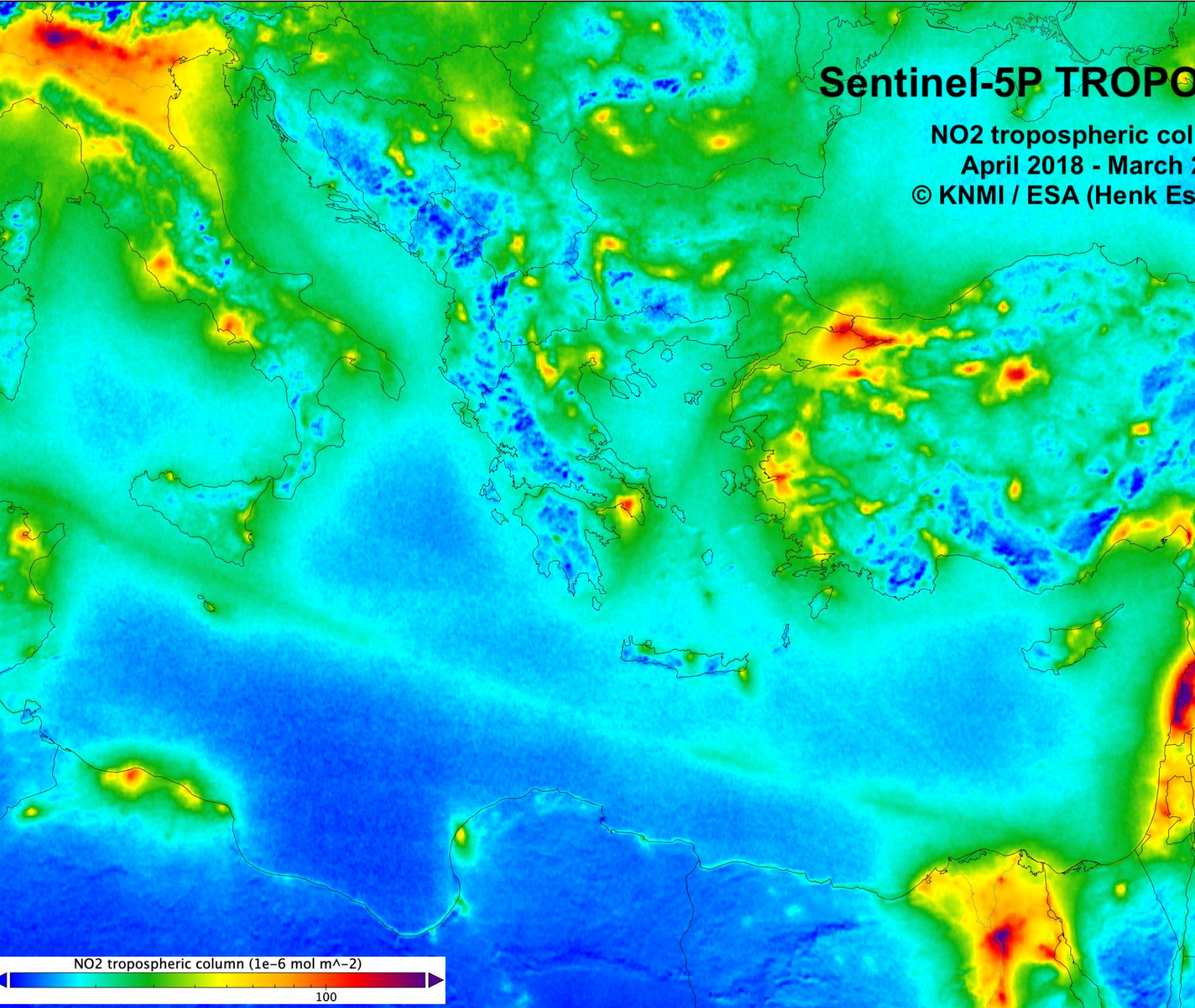


CONTACT

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Ioanna Skoulidou | ioannans@auth.gr

Quantifying South
Eastern Europe NO_x and
SO₂ emissions using
S5P/TROPOMI; from the
urban to the regional
scale.

M.E. Koukouli , I. Skoulidou,
A. Segers , A. Manders , J. Kuenen,
J. van Geffen , H. Eskes , P. Hedelt,
D. Loyola, T. Stavrou,
P. Tzoumaka , A. Kelessis,
D. Karagkiozidis and D. Balis

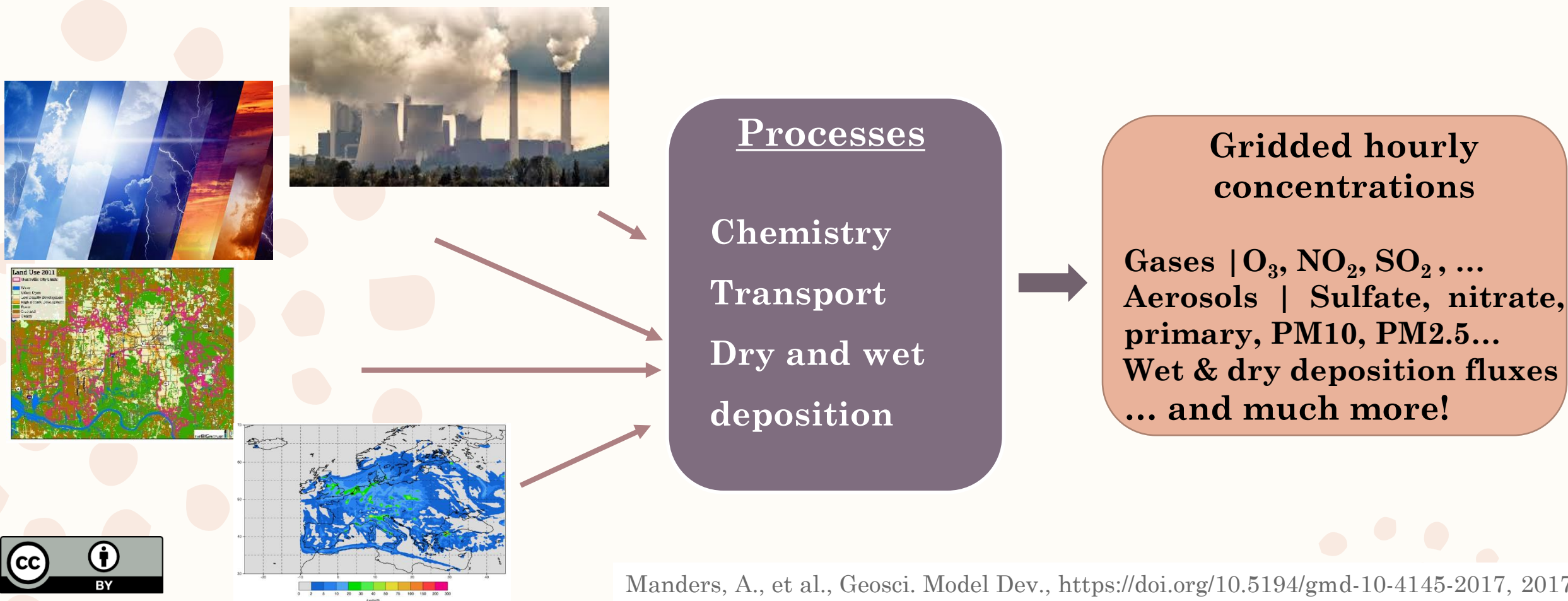


ROADMAP OF THE PRESENTATION

- LOTOS-EUROS simulations over Europe. The setup.
- Validation against in situ air quality measurements. The proof.
- Comparison of the simulations to S5P/TROPOMI NO₂ columns. The way towards EnKF inversions.
- S5P/TROPOMI SO₂ columns. The thorn in the system.

LOTOS EUROS CTM | <https://lotos-euros.tno.nl/>

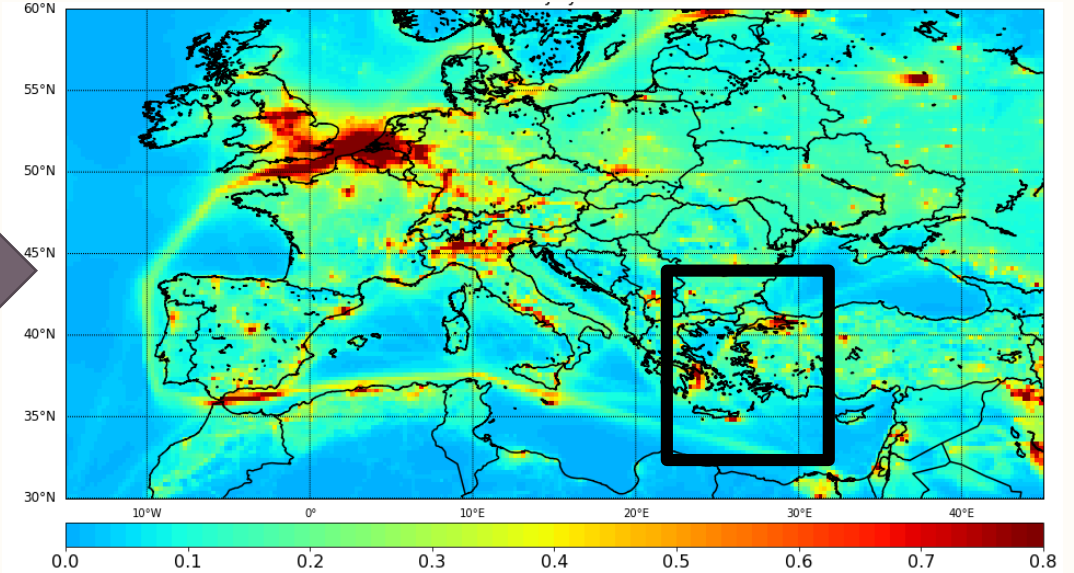
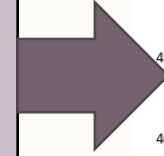
Open-source chemical transport model (CTM) used for a wide range of application
Simulates **air quality** and **deposition** on regional and sub-regional scales



LOTOS EUROS simulations in LAP/AUTH

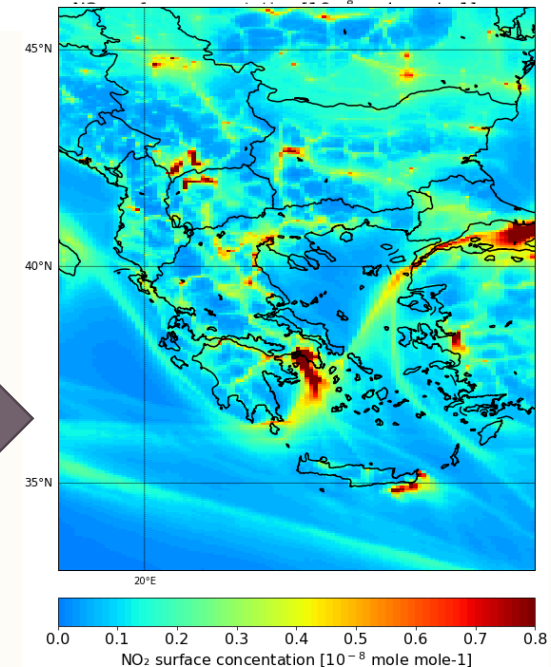
Coarse run

Horizontal resolution: $0.25^\circ \times 0.25^\circ$
Vertical resolution: 10 vertical levels
Meteorological data: ECMWF (7 x 7 km)
Anthropogenic Emissions: CAMS v2.2, year 2015 ($0.1^\circ \times 0.05^\circ$)
Fire emissions: GFAS
Boundary and initial conditions: CAMS near-real time



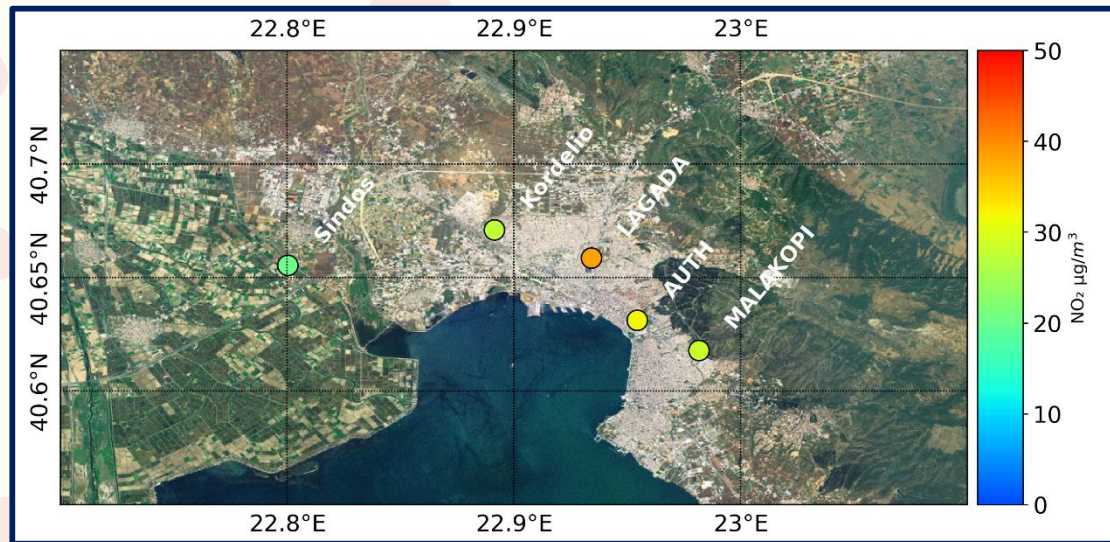
Nested run

Horizontal resolution: $0.10^\circ \times 0.05^\circ$
Boundary and initial conditions: Coarse run

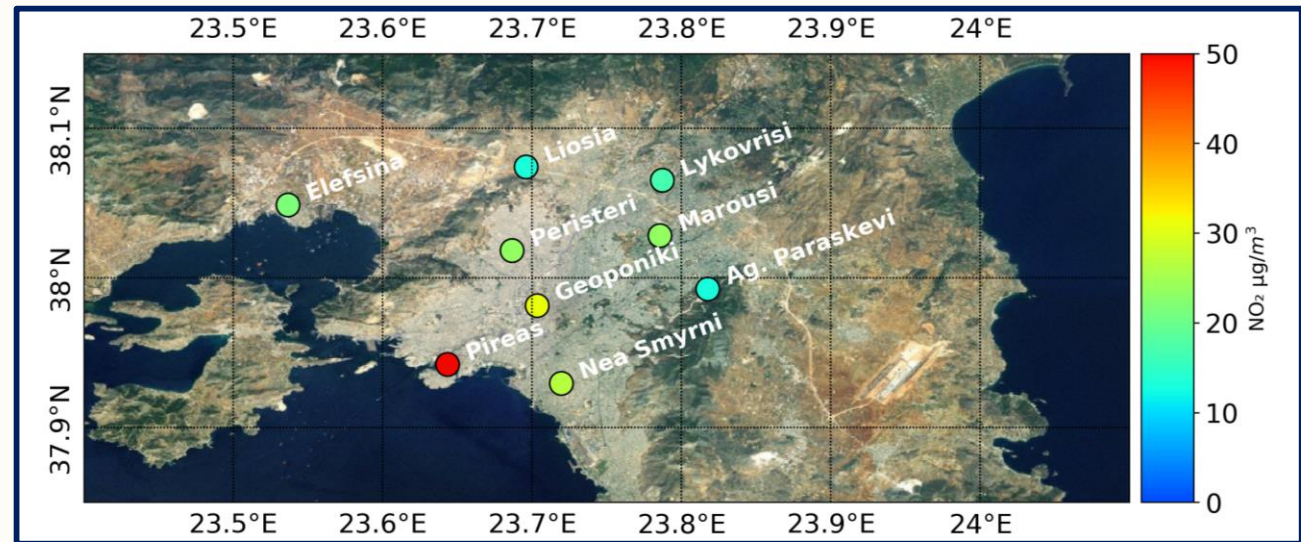


COMPARISON OF NO₂ SIMULATIONS WITH IN SITU MEASUREMENTS

- Hourly NO₂ measurements from the National Air Pollution Monitoring Network Available for the two largest and most populated cities of the country
- Selection of stations
 - Well distributed in the urban sprawl
 - Representative of specific location conditions

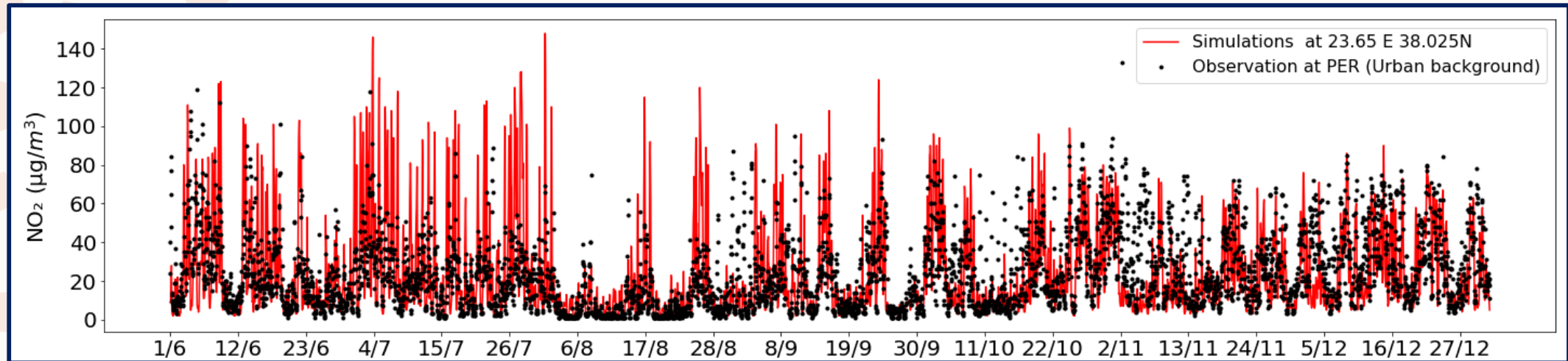
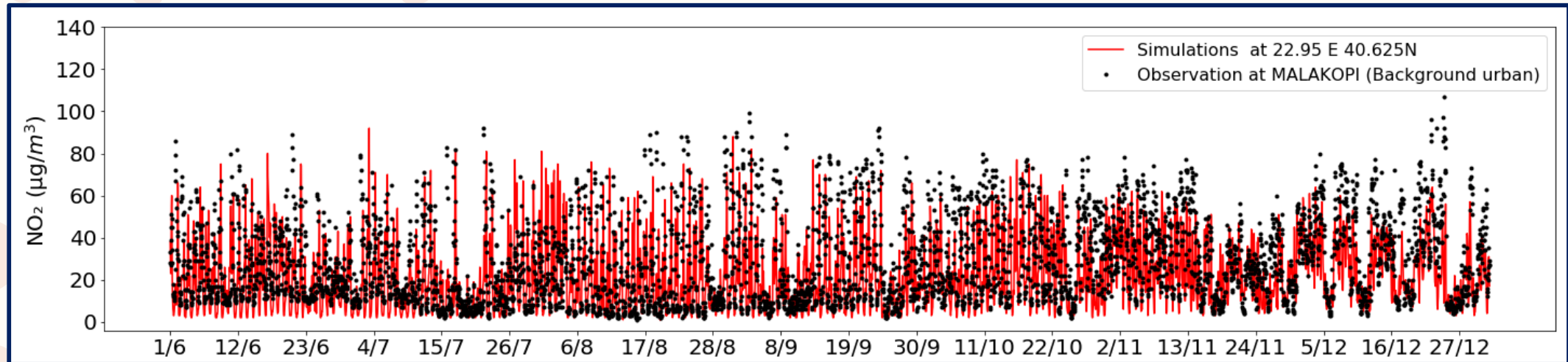


NO₂ Air Quality Stations over Thessaloniki
Colour bar: mean between June and December



NO₂ Air Quality Stations over Athens
Colour bar: mean between June and December

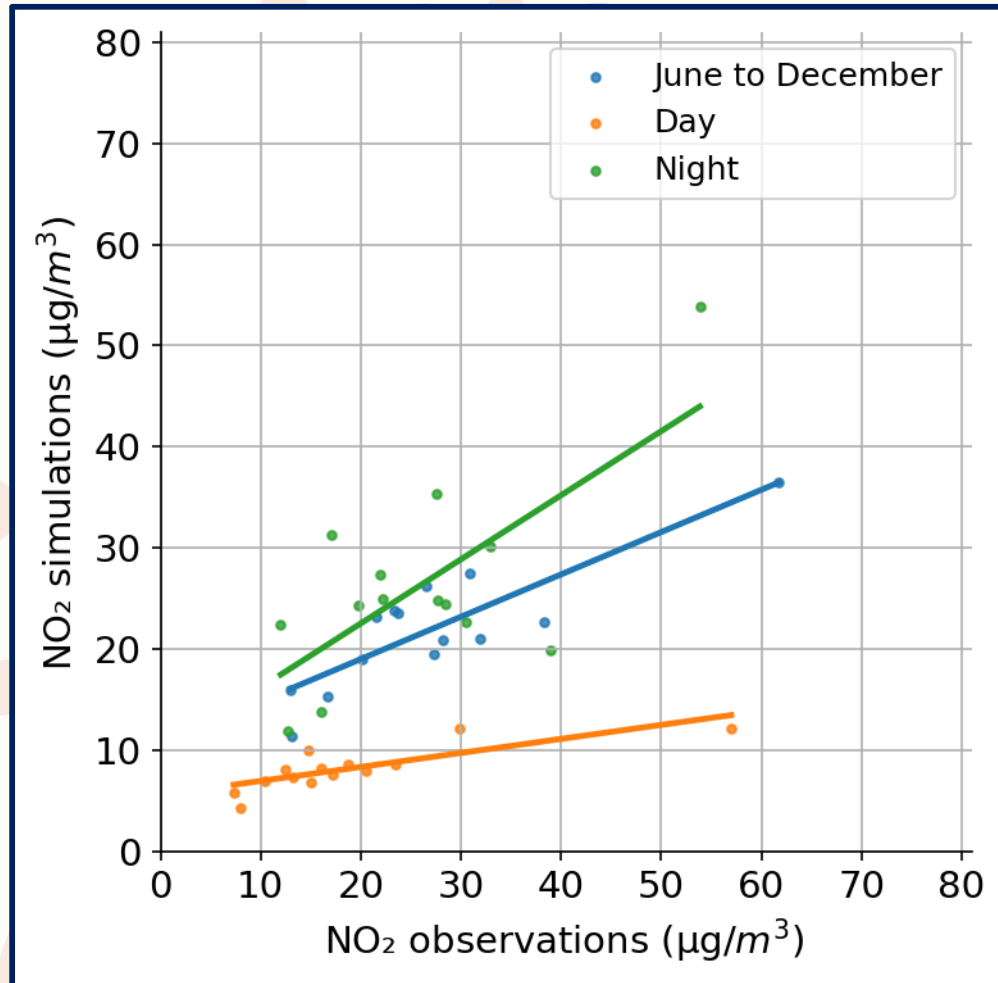
COMPARISON OF NO₂ SIMULATIONS WITH IN SITU MEASUREMENTS



Timeseries of surface NO₂ concentrations from the LOTOS EUROS [red] and in situ measurements [black] at a background station [upper] and an urban station [lower] in Athens between June and December 2018.

COMPARISON OF NO₂ SIMULATIONS WITH IN SITU MEASUREMENTS

14 AIR QUALITY STATIONS



June to December | $R = 0.76$

Model underestimates for most polluted stations

Daytime | 12:00-15:00 L.T. | $R = 0.73$

Model underestimates at all stations

Nighttime | 00:00-03:00 L.T. | $R = 0.67$

Model overestimation at less polluted stations

Scatter between surface mean NO₂ simulations and in situ measurements at 14 stations in Greece

TROPOMI

LOTOS-EUROS

DIFFERENCES

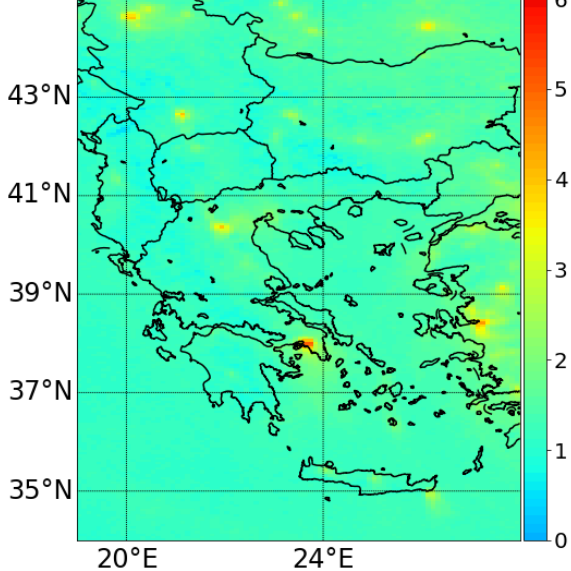
LOTOS-EUROS VS TROPOMI NO₂ TROPOSPHERIC COLUMNS.

JULY

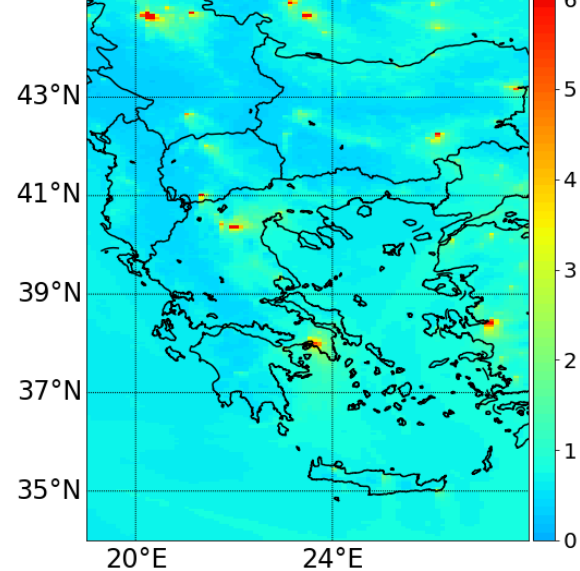
- S5P AK applied to CTM
- Spatial distribution agrees
- Higher background values of TROPOMI, mostly in summer
- LOTOS EUROS higher NO₂ in hotspots during December

DECEMBER

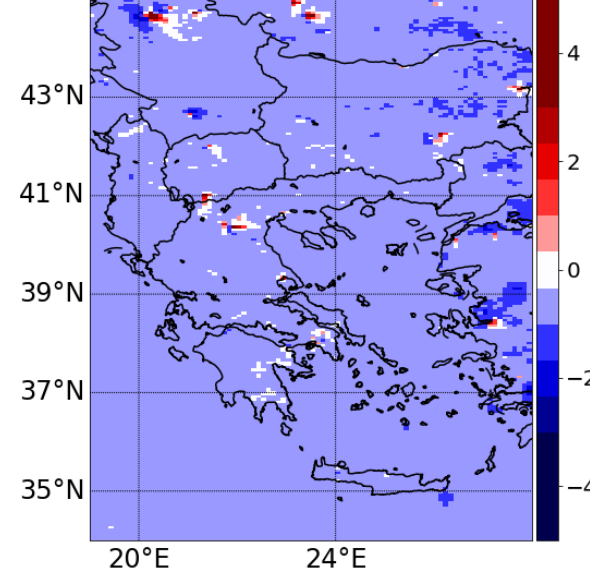
TROPOMI NO₂ (x 10¹⁵ molec/cm²)



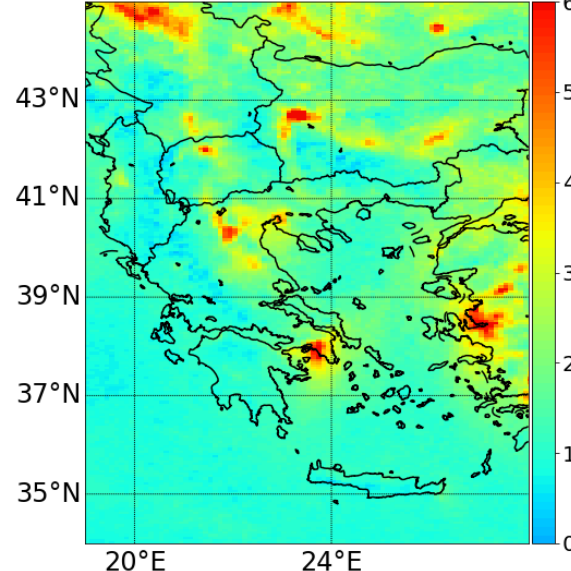
LOTOS EUROS NO₂ (x 10¹⁵ molec/cm²)



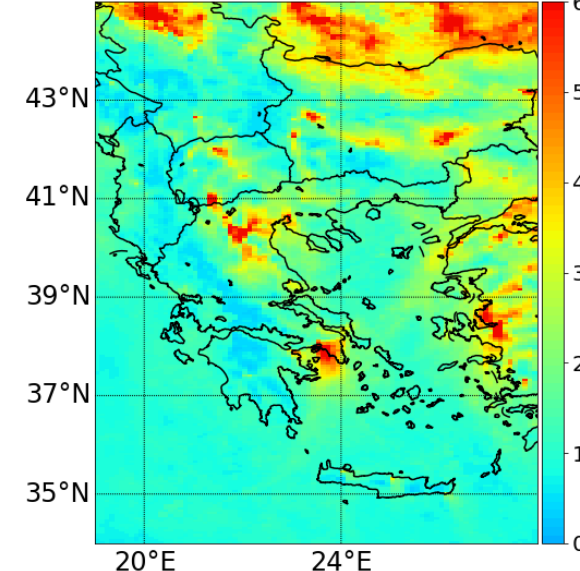
LOTOS EUROS - TROPOMI (x 10¹⁵ molec/cm²)



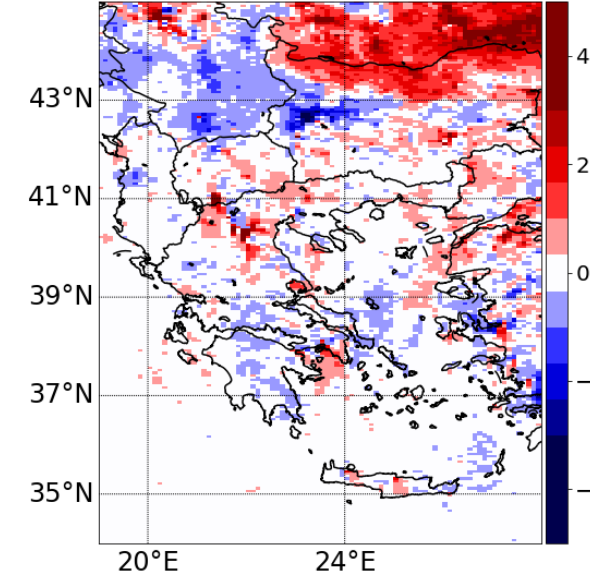
TROPOMI NO₂ (x 10¹⁵ molec/cm²)



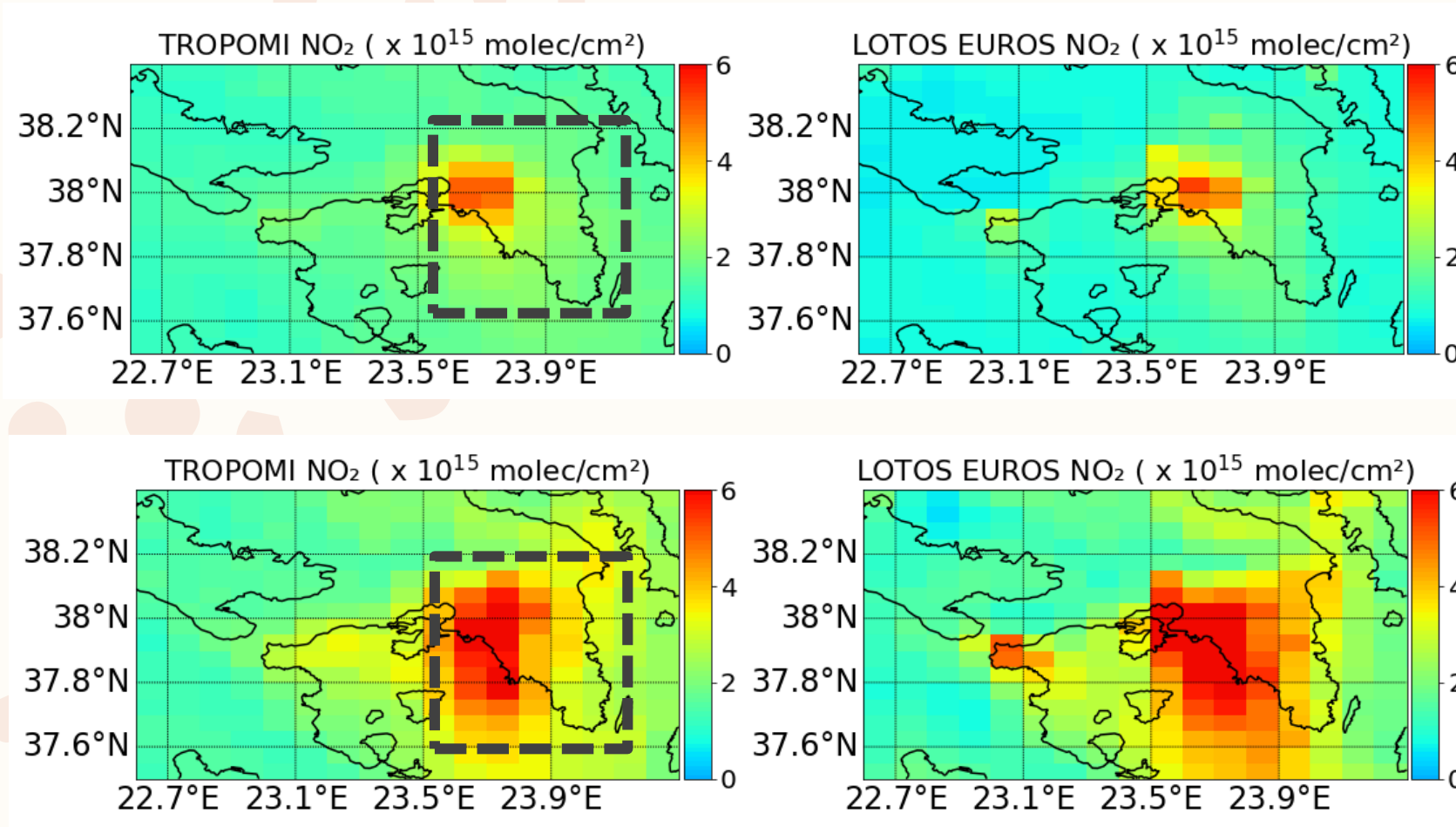
LOTOS EUROS NO₂ (x 10¹⁵ molec/cm²)



LOTOS EUROS - TROPOMI (x 10¹⁵ molec/cm²)



LOTOS-EUROS VS TROPOMI NO₂ TROPOSPHERIC COLUMNS | ATHENS

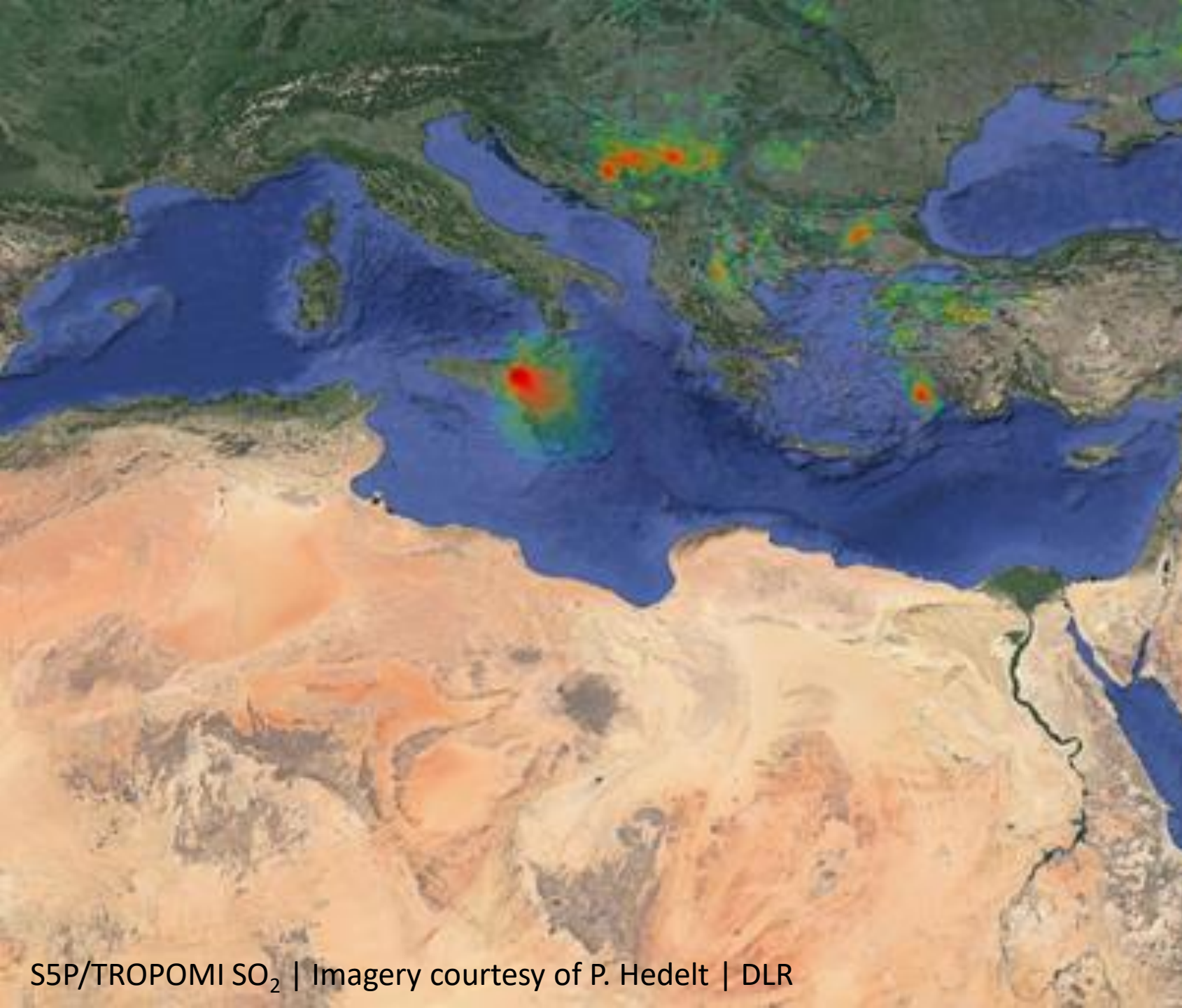


Metric	07.2018	12.2018
Correlation Coefficient R =	0.67	0.65
Slope	0.82	0.94
Bias [10^{15} molec/cm ²]	-0.52	0.74
Offset [10^{15} molec/cm ²]	-0.07	0.97

Mean NO₂ columns over the Athens (black dotted polygon) in July (top) and December (bottom) derived from TROPOMI (left) and LOTOS EUROS (right)

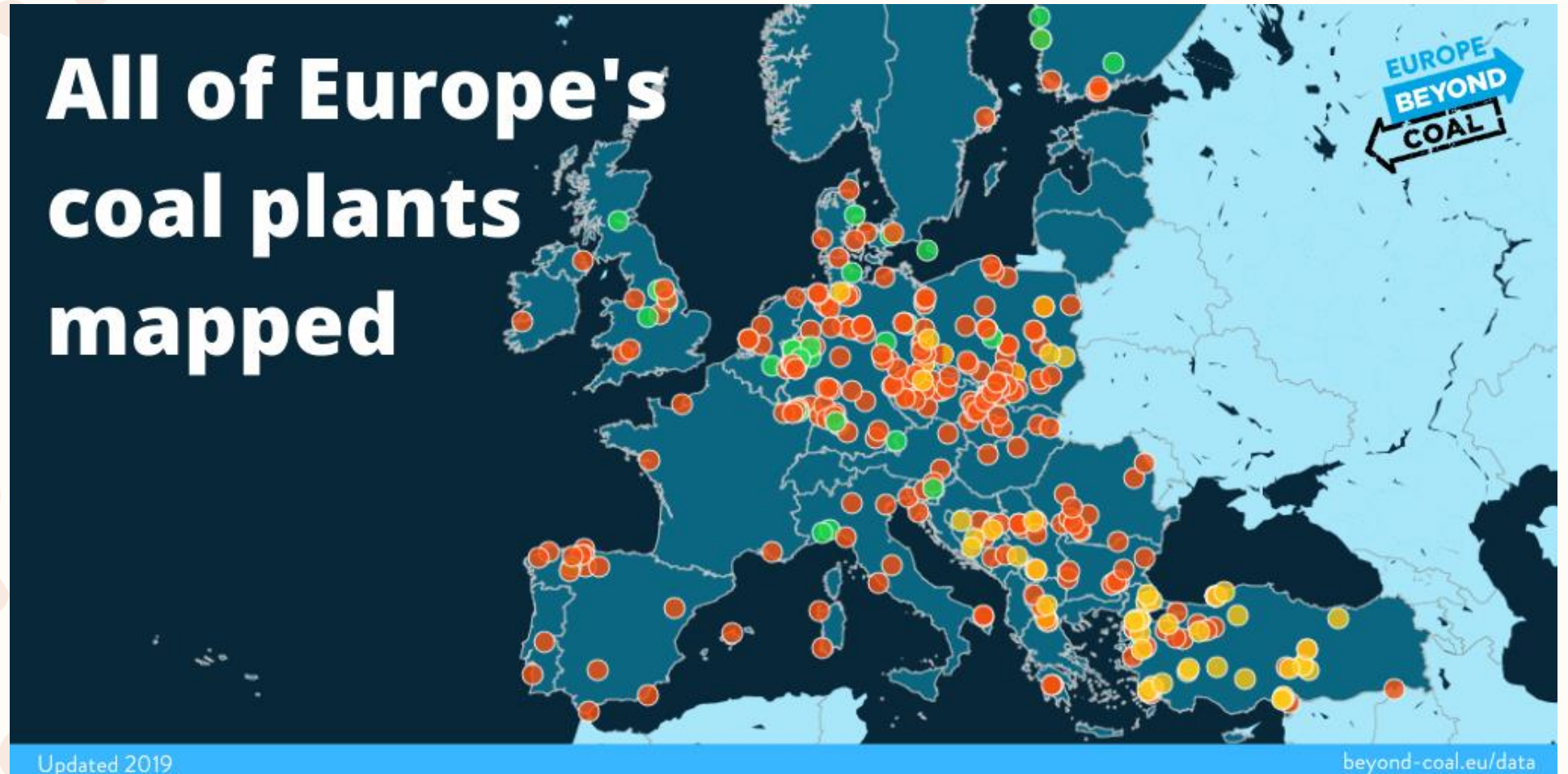
S5P/TROPOMI SO₂ columns.

- Numerous anthropogenic sources of SO₂ exist in the area. Plus Mt Etna, Sicily.

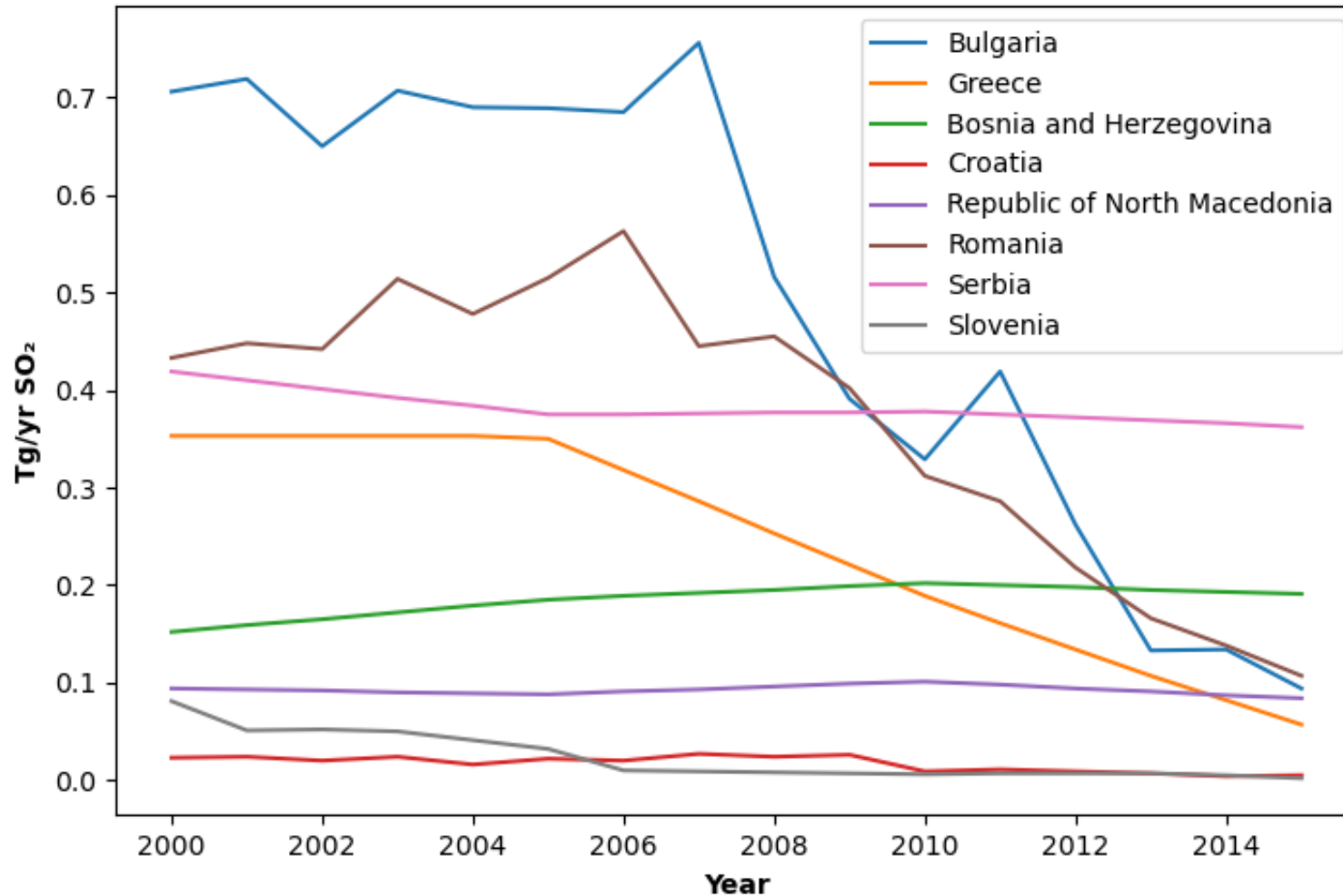


Coal burning is still a major source of power

In Eastern Europe especially



Power sector emissions over Eastern Europe



- Power Sector Emissions
- SO₂ (Tg/yr) for 2000-2015.
- CAMS-REG-AP-0.05°-TNO Europe-v2.2-SO₂
- Highest rates in decline in Bulgaria, Greece and Romania

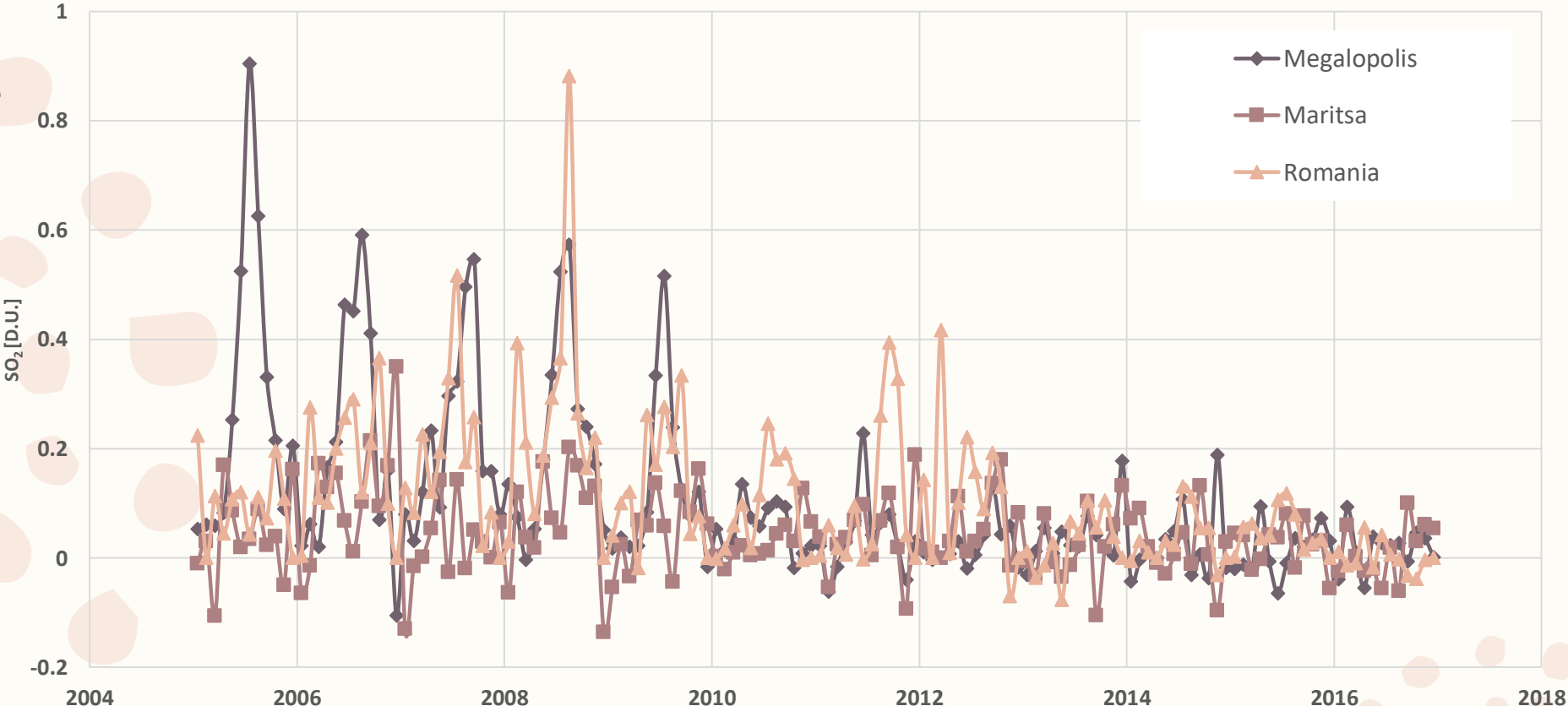
Data from <https://eccad.aeris-data.fr/>
Analysis by V. Aggelou, LAP/AUTH

Three major power plants in Eastern Europe

Monthly mean time series 2004-2017

<https://giovanni.gsfc.nasa.gov/giovanni/>

OMI/AURA PBL SO₂ COLUMN



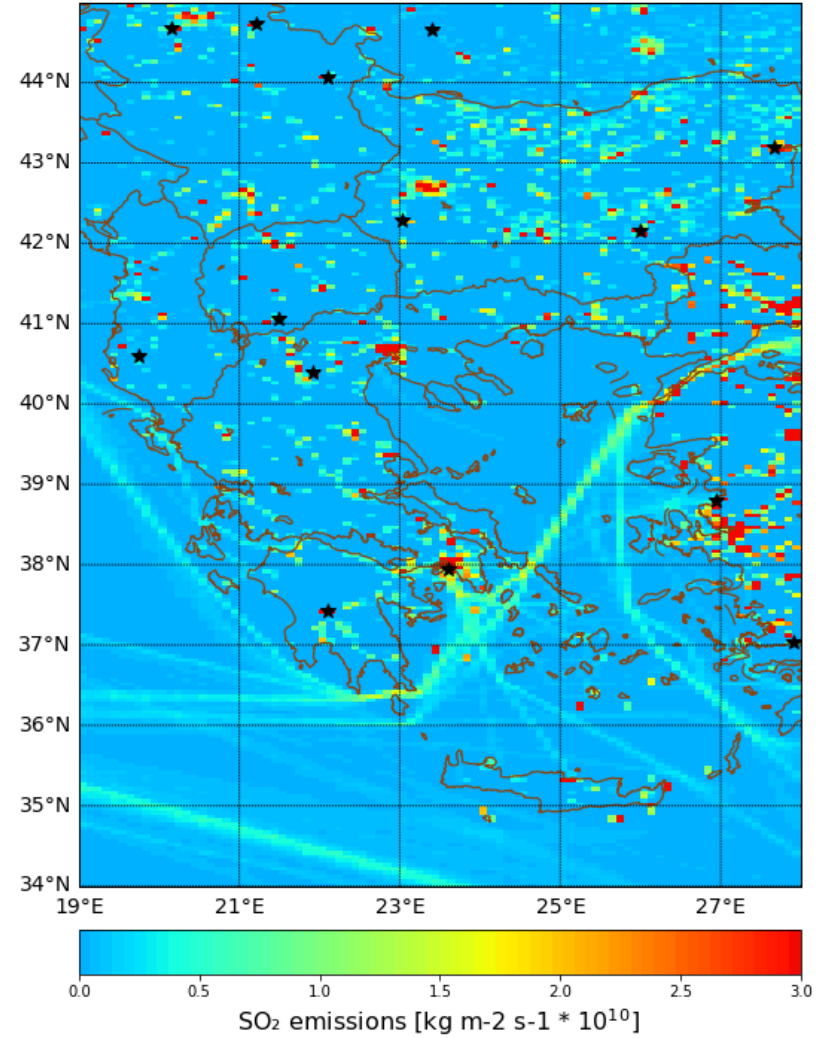
Megalopolis, Greece
Maritsa, Bulgaria
Turceni, Romania.



The current emission inventory

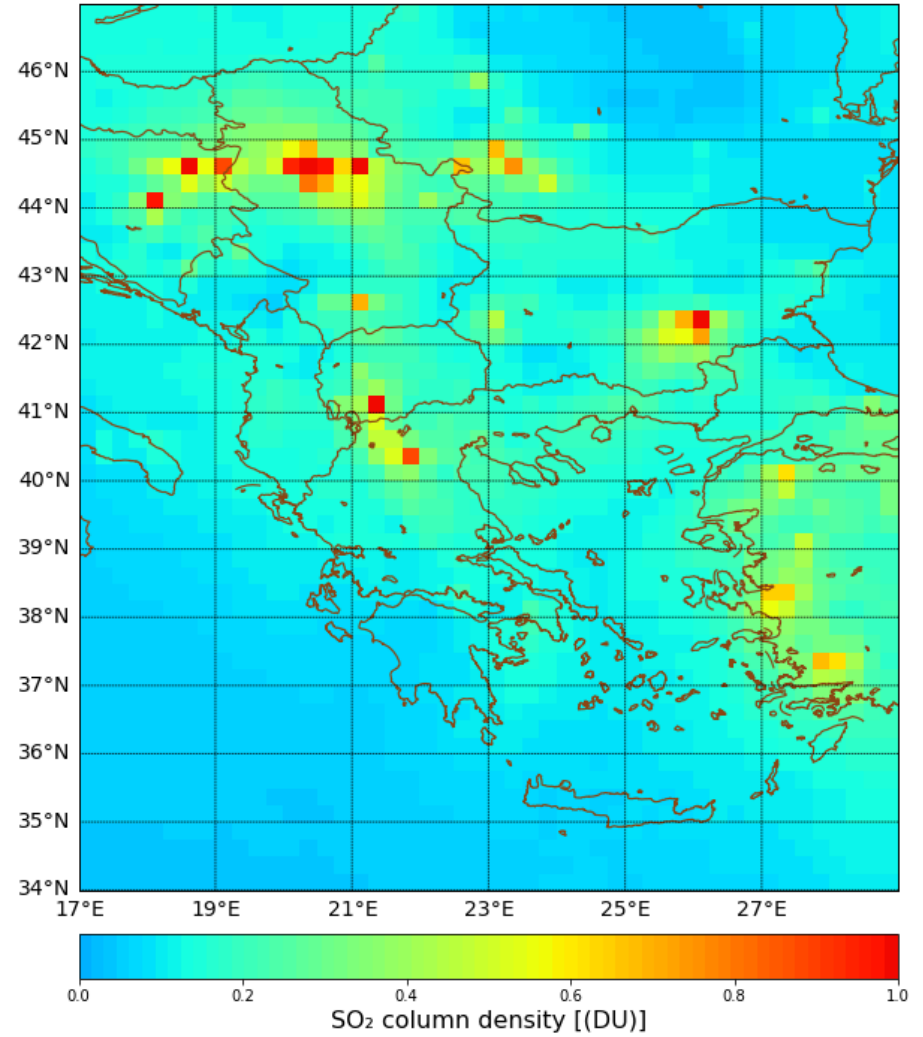
CAMS-REG v2 2015

SO₂ emissions in summer 2018



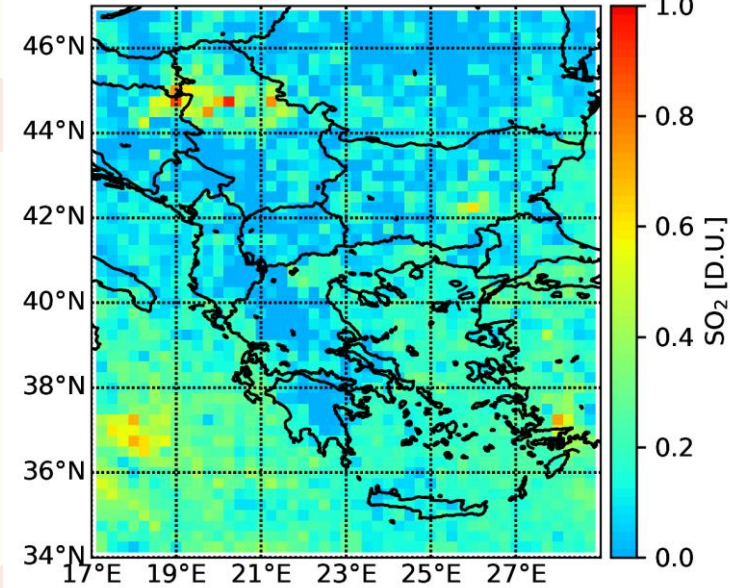
Summer time columns from LOTOS-EUROS

SO₂ column (summer)

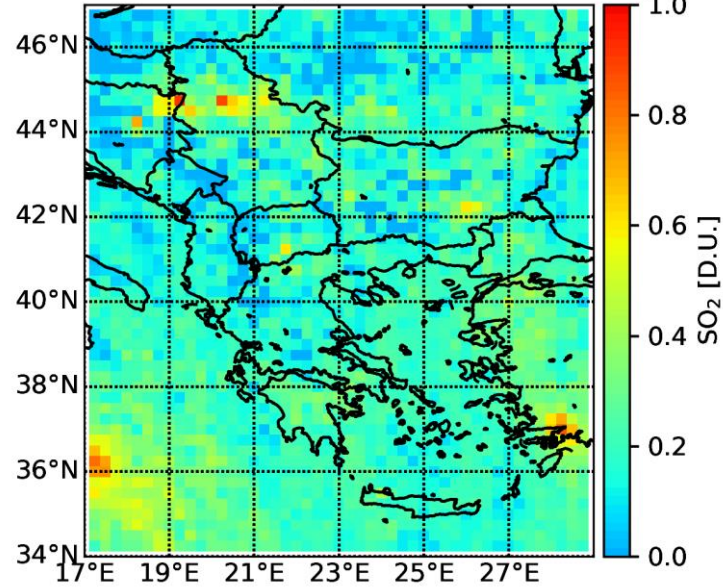


S5P/TROPOMI SO₂ Polluted Columns | From monthly to seasonal

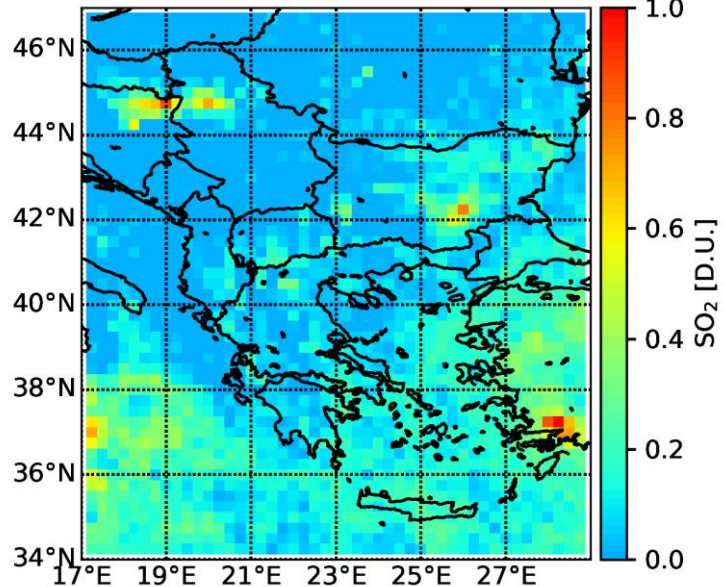
S5P/TROPOMI SO₂ Polluted VCD
June 2018



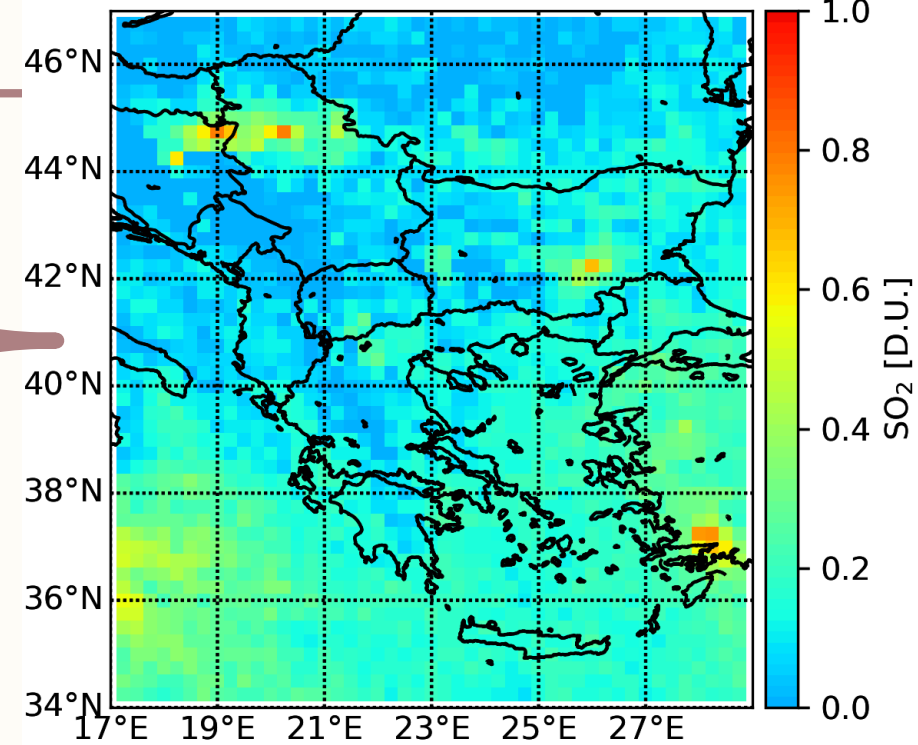
S5P/TROPOMI SO₂ Polluted VCD
July 2018



S5P/TROPOMI SO₂ Polluted VCD
August 2018

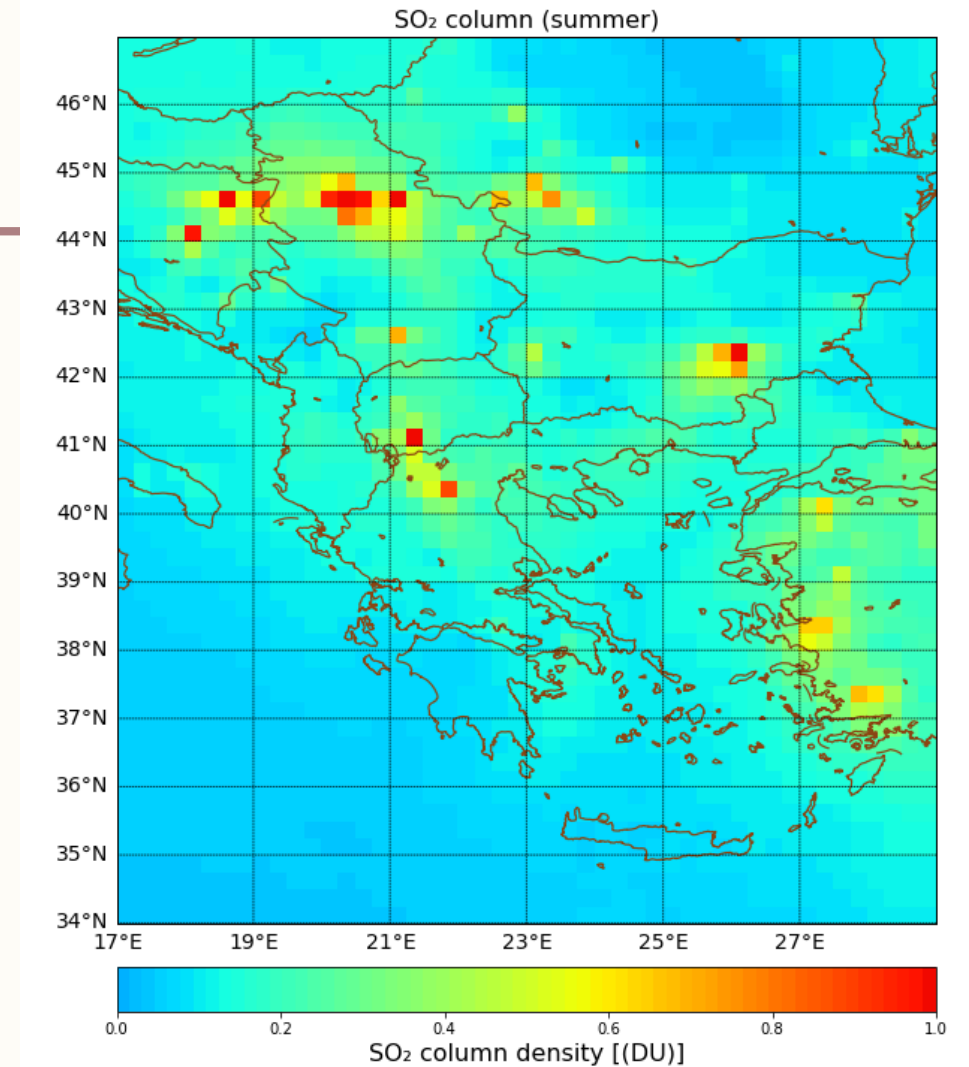
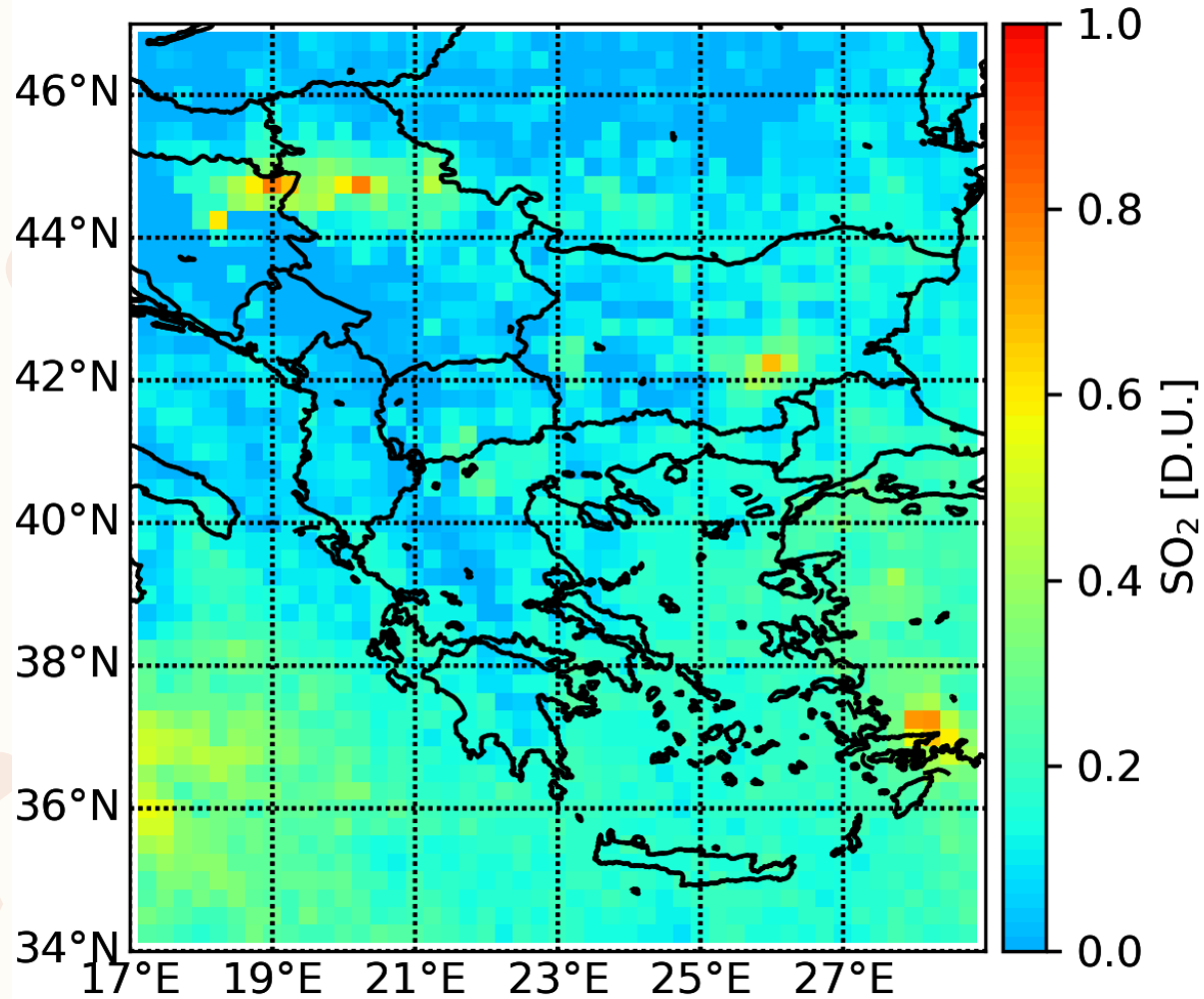


S5P/TROPOMI SO₂ Polluted VCD
Summer 2018



TROPOMI vs LOTOS-EUROS | Summer

S5P/TROPOMI SO₂ Polluted VCD
Summer 2018



Higher CTM columns result based on the 2015 emission inventory than sensed by TROPOMI on 2018 on point locations.



Acknowledgements

- This research was funded by the project "PANhellenic infrastructure for Atmospheric Composition and climatE change" (MIS 5021516) which is implemented under the Action "Reinforcement of the Research and Innovation Infrastructure", funded by the Operational Programme "Competitiveness, Entrepreneurship and Innovation" (NSRF 2014-2020) and co-financed by Greece and the European Union (European Regional Development Fund).
- We wholeheartedly acknowledge the support provided by the IT Center of the Aristotle University of Thessaloniki (AUPh) throughout the progress of this research work.
- We wholeheartedly acknowledge the support provided by the [Atmospheric Toolbox](#).