

Interactive comment on “Impact of external industrial sources on the regional and local air quality of Mexico Megacity” by V. H. Almanza et al.

Anonymous Referee #3

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This paper uses WRF-Chem and WRF-Flexpart to evaluate the impact of the Tula Industrial Complex on air quality in Mexico City and identifies possible impacts from other external sources that have received less attention to date. The results are policy relevant and the methodology is sound. Publication is recommended after minor revisions.

Minor Comments: In general, the paper is rather wordy. Maybe a few passes could be made to tighten up the language and leave out some material. For example, the list of megacity campaigns (pg 26581) is not really needed in this article.

1. pg26582, ln11-17: The impacts of regional sources on cities is highly dependent on geography. Hence studies for Europe may not be relevant here as neither the topography nor the geography of the built environment is similar to Mexico City. I would recommend limiting this whole sub-section (until the following page, ln18) to Mexico City.

Furthermore, the paper should be more careful to distinguish between SO₂ impacts and other impacts (mainly O₃). A casual reading of the paper may get confused about which reductions are for which pollutant. In order not to give a misleading impression, it would be good to clarify that SO₂ is not at present a health concern, whereas O₃ (and especially aerosols) are.

The list of megacity field campaigns from pg 26581 ln 14 to pg26582 ln 3 was removed

Given that the results of our study suggest that emissions from the Tula Refinery could be contributing to the ozone levels in Mexico City, we consider important to present the reader some works which can help to set the context of the findings presented in the manuscript. Thus, we kept the reference of Butler and removed the paragraph from pg 26582 ln 14 to pg26583 ln 4.

We moved the paragraph of pg26583 from ln 5 - ln 10 to pg26590 after ln 10. Please also see comment 5 of Referee # 2. Now it reads:

“The Lagrangian model FLEXPART (Stohl, 2005) as adapted by Doran et al., (2008) and Fast and Easter (2006a) to use WRF fields, is applied in order to further study this hypothesis. FLEXPART has been applied in previous studies related to MILAGRO field campaign. For instance, to corroborate the origin of nitrogen-containing organic carbon particles at T0 to local industrial emissions under stagnant flow conditions (Moffet et al., 2008), to show that Na and Zn

particles are transported from the northern part of the basin to the southeast of the MCMA (Johnson et al., 2006), and to illustrate that the morning aerosol at T0 contained both fresh and transported aged emissions from Tula (Moffet et al., 2010).”

Pg26585 ln 17 now it reads: “Even though the current level of sulfur dioxide does not present a health concern, unlike ozone and particulate matter, a brief discussion about potential reductions in SO₂ emissions from the TIC as a result of technological changes motivated by the construction of a new refinery in Tula region is also presented.”

2. Pg26588, ln21-23: What does this mean? What were the other tests performed?

Prior to conduct the simulations of this work, a sensitivity analysis to both grid and surface nudging coefficients was conducted in order to obtain meteorological fields accurate enough to study the simulations of this study. Additional parameters like the inclusion of Convective Parameterization in the third domain and calculation of diffusion in coordinate space for the first two domains and in physical space for the third domain were also evaluated. In addition, the transport of the TIC SO₂ plume was considered as an additional parameter for the evaluation of the meteorological fields against observations. This last criterion was included because of the interest in explaining the SO₂ peak on 24 March. All of these parameters were tested in two different model setups. The first setup was a single continuous integration for the simulation period. The second setup was a set of consecutive integrations of seven 36-h overlapping segments with frequent re-initializations.

3. Pg26589, ln3-4: Is this part of the sensitivity tests that were not shown? This section should be clarified. Maybe a table should be included in supplementary material to show the improvement due to FDDA. I'm not sure ln8-10 are necessary.

The results subsections could be clarified: Flaring could be 3.2.4, and the SO₂ reductions tests (pg26599 ln13 on) could be 3.2.5. It seems that only SO₂ emissions are reduced for these tests. This should be clarified. This should also be stated clearly in Table 3. Maybe also spell out that TIC = MHR + FPRPP, and that the other tests include full MCMA emissions?

Yes, it refers to the sensitivity analysis. Even though it was considered to briefly mention the sensitivity tests, it was decided to omit this part from the manuscript, since the main results are related to the Tizayuca source, the contribution of cement plants to SO₂ levels and the modeling of the ozone plume considering flaring-generated precursors. The emphasis of those tests was on improving the simulated wind direction. Table 1 shows the statistics for the baseline case of our previous study and the configuration used in the simulations for wind direction. However, there

was a slight increase in the error for the modeled temperature at some stations. Figure 13 shows the effect of the model configurations on the resulting SO₂ time series at T0 during the simulation period. The notation for the continuous integration is as follows: **RP** is the baseline case; **RPC**: including convective parameterization in the 3rd domain; **RP6** added 6th order diffusion; **RPnoP** no PBL nudging; **RP6C**: added 6th order + Convective Parameterization. The segmented integrations use an **H** instead of and **R** and follow the same terminology: **HRP**; **HRPC**; **HRP6**; **HRPnPBL** and **HRP6C**.

The sentence in page 26589 ln22 to ln 24 now reads: “However, the model does not reproduce the peak with the model configuration used in this work nor in the configuration of our previous study (Almanza et al., 2012).”

For this reason, parts of Section 3.1 were moved to Section 2.1, and the paragraph starting in pg 26588 ln 21 to ln 23 was rephrased: “Results showed that this model configuration reasonably represented meteorology and transport of the TIC plume during the simulation period.”

The paragraph from ln8 to ln10 was removed.

The results for flaring and reduction scenarios were reorganized as suggested. Now Section 3.2.4 presents the results for flaring and Section 3.2.5 presents the results for the scenarios of emissions reductions in the TIC, MCMA and the New Bicentenario Refinery.

Line 23 was changed as follows: “The emission rate for TIC (MHR + FPRPP) is set as suggested by measurements during MILAGRO campaign (Rivera et al., 2009).”

Line 27 was changed as follows: “The scenarios are presented in Table 3. MCMA emissions are considered in all scenarios.”

The title of Table 3 was changed as follows: “Scenarios of SO₂ emissions reductions in the TIC (MHR + FPRPP) and in the MCMA involving the New Bicentenario Refinery. Units are in kg s⁻¹. Baseline case assumes no reductions in MHR and FPRPP. All scenarios include MCMA emissions. The scenarios are defined as follows. S1: New Bicentenario Refinery emissions plus unchanged emissions in MHR, FPRPP and MCMA urban emissions; S2: NBR emissions plus reduced emissions just in MHR by 2012; S3: NBR emissions plus reduced emissions in MHR by 2017. FPRPP is unchanged; S4: NBR emissions plus reduced emissions in MHR by 2017 and assuming a 70 % reduction in FPRPP emissions; S5: Scenario S4 and assuming a 1/6th reduction of urban sources in the MCMA.”

4. Pg26601, ln15-29: This is speculation at this point. I think either there should be some WRF-Chem simulations to support this or it should be removed.

We consider it is important to mention about the changes in emissions of other pollutants. The paragraph was rephrased as follows: “At the same time, emissions of NO_x and VOCs would also change as a result of these technological changes. Further research on ozone formation for those cases is needed.”

Consequently, the paragraph from ln 17 to ln 27 was removed.

5. Pg26603, ln2: Please clarify the text to say that the emissions estimates of flaring are from a separate publication. At present the text is ambiguous. Also, "can be significant" could be quantified at this point.

In the conclusions, please quantify the impact on "regional emission dynamics" – from the results presented in the paper, the impacts are present but nonetheless small compared with the emissions in the MCMA.

The sentence in line 2 is changed as follows: “The mass flow rates of acetylene, ethylene and NO_x from our previous work (Almanza et al., 2012) were used to represent the precursor emissions of the elevated flares in the Refinery. They were estimated with a CFD combustion code.”

Sentence in line 7 now reads: “Thus, a contribution from flaring of about 7 ppb on the ozone levels in the upper northwest region of the basin is feasible”.

Technical details:

pg26580, ln10: "noticeably high" is not grammatically correct

Thank you. It was rephrased. Now it reads: “The estimated emission rate is about 2 kg s⁻¹”

pg26580, ln16: add acronym (TIC)

The acronym was added. The one in pg 26584 ln1 is removed.

Fig 4 Caption: "including the high SO₂ episode in the EI" - don't you mean including the Tizayuca source in the EI instead?

Thank you for the note. The paragraph has been corrected. Now it reads: "Model results of Tizayuca industrial emissions at T1. Dashed lines are forward dispersion simulations with WRF-FLEXPART taken the emissions as an episodic event (green and blue lines) and as a continuous emission (red and cyan lines). Solid lines are WRF-Chem simulations without including Tizayuca SO₂ source in the official 2006 Emissions Inventory (thick black line) and after including Tizayuca SO₂ source into the EI (golden line)."

Fig 8: Please clarify caption and labeling and zoom in on area of interest to make this figure clearer.

The figure caption was rephrased and showing the area of interest. It now reads: "Suggested contribution to regional ozone levels: (a) plume from the TIC-generated precursors on 25 March at 15 LST; (b) plume from flaring-generated precursors on 25 March at 15 LST; (c) plume from the TIC-generated precursors on 23 March at 13 LST; and (d) plume from the TIC-generated precursors on 25 March at 18 LST. Green dots represent the location of supersites and orange dots monitoring stations. Ozone units are in ppb."

pg26586, ln6: should be grid cells instead of nodes?

The sentence was changed: "The horizontal resolution of each domain is 27, 9 and 3 kilometers respectively, with 100 x 100 grid cells and 35 vertical levels."

pg26603, ln6-7: "and possibly are" needs correcting, eg. "could be underestimated, possibly due to ..."

Please be consistent in usage of "MCMA" and "Mexico Megacity"

*There are instances where it would be preferable to say "*the* Tula refinery" instead of just "Tula refinery," for example pg 26597, ln13 and 18.*

The sentence now it reads: "Nevertheless, this result suggests that official reported emission rates could be underestimated possibly due to assuming high combustion efficiencies"

The manuscript was reviewed for a consistent use of MCMA and Mexico Megacity, as well as when referring to the Tula Refinery.