 - 24 and 2013 Jun 16 - 29 for the Beijing case study;
- the month of August 2012, for the power plant case study.

Emission inventory

Anthropogenic emissions

Tier 1 runs

For the tier 1 run, the EDGAR fasttrack v. 4.2 will be used.

Temporal profile

There is no day-to-day variability in these runs.

Vertical profile

Please provide the vertical profile used in the tier 1 runs.

Tier 2 runs

The version of the EDGAR inventory needs to be determined.

It would be better for the Asian simulation to upgrade to the fasttrack v. 4.3.

Temporal profile

Depending on the outcome of the case studies, a temporal profile could be applied

Vertical profile

Depending on the outcome of the case studies, the vertical profile could evolve as well ?

Biogenic emissions

Please describe the biogenic emissions that have been/will be used

Required model outputs

Here are the required model outputs necessary for the nesting of the other simulation domains.

The outputs will be provided as 3-hourly data for the time periods listed here.

If hourly data are required for limited time periods, this should be mentioned.

This list should be completed by each modelling group.

3D Meteorology

- Specific humidity (Q)
- Cloud liquid water content (CLWC)
- Cloud ice water content (CIWC)
- Temperature (T)
- Wind components (U,V)

2D Meteorology

- Geopotential and land mask (Z/LSM)
- Snow depth (SD),
- Snow temperature (TSN)
- Skin temperature (SKT)
- Skin Reservoir Content (SRC)
- Soil temperature (STLi)
- Soil wetness (SWVLi)
- Logarithm of surface pressure (LNSP)

3D Tracers

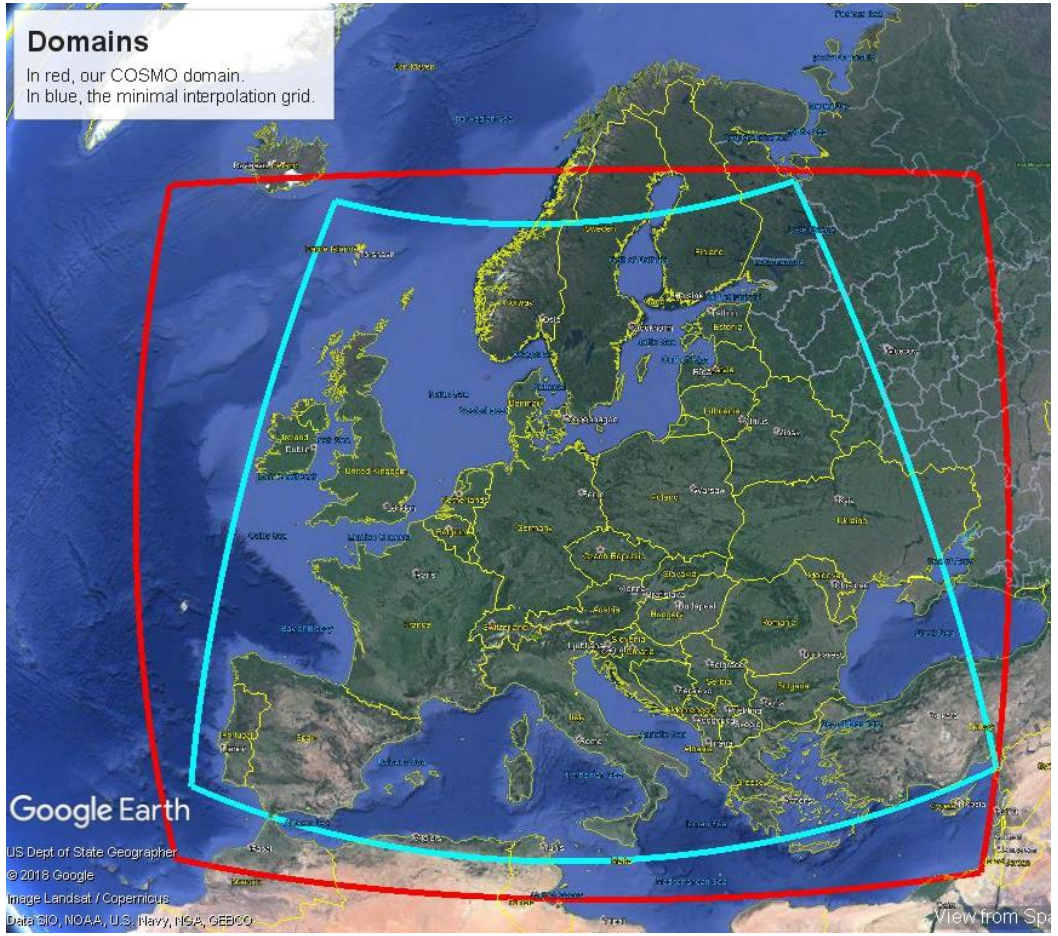
- CO2
- CO

2D Tracers

Task 2.1 Specification of model simulations

Example for European runs

- Model descriptions (COSMO-GHG, WRF-GHG, LOTOS-EUROS)
- Present day and future simulations
  - Periods, model configurations
  - Grid definitions (domain, projection)
- Model inputs
  - IC/BC from ECMWF (meteo, CO_2, CO)
  - Emissions (TNO/CAMS) including time functions and vertical distribution (?)
- Required output
- Computational resources



Task 2.2 Emissions and biospheric fluxes

Global emissions (JRC)

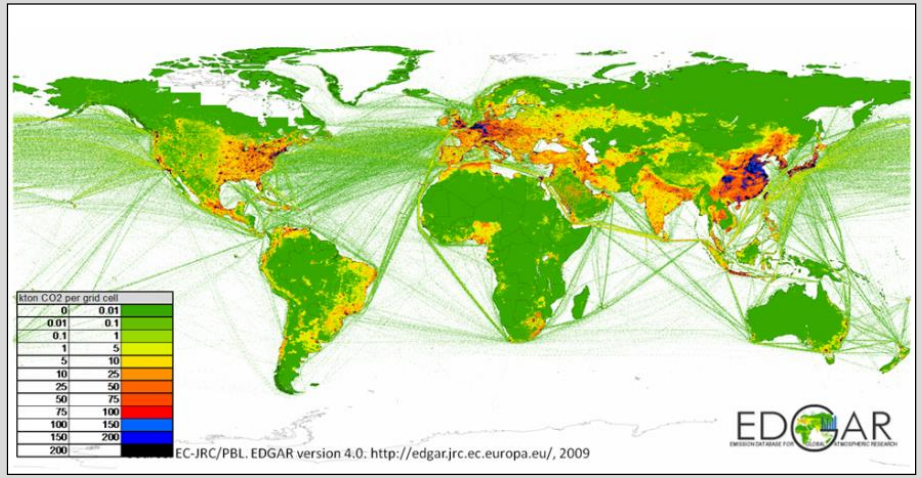
- Based on EDGAR
- Sector-specific global emission grid maps of CO_2, CO (CH_4?) for 2015 & 2030
- Special attention given to spatial (0.1°x0.1°) and temporal (hourly) distribution

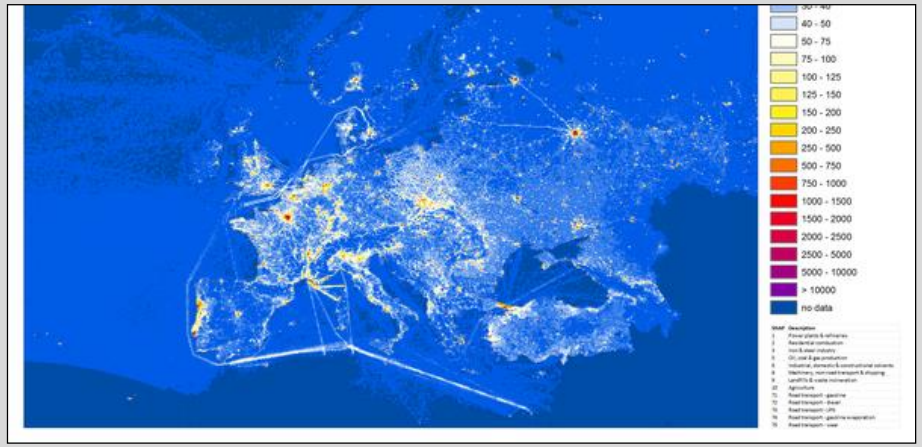
European / regional (TNO)

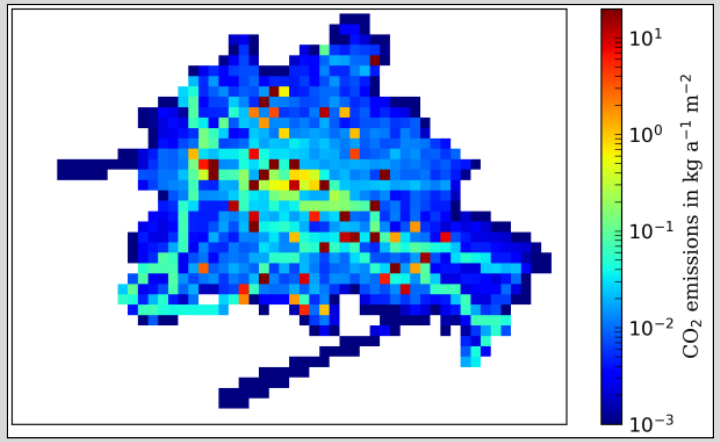
- Based on TNO/CAMS (formerly TNO/MACC)
- Downscaling with proxy data to ~1 km resolution for regional simulations
- Present-day (2015) and two future 2030 scenarios
- Meteo-driven emission timing

Berlin city emissions (Empa)

- Based on inventory of Senatsverwaltung of Berlin
- GIS shape files, rasterized to model grid(s)
- Vertical and temporal profiles depending on source category







CO_2 HUMAN EMISSIONS

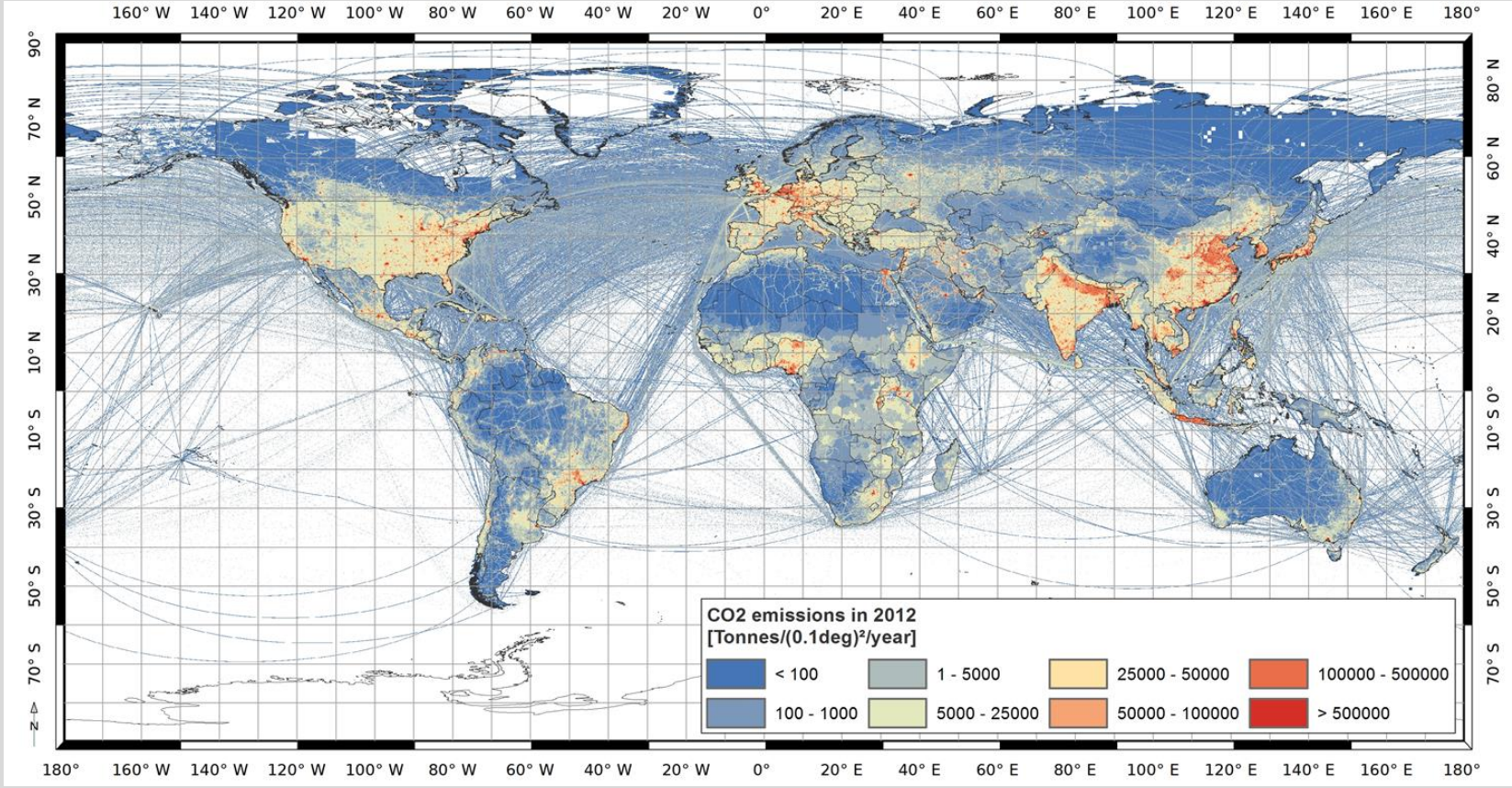
Global emissions

Present-day and future

- Based on EDGARv4.3.2 and EDGARv4.3.2FT approach up to year t-1
- and a scenario (e.g. CIRCE) for 2030
- Available by end of March 2018

Procedure for creating the gridmaps:

1) take the sector-specific CO_2 (ff/bf) gridmaps of 2012
2a) calculate country- & sector-specific ratios 2015/2012 based on the dataset of the new CO_2 report.
2b) calculate country-specific ratios 2030/2012 based on the CIRCE dataset (BAU)
3) apply factors to the gridcells for the country



European emissions

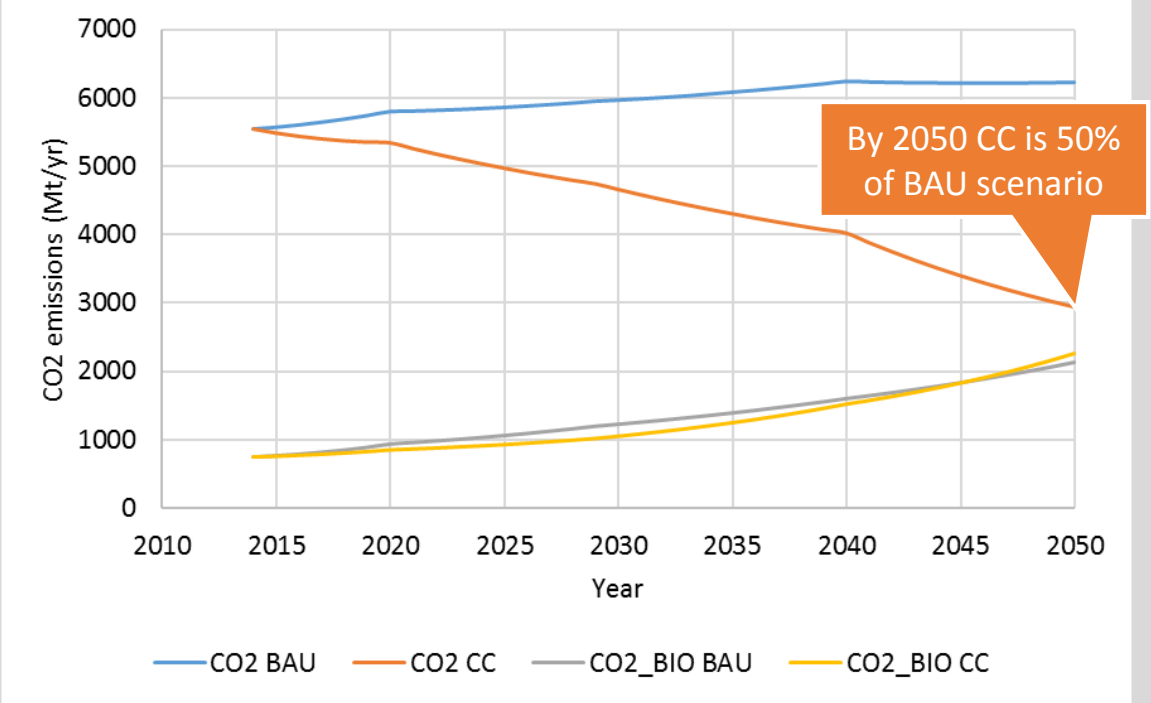
Present-day (2015) emissions

- Construction of 2015 European emission inventory for CO_2 and co-emitted species lined-up with CAMS81
- First 2015 dataset available by end of Mar 2018 (deadline CAMS81)
- Currently large effort on improving representation of point sources in the emission grids (next slide)

Future year (2030) scenarios

- A “climate change mitigation” (CC) scenario and a “business as usual” (BAU) scenario based on two global emission scenarios developed by the EDGAR team in the CIRCE project (Doering et al., 2010).

Projected European CO_2 emissions based on the CIRCE Business-As-Usual scenario (BAU) and Climate Change scenario (CC) for the entire European domain



Improved representation of point sources

AIM Creating dataset of all plants/facilities in sector 1A1a public power and heat production including emissions, fuel type and coordinates :

Datasets available:

E-PRTR

LCP

Platts WEPP

CARMA

Point sources are very important for CO_2 and strongly improve high resolution maps. Involves substantial manual checking and corrections.

CO2 emissions missing while facility was still active

Emissions of PM10 and SOx likely below threshold value

2015 partly empty

Before Gapfilling

TNO_ID	Unit	Pollutant	2001	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
TNO_0041	kg	CO2	551,000,000	672,000,000			417,000,000		780,000,000	818,000,000	653,000,000	762,000,000	738,000,000	968,000,000	888,000,000
TNO_0041	kg	NOX	1,870,000	2,230,000			1,130,000	672,000	626,000	312,000	289,000	401,000	295,000	449,000	402,000
TNO_0041	kg	PM10	136,000	51,500											
TNO_0041	kg	SOX	2,020,000	2,230,000			1,340,000	841,000	457,000						

example

TNO_ID	Unit	Pollutant	2001	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
TNO_0041	kg	CO2	551,000,000	672,000,000	616,228,442	592,208,455	417,000,000	361,225,059	780,000,000	818,000,000	653,000,000	762,000,000	738,000,000	968,000,000	888,000,000
TNO_0041	kg	NOX	1,870,000	2,230,000	1,897,200	1,633,680	1,130,000	672,000	626,000	312,000	289,000	401,000	295,000	449,000	402,000
TNO_0041	kg	PM10	136,000	51,500	25,100	95,140	34,960	36,300	13,000	70	60	70	2,600	3,428	12,036
TNO_0041	kg	SOX	2,020,000	2,230,000	1,960,500	1,929,580	1,340,000	841,000	457,000	-	-	-	3,700	43,000	33,543

From LCP- PM & SOx look strange..

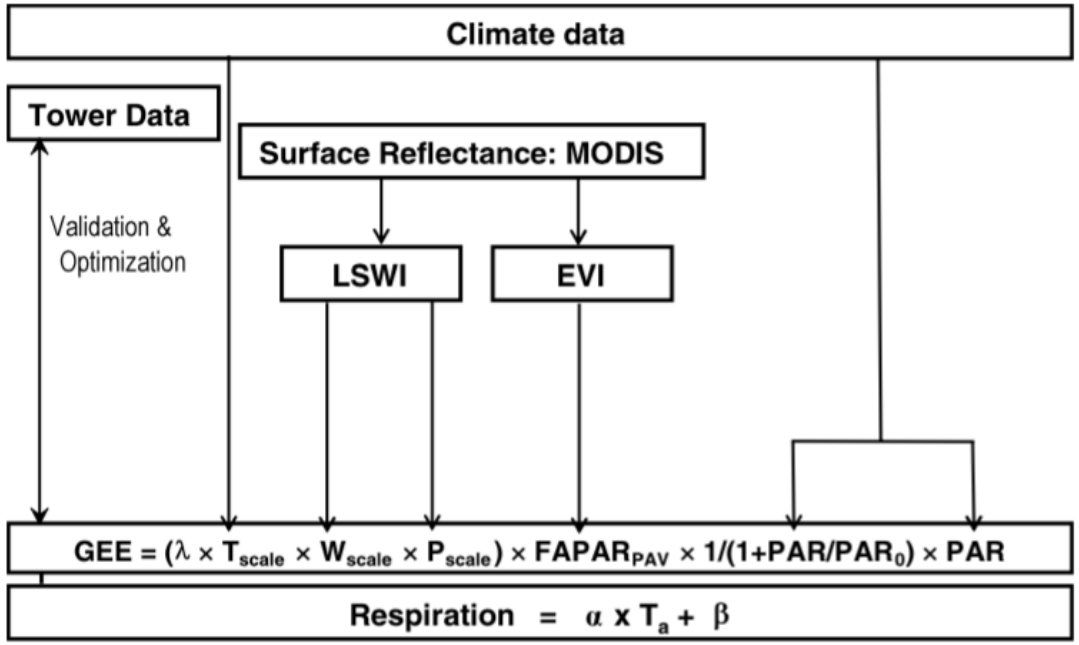
After gapfilling using LCP
But this is only possible for CO2, NOx, PM10 (dust) and SOx (SO2)

Same facility: Amercoeur #2 in 2009 closed # 3 in 2009 started

BIOSPHERE FLUXES

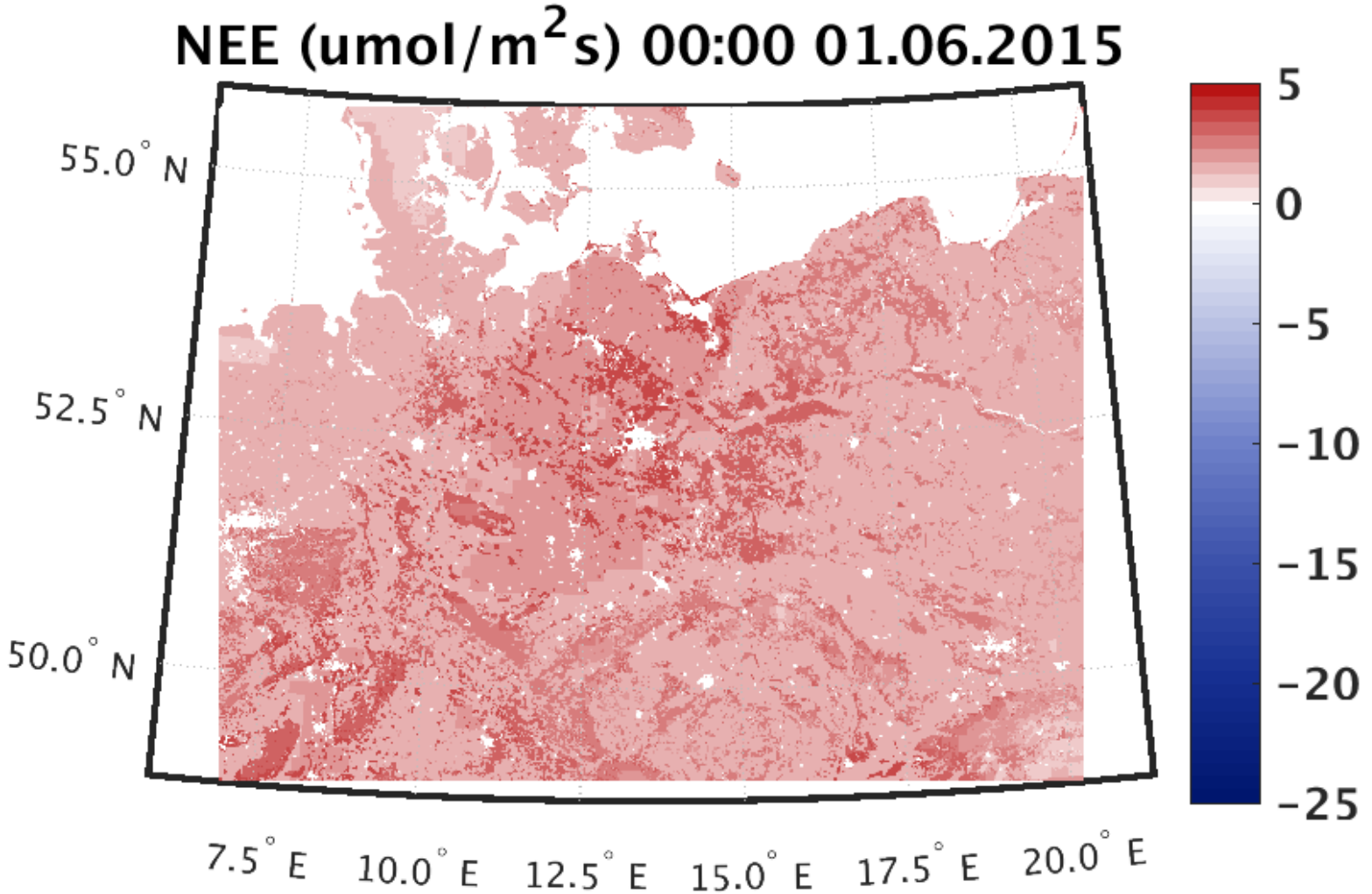
For use in WP2 and WP4

- Based on VPRM (Mahadevan et al., 2008), the Vegetation, Photosynthesis and Respiration Model
  - Uses MODIS 8-day reflectances at high resolution to produce indices EVI and LSWI
  - Requires meteorological input of temperature and shortwave radiation
  - Model parameters tuned to match flux tower measurements



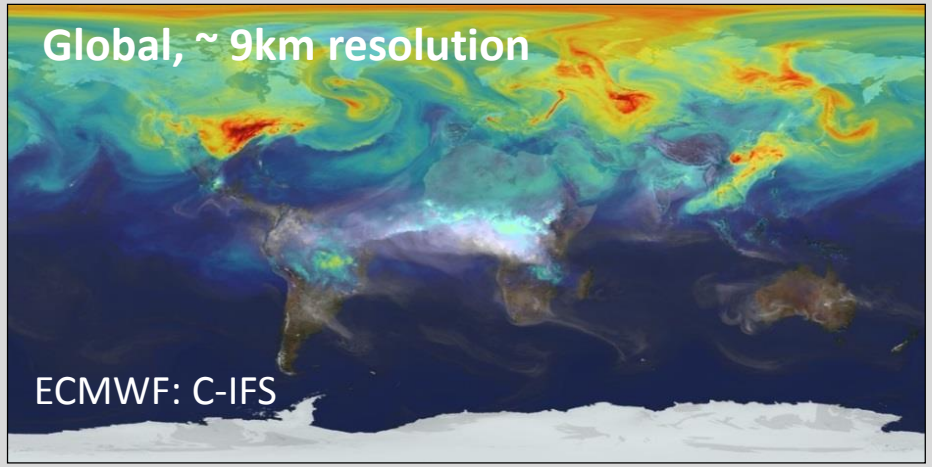
VPRM FLUXES

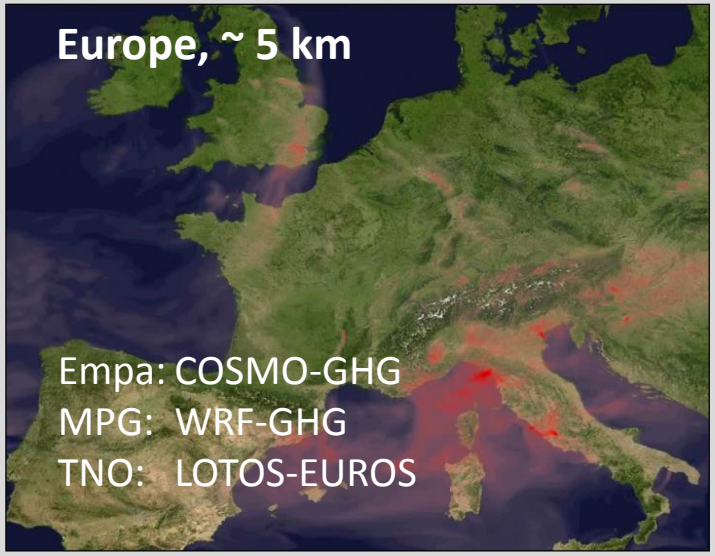
- Routinely produced at ~10 km, hourly resolution for all of Europe
- 1-km hourly fluxes already prepared for region around Berlin (at right)
- To be extended to full European domain for 2015
- Should be available in March

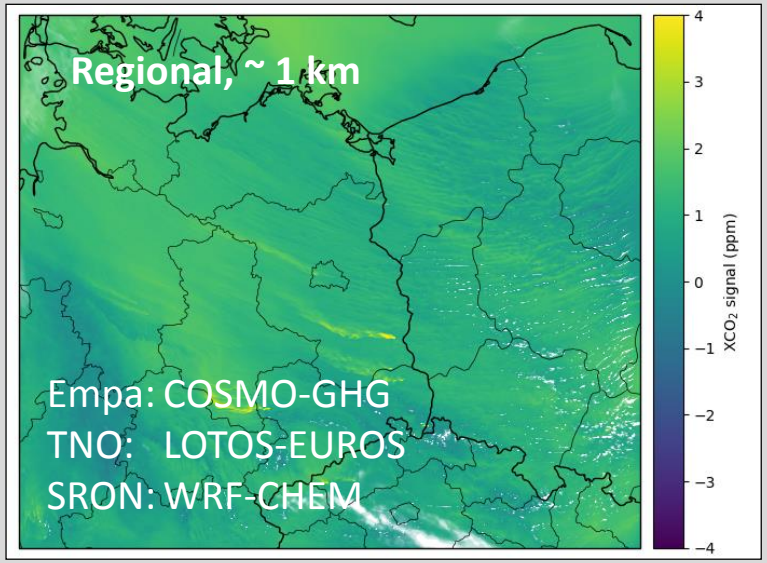


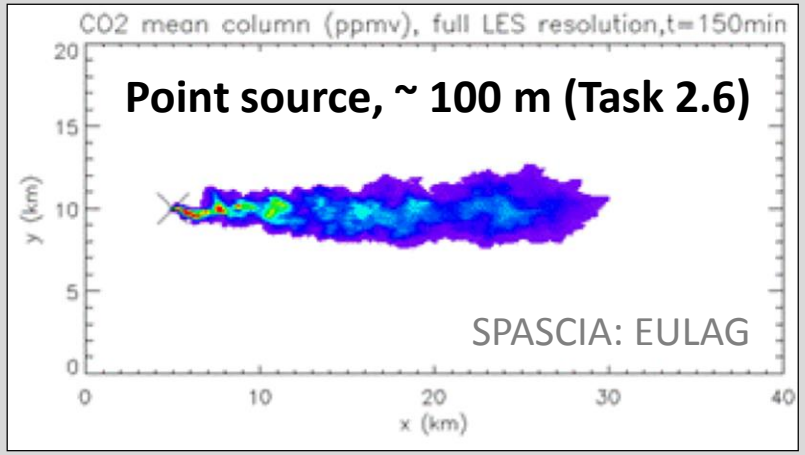
Task 2.3
Nature runs

- Global to regional to point source scale
- Smaller scales nested into larger scales
- Complete year 2015, emission scenarios for 2015 and 2030
- 2 global runs by ECMWF (Tier 1 & Tier 2)
- Simulations with passive CO_2 and CO tracers
- Full chemistry simulations by TNO for Europe and Beijing









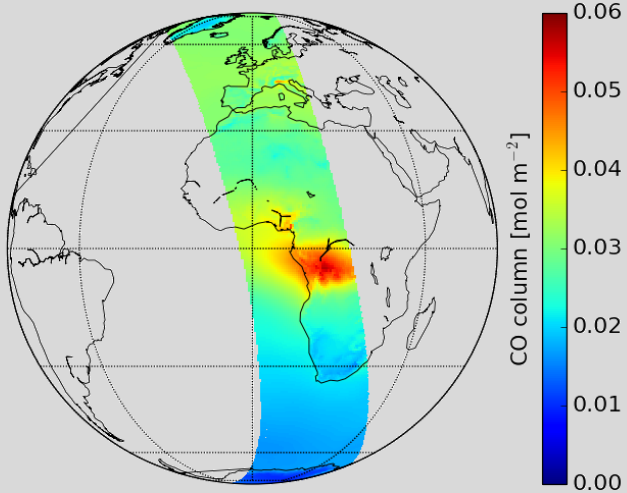
Task 2.4 Synthetic satellite observations

Generation of synthetic satellite observations (lead DLR)

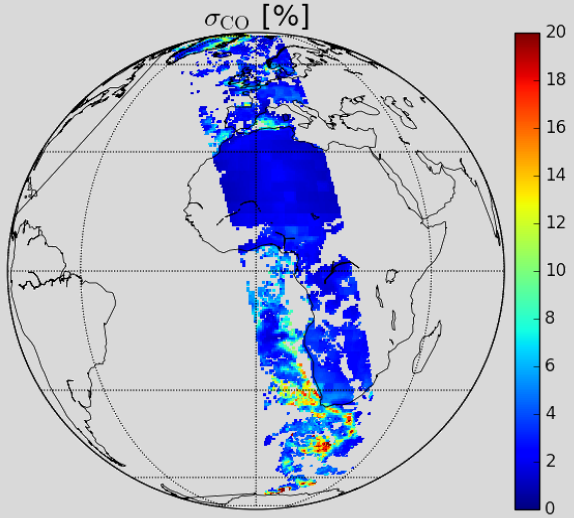
- SRON orbit simulator
- Sampling of model fields (global to regional) along simulated orbits
- Simple error parameterization for random and systematic errors
- More advanced/realistic XCO_2 retrieval errors including spatiotemporal error correlations, based on retrieval simulations for **subset** of nature runs

Example of orbit simulations for CO (J. Landgraf, SRON)

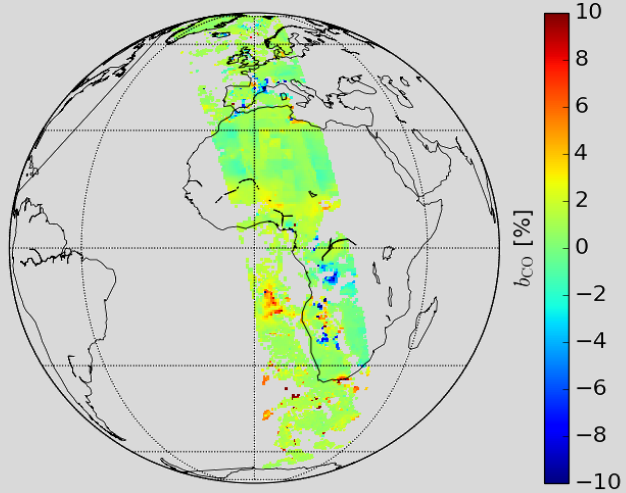
CO column



Precision



Systematic error



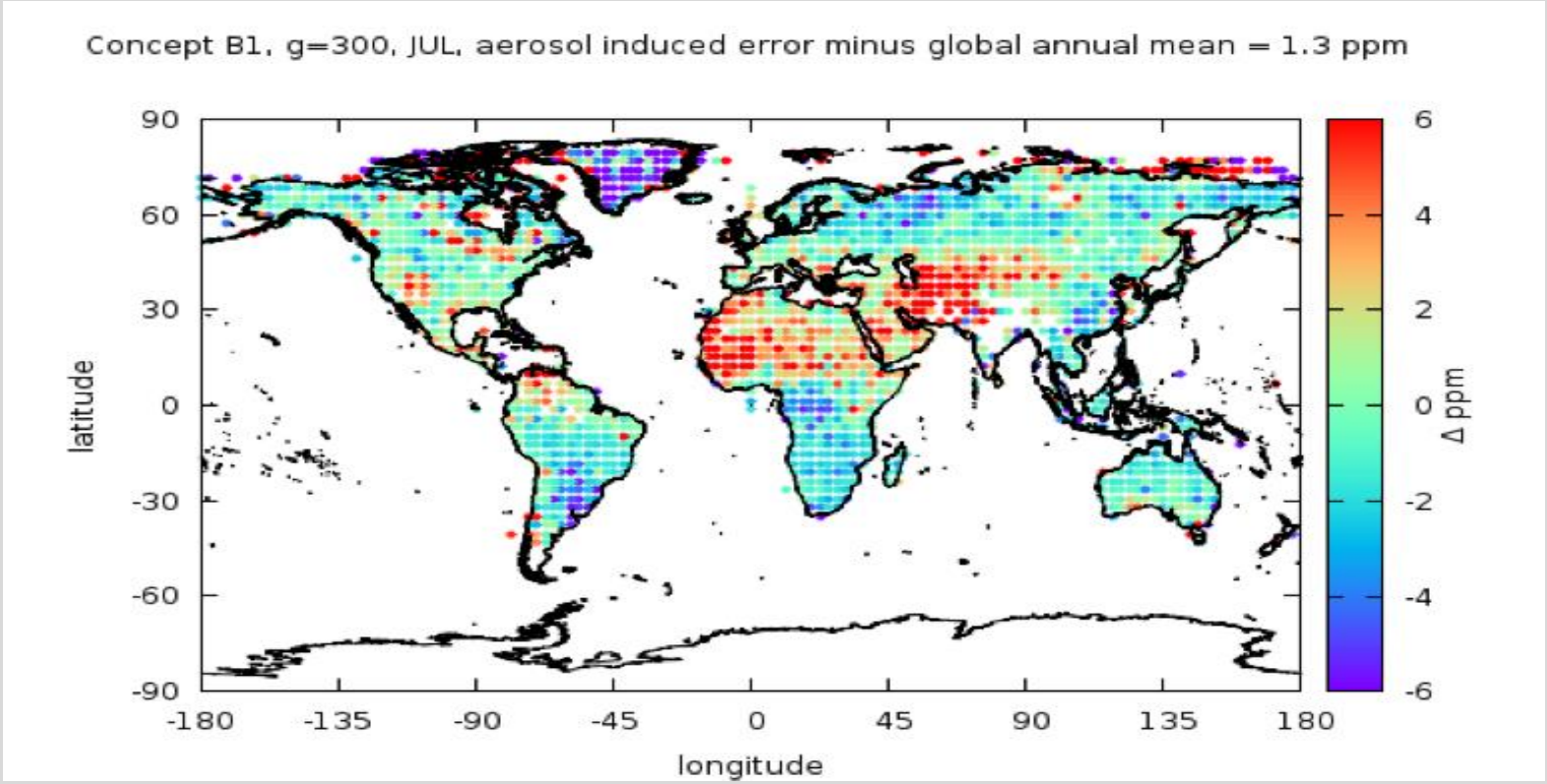
Task 2.5 Impact of aerosols

Impact of aerosols on XCO_2 (SRON)

- Investigate systematic XCO_2 errors in city plumes due to aerosols
- Regional WRF-Chem simulations of aerosols and CO_2 over Berlin and Beijing
- OSSEs to investigate impact of errors on inversion of city emissions

Result from ESA study on spectral sizing led by SRON

Aerosol induced error on XCO_2 using the CarbonSat low resolution measurements ensemble (provided by Butz et al, DLR)

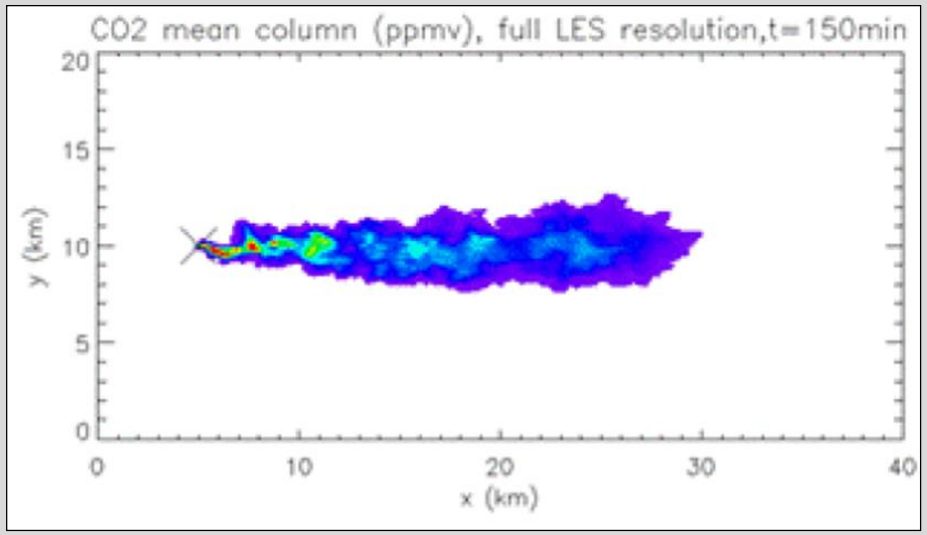


Task 2.6 Power plant plumes (T2.6)

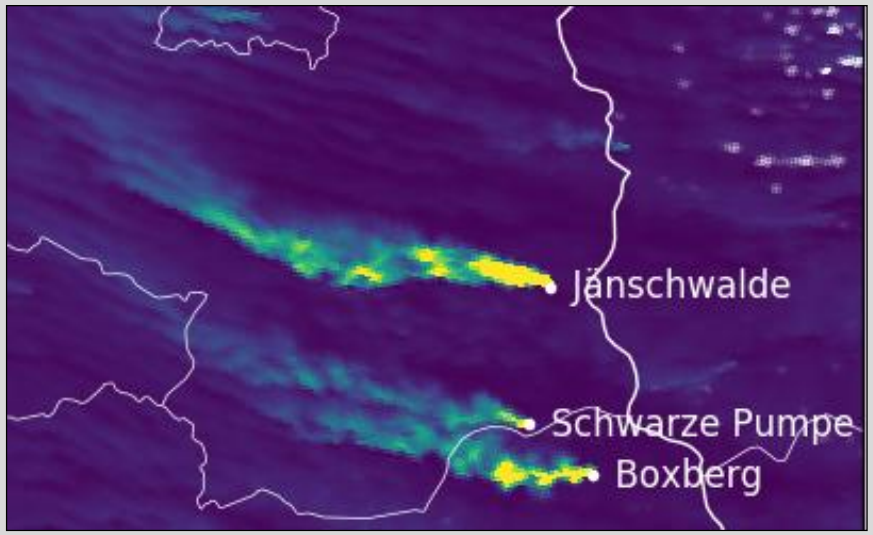
Simulation of XCO_2 in power plant plumes (SPASCIA)

- High resolution (100 m) LES simulations of power plant plume
- Representative weather situations with realistic meteo profiles
- Comparison with mesoscale simulations (COSMO-GHG)
- Investigate capability of recovering emissions from XCO_2 observations with imaging satellite with 2 km x 2 km pixels

EULAG LES simulation (100 m resolution)



COSMO-GHG simulation (1 km resolution)



WP2 outcomes and challenges

Outcomes

- Realistic nature runs at multiple scales
- Emission inventories and natural fluxes improved with respect to resolution and temporal variability
- Synthetic satellite observations with realistic error characteristics
- Impact of systematic errors due to aerosols on retrieval and on city plume emission estimation
- Requirements for observations of power plant plumes and improved characterization of representation error

Challenges

- Extensive computational resources required (CPU time and data storage)
- Timely provision of input data (IC/BC, emissions, biospheric fluxes) for simulations
- Dependency of simulations at smaller scales on those at larger scales
- Co-ordination of input and output data and formats (both within WP and across WPs)

Questions for WP2 breakout session

- Table of model simulations: Clear for global and European domain, less clear for Berlin and Beijing and point source simulations
- Task 2.5 (impact of aerosols): can we simulate periods in 2015 for Berlin?
- Emission data preparation, especially temporal and vertical emission profiles
- Initial and boundary conditions for limited area domains: required input (meteo, tracers, relaxation strategy
- Simulation of dry versus moist air mixing ratios: what is best approach?
- Minimal set of tracers in each domain
- Setup of full chemistry simulations by TNO for Europe, Berlin and Beijing
- Model output: meteo and tracer variables, formats, units, grids
- Aerosol fields for estimating systematic uncertainties in synthetic satellite data Global fields from ECWMF, European/Berlin/Beijing fields from TNO?
- Synergies with other WPs?

CO_2 Human Emissions

Dominik Brunner
Empa, Switzerland
05/02/2018