The importance of evaluation of local traffic emission factors

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

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.

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

Exceedance of O₃ limit values

Air Quality

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

- 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).

Pronóstico de calidad del aire y meteorológico para la CDMX

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

CMAQ ready emission data

Chemical Speciation

Temporal Allocation

✓ An emission processing tool to create high resolution emission data (1 hour, 1 km\(^2\)) for Mexico

✓ Flexible platform for emission scenario analysis

Guevara et al. (2017)
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 $\text{O}_3$ sensitivity to mobile-source emissions in the MCMA
When using MOBILE6.2-Mexico:

- Gasoline vehicles dominate NO\textsubscript{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\textsubscript{10}
- Diesel vehicles represent the ~17% of PM\textsubscript{2.5}
Estimation of MCMA mobile sources emissions: MOBILE6.2-Mexico versus MOVES-Mexico

When using MOVES-Mexico:

- NO\textsubscript{x}, CO and VOC mobile emissions are reduced by -42%, -53% and -63%.

- When comparing total emissions, the reductions are similar for NO\textsubscript{x} (-37%) since traffic is the dominant source.

- The changes for total VOC, PM\textsubscript{10} and PM\textsubscript{2.5} are lower (-26%, +8%, +6%) due to the large contributions of solvent and traffic resuspension to these pollutants.

<table>
<thead>
<tr>
<th></th>
<th>NO\textsubscript{x}</th>
<th>CO</th>
<th>VOC</th>
<th>PM\textsubscript{10}</th>
<th>PM\textsubscript{2.5}</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mobile Sources</td>
<td>-42%</td>
<td>-53%</td>
<td>-63%</td>
<td>70%</td>
<td>29%</td>
</tr>
<tr>
<td>Total Sources</td>
<td>-37%</td>
<td>-52%</td>
<td>-26%</td>
<td>8%</td>
<td>6%</td>
</tr>
</tbody>
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Discrepancy between the INEM and MCMA inventories in terms of agricultural waste burning PM\textsubscript{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

- 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 O₃.

- O₃ 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 with each type of car.
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\textsubscript{x} (-37%), CO (-52%) and VOCs (-26%), while slightly increased for PM\textsubscript{10} (+8%) and PM\textsubscript{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\textsubscript{3} concentrations are increased in the MCMA urban core region when just reducing traffic emissions.

  ❖ These results suggest that in order to reduce O\textsubscript{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.