



Co-ordinated by
ECMWF



**CO₂
Human
Emissions**

CHE – CO₂ HUMAN EMISSION – H2020

#CHE at #EUSpaceWeek

Gianpaolo Balsamo, Richard Engelen, Daniel Thiemert
for the CHE Coordination Team

7.12.2020 – 11.12.2020



CHE project: Earth Observation support for Paris Agreement

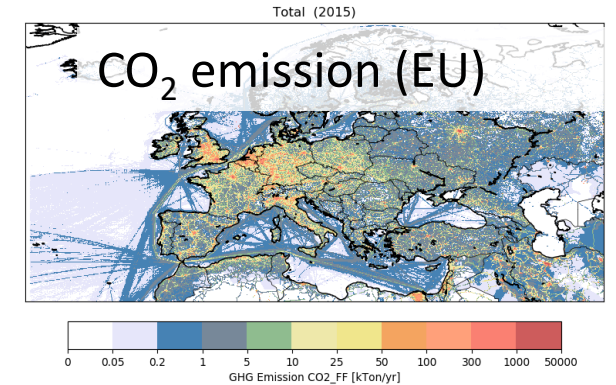
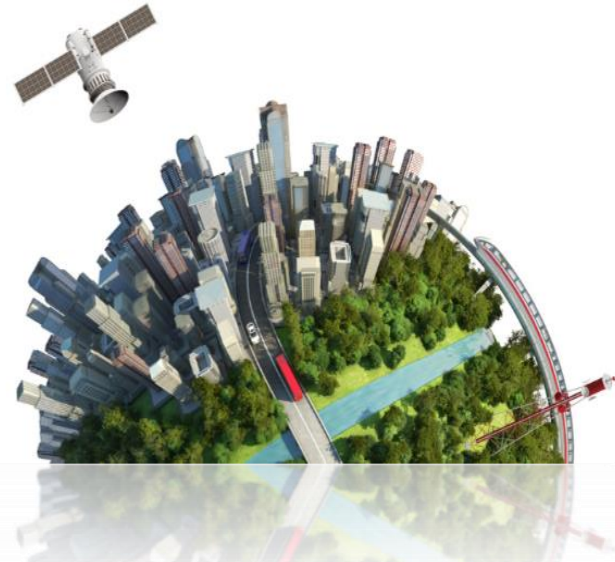
CO₂ Human Emission H2020 project (2017-2020):

Aims at building a European monitoring capacity for anthropogenic CO₂ emissions

Methodological asset (Integrated approach):

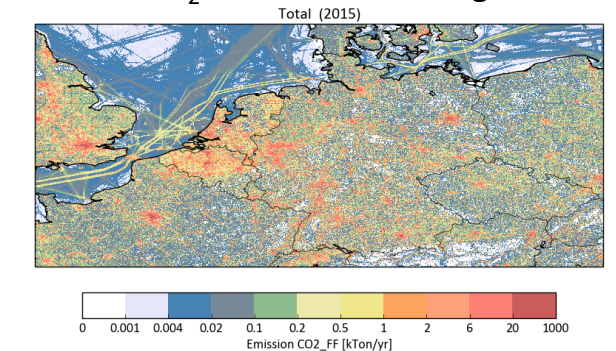
Obtains CO₂ emission estimation system driven by **Earth Observations** (remote sensing & in-situ) integrated within enhanced **Earth System Models**

Expertise asset (22-EU Partners Institutes):



5x5 km CO₂ emission over Europe

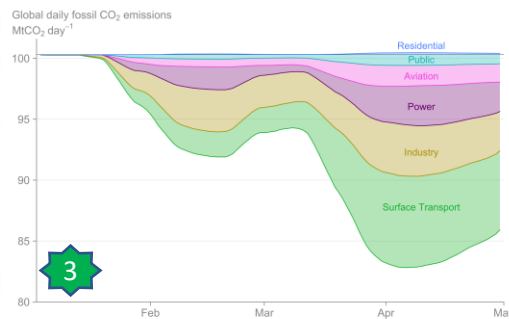
1x1 km CO₂ emission on a Target Domain



Temporary reduction in daily global CO₂ emissions during the COVID-19 forced confinement

Corinne Le Quéré^{1,2,3}, Robert B. Jackson^{3,4,5}, Matthew W. Jones^{1,2}, Adam J. P. Smith^{1,2}, Sam Abernethy^{3,4}, Robbie M. Andrew⁷, Anthony J. De-Gol^{1,2}, David R. Willis^{1,2}, Yuli Shan⁶, Josep G. Canadell¹, Pierre Friedlingstein^{10,11}, Felix Creutzig^{12,13} and Glen P. Peters¹

Government policies during the COVID-19 pandemic have drastically altered patterns of energy demand around the world. Many international borders were closed and populations were confined to their homes, which reduced transport and changed consumption patterns. Here we compile government policies and activity data to estimate the decrease in CO₂ emissions during forced confinements. Daily global CO₂ emissions decreased by ~17% (-11 to -25% for ±1σ) by early April 2020 compared with the mean 2019 levels, just under half from changes in surface transport. At their peak, emissions in individual countries decreased by ~26% on average. The impact on 2020 annual emissions depends on the duration of the confinement, with a low estimate of -4% (-2 to -7%) if pre-pandemic conditions return by mid-June, and a high estimate of -7% (-3 to -13%) if some restrictions remain worldwide until the end of 2020. Government actions and economic incentives postcrisis will likely influence the global CO₂ emissions path for decades.



Source: Le Quéré et al. Nature Climate Change (2020); Global Carbon Project

CHE attained accurate & readily usable CO₂ emission inventories

CHE prepared for Earth Observation global CO₂ data assimilation capacity

CHE demonstrated fast response during COVID-19 for CO₂ monitoring



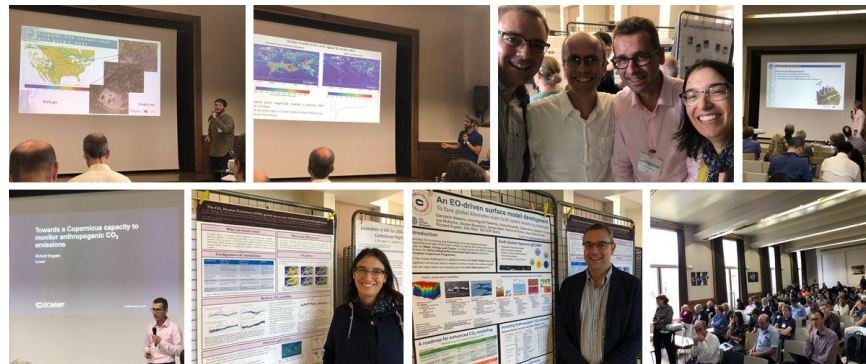
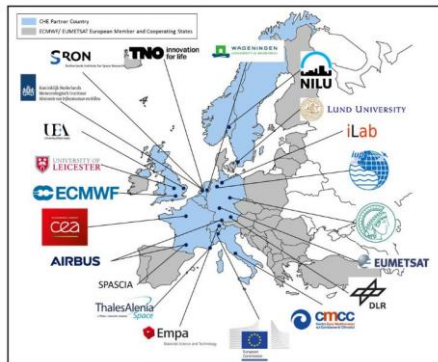
CHE @ EUSpaceWeek – I of III

Q1: Which three words best describe your project?

I can think of three words that define the CO₂ Human Emission project:

- **Passion** intended as determination
- **Science** and more generally Innovation
- **Precision** as a crucial ingredient

<https://www.che-project.eu/news/paris-ig3is-transcom-workshop-sees-large-participation-che-project>



<https://www.che-project.eu/news/successful-joint-che-verify-general-assembly>



CHE: About Passion/Determination

Passion is one of the driving forces at ECMWF, the European Centre for Medium Range Weather Forecasts, that is coordinating the CHE project.

We had the privilege to gather some of the **best experts in Europe for CO2 Science**, both at ECMWF and throughout the 22 European partner-institutes that compose the CHE project Consortium.

Passion & Determination were clear from the start, and particularly during the **COVID-19** pandemic, as the project remained on track, and more importantly, several groups engaged in estimating impact of lockdowns on CO2 emissions (we now know that it is about **6-7% for 2020** due to reduced mobility & industrial production).

These studies, partly funded by or connected to CHE, have already been published in prestigious journals making also an impact on the news from the *BBC* to the *New York Times*.

CHE: with Science/Innovation

Science & innovation have been key in converting the ambition & ideas from the European Commission into requirements for the prototypes that can tackle the enormous challenge of **measuring CO2 emissions from Space.**

Monitoring CO2 will rely on a **New European Constellation of Satellites** that will join the **Copernicus Family of Sentinels (CO2M).**

Converting these observations into CO2 emissions globally at unprecedented resolution, precision and coverage requires a whole set of innovative science developments.

CHE: striving for Precision

Precision describes well a key ingredient needed for succeeding in our challenge of estimating globally the CO₂ Human Emissions.

We know that to be able to reliably measure the CO₂ emission from Space and on the ground “**precision**” is needed in all the building blocks of the European CO₂ Monitoring and Verification Support Capacity.

The **CO₂MVS system** will provide an Earth Observation support to implement the **Paris Agreement** and to combat climate-change.

CHE @ EUSpaceWeek – II of III

Q2: Why your project has been successful?

CHE has been successful in making the first steps to design & develop innovative methodologies that can convert observations into policy-relevant information.

Within the CHE project we have produced some of the **highest resolution ensemble simulations of CO₂ emissions & atmospheric concentrations**, both at global scale and in regional zoom areas over Europe.

This data will be used to compare model simulations with satellite observations that are then injected into **global & regional data assimilation systems**

In CHE we have realised two studies one global and one looking at more regional European scales that can anticipate how much these innovative **Copernicus orbiting satellites** and **ground-based observations such as the ICOS and TCCON networks** will be able to support the European CO₂ emission monitoring.

CHE @ EUSpaceWeek – III of III

Q3: What's your advice to future applicants?

The work started in **CHE**, will continue in a follow-on project, **CoCO2**, which stands for Copernicus CO2, and which will deliver the prototype of the **Copernicus CO2** emissions Monitoring and Verification Support Capacity.

I feel strongly to suggest to future applicants to challenge themselves and work in a very collaborative spirit with their proposal and with their project partners to achieve a common goal.

CHE presented in the H2020 success stories

Interview at EU Space Week (11th December 2020) where CHE is among the selected projects as European Horizon-2020 success stories

The image shows a Zoom meeting interface. On the left, a dark blue sidebar contains the following information:

- Time: 09:00 - 11:00
- Profile picture of a man in a suit
- Event title: H2020 projects - success stories
- Buttons: Details, Q&A
- A list of names: Christophe Grudler, Mats Ljungqvist, Rodrigo da Costa, Gunnar Brandt, Jorge Ocón Alonso, Pedro Teixeira, Markus Probeck, Iñigo Adin, Raúl Arnau Prieto, William Roberts, Isabel Botey, Gianpaolo Balsamo, Ernst Pfeiffer, Fabian EnBle, Pedro Russo

On the right, two video thumbnails are visible. The left thumbnail shows a woman with blonde hair wearing a black top, speaking. The right thumbnail shows a man with glasses and a dark suit jacket over a light blue shirt, also speaking. The background of the Zoom window features various icons related to space and technology, such as a satellite, a heart with a pulse line, a location pin, a wind turbine, and a grid of numbers.

CHE @ EUSpaceWeek – Q & A

Q: The climate change is indeed a huge threat for us and the next generations. It is key to understand well the changes and their impact. Can you please tell us in more details how the data of CHE will be used after the project implementation? How the solution fits in your business? How do you plan to leverage the data?

Managing the Climate Crisis requires rapid reduction of the Anthropogenic **CO₂** emissions associated to Human activities. This is the way forward, to limit global warming to less than 2°C following the pathway indicated by **IPCC** and agreed by the **Paris Agreement** in **2015**.

“To Manage One Needs to Measure” and this the case also for **CO₂ emissions**. The European Commission has set the vision to measure **CO₂ from Space** within Copernicus and on the ground with in-situ networks. The CHE project has set the first steps in the building blocks of a future **CO₂ Monitoring and Verification Support Capacity**, to support the ambition goals of the Paris Agreement & the **Climate Neutrality in 2050**. In the CHE project we have been building & demonstrating this capacity and we had also identified the priority of developments to be ready for the future **CO₂M Copernicus mission** in **2025**.

To foresee how service elements will develop to leverage EO data is worth to look at **C3S & CAMS**, the Copernicus Climate Change & Atmospheric Monitoring Services, that integrate Earth Observations & Earth System Models in **Climate & Environmental Reanalyses**.



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ECMWF



**CO₂
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CHE @ EU SPACE WEEK

Further video support material

CHE web-site

<https://www.che-project.eu>



A CHE poster – presented at the UNFCCC

The CO₂ Human Emissions (CHE) project – moving towards a European capacity to Monitor Anthropogenic CO₂ Emissions

Gianpaolo Balsamo¹, Richard Engelen¹, Anna Agusti-Panareda¹, Nicolas Bousserrez¹, Dominik Brunner², Frédéric Chevallier³, Margarita Choulga¹, Hugo Denier van der Gon⁴, Greet Janssens-Maenhout⁵, Corinne Le Quéré⁶, Julia Marshall⁷, Joe McNorton¹, Wouter Peters⁸, Marko Scholze⁹, Daniel Thiemert¹ & CHE Team

(1) European Centre for Medium-Range Weather Forecasts (ECMWF); (2) Eidgenössische Materialprüfungs- und Forschungsanstalt (EMPA); (3) Commissariat à l'énergie atomique et aux énergies alternatives (CEA); (4) Nederlandse Organisatie voor toegepast-natuurwetenschappelijk onderzoek (TNO); (5) Joint Research Centre (JRC); (6) University of East Anglia (UEA); (7) Max-Planck-Institute for Biogeochemistry (MPI-BGC); (8) Wageningen University & Research; (9) Lund University

Contact email: gianpaolo.balsamo@ecmwf.int

1. Introduction

At the **United Nations Paris Climate Agreement** in December 2015, 196 nations signed up to limit their greenhouse gas emissions through Nationally Determined Contributions (NDCs) and a 5-yearly Global Stocktake (GSTs). To support this process the European Commission initiated the design and development of a new Copernicus service element that will use Earth observations to specifically target anthropogenic CO₂ emissions. Having started on 1st of October 2017 for 39 months, the CO₂ Human Emissions (CHE) project has been successfully coordinating efforts of its 22-Project Partners in the Consortium, to advance the development of a European monitoring and verification support capacity for anthropogenic CO₂ emissions.

2. Towards an operational Copernicus anthropogenic CO₂ emissions Monitoring & Verification Support capacity within CAMS Services

Core elements of the Monitoring and verification support capacity. Credit: European Commission CO₂ monitoring Task Force.

Based on the recommendations of two expert panels, the European Commission has proposed adding an anthropogenic CO₂ emissions **Monitoring and Verification Support (MVS)** capacity to its Copernicus Earth observation programme. This will support the European Commission and the Member States with their activities to combat climate change.

3. CHE structure & Key Output

The CHE project consists of four scientific work packages (WP1 – WP4), one work package on integration and recommendations for a future prototype (WP5), and two work packages for CHE international liaison (WP6) and CHE coordination and outreach (WP7).

- WP1 - Reconciling top-down and bottom-up estimates**
 - Assessing coherence of satellite + in-situ inversions & bottom-up inventory
- WP2 - Library of simulations**
 - Realistic CO₂ simulations "nature runs", from global & regional scale.
- WP3 - Uncertainty trade-off**
- WP4 - Attributing CO₂ emissions from in-situ**
 - Distinguishing between anthropogenic & biogenic CO₂ fluxes
- WP5 - Towards a prototype**
 - Integrating research of WP1 to WP4 for future operational capacity
- WP6 - International Stakeholder Coordination and Liaison**
 - Liaising with the EC-CO₂ TaskForce & International Stakeholders

4. Key results & references

Example of inventories emissions Intercompared (TNO, EDGAR, UNFCCC) & Gridded for use in Global/Regional Models

Example of Global Nature Runs Integrating CO₂ Emissions & Concentrations & The IPCC UNFCCC ECMWF data-chain

CO2M satellite constellation study in CCFDAS system to prepare the CO2MVS & Explore use of Near Real Time Activity Data as in CarbonMonitor

5. Summary

- CHE has been advancing to build an integrated anthropogenic CO₂ emissions monitoring and verification support capacity on a **global & regional scale**.
- Good progress has been made in the four scientific work packages, of which four examples are shown in the panel above (+ 3 YouTube Videos).
- The research advances are integrated in (WP 5) and provide clear recommendations for the development of a prototype system, for a future **Copernicus CO₂ Service**. Research & Development continue in the **CoCo2** project (2021-2023) to prepare for the GST-1.
- More info as well as all project results are publicly available on the CHE website: <http://www.che-project.eu>

Acknowledgements

The CHE project has received funding from the **European Union's Horizon 2020** research and innovation programme under grant agreement No 776186. This publication reflects the views only of the author, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

23.11. - 4.12. 2020

CLIMATE DIALOGUES 2020

UN Climate Change Dialogues 2020 (Climate Dialogues)

Lobby Conference Trade Expo Networking Resources Help

Earth Information Day 2020 - Poster Session Hub

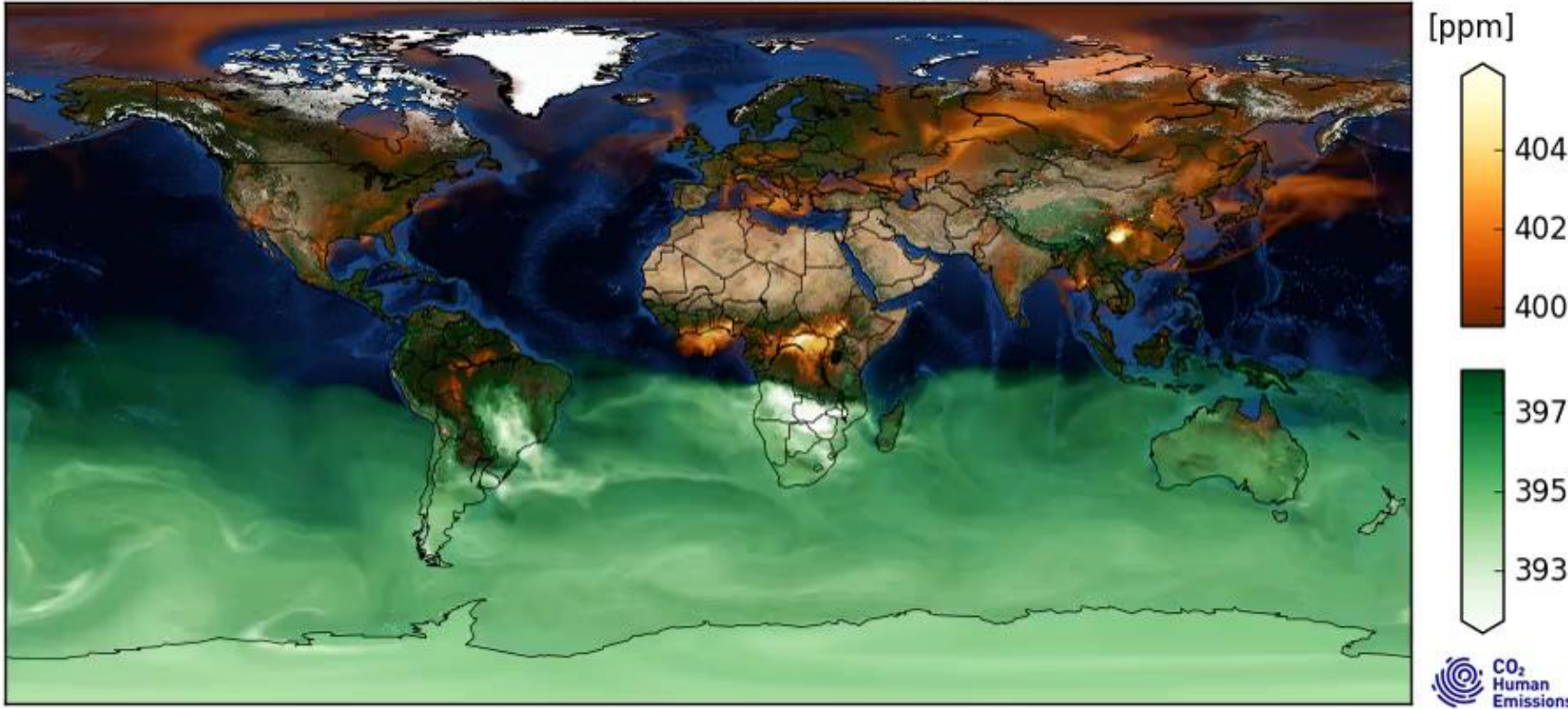
Description Resources Schedule a virtual meeting

Study **CO₂ in 2015** Paris Agreement's year prepares for **CO2M**

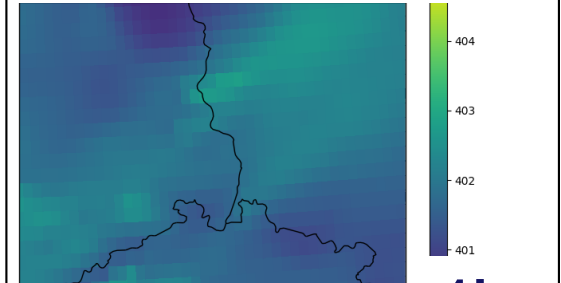
The CO2 Monitoring & Verification Support capacity developed in CHE focus on 3 scales: Global / Regional / Local

Global scale

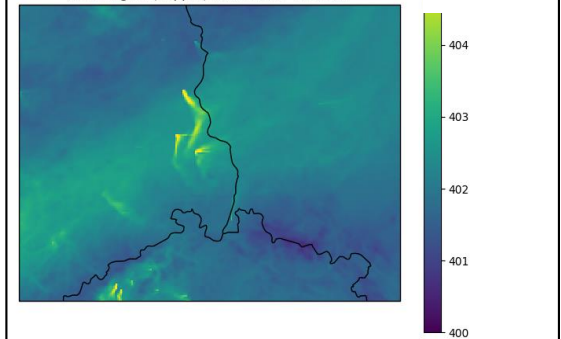
20150101 03 UTC XCO₂



Regional scale 9km



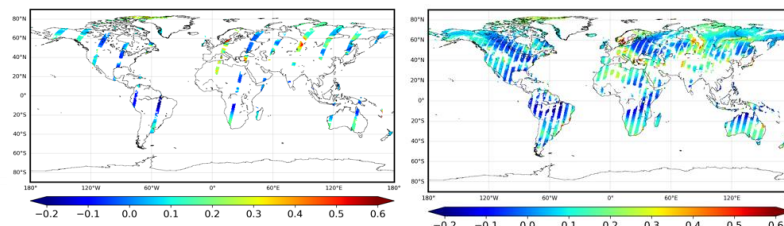
XCO₂ signal (in ppm) on 2015-03-09 09:00



Local scale



CO2M 2025 - OHB



Testing data assimilation with 1 & 4 satellites

CHE investigated the CO₂ human emission **detection capability** (of Observations & Modelling) to be **prepared** for the future dedicated **CO2M** European Satellite Mission

CHE efforts...both a Sprint & a Marathon...

Already about 10 publications within CHE, documenting efforts on CO₂ monitoring & verification progress: short-term & long-term

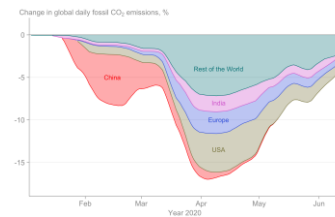
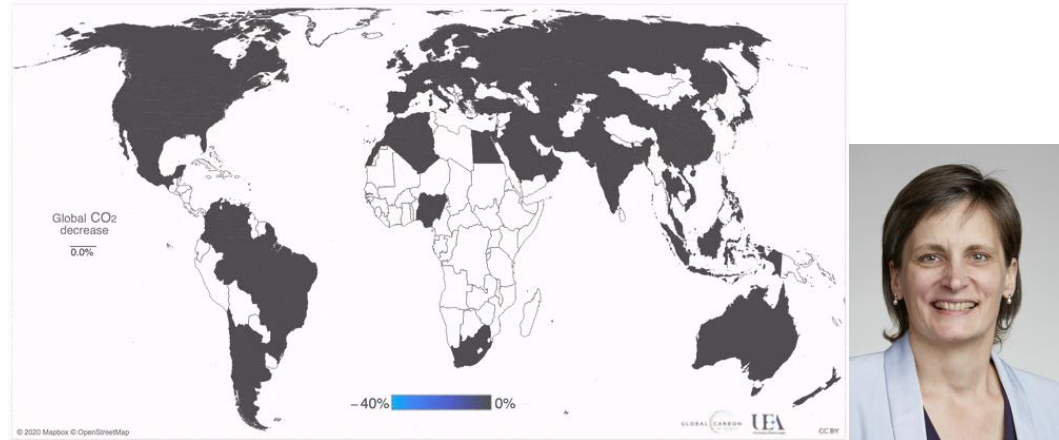


Temporary reduction in daily global CO₂ emissions during the COVID-19 forced confinement

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Changes in CO₂ emissions during the COVID-19 forced confinement 1 January 2020



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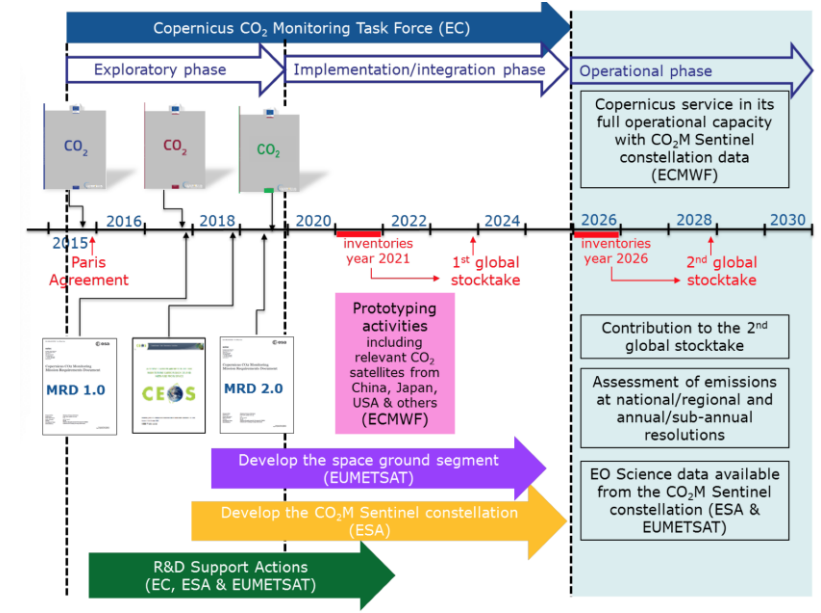
- Abstract
- Footnotes

RESEARCH ARTICLE | 10 FEBRUARY 2020

Towards an operational anthropogenic CO₂ emissions monitoring and verification support capacity

G. Janssens-Maenhout¹, B. Pinty², M. Dowell³, H. Zunker⁴, E. Andersson⁵, G. Balsamo⁶, J.-L. Bézy⁷, T. Brunhes⁸, H. Bösch⁹, B. Bojkov¹⁰, D. Brunner¹¹, M. Buchwitz¹², D. Crisp¹³, P. Ciais¹⁴, P. Counet¹⁵, D. Dee¹⁶, H. Denier van der Gon¹⁷, H. Dolman¹⁸, M. Drinkwater¹⁹, O. Dubovik²⁰, R. Engelen²¹, T. Fehr²², V. Fernandez²³, M. Heimann²⁴, K. Holmlund²⁵, S. Houweling²⁶, R. Husband²⁷, O. Juvvyns²⁸, A. Kentarchos²⁹, J. Landgraf³⁰, R. Lang³¹, A. Löscher³², J. Marshall³³, Y. Meijer³⁴, M. Nakajima³⁵, P. Palmer³⁶, P. Peylin³⁷, P. Rayner³⁸, M. Scholze³⁹, B. Sierk⁴⁰, J. Tamminen⁴¹, P. Veefkind⁴²

Bull. Amer. Meteor. Soc. (2020)
<https://doi.org/10.1175/BAMS-D-19-0017.1>



CHE project (2017 - 2020) – Month 38 of 39 ☺



Aim:

Build European monitoring capacity for anthropogenic CO₂ emissions

How:

CO₂ emission estimation system driven by Earth observations (remote sensing and in situ) combined with enhanced modelling system

Why:

To support the Paris Climate Agreement and its implementation



Project Duration:

39 month (38 ✓)

Project Funding:

3.75 M€ (1.25 M€/year)

Consortium Numbers

22 partners Institutes

Work Content Numbers

7 work-packages:

5-Science development,

1-International liaison,

1-Management & Coms

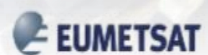
7 Milestones (6

✓)

45 Deliverables (35 ✓)

344.25 Person Month

(Eq 8.8 FTE)



CoCO2 project (2021 – 2023) approved 😊



Aim:

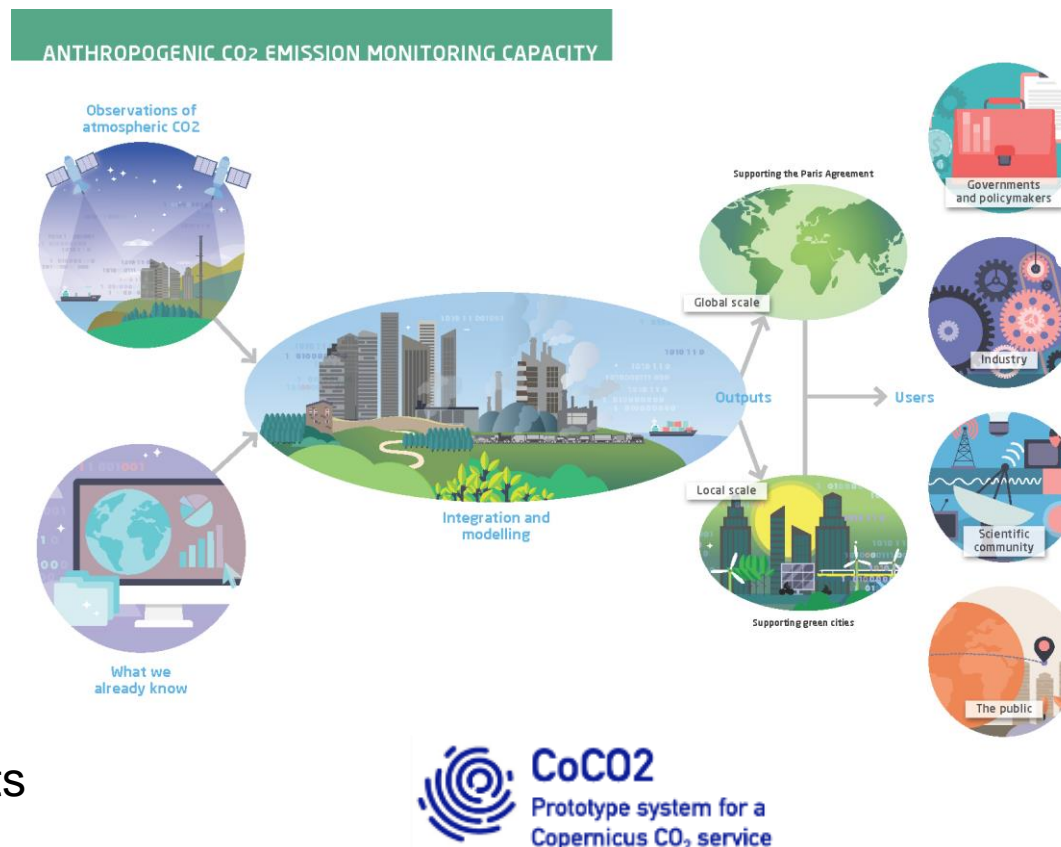
Consolidate a Copernicus CO2 pre-operational prototype for the 1st Global Stock Take (GST-1)

How:

CO₂ emission estimation system driven by Earth observations (remote sensing and in situ) combined with modelling to build an information products portfolio

Why:

To support the Paris Agreement in its operational implementation phase



Project Duration:

36 month

Project Funding:

9.00 M€ (3.00 M€/year)

Consortium Numbers

25 partners Institutes

Work Content Numbers

9 work-packages:

- 4-Science development,
- 1-Prototype integration,
- 1-Observations & Nat. link,
- 1-Information Products,
- 1-Coordination & Outreach
- 1-Ethics

25 Milestones

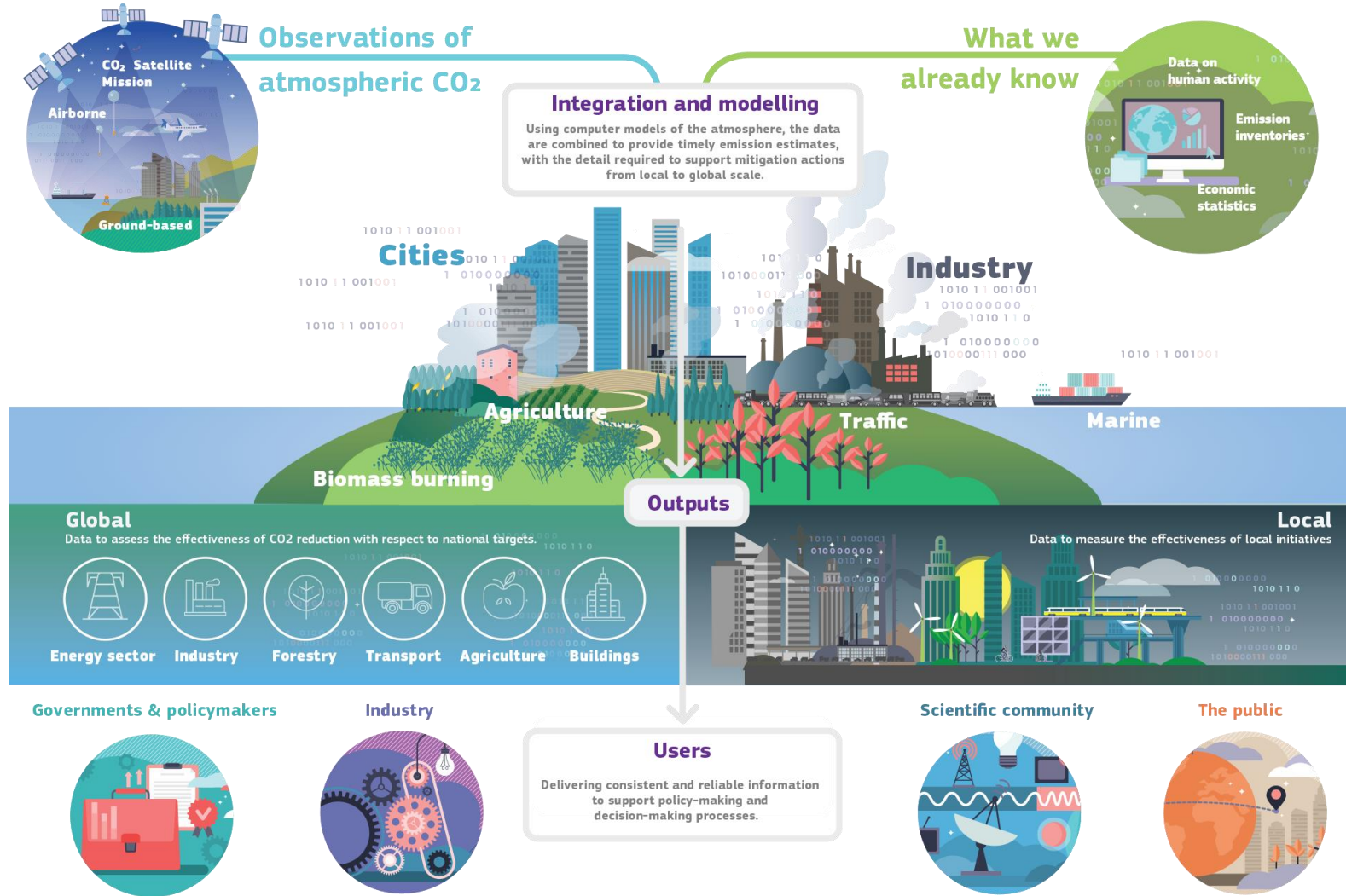
67 Deliverables

920 Person Month

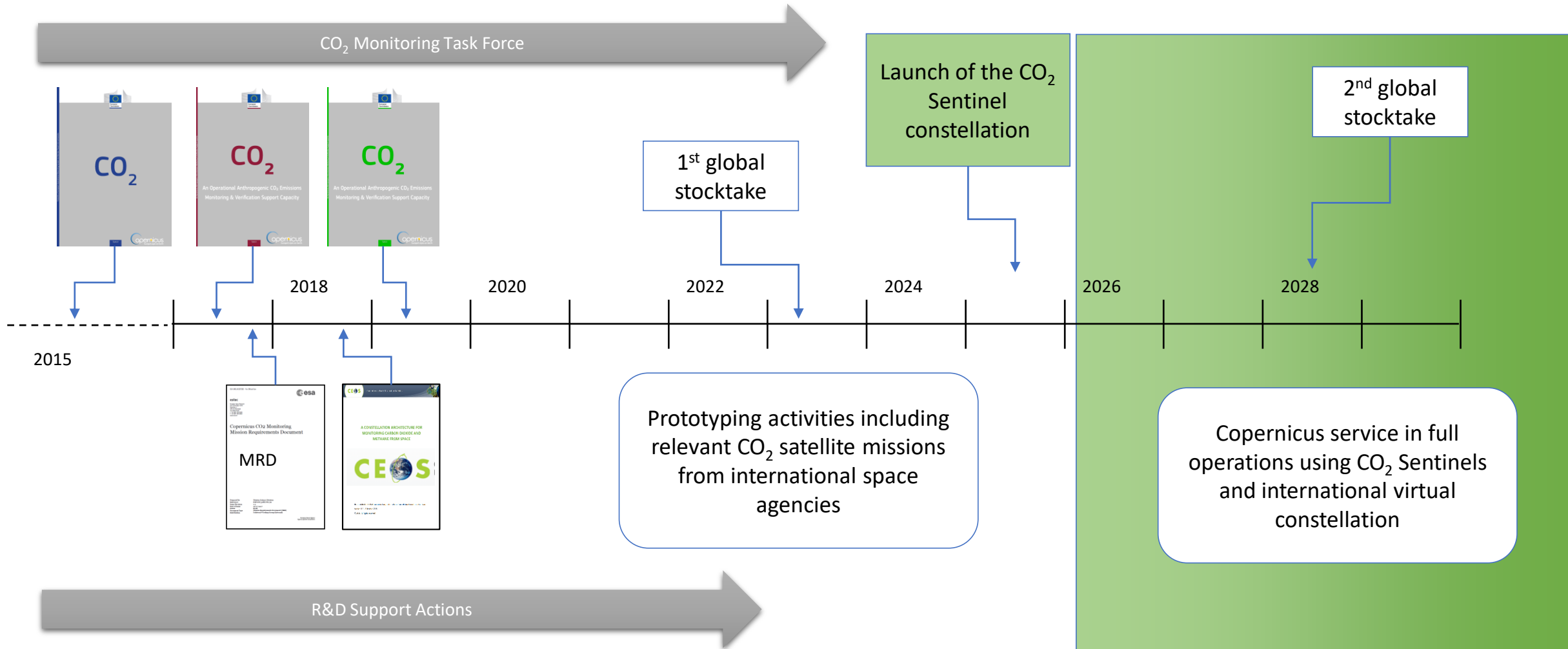
(Eq 25.5 FTE)



Future Copernicus CO₂MVS capacity



Roadmap towards Copernicus CO₂ service



Thanks to European CO₂ Task-Force



CHE

Social media #CHE + @che_project
https://mobile.twitter.com/che_project

