Accounting for biogenic CO_2 fluxes in urban areas: a review and high-resolution method to aid urban planning

Qing Luo[1], Ricard Segura-Barrero[2], Alba Badia[3], Thomas Lauvaux[4], Junwei Li[5], Jia Chen[5], Marc Guevara[3], Paula Castesana[3], Paula Camps[3], Gara Villalba[1,6]*

[1].Sostenipra Research Group, Institute of Environmental Sciences and Technology, Universitat Autònoma de Barcelona (UAB), Barcelona, Spain. [2]Laboratoire de Météorologie Dynamique, Institut Pierre-Simon Laplace, Paris, France. [3]Barcelona Supercomputing Center, Barcelona, Spain. [4]Molecular and Atmospheric Spectrometry Group, University of Reims Champagne Ardenne, Reims, France [5]Environmental Sensing and Modelling, School of Computation, Information and Technology, Technical University of Munich, Munich, Germany. [6]Department of Chemical, Biological and Environmental Engineering, Universitat Autònoma de Barcelona (UAB), Barcelona, Spain

qing.luo@uab.cat and Gara.Villalba@uab.cat

1. Motivation

Hi! What are biogenic CO_2 fluxes?

They are the exchanges of CO_2 between ecosystems and the atmosphere through processes like photosynthesis and respiration.

Why does it matter?

Because it helps us understand whether urban green infrastructure (GI; such as urban trees and parks) can lower CO_2 levels and support climate goals.

Why this work?

Research in this area lacks a systematic review. Moreover, the high-resolution method can estimate biogenic CO_2 fluxes at a 10 meters, providing scientific support for city-scale mitigation strategies involving GI.

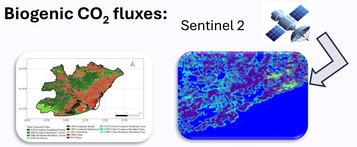
How can cities use this?

This work can help guide how GI should be implemented and managed to maximize climate benefits.

2. Data and Method

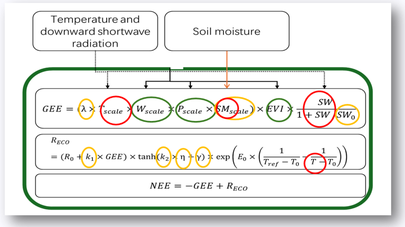
Case study: AMB(Metropolitan Area of Barcelona); April,December,2023

Biogenic CO_2 fluxes:

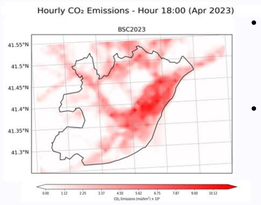


Eddy Covariance Tower*
parameters are optimized and calibrated using 33 flux towers over south-western Europe[1]

Vegetation Photosynthesis and Respiration Model (VPRM) [2][3]



Anthropogenic CO_2 emissions:



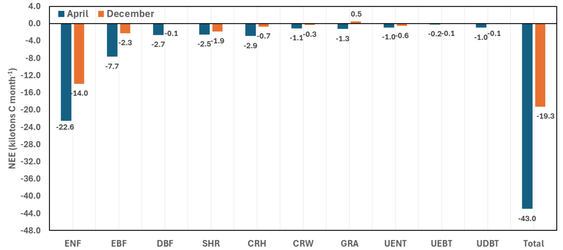
- **Respire** project by Barcelona Supercomputing Center[4]
- Emission estimates are calculated by sectors and provides 1 km × 1 km hourly data

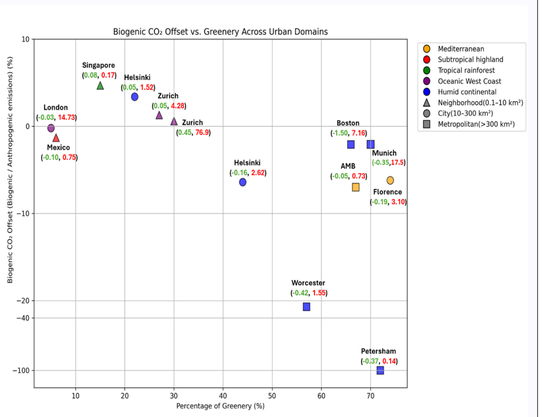
Biosphere Capture:

$$\frac{Biogenic\ CO_2\ emisssions}{Anthropogenic\ CO_2\ emissions} \times 100\%$$

The result from AMB is compared with other cities from literature review

3. Results





- Biogenic components in AMB uptake 10% and 4% of anthropogenic CO_2 emissions in April and December respectively
- Evergreen needleleaf forests and evergreen broadleaf forests act as the dominant regional carbon sinks. Grasslands shift from acting as net carbon sink in April to net carbon source in December.
- Cross-city analysis: the biogenic offset does not scale linearly with greenery

4. Conclusions

How to implement and manage GI to maximize climate benefits?

1) Preserve and protect existing high-performance ecosystems rather than implement new, low-density green spaces

2) Prioritize neighbourhood-scale assessments to evaluate and optimize the effectiveness of local tree planting and park management.

3) A standardized framework for accounting for biogenic CO_2 fluxes and uptake in urban areas should be established.

5. Outlook

What will you do next?

1) Extend the analysis period of the case study from 2 moths to full year

2) Combine WRF-Chem model and monitoring network (https://urbag.eu/ghg/) to constrain the estimated fluxes

This presentation participates in OSPP

Outstanding Student & PhD candidate Presentation contest

References: [1] Segura-Barrero, R., and Coauthors, 2025: Heat and Drought Events Alter Biogenic Capacity to Balance CO2 Budget in South-Western Europe. Glob. Biogeochem. Cycles, 39, e2024GB008163, https://doi.org/10.1029/2024GB008163 . [2] Mahadevan, P., and Coauthors, 2008: A satellite-based biosphere parameterization for net ecosystem CO2 exchange: Vegetation Photosynthesis and Respiration Model (VPRM). Glob. Biogeochem. Cycles, 22, https://doi.org/10.1029/2006gb002735. [3] Glauch, T., Marshall, J., Gerbig, C., Botía, S., Gałkowski, M., Vardag, S. N., & Butz, A. (2025). pyVPRM: A next-generation Vegetation Photosynthesis and Respiration Model for the post-MODIS era. EGUsphere, 1–45. https://doi.org/10.5194/egusphere-2024-3692 [4] High-Elective Resolution Modelling Emission System delta version (HERMES_A) (https://github.com/BSC-ES/HERMES_Delta)