Committee on Earth Observation Satellites

Space Agencies Response to the needs for GHG monitoring and reporting

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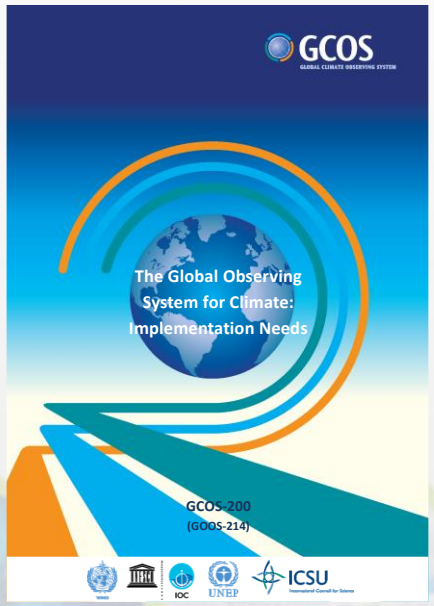
With contributions from D. Crisp (JPL/Caltech), J. Schulz (EUMETSAT), O. Ochiai (JAXA)

Global Climate Observing System: Implemenation Plan (GCOS-200)



Action T71:	Prepare for a carbon-monitoring system
Action	Preparatory work to develop a carbon monitoring system to be operational by 2035; Development development of comprehensive monitoring systems of measurements of atmospheric concentrations and of emission fluxes from anthropogenic area and point sources to include space-based monitoring, in situ flask and flux tower measurements and the necessary transport and assimilation models
Benefit	Improved estimates of national emissions and removals
Time frame	Initial demonstration results by 2023 – complete systems unlikely before 2030
Who	Space agencies
Performance indicator	Published results
Annual cost	US$ 10–100 billion

"Specifically CEOS and CGMS will undertake, over the next few years, dedicated preparatory work in a coordinated international context…:

- The definition of an architecture of space component elements to address the requirements of a CO_2 and GHG monitoring system , … This will provide a global holistic perspective both from the point of view of existing and planned space segment assets as well and that for an optimum global constellation.
- The documentation of best practices on the relationships between individual space agencies and their counterparts working on the modelling aspects, the inventories and in-situ data provision, …
- The further consolidation of partnerships and collaborations between the relevant international entities including: the relationship between CEOS and CGMS on the space component aspects, the partnership with the WMO and GEO on the broader framework, … and finally the relationships with GCOS itself, UNFCCC and IPCC TFI process in better defining the role for space-based observation in the inventory guideline process."

Recognition through SBSTA

United Nations

Framework Convention on Climate Change

FCCC/SBSTA/2017/L.21

Distr.: Limited
12 November 2017

Original: English

Subsidiary Body for Scientific and Technological Advice
Forty-seventh session
Bonn, 6–15 November 2017

Agenda item 8
Research and systematic observation

Research and systematic observation

9. The SBSTA recognized the progress made by the satellite community (see para. 4(e) above), in close collaboration with GCOS, in the development of the essential climate variable inventory.[16] It noted the usefulness of the essential climate variable inventory for climate services. It invited CEOS and CGMS to report on progress at future sessions of the SBSTA, as appropriate.

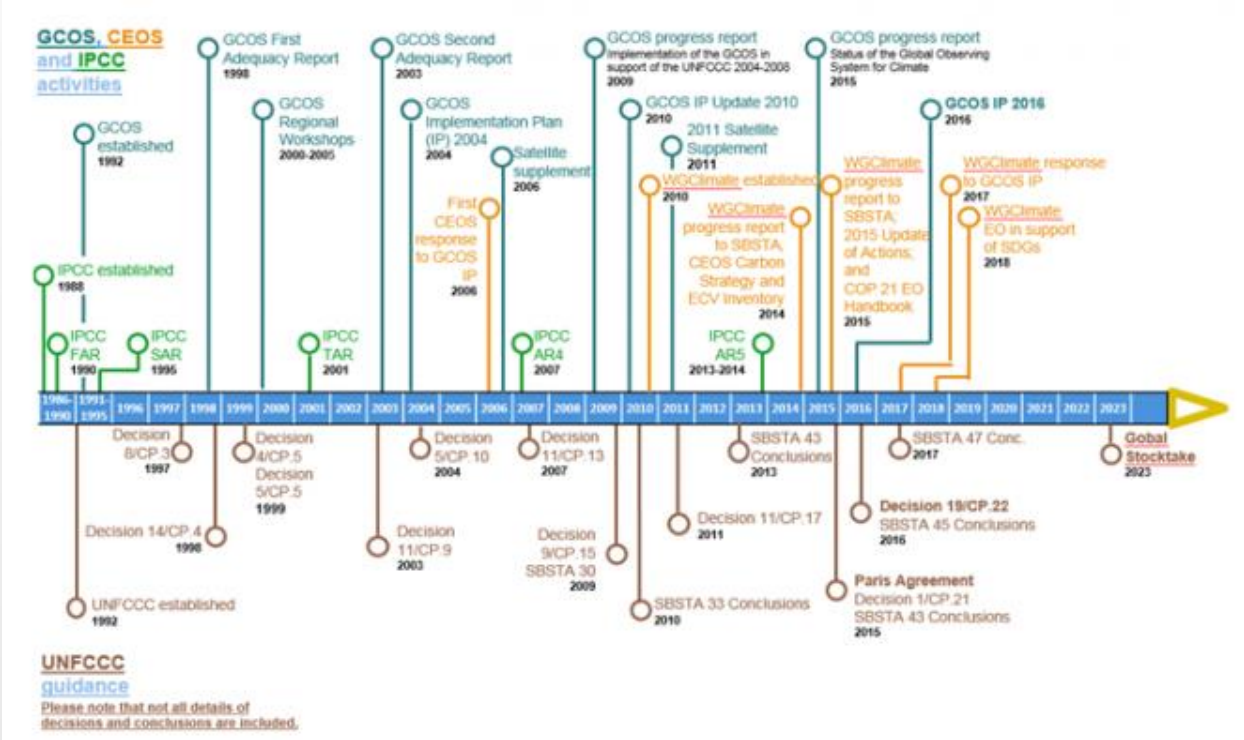
10. The SBSTA noted with appreciation the information provided in the submission referred to in paragraph 4(a) above on the Global Framework for Climate Services (GFCS).[17] It invited WMO to report on progress in implementing the GFCS at future sessions of the SBSTA, as appropriate.

11. The SBSTA invited the UNFCCC secretariat to communicate with the WMO secretariat, including with regional centres, to inform work on climate services.

12. The SBSTA noted the increasing capability to systematically monitor greenhouse gas concentrations and emissions, through in situ as well as satellite observations, and its relevance in support of the Paris Agreement.[18]

Systematic Observations through GCOS a structured process

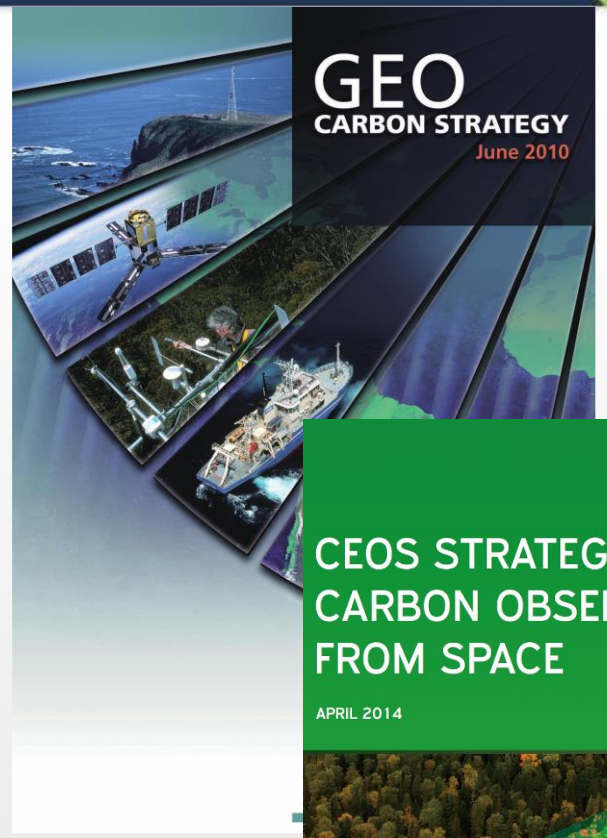
Measurement Domain	Essential Climate Variables (ECVs)
Atmospheric	Surface: Air temperature, Wind speed and direction, Water vapour, Pressure, Precipitation, Surface radiation budget. Upper-air: Temperature, Wind speed and direction, Water vapour, Cloud properties, Earth radiation budget, Lightning. Composition: Carbon Dioxide (CO_2), Methane (CH_4), Other long-lived greenhouse gases (GHGs), Ozone, Aerosol, Precursors for aerosol and ozone.
Oceanic	Physics: Temperature: Sea surface and Subsurface, Salinity: Sea Surface and Subsurface, Currents, Surface Currents, Sea Level, Sea State, Sea Ice, Ocean Surface Stress , Ocean Surface heat Flux Biogeochemistry: Inorganic Carbon, Oxygen, Nutrients, Transient Tracers, Nitrous Oxide (N_2O), Ocean Colour Biology/ecosystems: Plankton, Marine habitat properties
Terrestrial	Hydrology: River discharge, Groundwater, Lakes, Soil Moisture Cryosphere: Snow, Glaciers, Ice sheets and Ice shelves, Permafrost Biosphere: Albedo, Land cover, Fraction of absorbed photosynthetically active radiation, Leaf area index, Above-ground biomass, Soil carbon, Fire, Land Surface Temperature Human use of natural resources: Water use, GHG fluxes



CEOS Carbon activities – Carbon Strategy and support to GFOI

Space Data Coordination Group (SDCG) core business has been stable and sustainable - Satellite data acquisition and provision of assurance of data suitable for annual NFMS reporting

- GEO Carbon Report developed in June 2010 by team led by Ciais et al. (GCP).
- *CEOS Strategy for Carbon Observations from Space* – written in response to above, completed in March 2014 – *Wickland et al.*
- 42 Actions identified in the report for specific response



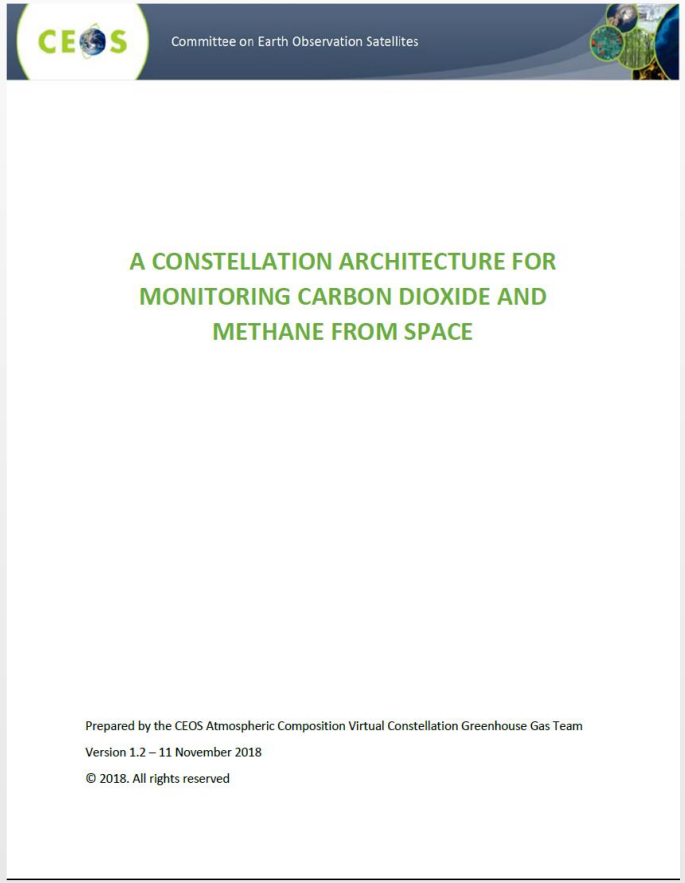
Global Forest Observations Initiative

http://ceos.org/home-2/the-ceos-carbon-strategy-space-satellites/

The CEOS Architecture for Monitoring Atmospheric CO_2 and CH_4 Concentrations

The CEOS Atmospheric Composition Virtual Constellation (AC-VC) white paper defines a global architecture for monitoring atmospheric CO_2 and CH_4 concentrations from instruments on space-based platforms

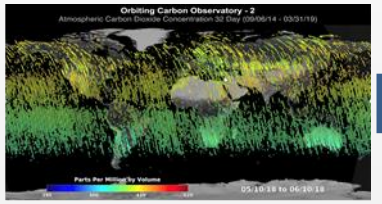
- 166-page document, 88 authors from 47 organizations
- Executive Summary (2 pages)
- Body of report (75 pages)
- Technical Appendices (42 pages)

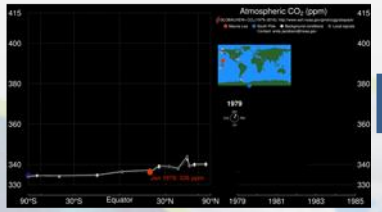


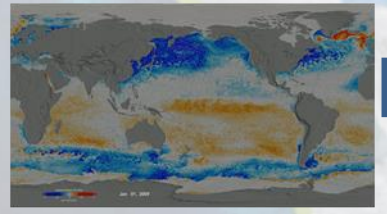
DOI: 10.2760/468219

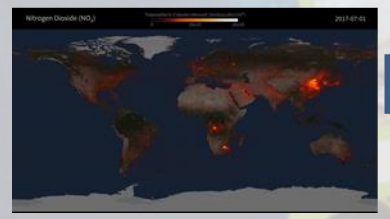
http://ceos.org/document_management/Virtual_Constellations/ACC/Documents/CEOS_AC-VC_GHG_White_Paper_Publication_Draft2_20181111.pdf

A System Approach is Adopted to Deliver Atmospheric CO_2 and CH_4 Inventories









Observations

- **Satellite Measurements of CO_2 and CH_4**
- **Ground and Airborne Measurements of CO_2 and CH_4**
- **Meteorology** Satellite & in-situ
- **Auxiliary Data** Satellite observations of CO, NO_2, clouds, aerosols …

Prior Information

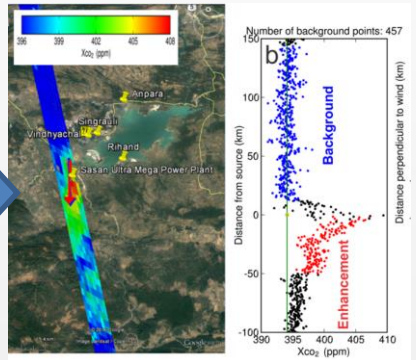
Fluxes, model parameters, emission reports, economic statistics.

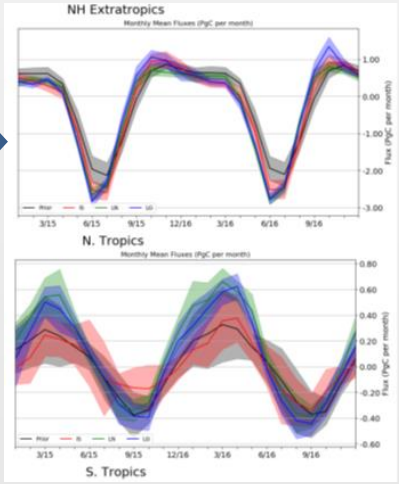
Integration & Attribution

- **Estimation system** Data assimilation and uncertainty estimation
- **Models** Transport, land & ocean carbon cycle, fossil fuel emissions.

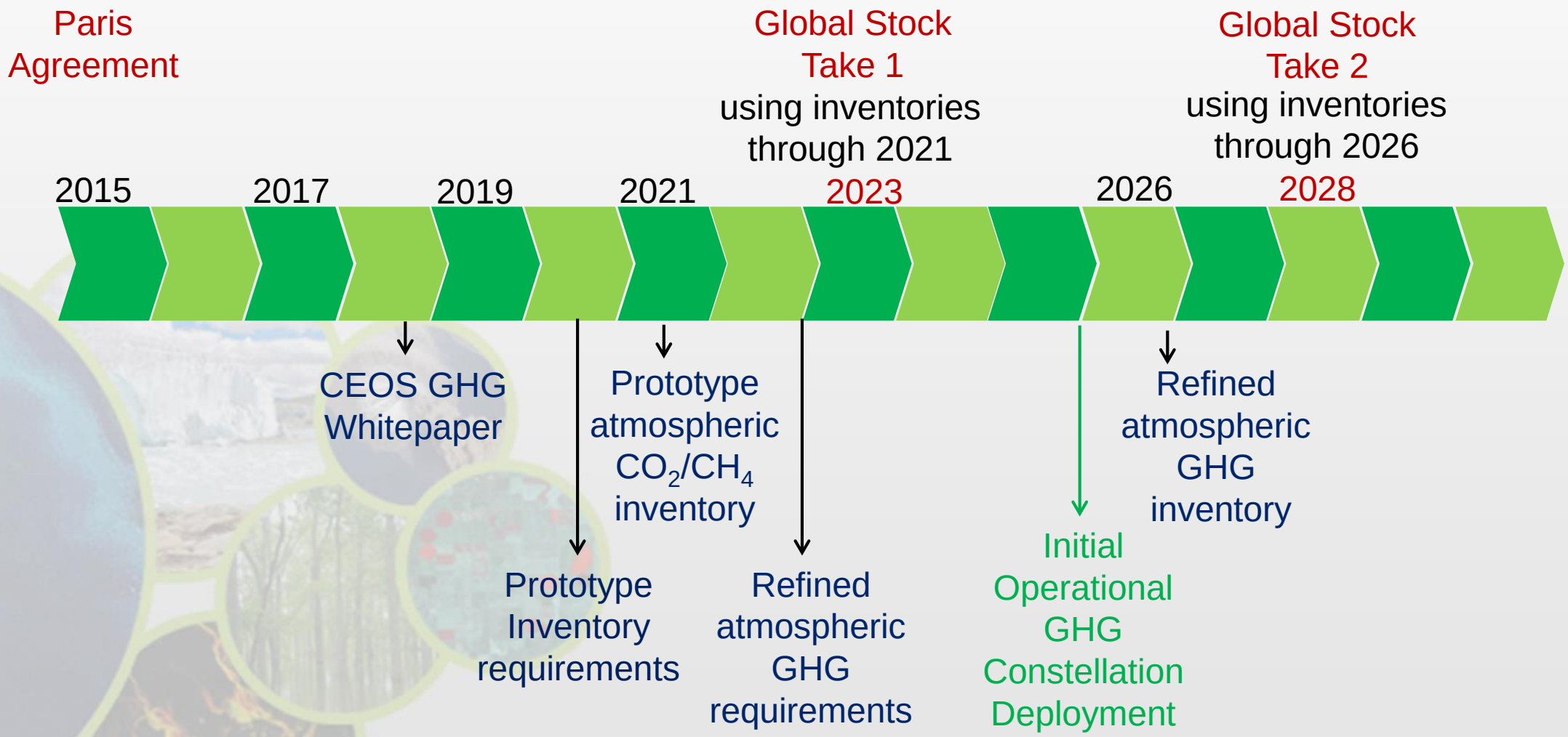
Outputs

- **CO_2 and CH_4 emissions & removals from Hot-spots** with uncertainties
- **Country/region CO_2 and CH_4 emissions & removals** with uncertainties
- Other Carbon Cycle Products





Roadmap Timeline



Proposed CEOS actions following 2018 Prioirty

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 (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 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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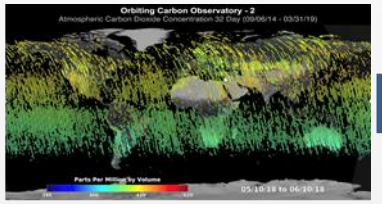

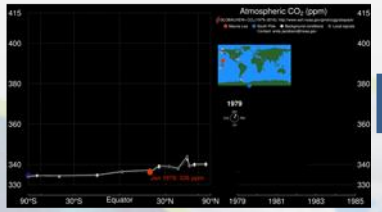

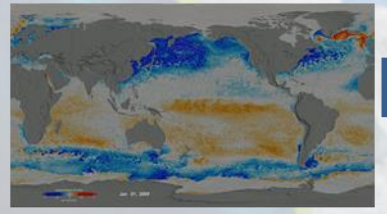

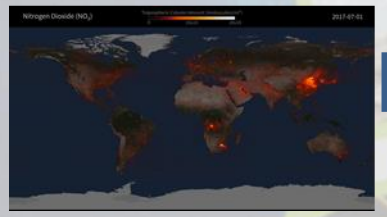

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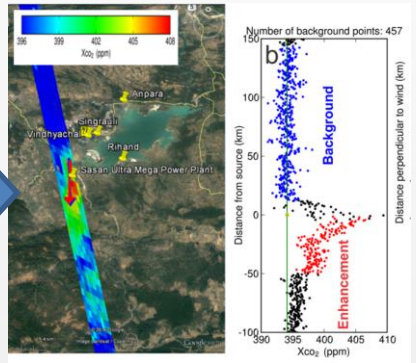
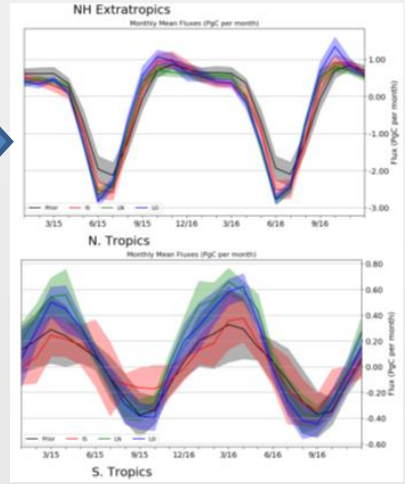




Biomass missions

Biomass data

Many current and upcoming missions will provide data that will be used to map biomass

Mission	Funding Agency	Expected Launch Date	Data Type	Geographic Domain	Biomass Product Resolution	Accuracy Requirement
ALOS-2	JAXA	2014	L-band SAR	Global	NA	NA
ICESat-2	NASA	Sept 15, 2018	532 nm photon counting lidar	Global	NA	Global
SAOCOM 1A	CONAE	October 8, 2018	L-band SAR	Global	NA	NA
GEDI	NASA	Dec 5, 2018	1064 nm waveform lidar	ISS (+/- 51.6°)	1 km	<20% SE for 80% of forested 1 km cells
SAOCOM 1B	CONAE	October 2019	L-band SAR	Global	NA	NA
ALOS-4	JAXA	2021	L-band SAR	Global	NA	NA
NISAR	NASA/ISRO	2021/2022	L/S-band SAR	Global	1 ha (<100 Mg/ha)	<20% RMS accuracy for <100 Mg/ha
BIOMASS	ESA	2022	P-band SAR	Global (excl N. America & Europe)	4 ha	Accuracy of 20%; 10 Mg/ha for <50 Mg/ha
MOLI	JAXA	~2022	1064 nm waveform lidar	ISS (+/- 51.6°)	500 m	NA
TanDEM-L	DLR	2022-2023?	L-band SAR	Global	1 ha	20% accuracy or 20 Mg/ha

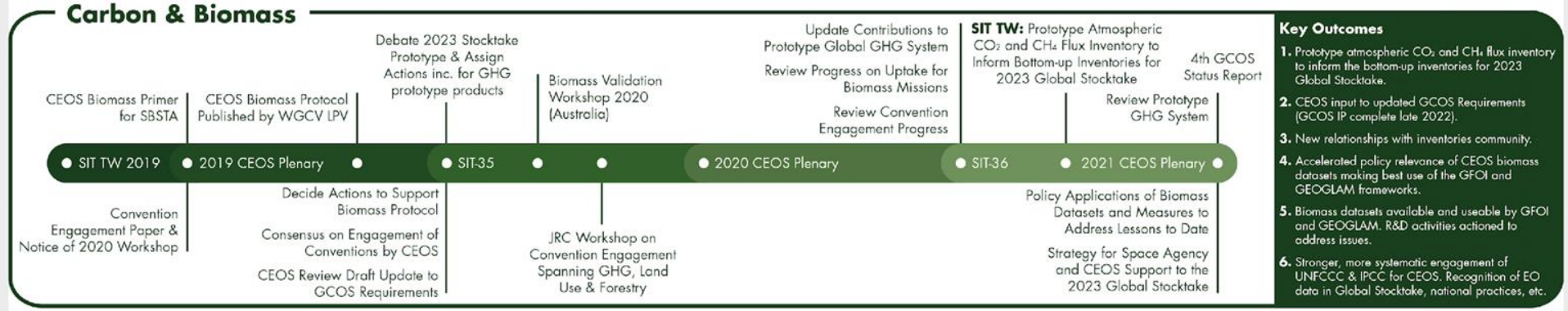
CEOS Biomass mission coordination

SDCG

Biomass, will potentially become an increasingly important topic for CEOS to address from multiple points-of-view in the forthcoming years.

- GFOI requested CEOS improvements to biomass estimation
- Biomass linking to GHG Roadmap and Global Stocktakes would be a high-level and worthy goal for CEOS engagement enhancing the WGCV/LPV CEOS Biomass Protocol team.
- Encourage CEOS agencies to consider how to form the best and comprehensive structure in CEOS and send specialists for more discussion.

Carbon & Biomass



- Supporting the GHG Roadmap process – escalating, elevating, and accelerating progress towards major milestones, including for the 2023 Global Stocktake. 2021 prototype flux products.
- Encouraging stronger and more systematic CEOS engagement with convention frameworks – building on IPCC outreach
  - **And national inventory communities as our future users**
- Reflecting large investment (2018-2024) in Above-Ground Biomass missions and seeking to accelerate the policy relevance of these new data (GFOI, GEOGLAM…)
- Promote uptake of biomass datasets beyond science community – forest monitoring, inventories…

GHG-AFOLU Workshop June 2020

- There are parallel engagememt activities of Earth Observation community with UNFCCC and in support of the Parties
- The system approach adopted for GHG should be comprehensive and extend to include AFOLU aspects
- Workshop to bring together EO communities from GHG and AFOLU aspects including there respective users and colleagues working on the policy interface
- (TBC) 10-12 June 2020 at European Commission's Joint Research Centre

The Committee on Earth Observation Satellites

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Conclusions

1. Clear Policy Framework (UNFCCC/ Paris Agreement)
2. Clear requirement setting process (GCOS)
3. Willingness political/programmatic for development
4. Willingness (and necessity) for cooperation at international level
5. Clear timeline for implementation (i.e. Global Stocktakes) – milestones
6. Clear understanding of need for System approach
7. Efforts required on transition Research to Operations
8. Fundamental need for active iterative dialogue with users/Inventory Community
9. Think holistically about integration of EO contributions to GHG & AFOLU
10. Embrace new capabilities in addressing AFOLU/REDD+ aspects i.e. Biomass