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SPATIAL VARIABILITY OF SOIL HEAT FLUX OF A SINGLE HONEY MESQUITE DUNE IN THE JORNADA BASIN

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1. INTRODUCTION

Spatial variation of soil properties has been of interest to a number of disciplines. Soil physicists have been interested in the spatial variation of properties affecting water transfer and compaction, while soil chemists have been interested in salinity and chemical properties. The reports in the literature on spatial studies are numerous and the reports on the scale of variation range from study to study and cover the range from a few centimeters to several meters.

Studies conducted on the spatial variation of surface temperature and soil water evaporation have relevance to the problems in energy balance variations across small areas. Vauclin et al. (1982) measured surface temperature across two transects of bare soil and found that the variation was dependent upon the surface soil water content which changed nonuniformly across the field. Hatfield et al. (1984) examined surface temperature variation within irrigated fields and reported that the variation increased as the soil water content decreased. Later, Lascano and Hatfield (1992) evaluated spatial variation of surface temperature, particle size distribution, and bulk density for a sandy clay loam soil. They concluded that for the first three days after irrigation the semivariograms were isotropic and did not exhibit a range for the semivariograms. They suggested that random samples could be collected for soil water evaporation measurements.

Energy balance studies that require a measurement of soil heat flux may be subject to the microvariations in soil physical and water contents. These variations would influence the estimation of the energy balance if the measurements were made in atypical location of the field. The objective of this study was to quantify the spatial variation in the soil heat flux measured with heat flux plates in the single dune in New Mexico

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2. MATERIALS AND METHODS

2.1 Study site

A single dune site was selected in the Honey Mesquite dunes of the Jornada Experimental Range near Las Cruces, New Mexico. The mesquite in this area was 2 m tall and the overall dune size was approximately 20 m^2. Twenty soil heat flux plates (REBS HFT-1 heat flux plate[1] Radiation & Energy Balance Systems, Inc., Seattle, Washington) were placed in a grid with 1 m between each of the plates. These were buried at a depth of 0.1 m below the surface. The spatial arrangement of the sensors represented bare soil, partially shaded and fully shaded areas of the dune.

Net radiation was recorded with a REBS Q6 net radiometer[1] at 30 minute totals. Data were collected from Day-of-Year 250 through 290 in 1996. Data collection interval was for 30 minutes aggregated from a 10 second scan interval.

2.2 Analytical Methods

Spatial analysis was conducted using semivariograms as described by Journel and Huijbregts (1978). Spatial correlation between two values $Z(x_i)$ and $Z(x_i + h)$ that are at locations x_i and $(x_i + h)$ can be described by the semivariogram function $\gamma(h)$ and estimated by

$$\gamma^*(h) = 1/2N(h)\sum_{i=1}^{N(h)}[z(i) - z(i+h)]^2$$

where h is the distance between pairs of observations, N(h) is the number of pairs of observations [z(i), z(I+h)]. These equations and the resulting semivariogram plots are readily obtained from several software codes. The semivariogram provides insights into the relationships among observations and reveals whether the observed values have a definite spatial pattern or behave as random points.

[1]Mention of a specific tradename or product by the USDA-Agricultural Research Service does not imply endorsement or preferential treatment.

3. RESULTS AND DISCUSSION

Recorded values of soil heat flux ranged from nearly 50 percent of net radiation to less than 1 percent for midday readings. The soil was dry during this period of time so the bare soil areas exhibited the largest soil heat flux values during midday, however, at night the differences were less distinguishable.

There was no discernable spatial structure between observations for the nighttime periods. In these observations the soil heat flux values equaled or exceeded net radiation. Soil heat flux values shifted from positive to negative values in the locations under full canopy 1 to 1.5 hours before sunrise and remained negative until later after positive net radiation values were recorded in the morning. These patterns were expected in the dataset.

Soil heat flux exhibited the largest range of vaues at midday and typical ranges were from 10 to 250 W m^{-2}. These variations were dependent upon time of day, position in the dune, microtopography, and vegetative cover. There was consistency within a position of the dune across days when a given time was evaluated. Throughout the day the variation among positions was dependent upon the factors listed above. The critical issue given values during positive net radiation conditions is to determine what values to use for soil heat flux. The variations induced by the position on the dune would greatly impact the values of soil heat flux used in an estimation of latent and sensible heat fluxes from an energy balance method.

Evaluation of the spatial variation of soil heat flux is difficult given all of the potential influences. The structure of the semivariogram changed throughout the day, however, was relatively consistent among days. This would indicate that once a sensor is positioned in an area the observations will represent the local environment regardless of other factors, e.g. changing weather, clouds, etc. However, without some understanding of the overall variation of soil heat flux and the spatial variation patterns the single observation may present a biased estimate of the overall area.

4. REFERENCES

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