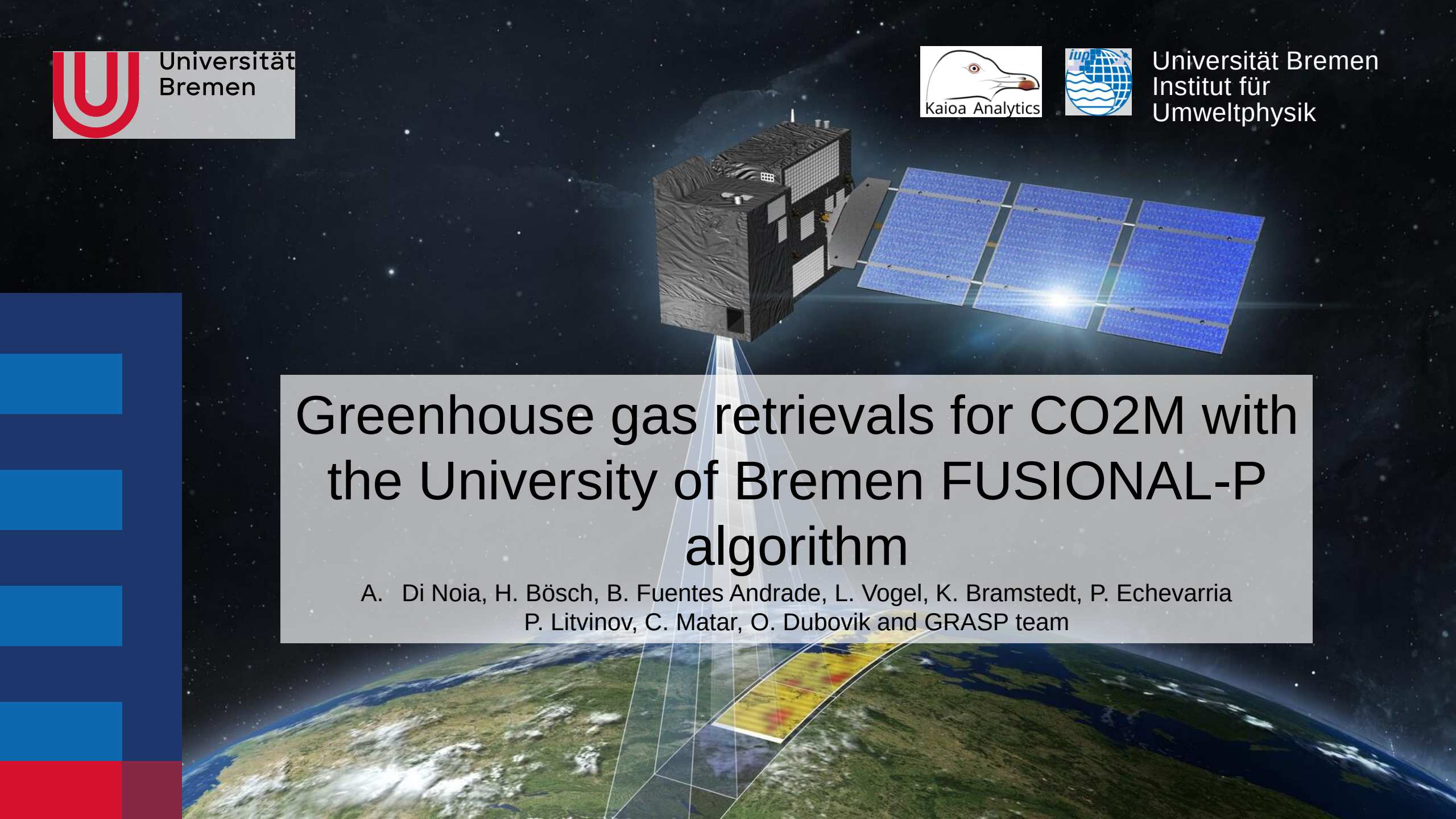

Universität Bremen

Kaioa Analytics

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Institut für
Umweltphysik

Greenhouse gas retrievals for CO2M with the University of Bremen FUSIONAL-P algorithm

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Universität Bremen

The FUSIONAL-P greenhouse gas retrieval algorithm

Institut für Umweltphysik

- Retrieves CO_2 and CH_4 from NIR/SWIR satellite measurements
- Based on optimal estimation
- Can be also used for SIF and HDO
- Can be applied to several instruments
  - GOSAT
  - OCO-2
  - TanSat
  - Future missions (Microcarb, CO2M)

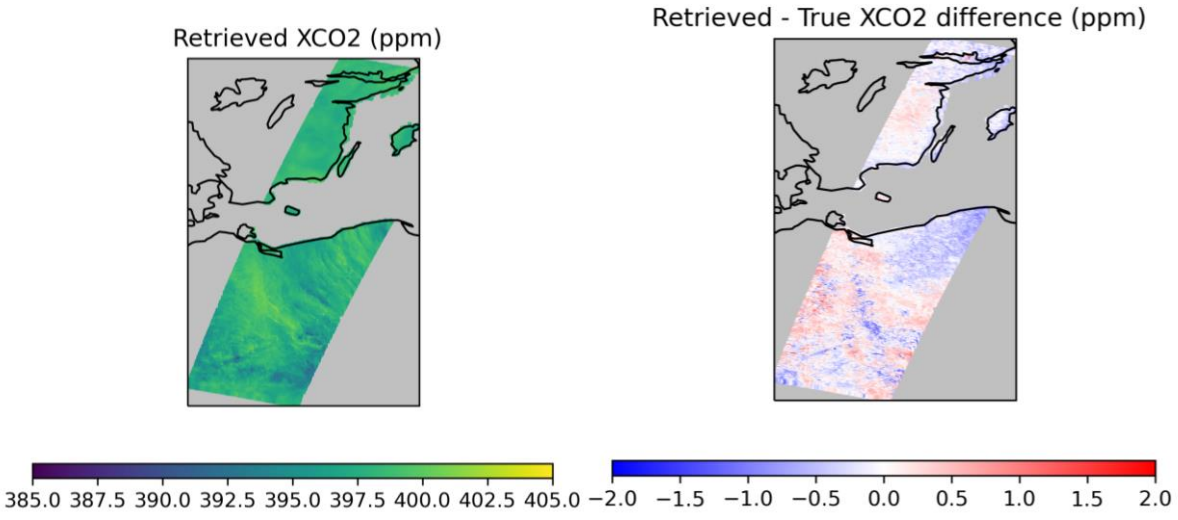
CO2M orbit simulation experiments

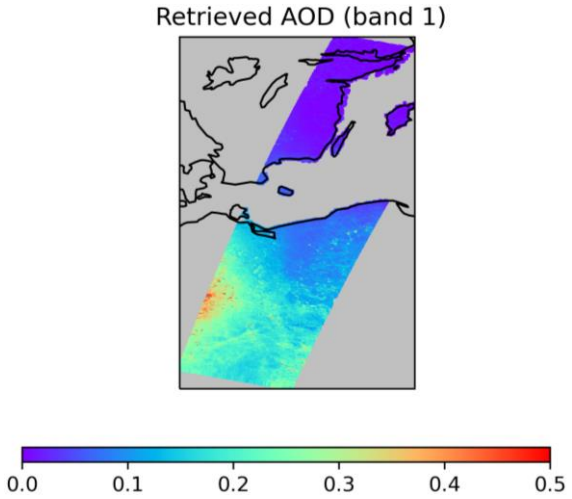
- Orbit simulations for simulated CO2M nadir and pitched orbits
- Input scenarios generated by EUMETSAT/RAL
- Full orbit simulations with no clouds
- Independent a priori used in the retrieval
- Orbit simulations experiments so far without MAP. Consequently, retrieval performance will be limited

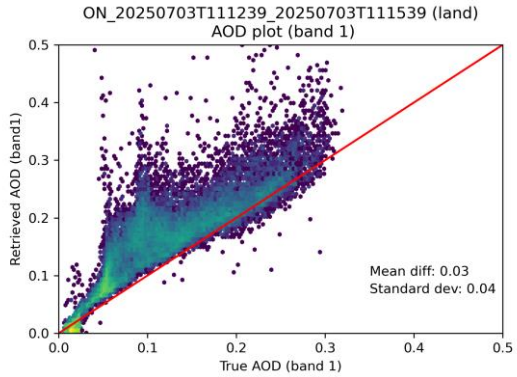
Variable	Input for simulations	A priori
CO_2	CHE global model	CAMS 16r1 + growth rate
CH_4	CHE global model	MACC 14r1 + growth rate
Aerosols	CAMS NRT	CAMS climatology
Surface	MODIS Ross-Li / Cox-Munk	Lambertian
Meteorology	CAMS NRT	ERA-5

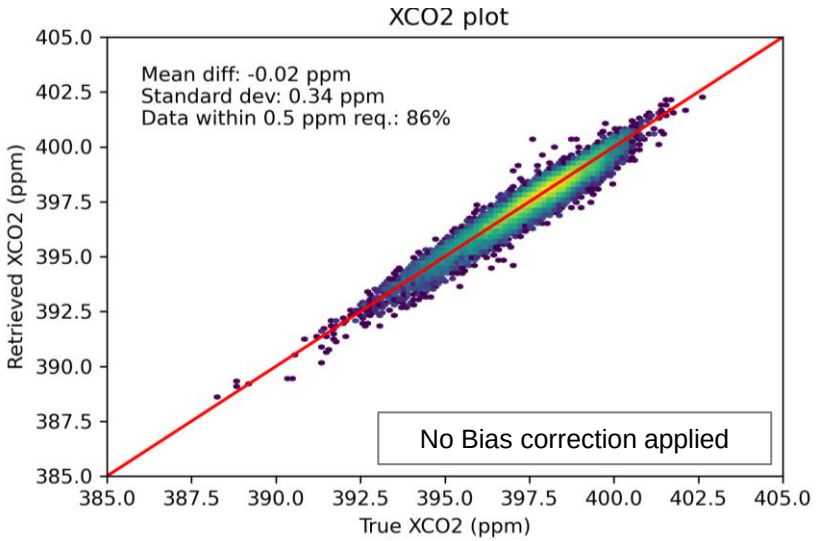
Retrieval results for high-res granule

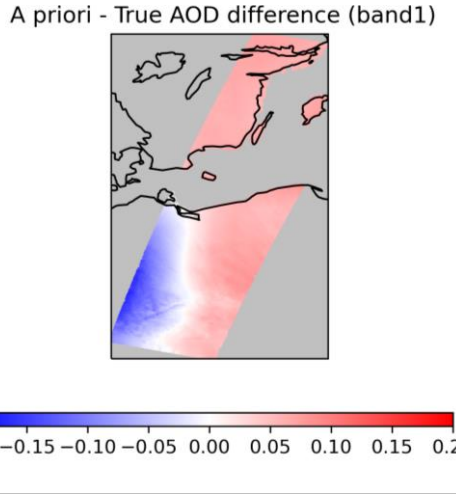
- Retrieval from independent a priori
- Berlin granule: high-resolution model data

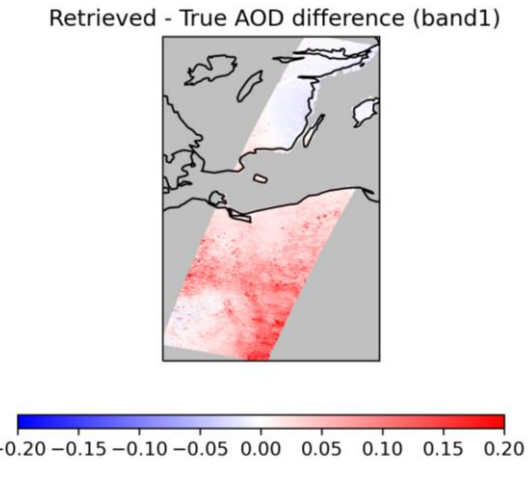






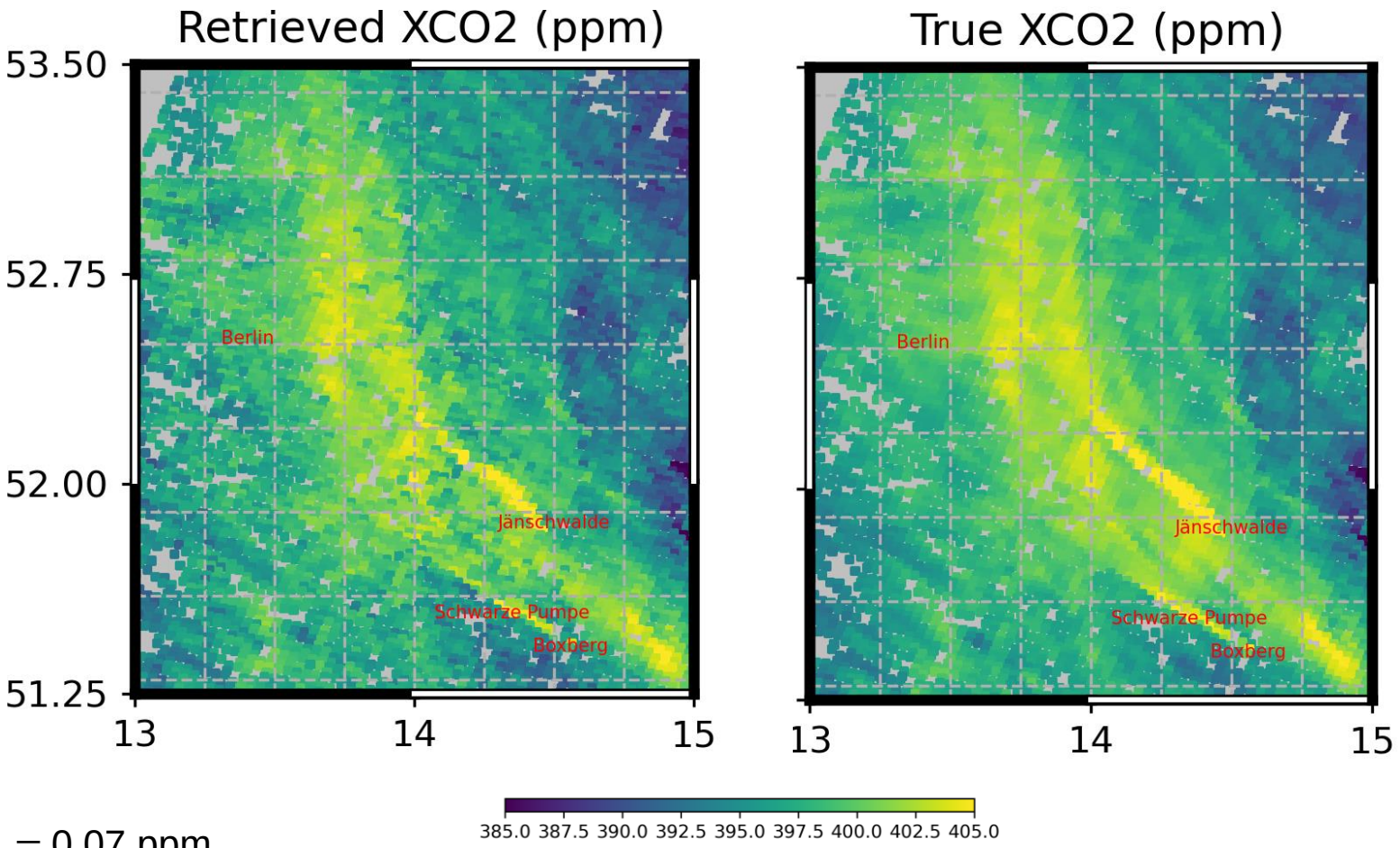






Zoom-in on CO_2 plume

- Power station plumes near Berlin: no bias correction applied



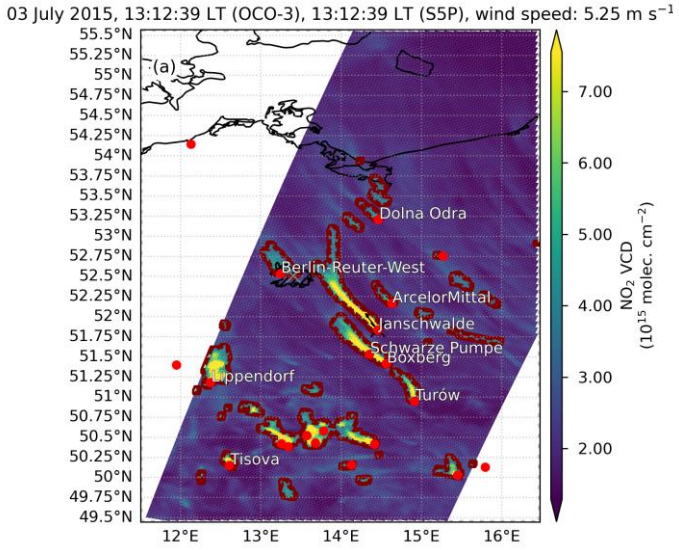
$\Delta XCO_2 = 0.07$ ppm
$\sigma(XCO_2) = 0.33$ ppm

Temptative emission quantification

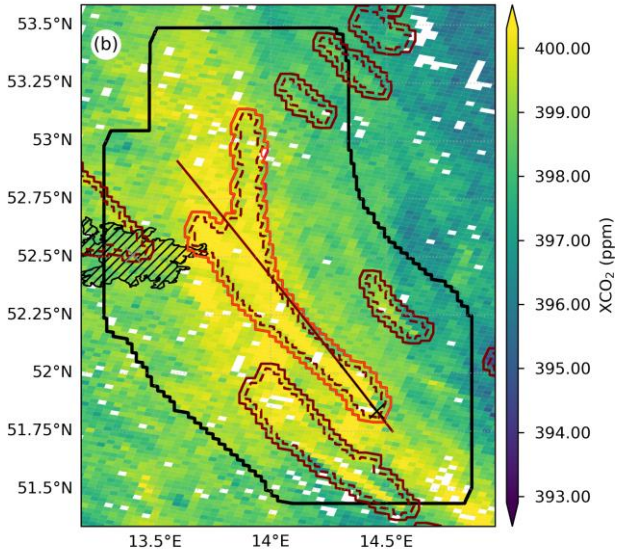
- Cross-sectional flux method by Fuentes Andrade et al. (2024), doi: 10.5194/amt-17-1145-2024
- Jänschwalde plume (estimated true emission 35.98 ± 4.33 $MtCO_2/yr$)
- Estimated emission from synthetic XCO2 retrieval: 31.31 ± 4.18 $MtCO_2/yr$
- Difference in line with expected uncertainty

Images courtesy of Blanca Fuentes Andrade

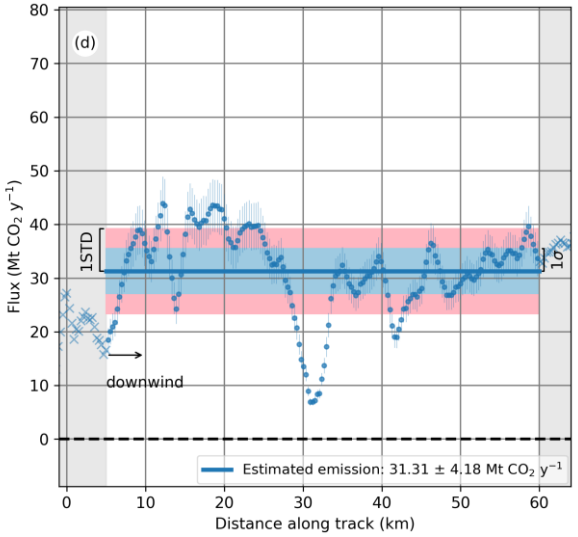
Plume detection from NO_2



CO2 plume segmentation

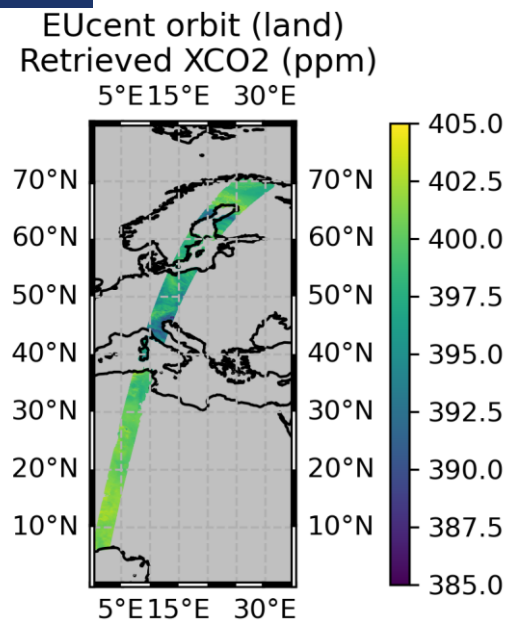


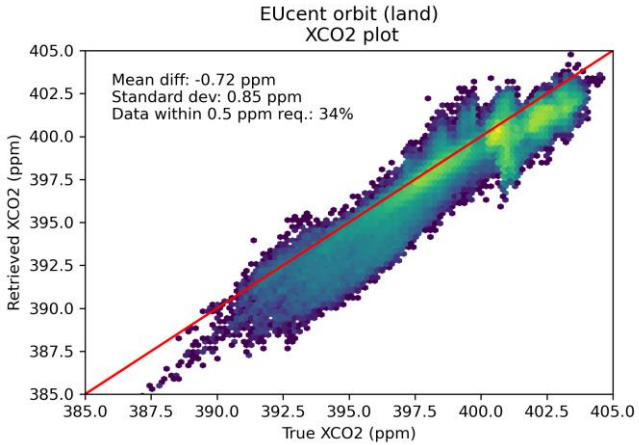
Cross-sectional flux

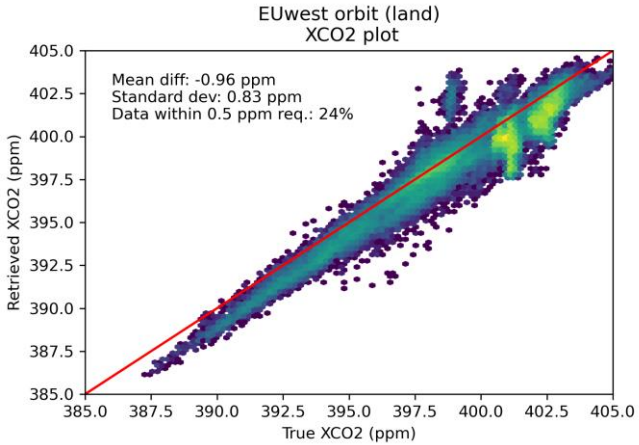


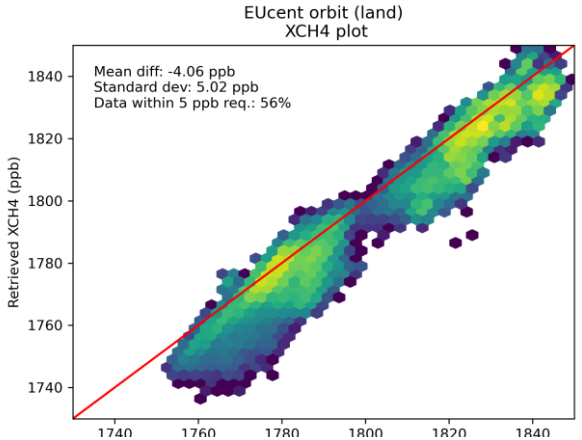
Full orbit results

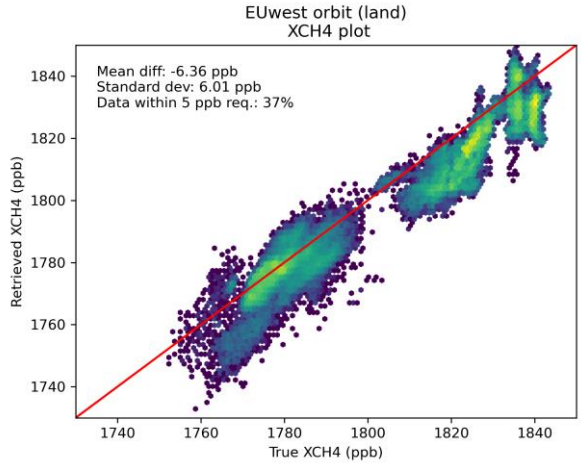
- Results for two full orbits – land only
  - EUcent (nadir)
  - EUwest (pitched)
- XCO_2 bias exceeds 0.5 ppm requirement (expected owing to a priori mismatch)
- XCH_4 bias within 5 ppb requirement for EUcent, exceeds it for EUwest

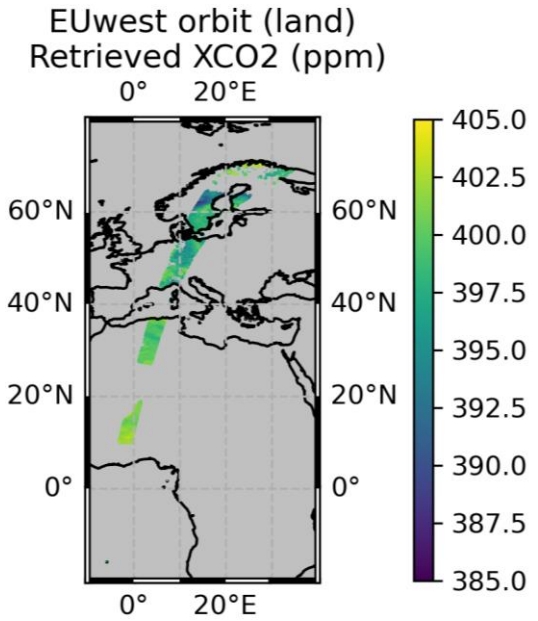




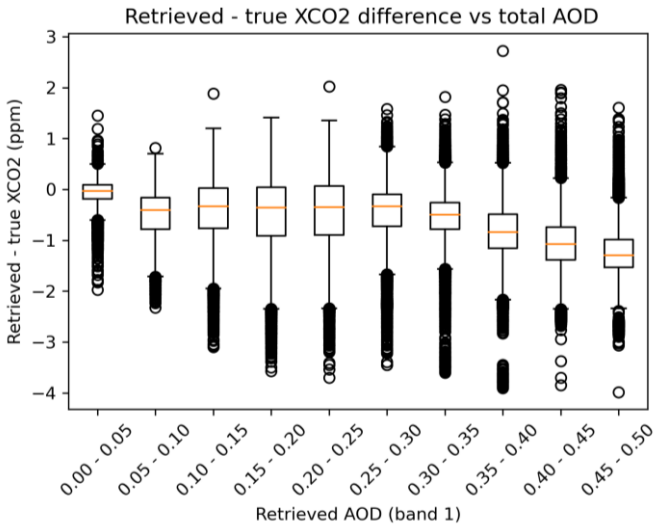


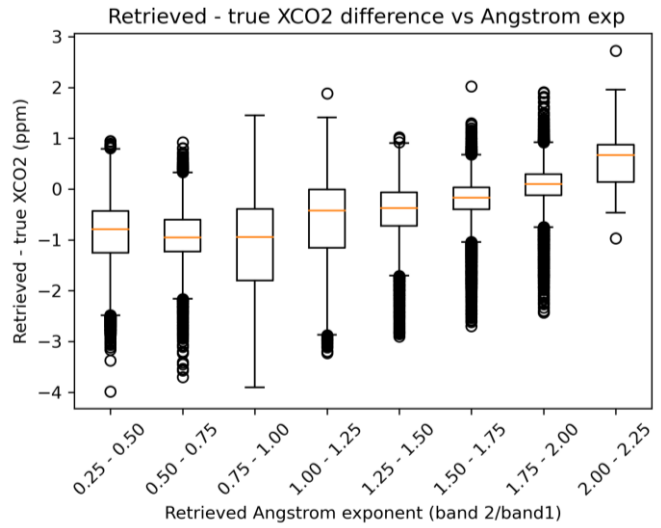


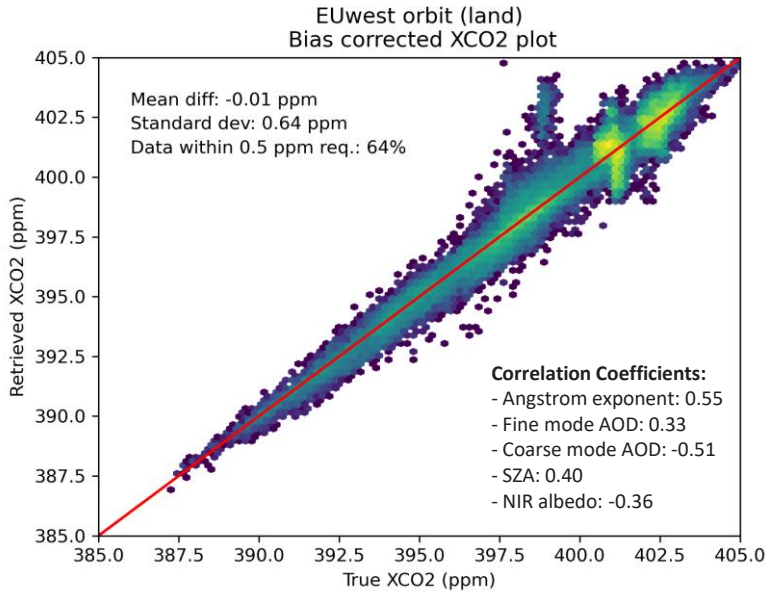




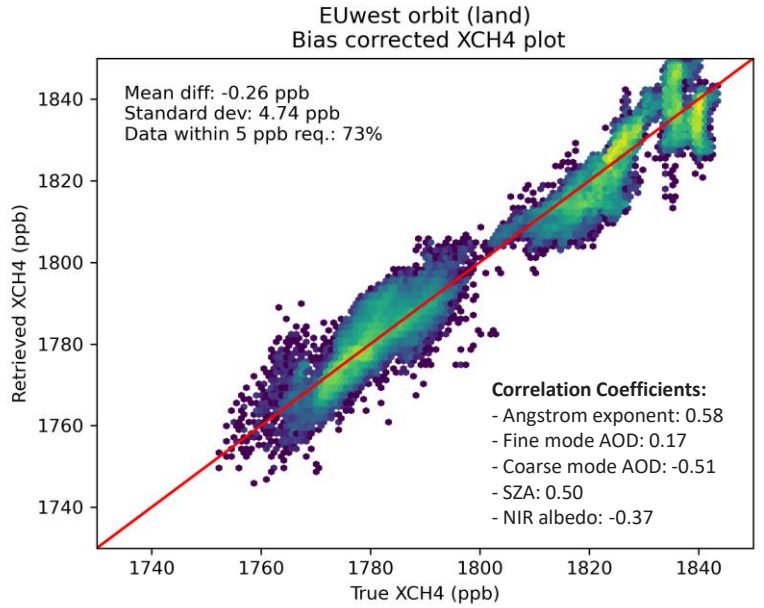
Bias correction







- XCO2 biases increase with AOD and aerosol size (i.e. lower Angstrom exponent)
- Errors can be reduced by bias correction. First tests with multi-linear regression carried out
- Approach to be refined (more variables, more sophisticated methods)



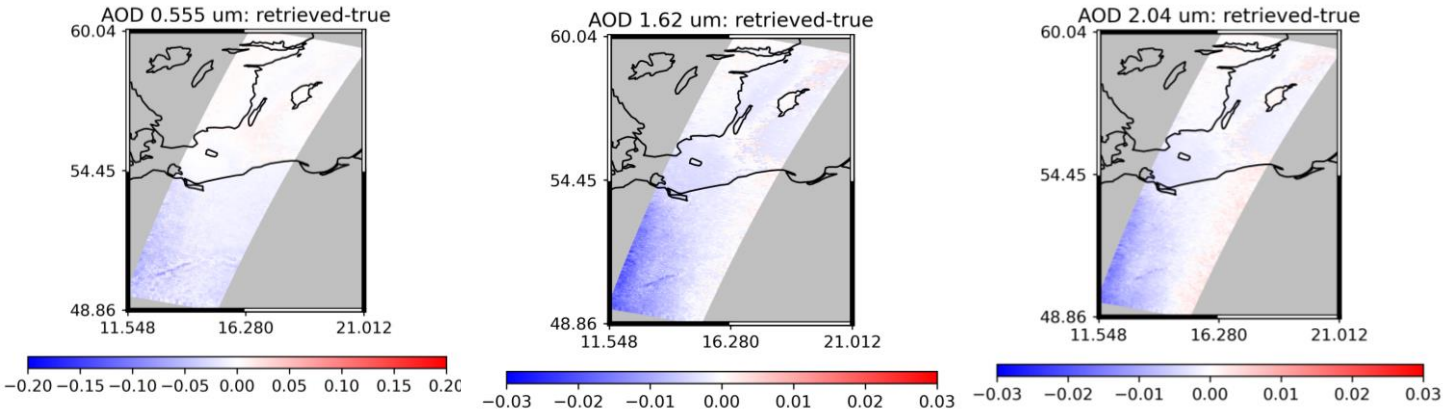
Use of MAP data

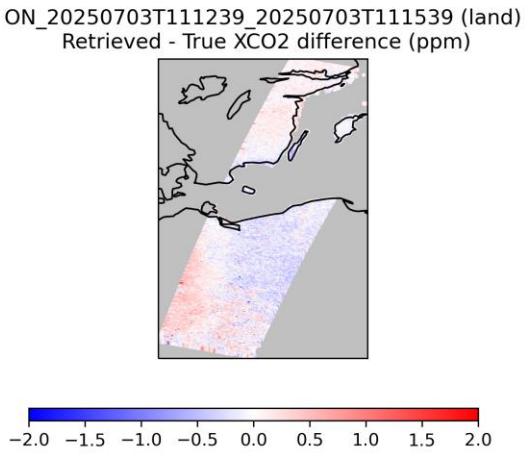
- L2 MAP information expected to reduce aerosol-related biases
- L2 product from GRASP team to be used as input for CO2 retrieval
- Tests on synthetic orbits coming up

MAP L2

- AOD
- SSA
- Volume concentrations
- Refractive index
- Volume mean radius
- Spherical particle fraction
- Vertical profile parameters

→ Scattering kernel LUT interpolation → FUSIONAL-P





Summary

- UOL-FP retrieval allows determination of CO_2 and CH_4 from SWIR spectral information
- Full orbit simulations for CO2M show that retrieval performs as expected
- Availability of MAP results expected to improve the CO_2 retrieval performance
- Further development still ongoing
  - Ocean glint retrievals
  - Non-scattering retrieval (SIF, proxy retrievals)