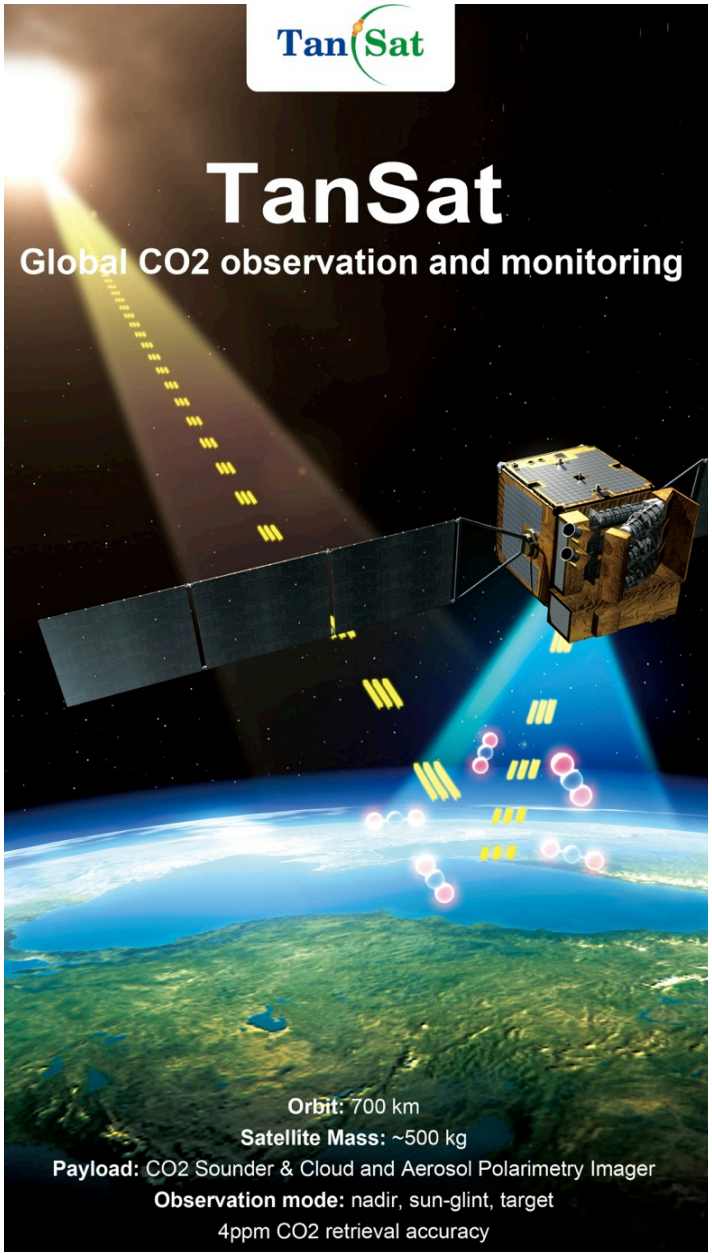


Towards high Precision XCO2 Retrievals from TanSat Observations

Dongxu Yang[1,2,3], Hartmut Boesch[1,4], Yi Liu[2,3], Peter Somkuti[5], and UoL GHG team and TanSat team

1 Earth Observation Science, School of Physics and Astronomy, University of Leicester, UK

2 Institute of Atmospheric Physics, Chinese Academy of Sciences, China

3 Shanghai Advanced Research Institute, Chinese Academy of Sciences, Shanghai, China

4 National Centre for Earth Observation, University of Leicester, UK

5. Colorado State University, Fort Collins, CO, USA

EGU General Assembly 2020

The TanSat Mission

- National High Technology Research & Development Programs by **Ministry of Science and Technology of China (MOST)** (2011-2017)
- Strategic Priority Research Program from **Chinese Academy of Sciences**
  - Climate Change: Carbon Budget and Relevant Issue
  - Space Science: Scientific Research Satellite
- NSMC (CMA) -- (2016- NOW) , Ground segment—Satellite data receive and process

TanSat mission kicked-off at 2011, launched at 2016

TanSat mission will join the ESA 3rd Party mission

Term-1

Measurement Goals

XCO2

1~4 ppmv

Monthly

500 x 500 km^2

Term-2

Measurement Goals

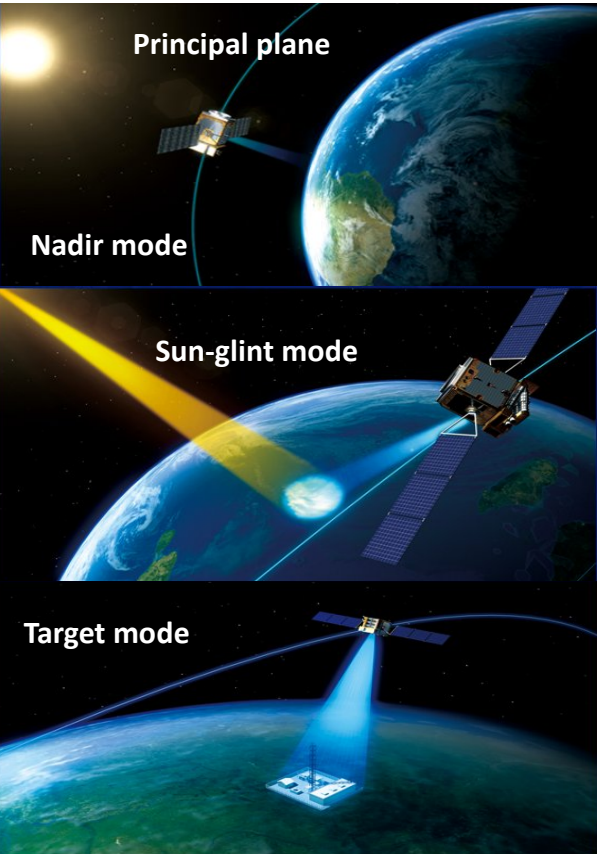
CO2 Flux

Relative flux error 20%

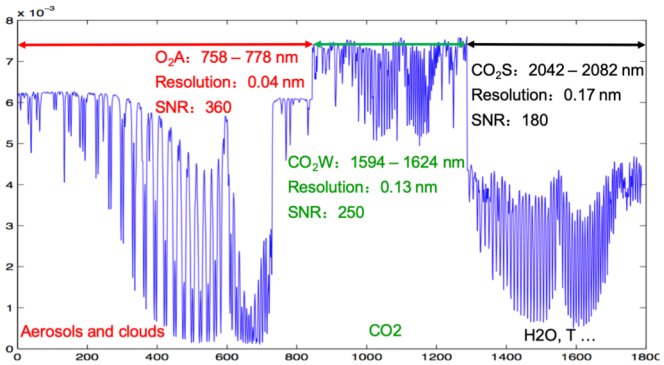
Monthly

500 x 500 km^2

TanSat & Instrument

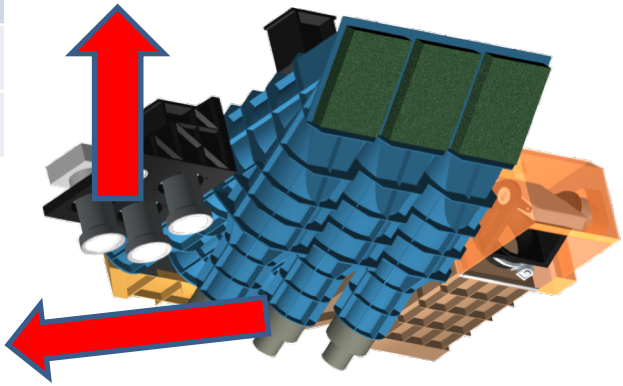


Name	Characters
Orbit type	sun-synchronous
Altitude	700 km
Inclination	98°
Local time	13:30
Weight	500Kg



Cloud and Aerosol Polarization Imager - CAPI

- A wide field multi-band imager with polarization channels
- UV: 0.38μm; VIS: 0.67μm; NIR: 0.87, 1.375 and 1.64μm
- Polarization: 0.67 & 1.64 μm



Atmospheric Carbon Dioxide Grating Spectrometer - ACGS

- Hyperspectral grating spectrometer with 3 bands

TanSat

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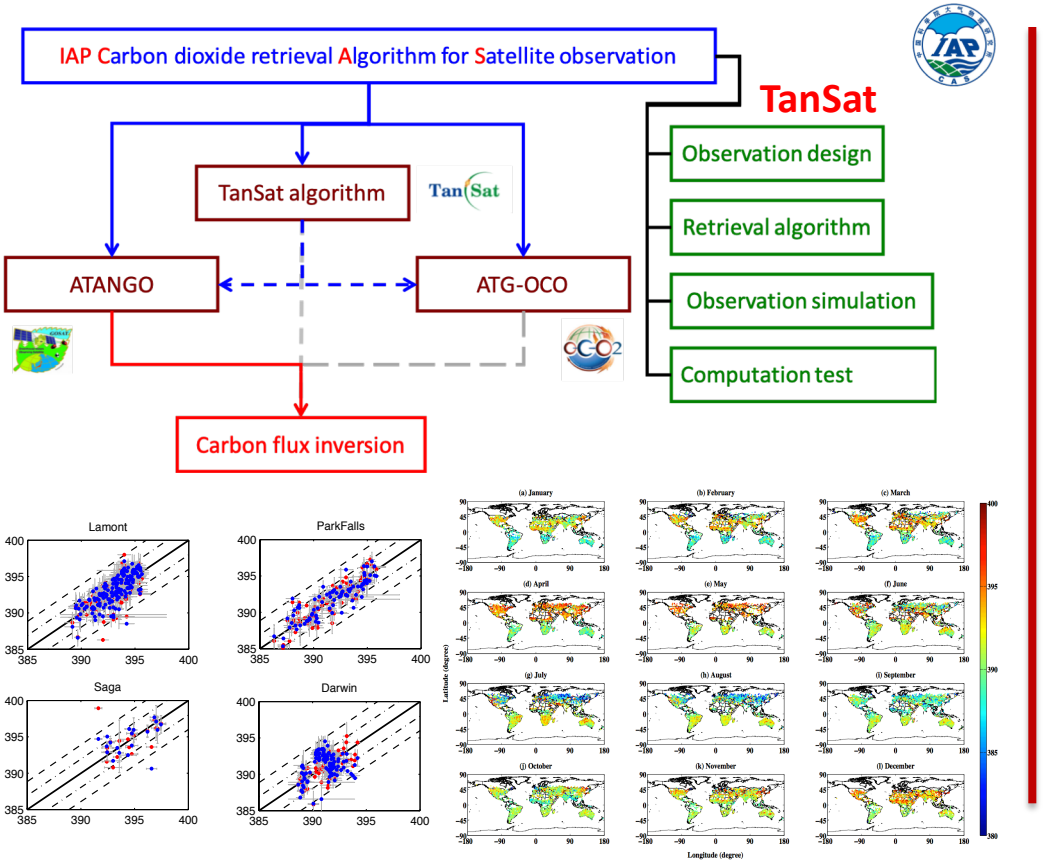
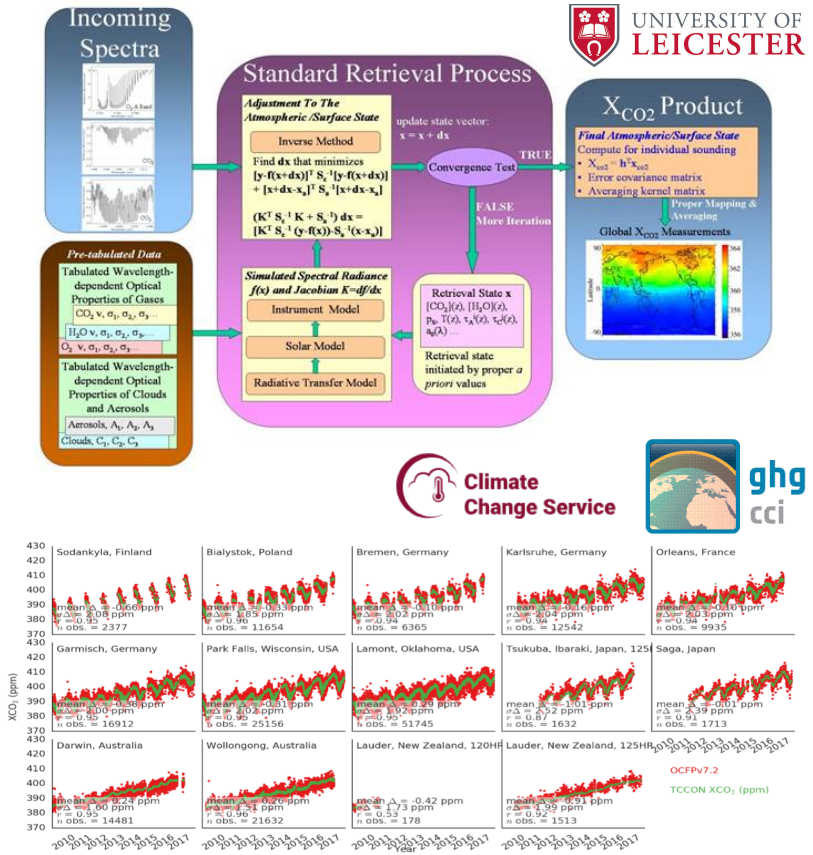
L2 Retrieval Algorithms

IAPCAS



(Yang et al., 2018, Liu et al., 2018)

UoL-FP



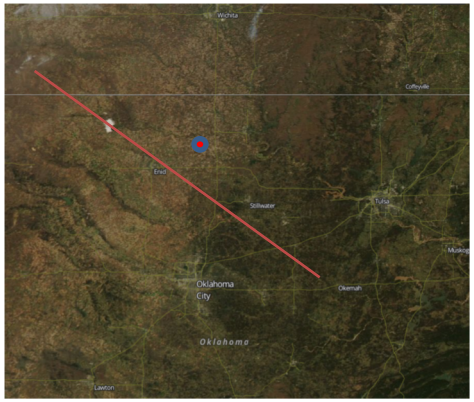
(Parker et al., 2011; Cogan et al., 2012; Boesch et al., 2013; Somkuti et al., 2018)

Here, a 2-band retrieval (NIR + 1.6 μm CO2 band) is used for IAPCAS and UoL-FP

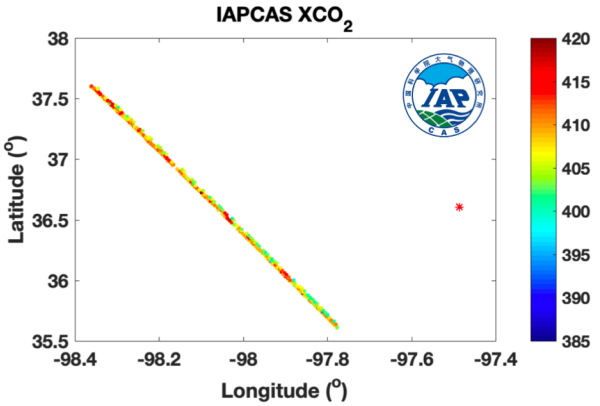
Preliminary Result: Comparison of Retrieval Results from Original L1B Data

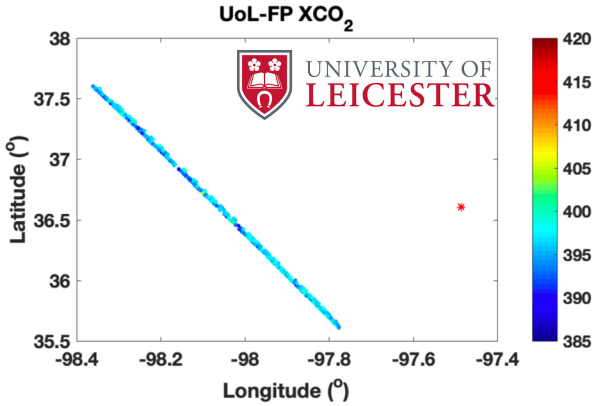
Retrieval comparison between

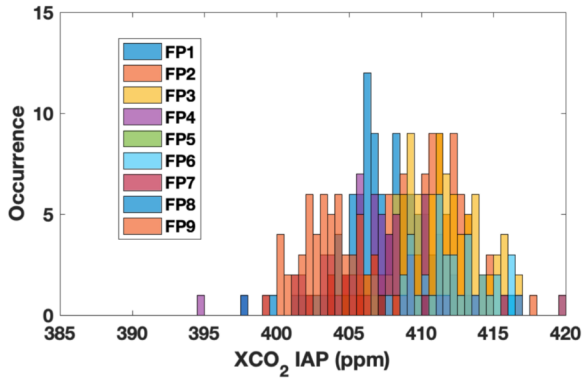
UoL-FP .VS. IAPCAS

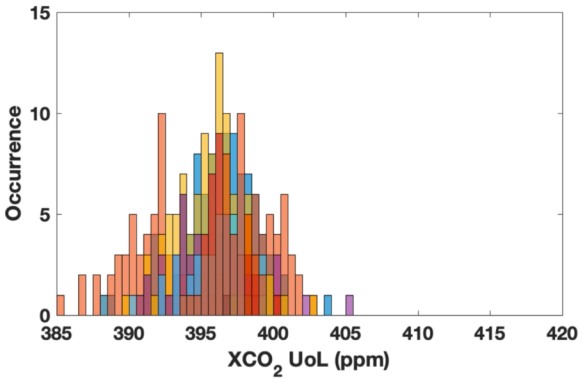


Case study, TanSat 8 Oct. 2017, around Lamont with almost cloud free condition









- Large spread of XCO2 retrieval results
- Poor consistency between different TanSat footprints (FP1-FP8)
- Large differences between UoL-FP and IAPCAS retrievals

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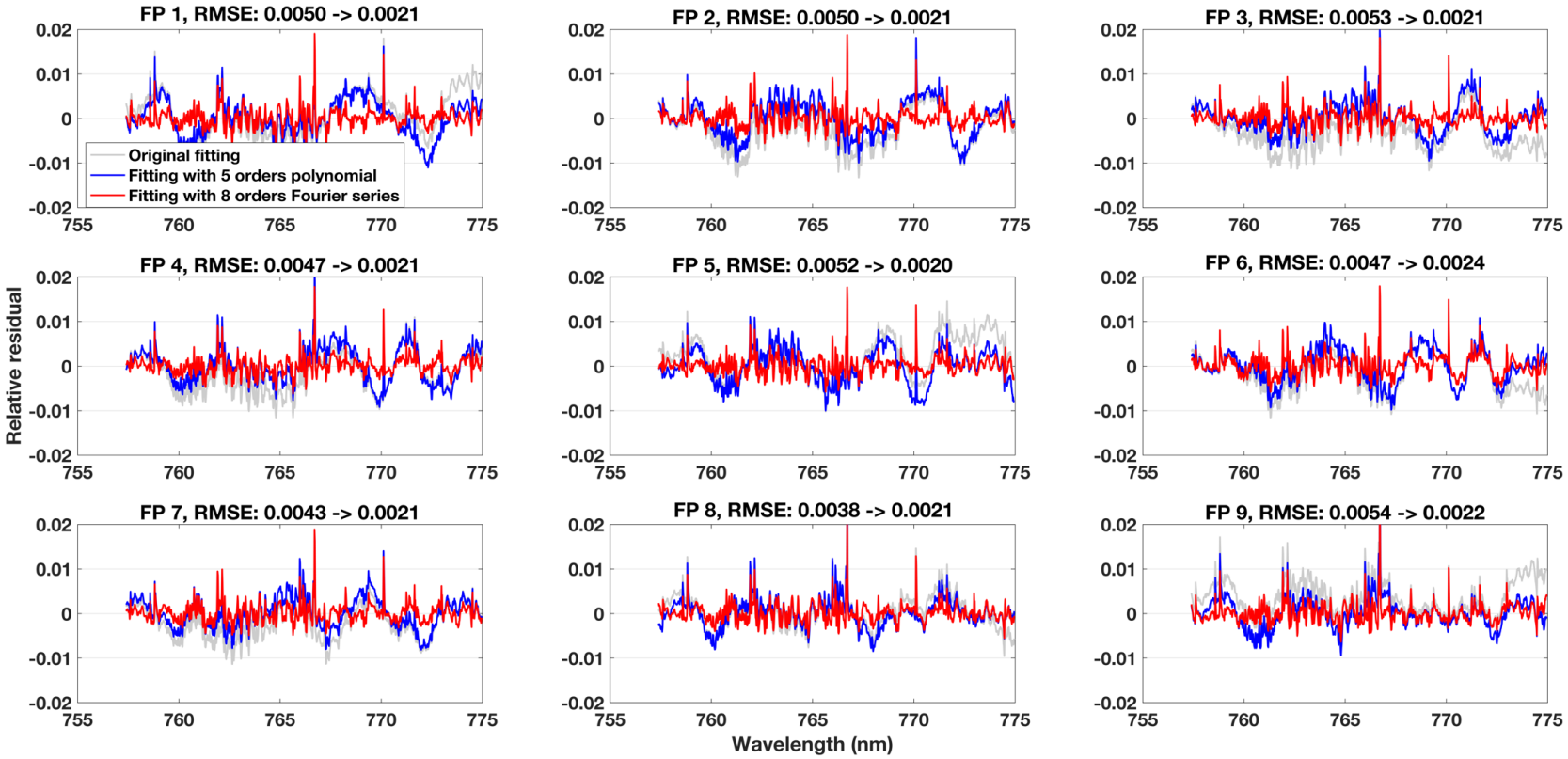
Analysis of TanSat Solar Measurements

- A persistent frequency pattern is observed in O_2 A band when compared to UoL-FP solar model
- A Fourier series correction has been developed for radiometric correction

➢ Method minimizes residual pattern when solar measurements are analyzed

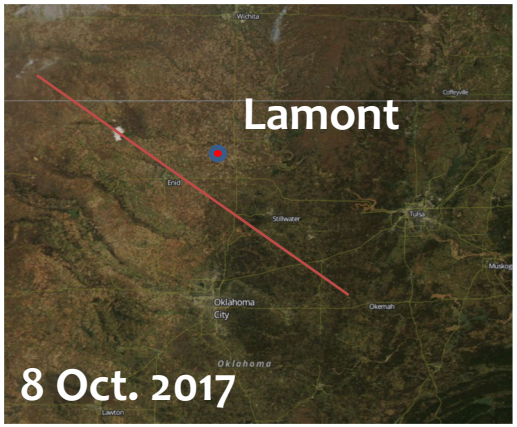


Yang et al. 2020 (submitted to JGR)

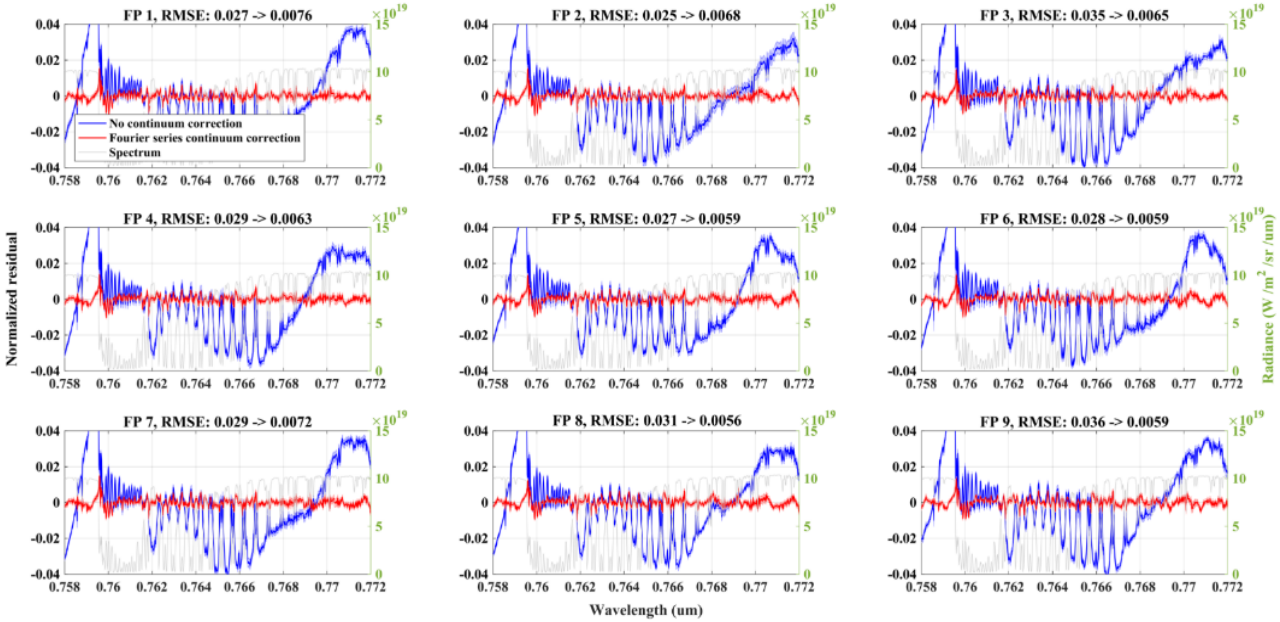
Impact of L1B Correction Method on XCO2 Retrievals

- New method for radiometric correction of TanSat L1b measurement leads to much improved the fitting residual and consistency of the XCO2 retrieval

TanSat overpass over Lamont



Mean O_2 A band fitting residuals



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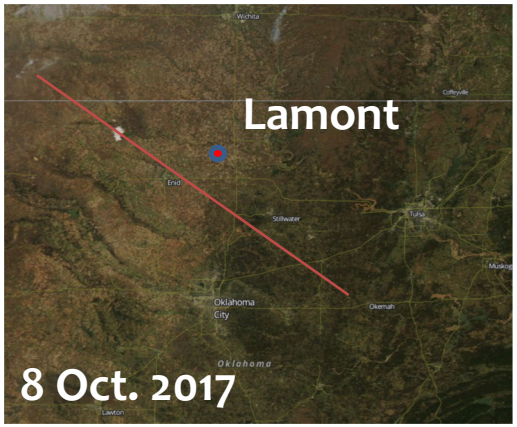
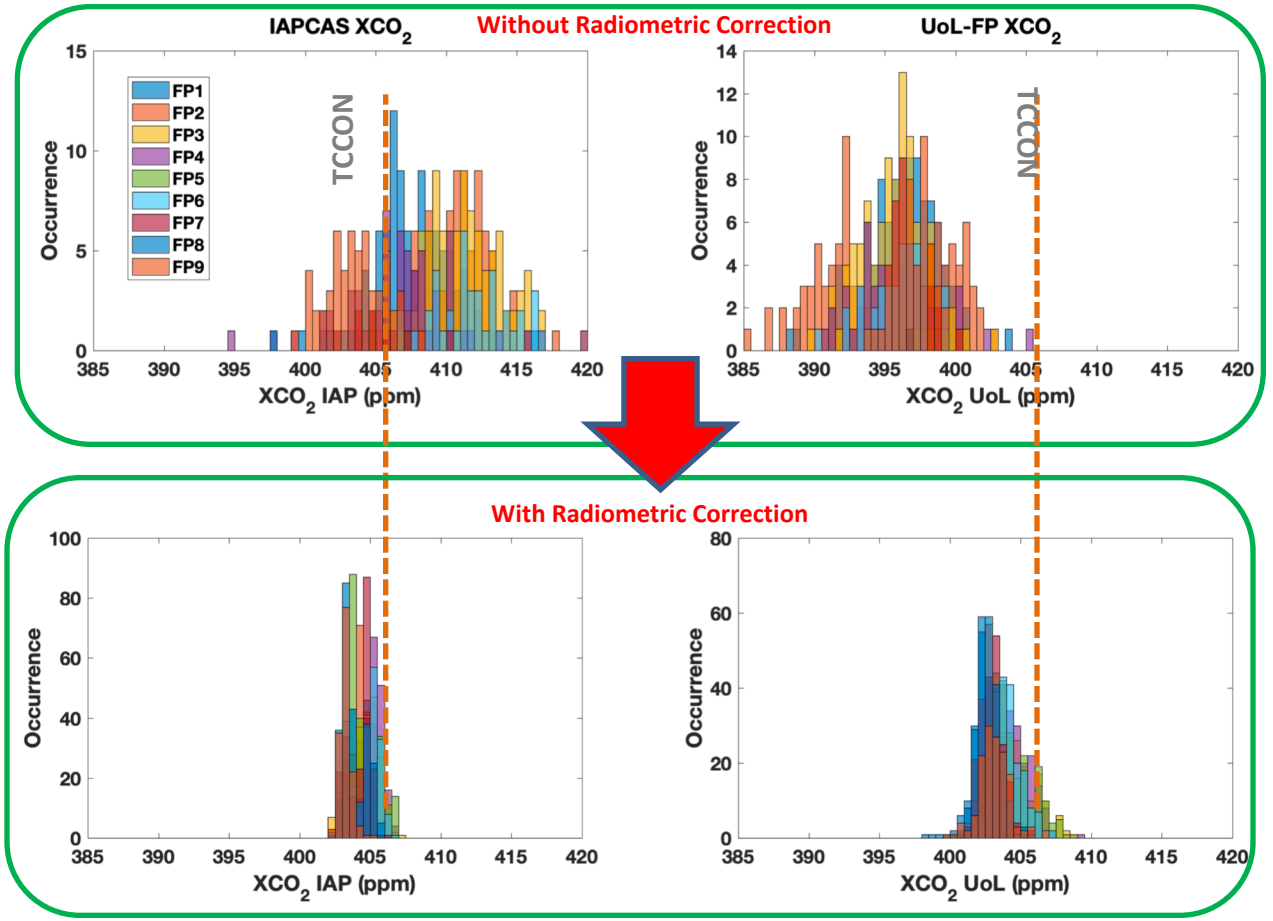




Yang et al. 2020 (submitted to JGR)

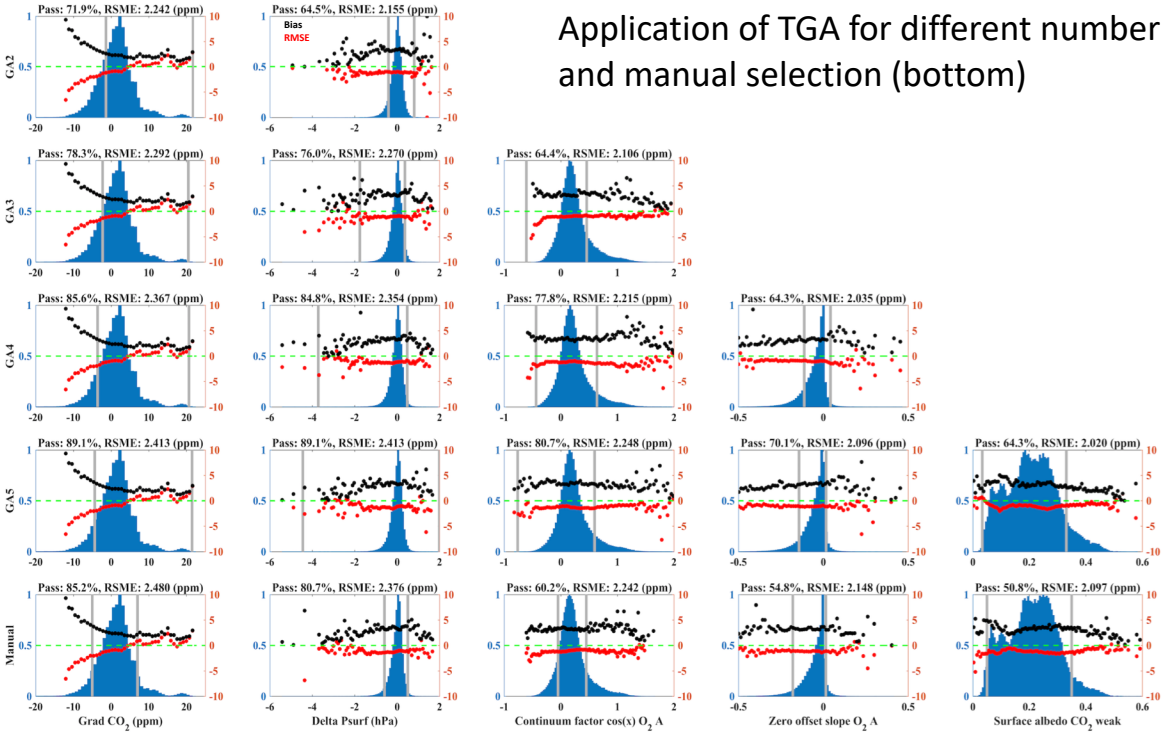
Filtering and Bias Correction

Application of Target Genetic algorithm for quality filtering of TanSat retrievals:

- Pre-selects transparency and complexity based on candidate filters selected according to correlation of error against TCCON
- Transparency of ~65% and 2 ppm RMSE can be achieved with 5 filters
- Empirical selection results in additional 13.5% loss of data

Bias correction based on multi-linear regression of same 5 parameters against TCCON

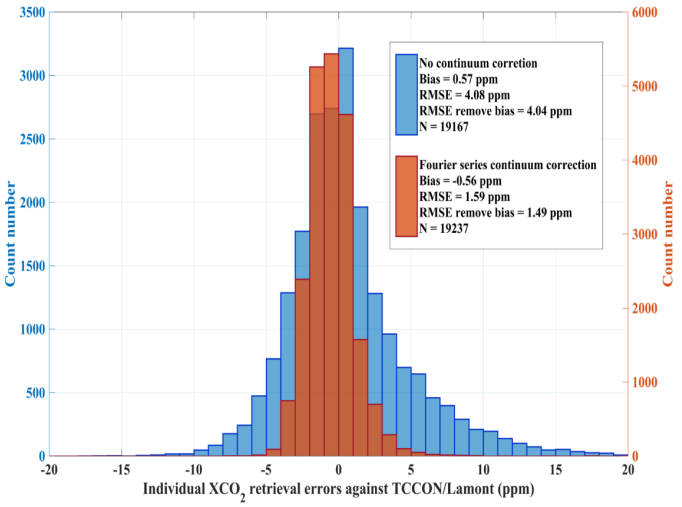
Increasing number of filter parameters for TGA



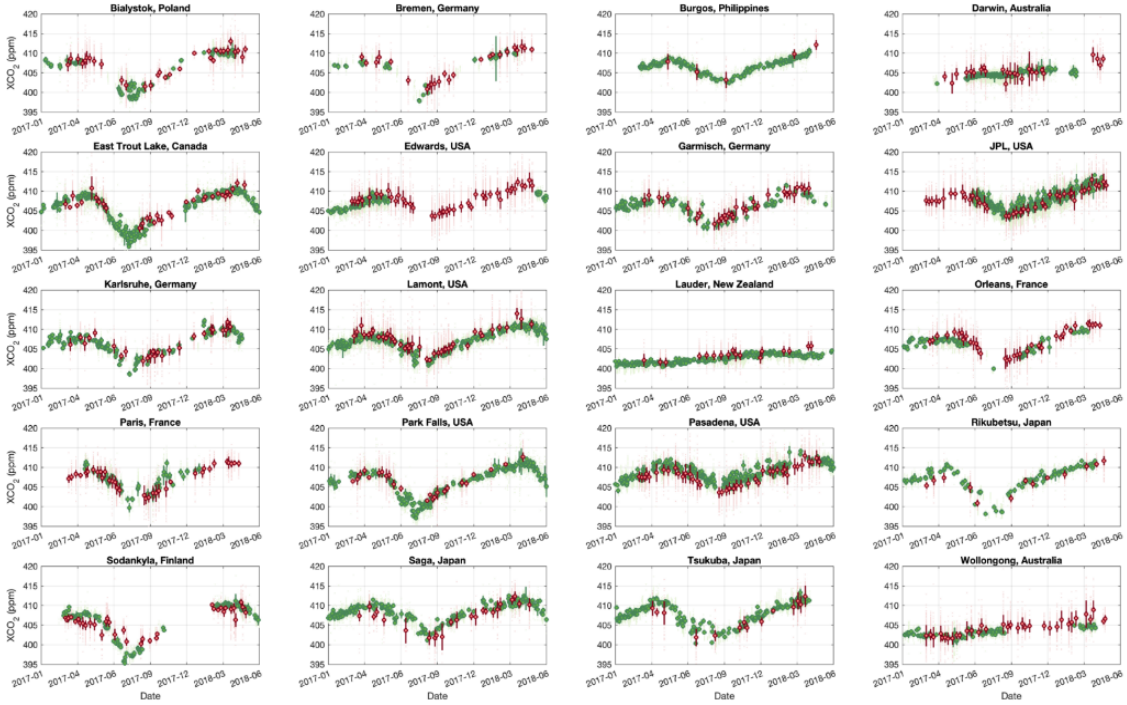
Application of TGA for different number filters and manual selection (bottom)

Yang et al. 2020 (submitted to JGR)

Validation of UoL-FP XCO_2 against TCCON



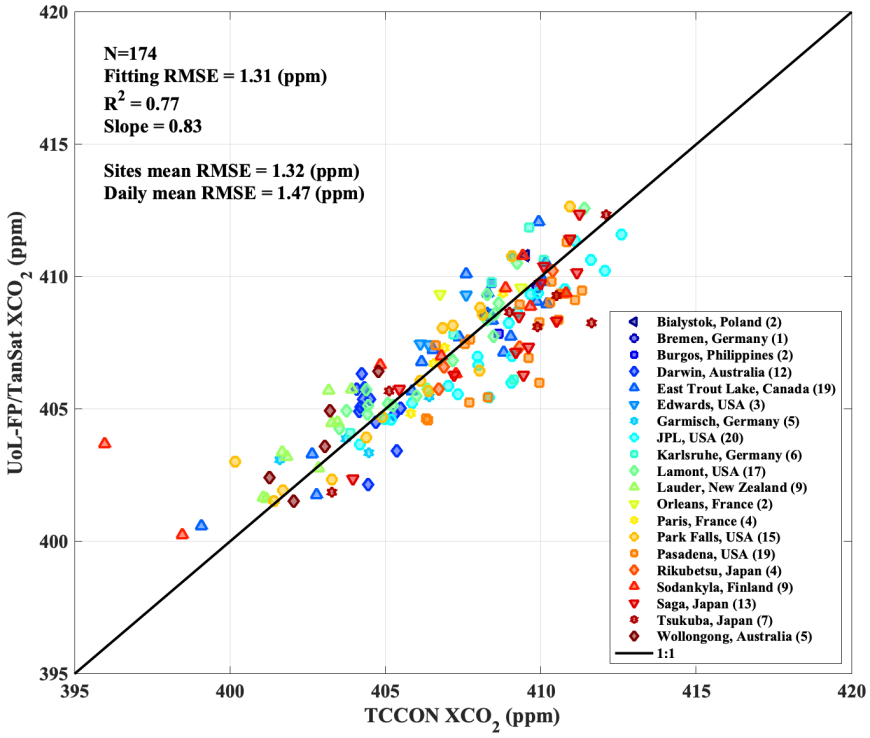
TCCON
TanSat



- Good comparisons of UoL-FP TanSat retrieval against TCCON similar to other missions (OCO-2, GOSAT)

Yang et al. 2020 (submitted to JGR)

Validation of UoL-FP XCO_2 against TCCON

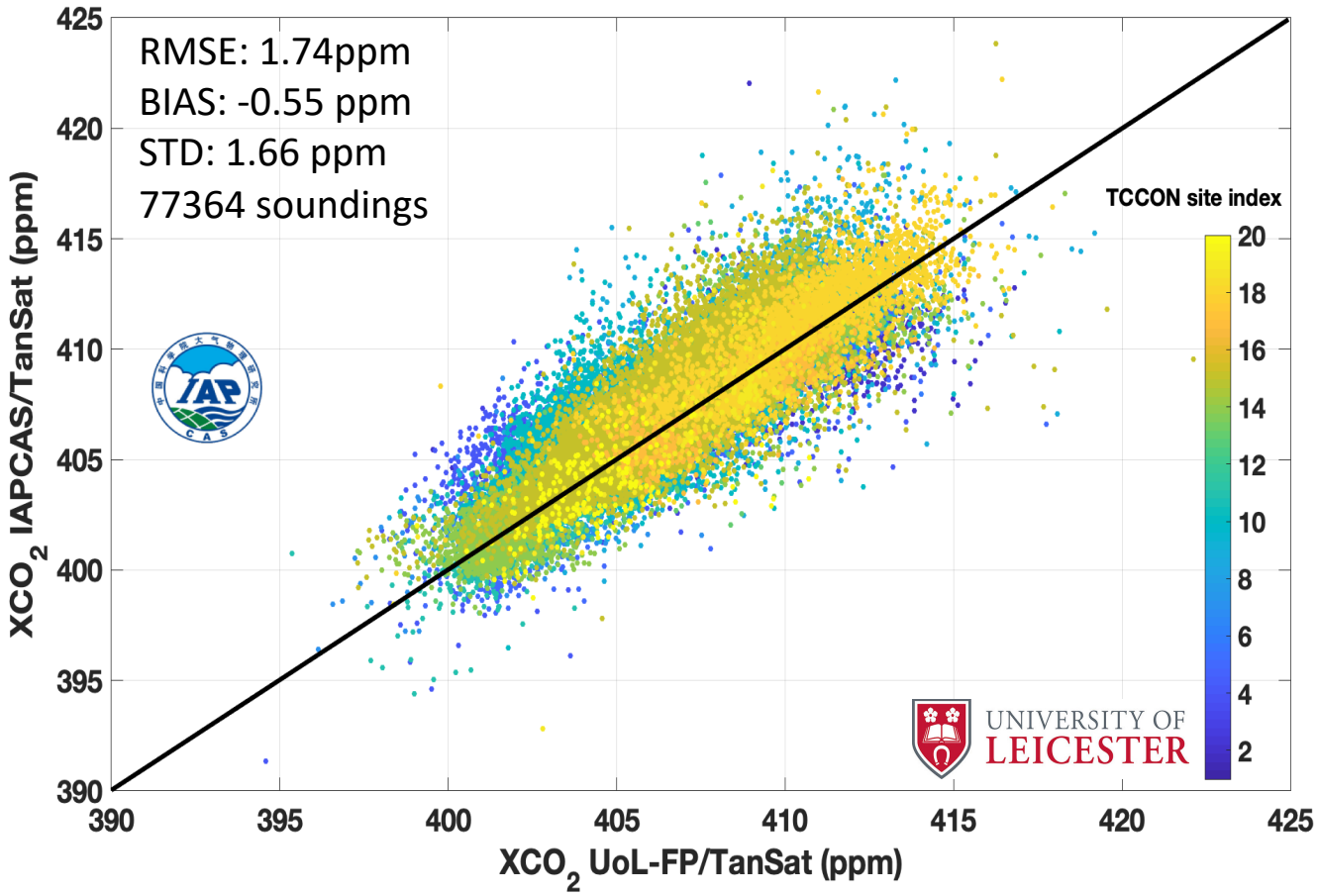


Site		validation	
	N (overpasses)	bias (ppm)	RMSE (ppm)
Bialystok, Poland	2	0.78	0.93
Bremen, Germany	1	-0.29	0.29
Burgos, Philippines	2	0.27	1.10
Darwin, Australia	12	0.29	1.36
East Trout Lake, Canada	19	0.21	1.12
Edwards, USA	3	1.36	1.39
Garmisch, Germany	5	0.24	1.18
JPL, USA	20	-1.12	1.39
Karlsruhe, Germany.	6	0.33	1.67
Lamont, USA	17	0.37	0.76
Lauder, New Zealand	9	1.19	1.40
Orléans, France	2	1.40	1.83
Paris, France.	4	0.048	0.62
Park Falls, USA	15	0.41	1.20
Pasadena, USA	19	-1.41	1.84
Rikubetsu, Japan	4	-0.85	1.12
Sodankylä Finland	9	1.17 (0.35)*	2.83 (1.25)*
Saga, Japan	13	-0.92	1.53
Tsukuba, Japan	7	-1.04	1.62
Wollongong, Australia	5	0.90	1.23

- Good comparisons of UoL-FP TanSat retrieval against TCCON similar to other missions (OCO-2, GOSAT)

Yang et al. 2020 (submitted to JGR)

Inter-comparisons of TanSat UoL-FP and IAPCAS Retrieval



- Direct intercomparisons show good agreement between UoL and IAPCAS retrieval
- Note that no bias correction si applied here to both retrievals

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Summary and Outlook

- We have applied the UoL-FP retrieval to TanSat XCO2 retrieval over TCCON sites
- By analyzing the solar calibration measurement, we found spectral artifacts can be effectively eliminated by applying a Fourier series model for radiometric correction
- This correction significantly improves fitting residual, and accordingly reduces XCO_2 retrieval RMSE against measurements from the TCCON
- After applying a bias correction and filtering, a mean RMSE of 1.47 ppm against TCCON is found with typical biases of a few tenths of a ppm for individual TCCON sites but larger biases (~1 ppm) are observed for some sites
- The methods developed in this study will be applied to IAPCAS XCO_2 retrieval which is used for the operational processing of TanSat L2 data. IAPCAS data will be available on the China GEO data service (www.chinageoss.org/tansat)
- UoL-FP TanSat data will be made available via ESA CCI+ website.