INTRODUCTION OF A GIS TOOL TO SUPPORT AIR QUALITY PLANNING

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ON-LINE

CONTENT OF THE TOOL

Map – OpenStreetMap

Roads – from Hungarian Public Roads

They are responsible for the operation and maintenance of nearly 32,000 km of national roads.9

Road and traffic data

Strategic Noise Maps

Gov. Decree 280/2004.(X.20.) on handling an assessment of environmental noise

Gov. Decree 25/2004.(XII.20) on the detailed rules of preparation of strategic noise maps and action plans

Air quality – national monitoring system

measurements

HOW ARE EMISSIONS CALCULATED?

$$Emission = Activity \times Emission\ Factor$$

Activity that is causing the emission

example: driving a car => fuel consumption (liter diesel / year)

distance driven (km / year)

heating your house => burning wood in a stove (kg/year)

producing heat (J/year)

Emission factor: Emission per unit of activity

example: driving a car

kg NO_x / l diesel or kg NO_x / km driven with car

heating your house

kg $PM_{2.5}$ / kg wood burned or kg $PM_{2.5}$ / J heating

HOW ARE EMISSIONS CALCULATED?

The Hungarian emission inventory typically contains the national Hungarian emissions for 1 year but emissions vary in space and time.

space: emissions vary from place to place

- cars drive on roads
- heating is in houses

time: emissions change with time

- there is more traffic during the peak hours than at night
- heating is mainly in winter time

MEASURES: HOW CAN YOU CHANGE EMISSIONS?

$$Emission = Activity \times Emission\ Factor$$

change in the activity: change number of cars and/ or drive less km/ car
=> make it more expensive to drive
=> do not allow (certain) cars : LEZ
=> offer alternatives (=modal shift)
change location/time of emission

change in the emission factor:
not all vehicles types have the same emission factor
=> do not allow (certain) cars : LEZ
=> incentives to replace vehicles
change speed of vehicles

THE TOOL - ATMO-PLAN

ATMO-PLAN is a web application (online tool) to calculate the effect of air quality measures

Air quality measures considered are only changes in emissions, **not** the effect of changes in exposure such as vegetation.

Online tool means you do not need to download any software, the access is from your web browser.

It is an interface that makes it easy to run air quality simulations so that with limited knowledge anyone can calculate the effect of an air quality measure. To simplify the calculation procedure also means that the developers have simplified the interaction so not everything is possible.

What is possible to be calculated with ATMO-PLAN?

Traffic measures with changes in
- network (remove / add roads)
- traffic volume (vehicle counts)
- vehicle fleet / types
- vehicle speed

Contributions from residential heating emissions according to fuel, building, heating appliance type + change these emission by scaling them (from 2022)

The traffic measures and residential emissions can be defined and changes within 1 or more zones

What is NOT to be calculated with ATMO-PLAN?

Calculation is for a year and a yearly average result is produced. You can not calculate for shorter periods such as a smog episode.

The time factors used to distribute the emissions over the hours of the year are fixed and can not vary over the model domain.

The measures are changing emissions, the tool can not be used for assessing the effect of vegetation on air quality.

Calculation in ATMO-plan is always for a whole year

Due to limitations in computer calculation capacity the problems that can be solved are limited in size

Size of problem to solve depends on:

1) size of calculation domain (A)
2) density of calculation mesh used (N = number points per unit A)
   (consider calculating Hungary with a single point)
3) number of emission sources considered (E)

$$calculation\ time \sim A * N * E$$

EXAMPLES FOR TRAFFIC SCENARIOS

TRAFFIC EMISSION CALCULATION EXAMPLES

- CHANGING THE SPEED OF TRAFFIC
- CHANGING WHERE TRAFFIC CAN DRIVE: CLOSURE OF A BRIDGE IN BUDAPEST

TRAFFIC EMISSIONS

$$Emission(pol, h, d, m) = TF(h, d, m) \times \sum_{vt,sp} EF(vt, sp, pol) \times kms\ (vt,sp)$$

TF: time factor dependent on hour (h), day of week (d) and month (m)

EF: emission factor dependent on vehicle type (vt), speed (sp) and pollutant (pol)

kms: distance travelled every year by vehicles of type (vt) at speed (sp)

TRAFFIC EMISSIONS: THE TYPE OF VEHICLES THAT CAN DRIVE

VEHICLE TYPES THAT CAN DRIVE

$$Emission(pol, h, d, m) = TF(h, d, m) \times \sum_{vt,sp} EF(vt, sp, pol) \times kms\,(vt,sp)$$

TRAFFIC EMISSIONS: THE SPEED OF VEHICLES

$$Emission(pol, h, d, m) = TF(h, d, m) \times \sum_{vt,sp} EF(vt, sp, pol) \times kms\ (vt,sp)$$

SPEED THAT VEHICLES CAN DRIVE

TRAFFIC EMISSIONS: WHEN VEHICLES CAN DRIVE

WHEN VEHICLE CAN DRIVE

$$Emission(pol, h, d, m) = TF(h, d, m) \times \sum_{vt,sp} EF(vt, sp, pol) \times kms\ (vt,sp)$$

TRAFFIC EMISSIONS: WHERE VEHICLES CAN DRIVE

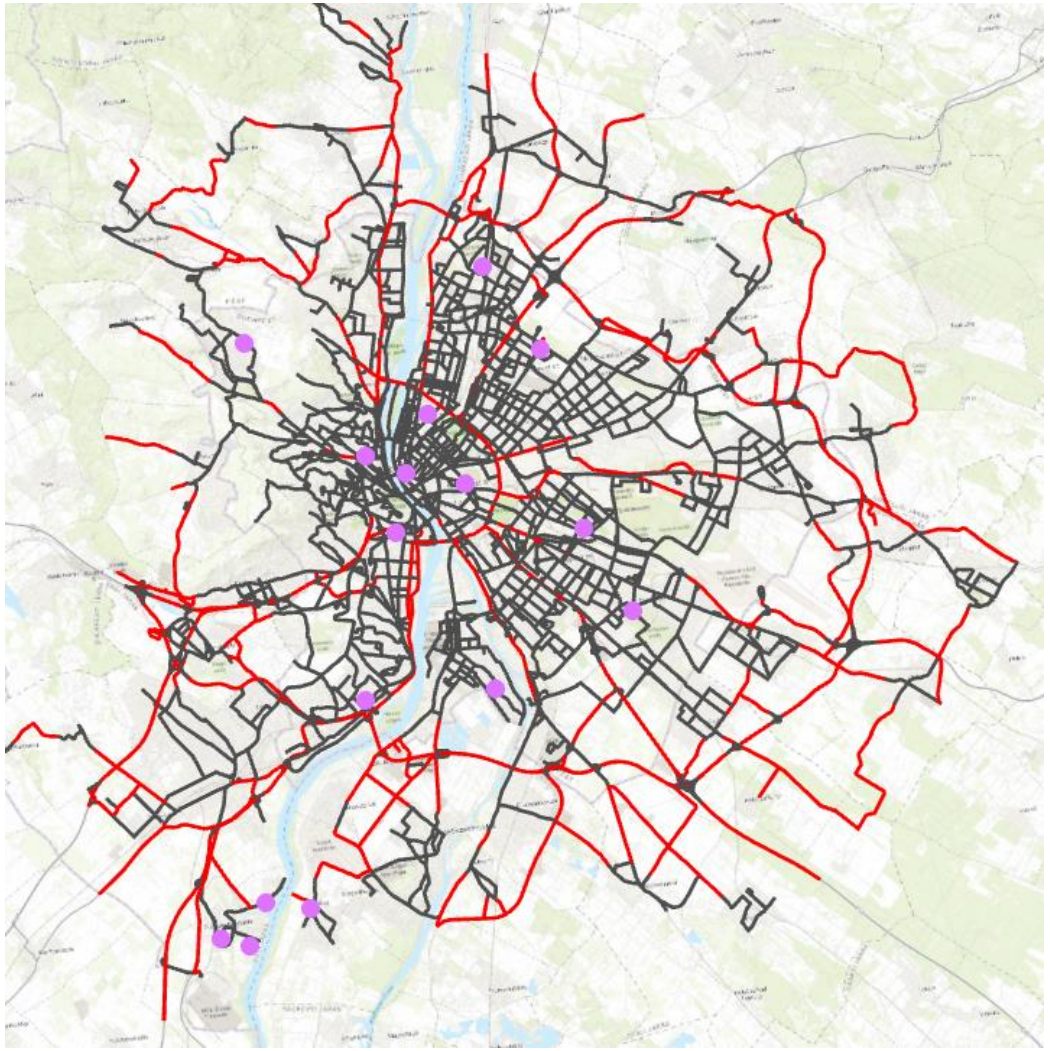
$$Emission(pol, h, d, m) = TF(h, d, m) \times \sum_{vt,sp} EF(vt, sp, pol) \times kms\ (vt,sp)$$

The formula does not say anything about **where** the emissions are taking place.

Emissions need to be assigned to the roads on which the traffic is driving.

Changes in the road network which can be both new roads being added or roads being removed or made less attractive for cars (toll road, lower speed) will affect where the traffic volume is located.

SCENARIO 1 - REDUCE SPEED LIMIT TO 50 KM/H



Roads with speed limit above 50 km/h are shown in red.

Scenario:

Set the speed limit to 50 km/h everywhere

SCENARIO 1 - REDUCE SPEED LIMIT TO 50 KM/H

Calculation procedure?

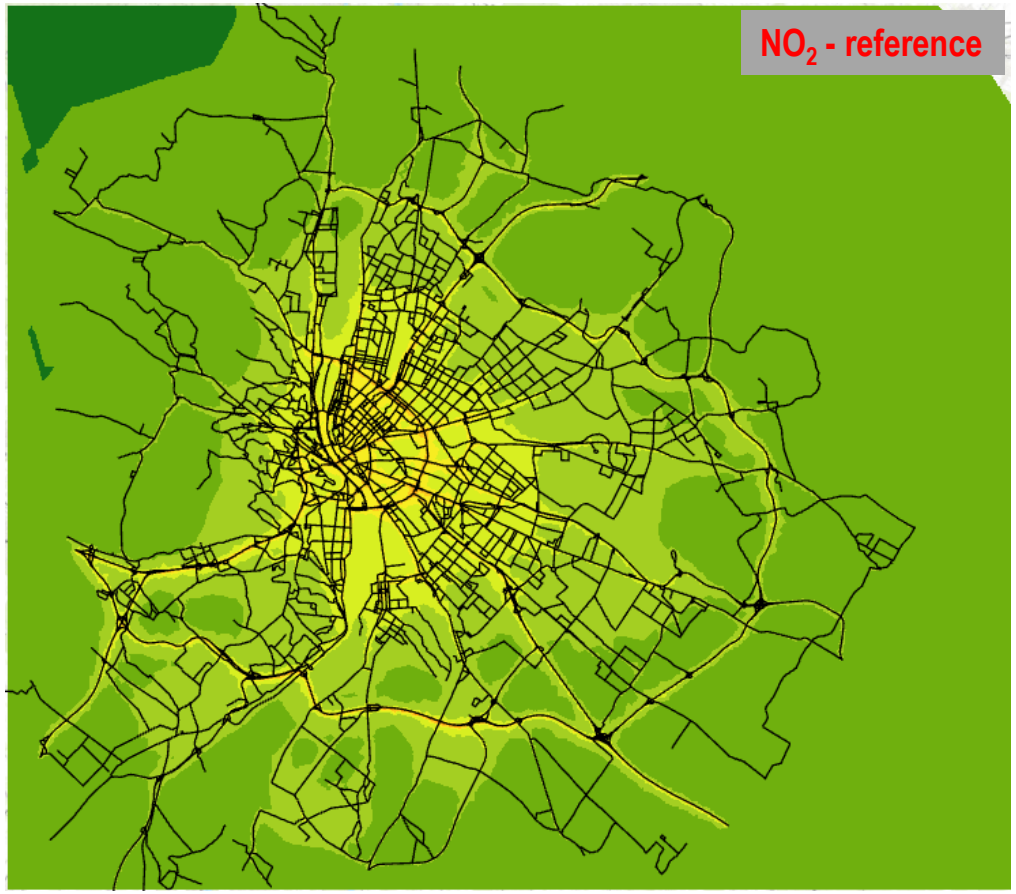
Change the speed limit on all roads to 50 km/h and recalculate the emissions.

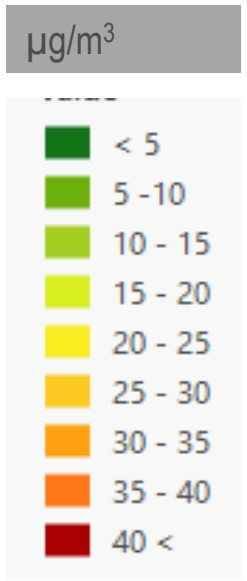
$$Emission(pol, h, d, m) = TF(h, d, m) \times \sum_{vt,sp} EF(vt, sp, pol) \times kms\ (vt,sp)$$

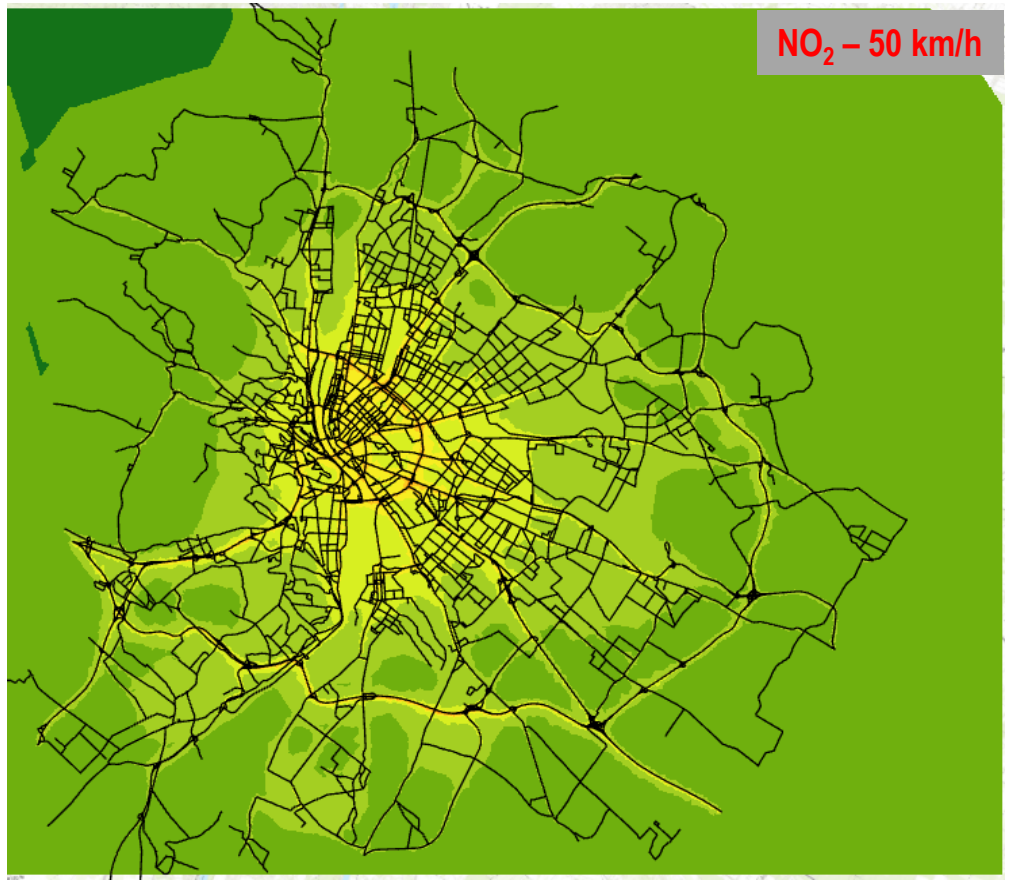
Reduce speed =>

- emission factor (EF) changes
- distance travelled (kms) above 50 km/h becomes 0 and distance travelled at 50 km/h increases

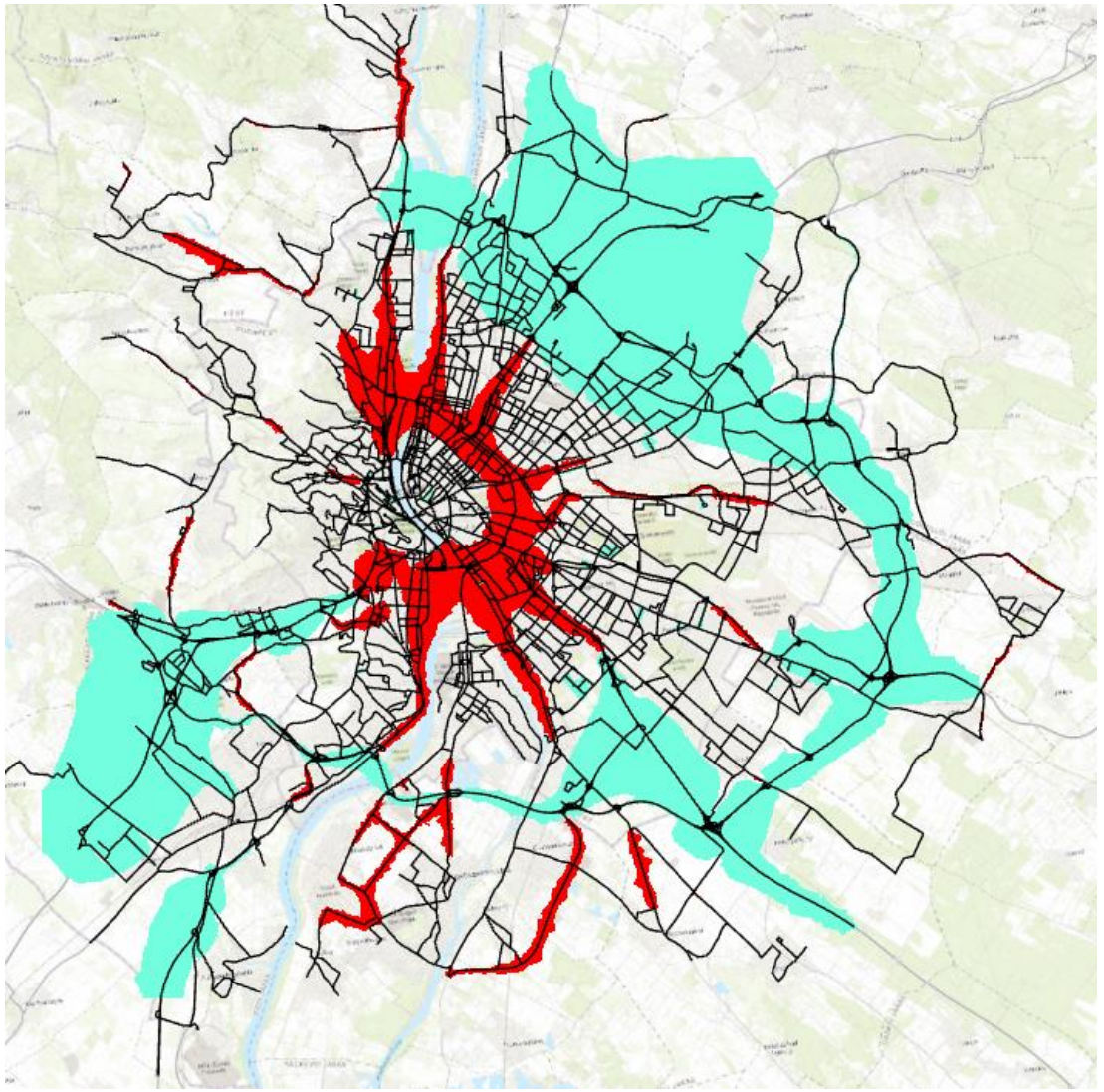
SCENARIO 1 - REDUCE SPEED LIMIT TO 50 KM/H



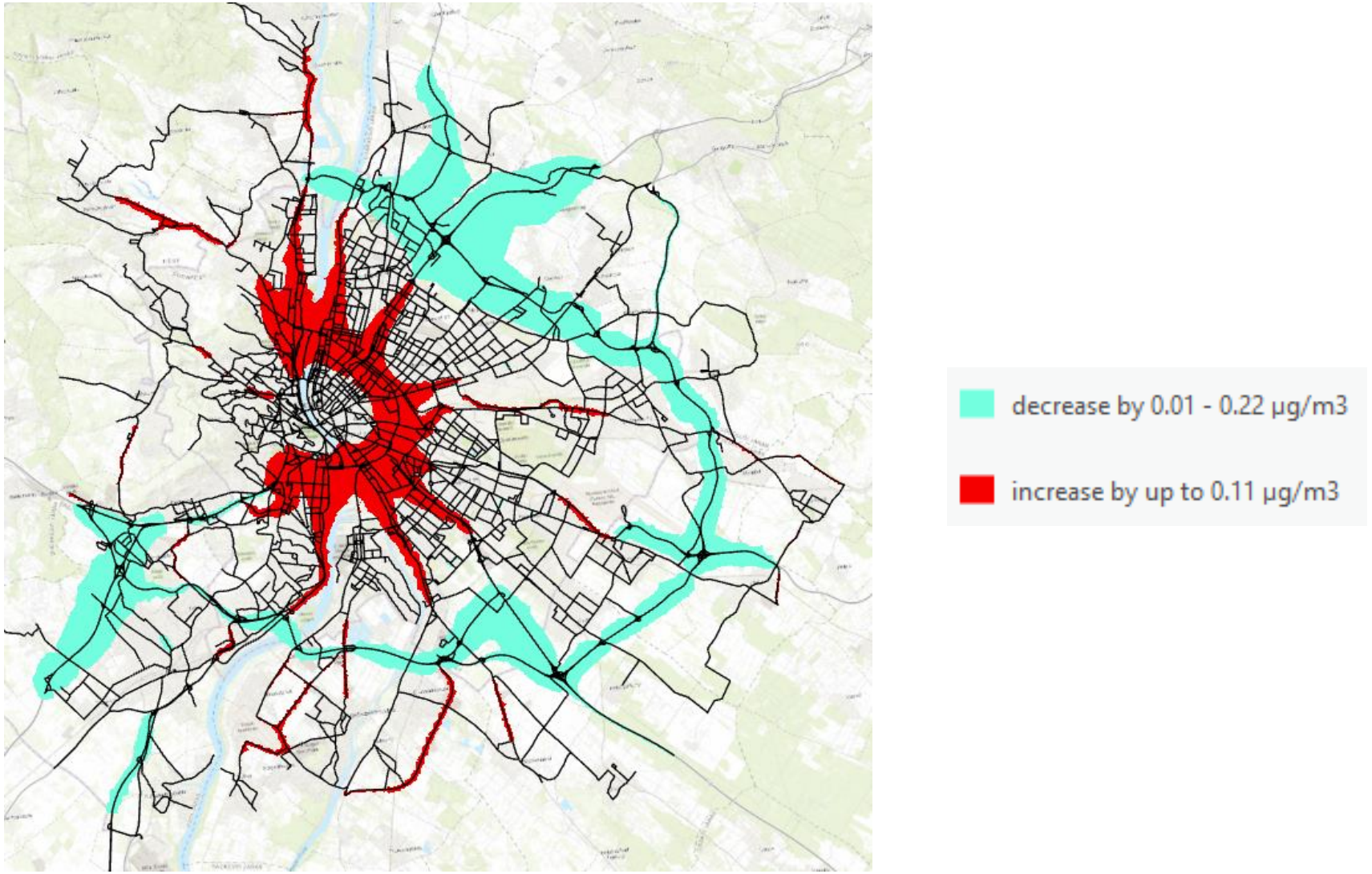




REDUCE SPEED LIMIT TO 50 KM/H: DIFFERENCE IN NO_2 CONCENTRATION



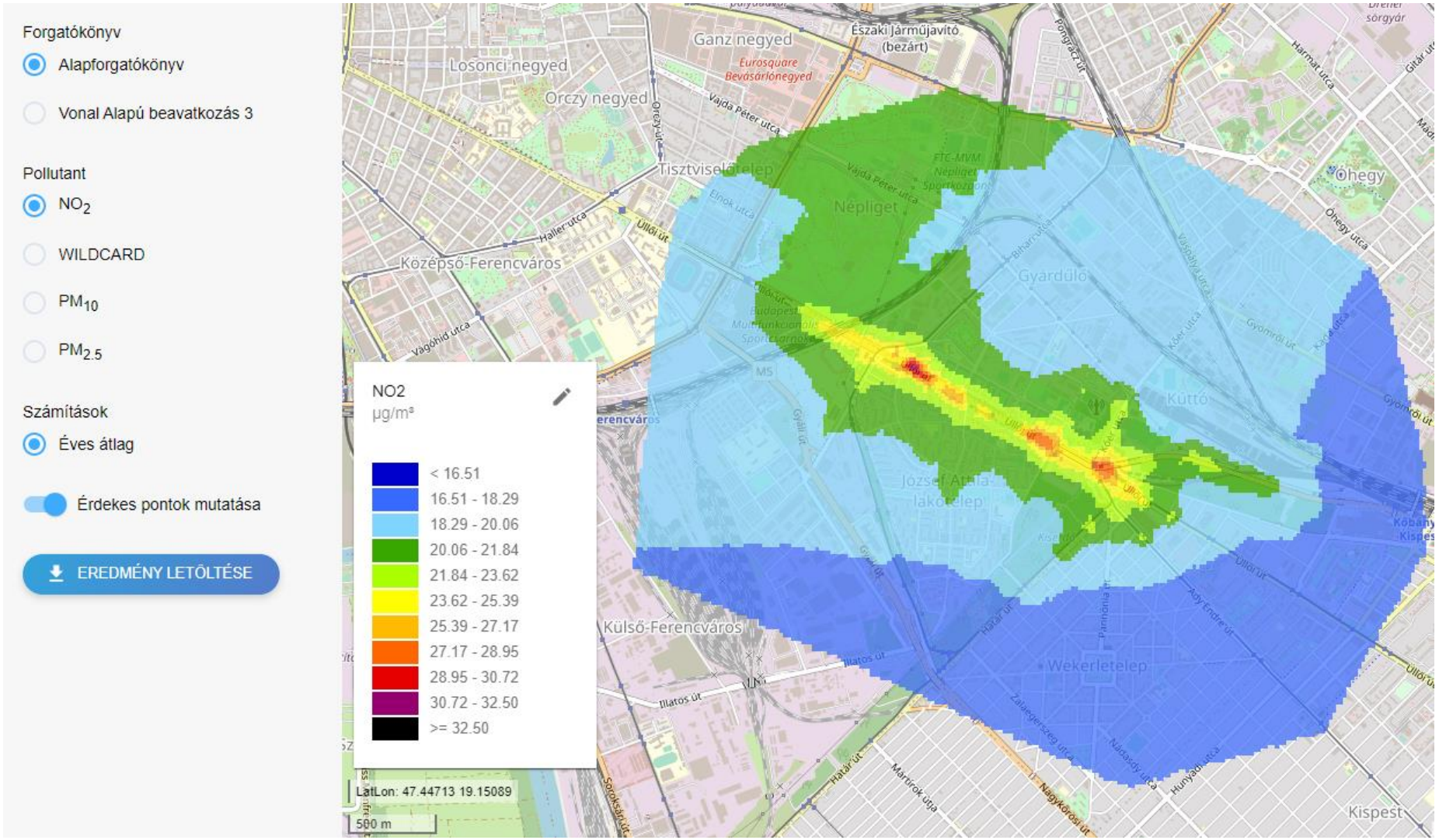
REDUCE SPEED LIMIT TO 50 KM/H: DIFFERENCE IN $PM_{2.5}$



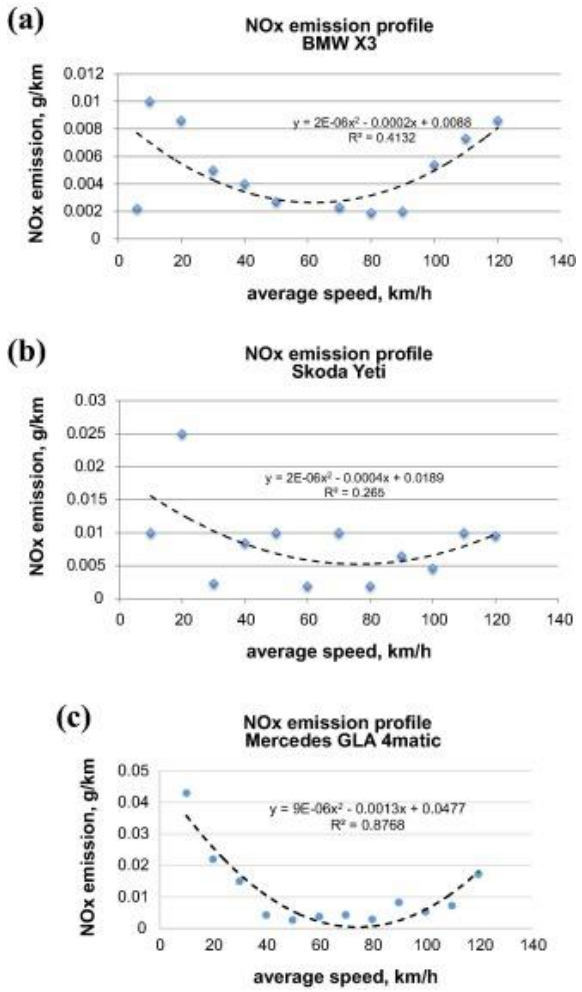
USER TEST - BUDAPEST

Speed limit change from 60 km/h to 50 km/h along a road section

Result: increase in NO_2, (NOx) emission



REDUCE SPEED LIMIT TO 50 KM/H



Why this result?

Lowering speed from 60 to 50 km/h some cars will produce higher NOx emissions!

Altering the speed from 60 to 50km/h is not good for emissions/air quality but it of course is a benefit for reducing road accidents or noise.

Olga V.Lozhkina and Vladimir N.Lozhkin
Estimation of nitrogen oxides emissions from petrol and diesel passenger cars by means of on-board monitoring: Effect of vehicle speed, vehicle technology, engine type on emission rates
Transportation Research Part D: Transport and Environment
Volume 47, August 2016, Pages 251-264

REDUCE SPEED LIMIT TO 50 KM/H

The yearly average emission is obtained using the COPERT methodology for a transport fleet that should be representative of Budapest in this specific case and taking into account the vehicle speed that is supplied as representative for the road for which we calculate the emissions. The methodology as described is the standard way of using emissions in an air quality model.

The emission factors vs speed in COPERT is not an emission factor for a constant speed but is the average emission factor for those instances when the car is driving at that speed. This is an average over typical positive and negative accelerations at that speed. The typical dynamics at a certain speed are therefore included in the COPERT emission factors.

The emission factors are derived from PEMS measurements. These measurements are categorized by speed intervals. For each interval an average is calculated and a speed dependent curve is fitted to these averages. These curves have a broad minimum around 70 km/h. Speed reduction to 50 or 30 km/h **increase** the emissions slightly.

SCENARIO 2 - CHANGING TRAFFIC: CLOSING THE LÁNCHÍD BRIDGE

The Lánchíd bridge will be closed.

This has an effect on **where** cars will drive.

Not only no longer traffic on the bridge (= 0 traffic volume on bridge)

but

also traffic will be lower near the bridge and higher in other places compared to the current situation.

SCENARIO 2 - CHANGING TRAFFIC: CLOSING THE LÁNCHÍD BRIDGE

Calculation procedure

- Too simple solution: select road segments of the bridge and set traffic counts to zero, with no traffic => no emissions

  This neglects the changes to the rest of the traffic!

- Correct solution: use a traffic model and calculate how closing the bridge changes the traffic on the network and recalculate the emissions based on the new counts.
  This requires traffic model calculation before you can calculate the air quality. The Budapest Public Transport Company provided the traffic model result for both the reference and the situation where Lánchíd is closed.

SCENARIO 2 - CHANGING TRAFFIC: CLOSING THE LÁNCHÍD BRIDGE

Calculation procedure

The new traffic model results will result in different traffic volumes.

$$-Emission(pol,h,d,m) = TF(h,d,m) \times \sum_{vt,sp} EF(vt,sp,pol) \times \textit{kms (vt,sp)}$$

Different traffic volumes => kms change

SCENARIO 2 - CHANGING TRAFFIC: CLOSING THE LÁNCHÍD BRIDGE

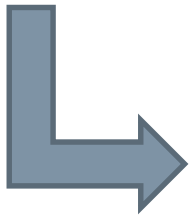
Setting bridge traffic volume to zero is too simple:

traffic will not disappear but use other roads!

Is this solution useless?

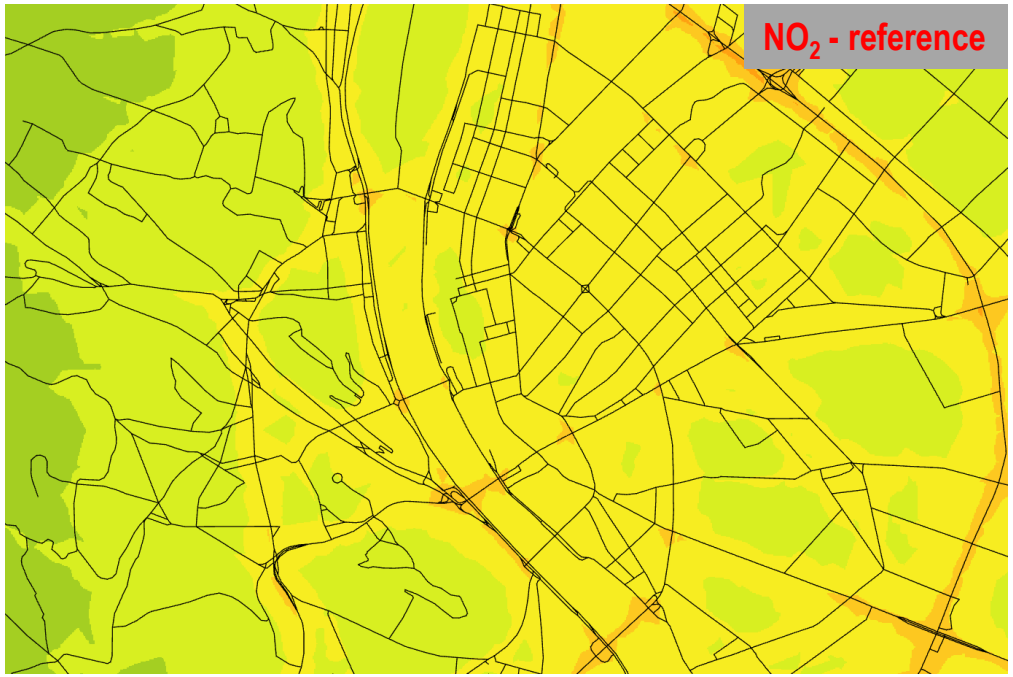
no, gives the best possible improvement in air quality to expect where the bridge is

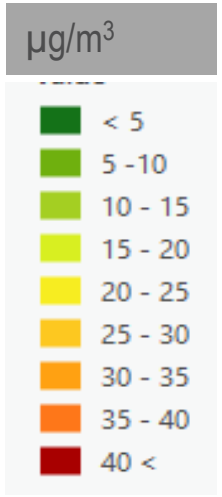
Better solution is to move the traffic on the bridge to other roads.

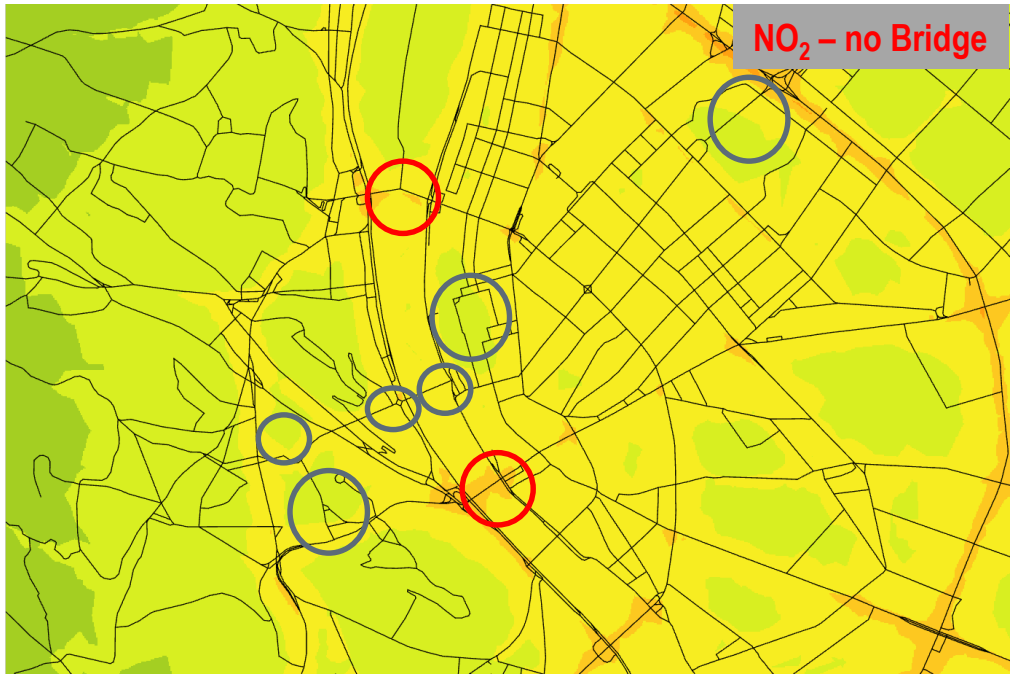


- manually
- with use of a traffic model and loading the traffic volumes from a file

SCENARIO 2 - RESULT IN NO_2 EMISSIONS



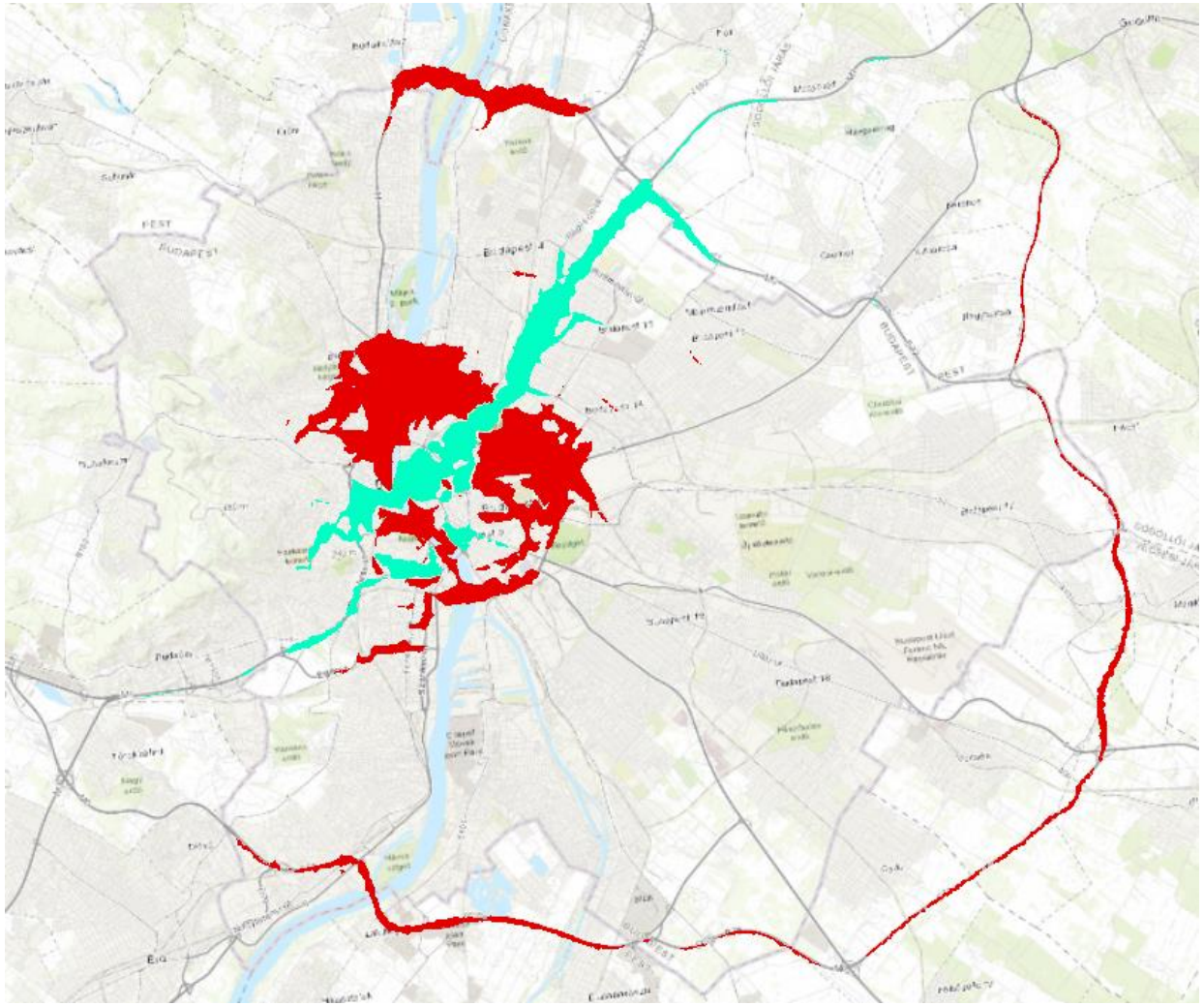




Increases

Decreases

SCENARIO 2 - RESULT IN NO_2 EMISSIONS



Annual average change NO_2

- decrease between 0.1 and 3.8 µg/m3
- -0,1- 0,1
- increase between 0.1 and 1.5 µg/m3

SCENARIO 2 - RESULT IN NO_2 EMISSIONS

Concentration decreases on bridge and roads leading to bridge but increases on parallel roads and on other bridges.

Effect is not very big (a few µg/m^3 max) with larger more localized decreases and smaller more diffuse increases. Changes are also noticeable further away on the ring road. This illustrates that you'll need traffic modeling to correctly represent the effect.

You can change the traffic counts used to calculate the emissions in ATMO-PLAN but it is the user that decides how much they change not the air quality tool. In this case a traffic model was used to calculate the new traffic numbers and these results are used as input.

TEST OPERATION

https://hungary-atmo-plan.marvin.vito.be/login

Base data regarding the given region/town:

- Roads: OpenStreetMap: https://www.openstreetmap.org/
- Point sources
- (residential emissions – next version, 2022)

Aim of test operation:

- Check for mistakes, missing road sections
- Correction of mistakes (e.g. speed limit)
- Location of point sources, emissions

THANK YOU FOR YOUR KIND ATTENTION

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