Section 3. Climate and the General Circulation

Urban Climatology

Urban and rural environments differ substantially in their micro-climate. These climatic differences are primarily caused by the alteration of the Earth's surface by human construction and the release of artificially created energy into the environment.

Energy Characteristics of Urban Areas

In a city, concrete, asphalt, and glass replace natural vegetation, and vertical surfaces of buildings are added to the normally flat natural rural landscape. Urban surfaces generally have a lower albedo, greater heat conduction, and more heat storage than the surfaces they replaced. The geometry of city buildings causes the absorption of a greater quantity of available incoming solar radiation and outgoing terrestrial infrared radiation. Even in early morning and late afternoon the urban areas are intercepting and absorbing radiation on their vertical surfaces. In urban areas, large amounts of heat energy are added to the local energy balance through transportation, industrial activity, and the heating of buildings.

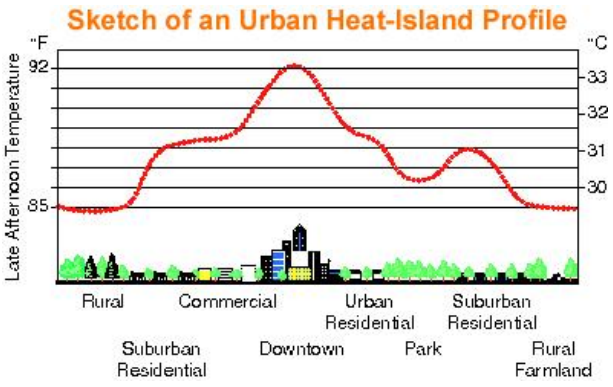

Figure 1: Temperatures in most cities are warmer than suburban rural areas. During the winter this is a small asset. However, during the summer the heat island causes discomfort, increased cooling use, and increased urban pollution.

In winter, the amount of heat generated from the burning of fossil fuels in New York City is 2.5 times greater than the heat absorbed from the sun. Finally, in rural areas, evaporation and transpiration from various natural surfaces act to cool the land surface and local atmosphere. In urban locations, drainage systems have been created to quickly remove surface water. Thus, little water is available for cooling.

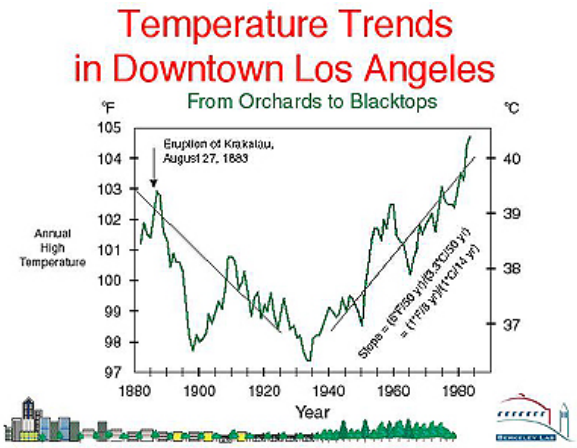

Figure 2: The annual maximum temperatures in Los Angeles show a cooling trend from the 1880s to the 1930s, probably because of increased irrigation and rapidly expanding orchards around the city. Since the 1940s, the temperatures have increased by about 6°F (1°F per decade).

Observed Climate of Cities

Urban areas tend to be warmer than the surrounding countryside. These differences in temperature are best observed at night under stable conditions when atmospheric mixing is at a minimum. Climatologists call this phenomenon the urban heat island. The urban heat island is strongest at the city center where population densities are highest and industrial activity is at a maximum. The heat island effect has been described in many cities around the world, and temperature differences between city and country can be as high as 6 degrees Celsius.

Wind in urban areas is generally calmer than those in rural areas. This reduction in velocity is due the frictional effects of the city's vertical surfaces. However, some street and building configurations within a city can channel the wind and increase its velocity through a venturi effect. Certain parts of

downtown Chicago and Winnipeg are noted for their unusually high wind speeds.

Climatologists have measured about up to 10% more rainfall in urban areas. This increase may be due to the combined effect of particulate air pollution and increased convectional uplift. Air pollution may enhance rainfall by increasing the number of condensation nuclei through the atmospheric addition of smoke and dust particles. The additional generation of heat within the city increases the number of convection currents over that surface. Convection is required to initiate the development of thunderstorms.

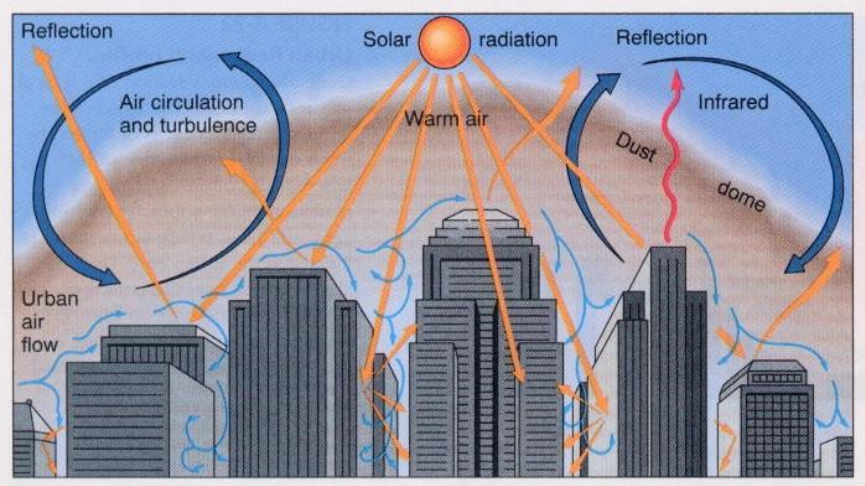

Figure 3: Insolation, wind movements, and dust dome in city environments.