P2.3

EXAMINATION OF THE RELATIONSHIP BETWEEN RADIATIVE AND AERODYNAMIC SURFACE TEMPERATURE OVER PATCHY SURFACES.

Chehbouni A.[1*], R.L. Scott[2], D.C. Goodrich[3], J.-P. Lhomme[1], Qi J.[3], Y.H. Kerr[4]

[1] ORSTOM/IMADES, , Hermosillo, , Sonora, Mexico
[2] HWR, University of Arizona, Tucson, AZ, USA
[3] USDA-ARS, Tucson, AZ, USA
[4] CESBIO, Toulouse, France

1 INTRODUCTION*

Thermal infrared remotely sensed surface temperature has been widely used in operational models to evaluate the spatial distribution of the energy balance components. However, the performance of the approach has been questioned over sparsely vegetated surfaces since radiative surface temperature cannot be assimilated into aerodynamic surface temperature. The difference between aerodynamic and radiative surface temperatures over sparsely vegetated surfaces has been heavily investigated for the past two decades. Most of these investigations, however, have been confined to sparse but homogeneous surfaces. The objective of this analysis is to address this same issue for a heterogeneous surface made up of two distinct and adjacent patches: sparse grass and sparse shrubs.

The particular objective here is to determine whether the result reported by Chehbouni et al., (1996) about the existence of an intrinsic relationship between the radiative-aerodynamic and radiative-air temperature differences is still valid for surfaces with mix vegetation patches. This research is being conducted in the San Pedro River watershed of southeastern Arizona and northeastern Sonora as part of the trans-border *SALSA* program (Goodrich et al. This issue).

2 MATERIAL AND METHOD

Two vegetation study sites (namely sparse grass site adjacent to sparse mesquite site) nearby Lewis Springs on the San Pedro River flood plain were chosen to examine water consumption of these two plant communities (Scot et al. in this issue). Over each sites, meteorological towers were erected since 1996. These towers were equipped with a set of standard meteorological instruments to measure the air temperature, relative humidity, wind speed, incoming solar radiation, air pressure, and precipitation. Additionally, the towers were outfitted with instruments to measure the available energy (net radiation and soil heat flux), the Bowen ratio. Surface temperature over both sites has been measured using an IRT aiming at the surface with an angle of 45 degrees. For this particular study surface temperature has been normalized to nadir.

3 RESULTS AND DISCUSSION

Over sparsely vegetated surfaces, sensible heat flux can be formulated in terms of aerodynamic surface temperature as:

$$H = \rho Cp \frac{To - Ta}{ra} \qquad (1)$$

where ρ is the air density (kg m^{-3}), C_p the specific heat of air at constant pressure ($J\ kg^{-1} K^{-1}$). T_a (°C) is the air temperature at a reference height (z) above the surface; T_o (°C) is the aerodynamic surface temperature defined at the mean canopy source height. Data over each site were used to examine the differences between radiative and aerodynamic temperatures. To do so, we have used data collected during an 11 days period (DOY 219 to DOY 230) at 10:30 AM (LT) (which is approximately the LANDSAT-TM time overpass in San Pedro). For each site aerodynamic temperature and aerodynamic resistance has been inverted from sensible heat measurements using an iterative procedure involving Equation (1), air temperature, wind speed, displacement height and the roughness length (Chehbouni et al., 1997).

In Figure 1 and 2, the differences between radiative and inverted aerodynamic temperature are compared to the differences between radiative and air temperature for grass and mesquite patch. Theses figures show that despite some scatters, especially for the mesquite site, the differences between the aerodynamic and radiative surface temperatures show that the deviation of T_o from T_r grew as the magnitude of T_r increased.

This result allows to formulate sensible heat flux using the expression suggested by Chehbouni et al. (1996-1997) as :

$$H = \rho Cp \beta \frac{Tr - Ta}{ra} \qquad (2a)$$

$$\beta = \frac{1}{\exp(L/(L - LAI)) - 1} \qquad (2b)$$

where T_r is radiative surface temperature; and LAI is the leaf area index. L is an empirical factor which was set here to 2.5.

Sensible heat flux over the entire transect can be obtained as a weighted average of sensible heat flux over grass and mesquite as:

$$< H >= fHm + (1 - f)Hg \qquad (3)$$

where H_g and H_m are the sensible heat flux emanating from the grass and the mesquite, and f is the fraction of the transect covered by the mesquite (about 0.7). On the other hand sensible heat flux over the transect can be formulated in terms of effective expressions (denoted by angle brackets) of the arguments in equations (1) and (2a-b) as:

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[*] *Corresponding author address :* A. Chehbouni Reyes & Aguascalientes Esq., Col. San Benito, Hermosillo, C.P. 83190, Sonora, Mexico ;Email: ghani@cideson.mx)

$$< H > = \rho Cp \frac{< To > - Ta}{< ra >} \tag{4}$$

$$< H > = \rho Cp < \beta > \frac{< Tr > - Ta}{< ra >} \tag{5}$$

By matching term by term equation 4 and equation 3 combined with Equation 1, effective aerodynamic resistance and temperature can be obtained as :

$$\frac{1}{< ra >} = \frac{f}{ram} + \frac{1-f}{rag} \tag{6}$$

$$< To > = \frac{fTom}{ram} + \frac{(1-f)Tog}{rag} \Big/ \frac{f}{ram} + \frac{1-f}{rag} \tag{7}$$

Where the subscript g stands for grass and m for mesquite. Similarly effective radiative temperature and effective β can be obtained by matching term by term equation 5 and equation 3 combined with Equation 2 as:

$$< \beta > = \frac{f\beta m}{ram} + \frac{(1-f)\beta g}{rag} \Big/ \frac{f}{ram} + \frac{1-f}{rag} \tag{8}$$

$$< Tr > = \frac{fTrm\beta m}{ram} + \frac{\beta g(1-f)Trg}{rag} \Big/ \frac{f\beta m}{ram} + \frac{(1-f)\beta g}{rag} \tag{9}$$

Using Equations (7) and (9), a cross plot of the differences between effective radiative and air temperatures and the differences between effective radiative and effective aerodynamic surface temperature is presented in Figure 3. It can be seen that the shape of Figure 3 is very similar to that in Figures 1 and 2, which suggest that the relationship between aerodynamic, radiative and air temperature is also valid over a surface made up of two distinct patches. This is of interest since this result suggests that the equation (2a-b) can be also applied to estimate sensible heat flux over patchy surfaces. Additional analysis and especially a formal validation are however required before drawing any firm conclusion.

4. ACKNOWLEDGMENT

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5. REFERENCE

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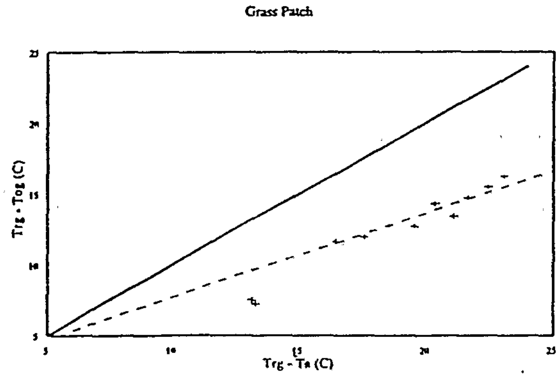

Figure 1: Differences between radiative and air temperatures against the differences between radiative and aerodynamic surface temperature over grass patch

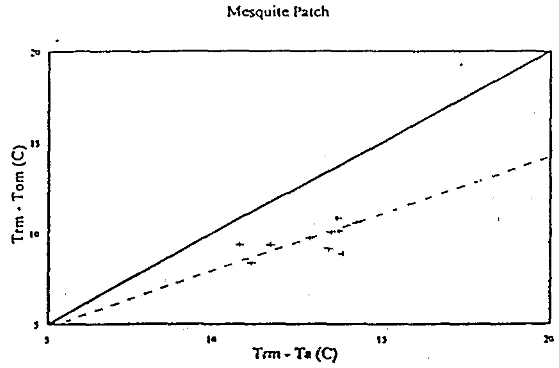

Figure 2: Differences between radiative and air temperatures against the differences between radiative and aerodynamic surface temperature over mesquite patch.

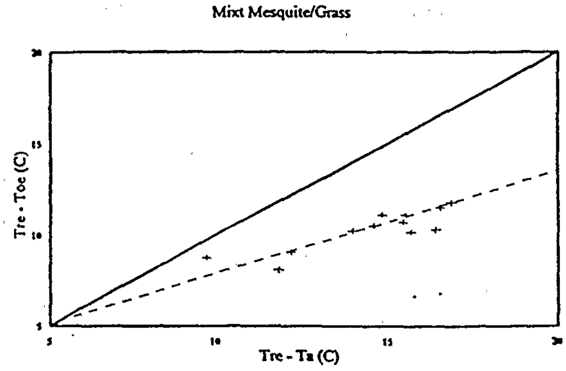

Figure 3: Differences between radiative and air temperatures against the differences between radiative and aerodynamic surface temperature over mix Grass/Mesquite.

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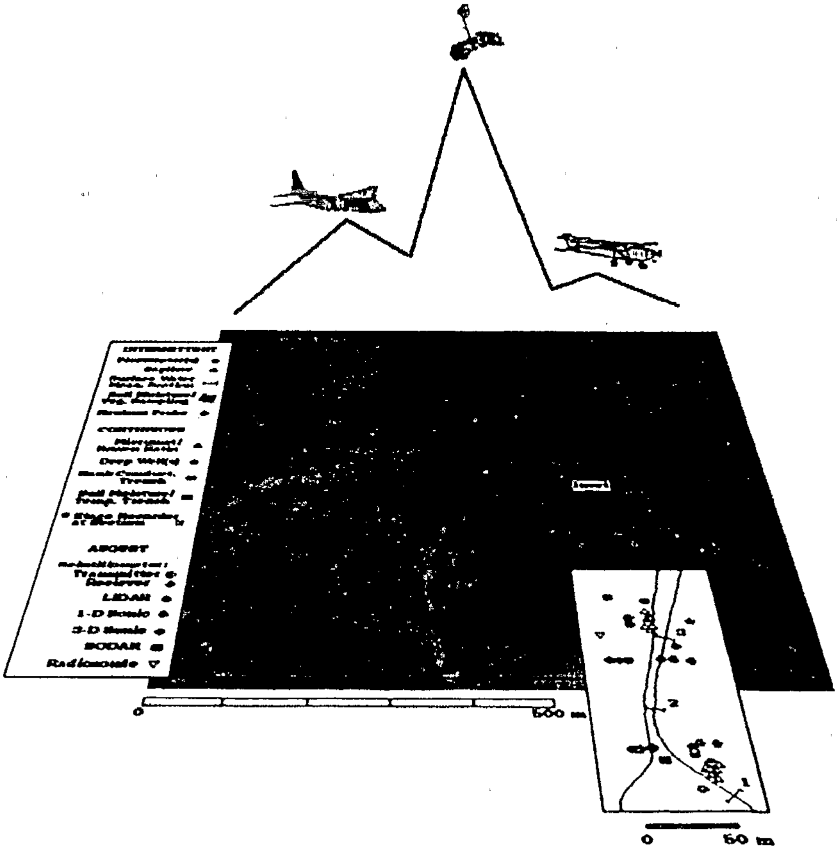

USDA Agricultural Research Service, Southwest Watershed Research Center
2000 E. Allen Road, Tucson, AZ 85719

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