The impact of improving public transportation on decreasing air pollution and greenhouse gases emissions: the case of Sao Paulo, Brazil

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EACH 15 anos

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Outline

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- Methodology
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  - Air quality simulations
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  - Air quality
- Discussion and conclusions

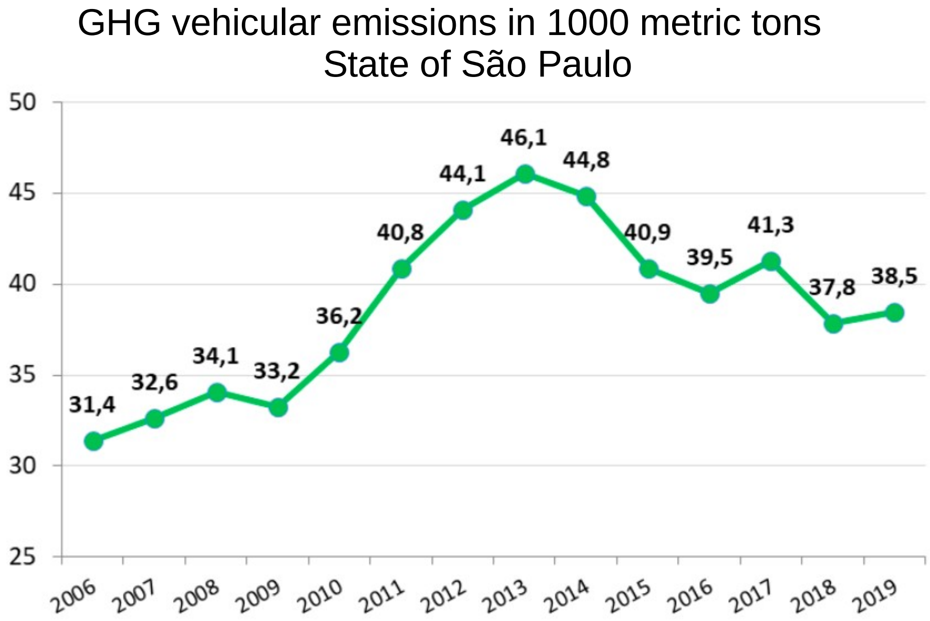
Metropolitan Area of São Paulo

- Air quality in São Paulo 2011-2020
  - PM 2.5: 27 exceedances (757 WHO)
  - Ozone (O_3): 168 exceedances (824 WHO)
- Population: 21 millions inhabitants
- Emissions in 2019 (CETESB, 2020) in 1000 metric tons per year:

Sources	CO	HC	NOx	MP	SOx
Vehicular	112.97	24.89	48.27	1.22	0.72
Industries (2008)	4.18	5.6	26.1	3.57	5.59
Liquid fuel base (2008)		3.68			
Total	117.15	34.17	74.37	4.79	6.31

Metropolitan Area of São Paulo

- Plan for Climate Action (Sao Paulo, 2019) → Paris Agreement:
  - 1) decrease in 45% GHG emissions by 2030 – carbon-free city by 2050;
  - 2) adapt to climate change impacts;
  - 3) provide equity in the distribution of social- environmental improvements.
- Road transportation (CETESB, 2011): 42 % of energy sector in the state in 2008 (37 % of total)



Public Transportation System

- Metro Survey (Origin-Destination) – typical day (Metro, 2019)
- 67.3 % motorized travels (30.9 % private cars, 36.4 % public transportation)
- Subways and metropolitan trains
- Stations planned but not implemented

http://www.metro.sp.gov.br/pdf/mapa-da-rede-metro.pdf

	Trips	Share
Subway	3,426,011	6.9%
Train	2,310,117	4.7%
Monorail	8,325	0.02%
Bus	14,449,505	29.1%
Chartered bus	351,980	0.7%
School bus	2,096,603	4.2%
Driving car	7,883,009	15.9%
Passenger in car	3,700,638	7.5%

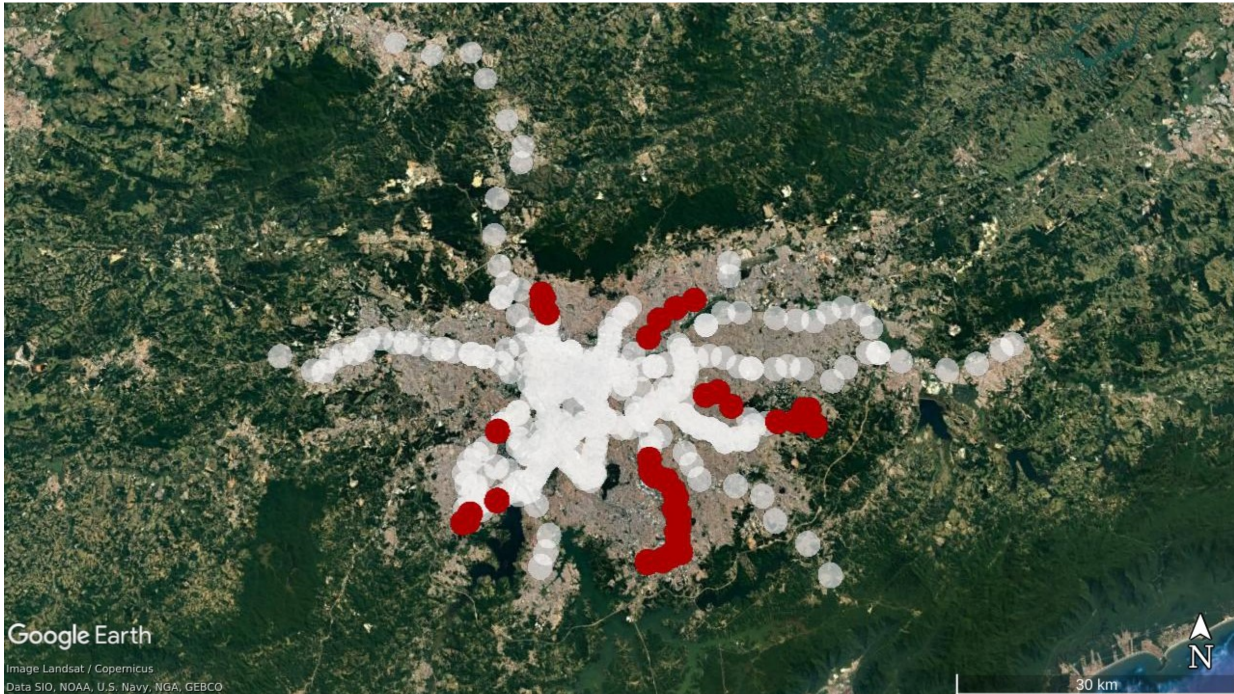
Source: Metro (2019)	Trips	Share
Taxi	507,752	1.0%
Driving motorcycle	972,864	2.0%
Passenger in motorcycle	103,270	0.2%
Bicycle	389,333	0.8%
Walking	13,349,876	26.9%
Others	115,142	0.2%
Total	49,664,424	100.0%

Main goal

- What are the impacts of transport policies for modal change near subway and metropolitan train stations on air quality and GHG emissions?

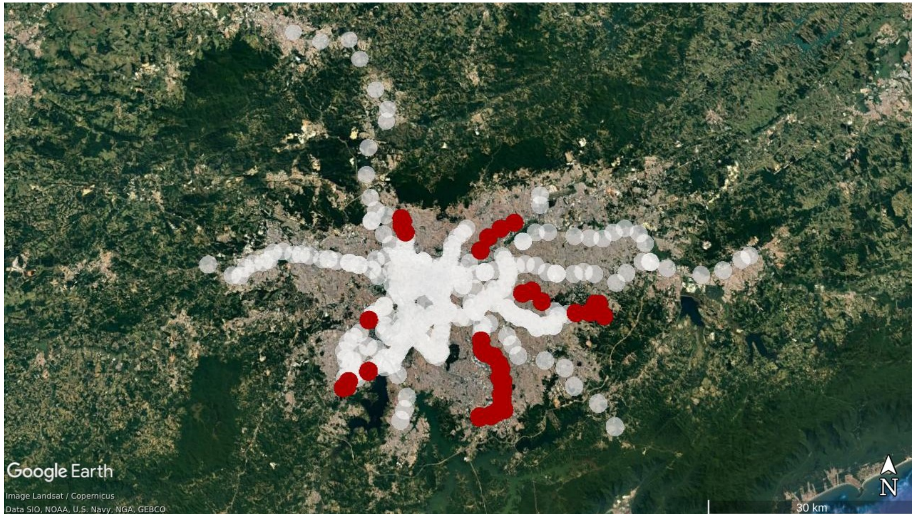
Methodology

- Scenarios
- Air quality simulations



Methodology

- Scenarios
  - CONTROL - Vehicular emissions in 2025 (Ribeiro et al., 2021)
  - Excluded from infrastructure (EXC) – reduced car emissions near planned stations – 5% of all car trips
  - Progressive (PRG) – reduced car emissions near all stations – 18% of all car trips
    - Near = trips that begin and end inside a buffer of 1.3 km ~15 minutes walk
- Air quality simulations



Methodology

- Scenarios
- Air quality simulations
  - QGIS (2021), Surrogate Tools, and SMOKE (https://cmascenter.org/) were used to spatially and temporally distribute emissions for each scenario (CONTROL, EXC, PRG)
  - WRF-Chem 4.1.2 (Grell et al., 2005): 3 nested domains (15, 3, 1 km horizontal spacing; 100, 101, 100 horizontal grid points; 50 vertical levels)
    - Boundary and initial conditions from MOZART (Emmons et al., 2010) and FNL (NCEP, 2015)
    - chem_opt = 8
    - Period: from 2 Jul 2018 0000 UTC to 10 Jul 2018 0600 UTC

Results

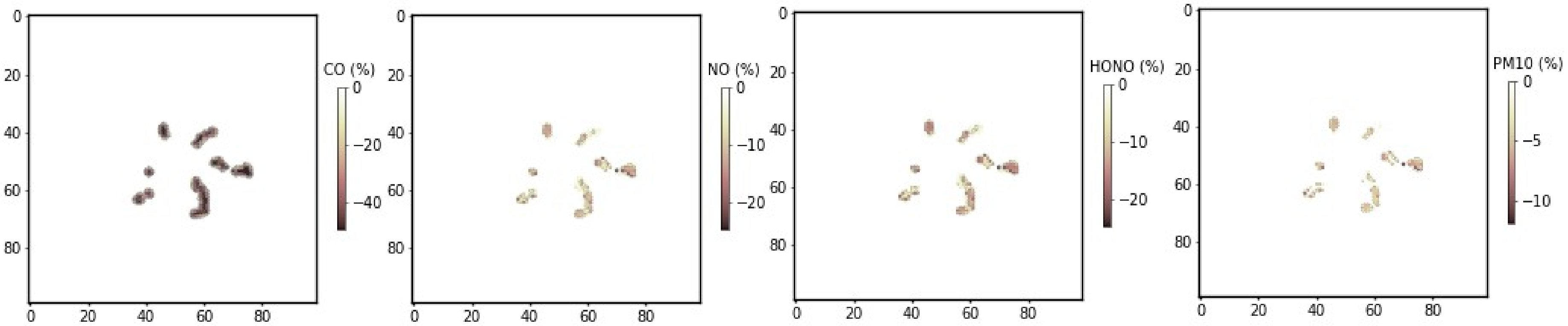
- Vehicular emissions

Pollutant (short ton)	CONTROL	EXC	PRG
CO	100,334	96,570 (-3,7%)	87,929 (-12,4%)
NO_x	38,801	35,588 (-8,3%)	34,757 (-10,4%)
SO_2	990	913 (-7,8%)	893 (-9,8%)
VOC	17,382	16,701 (-3,9%)	15,184 (-12,6%)
PM	773	704 (-8,9%)	697 (-9,8%)
CO_{2eq}	26,150,946	24,782,278 (-5,2%)	23,079,529 (-11,7%)

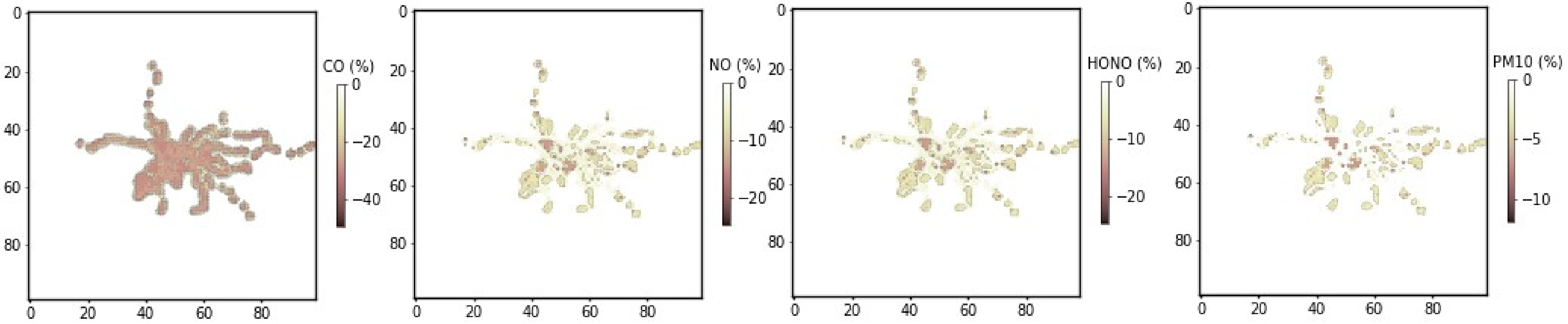
Ethanol

Results - emissions

EXC - CONTROL



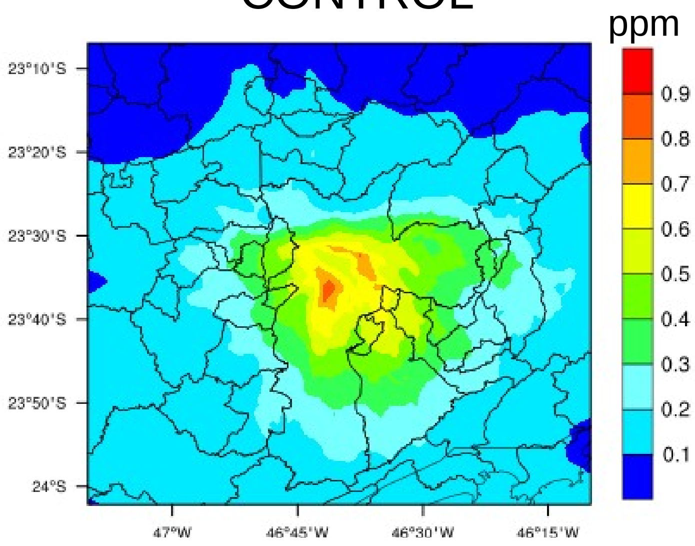
PRG - CONTROL



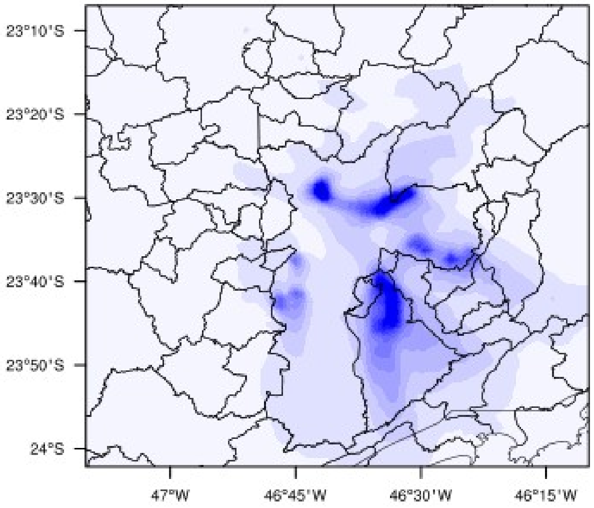
Results – Air quality simulations

CO

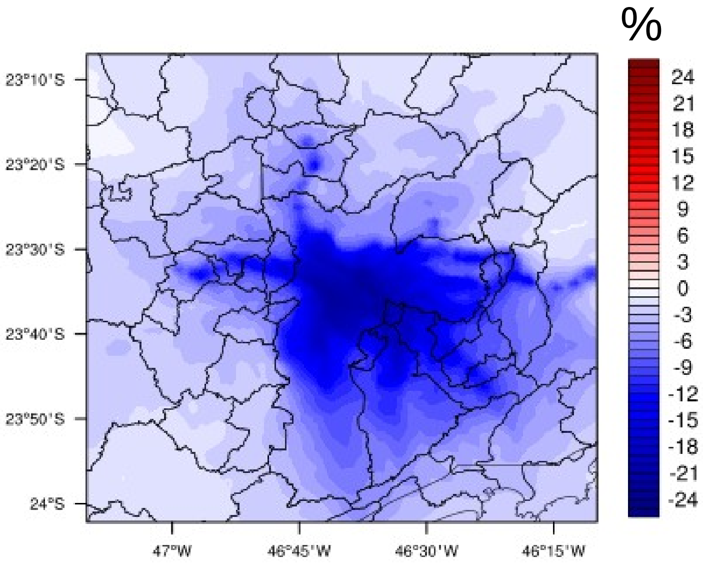
8-day average
CONTROL



CONTROL – EXC



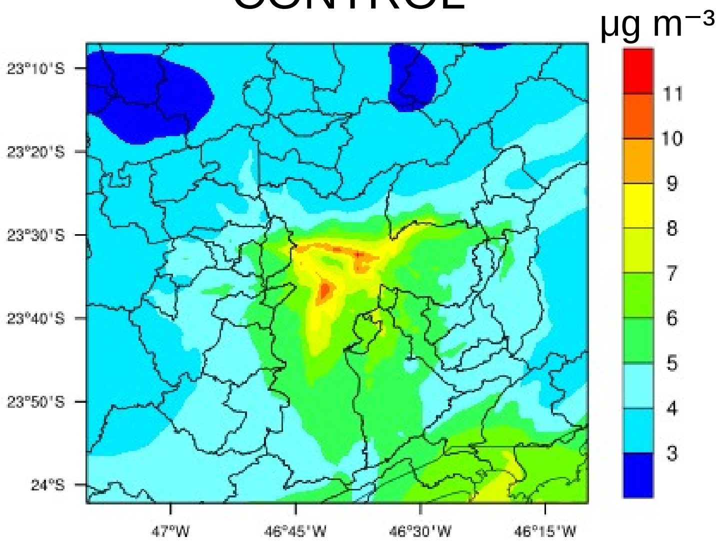
CONTROL – PRG



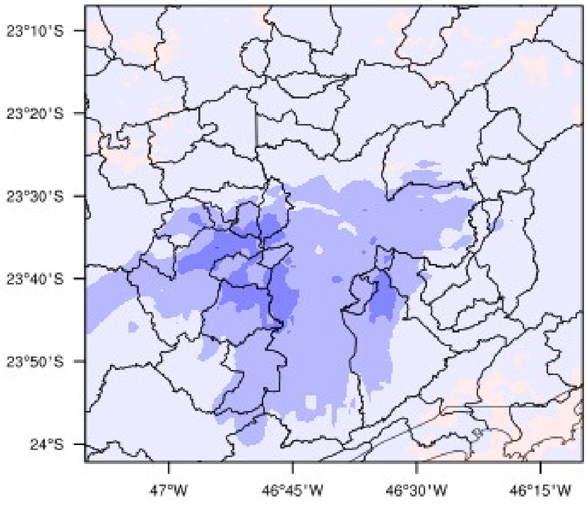
Results – Air quality simulations

PM 2.5

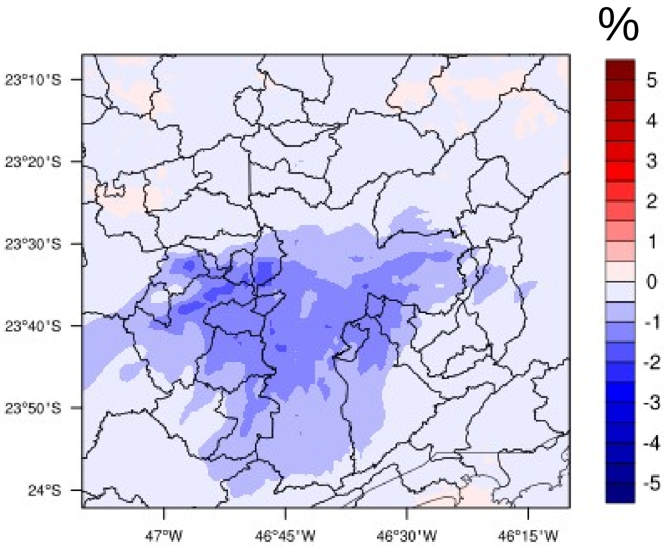
8-day average
CONTROL



CONTROL – EXC



CONTROL – PRG



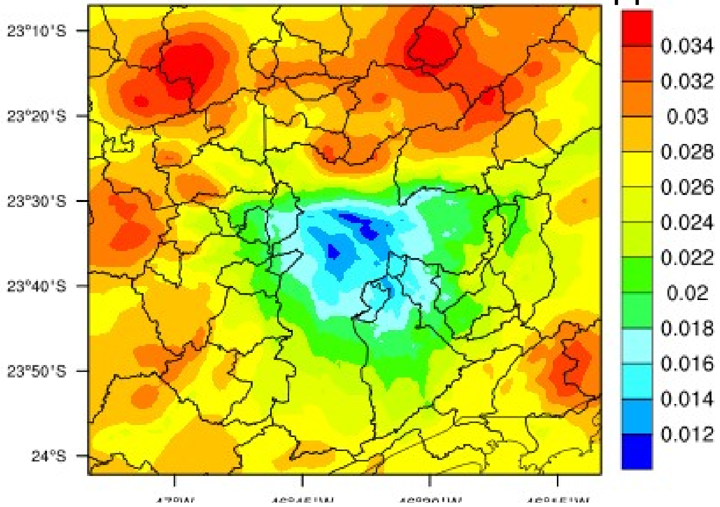
Results – Air quality simulations

O_3

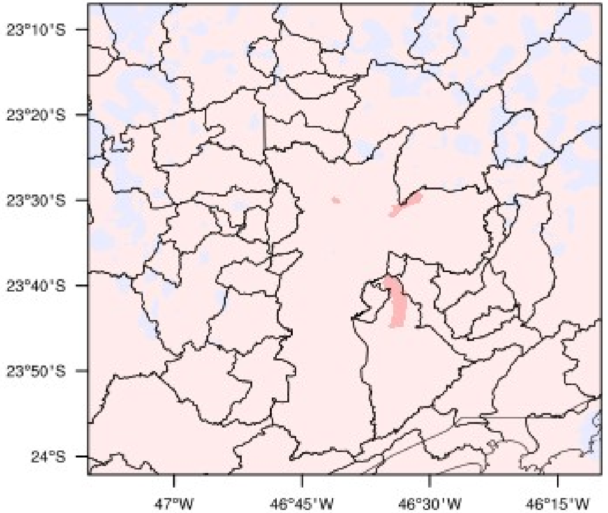
Winter!

8-day average
CONTROL

ppm

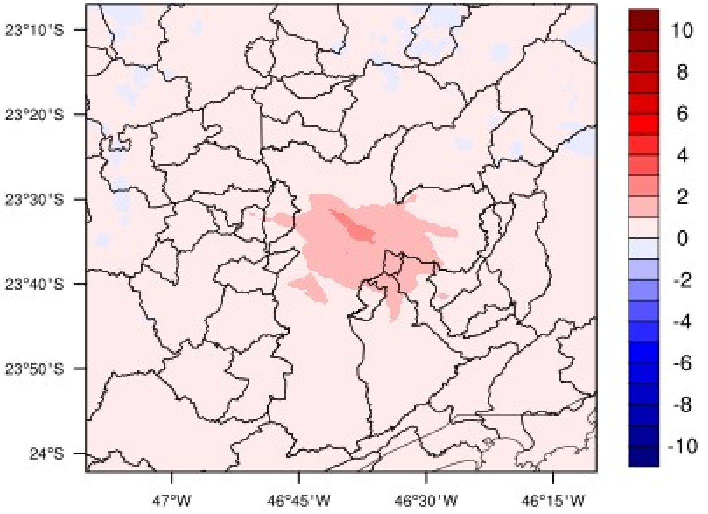


CONTROL – EXC



CONTROL – PRG

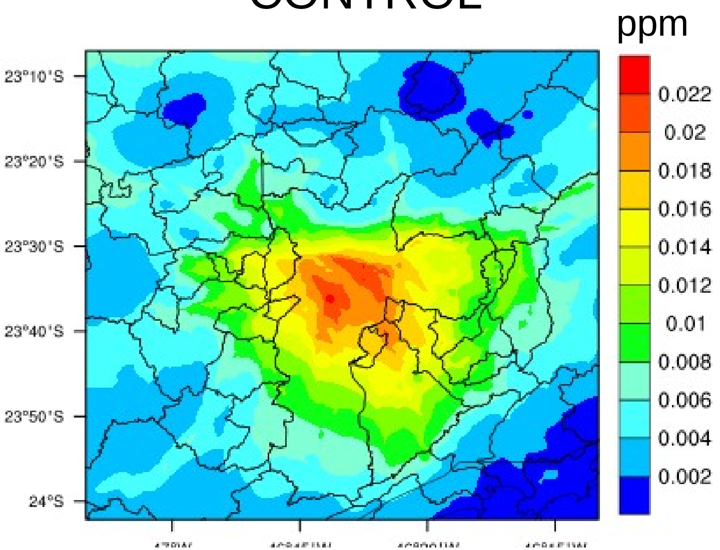
%



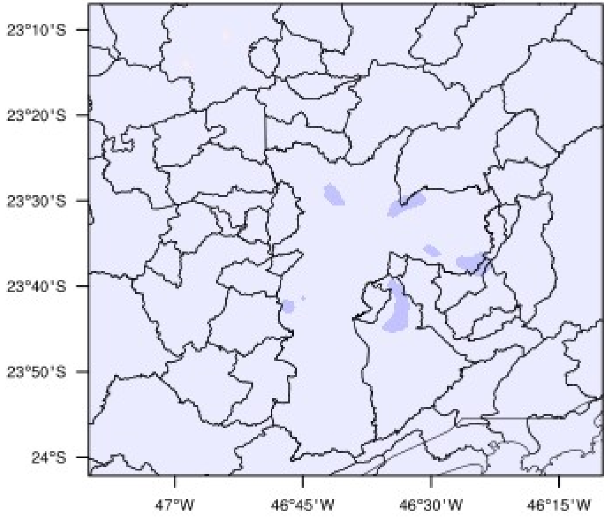
Results – Air quality simulations

NO_2

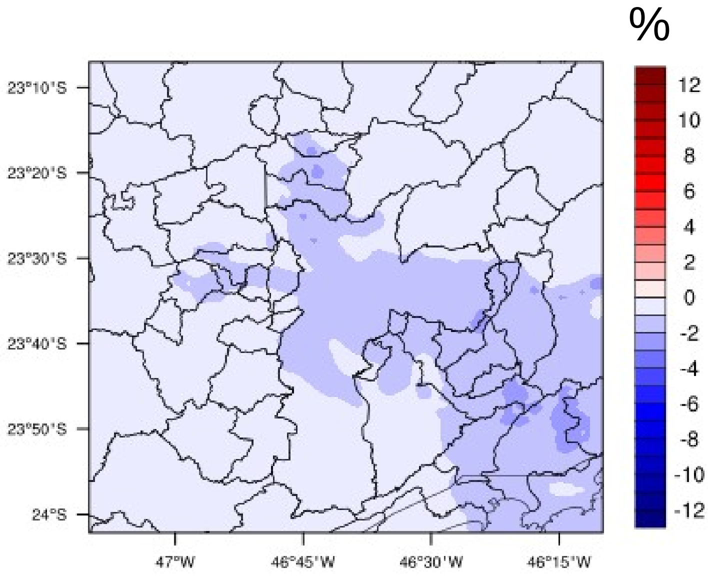
8-day average
CONTROL



CONTROL – EXC



CONTROL – PRG



Discussion and conclusions

- CO_{2eq} vehicular emissions proposed reduction is important, but not sufficient
- Greatest reduction in CO → cars
- Ozone shows slight increase in areas where its concentration is lower → in São Paulo a reduction in NO_x would increase O_3 → non-linear (Sánchez-Ccoyllo et al., 2006; Orlando et al., 2010; Chiquetto et al., 2020)
- Greatest air quality improvement in areas that are neglected → cobenefits
- Just the infrastructure may not ensure emission reductions → other policies needed
- On the other hand, infrastructure is necessary to provide access (1.3 km)
- The whole MASP may benefit from a change in transportation mode from motorized (careful with O_3 precursors)

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Thank you!

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