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EXCELENCIA SEVERO OCHOA

CDMX CIUDAD DE MÉXICO

SEDEMA

SECRETARÍA DEL MEDIO AMBIENTE

A modelling system for air quality forecast and air quality management in Mexico City

Marc Guevara Vilardell

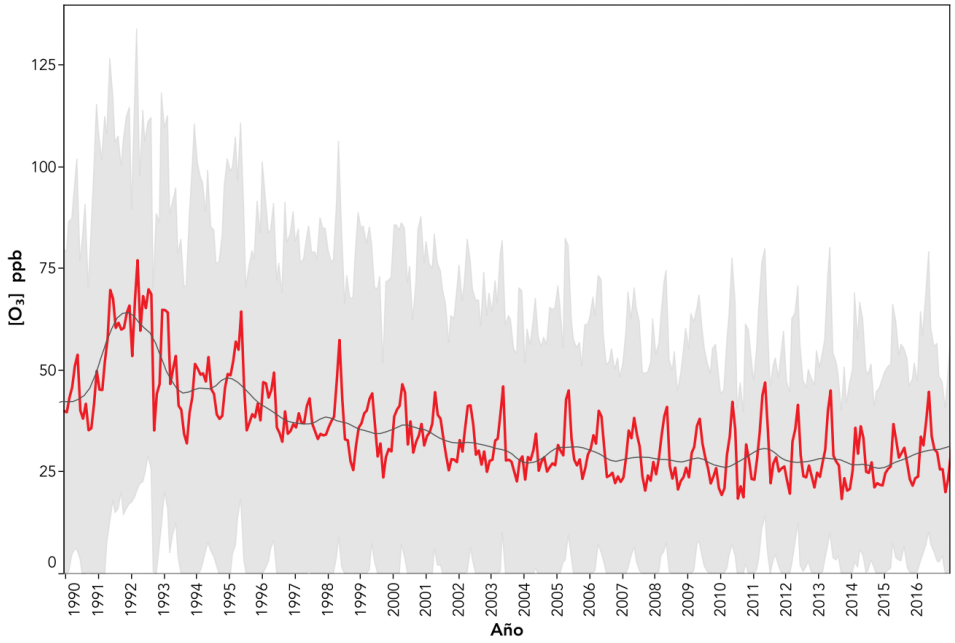
26/09/2018

Taller para la evaluación del PROAIRE 2011-2020 e identificación de estrategias para la mejora de la calidad del aire , CDMX, Mexico

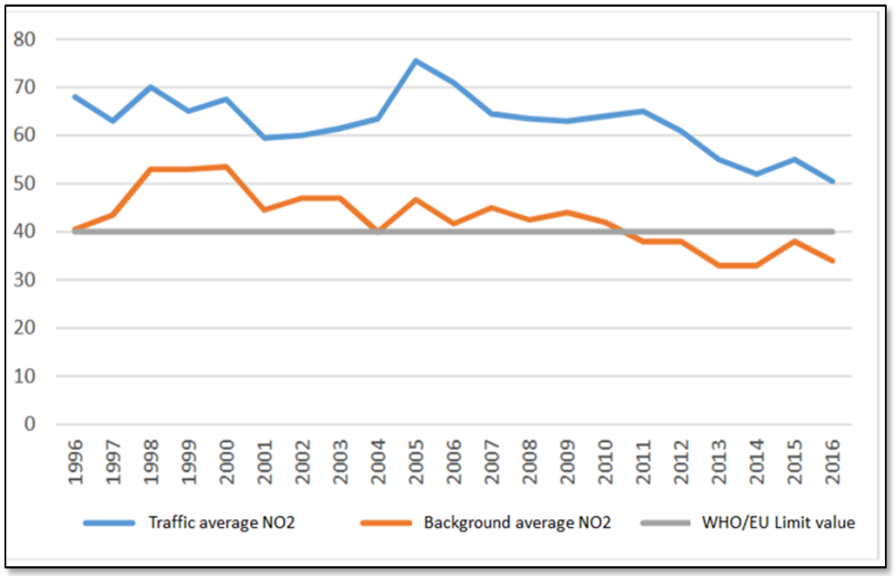
The great challenges to air pollution

Air pollution is improving overall but more work is needed to reduce exceedances

O_3 levels in CDMX (1990-2016)



NO_2 levels in BCN (1996-2016)



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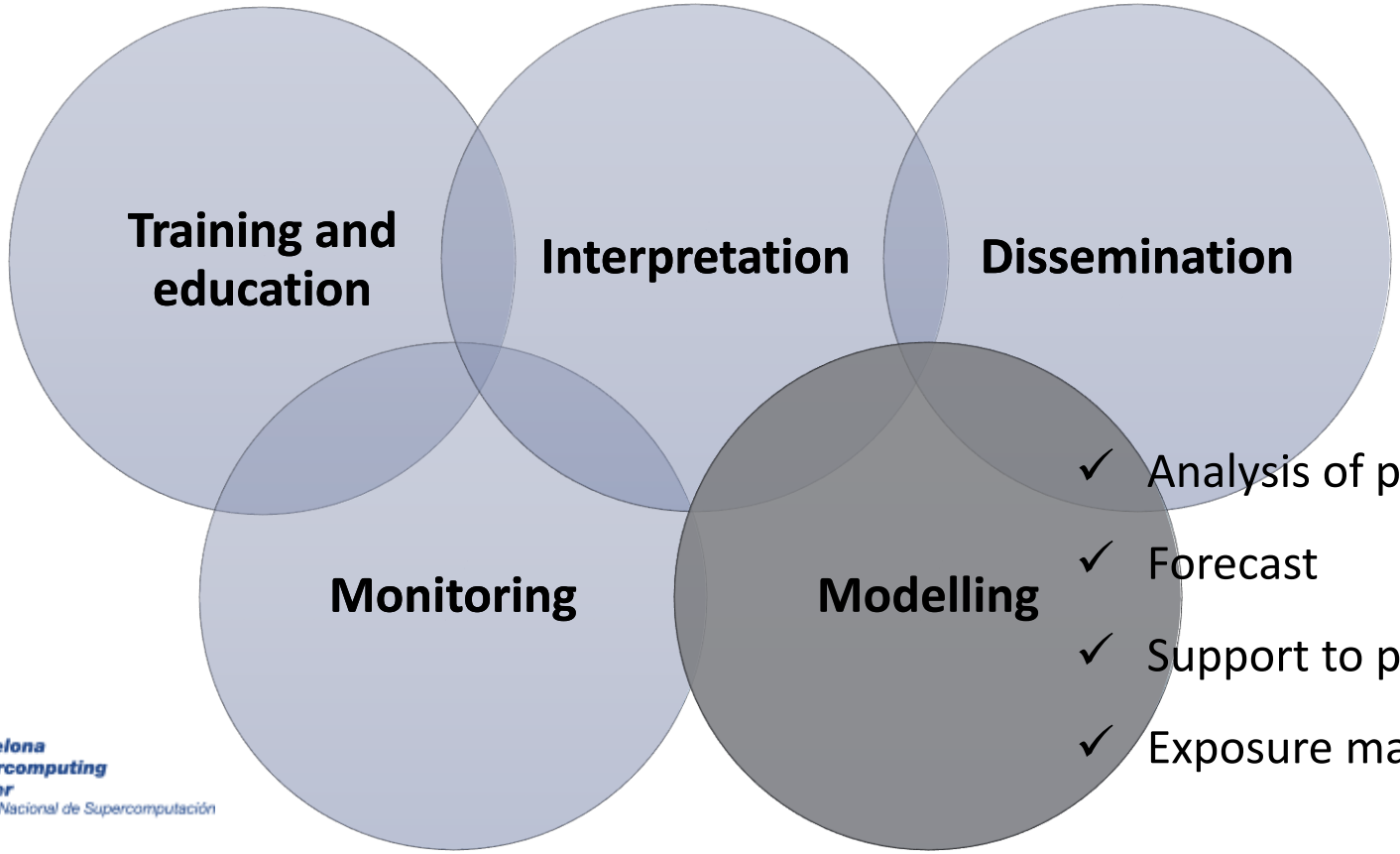
nature
International journal of science

Five steps to improve air-quality forecasts

A worldwide monitoring and modelling network would reduce the dramatic toll of air pollution on health and food production, urge Rajesh Kumar and colleagues.

https://www.nature.com/articles/d41586-018-06150-5

Rajesh Kumar ✉, Vincent-Henri Peuch, James H. Crawford & Guy Brasseur



- ✓ Analysis of past events
- ✓ Forecast
- ✓ Support to planning
- ✓ Exposure maps

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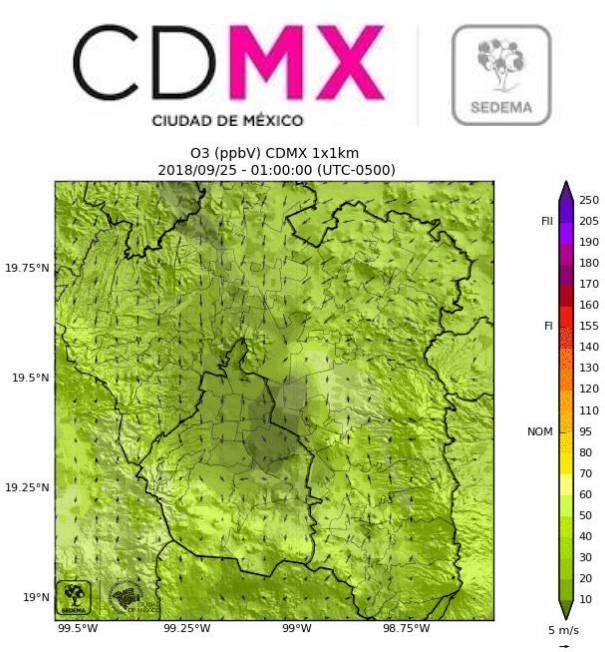
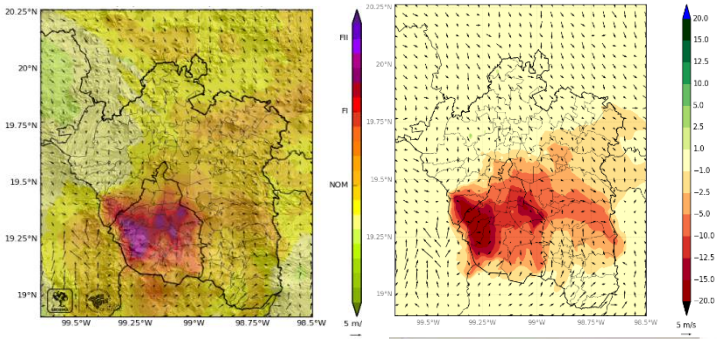
Air quality modelling system for Mexico City

A high resolution and flexible **forecasting** and **planning tool** for policy makers





http://www.aire.cdmx.gob.mx/pronostico-aire/

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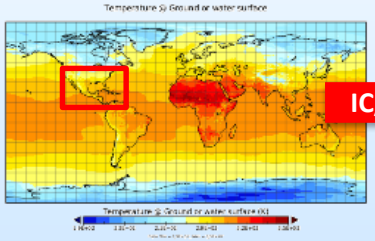
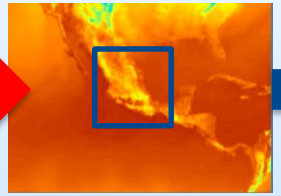
Workflow of the operational system

METEOROLOGICAL MODEL (WRF)



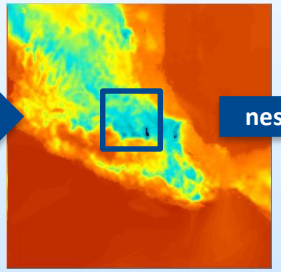
NCEP GFS
0.25º x 0.25º

IC/BC



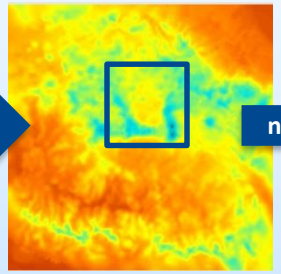
WRF-ARW
27 km x 27 km

nesting



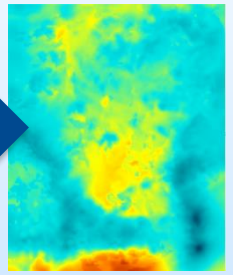
WRF-ARW
9 km x 9 km

nesting



WRF-ARW
3 km x 3 km

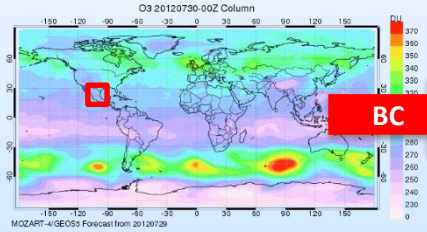
nesting



WRF-ARW
1 km x 1 km

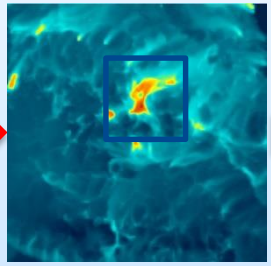
Meteo

AIR QUALITY MODEL (CMAQ)



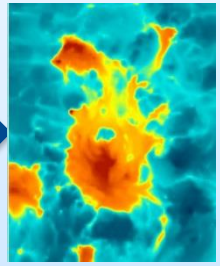
UCAR MOZART4
1.9 º x 2.5º

BC



CMAQ
3 km x 3 km

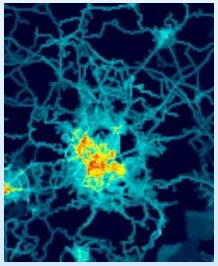
nesting



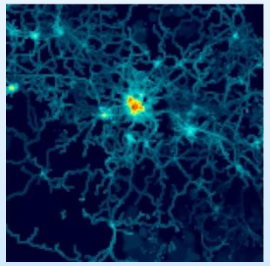
CMAQ
1 km x 1 km

Emis

EMISSION MODEL (HERMES-Mex)



HERMES-Mex
1 km x 1 km

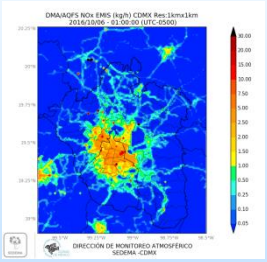


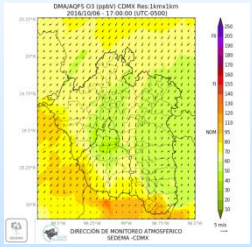
SECRETARÍA DEL MEDIO AMBIENTE

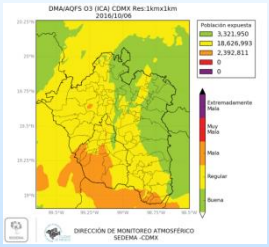
SEMARNAT

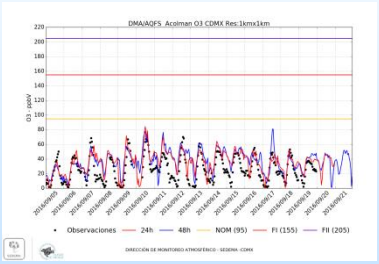
Post-procesos

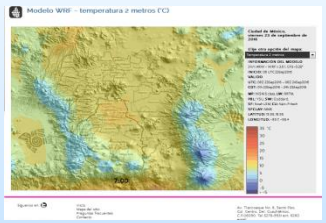
PRODUCTS





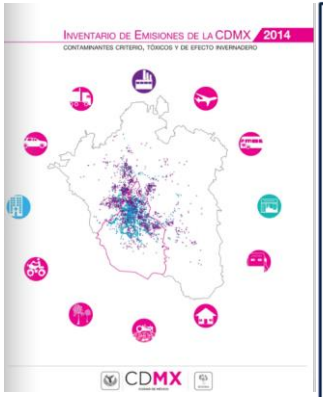


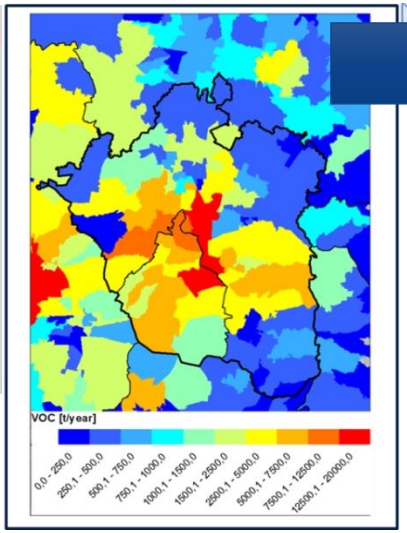




HERMES-Mex:
An emission processing tool for Mexico

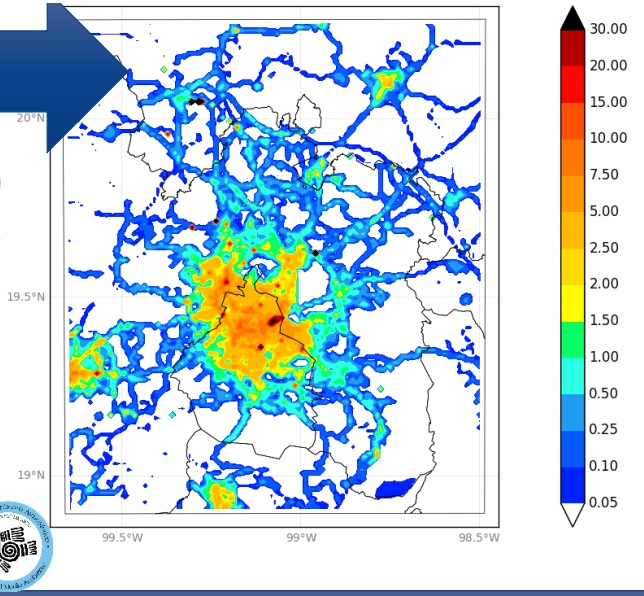
Official Emission Datasets





Spatial distribution (1km^2)
Temporal distribution (1h)
Speciation (CB05)
+ biogenic (MEGANv2.1)
+ forest fires (GFASv1.2)
+ trash burning

CMAQ ready emission data



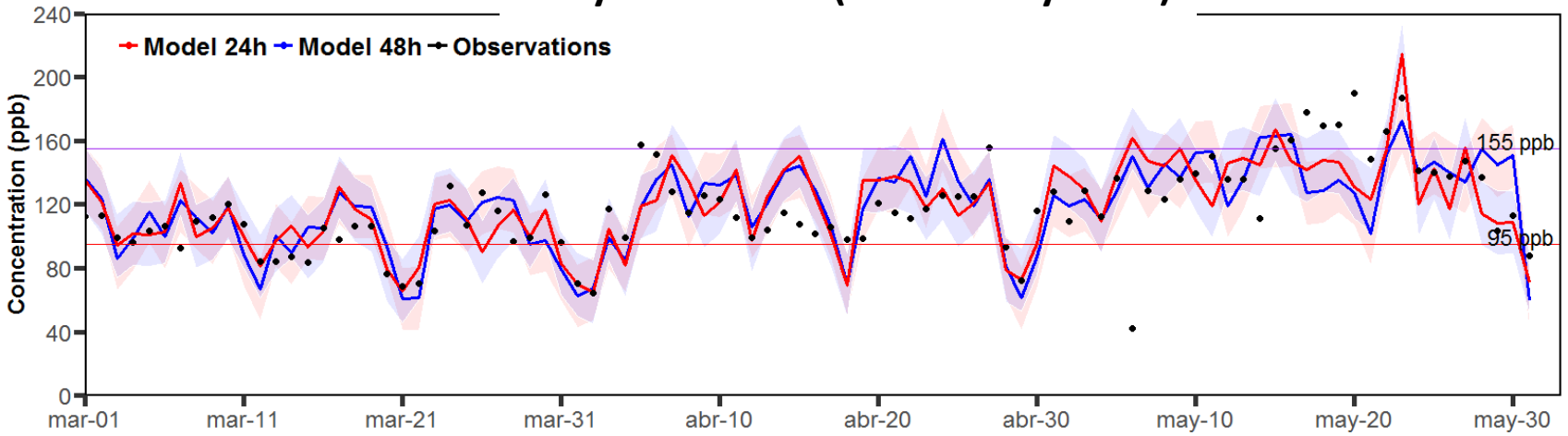
Flexible platform for emission scenario and contribution analysis:

- 101 emission source categories (source type, fuel, technology)
- Individual industrial facilities
- Option to deactivate or aply an scaling factor to individual sources

Forecast evaluation

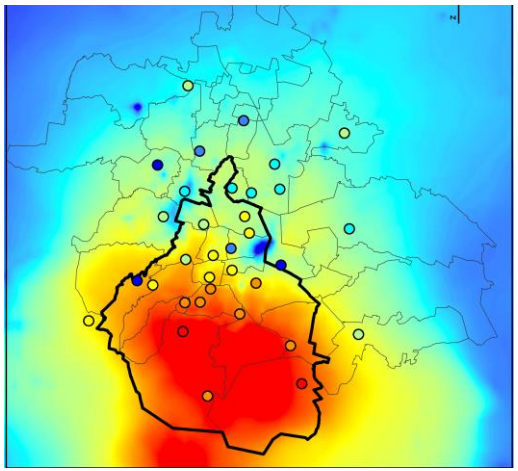
Near real-time evaluation of the modelled reults using observations from the Mexico City's automatic air quality monitoring network

Daily maximums (March-May 2017)

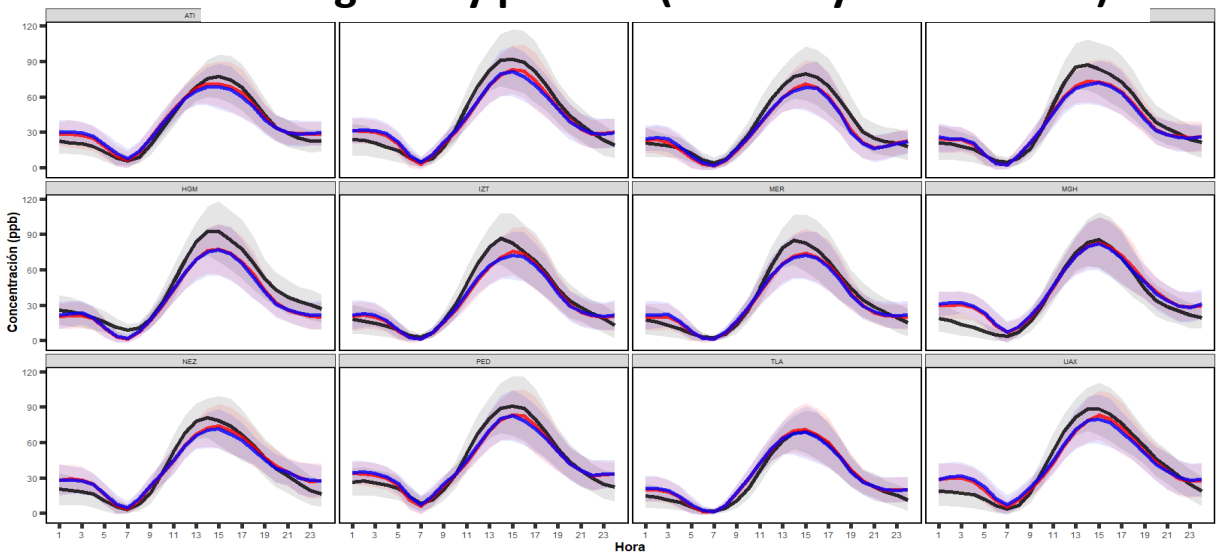


Mean 13:00 to 18:00h

March - May 2017

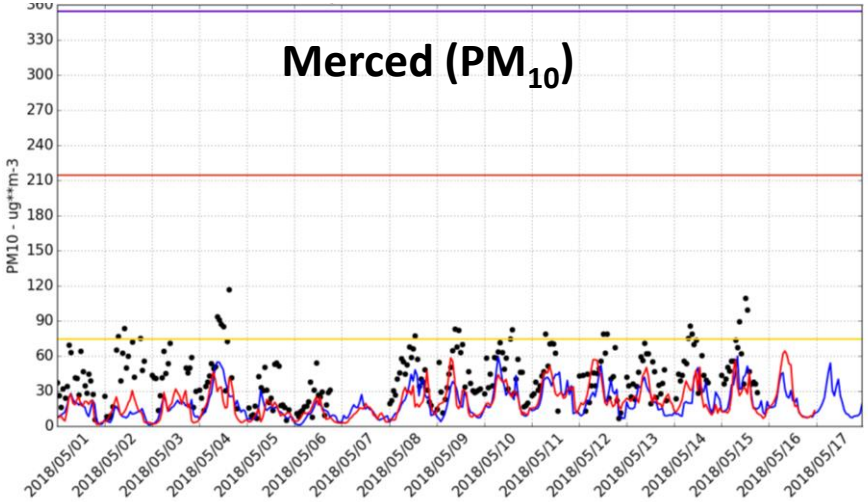


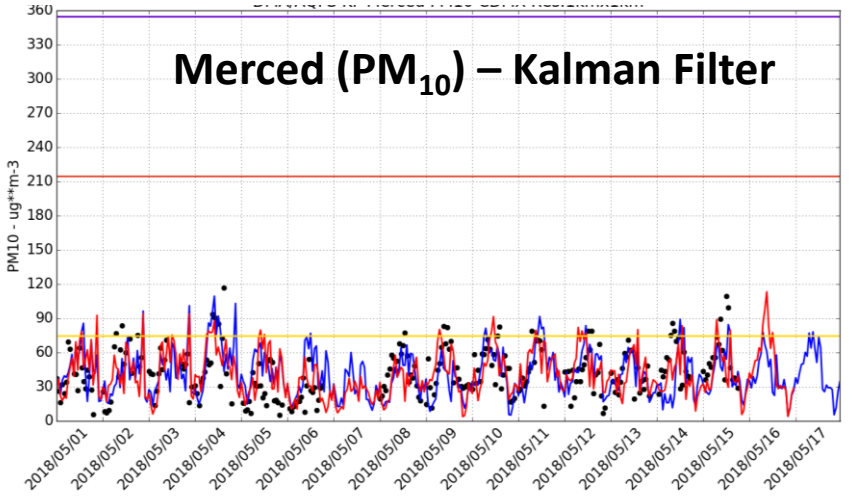
Average daily profiles (February – June 2018)



Bias reduction

Systematic Error Removal (Kalman Filter)

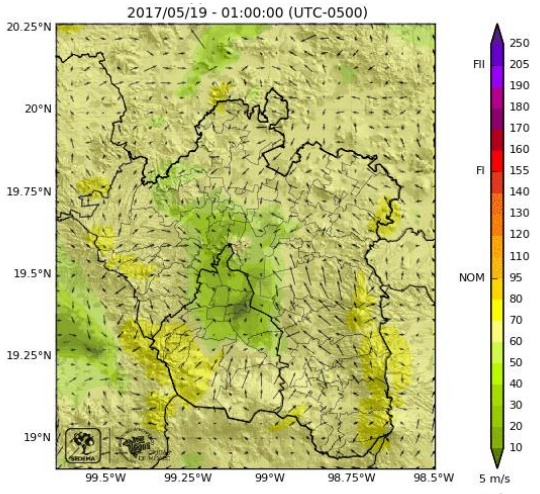




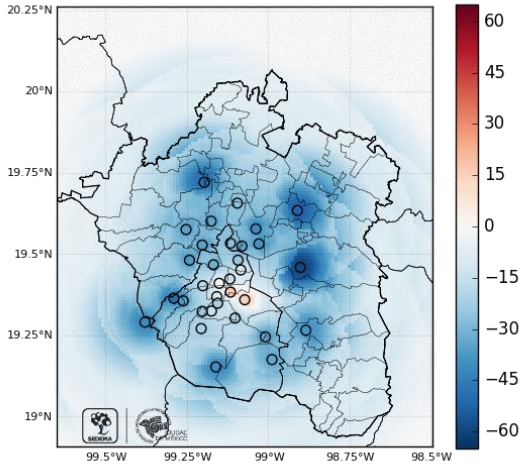
Observaciones — 24h — 48h — NOM (75) — FI (215) — FII (355)

Spatial Interpolation (Barnes Scheme)

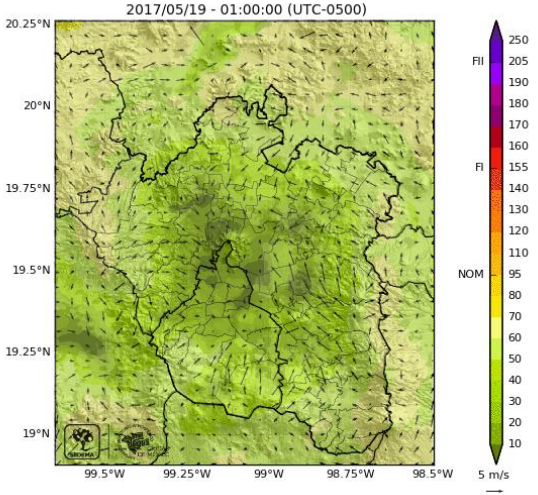
O_3 Forecast



Gridded bias



Improved O_3 forecast

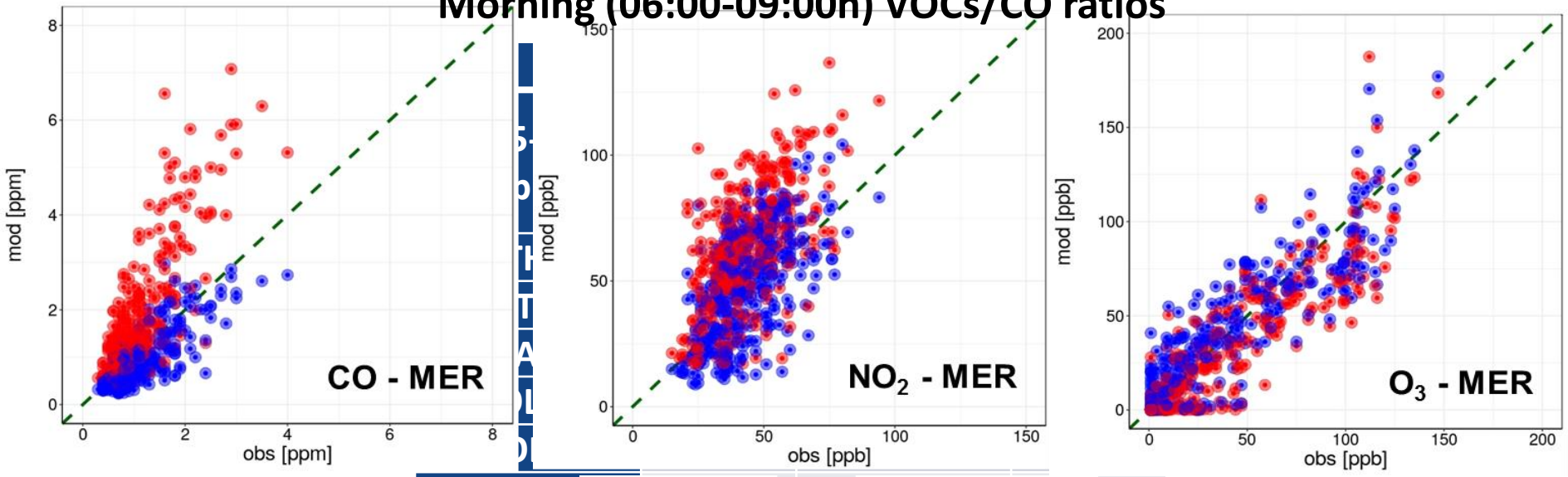


Road traffic emissions: MOBILE6.2-Mex versus MOVES-Mexico

Changes in the MCMA emissions when replacing MOBILE6.2-Mex for MOVES-Mexico

	NO_x	CO	VOC	PM_{10}	$PM_{2.5}$
Total Sources	-37%	-52%	-26%	8%	6%

Morning (06:00-09:00h) VOCs/CO ratios



ISOP			.3
BENZENE	1.2	1.6	1.6
TOL	7.8	9.2	13.9
XYL	2.5	5.5	6.4

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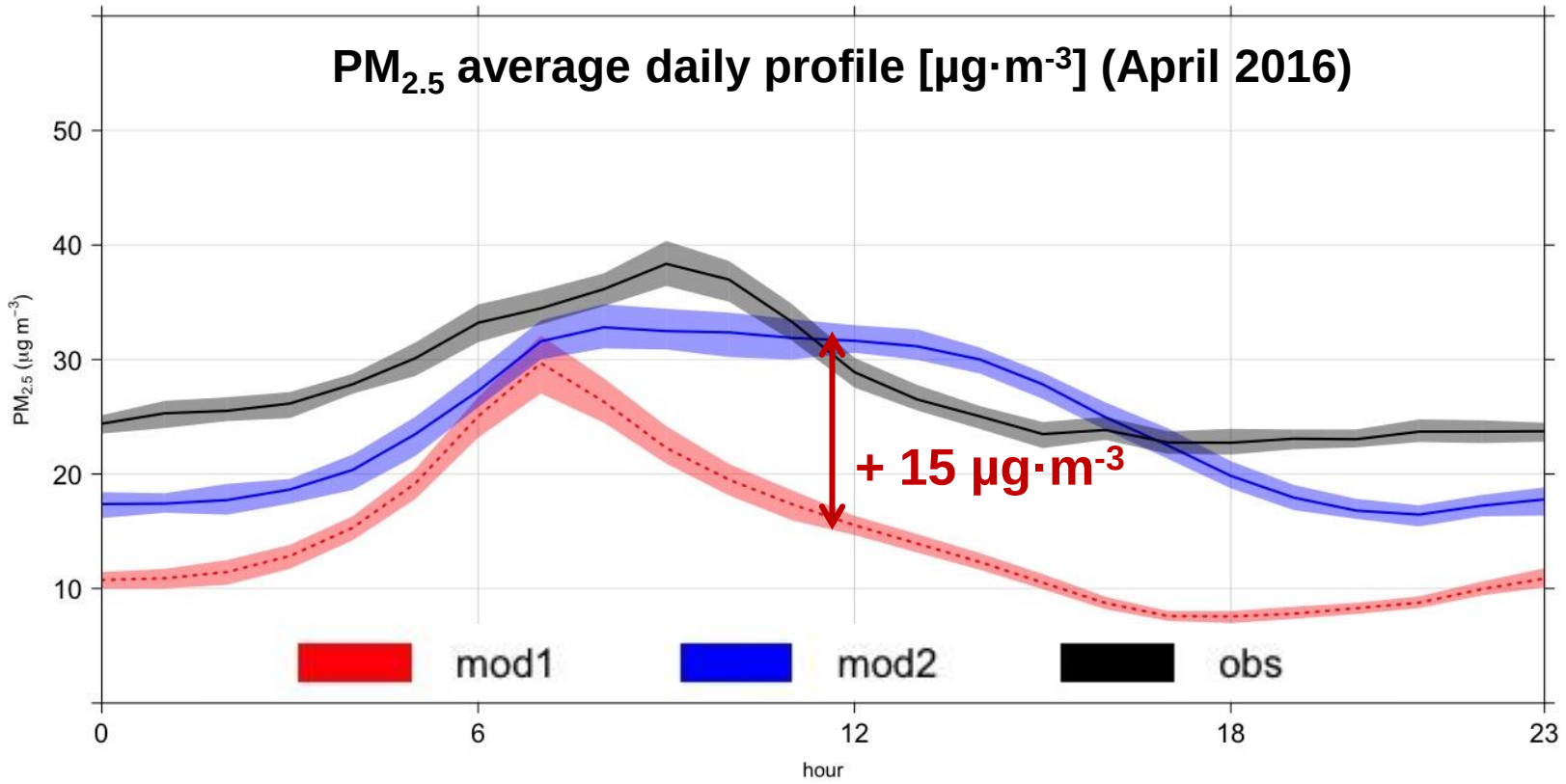
Updating the system to improve $PM_{2.5}$

Replacement of CMAQv5.0.2 for CMAQv5.2, which include the implementation of (Murphy et al., 2017):

- POA semivolatile partitioning and aging
- Potential SOA from combustion emissions



The Environmental Atmospheric Contingency Program (PCAA)

Case Study May 15th – 24th 2017:

- What is the impact of the PCAA on emissions and O_3 levels?
- Does the non-fulfillment of the PCAA's restrictions have a significant effect to its performance?
- What would be the impact if more restrictive measures are applied (Stage 2 instead of Stage 1 restrictions)?

Air Quality Index	O_3 (ppb, 1-hour)
0 – 50 (very good)	0 – 70
51 – 100 (good)	71 - 95
101 – 150 (regular)	96 – 154
151 – 200 (bad)	**155 – 204**
201 – 300 (very bad)	**205 – 404**

PCAA Stage 1

PCAA Stage 2

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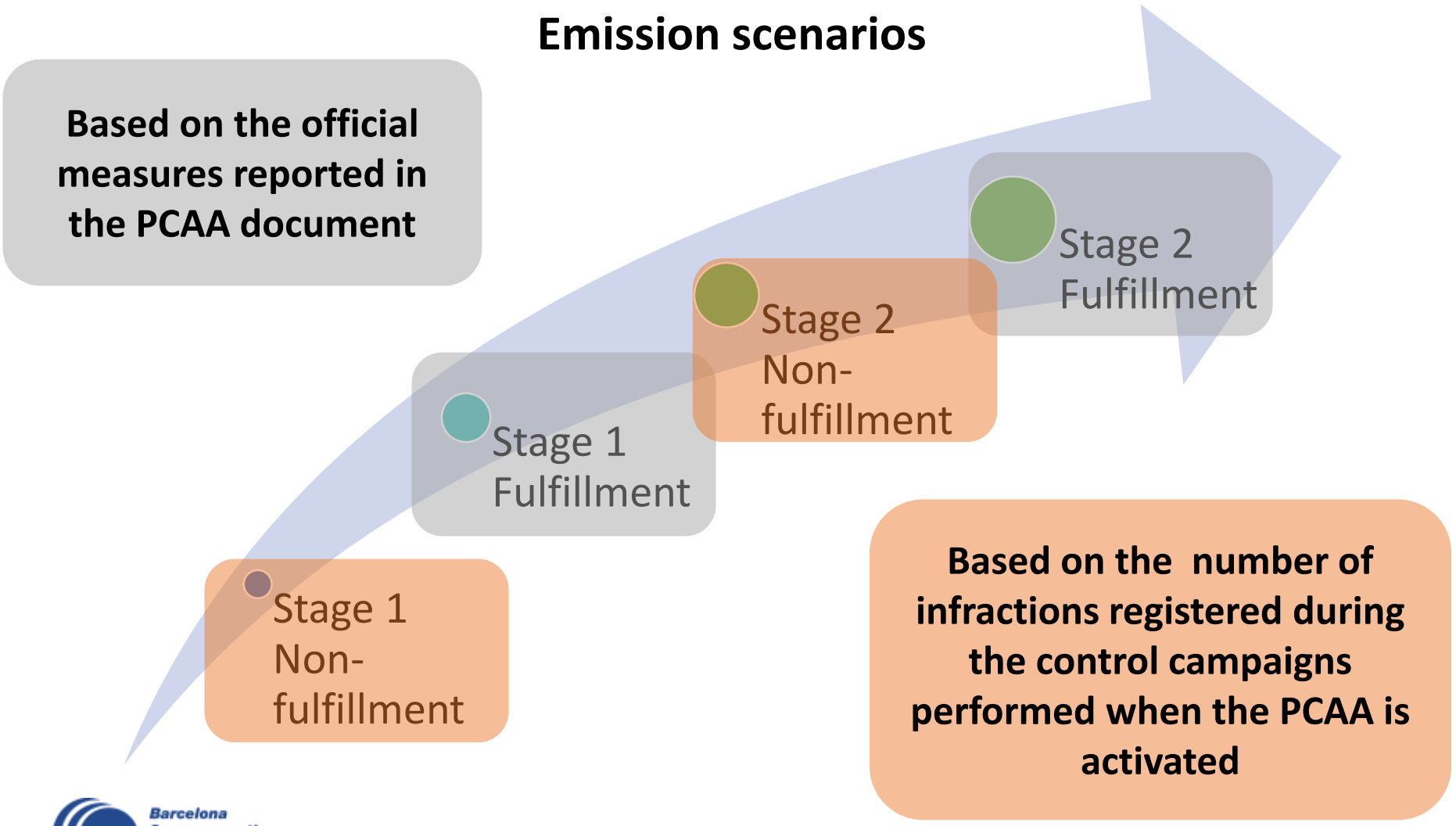
The Environmental Atmospheric Contingency Program (PCAA)

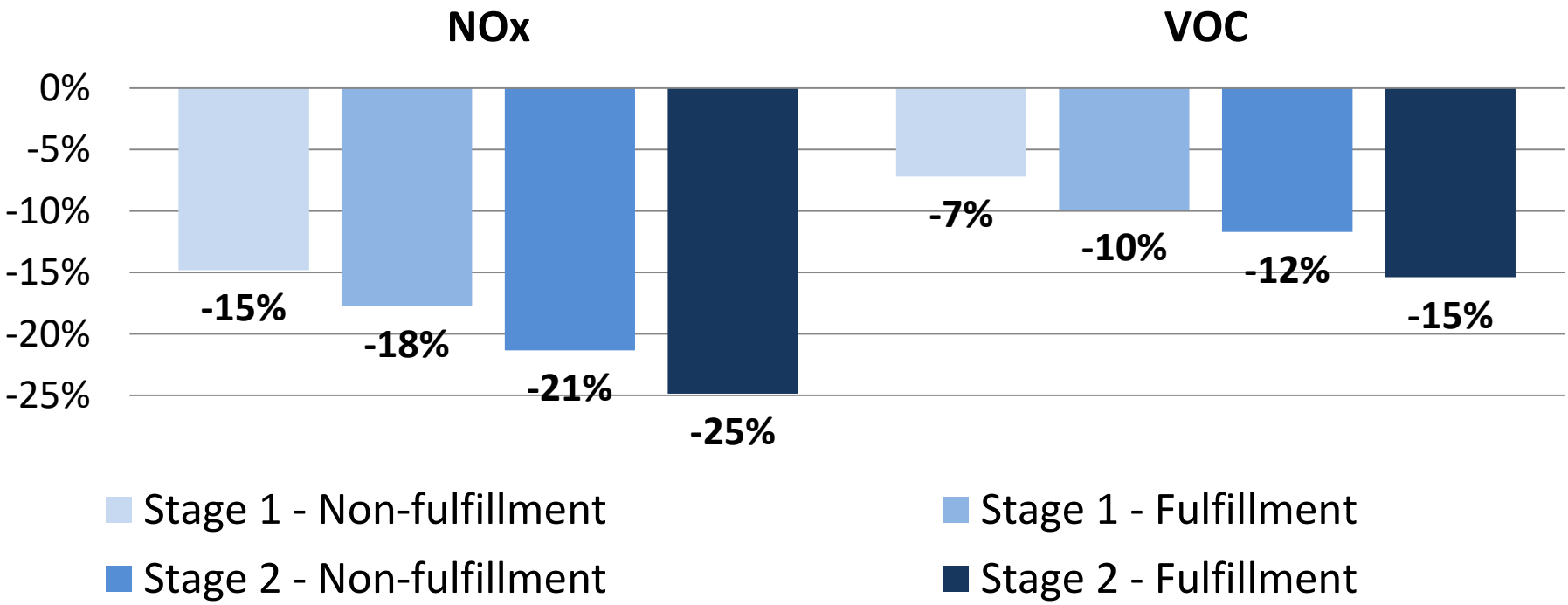


The Environmental Atmospheric Contingency Program (PCAA)

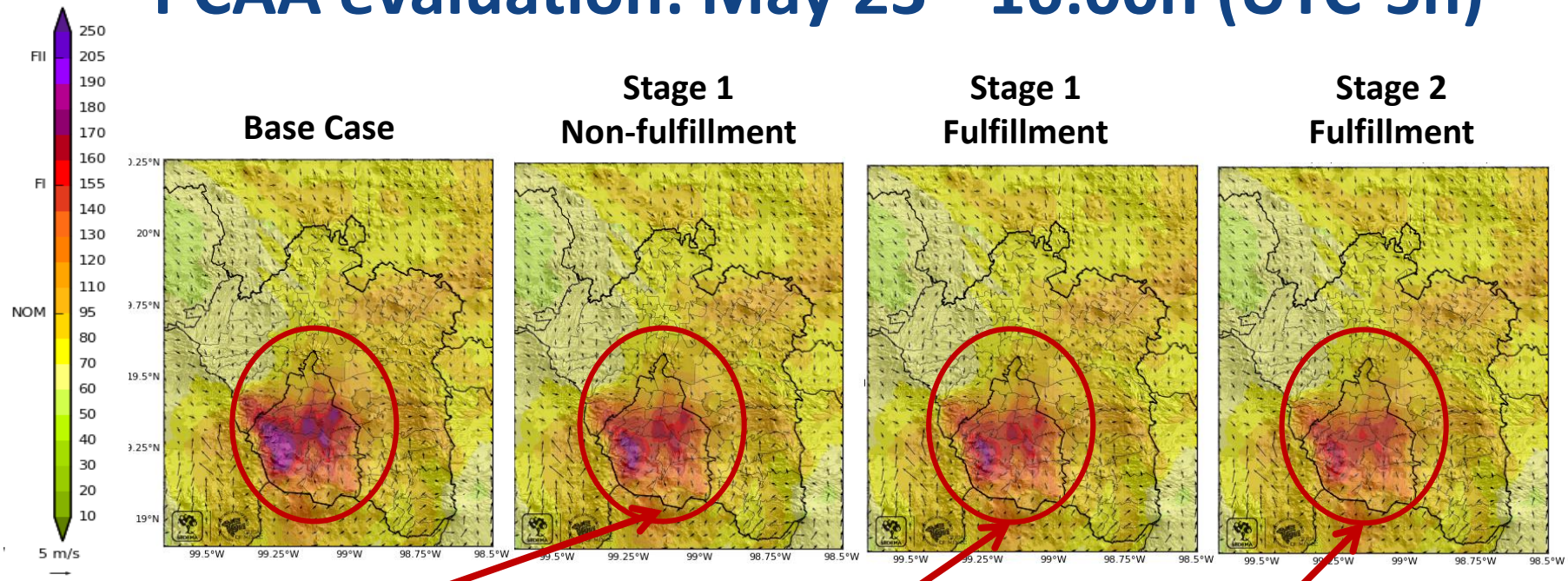
Reductions of **TOTAL** emissions in the MCMA are higher for NOx than for VOC (+8%):

1. PCAA's reductions mainly come from traffic restrictions in all scenarios
2. Total MCMA's NO_x emissions are governed by traffic (>75%), while **VOC are mainly dependent on** use of solvents/paints and leakage of fuels (>60%)

Not restricted by the PCAA



PCAA evaluation: May 23rd 16:00h (UTC-5h)



Average reduction: -6.3 ppb
Maximum reduction: -13.8 ppb

Average reduction: -8.1 ppb
Maximum reduction: -17.1 ppb

Average reduction: -12.2 ppb
Maximum reduction: -21.6 ppb

But some areas still remain above the hourly limit value (155ppb)

The Program to improve air quality in Mexico City (PROAIRE 2011 – 2020)

Emission scenarios

No-PROAIRE scenario
¿What would be the impact if no measures had been applied (2012-2016)?

2012

Base case scenario
April 2016

2016

PROAIRE2020 scenario
¿What will be the impact of the measures that are yet to be applied (2017-2020)?

2020

PROAIRE2020 + scenario
¿What would be the impact if extra measures for reducing VOC were applied (2017-2020)?

- **Local industries (-20%)**
- **Use of solvents (-30%)**
- **LPG leakage and incomplete combustion (-30%)**

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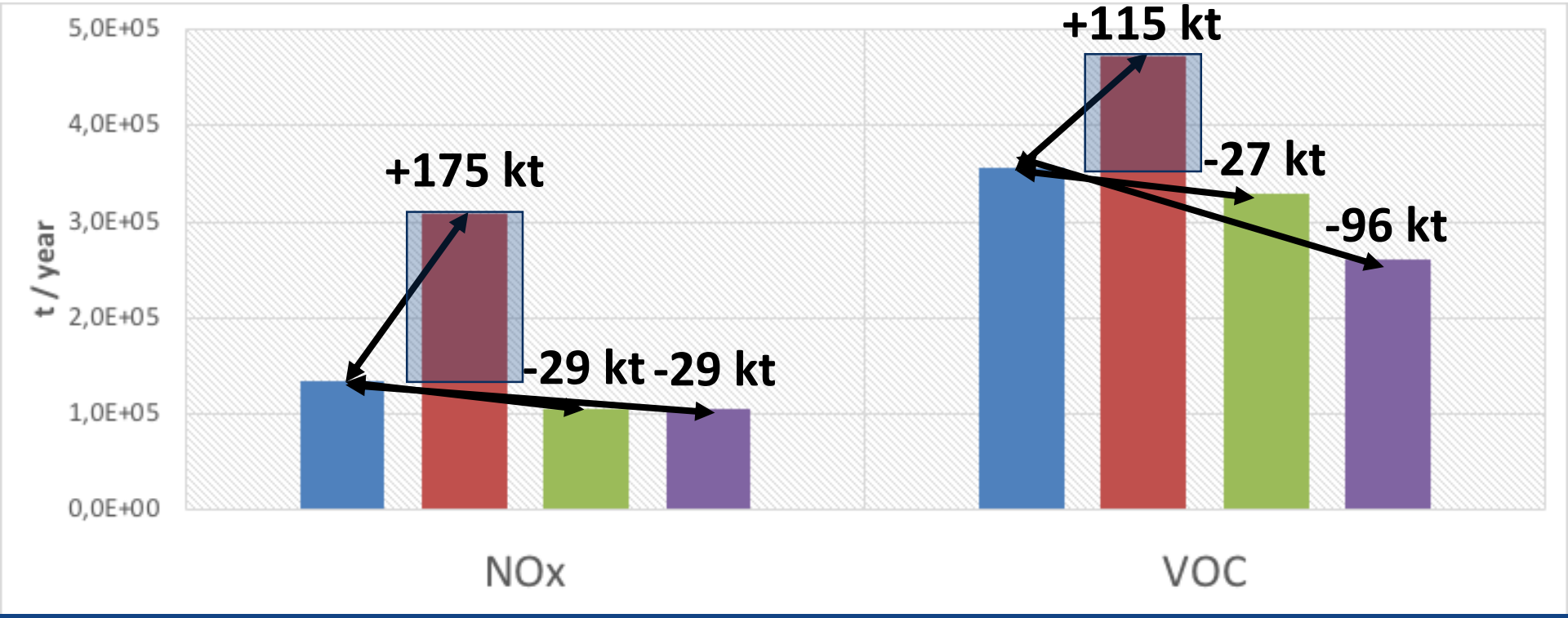
The Program to improve air quality in Mexico City (PROAIRE 2011 – 2020)

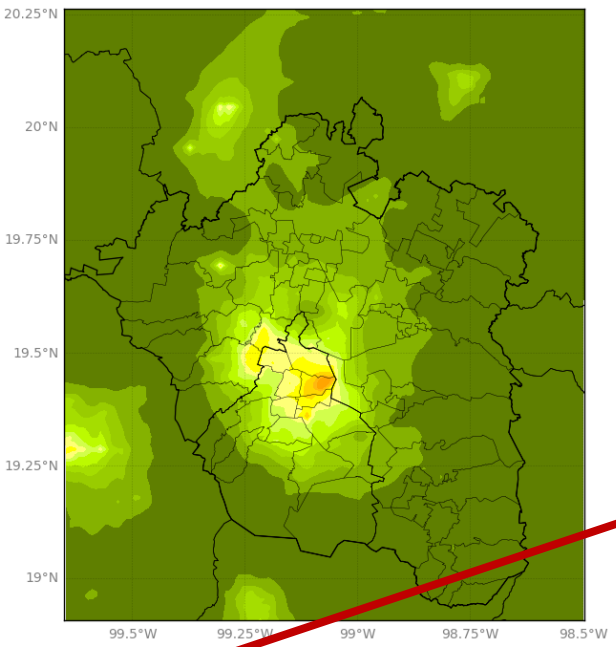
Total emissions in the MCMA for each scenario



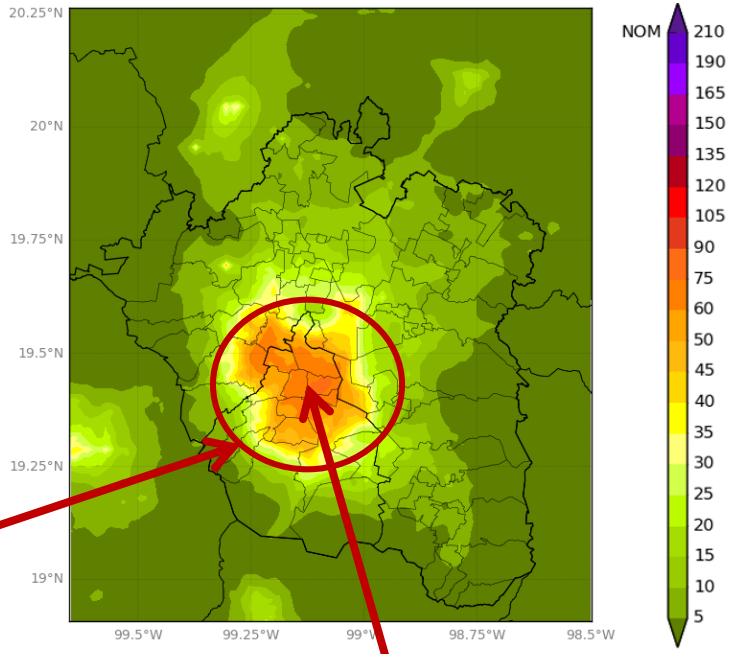
Only scenario in which the relative reduction of VOC emissions (-27%) is larger than the NOx one (-21%)

Scenario analysis – No-PROAIRE
NO_2 hourly average (April 2016)

Base Case

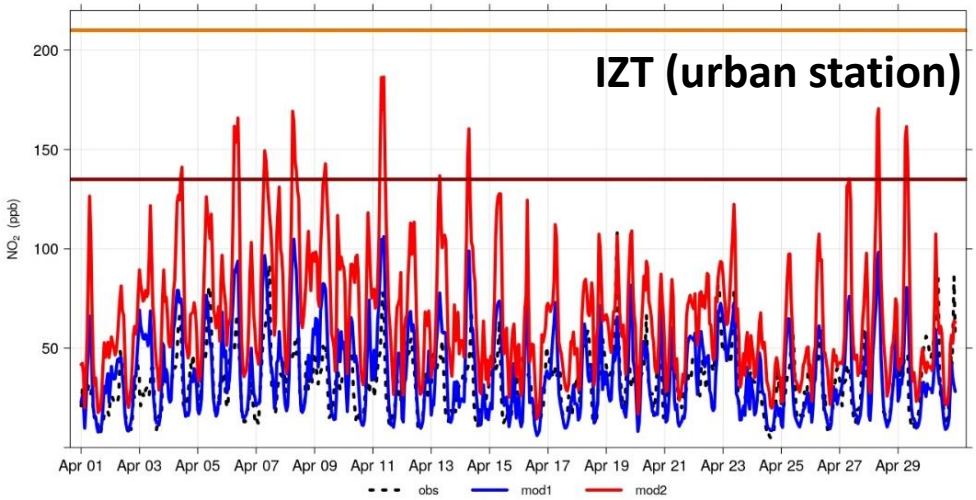


No -PROAIRE



Average increase: +26 ppb

Peak daily increase: up to +80 ppb
Exceedances of the WHO hourly limit value



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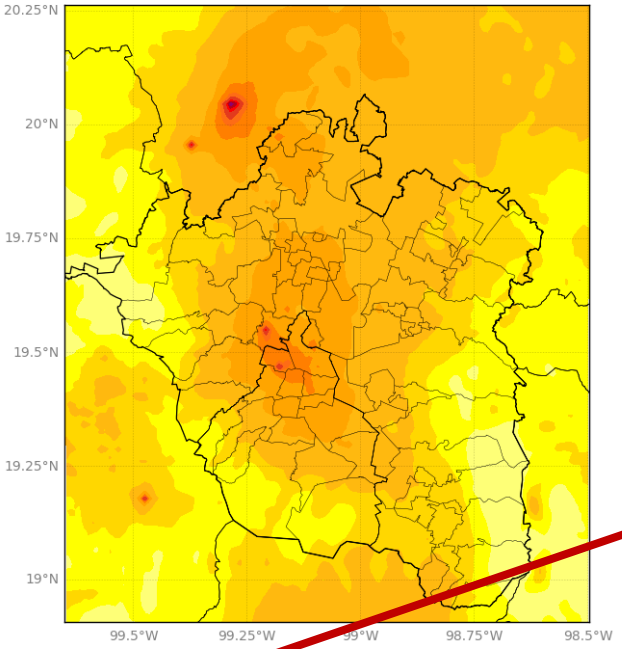
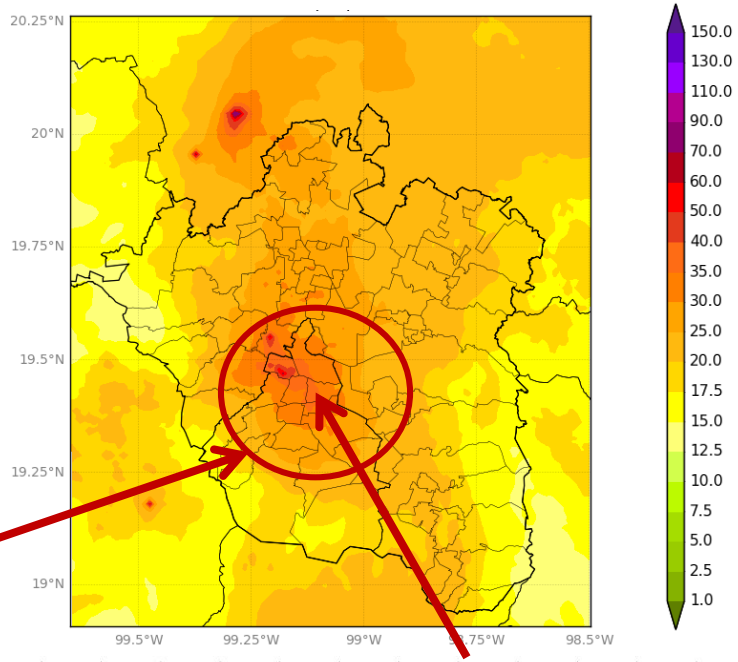
Scenario analysis – No-PROAIRE
$PM_{2.5}$ hourly average (April 2016)

Base Case

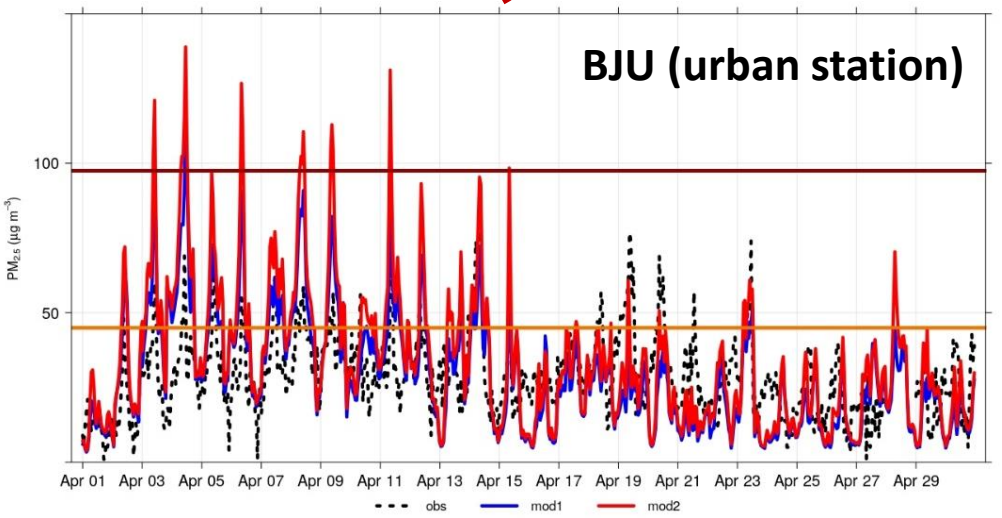


No -PROAIRE



Average increase: +4.5µg·m^{-3}

Peak daily increase: up to +30µg·m^{-3}



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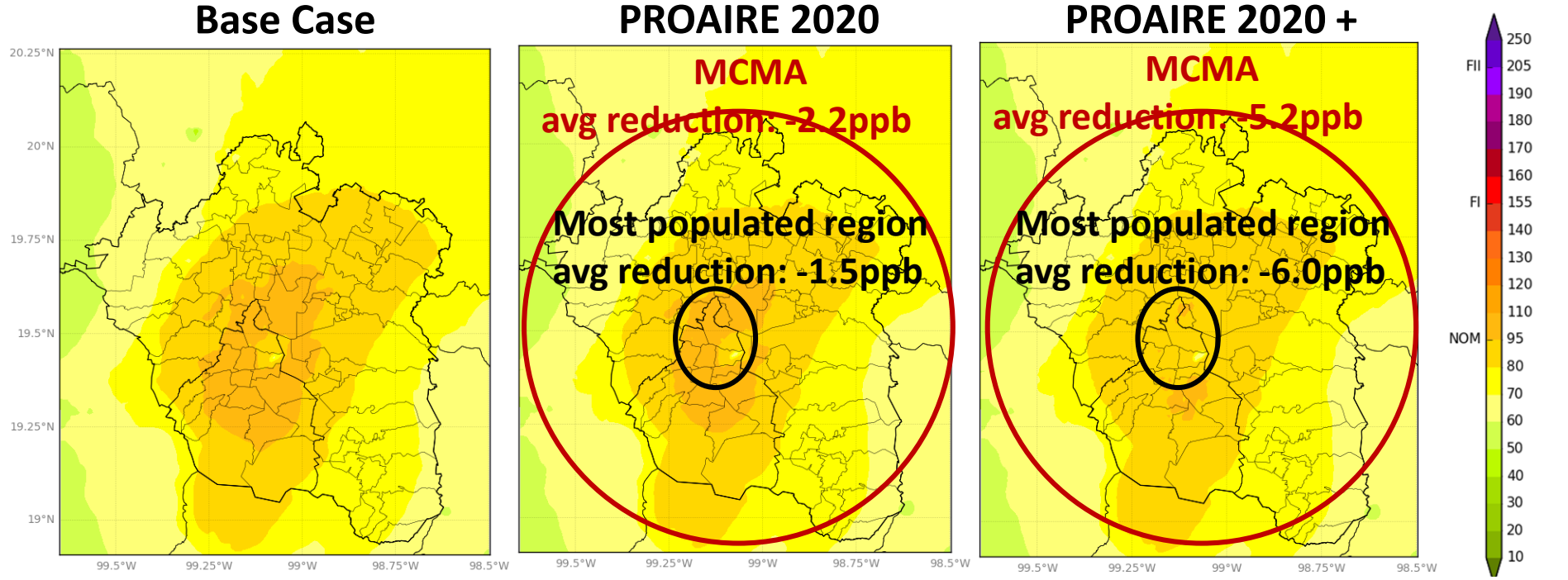
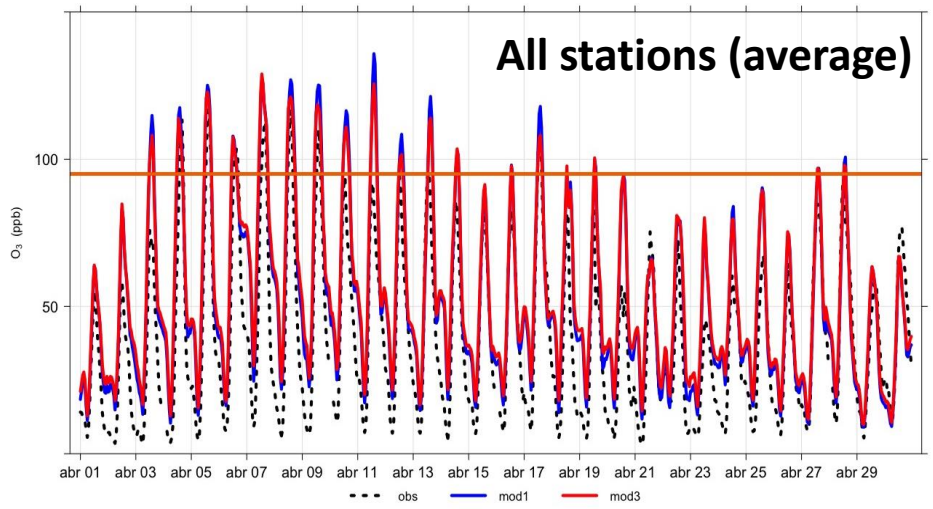
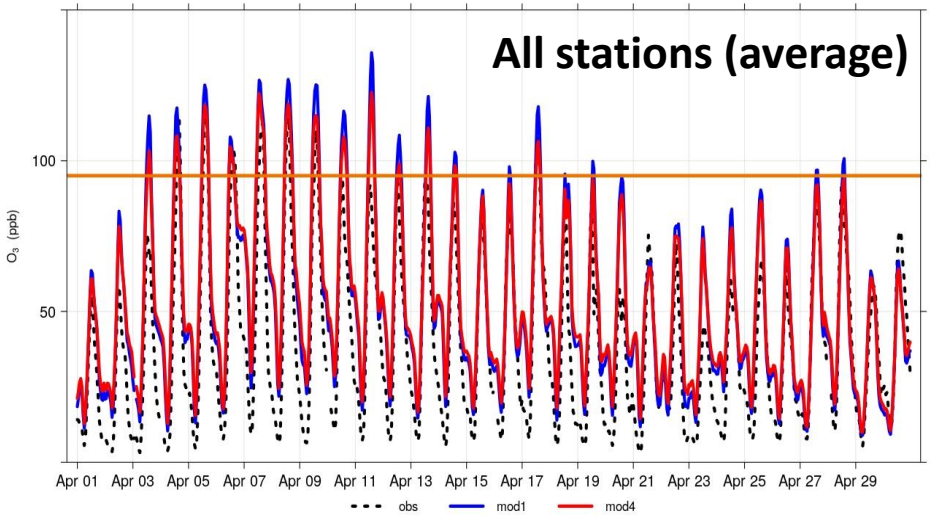
Scenario analysis – PROAIRE2020 & PROAIRE 2020+

O_3 hourly average (April 2016)







Take home messages

- The use of modelling tools (combined with observations) is crucial for the decision–making process on air quality management policies.
- Emissions are key inputs. The use of emission factors based on local and real world on-road measurements is necessary to improve their characterization.
- More actions to tackle VOC emissions should be included in future plans in order to effectively reduce the current O_3 levels (CDMX O_3 production is VOC-limited).
- The PVVO and HNC programs, which have proved to be effective for reducing NO_2 and $PM_{2.5}$, should be regularly updated in future plans to extend their effect to a larger amount of vehicles.
- Short term versus long term air quality plans/actions: where should we put more efforts? (reduce the peak or the average levels)
- Air pollution has no administrative boundaries: Policy coordination with other regional authorities and the central government is needed to control emission that are ocurring in the CDMX but are beyond its jurisdiction (e.g. cars coming from other municipalities, solvent content in products)

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EXCELENCIA SEVERO OCHOA

Superblocks (Superilles)

There is a scientific consensus that measures that affect citizen daily life will have to be applied to improve urban air quality.

Social sciences can enhance understanding of perceptions, attitudes, behaviors, and other human factors that drive levels of engagement with and trust in air quality managers.

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