CitySatAir

Monitoring urban NO_2 with TROPOMI data

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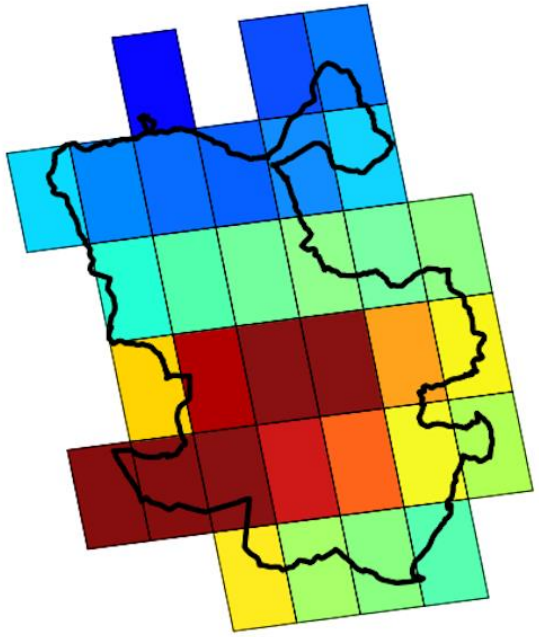
Instruments for urban air quality montoring

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



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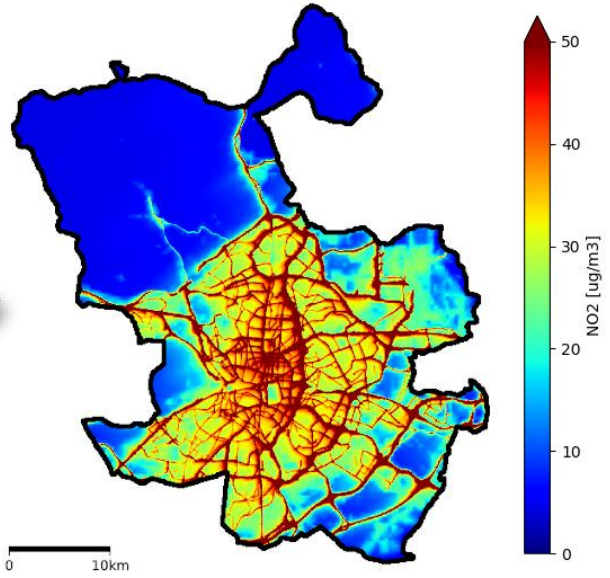
15 Jan 2019, 13:00 UTC
data assimilated from surface

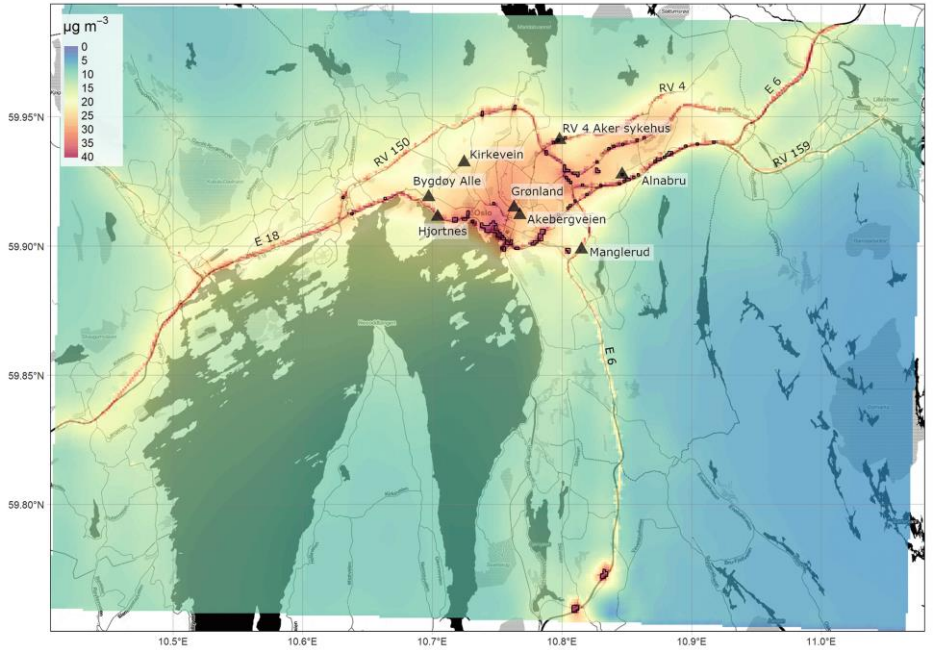


- Simulating individual retrievals avoiding information loss from gridding or averaging observations
- Applying averaging kernel including retrievals from partially cloudy scenes
- Emission update, not direct concentration assimilation concentration updates at overpass will disappear in few hours

Approach for Oslo

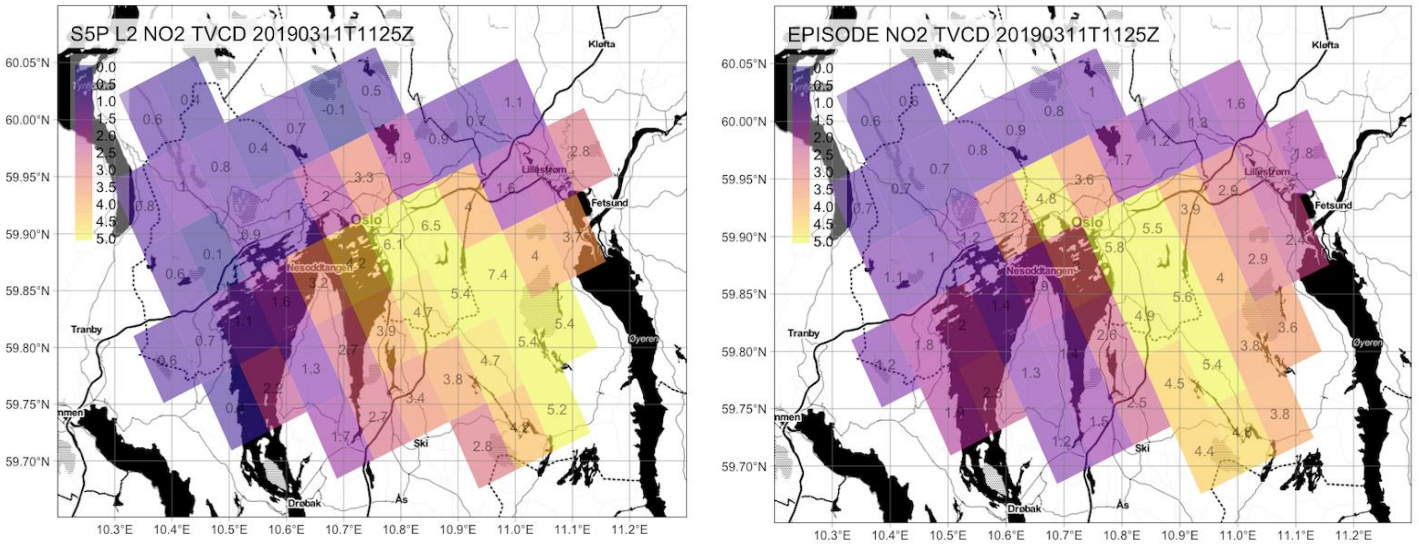
Using the **EPISODE** urban dispersion model (Hamer et al., 2020):
100 m resolution NO_2 fields

We compute TVCDs from EPISODE for each TROPOMI L2 retrieval/footprint (including AK)



Annually averaged NO_2 surface concentrations from the EPISODE model over Oslo (100 m × 100 m horizontal resolution).

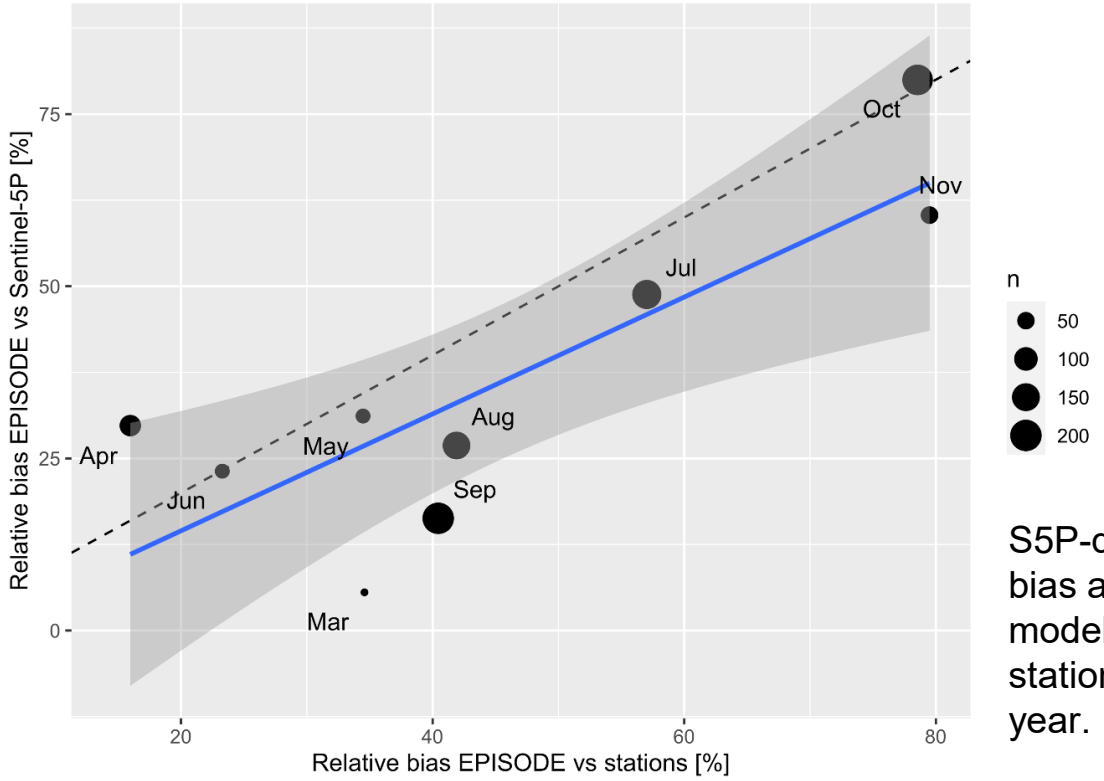
The black triangles indicate the locations of air quality observation stations.



Comparison of the NO_2 TVCD from TROPOMI (left) and the corresponding EPISODE NO_2 column (right) over Oslo region for 11 March 2019 at 11:25 UTC.

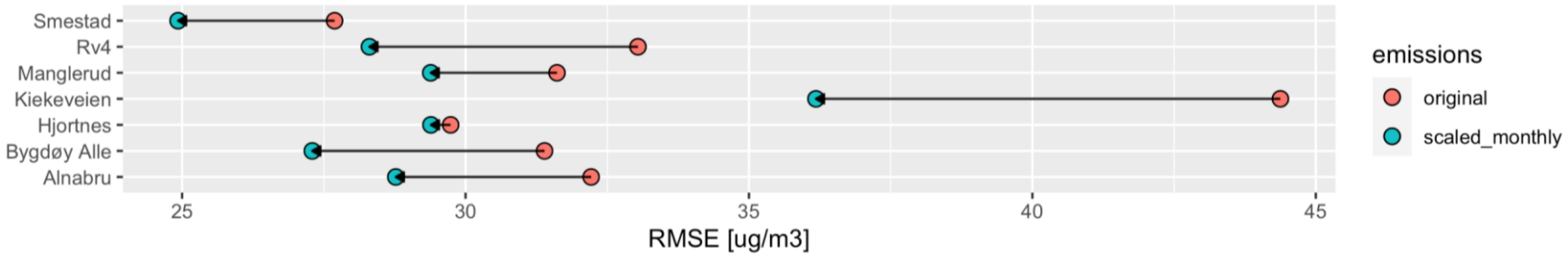
Results for Oslo

Detecting/correcting seasonal biases in EPISODE modelling



S5P-derived model bias agrees well with model bias against stations throughout the year.

Direct emission adjustment from simulated/observed columns

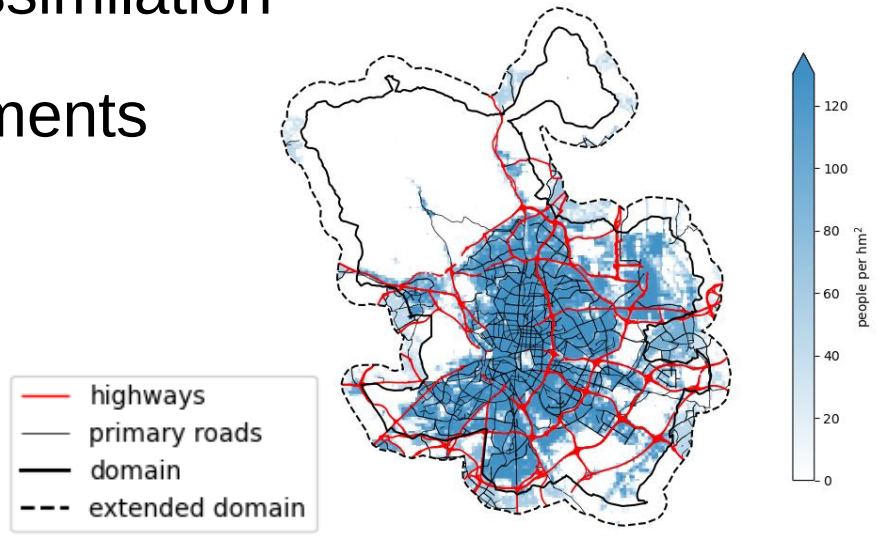


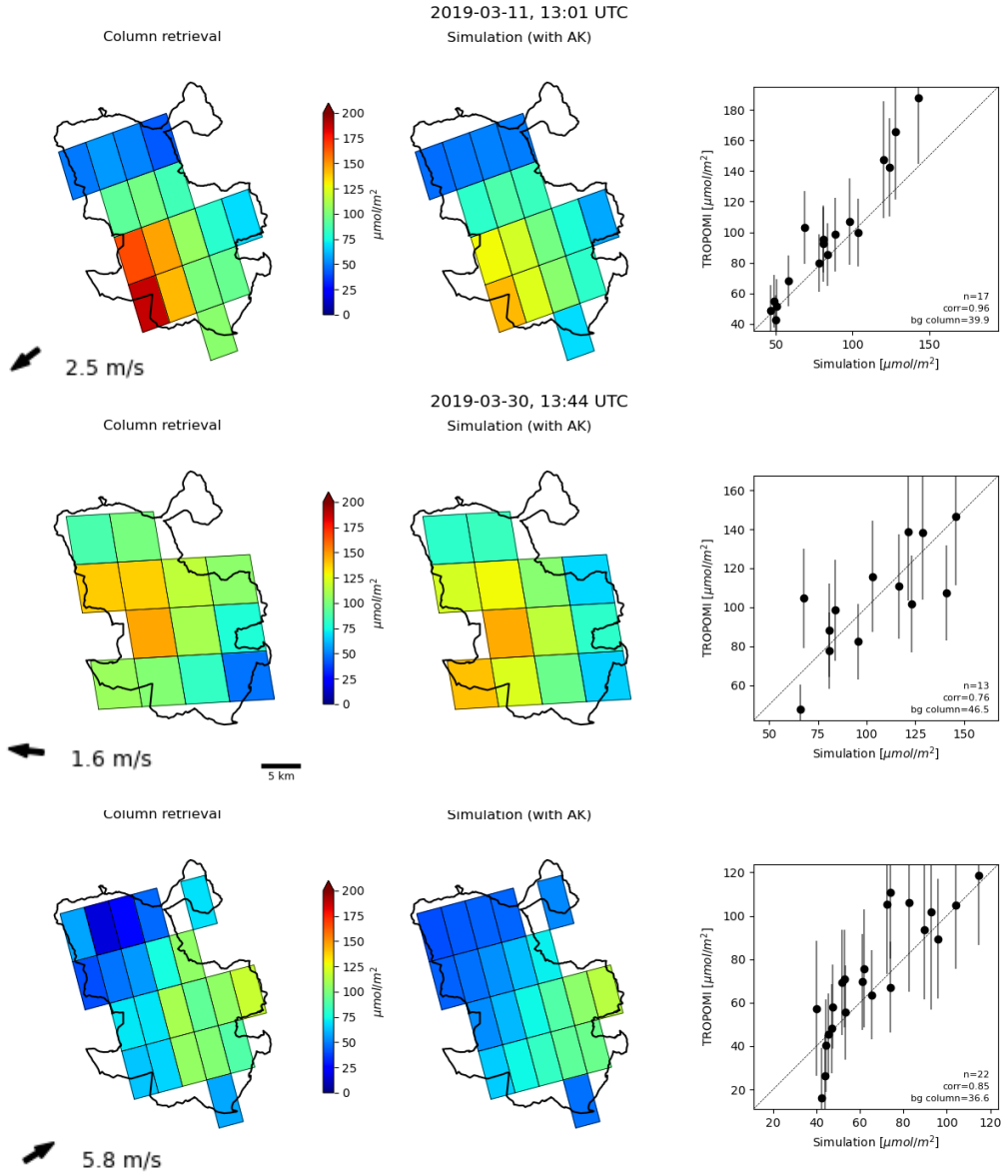
S5P/TROPOMI-corrected emissions result in up to **20% higher accuracy** of the EPISODE model simulations throughout the year.

Approach for Madrid

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

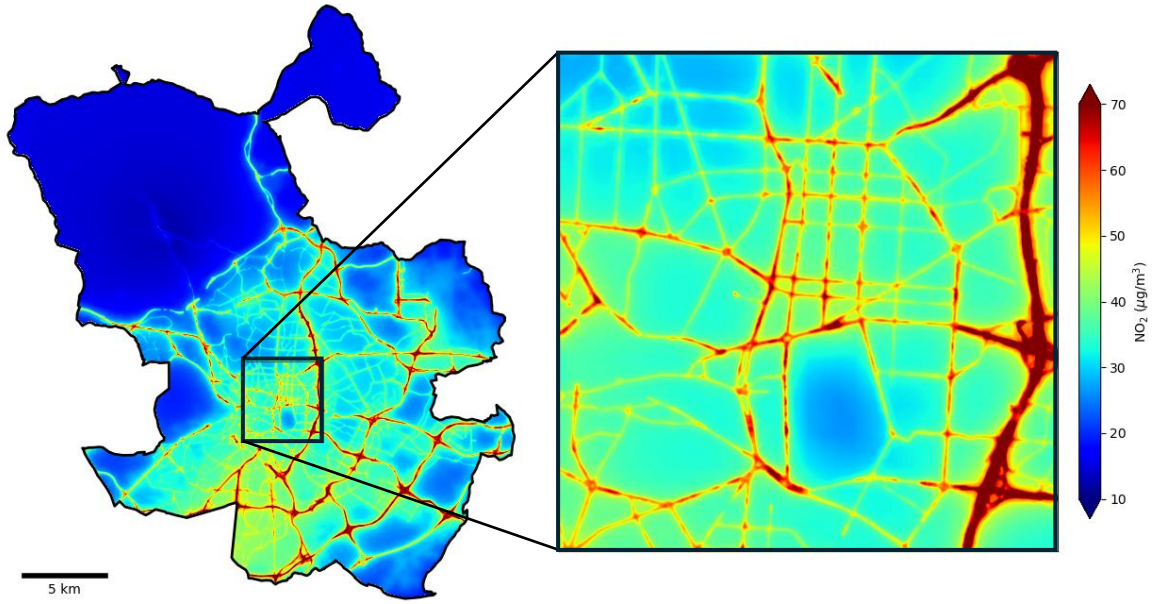
- Built around AERMOD
- Emission proxies for urban emissions
- Estimating emissions factors from space or ground observations
- Spatial assimilation of in-situ measurements



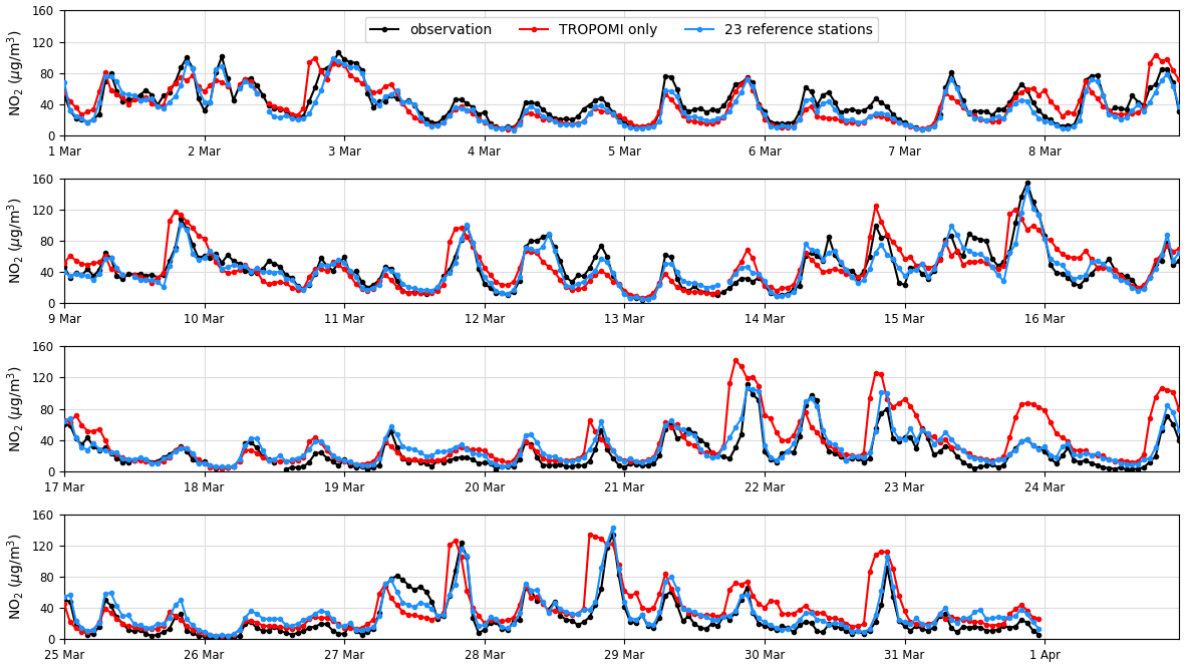


Results of the Retina Algorithm

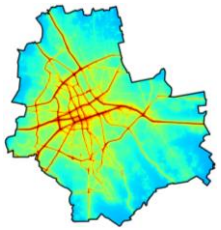
Madrid surface NO_2 concentrations, March 2019



Time series at Castellana street station, March 2019

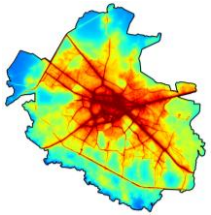


Warsaw



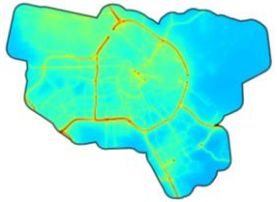
March 2021
TROPOMI (preliminary)

Sofia



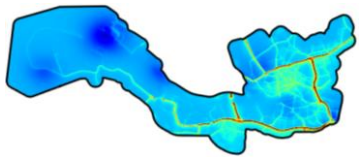
2021
Reference + Palmes tubes

Amsterdam



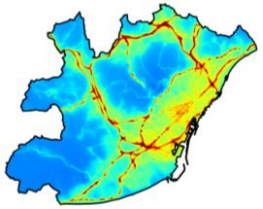
2023
Reference + Palmes tubes

Rotterdam



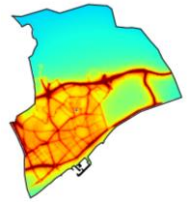
August 2022
Reference network

Barcelona

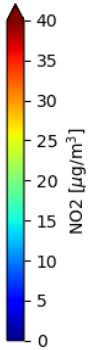


2023
Reference network

Mataró



January 2022
1 reference station

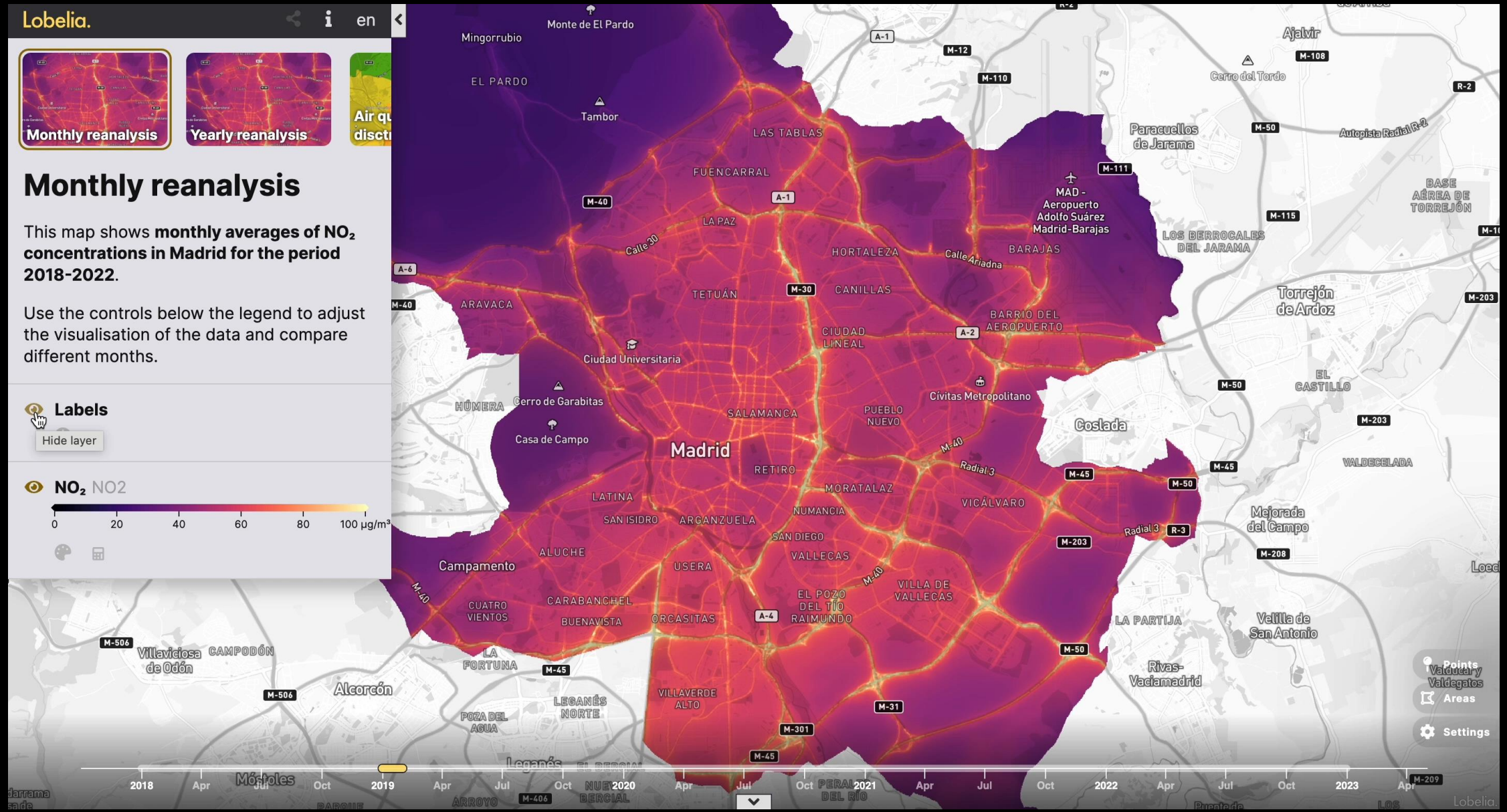


Added value of satellite data: Possibilities and limitations

- 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 hourly in-situ measurements (when available)
- Added value especially for cities with limited or no ground observations

Exploring the data with Lobelia Explore

- 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


Lobelia.
en
Monthly reanalysis
Yearly reanalysis
Air qu
disctr
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
Monte de El Pardo
Mingorrubio
EL PARDO
Tambor
LAS TABLAS
FUENCARRAL
LA PAZ
Calle 30
HORTALEZA
Calle Ariadna
BARAJAS
MAD - Aeropuerto Adolfo Suárez Madrid-Barajas
TETUÁN
CANILLAS
ARAVACA
BARRIO DEL AEROPUERTO
CIUDAD LINEAL
Ciudad Universitaria
Cerro de Garabitas
HÚMERA
Casa de Campo
SALAMANCA
PUEBLO NUEVO
Cívitas Metropolitano
Madrid
RETIRO
LATINA
MORATALAZ
VICÁLVARO
SAN ISIDRO
ARGANZUELA
NUMANCIA
SAN DIEGO
VALLECAS
ALUCHE
Campamento
USERA
CUATRO VIENTOS
CARABANCHEL
BUENAVISTA
ORCASITAS
EL POZO DEL TÍO RAIMUNDO
VILLA DE VALLECAS
LA FORTUNA
VILLAVERDE ALTO
LEGANÉS NORTE
POZA DEL AGUA
Leganés
Móstoles
Alcorcón
Villaviciosa de Odón
CAMPODÓN
Ajalvir
Cerro del Tordo
Paracuellos de Jarama
Autopista Radial R-2
BASE AÉREA DE TORREJÓN
LOS BERROCALES DEL JARAMA
Torrejón de Ardoz
EL CASTILLO
Coslada
VALDECELADA
Mejorada del Campo
Velilla de San Antonio
LA PARTIJA
Rivas-Vaciamadrid
Valdeolmos-Alalpardo
Valdetorres de Jarama
Points
Areas
Settings
2018
Apr
Jul
Oct
2019
Apr
Jul
Oct
2020
Apr
Jul
Oct
2021
Apr
Jul
Oct
2022
Apr
Jul
Oct
2023
Apr
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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

- More information: Bas Mijling - bas.mijling@knmi.nl - website: https://citysatair.nilu.no