



# FRENCH ACTIVITIES FOR GHG FROM SPACE

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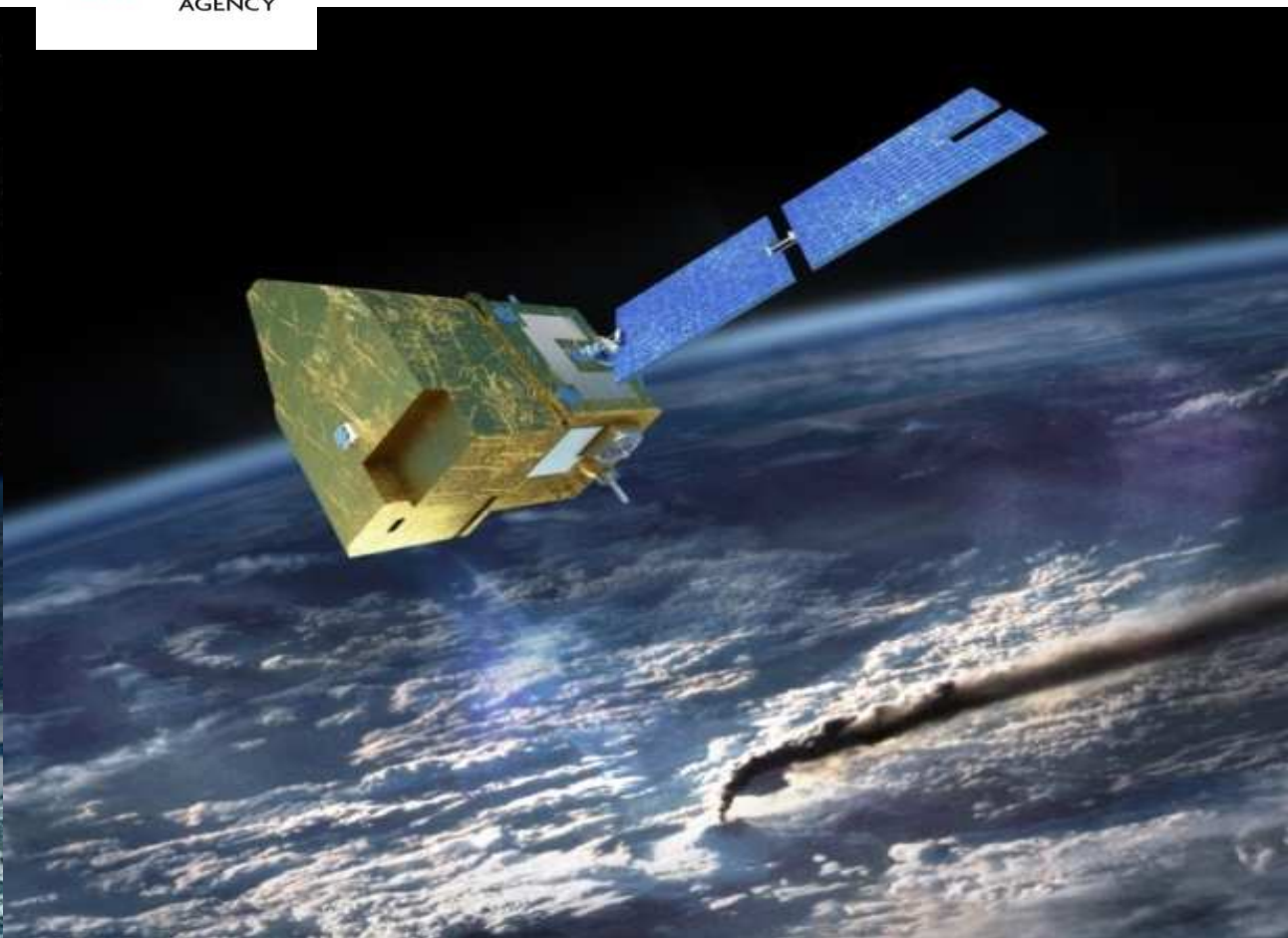
1. state-of-play on GHG missions and plans



**MERLIN FOR METHANE**



**MICROCARB for CO<sub>2</sub>**

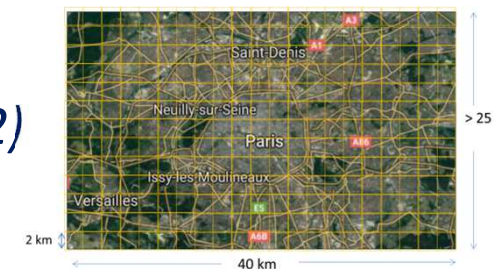
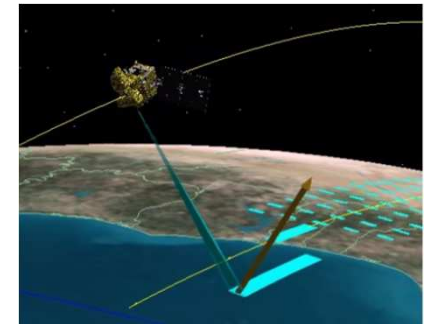


# MICROCARB objectives : CO<sub>2</sub> observations for fluxes



MicroCarb aims to make significant progress in answering the following scientific questions:

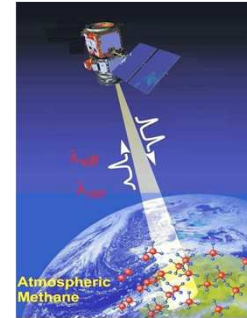
- Where are the main carbon sources and sinks ?
- What are the processes that control these fluxes ?
- What is the contribution of land use change to the net land flux?
- How does the Carbon cycle react to large climate perturbations such as El Niño/La Niña events?
- How will the carbon cycle react to climate change?
- *Demo: Can we estimate cities emissions using smaller pixels (2\*2 km<sup>2</sup>)*



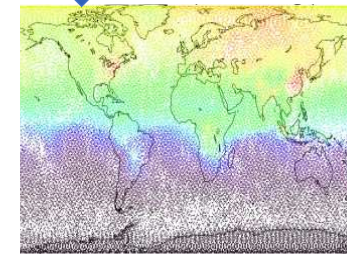
## MERLIN objectives : CH<sub>4</sub> Observations for fluxes



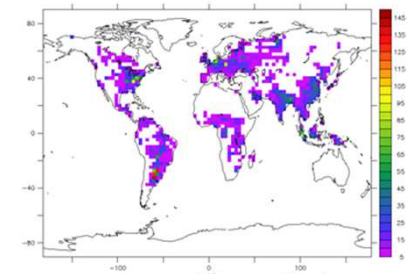
- Derive a Global Methane budget and contribute to reconcile top-down and bottom-up approaches using a new active mission which offer :
  - lower biases (<3ppb) than passive instruments (auto-calibrated)
  - day and night ( no sunlight needed)
  - At all latitudes (including high latitudes)
  - For all seasons
- It will open a new dimension of the space observation of greenhouse gases from space.



Columns



Fluxes



# Global methane budget 2003-2012 (TgCH<sub>4</sub>/yr)



## Bottom-up

**184 [40%]**

**192 [15%]**

Rice 35 [10%]  
Enteric ferm & manure 100 [20%]  
Landfills & waste 57 [20%]



**118 [20%]**

Coal 47 [80%]  
Gas & oil 71 [10%]

**35 [30%]**

**185 [90%]**

Fresh waters 99 [100%]  
Wild animals 10 [100%]  
Wild fires 3 [100%]  
Termites 9 [120%]  
Geological 60 [50%]  
Oceans 3 [100%]  
Permafrost 1 [100%]



Process-based budget  
(Bottom-up models & inventories)

**714 TgCH<sub>4</sub>/yr [600-853]**

## Natural wetlands

## Agriculture & waste



## Oil & gas exploitation



## Biomass & biofuel burning

## Other natural emissions



Mean [min max range %]

## Top-down

**176 [80%]**

**197 [64%]**

**115 [50%]**

**26 [54%]**

**54 [150%]**



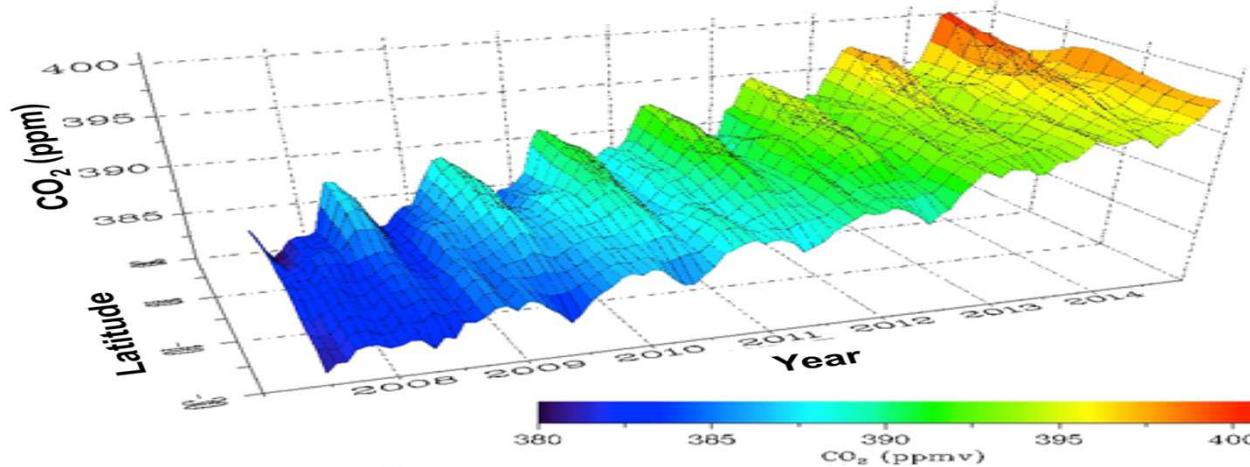
Atmospheric-based budget  
(Top-down inversions)

**568 TgCH<sub>4</sub>/yr [539-609]**

*Saunois et al.*

# And IASI & IASI-NG for GHG constraints and monitoring

Mid-tropospheric CO<sub>2</sub> from IASI/Metop-A  
Monthly evolution over July 2007-December 2014

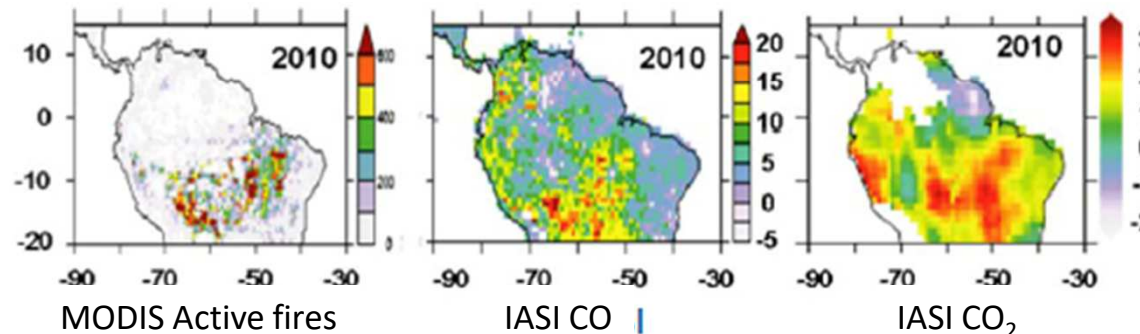


Global and regional variations as observed from space: IASI

Severe drought over Amazonia in 2010

→ Intense fire activities detected by MODIS over the arc of deforestation

→ High atmospheric CO and CO<sub>2</sub> well seen by IASI



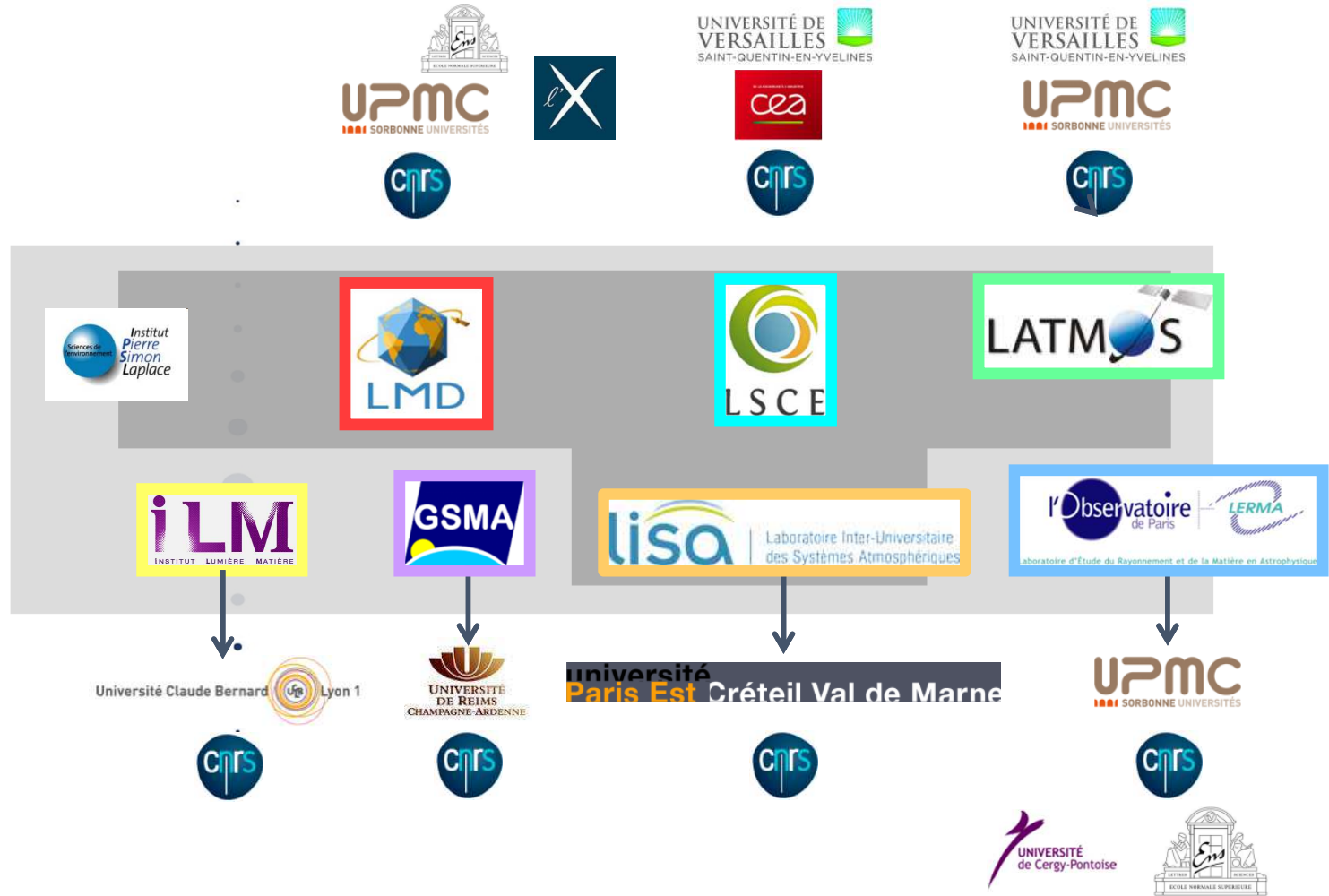
## 2. Ongoing activities with modelling community



CNES support project in French involved Laboratories and few companies

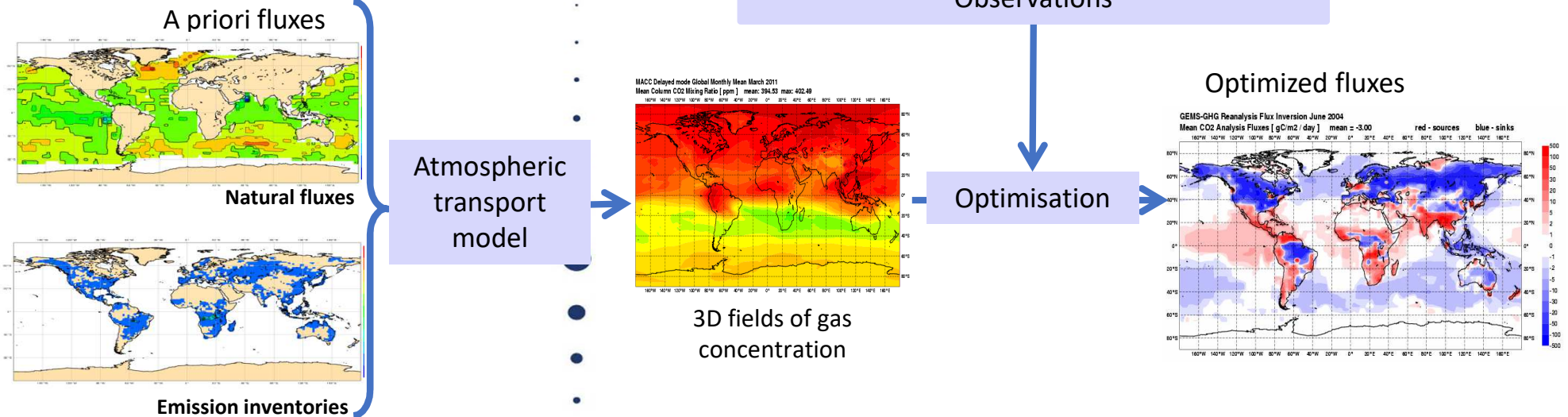
CNES fund PHD and post-doc research

CNES manage coordination with French research organisations



## 2. Ongoing activities with modelling community

- The atmosphere may be used as an integrator of the fluxes, sensitive to both sinks and emissions
- Effective to quantify regional GHG fluxes at global, continental, regional scales



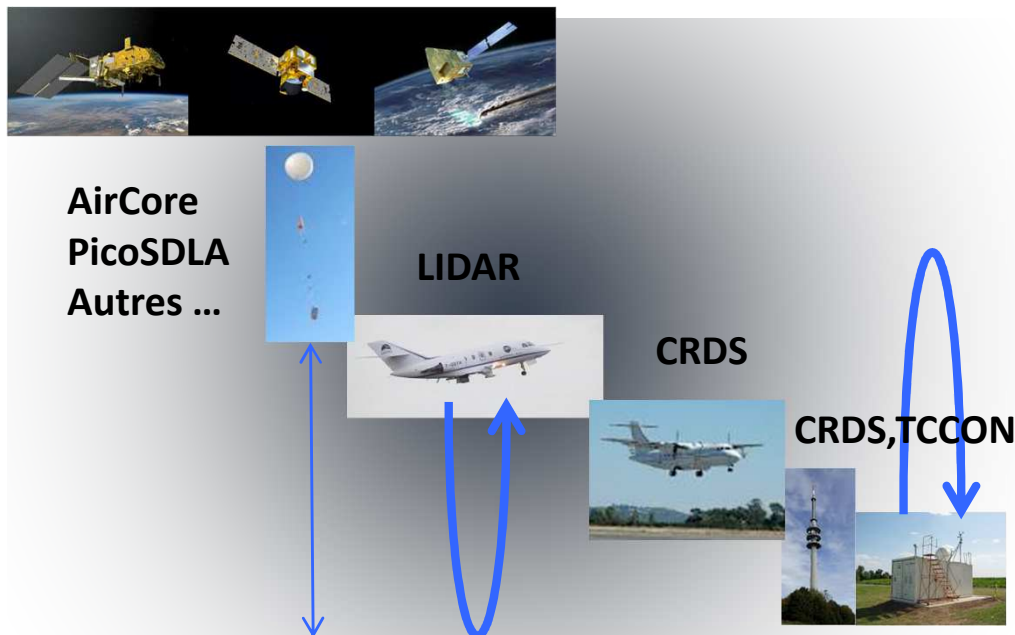
- Tools : LMDz et CHIMERE for atmospheric modeling , ORCHIDEE for Land interface, NEMO-PISCES for OCEAN & PYVAR for fluxes inversion



### 3. Ongoing activities with In-situ community

#### CNES organise and co-fund activities in research labs for Calibration & validation of GHG missions

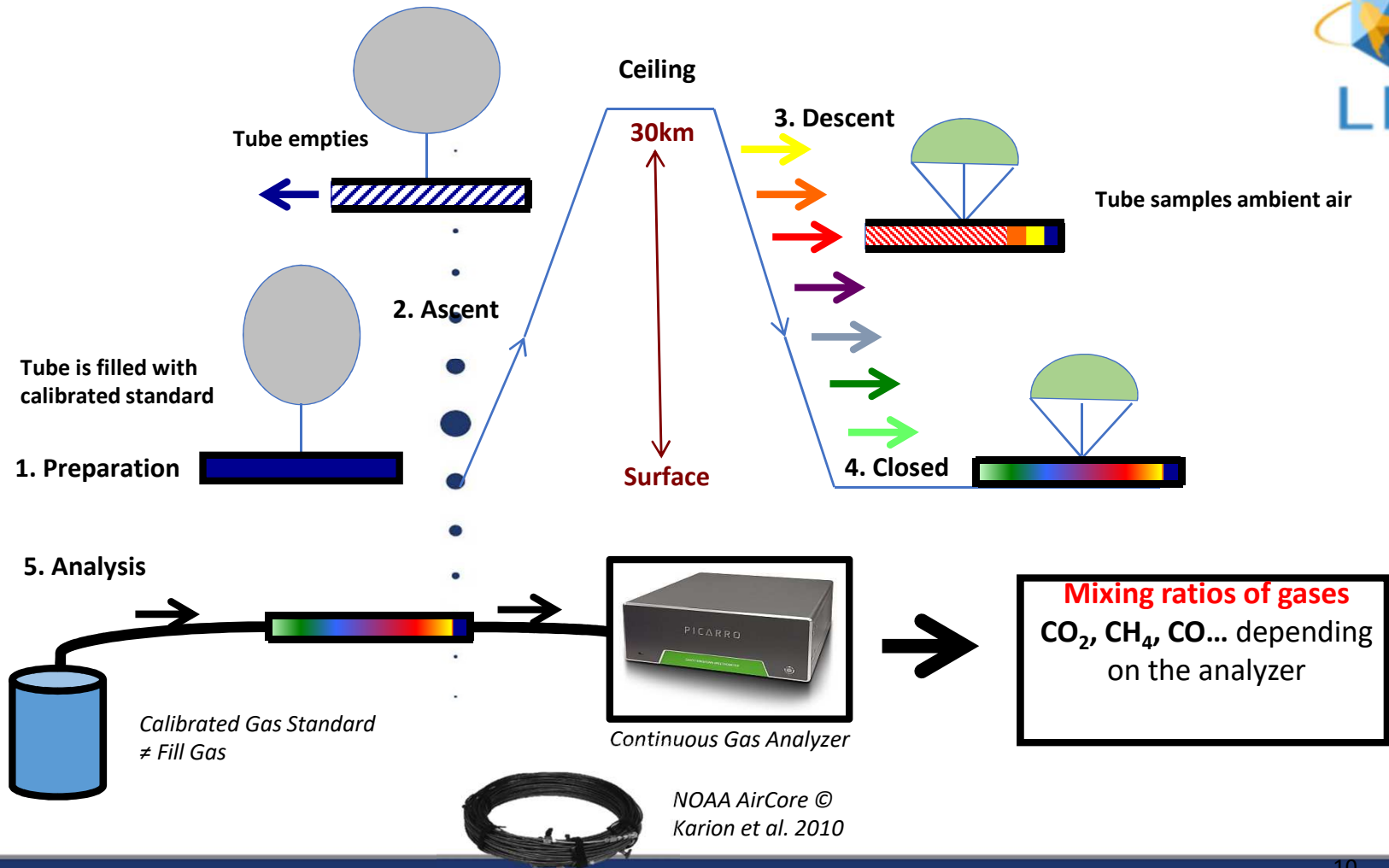
- Ensemble of in-situ and remote-sensed data for GHG, profiles and columns
- Possible synergies between GHG missions for calibrations & validation
- Organisation of campaigns



- Support TCCON & COCON instrumentation development ( Jussieu Site, and ASA, ..)
- Support PICARRO on SAFIRE (aircraft)
- Support ballon instrumentation ( AirCore, SDLA, ..)

# EXAMPLE : AirCore

AirCore = an atmospheric sampling system that allows **greenhouse gas measurements**



# La campagne MAGIC-CoMet (23-25 mai 2018)



## Monitoring of Atmospheric composition and Greenhouse gases through multi-Instruments Campaign

### Objectifs :

- Mieux connaître la répartition verticale des gaz à effet de serre  $\text{CO}_2$  et  $\text{CH}_4$ .
- Préparer les validations des missions Merlin, MicroCarb et IASI-NG.

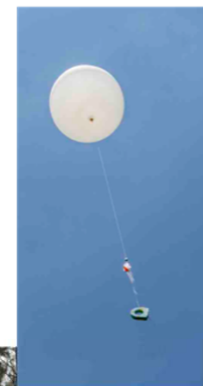
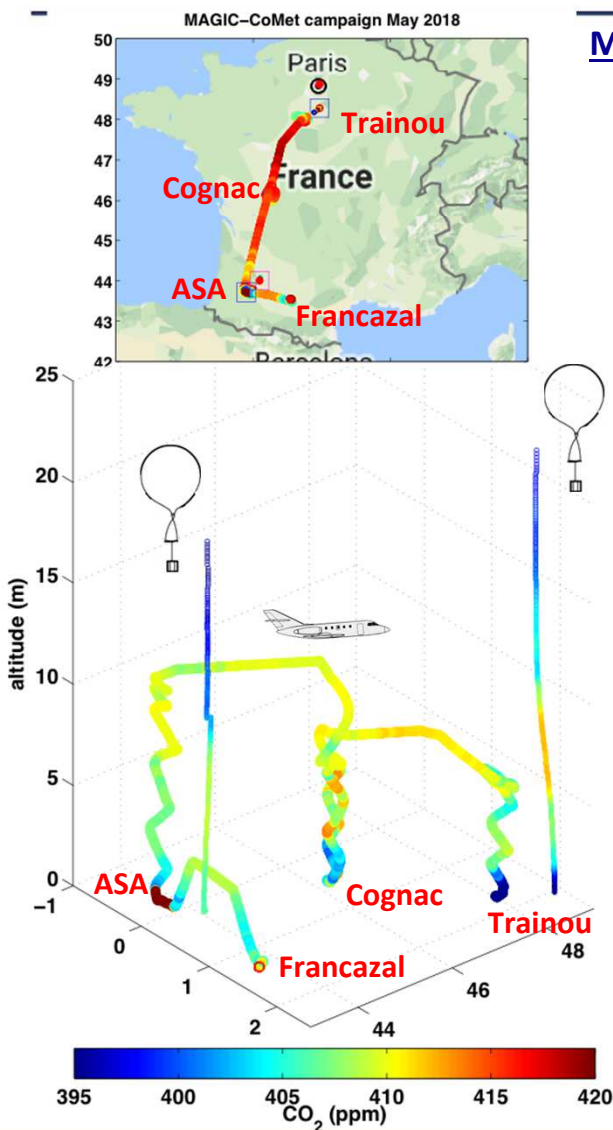
### Une campagne fortement collaborative :

- 40 scientifiques
- 5 laboratoires : LMD, LSCE, GSMA, LOA, LERMA
- Unité SAFIRE
- CNES (Merlin, MicroCarb, IASI-NG, ballons)



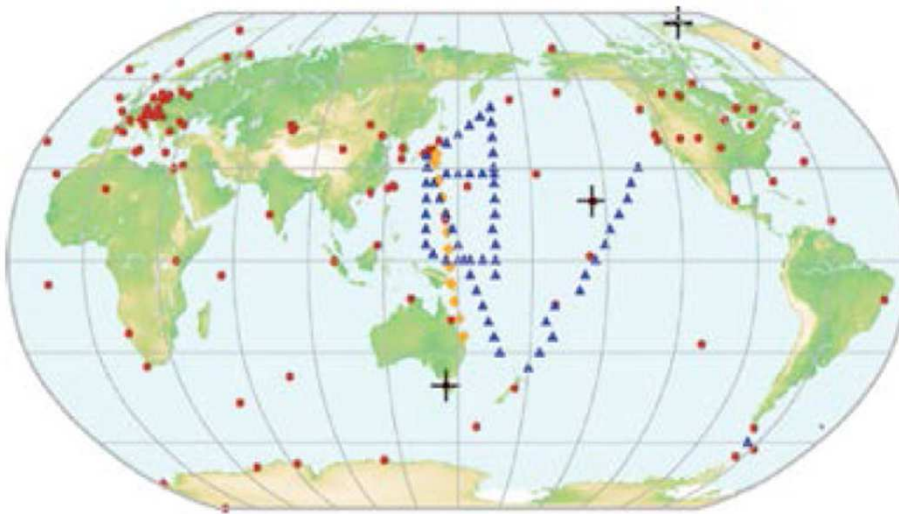
### Une campagne multi-instrumentée :

- 2 avions de recherche : SAFIRE/Falcon20, DLR/HALO
  - 19 lâchers de ballons (AirCore, Amulse, Radiosondages)
  - 4 spectromètres au sol (EM27/sunx2, CHRIS, TCCON)
  - Mesures satellites OCO-2 et IASI
- Mesures coordonnées sur 2 sites : Aire-sur-l'Adour et Trainou



# Atmospheric observations from the ground

- The atmosphere may be used as an integrator of the fluxes, sensitive to both sinks and emissions.
- From ground : atmospheric measurements of CO<sub>2</sub> have started in the 50s. More than 150 stations worldwide now.



● Ground-based   ● Aircraft   ▲ Ship   + GHG comparison sites

## 4. Any existing dialogue with Inventory community



With MicroCarb, socio-economic impact are expected and motivated the extra government funds in France through Future Investment Plan ( and in UK with a business case..)

Some request are made from private sectors to rely scientific missions (like MERLIN) to “private” initiatives like GHG-sat or Bluefield, also MicroCarb with nanosat constellation.. Still in progress..

At institutional level, some contacts just started with Ministry of Environment and in charge of inventory and negotiations to promote use of space data for verification..

Priority is given to research activities..  
All these points are progressing very slowly..



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## 5. Engagement/Involvement at international level (bilateral/multilateral) :

CNES is working in the frame CEOS AC-VC and bilateral MOU (JAXA, NASA, UKSA, DLR) for inter calibration mainly.

## 6. Target/focus of any relevant research funding :

Radiatif transfert, dynamical transport modelisation, adaptation of global and local assimilation schemes, man power and expertise..

Big concern for space agencies is continuity of network like TCCON which are required for calibration (at least for passive missions..)

Big Evolution for space agencies ? Application behind science is highly expected from GHG missions.. How to deal with that ??

Thank You !