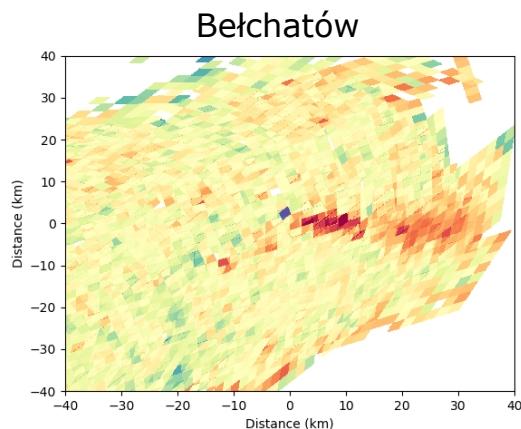


Quantifying CO₂ Emissions from Smaller Point Sources by Using Multiple OCO-3 Images

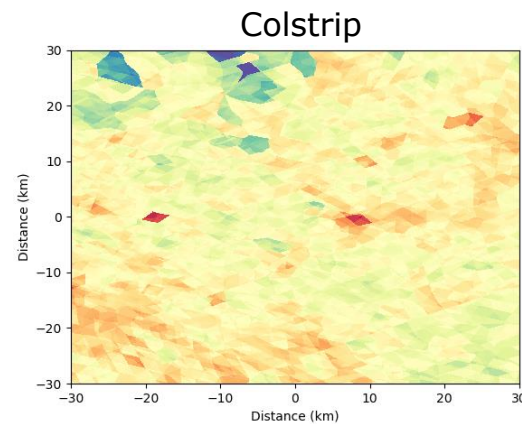
Jon-Paul Mastrogioacomo¹, Ray Nassar², Tim Hill¹, Ryan Pavlick³, Robert Nelson³, Christopher O'Dell⁴, Annmarie Eldering³, David Crisp³

(1) University of Waterloo, (2) Environment and Climate Change Canada, (3) Jet Propulsion Laboratory, (4) Colorado State University

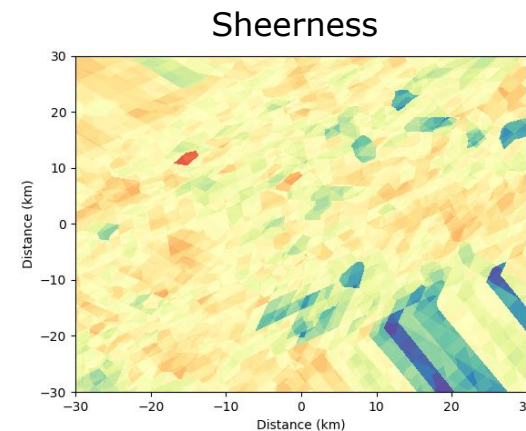
- NASA's Orbiting Carbon Observatory 3 (OCO-3) instrument launched in 2019 is newly capable of obtaining Snapshot Area Maps (SAMs)
- SAMs provide large area coverage of XCO₂ data and allow for CO₂ emission estimates of large point sources
- By using multiple SAMs of a single source, we can improve the plume and reduce background noise and attempt to quantify emissions of smaller point sources (~7 MtCO₂/year)
- SAMs are rotated to align plumes, XCO₂ data is interpolated onto a 50m grid, data is averaged and emission estimates are calculated with a Gaussian Plume Model
- Methodology is based on Hill & Nassar (2019)



Estimated: 28.4 ± 2.2 MtCO₂/yr
Reported: 27.0 Mt CO₂/yr
Correlation: 0.604



Estimated: 12.0 ± 1.5 MtCO₂/yr
Reported: 11.6 MtCO₂/yr
Correlation: 0.407



Estimated: 5.9 ± 2.5 MtCO₂/yr
Reported: 4.7 MtCO₂/yr
Correlation: 0.318



Canada

Methodology

- For each SAM, plume direction is identified based on correlation coefficient, wind history, and TROPOMI NO₂ plume
- SAMs are rotated to align plumes and data is interpolated onto regular grid at 50m resolution
- XCO₂ values are averaged on high resolution grid to make single new image
- Emission estimates are calculated with Gaussian Plume Model in MtCO₂/year
- Total uncertainty is combination of wind, background, enhancement, and rise uncertainties
- For some overpasses, we fill missing data with a nearest neighbour method

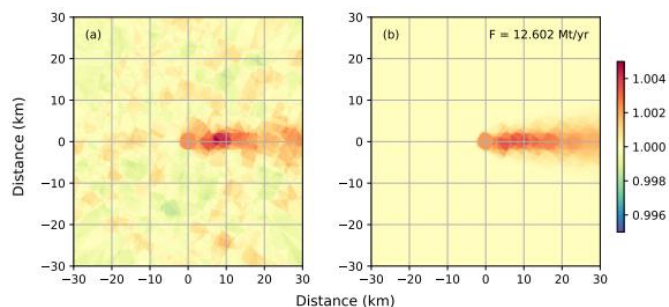
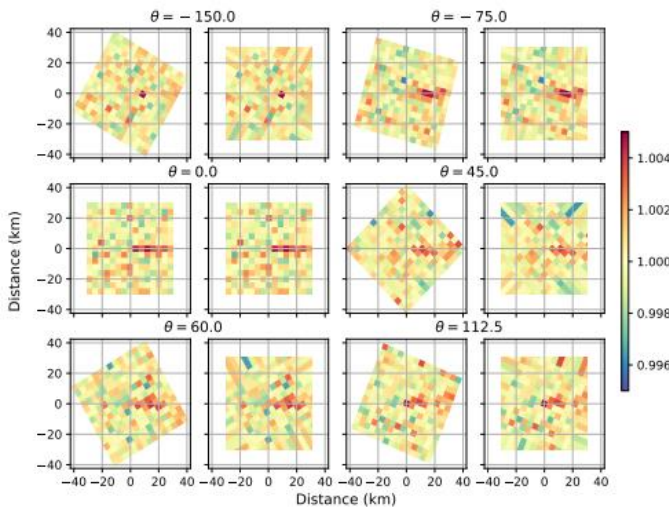
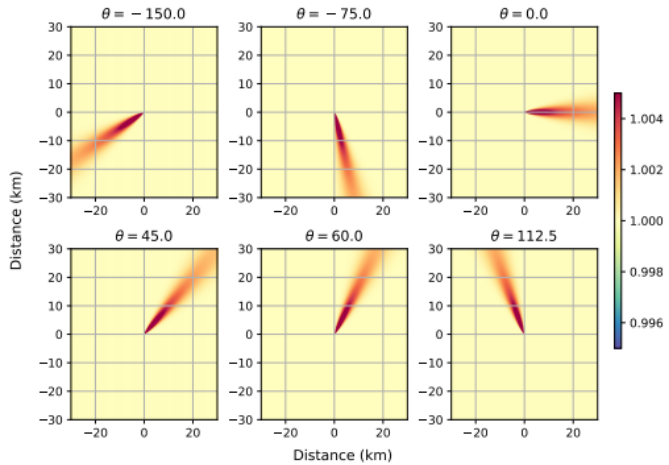
$$V(x, y) = \frac{F}{\sqrt{2\pi}\sigma_y(x)u} e^{-\frac{1}{2}\left(\frac{y}{\sigma_y(x)}\right)^2}$$

$$\varepsilon = \sqrt{\varepsilon_w^2 + \varepsilon_b^2 + \varepsilon_e^2 + \varepsilon_r^2}$$

$$\sigma_y(x) = a \cdot \left(\frac{x}{x_0}\right)^{0.894}$$

Future Improvements

- Simulated data show that >6 overpasses are needed to obtain acceptable level of correlation for power plants <8 Mt CO₂/year
- Method will become more widely applicable as SAMs become more numerous
- OCO-3 vEarly data has known geolocation error and swath-to-swath bias
- Likely to see improvements with v10 data

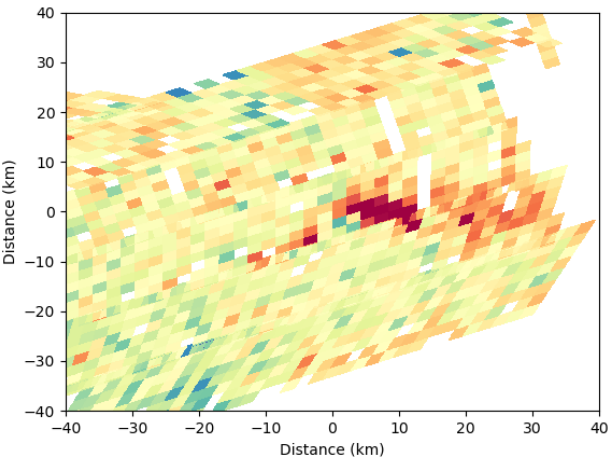


Simulated data (Hill & Nassar 2019)

Bełchatów Power Plant (LD, Poland)

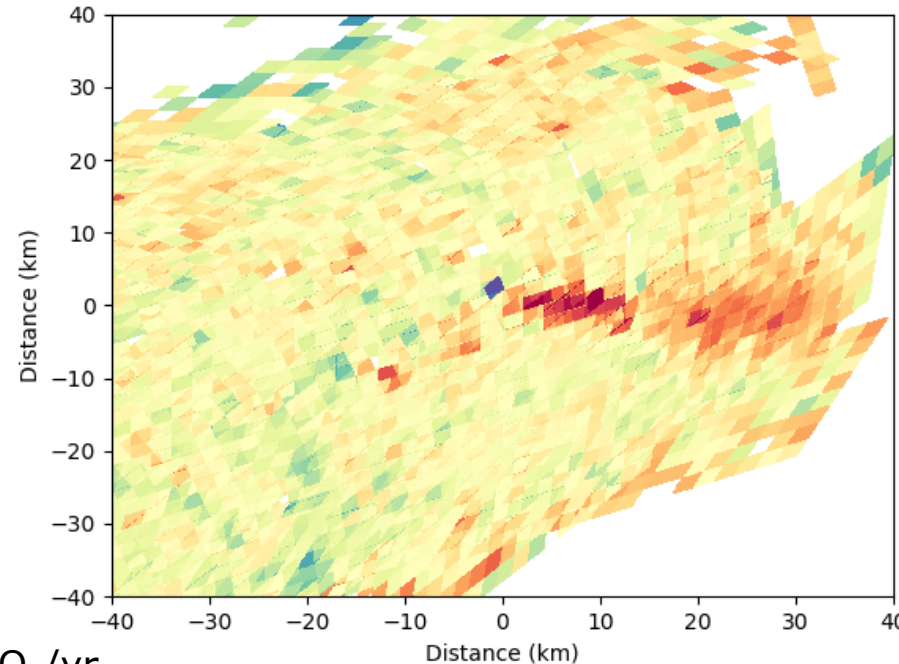
Latitude: 51.26598, Longitude: 19.32675

2020-04-10

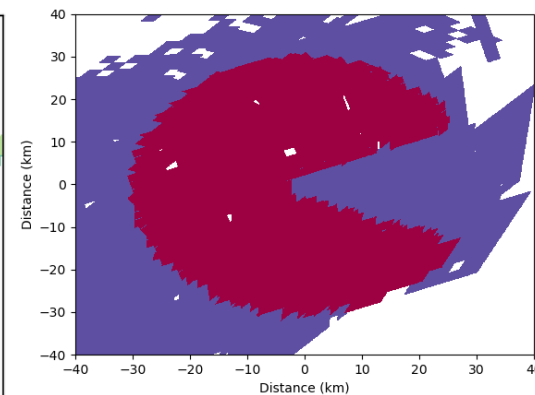


Estimated: 28.8 ± 3.5 MtCO₂/yr
Reported: 28.5 MtCO₂/yr
Correlation: 0.646
Wind Speed: 1.7 m/s

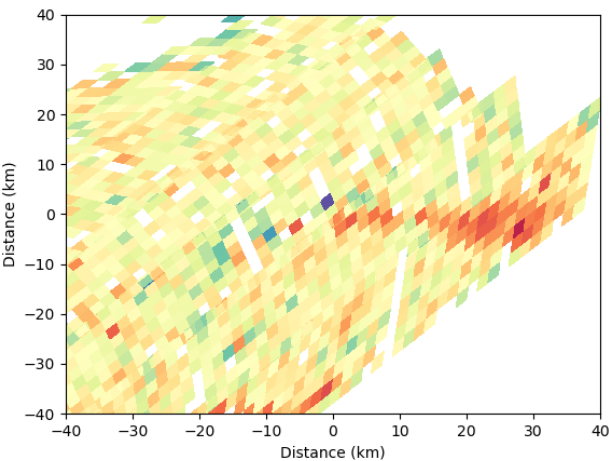
Averaged Image



Background



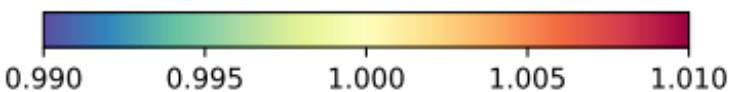
2020-04-17



Estimated: 24.3 ± 2.3 MtCO₂/yr
Reported: 25.6 MtCO₂/yr
Correlation: 0.407
Wind Speed: 3.8 m/s

Estimated: 28.4 ± 2.2 MtCO₂/yr
Average of daily reported: 27.0 Mt CO₂/yr
Correlation: 0.604

Source at origin, wind aligned with positive x-axis

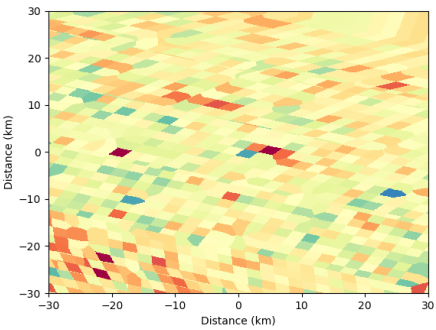


- For more detail on Bełchatów emissions estimates see: "Update on Quantifying Power Plant CO₂ Emissions with OCO-2 and OCO-3" by Nassar et al. (IWGGMS-17)
- Reported quantities based on 2017 EPRTR emissions data and ENTSO-E power generation data
- Good correlation and agreement between estimated and reported emissions

Colstrip Power Plant (MT, USA)

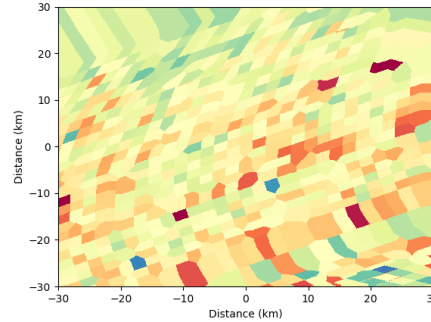
Latitude: 45.883486, Longitude: 106.612161

2020-02-09



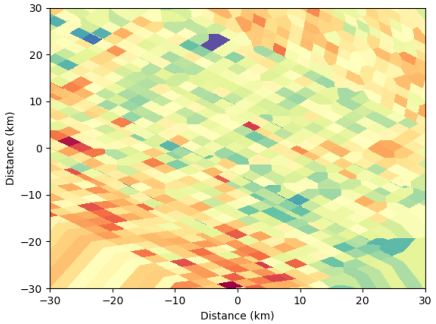
Estimated: 5.1 ± 0.8 MtCO₂/yr
Reported: 11.1 MtCO₂/yr
Correlation: 0.262
Wind Speed: 8.8 m/s

2020-12-03



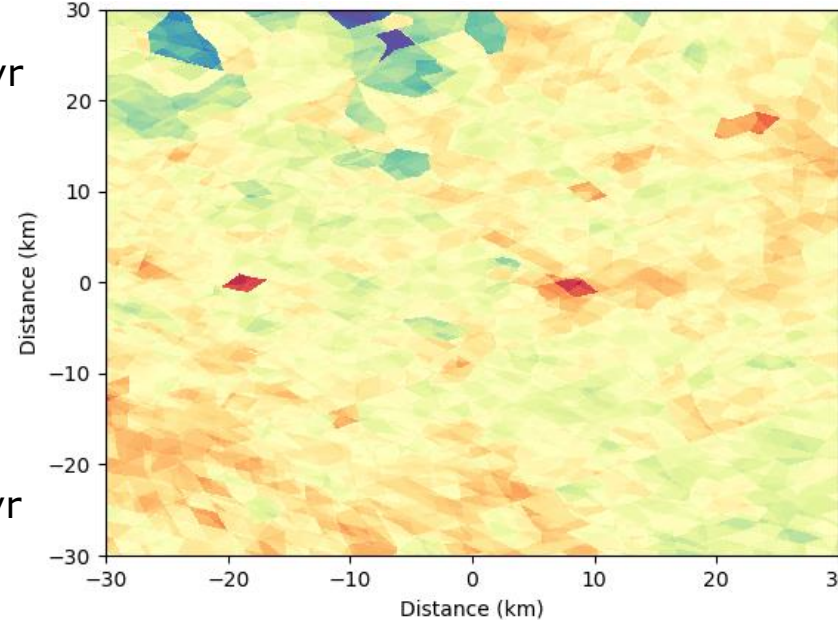
Estimated: 20.5 ± 2.6 MtCO₂/yr
Reported: 12.7 MtCO₂/yr
Correlation: 0.412
Wind Speed: 10.0 m/s

2020-02-22

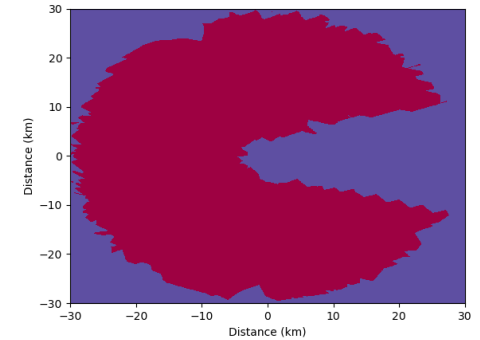


Estimated: 15.7 ± 5.1 MtCO₂/yr
Reported: 11.0 MtCO₂/yr
Correlation: 0.406
Wind Speed: 9.3 m/s

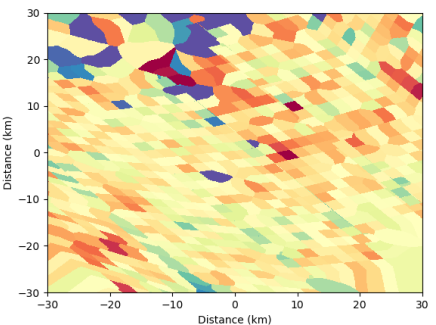
Averaged Imaged



Background



2020-04-03

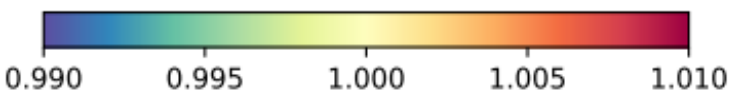


Estimated: 10.2 ± 1.7 MtCO₂/yr
Reported: 11.4 MtCO₂/yr
Correlation: 0.202
Wind Speed: 5.0 m/s

Estimated: 12.0 ± 1.5 MtCO₂/yr
Correlation: 0.407

Average of reported for these four days: 11.6 MtCO₂/yr

Source at origin, wind aligned with positive x-axis

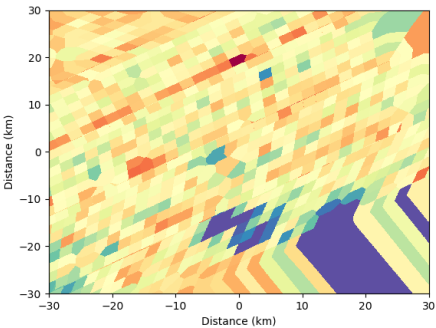


- Individual SAMs either have low correlation or poor agreement between estimated and reported emissions
- Averaged image has acceptable correlation and good agreement with average of daily reported emissions (US EPA)
- Averaged image has lowest percent uncertainty

Sheerness Power Plant (AB, Canada)

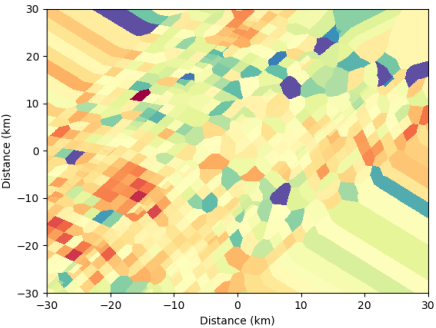
Latitude: 51.442222, Longitude: -111.792222

2020-04-06



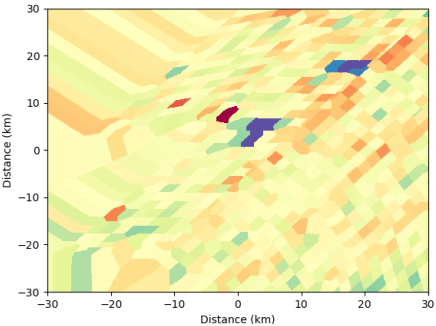
Estimated: 2.4 ± 2.1 MtCO₂/yr
Correlation: 0.271
Wind Speed: 4.1 m/s

2020-08-09



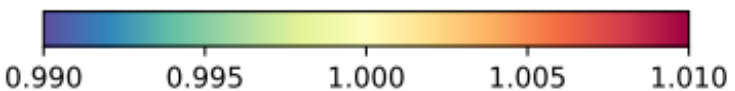
Estimated: 13.9 ± 2.8 MtCO₂/yr
Correlation: 0.294
Wind Speed: 11.1 m/s

2020-08-11

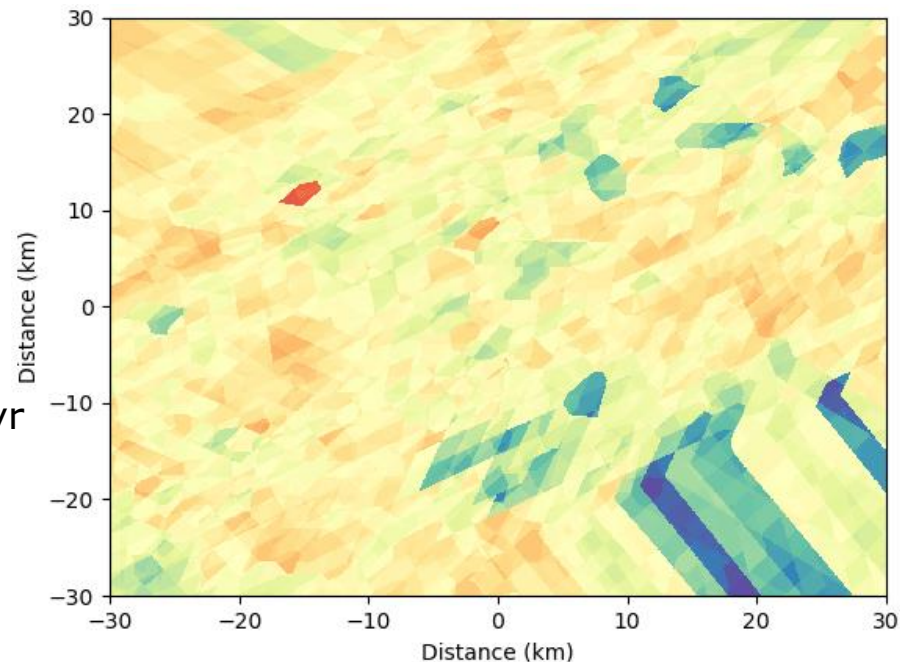


Estimated: 5.6 ± 1.1 MtCO₂/yr
Correlation: 0.236
Wind Speed: 6.3 m/s

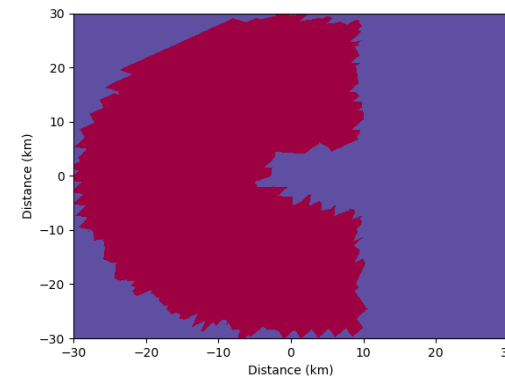
Source at origin, wind aligned with positive x-axis



Averaged Image



Background



Estimated: 5.9 ± 2.5 MtCO₂/yr
Correlation: 0.318

Reported 2019: 4.7 MtCO₂/yr

- While estimate is reasonable and within range of uncertainty, correlation is low
- Correlation and uncertainty likely to improve as more data becomes available
- Additional filtering applied for 2020-08-09 based on aerosol values
- Custom background chosen to reduce bias introduced by nearest neighbour method
- Most recent reported emissions are from 2019 (ECCC GHGRP)