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Evolution of anthropogenic aerosols in the coastal town of Salina Cruz, Mexico: Part I particle dynamics and land–sea interactions

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Abstract

Measurements of aerosol particles in a coastal city in southeast Mexico show that the concentrations and optical properties are strongly linked to land and sea breezes. Maximum concentrations of condensation nuclei (CN), black carbon (BC) and particle bound polycyclic aromatic hydrocarbons (PPAH) occur during land breeze periods and decrease with the sea breeze. The concentrations of particles in air from the ocean, however, remain significantly above background, maritime values as a result of the recirculation of anthropogenic emissions. The mass size distribution is dominated by particles larger than 5 μm when wind speeds exceed 4 m s^{-1}; otherwise, the uptake of water vapor onto unactivated particles is the process that dominates the growth of particles. Precipitation removes particles larger than 5 μm but CN, BC and PPAH concentrations are minimally affected.

Keywords: Particle dynamics; Pollution recirculation; Marine air quality

1. Background

Salina Cruz is a medium sized town situated on the Pacific coast of the Isthmus of Tehuantepec (16.2° N, 95.2° W). The city, with an official population of 230,000, is the southern terminal of the railroad that crosses the Isthmus of Tehuantepec and also serves as a southern port primarily for the products of one of Mexico's largest oil refineries. The presence of this refinery and its emission of copious quantities of gases and particles was the motivation for a project to measure these contaminants and evaluate their impact on the regional environment, especially related to processing by clouds (discussed in the Part II companion paper).

The presence of the particles from this area was first noticed in 2001 when the C-130 aircraft, operated by the US National Science Foundation, was making measurements in the Mexican Intertropical Convergence Zone (ITCZ) during the 2001 East Pacific Investigation of Climate (EPIC) project (Raymond et al., 2004) in a region approximately 700 km to the south of Salina Cruz. The concentration of condensation nuclei (CN) was four to five times higher when winds were from the direction of southern Mexico than when they were from the west (Baumgardner et al., 2005). Three years later, in February 2004, the same aircraft made measurements much closer to Salina Cruz (http://raf.atd.ucar.edu/Projects/GOTEX/docsum.html) and measured a plume

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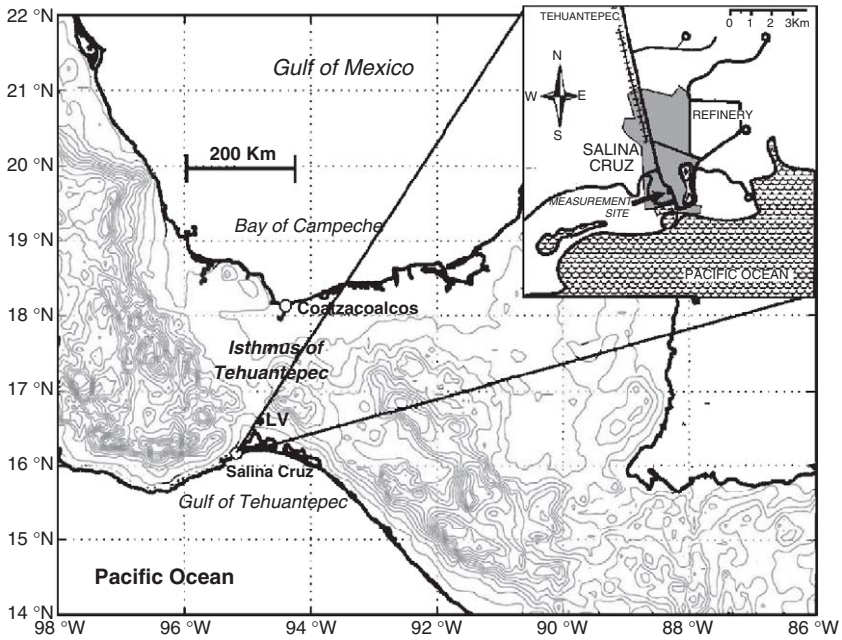

Fig. 1. Topographic map of the region around the city of Salina Cruz, Mexico. The first two contour lines are 50 and 200 m, respectively. Each additional line is 250 m. Map courtesy of R. Romero-Centeno.

of particles with sizes larger than 0.05 μm and concentrations greater than 50,000 cm^{-3}, 80 km downwind of the city (unpublished data).

The following spring, a research team from the Universidad Nacional Autónoma de México installed a suite of instruments in the city of Salina Cruz to measure the properties of gases and particles during the period June 4–18, close to the source of the pollution seen in previous studies over the ocean. The primary goal of the project was to evaluate the influence of anthropogenic emissions on cloud and precipitation processes and to estimate the effects of cloud processing of pollutants. According to climatological records of this region, the month of June is a period of maximum precipitation.

The measurement site was located in the town of Salina Cruz at the Mexican Oceanographic Research Institute[1] (N 16.178°, W 95.196°). The site was approximately one and a half kilometers north of the waterfront and south of the majority of vehicular traffic in the heavily populated areas. On the northeast border of the town, about 2 km from the measurement site, is a large oil refinery (inset, Fig. 1). As also shown in Fig. 1, the topography of Salina Cruz and the surrounding region is complex with numerous small hills within and around the city. The city is situated at the most southern end of the Isthmus of Tehuantepec, a narrow region that separates the Gulf of Mexico from the Pacific Ocean. In the central part of the Isthmus there lies a 40 km gap in the mountain range. The wind direction and magnitude are a combination of large scale meteorological conditions and topographical features (Romero-Centeno et al., 2003).

The majority of the particles at the research site come from local emissions. A road passes in front of the institute that is heavily used during the day by cars, local buses and large trucks. The majority of the trucks are diesel whereas the buses were a mixture of diesel and gasoline. An additional source of BC was a diesel burning train that passed infrequently on the eastern edge of the research site. Ships in the harbor to the south, less than a kilometer from the site, could also be seen to occasionally emit dark smoke, presumably from diesel engines.

In the following sections we present an evaluation of the evolution of the physical, optical and some of the chemical properties of aerosol particles with respect to meteorological conditions and precursor gases and identify the primary production and growth mechanisms. This paper, Part I of three parts, focuses on particle dynamics. Part II presents an analysis of the chemical composition of the particles and Part III is a modeling study of the air motion in this region.

[1] The research institute is part of the Mexican Navy operation in the Salina Cruz region.