Quantifying Carbon Dioxide and Methane Hotspots: A Simulation Study with the TANGO Satellite Initiative

Harikrishnan Charuvil Asokan[1], Jochen Landgraf[2], Leonie Scheidweiler[1], and André Butz[1]

[1] Institute of Environmental Physics, Heidelberg University, Heidelberg, Germany

[2] Netherlands Institute for Space Research SRON, Leiden, Netherlands

Objective

- GHG emission accuracy of high-resolution satellites, with priority in Europe, including the identification of both specific and diffuse emission sources.
- The scope and density of satellite measurements across Europe, focusing on the precision of emission rate estimates for various sources.
- Calibration and validation of emission estimation methods globally, leveraging identified hotspots to refine these processes.

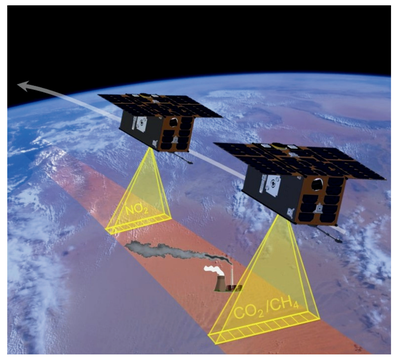
UNIVERSITÄT HEIDELBERG ZUKUNFT SEIT 1386

Get a Digital Copy: Scan Here

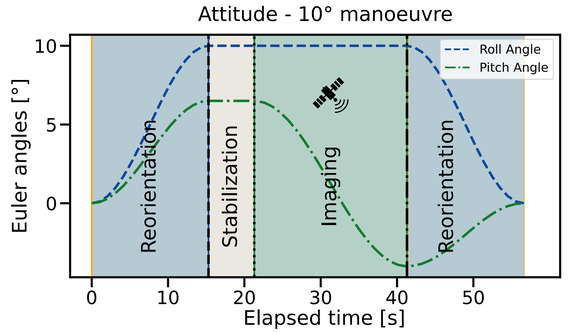
hari@uni-heidelberg.de

Twin Anthropogenic Greenhouse Gas Observers (TANGO) Mission

- Launch: 2027, part of ESA's SCOUT program
- Satellites: TANGO-Carbon & TANGO-Nitro
- Focus: CH_4, CO_2, and NO_2 emissions at industrial scales
- Technology: Cubesat with 1.6-µm sensor, High-res spectrometers, shortwave IR & visible spectra
- Resolution: 300x300 m over 30x30 km
- Target: ≥2 Mt/year CO_2, ≥5 kt/year CH_4 emissions



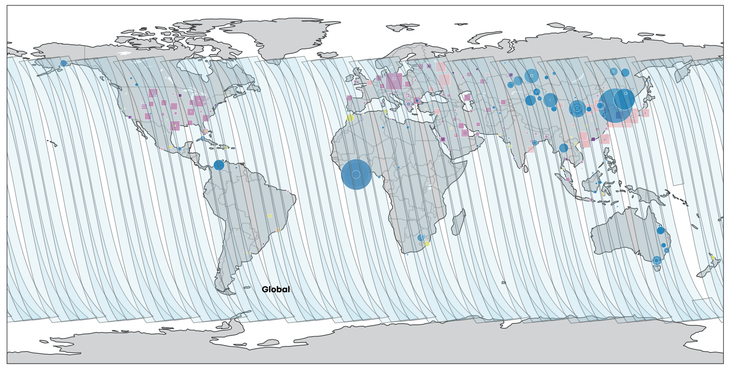
Development of a Global Emission Point Source Inventory



- Challenge: Limited coverage, small footprint
- Maneuver Constraint: Stabilization period post-roll maneuver limits imaging
- Observation Limitation: Can't observe all sources in one pass; prioritization required
- Simulation: 4-day seasonal trajectory simulations for global coverage
- Data Collection: Prioritize significant emission sources from global inventory (TNO) within observational constraints

Estimated Emission targets

Emissions 4 days of Spring, CO_2 priority

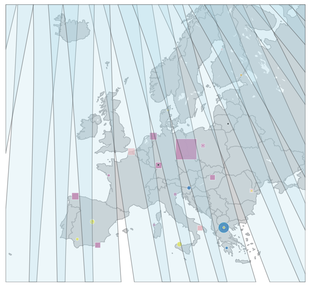


Sectors and Gases
- Power sector (CO_2): 286
- Iron/steel production (CO_2): 74
- Non-metallic minerals production (CO_2): 25
- Refineries and fuel transformation (CO_2): 40
- Chemical processes (CH_4): 1
- Fugitive emissions from coal mining (CH_4): 142
- Landfills (CH_4): 71
- Fossil fuel extraction (CH_4): 97

Total CO_2 targets: 425

Total CH_4 targets: 311

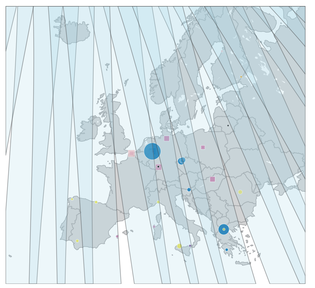
Emissions 4 days of Summer, CO_2 priority



Total CO_2 targets: 44

Total CH_4 targets: 13

Emissions 4 days of Summer, CH_4 priority

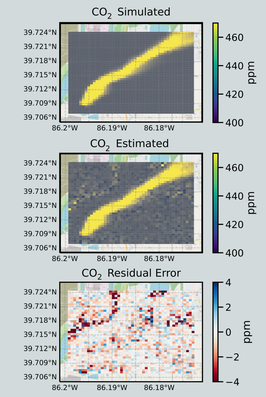


Total CO_2 targets: 41

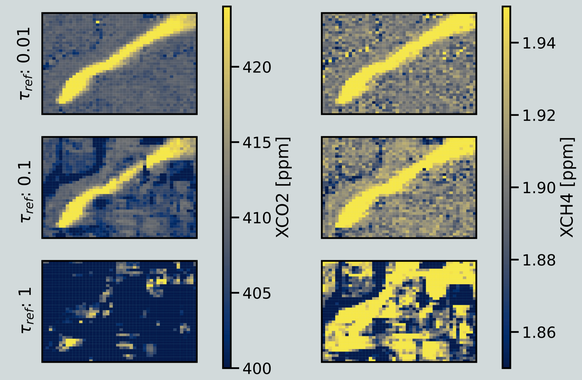
Total CH_4 targets: 32

Sectors and Gases	CO_2 Priority	CH_4 Priority
Chemical processes (CO_2)	1	2
Power sector (CO_2)	32	25
Iron/steel production (CO_2)	7	7
Non-metallic minerals production (CO_2)	2	-
Other industry (CO_2)	2	2
Fugitive emissions from coal mining (CO_2)	-	2
Refineries and fuel transformation (CO_2)	-	3
Chemical processes (CH_4)	1	2
Power sector (CH_4)	-	2
Fugitive emissions from coal mining (CH_4)	3	14
Landfills (CH_4)	9	14

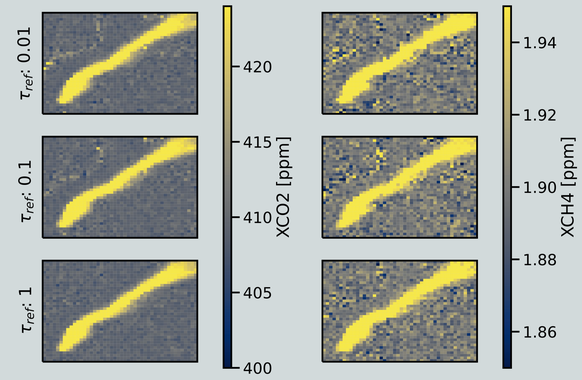
CO_2 retrieval for a CO2Image-like sensor: synthetic retrievals (RemoTeC) and emission estimates



Case 1: Baseline - Omit aerosol scattering effects



Case 2: Aerosol Scattering in Forward Model Only - Vary AOD, assess discrepancies.



Case 3: Consistent Aerosol Treatment - Include scattering effects in both models.

Outlook

- Develop a list of potential targets in Germany/Europe with a ranking of their importance and usefulness.
- Quantification of errors for CO_2 and CH_4 emission estimates.
- Explore complex aerosol scattering impact and other various sources of errors on retrieval accuracy.

Selected References

- Butz, A. et al. (2009). Retrievals of atmospheric CO2 from simulated space-borne measurements of backscattered near-infrared sunlight: accounting for aerosol effects. Appl. Opt., 48(18), 3322-3336. https://opg.optica.org/ao/abstract.cfm?
- Strandgren, J. et al. (2020). Towards spaceborne monitoring of localized CO2 emissions: an instrument concept and first performance assessment. Atmos. Meas. Tech., 13, 2887–2904. https://doi.org/10.5194/amt-13-2887-2020URI=ao-48-18-3322