



CHE & VERIFY General Assembly
Reading, 12-14 March 2019



CO₂ Monitoring Context

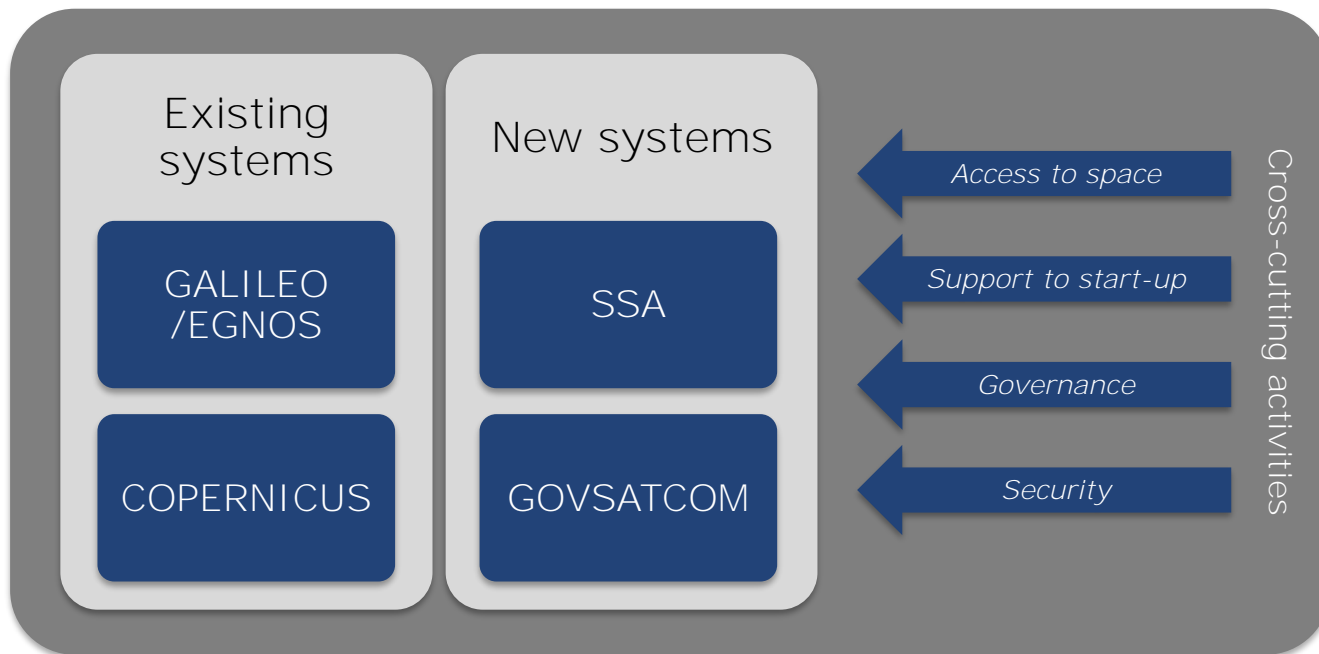
Hugo Zunker

European Commission
Copernicus Unit





Scope of the new regulation





Space in support of EU policies

Mapping of natural disturbances and weather-related challenges

Monitoring COP21 commitments and CO₂ emissions

Better execution of CAP due to policy monitoring and precision farming

Enabling technologies in automotive, aviation and maritime sectors

Supporting civil protection thanks to Emergency Management Service

Aiding the digitalisation through space and satellite communication



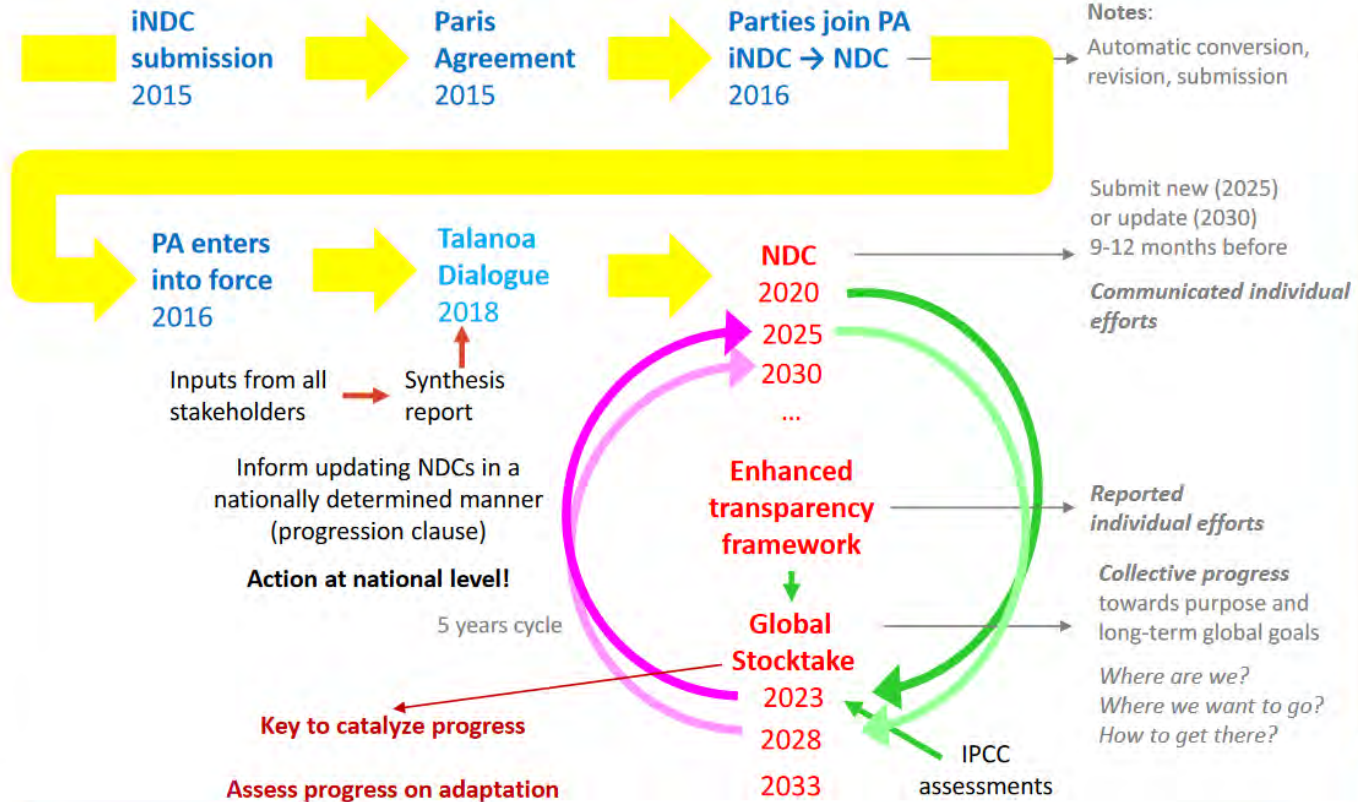
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The Commission's Ambition

- “New Copernicus missions such as CO2 monitoring will enable the EU to become a technological leader in the fight against climate change, in line with the commitments made under the Paris Agreement.”
- “A very significant new [Copernicus] service is about monitoring anthropogenic CO2 emissions to help countries in assessing their efforts to reduce CO2 emissions and to contribute to the stocktaking exercise as part of the UNFCCC process as defined in the Paris agreement.”

European Commission, Press Release IP/18/4022, 6. June 2018

Commissioner Bieńkowska, COP24 Katowice, 10. December 2018



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The CO₂ Monitoring Task Force: Achievements and Future Plans

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with contributions from ESA, EUMETSAT, ECMWF
& many experts ⁽³⁾

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⁽³⁾ Major international institutions



Genesis and evolution of the CO₂ Monitoring Task Force (CO₂ MTF)

1st period

Team of
International
experts



October 2015

2nd period

EC, ESA, EUMETSAT,
ECMWF,
team of European experts

CO₂ MTF Sub task A:
Space Component

CO₂ MTF Sub task B:
end-to-end system



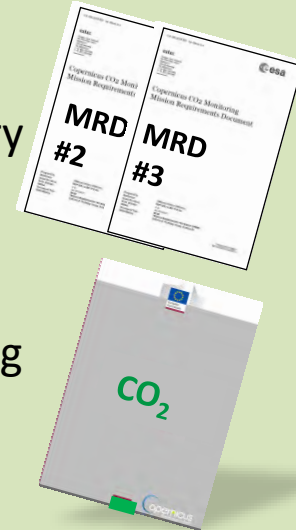
Winter 2017

3rd period

EC, ESA, EUMETSAT,
ECMWF,
team of European experts

Mission Advisory
Group

CO₂ Monitoring
Task Force



Spring 2018

present



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Boundary conditions

- Emphasis on **systems**: inventories, space-borne and in-situ observations, data assimilation framework, inversion system, transport models, decision support system
- Emphasis on **operational** intent
- Fundamentally underpinned by strong **user requirements** based on **international commitments** and corresponding **EU Policy implementation**
- Fundamental **international dimension** on multiple aspects of system implementation/development



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End-to-end System requirements to monitor anthropogenic CO₂

Accuracy

200-400
ton/year

1. **Detection of emitting hot spots** such as megacities or power plants.
2. **Monitoring the hot spot emissions** to assess emission reductions/increase of the activities.
3. **Assessing emission changes against local reduction targets** to monitor impacts of the NDCs.
4. **Assessing the national emissions and changes** in 5-year time steps to estimate the global stock take.

km &
daily scales

Space & Time



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Towards an anthropogenic CO₂ Monitoring & Verification Support Capacity

Global Stock

Take 1

CO₂ Task Force & ESA Mission Advisory Group

using inventories of 2026

Global Stock
Take 2

2017

2019

2021

2023

2025

2027

2029

system capacity built up

operation

Launch target for
Copernicus CO₂M
constellation

CO₂

MRD
#1

MRD
#2

MRD
#3

ESA studies

ESA CO₂M Phase A/B1

H2020 CSA: CHE

H2020: CHE Follow-on

H2020: VERIFY

CHE & VERIFY GENERAL ASSEMBLY



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Requirements from the Space Component

Requirements for XCO₂

- XCO₂ precision: **0.5 – 0.7 ppm**
- Systematic bias **< 0.5 ppm**
- Spatial resolution **4 km²**
- Continuously sampled swath width of **[200 – 400] km**
- Revisit around **2–3 days** (poleward of 40 deg) by **constellation of 2 to 3 satellites**
- Orbit equator crossing time **11:30 hrs**

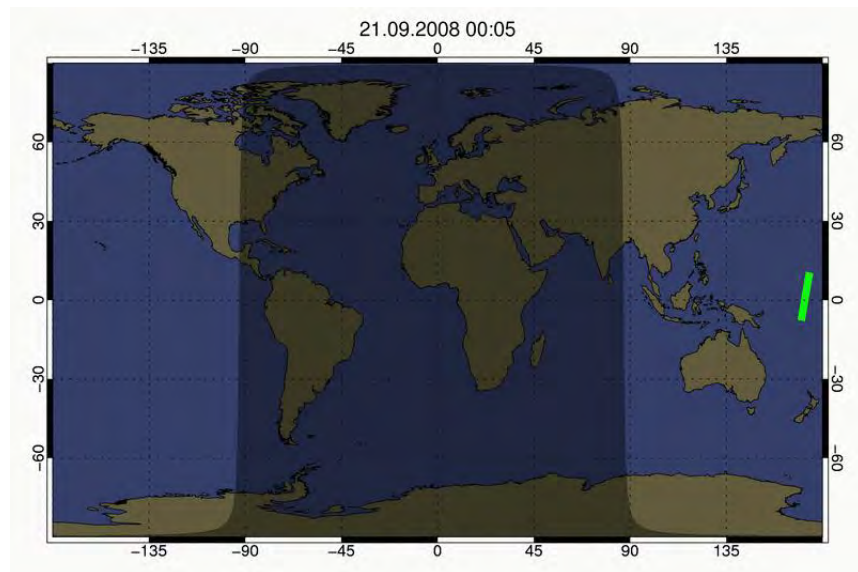
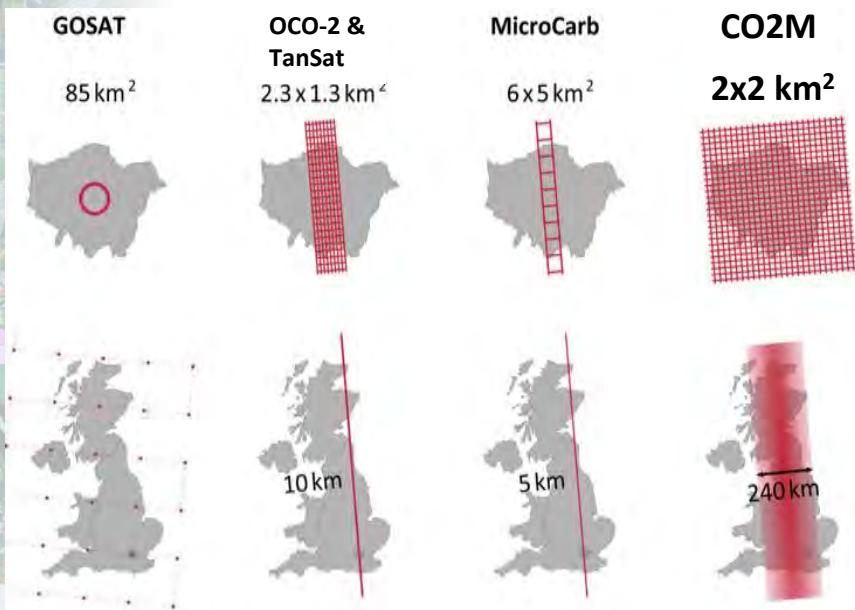
Auxiliary observations:

- **NO₂ observations** for plume detection separating anthropogenic from biogenic fluxes
- **Multi-Angle Polarimeter observations** for reduction of aerosol/cloud induced systematic errors
- **Cloud imager** at high resolution to assess the impacts of sub-pixel cloud contamination



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Spatial coverage of the CO2M constellation

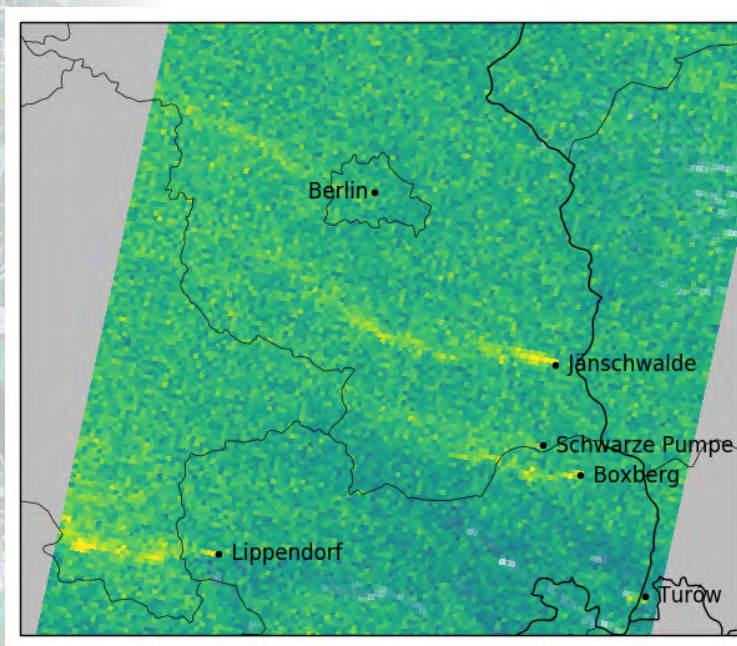




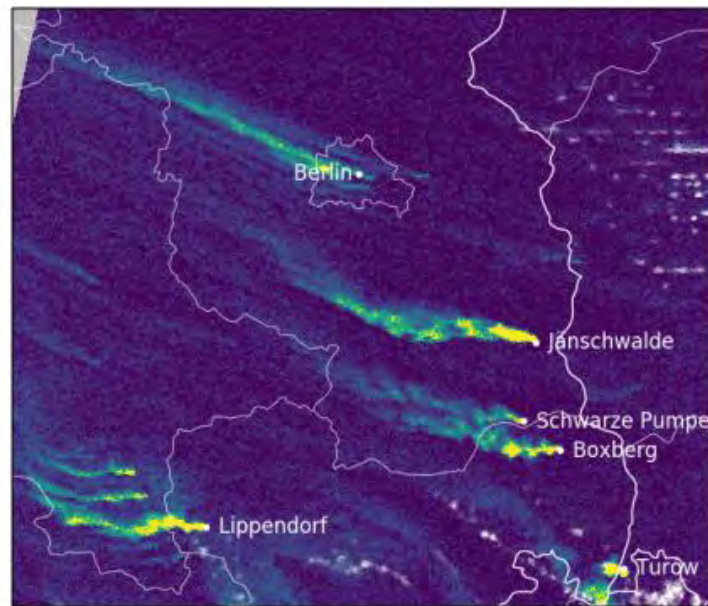
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Simulations of XCO₂ and NO₂ observations

NO₂ detection capabilities significantly improve the capability to detect weak CO₂ plumes



XCO₂ (0.5 ppm noise)

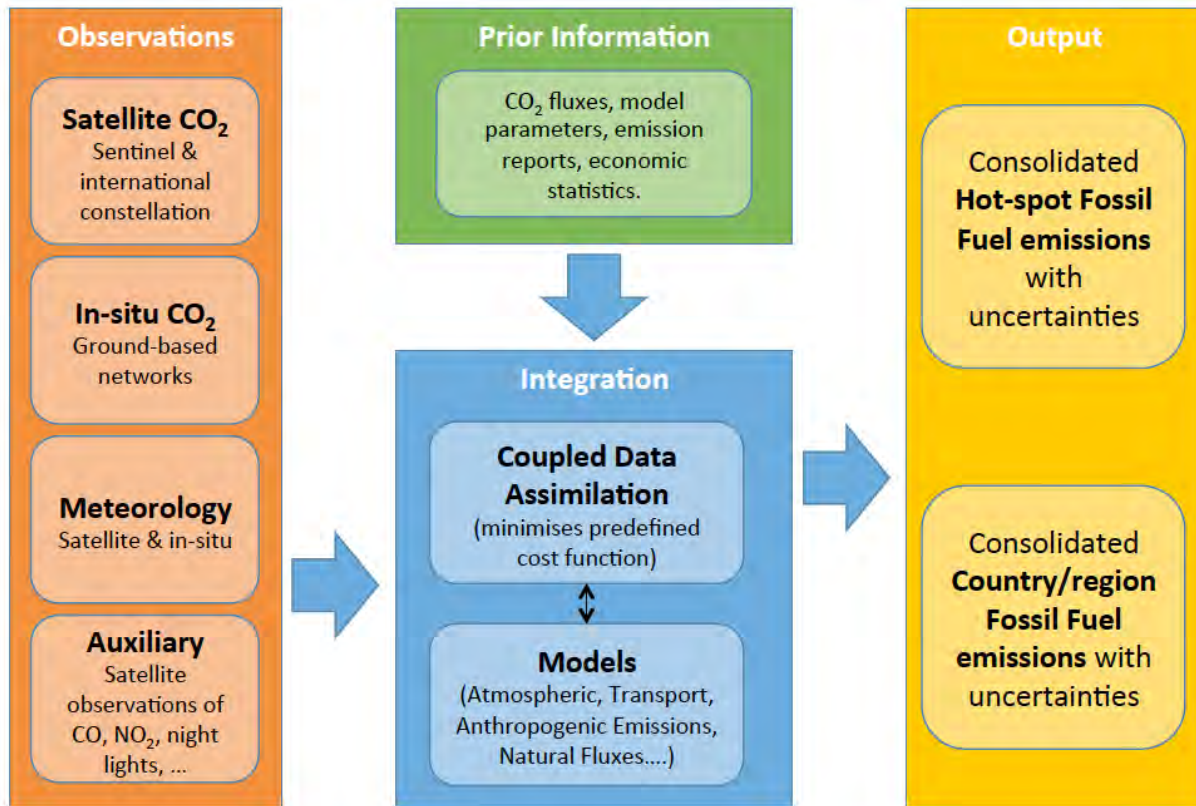


NO₂ (15% noise)



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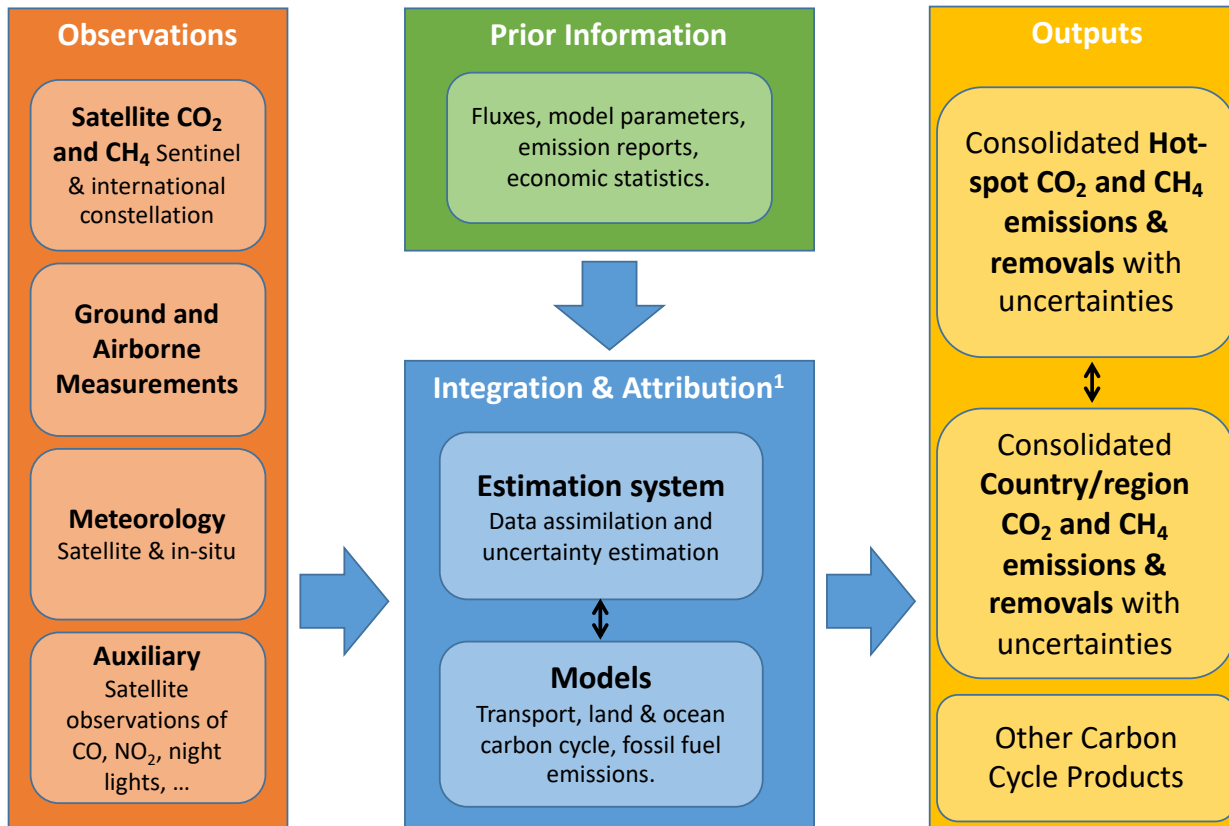
The End-to-End System: Core elements of the functional architecture





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The End-to-End System: A consensus system perspective





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The End-to-End System: Way Forward with 3 sub-groups

WG1 Assess system performance, critical issues on system design, functionalities for a decision support system, **road map**
BAMS IN BOX paper (milestone)

WG2 Outlining governance options and implementation planning
Work in progress with institutional partners

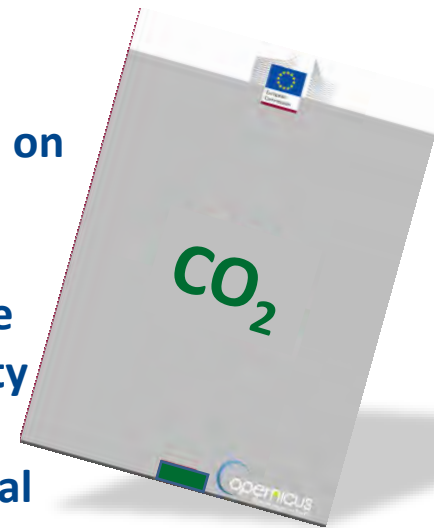
WG3 Assessing the requirements for in situ observations
Report to be available before Summer break



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Outline of WG3 report on in situ observations

- 1- Background and rationale
- 2- *In situ* observation needs for the end-to-end system
- 3- Estimation of CO₂ fluxes from global to urban scale based on existing *in situ* surface networks
- 4- *In situ* observation requirements for the Copernicus space component of the CO₂ Monitoring & Verification Support capacity
- 5- *In situ* observation requirements regarding the CEOS virtual constellation
- 6- Risk analysis
- 7- Recommendations





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Foundation for an international CO₂ and GHG monitoring system (2017-2018#)

1. Completion and follow-on activities of the Atmospheric Composition Virtual Constellation (AC-VC) whitepaper on defining an optimum constellation for CO₂ and GHG monitoring (joint competences of CEOS and CGMS, CEOS Carbon strategy).
2. Advance the relationships with CGMS for an operationally implemented and sustained observation capability (formal working relationship between CEOS and CGMS).
3. Place the space segment in the broader context of a fully sustained system for CO₂ monitoring (CEOS Agencies have counterparts in their individual countries/regions).





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Proposed CEOS actions

Time scale

1. **Link** the atmospheric GHG measurement and modeling communities and stakeholders in the national inventory and policy communities (through UNFCCC/SBSTA).
2. Exploit the capabilities of the **CEOS** and **CGMS** member agencies and the **WMO** Integrated Global Greenhouse Gas Information System (IG³IS) to integrate surface and airborne measurements of CO₂ and CH₄ with those from available and planned space-based sensors to develop a **prototype for the 2023 global stock take**.
3. to implement a complete, **operational**, space-based constellation architecture with the capabilities needed to quantify atmospheric CO₂ and CH₄ concentrations that can serve as a complementary system for estimating NDCs **in time to support the 2028 global stock take**.

Integrated System

In-situ Observations

FLUXNET

SOCAT

TCCON

ICOS

GEO
Carbon &
GHG
(GEO)

IG3IS
(WMO)



Third Country #1

Third Country #3

Third Country #2

Non-space "owner" countries

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Anthropogenic CO₂/GHG Emission
Monitoring and Verification Capacity
(prototype 2021)

Integration and Modelling

Space-based Observations

...

TANSAT & 2nd gen
LEOs (CMA)

OCO-2&3 (NASA)

GOSAT 1&2 (JAXA)

MicoCarb (CNES)

Copernicus -
supporting missions

LEO Missions

Copernicus
CO₂M LEO
Constellation
(launch in
2025)

Global GEO Ring

20



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The CHE proposal and its follow-on is expected to lay the mature foundation for an independent space-borne observation capacity for anthropogenic CO₂ in the context of Europe's Climate Change challenges. Coordination and networking efforts are expected to lay the foundation for the operational integration of all relevant European capacities as a subsequent step.



Thank you for your attention