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Purdue Univ, Lafayette, IN School of Mechanical Engineering

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Two dimensional numerical simulations of planetary boundary layer flow indicate that urbanization (increase of surface roughness, changes in surface albedo, and the addition of anthropogenic heat sources) has a greater influence on the urban heat island than the addition of pollutants (gaseous and particulate) which are active in the radiative transfer processes of the heat budget. Although mid-day surface temperatures are decreased by adding such pollutants, temperatures at other times of day are increased. These simulations also indicate that heat islands are most pronounced with a snow cover on the ground. The warmer surface temperatures enhance low level pollutant dispersal with a consequent 25% concentration reduction. These results indicate that a change in land use is an important factor in local climate and weather modification.

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EFFECTS OF POLLUTANTS AND URBAN PARAMETERS ON ATMOSPHERIC DISPERSION AND TEMPERATURE

by

R. Viskanta and T. L. Weirich
School of Mechanical Engineering
Purdue University
West Lafayette, Indiana 47907

Grant No. R803514

Project Officer

Francis S. Binkowski
Meteorology and Assessment Division
Environmental Sciences and Assessment Laboratory
Research Triangle Park, North Carolina 27711

ENVIRONMENTAL SCIENCES RESEARCH LABORATORY
OFFICE OF RESEARCH AND DEVELOPMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY
RESEARCH TRIANGLE PARK, NORTH CAROLINA 27711

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ABSTRACT

A study of the effects of anthropogenic pollutants and urbanization on the thermal structure and pollutant dispersal in the planetary boundary layer showed that urbanization had a greater influence on the surface temperature excess between urban and rural locations than the radiatively active pollutants. The net effect of gaseous and particulate pollutants was to decrease the surface temperature around the noon hours and to increase the temperature during the rest of the diurnal cycle. The increase in the surface temperature was most significant for winter simulations with snow covered ground. The maximum temperature at the urban center for a simulation with radiatively active pollutants was about 1 K warmer than for a corresponding simulation without the radiatively active pollutants. As a result of warmer surface temperature, pollutant dispersal near the ground was improved. The feedback between radiatively active pollutants, temperature structure and pollutant dispersal was significant and resulted in a maximum of 25 percent reduction in pollutant concentrations for the winter simulations.

During wintertime the assumed rates of anthropogenic heat release in the city were found to play a more important role in the formation of the urban heat island than the radiatively active pollutants. Increase in heat release raised the surface temperature and caused the surface layer to become less stable which improved pollutant dispersal. Changes in such interface parameters as the surface roughness, moisture availability and solar albedo were found to have significant effect near-surface temperatures in the city and on the urban-rural temperature differences. The findings indicate that a change in land use is a very important factor in climate and weather modification by urbanization and industrialization.

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LIST OF SYMBOLS

a_s	Absorptance of soil, $a_s = 1 - r_s$
C_n	Concentration of species n
$\dot{C}_n$	Volumetric rate of production of species n
$C_{w,sat}$	Concentration of water vapor at saturated conditions
c_p	Specific heat at constant pressure
D_n	Diffusion coefficient of species n
E_n	Exponential integral function
e_t	Emittance (emissivity) of the air-soil interface in the thermal part of the spectrum
F	Net radiative flux defined by Eq. (22)
F^+	Radiative flux in the positive z-direction
F^-	Radiative flux in the negative z-direction
f	Coriolis parameter
g	Gravitational constant
H	Turbulent (sensible) heat flux at the air-soil interface, see Eq. (10)
Δh_g	Latent heat of vaporization of water
I_λ	Intensity of radiation
$I_{b\lambda}$	Planck's function
K_z	Turbulent eddy diffusivity in the z-direction
k	Thermal conductivity
ℓ	Mixing length, see Eq. (20)

L	Latent heat flux at the air-soil interface, see Eq. (11)
M	Halstead's moisture availability parameter, see Eq. (13)
m_p	Surface source of pollutant emissions, see Eq. (14)
NP	Refers to radiatively nonparticipating
p	Pressure
P	Refers to radiatively participating
p_λ	Scattering distribution function, see Eq. (17)
q_{an}	Anthropogenic heat emission source at the surface, see Eq. (10)
$\mathring{q}$	Volumetric rate of heat generation
r_s	Albedo (reflectance) of the air-soil interface in the solar part of the spectrum
R	Relative humidity of soil or gas constant
Ri	Richardson number
T	Thermodynamic temperature
T_s	Temperature of the soil
t	Time
u	Horizontal north velocity component
v	Horizontal west velocity component
w	Vertical velocity component
x	Horizontal coordinate, see Figure 1
y	Horizontal coordinate
z	Vertical coordinate, see Figure 1
z_o	Surface roughness
α_s	Thermal diffusivity of soil
Θ	Potential temperature defined as $\Theta = T(p_o/p)^{R/c_p}$
κ	Absorption coefficient or the ratio of specific heat at constant pressure to specific heat at constant

	volume
λ	Wavelength
μ	Direction cosine
ν	Frequency
ρ	Density
σ	Scattering coefficient or Stefan-Boltzmann constant
ϕ	Azimuthal angle

<u>Subscripts</u>

n	Refers to species n
p	Refers to pollutants both aerosols and gases
w	Refers to water vapor
Δ	Refers to the bottom of the soil layer
δ	Refers to the edge of the planetary boundary layer
ν	Refers to frequency or per unit frequency
1	Refers to aerosol
2	Refers to pollutant gas
∞	Refers to top of the free atmosphere

<u>Superscripts</u>

M	Refers to turbulent eddy diffusivity of momentum
Θ	Refers to turbulent eddy diffusivity of heat
C_n	Refers to turbulent eddy diffusivity of mass of species n

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