Monitoring of Atmospheric composition and Greenhouse gases through multi-Instruments Campaigns

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https://magic.aeris-data.fr/

22 July 2021

Monitoring of Atmospheric composition and Greenhouse gases through multi-Instrument Campaigns

The MAGIC initiative: Established in 2017…

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Two main objectives:

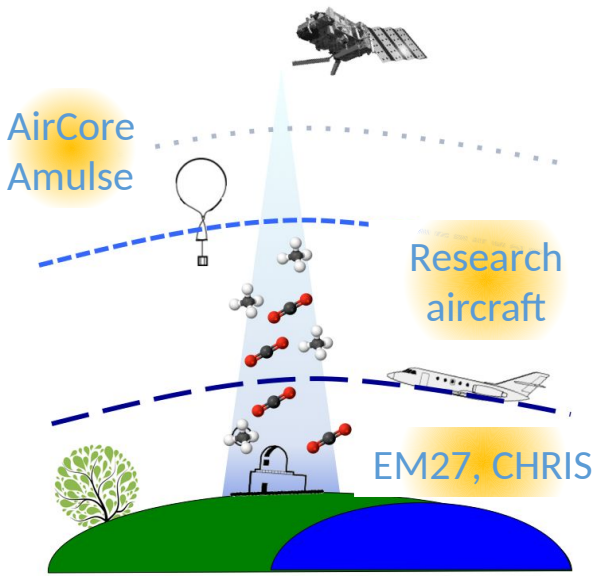
- To better understand atmospheric distribution and emissions of CH_4, CO_2 and related variables
- To validate current space missions (e.g. OCO-2, GOSAT-2, S5P, IASI) and prepare future ones (e.g. Merlin, MicroCarb, IASI-NG)

How?

- By organizing annual campaigns and network measurements and building numerical tools.
- By combining ground-based, airborne (aircraft, balloon) and satellite observations.
- By testing satellite airborne demonstrators.

7 entities involved

Multi-instrument campaigns



Network for vertical profiling

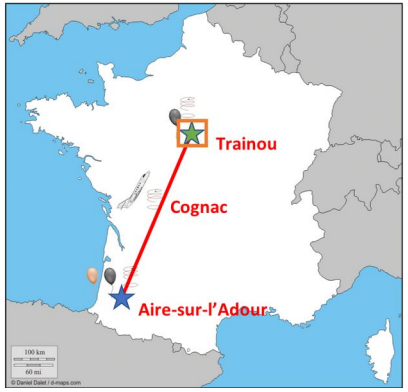
Consortium for total column measurements

Funding:

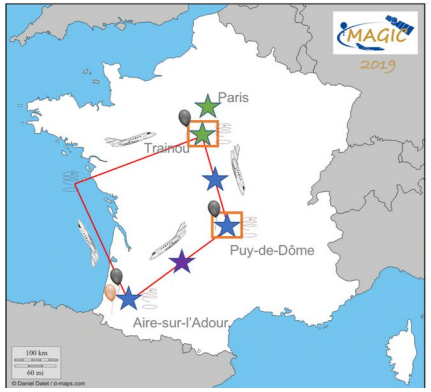
Monitoring of Atmospheric composition and Greenhouse gases through multi-Instrument Campaigns

Already 3 campaigns: May 2018, June 2019, September 2020

MAGIC-CoMet 2018



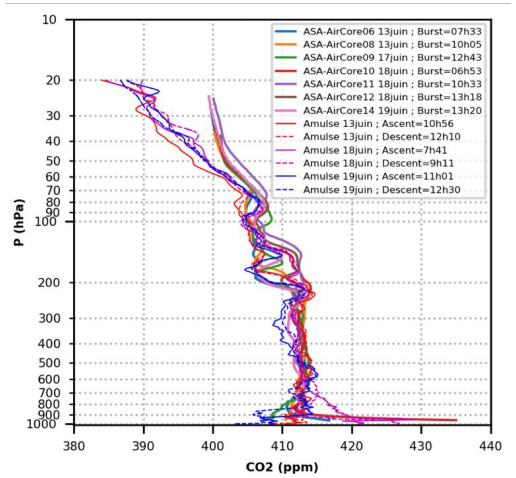
MAGIC 2019

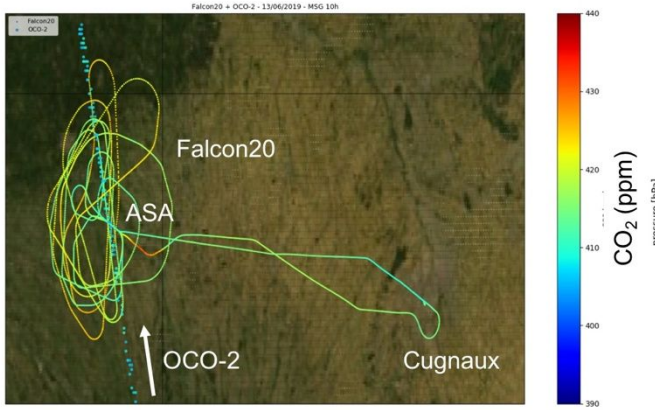


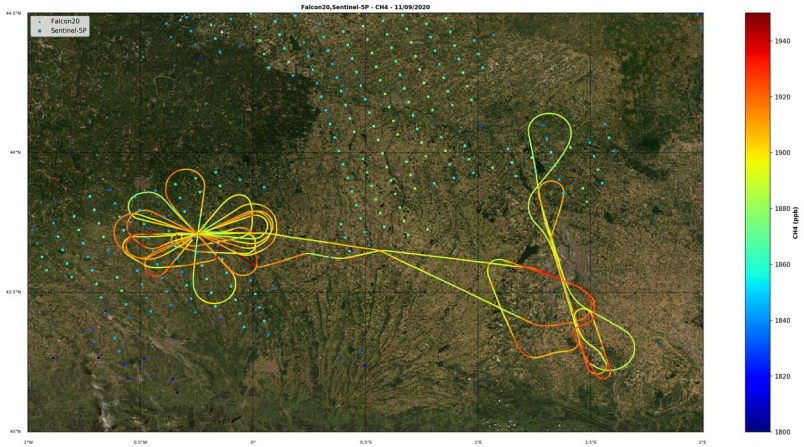
MAGIC 2020

Primary objectives:

- Comparison and validation of various techniques.
- Validation of various space missions: IASI, Sentinel-5P and OCO-2

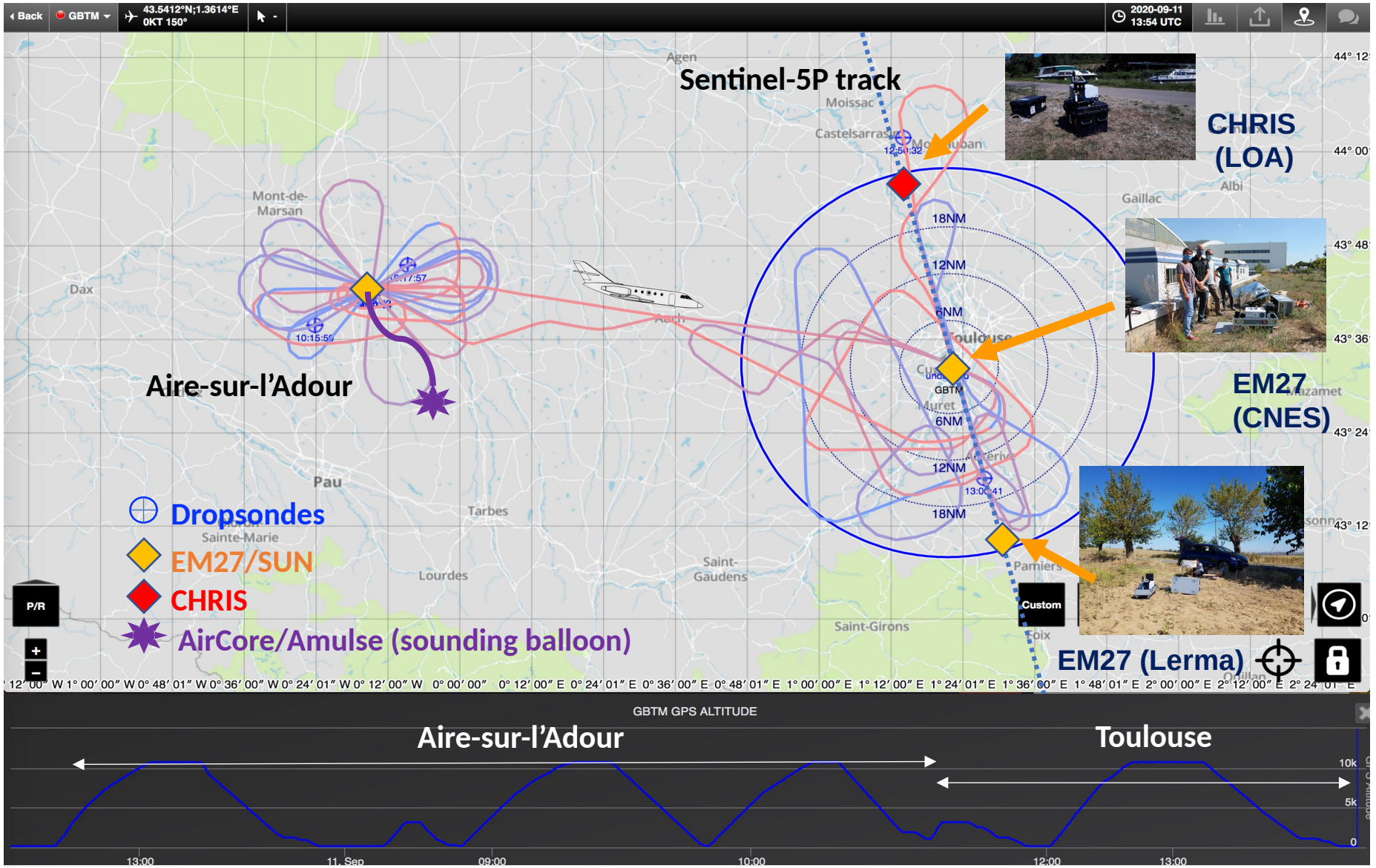






More information: https://magic.aeris-data.fr/

MAGIC 2020: September 11th : all instruments deployed



Satellites :

- **Sentinel-5P overpass: 12:55 UTC**
- **IASI-A overpass: 9:28 UTC**
- **IASI-C overpass: 9:56 UTC**

Falcon20 :

- 1er flight : 8:30-10:45 over ASA coloc IASI-A/C et ballons.
- 2e flight : 12:15-13:45 over Francazal coloc Sentinel-5P

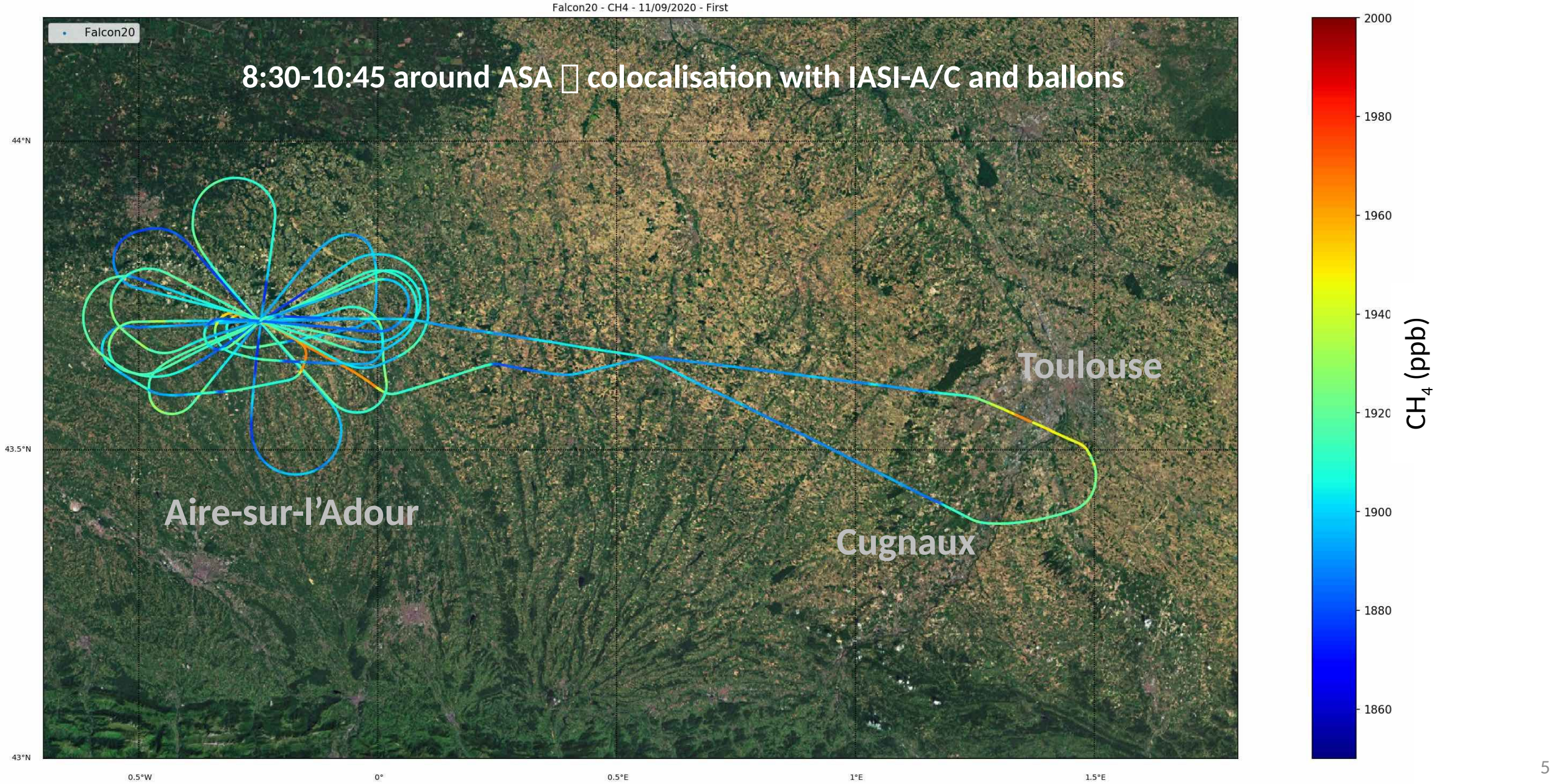
Balloon lauches from ASA (~1h30 ascent + 45mn descent) **:**

- AirCore at 08:00 : coloc IASI-A/C (descent)
- Amulse at 09:15 : coloc IASI-A/C (ascent)
- AirCore (descent) à 11:00 : coloc S5P
- Amulse at 12:45 : coloc S5P (ascent)
- AirCore à 14:00 (landing around 16h).

FTS : continuous measurement

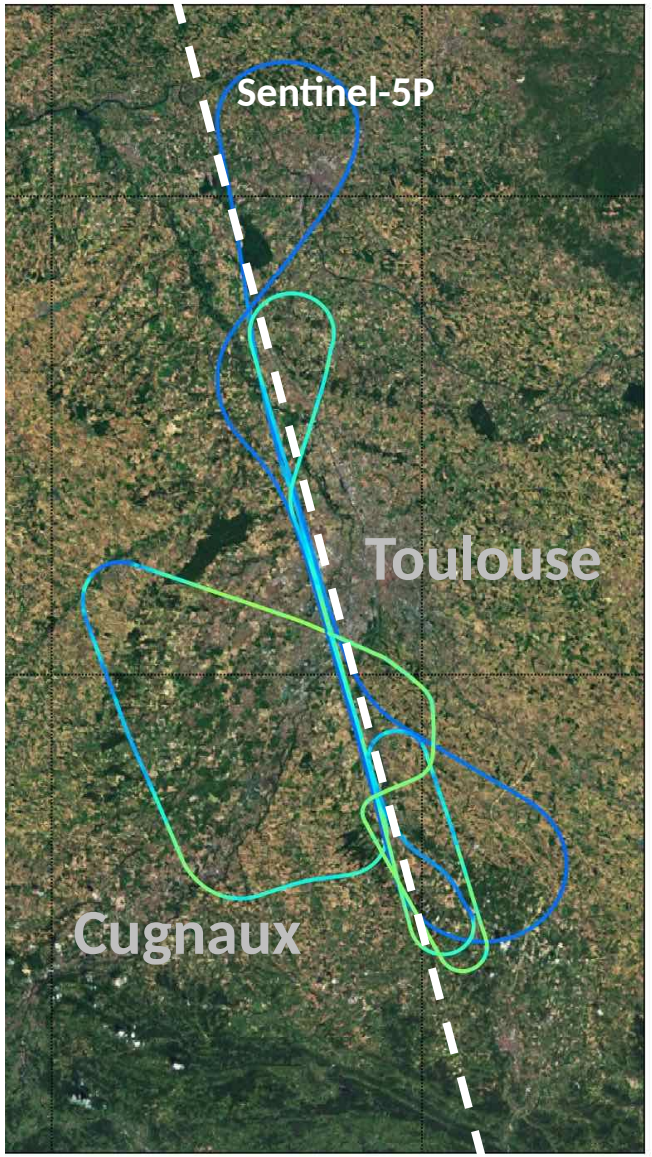
- **GSMA :** ASA – 7:00-15:00
- **CNES :** Francazal – 8:00-15:00
- **LOA :** North (Montech) – 10:00-15:00
- **LERMA :** South (Caujac) – 10:00-15:00

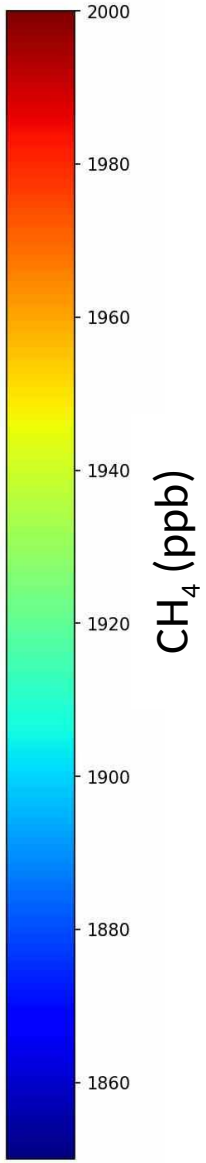
MAGIC2020: Falcon20 first flight



MAGIC2020: Falcon20 second flight and balloon launches

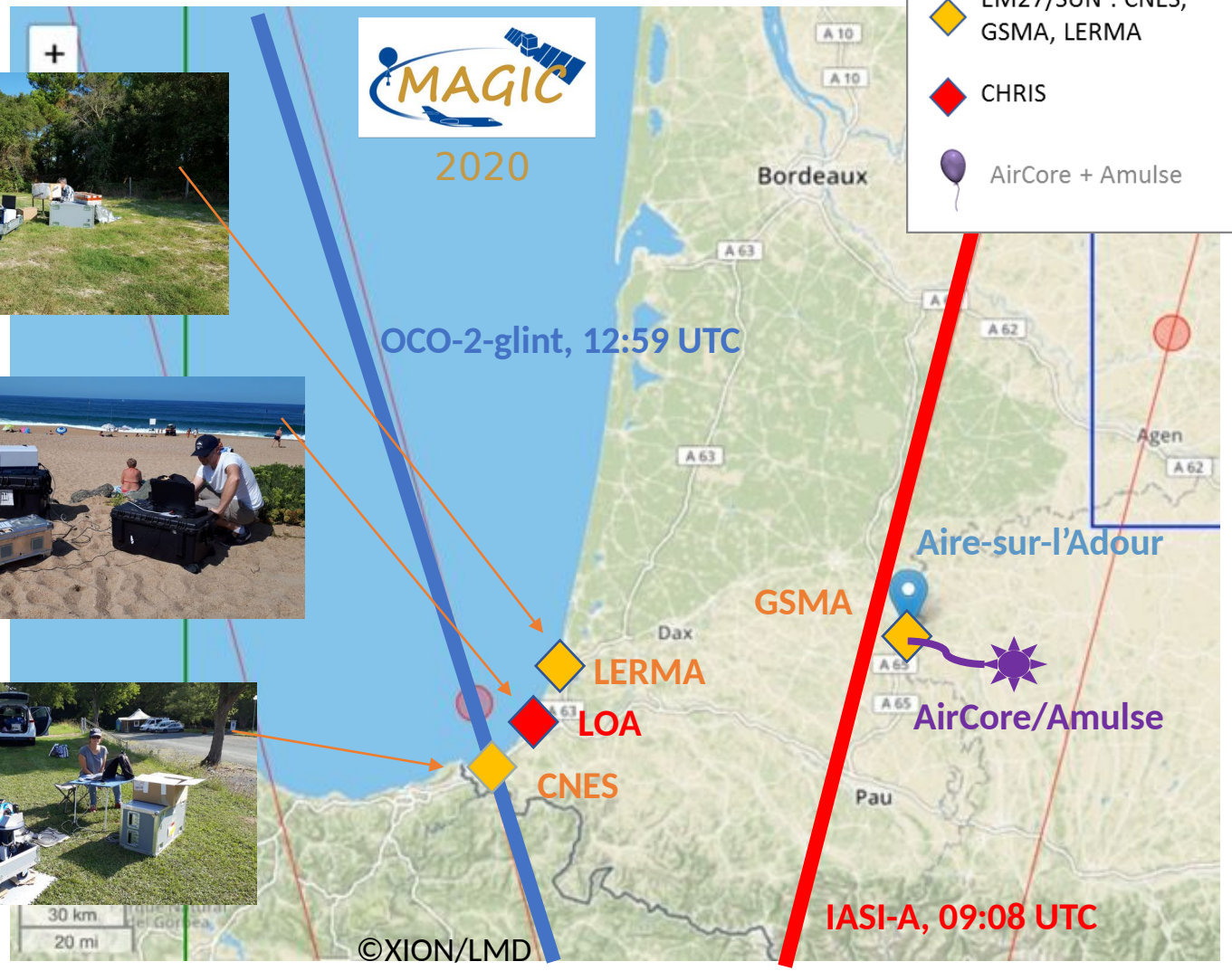
12:15-13:45 around Toulouse coloc Sentinel-5P





Successive balloon launches at ASA

MAGIC 2020: September 12th, Validation of OCO-2 in glint mode



OCO-2 overpass: 12:59 UTC

IASI-A overpass: 9:08 UTC

Balloons launches from ASA:

AirCore à 08:00 : coloc IASI-A (descent)
Amulse à 09:00 : coloc IASI-A (ascent)
AirCore à 12:00 : coloc OCO-2 (descent)
Amulse à 13:00 : coloc OCO-2 (ascent)

FTS: continuous measurement

GSMA : ASA – 7:00-15:00
CNES : Hendaye – 10:00-15:00
LOA : Anglet- 10:00-15:00
LERMA : Vieux Boucau – 10:00-15:00

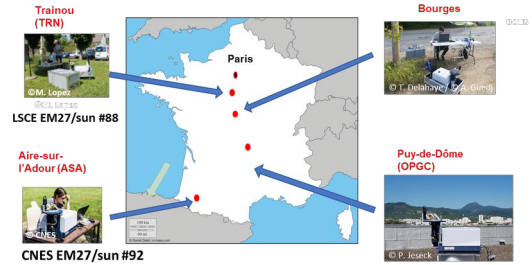
+ 13th September

GOSAT1 overpass with target mode over ASA : 13:46
GOSAT2 overpass with target mode over ASA : 13:19

Working group FTS for MAGIC

- All part of the Collaborative Carbon Column Observing Network initiated by KIT

- PROFFAST software for GHG retrieval
- Use of others retrieval codes, as the 4Artic code (based on optimal estimation) which will be used for the MicroCarb



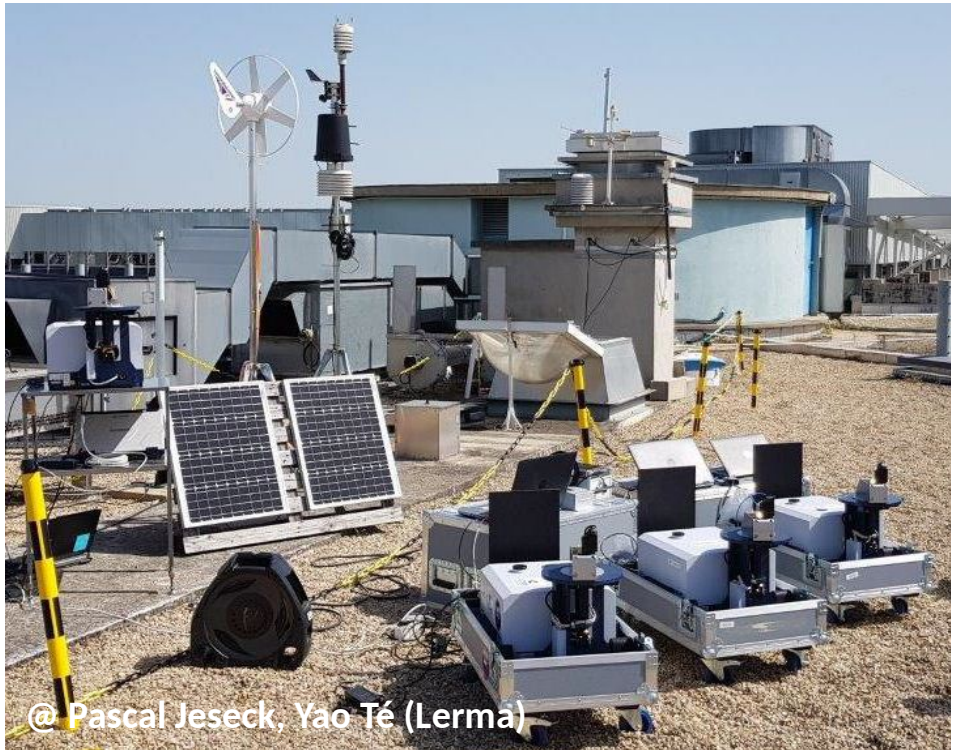
- Development of a test bench by LOA for radiometic calibration
- Development of a set up to measure ILS of all the EM27 involved in Magic (LERMA)

- We started <u>regular measurements</u> from several sites in France to:
  - Train with the EM27 instrument
  - Train with satellite overpasses
  - Establish temporal series

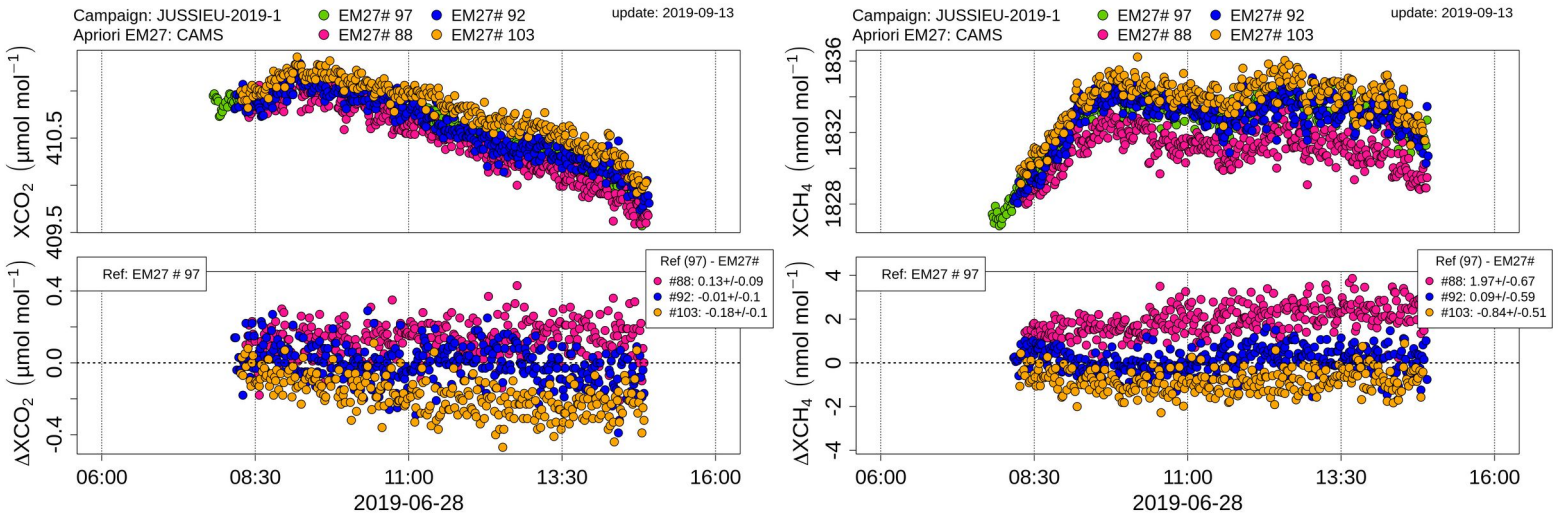
- Greg Osterman kindly sends CNES the forecast of OCO-2 observations over France

Thank you !

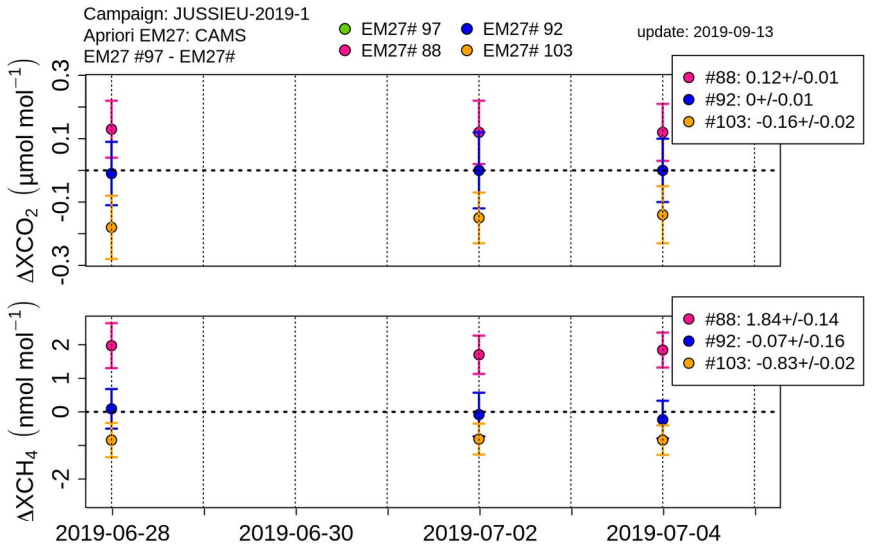
EM27 intercomparison in Paris (Jussieu – July 2019)



Set up LERMA



Processing LSCE



WMO targeted compatibility	
CO2	0.1 ppm
CH4	2 ppb
CO	2 ppb

2 EM27 intercomparison over time

- **Trainou [2 days, sept 2018]**

- ΔXCO2 = XCO2 (EM27#88-LSCE) – XCO2 (EM27#92-CNES) = 0,12 ppm +/- 0,1 ppm
- ΔXCH4 = XCH4 (EM27#88) – XCH4 (EM27#92) = 1,6 ppb +/- 0,58 ppb

- **Jussieu [3 days, oct 2018]**

- ΔXCO2 = 0,18 ppm +/- 0,12 ppm
- ΔXCH4 = 1,7 ppb +/- 0,78 ppb

- **Saclay [2 days, feb 2019]**

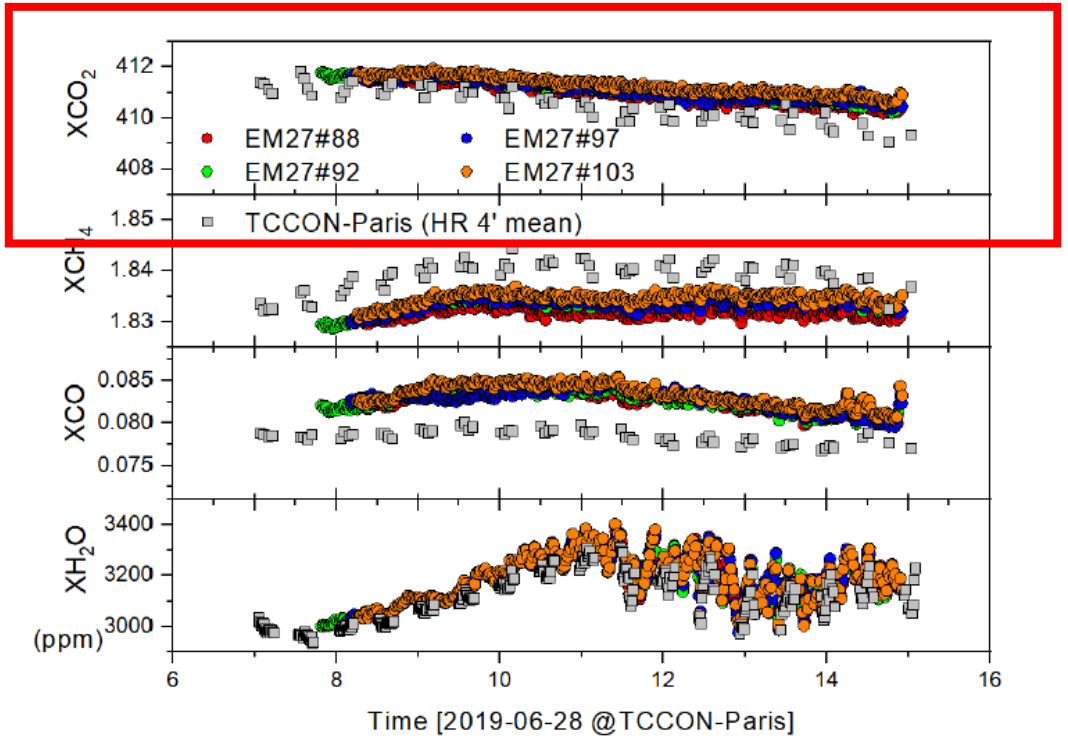
- ΔXCO2 = 0,05 ppm +/- 0,20 ppm
- ΔXCH4 = 0,56 ppb +/- 0,90 ppb

- **Jussieu [4 days, july 2019]**

- ΔXCO2 = 0,13 ppm +/- 0,15 ppm
- ΔXCH4 = 1,7 ppb +/- 0,83 ppb

→ Measurement differences between the same two instruments vary a little over time.

EM27/SUN versus TCCON-Paris (High Resolution)

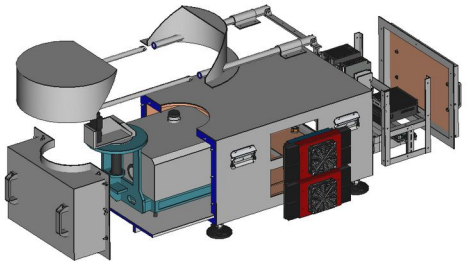


@11h-13h	EM27#all3	TCCON-HR	Différence (Δ)
XCO_2 (ppm)	409.09 ± 0.19	408.84 ± 0.32	0.25
XCH_4 (ppb)	1845.16 ± 1.00	1847.98 ± 1.39	-2.82
XCO (ppb)	79.27 ± 0.75	75.03 ± 0.47	4.24
XH_2O (ppm)	2455 ± 73	2469 ± 63	-14

Té, Inter-comparaison EM27 / TCCON-Paris, Synthèse MAGIC 2019, 23 juin 2020

Futur work of the Working group FTS for MAGIC

- EM27
- Use of others retrieval codes, as the 4Artic code (based on optimal estimation) which will be used for the MicroCarb
- Comparison of EM27 total columns with MAGIC campaign data : balloon based profils and in-situ Picarro airbone profiles using the last PROFFAST version which provides the column sensitivity values
- Development of a set up to measure ILS of all the EM27 involved in Magic (LERMA)
- Development of a stand alone waterproof casing
- Development of a test bench by LOA for radiometric calibration
- …data acquisition to be continued : MAGIC 2021



MAGIC2021: Towards high latitudes

- **Specific objectives:**
  - CH_4 and CO_2 emissions at high-altitude (~68°N)
  - Validation of space missions in this difficult environment.
- **Date and location: 14-26 August 2021 in Northern Sweeden, around Kiruna**
- **Joint campaign with annual CNES "StratoSciences" campaign.**
- **Team:** 6 joint CNRS labs + ONERA + CNES + DLR + SAFIRE
- **>20 instruments for GHG:**
  - ***Balloons***: AirCore-HR, AirCore-light, Amulse, Sample, SPECIES
  - ***Ground-based***: 3 confirmed EM27/SUN, CHRIS
  - ***Aircraft***: SAFIRE/ATR42 with CHARM-F (CH_4) and VEGA (wind) lidars, Picarros and SPIRIT (trace gases: CH_4, CO_2, CO, N_2O)
- **Funding**: CNES, CNRS, Ecole polytechnique, URCA, Sorbonne U., U. Lille, ONERA, DLR
- Looking for additional cooperations (Sodankyla, HEMERA flights@Kiruna, modelling teams)

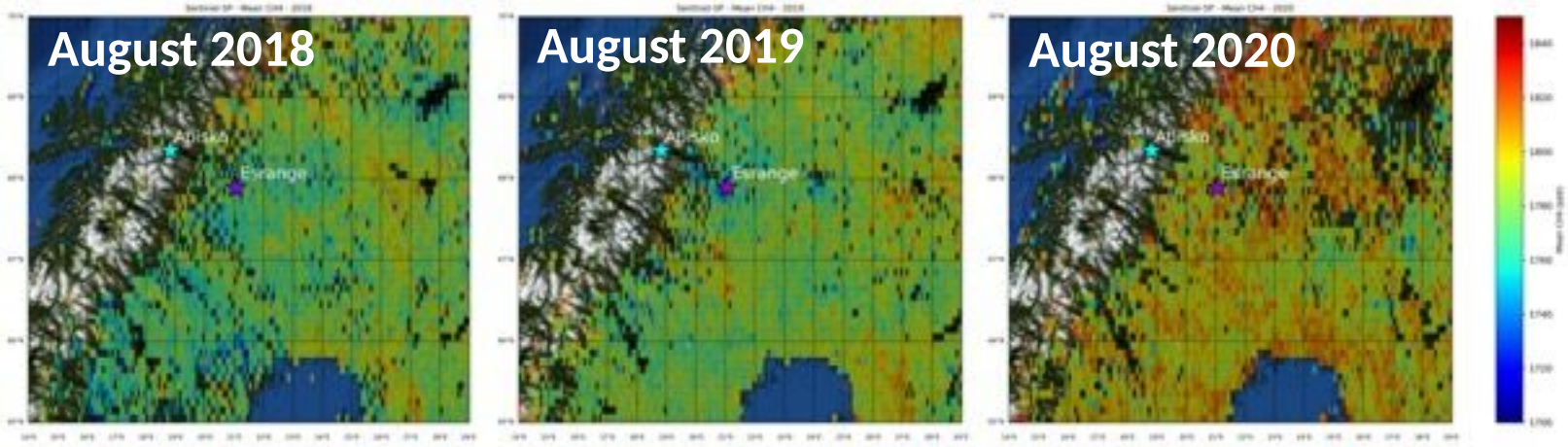
List of instruments

Vectors		Instruments		Team	Observation
Balloon	Meteorological balloons (BLD)	AirCore	5	LMD	0-30 km profiles (CO_2, CH_4, CO, T, H_2O, wind + *C isotopes*, N_2O)
		Amulse	5	GSMA	0-30 km profiles (CO_2, CH_4, H_2O, T)
	Open Stratospheric Balloons (BSO) *SUPER KLIMAT*	AirCore-HR	1	LMD	0-30 km profiles (CO_2, CH_4, CO, T, H_2O, wind + *C isotopes*, N_2O)
		AirCore-light	2	LMD	
		Amulse	1	GSMA	0-30 km profiles (CO_2, CH_4, H_2O, T)
		SAMPLE	1	GSMA	0-30 km profiles at a few points (CO_2, CH_4, H_2O, T)
		SPECIES	1	LPC2E	0-30 km profiles of many trace gases at ppt level
	BSO-*HEMERA1-TWIN*	*Contact to be taken with the team to include these GHG measurements*			
Ground	FTS	CHRIS	1	LOA	Weighted columns XCO_2, XCH_4, XCO, etc.
		EM27/SUN	3-4	CNESx1, GSMAx1, LERMAx1, *LSCEx?*	
ATR42 aircrfat	In-situ	Picarro	4	SAFIREx1, LSCEx1	In-situ concentration of CO_2, CH_4, CO
		SPIRIT	1	LPC2E	In-situ concentration of N_2O, CH_4, CO
	Lidar	CHARM-F (CH_4)	1	DLR	Weighted columns XCO_2, XCH_4
		LIVE (Wind)	1	ONERA-DOTA	Wind profile

Validation of satellites: OCO-2, S5P, GOSAT, IASI

Average of XCH4 and XCO2 in August over the last 3 years

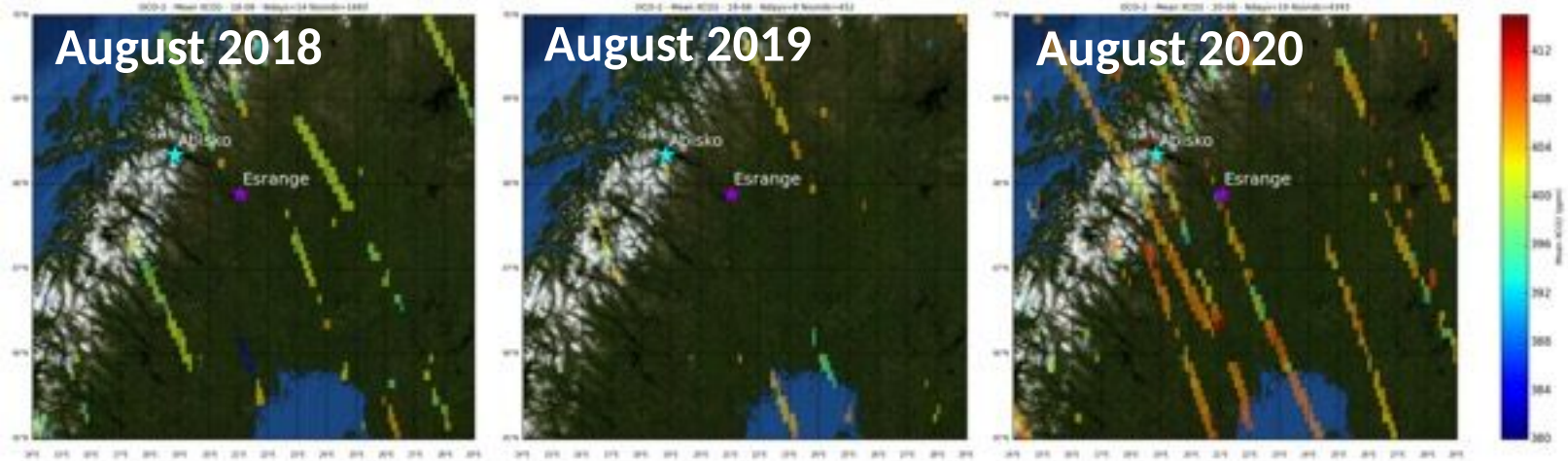
Sentinel-5P/XCH_4



XCH_4 (ppb)

- Few data over 70N
- No data over relief (East of Abisko)

OCO-2/XCO_2



XCO_2 (ppm)

- Few orbits in one month.
- High dependence to cloud coverage

Perspectives

- **Operational mode for AirCore-Fr network and EM27/SUN Fr consortium in the framework of ICOS and other networks (e.g. COCOON).**

- **High resolution / city targets : 2022, 2023**
  - Objective: Establishing CO_2/CH_4 budget of a big (e.g. Paris) and/or medium size city (e.g. Reims)
  - Deployment of EM27/SUN around the city + balloons/aircrafts

- **Tropics (Brazil or Namibia): >2024**
  - Objective: tropical emissions and specific atmospheric/surface conditions
  - In the framework of the establishment of a CNES balloon facility in one of these countries

- **Over high latitude campaigns (e.g. PolarCamp)**

- **And of course, specific cal/val campaigns during future GHG mission MicroCarb and Merlin commissioning phases**