Task CL-09-03c

Global Monitoring of Greenhouse Gases (GHG) from Space

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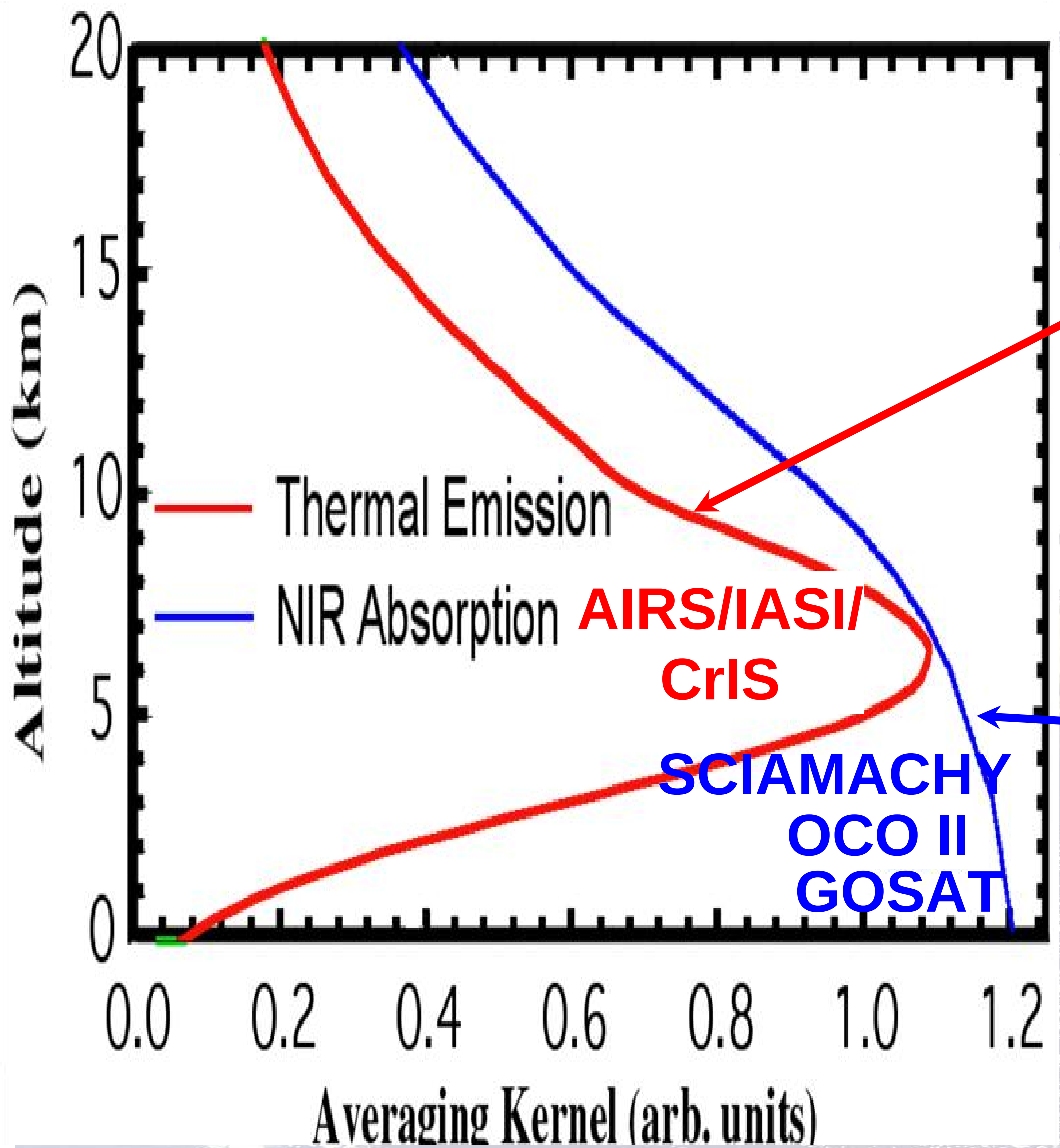
Global Monitoring of GHG from Space - Scope

CL-09-03c task's objectives

- Foster use of space-based GHG observations
- Generate data requirements for the next GHG monitoring missions.
- Create an international group with *CEOS ACC constellation* and Carbon Cycle CoP for the end-to-end utilization of space-based GHG data
- Validate GHG data products against ground-based systems existing observations and products to date from other satellites, aircrafts, and surface-based instruments (in-situ and total column)

New observing capabilities for GHGs



- Thermal instruments (e.g., AIRS, IASI, CrIS) measure mid-tropospheric column
  - Peak of vertical weighting is a function of T profile and water profile and ozone profile.
  - Age of air is on the order of weeks or months.
  - Significant horizontal and vertical displacements of the trace gases from the sources and sinks.
- Solar/Passive instruments (e.g., SCIAMACHY, OCO II, GOSAT) & laser approaches measure a lower troposphere weighted total column average.
  - Mixture of surface and near-surface atmospheric contribution
  - Age of air varies vertically.

Activities and Progress (1/2)

- **Foster the use of space-based GHG observations and consolidate data requirements for the next generation GHG monitoring missions**
  - **Requirements for space missions in GEO Carbon Strategy Report** (GEO-VI Plenary)
  - **CEOS Space Agencies will respond to the Requirements when finalized.**
  - **GEO Carbon CoP will implement a plan for an Integrated Carbon Observation program.**

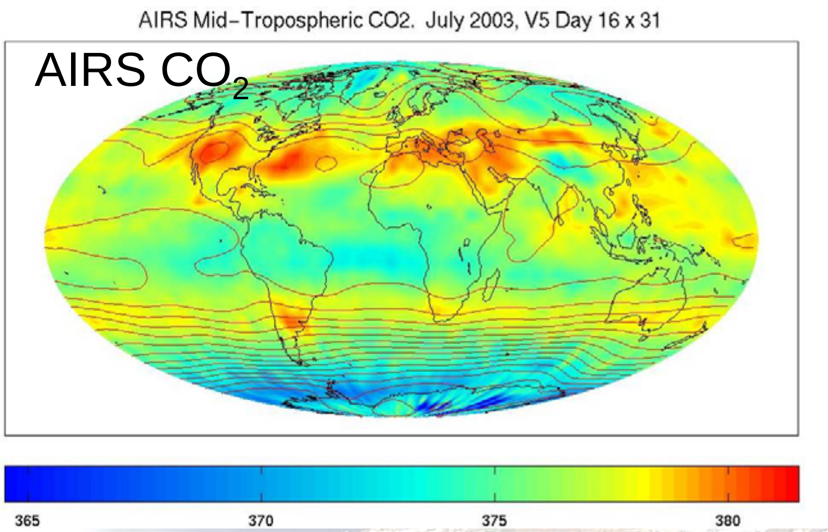
- **The Integrated Global Carbon Observing System is designed to support 2 major products used by policy makers in implementing carbon policy.**
  1. establishment of a robust and transparent carbon tracking system
  2. establishment of accurate carbon budgets at different scales.

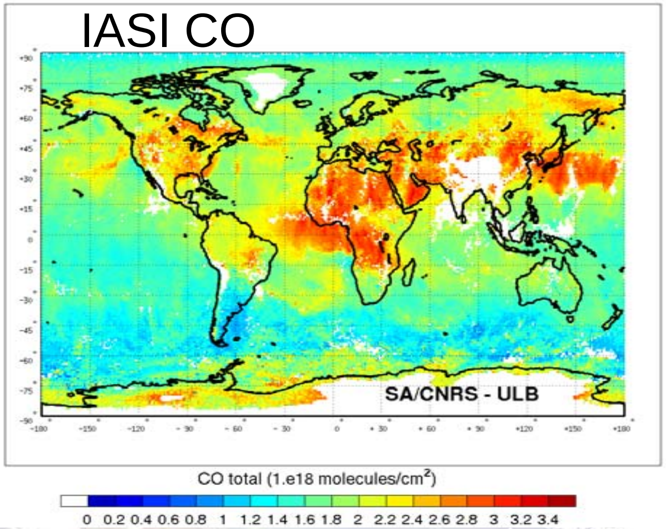
- **Gap analysis on the monitoring of CO_2 from space completed** (see related slides)

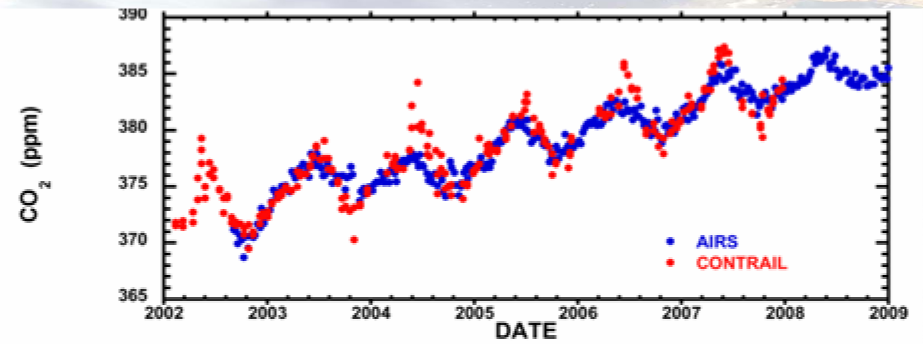
Activities and Progress (2/2)

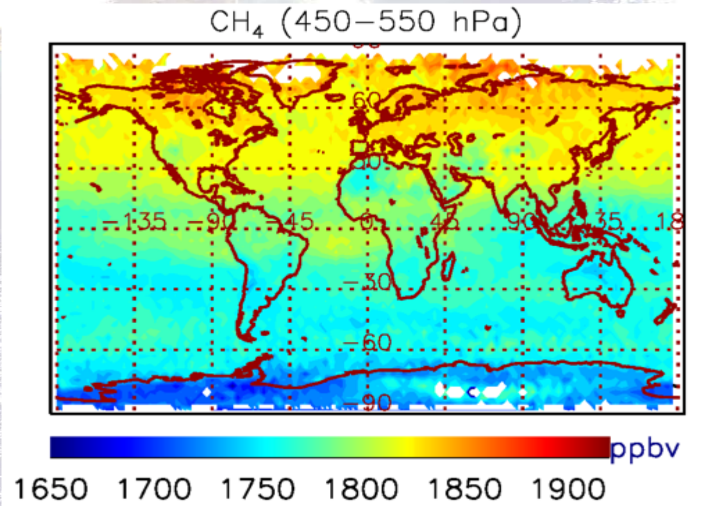
- Implement an easy access to GHG satellite observations and harmonise the next generation of GHG satellite observations.
  - addressed partly in GEO Carbon Strategy Report
  - develop “Carbon from Space web portal “
- Comparison and potential integration of GOSAT GHG products with mid tropospheric AIRS and IASI GHG products
  - On-going
- on collaboration with CEOS ACC (*Atmospheric Composition*) constellation including creation of a GHG constellation group.
  - On-going discussion

AIRS and IASI









AIRS Methane

Excellent agreement of AIRS CO2 with

JAL aircraft direct flask measurement

Relation to other "Carbon Tasks" (CL-09-03)

- "GHG Monitoring from Space" is closely linked to CL-09-03a (Integrated Global Carbon Observations (IGCO)) and CL-09-03b (Forest Carbon Tracking).

- a Carbon Task Force established to ensure the necessary coordination and integration of outcomes of these tasks
  - Members coming from 3 GEO "carbon tasks teams" and Carbon CoP
  - "GEO Carbon Showcase " for GEO ministerial summit based on the "A Global Carbon Tracking System " proposed by GEO Carbon CoP. Shall include the 3 GEO "Carbon Tasks"

- **.. And potential relation to other GEO Tasks** (from GEO WP):
  - Key related Tasks in other SBAs include:
    - DI-09-03 (Warning Systems for Disasters),
    - EN-07-02 (Energy Environmental Impact Monitoring),
    - EN-07-03 (Energy Policy Planning),
    - EC-09-01 (Ecosystem Observation and Monitoring Network),
    - EC-09-02 (Ecosystem Vulnerability to Global Change)

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Events in 2009

- CEOS SIT23, launch Carbon Task Force, 3-5 March 2009, Florida
- GEO Carbon Task Workshop, 20-21 May 2009, Canberra
- CEOS SIT24, 1st Carbon Task Force, 9-11 September 2009, Darmstadt
- GEO Carbon CoP kick-off, 14 September 2009, Jena
- IAF Plenary event (climate day) , 14 October 2009, Daejeon
- GEO Plenary & Carbon CoP side meeting, 14 November 2009, Washington D.C.
- IGOS Symposium , 15 November 2009, Washington D.C.
- 23rd CEOS Plenary, 2-4 November 2009, Phuket
- COP-15 side event, 7-18 December 2009, Copenhagen
  - >> CEOS Contribution to Greenhouse Gas Observations (Organized by EUMETSAT)

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Events in 2010

- APRSAF-16, 26-29 January 2010, Bangkok
- GEOSS-AP4, 10-12 March 2010, Bali
- CEOS ACC ,30-01 March 2010, Montreal
- CEOS SIT25 & 3rd Carbon Task Force, 12-14 April 2010, Tokyo
- GEO Work Plan Symposium, 17-19 May, Pretoria
- Carbon from Space Workshop & ACC, 6-8 September 2010, Oxford
- CEOS Plenary, 13-15 October 2010, Rio de Janeiro
- GEO –VII Plenary & GEO Ministerial Summit , 3-5 November 2010, Beijing
- COP-16 side event, 29-10 December 2010, Mexico

CO_2 Gap Analysis

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What are the Detailed Requirements ?

Profile or Column Atmosphere Layer	Application	Source	Accuracy (ppmv)			Δx (km)			Δz (km)			Repeat Cycle (h)		
			thresh	break	obj	thresh	break	obj	thresh	break	obj	thresh	break	obj
CO_2 Profile Lower Troposphere Weighted Columns	Chemistry	WMO	19	12	8	500	150	50	4	2	1	24	12	6
	Climate	GCOS	8	5	4	500	70	10	2	1	0.5	12	6	3
	Composition & Climate	EUMETSAT	19	12	8	250	50	10	5	2	0.5	24	12	6
CO_2 Profile Higher Troposphere Weighted Columns	Climate	GCOS	8	5	4	250	100	50	2	1.5	1	6	4	3
	Composition & Climate	EUMETSAT	19	12	8	250	50	10	5	2	0.5	24	12	6
CO_2 Profile Lower Stratosphere	Climate	GCOS	8	5	4	500	350	250	4	2	1	6	4	3
	Composition & Climate	EUMETSAT	19	12	8	250	100	50	3	2	1	168	24	12

- **GCOS Climate requirements are the most restrictive. For example, objectives of 4-ppm accuracy, 10-km spatial resolution and 3-hour repeat cycle are required in the lower troposphere.**

Source: WMO GOS Dossier Volume-5 compiled for WMO by B. Bizzarri.

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What are the Detailed Mission Capabilities ?

Detailed mission capability information is not currently available in the MIM or Systems Databases so this step requires extensive web searches. Hopefully, in the future this level of detail will exist in the databases so this process can be automated.

Mission	Instrument	Resolutions: Spatial Sample Δx (km)	Resolutions: Spatial Swath (km)	Resolutions: Vertical Δz (km)	Resolutions: Temporal Repeat Cycle Δt (hrs/days)	Accuracy: Total Troposphere Column
Nadir Absorption, Total Troposphere Columns weighted to the Lower Troposphere						
ENVISAT	SCIAMACHY	30 x 60	960		840 (35 days)	2% (8 ppm)
GOSAT	TANSO-FTS	10.5	790		72 (3 days)	1% (4 ppm)
OCO	OCO Spectrometer	1.3 x 2.25	10		384 (16 days)	0.25% (1 ppm)
ASCENDS	LAS	TBD	TBD		384 (16 days)	0.25% (1 ppm)
Nadir Emission, Total Troposphere Columns weighted to the Mid-Troposphere and Upper-Tropospl						
EOS-AQUA	AIRS / AMSU	13	1620		384 (16 days)	0.4% (1.5 ppm)
EOS-AURA	TES	0.5 x 5.0	50		384 (16 days)	0.3% (1.3 ppm)
Metop (A,B,C)	IASI	12	2052		12 hours	0.5% (2 ppm)
METOP and NOAA	HIRS	10	2240		12 hours	1% (4 ppm)
FY-3 (C,D,E,F,G)	IRAS	17	952		12 hours	0.5% (2 ppm)
NPOESS (1,3,4)	CrIS	14	2200		12 hours	0.5% (2 ppm)
Limb Viewing, Stratosphere Profiles						
SCISAT-1	ACE-FTS	500		3	annual	2.5% (10 ppm)
ENVISAT	SCIAMACHY	960		3	840 (35 days)	1% (4 ppm)
SCISAT-2	ACE-FTS	500		3	annual	2.5% (10 ppm)
ENVISAT	MIPAS	300		3	840 (35 days)	0.7% (3 ppm)
PREMIER	IMIPAS	300		3	840 (35 days)	0.7% (3 ppm)

Which Missions Meet the Requirements ?

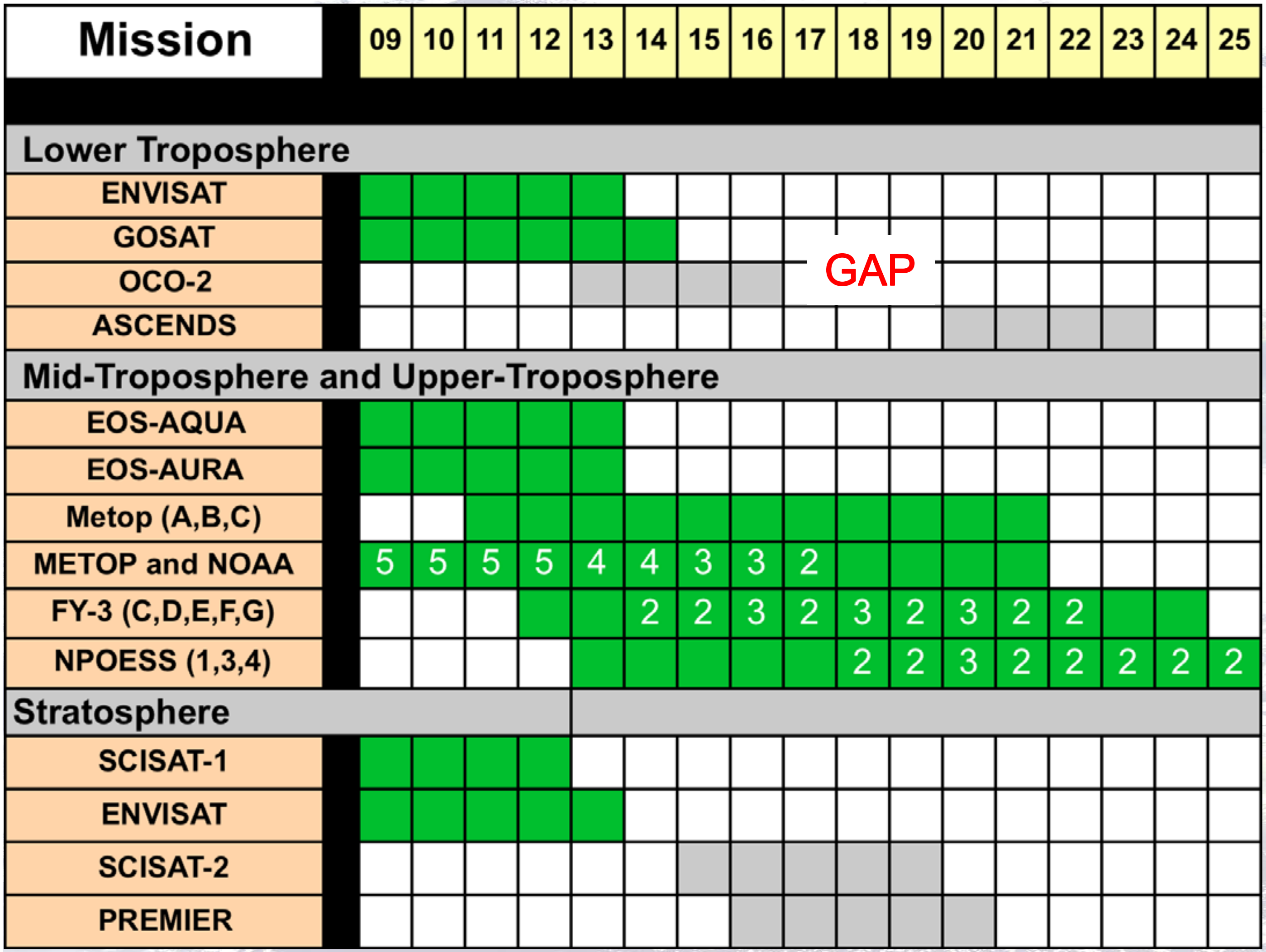
Mission	Instruments	Accuracy	Spatial	Temporal	Vertical
		Requirements Summary			
Lower Troposphere					
ENVISAT	SCIAMACHY				
GOSAT	TANSO-FTS				
OCO-2	OCO Spectrometer				
ASCENDS	LAS				
Mid-Troposphere and Upper-Troposphere					
EOS-AQUA	AIRS / AMSU				
EOS-AURA	TES				
Metop (A,B,C)	IASI				
METOP and NOAA	HIRS				
FY-3 (C,D,E,F,G)	IRAS				
NPOESS (1,3,4)	CrIS				
Stratosphere					
SCISAT-1	ACE-FTS				
ENVISAT	SCIAMACHY				
SCISAT-2	ACE-FTS				
ENVISAT	MIPAS				
PREMIER	IMIPAS				

Meets Some or All Objectives (maximum)
Meets Some or All Threshold Requirements (minimum)
DOES NOT MEET REQUIREMENTS

Largest issue is temporal sampling (repeat cycle) near the surface ...

Limited LEO missions do not allow adequate sampling to achieve desired threshold requirement of 24-hr (one-day) repeat cycle. GOSAT is best at 3-days due to its wide (790-km) crosstrack scanning capability, but it does not make constant measurements across the swath width.

Detailed Timeline Analysis



Detailed timeline analysis takes into consideration the instrument type and atmospheric layer.

Largest issue is the potential time gap beyond OCO-2.

It is unlikely that ENVISAT and GOSAT will last beyond 2015. OCO-2 has fuel for 8-years (till 2020). ASCENDS is uncertain for a 2020 launch and may be later.

OCO-2 may be the only near-surface CO_2 mission in 2015 with limited repeat cycle (16 days) and spatial coverage (swath width 10-km).

Gap Analysis Results

- Atmospheric CO_2 measurements in the lower troposphere (near surface), critical for measuring sources and sinks, have a time gap beyond 2016.

- Temporal sampling (repeat cycle) requirements are not met for all lower troposphere missions and most mid-troposphere missions.
    - GCOS threshold requirements are 12 hours (lower trop) and 6 hours (middle trop), which requires multiple coordinated LEO satellites with wide swath capabilities.

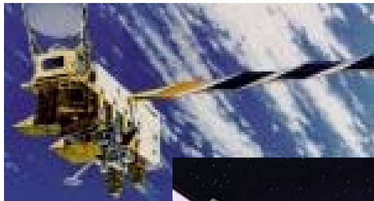
- Accuracy requirements (< 4-ppm) are met for all middle-troposphere instruments and most lower-troposphere instruments (exception is SCIAMACHY). Most future low-troposphere instruments expect ~1-ppm accuracy, which will significantly improve our knowledge of sources and sinks.

Potential Solutions to the Atmospheric CO_2 Gap Analysis

- **Extend existing missions**: Utilize the full mission capacity of ENVISAT and GOSAT to make total column CO_2 measurements in the lower troposphere at least until OCO or ASCENDS are launched.
- **Future mission lifetimes**: Consider designing future space missions with more capacity for extended operations beyond 10 or 15-years. Many existing missions, designed for 3 to 5 years, have lasted much longer and provided significant contributions.
- **Adjust new missions**: Optimize time overlap of current and future missions by adjusting launch schedules or adjusting orbits to maximize coverage or sampling.
- **Add new missions**: Consider the design and approval of new CEOS missions focused on near-surface (lower troposphere) atmospheric CO_2 measurements with a direct benefit to studies of sources and sinks and transport. The current plans only include NASA's OCO-2 and ASCENDS.
- **Add new instrument capabilities:** Consider adding CO_2 channels to existing instruments for incremental increases in cost or complexity.
- **Constellations**: Consider a long-term plan utilizing multiple satellites to maximize data acquisition and secure the required data for science and policy-makers.

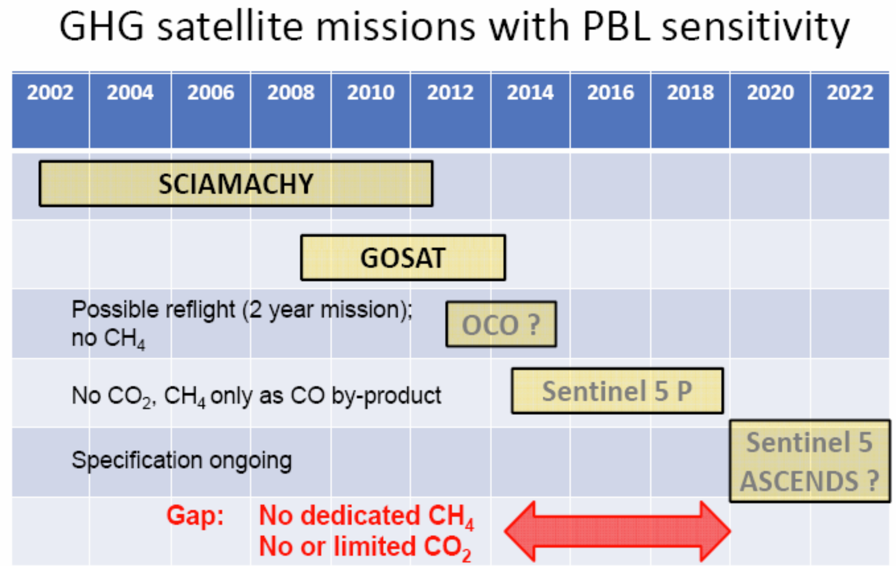
Greenhouse Gases Monitoring from Space
- Current and future prospects -

Aqua AIRS



EnviSat SCIAMACHY

Metop IASI



GOSAT

CH4	MICROCAR...	CarbonSat

Methane as observed by SCIAMACHY (WFMDv1.0)


Landfills

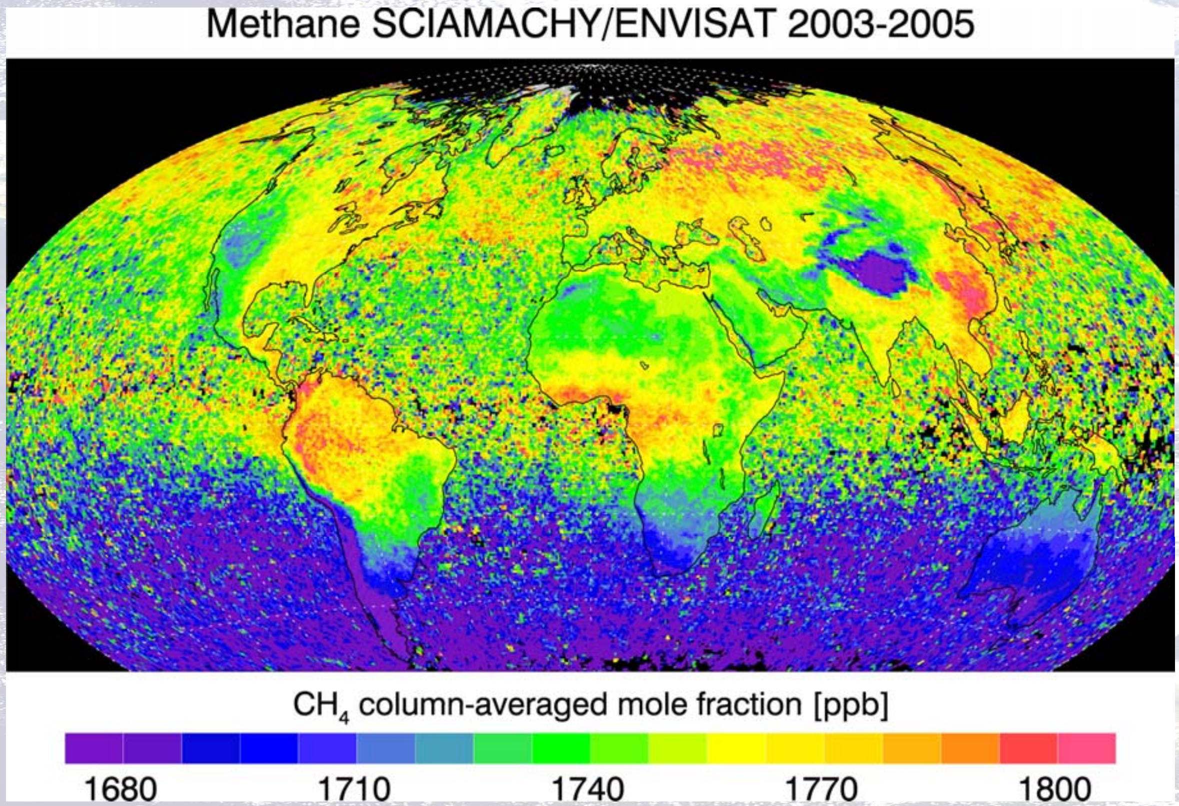

Coal mining


Wetlands


Rice

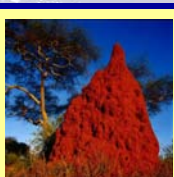

Ruminants


Wastewater




Energy

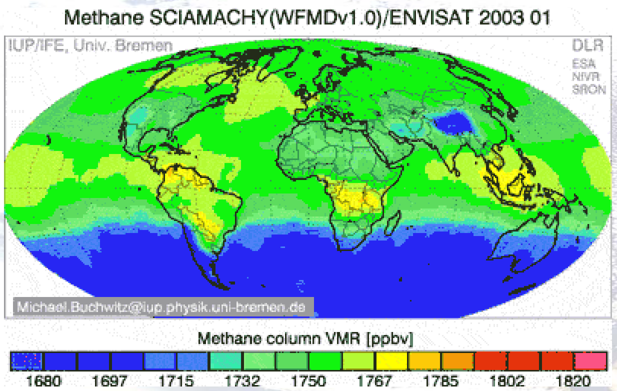

Natural gas


Termites


Hydrates

Thank you …

Questions ?



Global distribution of methane

Dr. Michael Buchwitz and Oliver Schneising from the Institute of Environmental Physics (IUP) at the University of Bremen in Germany produced the animation using Envisat SCIAMACHY observations from 2003 to 2005.

Credits: IUP/IFE, Univ. Bremen

Global distribution of carbon dioxide (CO2)

Dr. Michael Buchwitz and Oliver Schneising from the Institute of Environmental Physics (IUP) at the University of Bremen in Germany produced the animation using Envisat SCIAMACHY observations from 2003 to 2005.

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