Evaluation of IASI Level2 data with in-situ data acquired during the MAGIC campaigns

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THE MAGIC CAMPAIGNS

The MAGIC campaigns (*https://magic.aeris-data.fr*) are an innovating collaboration between several laboratories (LMD, GSMA , LERMA, LOA, LSCE, LPC2E, OPGC) along with SAFIRE and CNES, with the purpose of getting information on the vertical distribution of CO_2, CH_4, CO, N_2O, as well as temperature and humidity above given areas. The MAGIC campaigns took place above several regions of France: in 2018 the campaign was located in Aire-sur-l'Adour (ASA) and Trainou-Orléans (TRN), then extended over Puy-de-Dôme (PDD) and the Atlantic Ocean in 2019, while the MAGIC2020 campaign was limited to the ASA region. In 2021, the MAGIC campaign took place above the Artic Circle, in the region of Kiruna, involving three more laboratories (ONERA, NASA/JPL and King's College of London).

The MAGIC campaigns draw their originality from different aspects : *(1)* allowing a multi-instrument comparison to sound the atmosphere, involving 17 teams from 7 countries. *(2)* by its relative mobility in time and space, beeing able to follow the tracks of satellites which are into interests. *(3)* Giving information of the vertical composition of the atmosphere (up to 10km for airborne insruments and up to 35km for balloon-born instruments) in desired areas. *(4)* granting in-situ measurements to help to the comprehension of the dynamics of our atmosphere, preparing future satellites missions, and beyond exploring the capture and emission flows of GHG, essential to a better understanding of our climat.

In this poster, we present an evaluation of some IASI Level2 data using the different data obtained during the campaigns. Focus will be made on the evaluation of atmospheric temperature and water vapour profiles retrieved from IASI, as well as given by ECMWF ERA-Interim reanalysis. Profiles of trace and greenhouse gases made by balloon-borne instruments will also be used to evaluate CH_4 gas column retrieved from IASI, and to evaluate CO_2 given by CAMS forecasts.

References:

[1] Olivier Membrive et al, Atmos. Meas. Tech., 10, 2163–2181, 2017, doi.org/10.5194/amt-10-2163-2017

[2] M. Sprenger and H. Wernli, Geosci. Model Dev., 8, 2569–2586, 2015, doi:10.5194/gmd-8-2569-2015

[3] Characterizing atmospheric vertical distributions of thermodynamic variables and trace gases with combined ground-based and airborne measurements to validate space - Cyril Crevoisier [LMD]

[4] S10- 72 - Validation of weighted columns of CH4 and CO2 retrieved from space observations with balloon-borne AirCore - STAUFER Johannes [Thales Services Numérique]
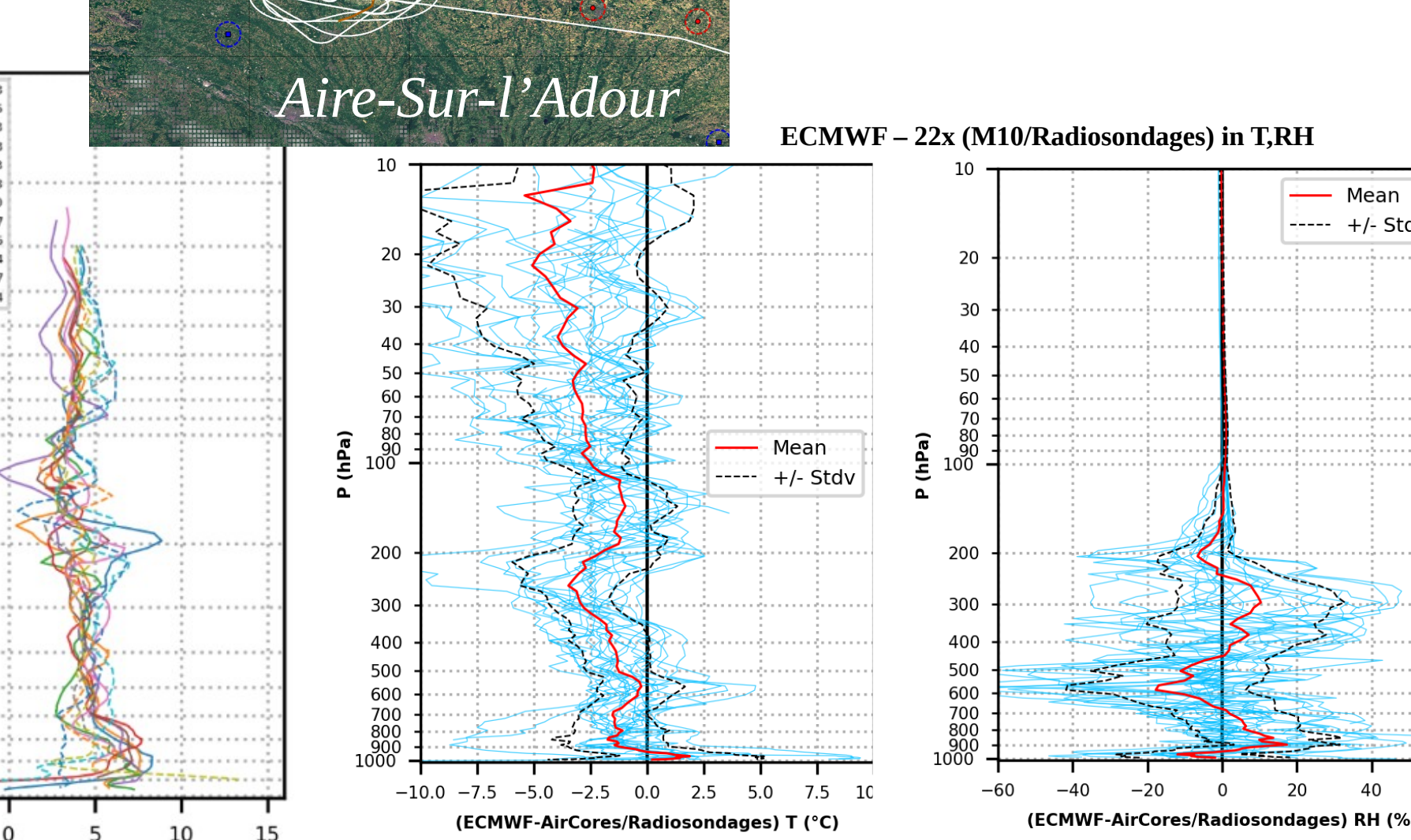
FOCUS ON THE MAGIC2019 CAMPAIGN
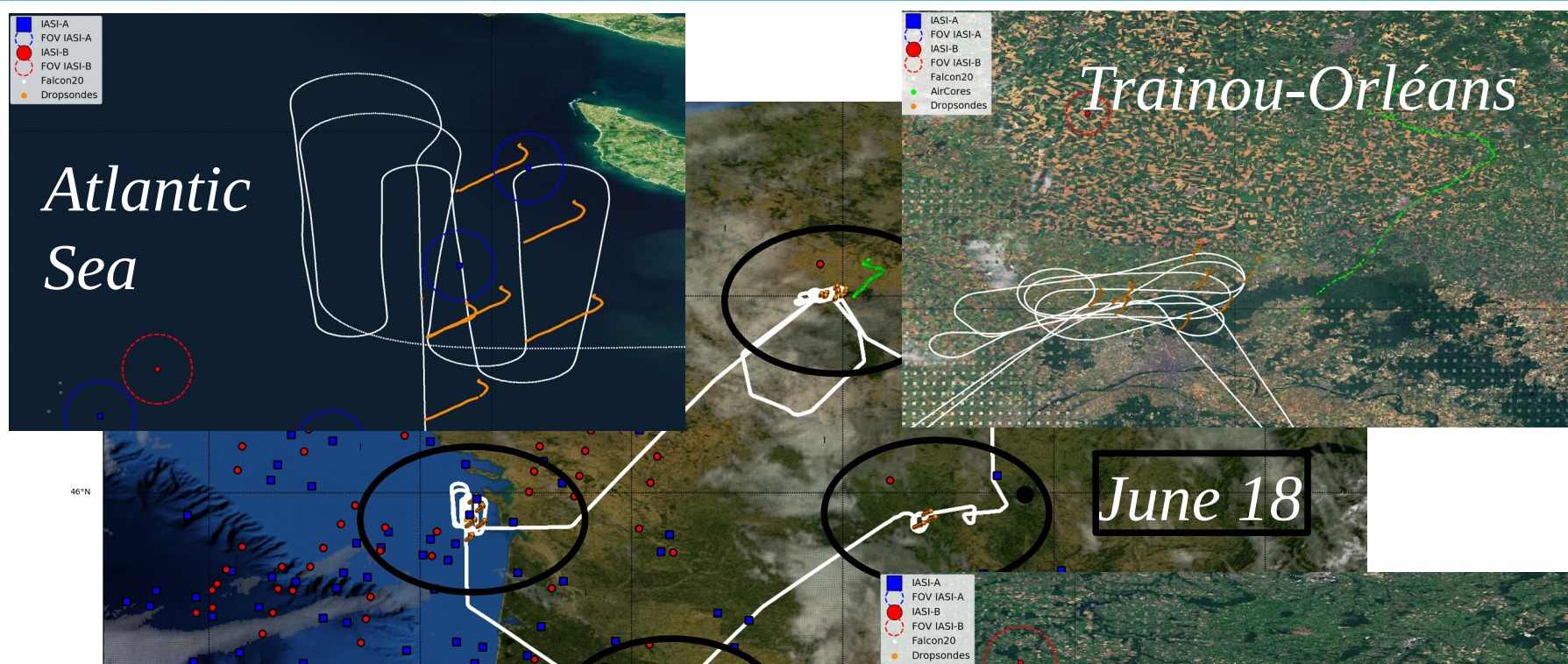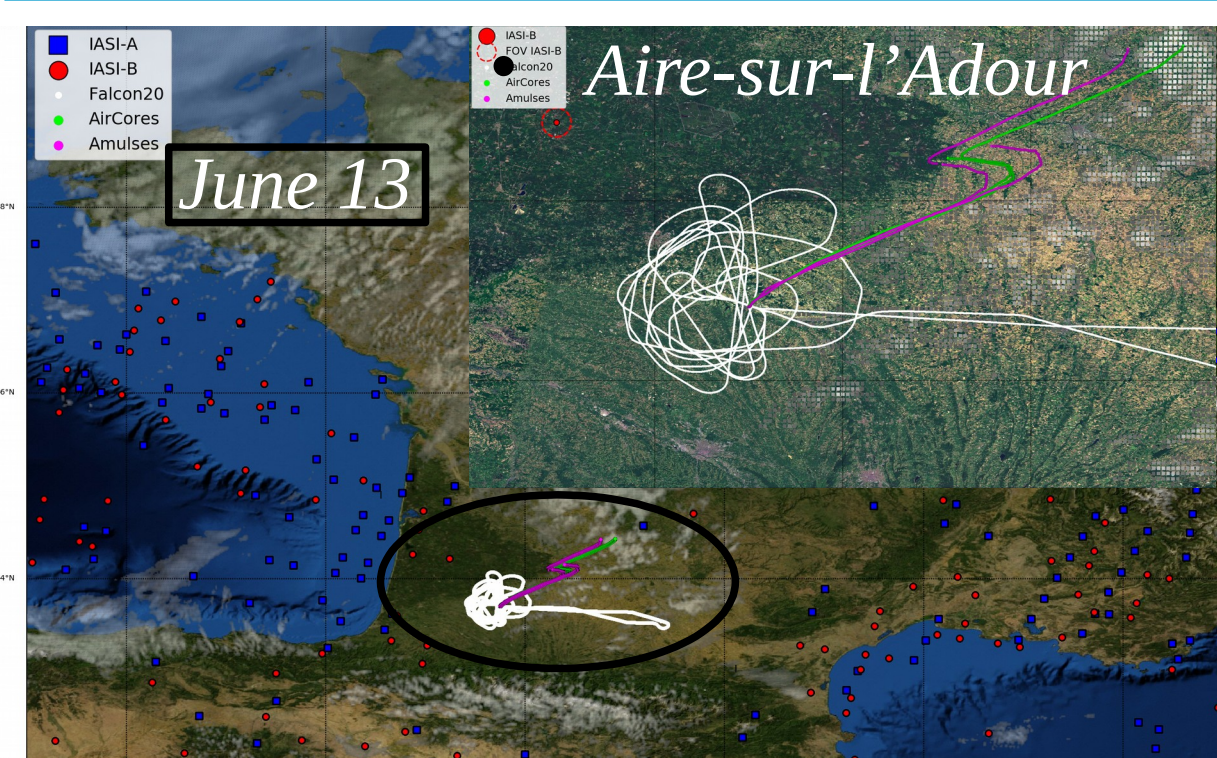
Illustrating the days of June 13 (left) and 18 (right), with Falcon flights above ASA, TRN, PDD and over the Atlantic Sea. Along with the launch of dropsondes, Amulses, AirCores along with M10 meteosondes and Radiosondages under BLD. Alltogether with the FOVs of IASI-A and IASI-B.
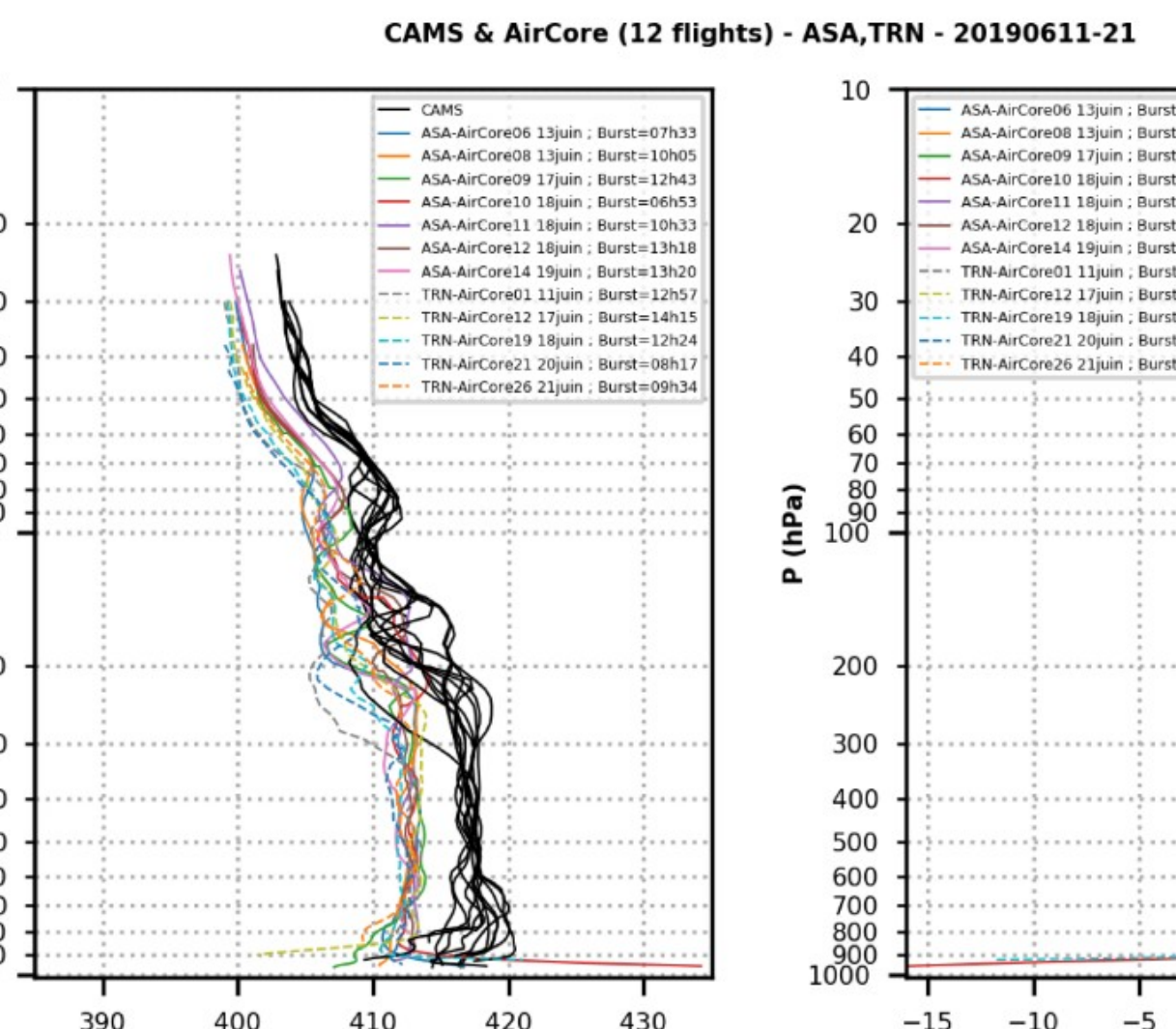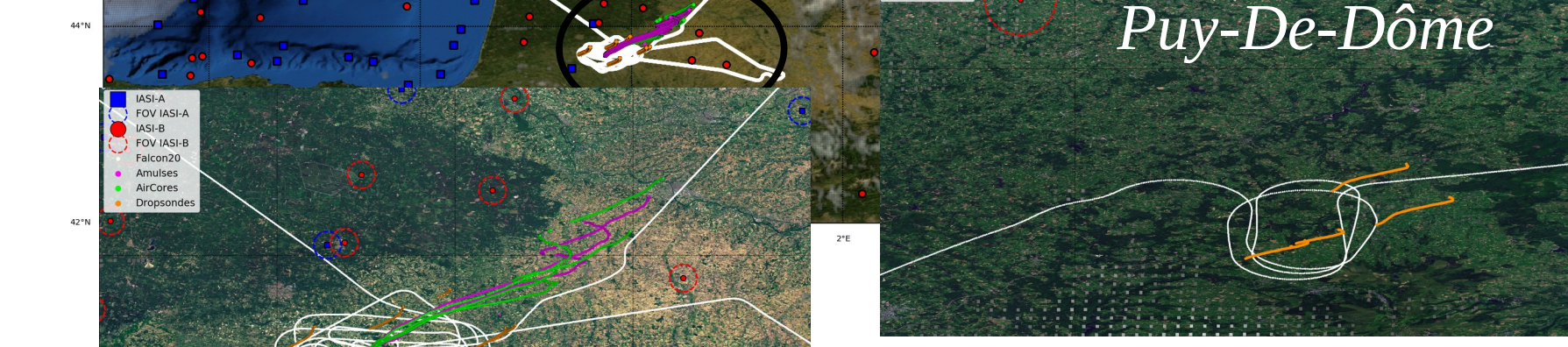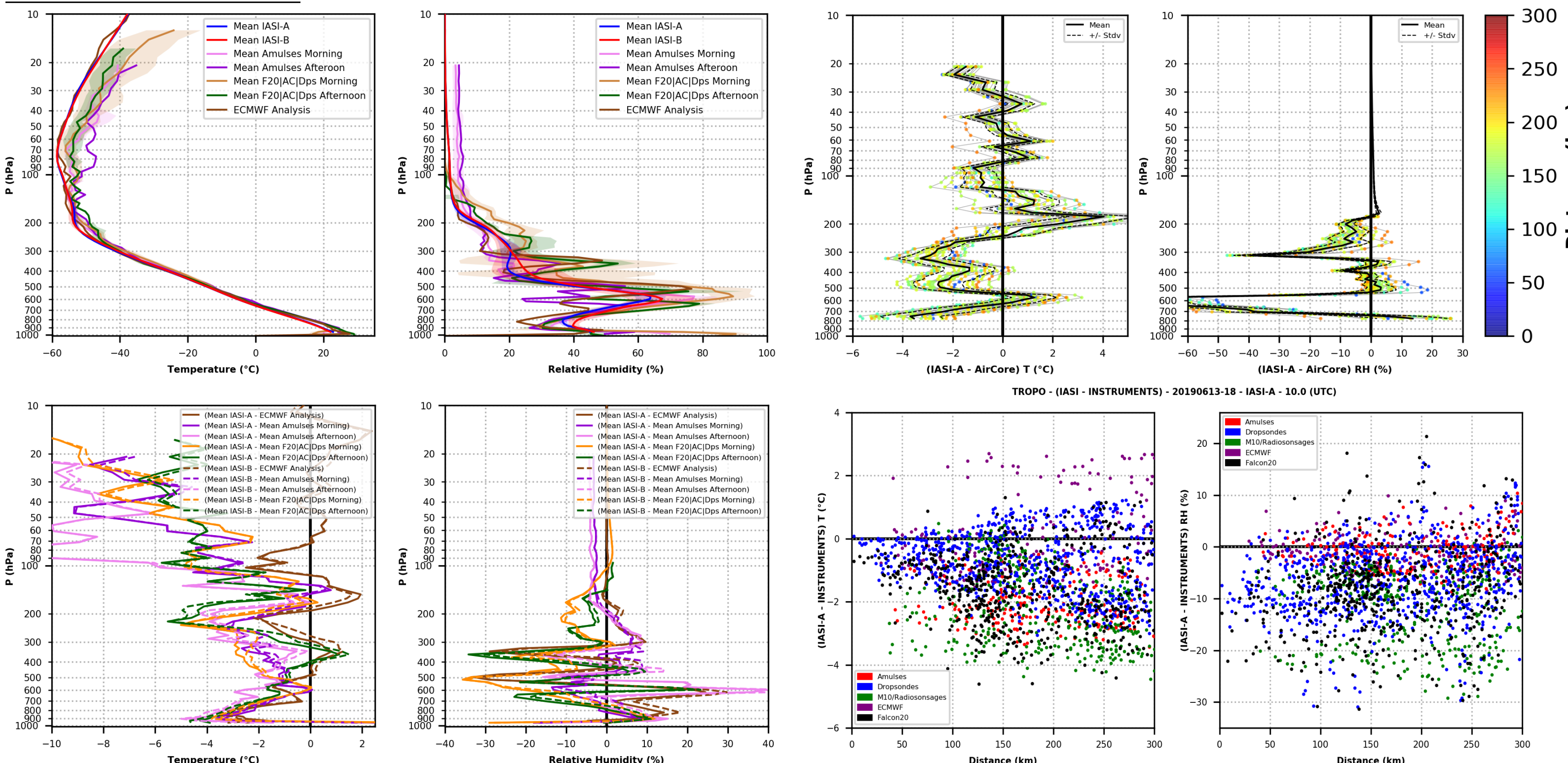

Comparison between all CO2 profiles measured by 12 AirCores and profiles from CAMS forecasts gwx3 (black). Bias of about 5 ppm over the entire column.

Comparison between all T,RH differences between 22 profiles issued from M10 meteosondes launched with AirCores, 2 indepedent sounding and profiles from ECMWF ERA-Interim reanalysis (black). Bias of -1.9 ± 2.49 °C in temperature and 0.5 ± 10.14% in relative humidity.

DESCRIBING SOME OF THE INSTRUMENTS INVOLVED

During the MAGIC2018-2019 campaigns, the Falcon20 ships flew, with notably onboard two G2401-m laser diode analyzers, developed by the company Picarro and allowed precise measurement of the concentration of CO2, CH4 and CO. This aircraft is mainly used for multidisciplinary research in the upper troposphere and low stratosphere. The SAFIRE unity also provided the ATR42 for the MAGIC2021 campaign in Sweden to provide GHG measurements along with measurement of flux with a lidar from ONERA. .

The AMULSE light laser diode spectrometer developed by the Group of molecular and atmospheric spectrometry (GSMA, CNRS / University of Reims Champagne-Ardenne) since 2014 allows the measurement of greenhouse gases (CO2, CH4 and H2O) under different types of platforms including weather balloons, captive balloons and drones. The principle of this instrument is based on direct absorption laser spectrometry coupled to Wavelength Modulation Spectroscopy (WF) spectrometry (2f / 1f) which allows accurate (<1%) and fast (<1s) measurement.

The AirCore flown during MAGIC campaigns is an atmospheric sampler based on an idea proposed by NOAA, and developed by the Laboratoire de Météorologie Dynamique (LMD, CNRS / Ecole Polytechnique/ENS Paris/Sorbonne University) , flying under a meteorological balloon. It allows the measurement of the vertical profiles (from the surface up to 35 km of altitude) of atmospheric concentration of greenhouse gases (CO2, CH4 and CO). It consists of a long tube of stainless steel placed under a meteorological balloon which, in the ascending phase, empties its air by its open end, to fill with air during its downward phase. The captured air column is then interpreted in terms of the vertical gas concentration profile using a Picarro type laser diode analyzer.

(IASI L2 – MAGIC measurements) T,RH comparisons for 2019

METHODOLOGY

We represent the mean profiles of T and RH for each instruments on June 18 in ASA, with the spatialy closest IASI-A and IASI-B profiles (up) and the difference (down). We separate the measurements in the morning and in the afternoon.

We look for every IASI-A profiles within a radius of 300km away from the {lat ,lon} mid-position of an AirCore profile, and make a difference in {T,RH} with IASI's profiles after adapting the M10 meteosonde profile to the pressure grid of IASI (top). For every profiles measured in the campaign, we calculate a mean difference on the troposphere (100-1013hPa) with every IASI-A profiles found within a 300km radius (bottom).

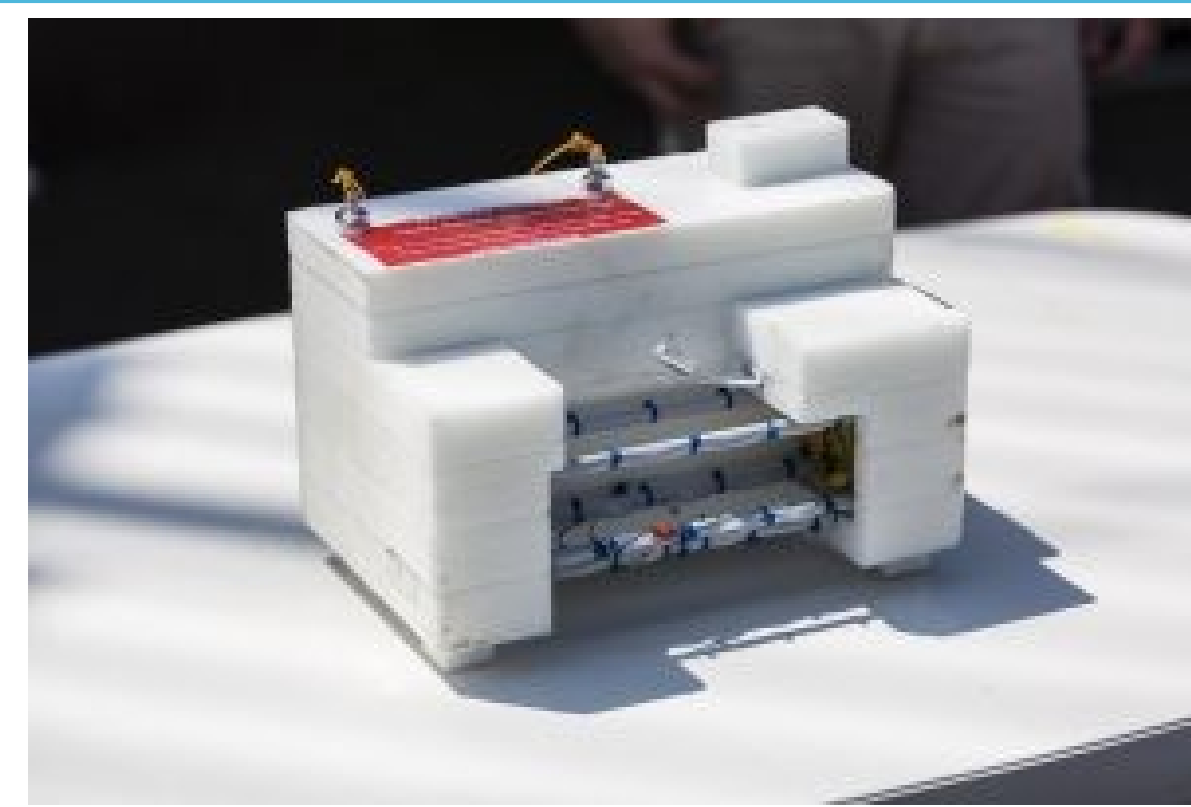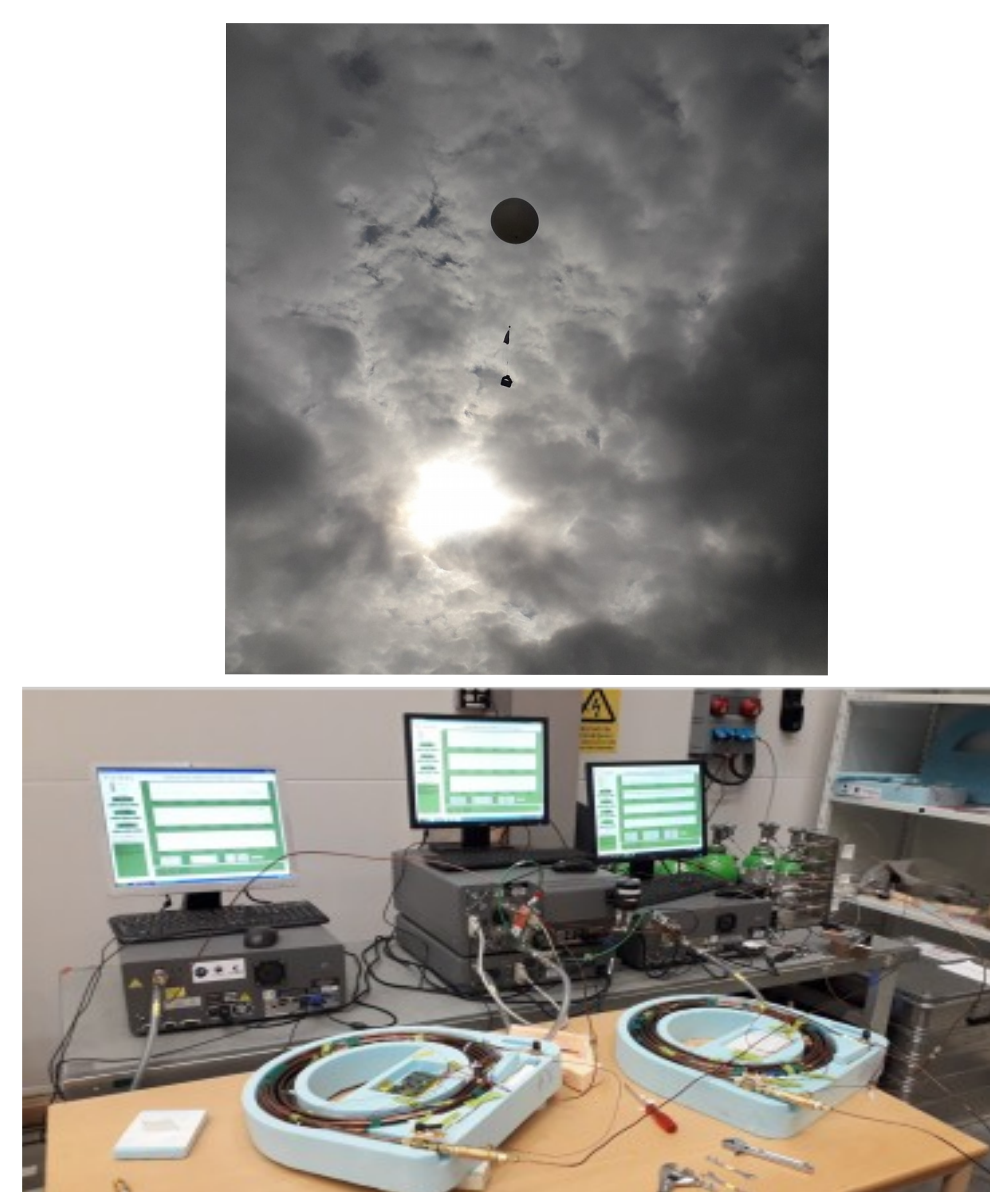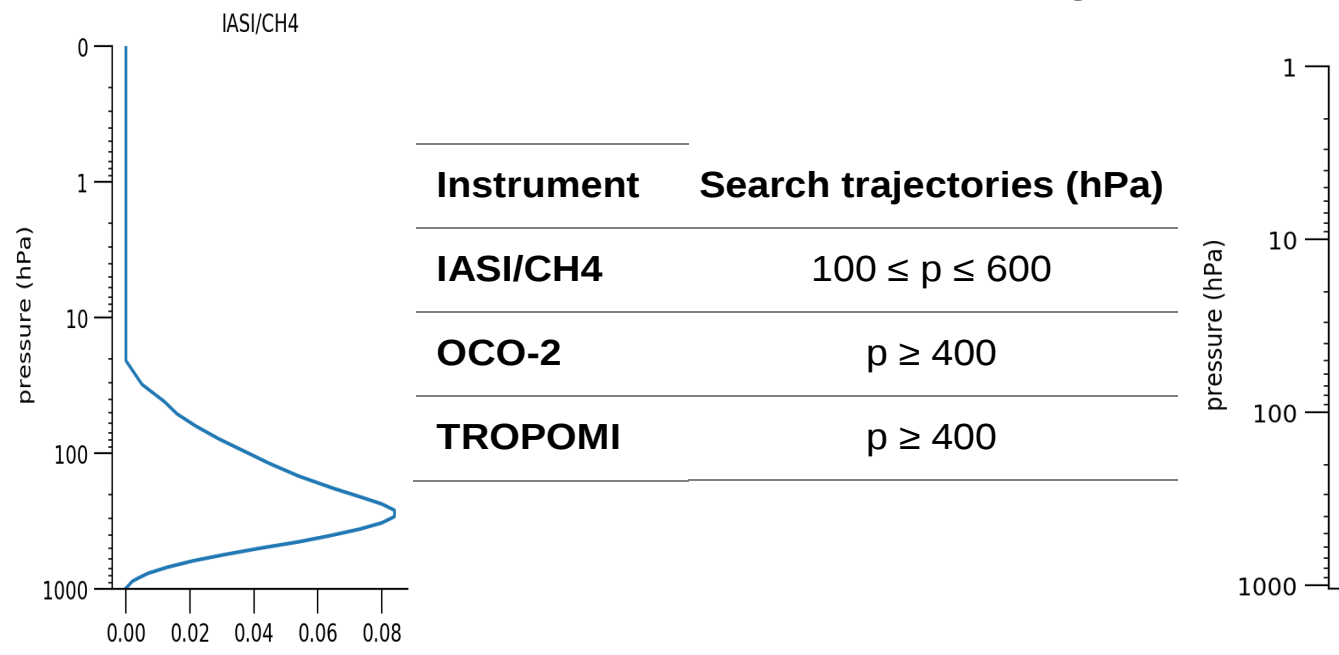### RESULTS
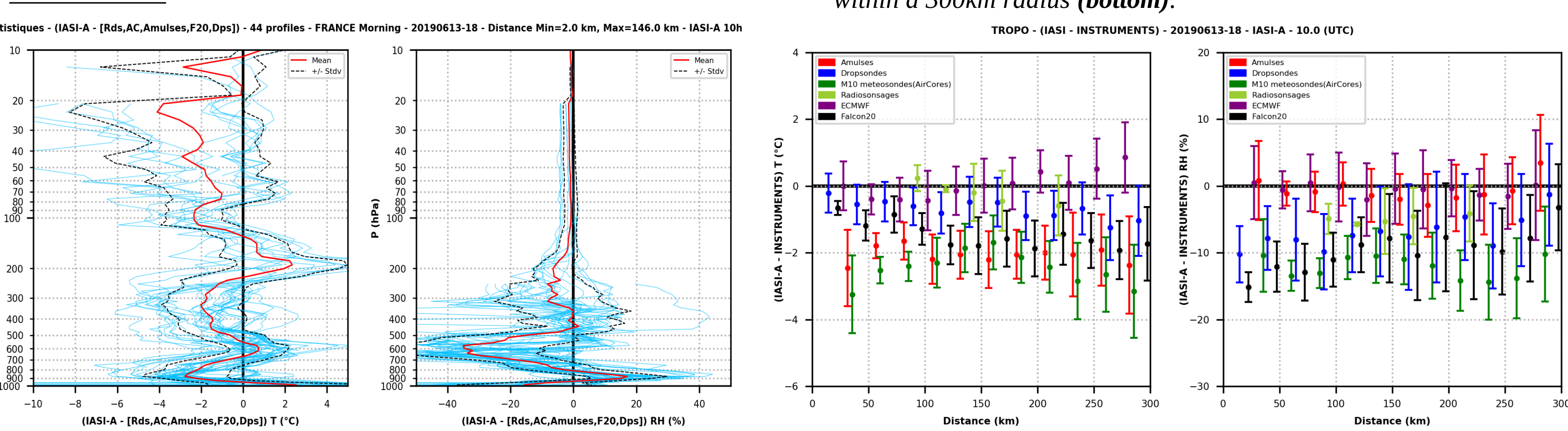
Comparison between **44 {T,RH} profiles** measured by M10 meteosondes launched with AirCores, Radiosondages, Dropsondes, Amulses, Falcon20, June 13 and 18 in the morning, and the closest IASI-A profile. Bias of **-0.97 ± 2.0 °C** in temperature and **-5.35 ± 9.28%** in relative humidity for the total column.

To account for the variability in space of IASI-A, we represent for a given instrument the difference in tropospheric T **(left)** and RH **(right)** between every profiles measured by a given instrument and all the IASI-A profiles encountered within a 300km radius. The panels show this difference as a function of the distance between all given instruments and IASI-A profiles, averaged on 25km bins (slight shift to differenciate instruments)

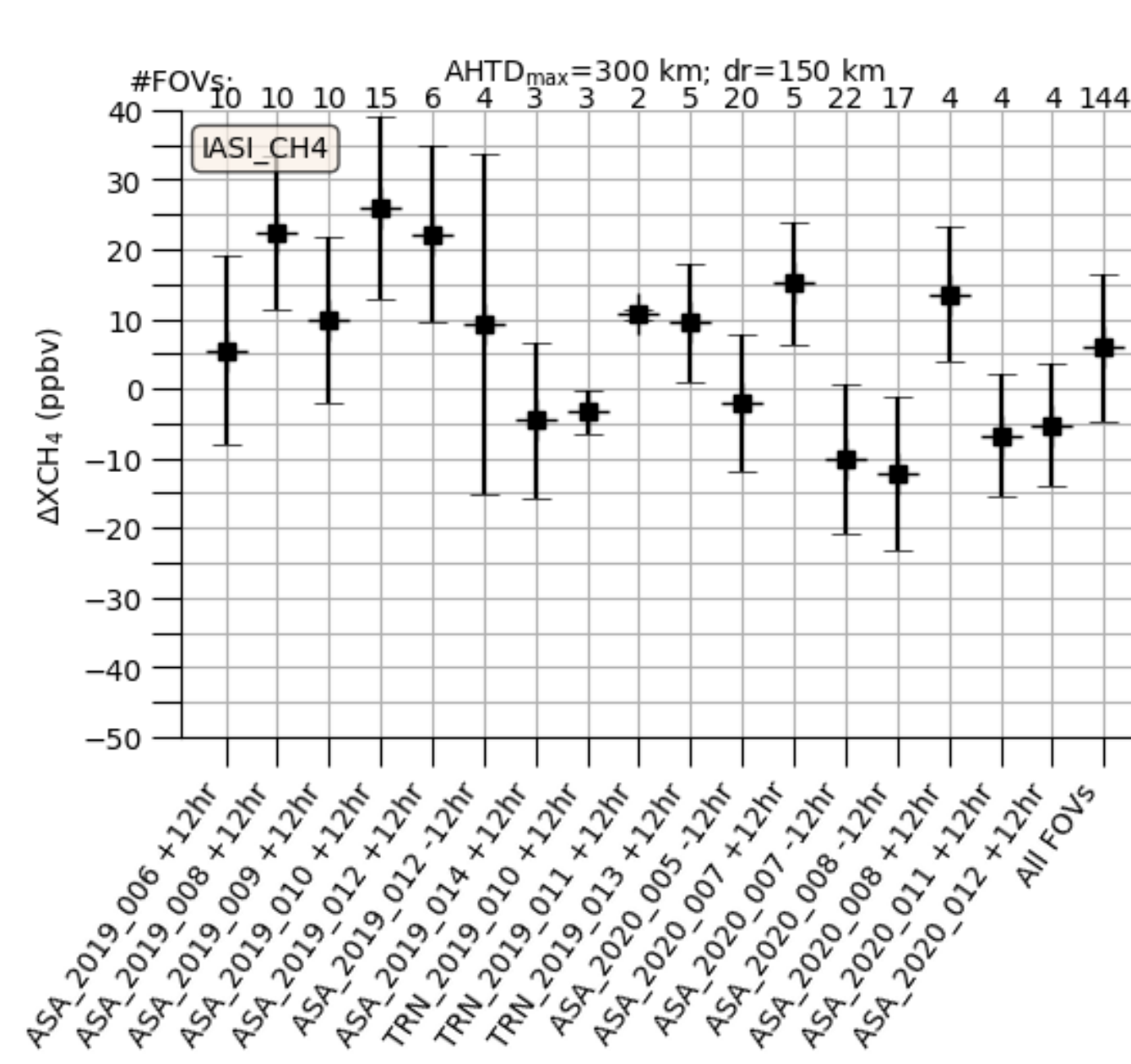## (IASI L2 – AirCores) XCH4 comparisons for 2019-2020

METHODOLOGY

LAGRANTO is an air mass colocalisation tool accounting for atmospheric horizontal transport. Also consider the vertical sensibility of GHG retrievals from satellites soundings.

- Initializing trajectories at the landing point of AirCore and its surrounding.
- Computing backward and forward trajectories (+/-12h) with LAGRANTO v2.5.
- ERA-5 (t,u,v,w,ps) at resolution 0,5°x0,5°, every 2h on 137lvl.
- AHTD computation (analyze divergence of trajectories).
- Vertical extension of profile with CAMS reanalysis hb0k.
- Finding colocation with 4 criteria :
  i) Trajectories forming a triangle, FOV within it
  ii) Distance between FOV and any trajectory <150km
  iii) Remove FOV too far from AirCore's landing point
  iv) Angle of triangle <145°
- Total column from AirCores takes IASI/CH4 weights into account.

Instrument	Search trajectories (hPa)
IASI/CH4	$100 \leq p \leq 600$
OCO-2	$p \geq 400$
TROPOMI	$p \geq 400$

RESULTS

15 different colocations were found between AirCores and at least one IASI FOV with the LAGRANTO method.

➤ This method is a compromise between the sample of FOVs to consider and the horizontal separation of trajectories.

➤ Using air parcel trajectories pushes the limits of usual colocation criteria, allowing further comparisons with AirCores separated in time and space with IASI FOVs.

➤ For IASI-C, a total of **144 FOVs** have been selected to compare with AirCores **(5.86 ± 10.49 ppb)**.

➤ This method shall be adapted for T and RH to see if we can reduce the dispersion in space observed with our comparisons between MAGIC's profiles and IASI's.

WARM THANKS TO ALL TEAMS AND CONTRIBUTORS INVOLVED IN THE MAGIC CAMPAIGNS