

Satellite remote sensing of carbon monoxide emissions from cities

Gijs Leguijt

g.leguijt@sron.nl

Date: 04-04-23

Supervisors:

J.D. Maasackers, H. Denier van der Gon,
A. Segers, I. Aben

SRON

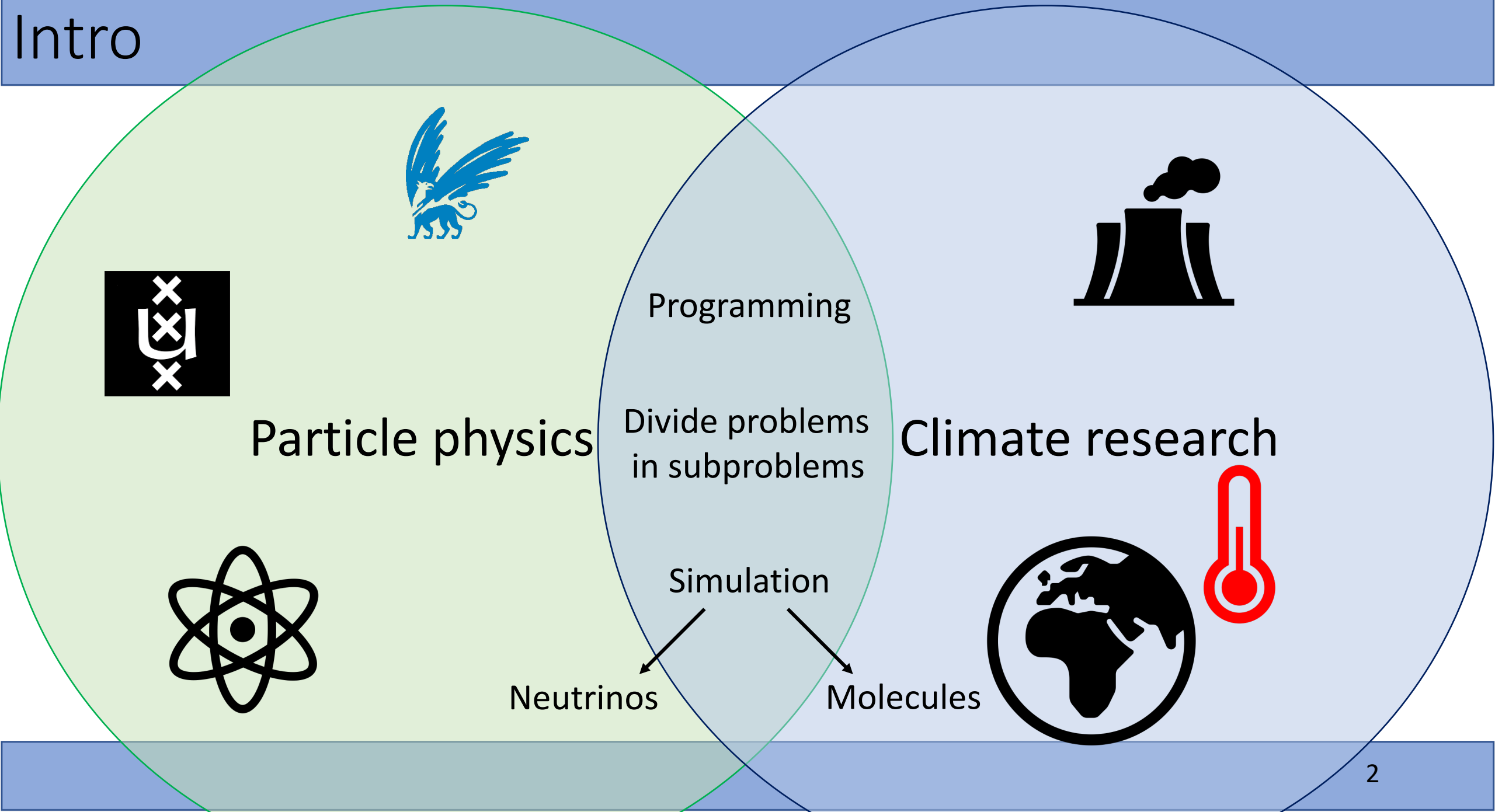
TNO



Air pollution over Cairo

Photo: Sebastian Horndasch

<https://www.flickr.com/photos/35079081@N07/>



Particle physics

Climate research

Programming

Divide problems in subproblems

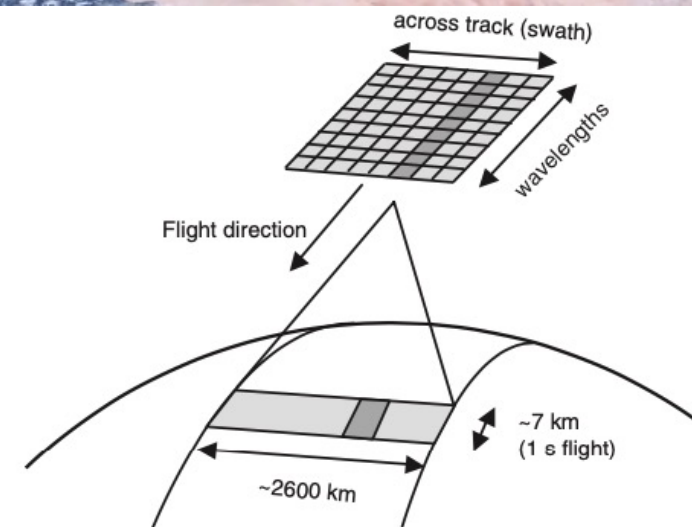
Simulation

Neutrinos

Molecules

TROPOMI

- TROPOspheric Monitoring Instrument
 - KNMI + SRON, Airbus DS-NL & TNO
- Sentinel-5 precursor (ESA satellite)
- Multispectral imaging spectrometer
 - measures CO, NO₂, CH₄, SO₂, O₃ and others
 - measures concentration
- Daily global coverage
- Pixel-size 5.5x7km



Why CO in Africa?

CO

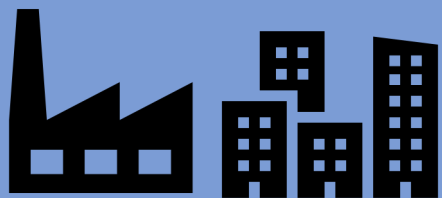


Co-emitted with CO₂
Affects CH₄ sink



TROPOMI:
revolution in data
availability

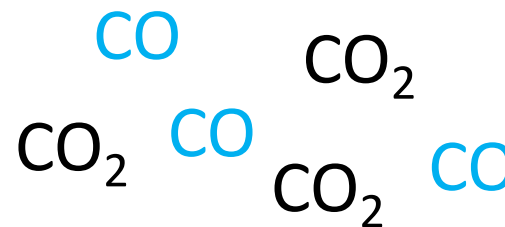
- CO₂
 - Long lifetime → **High background**
- CO
 - Shorter lifetime → **Lower background**



High urbanization



High uncertainty



Why look with a satellite?

Data from:

- Emission factor
- Industry
- Agriculture
- Population density
- Traffic
- Etc.



Emission



Policy

Independent verification

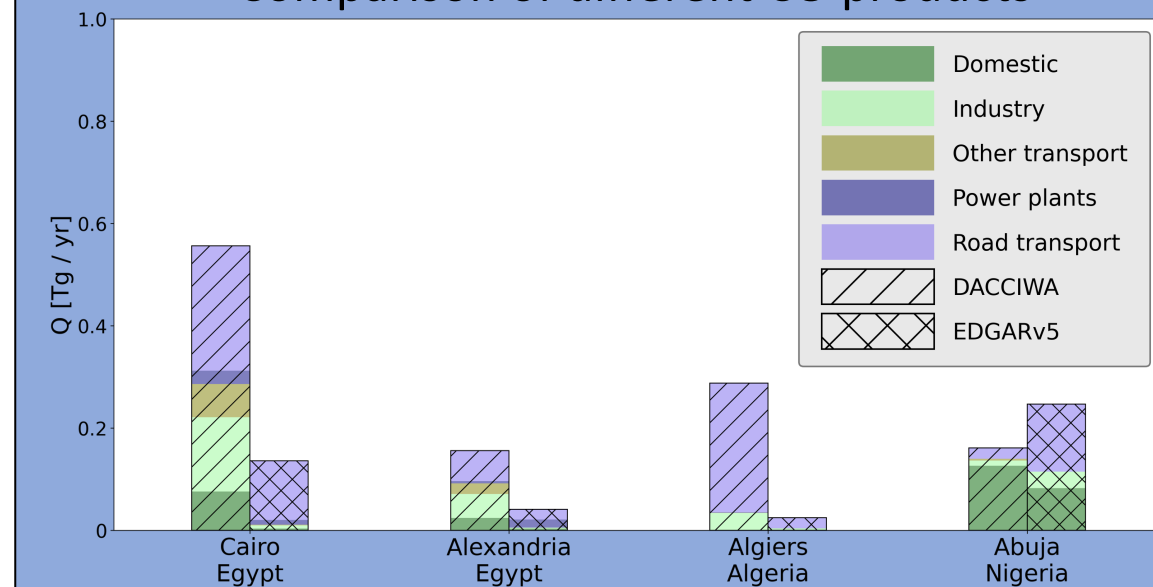


Satellite data



Emission quantification method

Comparison of different CO products

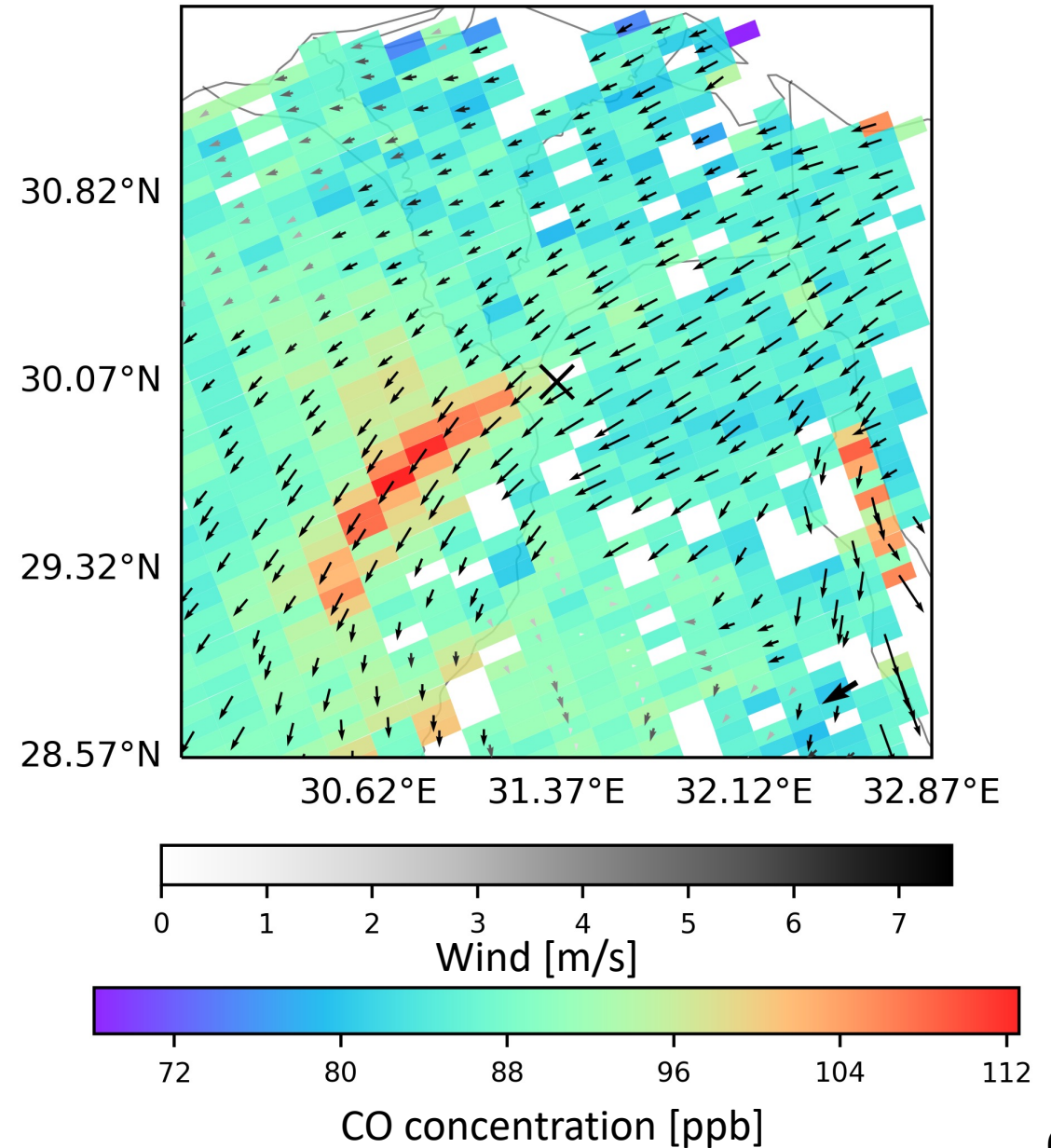


Quantifying plumes

- Look at a large number of cities
- Atmospheric simulations too slow



Cairo, January 19th, 2019

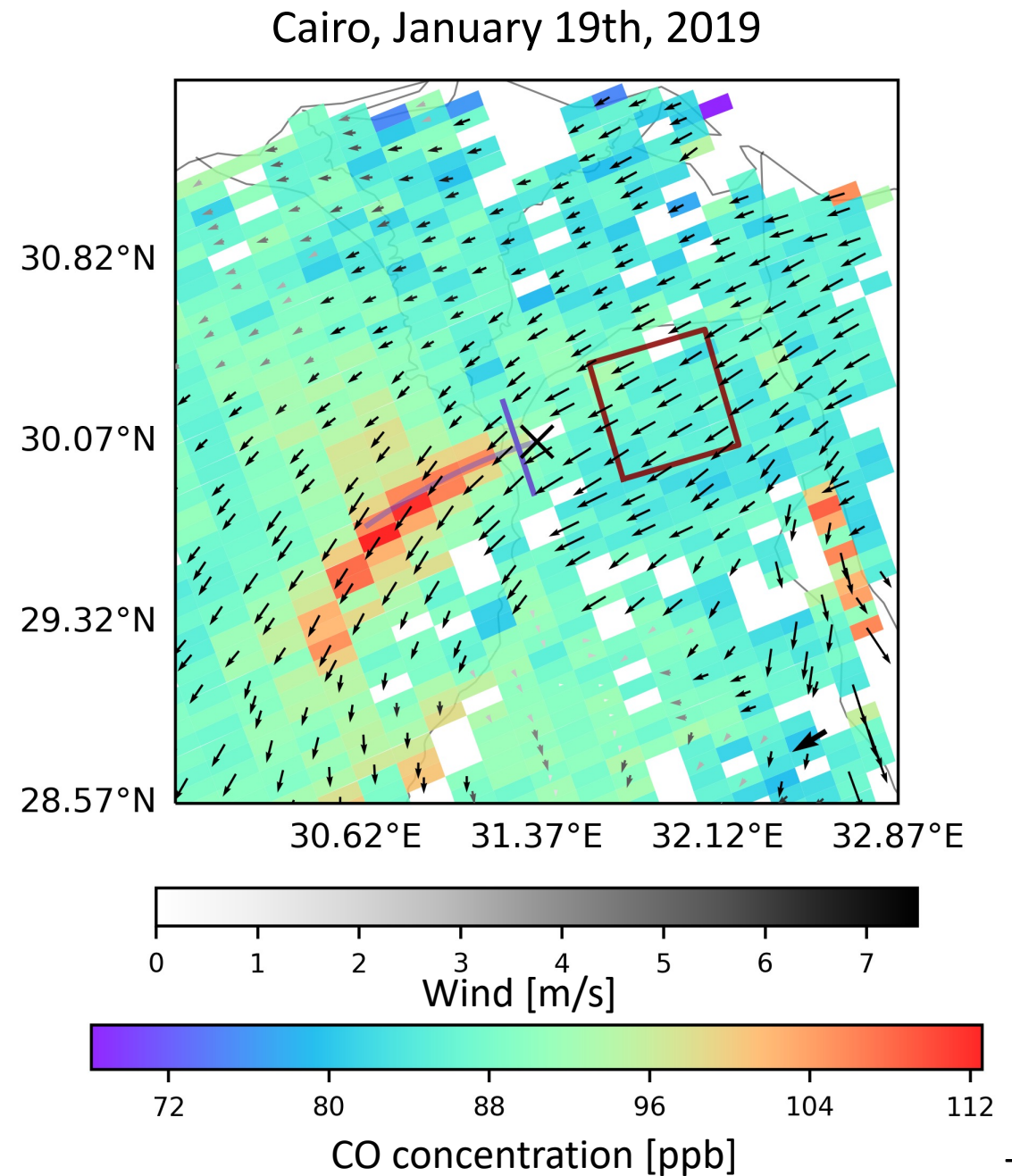


TROPOMI CO: (Borsdorff et al. 2018)

Wind: (Molod et al. 2012)

Quantifying plumes

- Fast methods
- CSF (Cross-Sectional Flux method)

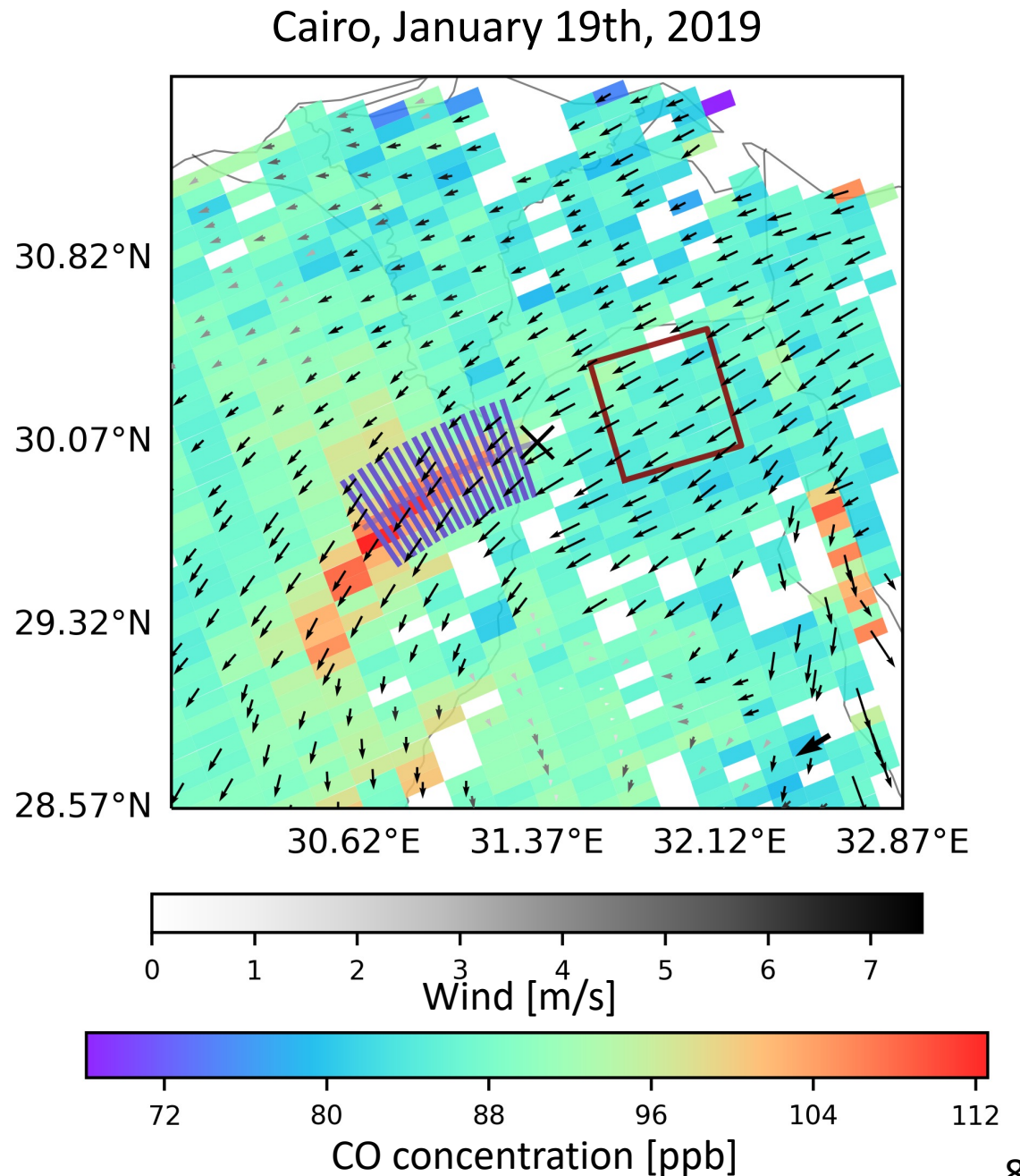


TROPOMI CO: (Borsdorff et al. 2018)

Wind: (Molod et al. 2012)

Quantifying plumes

- Fast methods
- CSF (Cross-Sectional Flux method)
- Issue: cities are not point sources
- Solution: calibration with simulation

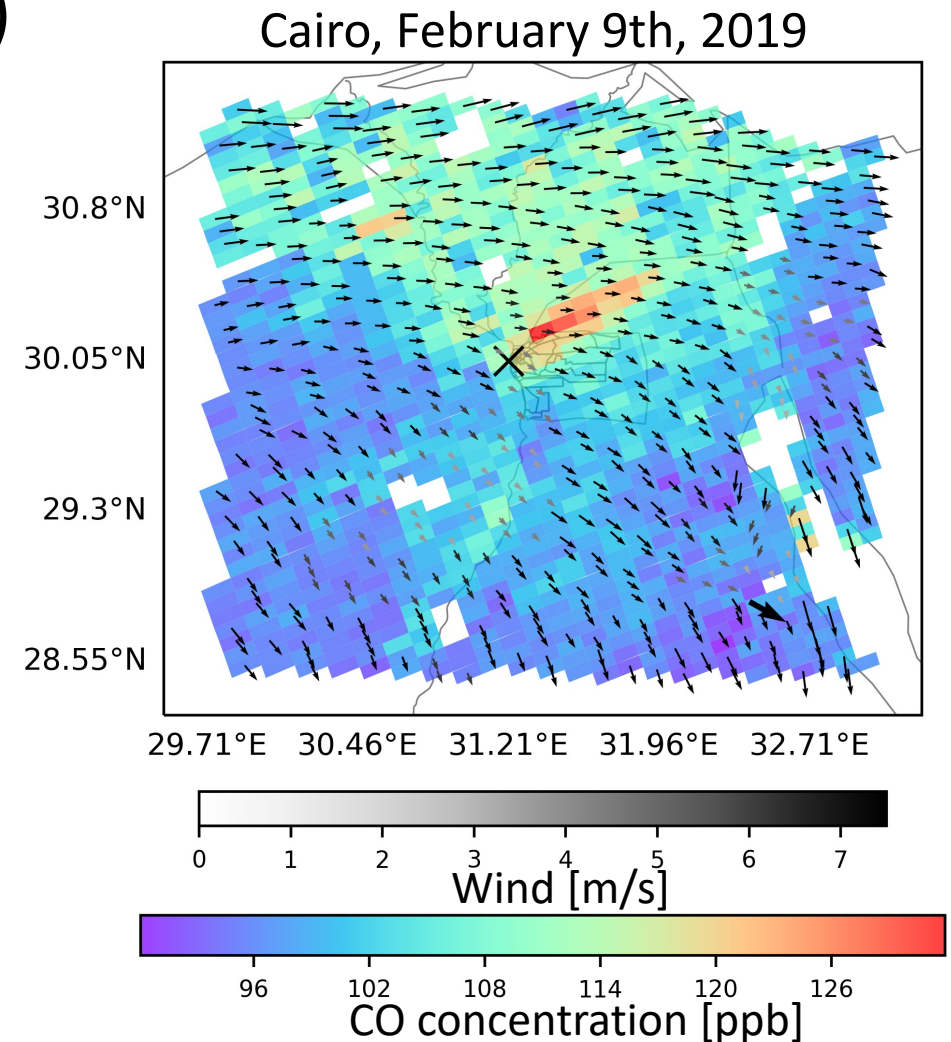


TROPOMI CO: (Borsdorff et al. 2018)

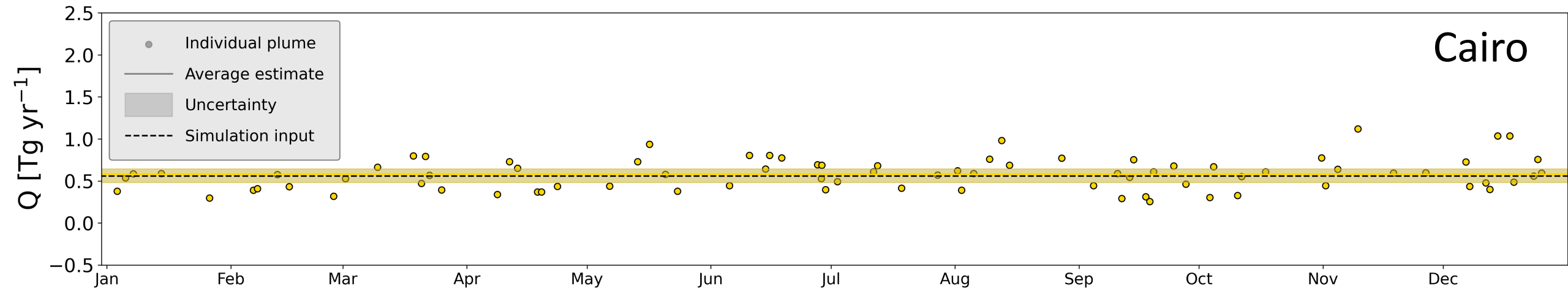
Wind: (Molod et al. 2012)

Simulating realistic plumes

- WRF (Weather Research and Forecasting model)
- Input: emission inventories
 - EDGAR (global, 2015)
 - DACCIWA (Africa, 2015)
- Output:
 - Like TROPOMI would see it
- Cities:
 - Cairo (Egypt) + Bamako (Mali) + Lagos (Nigeria)



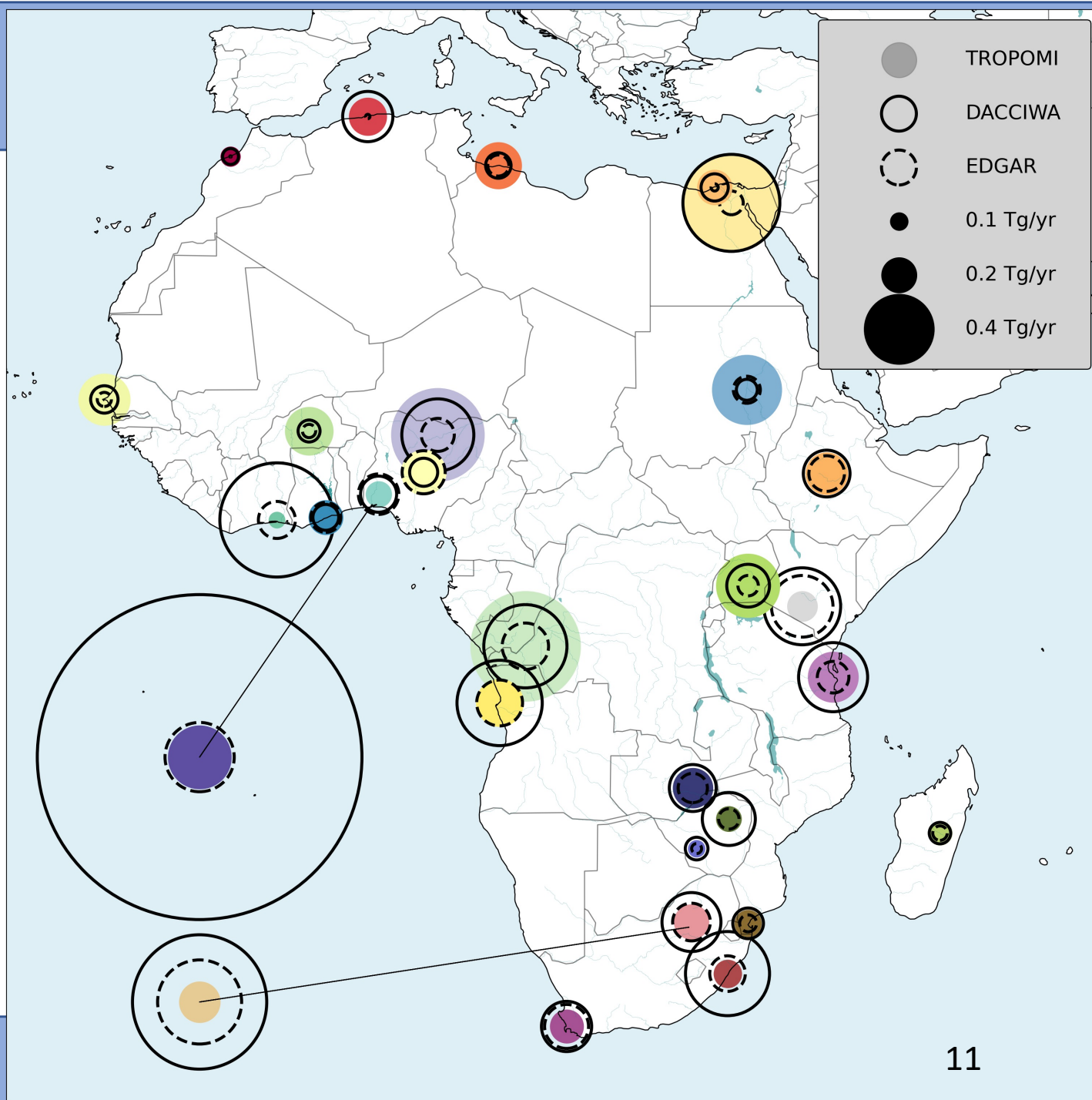
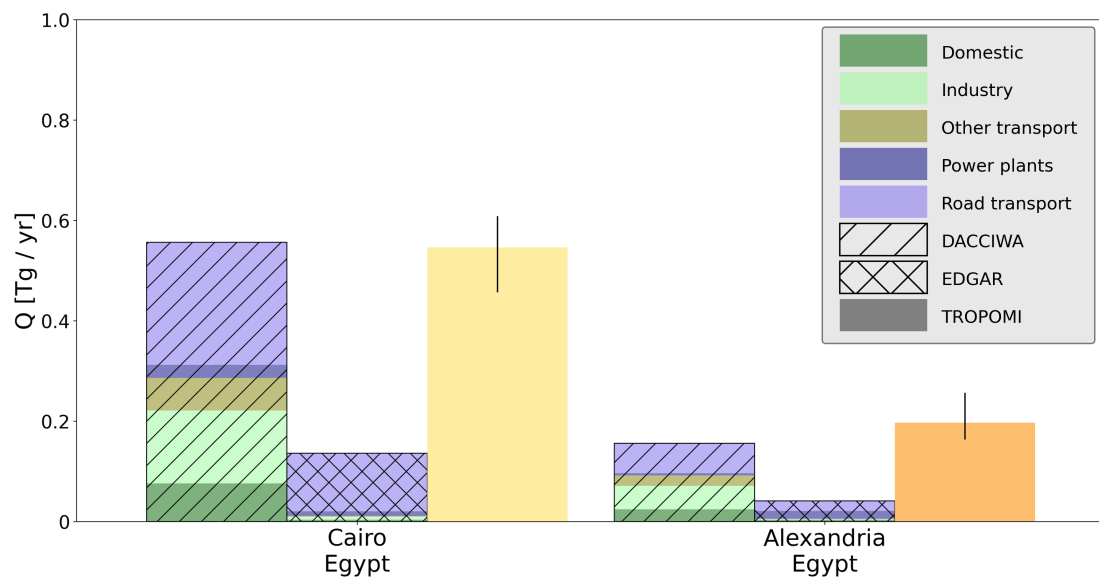
Reproducing simulation input using the CSF method



Inventory vs TROPOMI

Urban CO emissions from EDGAR v5 (2015), DACCIWA v1 (2015) and TROPOMI 2019-2021

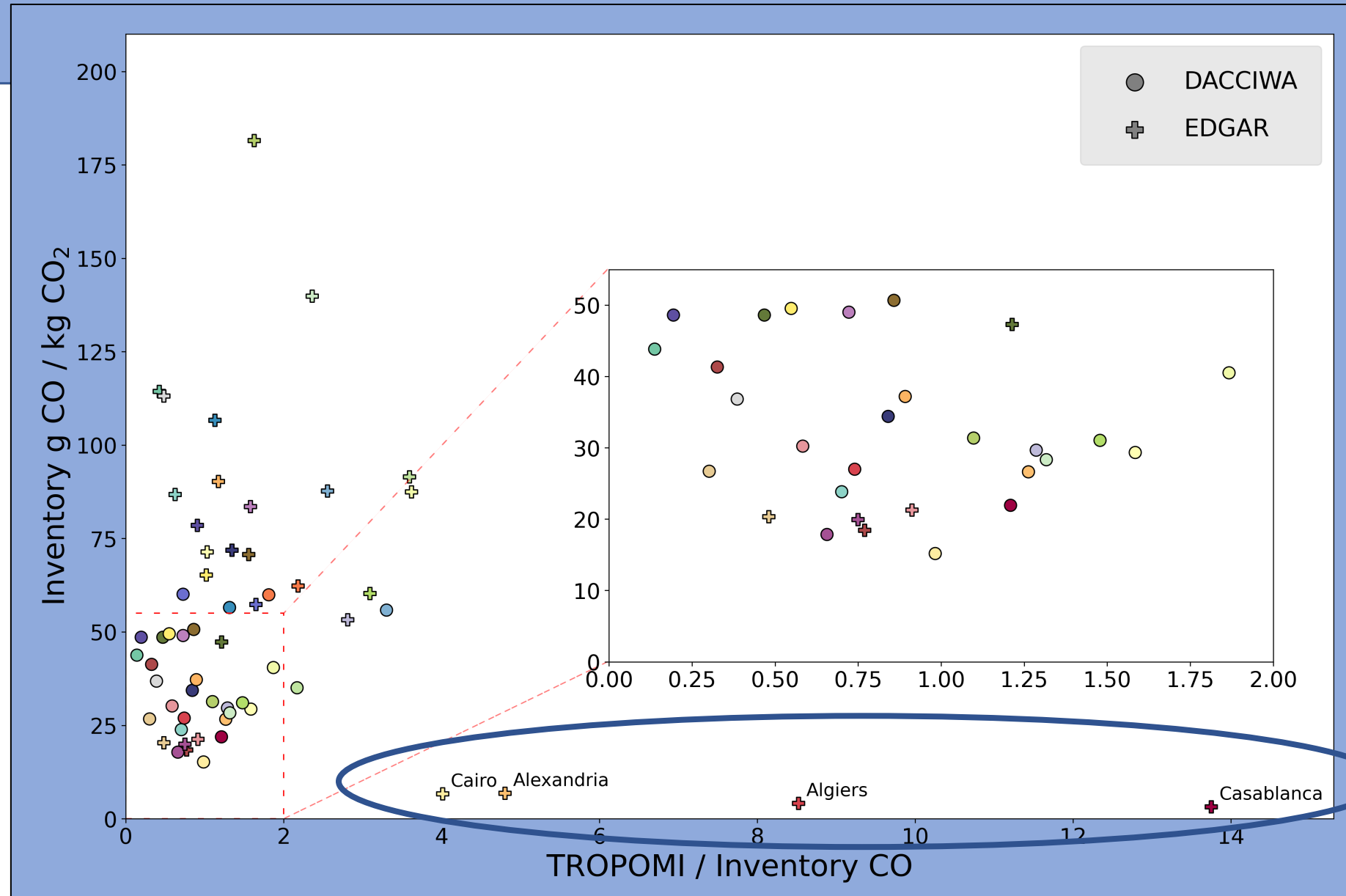
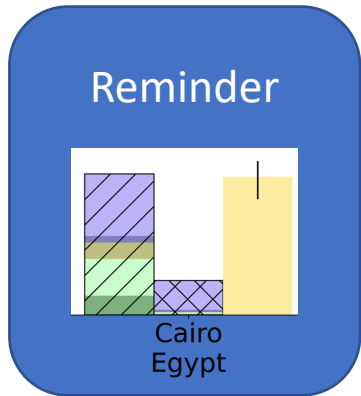
Markersize indicates emission rate



Outliers

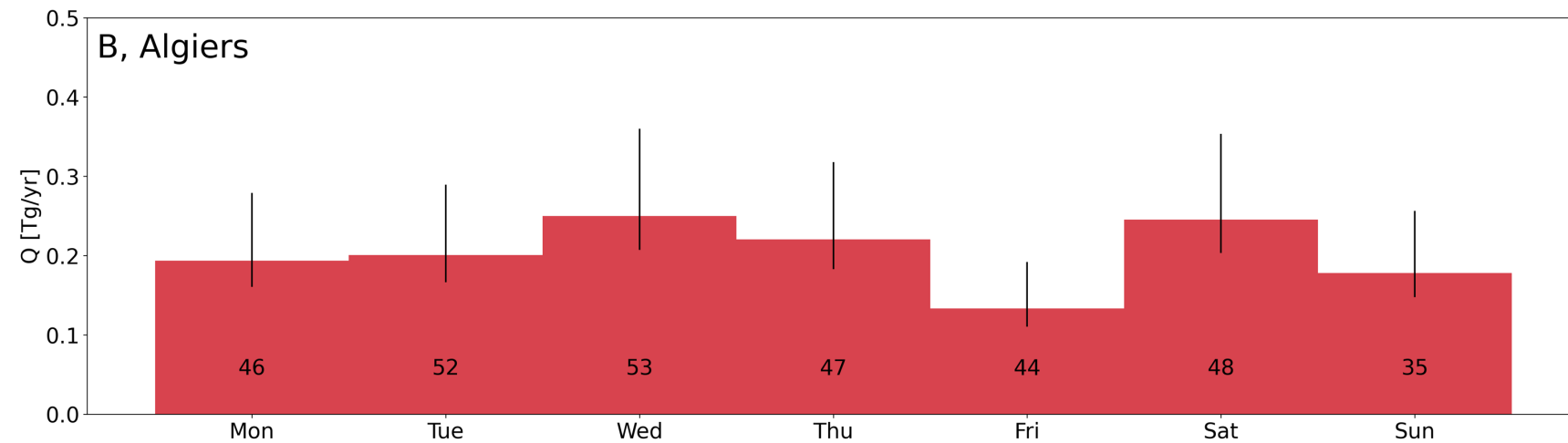
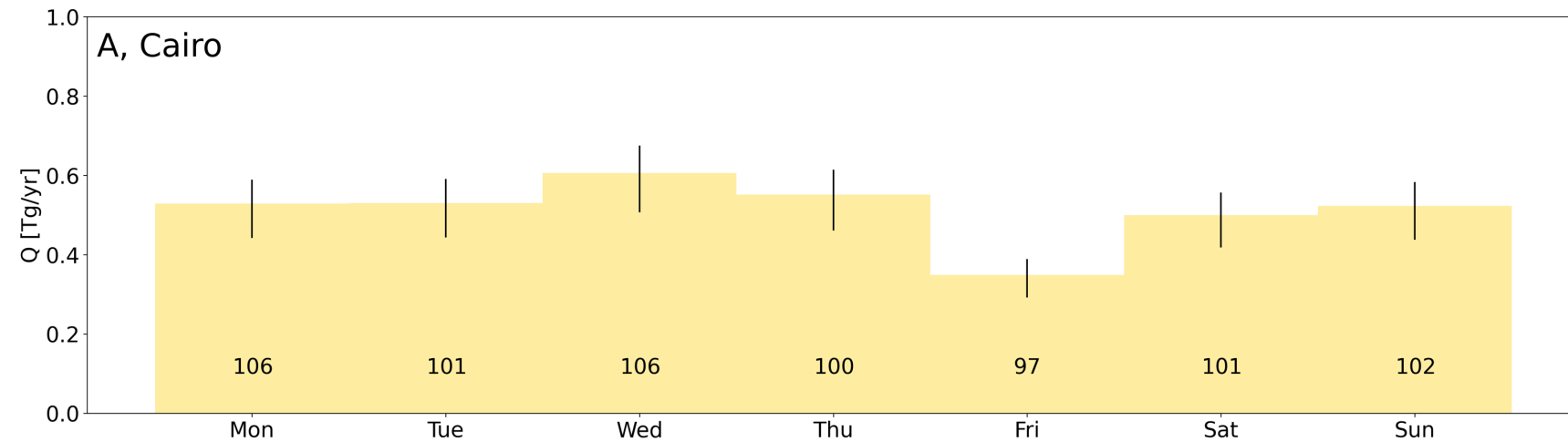
Northern Africa

- EDGAR may overestimate combustion efficiency



Temporal patterns

- Lower emissions on Friday for Islamic cities
- Also seen in concentrations (Rey-Pommier et al. 2022)



Conclusion

- Successful city CO emission quantification down to 0.1 Tg/yr using the TROPOMI instrument
- Collaboration with inventory compilers to make use of our estimates
- Temporal patterns: Friday emissions lower for Islamic cities
- A physics background is well suited for environmental research