



CO₂
Human
Emissions

Final Dissemination and Exploitation Report

Daniel Thiemert

che-project.eu



Co-ordinated by
 ECMWF



CO₂ Human Emissions

D7.7 Final Dissemination and Exploitation Report

Dissemination Level:	Public
Author(s):	Daniel Thiemert (ECMWF)
Date:	15/12/2020
Version:	1.0
Contractual Delivery Date:	31/12/2020
Work Package/ Task:	WP7/ T7.4
Document Owner:	ECMWF
Contributors:	All Partners
Status:	Final



CO₂ Human Emissions

CHE: CO₂ Human Emissions Project

Coordination and Support Action (CSA)
H2020-EO-3-2017 Preparation for a European
capacity to monitor CO₂ anthropogenic emissions

Project Coordinator: Dr Gianpaolo Balsamo (ECMWF)
Project Start Date: 01/10/2017
Project Duration: 39 months

Published by the CHE Consortium

Contact:

ECMWF, Shinfield Park, Reading, RG2 9AX,
gianpaolo.balsamo@ecmwf.int



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



Table of Contents

1	Executive Summary.....	5
2	Introduction.....	5
2.1	Background.....	5
2.2	Scope of this deliverable.....	5
2.2.1	Objectives of this deliverables.....	5
2.2.2	Work performed in this deliverable.....	5
2.2.3	Deviations and counter measures.....	6
3	Dissemination Activities.....	6
3.1	Report on Dissemination Activities.....	6
3.2	Open Data Products.....	17
4	Exploitation.....	19
5	IPR Register.....	21
6	Conclusion.....	26

Tables

Table 1: Dissemination Activities.....	9
Table 2: CHE Data products.....	17
Table 3: CHE Exploitation.....	19
Table 4: CHE IPR register.....	21

1 Executive Summary

To ensure that the CHE project remains visible and results are taken up by the wider community, dissemination and exploitation activities play a major role.

D7.7 provides a final overview of the activities performed by the project partners within the project and provides an update on the exploitation planning.

Exploitation activities remain focused on improving the various scientific elements produced within the CHE project, with the ultimate aim being to establish an anthropogenic CO₂ monitoring capacity within the Copernicus framework.

2 Introduction

2.1 Background

CHE, as a Coordination and Support Action, is bringing together European expertise and a consolidated approach to building an operational CO₂ emission monitoring capacity. CHE partners are at the forefront of developments in the compilation of emission inventories, the observation of the carbon cycle from ground-based and satellite measurements, the process modelling of the carbon cycle, atmospheric transport modelling, and data assimilation and inversion systems. There will be four main areas of work covering: observations, emission inventories, modelling and inversion systems.

The central questions that CHE will address are:

- What does it take to have a combined bottom-up and top-down estimation system capable of distinguishing the anthropogenic part of the CO₂ budget from the natural fluxes?
- How can we make the first steps towards such a system that can use the high spatial and temporal resolution of satellite observations to monitor anthropogenic emissions at the required time scales?
- And what does it take to transform a research system into a fully operational monitoring capacity?

CHE supports a large community by providing a library of realistic CO₂ simulations from global to city scale to examine the capacity for monitoring future fossil fuel emissions and to adequately dimension space mission requirements.

2.2 Scope of this deliverable

2.2.1 Objectives of this deliverables

The objective of D7.7 is to report on the dissemination activities of the CHE project and provide an update, where appropriate, exploitation plans. It also provides an IPR (Intellectual Property Rights) register of the results developed within the project.

2.2.2 Work performed in this deliverable

As per the initial deliverable D7.3 and its update D7.6, feedback from the partners was collected in the form of questionnaires, identifying the relevant aspects pertaining to both dissemination and exploitation.

2.2.3 Deviations and counter measures

No deviations have been encountered.

3 Dissemination Activities

3.1 Report on Dissemination Activities

CHE has been active on various dissemination streams, including publications, workshops, conferences, etc.

The following publications have been prepared to-date:

1. TNO_CAMS high resolution European emission inventory 2000-2014 for anthropogenic CO₂ and future years following two different pathways, Hugo A. C. Denier van der Gon, Jeroen J. P. Kuenen, Greet Janssens-Maenhout, Ulrike Döring, Sander Jonkers, Antoon Visschedijk, Earth System Science Data Discussions, [10.5194/essd-2017-124](https://doi.org/10.5194/essd-2017-124)
2. Satellite Observations of the Contrasting Response of Trees and Grasses to Variations in Water Availability, Sophia Walther, Gregory Duveiller, Martin Jung, Luis Guanter, Alessandro Cescatti, Gustau Camps-Valls, Geophysical Research Letters, 46/3, [10.1029/2018gl080535](https://doi.org/10.1029/2018gl080535)
3. Modelling CO₂ weather – why horizontal resolution matters, Anna Agustí-Panareda, Michail Diamantakis, Sébastien Massart, Frédéric Chevallier, Joaquín Muñoz-Sabater, Jérôme Barré, Roger Curcoll, Richard Engelen, Bavo Langerock, Rachel M. Law, Zoë Loh, Josep Anton Morguí, Mark Parrington, Vincent-Henri Peuch, Michel Ramonet, Coleen Roehl, Alex T. Vermeulen, Thorsten Warneke, Debra Wunch, Atmospheric Chemistry and Physics, 19/11, [10.5194/acp-19-7347-2019](https://doi.org/10.5194/acp-19-7347-2019)
4. Satellite observations of the contrasting response of trees and grasses to variations in water availability, Walther, Sophia; Duveiller, Gregory; Jung, Martin; Guanter, Luis; Cescatti, Alessandro; Camps-Valls, Gustau, [10.1029/2018GL080535](https://doi.org/10.1029/2018GL080535)
5. Scaling carbon fluxes from eddy covariance sites to globe: Synthesis and evaluation of the FLUXCOM approach, Martin Jung et al., Biogeosciences, vol. 17, p. 1343-1365, ISSN: 1726-4189, doi: 10.5194/bg-17-1343-2020
6. Ensemble-based satellite-derived carbon dioxide and methane column-averaged dry-air mole fraction data sets (2003-2018) for carbon and climate applications, Maximilian Reuter et al., Atmos. Meas. Tech., 13, 789-819, <https://doi.org/10.5194/amt-13-789-2020>, 2020.
7. Detectability of CO₂ emission plumes of cities and power plants with the Copernicus Anthropogenic CO₂ Monitoring (CO₂M) mission, Gerrit Kuhlmann et al., Atmos. Meas. Tech., 12, 6695–6719, <https://doi.org/10.5194/amt-12-6695-2019>, 2019. <https://www.atmos-meas-tech.net/12/6695/2019/>
8. Uncertainty analysis of a European high-resolution emission inventory of CO₂ and CO to support inverse modelling and network design, Ingrid Super et al., Atmos. Chem. Phys. Discuss., <https://doi.org/10.5194/acp-2019-696>, in review, 2019.
9. A Unified Vegetation Index for Quantifying the Terrestrial Biosphere, Gustau Camps-Valls et al., in review at Science Advances
10. Chevallier, F., B. Zheng, et al. (2020), Local anomalies in the column-averaged dry air mole fractions of carbon dioxide across the globe during the first months of the coronavirus recession, Geophys. Res. Lett, doi:10.1029/2020GL090244.

11. B. Zheng, G. Geng, P. Ciais, S. J. Davis, R. V. Martin, J. Meng, N. Wu, F. Chevallier, G. Broquet, F. Boersma, R. van der A, J. Lin, D. Guan, Y. Lei, K. He, Q. Zhang, Satellite-based estimates of decline and rebound in China's CO₂ emissions during COVID-19 pandemic, *Sci. Adv.* 2020; 6, in press.
12. J. McNorton, N. Bousseres, A. Agustí-Panareda, G. Balsamo, M. Choulga, A. Dawson, R. Engelen, Z. Kipping, Z. Lang, 2020: Representing Model Uncertainty for Global Atmospheric CO₂ Flux Inversions Using ECMWF-IFS-46R1, *Geosci. Model Dev. Discuss.*, 13, 2297-2313. <https://doi.org/10.5194/gmd-2019-314>.
13. J. McNorton, G. Arduini, N. Bousseres, A. Agustí-Panareda, G. Balsamo, S. Boussetta, M. Choulga, I. Hadade, R. J. Hogan, 2020: An Urban Scheme for the ECMWF Integrated Forecasting System: Single-Column and Global Offline Evaluation. *Journal of Advances in Modeling Earth Systems*, submitted.
14. M. Choulga, G. Janssens-Maenhout, I. Super, A. Agustí-Panareda, G. Balsamo, N. Bousseres, M. Crippa, H. Denier van der Gon, R. Engelen, D. Guizzardi, J. Kuenen, J. McNorton, G. Oreggioni, E. Solazzo, and A. Visschedijk, 2020: Global anthropogenic CO₂ emissions and uncertainties as prior for Earth system modelling and data assimilation. *Earth Syst. Sci. Data*, <https://doi.org/10.5194/essd-2020-68>, in discussion.
15. Quantifying CO₂ emissions of a city with the Copernicus Anthropogenic CO₂ Monitoring satellite mission, Kuhlmann et al., *Atmos. Meas. Tech.*, <https://doi.org/10.5194/amt-2020-162>, accepted, 2020.
16. Pisso et al. Assessing Lagrangian inverse modelling of urban anthropogenic CO₂ fluxes using in situ aircraft and ground-based measurements in the Tokyo area. *Carbon Balance Manage* (2019) 14:6 <https://doi.org/10.1186/s13021-019-0118-8> (partner URGE project)
17. Janssens-Maenhout, G., Pinty, B., Dowell, M., Zunker, H., Andersson, E., Balsamo, G., Bézy, J.-L., Brunhes, T., Bösch, H., Bojkov, B., Brunner, D., Buchwitz, M., Crisp, D., Ciais, P., Counet, P., Dee, D., Denier van der Gon, H., Dolman, H., Drinkwater, M., Dubovik, O., Engelen, R., Fehr, T., Fernandez, V., Heimann, M., Holmlund, K., Houweling, S., Husband, R., Juvyns, O., Kentarchos, A., Landgraf, J., Lang, R., Löscher, A., Marshall, J., Meijer, Y., Nakajima, M., Palmer, P., Peylin, P., Rayner, P., Scholze, M., Sierk, B., Veefkind, P., Towards an operational anthropogenic CO₂ emissions monitoring and verification support capacity, *Bul. Amer. Meteor. Soc.* (2020) 101 (8):E1439-E1451, doi: 10.1175/BAMS-19-0017.1, 2020
18. Luterbacher, J., Paterson, L., Castonguay, S., Tarasova, O., Vermeulen, A., Canadell, J. G., Jackson, R. B., Andrew, R. M., Friedlingstein, P., Jones, M. W., Le Quéré, C., Peters, G. P., Poulter, B., Saunois, M., Stavert, A., Baddour, O., Cazenave, A., Huss, M., Kennedy, J., Siegmund, P., Trewin, B., Ziese, M., Masson-Delmotte, V., Cullmann, J., Nitu, R., Ma, L., Stewart, B., Lavergne, T., Heil, P., Scaife, A., Hermanson, L., Smith, D., Olhoff, A., Christensen, J., Kappelle, M., Liu, J., Heslop, E., Fischer, A., Arico, S., Ryabinin, V., Aich, V., Rea, A., Lockett, D. and Pröscholdt, T. (2020) United in Science 2020: A multi-organization high-level compilation of the latest climate science information, World Meteorological Organization / United Nations Environment Program, http://public.wmo.int/en/resources/united_in_science
19. Le Quéré, C., Jackson, R. B., Jones, M. W., Smith, A. J. P., Abernethy, S., Andrew, R. M., De-Gol, A. J., Willis, D. R., Shan, Y., Canadell, J. G., Friedlingstein, P., Creutzig, F. and Peters, G. P. (2020) Temporary reduction in daily global CO₂ emissions during the COVID-19 forced confinement, *Nature Climate Change*, doi:10.1038/s41558-020-0797-x.

20. Canadell, P., Le Quéré, C., Creutzig, F., Peters, G., Jones, M. W., Friedlingstein, P., Jackson, R. and Shan, Y. (2020) Coronavirus is a 'sliding doors' moment. What we do now could change Earth's trajectory. The Conversation, <https://theconversation.com/coronavirus-is-a-sliding-doors-moment-what-we-do-now-could-change-earths-trajectory-137838> [Also available in French and Spanish.]
21. Creutzig, F., Lohrey, S., Emele, L., Le Quéré, C. and Jones, M. W. (2020) COVID-19 und CO₂ -Emissionen in Deutschland: Eine Analyse basierend auf den Schätzungen des Global Carbon Projects. German Federal Ministry of the Environment, Nature Conservation and Nuclear Safety, https://www.bmu.de/fileadmin/Daten_BMU/Download_PDF/Klimaschutz/covid_19_co2_deutschland_bf.pdf.
22. Smith, A. J. P., Jones, M. W., Abatzoglou, J. T., Betts, R. A., Canadell, J. G., Prentice, I. C., and Le Quéré, C. (2020) Climate Change Increases the Risk of Wildfires: September 2020, ScienceBrief.org, available at: <https://sciencebrief.org/briefs/wildfires>
23. Jones, M. W. (2020) Climate change as an enabler of wildfire, EU Commission DRIVER+ Project Advanced Crisis Management Conference, Brussels, https://www.driver-project.eu/wp-content/uploads/2020/03/Driver-Final-Conference-Programme-V1.0_WEB_Pages.pdf
24. Jones, M. W., Smith, A. J. P., Betts, R. A., Canadell, J. G., Prentice, I. C., and Le Quéré, C. (2020) Climate Change Increases the Risk of Wildfires: January 2020, ScienceBrief.org, available at: <https://sciencebrief.org/briefs/wildfires>
25. Peters, G. P., Andrew, R. M., Canadell, J. G., Friedlingstein, P., Jackson, R. B., Korsbakken, J. I., Le Quéré, C., Peregón, A. (2020) Carbon dioxide emissions continue to grow amidst slowly emerging climate policies. *Nat. Clim. Chang.* 10, 3–6.
26. Jackson, R. B., Friedlingstein, P., Andrew, R. M., Canadell, J. G., Le Quéré, C., Peters, G. P. et al. (2019) Persistent fossil fuel growth threatens the Paris Agreement and planetary health. *Environ. Res. Lett.* 14, 121001.
27. Friedlingstein, P., Jones, M. W., O'Sullivan, M., Andrew, R. M., Hauck, J., Peters, G. P., Peters, W., Pongratz, J., Sitch, S., Le Quéré, C., Bakker, D. C. E., Canadell, J. G., Ciais, P., Jackson, R. B., et al. (2019) Global Carbon Budget 2019, *Earth System Science Data*, doi:10.5194/essd-11-1783-2019.
28. Parker, R. J., Wilson, C., Bloom, A. A., Comyn-Platt, E., Hayman, G., McNorton, J., Boesch, H., and Chipperfield, M. P.: Exploring constraints on a wetland methane emission ensemble (WetCHARTs) using GOSAT observations, *Biogeosciences*, 17, 5669–5691, <https://doi.org/10.5194/bg-17-5669-2020>, 2020.

Under review

1. Le Quéré, C., Peters, Glen P., Friedlingstein, P., Andrew, R. M., Canadell, J. G., Davis, S. J., Jackson, R. B., Jones, M. W. (under review) Fossil CO₂ emissions in the post-COVID era, *Nature Climate Change*.
2. Jones, M. W., Abatzoglou, J. T., Veraverbeke, S., Andela, N., Lasslop, G., Smith, A. J. P., Burton, C., Betts, R. A., Werf, G. R. van der, Doerr, S. H., Canadell, J. G., Sitch, S. and Le Quéré, C. (under review) Human activities modulate regional fire trends despite the upwards pressure of global climate change, *Reviews of Geophysics*.
3. Jones, M. W., Andrew, R. M., Peters, G. P., Janssens-Maenhout, G., De-Gol, A. J., Ciais, P., Patra, P. K., Chevallier, F. and Le Quéré, C. (in revision) Gridded fossil CO₂ emissions and related O₂ combustion consistent with national inventories 1959-2018, *Scientific Data*.

4. Friedlingstein, P., Jones, M. W., O’Sullivan, M., Andrew, R. M., Hauck, J., Peters, G. P., Peters, W., Pongratz, J., Sitch, S., Le Quéré, C., Bakker, D. C. E., Canadell, J. G., Ciais, P., Jackson, R. B., et al. (under review) Global Carbon Budget 2020, *Earth System Science Data*.
5. Ciais, P., Bastos, A., Chevallier, F., Lauerwald, R., Poulter, B., Canadell, P., Hugelius, G., Jackson, R. B., Jain, A., Jones, M. W., Kondo, M., T., I. L., Patra, P. K., Peters, W., Pongratz, J., Petrescu, A. M. R., Piao, S., Qiu, C., Randow, C. Von, Regnier, P., Saunois, M., Scholes, R., Shvidenko, A., Tian, H., Yang, H., Wang, X. and Zheng, B. (under review) Definitions and methods to estimate regional land carbon fluxes for the second phase of the REgional Carbon Cycle Assessment and Processes Project (RECCAP-2), *Geoscientific Model Development*, doi:10.5194/gmd-2020-259.
6. Pickers, P., Manning, A. C., Le Quéré, C., Gerbig, C., Hoshina, Y., Tohjima, Y., Lujikx, I. T., Forster, G. L., and Sturges, W. (under review) Quantifying ffCO₂ using atmospheric O₂ observations, *Nature Climate Change*.
7. Paper submitted to https://www.atmospheric-measurement-techniques.net/for_authors/submit_your_manuscript.html : “A local to national-scale inverse modeling system to assess the potential of spaceborne CO₂ measurements for the monitoring of anthropogenic emissions” Author(s): Diego Santaren et al.

In terms of website statistics, since recording website analytics in June 2018, the website had over 98,000 visits, averaging ca 3,250 visits a month.

Further dissemination activities since the start of the project are presented in Table 1.

Table 1: Dissemination Activities

Type of dissemination and communication activities	Description
<i>Participation to a conference</i>	<ol style="list-style-type: none"> 1. 15 March 2018 SRON: Presentation at NAC2018, Utrecht, The Netherlands 2. 13 April 2018 ECMWF: Presentation at EGU2018, Vienna, Austria 3. 1-5 October 2018 ADS: SCARBO Presentation at the IAC conference in Bremen in October where CHE and VERIFY studies were mentioned for reference 4. 26-29 Nov 2018 EMPA: Presentation at ESA ATMOS 2018, Graz, Austria 5. 26 April 2019 EMPA: Presentation at EGU2019, Vienna, Austria 6. 26 April 2019 ECMWF: Presentation at EGU2019, Vienna, Austria 7. 26 April 2019 JRC: Oral presentation at EGU (Vienna, 12 April 2019) on the “Anthropogenic GHG monitoring and verification support capacity”, (given by Gianpaolo Balsamo on behalf of EC) 8. 13 - 17 May 2019 EMPA: Presentation at ESA Living Planet Symposium, Milano, Italy

	<ol style="list-style-type: none"> 9. 13 - 17 May 2019 JRC: Oral presentation at the ESA Living Planet Symposium (Milan, 14 May 2019) on “Bridging User Communities with Earth Observation Data in Support of the Paris Agreement”. 10. 13 - 17 May 2019 iLab: Presentation at the ESA Living Planet Symposium 11. 13 - 17 May 2019 MPG: Walther et al. ‘Advances in data-driven modeling of terrestrial carbon fluxes: resolving the diurnal cycle and efforts towards FluxCom2.0’, poster at the ESA Living Planet Symposium 2019 12. 02-05 September 2019 ULEIC: The NCEO and CEOI Earth Observation science, missions and technology conference: Nottingham Trent University. “Regeneration of CO₂ Satellite Column Data tailored to an Atmospheric inversion Scheme”, Webb et al. 13. 4-8 May 2020 ECMWF: Choulga, M., Janssens-Maenhout, G., Balsamo, G., McNorton, J., Solazzo, E., Bousserez, N., and Agustí-Panareda, A.: Anthropogenic CO₂ emission uncertainties, EGU General Assembly 2020, Online, 4–8 May 2020, EGU2020-10560, https://doi.org/10.5194/egusphere-egu2020-10560, 2020 https://meetingorganizer.copernicus.org/EGU2020/EGU2020-10560.html 14. 24 June 2020 (online) JRC: Poster presentation at the GEIA Conference, of "Uncertainties of global anthropogenic CO₂ emissions for 2015" by Choulga and Janssens-Maenhout et al. 15. 24-25 June 2020: ULEIC presentation at the NCEO and CEOI Science Virtual Conference 2020. https://www.nceo.ac.uk/wp-content/uploads/2020/09/Alex-New-Eo-Edited-Openshot.mp4 16. 15-17 September 2020 TNO: ICOS Science conference: Super et al., Uncertainties in a high-resolution gridded emission map and the importance for urban scale emission verification. https://www.icos-cp.eu/news-and-events/science-conference/icos2020sc 17. 15-17 September, 2020 TNO: ICOS Science conference Dellaert et al., Compiling a more complete inventory of public power and heat plant point source emissions in the EU. https://www.icos-cp.eu/news-and-events/science-conference/icos2020sc 18. 30 November, 2020 ECMWF: CHE presented at UNFCCC Earth Information Day https://unfccc.int/event/earth-information-day-2020 as part of the Climate Dialogues in a dedicated poster session (see the poster: https://unfccc.int/sites/default/files/resource/EID%20Poster%20T2%20CHE.pdf) 19. 7-11 December 2020 ECMWF: CHE at the EU Space Week https://www.euspaceweek.eu/ – CHE selected as H2020 success story (1 of 10 awards, out of 400 projects in EU Space)
Participation to a workshop	<ol style="list-style-type: none"> 1. 11 October 2017 NILU: Oral presentation at HARMO18 Conference, Bologna Italy. 2. 12 December 2017 NILU: Seminar at Bureau of Meteorology, Melbourne Australia.

	<ol style="list-style-type: none"> 3. 27-29 March 2018 ECMWF: Presentation at the BRI (Belt Road Initiative) Workshop, Salerno, Italy 4. 17 April 2018 NILU: Poster at EGU2018, Vienna, Austria 5. 18 April 2018 ECMWF: ASM Joint 28th ALADIN Workshop & HIRLAM All Staff Meeting 2018, Toulouse, France 6. 2-4 May 2018 ECMWF: CEOS AV-CV 14 meeting, NOAA, College Park, USA 7. 12-13 June 2018 ECMWF: Copernicus Anthropogenic CO₂ Monitoring Mission Advisory Group Meeting No. 1, ESA, Noordwijk 8. 18-19 June 2018 TNO: Workshop: Interfaces Between CEOS Agencies and the GHG Monitoring System; Joint Research Centre, Ispra (Italy), Hosted By: European Commission 9. 11-13 September 2018 TAS: 3rd ICOS science conference, Prague, Sept. 2018: "A city to national-scale inverse modeling system to assess the potential of space-borne CO₂ measurements for the monitoring of anthropogenic emissions", Author(s): Diego Santaren et al. 10. 17 September 2018 NILU: Poster at IG3IS Meeting, Lund, Sweden 11. 17-20 September 2018 WU: IGIS-Transcom Workshop, Lund, presentation on latest developments of WU within CHE 12. 17-20 September 2018 MPG: IGIS-Transcom Workshop, Lund, Presentation, https://fileshare.icos-cp.eu/s/R8LcanCpbQafw9X?path=%2FSession%201#pdfviewer 13. 17-20 September 2018 ECMWF: IGIS-Transcom Workshop, Lund, Poster Presentation 14. 17-20 September 2018 ECMWF: IGIS-Transcom Workshop, Lund, Poster presentation, https://fileshare.icos-cp.eu/s/qBMs522E5G8XFK4#pdfviewer 15. 17-20 September 2018 UEA: IGIS-Transcom Workshop, 16. 22 October 2018 ECMWF: Presentation at GCOS Science Day, Helsinki, Finland 17. 22 October 2018 EMPA: Presentation of the CHE project and ongoing developments to the "Laboratory for Air Pollution / Environmental Technology" at EMPA, https://polybox.ethz.ch/index.php/s/CxNzZ8EiJtlvjkK/download 18. 13 November 2018 ECMWF: Presentation at IG3IS Symposium, Geneva, Switzerland 19. 16-18 December 2018 ULUND: Symposium participation: Second ADAPT Symposium on Advanced Understanding, Monitoring and Prediction of Weather, Climate and Environmental systems, Pennsylvania State University, State College, Pennsylvania, http://adapt.psu.edu/2018EnKFWorkshop/SYMPOSIUM18/index.php?loc=symposium 20. 18 December 2017 ECMWF: Kick-off meeting of Phase B of the CO₂ Task Force B, Brussels
--	---

	<p>21. 21 Jan 2019 EMPA: Presentation at COSMO User Workshop, ETH Zurich, Switzerland</p> <p>22. 22 January 2019 JRC: CO2 Monitoring Task Force of the EC – Copernicus programme, Brussels</p> <p>23. 29 - 30 January 2019 JRC: CO2 Monitoring Mission Advisory Group meeting 3, Noordwijk</p> <p>24. 12 - 14 March 2019 ULEIC: Joint CHE-VERIFY General Assembly, ECMWF, Reading, UK. “Regeneration of CO2 Satellite Column Data tailored to an Atmospheric inversion Scheme”, Webb et al..</p> <p>25. 20 Mar 2019 EMPA: Presentation at ICCARUS 2019 workshop, Offenbach, Germany</p> <p>26. 6 April 2019 NILU: Poster at EGU2019, Vienna, Austria</p> <p>27. 3 -5 June 2019 ULEIC: The 15th International Workshop on Greenhouse Gas Measurements from Space (IWGGMS-15), at Hokkaido University in Sapporo, Hokkaido, Japan. “Regeneration of CO2 Satellite Column Data tailored to an Atmospheric inversion Scheme”, Webb et al..</p> <p>28. 5 June 2019 NILU: Oral presentation at HARMO19 Conference, Brugge, Belgium.</p> <p>29. 17-18 June 2019 JRC: CO2 Monitoring Task Force of the EC – Copernicus programme, Ispra</p> <p>30. 1-4 July 2019 CMCC: Helsinki-Hyytiälä: Workshop on strategies to monitor greenhouse gases in urban environments</p> <p>31. 15 - 17 July 2019 MPG: Walther et al. ‘Spaceborne observations of the land surface for the data-driven modelling of terrestrial carbon and energy exchange’, International Surface Working Group, 3rd workshop, 2019, Montreal</p> <p>32. 15 - 18 October 2019 MPG: Walther et al. ‘Towards disentangling human effects from nature: a data-driven approach to quantify biogenic carbon fluxes’, IG3IS-Transcom Workshop 2019, Paris</p> <p>33. 15 - 18 October 2019 CEA: poster presented at the IG3IS -Transcom workshop https://ig3is.wmo.int/en/events/ig3is-transcom-workshop-and-ig3is-science-team-meeting</p> <p>34. 15 - 18 October 2019 SRON: TransCom/IG3IS Workshop in Paris CTDAS-WRF: Greenhouse gas flux estimation with high resolution regional transport in an Ensemble Kalman Filter</p> <p>35. 15 - 18 October 2019 ULUND: Transcom/I3GIS workshop, Paris,</p> <p>36. 15 - 18 October 2019 iLab: Presentation at transcom</p> <p>37. 11 - 14 November 2019 CEA: Oral presentation at http://www.biomet.co.at/2nd-international-cos-workshop/</p> <p>38. 20 - 21 November 2019 JRC: CO2 Monitoring Mission Advisory Group meeting 5, Noordwijk</p> <p>39. 2-13 November 2019 UEA:</p> <p style="padding-left: 40px;">a. Peters, G., Jones, M. W. and Roeglj, J. (2019, December) The Global Carbon Budget 2019, 2019 United Nations</p>
--	---

	<p>Framework Convention on Climate Change (COP25), Madrid, https://seors.unfccc.int/applications/seors/reports/archive.html</p> <p>b. Kutsch, W., Volosciuk, C., Saigusa, N., Richter, C. and Jones, M. W. (2019, December) Integrated Carbon Observation System European Research Infrastructure Consortium (ICOS ERIC), 2019 United Nations Framework Convention on Climate Change (COP25), Madrid, https://seors.unfccc.int/applications/seors/reports/archive.html</p> <p>c. Balsamo, G., Engelen., R., Jones, M. W., Kutsch, W., Le Quéré, C., Pinty, B., Peylin, P., Salmon, E., Thépaut, J.-N. (2019, December) Towards a European Monitoring and Verification Support Capacity, 2019 United Nations Framework Convention on Climate Change (COP25), Madrid. https://seors.unfccc.int/applications/seors/reports/archive.html</p> <p>40. 22 – 23 January 2020 ULUND: CO2 Monitoring Task Force meeting, Brussels</p> <p>41. 6 April 2020 SRON: Presentation at EGU.</p> <p>42. March 2020 UEA: Jones, M. W. (2020, March) Climate change as an enabler of wildfire, EU Commission DRIVER+ Project Advanced Crisis Management Conference, Brussels, https://www.driver-project.eu/wp-content/uploads/2020/03/Driver-Final-Conference-Programme-V1.0_WEB_Pages.pdf</p> <p>43. 4 – 8 May 2020 ULUND: Presentation at EGU General Assembly, online, https://meetingorganizer.copernicus.org/EGU2020/EGU2020-8356.html</p> <p>44. 2-5 June 2020 SRON: Presentation at IWGGMS-16.</p> <p>45. 2-5 June 2020 EMPA: Presentation at IWGGMS-16.</p> <p>46. 2-5 June 2020, UB talk: International Workshop on Greenhouse Gas measurements from space 16 (IWGGMS-16), organized by EUMETSAT</p> <p>47. 2-5 June 2020: ULEIC presentation at the IWGGMS-16 conference. https://cdn.eventsforce.net/files/ef-xnn67yq56ylu/website/9/647_alex_webb_-_full_regeneration_of_co2_satellite_column_data_tailored_to_an_atmospheric_inversion_scheme.pdf</p> <p>48. 23 June 2020 TNO: H. Denier van der Gon presenting at Virtual workshop "Monitoring anthropogenic CO2 emissions with Copernicus" - https://www.copernicus.eu/en/events/events/online-monitoring-anthropogenic-co2-emissions-copernicus</p> <p>49. 22-24 June 2020 CMCC: presentation at the WMO/IG3IS urban monitoring and assessment workshop and contribution to the report preparation</p> <p>50. 24 June 2020 UEA: 4.Towards an International standard for Urban GHG Monitoring and Assessment, 22nd-24th June 2020 - attendance by Jones, M. W. https://ig3is.wmo.int/en/events/towards-international-standard-urban-ghg-monitoring-and-assessment</p>
--	--

	<p>51. 24-26 June 2020 EMPA: Presentation at EUMETSAT User Workshop on Satellite Atmospheric Composition</p> <p>52. July 2020 UEA: Jones, M.W. (2020, July) EU contribution to global CO₂ emissions and radiative forcing, CHE-VERIFY Joint General Assembly, Virtual, https://www.che-project.eu/events/che-verify-joint-general-assembly-2020</p> <p>53. July 2020 UEA: Le Quéré, C. (2020, July) Covid-19: Carbon Emissions and Climate Change, CHE-VERIFY Joint General Assembly, Virtual, https://www.che-project.eu/events/che-verify-joint-general-assembly-2020</p> <p>54. July 2020 UEA: Le Quéré, C. (2020, July) Covid-19: Carbon Emissions and Climate Change, Global Carbon Project Scientific Steering Committee 2020 meeting, Virtual.</p> <p>55. Global Carbon Project Scientific Steering Committee 2020 meeting - attendance by Jones, M. W and Le Quéré, C.</p> <p>56. 19 August 2020 UEA: APO virtual workshop, 19th August 2020. Attendance by Pickers, P. A. https://www.bowdoin.edu/physics/news-events/apo-workshop/</p> <p>57. 9 September 2020 ECMWF: CHE at the ESA CCI+ Colocation meeting</p> <p>58. 15 – 17 September 2020 ULUND: ICOS Science Conference 2020, online, https://www.icos-cp.eu/sc2020/abstracts#74</p> <p>59. 15-17 September 2020 ECMWF: Agusti-Panareda et al. : Using ICOS flux data to estimate prior uncertainty and its impact on simulated variability of atmospheric CO₂, ICOS Science conference, https://www.icos-cp.eu/sc2020</p> <p>60. 4 November 2020 JRC: Presentation of the CO₂ MVS to ational inventory agencies of the Climate Change Committee-Working Group 1</p> <p>61. 25-26 November 2020: CHE AFOLU Workshop https://www.che-project.eu/events/afolu-workshop</p> <p>62. JRC: Networking workshop of VERIFY: fossil CO₂ emissions – Uncertainties of CHE-EDGAR-ECMWF_v4.3.2_2015 highlighted</p>
Web-site	<ol style="list-style-type: none"> 1. Project Website 2. ECMWF: https://www.ecmwf.int/en/about/media-centre/focus/developing-european-capacity-monitor-worldwide-co2-emissions 3. JRC: https://ec.europa.eu/jrc/en/science-update/measuring-man-made-carbon-dioxide-co-emissions-support-paris-agreement 4. https://www.globalcarbonproject.org/carbonbudget/ 5. https://www.icos-cp.eu/science-and-impact/global-carbon-budget/2019 6. https://www.icos-cp.eu/gcp-covid19 7. https://www.mattwjones.co.uk/covid-19 8. https://sciencebrief.org/briefs/wildfires

	<p>9. ECMWF: https://www.ecmwf.int/en/about/media-centre/news/2020/ecmwf-led-co2-monitoring-project-track-2023-prototype</p>
<i>Press Release</i>	<ol style="list-style-type: none"> 1. https://www.ecmwf.int/en/about/media-centre/news/2018/experts-discuss-way-forward-ambitious-co2-monitoring-project 2. https://www.copernicus.eu/en/news/news/new-co2-green-report-2019-published 3. https://data.icos-cp.eu/objects/w6pTmRGYKqAm3c-siQrg5kqd 4. https://zueriost.ch/news/2020-03-30/satelliten-sollen-co2-dreckschleudern-aufspueren 5. Le Quéré, C., Jackson, R. B., Jones, M. W., Smith, A. J. P., Abernethy, S., Andrew, R. M., De-Gol, A. J., Willis, D. R., Shan, Y., Canadell, J. G., Friedlingstein, P., Creutzig, F. and Peters, G. P. (2020) Temporary reduction in daily global CO₂ emissions during the COVID-19 forced confinement, <i>Nature Climate Change</i>, doi:10.1038/s41558-020-0797-x. <ol style="list-style-type: none"> a. https://www.uea.ac.uk/news/-/article/covid-19-crisis-causes-17-drop-in-global-carbon-emissions 6. Friedlingstein, P., Jones, M. W., O'Sullivan, M., Andrew, R. M., Hauck, J., Peters, G. P., Peters, W., Pongratz, J., Sitch, S., Le Quéré, C., Bakker, D. C. E., Canadell, J. G., Ciais, P., Jackson, R. B., et al. (2019) Global Carbon Budget 2019, <i>Earth System Science Data</i>, doi:10.5194/essd-11-1783-2019. <ol style="list-style-type: none"> a. https://www.uea.ac.uk/news/-/article/global-carbon-emissions-increase-but-rate-has-slowed b. Press conference held at Science Media Centre London - Le Quéré, C., Peters, G. P. and Friedlingstein, P. c. Press conference held at UNFCCC COP25, Madrid - Peters, G. P. and Jones, M. W. 7. Jones, M. W., Smith, A. J. P., Betts, R. A., Canadell, J. G., Prentice, I. C., and Le Quéré, C. (2020) Climate Change Increases the Risk of Wildfires: January 2020, <i>ScienceBrief.org</i>, available at: https://sciencebrief.org/briefs/wildfires <ol style="list-style-type: none"> a. https://www.uea.ac.uk/news/-/article/climate-change-increases-the-risk-of-wildfires-confirms-new-review b. Press conference held at Science Media Centre London with live stream to Adelaide. 8. Smith, A. J. P., Jones, M. W., Abatzoglou, J. T., Canadell, J. G., Betts, R. A. (2020) Climate Change Increases the Risk of Wildfires: September 2020, <i>ScienceBrief.org</i>, available at: https://sciencebrief.org/briefs/wildfires <ol style="list-style-type: none"> a. https://www.uea.ac.uk/news/-/article/new-research-strengthens-evidence-for-climate-change-increasing-risk-of-wildfires
<i>Participation in activities</i>	<ol style="list-style-type: none"> 1. 13-15 February 2018 ECMWF: VERIFY Kick-off meeting, Brussels

<p><i>organised jointly with other H2020 project(s)</i></p>	<ol style="list-style-type: none"> 2. EMPA: Distribution of Deliverable 2.1 to members of the Verify project. 3. ADS: SCARBO website (http://scarbo-h2020.eu/) with reference to CHE Kick-off study, and to ECWMF (G. Balsamo) as part of the User Advisory Board. 4. 28 November 2018 ECMWF: JRC-VERIFY Progress Meeting, Ispra, Italy. 5. 4 October 2019 JRC: VERIFY Review meeting (Brussels) 6. 7-9 July 2020: Online CHE-VERIFY General Assembly 7. Jones, M. W. (2020) Climate change as an enabler of wildfire, EU Commission DRIVER+ Project Advanced Crisis Management Conference, Brussels, https://www.driver-project.eu/wp-content/uploads/2020/03/Driver-Final-Conference-Programme-V1.0_WEB_Pages.pdf
---	---

3.2 Open Data Products

The table below presents the current state on Open Data Products created within the CHE project. Further products (such as nature runs) are available on request.

Table 2: CHE Data products

DOI	Title/ identifier	Accessible (Yes/No)	Reusable (Yes/No)	Repository Link	Non- Repo sitory Link	DOI- linked public ation
https://catalogue.ceda.ac.uk/uuid/b06213c3f3934a689f89ab22aa50e471	XCO2 OCO-2 FOCAL v08	Yes	Yes	http://data.ceda.ac.uk/neodc/esacci/ghg/data/ci_plus/CO2_OC2_FOCA/v8.0	-	-
10.5281/zenodo.4048228	Synthetic XCO2, CO and NO2 observations for the CO2M and Sentinel-5 satellites	Yes	Yes	https://zenodo.org/record/4048228		https://doi.org/10.5194/amt-2020-162
10.18160/RQDW-BTJU	Supplementary data to: Temporary reduction in daily global CO2 emissions during the COVID-19 forced confinement (Version 1.0).	Yes	Yes	https://doi.org/10.18160/RQDW-BTJU		https://doi.org/10.1038/s41558-020-0797-x

CO₂ HUMAN EMISSIONS 2020

	Global Carbon Project					
10.5281/zenodo.3958283	Gridded fossil CO ₂ emissions and related O ₂ combustion consistent with national inventories 1959-2018	Yes	Yes	http://doi.org/10.5281/zenodo.3958283		Under review
10.5281/zenodo.4277267	Gridded fossil CO ₂ emissions and related O ₂ combustion consistent with national inventories 1959-2019	Yes	Yes	http://doi.org/10.5281/zenodo.4277267		Under review
10.5281/zenodo.3958283	Supplemental data of the Global Carbon Budget 2020	Yes	Yes	https://doi.org/10.5281/zenodo.3958283		Under Review
10.18160/gcp-2019	Supplemental data of the Global Carbon Budget 2019	Yes	Yes	https://doi.org/10.18160/gcp-2019		10.5194/essd-11-1783-2019

4 Exploitation

Deliverables D7.3 and D7.6 already outlined potential exploitation avenues. An update to the exploitation survey has confirmed that the products and activities described above remain relevant, with the main outcome of the CHE project being an operational service for monitoring of anthropogenic CO₂ emissions.

Table 3: CHE Exploitation

Exploitable Products	<ul style="list-style-type: none"> • A high-resolution inverse modelling framework using state-of-the art input • Emission and emission uncertainty gridmaps • XCO₂ retrieved from OCO-2 satellite mission • Methods to exploit Sentinel Carbon • Model outputs for designing observation system simulation experiments • Recommendations for the construction of a future prototype including roadmap to implementation and cost assessment of the service elements of a future CO₂ anthropogenic emission monitoring system. • Space-borne CO₂ monitoring instrument/mission concepts needed to fill the gap in terms of revisit time and observational performance and considering current CO₂ operational missions and those in development • A proposal of space based infrastructure for future Carbon Human Emission monitoring • CCFDAS that includes C14 observations. • Carbon Flux estimates based on multiple observational data streams including C14. • GridFEDv2019.1 (Jones et al., in revision) and GridFED2020.1 (Friedlingstein et al., 2020; Global Carbon Budget 2020, under review)
Exploitation Activities during the Project	<ul style="list-style-type: none"> • Incorporating results into existing modelling framework. • Scientific papers • Review state-of-the art • Competitive/ benchmark analysis • Contribution to IG3IS implementation plan, which outlines observation and modelling requirements for top-down emission estimation and how such a system could be implemented, due in 2018 • To make, as soon as possible, proposal for low cost system of measurements fitting requirements and agenda of next generation of space based instrument for Carbon Human Emission measurements • FOCAL algorithm (further development and application to OCO-2 co-funded by CHE) OCO-2 XCO₂ data product has been used to generate data products XCO₂_EMMA and XCO₂_OBS4MIPS (Reuter et al., AMT, 2020), which have been used as input data set for the Copernicus Climate Change Service and are available via the Copernicus Climate Data Store

<p>Exploitation Activities after the end of the Project</p>	<ul style="list-style-type: none"> • Expand the approach developed in CHE to a broader geographic area post-CHE, and upscale it so it's able to handle the masses of data that will become available. • Use of the OCO-2 data product by CHE inverse modellers • Scientific papers • Develop the regional CO₂ modelling system into a quasi-operational system supporting the operation of a Swiss CO₂ observing system with low-cost CO₂ sensors, high-precision instruments and possibly remote sensing. • Productisation/operationalisation, further developments, integration into other services • To develop low cost system of Carbon Human Emission measurements • Further developments: The FOCAL satellite XCO₂ retrieval algorithm and related OCO-2 data products have been improved during CHE. FOCAL is currently a candidate algorithm for CO₂M XCO₂ retrieval. FOCAL will therefore be further developed and used also after CHE.
<p>Consortium-wide/Joint Exploitation</p>	<ul style="list-style-type: none"> • Suite of modelling systems able to sensibly address the problem, potentially able to contribute to an ensemble estimation approach • Develop a strategy to operationalise functional parts of the modelling system described above • Longer-term goal would be operationalisation for Copernicus Climate Change Service (C3S) • Definition of a global CO₂ monitoring system of systems • End to End system of Carbon Human Emission measurements

5 IPR Register

The table below presents the current state on IPR created within the CHE project.

Table 4: CHE IPR register

Exploitable results/ IP Name	Description/ Functionality	(Joint) Owner(s)	TRL Level	Related deliverable	IP Protection (Patent, Trademark, etc.)	Confidential (if yes, embargo duration)
FOCAL algorithm	Retrieval algorithm for XCO ₂ from OCO-2	University of Bremen, Germany	N.A.	Input for D1.1, D1.2, D1.3 (Task 1.1)	None	None
OCO-2 XCO ₂	Data set OCO-2 XCO ₂ v08	University of Bremen, Germany	N.A.	Input for D1.1, D1.2, D1.3 (Task 1.1)	None	None
analytical inversion system	analytical inversion system for a large region of Europe centered on Belgium	CEA	6	WP3 + WP4	None	None
global analytical inversion system	global analytical inversion system for the co-assimilation of CO ₂ and COS concentrations	CEA	6	WP1	None	None
DECSO-CO ₂	Deriving CO ₂ emissions using NO _x emissions as proxy and use the CO ₂ /NO _x ratio from other sources	KNMI, TNO	3	D3.4	None	No

Exploitable results/ IP Name	Description/ Functionality	(Joint) Owner(s)	TRL Level	Related deliverable	IP Protection (Patent, Trademark, etc.)	Confidential (if yes, embargo duration)
European CO ₂ nature run with COSMO-GHG model	High-resolution (5km x 5 km) CO ₂ model simulation for year 2015; may serve as input for OSSE studies or for developing synthetic satellite obs.	EMPA	8	D2.4	None	None
Berlin area CO ₂ nature run with COSMO-GHG model	High-resolution (1 km x 1 km) CO ₂ model simulation for year 2015; may serve as input for OSSE studies (e.g. potential of satellite CO ₂ obs. to quantify emissions from cities & power plants.	EMPA	8	D2.4	None	None
COSMO-GHG simulations of 14C, CO and CO ₂ over Europe	COSMO-GHG simulations for 2 months in 2015 to study potential of additional tracers to distinguish between biospheric and fossil fuel CO ₂ .	EMPA	8	D4.4	None	None
Tier-1 high-resolution nature run	high resolution (9km) global nature runs for 2015 with CAMS configuration	ECMWF	8	D2.2	None	None
Tier 2 high resolution nature run	high resolution (9km) global nature runs for 2015 with CHE emission improvements, new initial conditions and new IFS model cycle	ECMWF	8	D2.6	None	None

Exploitable results/ IP Name	Description/ Functionality	(Joint) Owner(s)	TRL Level	Related deliverable	IP Protection (Patent, Trademark, etc.)	Confidential (if yes, embargo duration)
ensemble of simulations	ensemble of simulations at 25km for January and July 2015	ECMWF	6	WP2	None	None
Improved global emission gridded dataset	Improved global emission gridded dataset based on EDGARv4.3FT2015	ECMWF	8	D3.3	None	None
Gridded uncertainty of emission sectors	Gridded uncertainty of emission sectors based on IPCC methodology	ECMWF	8	D3.3	None	None
CCFFDAS C14 Module	Assesses constraint of C14 observations on carbon fluxes	iLab/LU	-	D3.6	None	01.01.2025
GCP-GridFEDv2019.1	Gridded (0.25 degree) emissions dataset for the period 1959-2018, consistent with the national inventory of the global carbon project. Updated annually.	Principal owner: Jones, Matthew W. (UEA). Co-owners: Andrew, Robbie M.; Peters, Glen P.;	Already in use.	Uncertainty informed by D4.3	Not formal.	

Exploitable results/ IP Name	Description/ Functionality	(Joint) Owner(s)	TRL Level	Related deliverable	IP Protection (Patent, Trademark, etc.)	Confidential (if yes, embargo duration)
		Janssens- Maenhout, Greet; De-Gol, Anthony J.; Ciais, Philippe; Patra, Prabir K.; Chevallier, Frederic; Le Quéré, Corinne				
GCP-GridFEDv2020.1	Gridded (0.25 degree) emissions dataset for the period 1959-2019, consistent with the national inventory of the global carbon project. Updated annually.	Principal owner: Jones, Matthew W. (UEA). Co-owners: Andrew, Robbie M.; Peters, Glen P.;	Already in use.	Uncertainty informed by D4.3	Not formal.	<i>Embargo to 7th December 2020</i>

Exploitable results/ IP Name	Description/ Functionality	(Joint) Owner(s)	TRL Level	Related deliverable	IP Protection (Patent, Trademark, etc.)	Confidential (if yes, embargo duration)
		Janssens- Maenhout, Greet; De-Gol, Anthony J.; Ciais, Philippe; Patra, Prabir K.; Chevallier, Frederic; Le Quéré, Corinne				

6 Conclusion

D7.7 reported on the dissemination activities performed in the CHE project, and reviewed the dissemination and exploitation plans. It also provided a comprehensive overview of data products made openly available, as well as an IPR register.

Document History

Version	Author(s)	Date	Changes
0.1	Daniel Thiemert (ECMWF)	14/12/2020	Initial version
1.0	Daniel Thiemert (ECMWF)	15/12/2020	Final version after review

Internal Review History

Internal Reviewers	Date	Comments
Gianpaolo Balsamo (ECMWF)	15/12/2020	Approved with comments
Richard Engelen (ECMWF)	15/12/2020	Approved with comments

Estimated Effort Contribution per Partner

Partner	Effort
ECMWF	0.25
Total	0.25

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.