CNES ACTIVITIES & PROJECTS ON GHG

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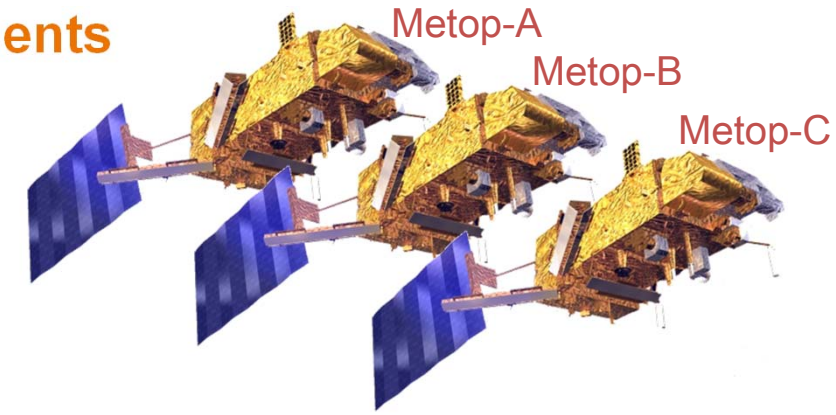
SOMMAIRE

- IASI PROGRAM & RESULTS FOR CH4 & CO2
- MERLIN PROJECT
- MICROCARB STUDY

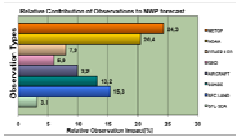
THE IASI STORY..

CNES developed TIR sounder instruments for Eumetsat

- IASI 1 (2006-now) & IASI 2 (2012-now)
- IASI 3 to be launched with metop-C (2018)

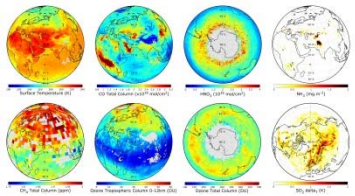


Weather prediction



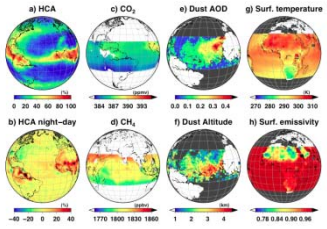
Global NWP, LAM, mesoscale models

Atmospheric composition



More than 20 species detected, some well quantified (O_3, CO, CH_4), some only detected (SO_2, HNO_3, NH_3, formic acid, methanol) in special situations (fires, volcanoes)

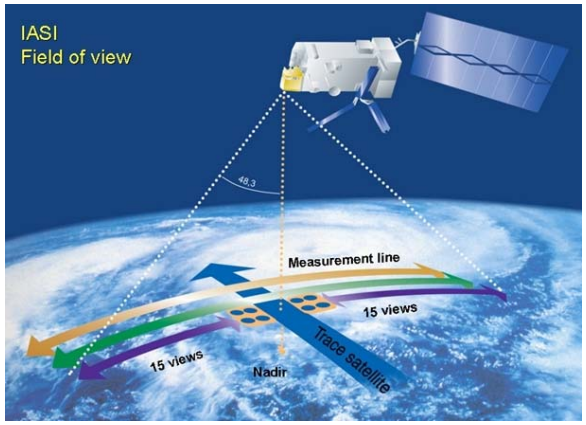
Climate



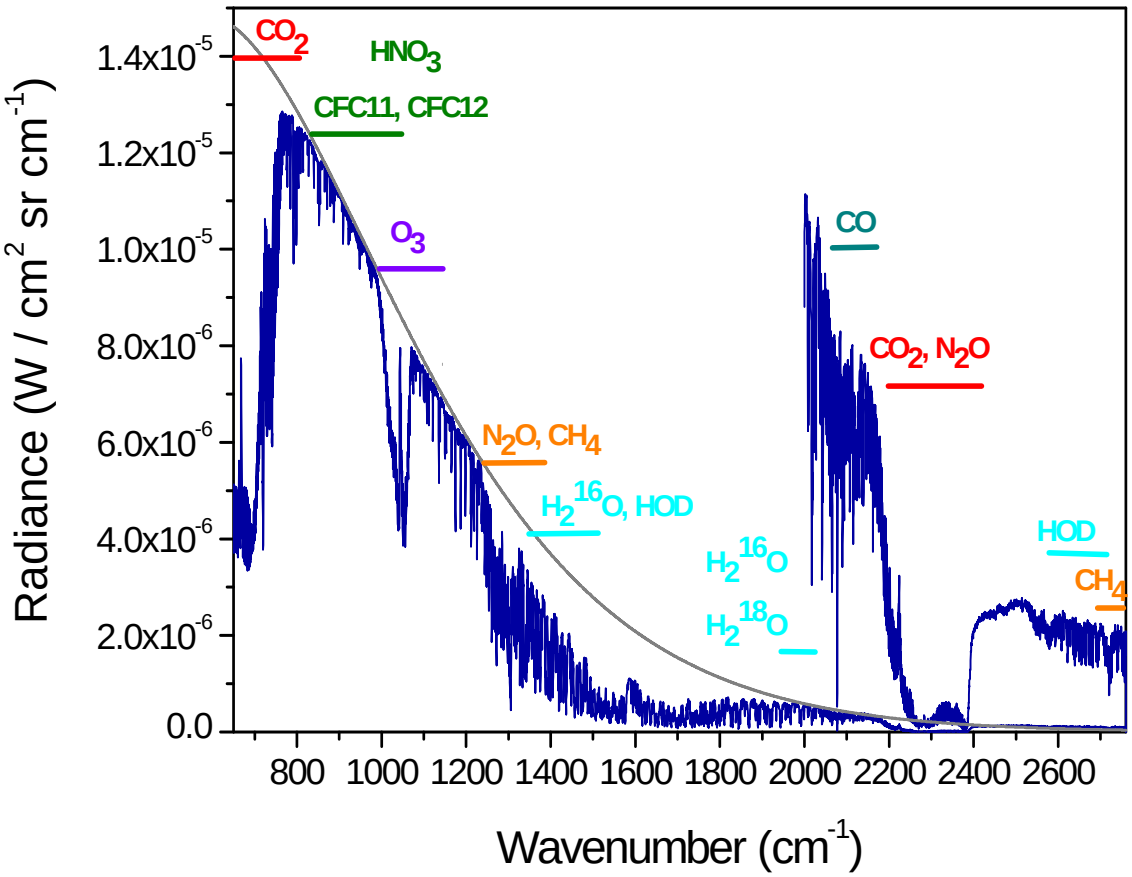
- Essential Climate Variables: T, WV, GHG, Surface characteristics, Clouds, Aerosols.
- Reference for the GSICS.

THE IASI STORY..

Broad spectral coverage (645-2760 cm^{-1} without gaps) → simultaneous sounding of many trace gases
Pixel : 12km diameter

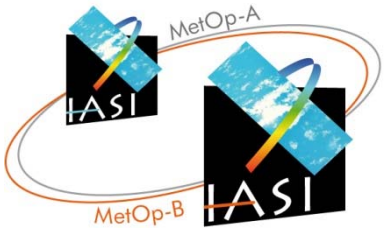


SA/CNRS – ULB



⊕ Thermal + reflected solar radiation during daytime → possible improvements on the retrieval performances for CH_4 and HDO

THE IASI STORY..



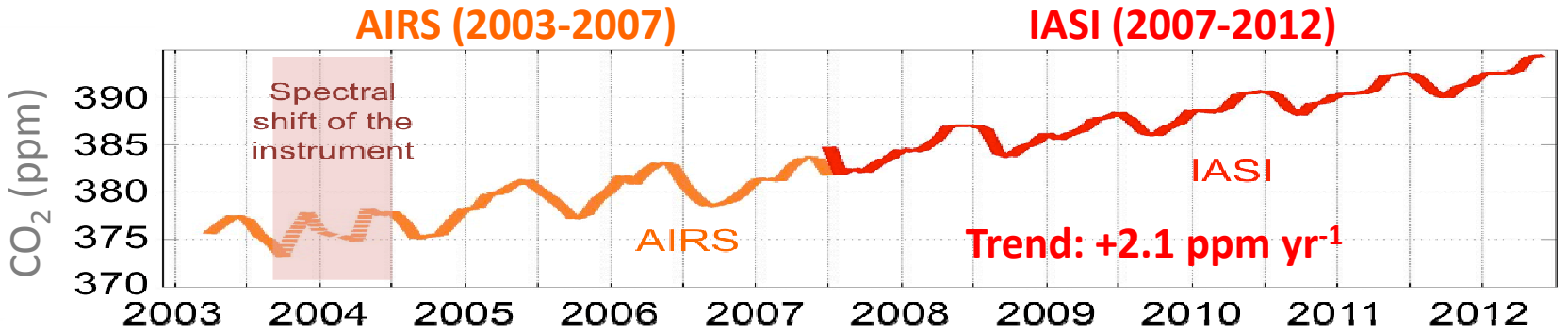
Cyril Crevoisier, Cathy Clerbaux, Vincent Guidard, Thierry Phulpin,
Raymond Armante, Brice Barret, Claude Camy-Peyret,
Jean-Pierre Chaboureau, Gaelle Dufour, Juliette Hadji-Lazaro,
Hervé Herbin, Nicole Jacquinet, Lydie Lavanant, Sébastien Payan,
Eric Péquignot, Clémence Piérangelo, Didier Renaut, Claudia Stubenrauch

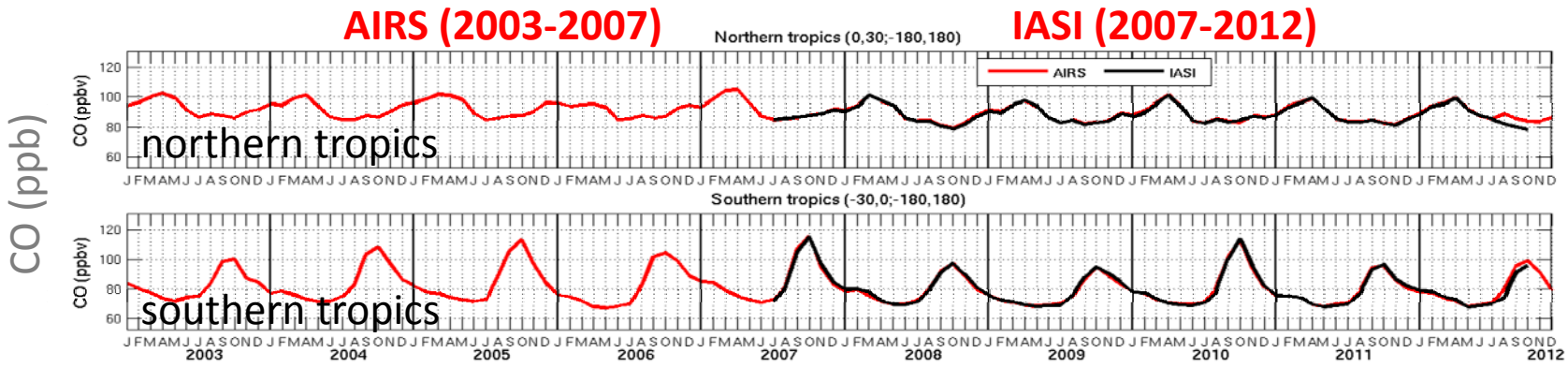
Greenhouse gases: CO_2 and CH_4 and CO

Objective: to better understand surface sources and sinks of greenhouse gases and the related processes (transport, flux).

IASI contribution: mid-tropospheric columns of CO_2, CH_4 and CO over both land and sea, day and night.

Methods: non linear inference scheme for CO_2 and CH_4 and spectral double differential approach for CO.

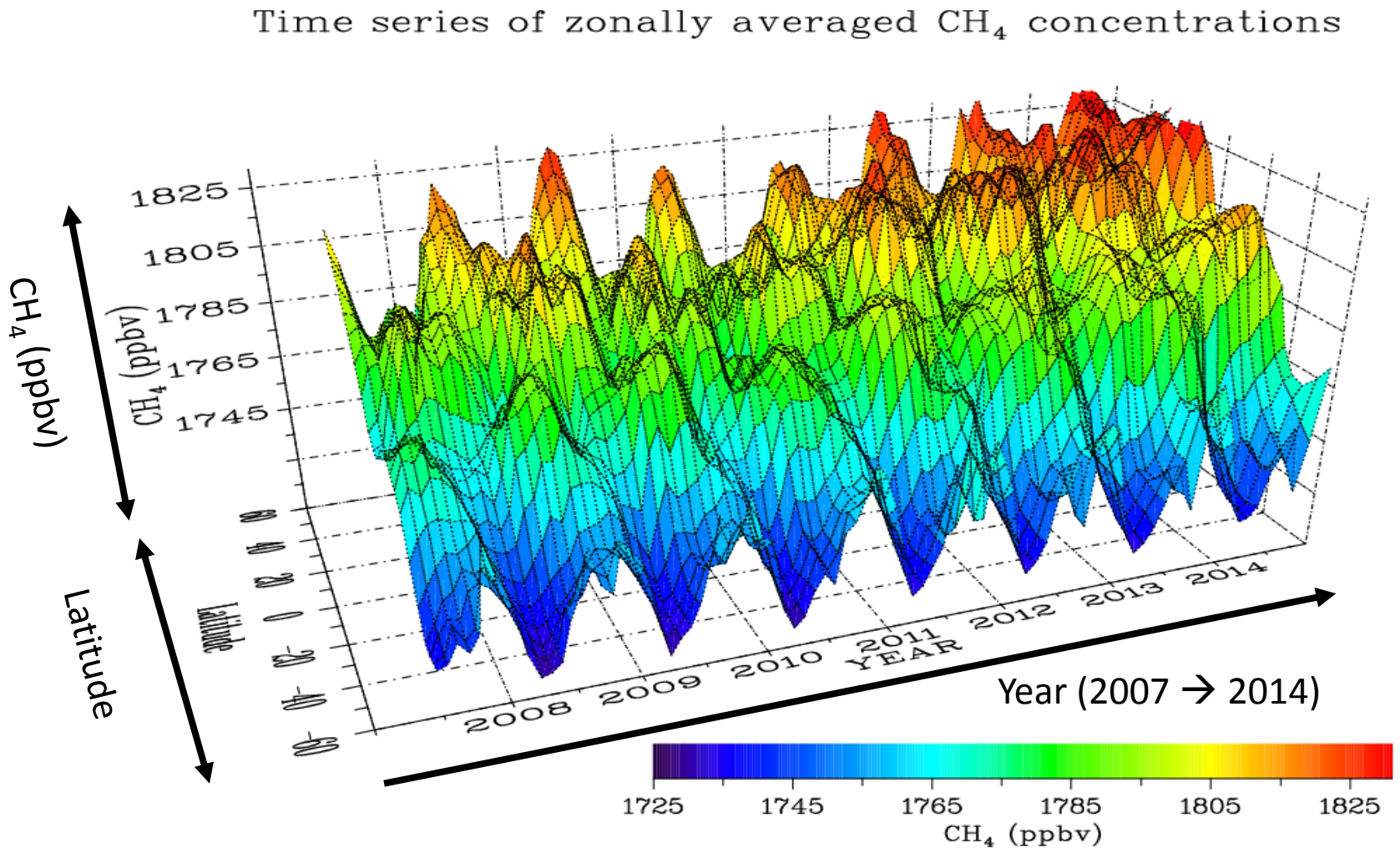




Chédin et al., 2003; Crevoisier et al., GRL, 2004; ACP 2009; ACP 2012; Thonat et al., AMT, 2013

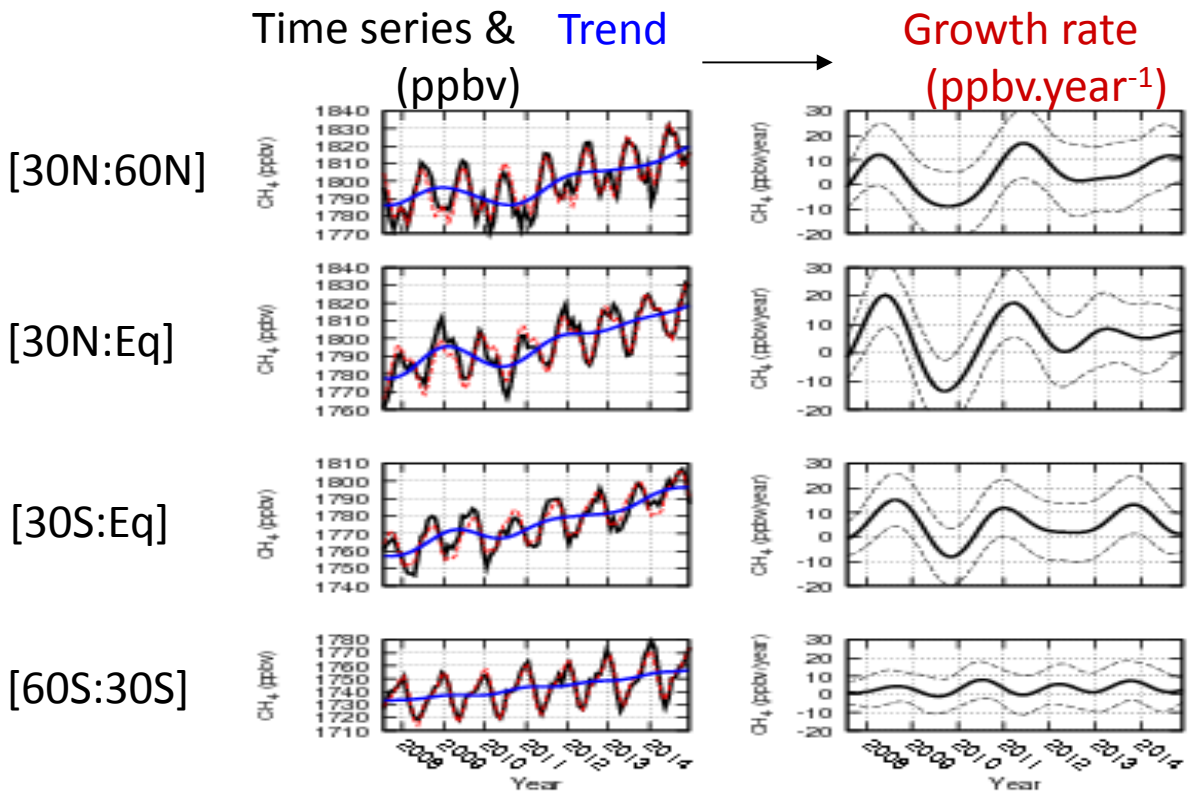
Greenhouse gases: CO_2 and CH_4 and CO

CH_4 flying carpet



Greenhouse gases: CO_2 and CH_4 and CO

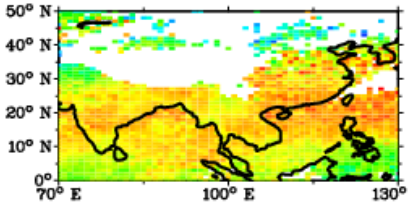
Long-term variations of CH_4



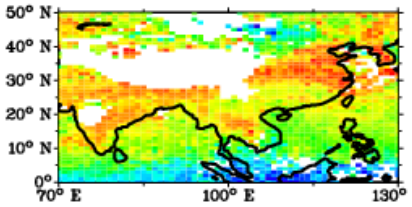
Latitude band	Averaged growth rate (ppbv.year-1) IASI	surface stations	increase of CH_4 (ppbv) (Jul 2007-Dec 2014)
[60N:30N]	4.54 +/- 7.15	4.90 +/- 3.96	~ 33
[30N:Eq]	5.49 +/- 8.46	6.52 +/ 2.90	~ 41
[30S:Eq]	5.31 +/- 5.92	5.53 +/ 4.25	~ 39
[60S:30S]	3.12 +/- 2.42	5.37+/- 2.28	~ 23

IASI mid-tropospheric column of CH_4 over Asia

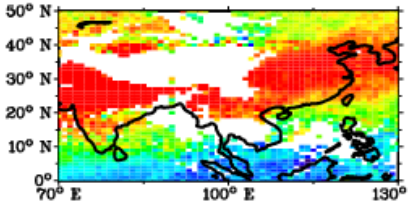
JFM



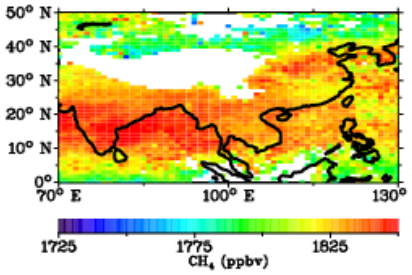
AMJ



JAS



OND



- Strong emission of CH_4 by rice paddies in summer.
- Rapid uplift to the mid-troposphere due to monsoon convection.
- Then Southward transport towards Indonesia.

Although IASI is sensitive to mid-troposphere, it does provide information on surface fluxes.

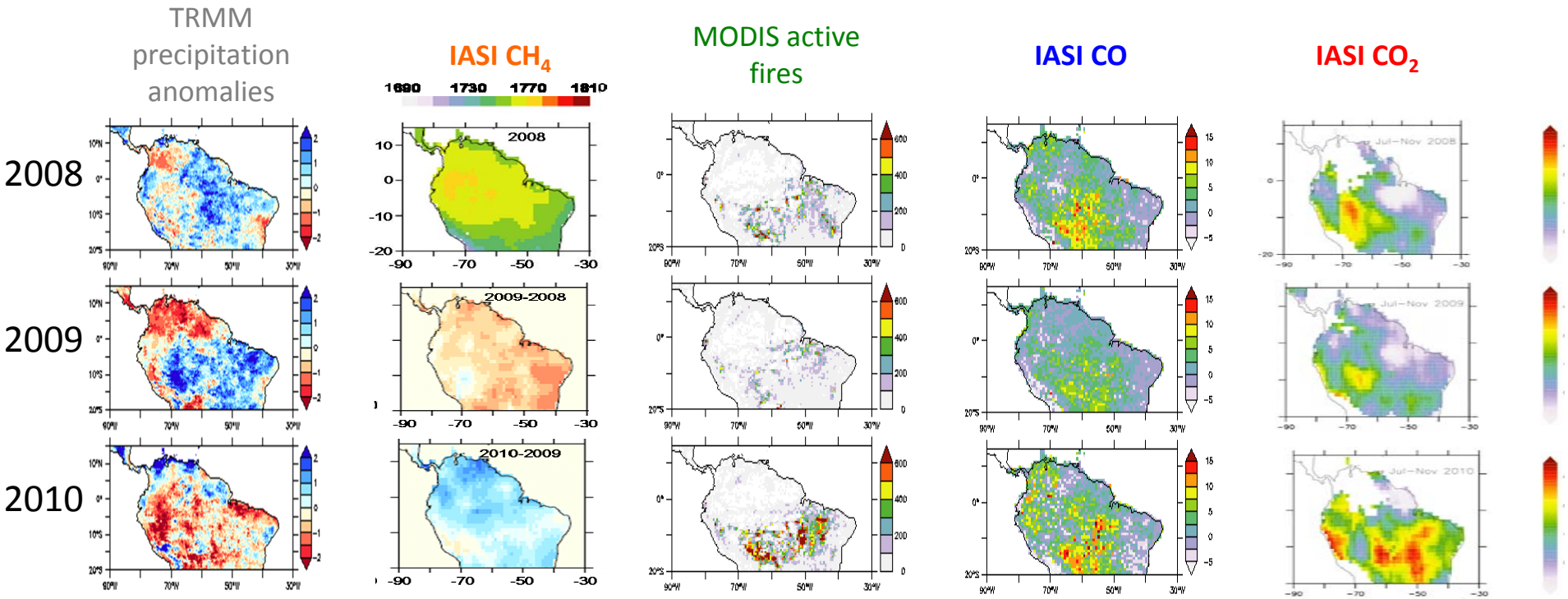
- Use of LSCE Bayesian 'inversion' system of surface fluxes.

→ Good statistical consistency between CH_4 flux estimates from surface network, GOSAT and IASI.

Cressot et al., ACP, 2014

Multi-species study of 2009 Amazonian drought

Severe drought from mid-2009 to the end of 2010 originating from the combination of El Niño conditions during the wet season followed by a warming of the tropical North Atlantic during the dry season .



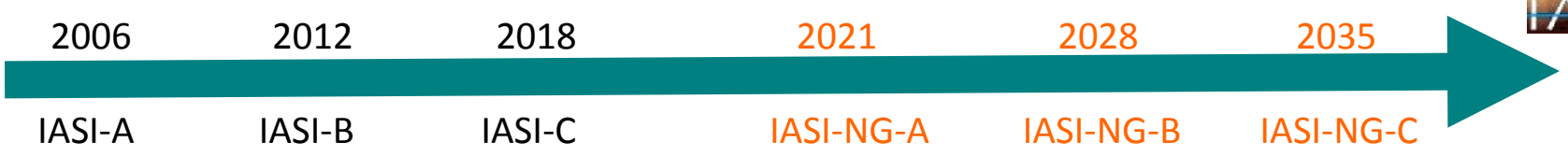
→ Decrease of CH_4 seen by IASI in 2010: due to decrease of wetland emission

→ Increase of fires seen by MODIS (especially over the arc of deforestation).

→ Increase of **CO** and **CO_2** due to fire emissions.

IASI multi-species observation allows the characterisation of regional climate events.

The IASI-NG mission



- **Objectives of the mission:**
  - To assure the continuity of IASI for NWP, atmospheric chemistry and climate applications.
  - To improve the characterization of the lower part of the troposphere, the UT/LS region and, more generally, of the full atmospheric column.
  - To improve the precision of the retrievals and to allow the detection of new species.

  ➡ **Solution**: Improvement of spectral resolution and radiometric noise.

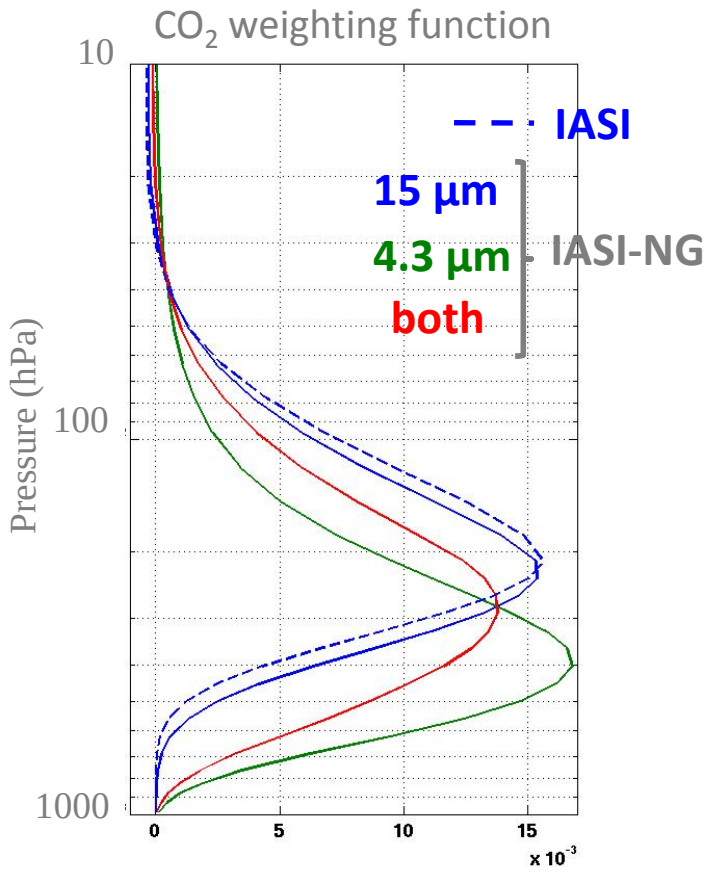
- **IASI-NG Characteristics**:
  - -spectral coverage: 645 - 2760 cm^{-1} (*similar to IASI*).
  - -spectral resolution: 0.25 cm^{-1} after apodisation (*0.50 cm^{-1} for IASI*)
  - -spectral sampling: 0.125 cm^{-1} (*0.25 cm^{-1} for IASI*).
  - -reduction of the radiometric noise by at least a factor of ~2 as compared to IASI.
  - -spatial sampling: 12km FOV.

IASI-NG: Mid-tropospheric columns of CO_2 and CH_4

Carbon dioxide

Spectral bands for IASI-NG	Improvement of the CO_2 precision
15 µm	30 %
4.3 µm	0 %
15 + 4.3 µm	45 %

•IASI-NG will enable the use of 4.3 µm channels, giving access to a lower part of the atmosphere, with a much improved precision.



Methane

Spectral bands for IASI-NG	Improvement of the precision
7.7 µm	44 %

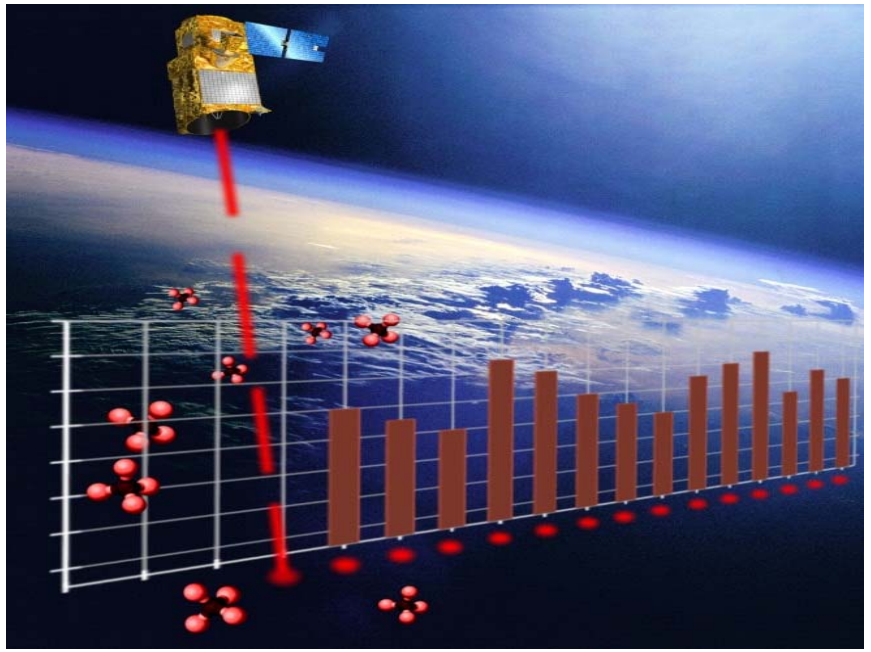
•Less interference with water vapor lines.

•Strong and needed complementarity with SWIR obs. (UVNS/Sentinel5?).

•Still relies on synergy (synchronized observation) with MWS!

MERLIN: A lidar for CH4

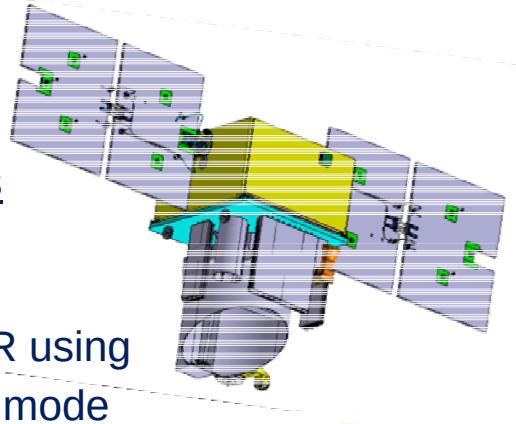
- CNES-DLR cooperation initiated after COP15 (dec2009)
- More than 9 labs in France & Germany (LSCE, LMD, LATMOS, DLR-I, MPI-Jena, U Bremen, ..)
- Now in Phase B. C/D should start in 2016 for a launch in 2019.



Scientific objectives

- ✦to improve the understanding of the CH4 exchanges at the surface
  - » Identification and monitoring of the global carbon sources and sinks
- ✦And Assess how these exchanges may be impacted by the climate change

MERLIN FACTS

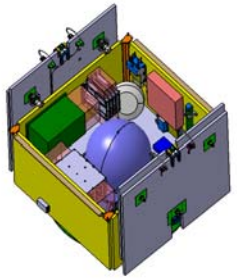


- Low Earth orbit satellite for global methane column measurements

- Measurement principle:

  Integrated Path Differential Absorption (IPDA) LIDAR in the near IR using pulsed laser transmitter and range-gated receiver in nadir-viewing mode

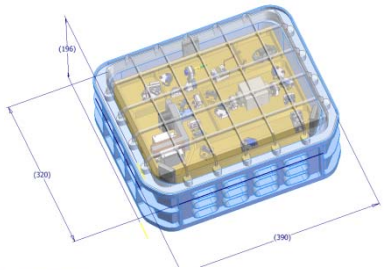
  - ✓ First space-borne system



- Franco-German cooperation (CNES & DLR Space Administration):

  MYRIADE Evolutions platform, satellite operation, launch, F part of payload ground segment

  IPDA LIDAR system, G part of payload ground segment



- Main data product:

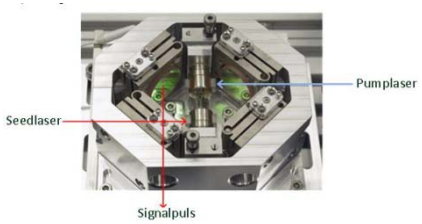
  Column-weighted dry-air mixing ratios of methane, over satellite sub-track.

- Satellite class:

  Small satellite (CNES MYRIADE Evolutions platform)

- Launch date: 2019 (3 years mission)

- Mission status: Phase B



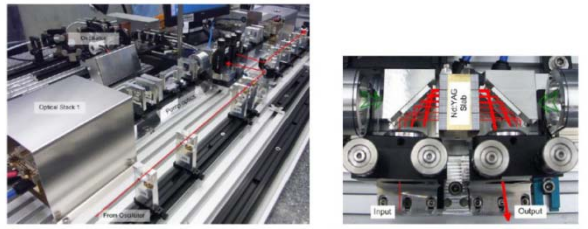
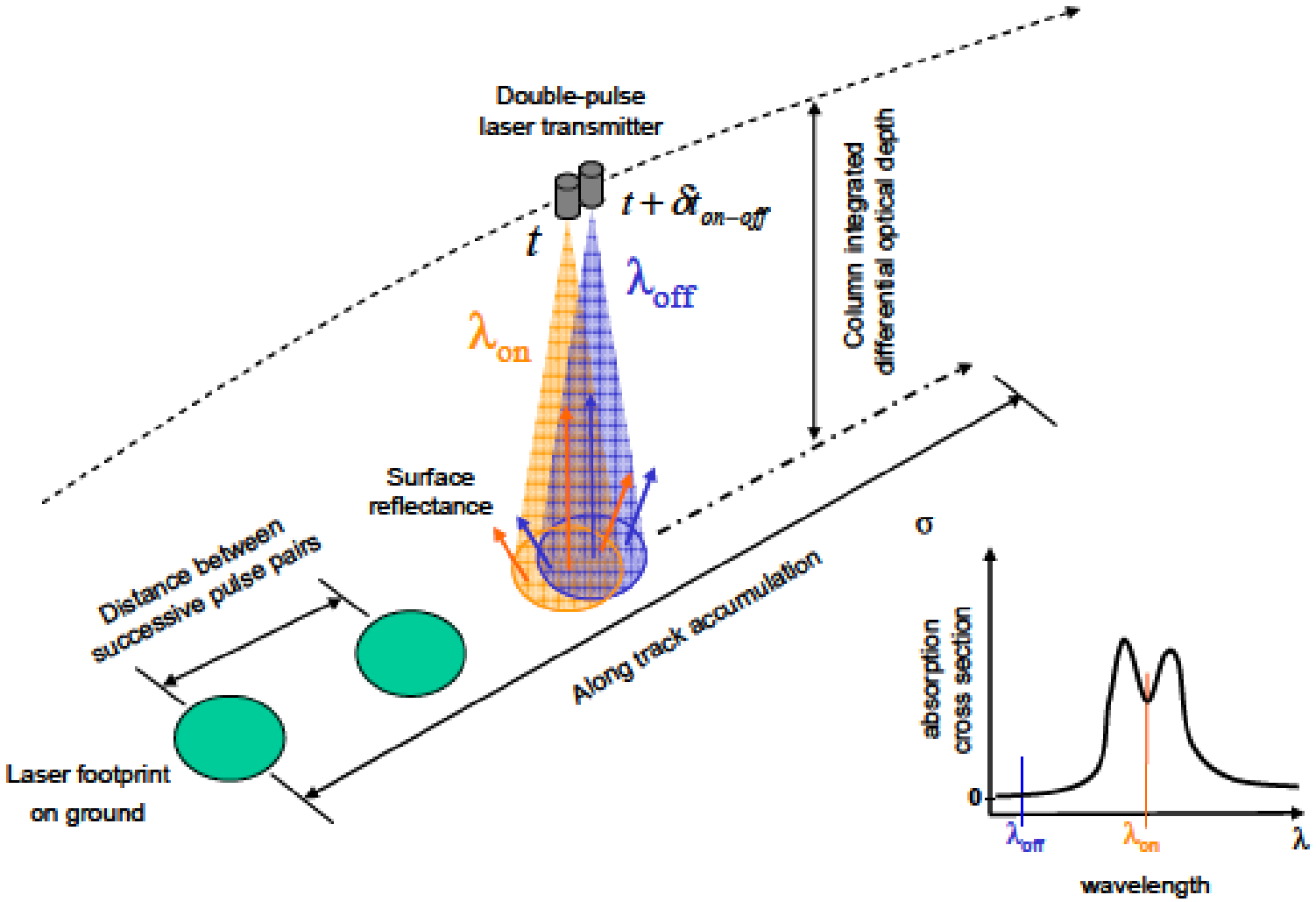


Figure 10: Laboratory setup amplifier with oscillator in the background (left), close-up of the slab with folding path (right)

Measurement Method: Integrated-Path Differential Absorption (IPDA) Lidar



MERLIN specifications

	Threshold	Breakthrough	Target
Precision	36 ppb 2 %	18 ppb 1 %	8 ppb 0.5 %
Systematic error	3 ppb	2ppb	1 ppb
Horizontal sampling Accumulation	50 km	50 km	50 km
Objectives	Large wetland fluxes, inter-hemisphere gradients, seasonal and annual budgets on continental scale	Seasonal and annual budgets on country-scale resolves country-scale gradients	Highest Methane flux estimate quality (set by sampling error and model accuracy where any further measurement accuracy would not give better flux estimates) Kyoto protocol like monitoring

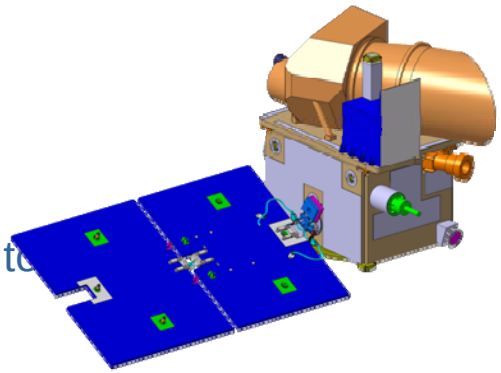
Microcarb- Phase A

Scientific objectives

- Measure CO2 column with precision less than 1ppm
- to improve the understanding of the CO2 exchanges at the surface
  - » Quantification of CO2 surface fluxes at regional scales (500 km)²
  - » Identification and monitoring of the global carbon sources and sinks
- And Assess how these exchanges may be impacted by the climate change

Concept and requirements

- Grating spectometer on a micro satellite
- 3 bands (O2, CO2), Foot print 25km2, swath 15 km, SNR 200 t



Status

- Conclusion of Phase A with vey positive feedback:
  - Instrument compact (less than 60 kg)
  - Quick development (could be launched in 2020)
  - Compatible with microsatellte (Myriade)
- Still in discussion for a possible phase B. No decision for now.

MICROCARB SPECIFICATIONS

Masse	< 57kg	
Consommation	< 61 W	
Débit TM moyen	< 5 Mbits/s	
Refroidissement	Passif	
Résolution spatiale	6 x 5 km²	
Détecteur 1	Silicium CCD	
Détecteur 2	HgCdTe NGP Sofradir (développé pour S5)	
Gaz mesurés	D1 **O_2 :0,76 µ** **(pour calcul de la pression de surface et le rapport de mélange d'air sec)**	D2 $O_{2:}$1,26 µ H_2O: 1,32µ **CO_2 :1,6 µ** A Noter présence de raie de CH_4 à 1,7 µ (bonus, pas d'optimisation de l'instrument) **CO_2 :2 µ**
Pouvoir de résolution	25 000	
Fonction de mérite	0,36 (objectif Phase A < 0,40 Compatible des exigences sur mesure concentration CO2 <1 ppm	

Thank you for your attention !