Committee on Earth Observation Satellites

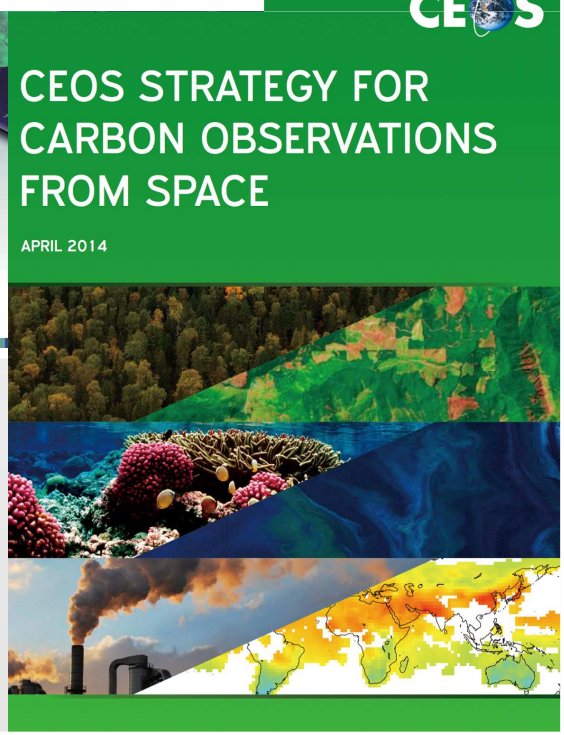
Carbon Strategy Implementation

Mark Dowell

European Commission – JRC

CEOS Carbon activity - history and Background

- 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– first discussed at SIT Technical Workshop in September 2013
- April 2014:Proposed establishment of a study team to take forward the Actions and also identify formal CEOS mechanism to manage Actions.



COP-21: Paris Agreement Article 7 (7c)

- Strengthening scientific knowledge on climate, including research, systematic observation of the climate system and early warning systems, in a manner that informs climate services and supports decision- making
- Developing the Transparency Framework (the need to promote transparency, accuracy, completeness, consistency, and comparability, and environmental integrity) & Global Stock-take

SBSTA Conclusions:

- Noted with appreciation the [Status] report by GCOS
- Encouraged GCOS to consider the outcomes of the twenty-first session of the Conference of the Parties when preparing the GCOS IP 2016
- Invited GCOS to collaborate with relevant partners to continue enhancing access to, and understanding and interpretation of, data products and information to support decision-making on adaptation and mitigation at national, regional and global scales

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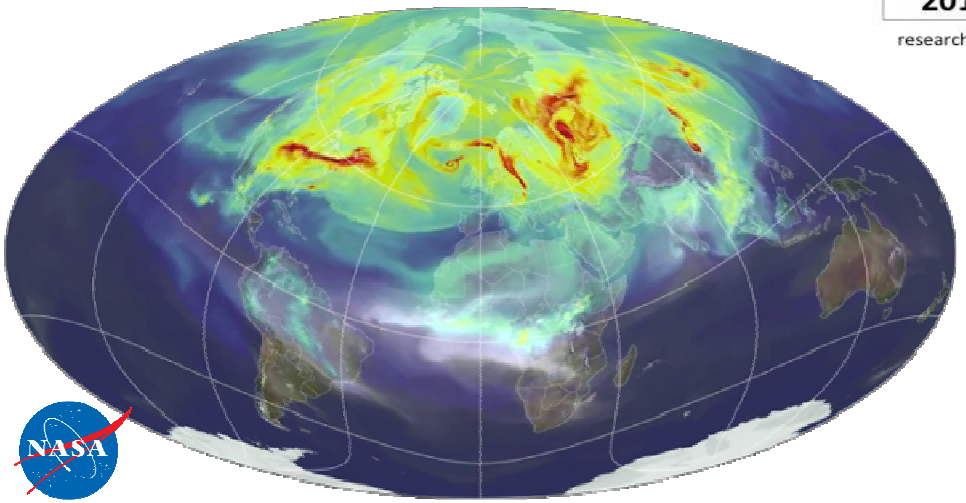
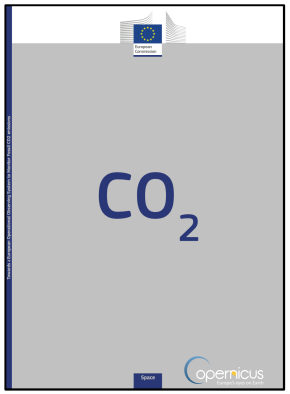
SCIENCE

Potential Eyes in the Sky on Greenhouse Gases

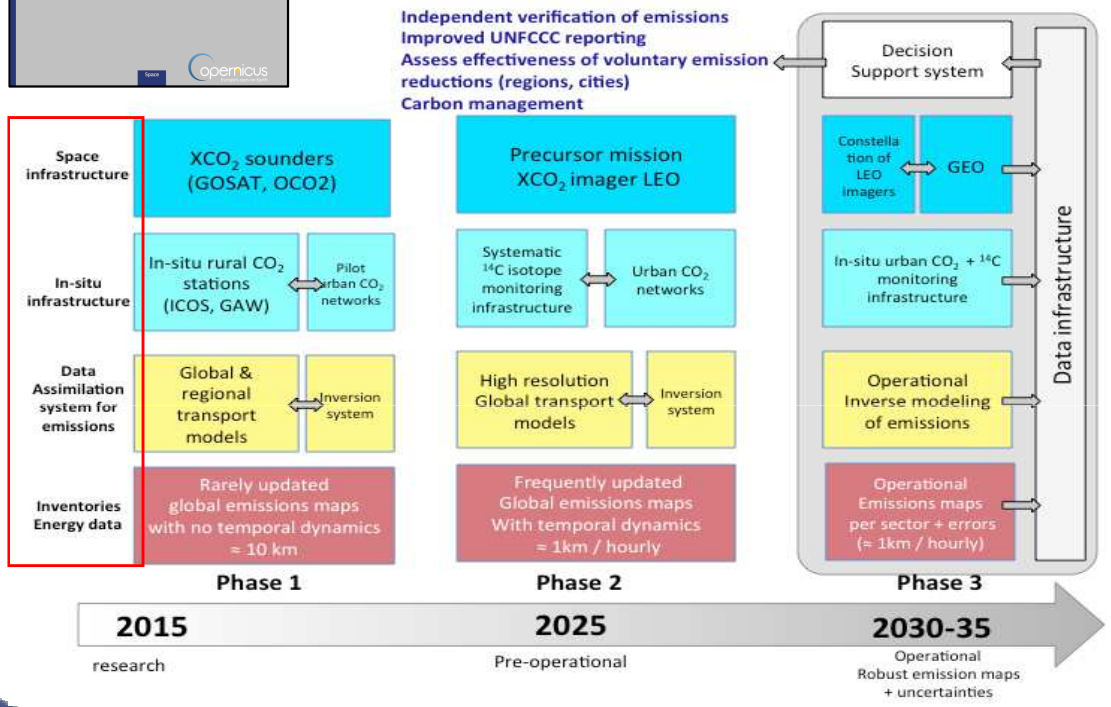
By **WILLIAM J. BROAD** MAY 9, 2016

An artist's rendering of a monitoring satellite. Jet Propulsion Laboratory/NASA





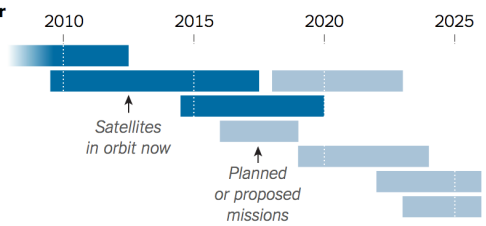
Systems Approach
International effort and coordination



Monitoring CO2 From Space

A series of research satellites will test instruments and sensors for a proposed fleet of satellites that would monitor carbon dioxide emissions around the globe by 2030.

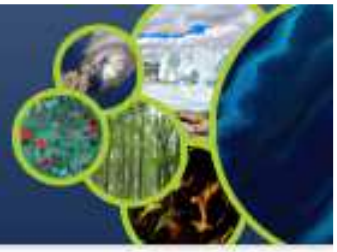
Satellite	Agency or country
Environmental Satellite	ESA
Greenhouse Gases Observing Satellites	Japan
Orbiting Carbon Observatory-2	NASA
Chinese Carbon Dioxide Observation Satellite	China
MicroCarb	France
CarbonSat	ESA
Ascends	NASA



Source: European Commission

By The New York Times

Truly cross-cutting within CEOS



Spreadsheet identified lead CEOS “Entity” as:

- Atmospheric Chemistry-VC: 6 Actions
- Land Surface Imaging-VC: 4 Actions
- Working Group Climate: 7 Actions
- Working Group Calibration/Validation: 11 Actions
- Strategic Implementation Team: 7 Actions
- N/A: 2 Actions
- Other WGs and VCs named as contributing

Some Actions have been undertaken…(from LSI-VC)

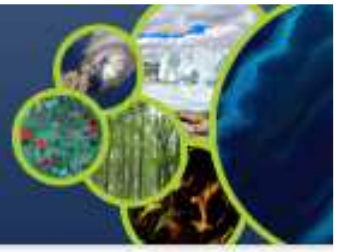
- ***CARB-08-03:*** *CEOS Agencies with historical moderate-resolution (~250 m - 1 km) satellite data records will strive to ensure these data are publicly available …*

Mission	Instrument	Agency	Launch	Policy	Repeat or Revisit	Swath	Resolution
Optical - Moderate Resolution (250 to 1000m)							
Terra	MODIS	NASA	Dec 1999	Open	1 day	2330 km	250, 500, 1000m
Aqua	MODIS	NASA	May 2002	Open	1 day	2330 km	250, 500, 1000m
SPOT-5	VGT-2	CNES	May 2002	Open	1 day	2276 km	1150 m
Suomi-NPP	VIIRS	NASA	Oct 2011	Open	1 day	3000 km	375, 750m
MTSAT-2	Imager	JMA	Feb 2006	Open	<1 day	Full Earth Disk	1, 4km
MTSAT-1R	JAMI	JMA	Feb 2005	Open	<1 day	Full Earth Disk	1, 4km
COMS	MI	KARI/KMA/ITT	Jun 2010	Open	<1 day	Full Earth Disk	1, 4km
Meteosat-10	SEVIRI	EUMETSAT/ESA	Jul 2012	Open	<1 day	Full Earth Disk	1, 3km
HJ-1B	IR	CAST	Sep 2008	TBD		720 km	150, 300m
Terra	MISR	NASA	Dec 1999	Open		380 km	275m, 550m, 1.1km
COMS	GOCI	Korea	Jun 2010	Open		1440 km	236 x 500m
BJ-2	CCD camera	ISRO	Jul 2015	Open	<1 day	Full Earth Disk	1km
Elektro-L N1	MSU-GS	Russia	Jan 2011	Open		Full Earth disk	1000, 4000 m
Proba-V	VGT-P	ESA/BELSPO	May 2013	Fee *	1 day	2285 km	100, 300, 1000m
Sentinel-3A	OLCI	ESA	Feb 2016	Open	4 days	1270 km	300, 500, 1000m

- ***CARB-08-04:*** *CEOS Agencies with historical medium-resolution (~30 m -100 m) satellite data records will strive to ensure these data are publicly available …*

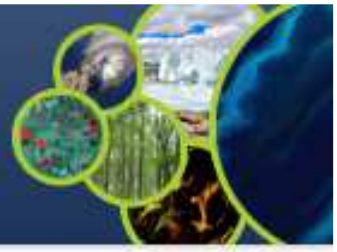
Mission	Instrument	Agency	Launch	Policy	Repeat or Revisit	Swath	Resolution
Optical - Medium Resolution (10 to 250m)							
Landsat-7	ETM+	NASA/USGS	Apr 1999	Open	16 days	183 km	15, 30, 60m
NMP-EO-1	ALI	NASA	Nov 2000	Open	16 days	185 km	10, 30m
HJ-1A	HSI	CRESDA/CAST	Sep 2008	Open	31 days	50 km	100m
HJ-1A	CCD	CAST	Sep 2008	Open	31 days	360 km (per set)	30m
UK-DMC2	SLIM-6-22	UKSA	Jul 2009	Fee	7 days	640 km	22 m
Deimos-1	SLIM-6-22	Commercial	Jul 2009	Fee	7 days	640 km	22 m
Meteor-M N1	KMSS	ROSKOSMOS	Sep 2009	Open	~ 4 days *	900 km	60 m, 120 m
ResourceSat-2	AWiFS	ISRO	Apr 2011	Fee	5 days	740 km	56 m
ResourceSat-2	LISS-3	ISRO	Apr 2011	Fee	24 days	141 km	23.5 m
Landsat-8	OLI + TIRS	NASA/USGS	Feb 2013	Open	16 days	183 km	15, 30, 100m
CBERS-4	WFI-2	INPE/CAST	Dec 2014	TBD	5 days	866 km	73 m
CBERS-4	MUXCam	INPE/CAST	Dec 2014	TBD	26 days	120 km	20 m
CBERS-4	IRS (China)	INPE/CAST	Dec 2014	TBD	26 days	120 km	40, 80m
Proba	CHRIS	ESA/UKSA	Oct 2001	Open	7 days	14 km	18, 36m
NMP-EO-1	Hyperion	NASA	Nov 2000	Open	16 days	185 km	30m
SJ-9A	MUX	CRESDA	Oct 2012	Open	69 days	30 km	10m
Sentinel-2A	MSI	ESA	Jun 2015	Open	10 days	290 km	10, 20m
Sentinel-2B	MSI	ESA	2016	Open	10 days	290 km	10, 20m

Proposed Process



- Forego the “traffic light” approach to monitoring and review Carbon Action for some time [Although we will internally keep an overview of overall progress]
- Identify a number (~ 5) of WG and VC proposed initiatives
- These will also act as “prototypes” for number of crosscutting aspects related to the Carbon Action implementation i.e.:
  - Initiatives addressing multiple Actions
  - Initiatives across multiple CEOS entities VCs & WGs
  - Initiatives addressing multiple thematic examples from the same Carbon Action
  - Initiatives which “CEOSize” efforts previously undertaken within a specific CEOS Agency or through bilateral efforts
- In parallel we would continue several shorter–term and supporting activities: GEO Carbon & GHG Inititaive engagement, mapping Agency level projects onto Carbon Actions, 2 yr CEOS Carbon Workshop

Shorter term outputs: WGCV



- By end March 2017: Carbon Action #8 - related to LPV subgroup - identifying priorities of land data products to validate
- LPV document its current list of validated land data products and candidate land data products to be validated. The list of land products will be compared to the Carbon Task Force report to identify possible gaps and resources that would be needed to assess those gaps.
- Also by end of March 2017, document a set of best practice validation protocols with documented methods and an online platform for intercomparison of terrestrial carbon products. This is part of closing out Carbon Action #8 as well as making significant progress on Carbon Action #34 when coupled with identifying the best mechanism for making WGCV intercomparisons of carbon products available.

Initial Proposed Initiatives

1. ACC: aiming for a white paper on a Carbon constellation;
2. LSI-VC: adopt GEOGLAM gap analysis
3. WGClimate: focusing their gap analysis work on carbon-specific ECVs;
4. WGISS: on a carbon data portal to facilitate the discoverability and accessibility of ECV products and space-borne CDRs relevant for the carbon actions.;
5. NASA-ESA: on cal/val and production of biomass products from CEOS missions – based on previous bi-lateral NASA/ESA initiative
6. WGCV [Shorter term activities described before] + process for mapping across
7. JAXA: on the opportunity to engage with IPCC Inventories and promote satellite EO

These address a good cross-section of Actions across the Carbon Strategy

ACC Initiatives

Deliveries:

- Merged CARB AI 16+18: ACC to support the organisation of yearly IWGGMS (International Workshop on Greenhouse Gas Measurements from Space): next planned at FMI (Helsinki, Finland) on 6-8 June 2017
- Merged CARB AI 17+19+23: ACC will prepare a white paper within 2 years (?)
- CARB AI 20: ACC will write a Technical Note within 2 years

People involved:

ACC GHG activities lead: D. Crisp (NASA)

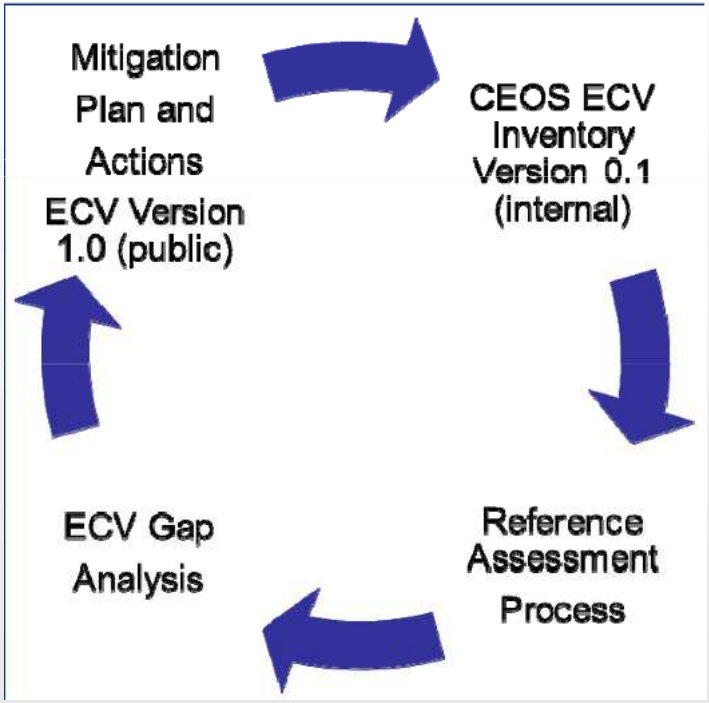
M. Nakajima, K. Shiomi (JAXA) – GOSAT, GOSAT2; D. Crisp (NASA) – OCO2, OCO3; Y. Liu (CAS) – TanSat; C. Zehner, Y. Meijer (ESA) – S5P, S5, future GHG Sentinel; A. Friker (DLR) – MERLIN - tbc; C. Deniel (CNES) - MERLIN, MicroCarb, R. Munro (EUMETSAT) – IASI, IRS; D. Edwards (NCAR) – GEO CH4; A. Butz - (DLR) GEO CO2; B. Pinty (EC) - tbc; – expecting updates follwing recent ACC-12 meeting, Seoul, 13-14 Oct 2016

Draft Mandate for Satellite Carbon report content, undertaken by ACC-VC (i)

- Based on existing requirements. define the key characteristics of a global architecture for carbon (CO_2, CH_3) measurements from space.
- Consider observational needs for both composition and fluxes, natural and anthropogenic
- Include known plans and considerations from space agencies worldwide in overall system architecture to ensure global consistency of design
- Incorporate potential observations from both GEO and LEO potential missions in an optimal system, and consider optimal acquisition strategies across the system including orbits, equator crossing times, sensor characteristics etc.
- Include instrument on-orbit calibration and geophysical validation aspects
- Build on work already undertaken by ACC-VC in response to the CEOS Carbon Strategy
- Provide a reference architecture against which individual agencies can develop their plans to optimise joint implementation.
- Report at Plenary 2017, with interim report SIT (April 2017)

WGClimate Initiative

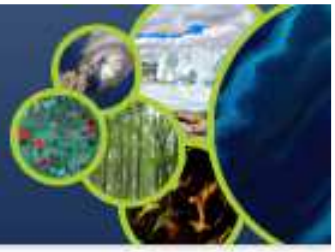
For consistent ECV Carbon products take advantage of Inventory output to produce subset of ECV Products contributing to Carbon Strategy



Actions assigned to WGClimate

Encourage the production and availability of high-quality, consistent long time series data products based on multiple sensors and missions for carbon and climate science and for model-data and data-data intercomparison exercises.	WGCV AC-VC LSI-VC OCR-VC
Make publicly available all information necessary to document the accuracy, clarity, and traceability of the satellite data and data products they produce.	WGCV VCs
Coordinate efforts to develop compatible (e.g., temporal and spatial resolution, grids, data formats, common auxiliary data, units) carbon data products from multiple missions	OCR-VC AC-VC LSI-VC WGCV
Ensure the long-term accessibility of satellite data and data products for carbon cycle science and policy. This must include arrangement for secure archives, documentation, and metadata as well as for provisions for easy discovery and access	WGISS
Serve as a point-of-contact for appropriate satellite products for major model-data intercomparison exercises related to the carbon	WGClimate chair membership on

ECVs/CDRs Discovery and Access through WGISS Systems

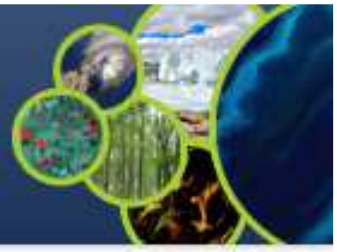


- **Objective**: facilitate discoverability and accessibility of ECV Products and space-born CDRs relevant for the CEOS Carbon Action via WGISS Interoperability Systems & Standards (FedEO/CWIC/IDN, OpenSearch).

- **Approach**: start from results of WGClimate Questionnaire for ECV Inventory population; tailoring for Carbon Action and gaps identification wrt data records already discoverable/accessible through WGISS systems (Q1/Q2 2017); feasibility analysis, priorities setting and liaising with relevant organizations (Q2/Q3 2017); start technical activities (Q3/Q4 2017).

- **Additional Resources**: support from WGClimate and experts for priorities setting; activities at data providers' side to be carried out by relevant entities.

WGISS Carbon Portal

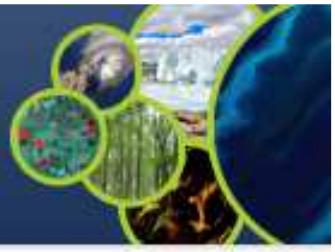


- **Objective**: development as WGISS project of a CEOS WGISS Carbon Portal prototype similar to the Water portal (http://waterportal.ceos.org/) to allow displaying Carbon datasets and providing assistance to scientists and general users in the development of related services & tools.

- **Approach**: collection of needs from Carbon (or WGClimate) experts on what needs to be in the portal (Q1/Q2 2017); Carbon Portal requirements definition and system design (Q2/Q3 2017); start development (Q3/Q4 2017).

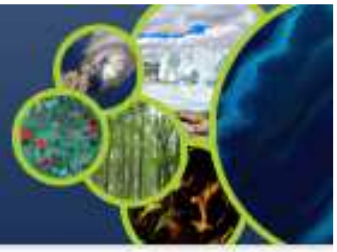
- **Additional Resources**: requirements definition and development resources provided by NOAA; support from WGClimate and experts for requirements definition.

GEO Carbon and GHG Initiative



- Accepted as a GEO Initiative at 3rd GEO Programme Board 2016
- The GEO C and GHG initiative provides cross integration and coordination of the interfaces (between: atmosphere, ocean and terrestrial domains; space-based, air-borne and in-situ monitoring systems;). It builds on existing strategies, initiatives, networks and infrastructures, and integrates them with the missing pieces to obtain a comprehensive globally coordinated GHG observation and analysis system.
- Key Elements
  - Task 1: User needs and policy interface (policy and science requirements)
  - Task 2: Data access and availability (CEOS esp WGISS)
  - Task 3: Optimization of observational networks (CEOS)
  - Task 4: Budget calculation consistency (Global, Regional, sub-Regional, National, Local) (CEOS Carbon Strategy)
- CEOS POC: Stephen Plummer, ESA – member of Executive Committee

Summary



1. Plenary to agree on overall approach i.e. a smaller number of dedicated activity addressing multiple Actions
   - Update would be provided at Plenary added at Plenary 2017, process to be reviewed at Plenary 2018
   - Additional initiatives could be added if critical mass and resources available
2. Plenary to comment on initial Initiatives proposed
   - Identify major omissions we should follow-up on
   - “Generous” offers of dedicated resources welcome

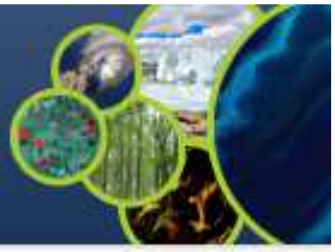
3. Additional comments welcome on:
   - Organisation of dedicated CEOS Carbon Workshop (across WGs and VCs) first one Q2-Q3 2017 – then every 2 yrs
   - GEO Carbon and GHG Initiative engagement and involvement with other external stakeholders (e.g. IG3IS)

Engagement with UNFCCC and IPCC

- IPCC Task Force on National Greenhouse Gas Inventories (TFI) developed “2006 IPCC Guidelines for National Greenhouse Gas Inventories” which will be updated and released in 2019.
  - The current guidelines 2006 indicates that each country preferably use independent data to verify GHG inventories, and also indicates that satellite data has limitations in spatial, vertical and temporal resolution.
  - Discussion for updating the guidelines is underway and its outline was defined at the IPCC plenary in October. Update of verification guidance is expected, expecially the guidance with atmospheric measurement and new datasets.

    Republic of Korea, supported by Belgium and Japan, proposed to include direct measurement of GHG emissions from sources, noting that they help to improve accuracy of estimates.

Short & Longterm Implications for WGClimate



- This activity in WGClimate will demonstrate a cross-cutting use of Gap Analysis output
  - Linked to activity with WGISS on data discoverability and portal

- Constellation paper from ACC will provide a “marcoscale” space segement analysis we can intercompare (future) records with

- In the longer term WGClimate needs to do some soul-searching on the relationship with the CEOS Carbon Strartegy as at some point the question will come back to us…