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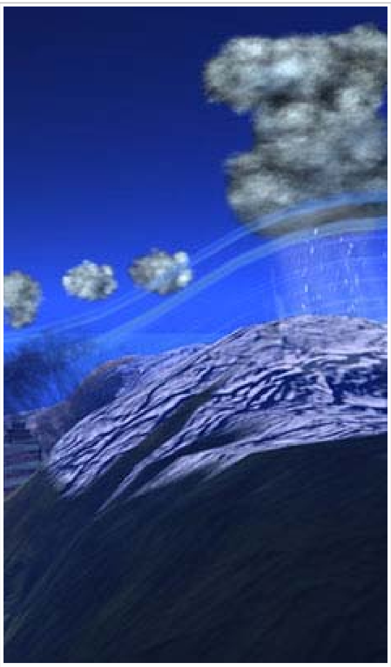

Pollution Reduces Winter Precipitation
In winter, moist air flows off the ocean and rises over the hills downwind of a coastal city, dropping its rain and snow mainly as it ascends the hills. As pollution from the city is pushed into the clouds by the hills downwind of the city, it interferes with droplet formation in the clouds and makes them smaller, as observed by NASA's satellites. The smaller cloud droplets convert more slowly into precipitation. Instead of precipitating, much of the water in the clouds evaporates, reducing the net rainfall downwind of the urban area by up to 15% to 25% on a seasonal basis. First is the unpolluted, then the polluted case. Credit: NASA

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Project Objectives

The SOAR research aircraft approaching and penetrating a mountain wave cloud over the California Sierra Nevada on 27th February 2005. The accompanying CIP image shows 100 to 200µm hydrometeors recorded during the cloud penetration at –17^{o}C)

SOAR is engaged in a study to document and model the effects of urban and industrial air pollution in California on clouds, precipitation, and stream flows in mountainous terrain downwind of the pollution sources. This effort involves hydrological analyses, satellite-based cloud analyses and numerical modeling in order to obtain insights into the recently-documented (Givati and Rosenfeld, 2004a) detrimental impacts of air pollution on precipitation in several locations in the world, most recently in California.

The focus of the overall investigation of the effect of pollution on Sierra Nevada winter precipitation is on the nature and source of the pollutants that are apparently decreasing the orographic component of the precipitation over the portions of the Sierra Nevada that are climatologically downwind of known pollution sources such as the San Francisco/Oakland/San Jose Metropolis and Southern California including Los Angeles and San Diego. A program, called the Suppression of Precipitation (SUPRECIP) Experiment, was conducted to provide the needed documentation. The number, sizes and concentrations of ingested aerosols and the resulting internal cloud microphysical structure were documented in February and March of 2005.

An important component of SUPRECIP was the use the SOAR cloud physics aircraft, to reach two objectives:

1. Measure atmospheric aerosols in pristine and polluted clouds and the impact of the aerosols on cloud-base microstructure, on the evolution with height of the cloud drop-size distribution and on the development of precipitation under warm and mixed-phase processes.
2. Validate the multi-spectral satellite inferences of cloud structure and the effect of pollutants on cloud processes especially the suppression of precipitation.

Instrumentation during SUPRECIP

- The SOAR research aircraft, leased for up to 70 hours of flight time, equipped with cloud-physics instrumentation and aerosol instruments. The cloud physics instruments used were the DMT CIP and DMT CDP. In addition, the DMT CCN counter, the DMT modified PCASP and the Texas A&M University DMA/TDMA were used during this campaign. The DMT modified FSSP was used for comparisons with the DMT CDP.

- Satellite inferences of cloud microstructure were made in terms of their effective radius. The satellite inferences were made for all of the cloud pixels within a series of boxes along the flight track. Each box was defined such that it encompassed some of the individual aircraft cloud passes. This made it possible to compare the effective diameters for the cloud passes at the height and temperature of the pass with the satellite inferences of the effective diameters at the 50th percentile for the composite cloud for all clouds in the box. Considering the differences in scale (i.e., individual cloud passes vs. the composite cloud within a box that contains the cloud passes) and time, the agreement is remarkably good (linear correlation = 0.73), giving increased credibility to the satellite inferences of suppressed precipitation-forming processes associated with pollution.

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