Co-ordinated by ECMWF

CoCO2
Prototype system for a Copernicus CO_2 service

WP2 PRIOR AND ANCILLARY INFORMATION
COCO2 PRESENTATION DAY

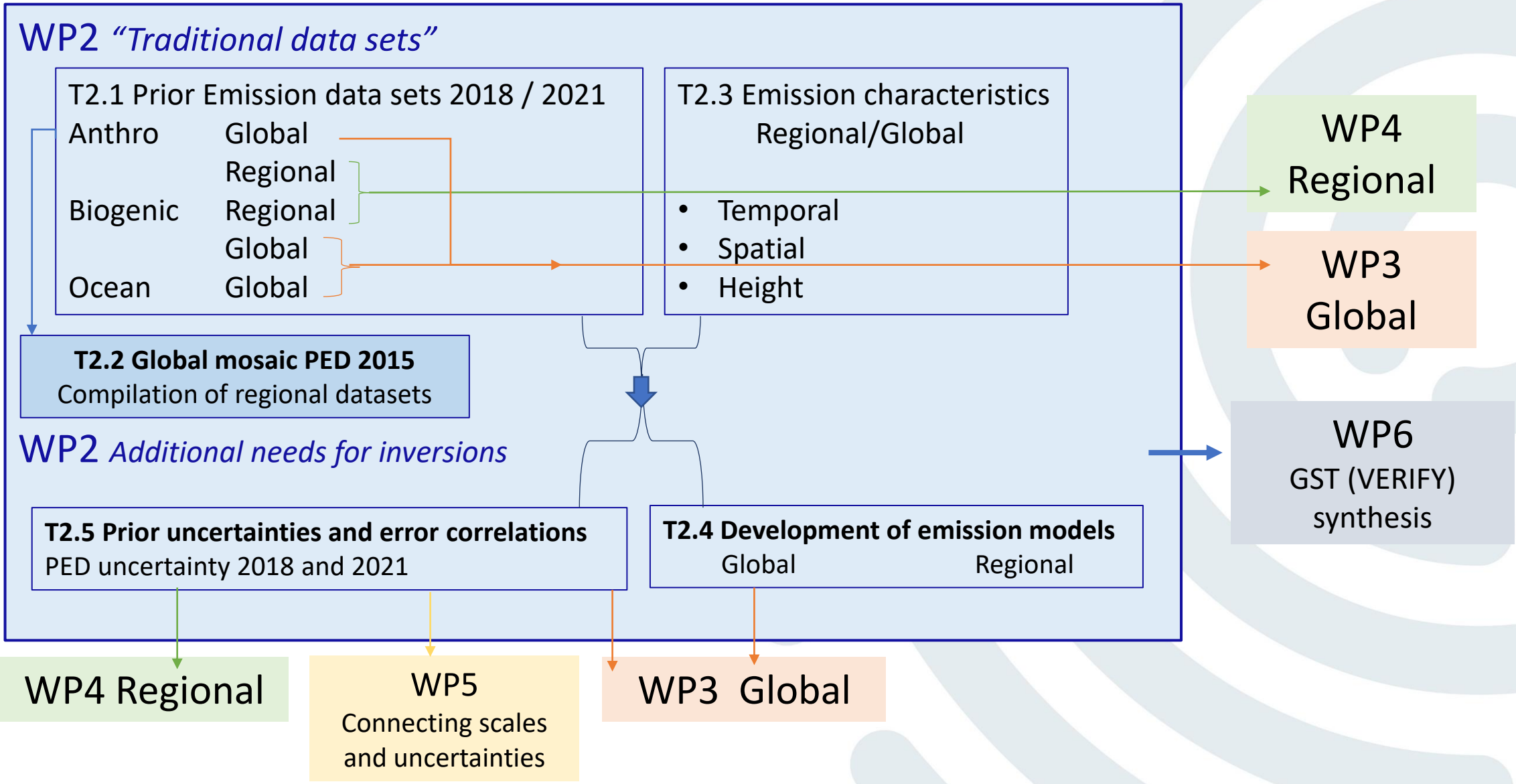
Hugo Denier van der Gon and CoCO2 WP2 team

5 December 2022

WP2 includes 48 colleagues from TNO, JRC, BSC, MPG-Jena, LSCE, Lab AERO, AGH, ICOS, LundU, UEdinburgh, CyI, iLab, ECMWF, DWD, Cicero, DLR, Mercator-ocean, VU-A'dam

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 958927.

WP2 overview and coherence



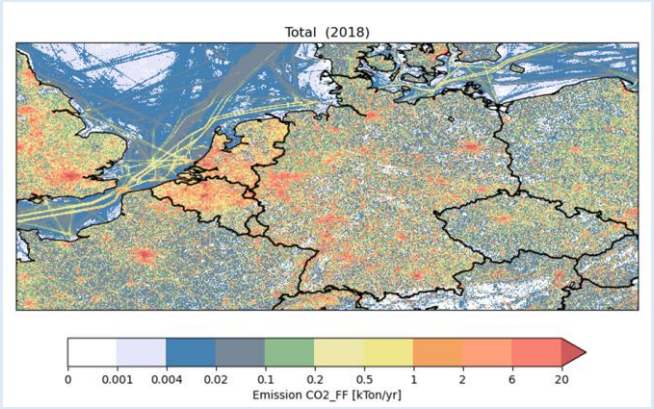
T2.1 Prior Emission data sets

- CoCO2 Year 1 -> 2018 prior dataset
- CoCO2 Year 2 -> 2021 prior dataset

Contributors:

JRC, BSC, MPG-Jena, LSCE, CNRS Lab AERO, DLR, Mercator-ocean, TNO

Report avaible on Confluence WP2 project space.

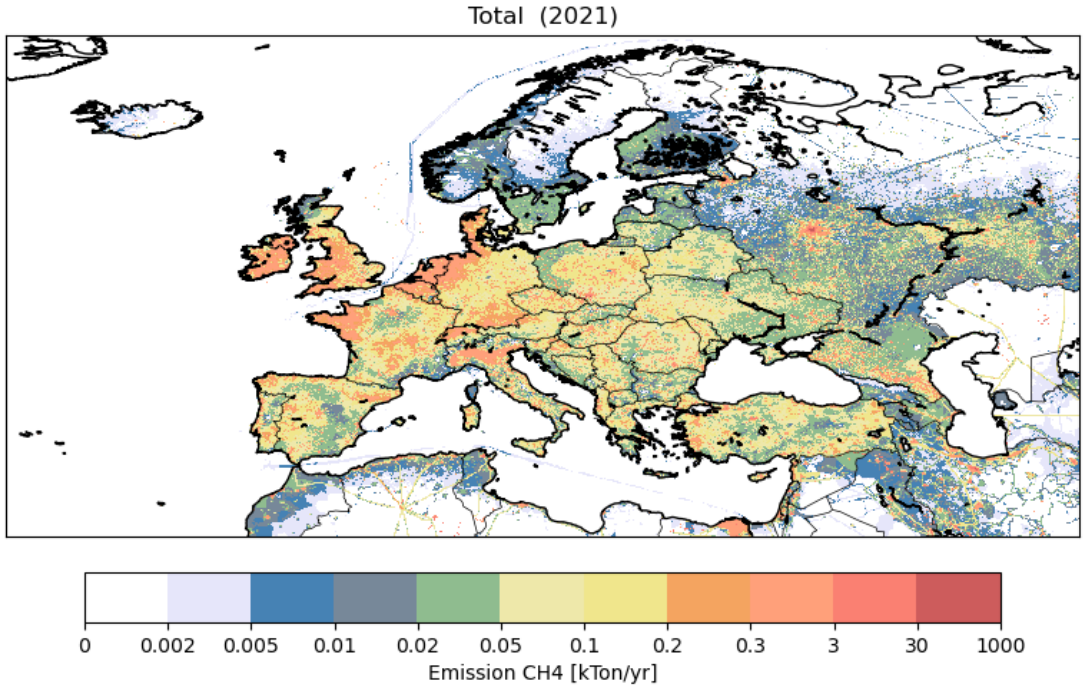


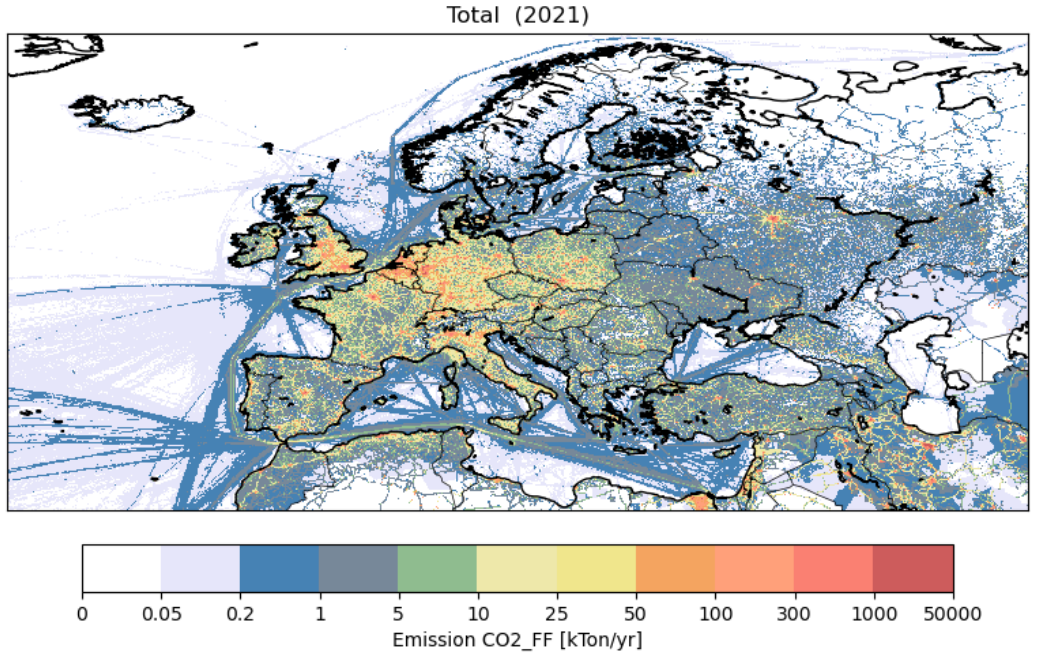
In 2022: 1x1 km zoom version PED2018 Emission totals by country and sector consistent with the European 2018 PED dataset
Shared with WP2 and WP4 CoCO2 email list.
Access the data through TNO FTP site.

Contact stijn.dellaert@tno.nl

CoCO2 2021 PED Anthropogenic Regional Emission Data (TNO)

Bigger challenge than 2018 PED: no reported data available!
Applied a “future years” developed under VERIFY, collect statistics where available, 2021 shipping through CAMS collaboration (courtesy FMI - global data set); improved point source locations and splits (feedback on PED 2018)





QC: Data were tested in TNO LOTOS-EUROS model before delivery –> some small corrections made
Available from TNO ftp site -> shared with WP4

Contact Hugo.deniervandergon@tno.nl

stijn.dellaert@tno.nl

Global Anthropogenic PED 2018 /2021 (CNRS) - steps

1. **Development of a regional inventory for Africa DACCIWAv2 for air pollutants and GHG (CO2ff, CO2bf and CH4) for the period 2010-2018**
   - Emissions for combustion sources based on DACCIWAv1 (Keita et al. 2021)
   - Emissions for non combustion sources (new fugitive emissions + emissions from CAMS-GLOB-ANTv5.3)
   - Also feeds into T2.2

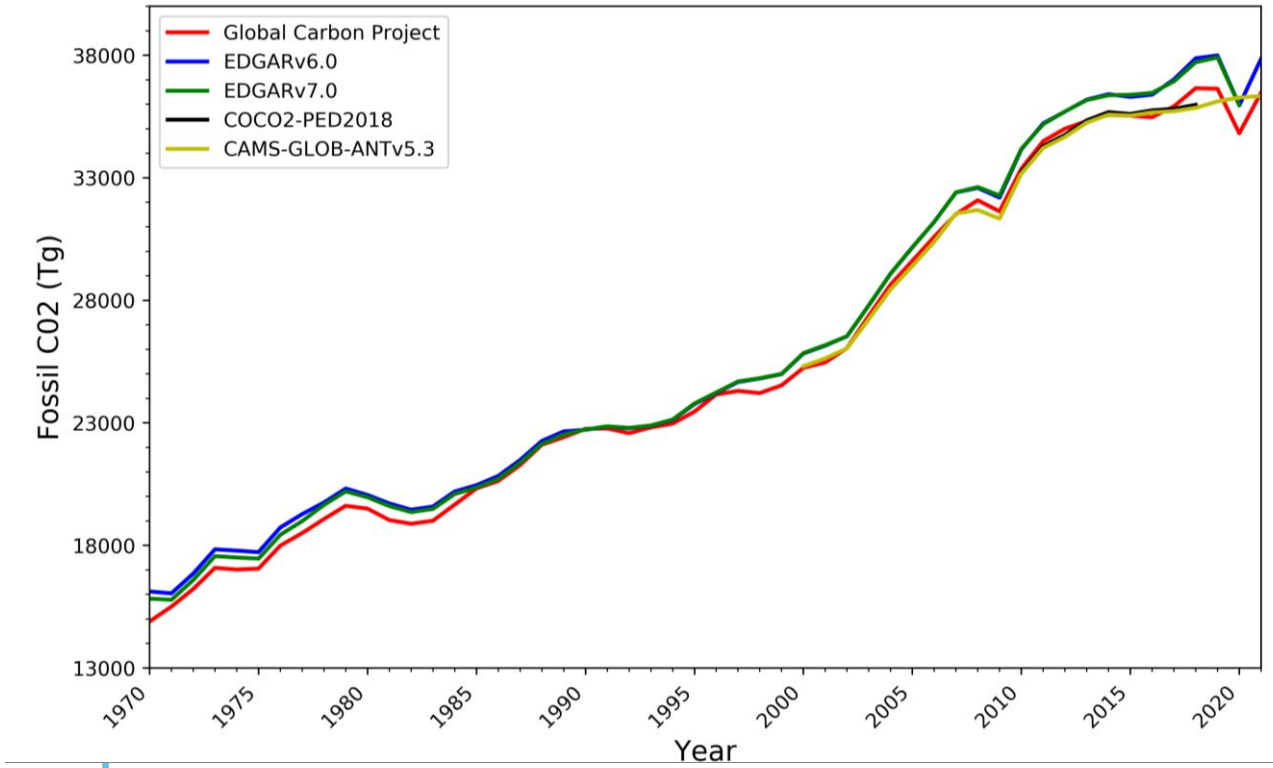
2. **Development of the CoCO2-PED2018 global anthropogenic emissions, a merge of CAMS-GLOB-ANTv5.3 inventory and DACCIWAv2 for Africa**
   - Apply CAMS-GLOB-TEMPO to DACCIWAv2 to obtain monthly averages of emissions
   - Lumped of CAMS-GLOB-ANTv5.3 following seven main “groups of sectors”: Energy_s, Energy_a, Manufacturing, Settlements, Aviation, Transport and Others as DACCIWAv2

3. **Development of the CoCO2-PED2021 global emissions (CO2ff and CO2bf) based on Global Carbon Budget project 2021 CO2ff emissions and CoCO2-PED2018 data**

4. **(on going) Comparisons to analyse available 2018-2021 CH4 global emissions to define the most accurate trends for providing a 2021 CH4 emission field.**

Global Anthropogenic PED 2018 /2021 (CNRS)

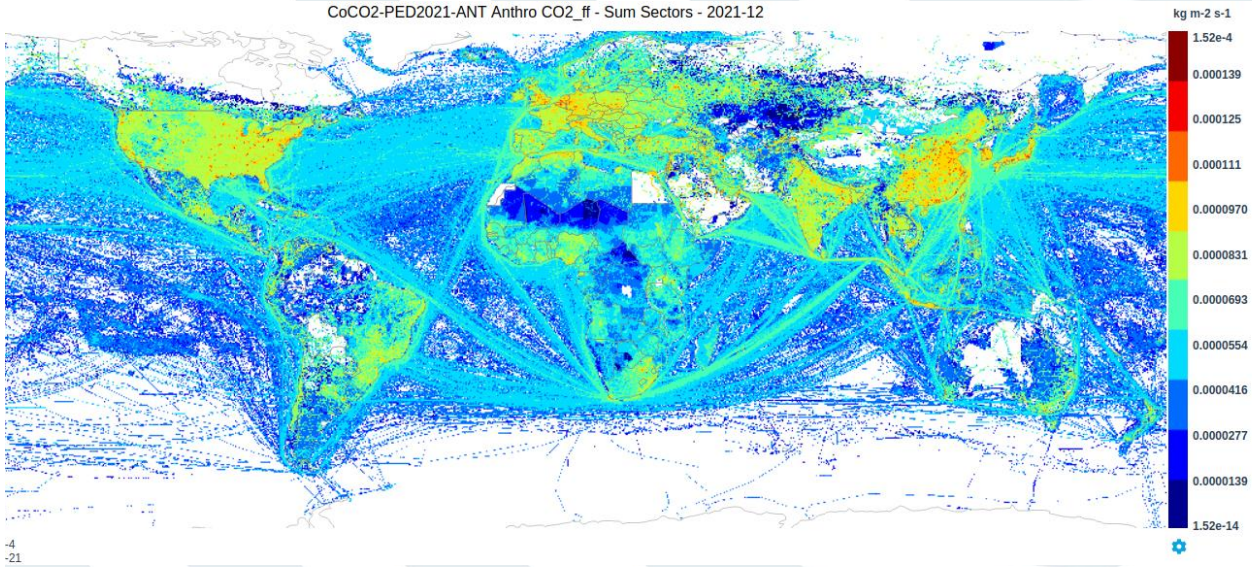
CO_{2ff} emissions across global inventories similar, ~3.5% for the most important differences.



Comparison CO_{2ff} emissions from some global inventories

CO2ff&bf 2018, 2021 available from ECCAD (GEIA emisison data portal)

- Global Carbon Project CO_{2ff} is slightly higher than COCO2 (0.57%) over 2010-2012, lower (0.35%) over 2013-2016



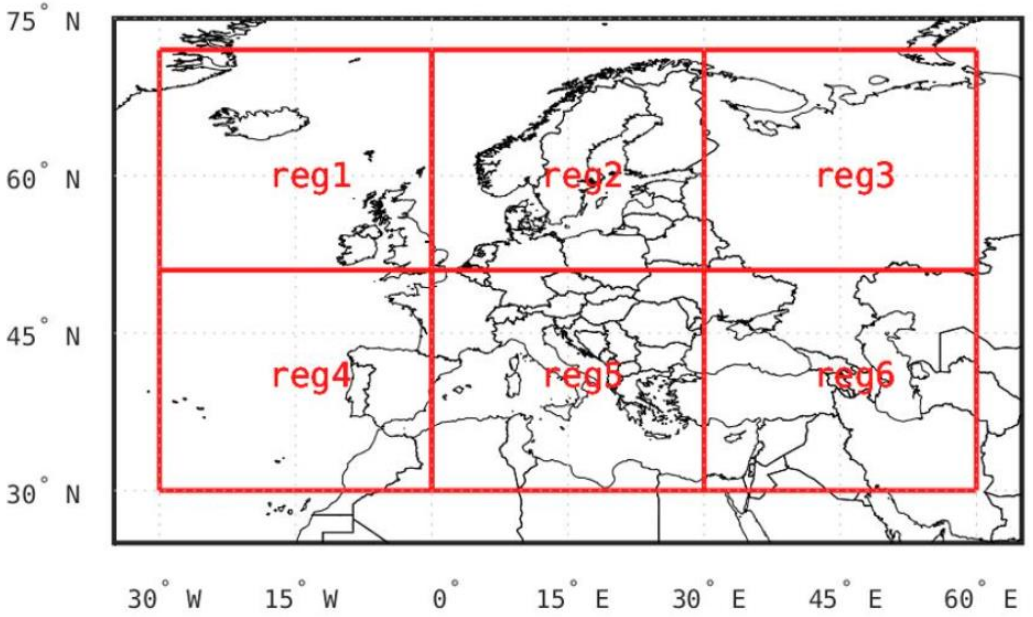
Map of 2021-12 CO_{2ff} emissions from CoCO2-PED2021

Contact: sekou.keita@aero.obs-mip.fr
claire.granier@aero.obs-mip.fr

T2.1 Regional Biogenic fluxes 2017-2021 (DLR)

Vegetation Photosynthesis and Respiration Model (VPRM) at hourly, ~1-km resolution

- Carried out at spatial resolution of 1/120° latitude and 1/60° longitude
- Domain broken into 6 tiles
- Fluxes calculated using ERA5 meteorology, hourly, Re and GPP stored at model grid
- Storage solution found through German DKRZ computing centre, 8.7 TB in total
- Extended back to 2017 and extra years 2019 and 2020 added following WP4 partner request (UEDIN)
- Some users outside the project already (IUP-Heidelberg)
- Documented on the Task 4.4 Confluence page (readme)



Download links
2017
2018
2019
2020
2021

Region	Lower left corner (lat, lon)	Upper right corner (lat, lon)
Reg1	51° N, 30° W	72° N, 0°
Reg2	51° N, 0°	72° N, 30° E
Reg3	51° N, 30° E	72° N, 60° E
Reg4	30° N, 30° W	51°N, 0°
Reg5	30°N, 0°	51°N, 30° E
Reg6	30°N, 30° E	51°N, 60° E

Contact: Julia.Marshall@dlr.de

T 2.1 – global high-resolution biogenic CO2 fluxes (MPI-BGC Jena)

Product specs: Global, 0.05°, hourly, 2018-2021

(will be extended to 2001; GPP also available)

Data and Methods: machine learning model trained on flux tower data using satellite observations from MODIS and meteorological data

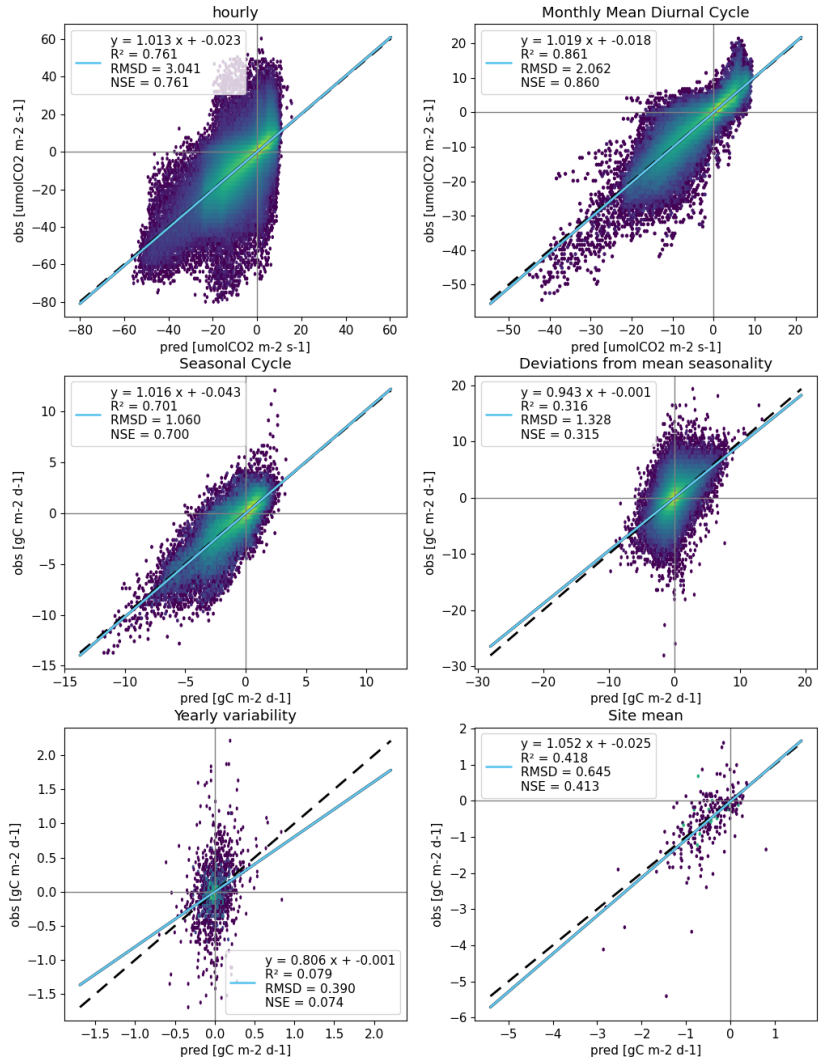
- Based on ~ 13 million hourly NEE observations from 250 flux towers
- Predictors: EVI, NIRv, LSTs (day and night) from MODIS; short wave radiation, air temperature, vapour pressure deficit, potential radiation (and ist derivative), vegetation type
- Training uses flux tower measured meteo; global forward run uses ERA5 meteo
- Machine learning method: boosted regression tree ensemble (XGBOOST)

➢ Contact Jacob Nelson, Martin Jung, FLUXCOM-X Team @MPI-BGC Jena

➢ A data paper is in prep

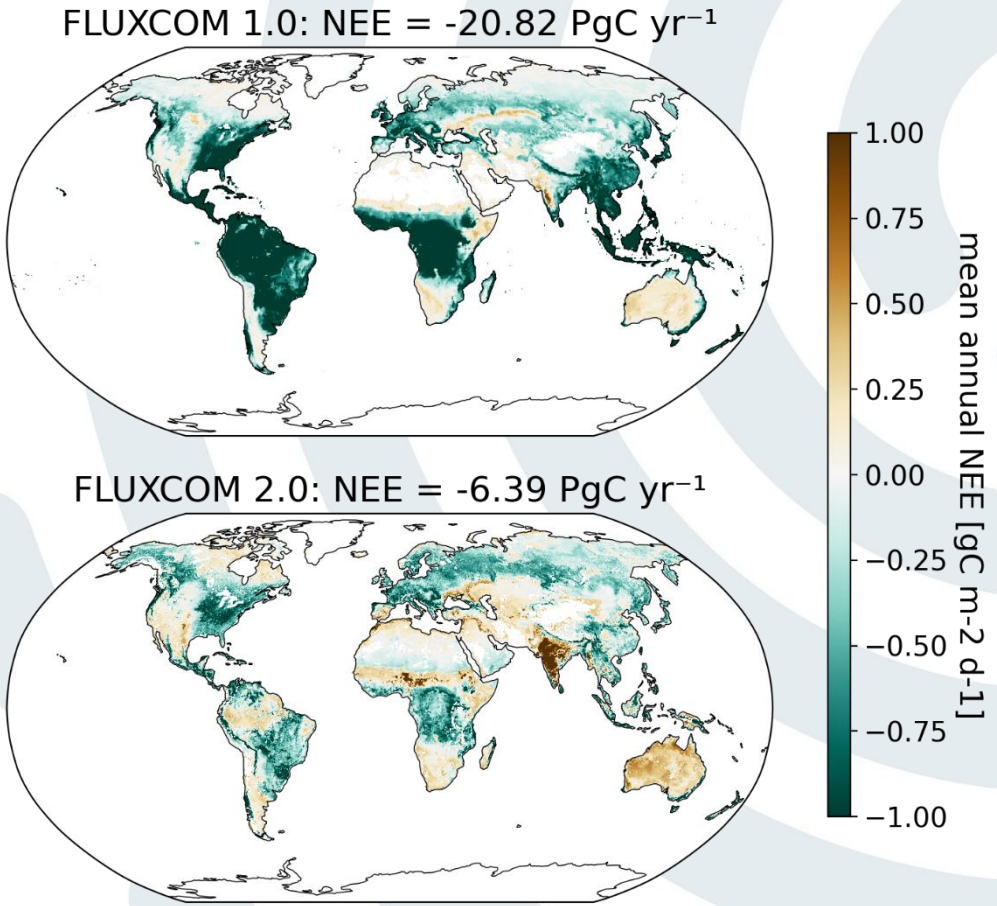
Results FLUXCOM 2

Results from “leave tower out” cross-validation



Comparison with FLUXCOM 1

- Unrealistic sink in tropics disappeared
- Improvements due to better flux tower data (?)

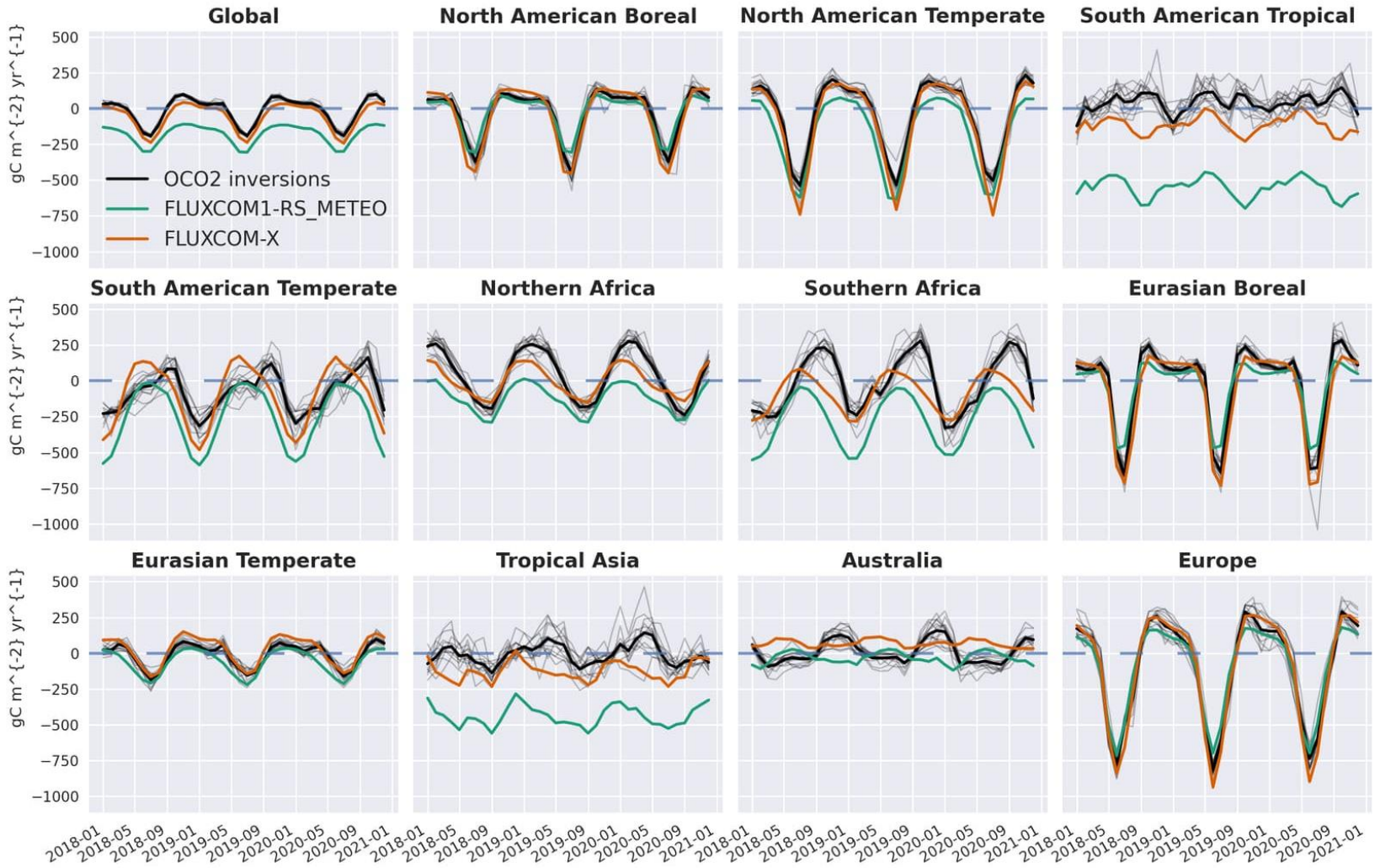


Comparison to OCO-2 MIP inversions

New product much more in Line with observations

OCO-2 MIP: using sat+in-situ CO2 data (LNLGISS)

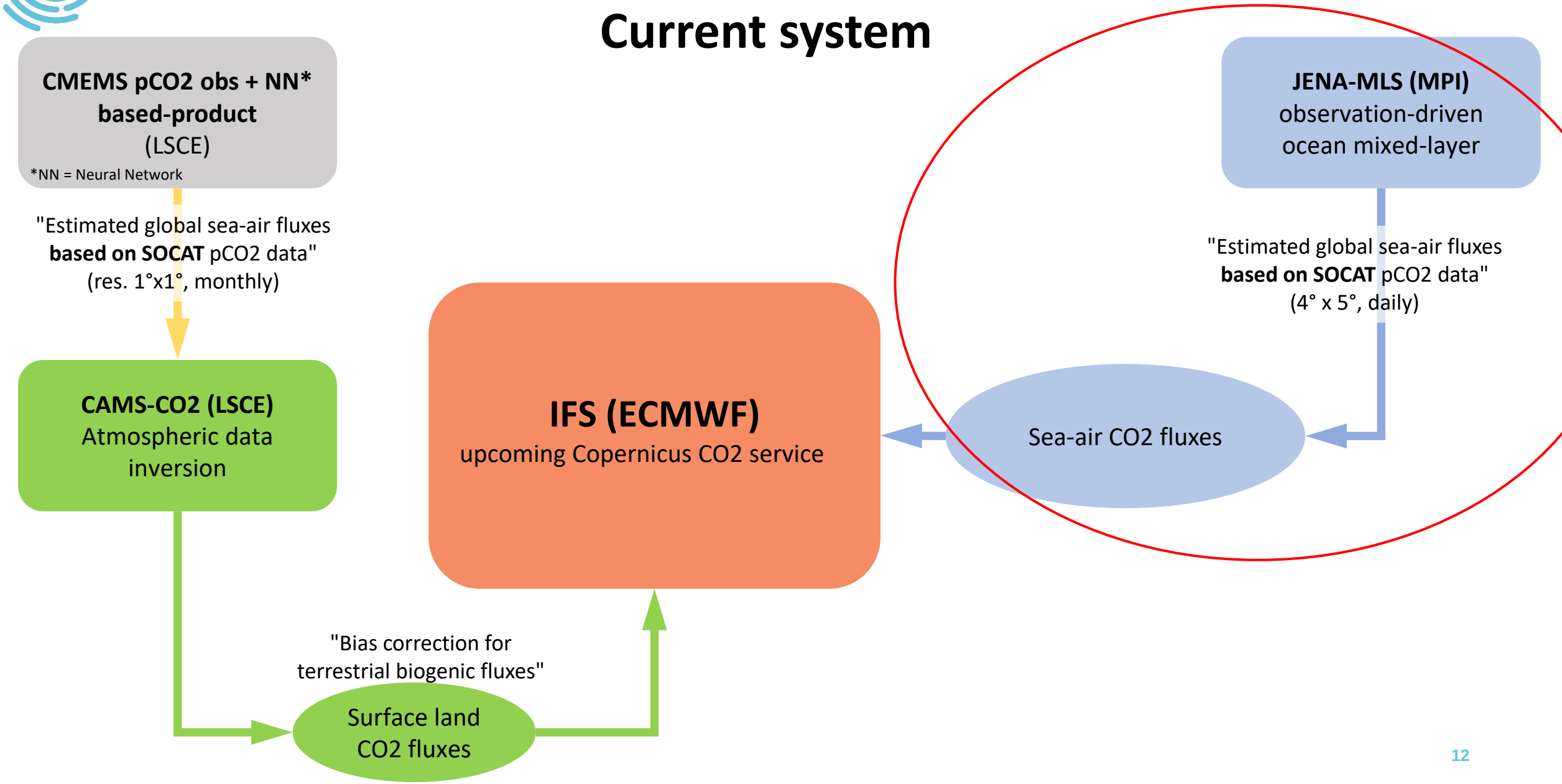
No accounting for discrepancies due to fire emissions so far



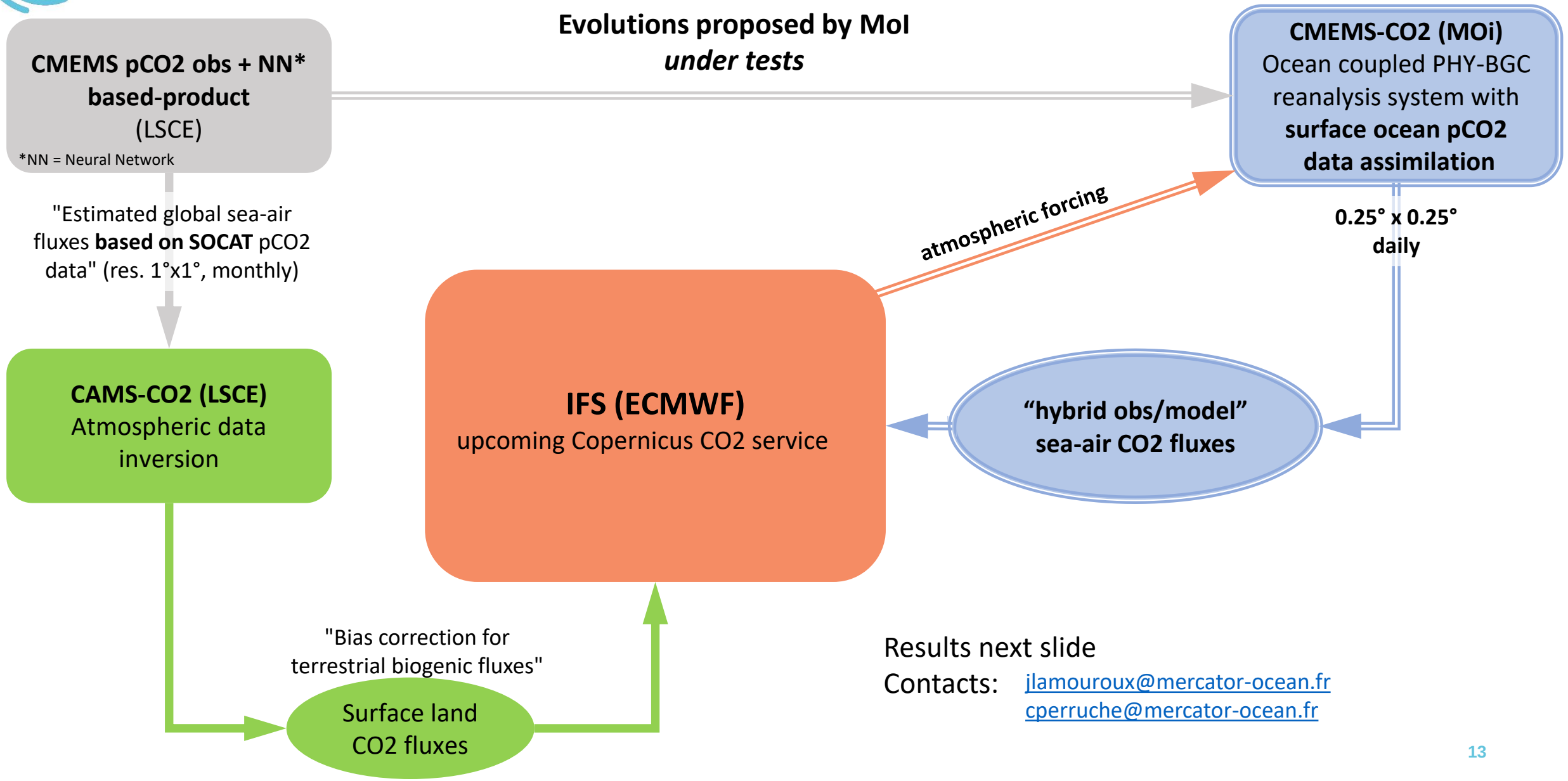
Courtesy: Brendan Byrne and the OCO-2 MIP team

T2.1 Ocean fluxes CO2 Copernicus monitoring system

Current system



T2.1 Ocean fluxes CO2 Copernicus monitoring system



Results next slide

Contacts: jlamouroux@mercator-ocean.fr
cperruche@mercator-ocean.fr

Towards the surface ocean pCO2 data assimilation @MOi

Prototype of spCO2 data assimilation module in MOi analysis system

- **Preprocessing:** monthly to weekly ocean spCO2 data
- **Data assimilation:** production of weekly increments of ocean spCO2
- **Statistical correction of the ocean model:** direct application of the spCO2 increment onto the diagnostic calculation of the air-sea CO2 flux (no injection into the model "dynamics"), so as to ensure the stability of the simulation
- **Provided to IFS colleagues:**
  - 0.25° x 0.25° daily fields of "upgraded" air-sea CO2 fluxes
  - first impact assessment expected shortly

New hybrid model/obs product:

➔ close to obs-based CMEMS product on average

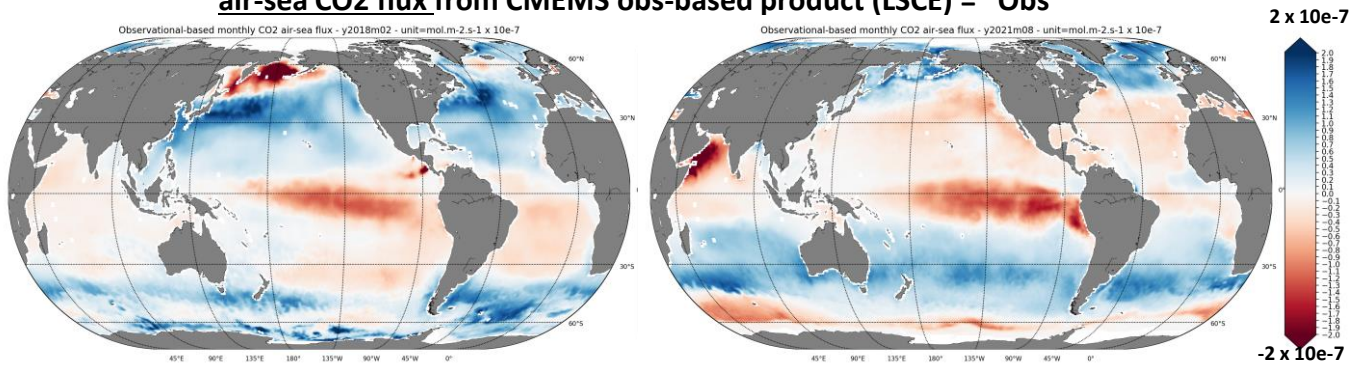
➔ Better spatial and temporal resolution (0.25° x 0.25° , daily frequency)

➔ First assesments by WP3 expected before end of year

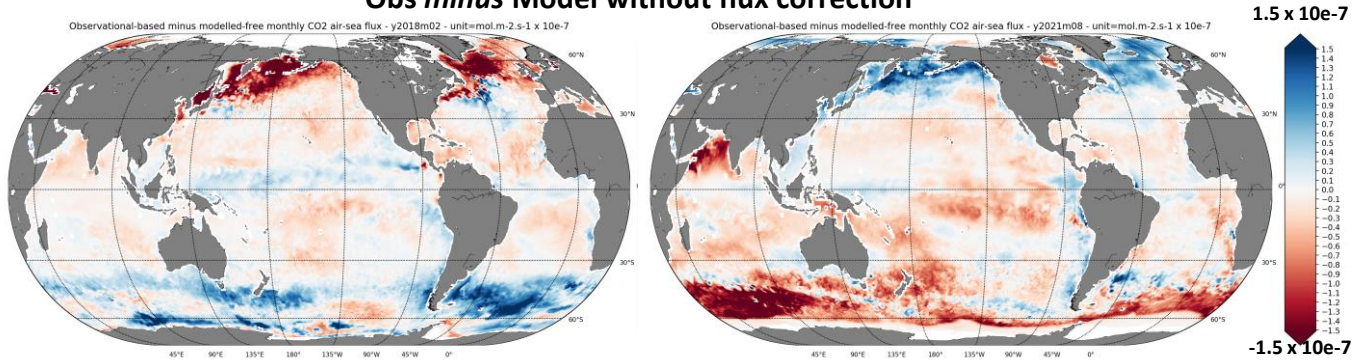
Monthly fields

02/2018 **08/2021**

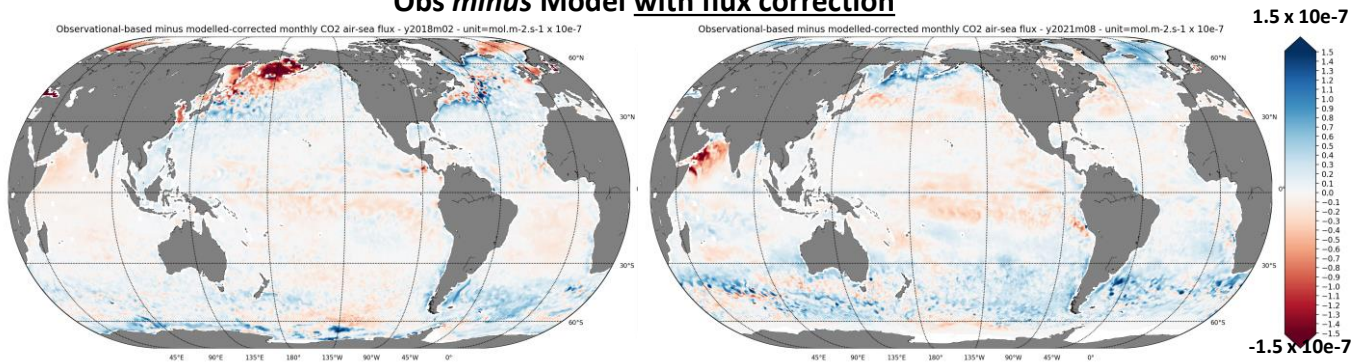
air-sea CO2 flux from CMEMS obs-based product (LSCE) = "Obs"



Obs *minus* Model without flux correction



Obs *minus* Model with flux correction



T2.2: Global mosaic PED 2015 (JRC)

CoCO2-MOSAIC v1.0

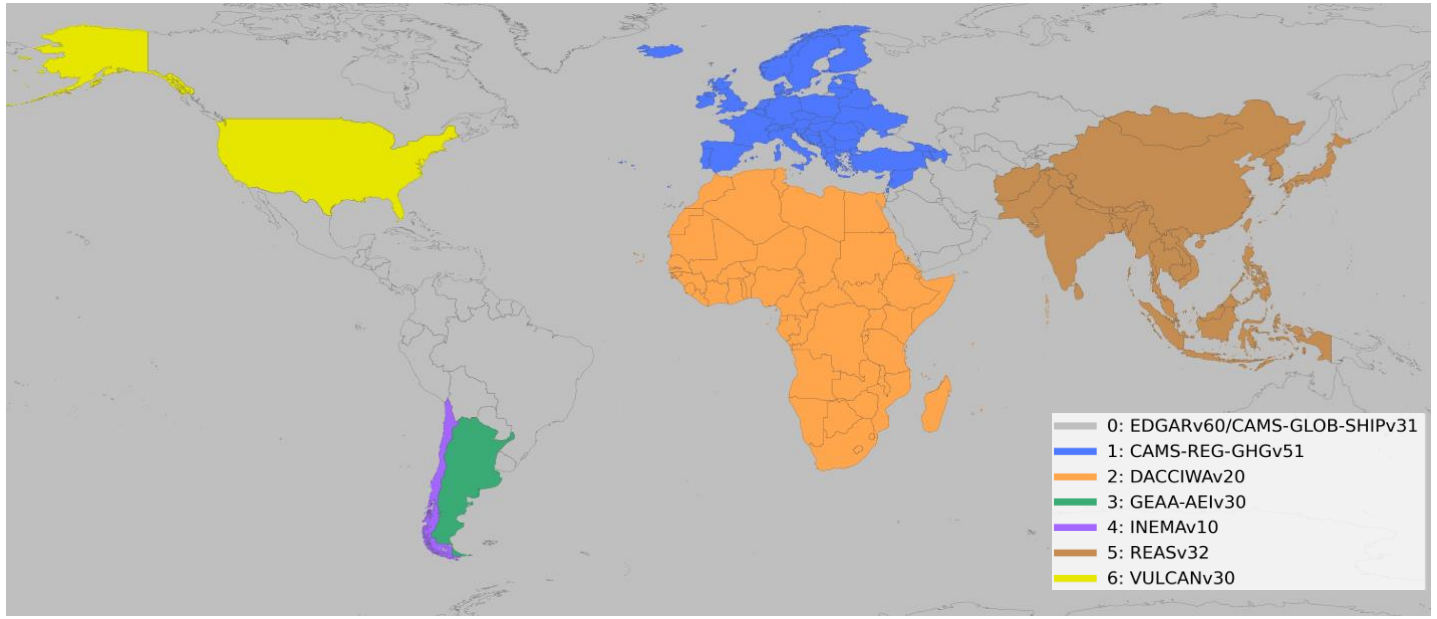
Global mosaic of regional emission inventories for 2015.

- Task members: EC/JRC, TNO, CNRS-LA

GOAL: integrate existing regional emission inventories (typically providing the most detailed information) to have a regionally accepted reference for evaluating the global emission inventories used in global inversions.

- **Six regional inventories** (adapted in collaboration with the regional teams).
- **Gap-filled** with EDGAR 6.0, CAMS-GLOB-SHIP 3.1 and CAMS-GLOB-TEMPO 3.1

Inventory mask



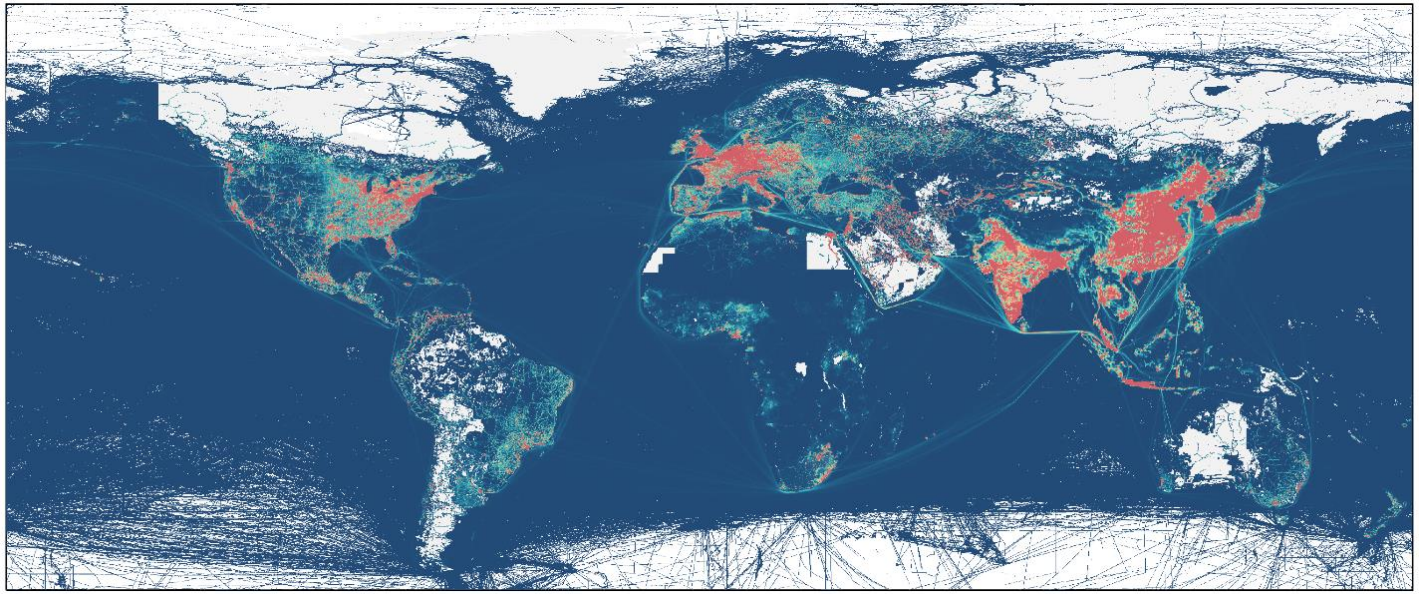
T2.2: Global mosaic PED 2015

CoCO2-MOSAIC v1.0 Product details:

- **Target year**: 2015.
- **Temporal resolution**: monthly.
- **Spatial resolution**: 0.1°x0.1°
- **Species**: CO2ff (fossil fuel) & CO2bf (biofuel) emission flux [kg/m2/s]
- **Sectors (x7)**:

1. energy_s (super-emitters)
2. energy_a (average emitters)
3. manufacturing,
4. settlements,
5. transport,
6. aviation,
7. other

Emission layer (CO2ff, all sectors)



Contact: Ruben.URRACA-VALLE@ec.europa.eu

T2.2: Global mosaic PED 2015

Task 2.2 STATUS: completed

The CoCO2 T2.2 was completed on November with the official submission of D2.3. The deliverable includes:

- **CoCO2-MOSAIC report**: available online at https://coco2-project.eu/sites/default/files/2022-11/CoCO2-D2.3-V0-2_2.pdf
- **CoCO2-MOSAIC v1.0 product**: available internally at CoCO2 FTP.

ADDITIONAL OUTPUTS – next steps

A paper for ESSD journal is under preparation:

- Describing the mosaic methodology.
- Adding emissions not covered by regional inventories: high-altitude aviation emissions from EDGAR, LULUCF net fluxes from Grassi et al 2022.
- Comparing the mosaic against global emission inventories, including the CoCO2-PED.
- Releasing the product publicly at **ZENODO** and at the **JRC DATA CATALOGUE.**

Contact: Ruben.URRACA-VALLE@ec.europa.eu

T2.3 – Improvement of the spatio-temporal representation of emissions (BSC)

Subtasks:

- T2.3.a Temporal profiles

Construction of a dataset of updated global temporal profiles for the road transport, aviation, shipping, residential combustion and public energy sectors.

- T2.3.b Improvement of spatial representation

A global catalogue of CO2 emissions and co-emitted species (i.e., NOx, SOx, CO, CH_4) from power plants with associated exact geographical location, temporal and vertical distribution profiles.

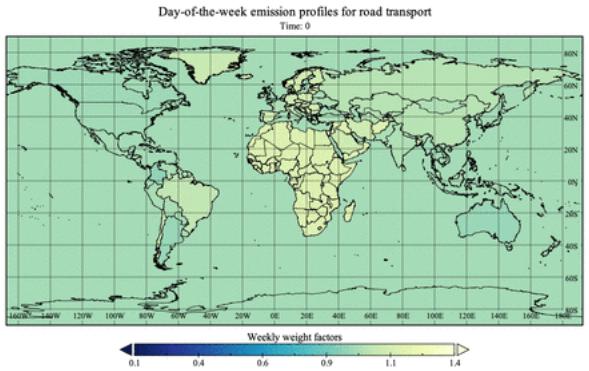
Results from the two products used to provide recommendations on the temporal and vertical distribution profiles to be considered in the global CoCO2 nature runs performed in WP3.

Contact: marc.guevara@bsc.es

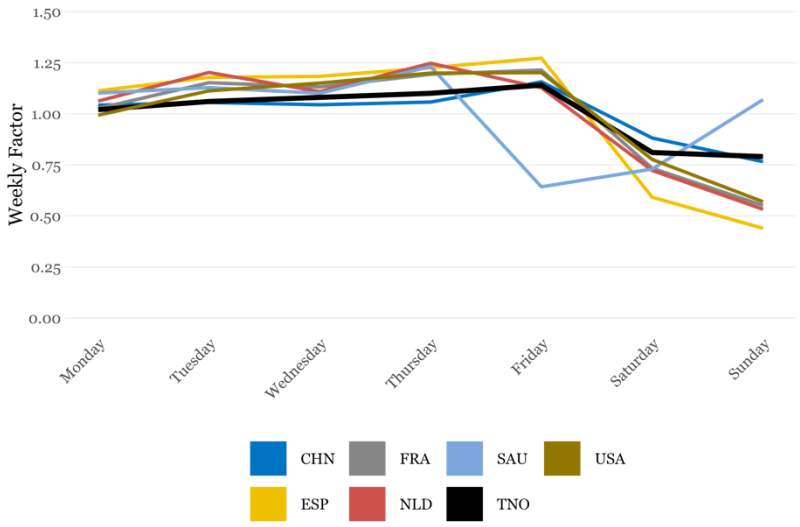
T2.3.a Temporal profiles – Road transport

Construction of country-dependent day-of-the-week and hourly emission temporal profiles (for weekdays, Saturdays and Sundays) for road transport sector based on [TomTom congestion statistics]

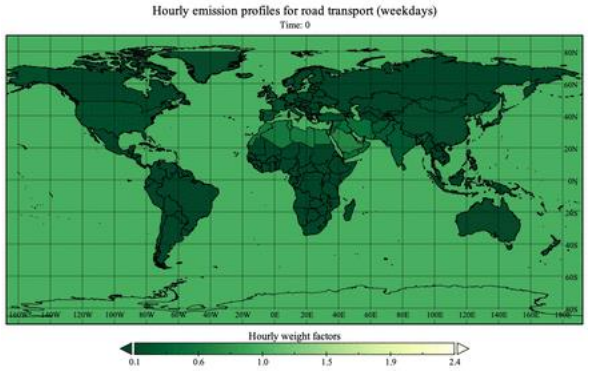
Day-of-the week profiles



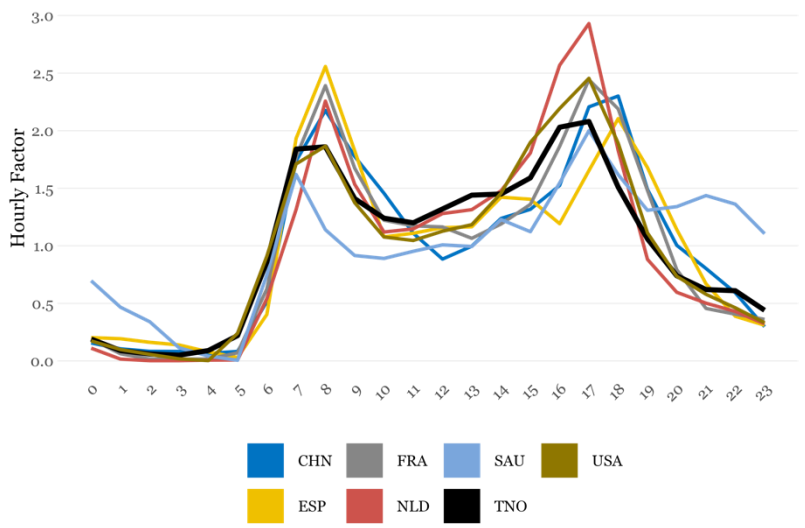
Weekly temporal profiles for road transport



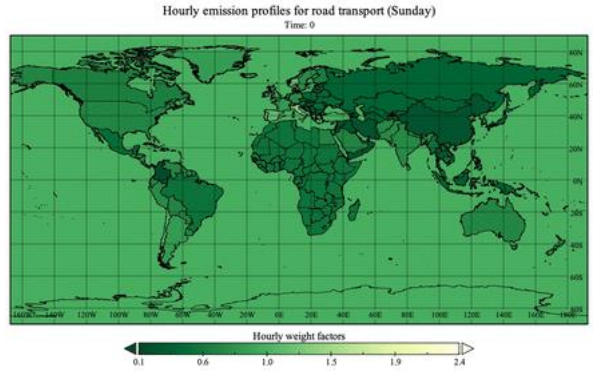
Hourly profiles (weekdays)



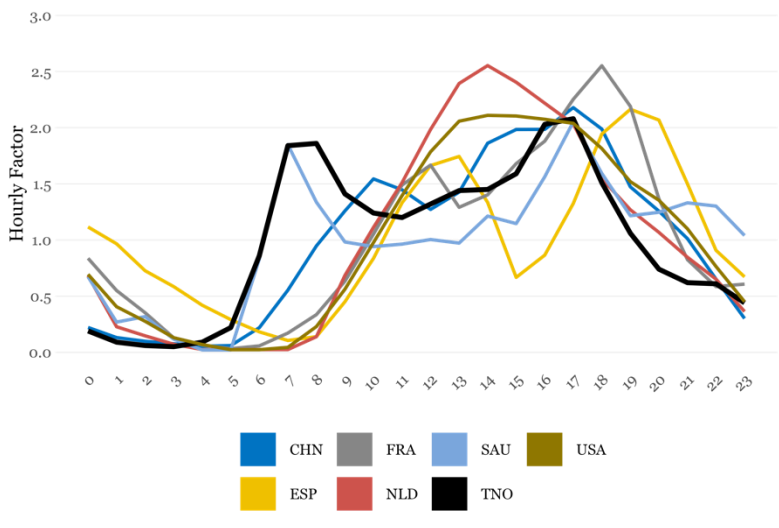
Hourly temporal profiles for road transport (Weekdays)



Hourly profiles (Sundays)

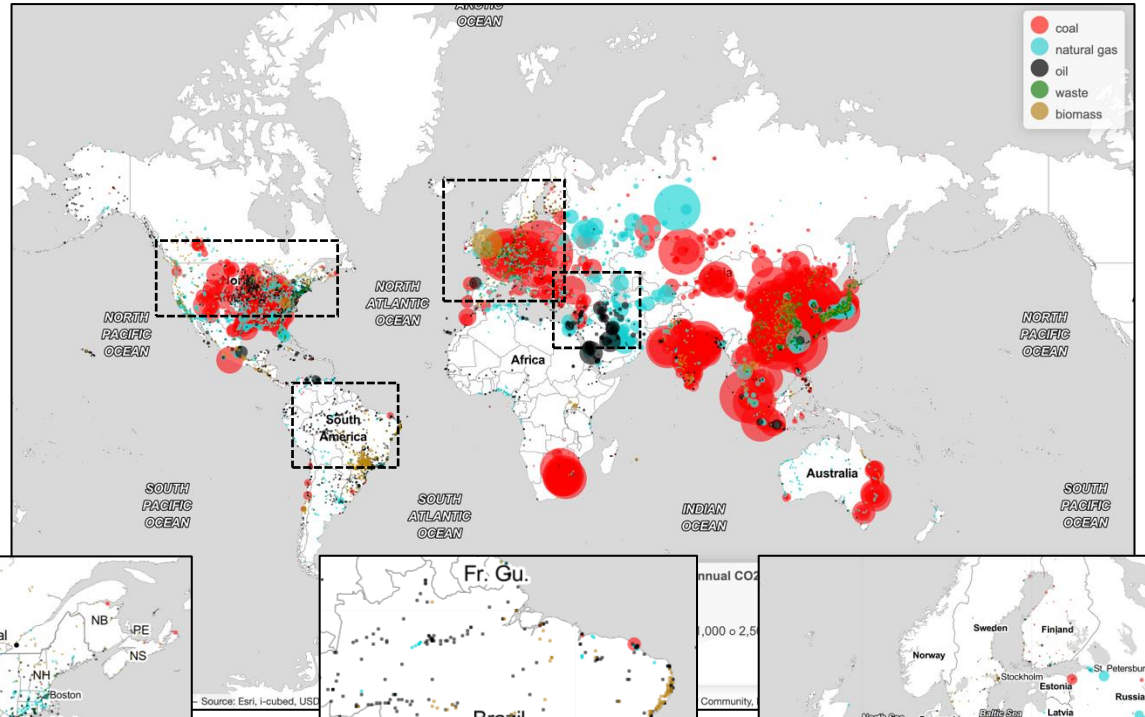


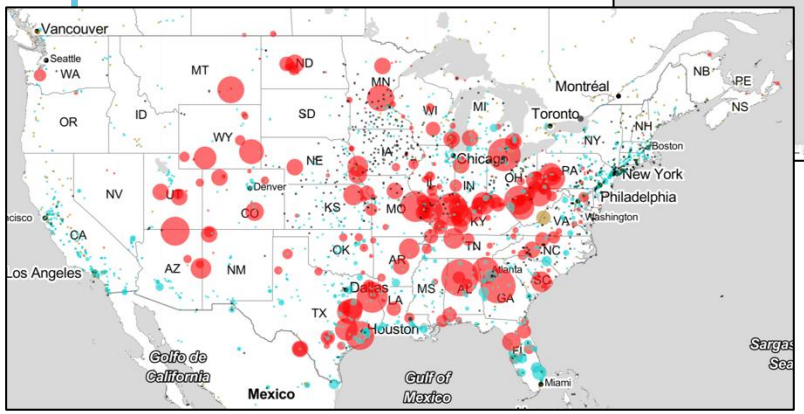
Hourly temporal profiles for road transport (Sunday)

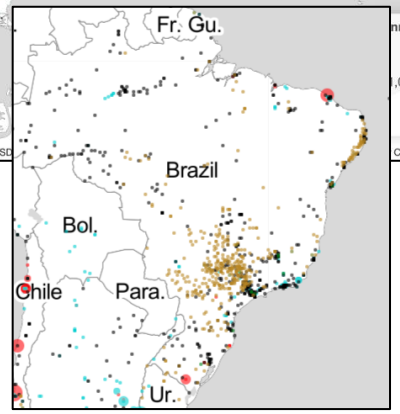


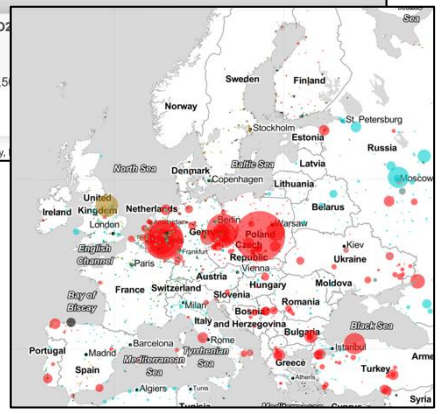
T2.3.b Improvement of spatial representation

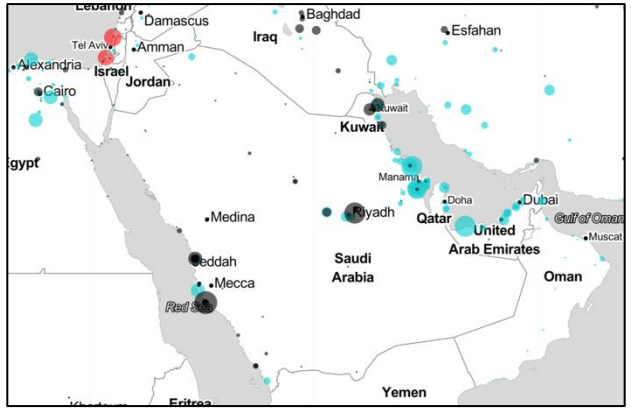
- Construction of a global power plant database at their exact location (coal, natural gas, oil, biomass and waste)
- Estimation of 2018 annual emissions for CO_2 + co-emitted species (i.e., NO_x, SO_2, CO, CH_4) per facility
  - **EU27 + UK + Norway + Switzerland + Serbia**: Based on E-PRTR and LPS
  - **Rest of the world**: Mosaic of WRI, GEM, eGRID, IndustryAbout, … + IEA statistics + IPCC EF & emission ratios





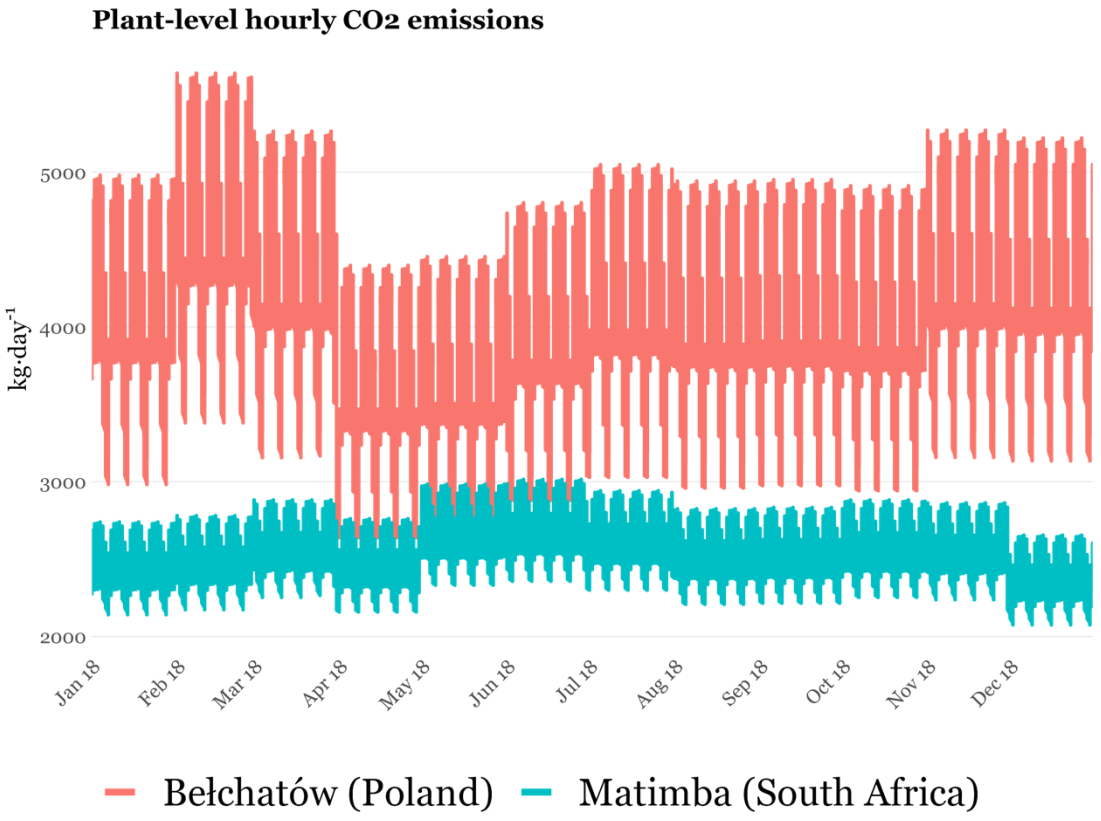


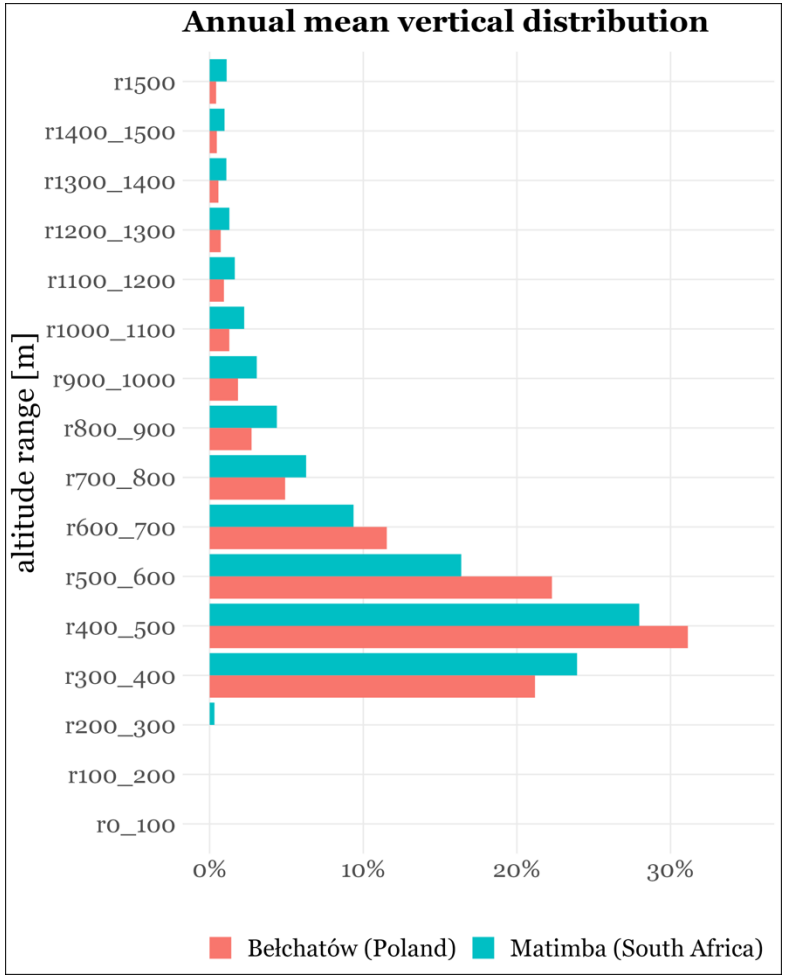




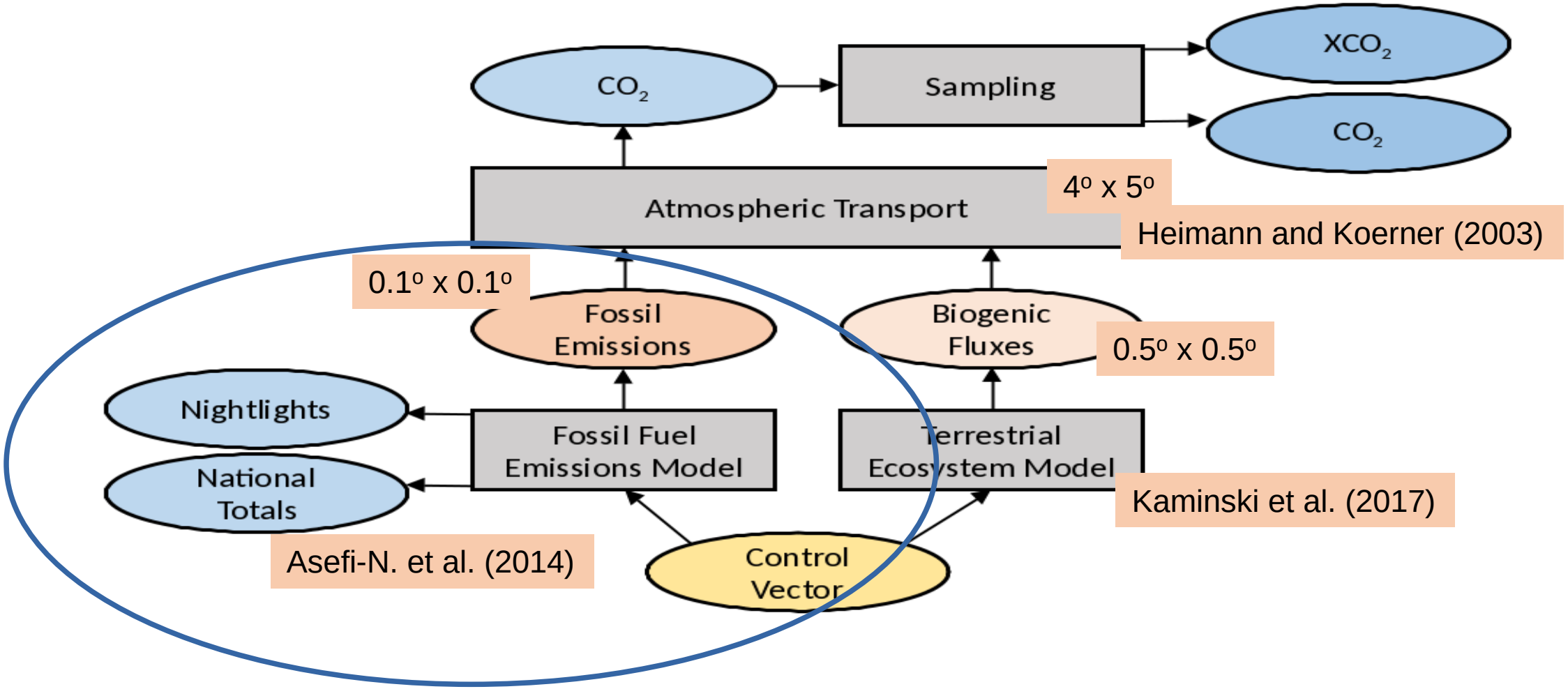
T2.3.b Improvement of spatial representation

- Constructed country- and fuel-dependent temporal profiles and linked to each facility
- Estimated plant-level vertical distribution profiles based on HERMESv3 hourly plume rise calculations





T2.4 Emission models: CCFFDAS Modelling Chain (iLab)



T2.4: Sectoral fossil fuel emission model (iLab)

The T2.4 team comprises iLab, TNO, and ULUND.

- Task runs from M6 to M30; develops sectoral fossil fuel emission models for
  - **energy generation**
  - **heating**
  - **road transport**
  - **and the complement (Other sector).**

- Task implements these models & tests models with input for 2018
- Provides models with tangent and adjoint versions for inclusion into data assimilation systems
- Input Data include
  - road atlas
  - population density
  - meteorological variables
  - power plant emissions
- Regional and global models differ in the quality of the input data
- **Initial version planned in 2022 (D2.5) and finetuning in 2023.**

Contact: thomas.kaminski@inversion-lab.com

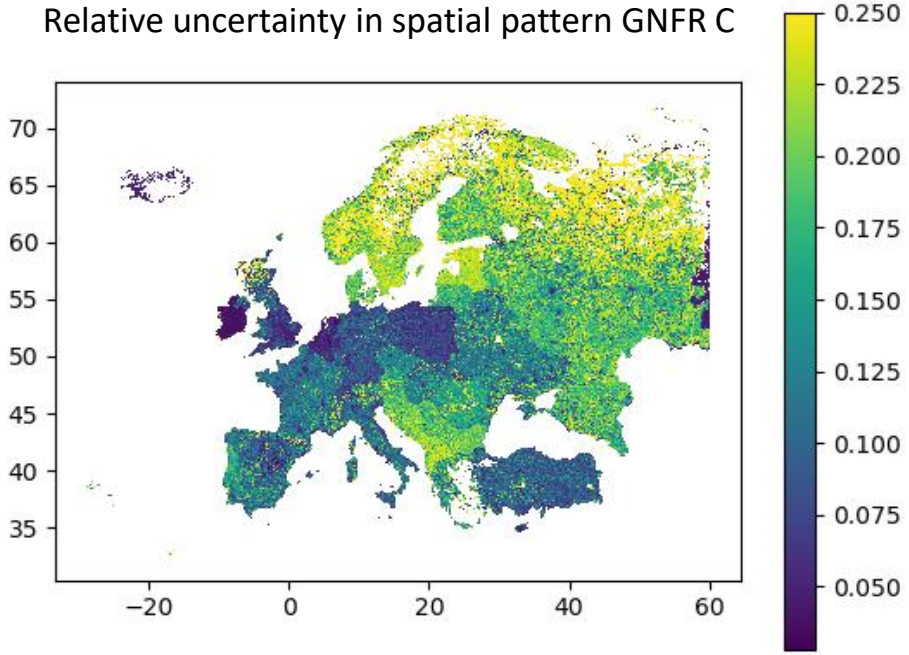
T2.5: prior uncertainties and error correlations (TNO, ECMWF)

Goal: Provide prior emission uncertainties to model WPs related to regional (TNO GHGco v4) and global (EDGAR v6.0) emission products; better understand uncertainties in emissions and identify focus points for improvement

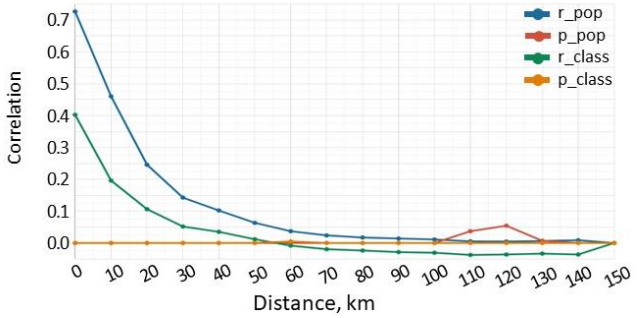
Product:

- Description of uncertainties in emissions of CO2 (also CO and NOx for regional product), taking into account lognormal error distributions
- Description of spatial errors and error correlation lengths
- Includes estimate of error correlation CO and CO2

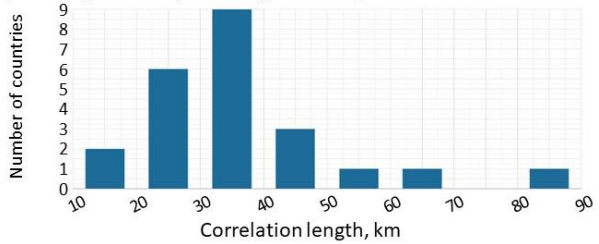
Relative uncertainty in spatial pattern GNFR C



United Kingdom (WDS): Pearson's correlation r and p values [correlationLength = 70-80 km]

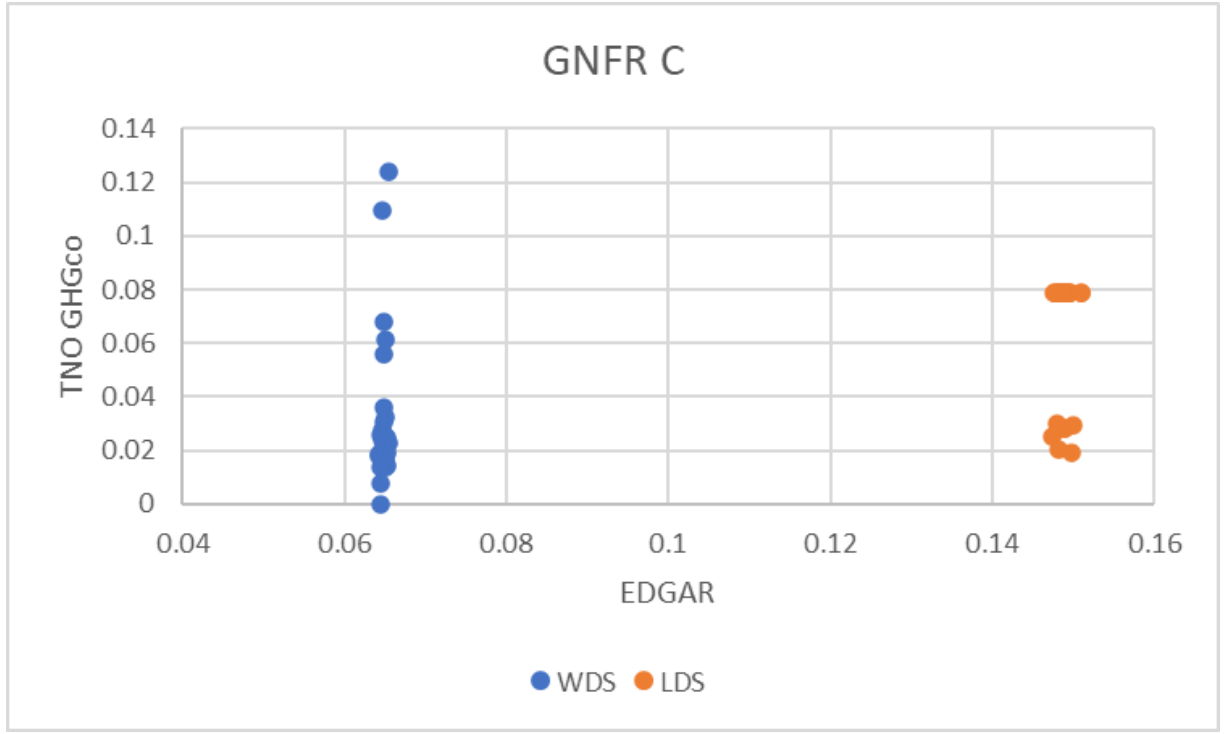


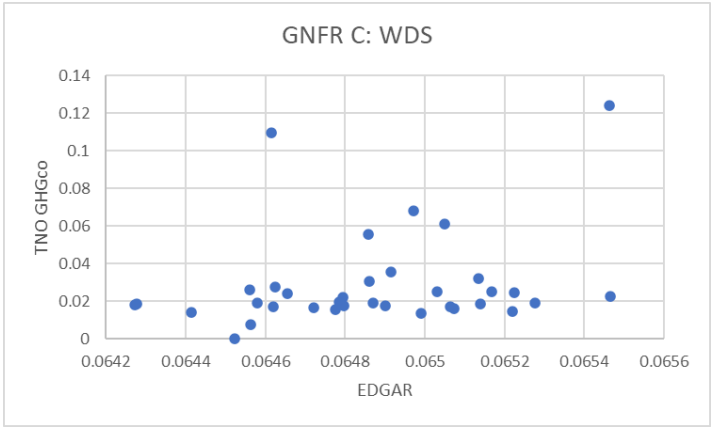
27 European countries (WDS): correlation length (based on population density and [meanLength = 31 km, modeLength = 30 km]

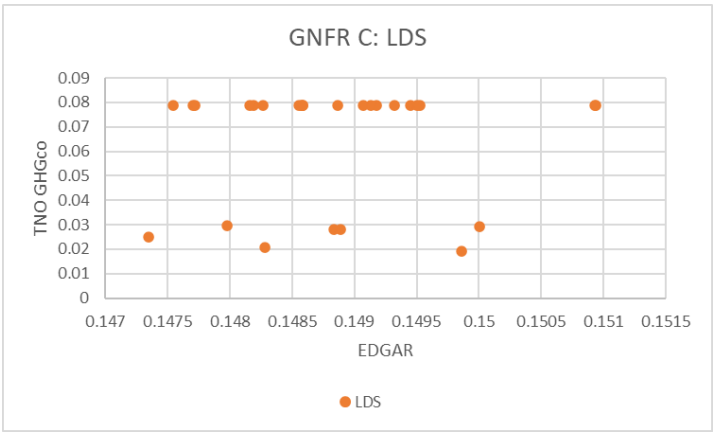


Comparison global and European uncertainties

- Comparison of CO2 emission uncertainties for European countries
  - Approach for EDGAR (global) more generic, **using IPCC default values** for well-developed (WDS) and less-developed (LDS) countries
  - Approach for TNO GHGco more specific, **using reported country-level** uncertainties per NFR-fuel combination







T2.5 Next steps

This is a first product, a final product is due next summer. This will include:

- More sectors for which spatial errors are included
- CO and NOx uncertainty estimates for the global domain
- Estimation of temporal errors and correlation lengths
- Improve description of error correlations between pollutants
- A revision of the format in which to deliver these data (better align with modeller needs)

Additionally: Working on scientific publications

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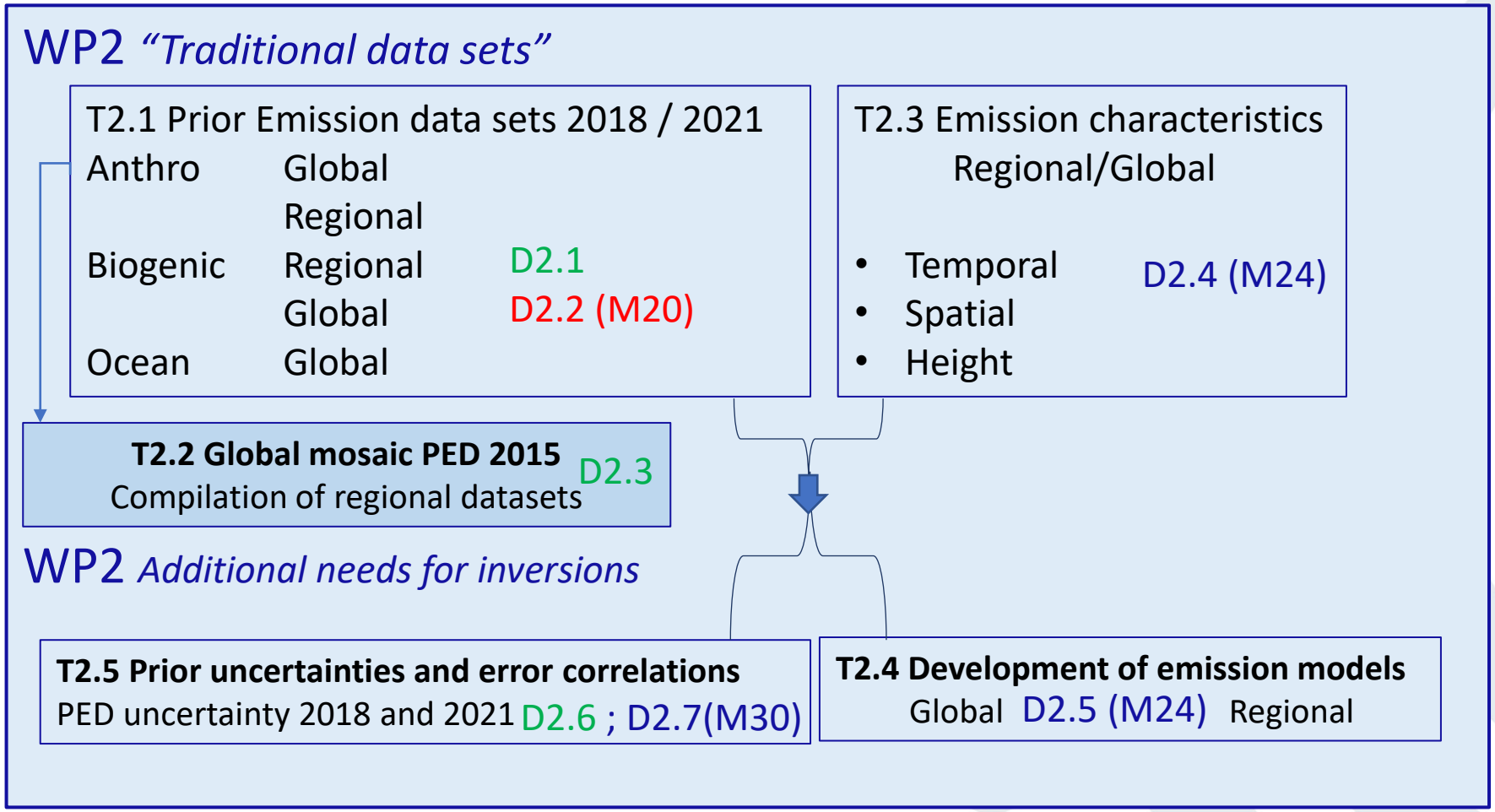
WP2 status = ~on track and some remarks



- At start of the 3rd year most products delivered; will need feedback from users
- Additional work needed? e.g. Additional data needed to make the T2.2 mosaic suitable for model use
- Publish results alone or jointly with other WPs / users.

THANK YOU

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Prototype system for a Copernicus CO_2 service

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