Co-ordinated by ECMWF

CO2 Human Emissions

WP3 OVERVIEW

Coordinating Efforts on Uncertainty trade-off for fossil fuel emissions

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JRC / Lund University
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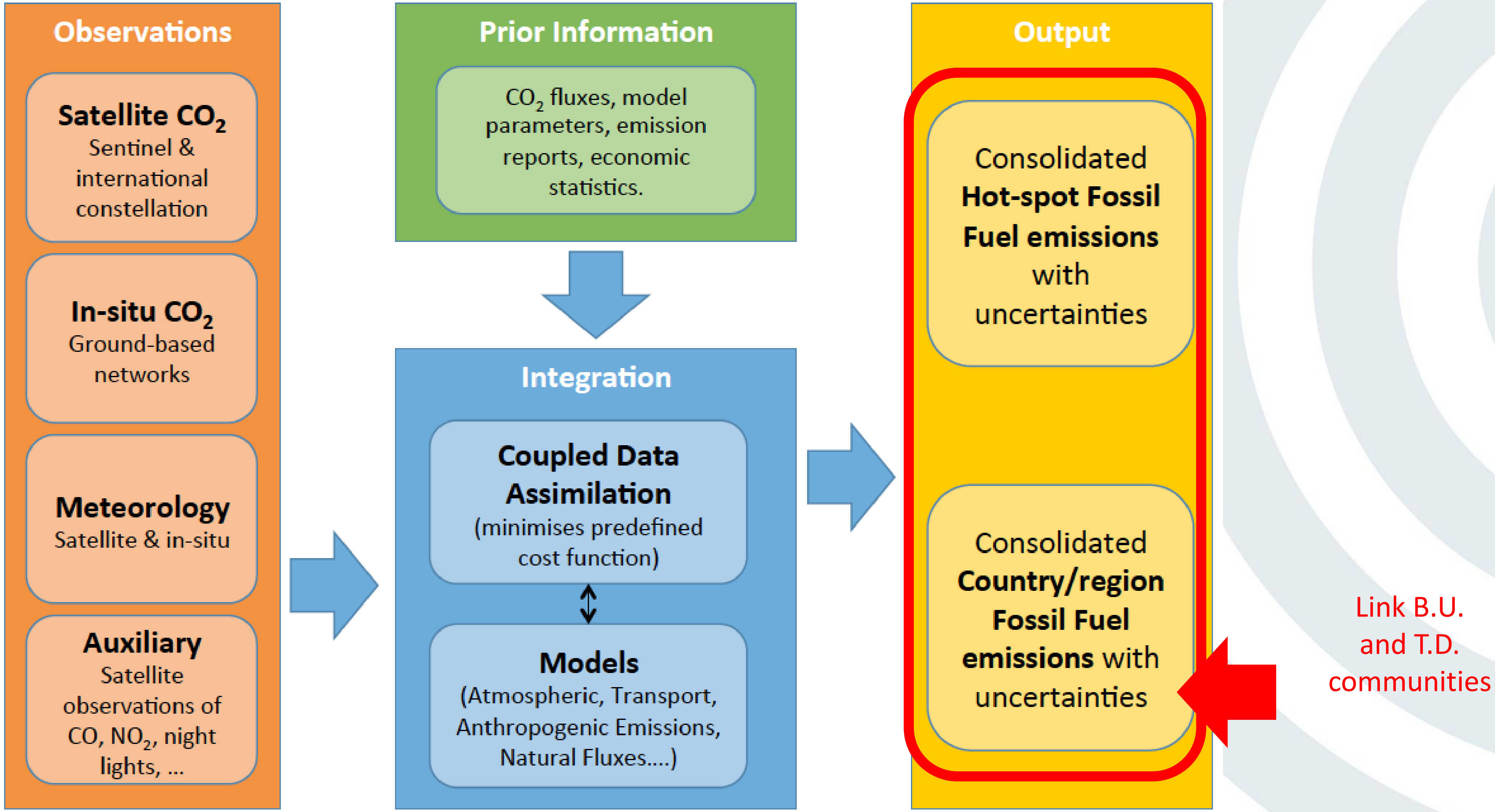
CHE WP3: Rationale

WP3: Uncertainty trade-off for fossil fuel emissions

- From: H2020-CSA-EO3 call: "*The monitoring of anthropogenic emissions from space-borne sensors involves inverse transport modelling methods together with source and sink process models that have intrinsic limits regarding accuracies... It is essential to assess these…, so that the emission uncertainties associated with ensemble CO2 observations can be estimated … The potential synergies between actual CO2 emissions estimates based on physical measurements and those derived from inventories and statistics should be addressed* as well *… "*

- From: 2015 CO2 monitoring report: "*The inversion of fossil CO2 emissions using atmospheric data will require … also a very good representation of regional atmospheric transport processes in atmospheric models, and a more detailed provision of gridded emissions* data to be used as a priori *... The approach recommended is a Fossil Fuel Data Assimilation System (FFDAS) that will combine atmospheric observations with other data-streams such as emission information and proxy data, and will provide optimized emissions maps with their uncertainty. We recommend that detailed end-to-end simulations of the performances of an operational observation system of fossil CO2 emissions should be carried out for different satellite and in-situ networks configurations.*"

CHE WP3: Background Report



From: 2017 CO2 MTFB report

Pinty et al. (2017) An Operational Anthropogenic CO2 Emissions Monitoring & Verification Support capacity - Baseline Requirements, Model Components and Functional Architecture, doi: 10.2760/08644, European Commission Joint Research Centre, EUR 28736 EN

CHE WP3: Overview

Uncertainty trade-off for fossil fuel emissions: Objectives

- Provide high-resolution (~km, hourly) prior biogenic fluxes with quantified uncertainties based on upscaling of eddy covariance flux measurements
- Provide prior gridded anthropogenic emissions and their uncertainties and per sector
- Evaluate the current status and possible improvements from enhanced space-borne and in-situ observation scenarios for fossil CO2 emissions quantification based on
  OSSEs (Observation System Simulating Experiments) studies, &
  QND (Quantitative Network Design) studies, with:
  - high-resolution inverse transport modelling of CO2
  - high-resolution inverse transport modelling of CO2 and co-emitted species (NOx)
  - advanced carbon cycle-fossil fuel data assimilation systems

CHE WP3: Overview

Uncertainty trade-off for fossil fuel emissions: 5 Tasks

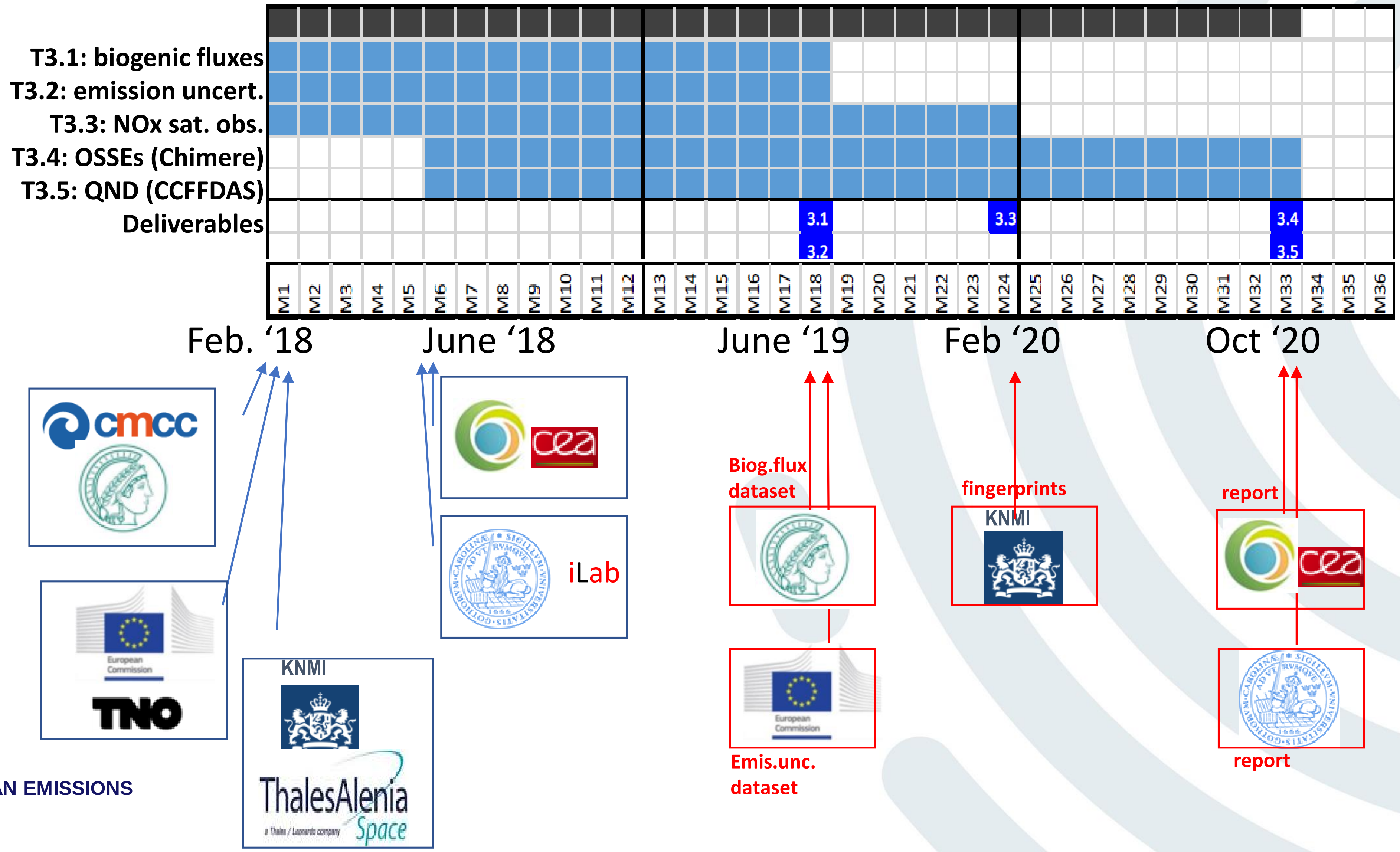
- T3.1: Estimate biogenic fluxes and associated uncertainties from independent observations (MPG-BGC, by June 2019)
- T3.2: Provide emission uncertainties & correlations from inventories and statistics – for global emission gridmaps of EDGAR (JRC, by June 2019)
- T3.3: Explore the role of satellite observations of NOx for estimation of fossil CO2 emissions (KNMI, by February 2020)
- T3.4: Conduct OSSEs with an inverse transport modelling system to establish inversion strategy (CEA-LSCE, by October 2020, will start June 2018)
- T3.5: Perform QND experiments with advanced data assimilation systems (CC-FF-DAS) to establish inversion strategy (LUND/iLab, by October 2020 will start June 2018)

CHE WP3: Overview

Uncertainty trade-off for fossil fuel emissions: 5 Deliverables

- D3.1: Net biospheric CO2 fluxes (~km, hourly) with quantified uncertainties estimated from independent in-situ network of eddy covariance measurements
- D3.2: Fossil CO2 emissions per sector with quantified uncertainties for 0.1˚ x 0.1˚ global gridmaps and hourly profiles (uncertainty gridmaps)
- D3.3: Fingerprints of fossil CO2 sources with uncertainties based on observations of NOx emissions
- D3.4: Report on a set of inversion strategies blending bottom-up and top-down approaches for estimating fossil CO2 emissions (based on OSSEs)
- D3.5: Evaluation report (in terms of posterior uncertainties) of the current status and possible improvements from enhanced space-borne (CO2 and NOx) and in-situ observation scenarios for fossil CO2 emissions quantification based on OSSEs and QND studies

CHE WP3: Schedule



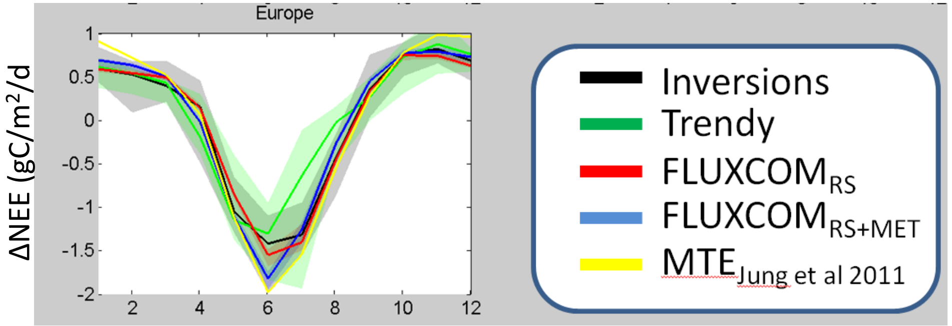
CHE WP3: Task 3.1

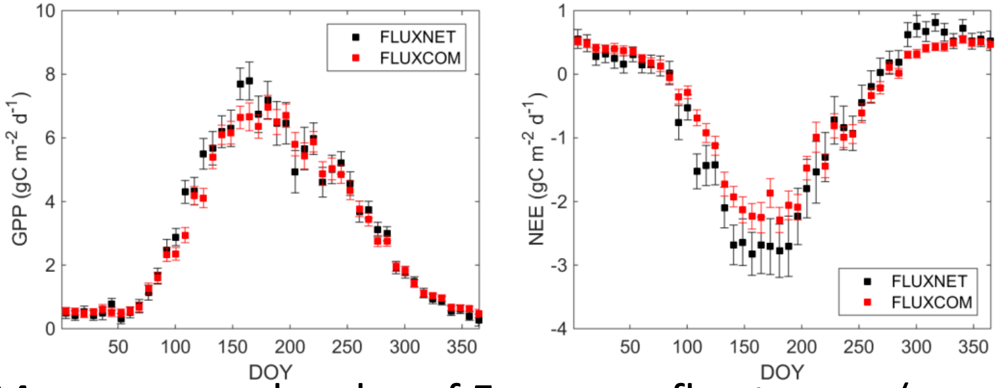
Biospheric NEE fluxes for Europe (direct land use change fluxes not included)

→ Machine learning based using flux tower, remote sensing, & reanalysis data

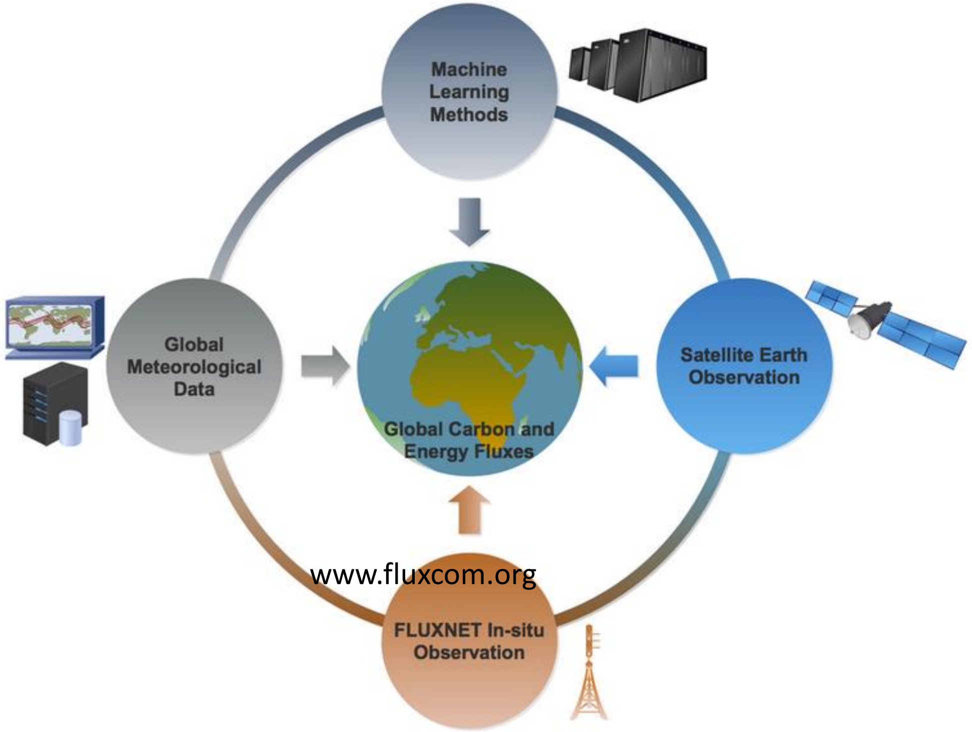
→ @ 0.1° & hourly temporal resolution

Seasonality works well (FLUXCOM results)





Mean seasonal cycles of European flux towers (cross-validated)

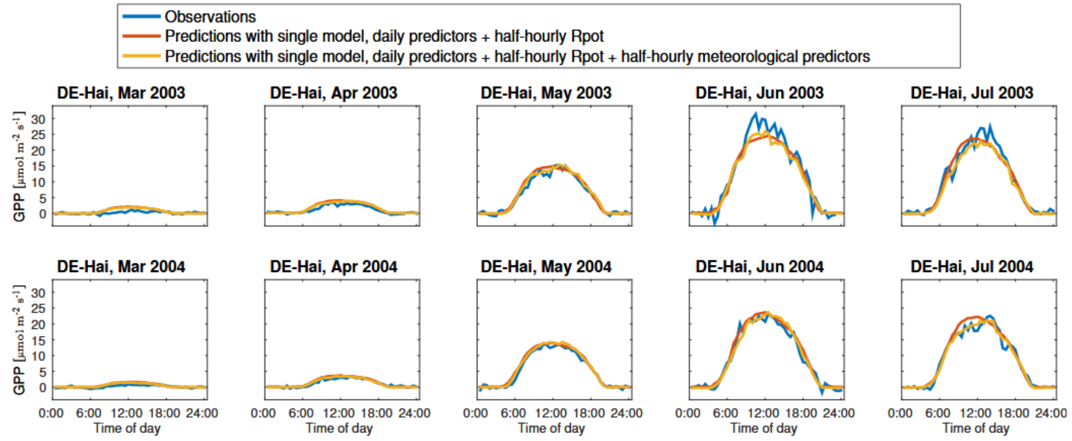


www.fluxcom.org

Max Planck Institute for Biogeochemistry

CHE WP3: Task 3.1

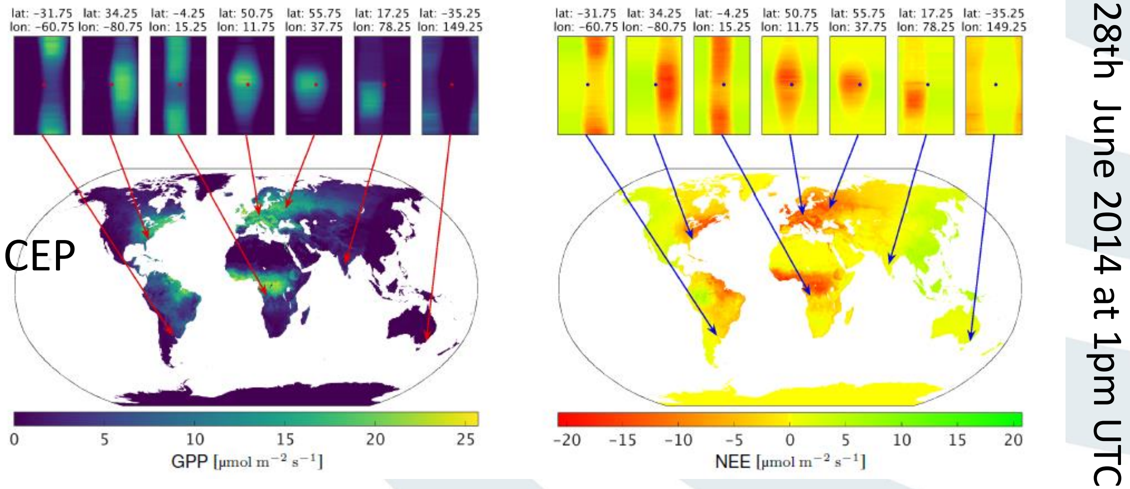
Proof of concept“ and 1st prototype product with diurnal variations (H2020 BACI) @0.5° & half-hourly



Bodesheim et al. 2018 (ESSD)

- → Uses daily meteorology, subdaily potential radiation, mean seasonal cycles of land surface remote sensing
- → Based on FLUXNET La Thuile (data until 2006)
- → Works well for mean diurnal cycles

Global products based on CRUNCEP



CO_2 HUMAN EMISSIONS

Max Planck Institute for Biogeochemistry

CHE WP3: Task 3.1

Strategy for CHE (Martin Jung & Sophia Walther @MPI-BGC)

- version 0 based on Bodesheim et al. 2018
  - Incorporating subdaily weather with hourly ERA-5 reanalysis
  - Available by end of 2018
- Building a new approach for CHE (a lot of work!)
  - Updated and improved biosphere flux over the course of the project
  - Using recent European flux data (collaboration with Dario Papale, getting the flux data and in shape is tedious and time consuming!)
  - Various advancements wrt to methods and ingested data
  - First products (hopefully) by end of 2019

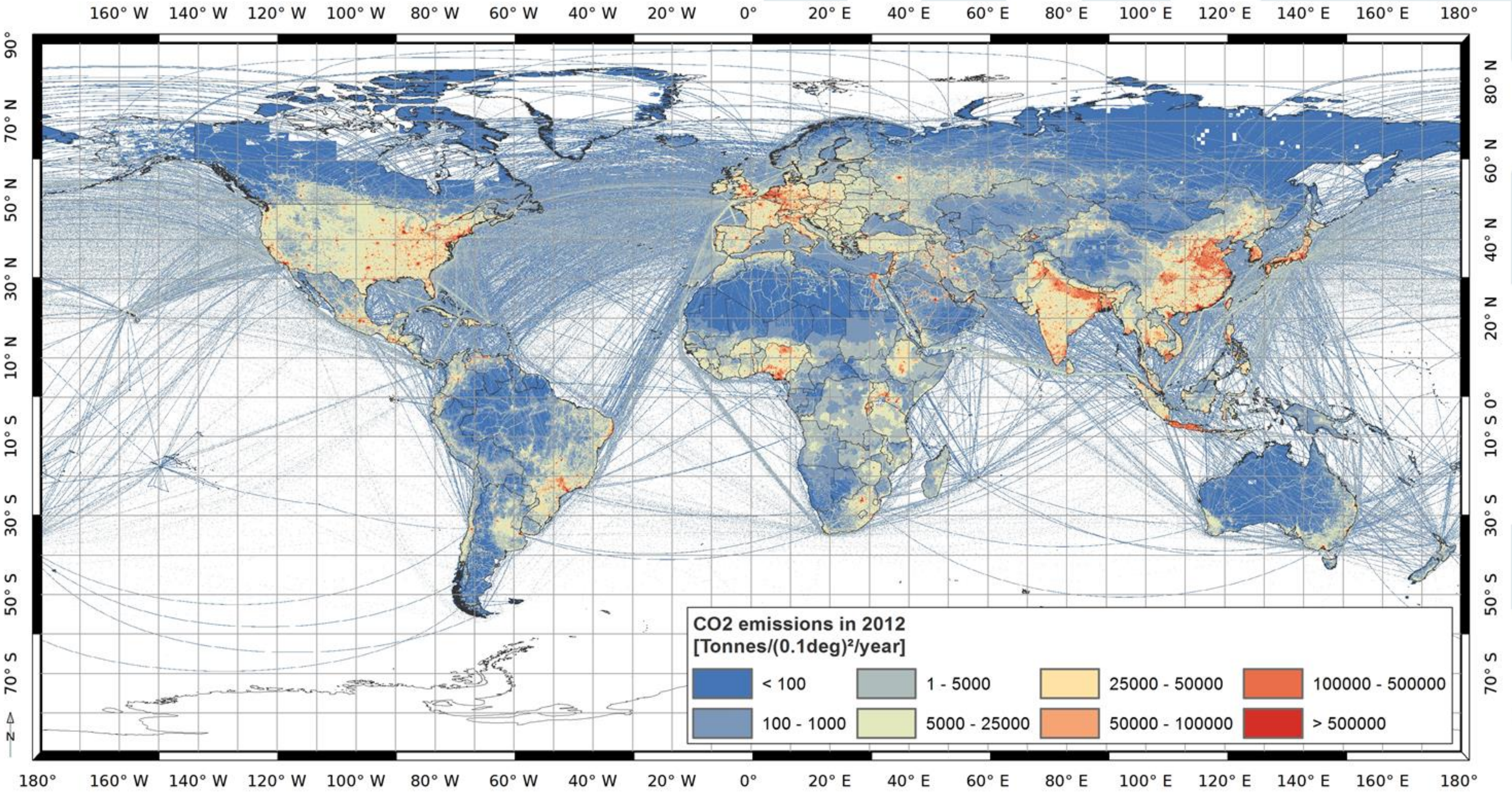
CHE WP3: Task 3.1

- Discussion on requirements and feasibility needed
  - Fixing domain, spatial, temporal resolution
  - Aspects of uncertainty characterisation
  - Requirements on being e.g. gap-free? quasi operational? transferable to other regions? Consistency of meteo forcing with other modelling activities?
- Sophia Walther (PostDoc) starting in March

CHE WP3: Task 3.2

EDGAR CO2 maps will be delivered by JRC

- Based on EDGARv4.3.2 and EDGARv4.3.2FT approach up to 2015/2016
- (end March 2018)

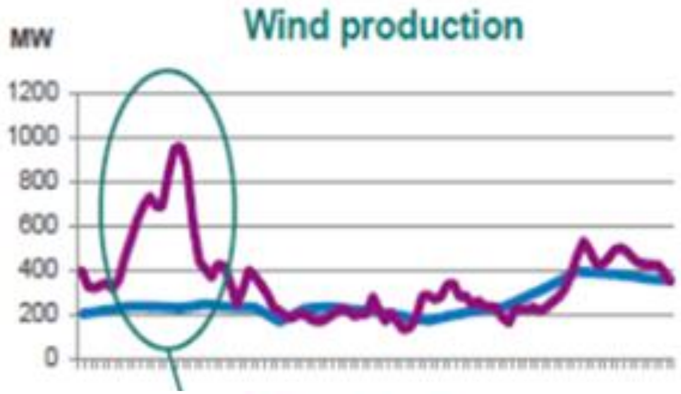


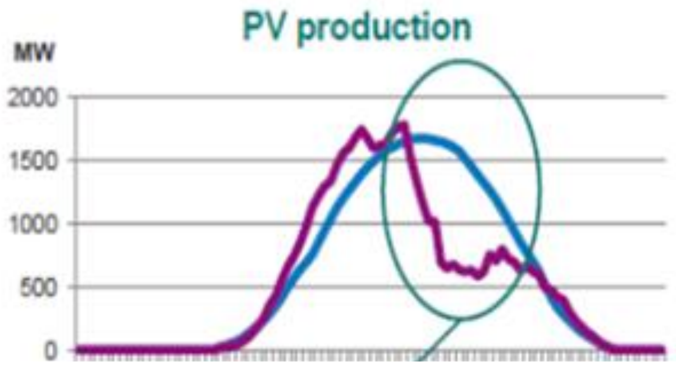
CHE WP3: Task 3.2

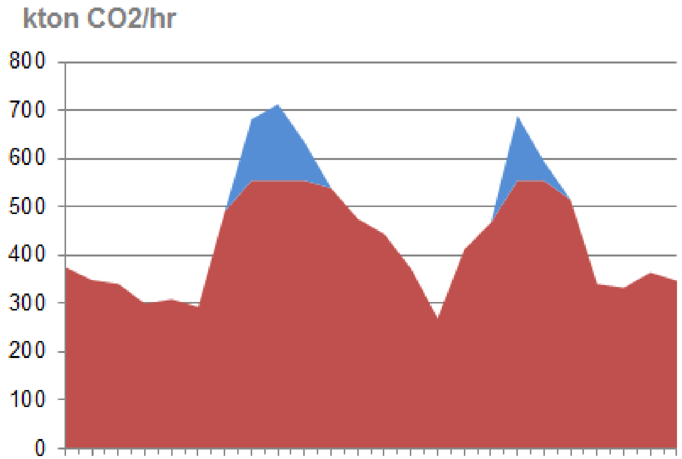
Example Belgium, Tuesday 10/06/2014

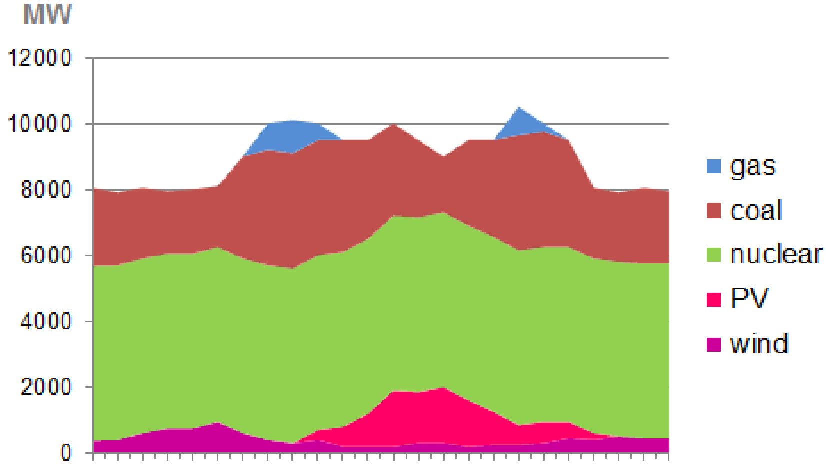
Emission uncertainties & correlations from inventories & statistics for global emission gridmaps of EDGAR

- Will be done by ECMWF
  - Started in February 2018
  - With support of JRC
- Two steps:
  - Uncertainties on the sector- & country-specific annual/monthly emission inventories
  - Representativeness of the spatial & temporal distributions
- (by March 2019)



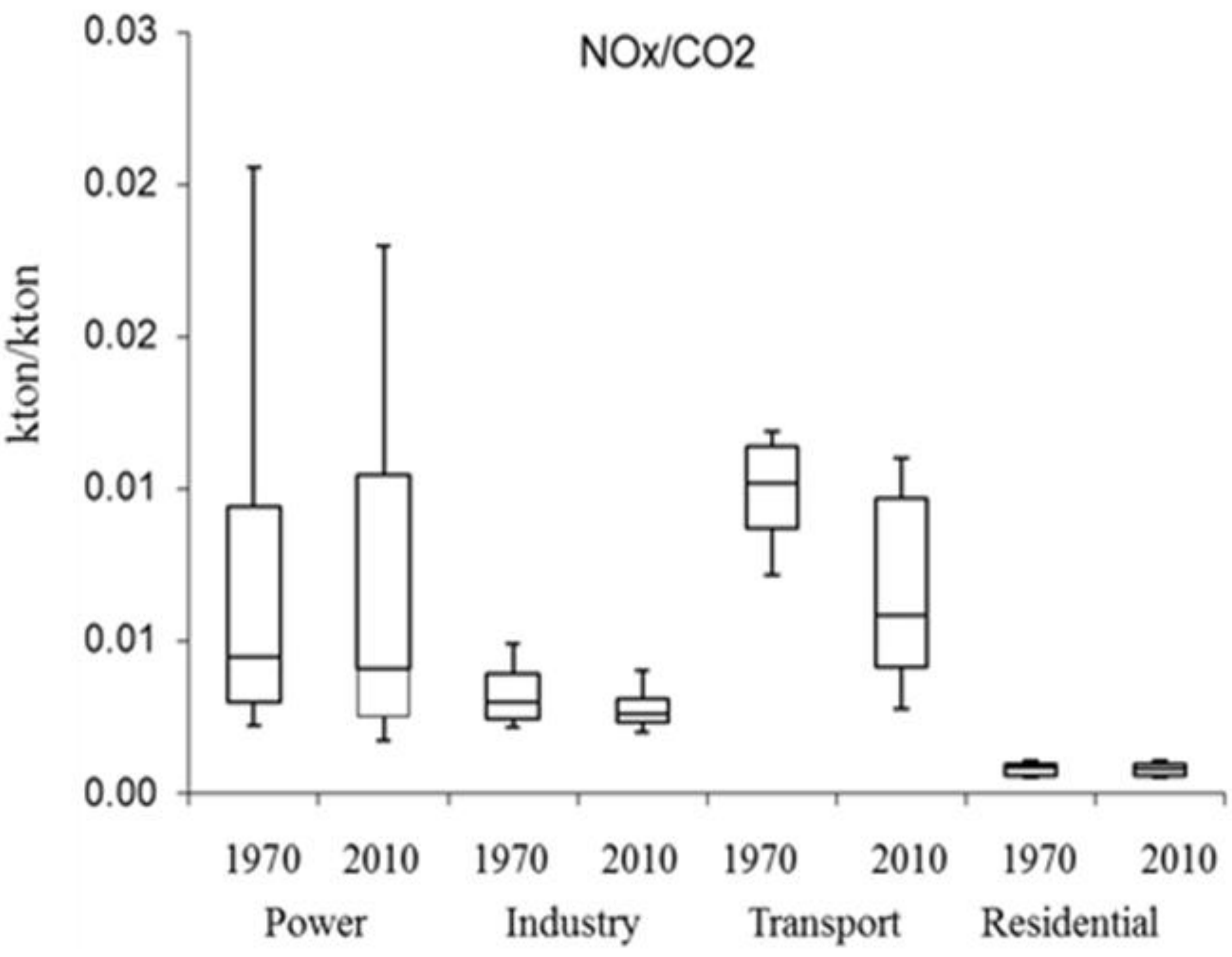


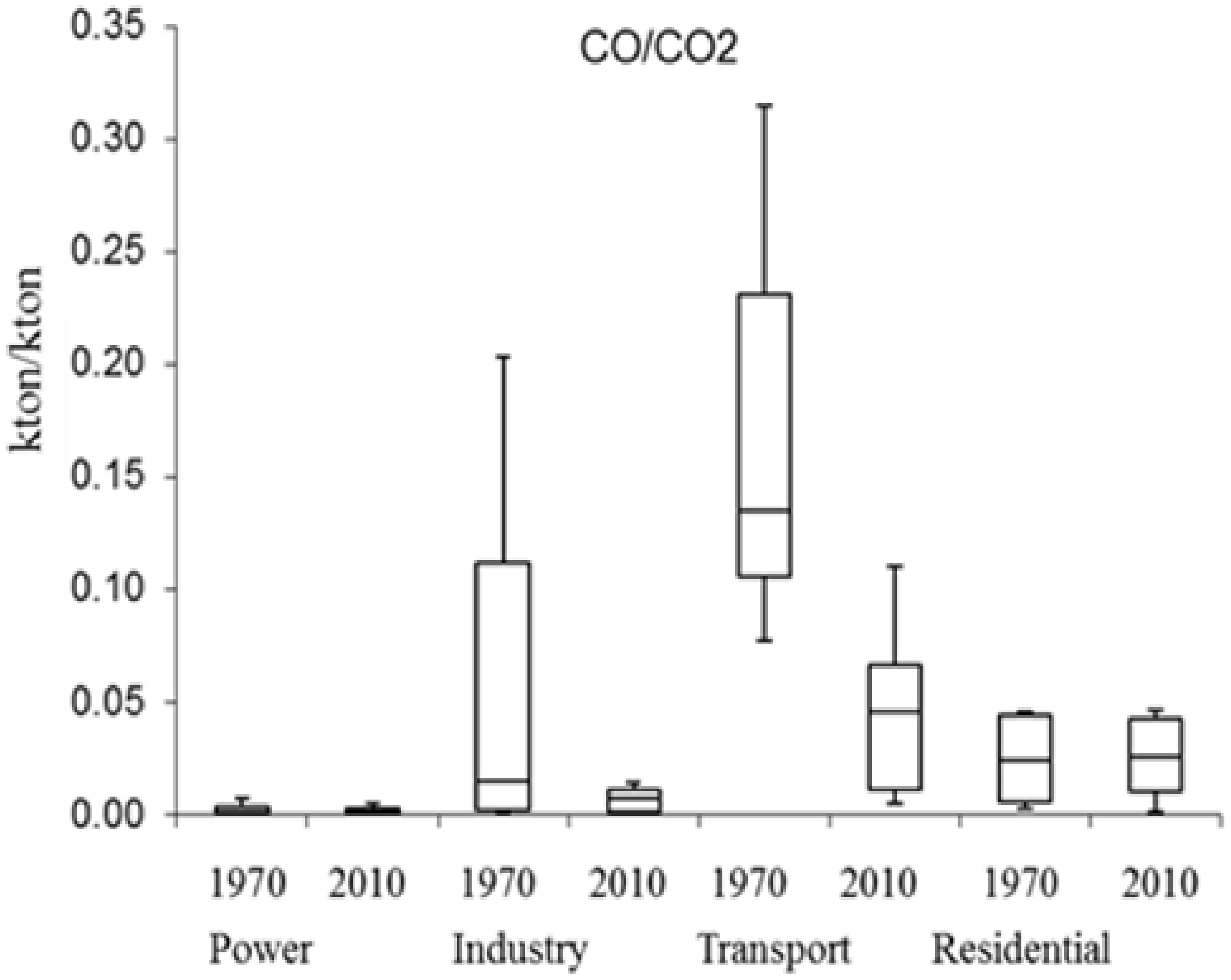




CHE WP3: Task 3.2

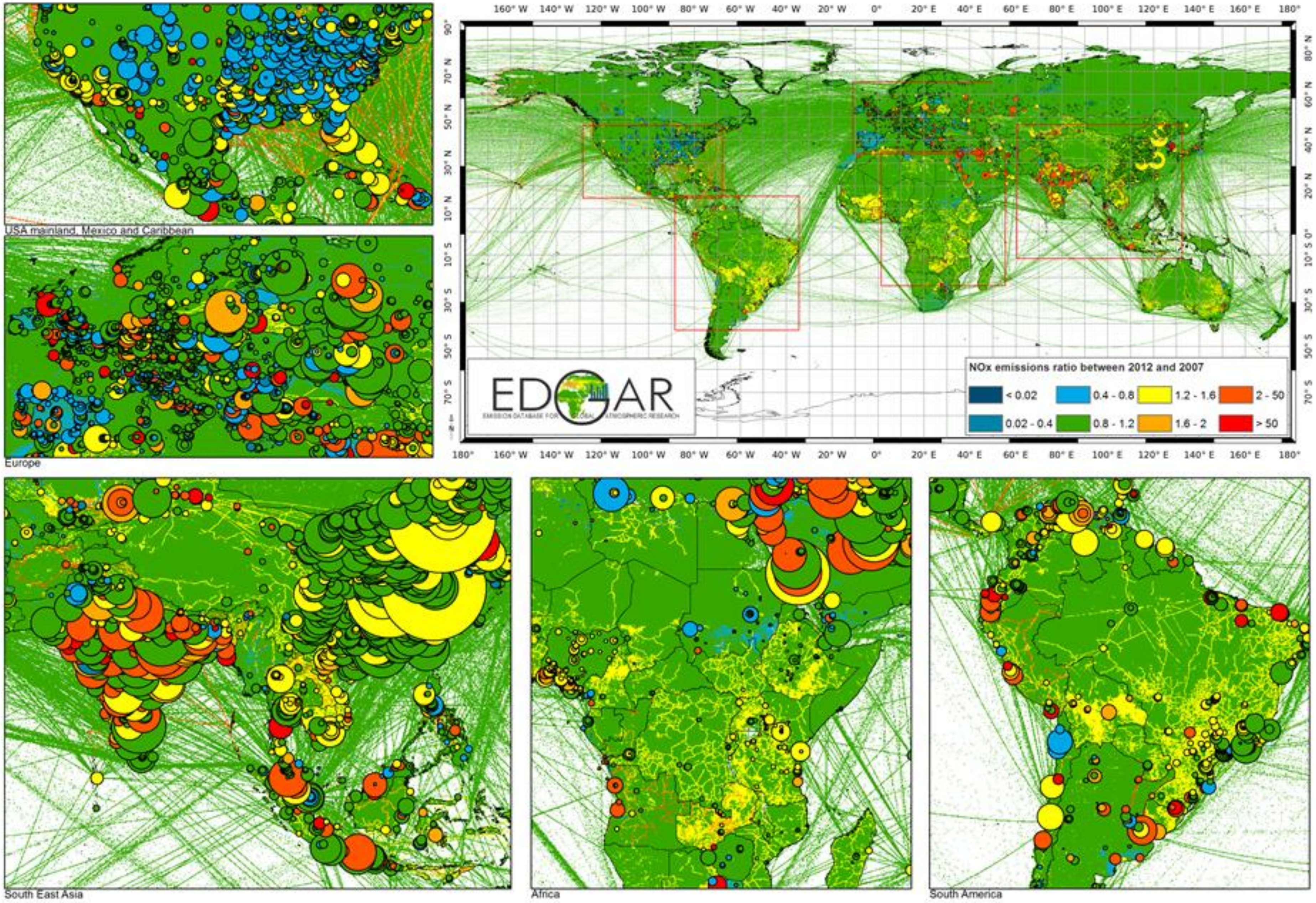
Connection with CHE WP3: Task 3.3





CHE WP3:
Task 3.2

Connection with CHE WP3: Task 3.3



CHE WP3: Task 3.3

Role of satellite observations of NOx for estimation of fossil CO2 emissions

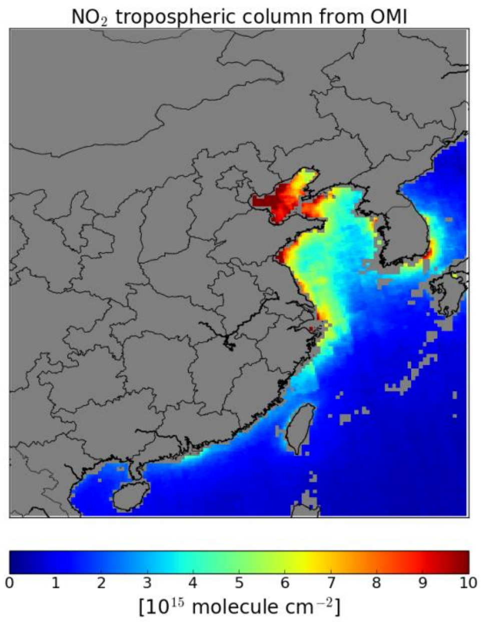
- Future capabilities of satellite observations for NO2
- DOMINO2 OMI-based NOx emissions (2007-2016)
- Reprocessing regional NOx emissions with the improved NO2 data record of the QA4ECV project (2007-2017).
- Use of EDGAR sector-specific emission ratios to associate NOx emissions with fossil CO2 sources with a focus on Europe.
- Use of EDGAR source sector and activity data to analyse uncertainties.
- 2019+ : Explore TROPOMI-based NOx emissions (2018-)

CHE WP3: Task 3.3

Example using OMI NO2 satellite data for CO2

- The derived NO_x emissions from OMI NO2 satellite observations are associated with CO_2 emissions from shipping and offshore activities in Chinese seas. Emission ratios of the STEAM model (Jalkanen, FMI) are used.

NO_2 concentrations



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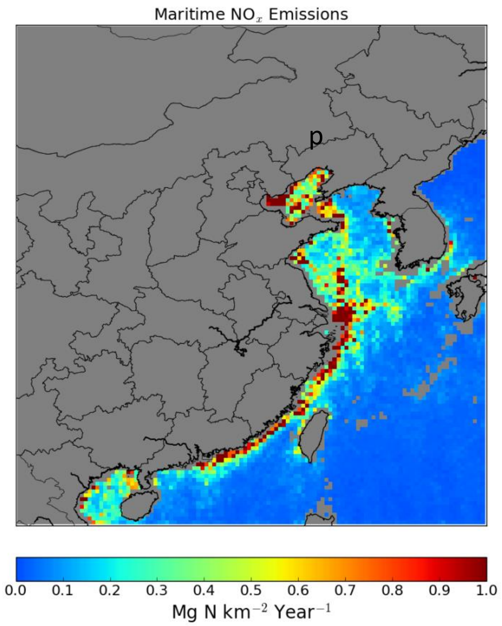
Maritime NO_2 emissions



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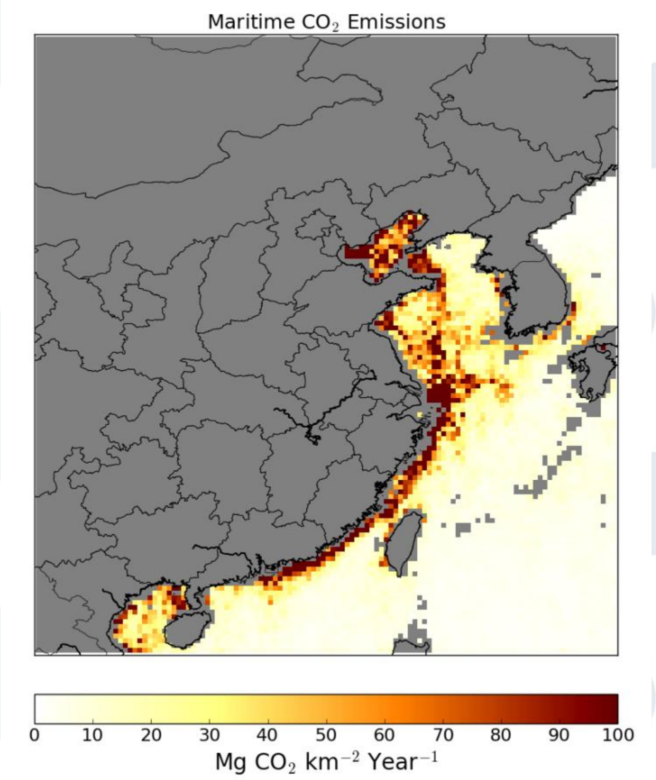
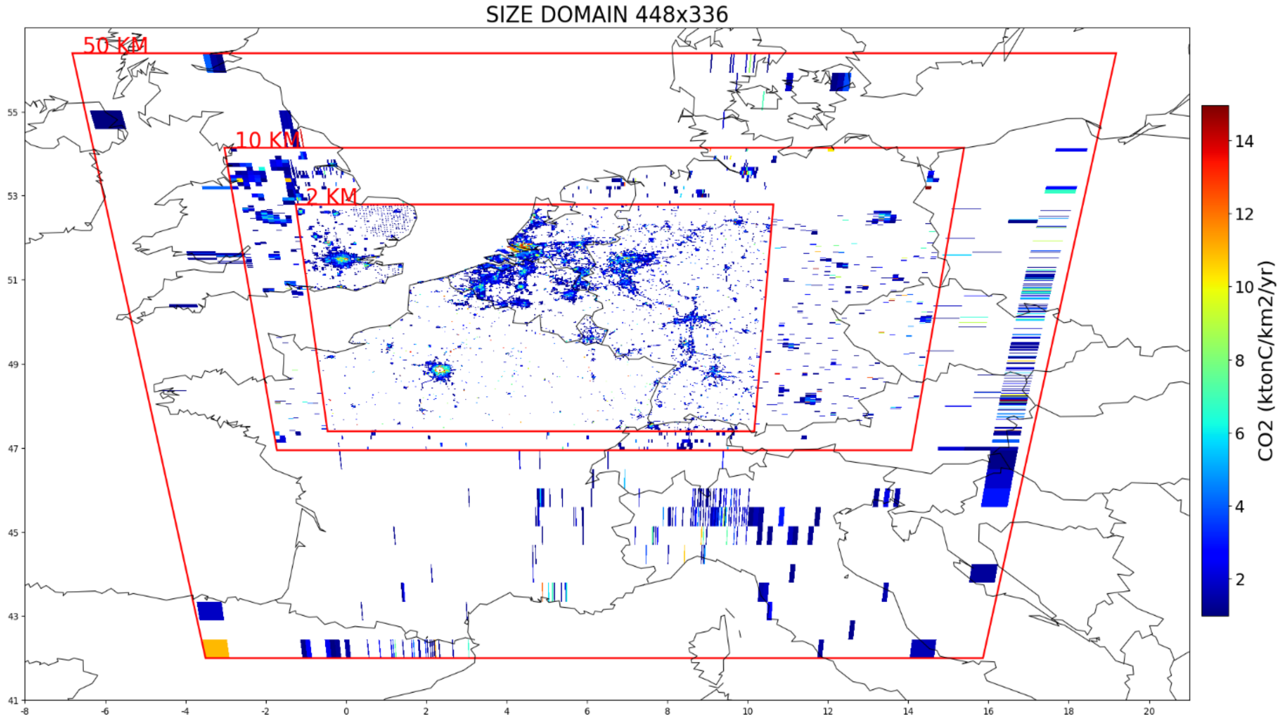


CHE WP3: Task 3.4

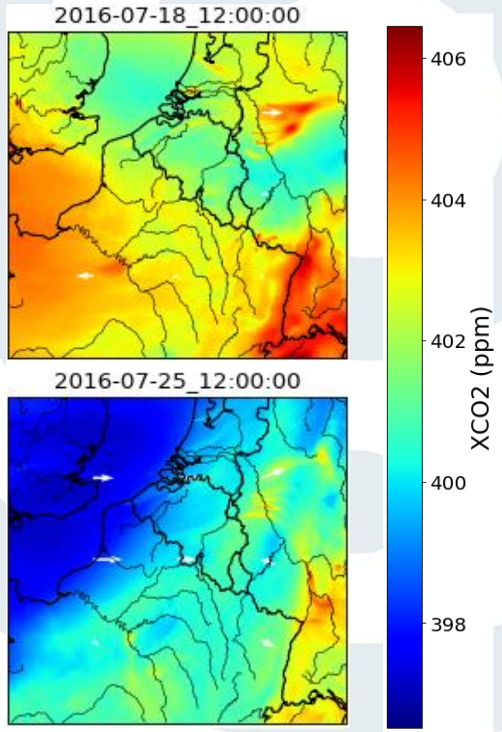
High resolution CO2 transport modelling in Western Europe — E. Potier and colleagues

- Transport configuration based on the regional CHIMERE model linking the local scales in Benelux - Northern France – Western Germany to the European scale (dvlpt: D. Santaren)
- 100-200 sources (cities & industrial sites in the HR area, regional budgets in the lower resolution part of the domain + sectorial decomposition) to be monitored individually at hourly to daily time resolution.

➢ Analytical inversion: computation of the response functions to all these sources.



The zooms in the CHIMERE;
CO2 emission map based on IER-Stuttgart products



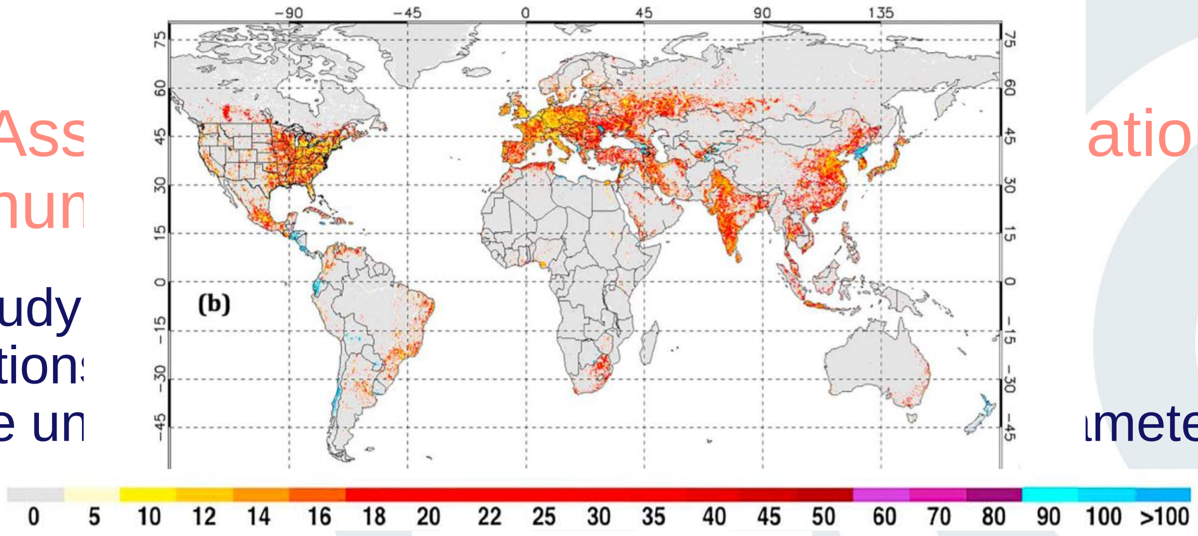
XCO2 variations in the 2 km res. domain in July at 12:00

CHE WP3: Task 3.5

Fossil Fuel Carbon Cycle Data Ass ation
in the terrestrial biosphere and hun

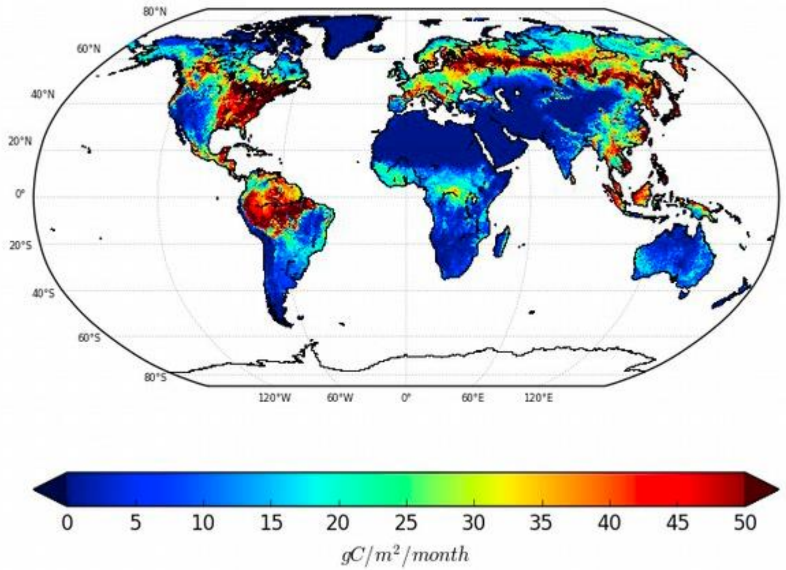
- QND (Quantitative Network Design) study
  terrestrial and socioeconomic observation
  uncertainties (QND studies investigate un ımeters
  and other quantities of interest)

Sigma fossil fuel emissions (%)

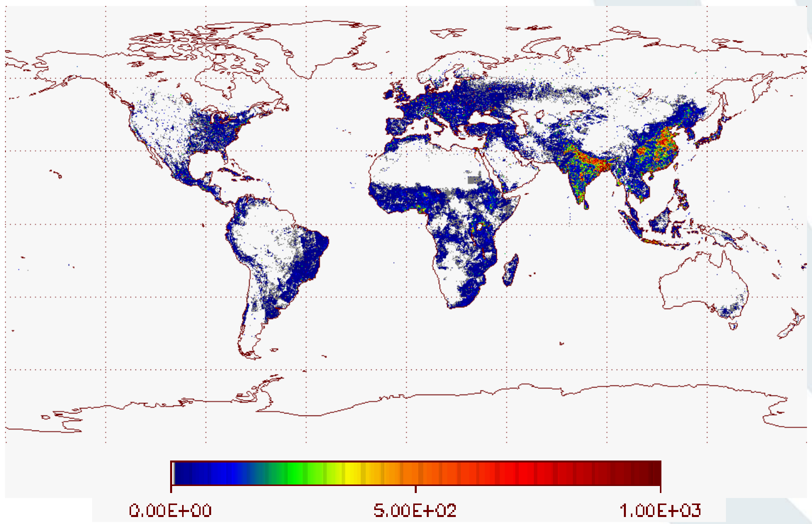


(Asefi-Najafabady et al., 2014)

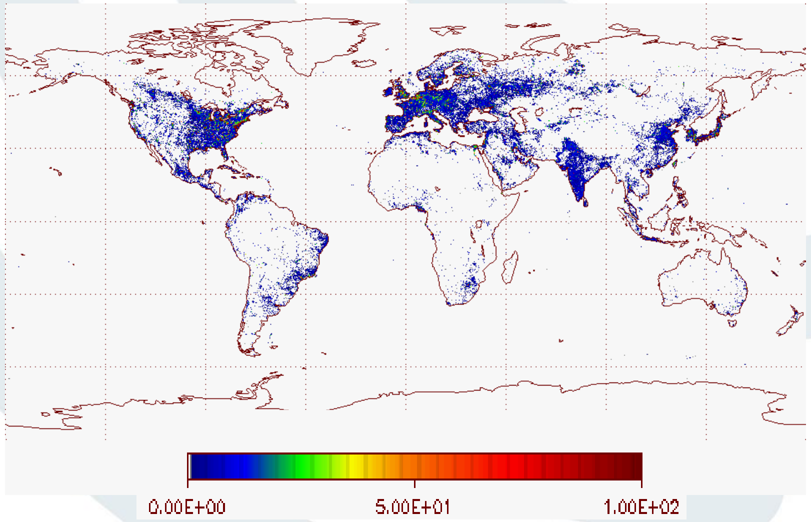
Sigma NPP (July 2010)



Population density [no. of people/m^2]



Nightlights (arbitrary units)



THANK YOU

CO2 Human Emissions