Geophysical Research Abstracts
Vol. 15, EGU2013-576, 2013
EGU General Assembly 2013

Contribution of Tula Refinery flaring emissions to the Mexico megacity

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Flaring is an important source of greenhouse gases, particulate matter and Volatile Organic Compounds (VOCs) in both upstream and downstream operations in the oil and gas industry. In 2010 Mexico was the eleventh emitting country with 2.5 billion cubic meters of gas flared (World Bank, 2012). Black carbon (a component of soot) emissions from flaring facilities are of particular interest because soot is considered a short-lived climate forcer (SLCF) (UNEP, 2011).

In 2011 there were 23 megacities of at least 10 million inhabitants. It is expected that this number increase to 37 by 2025, which will include one more in Northern America (NA) and two more in Latin America (UN, 2012). International collaborative projects like MILAGRO in NA and MEGAPOLI/CityZen in Europe, have been conducted to assess the impact of megacities air pollution at several scales. The former focused on the air pollution plume of Mexico City Metropolitan Area (MCMA), the largest megacity in NA.

This work studies the contribution of flaring emissions from Tula Refinery to regional air quality. This is accomplished in two steps. First, the flame of a representative sour gas flare is modeled with a CFD combustion code in order to estimate emission rates of combustion by-products of interest for air quality. Mass flow rates of acetylene, ethylene, nitrogen oxides, carbon monoxide, soot and sulfur dioxide are obtained. The emission rates of NO_2 and SO_2 are compared with measurements obtained at Tula as part of MILAGRO field campaign. The rates of soot, VOCs and CO emissions are compared with estimates obtained by Instituto Mexicano del Petróleo (IMP). The second stage takes the flaring emission rates of the aforementioned species as inputs to WRF-Chem in order to simulate the chemical transport of the plume from 22 March to 27 March of 2006. The air quality model presented reliable performance of the resolved meteorology, with respect to the Mean Absolute Error (MAE), Root Mean Square Error (RMSE), mean bias (BIAS), vector RMSE and Index of Agreement (IOA).
WRF-Chem outputs of SO_2 and soot are compared with surface measurements obtained at the three supersites of MILAGRO campaign. Results suggest a contribution of Tula flaring activities to the total SO_2 levels at the urban supersite (T0) of 37 %, and of 39 % at the suburban supersite (T1). In the MCMA, modeled SO_2 is compared with representative monitoring stations of the MCMA Monitoring Network (RAMA). The suggested contribution is about 43 % and 36 % at the north and south regions of the basin respectively. As for soot, results indicate low contribution at the three supersites, with less than 0.1% at three supersites. According to the model, the greatest contribution of Tula flaring emissions to the three supersites and the MCMA basin occurred on 23 March, which coincided with the third cold surge event reported during the campaign.