Preparation of the validation of the MicroCarb and Merlin satellite missions using FTS measurements

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## 2 GHG space missions

<table>
<thead>
<tr>
<th></th>
<th>MERLIN</th>
<th>MicroCarb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Partners</td>
<td>joint French and German space mission</td>
<td>Joint French, UK, and Eumetsat</td>
</tr>
<tr>
<td>Launch</td>
<td>mid-2024.</td>
<td>2021</td>
</tr>
<tr>
<td>Main product: dry-air mixing ratio columns</td>
<td>XCH4</td>
<td>XCO2</td>
</tr>
<tr>
<td>Precision</td>
<td>22 ppb</td>
<td>1 ppm</td>
</tr>
<tr>
<td>Systematic error</td>
<td>3 ppb</td>
<td>0.1 ppm</td>
</tr>
</tbody>
</table>

### Performances to be checked

### Goals of Validation

- Evaluate the performance of the products in relation to the requirements of the mission before making them available to the scientific community.
- Evaluate the quality of the data by comparing the products to the data of other sensors considered as a reference.
MAGIC 2019 campaign

- Preparing validation activities for future GHG missions (Merlin, MicroCarb and IASI-NG)
- Establish the merits of various instrumentations to study CH4 and CO2 and other variables
- Dates: 11-21 June 2019, 3 flights and deployment over 10 days in France
- 7 laboratories: LMD, LSCE, LERMA, LOA, GSMA, LPC2E, OPGC
- Instruments:
  - 3 balloons sites for atmospheric samplers (CO2 and CH4 profiles)
    - AirCore (LMD) (air sampler)
    - Amulse (GSMA) (spectrometer)
  - SAFIRE Falcon 20
    - Picarros and other instruments: 4 sounding sites
  - 6 Fourier Transform Spectrometers (XCO2 and XCH4): 2 TCCON stations, CHRIS (LOA), and 4 EM27

https://magic.aeris-data.fr
EM27 deployment during the MAGIC 2019 campaign

- All part of the Collaborative Carbon Column Observing Network initiated by KIT
- Review of instruments performance and characteristics performed at KIT:
  - Alignement
  - ILS measurements
- PROFFAST software for GHG retrieval
MAGIC 2019 : Total columns retrieved from the EM27 spectra using PROFFAST

- Creation of EM27 (FTS) Magic Working group:
  - Improve the use of this new instrument
  - Entities involved: LERMA, LSCE, GSMA, LOA, LMD, CNES

Data acquisition : LERMA and LMD, Processing LSCE
EM27 spectra processing: Columns retrieval principle using PROFFAST code

An automatized processing chain using PROFFAST has been developed by the LSCE.
Sensitivity study: NCEP vs CAMS prior

ΔXCO2 = 0.01 ppm
ΔXCH4 = 0.59 ppb
ΔXCO = 1.01 ppb
ΔXH2O = -0.65 ppm

**Processing LSCE**

<table>
<thead>
<tr>
<th>APRIORI</th>
<th>CAMS (European)</th>
<th>TCCON - NCEP (US)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resolution</td>
<td>0.1 * 0.1 degree</td>
<td>2.5 * 2.5 degree</td>
</tr>
<tr>
<td>Vertical levels</td>
<td>137</td>
<td>70</td>
</tr>
</tbody>
</table>
EM27 intercomparison in Paris (Jussieu – July 2019)

Set up LERMA
Processing LSCE

© Pascal Jeseck, Yao Té (Lerma)

WMO targeted compatibility
CO2 0.1 ppm
CH4 2 ppb
CO 2 ppb
2 EM27 intercomparison over time

- **Trainou [2 days, sept 2018]**
  \[ \Delta X_{CO2} = X_{CO2} \text{ (EM27#88-LSCE)} - X_{CO2} \text{ (EM27#92-CNES)} = 0.12 \text{ ppm } +/- 0.1 \text{ ppm} \]
  \[ \Delta X_{CH4} = X_{CH4} \text{ (EM27#88)} - X_{CH4} \text{ (EM27#92)} = 1.6 \text{ ppb } +/- 0.58 \text{ ppb} \]

- **Jussieu [3 days, oct 2018]**
  \[ \Delta X_{CO2} = 0.18 \text{ ppm } +/- 0.12 \text{ ppm} \]
  \[ \Delta X_{CH4} = 1.7 \text{ ppb } +/- 0.78 \text{ ppb} \]

- **Saclay [2 days, feb 2019]**
  \[ \Delta X_{CO2} = 0.05 \text{ ppm } +/- 0.20 \text{ ppm} \]
  \[ \Delta X_{CH4} = 0.56 \text{ ppb } +/- 0.90 \text{ ppb} \]

- **Jussieu [4 days, july 2019]**
  \[ \Delta X_{CO2} = 0.13 \text{ ppm } +/- 0.15 \text{ ppm} \]
  \[ \Delta X_{CH4} = 1.7 \text{ ppb } +/- 0.83 \text{ ppb} \]

Measurements: LSCE and LERMA
Processing: LERMA

Measurement differences between the same two instruments vary a little over time.
EM27 vs TCCON in Paris (Jussieu – July 2019)

Preliminary

EM27 vs TCCON-HR + 4' mean

EM27-KIT 1' :
\[ X_{CO2} = 409.35 \pm 0.34 \text{ ppm} \]

TCCON-HR 1' :
\[ \Delta X_{CO2} = 0.33 \text{ ppm} \]
\[ X_{CO2} = 409.02 \pm 0.66 \text{ ppm} \]

TCCON-HR 4' mean @ 11h-13h :
\[ X_{CO2} = 408.84 \pm 0.32 \text{ ppm} \]
\[ \Delta X_{CO2} = 0.51 \text{ ppm} \]

EM27-KIT 1' :
\[ X_{CH4} = 1840.47 \pm 1.47 \text{ ppb} \]

TCCON-HR 1' :
\[ \Delta X_{CH4} = -6 \text{ ppb} \]
\[ X_{CH4} = 1846.48 \pm 3.47 \text{ ppb} \]

TCCON-HR 4' mean @ 11h-13h :
\[ X_{CH4} = 1847.98 \pm 1.39 \text{ ppb} \]
\[ \Delta X_{CH4} = -7.51 \text{ ppb} \]

Integration duration : TCCON-Orléans: 4' TCCON-Paris: 1'

Set up and processing : LERMA
EM27 vs TCCON in Paris (Jussieu – July 2019)

EM27-KIT:  
\[ \text{XCO}_2 = 409.35 \pm 0.34 \text{ ppm} \]

TCCON-LR:  
\[ \text{XCO}_2 = 408.52 \pm 0.39 \text{ ppm} \]

\[ \Rightarrow \Delta \text{XCO}_2 \sim 0.83 \text{ ppm} \]

EM27-KIT:  
\[ \text{XCH}_4 = 1840.47 \pm 1.47 \text{ ppb} \]

TCCON-LR:  
\[ \text{XCH}_4 = 1845.54 \pm 1.71 \text{ ppb} \]

\[ \Rightarrow \Delta \text{XCH}_4 \sim -4.96 \text{ ppb} \]
Futur work of the working group

- 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.

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

- 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 2020, France.
Thanks