

Scaling up EM27 Operation Using Automation

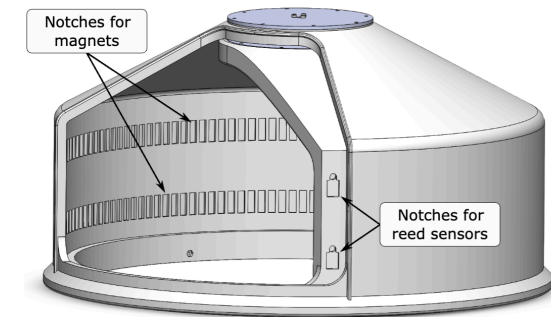
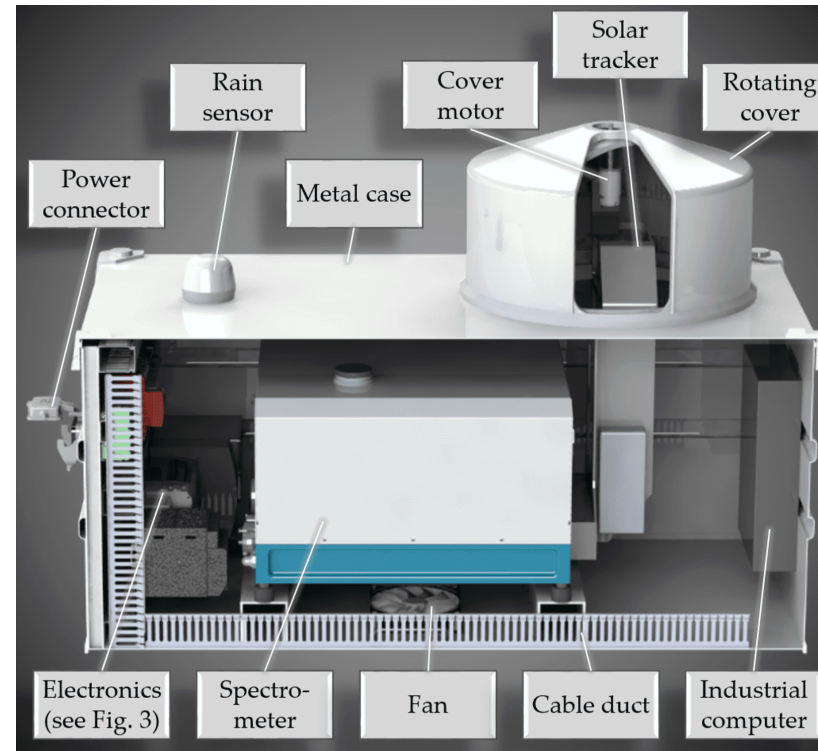
# TUM's EM27 Retrieval Pipeline

Technical University of Munich | Prof. Jia Chen

Professorship of Environmental Sensing and Modeling

**Moritz Makowski, 6 June 2024**

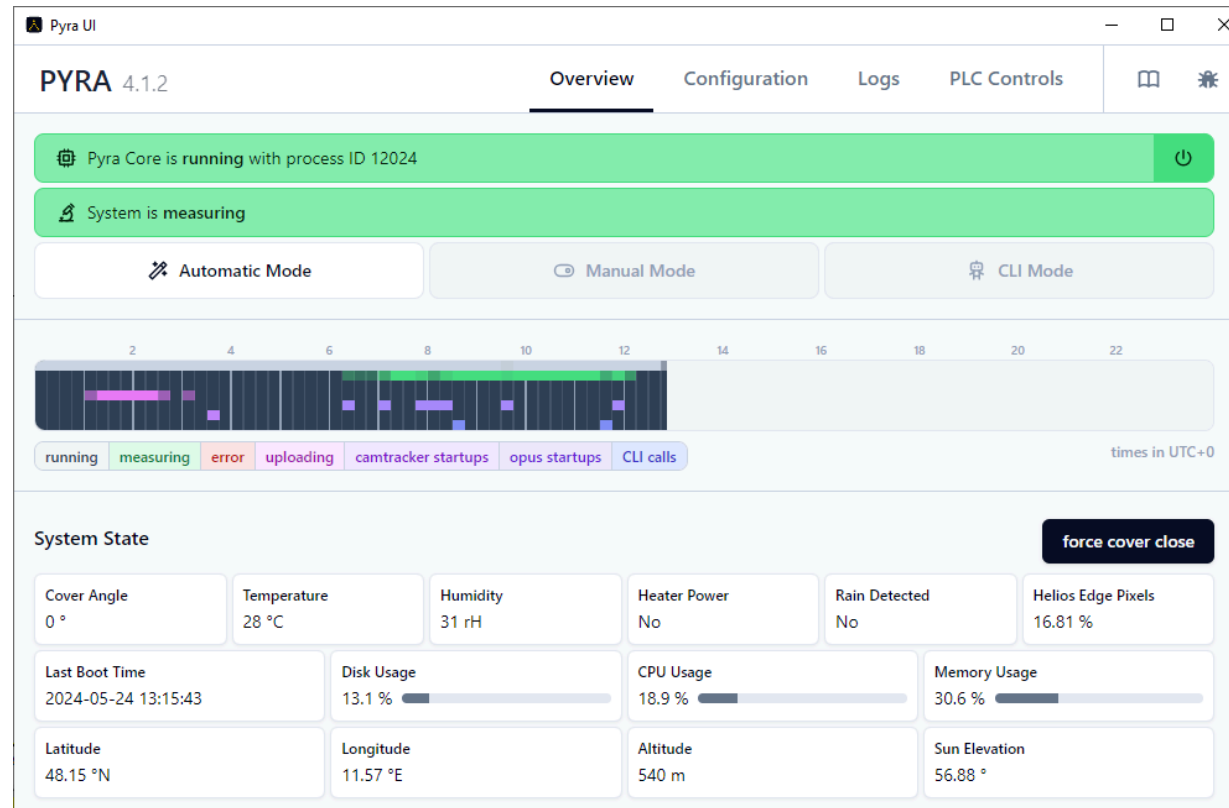
# EM27 Automation Stack: Enclosure Hardware & Software



**Heinle and Chen:** Automated Enclosure and Protection System for Compact Solar-Tracking Spectrometers. Atmos. Meas. Tech., 2018, <https://doi.org/10.5194/amt-11-2173-2018>

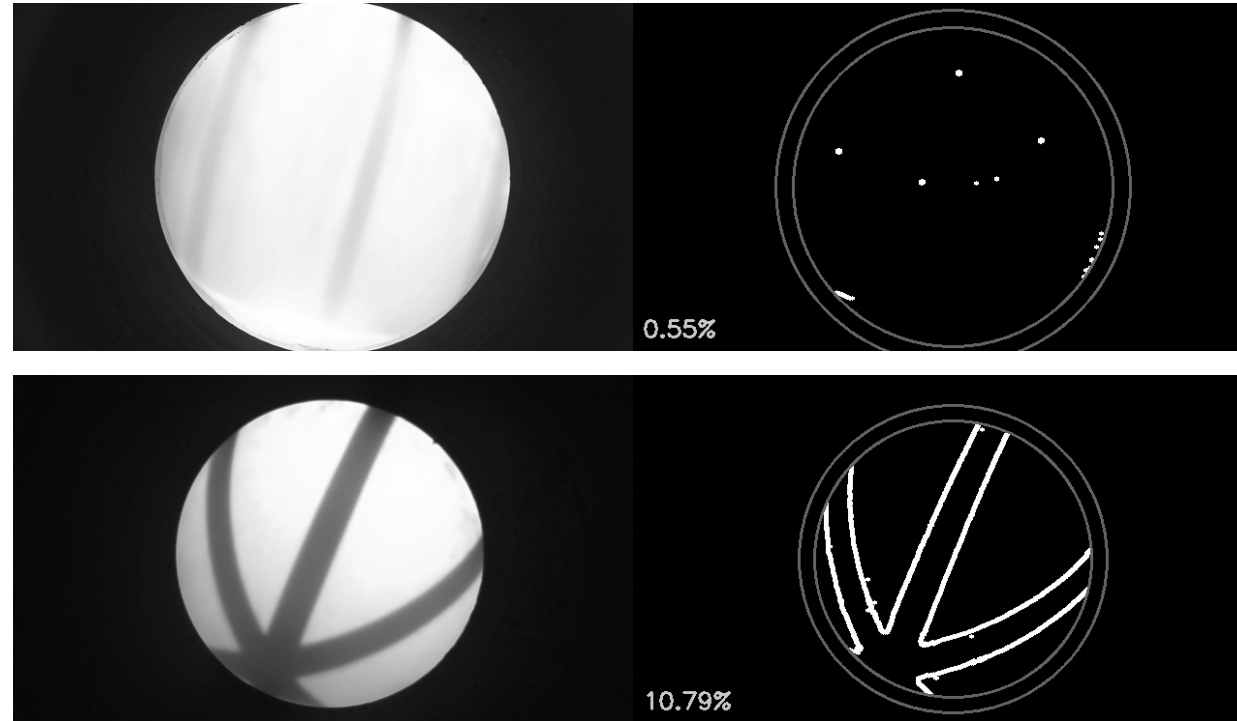
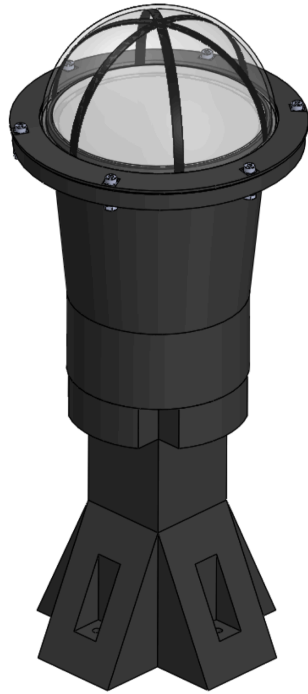
**Dietrich, Chen et al.:** MUCCnet: Munich Urban Carbon Column network. Atmos. Meas. Tech., 2021, <https://doi.org/10.5194/amt-14-1111-2021>

# EM27 Automation Stack: Pyra



**Aigner, Makowski et al.:** Pyra: Automated EM27/SUN Greenhouse Gas Measurement Software. Journal of Open Source Software, 2023, <https://doi.org/10.21105/joss.05131>

# EM27 Automation Stack: Helios



**Voggenreiter:** VBDS - A Vision-Based Direct Sunlight Detector and Its Integration into Pyra, Master Thesis, 2019

**Makowski:** Improving the Evaluation of Sun Conditions in PYRA 4 (Helios), Interdisciplinary Practical, 2023

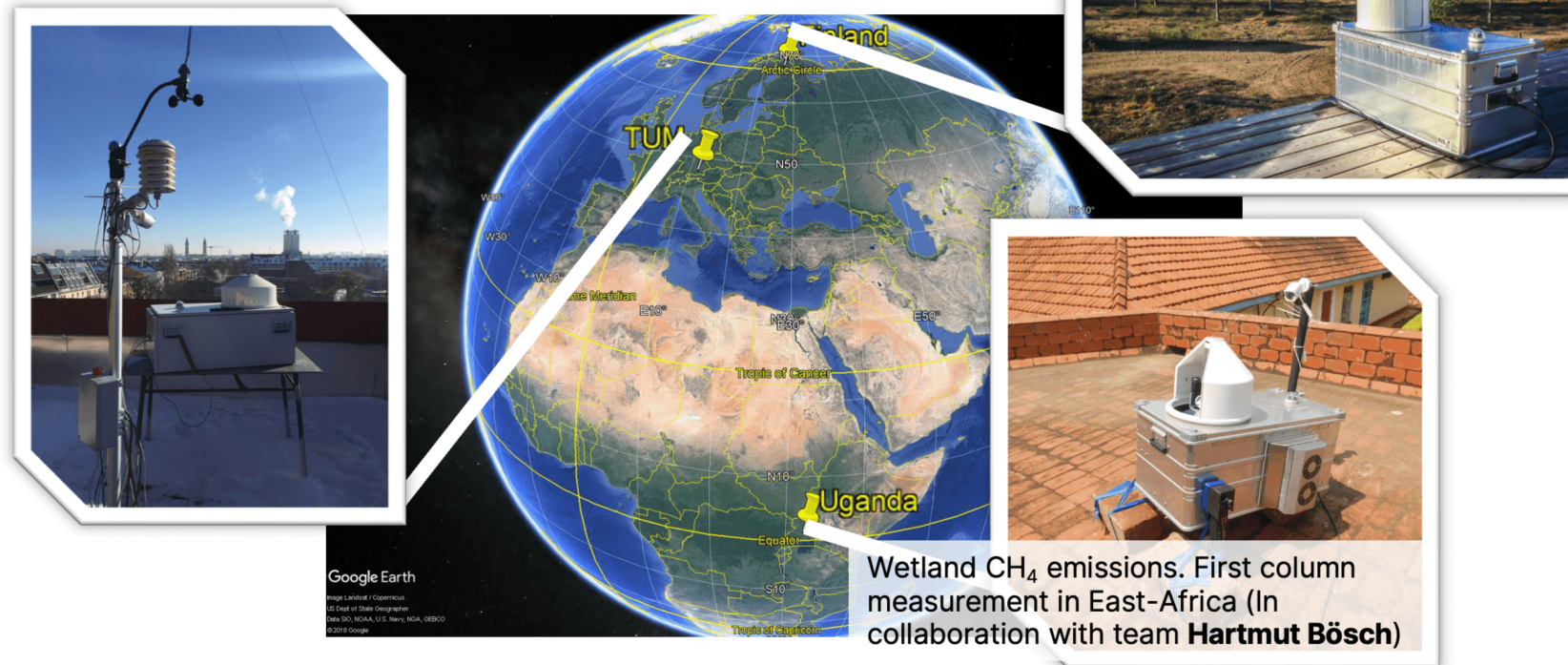


# MUCCnet Generates a Lot of Data



Dietrich, Chen et al.: MUCCnet: Munich Urban Carbon Column network. Atmos. Meas. Tech., 2021, <https://doi.org/10.5194/amt-14-1111-2021>

# MUCCnet Generates a Lot of Data



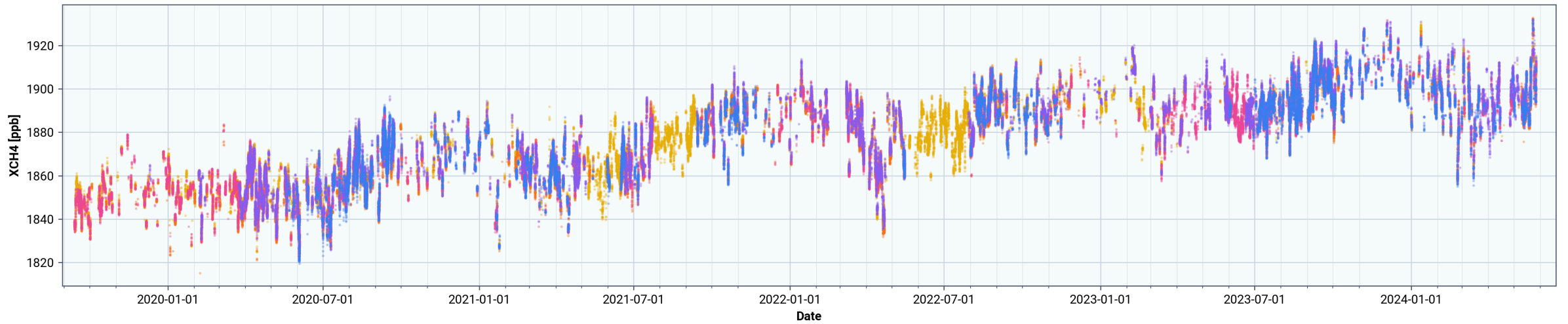
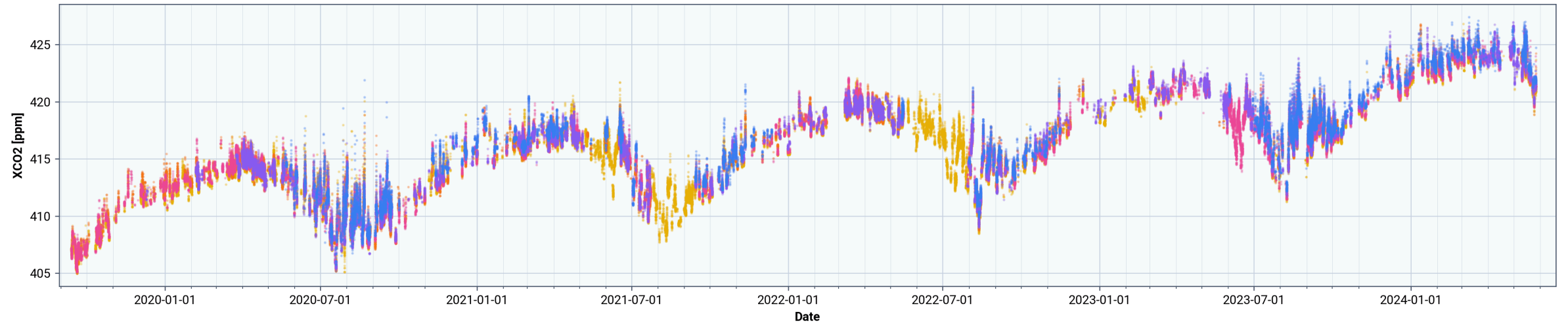
**Tu et al.:** Intercomparison of atmospheric CO<sub>2</sub> and CH<sub>4</sub> abundances on regional scales in boreal areas using CAMS analysis, COCCON spectrometers, and Sentinel-5 Precursor satellite observations. *Atmos. Meas. Tech.*, 2020, <https://doi.org/10.5194/amt-13-4751-2020>

**Humpage et al.:** Greenhouse gas column observations from a portable spectrometer in Uganda, *Atmos. Meas. Tech. Discuss.*, 2023, <https://doi.org/10.5194/amt-2023-234>

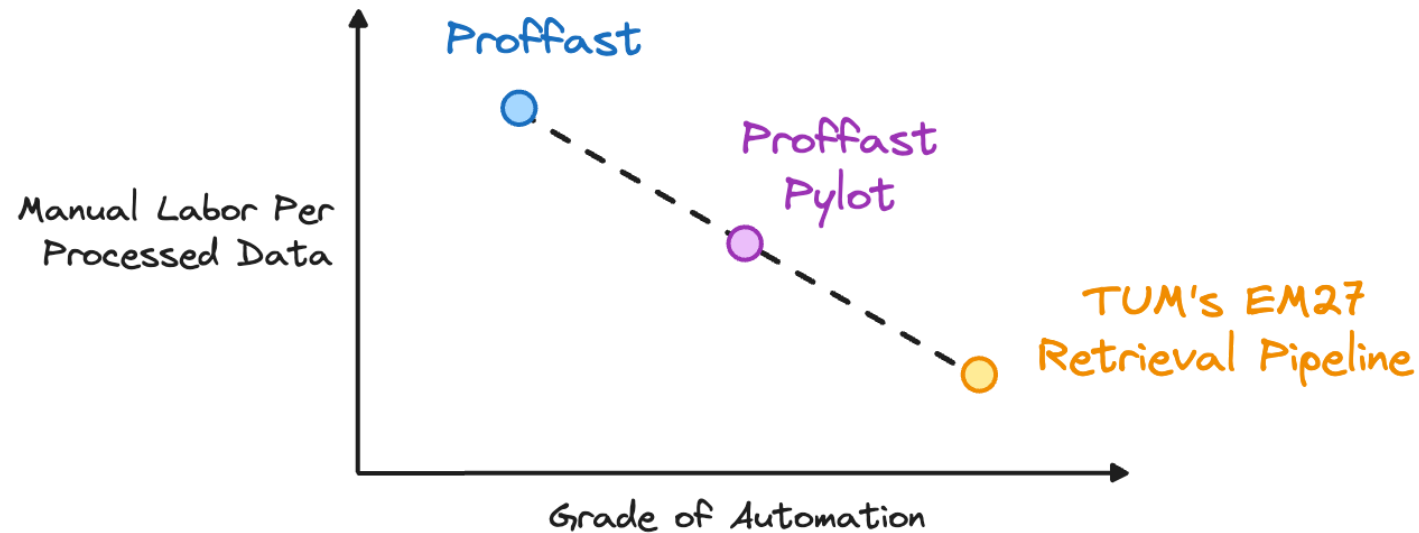


ma (61) mb (86) mc (115) md (116) me (117)

MUCCnet over the years - 2019-09-13 to 2024-06-05



# Running a Retrieval: Levels of Automation



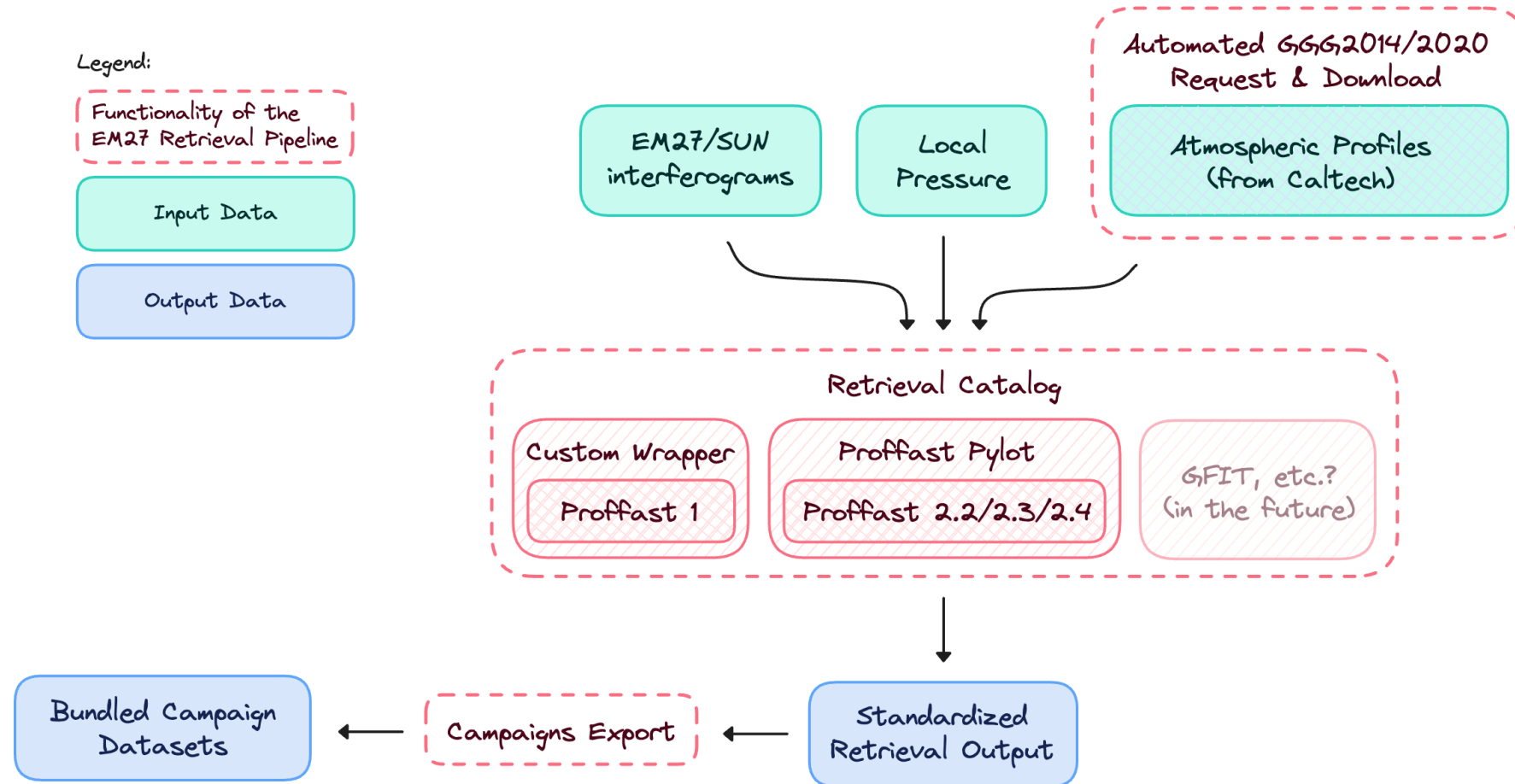
**Hase:** COCCON Data Processing, 2023, <https://www.imk-asf.kit.edu/english/3225.php>

**Sha et al.:** Intercomparison of low- and high-resolution infrared spectrometers for ground-based solar remote sensing measurements of total column concentrations of CO<sub>2</sub>, CH<sub>4</sub>, and CO. Atmos. Meas. Tech., 2020, <https://doi.org/10.5194/amt-13-4791-2020>

**Feld, Herkommer et al.:** PROFFASTpylot: Running PROFFAST with Python. Journal of Open Source Software, 2024, <https://doi.org/10.21105/joss.06481>



# Running a Retrieval: Pipeline Steps



# Pipeline Features (1)

## Universal:

- Automated request of GGG2014/GGG2020 priors from `ccycle.gps.caltech.edu`
- Run Proffast 1, 2.2, 2.3, 2.4 retrievals on any Unix system
- Designed to include other retrieval algorithms (e.g., GFIT) and atmospheric priors (e.g., CAMS) in the future

## Fast:

- Parallel execution of individual retrieval jobs
- OPUS file corruption filter: [tum-esm-utils.netlify.app/example-usage#test-which-interferograms-cannot-be-processed-by-proffast-2](https://tum-esm-utils.netlify.app/example-usage#test-which-interferograms-cannot-be-processed-by-proffast-2)

## Pipeline Features (2)

### Reliable:

- Containerised execution of individual days
- CI tests of pipeline components and retrieval containers

### Mature:

- Full documentation and API reference: [em27-retrieval-pipeline.netlify.app](https://em27-retrieval-pipeline.netlify.app)
- Provide the Metadata either as local files or as centrally versioned files on GitHub: [em27-retrieval-pipeline.netlify.app/guides/metadata](https://em27-retrieval-pipeline.netlify.app/guides/metadata)

# Configuring the Pipeline

Configuration files required to run the pipeline:

- `locations.json`, `sensors.json`, `campaigns.json` :  
[em27-retrieval-pipeline.netlify.app/api-reference/metadata](https://em27-retrieval-pipeline.netlify.app/api-reference/metadata)
- `config.json` :  
[em27-retrieval-pipeline.netlify.app/api-reference/configuration](https://em27-retrieval-pipeline.netlify.app/api-reference/configuration)



# Using the Pipeline (1)

- Request & download atmospheric profiles from `ccycle.gps.caltech.edu` :

```
python cli.py profiles run
```

- Run the retrieval:

```
python cli.py retrieval start
```

- (Optional) Export the results:

```
python cli.py export run
```

## Using the Pipeline (2)

**In General:** The pipeline produces all outputs it does not find on the system. You point it to the metadata and the data and don't explicitly tell which jobs to run.

- Observe the progress of the retrieval

```
python cli.py retrieval watch
```

2851 processes pending . 3 processes in progress . 1641 processes done

Container ID	Sensor ID	Datetime	Location ID	IFG Count	Run Time
awesome-kepler	md	2022-08-16 00:00:00+00:00 - 2022-08-16 23:59:59+00:00	TUM_I	2241	22m 32s
recursing-banach	mb	2022-08-15 00:00:00+00:00 - 2022-08-15 23:59:59+00:00	TUM_I	920	2m 02s
strange-sammet	mc	2022-08-15 00:00:00+00:00 - 2022-08-15 23:59:59+00:00	TUM_I	826	1m 04s

Press Ctrl+C or close the terminal to stop watching. This will not stop the automation

# Getting Started

1. Read "Getting Started" guide: [em27-retrieval-pipeline.netlify.app](https://em27-retrieval-pipeline.netlify.app)
2. Set up metadata & configure pipeline on your system
3. Validate the setup using the integrity tests
4. Star the Pipeline repository ([github.com/tum-esm/em27-retrieval-pipeline](https://github.com/tum-esm/em27-retrieval-pipeline)) and the Pylot repository ([gitlab.eudat.eu/coccon-kit/proffastpylot](https://gitlab.eudat.eu/coccon-kit/proffastpylot)) not to miss any future releases.

# Community Outlook

**Use the pipeline – give feedback on usability – contribute your own features.**

Either use GitHub Discussions ([github.com/tum-esm/em27-retrieval-pipeline/discussions/categories/general](https://github.com/tum-esm/em27-retrieval-pipeline/discussions/categories/general)) or write an email to me ([moritz.makowski@tum.de](mailto:moritz.makowski@tum.de)).



## Thanks to the Other Collaborators!

**EM27 Retrieval Pipeline:** Jia Chen, Frank Hase, Friedrich Klappenbach, Andreas Luther, Lena Feld, Marlon Müller, Vyas Giridharan

**MUCCnet:** Jia Chen, Florian Dietrich, Frank Hase, Friedrich Klappenbach, Andreas Luther, Juan Bettinelli, Klaus Kürzinger, Junwei Li, Josef Stauber, Patrick Aigner, Lena Feld - *and many more*

**KIT Team:** Frank Hase, Lena Feld, Benedikt Herkommer