Deriving CO₂ emissions of point sources from OCO-3 XCO₂ and S5P NO₂ data

B. Fuentes Andrade, M. Buchwitz, M. Reuter, H. Bovensmann, J.P. Burrows,
Institute of Environmental Physics, University of Bremen, Germany

- Carbon dioxide (CO₂) is the most important anthropogenic greenhouse gas leading to climate change. Almost 90% of the anthropogenic CO₂ emissions come from the combustion of fossil fuels, mostly emitted from localized sources.

- Satellite observations are needed to verify and complement the national greenhouse gas inventories (Paris Agreement).

- We are developing methods to obtain CO₂ emission information of localized sources (e.g. power plants and cities) using OCO-3 XCO₂ SAMs and NO₂ slant columns from TROPOMI.

- This will also serve as a preparation for the future CO2M mission, which will retrieve both XCO₂ and NO₂ slant columns.
Deriving CO₂ emissions of point sources from OCO-3 XCO₂ and S5P NO₂ data

**Motivation**

**CO₂ and NO₂ originate from the combustion of fossil fuels**

**CO₂**

XCO₂ enhancements due to the anthropogenic emissions from point sources are usually small compared to the large background values.

**NO₂**

It has a much shorter lifetime than CO₂ and therefore its enhancements in the vertical column densities due to anthropogenic emissions largely exceed background values.

NO is co-emitted with CO₂ in the combustion of fossil fuels and it rapidly reacts with O₃ to form NO₂⁻.

---

**Co-located and in temporal proximity observations of CO₂ and NO₂ allow us to detect the emission plume and its shape**

**Reuter et al., 2019**

Towards monitoring localized CO₂ emissions from space: co-located regional CO₂ and NO₂ enhancements observed by the OCO-2 and S5P satellites

---

**Friedlingstein et al. 2020: Global Carbon Budget 2019. Earth System Science Data.**

---

**Funding**

Funded by: Deutscher Wetterdienst

Wetter und Klima aus einer Hand

Blanca Fuentes Andrade

Institute of Environmental Physics (IUP)

University of Bremen
Deriving CO$_2$ emissions of point sources from OCO-3 XCO$_2$ and S5P NO$_2$ data

**Datasets**

**NO$_2$ data**

NO$_2$ slant columns retrieved by TROPOMI on S5P with DOAS (Differential Optical Absorption Spectroscopy) from IUP Bremen.

Swath of about 2600 km and spatial resolution of 3.5 x 7 km$^2$ at nadir.

---

**XCO$_2$ data**

OCO-3 level 2 XCO$_2$ from NASA.

Snapshot Area Maps (SAMs).

Spatial resolution 1.6 x 2.2 km$^2$.

---

**Belchatów Power Station, Poland**

10/04/2020

OCO-3: 13:35 UTC

S5P: 12:37 UTC
Deriving CO$_2$ emissions of point sources from OCO-3 XCO$_2$ and S5P NO$_2$ data

Method to estimate the emission flux

1. Spatial averaging

2. Enhancements selection and clustering

3. Extension of the borders of the plume

Kuhlmann et al., 2019

Detectability of CO$_2$ emission plumes of cities and power plants with the Copernicus Anthropogenic CO$_2$ Monitoring (C2M2) mission

Funded by Deutscher Wetterdienst

Wetter und Klima aus einer Hand

University of Bremen

Blanca Fuentes Andrade

Institute of Environmental Physics (IUP)

University of Bremen
Deriving CO₂ emissions of point sources from OCO-3 XCO₂ and S5P NO₂ data

Method to estimate the emission flux

XCO₂ enhancements

_flux estimation

1. Definition of cross sections along track.
2. Wind information from ERA5 Reanalysis.
3. Filling in missing data: Gaussian approach.
4. Computation of cross sectional flux as:

\[ \Phi_k = \frac{v_\perp n_e M_{CO_2}}{N_A} \sum \Delta l_i (\Delta XCO_2)_i \]

- \( v_\perp \): wind speed perpendicular to cross section,
- \( n_e \): number of dry air particles per unit area,
- \( M_{CO_2} \): molar mass of CO₂,
- \( N_A \): Avogadro constant,
- \( \Delta XCO_2 \): XCO₂ enhancement in ppm for each pixel \( i \) along \( k \)-th cross section,
- \( \Delta l_i \): length of pixel \( i \) along \( k \)-th cross section.
Deriving CO$_2$ emissions of point sources from OCO-3 XCO$_2$ and S5P NO$_2$ data

Results for the Belchatów Power Station (Poland)

First estimation of the flux: 32 ± 19 MtonsCO$_2$/year

First estimation of the flux: 27 ± 18 MtonsCO$_2$/year

- Significant variation of the cross-sectional flux as a function of the distance from the source (to be investigated).
- Flux estimation is approximately at overpass time, not an annual average.
- Uncertainty via standard deviation (preliminary, to be improved).
- Annual emissions*: 37.6 MtonsCO$_2$ in 2017, according to the E-PRTR (European Pollutant Release and Transfer Register).

*Typical uncertainty, at a 95% level of confidence, is less than 10% of full scale.

Funded by
Deutscher Wetterdienst
Wetter und Klima aus einer Hand

Blanca Fuentes Andrade
Institute of Environmental Physics (IUP)
University of Bremen