



Jet Propulsion Laboratory
California Institute of Technology

Unveiling Emissions: Comparing OCO-3 and EMIT Observations of CO₂ Point Sources from the ISS

Robert R. Nelson¹, Daniel H. Cusworth^{2,3}, Andrew K. Thorpe¹, Jinsol Kim², Clayton Elder¹, Charles E. Miller¹, Riley M. Duren^{1,2,3}, Ray Nassar⁴, and Jon-Paul Mastrogiacono⁵

¹ Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA, USA

² Carbon Mapper, Pasadena, CA, USA

³ Arizona Institutes for Resilience, University of Arizona, Tucson, AZ, USA

⁴ Environment & Climate Change Canada, Toronto, Ontario, Canada

⁵ University of Toronto, Toronto, Ontario, Canada

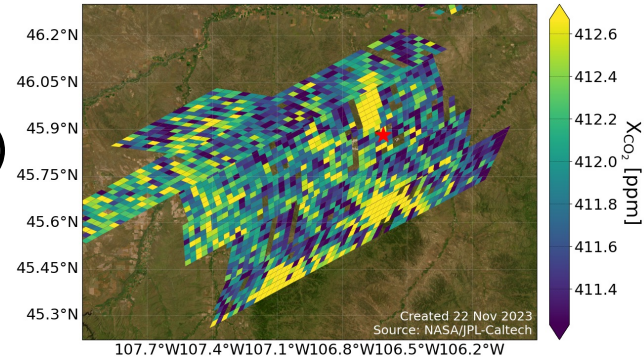
IWGGMS-20 – 30 May 2024

© 2024 All rights reserved

Missions



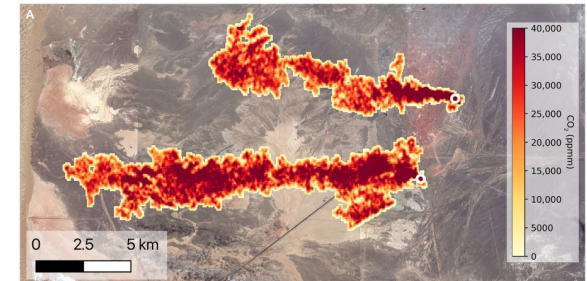
- Orbiting Carbon Observatory-3 (OCO-3)
 - May 2019, ISS
 - **2×2 km²** pixel resolution
 - ~0.1 nm spectral resolution
 - Snapshot Area Mapping (SAM) mode:
 - ~80×80 km² maps of XCO₂



Colstrip Power Plant (13 August 2021)



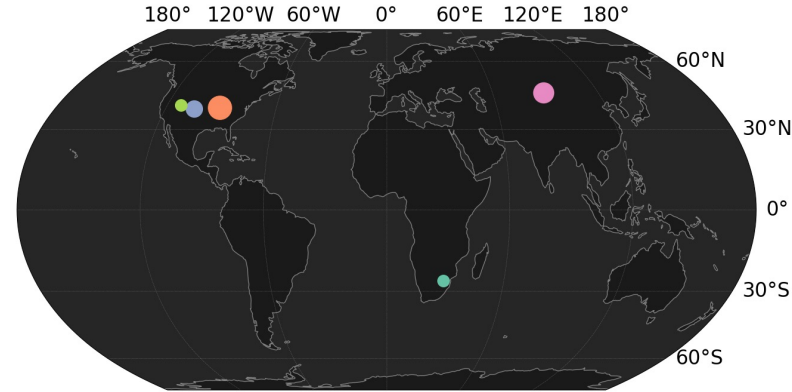
- Earth Surface Mineral Dust Source Investigation (EMIT)
 - July 2022, ISS
 - **60×60 m²** spatial resolution
 - 7.4 nm spectral resolution
 - 75 km-wide nadir swath
 - Initial focus on arid regions



Thorpe *et al.*, 2023

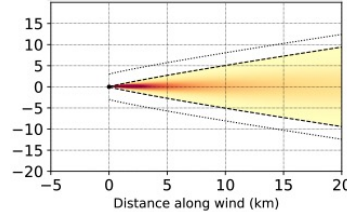
Methodology

- Both on the ISS, but only **11 collocated cloud-free observations** of power plants before OCO-3 was stored in Nov. 2023



- Gaussian Plume Model (OCO-3)*

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

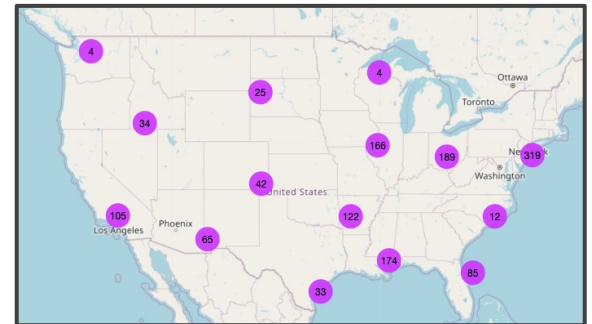


- Integrated Mass Enhancement (OCO-3, EMIT)*

$$\text{IME} = \sum_{i=1}^N \Delta\Omega_i \Lambda_i \quad Q = \frac{U_{eff}}{L} \text{IME}$$



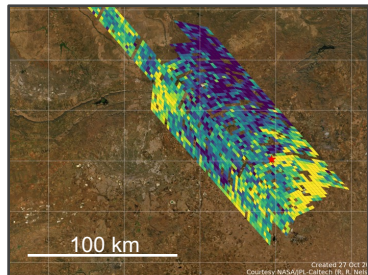
- US cases validated by hourly EPA CEMS



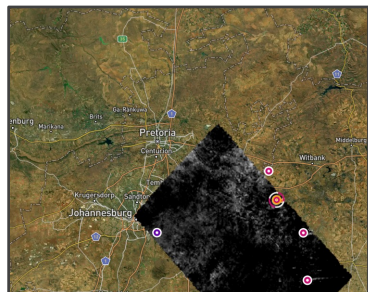
*Following Varon et al., 2018, Nassar et al., 2017, 2022, Cusworth et al., 2023

Example: Kendal Power Plant (South Africa, 9 Sep. 2022)

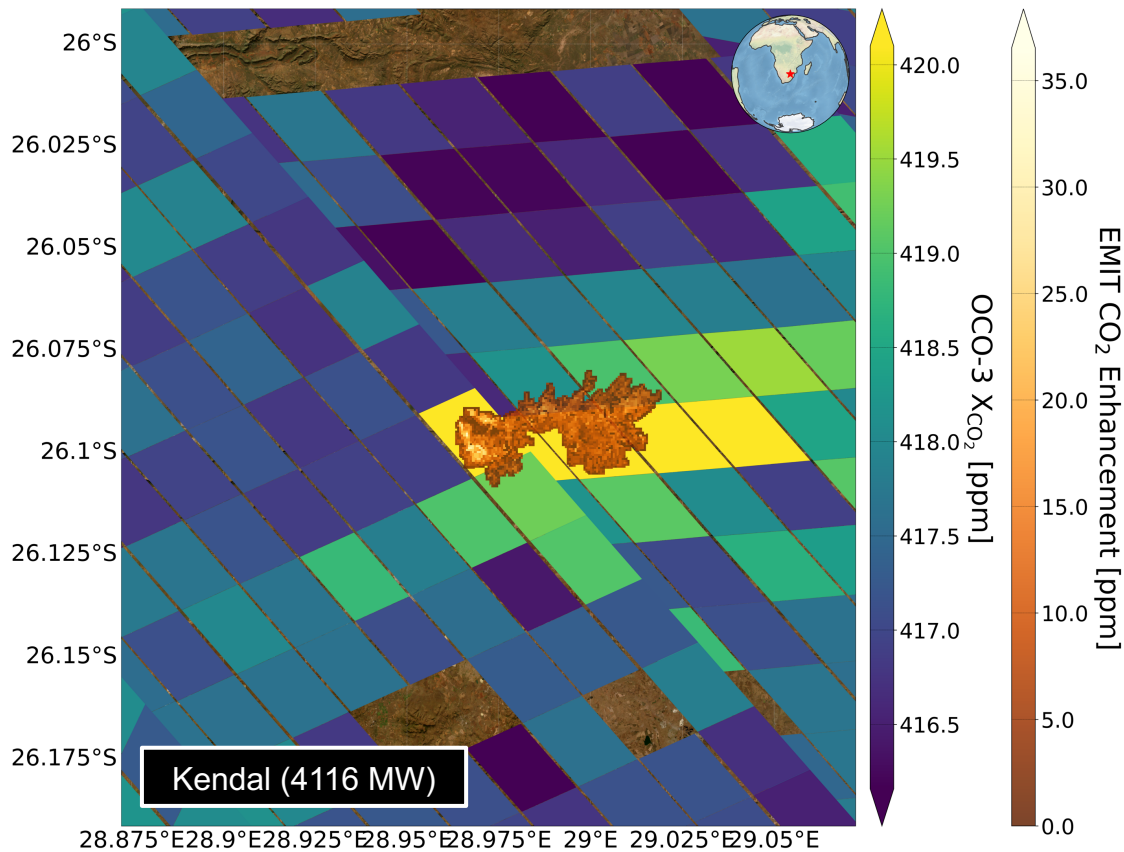
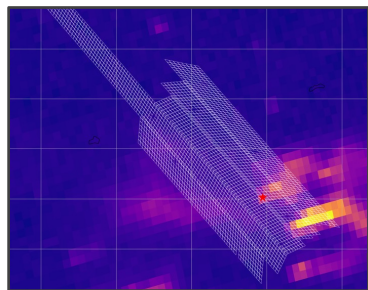
OCO-3 SAM
XCO₂



EMIT
Coverage

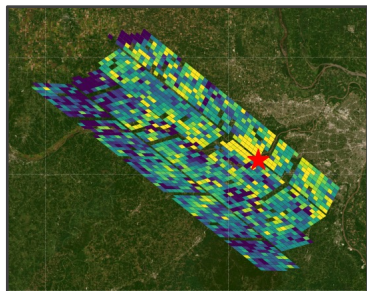


TROPOMI
NO₂

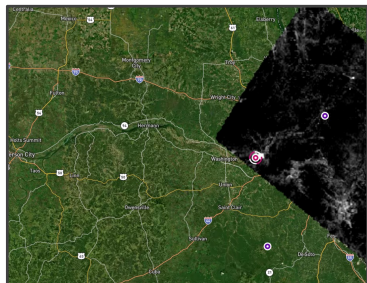


Example: Labadie Power Plant (US, 24 April 2023)

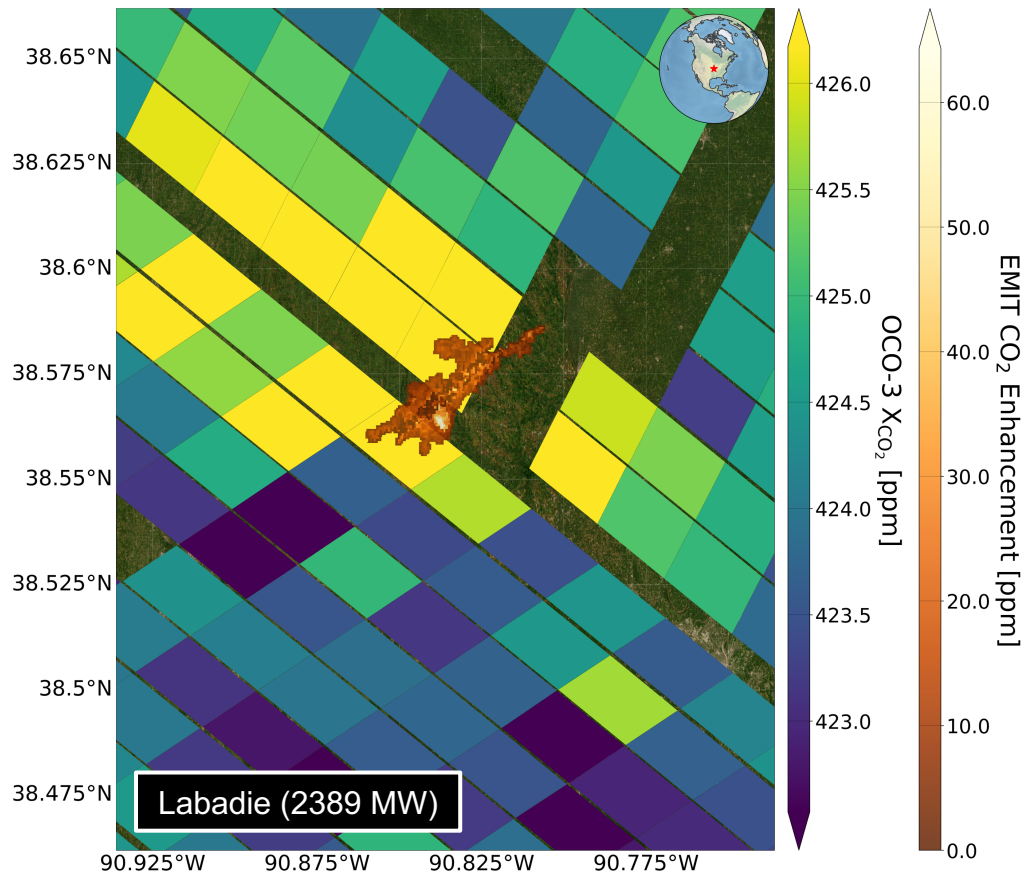
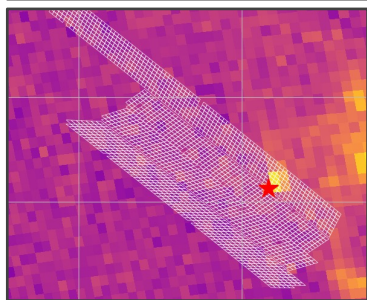
OCO-3 SAM
XCO₂



EMIT
Coverage

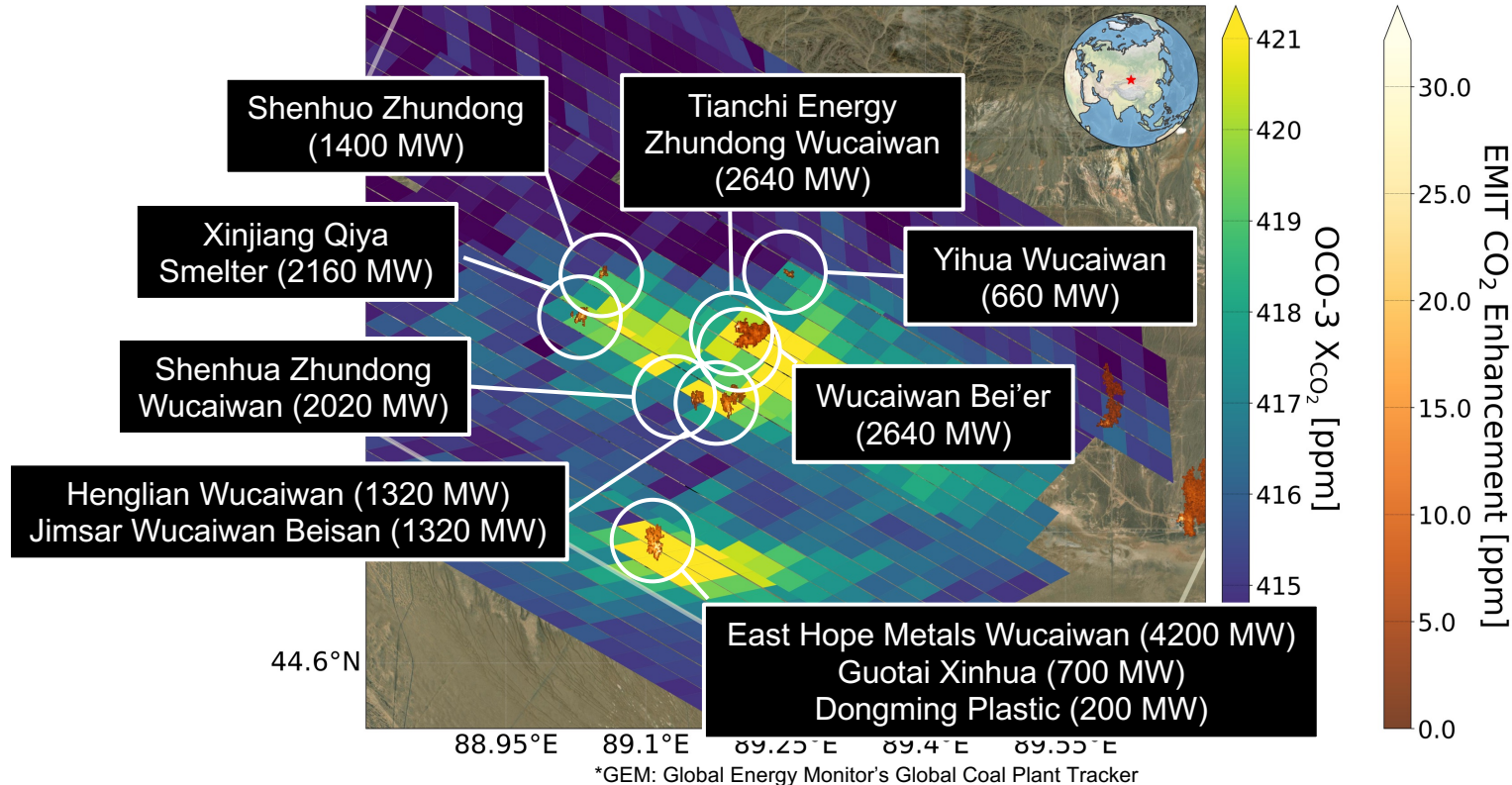


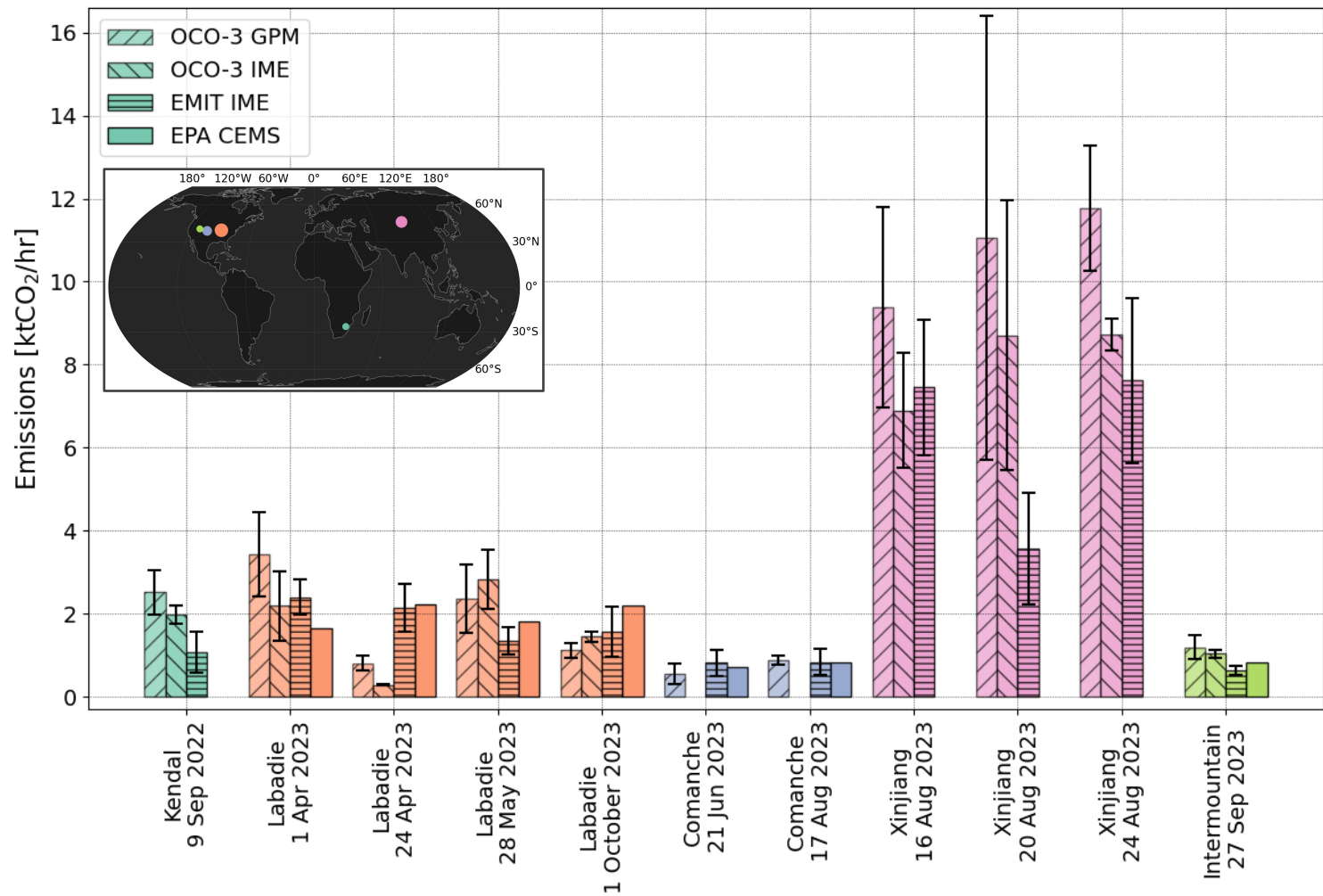
TROPOMI
NO₂

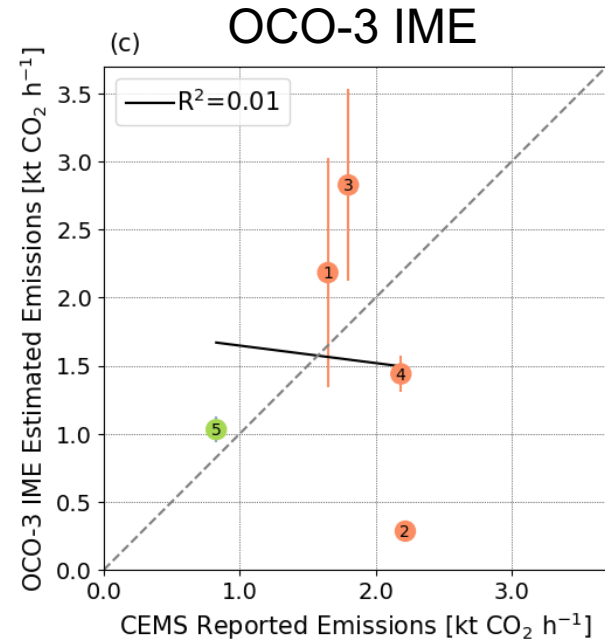
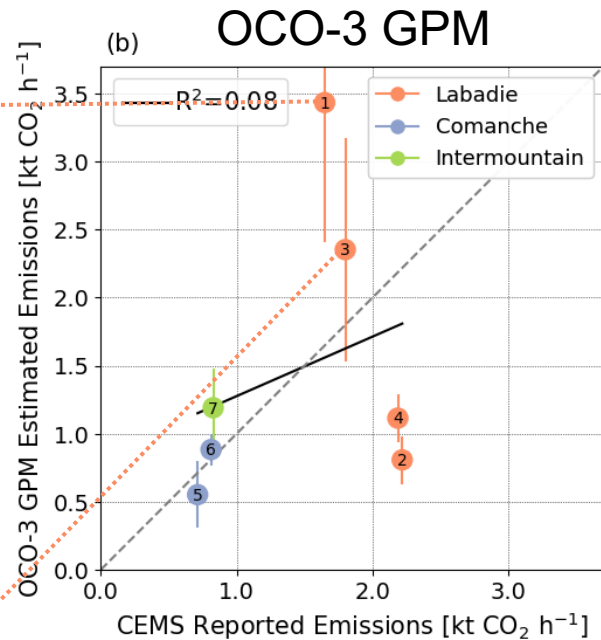
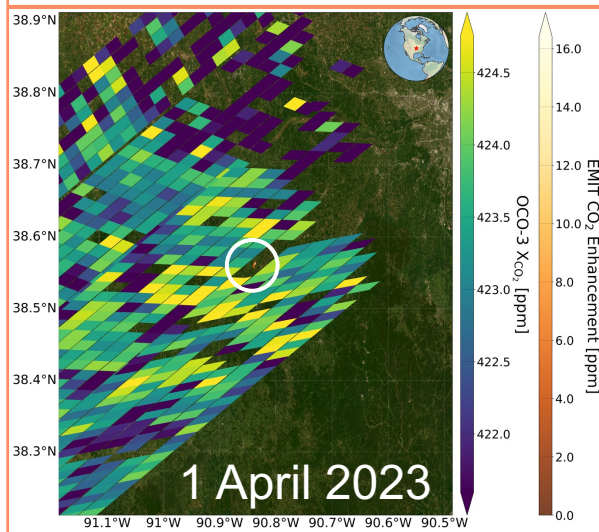
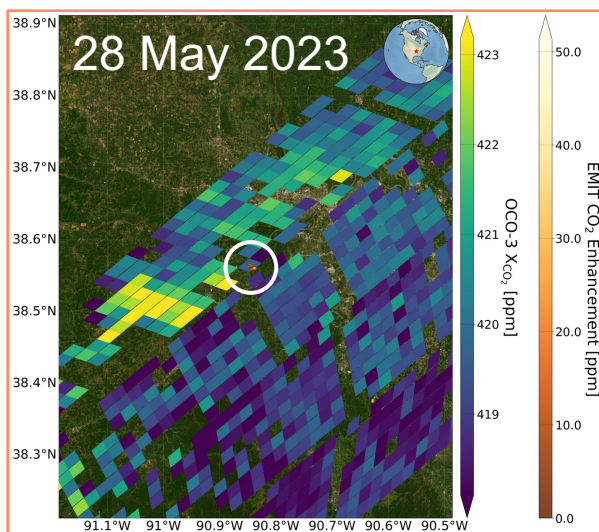


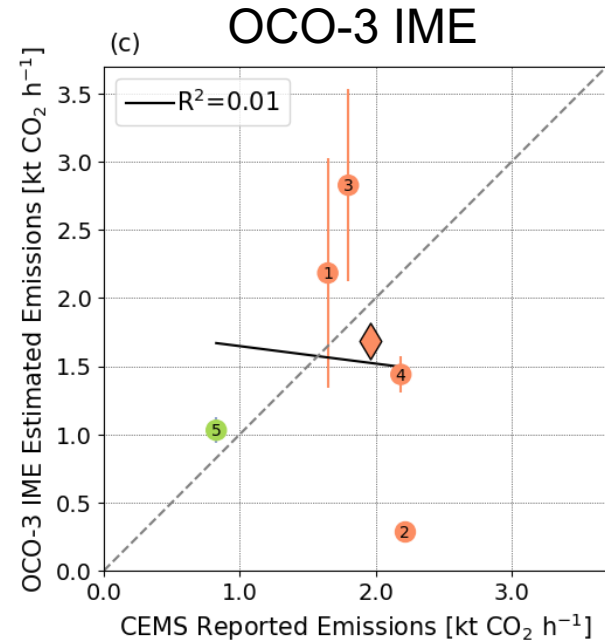
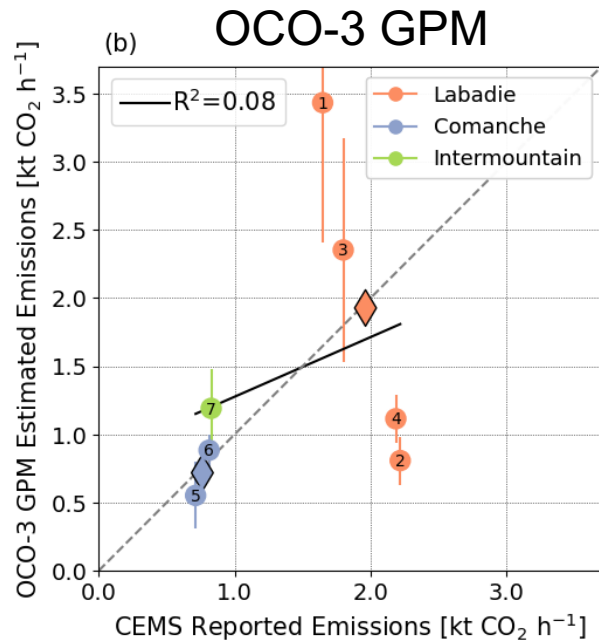
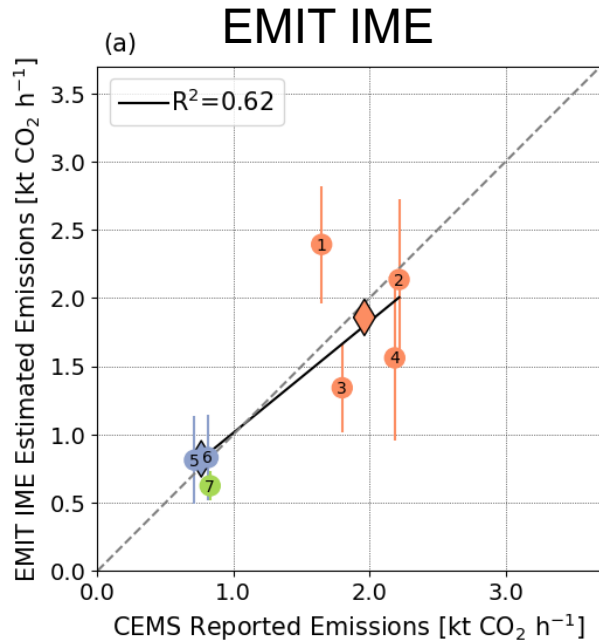
Example: Power Plant Complex (China, 20 August 2023)

- At least 11 power plants* within the OCO-3 SAM





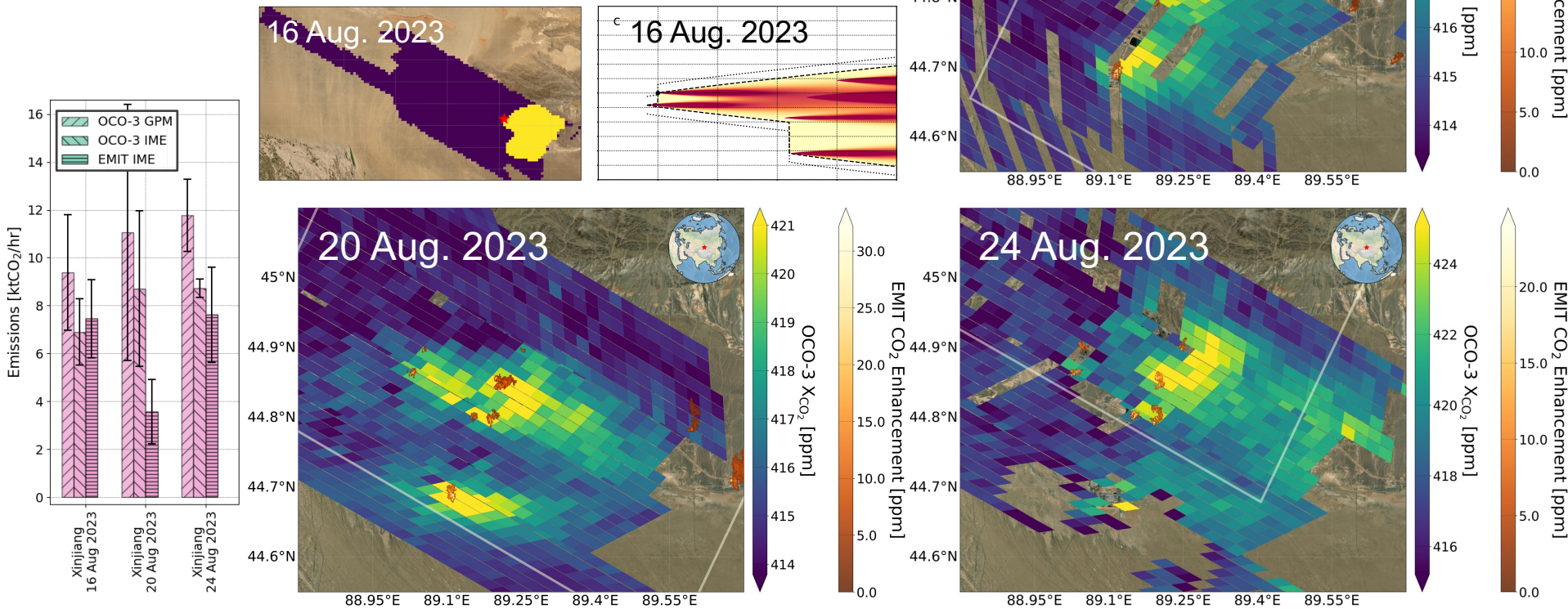




- Averaging by site improves agreement with CEMS

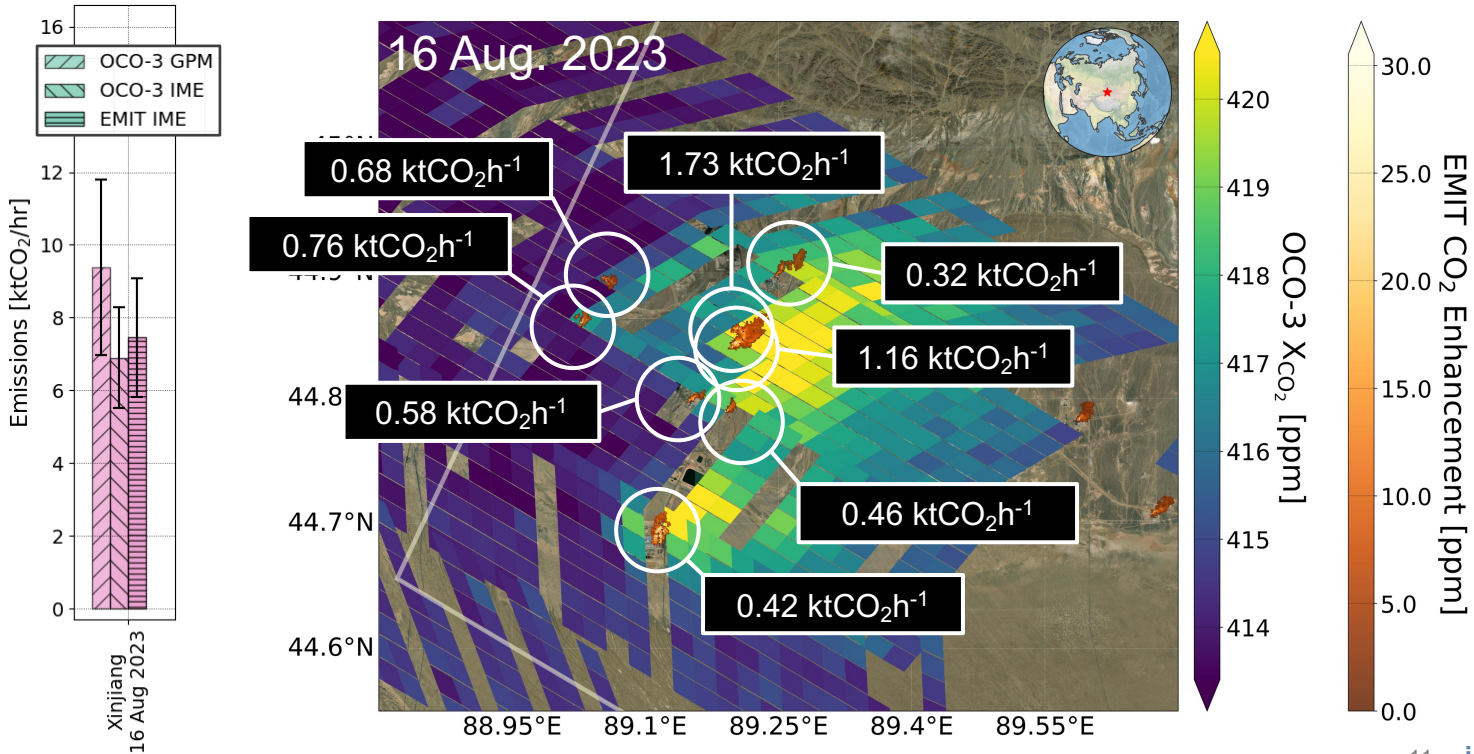
CO₂ emission rate differences

- OCO-3 IME missing downwind part of plumes
- EMIT missing diffuse signal or small sources?



Example: Power Plant Complex (China, 16 August 2023)

- EMIT can discern individual power plants



Conclusions

- This study suggests that both **OCO-3** and **EMIT** can accurately estimate **CO₂ emission rates from power plants**, but that precision may be limited by:
 - Background estimation errors
 - Plume coverage (e.g., swath width, clouds)
 - Other errors (e.g., wind field source)
- The simultaneous observation of point sources with two unique instruments allows us to **take advantage of their different spatial resolutions**, with EMIT discerning the **relative contributions** of multiple emitting power plants to the net emission and OCO-3 constraining the entire scene
- OCO-3 will be reinstalled later this summer and EMIT's extended mission was approved -> **more collocated observations!**

