NASA Facts

National Aeronautics and
Space Administration

Marshall Space Flight Center
Huntsville, Alabama 35812

FS-2000-09-167-MSFC **September 2000**

NASA's 'Heat Hunters'

Combating effects of the Urban Heat Island at the Global Hydrology and Climate Center

These flyover shots of Baton Rouge, La., represent a typical aerial view of the city (left) and a thermal readout of metropolitan hot spots, indicated by the lighter patches.

The "urban heat island" effect is a phenomenon unique to cities. Urban areas — often dominated by asphalt, concrete and other non-reflective paving and roofing materials — contain little natural vegetation to shade buildings, block solar radiation and cool the air. Thus, urban centers get much hotter during the day than rural or vegetated areas. That heat is stored and released at night, creating hot-air "domes" over cities that can keep temperatures as much as 12 degrees Fahrenheit warmer overnight than in suburbs or neighboring woodlands.

By conducting flyover tests using remote sensing technology developed for the space program, NASA's "heat hunters" — researchers at the Global Hydrology and Climate Center in Huntsville, Ala. — document patterns of urban heat formation in metropolitan centers. This information enables them to determine strategies to reduce heat islands, such as planting "urban forests" or installing reflective roofing and paving materials to bounce thermal energy back into the atmosphere.

A thermal scanner carried aboard a NASA jet collects data to help NASA scientists determine "what's hot and what's not" across the urban landscape. The scanner takes "snapshots" of surface temperatures across a city, identifying its hottest and coolest surfaces. These thermal images enable the heat hunters to identify areas that would benefit from tree planting and installation of reflective roofing or paving materials. They also provide information enabling city planners and government officials to determine which urban areas are most in need of heat island reduction strategies.

Effects of the urban heat island:

- **Overtaxed power supplies** — As much as one-sixth of the electricity consumed in the United States is used for cooling purposes, at an annual cost of $40 billion. As temperatures rise, more cooling energy is needed to maintain comfort levels, especially in large buildings. And because most downtown air conditioning systems are situated on rooftops — which are often dark in color and retain more heat — these systems are forced to work even harder to cool the air, thus raising energy costs.
- **Ozone formation** — Big cities experience a marked upswing in formation of ozone, a photochemical oxidant and the major component of smog — a serious human health threat. Sunlight and temperature exacerbate ozone formation, causing peak ozone levels during the summer season, and NASA scientists contend that urban heat islands further stimulate ozone production over affected areas.
- **Weather phenomena** — Domes of trapped, heated air can actually initiate development of thunderstorms over urban areas, leading to increased precipitation over or downwind of cities.
- **Impact on human health** — Elevated nighttime urban temperatures during prolonged heat waves increase the risk of heat-related deaths among the elderly.

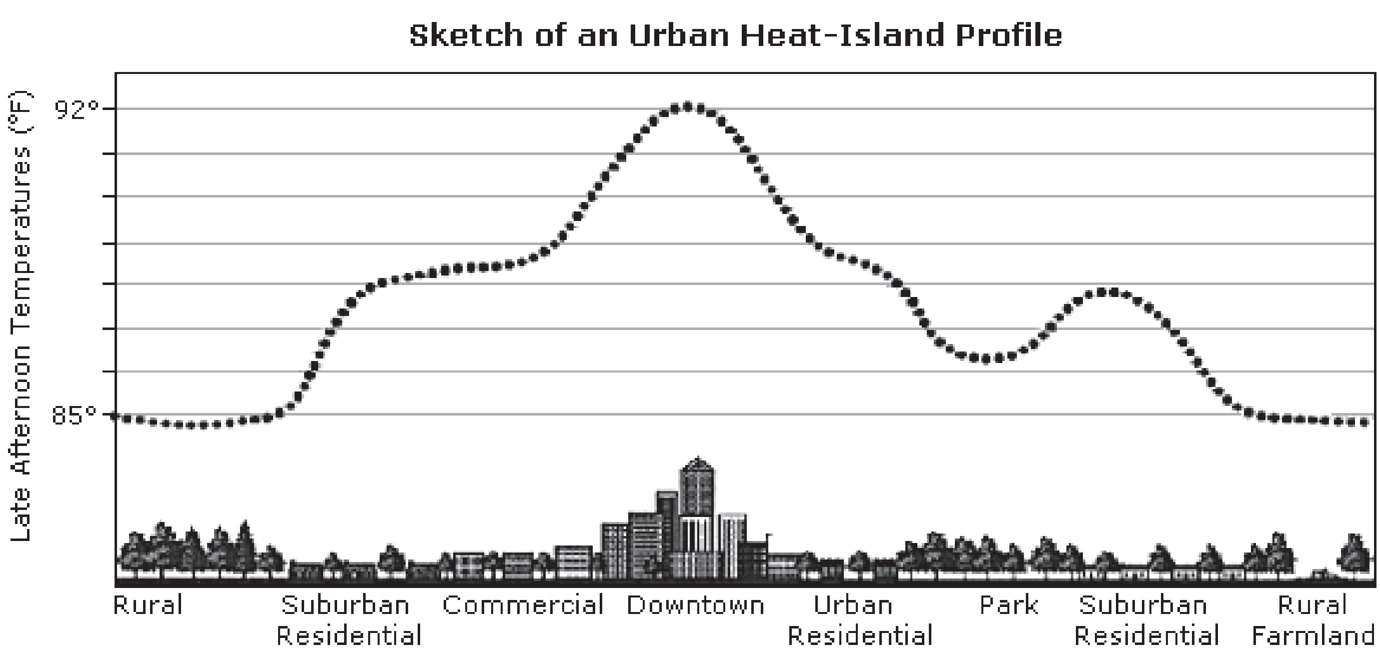
Beating the Urban Heat

According to NASA's heat hunters, the long-term strategy of installing reflective materials for roofs and pavements can cut down the urban heat island effect and help reduce associated economic, environmental and health-related costs. Lowering the burden on air conditioning systems alone could reduce harmful emissions and save millions of dollars a year on utility bills.

Improved roofing materials naturally keep buildings cooler, further reducing energy bills. Research indicates that buildings with highly reflective roofs require up to 40 percent less cooling energy than buildings covered with darker, less reflective roofs.

Roads, parking lots and driveways paved with dark, heat-absorbing materials such as asphalt also contribute to the urban heat island effect. Increasing the albedo, or reflectivity, of these surfaces through the use of lighter-colored paving materials helps cool the surrounding air.

Of primary importance to the health of a city is the strategic planting of trees throughout urban centers. Trees shade hot surfaces such as concrete parking lots and asphalt walkways, preventing storage of excess thermal energy and affording passersby greater comfort from direct sunlight. Trees cool their surroundings by drawing heat from the air, aiding in



An aerial view of downtown Atlanta, the first major city studied by NASA's urban heat hunters.

evaporating water from their leaves. By lowering circulating air temperatures, trees decrease ground-level ozone, reducing smog.

Strategically placed, mature trees can effectively reduce heating and cooling costs of a typical home or single-story office builiding by 20 percent or more.

Research History

NASA researchers Dr. Jeff Luvall, Dr. Dale Quattrochi and Maury Estes of the Global Hydrology and Climate Center launched their campaign to understand and combat the urban heat island effect in summer of 1996.

To conduct their research, the heat hunters partnered with academic and federal researchers from San Jose State University in San Jose, Calif.; the University of Georgia in Athens; Colorado State University in Fort Collins; Utah State University in Logan City; the Lawrence Berkeley National Laboratory in Berkeley, Calif.; and the National Oceanic and Atmospheric Administration's National Climatic Data Center in Asheville, North Carolina.

Using heat and weather data gathered by these partners, Luvall and Quattrochi conducted a three-year analysis of Atlanta's land-use temperatures and air quality, which provided a foundation for their theories about the prevalence and potential dangers of the phenomenon.

Early in their research, the heat hunters recognized that despite the prevalence of urban heat island effects in many cities, the intensity of the phenomenon varied from city to city according to conditions such as climate, topography and the degree and pattern of urbanization.

To better gauge the effectiveness of heat island reduction strategies in a particular area, NASA partnered with the Lawrence Berkeley Laboratory, the Environmental Protection Agency and the Department of Energy to study different urban centers and their heat island effects.

In 1998, the partnership initiated the Urban Heat Island Pilot Project, which measured the urban heat island effect in three American cities: Sacramento, Calif., Baton Rouge, La., and Salt Lake City. In each study, NASA's findings led to greater awareness — among urban planners, government officials and the general public — of the implications of the urban heat island and the potential methods of reducing risks associated with the phenomenon. The active involvement of government, industry and key non-profit groups within each city provided a critical link between NASA technology and its real-world use to help solve problems in their communities.

Additional studies are being conducted in the summer of 2000, including a flyover study of Houston, Texas. Studies of other metropolitan areas are expected to follow.

NASA heat hunters Dr. Jeff Luvall (left) and Dr. Dale Quattrochi take thermal readings on Atlanta rooftops

More about the Global Hydrology and Climate Center

The Global Hydrology and Climate Center is a joint venture between government and academia to study the global water cycle and its effect on Earth's climate. Funded by NASA and its academic partners, and jointly operated by NASA's Marshall Space Flight Center and the University of Alabama in Huntsville, the Center is an integral part of the recently founded National Space Science and Technology Center — a statewide research collective headquartered in Huntsville.

The Center conducts research in a number of critical areas. Satellite tracking of hurricanes promises to improve global severe-weather forecasting capabilities; research into lightning activity is providing new insight on the formation of tornadoes; and NASA remote sensing technologies explore new ways to improve the health of our cities, aid farm productivity and identify outbreaks of disease.

Urban heat island research at the Global Hydrology Center is supported by NASA's Earth Science Enterprise, which is responsible for a long-term, coordinated research effort to study the effects of natural and human-induced changes on the global environment. Enterprise studies are aimed at making economic and social benefits of Earth science research available to the private sector and to the general public.

More About the Marshall Center

NASA's Marshall Space Flight Center in Huntsville, Ala., is NASA's premier organization for development of space transportation and propulsion systems, NASA's leader in microgravity research — unique scientific studies conducted in the near-weightlessness of space — and NASA's leader for advanced large optics manufacturing technology.

In the past, Marshall played key roles in the development and operation of the Saturn V rocket, Skylab, the Lunar Roving Vehicle, Spacelab and the Hubble Space Telescope. Today, the Center's primary management responsibilities include Space Shuttle propulsion systems; the Chandra X-ray Observatory; future large-scale space optics systems; the X-33 and X-34 rocket planes and X-37 space plane; and science operations aboard the International Space Station.

Marshall also is responsible for developing advanced space transportation systems designed to further humankind's exploration of space while slashing the cost of getting there from today's $10,000 per pound to only hundreds of dollars per pound, or even less. The Center is working to bring a future among the stars closer to reality for the people of Earth.

National Aeronautics and
Space Administration
George C. Marshall Space Flight Center
Marshall Space Flight Center, Alabama 35812

Pub 8-1219