GHG meas. @BIRA-IASB

Overview of ongoing and future plans for long-term and campaign based greenhouse gas measurements by BIRA-IASB

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ROYAL BELGIAN INSTITUTE FOR SPACE AERONOMY

GHG Remote Sensing Measurement Networks for Satellite Validation

NDACC IRWG

http://ndacc.org

- Bruker 120HR/125HR
- Resolution 0.0036 cm^{-1}
- Profile retrievals (limited vertical resolution, at least tropo/strato partial columns)

TCCON

http://tccon.org

- Bruker 125HR
- Resolution 0.02 cm^{-1}
- Profile scaling retrievals

COCCON

http://www.imk-asf.kit.edu/english/COCCON.php

- Bruker EM27/SUN
- Resolution 0.5 cm^{-1}
- Profile scaling retrievals

GHG Remote Sensing Measurement Networks for Satellite Validation

NDACC IRWG

http://ndacc.org

- Bruker 120HR/125HR
- Resolution 0.0036 cm^{-1}
- Spectral range: SWIR, MIR and TIR
- Measurements every ±10'
- 21 stations worldwide

- Targets: O_3, CH_4, N_2O, (CO_2, HCHO, SF_6, CFC, HCFC, H_2O, HDO not official), CO, HNO_3, HCl, HF, HCN, C_2H_6, $ClONO_2$, (C_2H_2, PAN, OCS, CH_3OH, NH_3, HCOOH, NO_2 not official)
- Profile retrievals (limited vertical resolution, typically tropo/strato partial columns)
- Retrieval software: SFIT or PROFFIT
- No central processing, QA/QC for selected targets in CAMS operational validation

TCCON

http://tccon.org

- Bruker 125HR
- Resolution 0.02 cm^{-1}
- Spectral range: SWIR
- Measurements every ~ 3'
- 28 stations worldwide

- Targets: CO_2, CH_4, N_2O, H_2O, HDO, CO, HF

- Profile scaling retrievals (profile retrievals in development)
- Retrieval software GGG
- Central QA/QC

COCCON

http://www.imk-asf.kit.edu/english/COCCON.php

- Bruker EM27/SUN
- Resolution 0.5 cm^{-1}
- Spectral range: SWIR
- Measurements every ~ 1'
- > 60 instruments worldwide (some fixed sites but mostly for campaigns)
- Targets: CO_2, CH_4, CO

- Profile scaling retrievals
- Retrieval software PROFFAST
- Central calibration & processing facility at KIT

GHG Remote Sensing Measurement Networks for Satellite Validation

NDACC IRWG

http://ndacc.org

- Operational use in: ESA MPC TROPOMI validation, CAMS validation (RD delivery supported by CAMS)
- Recent and ongoing harmonisation efforts in QA4ECV, GAIA-CLIM, CAMS27, C3S-311a-Lot3 (BARON)
  Upcoming SFIT/PROFFIT to improve harmonization of uncertainties evaluation, better spectroscopy
- Selected NDACC stations joined EU research infrastructure ACTRIS: with central processing facility, QA/QC, training…
- CO_2 retrieval strategy under development (IUP/UB & BIRA-IASB)

TCCON

http://tccon.org

- Operational use in: OCO-2/3 & GOSAT/2 Cal/Val, CAMS validation, ESA TROPOMI validation (limited RD delivery)…
- GGG2020 show improved prior profiles (shape and possible bias), no CO calibration factor, improve spectroscopy, reduce remaining airmass and H_2O dependences, reduce scatter in CO product, improve diagnostics for instrumental issues.
- Negotiations ongoing for selected TCCON stations to join EU research infrastructure ICOS, with central processing facility
- Profile retrievals under development. Tropospheric partial columns can be derived indirectly

COCCON

http://www.imk-asf.kit.edu/english/COCCON.php

- Operational usage in: OCO-2/3, GOSAT/2, S5P TROPOMI validation (started in 2020)…
- Planned update foreseen for PROFFAST, redefined spectroscopic descriptions + improved line lists
- EM27/SUN as travelling standard for TCCON, COCCON can complement TCCON, support by ESA for COCCON-PROCEEDS, follow-up crucial for current capabilities of COCCON
- Towards extension of COCCON with **VERTEX70** and **IRcube** (2 other low resolution FTIR instruments – with higher spectral resolution and additional species) – ESA FRM4GHG project https://frm4ghg.aeronomie.be

GHG Remote Sensing Measurement Networks for Satellite Validation

New developments:

- Retrieval of **CH_4 vertical profile** information from **TCCON NIR spectra** with 2.4 DOFs (https://doi.org/10.5194/amt-12-6125-2019) – EU H2020 – RINGO

ESA FRM4GHG project https://frm4ghg.aeronomie.be

- Retrieval of **CH_4 and N_2O** total columns from **low-resolution (0.2 cm^{-1}) Bruker Vertex70** in the **mid-infrared** region (https://doi.org/10.5194/amt-2022-17);
  first comparison of **HCHO retrievals** with high-resolution show promising results, further improvements under testing.

- **Traveling standard instrument** operating autonomously **for NIR** using **EM27/SUN** developed and already deployed at TCCON stations in Japan, Canada, next will be Australia. (Lead by KIT)

- Development of **autonomous mobile set-up** for field deployment of **low-resolution spectrometers** – compact solar tracker and thermally isolated waterproof enclosure, Stirling-cooled InSb detector for measurements in MIR region. (Lead by BIRA-IASB and U.Bremen)

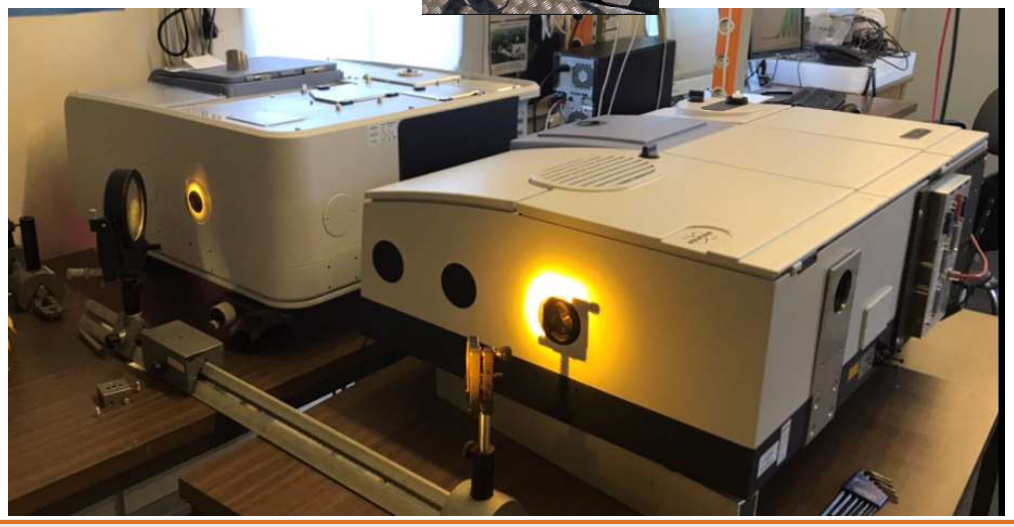
- **Fiber optics feed** for coupling solar radiation to low-resolution spectrometers (IRCube, EM27/SUN, …). (Lead by U. of Wollongong)

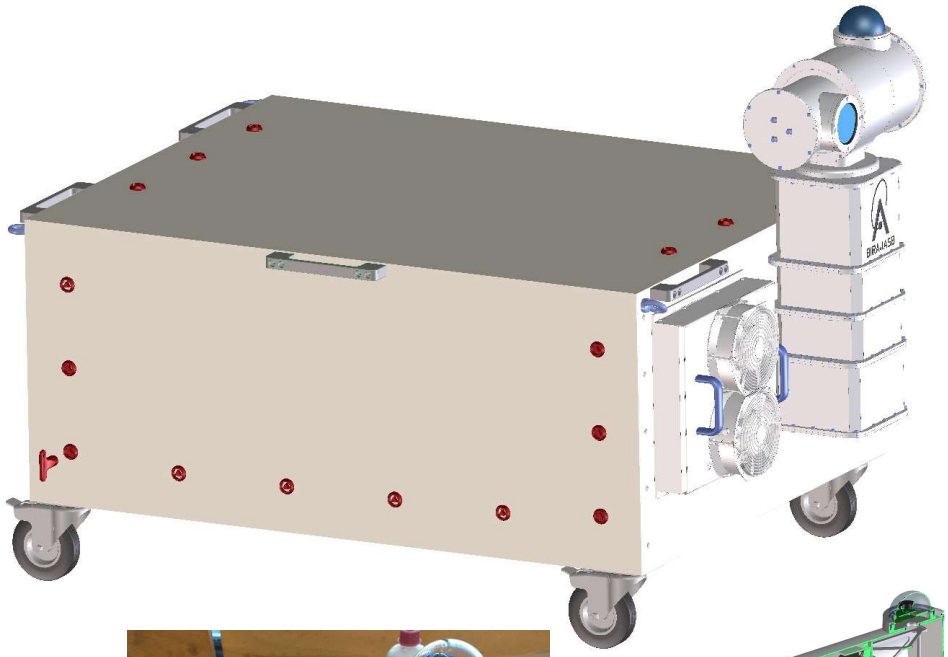
- Develop **AirCore** observation of additional species (**N_2O , OCS**). (Lead by U.Groningen & FMI)

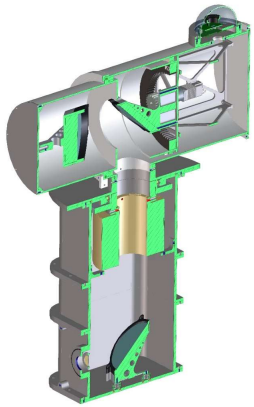
Vertex-70/Invenio low-resolution spectrometer – autonomous setup

Bruker Invenio

Bruker Vertex70

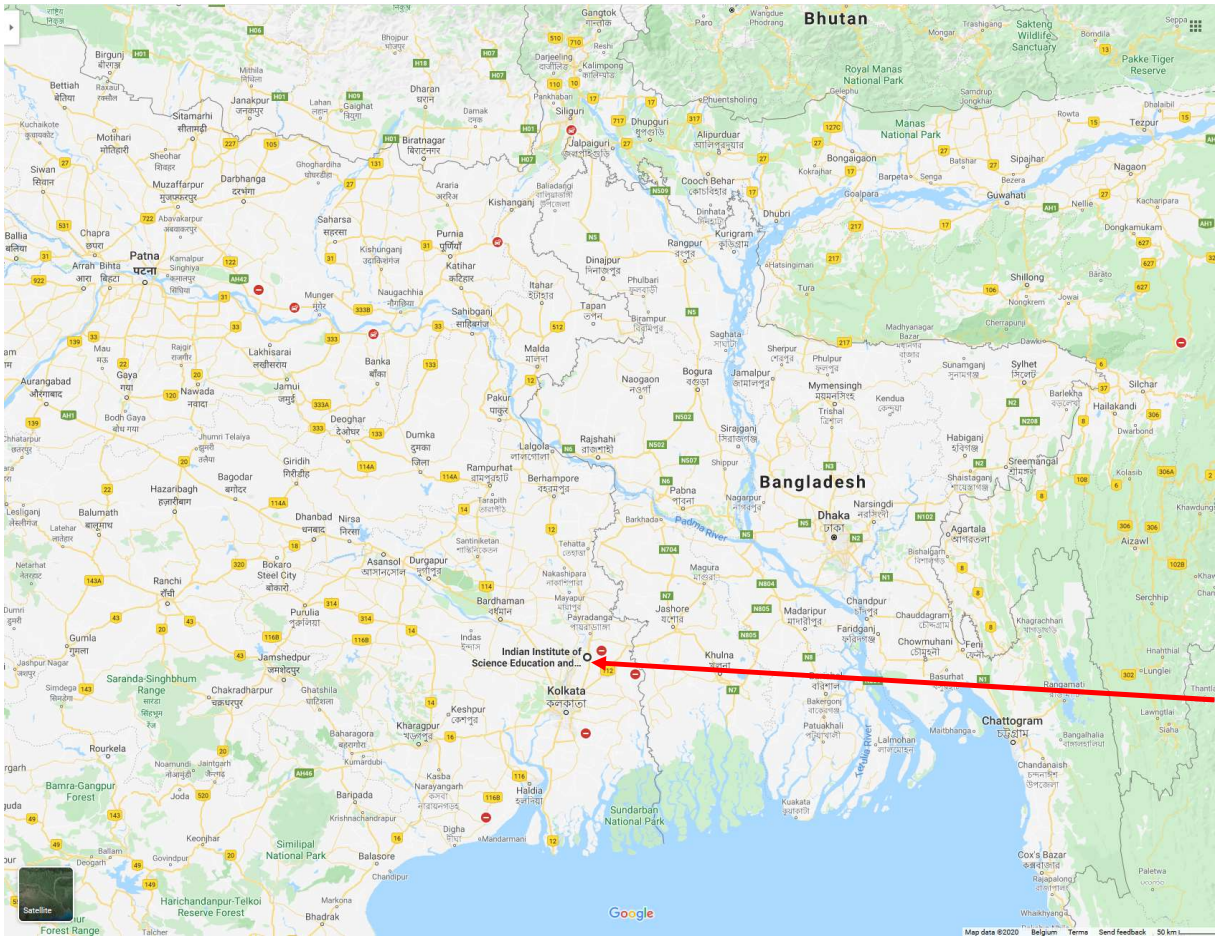






S5PVAL-Kolkata campaign

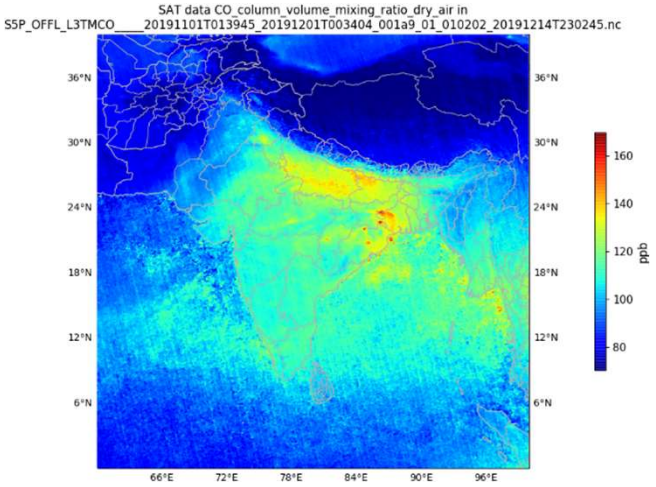
S-5p validation campaigns: https://s5pcampaigns.aeronomie.be/index.php/campaigns/s5pval-kolkata

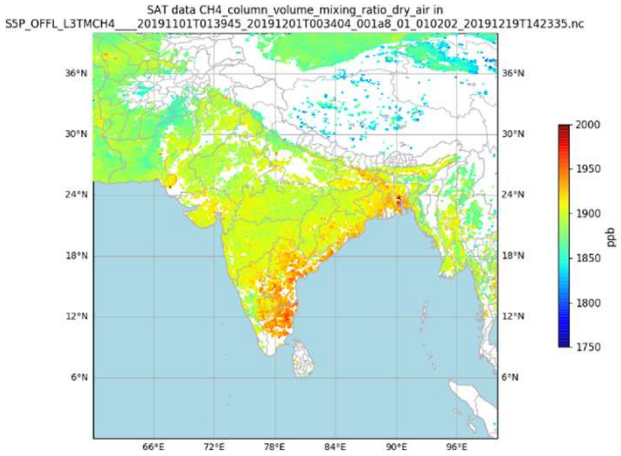


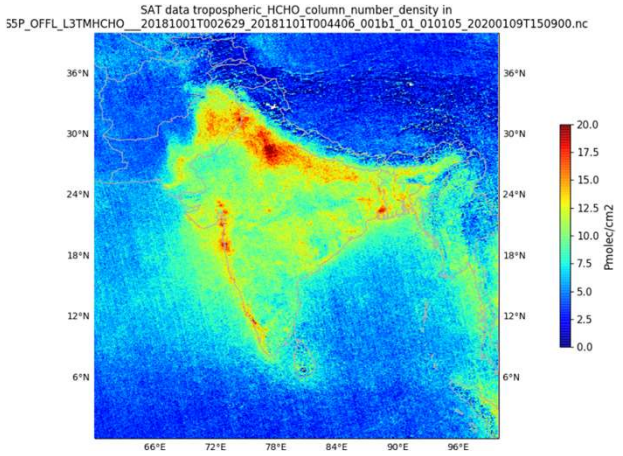
India Institute of Science Education and Research Kolkata (IISER Kolkata; 22°57'50" N, 88°31'28" E)

Google map showing the location of IISER Kolkata

S5PVAL-Kolkata campaign







Monthly averaged S5P XCO (left) and XCH_4 (middle) over India for November 2019
Location of the site is marked as a black dot on the left figure

Monthly averaged S5P HCHO over India for October 2018

S-5p validation campaigns: https://s5pcampaigns.aeronomie.be/index.php/campaigns/s5pval-kolkata

S5PVAL-Kolkata campaign

Laboratory space for installing Bruker Vertex70

Roof top – need to create a hole for light passage

Roof side for installing the solar tracker

Back side of the roof, no higher building to obstruct solar view

S-5p validation campaigns: https://s5pcampaigns.aeronomie.be/index.php/campaigns/s5pval-kolkata

S5PVAL-Kolkata campaign

Time plan:

06 October 2022 – Instrument shipped from BIRA-IASB

12 October 2022 – Instrument arrival at Kolkata Airport

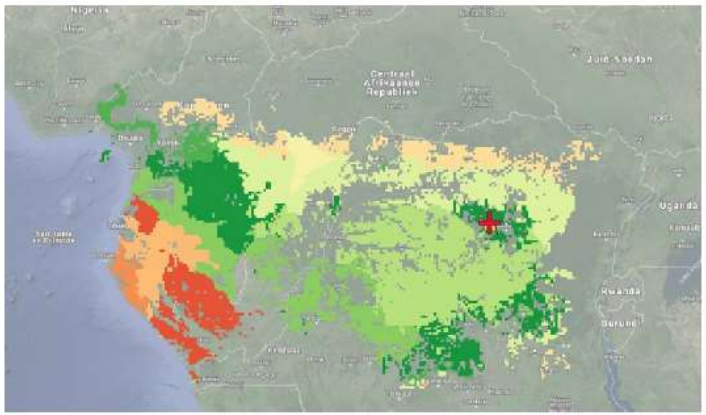
18 – 28 October 2022 – Site visit for instrument deployment; use of our standard solar tracker set-up as TCCON/NDACC

End 2024/Beginning 2025 – End of campaign (at least two years of measurements)

Contact us if you are interested in the data/collaboration for targeting the site

DR Congo campaign – ICOS-BE project

The site is in the very heart of the Congo Basin, on the bank of the Congo River roughly 100 km northwest of Kisangani, Democratic Republic of Congo. It is located in an old growth mixed-species tropical rainforest.
Location: Coordinates: **0°48'52.5"N, 24°30'08.8"E**
Tropical rainforest, Flux and meteorological data since October 2020
Measures Greenhouse gases (CO2, CH4, N2O), ozone, black carbon, NOx and meteorological data (ICOS-BE station)
PI: Prof. dr. Ir. Pascal Boeckx; **Co-PI:** Prof. dr. Hans Verbeeck



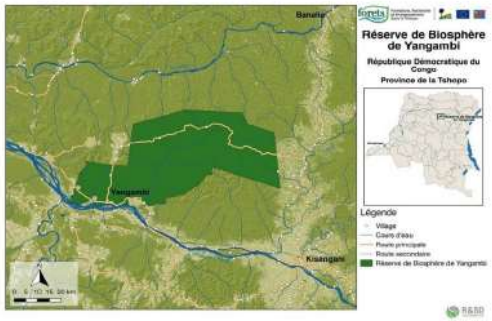
Forest types (n = 10) in central Africa show 3 principle groups based on functional traits: wood density, maximum diameter, and deciduousness), + = CongoFlux

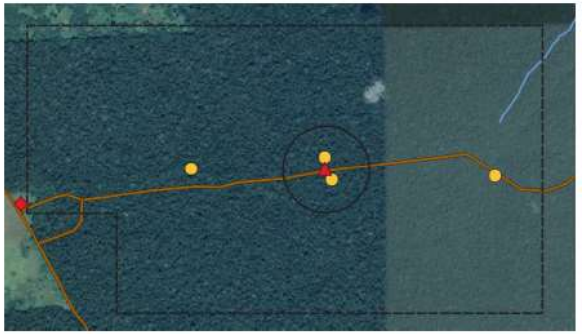
Adapted from Réjou-Méchain et al. 2021, *Nature*

-https://www.congo-biogeochem.com/congoflux
-https://www.icos-belgium.be/ESCongoFlux.php
-https://www.youtube.com/watch?v=56_0hb9KqsY

DR Congo campaign – ICOS-BE project

CONGOFLUX - YANGAMBI





GHENT UNIVERSITY

DR Congo campaign – ICOS-BE project

Time plan:

2023 – Preparation of the Invenio spectrometer, integration of the compact solar tracker and box
testing of the automation setup in Belgium, campaign in Belgium at an co-located ICOS ecosystem site

2024 & 2025 – Deployment of the set-up in DRC at the Congoflux tower site (solar park). 2 Years of measurements

Contact us if you are interested in the data/collaboration for targeting the site

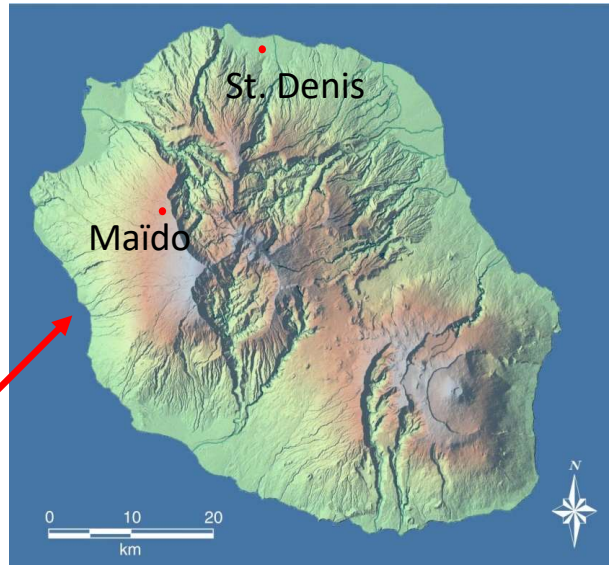
FTIR long-term deployments at Ile de La Réunion

An unique atmospheric observatory situated in the Indian Ocean, about 700 km east of Madagascar and 170 km southwest of Mauritius providing the background state. In addition, we see the influence of biomass burning in Madagascar, South Africa and South America

One of the very few atmospheric observation stations providing both in-situ and remote sensing greenhouse gas (GHG) data for atmospheric components in the southern hemisphere

Two dedicated sites – St. Denis (85 m.a.s.l) and Maïdo (2157 m.a.s.l)

Google Earth



FTIR long-term deployments at Ile de La Réunion

Location: University of St. Denis (-20.901° N, 55.485° E, 85 m.a.s.l)

Instrument characteristics: Bruker IFS 125HR, CaF_2 Beamsplitter and optics, home-built sun-tracker and electronics

Networks: TCCON (InGaAs and Si) and NDACC (InSb) (since September 2011)

Currently not operational due to solar tracker motor issues – site visit planned before the end of the year to get the instrument operational again.

Sun tracker for the Bruker IFS 125HR

FTIR spectrometer – Bruker IFS 125HR

FTIR long-term deployments at Ile de La Réunion

Location: Maïdo observatory (-21.079° N, 55.384° E, 2157.7 m.a.s.l)

Instrument characteristics: Bruker IFS 125HR, KBr Beamsplitter and optics, home-built sun-tracker and electronics

Networks: NDACC (InSb and HgCdTe) and TCCON (InGaAs) (since March 2013)

Maïdo observatory

FTIR spectrometer – Bruker IFS 125HR

FTIR long-term deployment at Porto Velho

- Site location: Porto Velho – in the amazon forest in Brazil
- At the campus of Instituto Federal de Educação, Ciência e Tecnologia de Rondônia - Porto Velho (-8.774° N, 296.128° E, 87.0 m.a.s.l) in Brazil.
- Laboratory constructed for hosting our Bruker spectrometer
- Bruker IFS 125M Instrument installed and measurements started on 15 July 2016
- The location of the site in the Amazonas gives an unique opportunity as a low albedo site, humid conditions, first site in south American continent providing data for S5P CH_4 and CO validation (contributing to latitude & global coverage), high CH_4 and CO from ground conditions. The dataset will help for checking possible variations of S5P CH_4 and CO data with respect to ground characteristics.
- We are almost ready to start TCCON & NDACC like measurements at Porto Velho.
- Instrument packed and ready to be shipped to Brazil, waiting for paper-works.
- Planned to be installed before the end of this year.

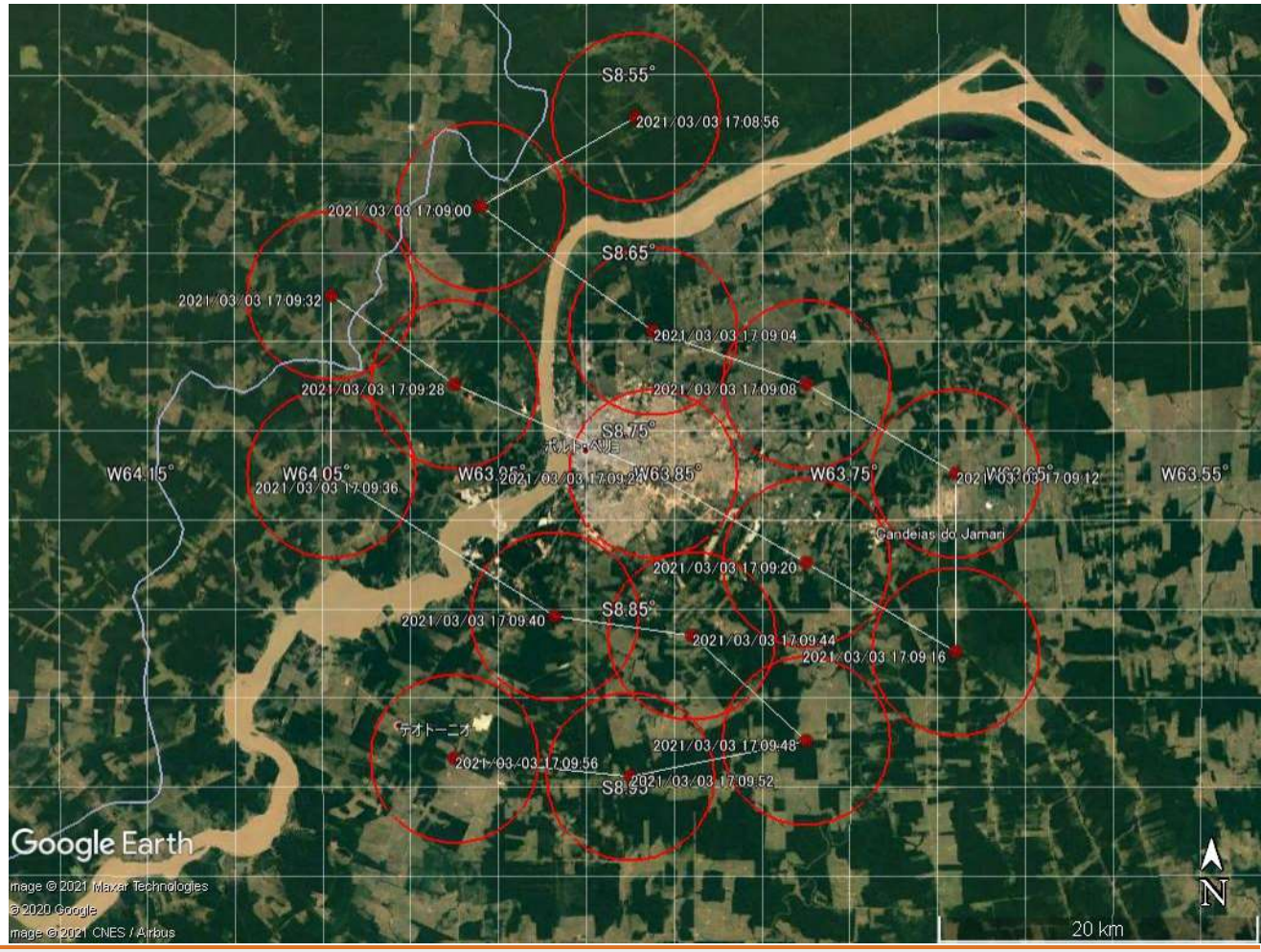
FTIR long-term deployment at Porto Velho

Porto Velho campus

Porto Velho campus entrance – picture from google maps

FTIR long-term deployment at Porto Velho

GOSAT and GOSAT-2 target observation based on 16 point pattern set-up by NIES



Low-res. FTIR deployment in Belgium

As part of the Belgian national project – VERBE & other proposed project(s)

– we aim to establish a national GHG emission monitoring and verification support (MVS) capacity

We will set-up in-situ and remote sensing measurement instrument(s) in Belgium. Amongst which will be low-resolution FTIR(s).

Thank you for your attention!

Questions / comments to mahesh.sha@aeronomie.be