Madrid-Methane Remote Sensing TROPOMI-S5P

Alberto Álvaro-Díaz
Cristina Prados-Román

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1. M-MethaneRS campaign

Scheme

UNIVERSITÄT HEIDELBERG
ZUKUNFT SEIT 1386

INTA
Instituto Nacional de Técnica Aeroespacial

Universidad Carlos III de Madrid

AEMet
Agencia Estatal de Meteorología

DLR

Umwelt Bundesamt

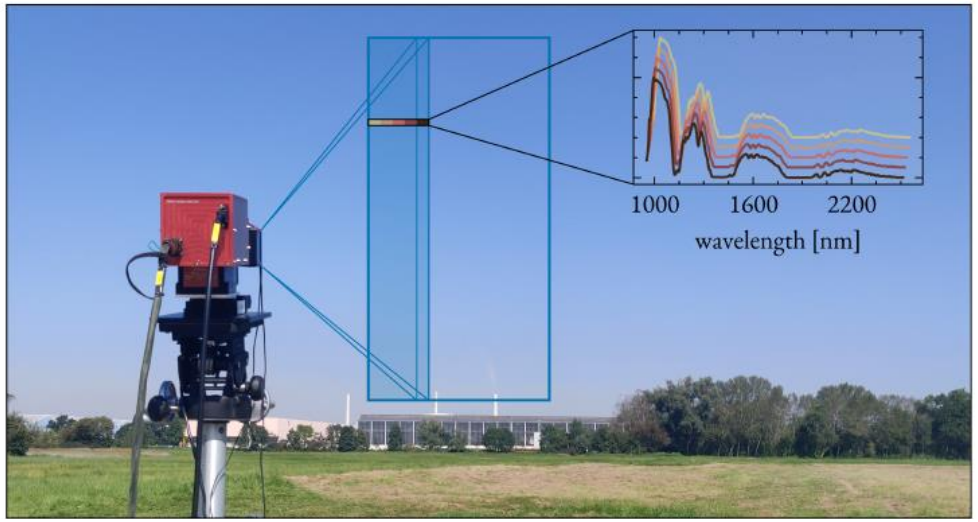
June 26th - July 12th 2024

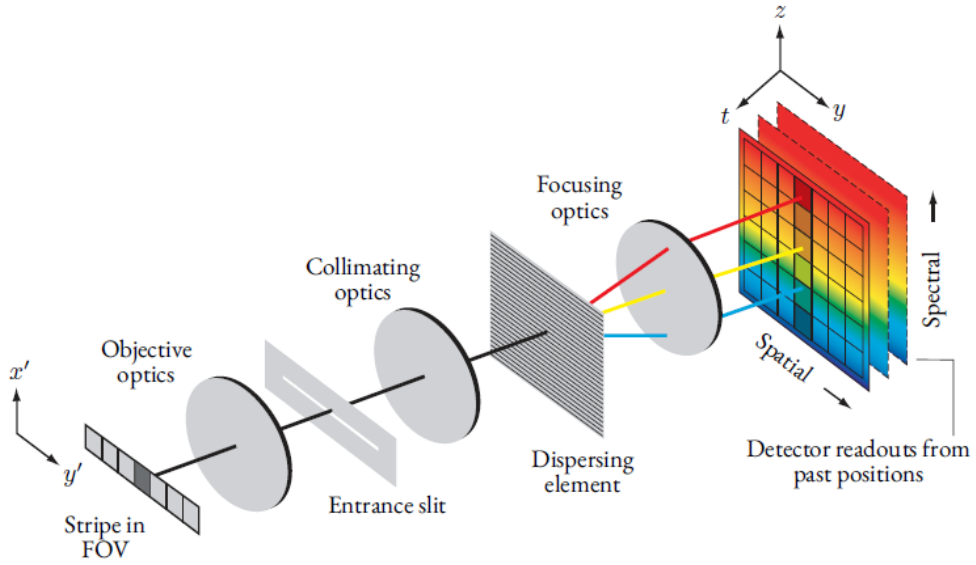
Pinto

Valdemingomez

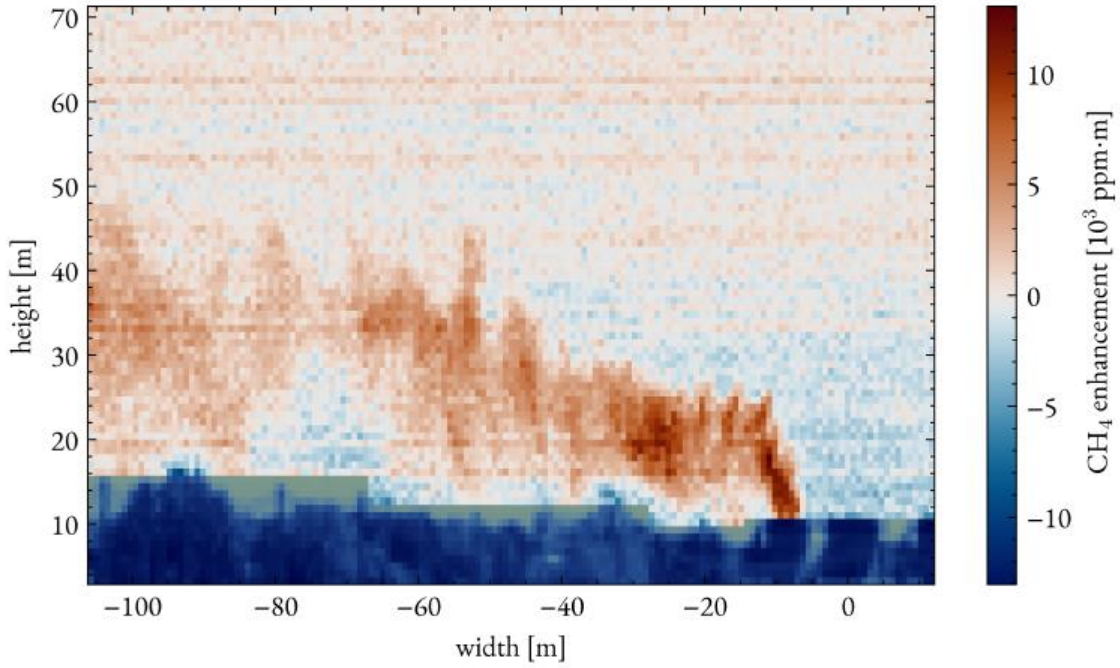
1. M-MethaneRS campaign

Instrumentation I : HySpex SWIR Camera





The same camera Aircraft



Knapp (PhD Thesis, 2024)

1. M-MethaneRS campaign

Instrumentation II: Satellites (CH_4)

EnMAP
Private data
30x30m

Bundesministerium
für Wirtschaft
und Klimaschutz

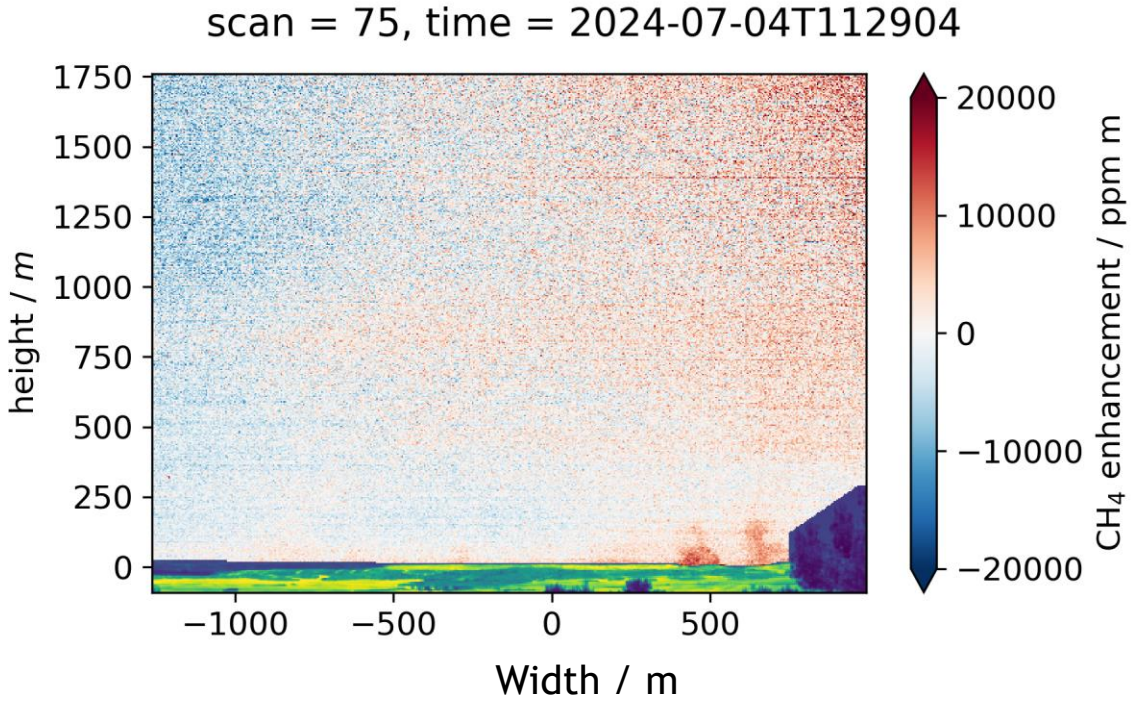
SP5-TROPOMI
Open Data
7.5x5.5km (CH_4) 5.5x5.5km (NO_2)

GHGSat
Private data
25x25m

GHGSAT

1. M-MethaneRS campaign

Outputs: HySpex (ground)



(Preliminary data)

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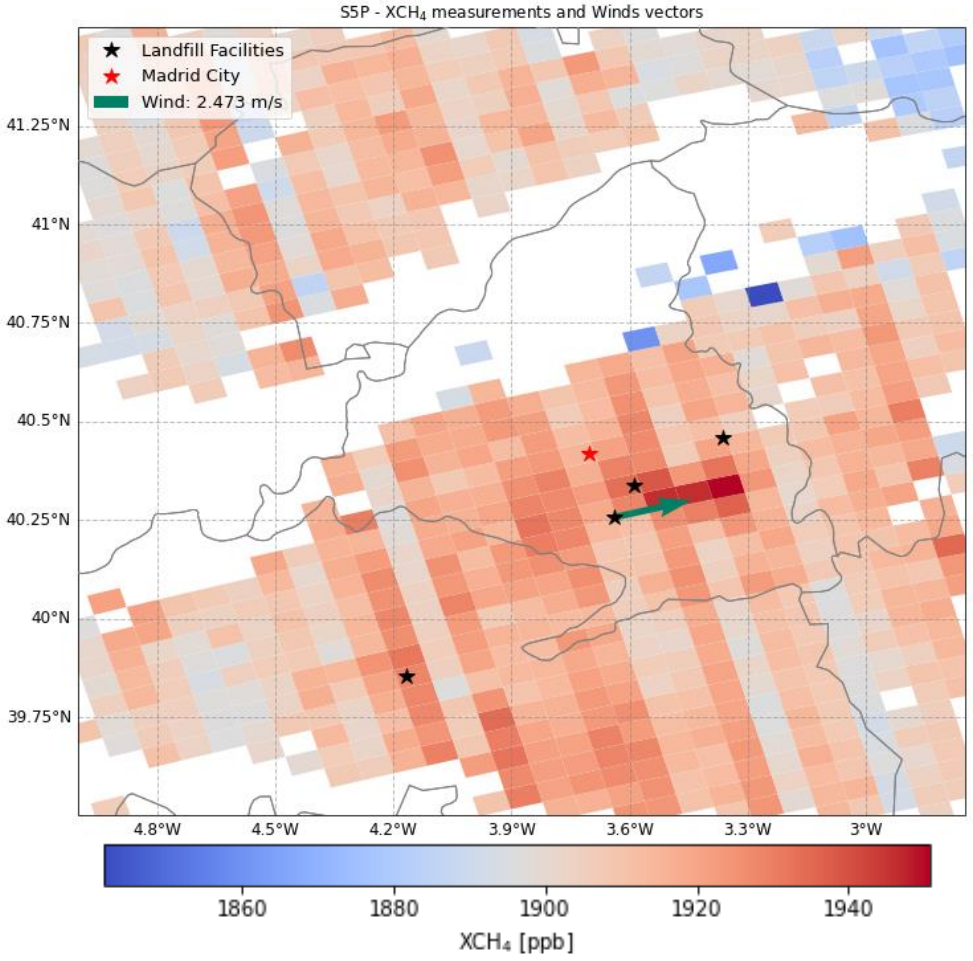
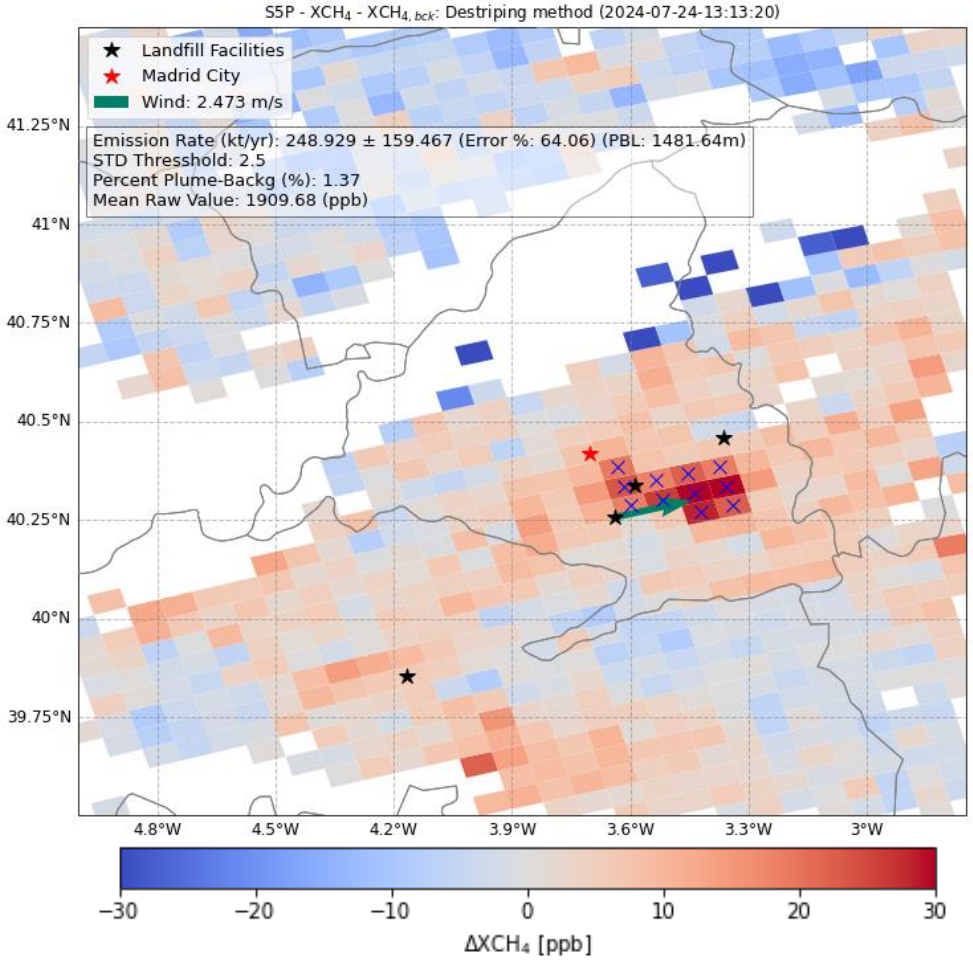
2. SP5-TROPOMI

Outputs: TROPOMI

Raw



Processed



2.1. Integrated Mass Enhancement (IME)

Formulation

$$Q = \frac{IME \cdot U_{eff}}{L}$$

$$IME = \sum_{\mathrm{i}} A_{\mathrm{i}} \cdot ME_{\mathrm{i}} \longrightarrow \text{Background substraction}$$

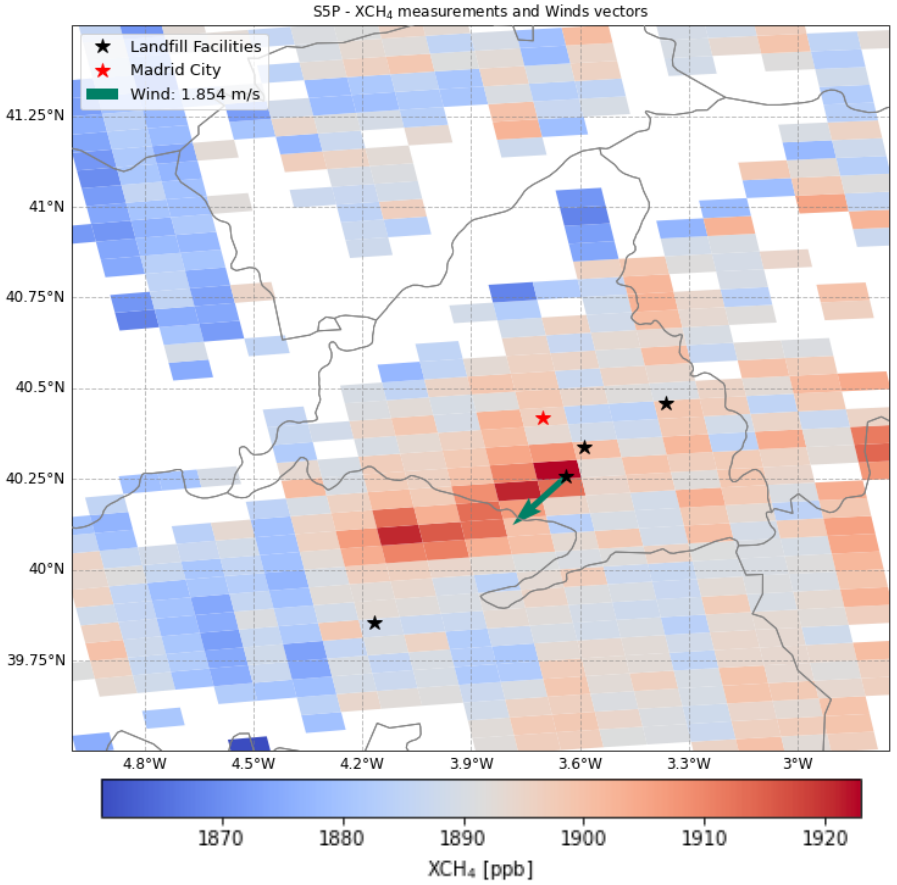
$$L = \sqrt{N \cdot A} \longrightarrow \text{Plume selection}$$

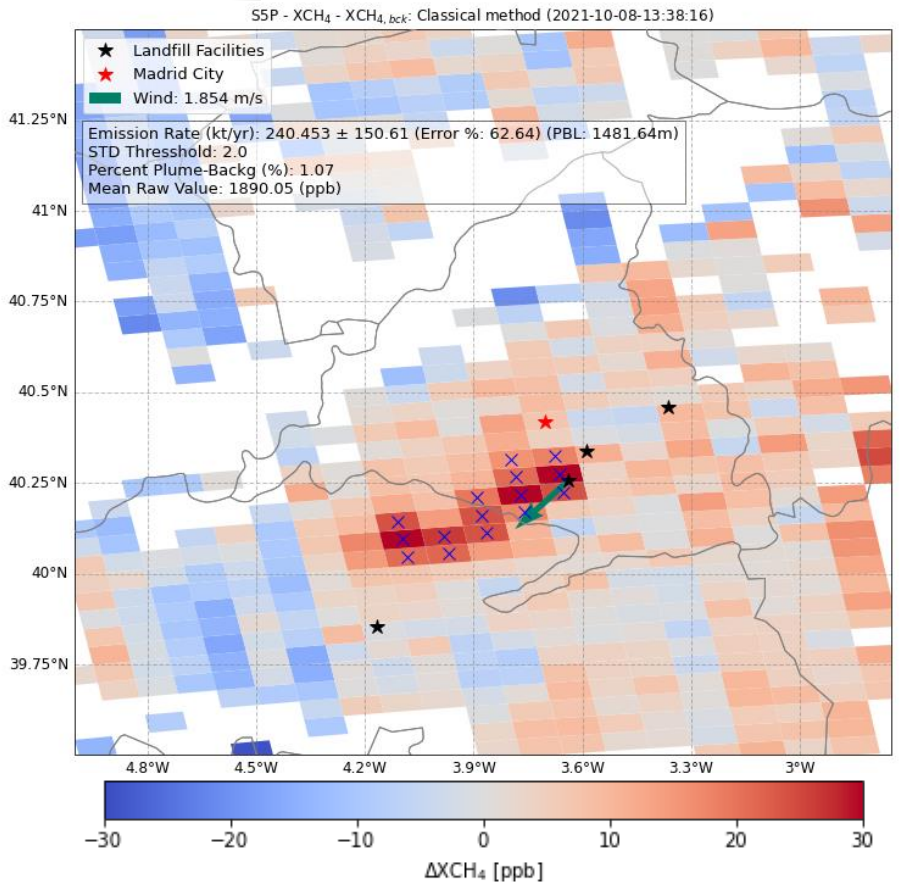
$$U_{eff} = U_{PBL} \longrightarrow \text{Wind selection}$$

2.1. Integrated Mass Enhancement (IME)

Background Substration: Classical method

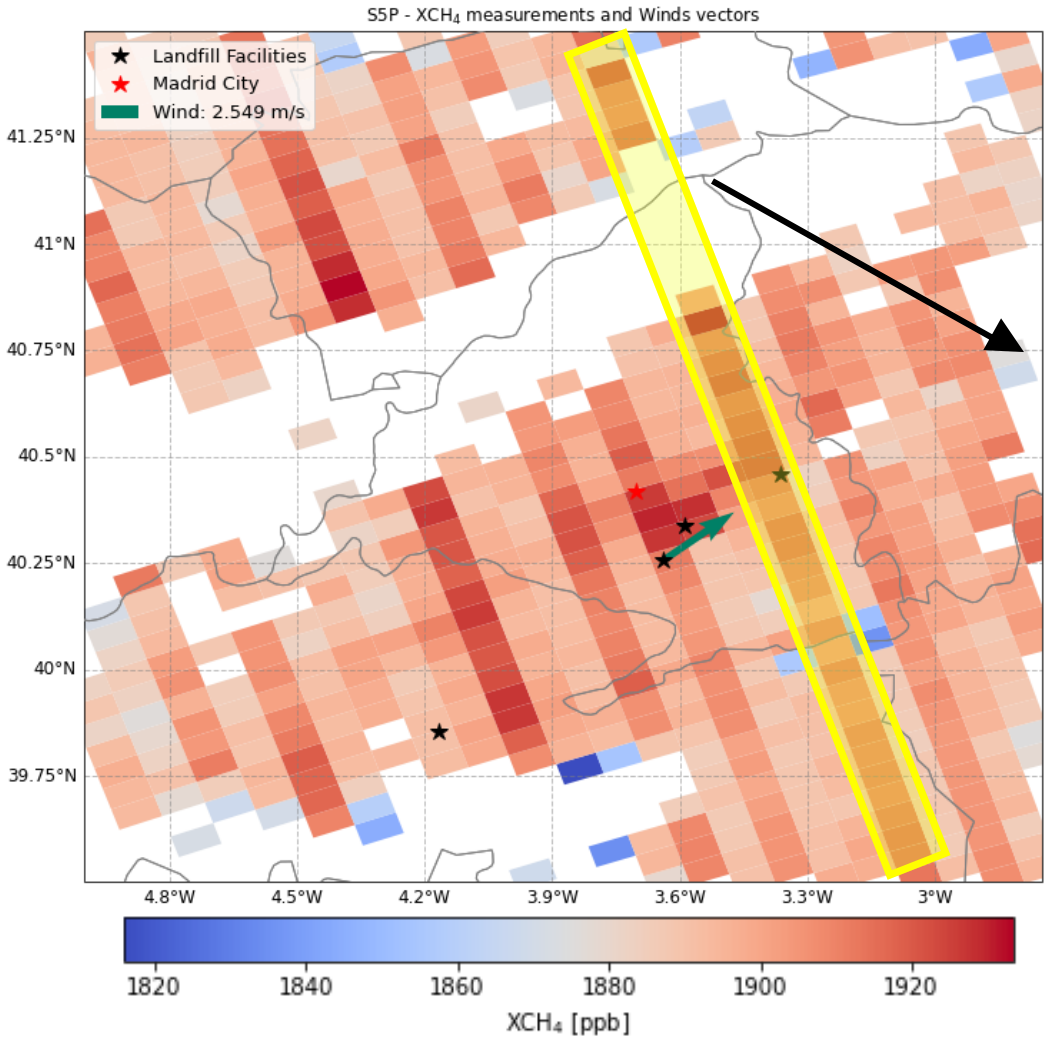
Mean value for the **whole** image is subtracted → Find plume pixels via threshold → Mean value is calculated again without plume pixels

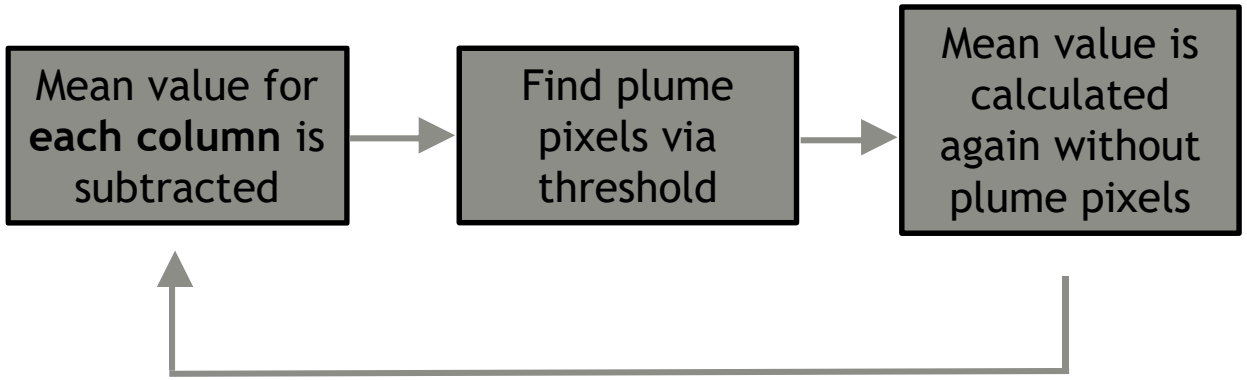




2.1. Integrated Mass Enhancement (IME)

Background Substration: Destriping method I

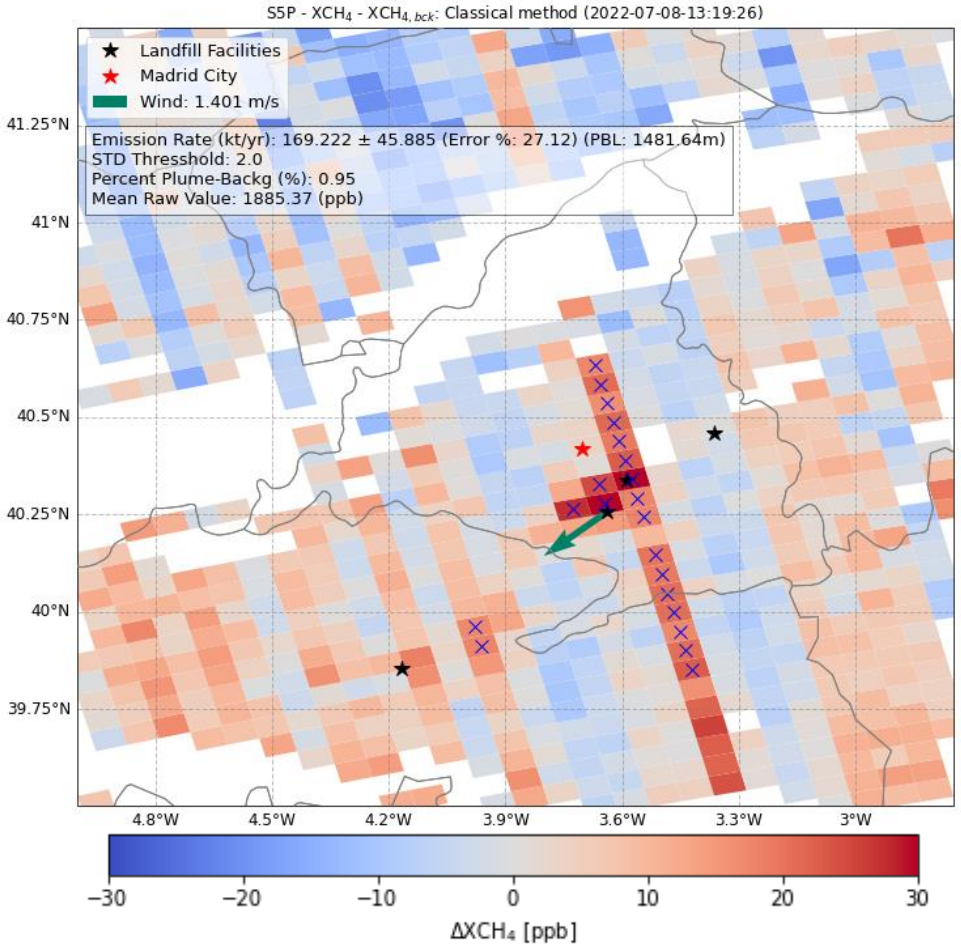




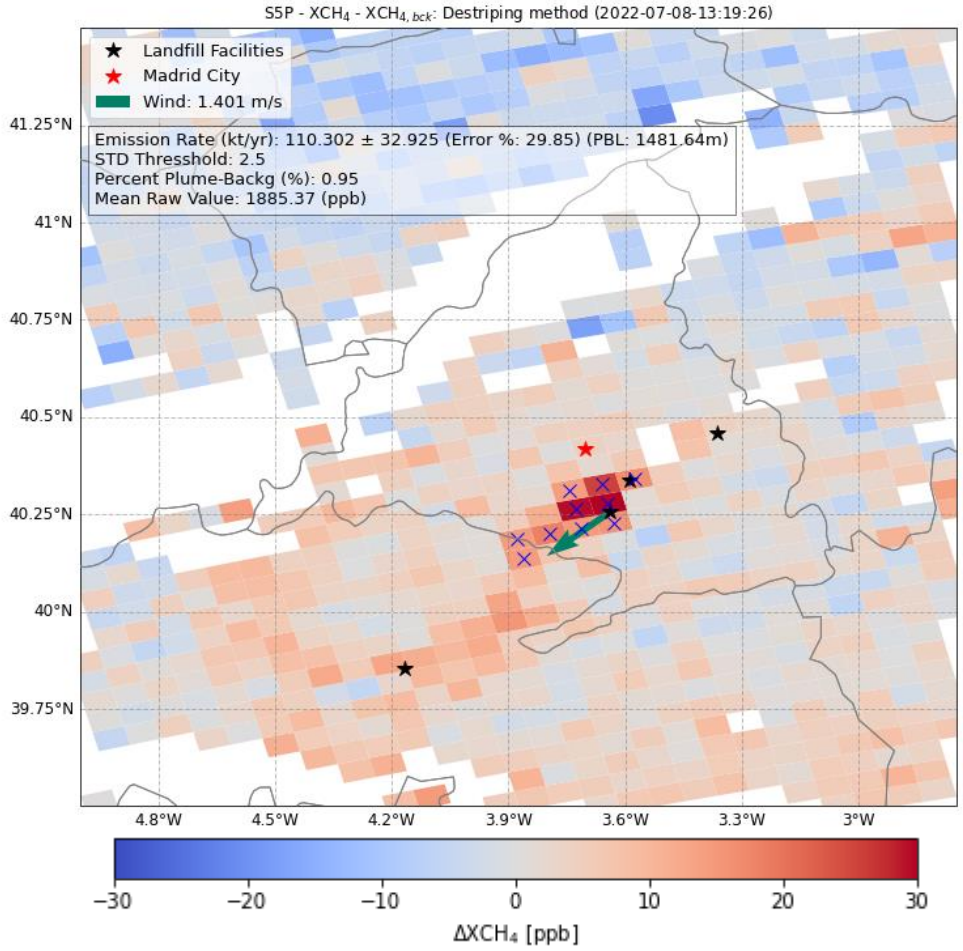
2.1. Integrated Mass Enhancement (IME)

Background Substration: Destriping method II

Classical method



Destriping method



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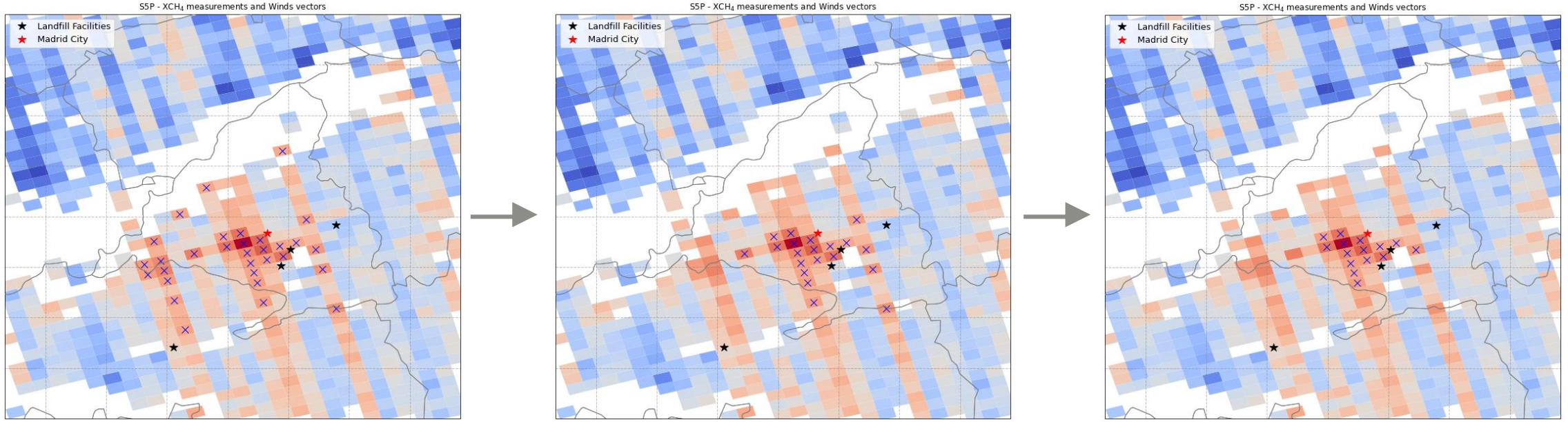
2.1. Integrated Mass Enhancement (IME)

Plume selection

$$T = \overline{\mathrm{XCH_4}} + N \cdot \sigma_{\mathrm{XCH_4}}$$

Mean value for **whole image** is calculated → Find pixels which are above N times STD → Mean value is calculated again without plume pixels → Pixels must be surrounding the landfill → Pixels must be in contact



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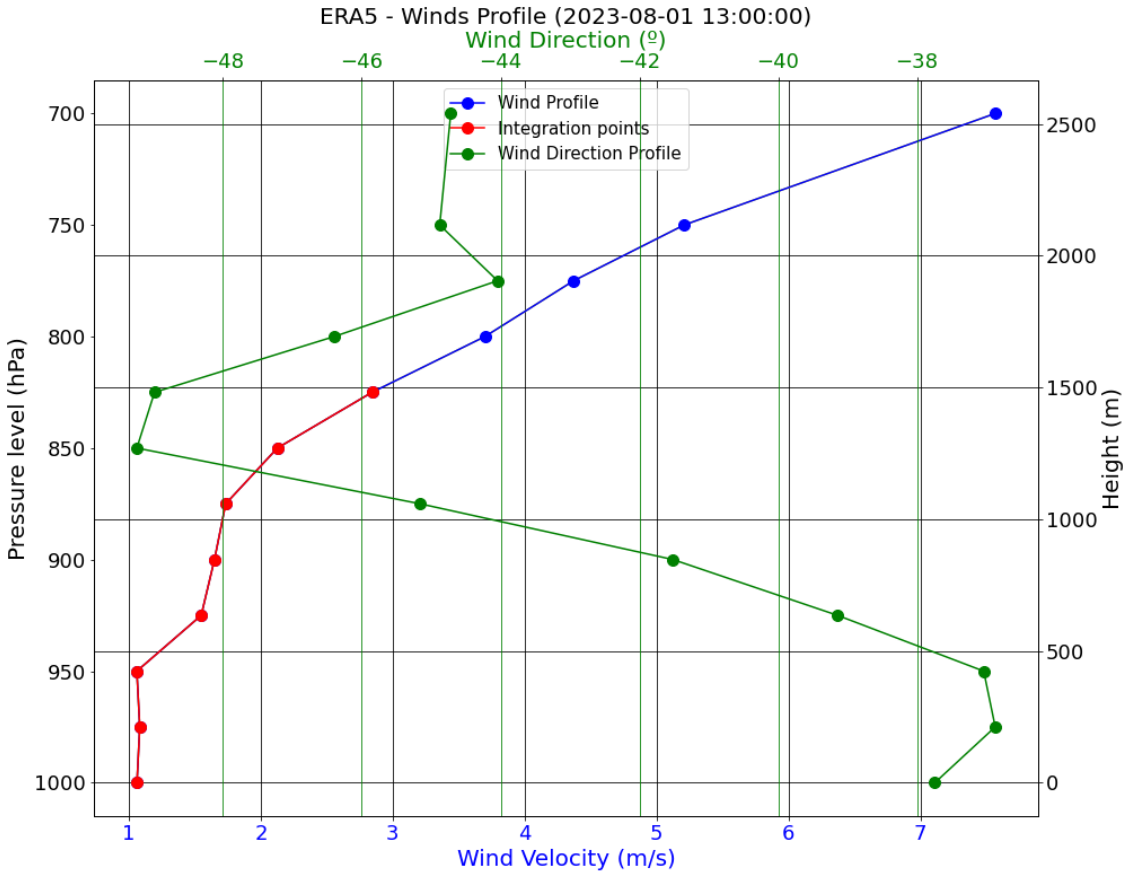
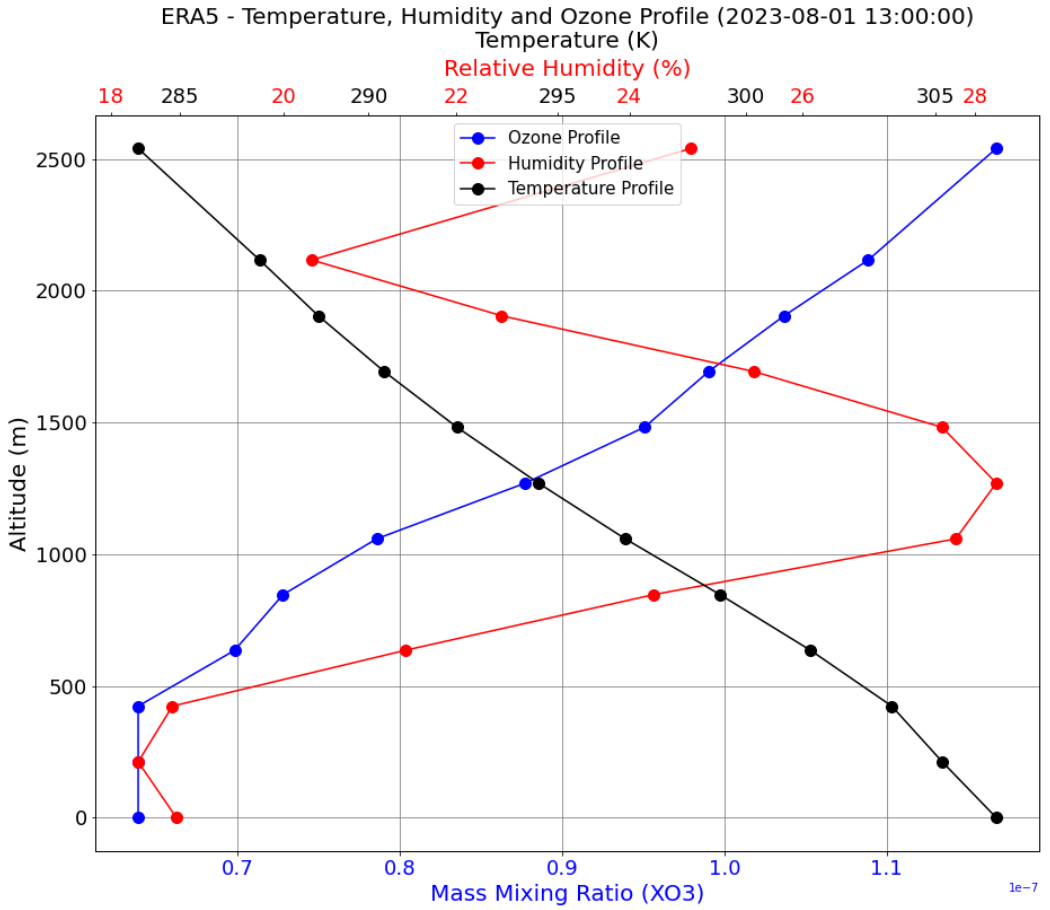
$$U_{eff} = U_{PBL} \longrightarrow \text{Wind selection}$$

2.1. Integrated Mass Enhancement (IME)

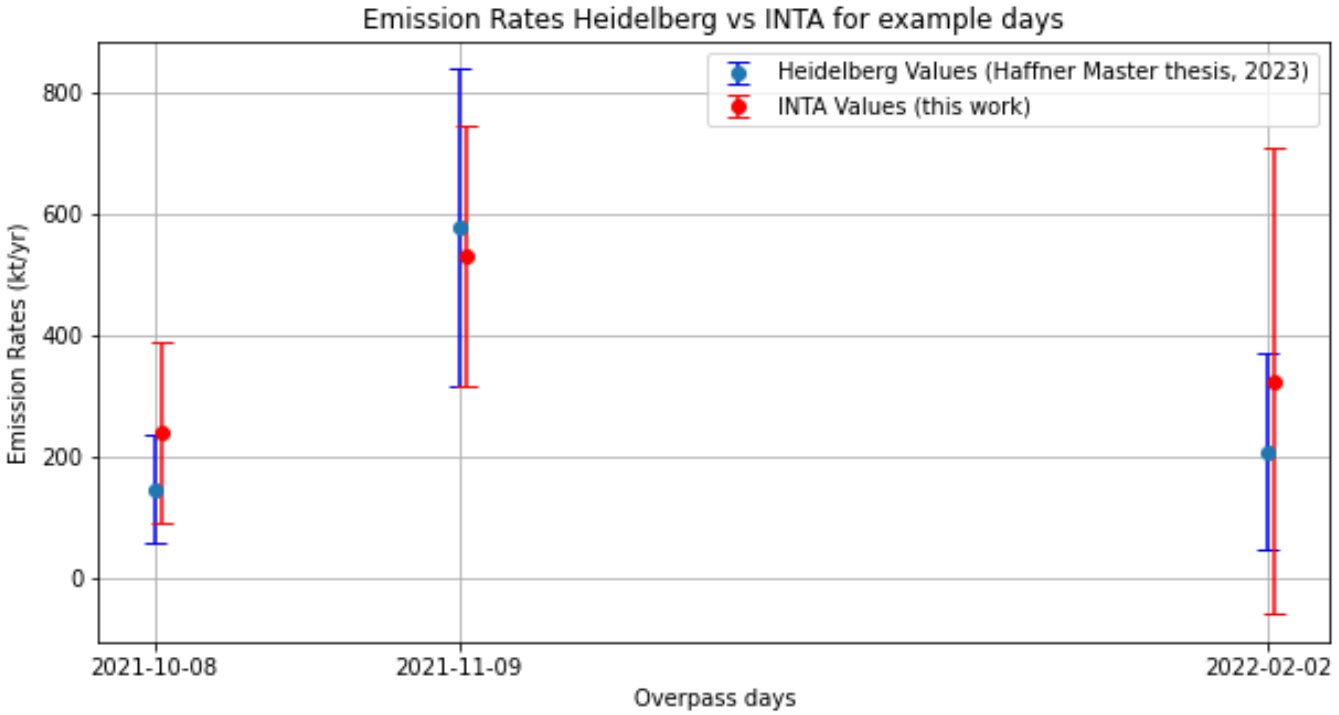
Wind selection: Planetary Boundary Layer (PBL)

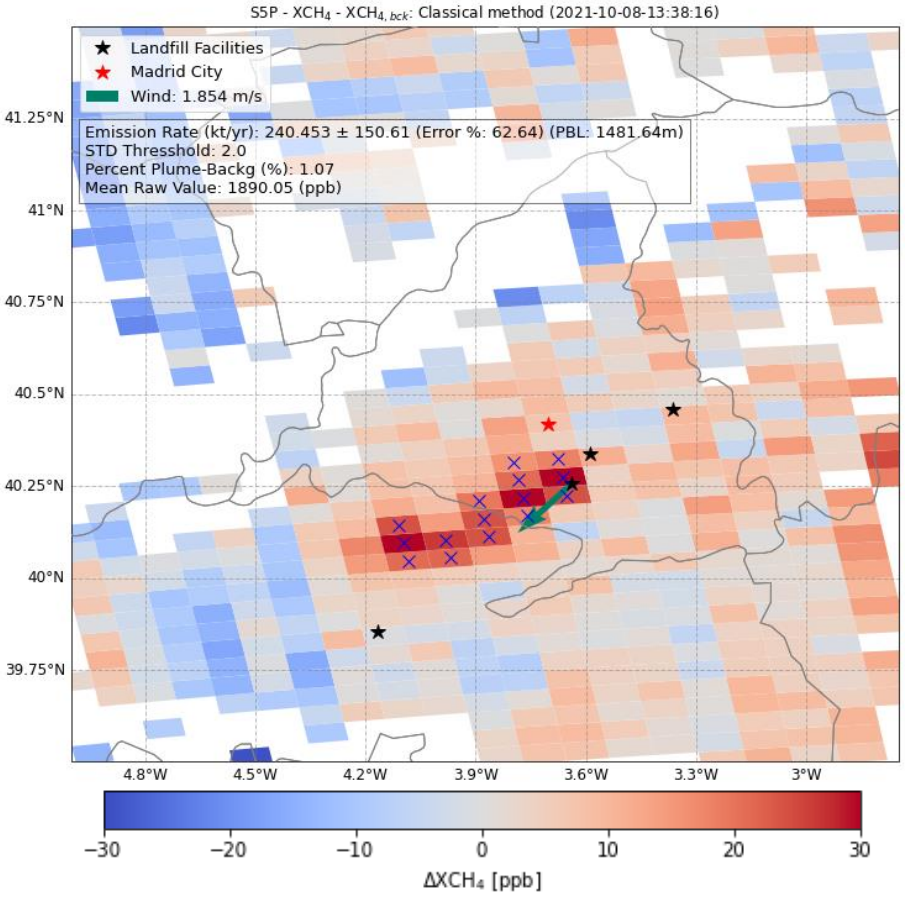




2.2. Comparision Heidelberg Team

Example days





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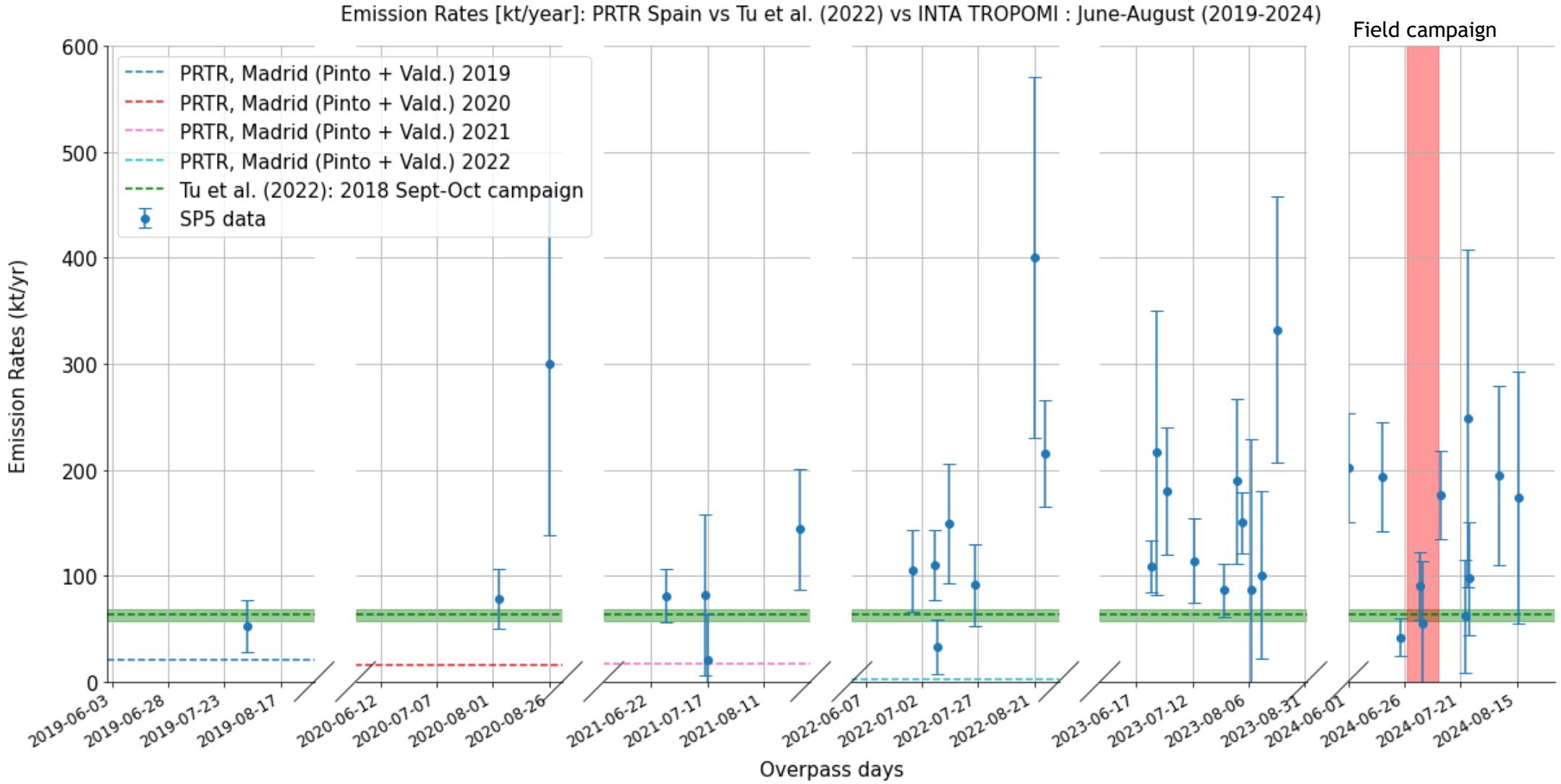
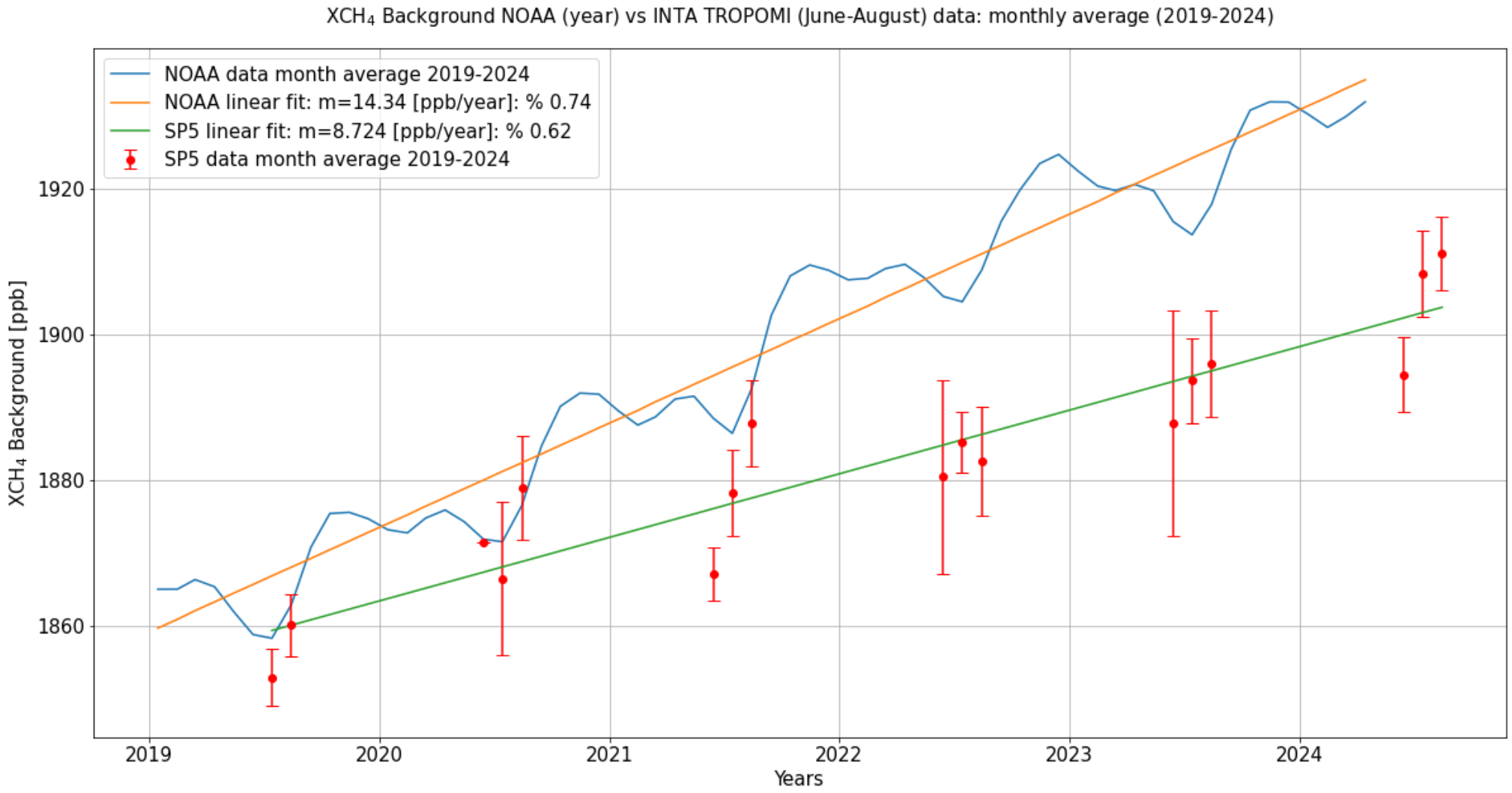
3.1. Emission Rates (Summer)

2019 - 2024



3.2. Background trends

2019 - 2024: Seasonality NOAA



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4. ANSER-AT links

Proof the method

- Emission Rate Estimation:
  - PBL selection
  - Plume selection
  - Integrated Mass Enhancement (IME)

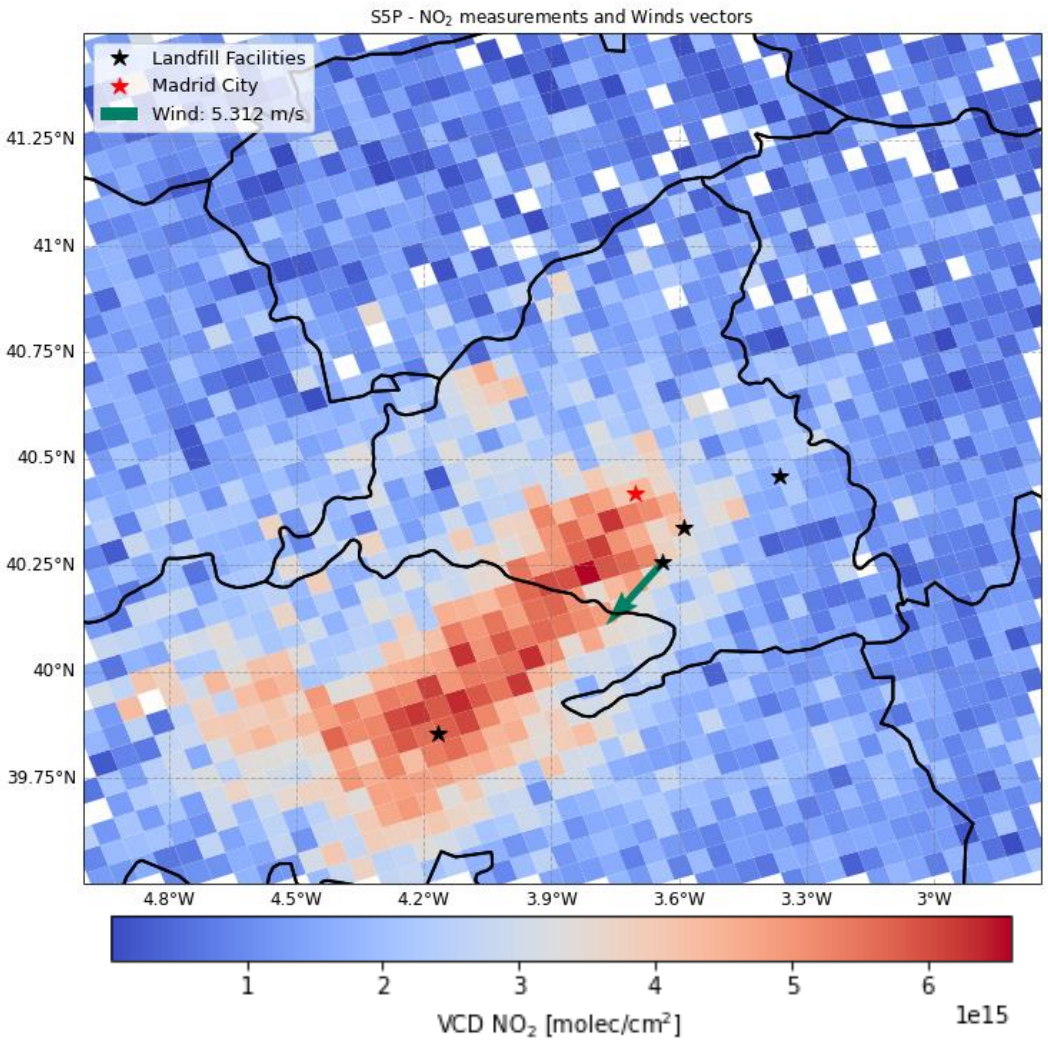
- The method works for other gases: **Santaren** (AMTD, 2024)
  - Long-lived gases → CH_4, CO_2
  - Short-lived gases → NO_2

Use TROPOMI to seek plumes

4.1. Verification of the method for NO_2

Overpasses

Raw



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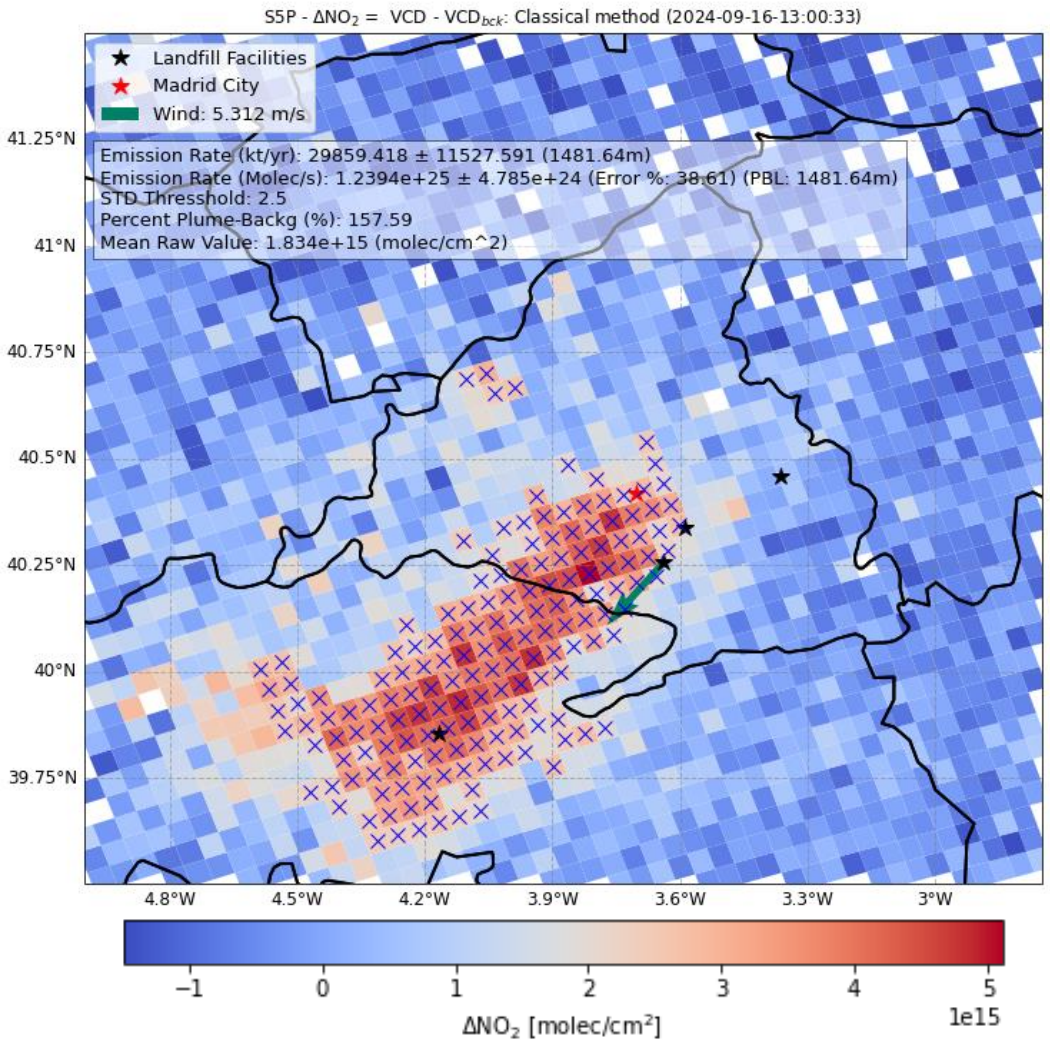
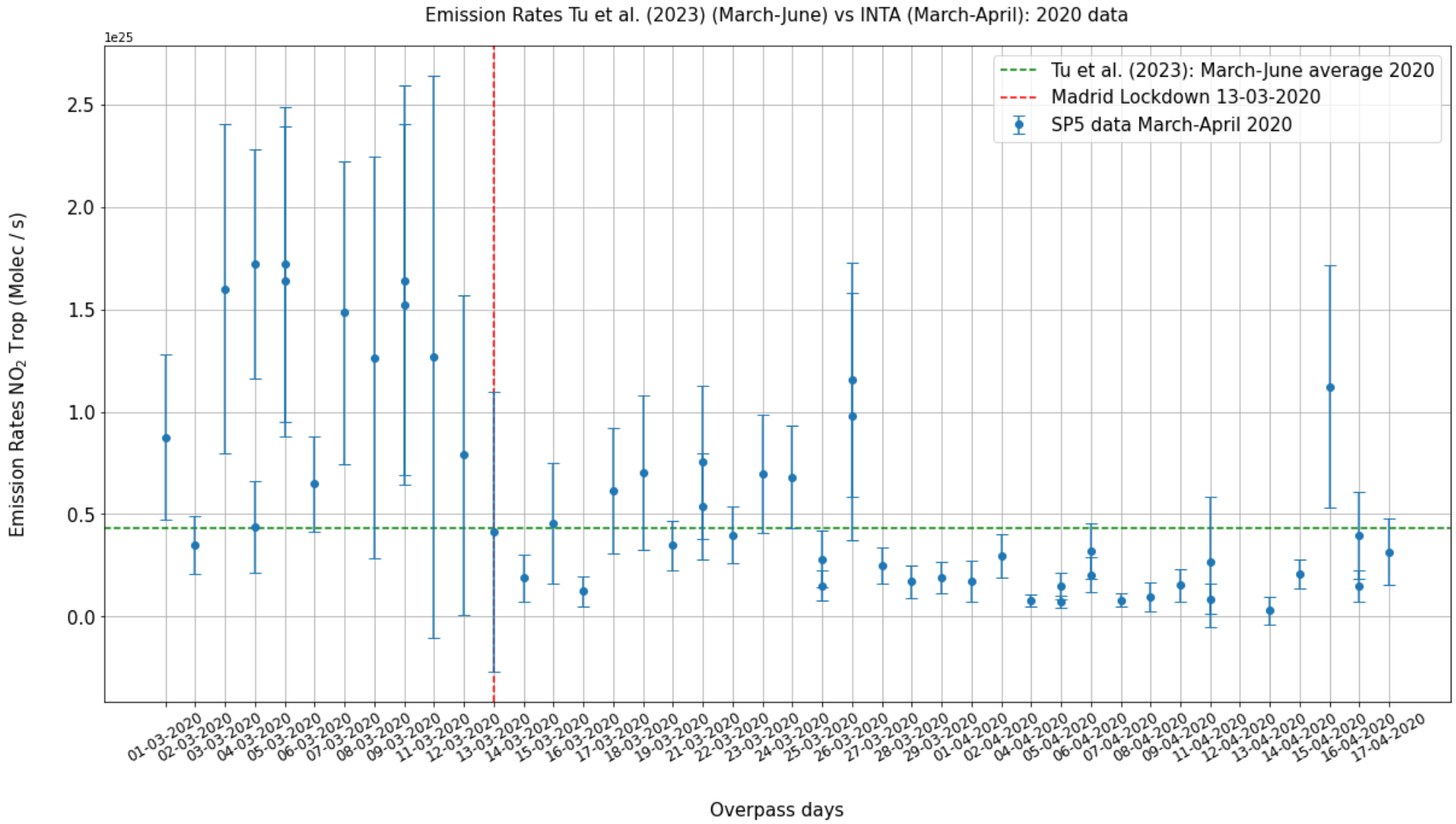


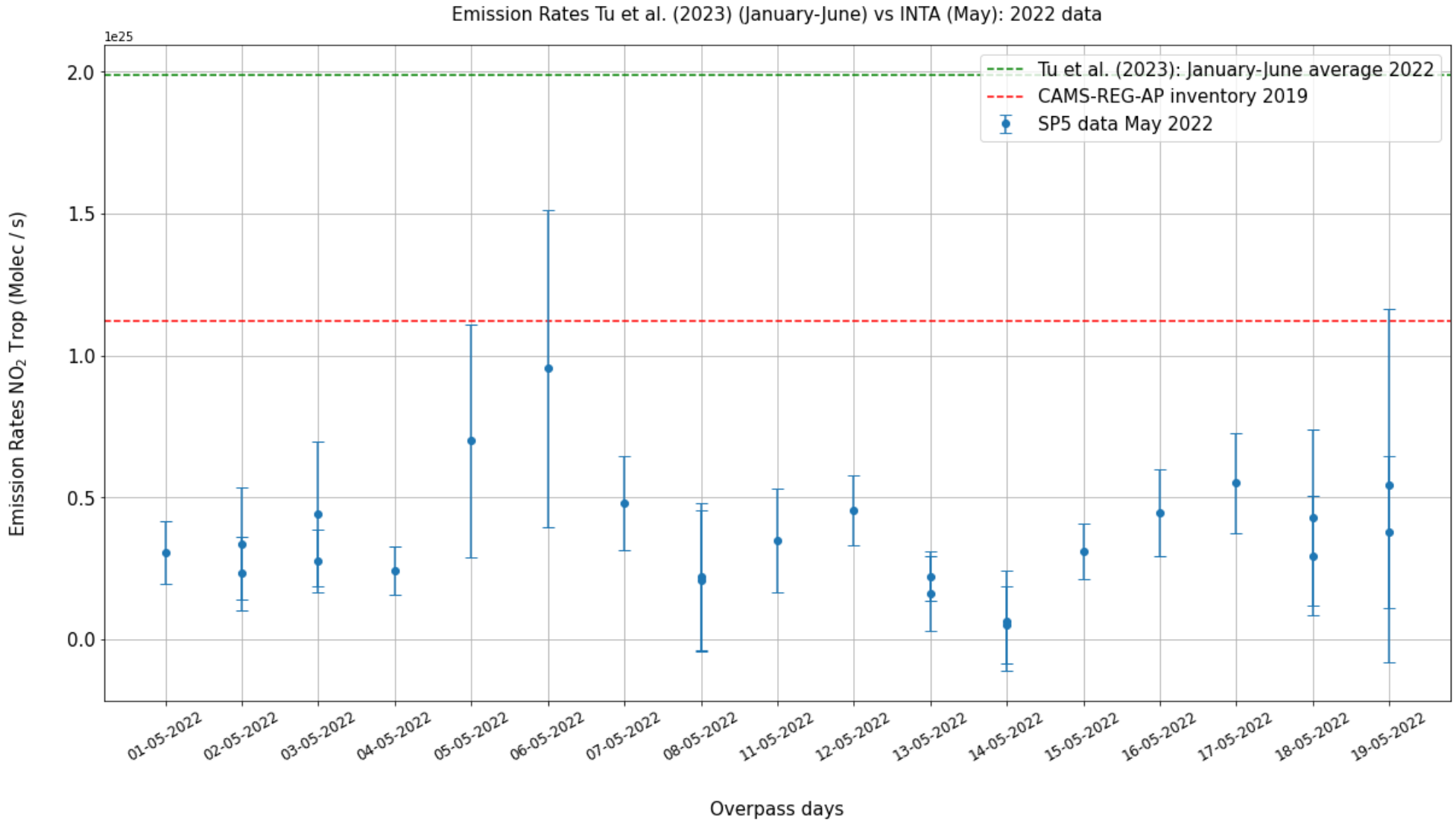
4.1. Verification of the method for NO_2

Emission Rates: Effects of Madrid Lockdown



4.1. Verification of the method for NO_2

Seasonality (anthropogenic)



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5. Ongoing work

- ERA5
  - Latitude-longitude grid resolution 0.25x0.25º
  - Altitude resolution 37 pressure levels

- HARMONIE-AROME Model (AEMET) (**Bengtsson** et al. 2017)
  - More spatial (2.5x2.5km) and altitude resolution (17 levels)
  - PBL altitude as ouput

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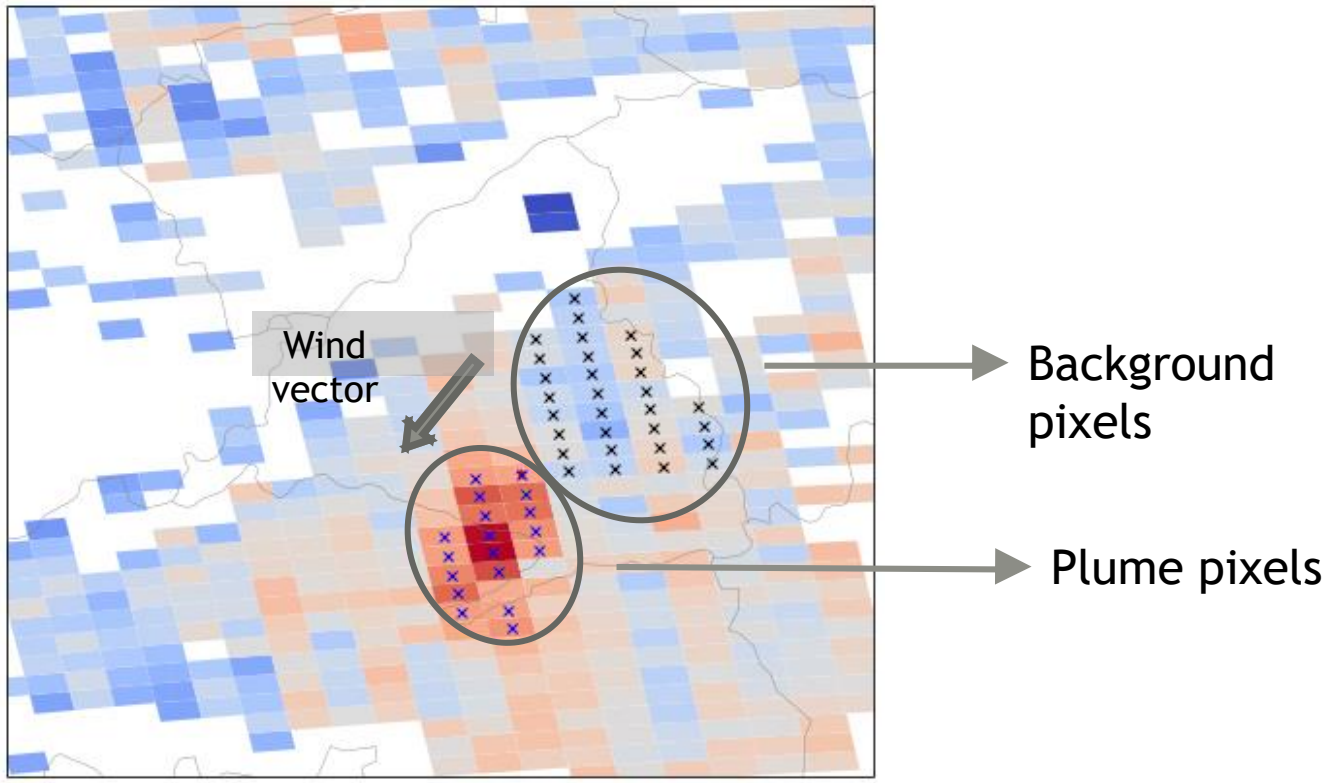
6. Work Done

- ERA5
  - Automated download script for pressure levels and ground parameters
- SP5-TROPOMI
  - Automated download script for data filtered
- Up-Wind method

2.1. Integrated Mass Enhancement (IME)

Background Substration: Up-wind



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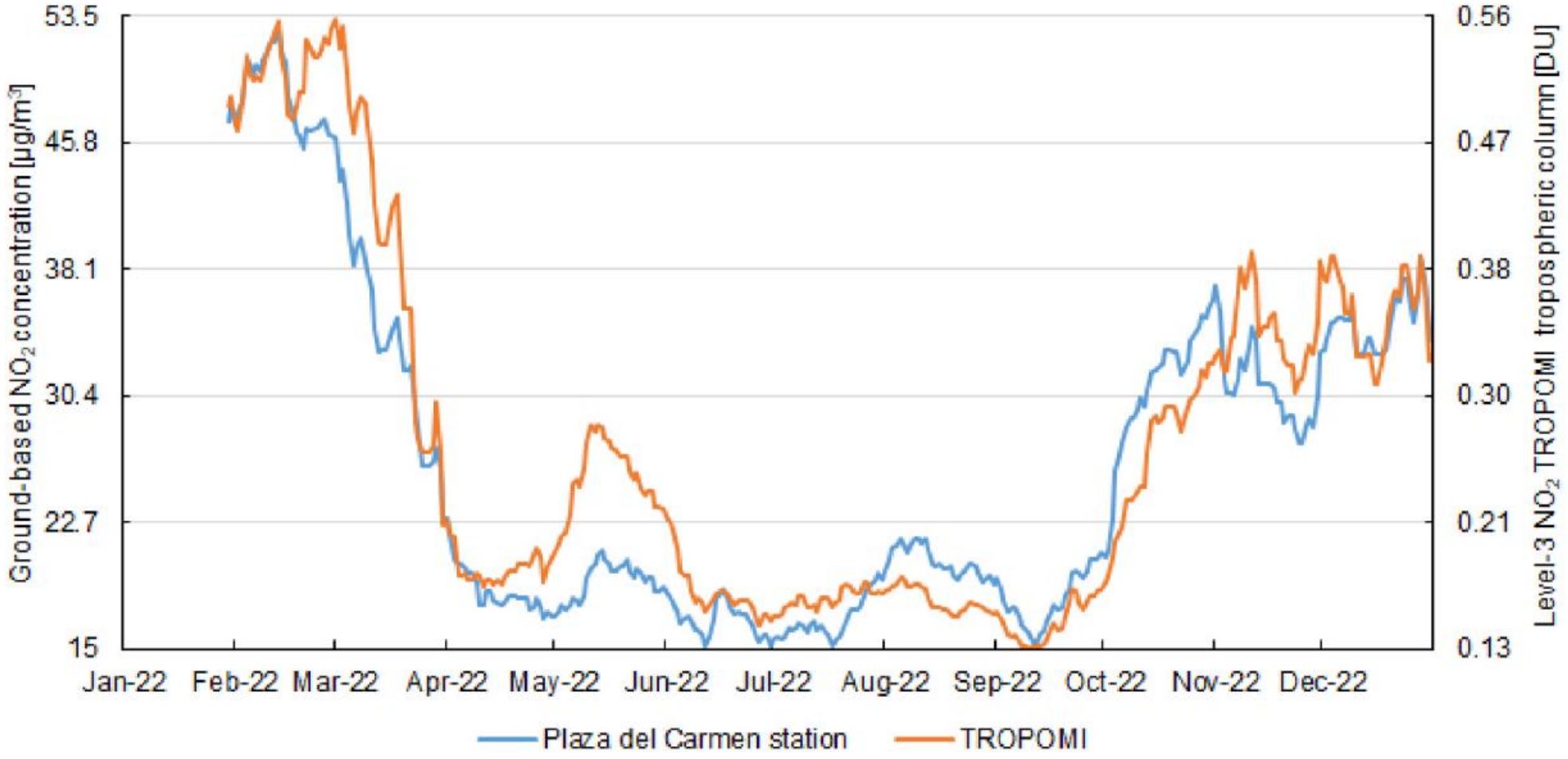
Seasonality (anthropogenic)



Morillas et al. (AE, 2024)