# The first year of COCCON EM27/SUN operation in Rome

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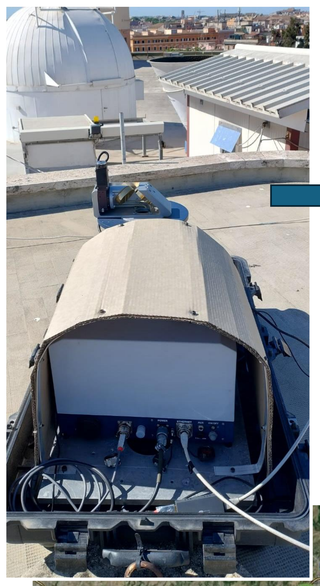
**Abstract**

In the framework of the collaboration between the European Space Agency (ESA) and the Karlsruhe Institute of Technology (KIT) and in the context of the COllaborative Carbon Column Observing Network activities[1], in June 2023 an EM27/Sun FTIR spectrometer was installed in the Atmospheric Physics Laboratory (APL, 41.90° N, 12.51° E) of Sapienza University, Rome downtown. It is the first instrument of this type operating in Italy. The APL site is part of the "Boundary-layer Air Quality-analysis Using Network of Instruments" supersite[2] and was selected as specific urban site thanks to its favourable position and the simultaneous operation of the BAQUNIN instrumental suite (Iannarelli et al., 2022[3]). Since then, the BAQUNIN team performed measurements in cloud free conditions, and processed the acquired measurements using the PROFFAST v2.4 software[4] and PROFFASTpylot v1.3 software[5] to retrieve accurate information about the greenhouse gas (GHG) columnar amounts of $H_2O$, CO, $CO_2$ and $CH_4$, with the aim of monitoring the daily evolution of such species in the urban environment and to provide high quality GHG data for satellite Cal/Val purposes. This work presents the instrumental setup of the *COCCON-Rome* site, reports on the retrieved GHG abundances acquired during the first year of operation, and provides a preliminary comparison with independent data sources, like AERONET[6] for $H_2O$, and the new JAXA Earth Observation Research Center (EORC)[7] GOSAT and GOSAT-2 GHG products obtained through ad hoc designed satellite observation patterns.

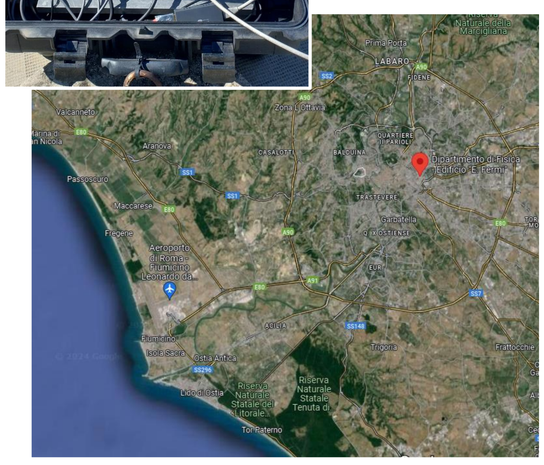
## 1. EM27/Sun in BAQUNIN APL

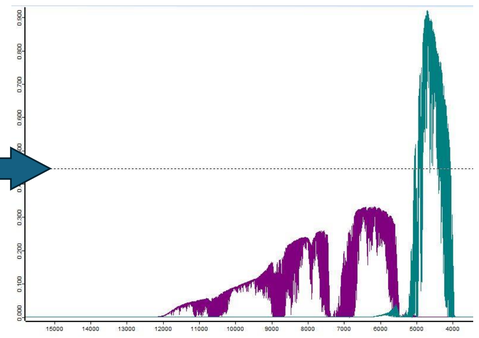


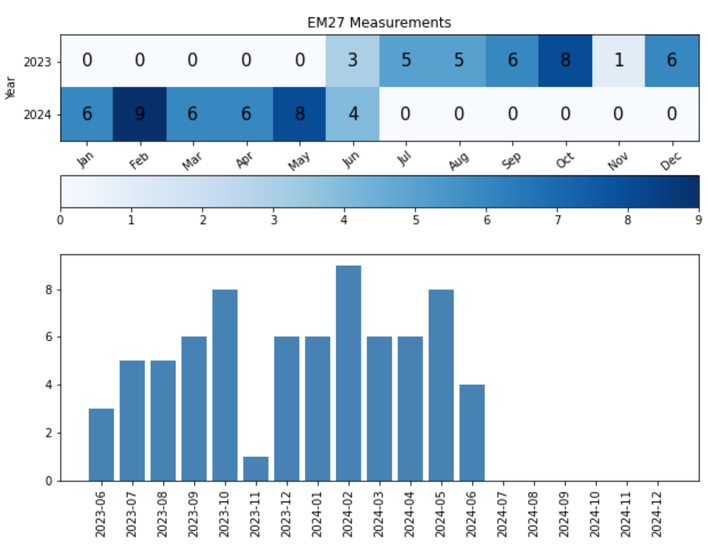
| BAQUNIN APL | |
|---|---|
| Latitude [deg] | 41.902 |
| Longitude [deg] | 12.516 |
| Altitude [km] | 0.077 |

Measurement start:
**22/06/2023**

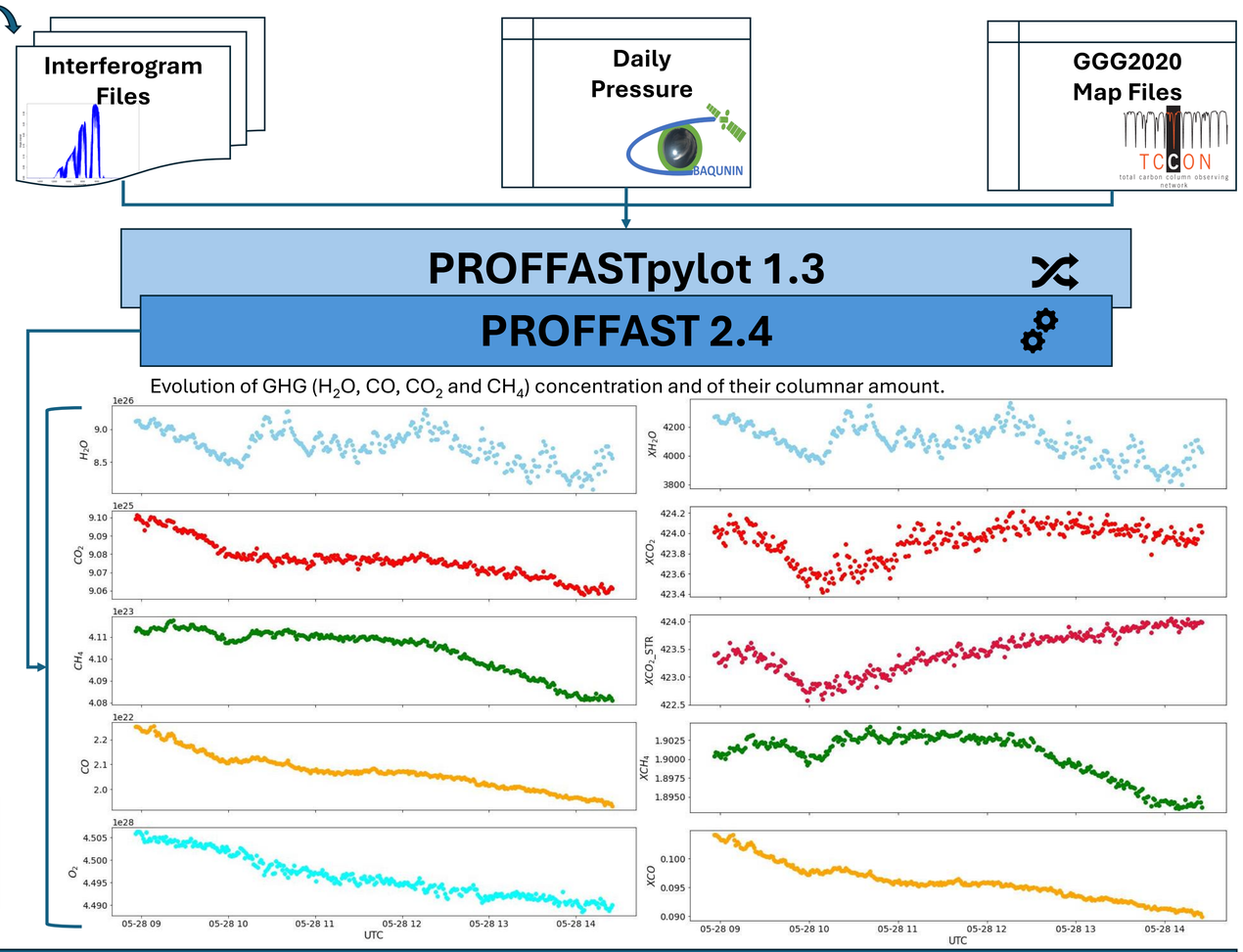
*EM27/SUN on the rooftop of Physics Dept. in Sapienza University*



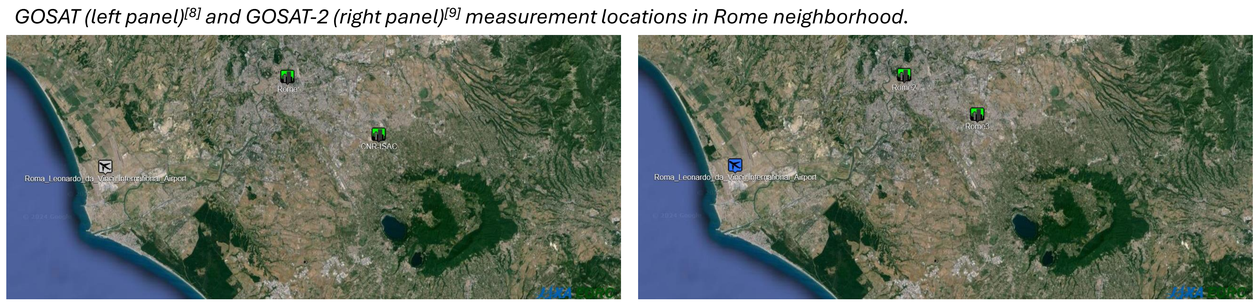



## 2. Data Processing

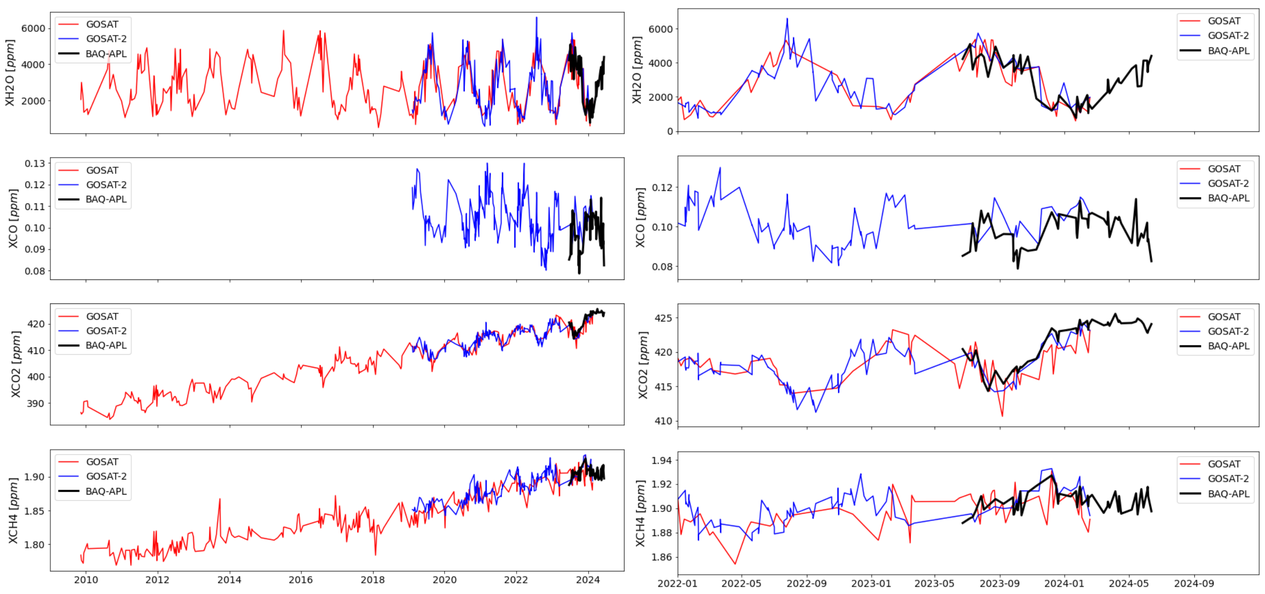



## 3. GHG matchups: COCCON, GOSAT and GOSAT-2

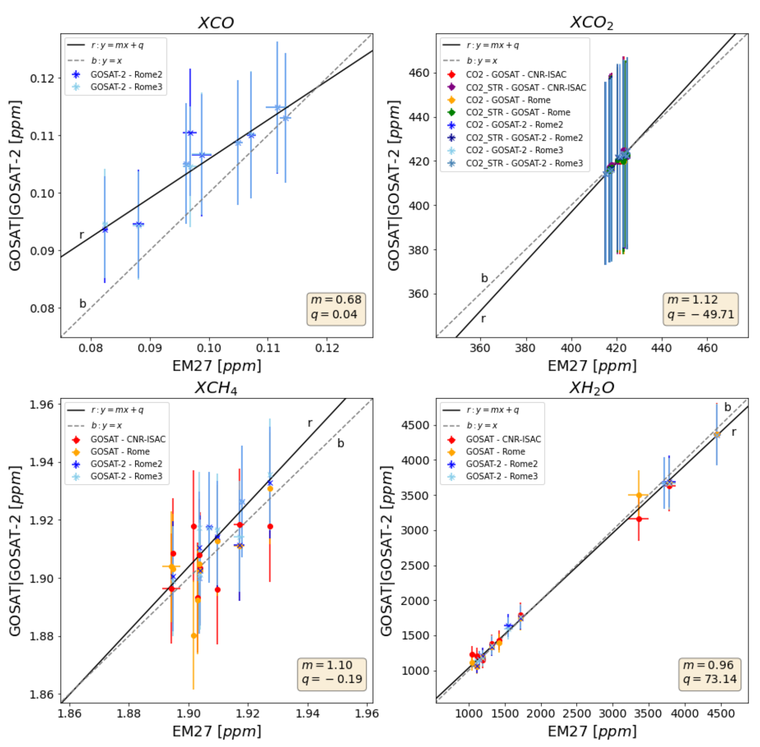
*GOSAT (left panel)[8] and GOSAT-2 (right panel)[9] measurement locations in Rome neighborhood.*




*GHG measurements of GOSAT (Rome site in red) and GOSAT-2 (Rome2 site in blue) compared with EM27/SUN measurements (black). EM27/SUN measurements have been averaged in a 1-hour time window around GOSAT/GOSAT-2 overpasses.*




*GOSAT/GOSAT-2 vs EM27/SUN measurement per columnar amount of GHG species. Uncertainties on GOSAT measurements taken from Kuze et al., 2022[10].*

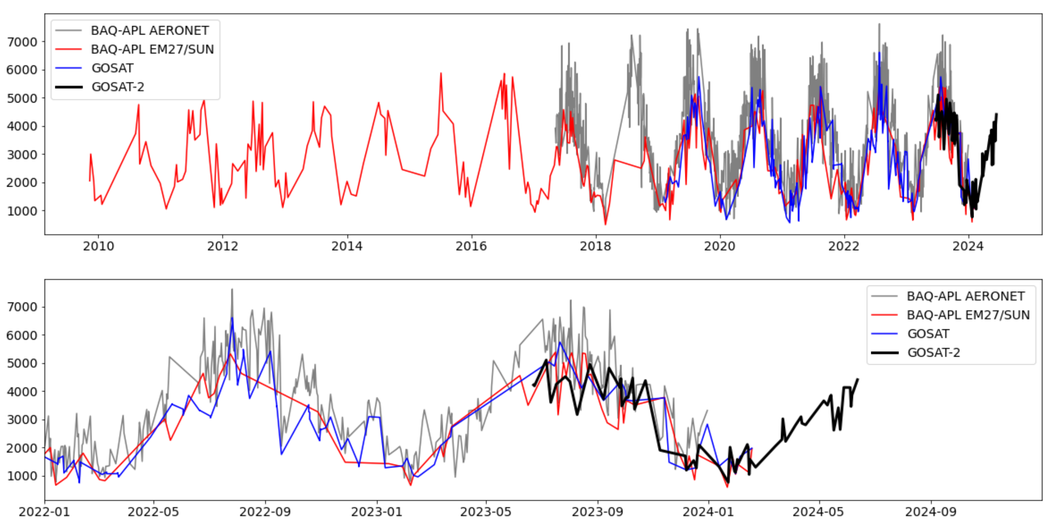



$$d = M_E - M_{G/G2}$$

$$D = 100\frac{M_E - M_{G/G2}}{M_E}$$

| | GOSAT CNR/ISAC | GOSAT Rome | GOSAT-2 Rome2 | GOSAT-2 Rome3 |
|---|---|---|---|---|
| BIAS d(XCO) | - | - | -0.006 | -0.006 |
| STD d(XCO) | - | - | 0.004 | 0.004 |
| BIAS d($XCO_2$) | 0.6 | 1.6 | 0.8 | 0.7 |
| STD d($XCO_2$) | 1.2 | 0.9 | 0.7 | 0.9 |
| BIAS d($XCH_4$) | -0.001 | 0.001 | -0.004 | -0.005 |
| STD d($XCH_4$) | 0.01 | 0.01 | 0.005 | 0.006 |
| BIAS d($XH_2O$) | 6.1 | 3.4 | 13.3 | 13.0 |
| STD d($XH_2O$) | 116 | 75 | 58 | 59 |
| BIAS D(XCO) | - | - | -6.8 | -6.3 |
| STD D(XCO) | - | - | 4.7 | 4.2 |
| BIAS D($XCO_2$) | 0.1 | 0.4 | 0.2 | 0.2 |
| STD D($XCO_2$) | 0.3 | 0.2 | 0.2 | 0.2 |
| BIAS D($XCH_4$) | -0.03 | 0.08 | -0.2 | -0.2 |
| STD D($XCH_4$) | 0.5 | 0.5 | 0.3 | 0.3 |
| BIAS D($XH_2O$) | -2.2 | -0.1 | -0.1 | -0.3 |
| STD D($XH_2O$) | 7.1 | 3.6 | 2.8 | 2.3 |

## 4. $XH_2O$ matchups: AERONET, GOSAT and GOSAT-2




*AERONET CIMEL dataset (hosted in BAQUNIN APL[2]) has been firstly expressed into ppm and then managed as for the EM27/SUN.*

*$XH_2O$ trends of GOSAT (Rome site) have been reported in red, GOSAT-2 (Rome2 site) in blue, AERONET is the grey series and EM27/SUN the black one.*

## 5. References

1. **COCCON web site**, https://www.imk-asf.kit.edu/english/COCCON.php
2. **BAQUNIN web site**, https://www.baqunin.eu/
3. **Iannarelli et al., 2022**, A. M. Iannarelli, A. Di Bernardino, S. Casadio, C. Bassani, M. Cacciani, M. Campanelli, G. Casasanta, E. Cadau, H. Diémoz, G. Mevi, A. M. Siani, M. Cardaci, A. Dehn, P. Goryl, "The Boundary Layer Air Quality-Analysis Using Network of Instruments (BAQUNIN) Supersite for Atmospheric Research and Satellite Validation over Rome Area". Bull. Am. Meteorol. Soc. 2022, 103, E599–E618, https://doi.org/10.1175/BAMS-D-21-0099.1
4. **PROFFAST v2.4 web page**, https://www.imk-asf.kit.edu/english/3225.php
5. **PROFFASTpylot v1.3 documentation**, https://www.imk-asf.kit.edu/english/4261.php
6. **AERONET web site**, https://aeronet.gsfc.nasa.gov/
7. **EORC web site**, https://www.eorc.jaxa.jp/GOSAT/index.html
8. **GHG Trend Viewer with GOSAT long-term target observations**, https://www.eorc.jaxa.jp/GOSAT/CO2_monitor/index_Ver.K.html
9. **GHG Trend Viewer with GOSAT-2 long-term target observations,** https://www.eorc.jaxa.jp/GOSAT/CO2_monitor/index_Ver.K.G2.html
10. **Kuze et al., 2022**, A. Kuze, Y. Nakamura, T. Oda, J. Yoshida, N. Kikuchi, F. Kataoka, H. Suto, K. Shiomi, "Examining partial-column density retrieval of lower-tropospheric $CO_2$ from GOSAT target observations over global megacities". Remote Sensing of Environment, 273 (2022 ), Article 112966, https://doi.org/10.1016/j.rse.2022.112966