INTRODUCTION

The urban heat island (UHI) effect is expressed in increased air and surface temperature in urbanized areas compared to the countryside. It occurs as a result of increased sensible heat flux from land surfaces to the atmosphere near cities. Sensible heat flux consists of two components: discharged anthropogenic heat and heat radiation due to solar input. Heat from solar radiation is often enhanced by artificial land surfaces that are characterized by high heat capacities and conductivities. Another factor of UHI is the decrease in vegetation cover. Evapotranspiration associated with high vegetation cover significantly reduces surface temperature. Understanding and quantifying UHI factors is an important step toward developing adequate mitigation strategies.

Two approaches to the analysis of UHI exist. In situ measurements by eddy covariance provide accurate determination of heat fluxes in urban environments at the roof-level (Alef, 2003; Oke, 1998). However this method is incapable of capturing the variety of land surfaces and spatial heterogeneity, even at the fine scale, of urban landscapes. Yet the spatial distribution of transpiration and surface heat fluxes can be estimated using remote sensing data coupled with local meteorological observations (Chrysoulakis, 2003; Kato & Yamaguchi, 2003; Schmugge et al., 1998). In this project we implement the method proposed by Schmugge et al. (1998) and Kato and Yamaguchi (2005) for estimating heat fluxes and separating the anthropogenically discharged heat and natural heat radiation from the sensible heat flux in urban areas by combining remote sensing and meteorological data.

REMOTE SENSING DATA

- We used cloud-free and atmospherically corrected ASTER (Advanced Spaceborne Thermal Emission and Reflection Radiometer) Level 1B and 2 data products of surface spectral reflectance, spectral emissivity, and surface temperature (Figure 1). Nominal ground spatial resolution is 15 m for the three Visible and Near-infrared, 30 m for six Shortwave infrared, and 90 meters for five Thermal spectral channels. Narrow band spectral emissivities were converted to broadband emissivity using linear equation proposed by Ogawa et al. (2003). This poster is based on the processed set of image products for nightime (collected on June 21, 2003 at 9:40 pm MST).

- LandSat Enhanced Thematic Mapper (ETM+) image (30 m pixels) from May 2002 was used to create the land use – land cover map (Figure 2). Classification was performed using the expert system approach (Steelman et al., 2001).

- 10-meter National elevation dataset (DEM) Digital Elevation Model (DEM) by USGS and City of Phoenix street network layer were used as reference data and to model temperature gradients.

Figure 1. Surface temperature from nighttime ASTER image (June 21, 2003, 9:40 pm MST)

Figure 2. LandSat ETM+ produced 12-class land cover classification of CAPLTER (Spring 2000)

PRELIMINARY RESULTS AND FUTURE WORK

Spatial distribution of summer nighttime net radiation shows strong dependence on the urban landscape pattern. It is generally higher in the urban core and along transportation networks, and decreases with elevation and away from the built-up areas. Some natural areas with exposed bedrock and agricultural fields also have higher net radiation. Ground heat flux (Figure 6) is inversely related to the urban spatial pattern by being the lowest in urbanized area characterized by high degree of impervious surfaces such as pavements, buildings etc. The sensible heat flux due to anthropogenic factors (Has) cannot be computed with sufficient accuracy for nighttime due to the absence of solar radiation which causes the effect of relative increase of air and surface temperatures on heat fluxes. Kato and Yamaguchi (2005) used H in place of the Has for their nighttime data stating that no sensible heat flux was discharged from most of their study area except in the urban, industrial areas, and water. They found the spatial distribution of Has in the daytime correlated well with the urbanized areas where energy consumption is the highest. Figure 7 illustrates the combined effect of the two heat fluxes (H and LE) derived by a simple subtraction of G from the net radiation. Since dry built-up portion of the urban landscape does not have any latent heat flux most of the increased heat can be attributed to the sensible heat flux. Preliminary analysis has shown negligible sensible heat flux calculated by the equation, which allows us to conclude that most of the increased heat in the urban area as shown on the map (Figure 7) is Has.

Figure 3. Atmospheric temperature corrected by DEM, relative humidity, air pressure inferred from hydrostatic equation, and atmospheric vapor pressure interpolated for the study area (June 21, 2003 at 9:40 pm). CAPLTER boundary is in red.

Figure 4. Schematic diagram of heat balance at urban land surface. Rn is net radiation, A = anthropogenic heat discharge, G = ground heat flux, LE = latent heat flux, and H = sensible heat flux (redrawn from Kato & Yamaguchi, 2005).

Figure 5. Net radiation of the study area on June 21, 2003 at 9:40 pm

Figure 6. Ground heat flux of the study area on June 21, 2003 at 9:40 pm

Figure 7. Sensible and latent heat fluxes subtracted from net radiation on June 21, 2003 at 9:40 pm

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