

## **Tropospheric ozone and its effects on the main agricultural crops of the region**

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In recent years, as a consequence of climatic change, the global scientific community has focused on polar regions, but mountain systems are extremely fragile and may be irreversibly damaged by different natural disturbances such as hurricanes (very frequent in the Caribbean) and forest fires, but also by anthropogenic aerosol emissions, which have contributed to the deterioration of these fragile ecosystems. These primary aerosols are precursors to the formation of tropospheric ozone, which causes irreversible damage in forests, to vegetation in general, and to human health, negatively influencing food security and biodiversity (Ramírez et al. 2008). Ozone has a direct influence on global change. It is the third most important greenhouse gas, contributing 25% of the anthropogenic component of global warming, thereby affecting the climate system (MARM, CIEMAT. 2010). The objective of monitoring in Panama, México, and Cuba has been to show that ozone levels have effects in both mountainous and non-mountainous areas, and that early-warning systems are necessary to mitigate damage to agricultural crops. MATERIALS AND METHODS Central America and the Caribbean contain important mountain ecosystems, but few countries in this region collect ozone data in mountains. Consequently, sites in Panama, México, and Cuba were selected, choosing the months of greatest agricultural productivity to collect data. In Cuba, ozone data were collected in the western and central parts of the country, in Habana (at sea level), Montañas del Escambray (1140 m asl), and Ciego de Ávila (sea level). In Panama, at the meteorological station in Tocumen (sea level). In México, in Parres, southwest of the Distrito Federal (3100 m asl), and at San Luís en Xochimilco (2000 m asl) south of the Distrito Federal. In all these sites, ozone was measured continuously by dry deposition, and analyzed using meteorological parameters and synoptic maps at different altitudes. RESULTS Cuba: The period of maximum concentrations (from October to March) is the most important for ensuring national food security, because then the principal agricultural crops mature (Ramírez et al. 2010). During this stage, levels of ozone can reach 120 ppb. During March 2010, ozone concentrations were quite evident in the three study sites. In all these sites it was observed that ozone exceeded the permissible limit established in Cuba as hazardous for agricultural crops (40 ppb), when the region was influenced by continental air masses as a consequence of the arrival of cold fronts and high-pressure centers. Although levels of ozone high enough to produce severe crop damage were observed throughout the month, in the first ten days of observation levels rose above 70 ppb, coinciding with hazardous meteorological phenomena. Throughout the country damage to garlic, onions, and potatoes was observed, but in certain places where projections of ozone from the meteorological institute enabled counter-measures to be taken by the agricultural ministry, damages were less. México In August 2002, results from mountainous areas and selected non-mountainous areas were similar to those from Cuba, with respect to the difference between mountains and lower elevations, but the maximum for Parres was 190 ppb. In both Parres and San Luis, 95% of the days exceeded the harmful levels for crops established by Cuba and other countries. They also exceeded the limits for hazard to human health (110 ppb) on 52% of the days Parres and on 57% in San Luis. Panamá At Tocumen, more than 50% of the values exceeded the threshold of 40 ppb established for agricultural crop protection in Cuba in July of 2008; 48% exceeded it in August and 57% in September. CONCLUSIONS The high levels of ozone found in the three countries exceeded the limits established for the protection of both agricultural crops and forests, putting food security at risk. It is necessary to continue research in these countries and