Co-ordinated by ECMWF

CO_2 Human Emissions

OVERVIEW OF CHE OBJECTIVES

Science Coordination & Support To Deliver Services

Gianpaolo Balsamo
Project Coordinator- ECMWF
05/02/2018

CHE-CO2 Human Emission Project (& its numbers)

Aim:
Build European monitoring & verification support capacity for anthropogenic CO2 emissions

How:
Monitoring/Verification System (MVS) driven by Earth observations, from remote sensing and in situ, combined with enhanced modelling systems, that includes CO2 fossil fuel emissions, along with other natural and anthropogenic CO2 emissions & transport.

Why:
To support the Paris Climate Agreement and its implementation

ECMWF AIRBUS cmcc DLR Empa EUMETSAT iLab European Commission cea

Lund University NILU SPASCIA SRON ThalesAlenia Space TNO innovation for life UEA University of Leicester Wageningen University & Research

Project Duration:
39 month

Project Funding:
3.75 ME (1.25 ME/year)

Consortium Numbers
22 partners Institutes

Work Content Numbers
7 work-packages:
5-Science development, **1**-International liaison, **1**-Management & Coms
7 Milestones
45 Deliverables

344.25 Person Month
(Eq 8.8 FTE)

3 Project Reviews
(M15, M27Tech, M39)

SCIENCE

The CHE assets

CO_2 HUMAN EMISSIONS

CHE Leadership and Expertise

CHE leadership & expertise ensure Monitoring of the project & its progress:

WPL in WP1 Corinne Le Quéré (UEA) and Wouter Peters (WAGENINGEN)

WPL in WP2 Dominik Brunner (EMPA) and Hugo Denier van der Gon (TNO)

WPL in WP3 Greet Maenhout (JRC) and Marko Scholze (LUND)

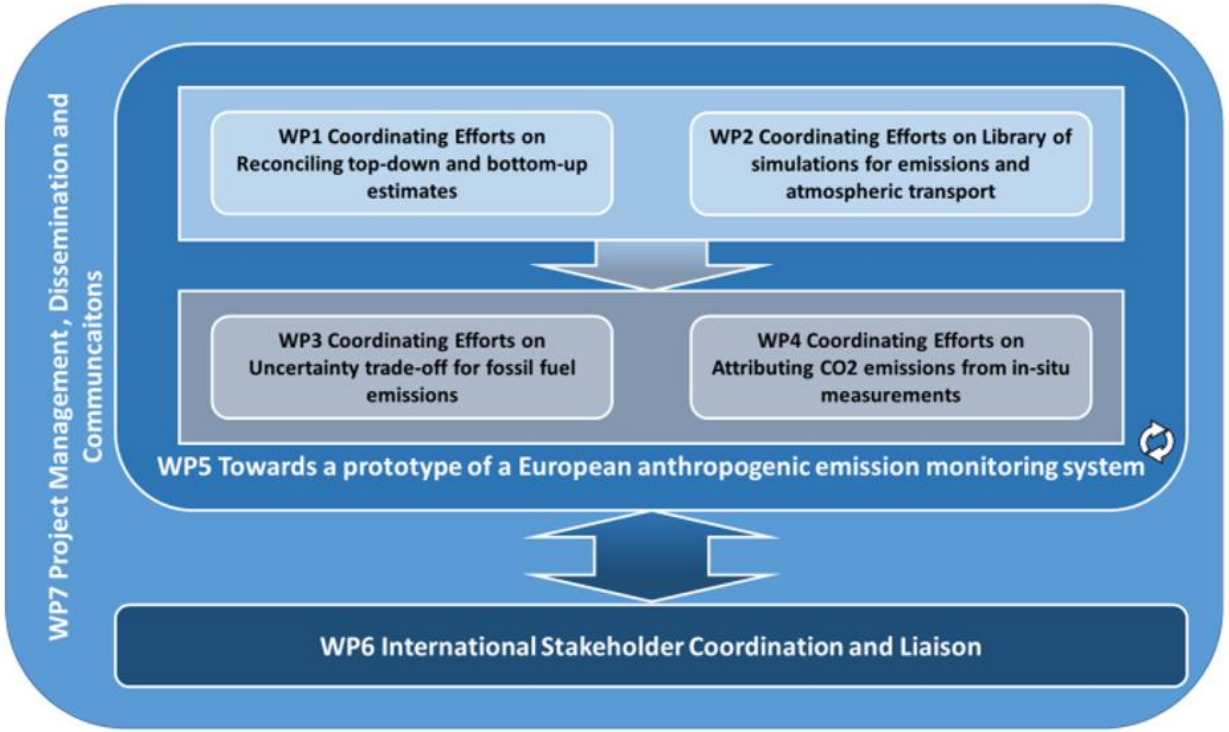
WPL in WP4 Frédéric Chevallier (LSCE) and Julia Marshall (MPI-BGC)

WPL in WP5 Anna Agusti-Panareda and Gianpaolo Balsamo (ECMWF)

PIL in WP6 Richard Engelen (ECMWF)

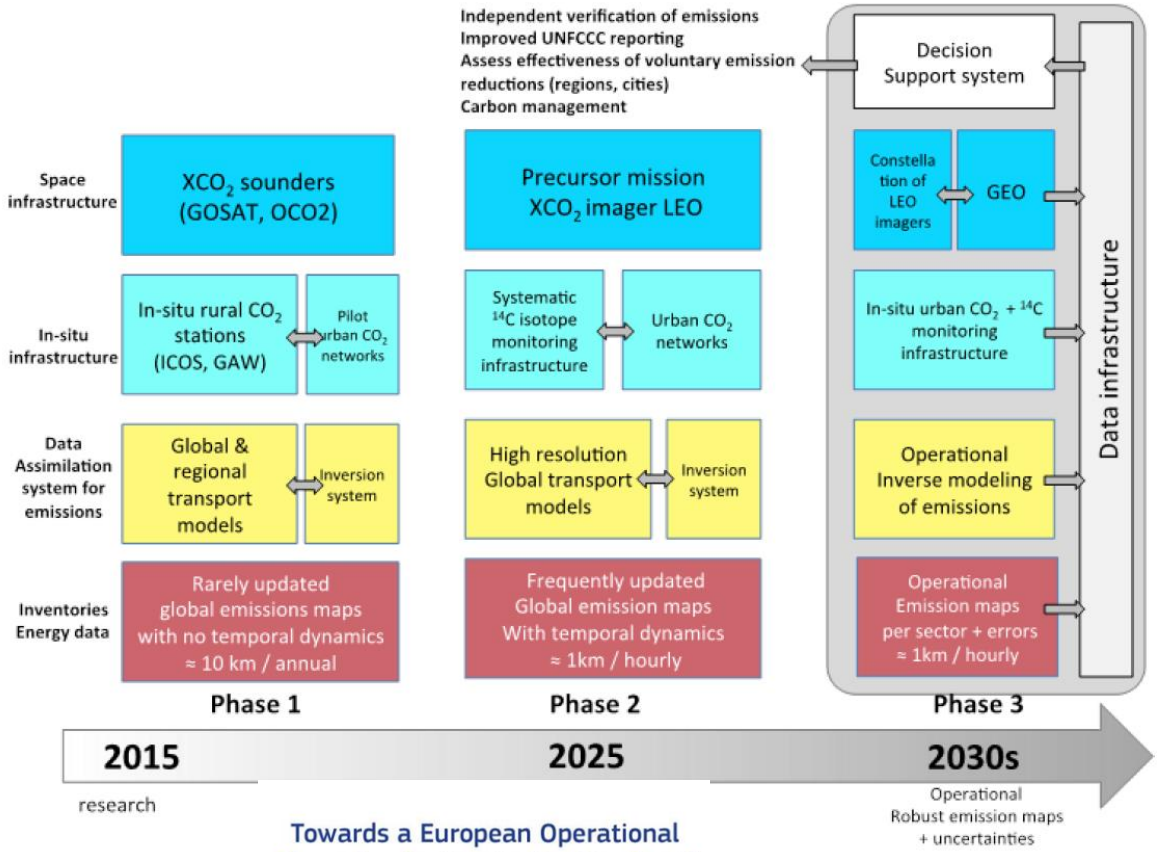
PM in WP7 Daniel Thiemert (ECMWF)

COO Gianpaolo Balsamo (ECMWF)



Work-Package Leaders (**WPL**), Project International Liaison (**PIL**), Project Manager (**PM**), Project Coordinator (**COO**)

CHE Foundation: 2015 fossil CO2 monitoring and TFs report

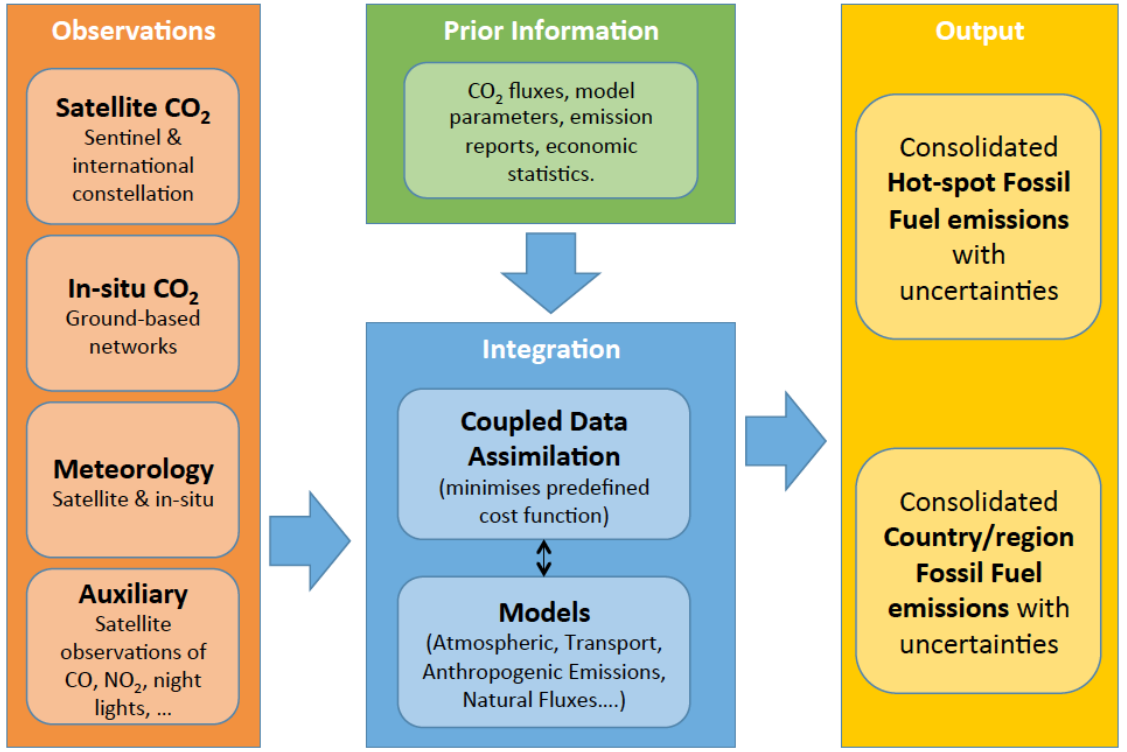


Towards a European Operational Observing System to Monitor Fossil CO_2 emissions

CO_2 HUMAN

Final Report from the expert group

Recommended steps for implementation of a fossil CO2 monitoring system



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

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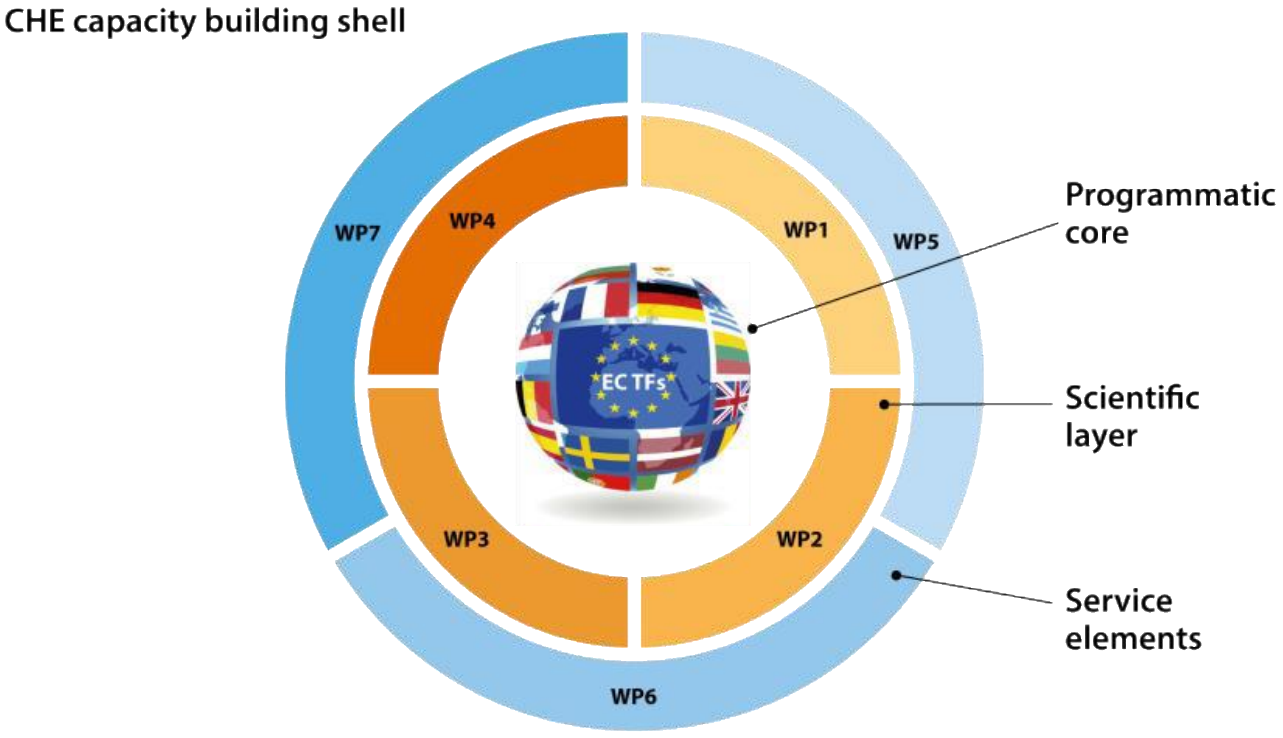
CHE Structure and Work Package Breakdown

CHE, H2020-Coordination and Support Action



CHE WBS

WP1 Coordinating Efforts on Reconciling top-down and bottom-up estimates, led by UEA 60.5 PM (39M, 1-39)

WP2 Coordinating Efforts on Library of simulations for emissions and atmospheric transport, led by EMPA (64.5 PM)

WP3 Coordinating Efforts on Uncertainty trade-off for fossil fuel emissions, led by ULUND (69.5PM)

WP4 Coordinating Efforts on Attributing CO2 emissions from in-situ measurements, led by CEA (57.0 PM)

WP5 Towards a prototype of a European anthropogenic emission monitoring system, led by ECMWF 55.25 PM (24M 15-39)

WP6 International Stakeholder Coordination and Liaison, led by ECMWF (19.5 PM)

WP7 Project Management, Dissemination and Communication, led by ECMWF (18.0 PM)

CHE Connectivity & Stewardship

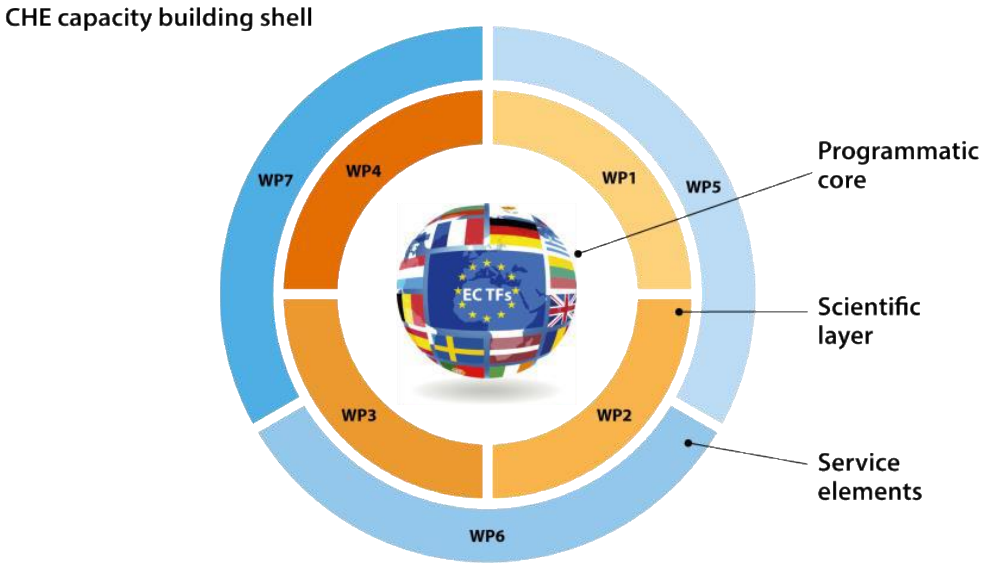
CHE Project steering is further ensured by the following roles:

External Advisory Board (EAB) and External Expert Group (EEG)

EAB Han Dolman (Chair of EAB, VU NL), Pierre-Yves Le Traon (CMEMS, France), Mark Dowell (CLMS, INT), Sonia Seneviratne (ETH, Switzerland), Guy Brasseur (WCRP, Germany),Werner Kutsch (ICOS, Finland)

EEG Peter Rayner (Chair of EEG, U MELBOURNE, AU), Kevin Gurney (ARIZONA SU, US), Kevin Bowman (NASA JPL, US), Arlyn Andrews (NOAA, US), Pep Canadell (CSIRO, AU), Saroja Polavarapu (ECCC, Canada), Jing M. Chen (U NANJING, China, U TORONTO, Canada), Lu Daren (CAS, Tansat-PI, China), Chris O'Dell (CSU, US), Shamil Maksyutov (CGER/NIES, Japan), Paul Palmer (EDINBURGH, UK), Heather Graven (IMPERIAL, UK) Alex Vermeulen (Carbon Portal, Sweden)

CHE: WP1-2-3-4 Overview



WP1 Coordinating Efforts on **Reconciling** top-down and bottom-up estimates

WP2 Coordinating Efforts on **Library of simulations** for emissions and atmospheric transport

WP3 Coordinating Efforts on **Uncertainty trade-off** for fossil fuel emissions

WP4 Coordinating Efforts on **Attributing** CO2 emissions from in-situ measurements

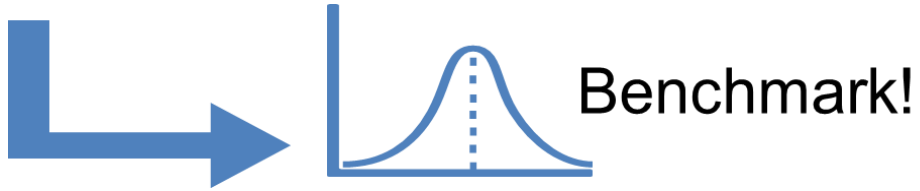
WP1: Reconciling top-down and bottom-up estimates

Lead: Wouter Peters/Maarten Krol (WU, Netherlands) Corinne LeQuere (UEA, United Kingdom)

Participants: UEA, ECMWF, ADS, SAS, ADS GMBH, EUMETSAT, iLAB, CEA, ULUND, TAS, UB, ULEIC, WU

WP1 include

- Task 1.1: Deliver a cross section of remote-sensing data products needed in the data assimilation chain to constrain anthropogenic carbon emissions
- Task 1.2: Develop novel techniques to constrain anthropogenic and natural carbon emissions from joint surface and space- based carbon cycle data
- Task 1.3: Reconcile top-down and bottom-up carbon dioxide source/sink estimates at multiple levels of integration using a community access platform



- Task 1.4: Document current shortcomings and needed developments in space-based monitoring of fossil fuel CO2 emissions

WP2: Library of simulations - emissions & transport

Lead: Dominik Brunner (Empa) & Hugo Denier van der Gon (TNO)

Participants: DLR, ECMWF, JRC, MPG, SPASCIA, SRON, TNO

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

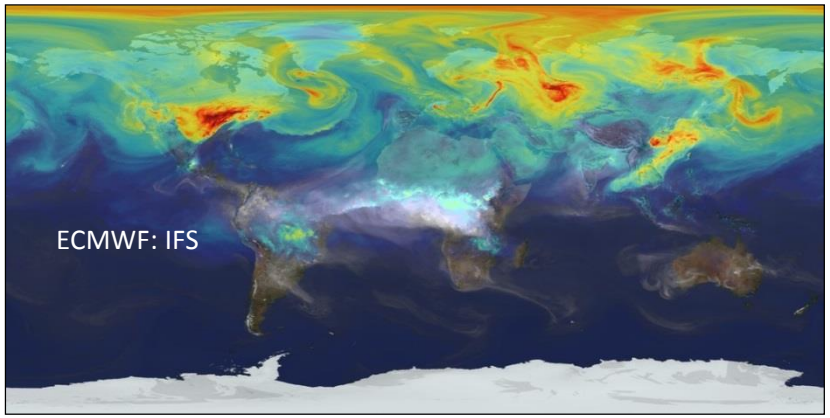
- Simulations for present-day and future emission scenarios
- From global to regional to point source scale
- Provide simulation input for other WPs

Support assessment of requirements for a future CO_2 space missions

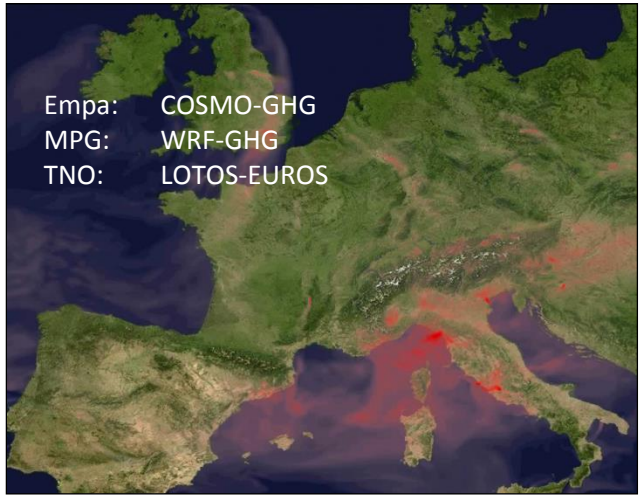
- Generate collection of synthetic satellite observations with realistic error characteristics, by combining model output with orbit simulations
- Investigate influence of aerosols on CO_2 retrieval in urban plume
- Investigate influence of small-scale and fluctuating nature of power plant plumes on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

WP2: Embracing multi-scale, from local to global

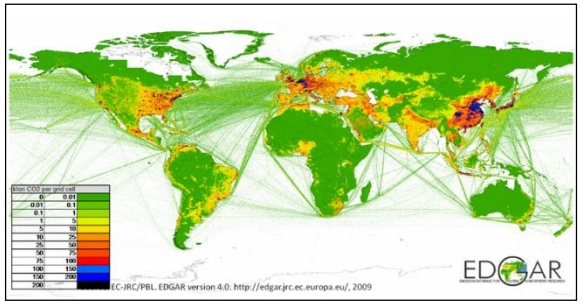
Global, ~ 9km resolution, ECMWF

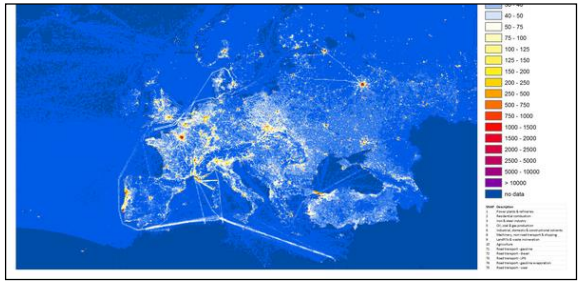


Europe, ~ 5 km, Empa, TNO, MPG

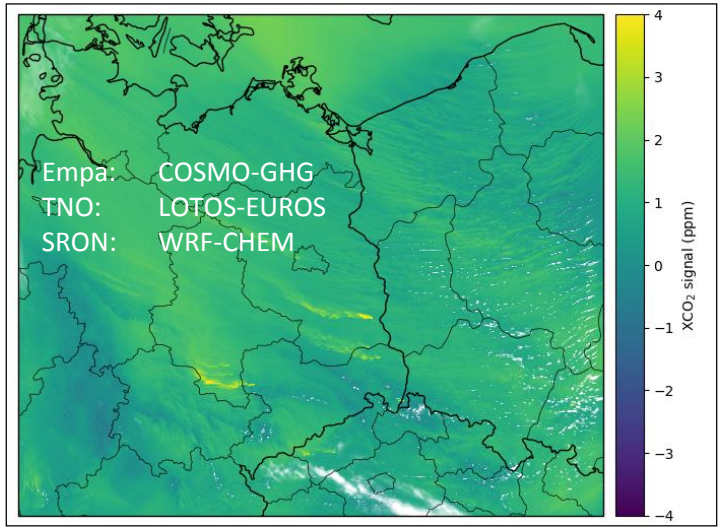


Global, Regional City emissions

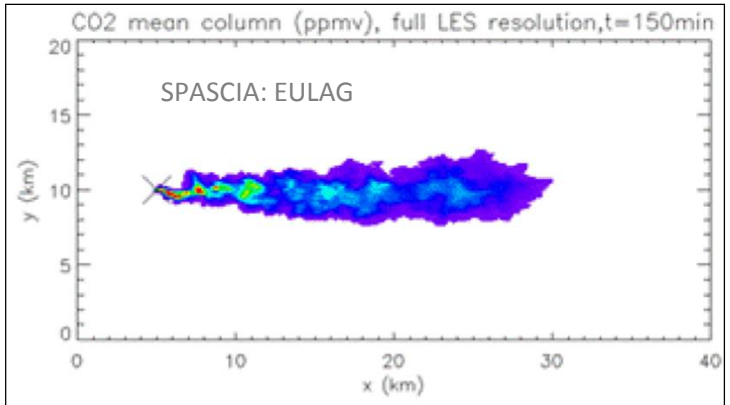


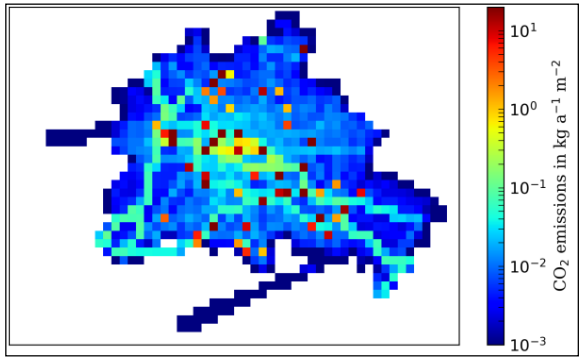


Regional, ~ 1 km, Empa, TNO, SRON



Point source, ~ 100 m, SPASCIA





WP3: Uncertainty trade-off - fossil fuel emissions

Lead: Marko Scholze (ULUND) and Greet Janssens-Maenhout (JRC)

Participants: ECMWF, CMCC, ULUND, iLab, JRC, KNMI, CEA-LSCE, MPG-BGC, TAS, TNO, UEA

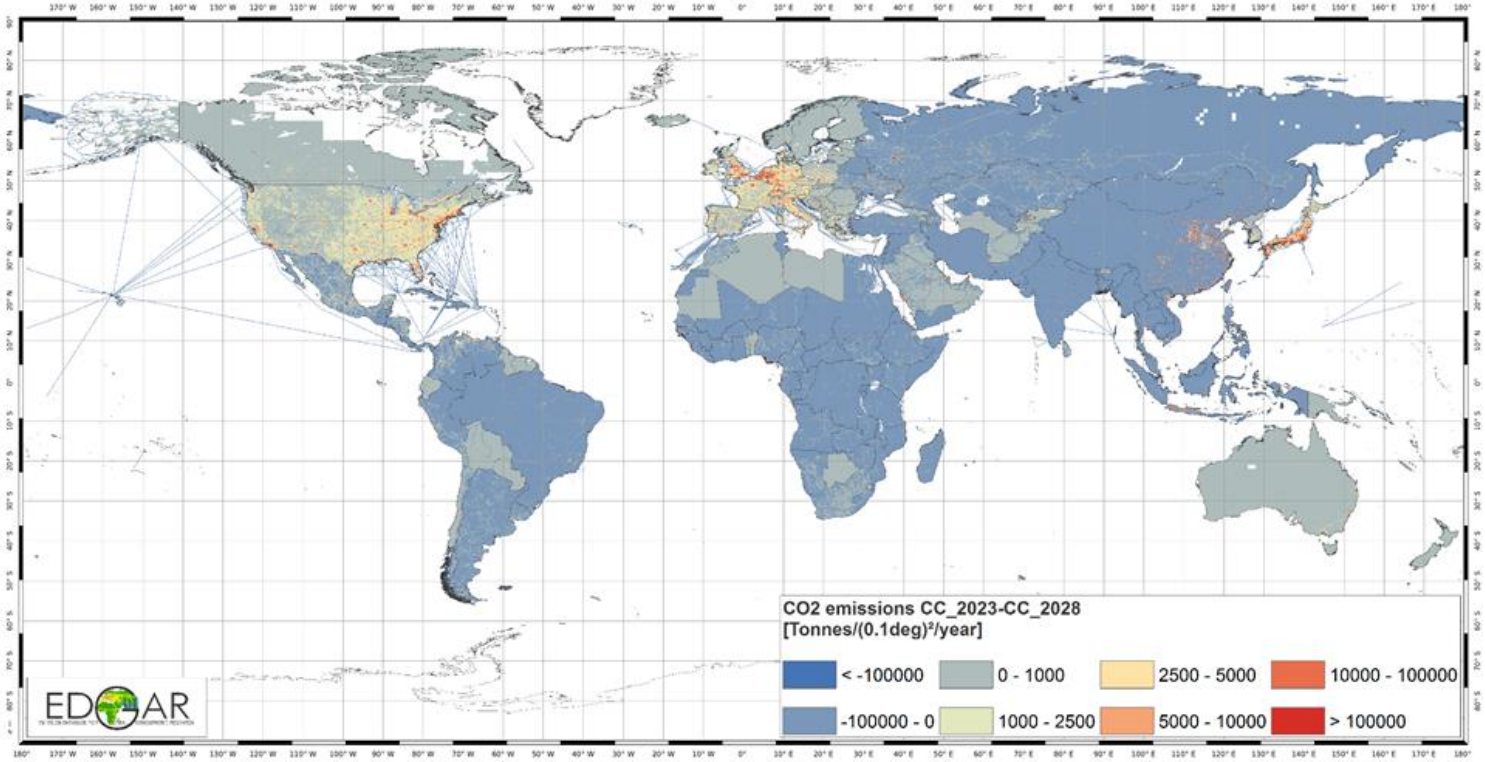
Provide high-resolution (~km, hourly) prior biogenic fluxes with quantified uncertainties based on upscaling of eddy covariance flux measurements

Provide prior gridded anthropogenic emissions and their uncertainties and per sector

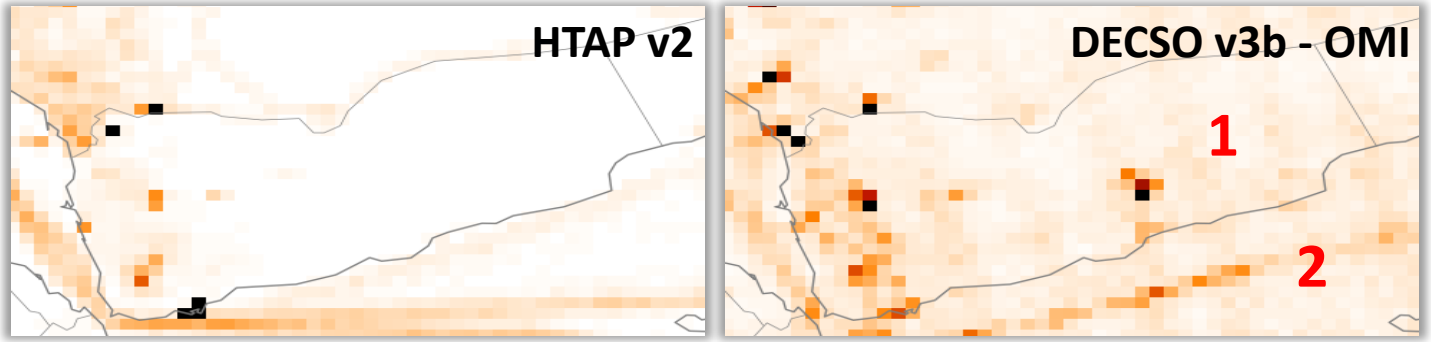
Evaluate the current status and possible improvements from enhanced space-borne and in-situ observation scenarios for fossil CO2 emissions quantification based on OSSEs and QND studies

- 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

WP3: Estimation of emissions uncertainties



Example: NOx emissions in Yemen



T3.1: Estimate biogenic fluxes and associated uncertainties from independent observations (MPG-BGC, by March 2019)

T3.2: Provide emission uncertainties & correlations from inventories and statistics – for global emission gridmaps of EDGAR (JRC, by March 2019)

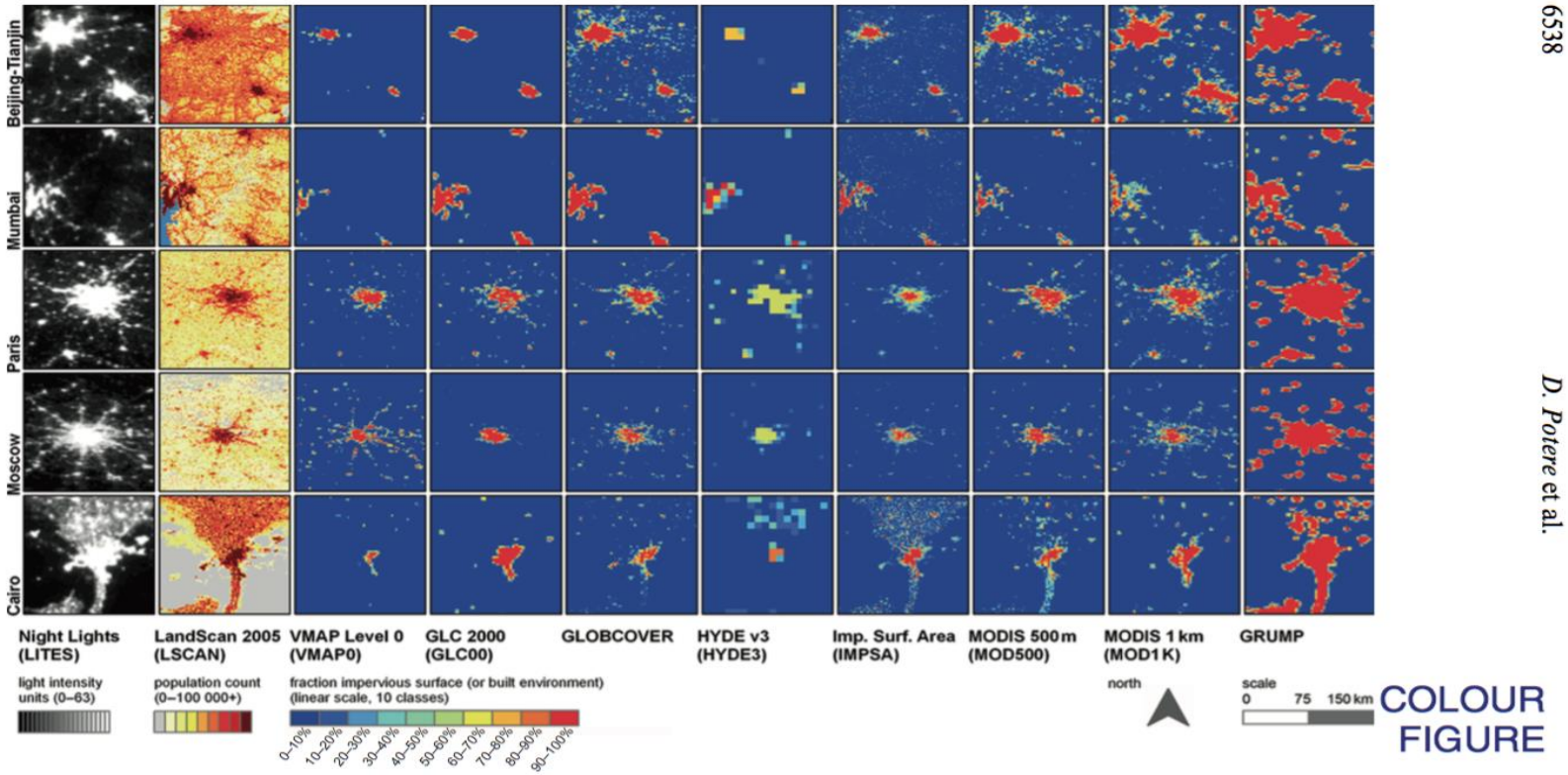
T3.3: Explore the role of satellite observations of NOx for estimation of fossil CO2 emissions (KNMI, by September 2019)

T3.4: Conduct OSSEs with an inverse transport modelling system to establish inversion strategy (CEA-LSCE, by June 2020)

T3.5: Perform QND experiments with advanced data assimilation systems (CC-FF-DAS) to establish inversion strategy (LUND/iLab, by June 2020)

Mapping human settlement

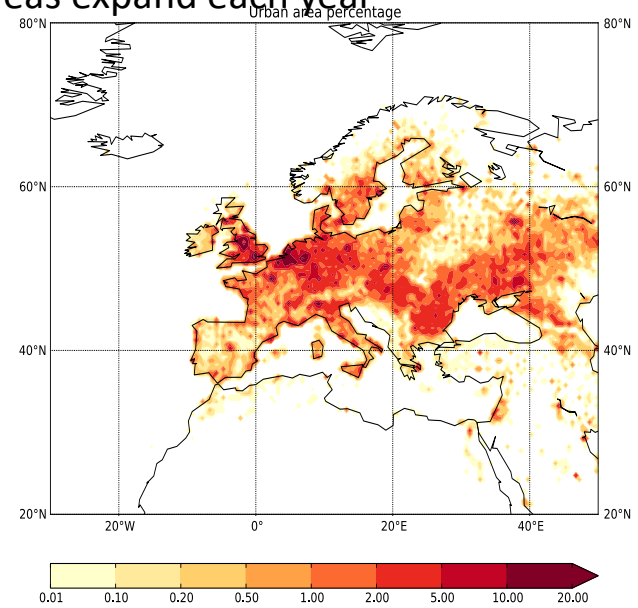
Classifying automatically urban areas (fraction and height) is an extremely complex task. Urban areas expand each year



6538

D. Potere et al.

Figure 1. The eight global urban maps and two urban-related maps for Beijing-Tianjin, China (top row), Mumbai, India (second row), Paris, France (third row), Moscow, Russia (fourth row), and Cairo, Egypt (bottom row). LITES, LSCAN and IMPSA are at native 30 arc-second resolution, HYDE3 is at native 5 arc-minutes, and the remaining maps have been aggregated from 30 arc-seconds to 1.5 arc-minutes for display. This aggregation effectively converts their legends from binary (urban/rural) to continuous (percentage urban).



- Urban area (a, in %, from ECOCLIMAP Masson et al., 2003) see:
- Balsamo et al. 2014 ECMWF TM729

- Urban area dataset comparison on selected cities (Potere et al., 2009 IJRS) reveal large uncertainties and discrepancies

WP4: Attributing CO2 emissions from in-situ measurements

Lead: Frédéric Chevallier, Julia Marshall

Participants: CMCC, CEA-LSCE, EMPA, MPG-BGC, NILU, TNO, UEA, ULUND

1. Explore the practical implications of distinguishing between anthropogenic (meaning fossil fuel emissions, and also non-fossil waste burning, biofuels, etc.) vs. biogenic CO_2 fluxes.
2. Optimization of the space-time sampling of $^{14}CO_2$, CO and APO.

T4.1 High-resolution scenarios of CO_2 and CO emissions (Lead: TNO, M1-M12)

T4.2 Attribution Problem (Lead MPG:, M1-M33)

T4.3 Practical Recommendations (Lead: CEA, M25-M36)

Outcomes

Survey current European in-situ observation capacity.

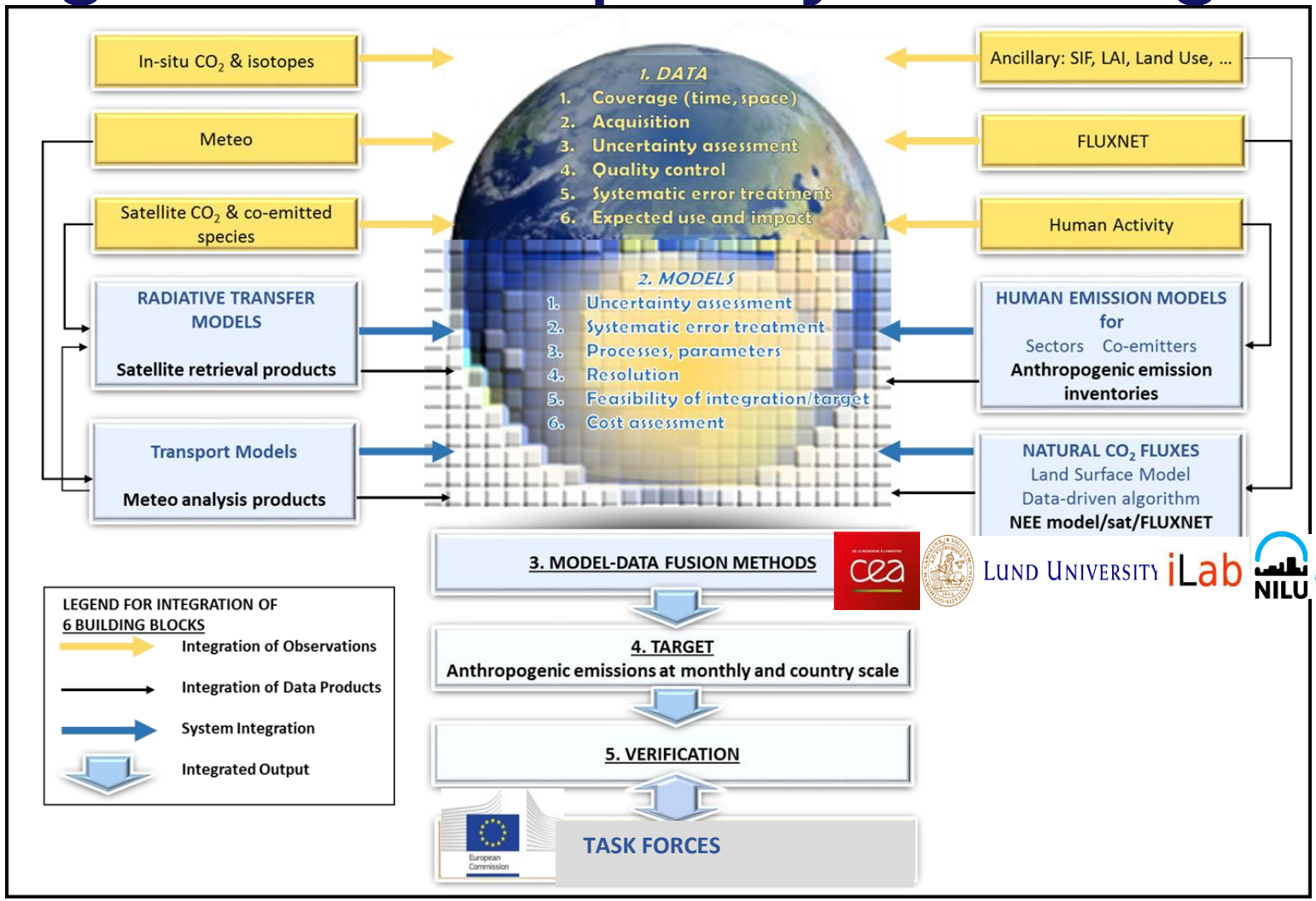
Define an operational strategy to separate anthropogenic CO_2 emissions from biogenic fluxes at regional and global scales through the use of additional tracers.

Shape the appropriate dimension and distribution of the corresponding in-situ network.

SERVICE ELEMENTS REQUIREMENTS

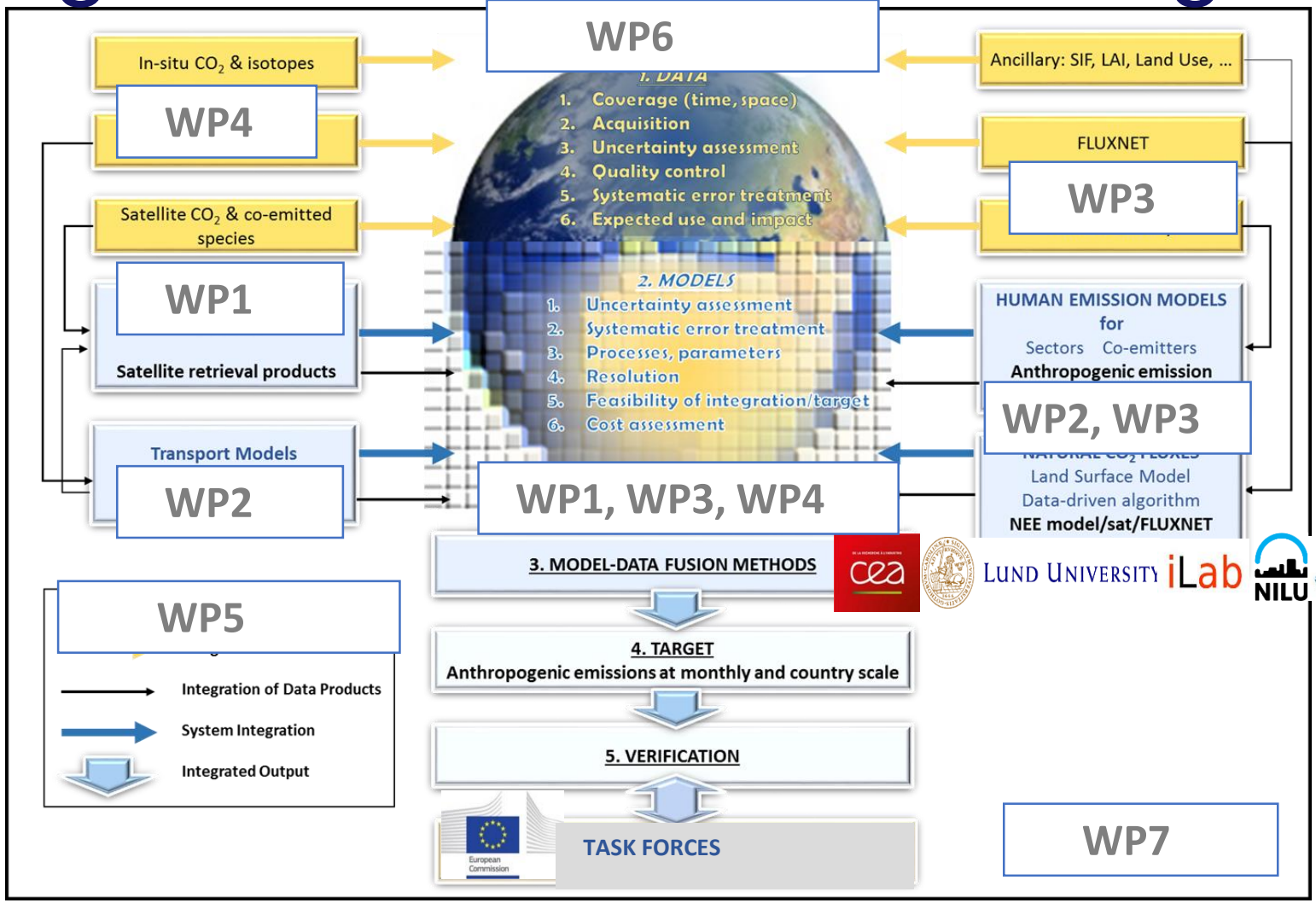
CO_2 HUMAN EMISSIONS

CHE Integration & capacity building



VERIFY
project

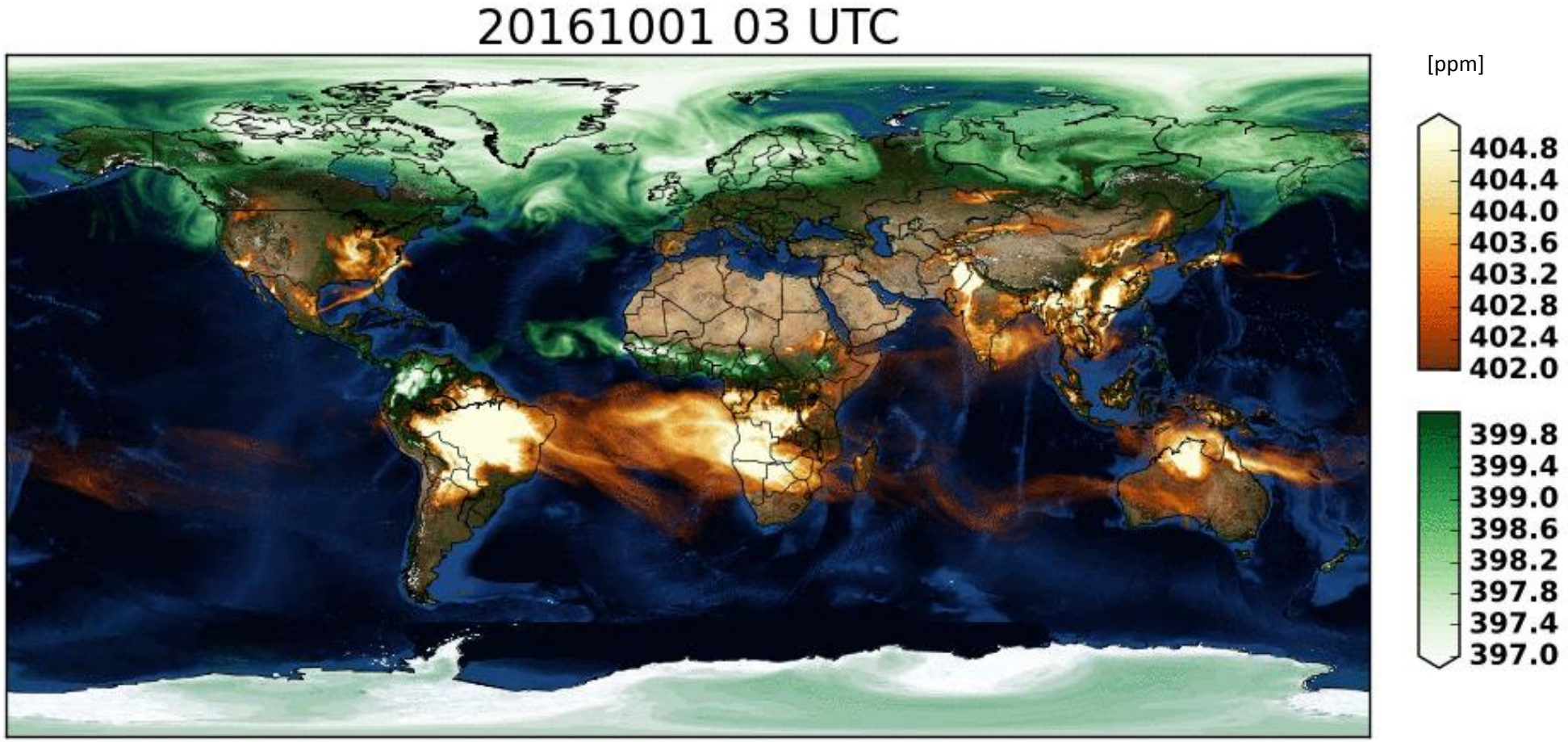
CHE Integration & capacity building



VERIFY project

CHE examples of building blocks

CO_2, CH_4, CO, tagged tracers at Tco1279 (~9km) L137



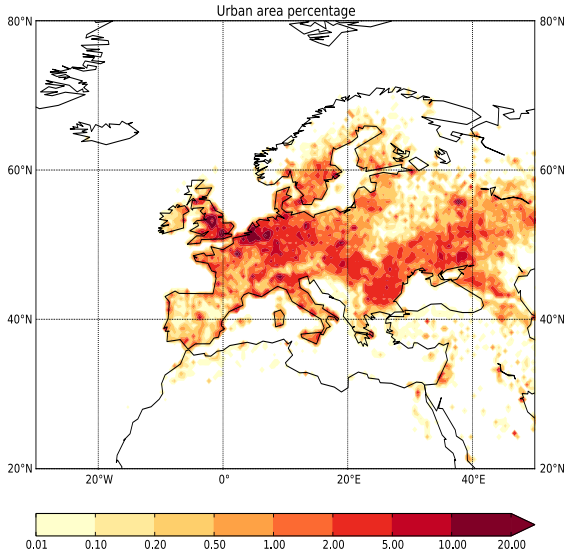
- CTESSEL NEE (BFAS correction Agusti-Panareda et al. ACP 2016
- EDGARv4.2FT2010
- Takahashi et al. (2009)
- GFAS biomass burning
- IFS transport
- Bermejo & Conde mass fixer (Agusti-Panareda et al. GMD 2017)

Forecasts of the CO2 variations from a 400 ppm concentration background. A call for high res.!

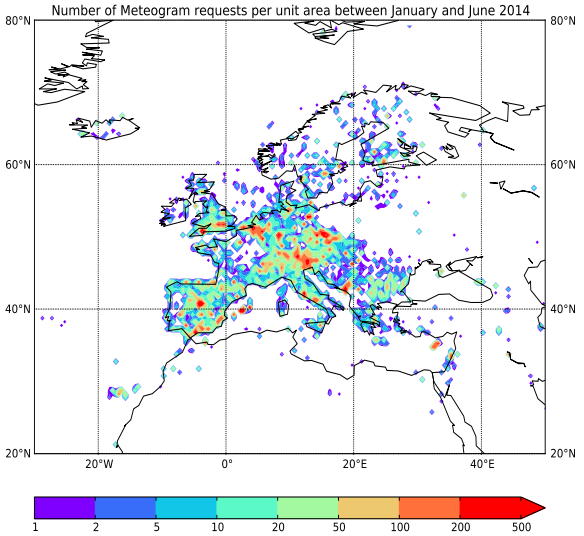
Thanks to Anna Agusti-Panareda, Richard Engelen & All CAMS-Team

CHE linkage with mapping & Weather

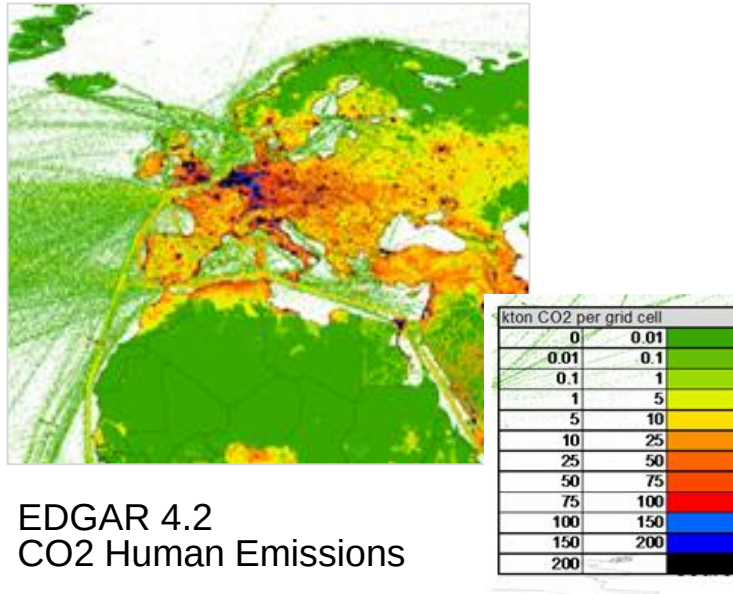
- Urban areas are important for the accurate prediction of extreme events such as heatwaves and urban flooding and need to be represented in ECMWF model.
- Best and Grimmond (2015) suggested that simple models may be well adapted to global applications
- Users lives urban areas and look at the forecast for urban locations.
- Urban maps combined with emission factors can provide CO2 anthropogenic fluxes



- Urban area (a, in %, from ECOCLIMAP, Masson et al., 2003)



- Number of ECMWF forecast product requests from Member-States



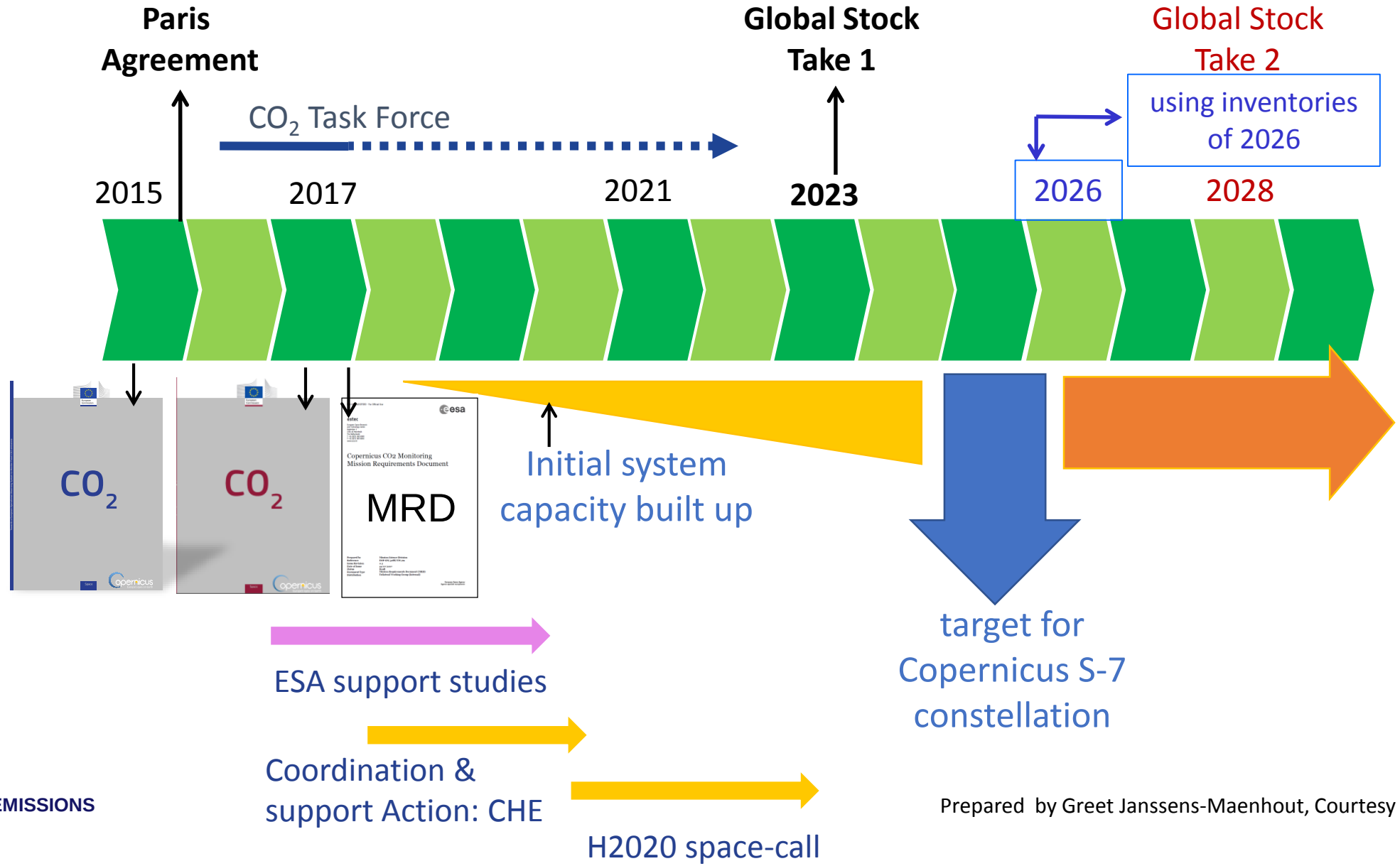
- EDGAR 4.2
  CO2 Human Emissions

The Global Data Processing and Forecasting System (GDPFS)

WMO OMM

Prepared by Michel Jean, Science Summit Presentation, Courtesy of Sarah Jones/Paolo Ruti WWRP/WMO

CHE in the CO2-MVS timeline



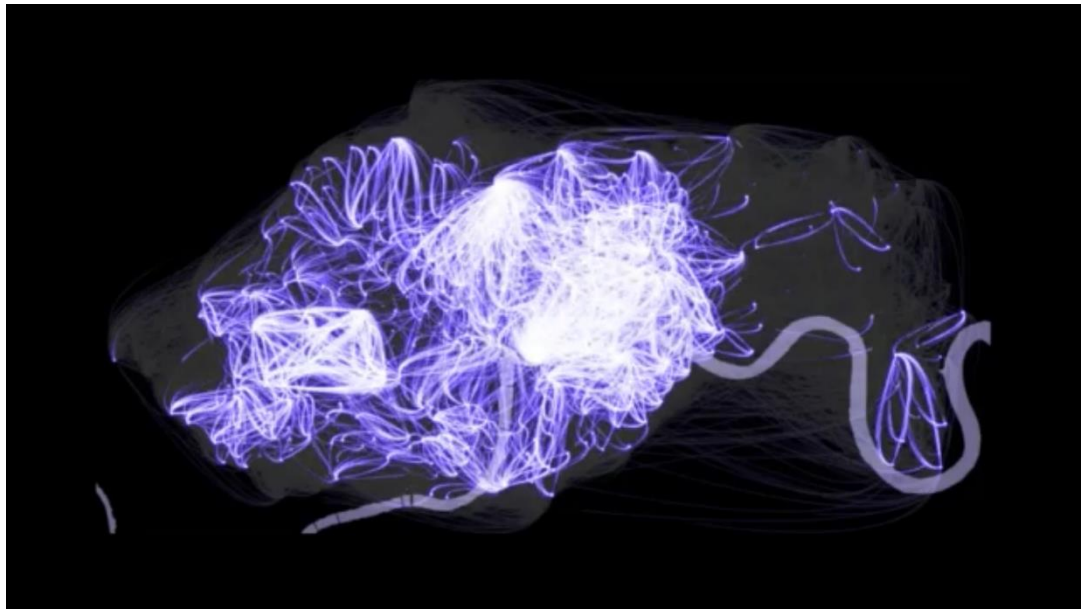
Prepared by Greet Janssens-Maenhout, Courtesy of EC Colleagues

Outlook & Vision

- Monitoring and Verifying CO2 Human Emission will engage new methods, new observations and a new generation of scientists!

EU Flights in 24-hour

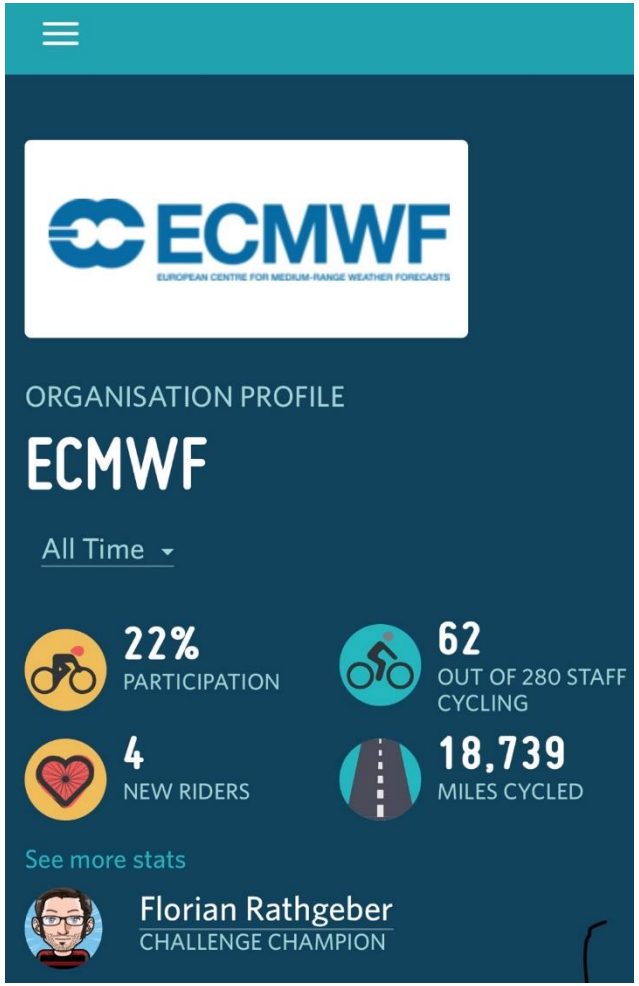
https://vimeo.com/88093956



London bycycles in 24-hour

https://www.youtube.com/watch?v=FaRBUnO5PZI

CHE needs everyone's involvement



https://www.lovetoride.net/bikesmart/companies/16869

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Gianpaolo Balsamo
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