CoCO2

Prototype system for a Copernicus CO_2 service

Mid-Term Dissemination and Exploitation Report 2

Tanya Warnaars

coco2-project.eu

Co-ordinated by ECMWF

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D9.7 Mid-Term Dissemination and Exploitation Report 2

Dissemination Level:	Public
Author(s):	Tanya Warnaars (ECMWF)
Date:	10/11/2022
Version:	1.0
Contractual Delivery Date:	31/12/2022
Work Package/ Task:	WP9/T9.4
Document Owner:	ECMWF
Contributors:	All Partners
Status:	Final

CoCO2: Prototype system for a Copernicus CO_2 service

Coordination and Support Action (CSA)
H2020-IBA-SPACE-CHE2-2019 Copernicus evolution – Research activities in support of a European operational monitoring support capacity for fossil CO2 emissions

Project Coordinator: Dr Richard Engelen (ECMWF)
Project Start Date: 01/01/2021
Project Duration: 36 months

Published by the CoCO2 Consortium

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The CoCO2 project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 958927.

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1 Executive Summary

To ensure that the CoCO2 project remains visible and results are taken up by the wider community, dissemination and exploitation activities play a major role.

Deliverable 9.7 provides an update of the activities performed by the project partners within the last 24 months of the project, and reviews both dissemination and exploitation plans.

In the past 24 months, the total number of journal papers published has reached 19. In the past 12 months alone, CoCO2 researchers presented their work 24 times in conferences and 10 times in workshops; and participated in one event organised by other H2020 projects. One workshop was organised by the project. Furthermore CoCO2 was mentioned in the Cordis news article on the Global Carbon Budget for 2022.

Exploitation activities remain focused on improving the various scientific elements produced within the CoCO2 project, with the ultimate aim being to establish an anthropogenic CO2 monitoring capacity within the Copernicus framework.

2 Introduction

2.1 Background

To support EU countries in assessing their progress for reaching their targets agreed in the Paris Agreement, the European Commission has clearly stated that a way to monitor anthropogenic CO2 emissions is needed. Such a capacity would deliver consistent and reliable information to support policy- and decision-making processes.

To maintain Europe’s independence in this domain, it is imperative that the EU establishes an observation-based operational anthropogenic CO2 emissions Monitoring and Verification Support (MVS) capacity as part of its Copernicus programme.

The CoCO2 Coordination and Support Action is intended as a continuation of the CO2 Human Emissions (CHE) project, led by ECMWF. In the Work Programme, ECMWF is identified as the predefined beneficiary tasked to further develop the prototype system for the foreseen MVS capacity together with partners principally based on the CHE consortium. In addition, CoCO2 will continue some of the work initiated in the VERIFY project as well.

The main objective of CoCO2 is to perform R&D activities identified as a need in the CHE project and strongly recommended by the European Commission's CO2 monitoring Task Force. The activities shall sustain the development of a European capacity for monitoring anthropogenic CO2 emissions. The activities will address all components of the system, such as atmospheric transport models, re-analysis, data assimilation techniques, bottom-up estimation, in-situ networks and ancillary measurements needed to address the attribution of CO2 emissions. The aim is to have prototype systems at the required spatial scales ready by the end of the project as input for the foreseen Copernicus CO2 service element.

2.2 Scope of this deliverable

2.2.1 Objectives of this deliverables

The objective of D9.7 is to report on the dissemination activities of the past 12 months and provide an update, where appropriate, to the dissemination and exploitation plans.

2.2.2 Work performed in this deliverable

Following the same process as the initial deliverable D9.3, plus the report at month 12 (D9.6) feedback from each partner was collected in the form of questionnaires, identifying the relevant aspects pertaining to both dissemination and exploitation.

2.2.3 Deviations and counter measures

None encountered.

3 Dissemination Activities

3.1 Report on Dissemination Activities

CoCO2 has been active on various dissemination streams, including publications, workshops, conferences, etc.

The list of publications have strongly increased over the past 12 months and a full list of all 19 publications is attached in Annex 1 to this report.

In terms of website statistics, since January 2022 the website has had 31,000 visits as shown in figure 3.1.1. It is interesting to note that visitors are mostly finding the website by an organic search rather than direct or referral, indicating a good level of findability of the website and updating of its content helps with this visibility.

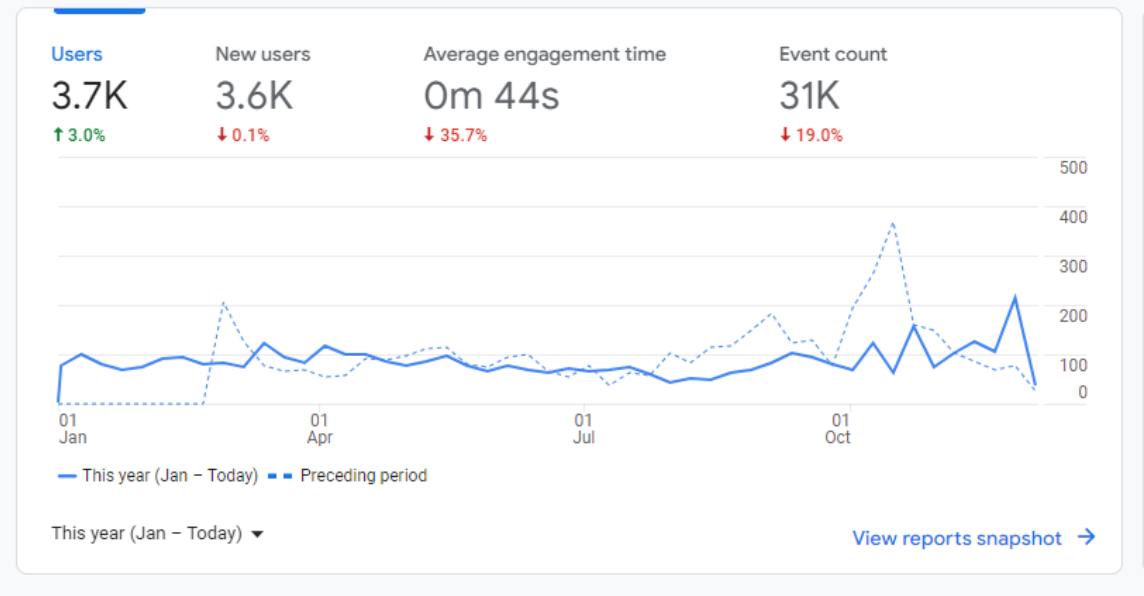

Figure 1: 12 month report on users of the CoCO2 website

Figure 2: distribution of users by geographic location

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**
Conference Participation *Participation to a conference*	**Conference Participation during 2nd year (Jan-Dec2022)** 1. ICOS /ECMWF: COP27 EO for Climate Action: Mitigation. S. Parampil et al: In situ observations support the Methane Pledge The Nord Stream leaks case study 2. FORTH: ICOS Science Conference 2022, Utrecht, the Netherlands, 14 September 2022, Konstantinos Politakos et al., Five years of urban eddy covariance CO2 emissions correlated with dynamic shifts in urban structure and traffic regulations in the city center of Heraklion, Greece 3. UEdin: American Geophysical Union (AGU) Fall Conference 2022, Chicago, IL, USA, 12-16 December 2022, Scarpelli et al., "Estimating combustion and non-combustion fluxes of carbon dioxide using satellite observations over Europe" 4. FMI: LPS 2022, Iolanda Ialongo/Janne Hakkarainen, Analyzing local carbon dioxide and nitrogen oxide emissions from space using statistical methods: An application to the synthetic SMARTCARB dataset 5. EMPA: Annual meeting of the Swiss Physical Society, Bern, 27-30 Jun 2022, D. Brunner, Monitoring and tracking carbon dioxide emissions from satellites.

	6. EMPA: ESA Living Planet Symposium, Bonn, Germany, 23-27 May 2022, G. Kuhlmann et al., A Python software library for "Data-Driven Emission Quantification" (ddeq) of cities and point sources in satellite images 7. EMPA: ESA Living Planet Symposium, Bonn, Germany, 23-27 May 2022, E. Koene, Reducing uncertainties in annual CO2 point source emission estimates from CO2M CO2 and NO2 images using computer vision techniques and multi-plume models 8. EMPA: COSMO/ICON User Workshop, [virtual], 13 Jan 2022, E. Koene, A comparison of power plant plume simulations between COSMO-GHG and Large Eddy Simulations 9. ECMWF/All partners: ICOS Science Conference 2022, Utrecht, the Netherlands, 13 September 2022, Anna Agusti-Panareda et al.: The CoCO2 global nature run as an evaluation tool of the integrated earth system model to support the monitoring of greenhouse gas emissions 10. ECMWF/All partners: ICOS Science Conference 2022, Utrecht, the Netherlands, 13 September 2022, Nicolas Bousserez et al.: Towards a Copernicus Monitoring Service for Anthropogenic Greenhouse Gas Emissions: Methodology and First Results from the IFS Global Inversion System 11. ECMWF/IPMA/LSCE: ESA Living Planet Symposium 2022, Bonn, 23-27 May 2022, Anna Agusti-Panareda et al., "Assessing the changes in GPP from the new ecland photosynthesis model associated with changes in LAI, land cover and climate using satellite-based Earth Observation datasets ". 12. ECMWF/IPMA/MPI-BGC/CMCC/LSCE, ESA 4th Carbon from space workshop, ESA-ESRIN Frascati, Italy, Anna Agusti-Panareda et al. "Estimation of terrestrial biogenic CO2 fluxes from IFS model inversions: first results from the CoCO2 project and future prospects for the CAMS global CO2 emission monitoring service". 13. ECMWF/All partners: UNFCCC Earth Information Day at COP27, Sharm El Sheikh, 9 November 2022: https://unfccc.int/event/earth-information-day-2022 (https://unfccc.int/sites/default/files/resource/Poster_COP27_CoCO2-CAMS-ECMWF-Engelen.pdf) 14. LSCE: ICOS Science Conference 2022, Utrecht, the Netherlands, 15 September 2022, E. Potier et al., "Combination of XCO2 imagery and in-situ CO2 and 14CO2 measurements to monitor fossil fuel CO2 emissions at regional to local scales" 15. CICERO: CO2M Roadmap for Norway, Oslo, 24 October 2022, Glen Peters "CO2 Monitoring and Verification Support" 16. ECMWF/All partners: Final General Assembly of VERIFY, Paris, 9-11 May, 2022: Networking meeting, Richard Engelen "The VERIFY legacy in CoCO2 and CAMS", CoCO2 CAMS_CO2.pdf (ipsl.fr) 17. CEREA / LSCE: Sentinel-5P Mission, October, Taormina: 5 years Anniversary, Dumont Le Brazidec, J., et al. *CO2 plume detection using deep neural networks and simulated XCO2 fields* 18. CEREA / LSCE: Harmonisation within Atmospheric Dispersion Modelling for Regulatory Purposes , September 27-30, Portugal, Dumont Le Brazidec, J., et al. *CO2 plume detection using deep neural networks and simulated XCO2 fields*

	19. CEREA / LSCE: (online) ICOS Science Conference September 13-15, Utrecht, Dumont Le Brazidec, J., et al. *CO2 plume detection using deep neural networks and simulated XCO2 fields* 20. CEREA / LSCE: (online) IWGGMS-18, July 12-14, Dumont Le Brazidec, J., et al. *CO2 plume detection using deep neural networks and simulated XCO2 fields* 21. iLab/ULUND/TNO/VUA: ICOS Science Conference September 13-15, Utrecht, Kaminski et al., *Combined use of atmospheric and other data streams to constrain natural fluxes and anthropogenic fossil fuel emissions through CarbonCycle Fossil Fuel Data Assimilation.* 22. iLab/ULUND/VUA/EMPA/TNO: ESA Living Planet Symposium 2022, Bonn, 23-27 May 2022, Kaminski et al., *Assessing the constraint of the CO2 monitoring mission on fossil fuel emissions from power plants and a city in a regional carbon cycle fossil fuel data assimilation system* 23. iLab/ULUND/ECMWF: ESA Living Planet Symposium 2022, Bonn, 23-27 May 2022, Scholze et al.,Assessments of in-situ and remotely-sensed CO2 observations in a Carbon Cycle Fossil Fuel Data Assimilation System to estimate fossil fuel emissions 24. iLab/ULUND/ECMWF: Swedish Climate Symposium, Norrköping, 17 May 2022, Scholze et al.,Assessments of CO2 observations in a Carbon Cycle Fossil Fuel Data Assimilation System to estimate fossil fuel emissions
	Conference Participation during 1st year (Jan - Dec 2021) 1. FORTH: EGU General Assembly 2021, virtual event, 27 April 2021, Konstantinos Politakos, Carbon dioxide emissions variability monitoring, based on four years of Eddy Covariance measurements in a typical Mediterranean city , https://meetingorganizer.copernicus.org/EGU21/EGU21-7723.html 2. iLab/ULUND: EGU General Assembly 2021, virtual event, 27 April 2021, T Kaminski, M Scholze at al., Assessing the constraint of the CO2 monitoring mission on fossil fuel emissions from power plants and a city in a regional carbon cycle fossil fuel data assimilation system, https://meetingorganizer.copernicus.org/EGU21/EGU21-16139.html 3. iLab/ULUND: EGU General Assembly 2021, virtual event, 27 April 2021, H Chen, M Scholze, T Kaminski at al., Assessment of radiocarbon observations for constraining fossil fuel emissions in a comprehensive Carbon Cycle Fossil Fuel Data Assimilation System, https://meetingorganizer.copernicus.org/EGU21/EGU21-13258.html 4. iLab/ ULUND: AOGS2021 virtual, 1-6 August 2021, H Chen, M Scholze, T Kaminski at al., Assessing the Uncertainty in Top-down Greenhouse Gas Emissions Estimates, https://meetmatt-svr.net/Timetable/SlotScheduleAll?cfId=3&dayId=15&slotId=17&sId=1#collapse_13764 5. VUA: IWGGMS-17, online, 14-17 June 2021, “Constraining global methane emissions using TROPOMI data” 6. VUA: Royal Society, Rising Methane: Is warming feeding warming, online, 4-6 December 2021, “The satellite view on global methane”

	7. VUA: ESA ATMOS 2021, online, 22-26 November 2021, “Recent change in global methane constrained by TROPOMI and IASI” 8. MF: IGARSS, e-conference, 12 July 2021, Calvet, J.-C., B. Bonan, A. Mucia, D. Shamambo, Y. Zheng, and C. Albergel. Integrating satellite-derived vegetation variables into the ISBA model: A sequential data assimilation approach. https://igarss2021.com/IG21_ProgramGuide.pdf 9. JRC: COP26 Conference, Glasgow, 1/11/21, 14:30-15:30, M. Dowell, “EO for Climate Action: Mitigation, REDD+, and the Global Stocktake”, European Union side events at COP26 (cop26eusideevents.eu) 10. ECMWF: COP26, EO for Climate Action: Mitigation, REDD+, and the Global Stocktake, virtual, 1 November 2021 11. EMPA: ATMOS2021, [virtual], 24.11.2021, Erik Koene, Enhancing and Detecting CO_2 Plumes in Satellite Images Using Computer Vision Denoising, Inpainting, and Ridge Tracing, [no link available] 12. EMPA: Swiss National GAW/GCOS Symposium, Bern, 13-14 Sep 2021, Dominik Brunner, Estimating emissions from ground-based and space-borne trace gas observations, https://www.meteoschweiz.admin.ch/home/forschung-und-zusammenarbeit/internationale-zusammenarbeit/gcos/swiss-national-gaw-gcos-symposium-september-13-to-14th-2021.html 13. EMPA: IWGGMS-17, [virtual], 14-17 Jun 2021, Dominik Brunner, Uncertainties in the simulation of XCO2plumes from power plant emissions: A comparison between 6 high-resolution atmospheric transport models. 14. EMPA: EGU General Assembly 2021, [virtual], 19-30 Apr 2021, Gerrit Kuhlmann, Quantifying CO2 emissions of power plants with the CO2M mission.
Workshop Participation	**Workshop Participation during 2nd year (Jan-Dec2022)** 1. ECMWF: CoCO2 presentation during meeting between ECMWF, DWD, and UBA, virtual, 4 February 2022 2. ECMWF: CEOS-AC-VC meeting, virtual, 13 March 2022 3. ECMWF: VERIFY Inventory Agency Networking meeting, Paris, 10 May 2022 4. ECMWF/ULUND: CO2 Task Force, virtual, 13 June 2022 5. ECMWF/ULUND: Lunchtime conference: Observation-based GHG monitoring and verification - key outcomes of the VERIFY project, virtual, 8 July 2022 6. ECMWF: Copernicus User Forum (as part of a CAMS progress presentation), Brussels, 28 September 2022 7. ECMWF/ULUND: IPCC Expert Meeting on Use of Atmospheric Observation Data in Emission Inventories, Geneva, 5 - 7 September 2022 8. ECMWF: CO2M MAG, hybrid, 6 - 7 October 2022 9. iLab/ULUND: 4th ESA Carbon from Space Symposium, 25-28 October 2022 10. CMCC: FACCE-JPI – JPI Climate workshop on the use of emerging science to improve agricultural GHG inventories for the UNFCCC reporting - 19 and 20 October 2022, Brussels

	Workshop Participation during 1st year (Jan - Dec 2021) 1. ECMWF: CO2 Task Force meeting, virtual, 29 January 2021 2. ECMWF: European Parliament Panel for the Future of Science & Technology, Use of AI, big data and space technologies in terrestrial management, virtual, 23 February 2021 3. ECMWF: CAMS user workshop Norway, virtual, 24-25 March 2021 4. ECMWF: CO2M Mission Advisory Group, virtual, 21-22 April 2021 5. ECMWF: ESA EO4UNFCCC workshop, virtual, 15 April 2021 6. ECMWF: ACTRIS Innovation in Atmospheric Sciences Virtual Workshop, virtual, 18 May 2021 7. ECMWF: CAMS General Assembly, virtual, 8-10 June 2021 8. ECMWF: CEOS-AC-VC meeting, virtual, 7-11 June 2021 9. ECMWF: IWGGMS-17, virtual, 14-17 June 2021 10. ECMWF: NASA Carbon Research Program Policy Speaker Series, virtual, 7 June 2021 11. ECMWF: CAMS user workshop France, virtual, 30 June 2021 12. ECMWF: CO2 Task Force meeting, virtual, 31 August 2021 13. ECMWF: CO2M Mission Advisory Group, virtual, 30 September 2021 14. ECMWF: Copernicus Relay seminar on remote sensing-based GHG assessment in AFOLU, Latvia, virtual, 28 October 15. ECMWF: Earth information day, virtual poster session, 3 November 2021 16. ECMWF: JRC workshop about GHG & AFOLU on Systematic Observation, virtual, 15,18, 19 November 2021 17. ECMWF: CO2M Mission Advisory Group, virtual, 29 November 2021. 18. VUA: COCO2: Workshop int. CH4 intercomparison, online, 11-6-2021 19. VUA: COCO2: User consultation workshop – How can Copernicus CO2MVS capacity support cities?, online, 6-10-2021 20. JRC: VERIFY Mini WORKSHOP on GHG Monitoring and Verification: Exchange of practices between EU, USA, China and Indonesia (25 May 2021, virtual, organised by JRC) 21. JRC: Copernicus-VERIFY WORKSHOP on Advancing GHG emissions of Agriculture, Forestry and Other Land-Use sectors through Earth Observation (or Systematic Observation contributions and synergies for GHG & AFOLU) (15,18, 19 November 2021, virtual organised by JRC) 22. CEA: CoCO2 General Assembly, 16-18 Nov 2021, F Chevallier, G Broquet, WP4 and 6 highlights, https://www.coco2-project.eu/events/1st-general-assembly
Web-site	1. www.coco2-project.eu
Press Release/ Article	**Released during 2nd year (Jan-Dec2022)** 1. ECMWF: National Geographic Italy: ANIDRIDE CARBONICA L'ALTRA FACCIA. publication date 12 Nov. 2022 2. EMPA: Article in newsletter of the Swiss Physical Society, Brunner, D., Meijer, Y. and Crisp, D., Monitoring carbon

	dioxide emissions from space, SPS communications, no. 68, Oct 2022, p. 19-21. 3. ULUND: Radio Interview, Swedish Radio (SR): Nya satellite avslöjar dolda utsläpp av växthusgaser, 5 Oct. 2022, https://sverigesradio.se/avsnitt/nya-satelliter-avslojar-dolda-utslapp-av-vaxthusgaser
	Released during 1st year (Jan-Dec2021) 1. EMPA: Newspaper article, Tagesanzeiger, 02.11.2021, Klimakonferenz in Glasgow – Klimaüberwachung aus dem All, https://www.tagesanzeiger.ch/wie-aus-dem-all-die-klimaplaene-kontrolliert-werden-326869502002 2. AGH: Short note at the Krakow tethered balloon touristic viewing platform informing about start of vertical profiles measurement campaign (in polish) – publication date 11.03.2021 http://balonwidokowy.pl/2021/03/11/rozpoczynamy-kampanie-pomiarow-lotniczych-w-ramach-europejskiego-projektu-copernicus/ 3. AGH: Information in English regarding measurement campaigns conducted on tethered balloon touristic viewing platform within CoCO2 project – publication date 2.06.2021 http://balonwidokowy.pl/en/2021/06/02/another-co2-measuring-campaign-during-the-night/ 4. AGH: Next short note about CoCO2 balloon campaigns(in polish) – publication date 26.11.2021 http://balonwidokowy.pl/2021/11/26/listopadowa-dobowa-kampania-pomiarowa/ 5. AGH: Article in “Science in Poland” portal. Information about activities of AGH-UST scientists at touristic balloon including GHG measurements in the frame of CoCO2 project (in polish) – publication date 30.09.2021 https://scienceinpoland.pap.pl/aktualnosci/news%2C89471%2Cbadanie-smog-nad-krakowem-utrzymuje-sie-do-wysokosci-100-metrow.html 6. AGH: Article in “Krakow.pl” portal informing about the collaboration between AGH-UST scientists and Krakow tethered touristic balloon (including CoCO2 measurement campaigns) (in polish) - publication date 24.10.2021 https://www.krakow.pl/aktualnosci/253122,1926,komunikat,naukowcy_zbadali_jakosc_powietrza_na_balonie_widokowym.html?_ga=2.185220268.463519857.1632947100-145003845.1632947100 7. AGH: Article in internet portal for pilots (“dlapilota.pl”). Information about scientific activities at Krakow touristic balloon including CoCO2 vertical CO2 profile measurements (in polish) – publication date 29.09.2021 https://dlapilota.pl/wiadomosci/polska/z-balonu-widokowego-naukowcy-zbadali-jakosc-powietrza
Organisation of a workshop	**Workshop Organised during 2nd year (Jan-Dec2022)** 1. CoCO2 Presentation Day, virtual, 5 December 2022, https://coco2-project.eu/events/coco2-presentation-day

	Workshop Organised during 1st year (Jan-Dec2021) 1. CoCO2 General Assembly, 16-18 November 2021, https://www.coco2-project.eu/events/1st-general-assembly 2. A virtual CoCO2 User consultation workshop: How can atmospheric observations support city-scale GHG inventories?, 6 October 2021, https://www.coco2-project.eu/events/how-can-atmospheric-observations-support-city-scale-ghg-inventories
Participation in activities organised jointly with other H2020 project(s)	**Activities during 2nd year (Jan-Dec2022)** 1. ECMWF/ULUND: Verify General Assembly, Paris, 9 - 11 May 2022
	Activities during year 1st year (Jan-Dec2021) 1. VUA: VERIFY General Assembly, 28-29/4 2021 2. ECMWF: VERIFY General Assembly, virtual, 28-29 April 2021

3.1 Update to Dissemination Plan

CoCO2 has, in deliverable D9.3, provided an initial plan for Dissemination and Communication Activities. Figure presents the current status at month 12 and at month 24.

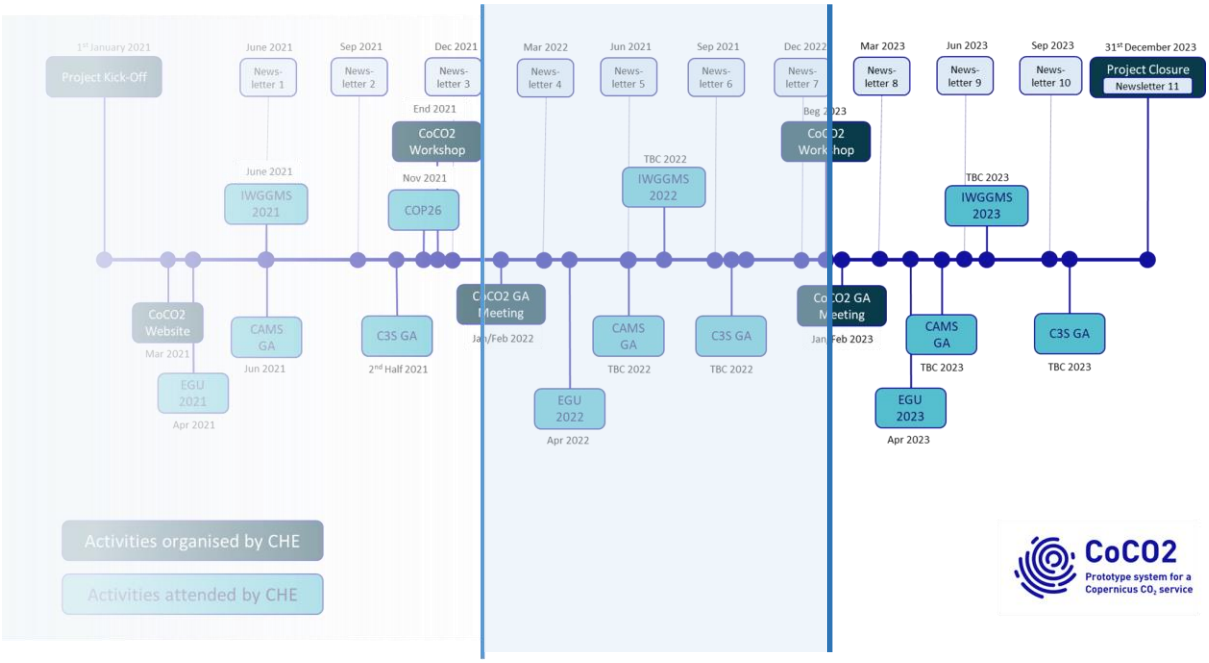

Figure 3: CoCO2 Dissemination Plan

All activities foreseen in the plan to be organised by CoCO2 were realised. The project workshop takes the form of a CoCO2 presentation day, that was held virtually on 5 Dec and is an opportunity to hear updates from the different WPs on their progress the past year and to plan the months ahead. The presentations and the recording are available from the CoCO2 website (https://coco2-project.eu/events/coco2-presentation-day)

CoCO2 has had some high-profile achievements the past year, and had a good presence at UNFCCC CoP27 as well as contributing key results to the UNFCCC Global Stocktake. Our main dissemination pathway remains the CoCO2 website www.coco2-project.eu which has provided regular updates and news items.

The remainder of the CoCO2 Dissemination Plan remains relevant with the timing and number of newsletters to be decided based on availability of news items. To date, at month 24, we have a good number of publications however this will continue to increase as work and analysis of results of the WPs 1 to 8 becoming available and are completed.

4 Exploitation

Deliverable D9.3 already outlined potential exploitation avenues, as presented here again in Table 2.

Table 2: CoCO2 Exploitation

Exploitable Products	• Operational production of assimilated ocean pCO2 products • Datasets and publications • Emission datasets • Incorporate the resulting CoCO2 emission datasets in the HERMESv3_GR emission inventory library (https://earth.bsc.es/gitlab/es/hermesv3_gr), so that they can be used by the community of modellers that use chemical transport models • GHG fact sheets per country per sector or city/emission plant level • Improved inversion system that will allow calculations for current and historical CO2 emissions, using top-down methods, on the local scale Krakow), national scale (Poland) and beyond, if possible applicable to other atmospheric constituents • University courses in top-down modelling of greenhouse gases • Material to demonstrate the CO2 MVS capabilities to support discussion with national authorities • CoCO2 nature runs • Foreground elements of the global, regional and local prototype systems and/or their documentation
Exploitation Activities during the Project	• Benchmark analysis, operationalization (2021, 2022) • Links with CAMS (if this can be considered as exploitation) • Integration of the resulting emission datasets into the HERMESv3_GR emission inventory library during the last year of the project • Workshops with stakeholders
Exploitation Activities after the end of the Project	• Operational production of assimilated air-sea pCO2 products • Services for agriculture (2024), Improved land surface conditions in atmospheric models, i.e. numerical weather prediction models, air quality models, and climate models (2025) • Exploitation activities post-CoCO2 will depend on the results of the research conducted in CoCO2 • Within Copernicus CO2MVS this process of consultation with stakeholders will continue and intensify

	• Further development of the inverse modelling system of CO2 on local and national scale, 2024-2027 • Preparing and performing new university course on data assimilation methods for students based on results obtained in the scope of CoCO2, 2024-2028 • Further development of emission estimation algorithms and inverse modeling techniques as well as uncertainty characterization. • Direct implementation of global CO2MVS component in CAMS
Consortium-wide/Joint Exploitation	• Vegetation description component of CAMS • Country-factsheets (D6.1 or further developments of these) • New methodology for GHG emission quantification using atmospheric data; Synthesis • Definition and demonstration of the CO2MVS prototype

An update to the exploitation survey run for Deliverable D9.3 has confirmed that the products and activities described above remain relevant, with the main outcome of the CoCO2 project being an operational service for monitoring of anthropogenic CO2 emissions.

5 Conclusion

This Deliverable 9.7 has reported on the dissemination activities performed of the past 24 months of the project, to demonstrate the continued activities of the partners. Furthermore the achievements of the past 12 months have been highlighted. In addition the partners have reviewed the dissemination and exploitation plans to ensure they remain relevant and current to the present.

The exploitation plan is a living document and as we enter into the final period of the project we are establishing the relevant activities to be performed after the end of the project, and have setup an IPR register on the project's internal Wiki page to serve as a reference point for project partners.

ANNEX 1: Publications of CoCO2 for the full 24 months of the project

No.	Type	Title	Authors	Title of the Journal/Proc./Book	DOI
1	Article in Journal	Satellite-based estimates of nitrogen oxide and methane emissions from gas flaring and oil production activities in Sakha Republic, Russia	Iolanda Ialongo; Nadezhda Stepanova; Nadezhda Stepanova; Janne Hakkarainen; Henrik Virta; Daria Gritsenko	Atmospheric Environment: X, Vol 11, Iss , Pp 100114-(2021)	10.1016/j.aeaoa.2021.100114
2	Article in Journal	Assimilation of atmospheric CO2 observations from space can support national CO2 emission inventories	Thomas Kaminski; Marko Scholze; Peter Rayner; Michael Voßbeck; Michael Buchwitz; Maximilian Reuter; Wolfgang Knorr; Hans Chen; Anna Agusti-Panareda; Armin Löscher; Yasjka Meijer	Environ. Res. Lett.	10.1088/1748-9326/ac3cea
3	Article in Journal	Assimilation of passive microwave vegetation optical depth in LDAS-Monde: a case study over the continental US	Mucia, A. and Bonan, B. and Albergel, C. and Zheng, Y. and Calvet, J.-C.	Biogeosciences	10.5194/bg-2021-248
4	Article in Journal	Quantifying CO2 Emissions of Power Plants With CO2 and NO2 Imaging Satellites	Kuhlmann Gerrit, Henne Stephan, Meijer Yasjka, Brunner Dominik	Frontiers in Remote Sensing	10.3389/frsen.2021.689838
5	Article in Journal	Large CO2 emitters as seen from satellite: Comparison to a gridded global emission inventory	Chevallier, F., Broquet, G., Zheng, B., Ciais, P., & Eldering, A	Geophysical Research Letters	10.1029/2021gl097540
6	Article in Journal	How well do we understand the land-ocean-atmosphere carbon cycle?	David Crisp; Han Dolman; Toste Tanhua; Galen A McKinley; Judith Hauck; Ana Bastos; Stephen Sitch; Simon Eggleston; Valentin Aich	Reviews Of Geophysics (8755-1209) (Amer Geophysical Union), 2022-06 , Vol. 60 , N. 2 , P. e2021RG000736 (64p.)	10.1002/essoar.10506293.2
7	Article in Journal	Comparing national greenhouse gas budgets reported in UNFCCC inventories against atmospheric inversions	Zhu Deng; Philippe Ciais; Zitely A. Tzompa-Sosa; Marielle Saunois; Chunjing Qiu; Chang Tan; Taochun	https://hal-insu.archives-	10.5194/essd-14-1639-2022

No.	Type	Title	Authors	Title of the Journal/Proc./Book	DOI
			Sun; Piyu Ke; Yanan Cui; Katsumasa Tanaka; Xin Lin; Rona L. Thompson; Hanqin Tian; Yuanzhi Yao; Yuanyuan Huang; Ronny Lauerwald; Atul K. Jain; Xiaoming Xu; Ana Bastos; Stephen Sitch; Paul I. Palmer; Thomas Lauvaux; Alexandre d'Aspremont; Clément Giron; Antoine Benoit; Benjamin Poulter; Jinfeng Chang; Ana Maria Roxana Petrescu; Steven J. Davis; Zhu Liu; Giacomo Grassi; Clément Albergel; Francesco N. Tubiello; Lucia Perugini; Wouter Peters; Frédéric Chevallier	ouvertes.fr/insu-03659874	
8	Article in Journal	A comprehensive and synthetic dataset for global, regional and national greenhouse gas emissions by sector 1970-2018 with an extension to 2019	J. C. Minx; J. C. Minx; W. F. Lamb; W. F. Lamb; R. M. Andrew; J. G. Canadell; M. Crippa; N. Döbbeling; P. M. Forster; D. Guizzardi; J. Olivier; G. P. Peters; J. Pongratz; J. Pongratz; A. Reisinger; M. Rigby; M. Saunois; S. J. Smith; E. Solazzo; H. Tian	eISSN: 1866-3516	10.5194/essd-13-5213-2021
9	Article in Journal	Global patterns of daily CO2 emissions reductions in the first year of COVID-19	Liu, Zhu; Deng, Zhu; Zhu, Biging; Ciais, Philippe; Davis, Stephen J.; Tan, Jianguang; Andrew, Robbie M.; Boucher, Olivier; Ben Arous, Simon; Canadell, Josep G.; Dou, Xinyu; Friedlingstein, Pierre; Gentine, Pierre; Guo, Rui; Hong, Chaopeng; Jackson, Robert B.; Kammen, Daniel M.; Ke, Piyu; Le Quéré, Corine; Monica, Crippa; Janssens-Maenhout, Greet; Peters, Glen P.; Tanaka, Katsumasa; Wang, Yilong; Zheng, Bo; Zhong, Haiwang; Sun, Taochun; Schellnhuber, Hans Joachim Schellnhuber	Nat. Geosci.	10.1038/s41561-022-00965-8

No.	Type	Title	Authors	Title of the Journal/Proc./Book	DOI
10	Article in Journal	Global fossil carbon emissions rebound near pre-COVID-19 levels	Jackson, R B; Friedlingstein, P; Le Quéré, C; Abernethy, S; Andrew, R M; Canadell, J G; Ciais, P; Davis, S J; Deng, Zhu; Liu, Zhu; Korsbakken, J I; Peters, G P	Environmental Research Letters	10.1088/1748-9326/ac55b6
11	Article in Journal	Technical note: A view from space on global flux towers by MODIS and Landsat: The FluxnetEO dataset	Sophia Walther; Simon Besnard; Jacob A. Nelson; Tarek S. El-Madany; Mirco Migliavacca; Ulrich Weber; Sofia L. Ermida; Sofia L. Ermida; Christian Brümmer; Frederik Schrader; Anatoly S. Prokushkin; Alexey Panov; Martin Jung	Biogeosciences	10.5194/bg-2021-314
12	Article in Journal	Direct observations of CO2 emission reductions due to COVID-19 lockdown across European urban districts	Giacomo Nicolini; Gabriele Antoniella; Federico Carotenuto; Andreas Christen; Philippe Ciais; Christian Feigenwinter; Beniamino Gioli; Stavros Stagakis; Erik Velasco; Roland Vogt; Helen C. Ward; Janet Barlow; Nektarios Chrysoulakis; Pierpaolo Duce; Martin Graus; Carole Helfter; Bert Heusinkveld; Leena Järvi; Thomas Karl; Serena Marras; Valéry Masson; Bradley Matthews; Fred Meier; Eiko Nemitz; Simone Sabbatini; Dieter Scherer; Helmut Schume; Costantino Sirca; Gert-Jan Steeneveld; Carolina Vagnoli; Yilong Wang; Alessandro Zaldei; Bo Zheng; Dario Papale	Science of the Total Environment, Elsevier, 2022,	10.1016/j.scitotenv.2022.154662
13	Article in Journal	Comparing national greenhouse gas budgets reported in UNFCCC inventories against atmospheric inversions	Zhu Deng; Philippe Ciais; Zitely A. Tzompa-Sosa; Marielle Saunois; Chunjing Qiu; Chang Tan; Taochun Sun; Piyu Ke; Yanan Cui; Katsumasa Tanaka; Katsumasa Tanaka; Xin Lin; Rona Thompson; Hanqin Tian; Yuanzhi Yao; Yuanyuan Huang;	eISSN: 1866-3516	10.5194/essd-2021-235

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			Ronny Lauerwald; Atul K. Jain; Xiaoming Xu; Ana Bastos; Stephen Sitch; Paul I. Palmer; Thomas Lauvaux; Alexandre d'Aspremont; Clément Giron; Antoine Benoit; Benjamin Poulter; Jinfeng Chang; A.M.R. Petrescu; Steven J. Davis; Zhu Liu; Giacomo Grassi; Clément Albergel; Frédéric Chevallier		
14	Article in Journal	Global nature run data with realistic high-resolution carbon weather for the year of the Paris Agreement	Anna Agustí-Panareda; Joe McNorton; Gianpaolo Balsamo; Bianca C. Baier; Nicolas Bousserez; Souhail Boussetta; Dominik Brunner; Frédéric Chevallier; Margarita Choulga; Michail Diamantakis; Richard Engelen; Johannes Flemming; Claire Granier; Marc Guevara; Hugo Denier van der Gon; Nellie Elguindi; Jean-Matthieu Haussaire; Martin Jung; Greet Janssens-Maenhout; Rigel Kivi; Sébastien Massart; Dario Papale; Mark Parrington; Miha Razinger; Colm Sweeney; Alex Vermeulen; Sophia Walther	Scientific Data , Nature Publishing Group, 2022, 9, pp.160	10.1038/s41597-022-01228-2
15	Article in Journal	Analyzing Local Carbon Dioxide and Nitrogen Oxide Emissions From Space Using the Divergence Method: An Application to the Synthetic SMARTCARB Dataset	Janne Hakkarainen, Iolanda Ialongo, Erik Koene, Monika E. Szeląg, Johanna Tamminen, Gerrit Kuhlmann, Dominik Brunner	Frontiers in Remote Sensing	10.3389/frsen.2022.878731
16	Article in Journal	Analyzing nitrogen oxides to carbon dioxide emission ratios from space: A case study of Matimba Power Station in South Africa	Janne Hakkarainen, Monika E. Szeląg, Iolanda Ialongo, Christian Retscher, Tomohiro Oda, and David Crisp	Atmospheric Environment: X	10.1016/j.aeaoa.2021.100110

No.	Type	Title	Authors	Title of the Journal/Proc./Book	DOI
17	Article in Journal	Complementing XCO₂ imagery with ground-based CO₂ and ¹⁴CO₂ measurements to monitor CO₂ emissions from fossil fuels on a regional to local scale	Elise Potier; Grégoire Broquet; Yilong Wang; Diego Santaren; Antoine Berchet; Isabelle Pison; Julia Marshall; Philippe Ciais; François-Marie Bréon; Frédéric Chevallier	Atmospheric measurement techniques.	10.5194/amt-15-5261-2022
18	Article in Journal	Fluxes of Carbon Dioxide From Managed Ecosystems Estimated by National Inventories Compared to Atmospheric Inverse Modeling	Frédéric Chevallier	ISSN: 0094-8276	10.1029/2021gl093565
19	Article in Journal	Global Daily CO_2 emissions for the year 2020	Liu, Zhu; Deng, Zhu; Ciais, Philippe; Tan, Jianguang; Zhu, Biqing; Davis, Steven J.; Andrew, Robbie; Boucher, Olivier; Arous, Simon Ben; Canadel, Pep; Dou, Xinyu; Friedlingstein, Pierre; Gentine, Pierre; Guo, Rui; Hong, Chaopeng; Jackson, Robert B.; Kammen, Daniel M.; Ke, Piyu; Quere, Corinne Le; Monica, Crippa; Janssens-Maenhout, Greet; Peters, Glen; Tanaka, Katsumasa; Wang, Yilong; Zheng, Bo; Zhong, Haiwang; Sun, Taochun; Schellnhuber, Hans Joachim	Nature Geoscience	10.48550/arxiv.2103.02526

Document History

Version	Author(s)	Date	Changes
0.1	Tanya Warnaars (ECMWF)	06/12/2022	Initial version with all inputs
1.0	Tanya Warnaars (ECMF)	18/01/2023	Final version

Internal Review History

Internal Reviewers	Date	Comments
Hugo Denier van der Gon (TNO)	21/12/2022	Minor text edits

Estimated Effort Contribution per Partner

Partner	Effort
ECMWF	0.2
Total	**0.2**