Validation of IASI Level 2 products using vertical profiles measured by balloon-borne AirCore air sampler

Jérôme Pernin[1], Axel Guedj[1], Thomas Ponthieu[1], Lilian Joly[2], Nicolas Dumélié[2], Michel Ramonet[3], Morgan Lopez[3], Serge Cruzel[4], Cyril Crevoisier[1]

[1] ***Laboratoire de Météorologie Dynamique/IPSL***, *Ecole polytechnique, 91128 Palaiseau Cedex, France*
[2] ***Groupe de Spectrométrie Moléculaire et Atmosphérique***, *Groupe Université de Reims Champagne-Ardenne, Campus Moulin de la Housse, Reims, France*
[3] ***Laboratoire des Sciences du Climat et de l'Environnement/IPSL***, *CEA - Orme des Merisiers, Gif sur Yvette, France*
[4] ***Centre National d'Etudes Spatiales***, *Aire-sur-l'Adour, France*

IASI on board Metop-A/B/C

AirCore under balloon

AirCore and IASI Level 2 products used

- **AirCore level 2/1 products :**

VARIABLE	TYPE	PRODUCT	VERSION	DATA TYPE
CH4, CO T, RH	Level 2 Level 1	AirCore-FR	PRE-RELEASE 2024	Vertical profile

VS

- **IASI level 2 products for Metop-A/B/C :**

VARIABLE	TYPE	PRODUCT	VERSION	DATA TYPE
CH4	Level 2	LMD	v10.2	Mid-Tropospheric Column
CO		EUMETSAT	v20151001	Vertical profile
T, Q		EUMETSAT	CDR 1.1	Vertical profile

Pre-release 2024 AirCore-FRench dataset

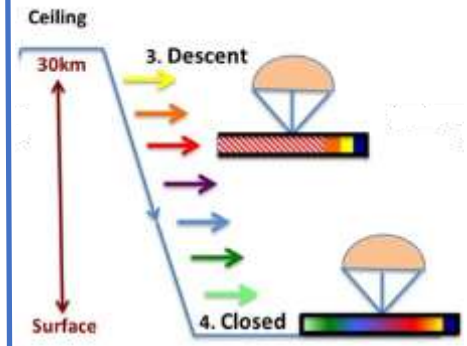
AirCore atmospheric air sampler

Preparation before launch

T, RH

Launch

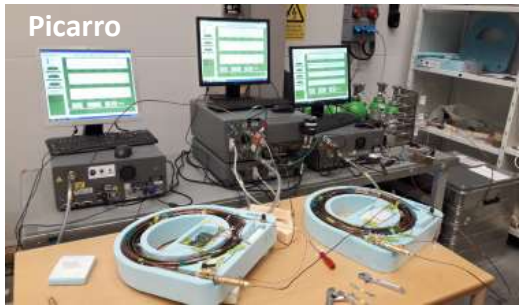
Air sampling during descent



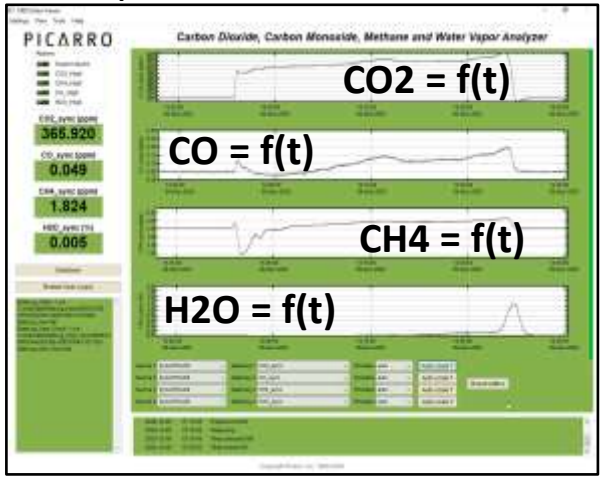
@ Olivier Membrive

Nacelle Recovery

Air core sample analysis

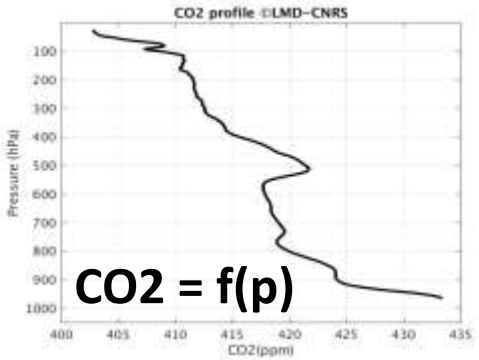


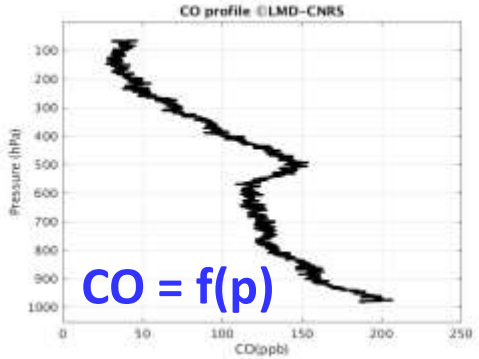
Example with G2401 Picarro :

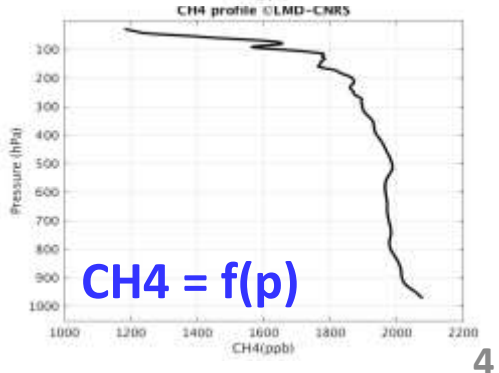


Gas concentrations are calibrated on international standard scales before being processed.

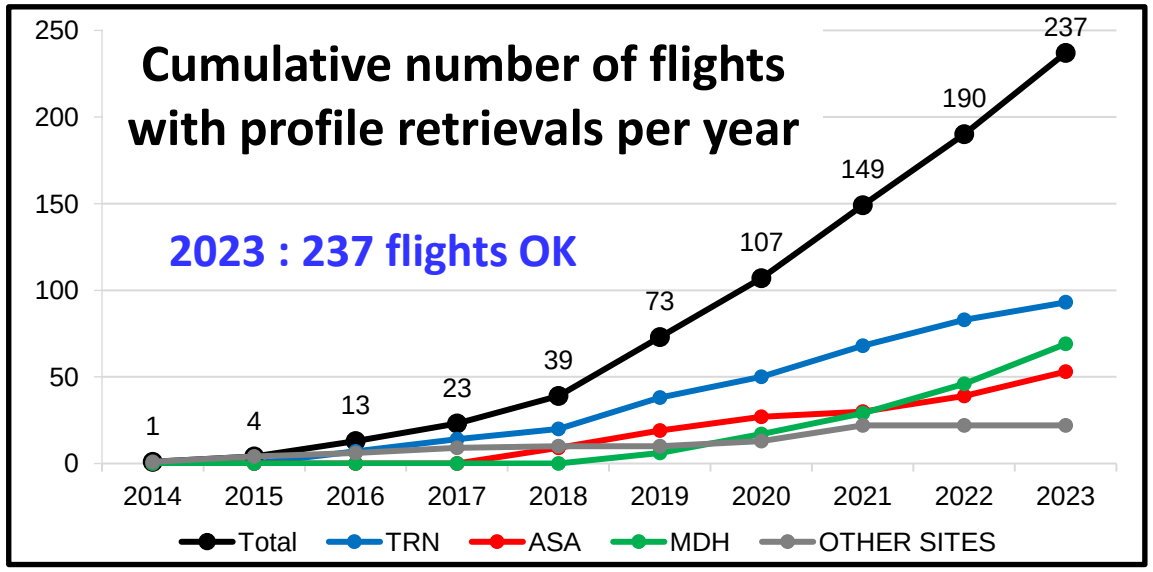
Data processing

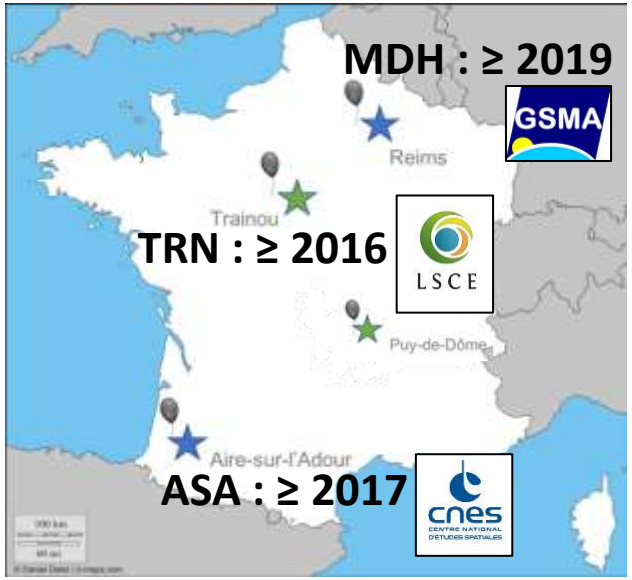




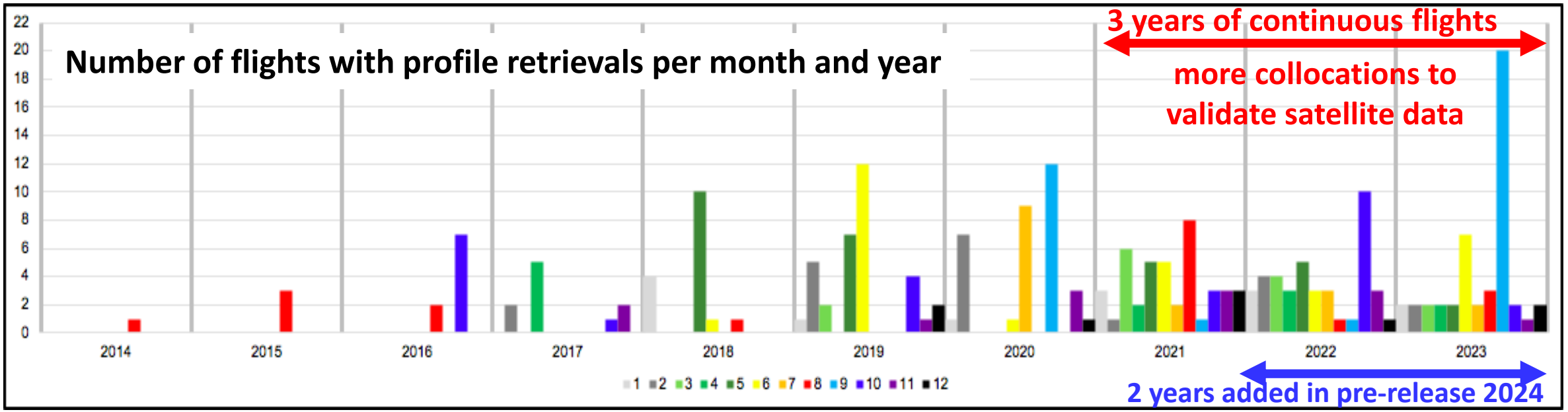


AirCore French program (AirCore-FR)

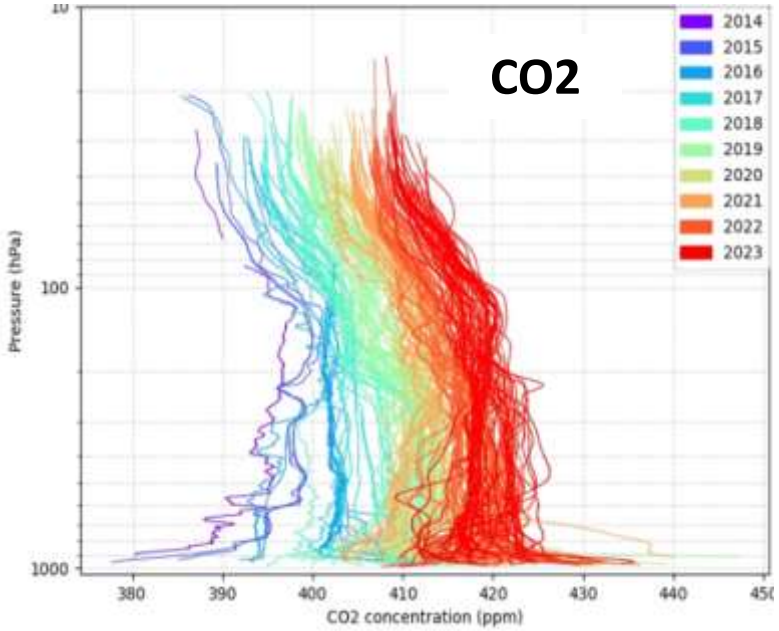


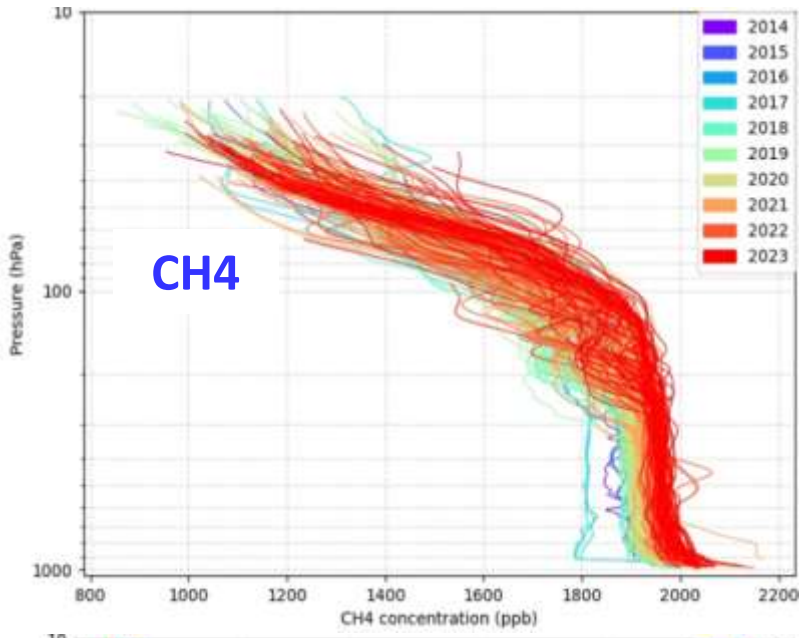


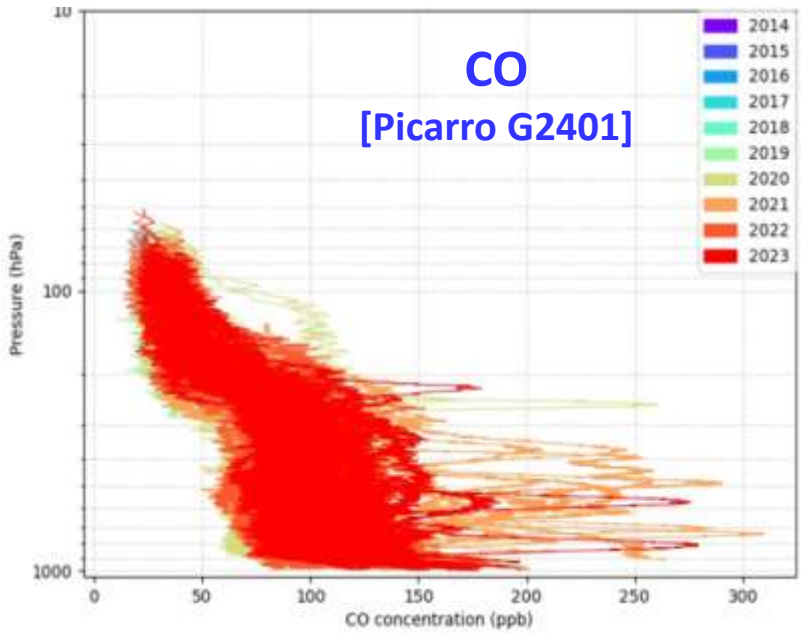
French regular launch sites

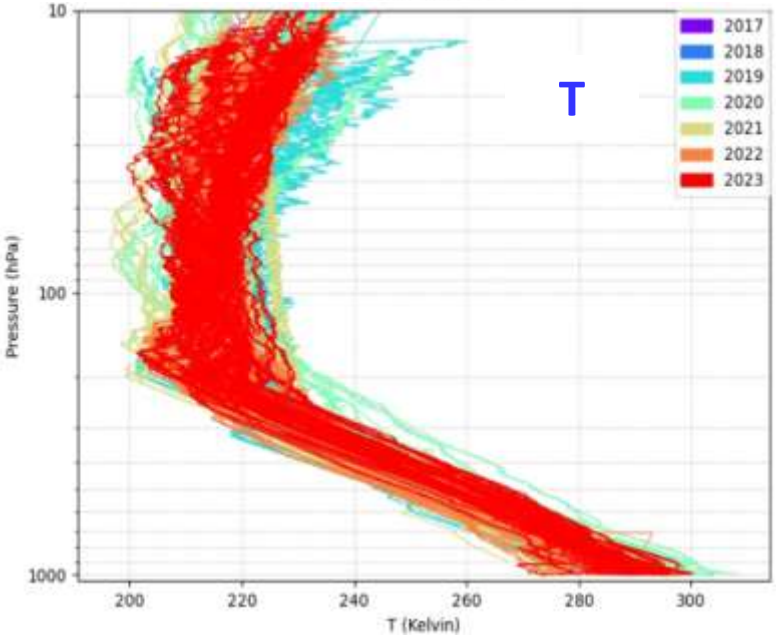


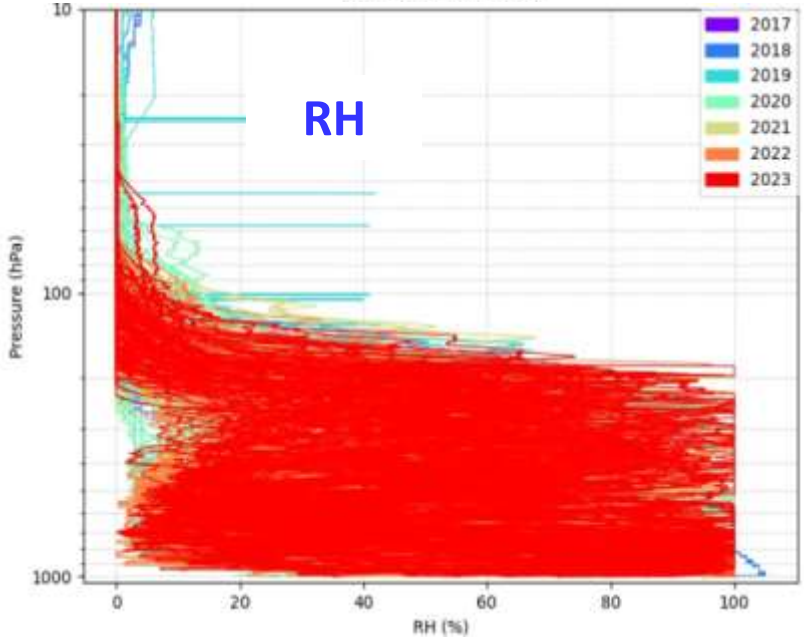
AirCore dataset illustration

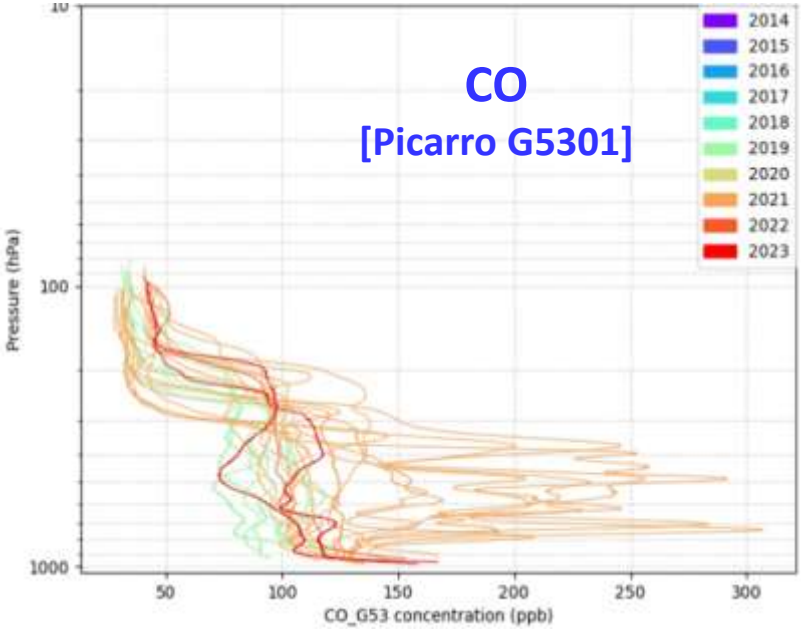








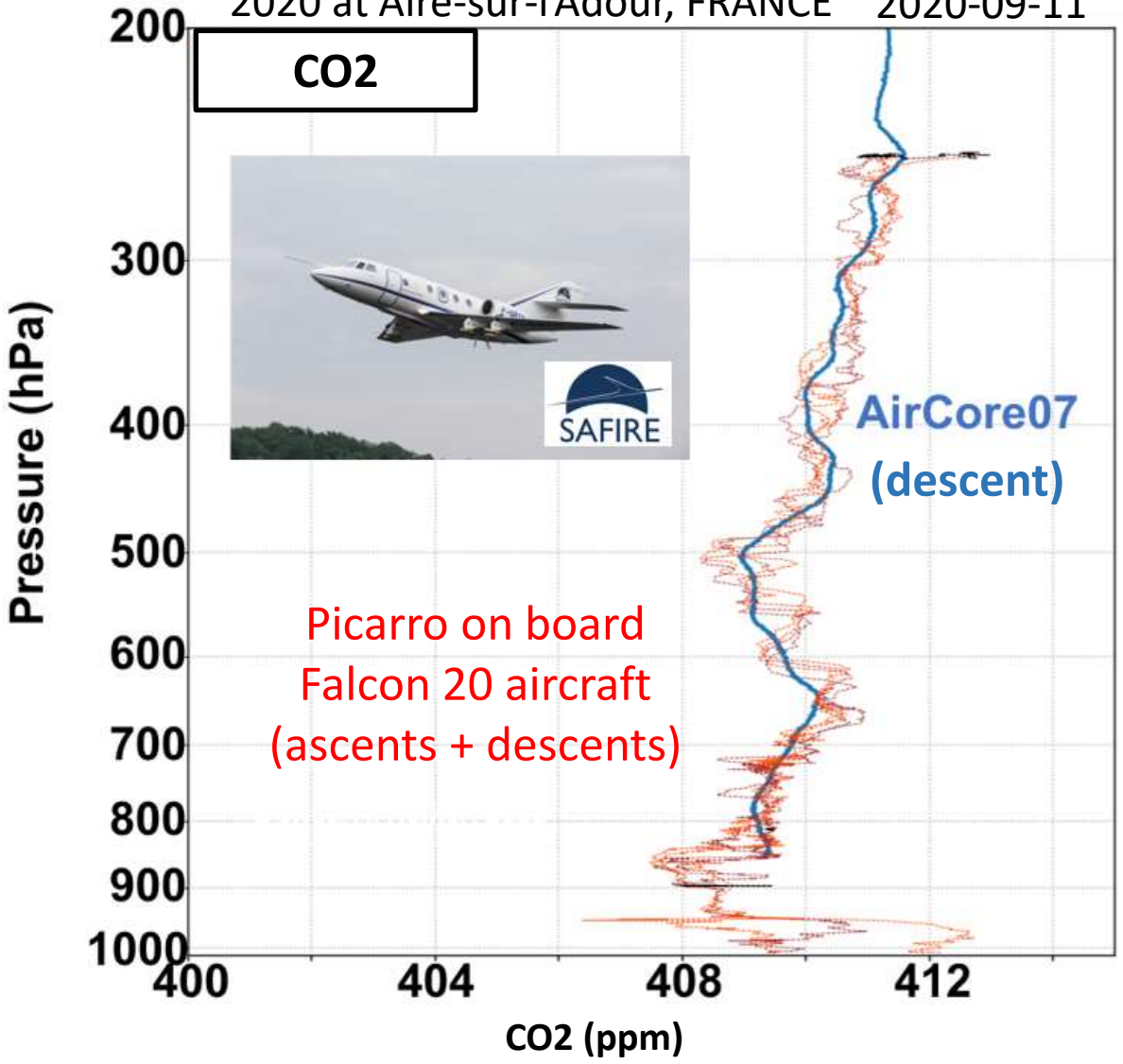




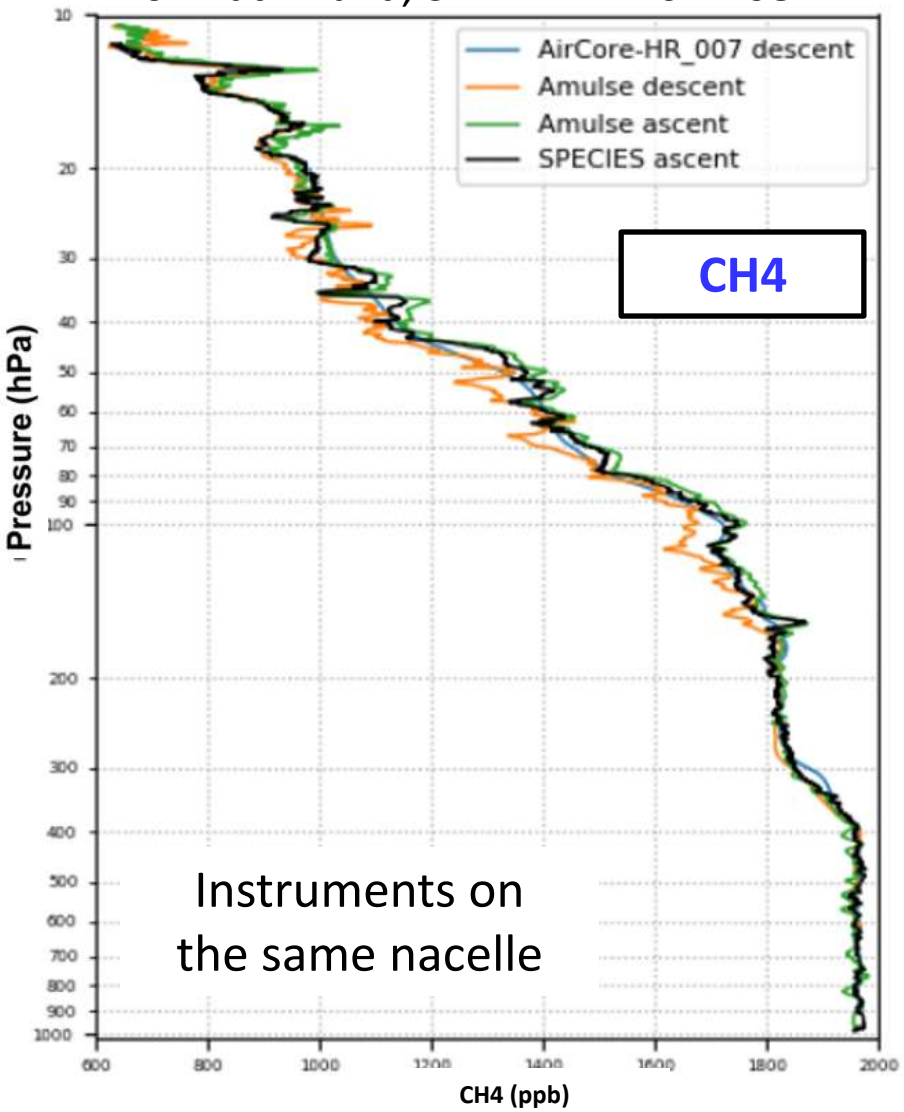
AirCore dataset validation examples

Multi-instruments campaign MAGIC

2020 at Aire-sur-l'Adour, FRANCE 2020-09-11



2021 at Kiruna, SWEDEN 2021-08-22



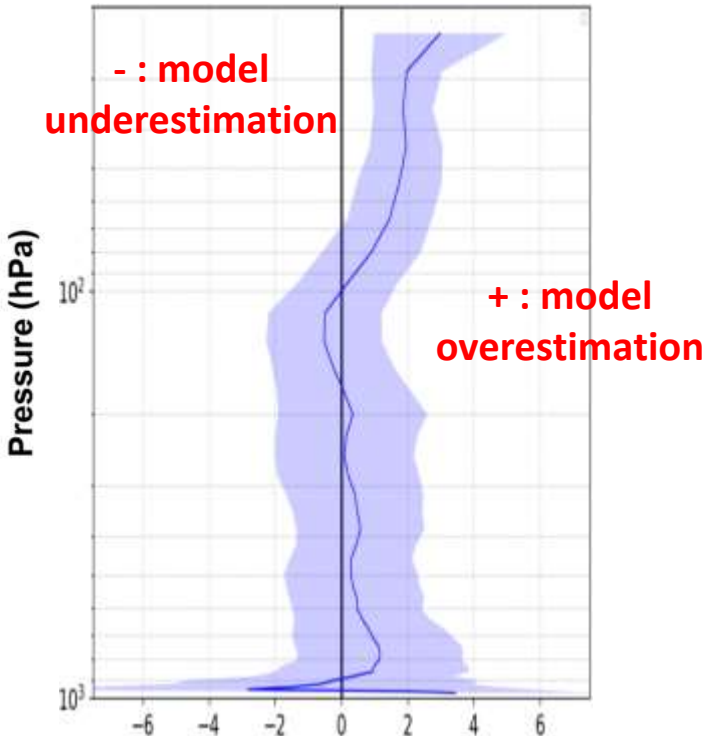
Example of evaluation of atmospheric transport model with AirCore-FR dataset

Evaluation of transport models CAMS (Copernicus Atmosphere Monitoring Service)

Comparison between CAMS and AirCore profiles

CAMS reanalysis egg4

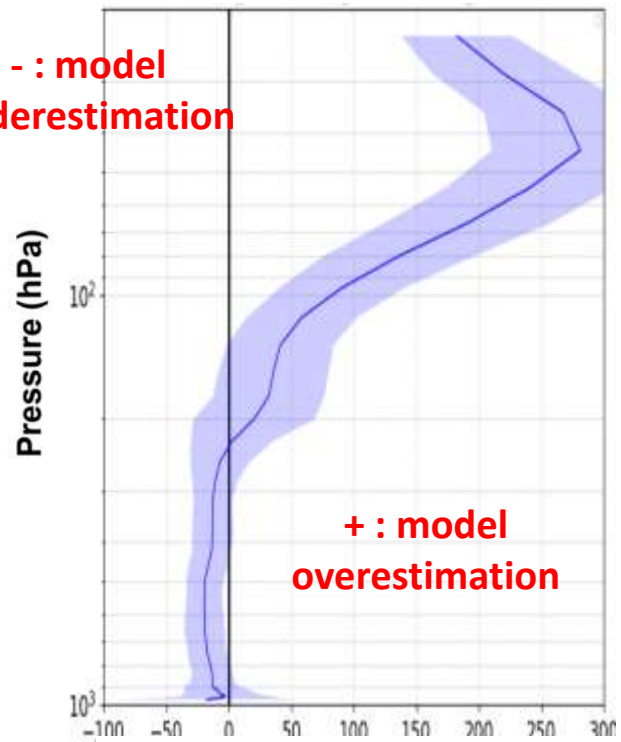
CO2 (CAMS - AirCore)



C-IFS – AirCore CO_2 (ppm)

CAMS reanalysis egg4

CH4 (CAMS - AirCore)



C-IFS – AirCore CH_4 (ppb)

- Strong overestimation of CH_4 and to a lesser extent of CO_2 in the stratosphere.
- Underestimation of CH_4 in the troposphere.

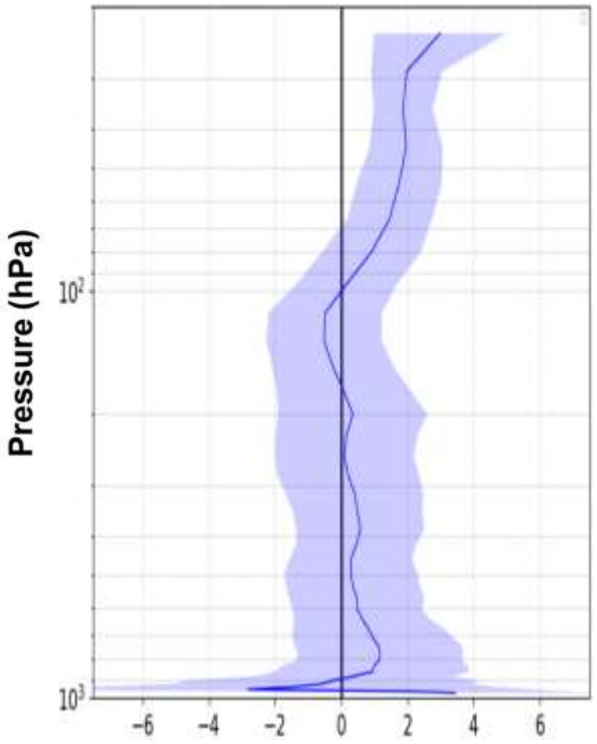
Mean
+/-Stdv

Evaluation of transport models CAMS (Copernicus Atmosphere Monitoring Service)

Comparison between CAMS and AirCore profiles

CAMS reanalysis egg4

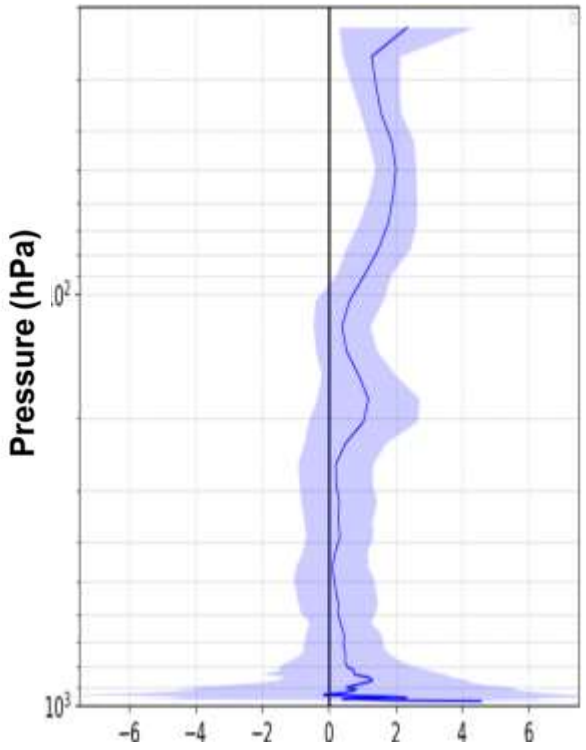
CO2 (CAMS - AirCore)



C-IFS – AirCore CO_2 (ppm)

CAMS optimized flux v22r1

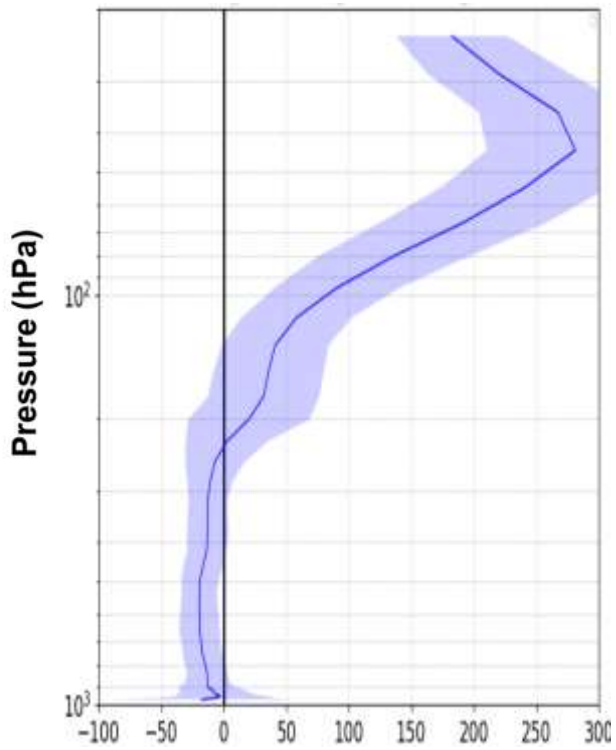
CO2 (CAMSflux - AirCore)



LMDz – AirCore CO_2 (ppm)

CAMS reanalysis egg4

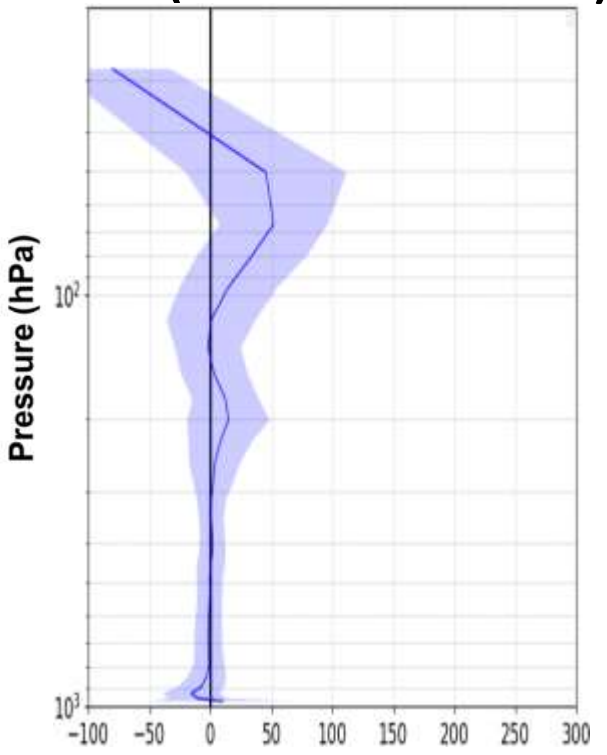
CH4 (CAMS - AirCore)



C-IFS – AirCore CH_4 (ppb)

CAMS optimized flux v22r2

CH4 (CAMSflux -AirCore)



TM5 – AirCore CH_4 (ppb)

Mean
+/-Stdv

- Strong overestimation of CH_4 and to a lesser extent of CO_2 in the stratosphere.
- Underestimation of CH_4 in the troposphere.
- Simulations with optimized fluxes reduces both the tropo. and strato. biases as well as the overall standard deviations.

10

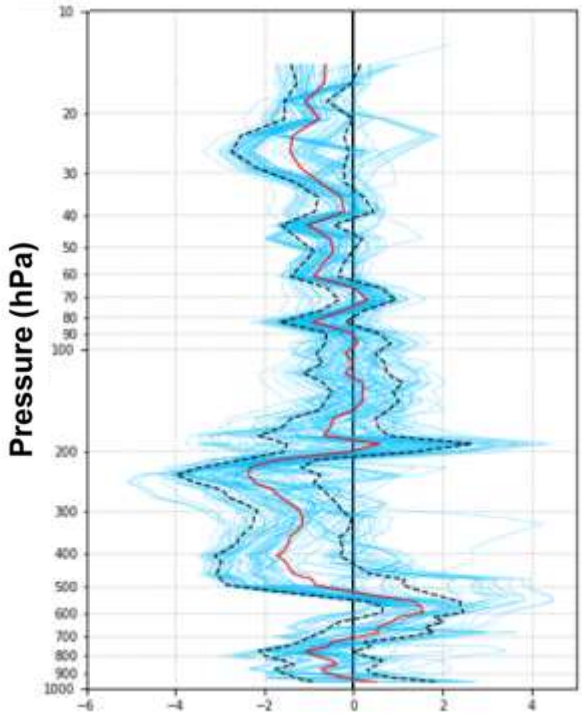
Examples of evaluation/validation of IASI Level 2 products with AirCore-FR dataset

T profile

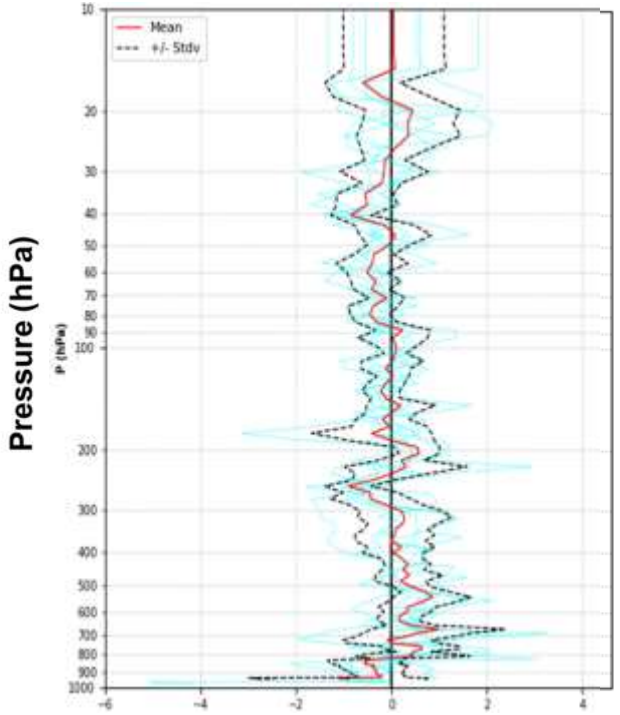
Collocation
≤ (100km, 2h)

MAGIC 2021
(**High Latitudes**: Kiruna, SWEDEN)

(IASIB – AirCore) T (K)



(ERA5 – AirCore) T (K)



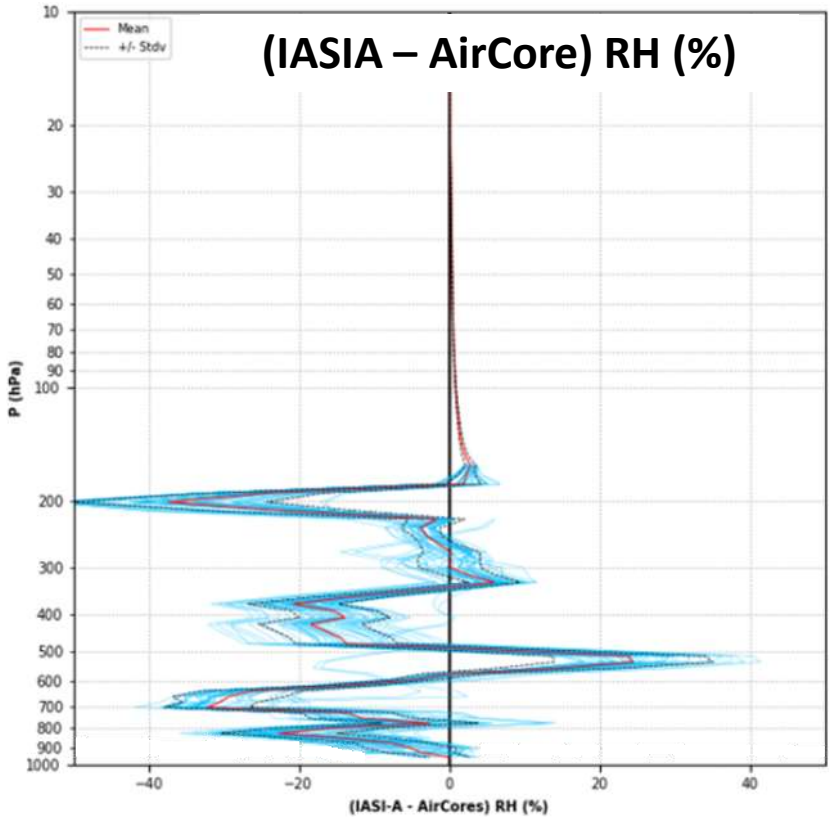
Similar behaviours with IASI-A and IASI-C

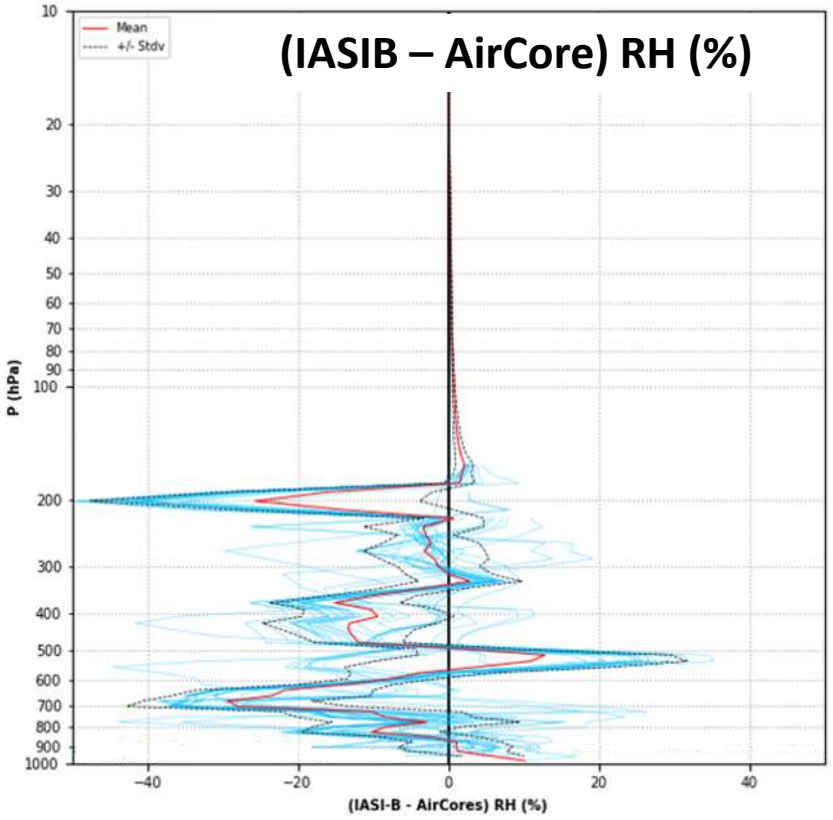
Singular mid-tropospheric bias in high latitudes seems to be detected in IASI Level 2
(seems to be confirmed by using AirCore profiles at Sodankyla, FINLAND from FMI/Groningen university dataset)

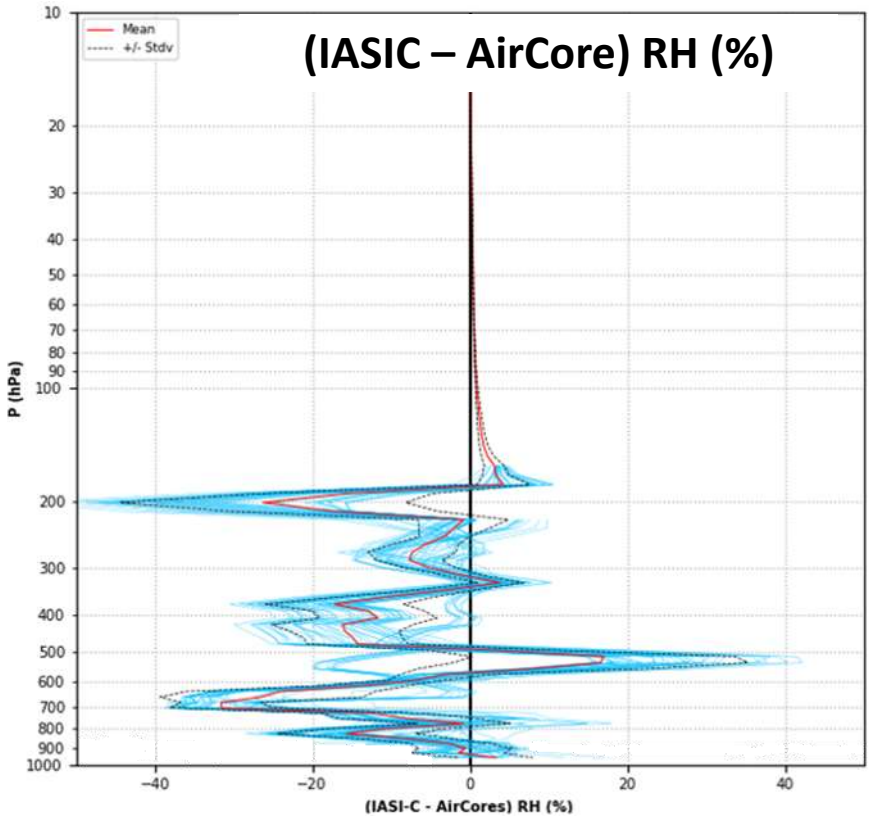
RH profile

Collocation
≤ (100km, 2h)

MAGIC 2021
(**High Latitudes**: Kiruna, SWEDEN)







Similar results with the 3 instruments IASI-A, IASI-B and IASI-C
Bias between -50 and 40 %

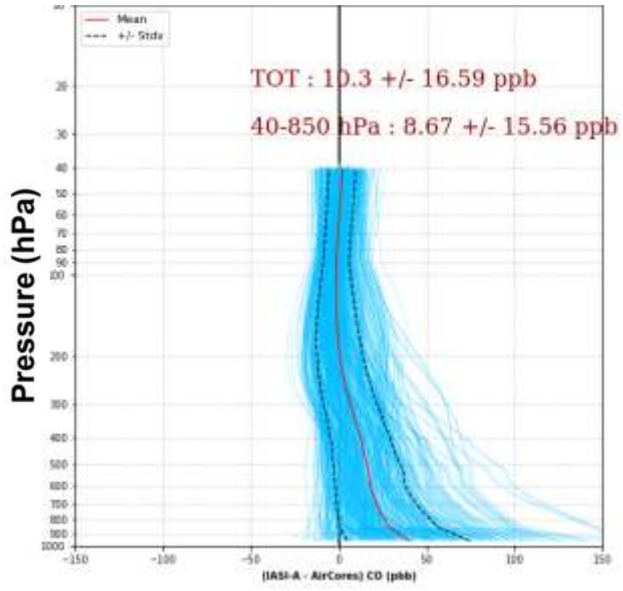
CO profile

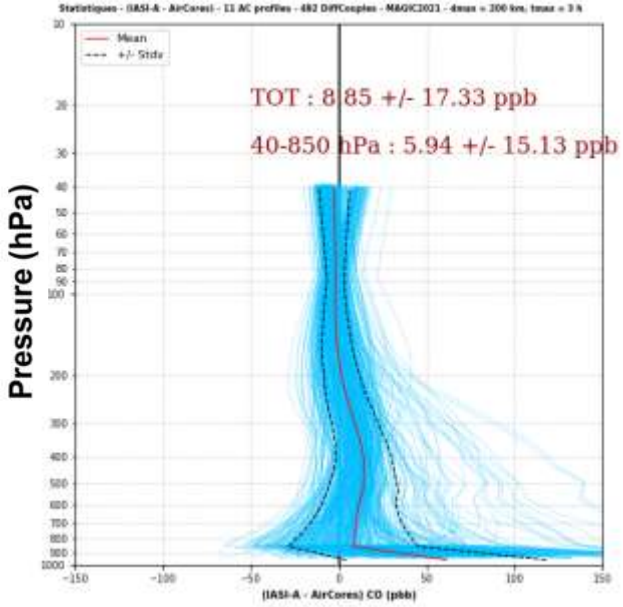
Collocation
≤ (200km, 3h)

MAGIC 2019
Mid-Latitudes
(FRANCE)

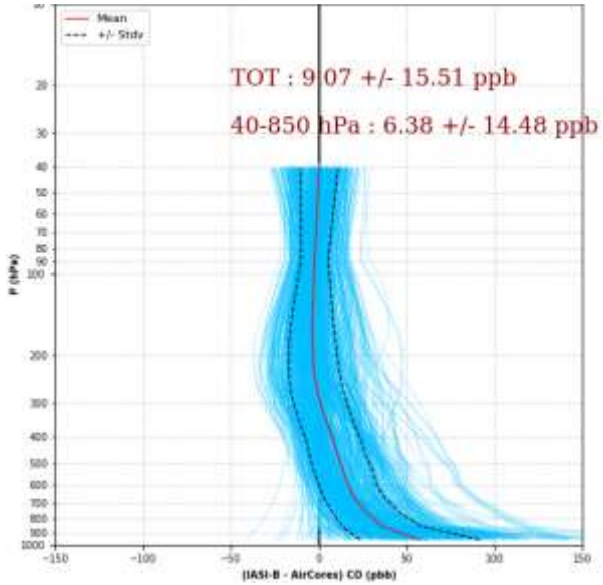
MAGIC 2021
High Latitudes
(Kiruna, SWEDEN)

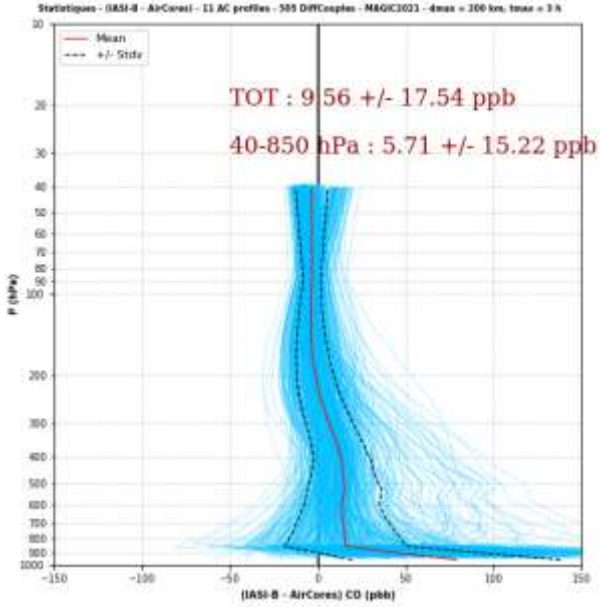
(IASIA – AirCore) CO (ppb)



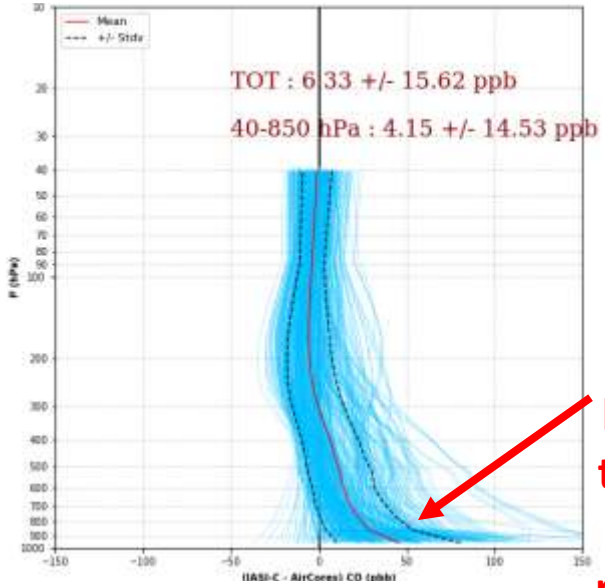


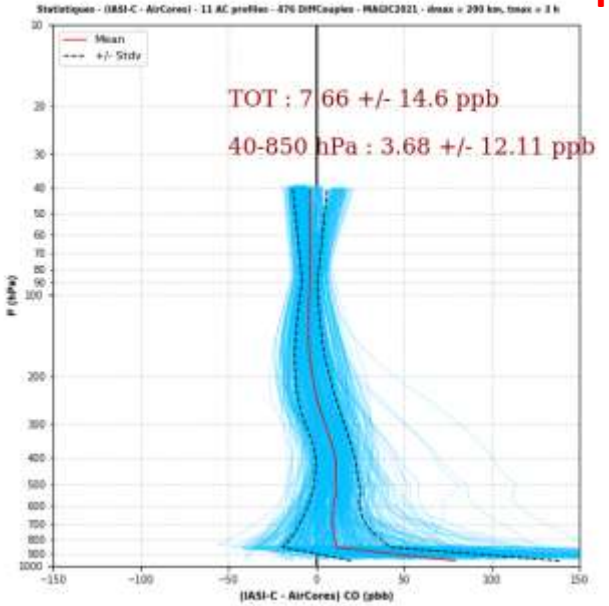
(IASIB – AirCore) CO (ppb)





(IASIC – AirCore) CO (ppb)

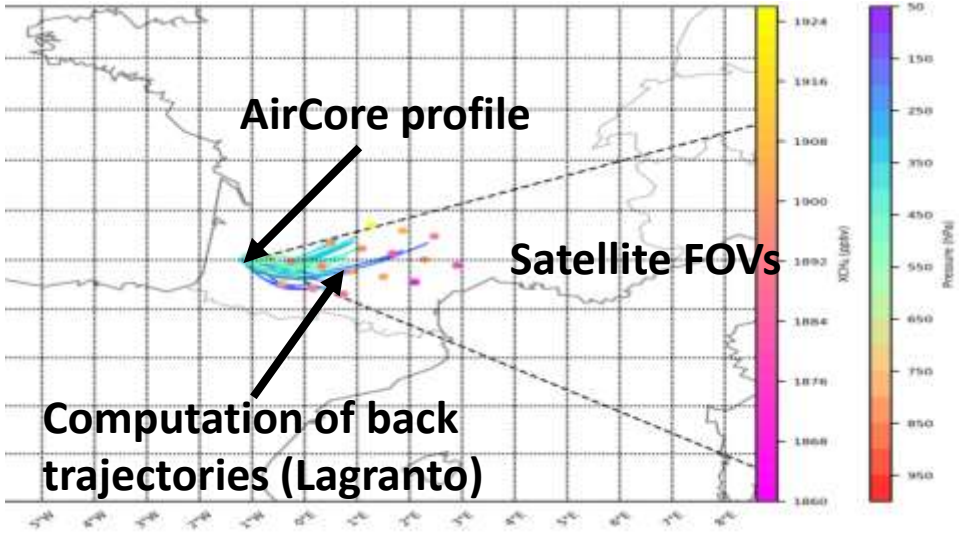




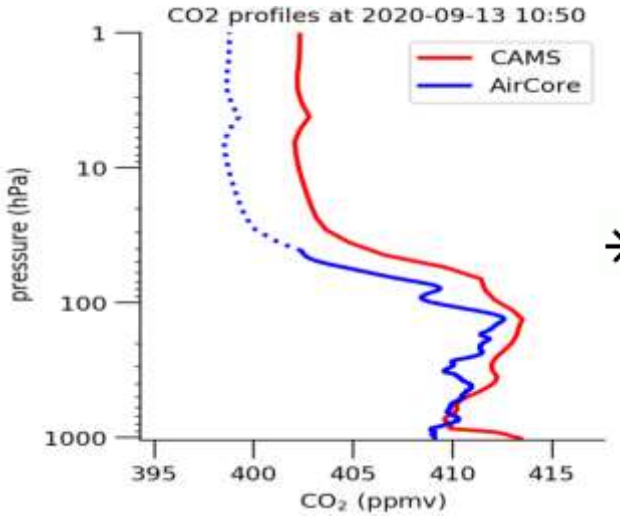
Significant biases near the surface, similar to results from previous airborne missions

CH4 mid-tropospheric column

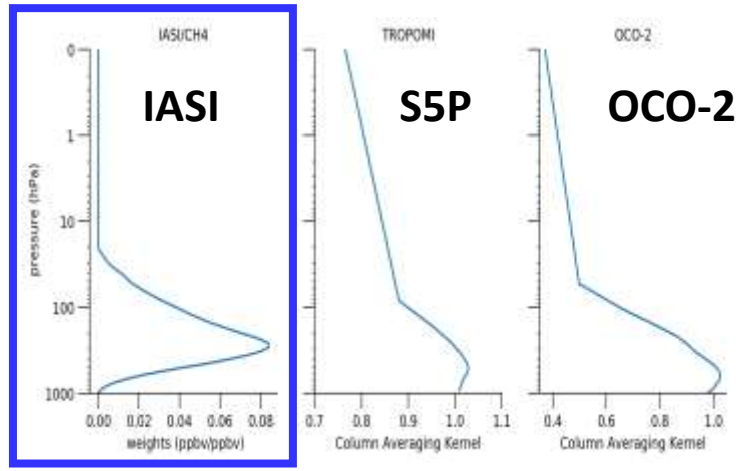
1. Identification of a cone for spatio-temporal colocations between AirCore and satellite in the same airmass



2. Extrapolation of AirCore profiles with CAMS



3. Application of satellite vertical sensitivity



4. Column from AirCore which would be seen by the satellite instrument

VS

Column from satellites via inversion algorithms

(AirCore – Satellite) column

Satellite	Version	Gas	mean ± stdv (AirCore-Satellite)	#FOVs	#AirCore
IASI-A	v10.2	**CH4**	**0.1 ± 13.0 ppb**	3037	35
IASI-B	v10.2	**CH4**	**2.3 ± 13.0 ppb**	3433	49
IASI-C	v10.2	**CH4**	**-1.1 ± 17.0 ppb**	2511	29
TROPOMI	L2 OPER	CH4	-9.5 ± 11.9 ppb	8472	33
OCO-2	LtCO2 B10206 Ar	CO2	0.99 ± 0.93 ppm	5212	11

Stability of the 3 IASI-A/B/C instruments with standard deviations confirming the expected random errors of the retrievals

Conclusion

Conclusions

- **AirCore** instrument : **(CO2, CH4, CO) Level 2 vertical profiles up to ~30km** (flight descent).
  Meteosonde : **(T, RH) Level 1 vertical profiles (**flight ascent/descent).

- AirCore allows:
  - To validate satellite products (profiles/columns) : IASI-A/B/C, MicroCarb (2025), IASI-NG (2026), Merlin (2029)
  - **To evaluate atmospheric transport models** and understand underlying vertical exchanges
  - To validate column retrieval bias correction (e.g.: XCO2 OCO-2)
  - To validate GHG columns measured from the ground (TCCON, EM27/SUN)
  etc

- **New release 2024 of AirCore-FR dataset coming very soon on AERIS platform**
  (2022 and 2023 flights added, processing homogenization, adjusted to CO2 international standard scale, …).

- **AirCore dataset mainly in mid-latitudes and some in polar areas**

  ➔ **Focus on tropics with MAGIC multi-instruments campaign in Brazil (summer 2026) !**

Contact:

jerome.pernin@lmd.ipsl.fr
(or generic mail aircore@lmd.ipsl.fr)

Website and data access:

https://aircore.aeris-data.fr/
(RELEASE 2024 AirCore dataset coming soon)