European Commission

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

CO_2 Monitoring Context

Hugo Zunker

European Commission
Copernicus Unit

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Europe's eyes on Earth

Space

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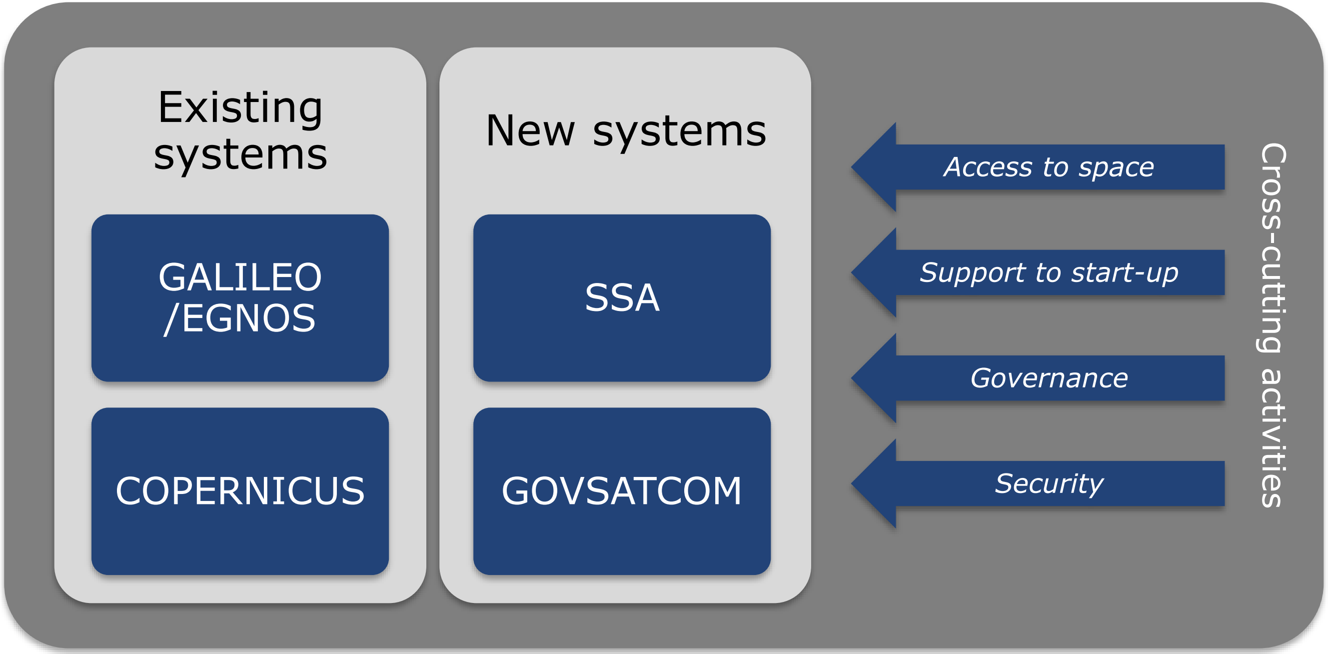
Scope of the new regulation



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Space in support of EU policies

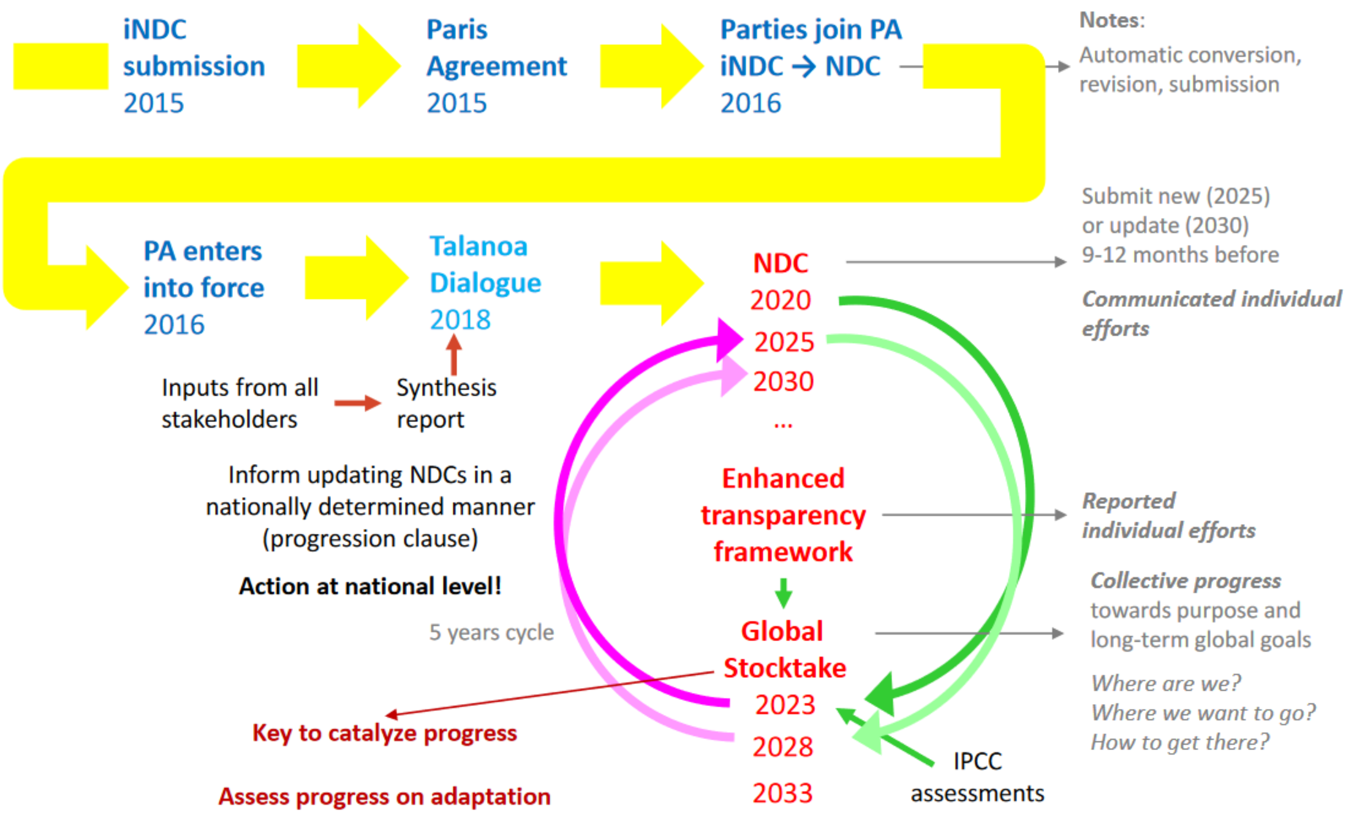
- Mapping of natural disturbances and weather-related challenges
- Monitoring COP21 commitments and CO_2 emissions
- Better execution of CAP due to policy monitoring and precision farming
- Enabling technologies in automotive, aviation and maritime sectors
- Supporting civil protection thanks to Emergency Management Service
- Aiding the digitalisation through space and satellite communication

The Commission's Ambition

- “New Copernicus missions such as CO_2 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.”
  European Commission, Press Release IP/18/4022, 6. June 2018

- “A very significant new [Copernicus] service is about monitoring anthropogenic CO_2 emissions to help countries in assessing their efforts to reduce CO_2 emissions and to contribute to the stocktaking exercise as part of the UNFCCC process as defined in the Paris agreement.”
  Commissioner Bieńkowska, COP24 Katowice, 10. December 2018

Paris Agreement | The "ambition" cycle



Source: Dr. Florin Vladu, Manager, UNFCCC Secretariat, Bonn, 6 May 2018

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The CO_2 Monitoring Task Force: Achievements and Future Plans

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with contributions from ESA, EUMETSAT, ECMWF

& many experts [3]

[1] EC DG-GROW, Copernicus unit I.2, Brussels, Belgium

[2] EC JRC, Directorate for Sustainable resources, unit D.6, Ispra, Italy

[3] Major international institutions

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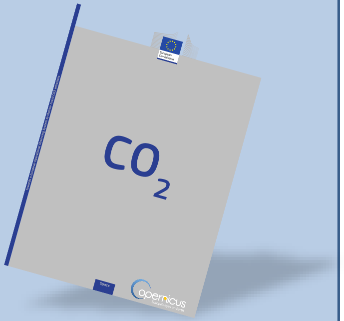
Genesis and evolution of the CO2 Monitoring Task Force (CO2 MTF)

1st period

Team of International experts

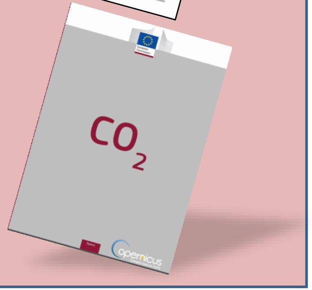


2nd period

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

CO_2 MTF Sub task A: Space Component

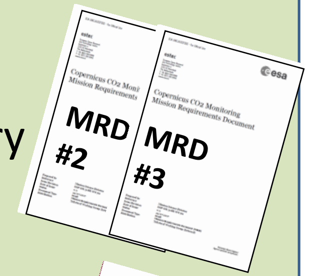
CO_2 MTF Sub task B: end-to-end system



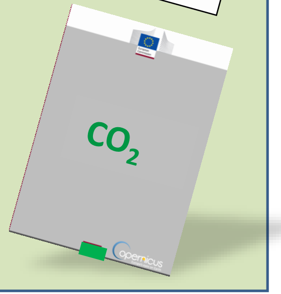
3rd period

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

Mission Advisory Group



CO_2 Monitoring Task Force



October 2015 — Spring 2016 — Winter 2017 — Spring 2018 — present

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

End-to-end System requirements to monitor anthropogenic CO_2

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Accuracy

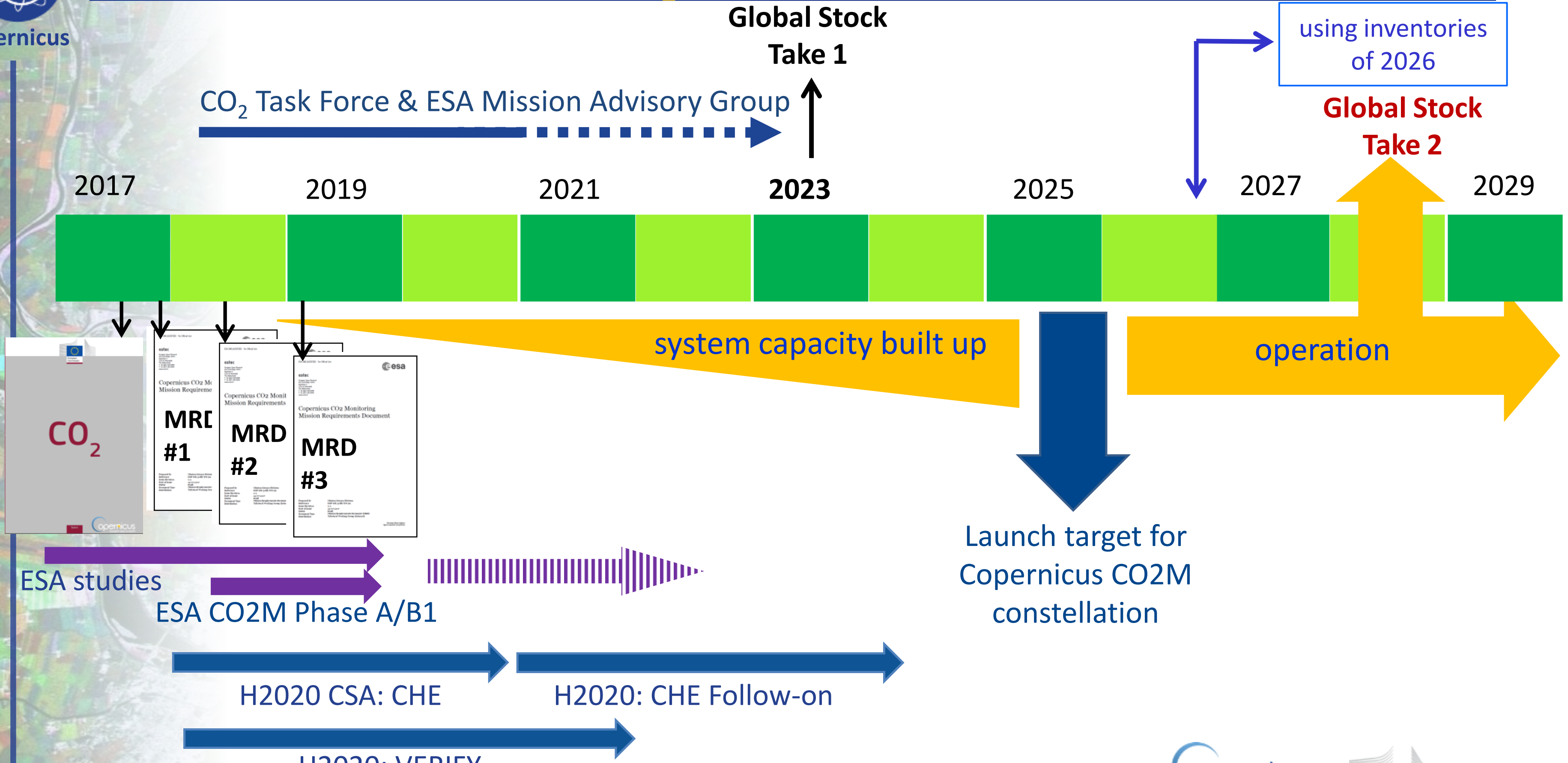
200-400 ton/year

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

Towards an anthropogenic CO_2 Monitoring & Verification Support Capacity



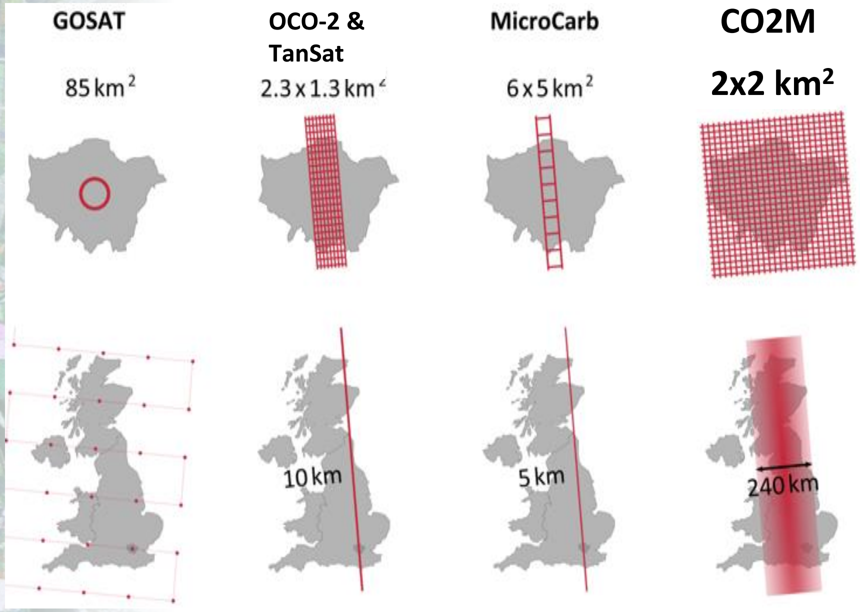
Requirements from the Space Component

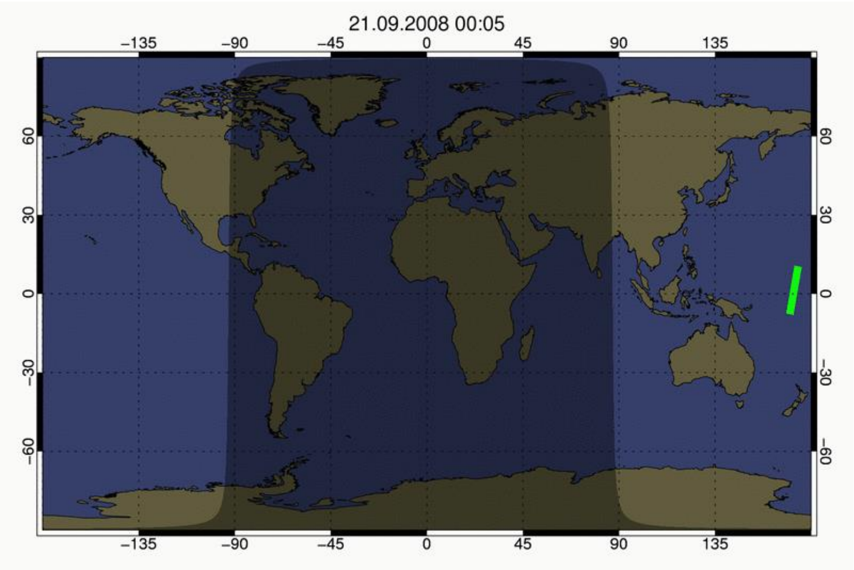
- ## Requirements for XCO2
- XCO_2 precision: **0.5 – 0.7 ppm**
- Systematic bias **< 0.5 ppm**
- Spatial resolution **4 km^2**
- Continuously sampled swath width of **[200 – 400] km**
- Revisit around **2–3 days** (poleward of 40 deg) by **constellation of 2 to 3 satellites**
- Orbit equator crossing time **11:30 hrs**

- ## Auxiliary observations:

- **NO_2 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

Spatial coverage of the CO2M constellation





Credits: IUP, Bremen

Simulations of XCO2 and NO2 observations

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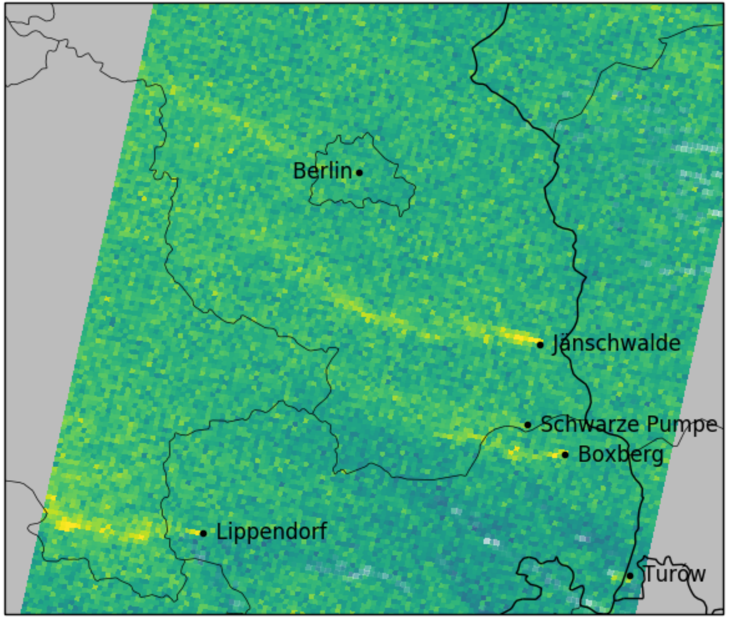
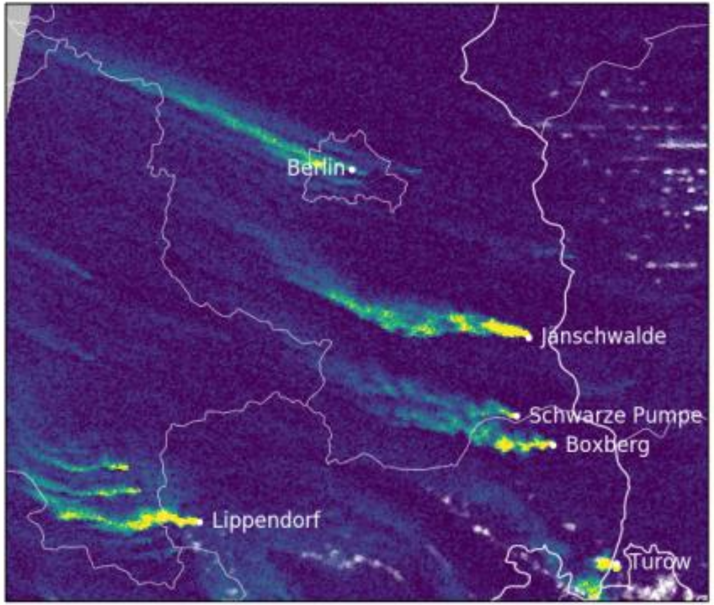
NO_2 detection capabilities significantly improve the capability to detect weak CO_2 plumes



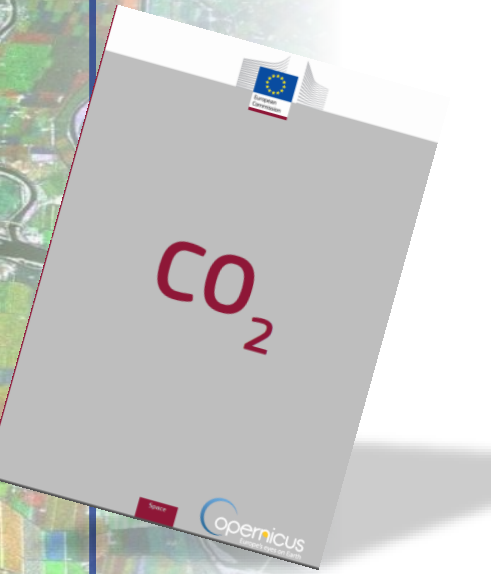
XCO_2 (0.5 ppm noise)



NO_2 (15% noise)

ESA support study using HR test data from S5P/TROPOMI during the commissioning phase

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



Observations

Satellite CO_2
Sentinel & international constellation

In-situ CO_2
Ground-based networks

Meteorology
Satellite & in-situ

Auxiliary
Satellite observations of CO, NO_2, night lights, ...

Prior Information

CO_2 fluxes, model parameters, emission reports, economic statistics.

Integration

Coupled Data Assimilation
(minimises predefined cost function)

↕

Models
(Atmospheric, Transport, Anthropogenic Emissions, Natural Fluxes....)

Output

Consolidated **Hot-spot Fossil Fuel emissions** with uncertainties

Consolidated **Country/region Fossil Fuel emissions** with uncertainties

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

Observations

Satellite CO_2 and CH_4 Sentinel & international constellation

Ground and Airborne Measurements

Meteorology
Satellite & in-situ

Auxiliary
Satellite observations of CO, NO_2, night lights, …

Prior Information

Fluxes, model parameters, emission reports, economic statistics.

Integration & Attribution[1]

Estimation system
Data assimilation and uncertainty estimation

Models
Transport, land & ocean carbon cycle, fossil fuel emissions.

Outputs

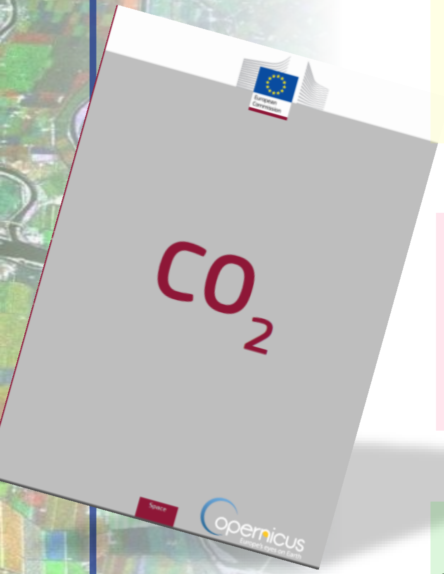
Consolidated **Hot-spot CO_2 and CH_4 emissions & removals** with uncertainties

Consolidated **Country/region CO_2 and CH_4 emissions & removals** with uncertainties

Other Carbon Cycle Products

1: Between biogenic and anthropogenic sources

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

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 CO_2 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 CO_2 Monitoring & Verification Support capacity
- 5- *In situ* observation requirements regarding the CEOS virtual constellation
- 6- Risk analysis
- 7- Recommendations

Foundation for an international CO_2 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 CO_2 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 CO_2 monitoring (CEOS Agencies have counterparts in their individual countries/regions).

#Under the chairmanship of CEOS by the Commission

Proposed CEOS actions

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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 CO_2 and CH_4 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 CO_2 and CH_4 concentrations that can serve as a complementary system for estimating NDCs in time to support the 2028 global stock take.

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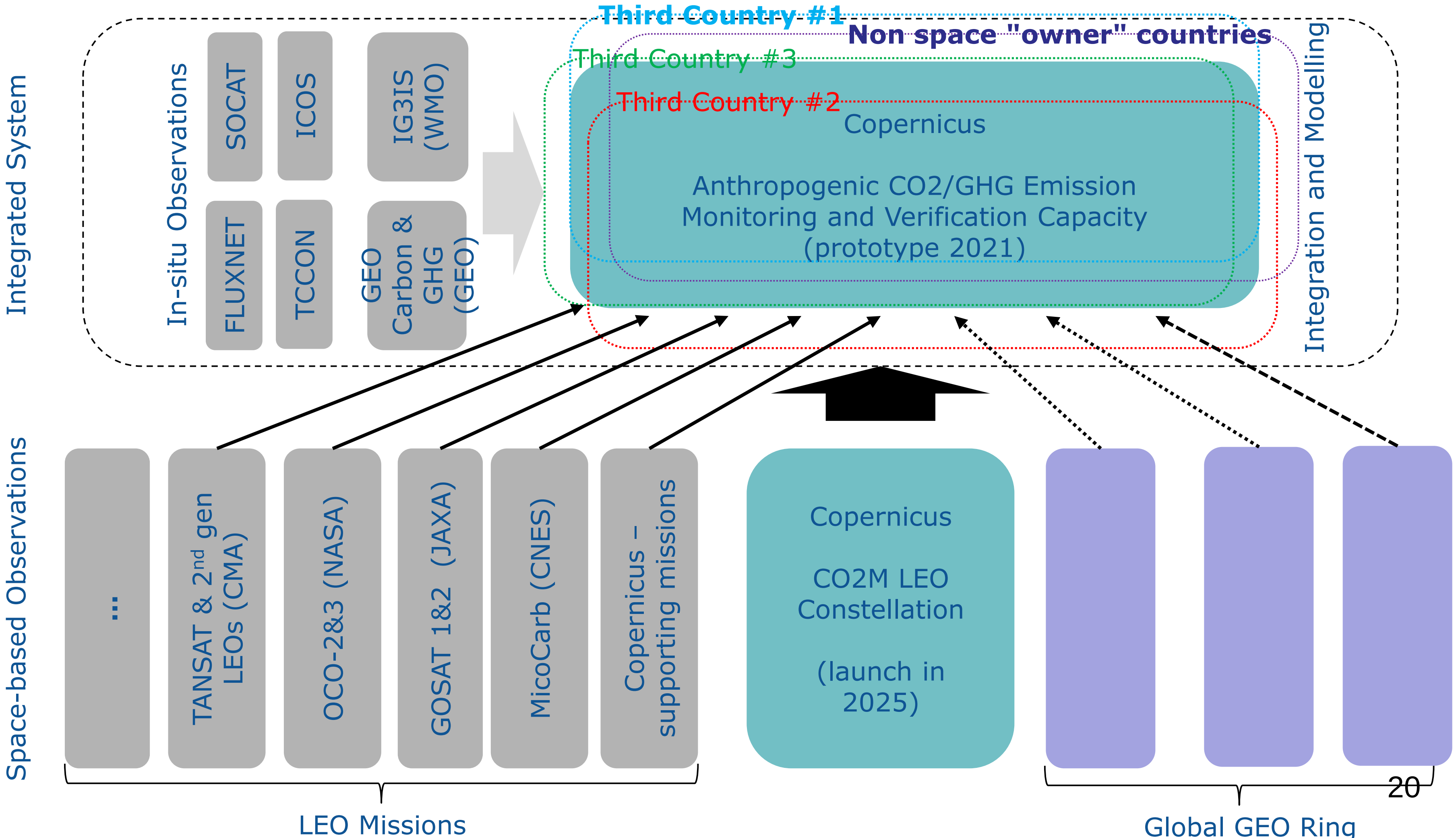
Third Country #1
Non space "owner" countries
Third Country #3
Third Country #2
Integrated System
In-situ Observations
SOCAT
ICOS
IG3IS (WMO)
FLUXNET
TCCON
GEO Carbon & GHG (GEO)
Copernicus
Anthropogenic CO2/GHG Emission Monitoring and Verification Capacity (prototype 2021)
Integration and Modelling
Space-based Observations
...
TANSAT & 2nd gen LEOs (CMA)
OCO-2&3 (NASA)
GOSAT 1&2 (JAXA)
MicoCarb (CNES)
Copernicus – supporting missions
Copernicus
CO2M LEO Constellation
(launch in 2025)
LEO Missions
Global GEO Ring

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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 CO_2 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.**

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Thank you for your attention

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