Towards a roadmap for GHG monitoring

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WGClimate 10

Proposed CEOS Actions

1. Link the atmospheric GHG measurement and modeling communities and stakeholders in the national inventory and policy communities (through UNFCCC/SBSTA), to refine requirements;

2. Exploit the capabilities of the CEOS and CGMS member agencies and the WMO Integrated Global Greenhouse Gas Information System (IG^3IS) 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, global atmospheric CO_2 and CH_4 flux product in time to support inventory builders in their development of GHG emission inventories for the 2023 global stocktake; and

3. Use the lessons learned from this prototype product to facilitate the implementation of 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 stocktake.

Reference docs

link to GHG Whitepaper
link to CEOS Carbon Strategy
link to Ispra GHG Workshop minutes
link to 32nd CEOS Plenary presentation on way forward
link to GCOS-200 - 2016 Implementation Plan
link to IG3IS Implmentation Plan
link to CGMS-46 MInutes (see Pleanry session K)
link to WIGOS 2040 vision

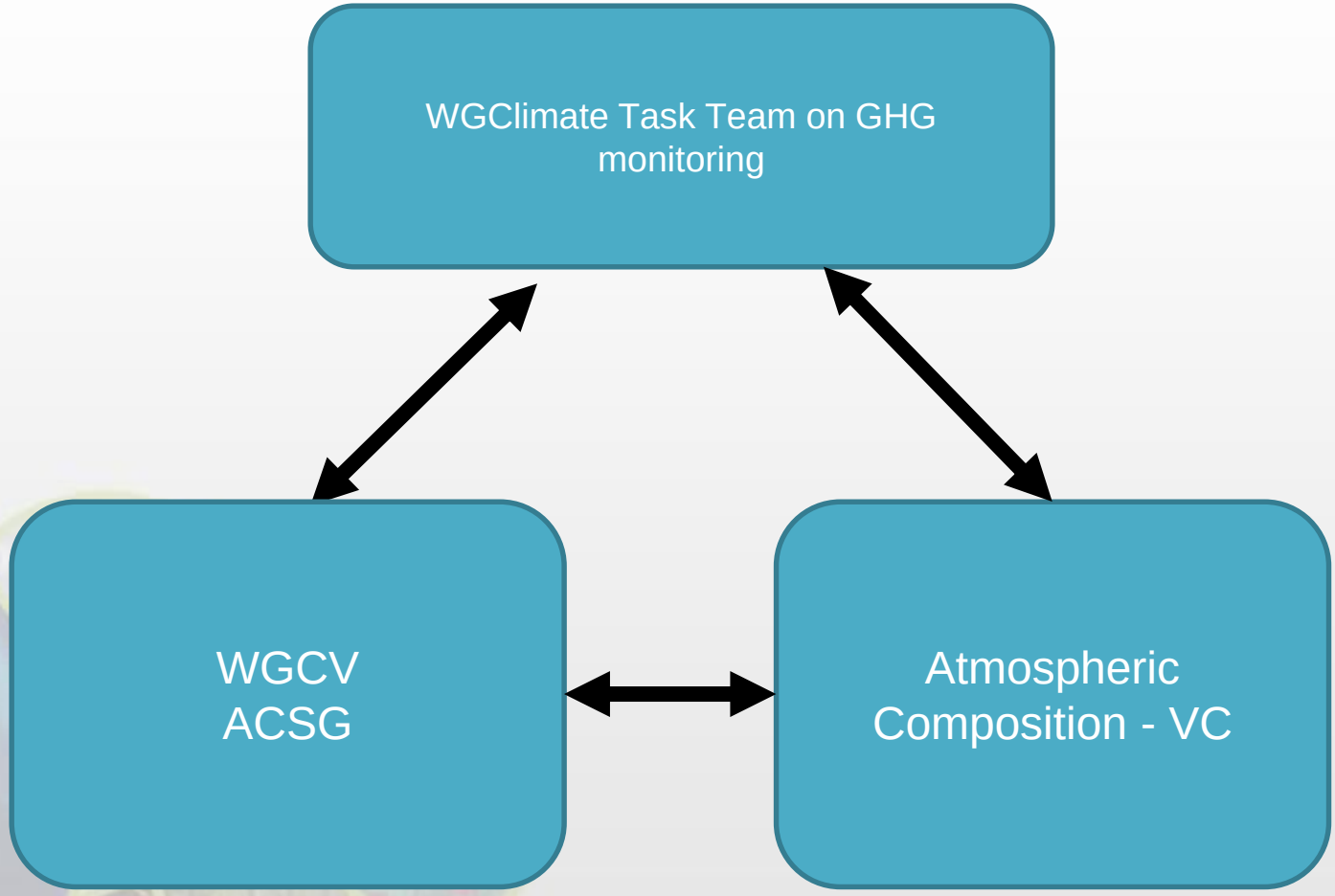
https://docs.google.com/spreadsheets/d/1XIR_3zmbyN4ats9vKhWzlUiUEqFPRzyGsQqT17oJmlc/edit?usp=sharing

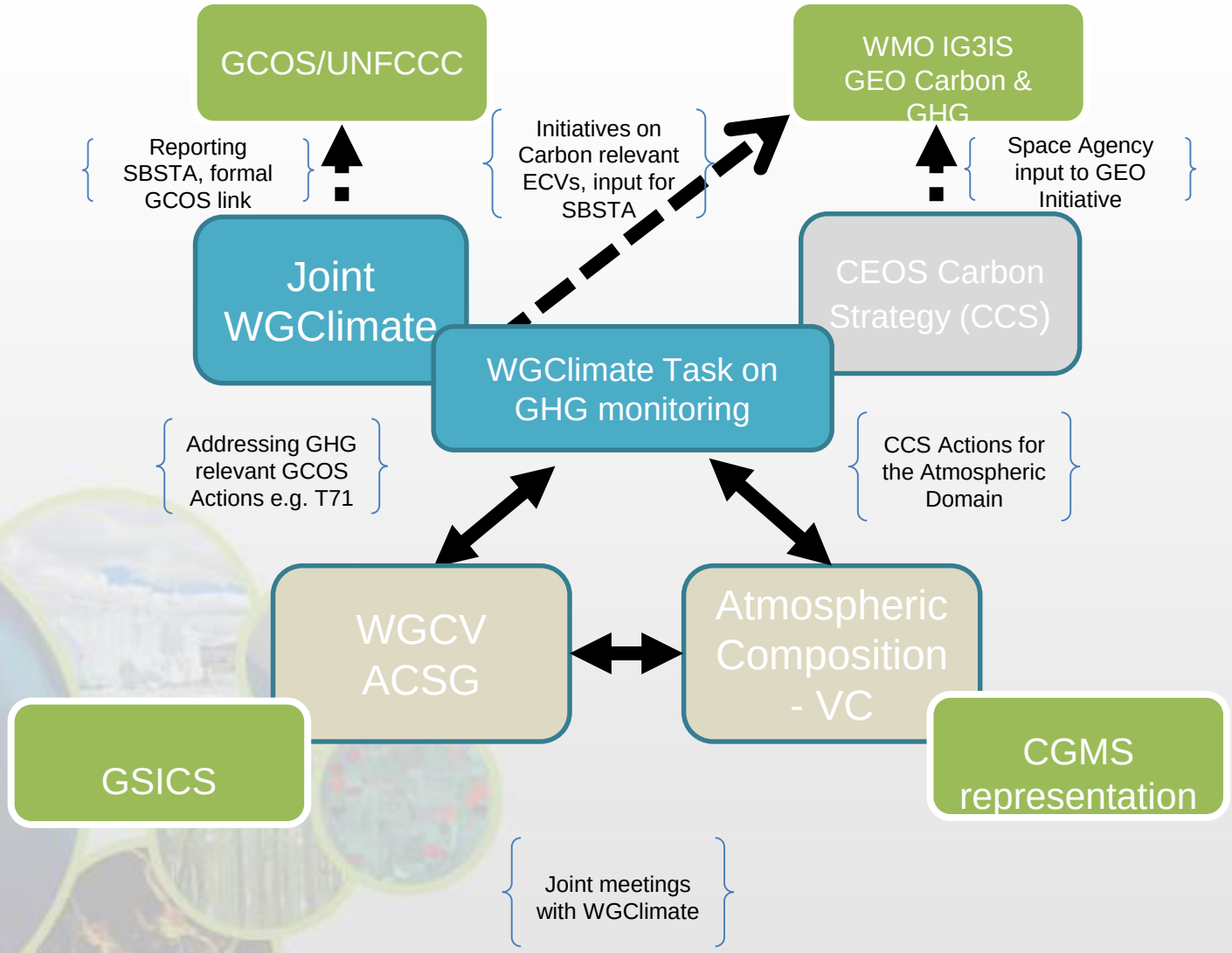
Way Forward 1/2

1	A prototype system, based on available space-based and ground-based atmospheric measurement assets and modelling capabilities, should be designed and implemented in time to inform the first global stocktake in 2023. To support this stocktake, the initial global atmospheric CO2 and CH4 flux products must be available by 2021.
2	The initial operational system should exploit the lessons learned from the development and use of the prototype product as well as new space-based measurement and modelling capabilities to produce space-based CO2 and CH4 flux products in time to support the second global stocktake in 2028.
3	To meet these goals within a decade, it is imperative that individual research and operational space agencies work within CEOS, CGMS and other international coordination bodies (i.e. WMO IG3IS, GCOS, GEO-C) to define a roadmap with specific programmatic milestones for developing virtual and then dedicated constellations that can deliver harmonized, space-based climate data records for CO2 and CH4.
4	The preparation of this report has demonstrated the benefits of the complementary viewpoints provided by CEOS and CGMS for advancing the implementation of system that incorporates both research and operational elements within the timeframe available. In particular, the CGMS partners could provide insight into the process of gathering user requirements for timeliness, reliability, traceability, reprocessing, quality assurance, and providing user support for an operational product. A continued engagement by both entities is required and some formalisation of the relationship would be advantageous. The joint CEOS/CGMS Working Group on Climate could lead this effort.
5	As recognised in Chapter 2, a broad system approach is required to develop a top-down atmospheric inventory approach that complements the bottom-up inventories. This system integrates the satellite observations, in situ (surface, aircraft, and balloon) measurements, modelling components (retrieval, inversion, biogeochemical processes and transport), prior information and ancillary data.
6	To ensure that the space agencies are working together and building the necessary partnerships with the relevant stakeholders (i.e. UNFCCC/SBSTA) and the primary product users in the inventory community to address the overall system implementation goals, they should work through CEOS and CGMS to strengthen the ties to these stakeholders and customers.
7	In Chapter 6, the GCOS requirements were adopted as the basis in the formulation of a baseline operational CO2/CH4 constellation because GCOS provides an independent basis for the requirements. However, these requirements predated the Paris Agreement, which changed the focus of CO2 and CH4 monitoring efforts to anthropogenic emissions at national scales. Further analysis and revision of the space-based measurement and analysis requirements are needed to address this new focus. The CEOS and CGMS agencies should work with GCOS and other partner organizations and stakeholders in an iterative approach to further refine those requirements over the next few years.

Way Forward 2/2

8	CEOS, CGMS and their partners should continue to support the necessary OSSE experiments, which remain of critical importance in further refining the detailed requirements of the space-based elements of the constellation (sensor precision, accuracy, and resolution, orbit and mission coordination). The near-term objective is to develop a prioritized list of the required OSSE experiments and end-to-end system simulations to optimize the overall system design, resolve system-level uncertainties, and facilitate the coordination of activities among the CEOS and CGMS agencies. The output from these experiments should be made available to the CEOS and CGMS Principals periodically, in a format conducive to discussions with their mission and orbit planning organizations.
9	Over the last 15 years, research missions have provided considerable insight into instrument calibration, validation and the broader aspects of uncertainty quantification and quality control. Appendix 4 of this report summarizes the lessons learned from SCIAMACHY, GOSAT, and OCO-2. In the short-term, these lessons represent best practices that should be extracted and generalised by the CEOS/CGMS Working Group on Calibration and Validation (WGCV) and the Global Space-based Intercalibration System (GSICS) so that they are available as Cal-Val strategy "protocols" for space agencies that are now considering missions.
10	The strategy for cross-calibrating the GOSAT and OCO-2 instruments has employed common standards, including observations of the Sun, Moon, and surface vicarious calibration sites, such as Railroad Valley, Nevada, U.S.A. Additional effort by WGCV and GSICS is needed to maintain and improve the quality of these standards to better address the calibration needs of space-based CO2 and CH4 sensors.
11	TCCON has provided the primary transfer standard to relate space-based XCO2 and XCH4 estimates to the ground-based in situ standards maintained by the WMO GAW network. This network must be maintained and augmented using portable, ground-based remote sensing instruments (e.g. EM27/SUN), in situ sensors on fixed-wing aircraft (commercial aircraft, such as CONTRAIL, IAGOS) and balloons (AirCore), and airborne remote sensing instruments (MAMAP, CHARM-F etc.) to provide a more robust and accurate operational validation approach.
12	CGMS and CEOS should work with their member agencies to identify and promote standards in product specification, formats, pre-processing etc. and product inter-comparisons should be routinely undertaken and supported on a sustained basis to produce seamless, interoperable datasets that can be used in the broader system implementation.
13	Agencies should consider a centralized (but possibly geographically distributed) repository for hosting quality-controlled CO2 and CH4 products, with internal capability for product inter-comparison.
14	The capabilities required to meet the needs of the UNFCCC and the Parties to the Convention are already at the limit of the state-of-the-art for existing, space-based measurement technology. The CEOS and CGMS agencies should therefore continue to pursue complimentary technologies for both sensors (e.g. wide swath passive CO2 and CH4 imagers, active lidar) and mission design (e.g. HEO). These development efforts should be coordinated to keep the Principals updated on additional needs and capabilities that would be useful to consider for future mission opportunities.
15	There is a significant need for systematically produced ancillary measurements. These measurements are needed both to improve the accuracy of the XCO2 and XCH4 retrievals (i.e. coincident observations of clouds and aerosols) and to facilitate their interpretation within the context of the anthropogenic and natural carbon cycle (i.e. SIF, NO2 and CO). Here, the proposed atmospheric CO2 and CH4 monitoring system could substantially benefit from the full scope of carbon cycle observations included in the CEOS Carbon Strategy. The CEOS partner agencies should therefore continue to support that strategy. The coordination mechanism identified to address follow-up to the current work should provide an assessment of prioritized products to be addressed in a coherent way, across agencies, to ensure seamless input to the system.
16	To ensure that the initial operational constellation and associated atmospheric CO2 and CH4 monitoring system can meet the sustained operational needs, a system engineering effort should be undertaken early in the implementation. This effort is needed to ensure that the requirement-reliability-traceability-fitness-for-purpose cycle is adequately planned and that the user uptake, user support and training and capability building elements are defined and prototyped. The CEOS and CGMS agencies and their partners at WMO have the necessary competences to start addressing these requirements and can help to assess the scope of these activities at the different levels of the implementation.


WGClimate Task Team on GHG monitoring
WGCV ACSG
Atmospheric Composition - VC


GCOS/UNFCCC
WMO IG3IS
GEO Carbon & GHG
Reporting SBSTA, formal GCOS link
Initiatives on Carbon relevant ECVs, input for SBSTA
Space Agency input to GEO Initiative
Joint WGClimate
CEOS Carbon Strategy (CCS)
WGClimate Task on GHG monitoring
Addressing GHG relevant GCOS Actions e.g. T71
CCS Actions for the Atmospheric Domain
WGCV ACSG
Atmospheric Composition - VC
GSICS
CGMS representation
Joint meetings with WGClimate

ROADMAP FOR AN OPERATIONAL CO_2 EMISSIONS MONITORING SERVICE