CitySatAir

Monitoring urban NO$_2$ with TROPOMI data

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Instruments for urban air quality montoring

| Source	Advantage	Disadvantage
Reference network	▪ Accurate measurements ▪ Hourly measurements	▪ Sparse network, if present at all
Low-cost sensors	▪ Dense networks possible ▪ Hourly measurements	▪ Inaccurate measurements, data quality issues such as bias
Satellite (polar orbiting)	▪ Global coverage ▪ homogeneous measurements	▪ Daily measurements (when not too cloudy) ▪ Coarse spatial resolution ▪ Tropospheric columns, not surface measurements
Regional air quality models (CTM)	▪ Good description of various species ▪ Hourly concentration fields ▪ Vertical description of air pollution	▪ Low resolution compared to urban landscape (CAMS has 10 km resolution)
Urban air quality models	▪ High spatial and temporal resolution	▪ Realistic input data (emissions and meteorology) not always available
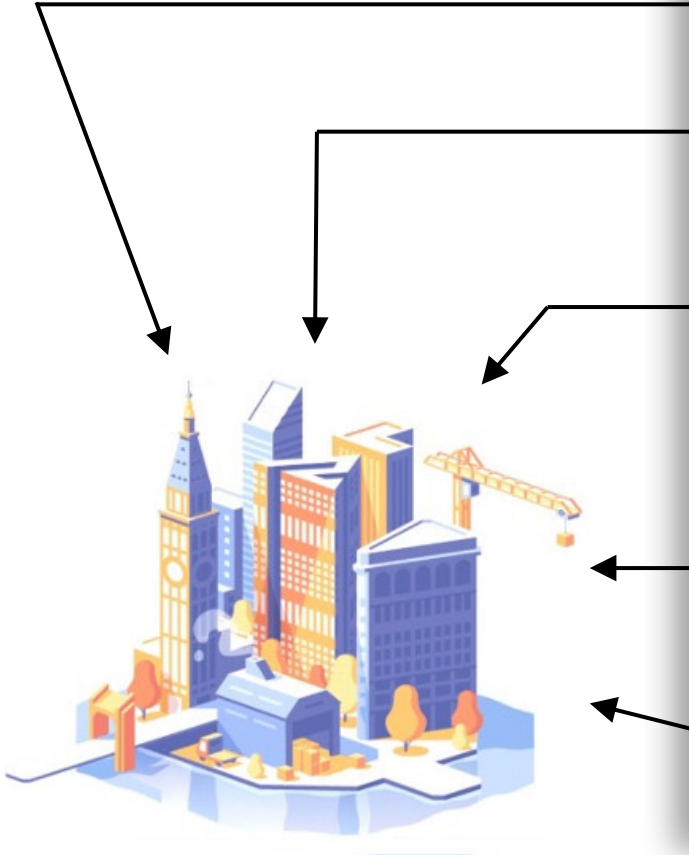
Using tropospheric NO$_2$ columns from space
Making the best of individual TROPOMI retrievals

15 Jan 2019, 13:32 UTC
as seen from space by TROPOMI/S5P
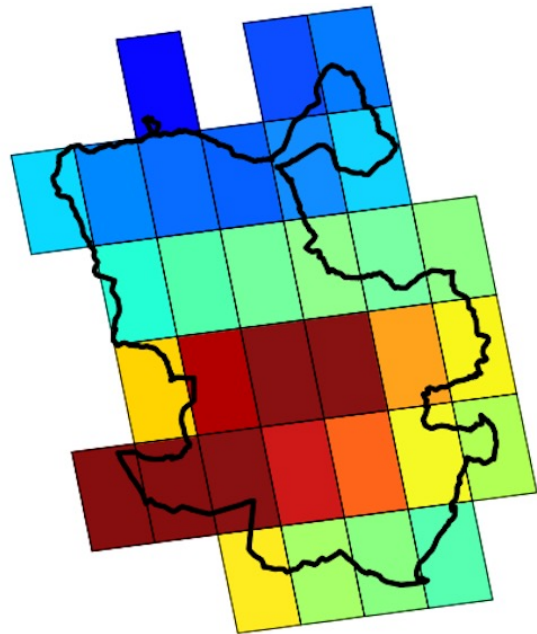
15 Jan 2019, 13:00 UTC
**data assimilated from surface**

?

NO2 [ug/m3]
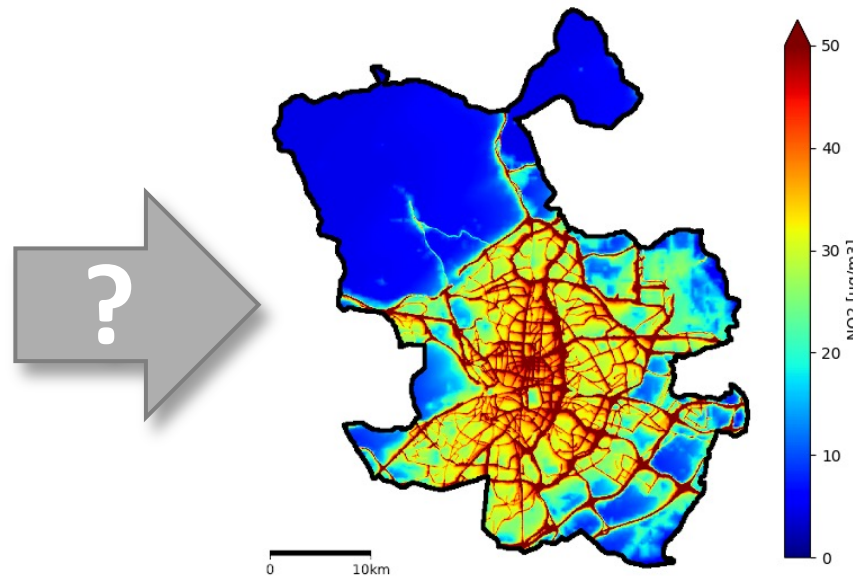
■ Simulating individual retrievals
avoiding information loss from gridding or averaging observations

■ Applying averaging kernel
including retrievals from partially cloudy scenes

■ Emission update, not direct concentration assimilation
concentration updates at overpass will disappear in few hours

Approach for Madrid

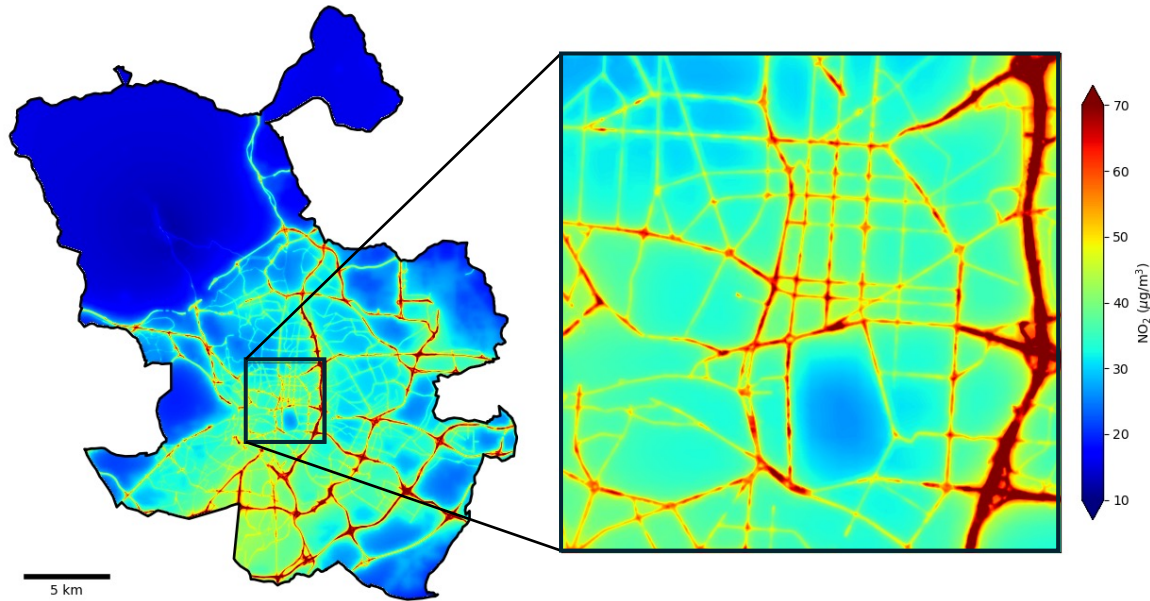**Retina algorithm** (Mijling, Atmos. Meas. Tech., 2020)

- Built around AERMOD
- Emission proxies for urban emissions
- Estimating emissions factors from space or ground observations
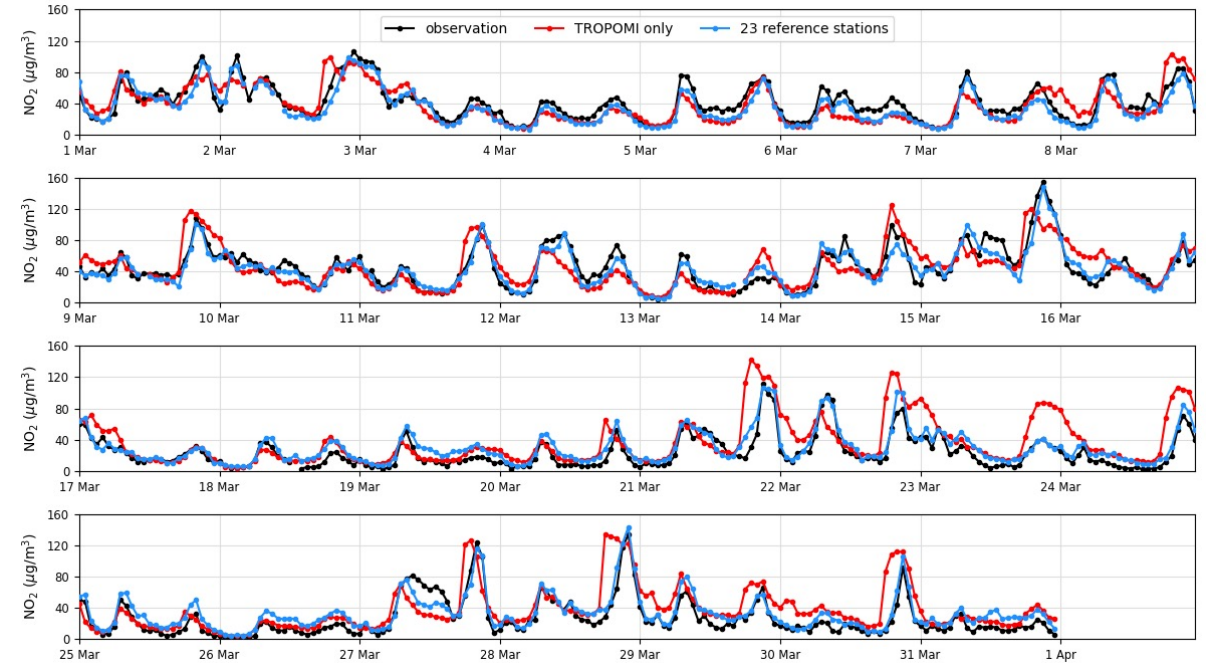- Spatial assimilation of in-situ measurements
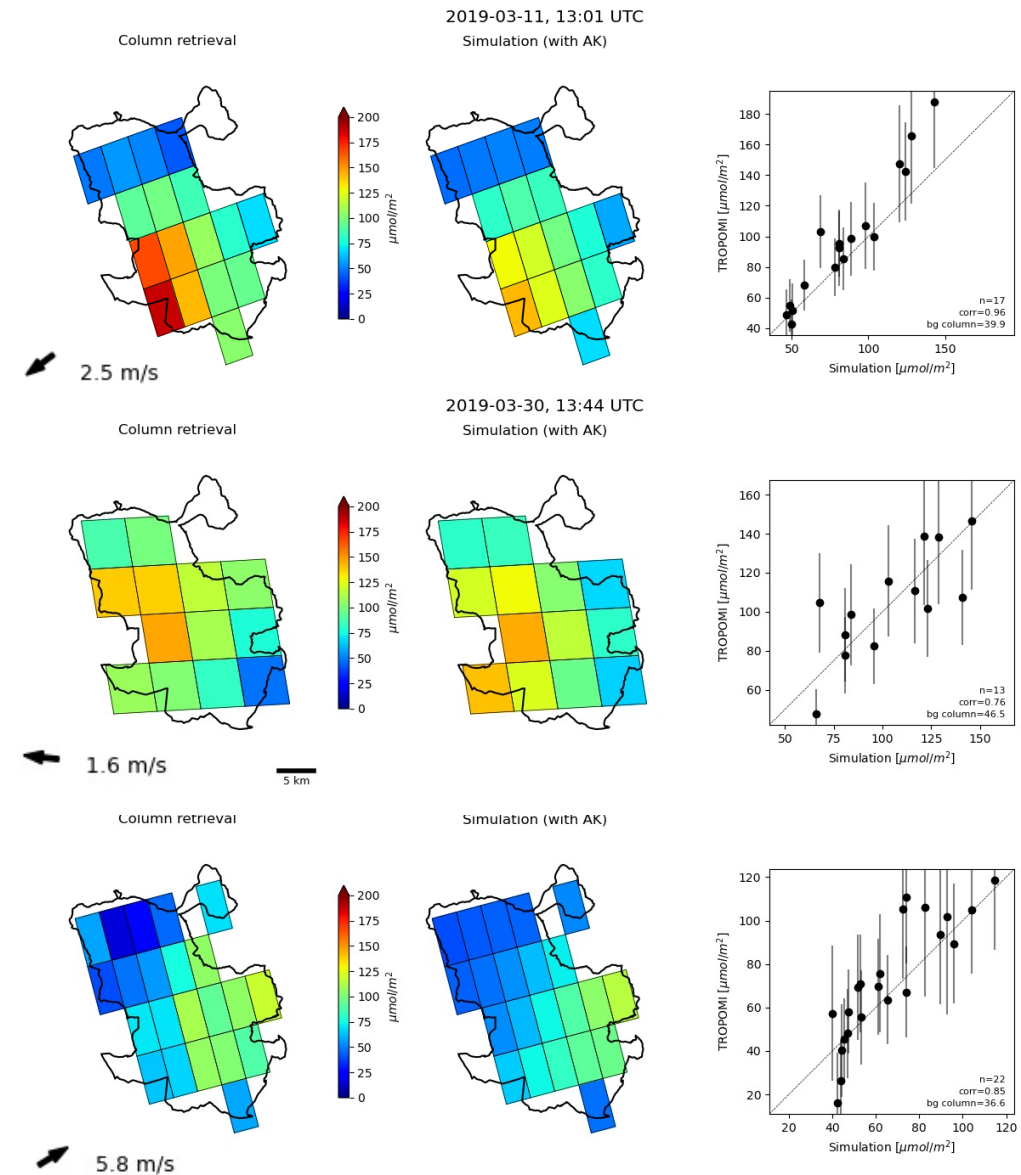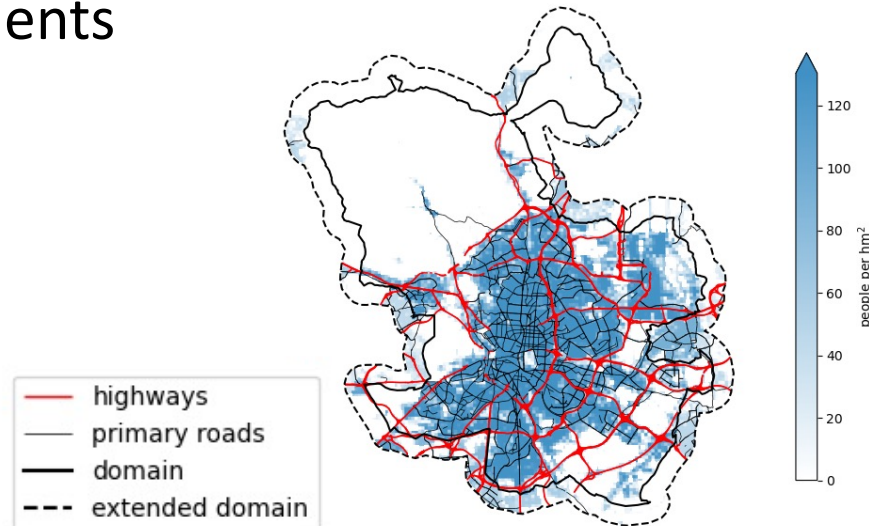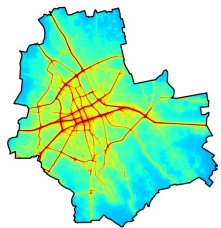
Results of the Retina algorithm

Madrid surface NO$_2$ concentrations, March 2019
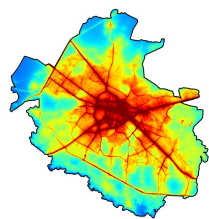

Time series at Castellana street station, March 2019

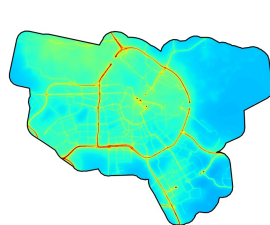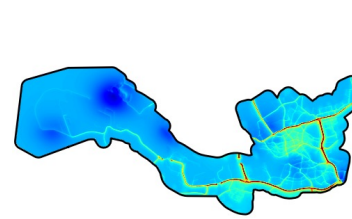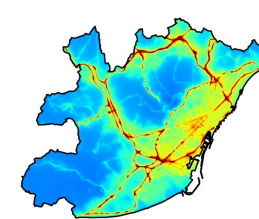| Warsaw	Sofia	Amsterdam	Rotterdam	Barcelona	Mataró
March 2021 TROPOMI (preliminary)	2021 Reference + Palmes tubes	2023 Reference + Palmes tubes	August 2022 Reference network	2023 Reference network	January 2022 1 reference station
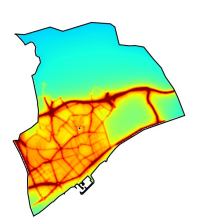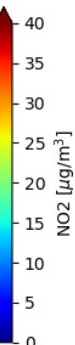
Added value of satellite data: Possibilities and limitations

- TROPOMI can be used to improve estimations of urban emissions, resulting in improved simulation of NO_2 surface concentrations

- At high latitudes: small signal, months without sampling

- TROPOMI misses diurnal cycle

- Difficult to beat networks of hourly in-situ measurements (when available)

- Added value especially for cities with limited or no ground observations

Exploring the data with Lobelia Explore

Reanalysis of hourly NO$_2$ concentrations in Sofia from January to April 2022

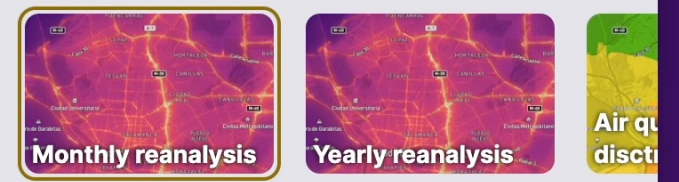https://explore.lobelia.earth/retina

- Serverless architecture increases performance and reduces costs

- Spatial and temporal evolution of air pollution

- User-friendly exploration of a point, area, transect or the whole city

Monthly reanalysis

Yearly reanalysis

Air qu
distr

Monthly reanalysis

This map shows **monthly averages of NO$_2$ concentrations in Madrid for the period 2018-2022**.

Use the controls below the legend to adjust the visualisation of the data and compare different months.

Labels

Hide layer

NO$_2$ NO2

| 0 | 20 | 40 | 60 | 80 | 100 µg/m³ |

2018   Apr   Jul   Oct   2019   Apr   Jul   Oct   2020   Apr   Jul   Oct   2021   Apr   Jul   Oct   2022   Apr   Jul   Oct   2023   Apr

Points

Areas

Settings

Outlook

- Generation long time series, study emission trends

- Rotterdam + Warsaw

- Towards faster/generic implementation in new cities

- Open source code for Retina algorithm

- Preparation for Sentinel-4: hourly data captures diurnal cycle

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