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FAIRMODE
Forum for air quality modelling in Europe

The importance of evaluation of local traffic emission factors

FAIRMODE Technical Meeting
19-21 June 2017, Athens, Greece

Marc Guevara

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Ozone air pollution in the Mexico City Metropolitan Area (MCMA)

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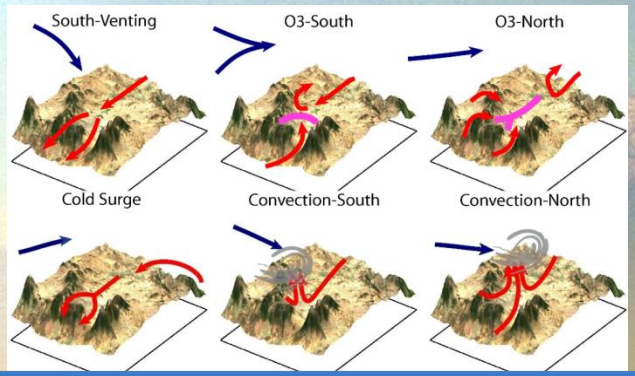
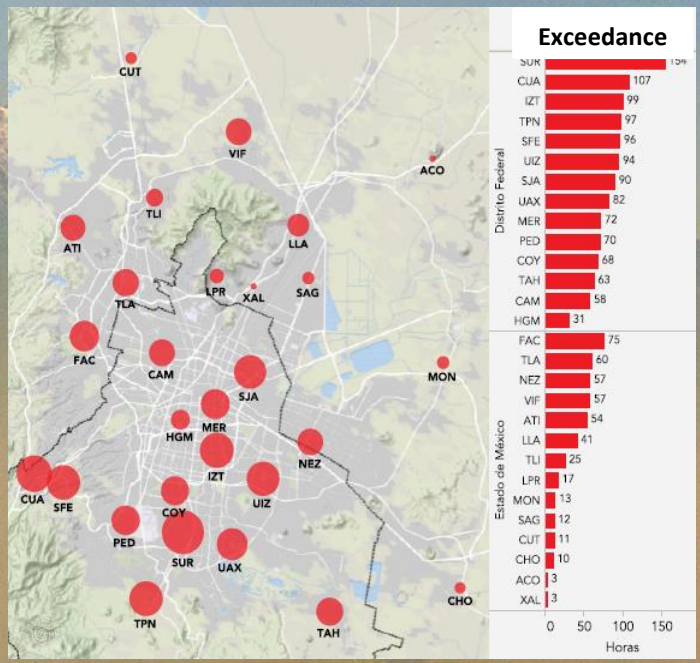
Meteorology



Local meteorology strongly influenced by the surrounding terrain that favours stagnant conditions and air pollution episodes

Air Quality



Exceedance of O_3 limit values

Emissions

Second largest metropolitan area in the world: More than 86,000 million vehicle-kilometre travelled per year (90% gasoline)

Planning policies

Mexico City limits private car use to battle pollution

Despite criticism, authorities take drastic measures to tackle the city's first environmental emergency in 14 years.

ALJAZEERA

Need for a management tool to develop and evaluate emission mitigation measures

Air Quality Forecast System for Mexico City: A computational tool for air quality management

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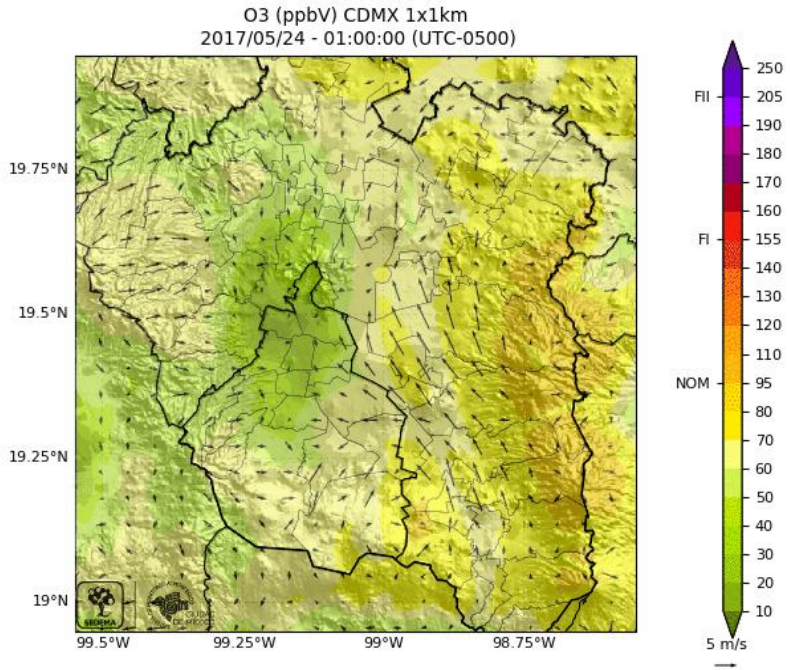
- ✓ **Complement the public information service provided by the monitoring network**
- ✓ **Know in advance the possibility that air pollution episodes occur**
- ✓ **Contribute to the development and evaluation of air quality plans (ProAire)**



WRF/HERMES-Mex/CMAQ (1km²)

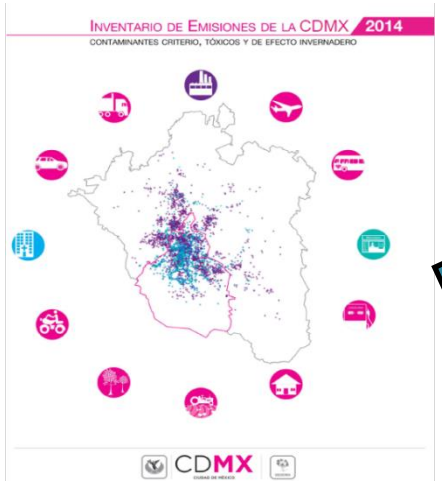
http://www.aire.cdmx.gob.mx/pronostico-aire/

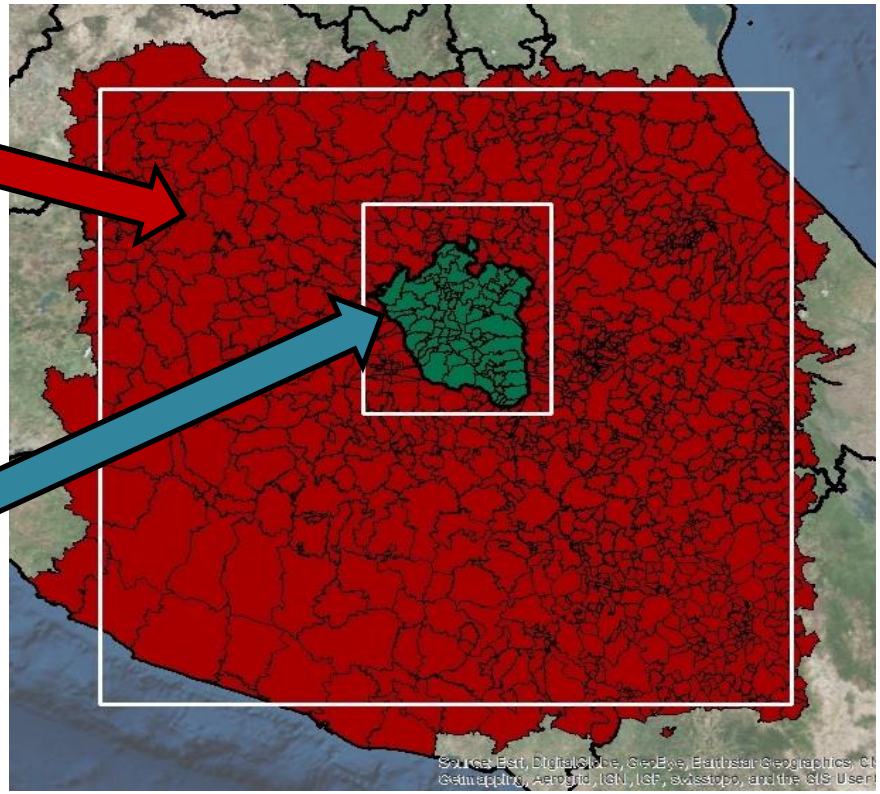
HERMES-Mex: An emission processing system for the Mexico City metropolitan area

- Two official inventories are used: (1) the MCMA 2014, developed by the SEDEMA (bottom-up), and (2) the INEM 2013, developed by the SEMARNAT (top-down).

- The two inventories report annual emissions at the municipality level and cover point sources (23), area sources (45) and mobile sources (13).

- Biogenic emissions estimated using MEGANv2.1 (Guenther et al., 2012)

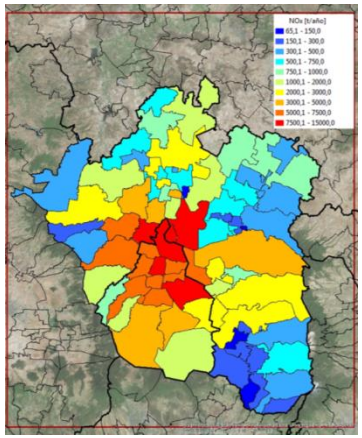




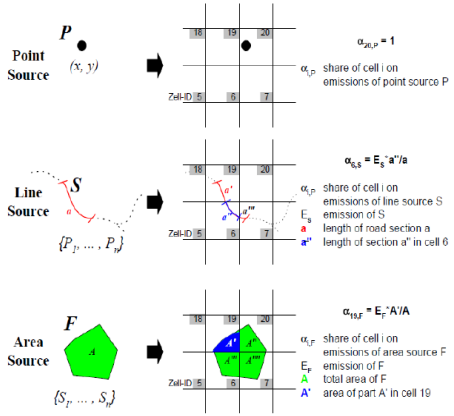
HERMES-Mex: An emission processing system for the Mexico City metropolitan area

- From annual municipal emissions to gridded hourly emissions

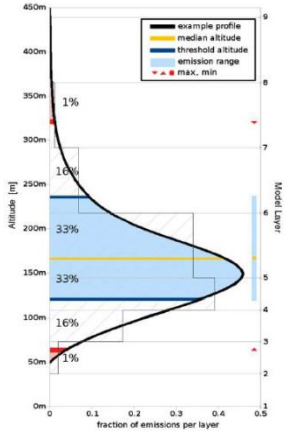
Emission Datasets



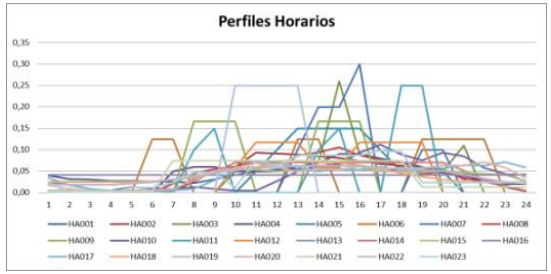
Spatial Allocation



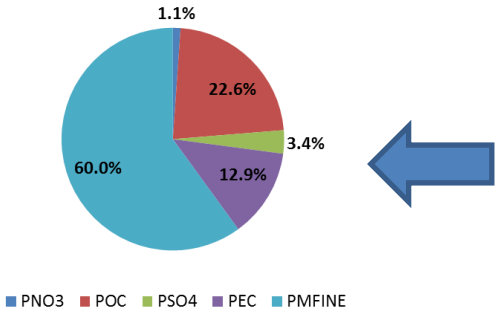
Vertical Allocation



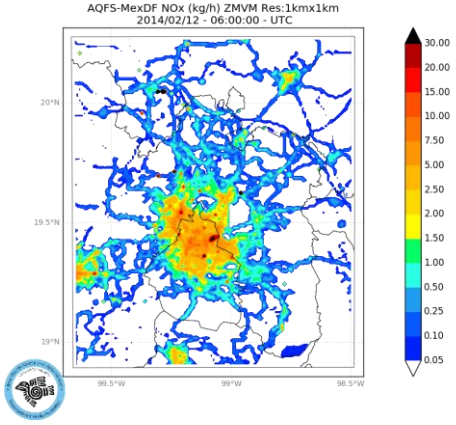
Temporal Allocation



Chemical Speciation



CMAQ ready emission data



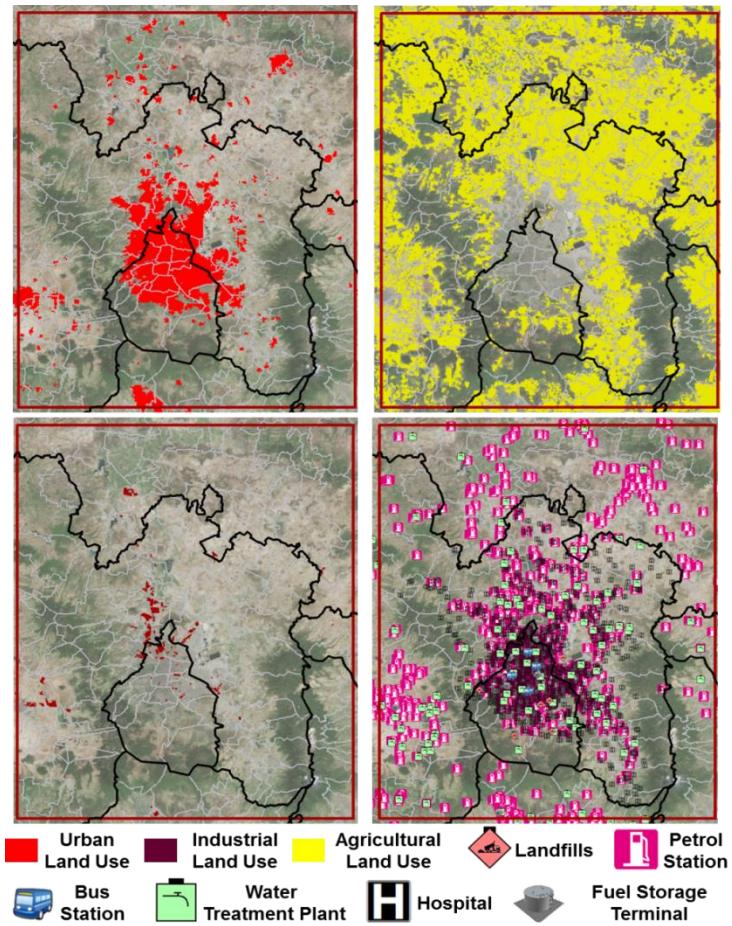
Guevara et al. (2017)

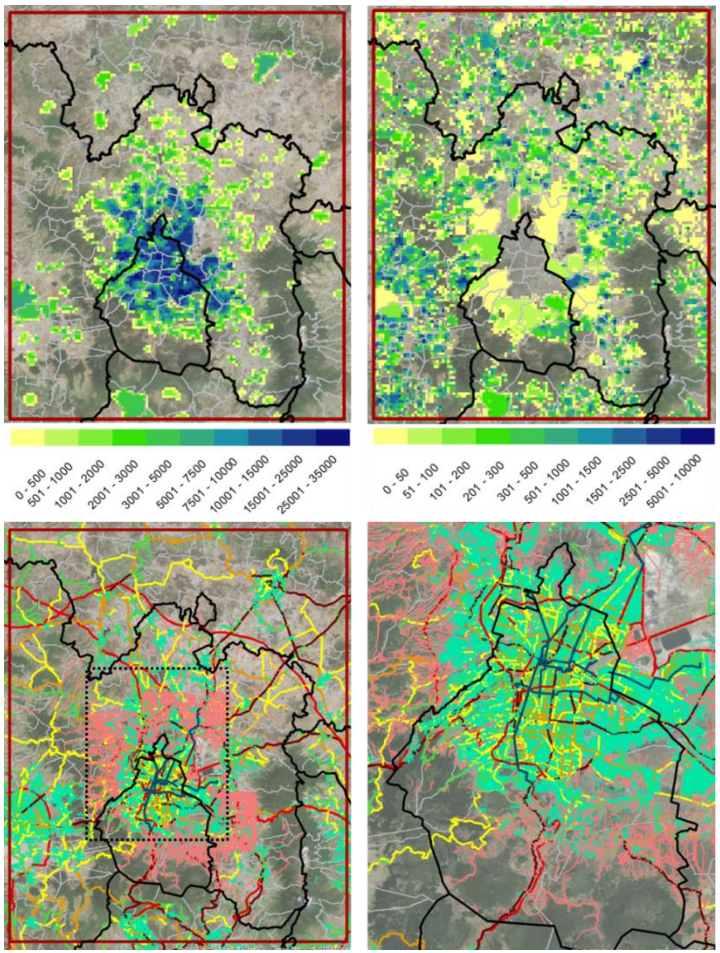
- ✓ An emission processing tool to create high resolution emission data (1hour, 1km^2) for Mexico
- ✓ Flexible platform for emission scenario analysis

HERMES-Mex: An emission processing system for the Mexico City metropolitan area

- **Area sources**: Use of multiple local spatial proxies. Urban/industrial/agricultural land uses, urban/rural population, installations (bus terminals, gas stations, hospitals,…)

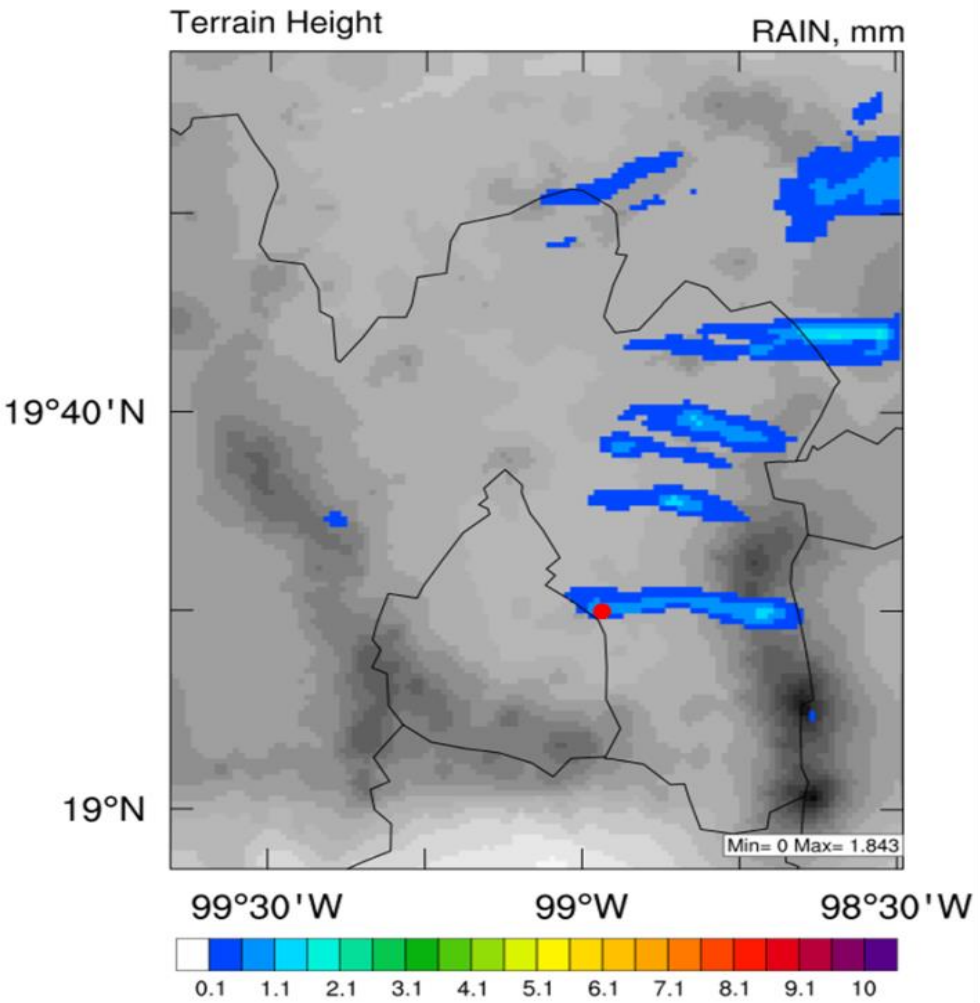
- **Mobile sources**: Road network map classified according to 8 types of roads. Traffic counts are used to assign specific weight factors to each type of road and vehicle

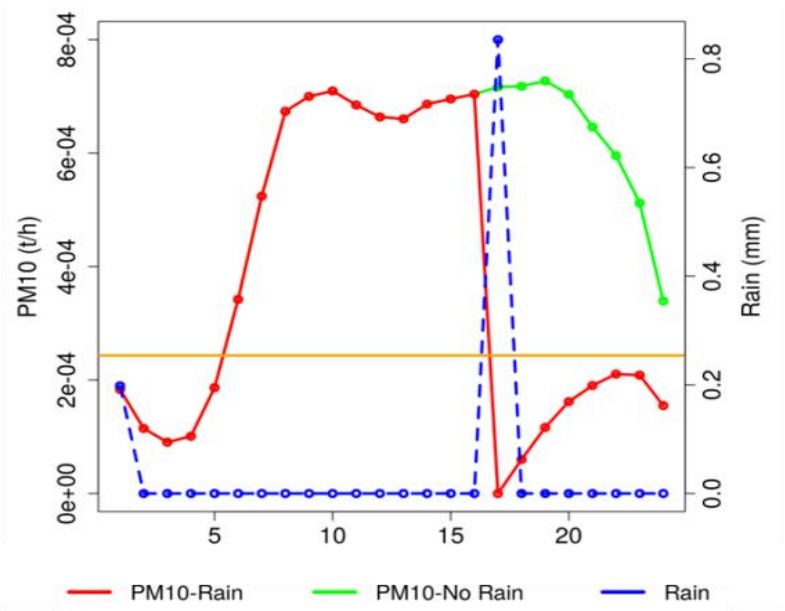


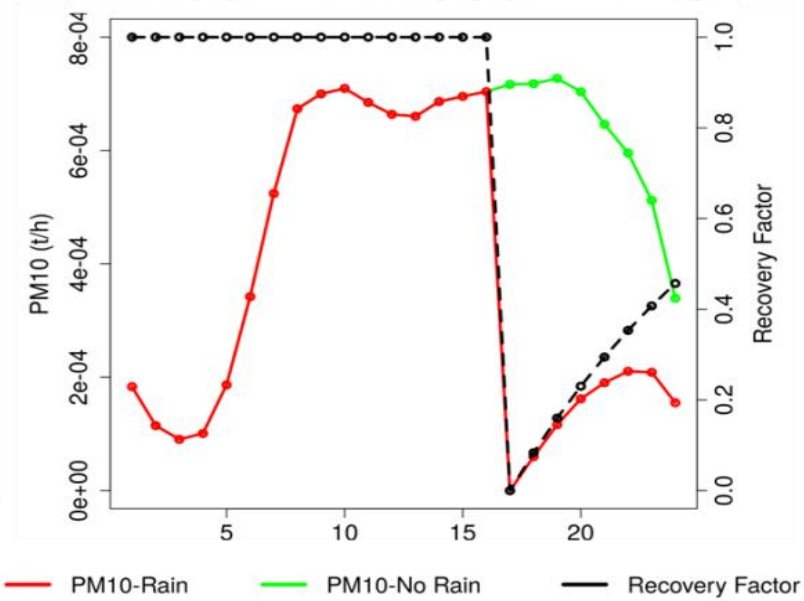


HERMES-Mex: An emission processing system for the Mexico City metropolitan area

- Estimating the effect of rain events on traffic resuspension emissions; Amato et al. (2012) methodology







Estimation of MCMA mobile sources emissions: MOBILE6.2-Mexico versus MOVES-Mexico

- **Until 2016, mobile source official emissions** were calculated using the Mobile Source Emission Factor Model for Mexico (**MOBILE6.2-Mexico**) (ERG, 2003).

- Despite assembling data from previous local works, the **emission rates** and degradation factors of MOBILE6.2-Mexico are based upon a relatively **small dataset of emission testing results** (< 1,000 vehicles) that are **currently outdated**.

- The National Institute of Ecology and Climate Change **(INECC) required an update to** the MOtor Vehicle Emission Simulator for Mexico (**MOVES-Mexico**) for official emission reporting.

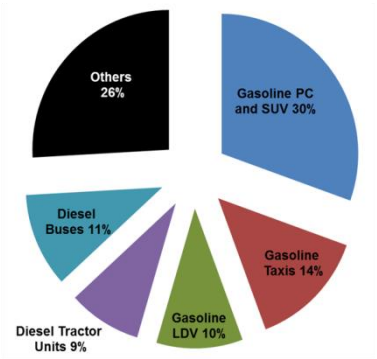
- Mexico emission data collected between 2008 and 2014 using **Remote Sensing Devices** (RSD) was used **to calibrate MOVES-Mexico** (Koupal et al., 2016).

1. **Comparing and evaluating the performance of MOBILE6.2-Mexico and MOVES-Mexico to simulate emissions and air quality concentrations in the MCMA**

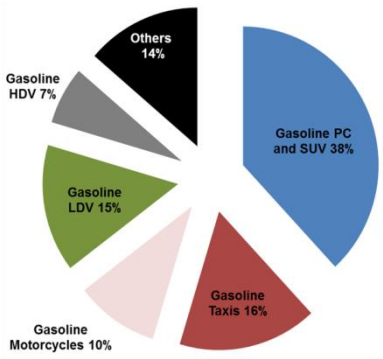
2. **Analyzing the O_3 sensitivity to mobile-source emissions in the MCMA**

Estimation of MCMA mobile sources emissions: MOBILE6.2-Mexico versus MOVES-Mexico

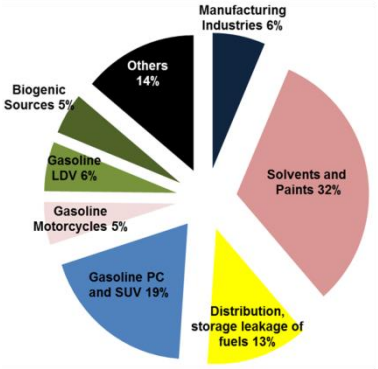
NO_x = 9,769Mg



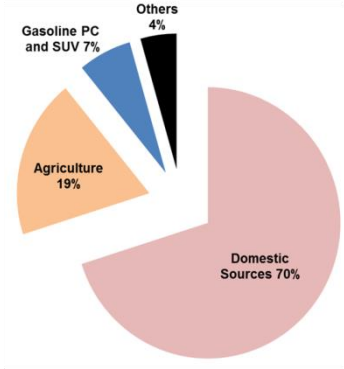
CO = 65,895Mg



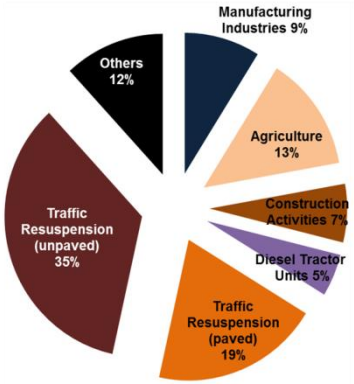
VOC = 20,484Mg



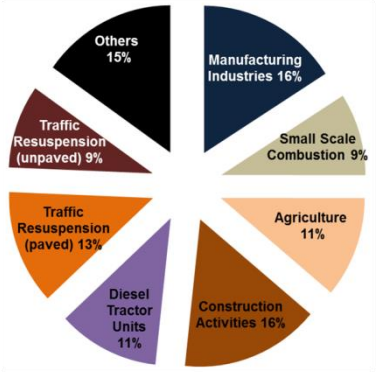
NH_3 = 2,032Mg



PM_{10} = 1,541Mg



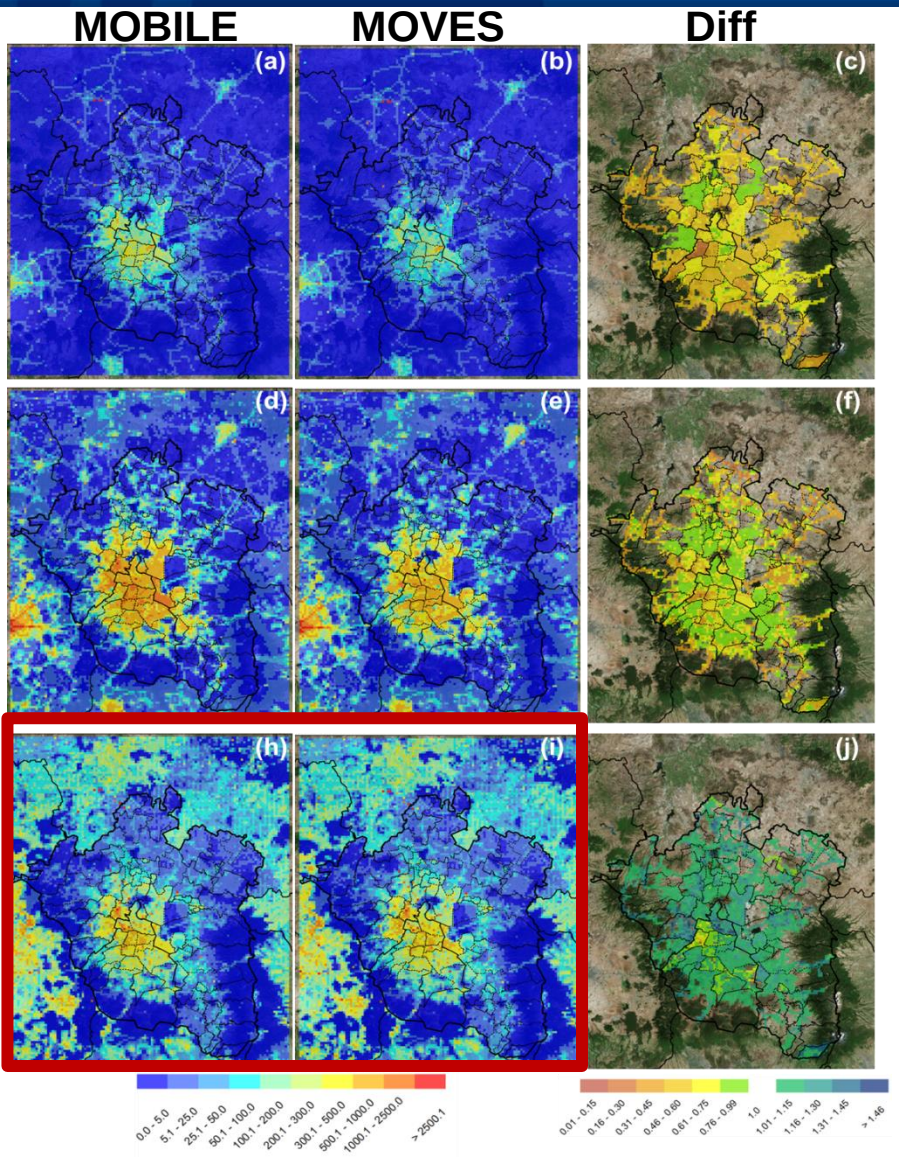
$PM_{2.5}$ = 584Mg



When using MOBILE6.2-Mexico:

- Gasoline vehicles dominate NO_x (~60%) and CO (~92%) emissions.
- The use of solvents and paints and the distribution, storage and leakage of fuels are the largest source of VOC emissions (~45%), with gasoline vehicles contributing 36%.
- Dust resuspension from unpaved and paved roads represents 55% of total PM_{10}
- Diesel vehicles represent the ~17% of $PM_{2.5}$

Estimation of MCMA mobile sources emissions: MOBILE6.2-Mexico versus MOVES-Mexico



When using MOVES-Mexico:

- NO_x, CO and VOC mobile emissions are reduced by -42%, -53% and -63%.
- When comparing total emissions, the reductions are similar for NO_x (-37%) since traffic is the dominant source.
- The changes for total VOC, PM10 and PM2.5 are lower (-26%, +8%, +6%) due to the large contributions of solvent and traffic resuspension to these pollutants.

	NO_x	CO	VOC	PM_{10}	$PM_{2.5}$
Mobile Sources	**-42%**	-53%	**-63%**	70%	29%
Total Sources	**-37%**	-52%	**-26%**	8%	6%

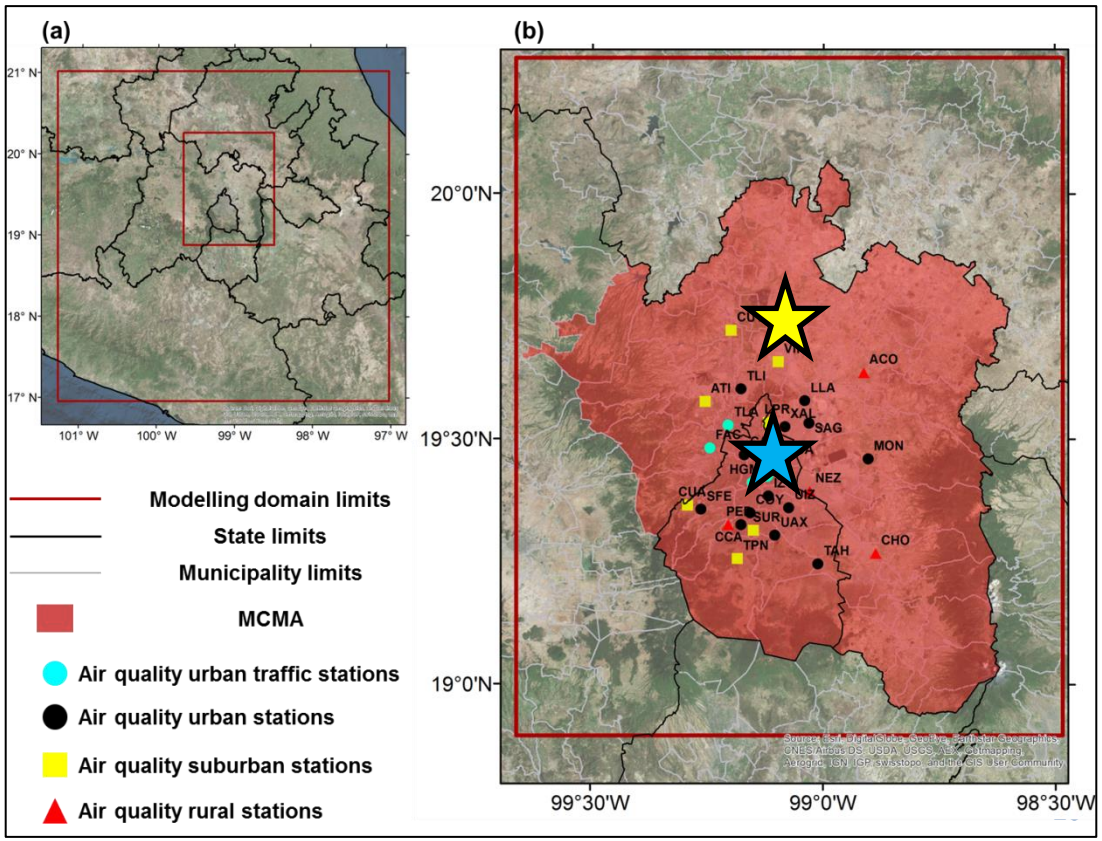
Discrepancy between the INEM and MCMA inventories in terms of agricultural waste burning $PM_{2.5}$ emissions (factor of 10) → Bottom-up versus top-down

The impact of changing the emission factor model on air quality modelled concentrations

- February 14 - 28, 2014: Activation of the O_3 environmental pre-contingency alert.
- WRF-ARWv3.6/HERMES-Mex/CMAQv5.0.2 at 3x3km and 1x1km. Global meteorological and chemical ICON/BCON from GFS and MOZART-4.
- Comparison with measurements from the RAMA air quality monitoring network for CO, NO_2, O_3 and $PM_{2.5}$

- Focus on areas with a strong influence of traffic sources and suburban zones.
- Two air quality simulations:

1. Run with the MOBILE6.2-Mexico traffic emissions.
2. Concentrations modelled when using MOVES-Mexico.



The impact of changing the emission factor model on air quality modelled concentrations

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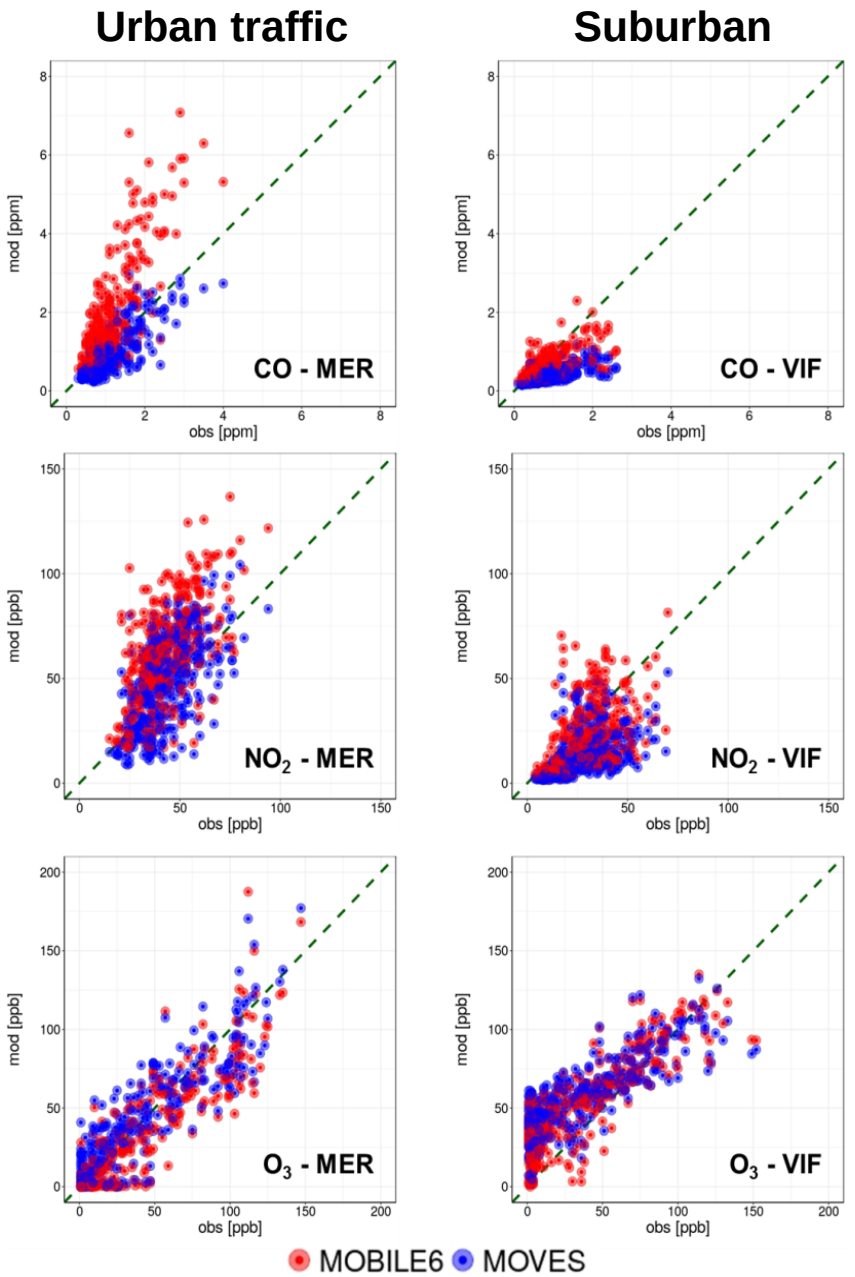
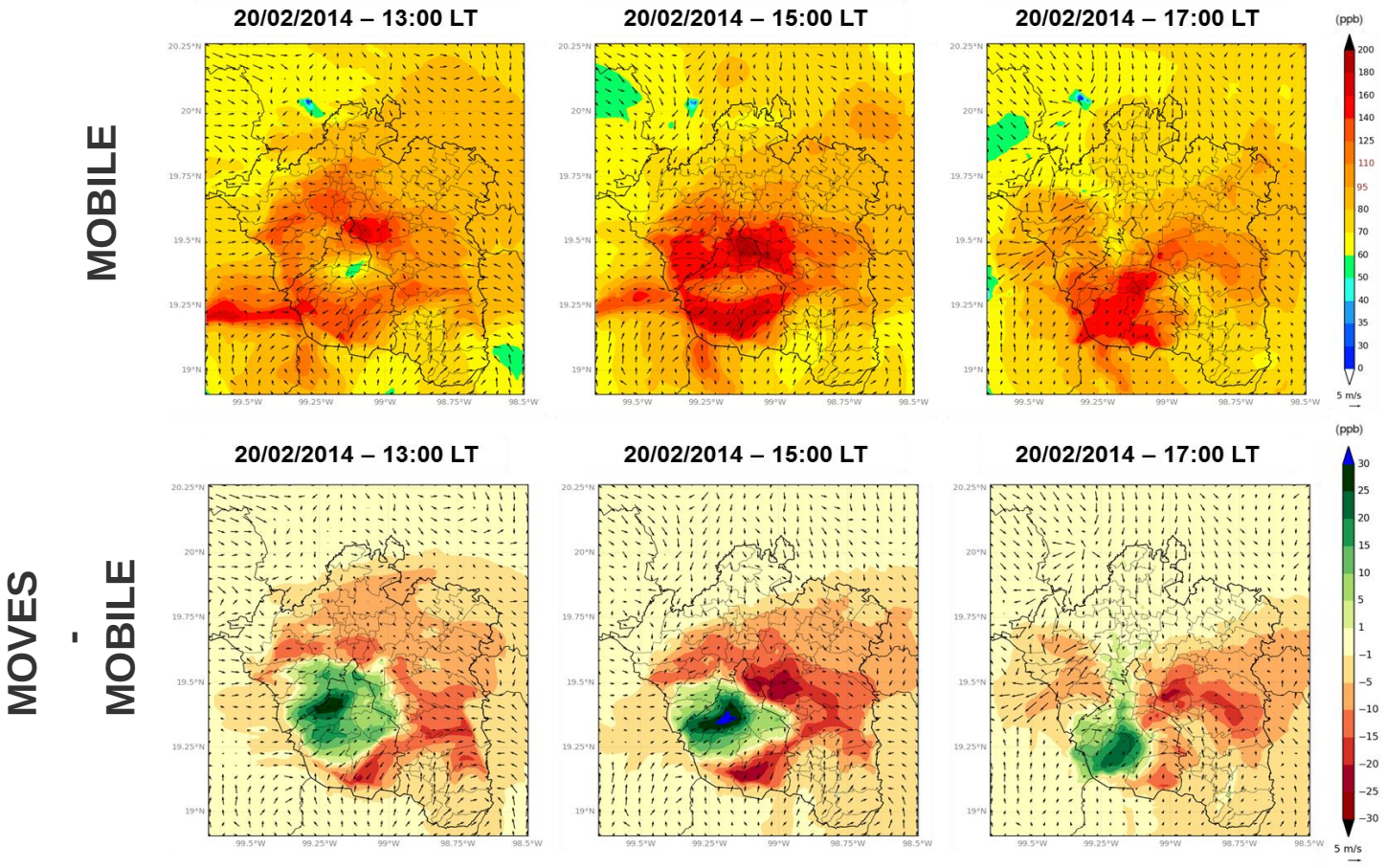
- Reduction of the overestimation of CO and NO_2 peaks in urban traffic stations.
- Increase of the CO and NO_2 underestimation in suburban areas (biomass and trash burning).
- Despite reducing O_3 precursors, concentrations remain similar or even increased. Reduction of NO_x (-37%) is larger than for toluene (-21%).



The impact of changing the emission factor model on air quality modelled concentrations

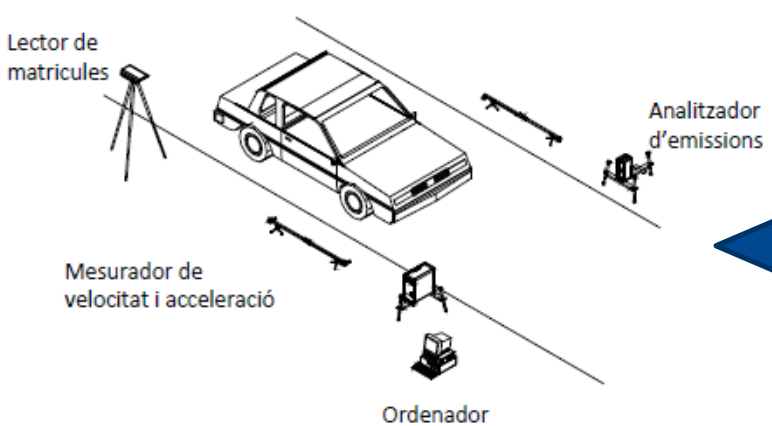
- 20th February: weak synoptic forcing associated with an anticyclone that lead to the formation of a convergence zone in the south of the MCMA and subsequent high O_3.

- O_3 peaks are increased in the core urban area when using MOVEs-Mexico while generally decreasing in mountain areas (up to ±30ppb). The urban core area is VOC-limited, while the surroundings are mostly NOx-limited.



Real-world vehicle fleet composition and emission characterization in Barcelona

- RSD campaign to characterise the vehicle fleet composition and the emission rates associated which each type of car.



			NOx				
CIUTAT Gasoil HDV (12t a 20t)	RSD Nº registros	RSD Vel media	RSD NOx [g/km] (valor medio) (**)	RSD NOx [g/km] (desviación tipo) (**)	COPERT4 (*) (HOT+COLD) NOx [g/km] @21,3kmh	NORMA EURO NOx [g/km]	RSD / CORINAIR
Pre-EURO	19	26,3	**16,98**	5,58	15,477	(X)	10%
EURO I	24	23,2	**11,31**	6,05	9,854	(X)	15%
EURO II	78	25,0	**13,32**	6,36	10,585	(X)	26%
EURO III	248	25,4	**12,53**	6,96	8,972	(X)	40%
EURO IV	160	26,6	**11,11**	5,51	5,185	(X)	114%
EURO V	40	24,7	**9,11**	5,32	2,998	(X)	204%
TOTAL/PROMIG	569	25,6	**12,10**	6,27	7,963		52%

Conclusions

- **It is important to use appropriated and validated traffic emission factors when developing / applying air quality tools for air quality planning**

  - When replacing MOBILE6.2-Mexico by MOVES-Mexico, total emission estimations in the MCMA are reduced for NO_x (-37%), CO (-52%) and VOCs (-26%), while slightly increased for PM_{10} (+8%) and $PM_{2.5}$ (+6%).

  - The air quality system's performance clearly improves in urban stations with a strong influence of traffic sources when changing from MOBILE6.2-Mexico to MOVES-Mexico traffic emissions

- **Response of pollutant concentrations to emission reductions is not linear**

  - Average peak O_3 concentrations are increased in the MCMA urban core region when just reducing traffic emissions.

  - These results suggest that in order to reduce O_3 concentrations, emission control policies of mobile sources should be simultaneously combined with reductions of those activities related to the use of solvents and distribution of LPG.