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A comparison between Cal–Mex in Tijuana and Cal-Nex in Pasadena on aerosol optical properties, ozone and reactive nitrogen

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ABSTRACT

Results of atmospheric measurements during Cal–Mex field campaign are presented in this work. Cal–Mex was designed to provide insight into trans-border pollution transport in the Tijuana–San Diego area overlapping the last stage of project Cal-Nex. $PM_{2.5}$, size distribution, optical properties, ozone and reactive nitrogen species among others, were continuously measured at Parque Morelos (PQM), the supersite for Cal–Mex, located inside the metropolitan area of Tijuana. Although PM and ozone levels at PQM were low during the campaign, we show that besides Tijuana sharing the same air basin with San Diego, it also shares the same synoptic conditions that leads to the occurrence of ozone events in the metropolitan area of Los Angeles. Furthermore, comparisons of ozone, NOy, HNO_3, mass absorption efficiency (MAE), aerosol absorption (σ_{abs}) and scattering (σ_{sct}) coefficients show common features between Cal–Mex PQM and Pasadena at Cal-Tech, one of the Cal-Nex project supersites. Air parcels arriving to PQM from NW (San Diego) exhibit MAE characteristics of aged aerosol. In

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addition, NOx/NOy ratios are in the transition stage between photochemically young and aged parcels, indicating that, maybe, aged parcels were enriched with more locally recent emissions.

1. Introduction

The effect of aerosols on climate and the environment has been extensively studied by the international scientific community (IPCC, 2007). Particles suspended in air from both anthropogenic and natural sources are known to affect air quality, Earth's energy budget, and also contribute to global climate change (WHO, 2006; IPCC, 2007). Aerosol particles change and age during their atmospheric lifetime, modifying their optical and hygroscopic properties that subsequently determine their radiative characteristics and the ability to affect the clouds precipitation efficiency and microphysical structure (Adler et al., 2013; Kaufman and Koren, 2006; Yu et al., 2006). Moreover, fine particles with diameters smaller than 2.5 μm affect visibility and have the potential to produce respiratory diseases (Pope and Dockery, 2006).

On the other hand, tropospheric ozone (O_3) is both an air pollutant and a greenhouse gas. Ozone has adverse health effects on humans and on vegetation, and is a major constituent of smog (Finlayson-Pitts and Pitts, 1999; Jacob, 1999). Ozone is produced in the troposphere through photochemical oxidation reactions of volatile organic compounds (VOCs) and CO in the presence of nitrogen oxides (NOx = NO + NO_2). Tropospheric NOx has a relatively short lifetime of several hours to a few days (Finlayson-Pitts and Pitts, 1999). NO_2 and NO are often, through their daytime chemistry, coupled in the troposphere. NO_2 reacts with the hydroxyl radical (OH) to form nitric acid (HNO_3).

Tijuana, Mexico, is in the northwestern corner of the Baja California Peninsula, bordered on the north by San Diego in California, US (Fig. 1). It is the most important city of the state of Baja California. According to the 2010 Mexico census, the Tijuana metropolitan area had a population of 1,559,683 inhabitants (INEGI, 2011). Since the Border Industrialization Program carried out by the Mexican government in 1965 (Ferrante, 2012) and the North American Free Trade Agreement (NAFTA) in 1994 (Hufbauer and Schott, 2005), many labor-intensive factories, called "maquiladoras" have been established in the city. Currently, 80% (2300 approximately) of maquiladoras in Mexico are concentrated in the 10 largest cities along the border with the United States (INEGI, 2000). There are more than 800 maquiladoras in Tijuana, which take advantage of its proximity to the border city of San Diego for the easy exchange of raw materials and products. All of these industrial developments, and the increased growth of population in this metropolitan area, are expected to adversely affect the air quality. This city was the subject of project Cal–Mex 2010 (Bei et al., 2013), a collaborative effort between several educational and government institutions of Mexico and the United States. Its main goals were to understand trans-border pollution in the Tijuana–San Diego area, a binational metropolitan area and possibly the most active border crossing in the world. Cal–Mex took place during May and June of 2010 and was designed to run in parallel to the last stage of project Cal-Nex with the additional goal of contributing with information on the Mexican side of the border to Cal-Nex (Ryerson et al., 2013).

Few studies have been carried out to assess air quality at Tijuana Metropolitan Area (SPA, 2011). In general, the majority of the studies on the origin of the air pollution in the Tijuana–San Diego air basin have pointed out that Tijuana might be the most important contributor to this problem. Since the mid 1970's, Becker et al. (1976) proposed that Tijuana would become a much larger contributor of air pollutants to San Diego, based on the hypothesis that a high growing economic development for Tijuana would be associated with a rapid population increase, but with the less stringent pollution control measurements of San Diego. Mukerjee (2001) reported a characterization of emissions and other criteria pollutants to assess air quality impact from economic activities like border traffic and industrial emissions. Similar analysis of the meteorology on the air pollution in the Tijuana–San Diego region have suggested that the ozone problem is complicated by transported air pollution from the South