How evapotranspiration varies across urban neighborhoods- application of LUMPS model

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Study

The greater-Phoenix metropolitan area has endured drought conditions for almost a decade as well as felt effects of the urban heat island phenomenon in summer months. The primary aim of this pilot study is to quantify the amount of water-loss through evapotranspiration in varying neighborhoods. Urban landscapes differ among the greater-Phoenix area; plant and surface cover can affect the amount of water used to maintain such landscapes and contribute to evapotranspiration rates.

Materials and Methods

In this study the Local Scale Urban Meteorological Parameterization Scheme (LUMPS; Grimmond and Oke 2002) was applied to estimate outdoor water use for selected neighborhoods in the Phoenix metropolitan region. LUMPS has been shown to simulate the components of the urban surface energy balance consistently with a high accuracy (Grimmond and Oke 2002). Net all-wave radiation is modeled according to Offerle *et al.* (2003). Heat storage is determined using the Objective Hysteresis Model (Grimmond and Oke 1999). The turbulent sensible and latent heat fluxes calculations are based on urban modifications to deBruin and Holtslag (1982).

The urban surface energy balance is given as:
$(Q^* = Q_H + Q_E + \Delta Q_S)$

H = sensible heat λE = latent heat
Q* = net all-wave radiation ΔQ_S = heat storage

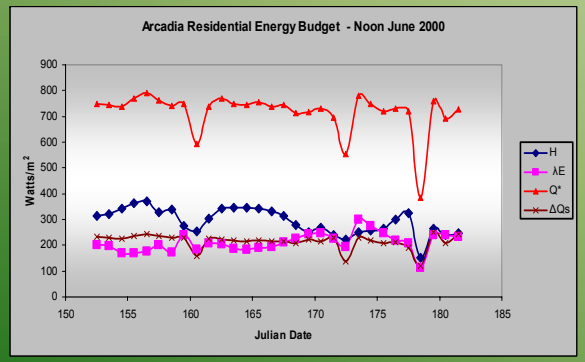

Figure 1. Example of the urban surface energy budget at noontime for June 2000 in Arcadia neighborhood.

Data Inputs

Hourly meteorological data from surface stations, such as air temperature, relative humidity, wind speed, wind direction, and incoming solar radiation was taken from Sky Harbor International Airport from the month of June 2000.

Fraction Covers (Table 1) are gross approximations using land cover classification files from work by Stefanov (2001) as well as land parcel information from the Assessor's office of Arizona. Selected neighborhoods are representative of census tracts in 2000 for Maricopa County, Arizona

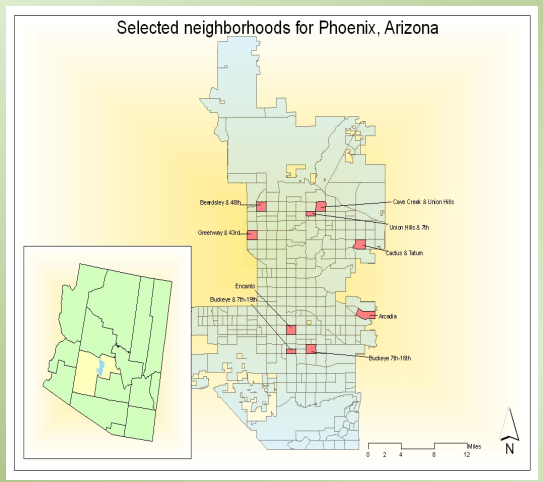

Table 1. Percentage of land cover for each classification of LUMPS input for neighborhood

Neighborhood	Buildings	Impervious Surfaces	Unmanaged Soil	Vegetation	Water
Arcadia	21.86	13.64	5.00	53.00	6.50
Beardsley & 46th	28.30	15.30	24.20	28.40	3.80
Buckeye 7th-16th	21.30	51.70	21.00	5.90	0.10
Buckeye 7th-19th	7.60	75.30	13.20	3.80	0.10
Cactus & Tatum	32.40	14.30	16.50	36.00	0.80
Cave Creek & Union Hills	19.60	17.90	59.30	2.90	0.30
Encanto	15.60	42.50	25.50	16.00	0.40
Greenway & 43rd	31.50	13.60	49.90	4.90	0.10
Union Hills & 7th	30.70	22.50	40.50	6.00	0.30

Results

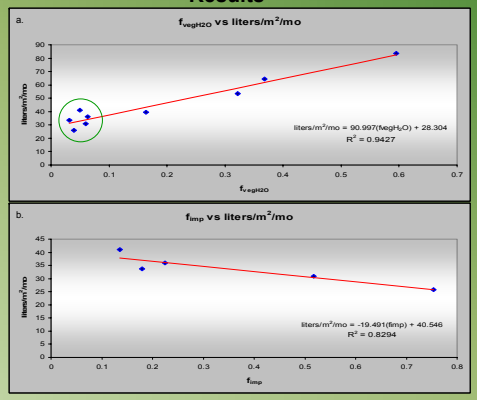

Figure 2 (a): Illustrates the impact of the fraction of vegetation and water cover (f_{vegH2O}) on monthly water loss. **(b)**: Circled segment of Fig 2 (a) indicates the relationship between the fraction of impervious cover (f_{imp}) and monthly water use in loss (<0.1) vegetative fraction sites.

Conclusions

Across the nine City of Phoenix neighborhoods, the following preliminary conclusions are evident for the month of June, 2000:

1. There is a highly significant correlation between the fraction of area of vegetation/water (f_{vegH2O}) and the evaporative fluxes to the atmosphere, and thus in the liters/m² per month in the various census tracts (see Fig. 2). Results show a large range from ca. 25 to over 80 liters/m² per month.

2. Below the threshold of f_{vegH2O} of 0.10, liters/m² per month across five lower moisture locations are not related to variable f_{vegH2O}, but inversely to f_{imp} - the fraction of impervious surface area.

3. According to the LUMPS model, an increase of 10% vegetation equates to 9.1 liters/m² per month of water lost. For an average residential lot, this is 8800 liters per month and could increase water use by ~15% in June.

References

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