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Micro-climate on sparse grassland of Nalaikh, Mongolia

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I Introduction

Semi-arid environments cover 40% of the Earth's land surface and therefore are a significant component of the Earth's climate system. The dominant feed back of ground surface to atmosphere forcing in semi-arid regions is occurring in summertime, which can be extremely resulting in great variability in soil moisture and in latent and sensible heat fluxes. In addition, local water cycle is strongly influenced by processes occurring at ground surface Therefore, it appeared necessary to consider the variability of microclimatic conditions to better understand hydrological land surface processes.

1. Observation site description

An observation site was established on sparse grassland at Nalaikh in northeastern Mongolia at 47º 45' N, 107º 20' E, 40 km southeast of Ulan Bator (Fig. 1), the periphery of the sub-Arctic permafrost region. Vegetation was uniformly sparse grass with a coverage of 38-60% during the maximum growth period. The maximum grass height in mid-July was less than 20 cm. Grass roots develop mainly in the surface ground layer (the top 50 cm).

2. Observation terms

In summer of 2004 (May to September) observation was carried out using meteorological tower and ultra-sonic meter. An automatic climate observation system (ACOS) recorded profile of air temperature (*T*), humidity (*q*) and wind speed (*U*), as well as radiation budget (*Qn*) and ground heat flux (*Qg*). Latent heat (*Qe*), sensible heat (*Qh*) and friction wind (*u**) speed was measured by ultra-sonic meter. All terms above was recorded by 10 minutes interval.

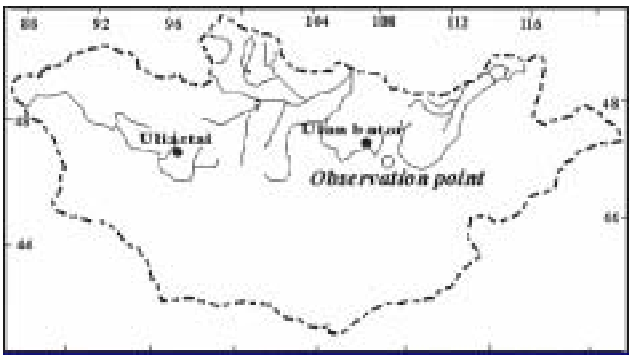

Fig. 1 Location of observation point: Nalaikh, Mongolia (47º 45' N, 107º 20' E).

Phenology observations included the coverage and biomass of grass and water content in grass leaves and were made at 10 day intervals as well. Observations were conducted at four 50 × 50 cm plots; the presented results are averages from these four plots.

II Results and analysis

1. Climate conditions

The mean air temperature was an average of 12.7 ºC from May to September. The mean relative humidity was 61%. Specific humidity was 5.5 g/kg during the period of plant growth but 0.5 g/kg for other periods. The prevailing wind was from the NW-ENE with annual mean wind speed of 3.4 m/s, which higher than annual mean wind speed (2.6 m/s).

2. Heat fluxes

Under mean albedo of 0.12, *Qn*, *Qg* were averaged of 117.4 and 5.5 Wm^{-2} respectively. Accordingly, the average *Qh* was 48.4 Wm^{-2}. And *Qe* was 21.1 Wm^{-2}, which implying evapotranspiration of 0.74 mm/d.

3. Stability of atmosphere near ground surface

Static stability of study atmospheric layer (within height of 4 m) is evaluated by Richardson number (*Ri*):

$$Ri = \frac{g}{T}\frac{\partial T}{\partial z}\left(\frac{\partial U}{\partial z}\right)^{-2} \qquad (1)$$

where *z* denotes height. In accordance to *Ri*, the state of the layer can be classified to be stable, neutral and unstable. Time frequency of every state has been statistical analyzed by daily basis. Frequency was averaged of 42.3, 19.3 and 38.4% for unstable, neutral and stable respectively. 89% of stable layer occurred in nighttime (21:00 to 7:00), in accordance to mean wind speed of 1.7 m/s. There no any regular diurnal variation for neutral layer occurring, which just 36% occurred in nighttime, but just response to stronger wind.

4. Aerodynamic profile of wind, air temperature and humidity

Stratified profiles of wind, air temperature and specific humidity are logarithmically statistical analyzed to dress aerodynamic roughness. Clear different structure can be read to individual atmospheric state. Aerodynamic roughness has been deduced in Table 1.

5. Turbulence analysis

Table 1 Aerodynamic roughness for wind (*Zo*), for temperature (*Zt*) and for humidity (*Zq*).

Atmospheric state	*Zo* (cm)	*Zt* (cm)	*Zq* (cm)
Unstable	1.1	1.5	$1.5*10^{-20}$
Neutral	2.2		$2.0*10^{-12}$
Stable	7.6	3.9	

In Monin-Obukhov similarity theory, stratified buoyancy parameter ζ is definite as:

$$\xi = z / L \tag{2}$$

where L is Monin-Obukhov length. Stability function for heat φh, water vapor φw and momentum φm are essential parameters to estimate transfer coefficient. The variation of φh versus ζ is show in Fig. 2.

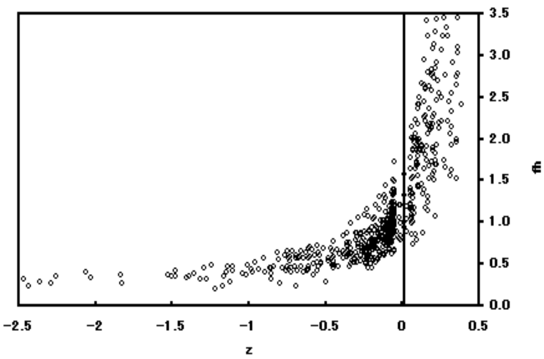

Fig. 2 Variation of Monin-Obukhov length for heat (*φh*) versus Buoyancy parameter (*ζ*) at study site.

III Concluding marks

Transfer coefficient for heat and water vapor can be estimated as:

$$Ch = k^2 (\phi m * \phi h)^{-1} \tag{3}$$

$$Ch = k^2 (\phi m * \phi w)^{-1} \tag{4}$$

Using the result presentative shown in Fig. 7 and correlation:

$$\varsigma = \begin{cases} Ri & Ri < 0 \\ Ri/(1-5Ri) & 0 \le Ri \le 0.2 \end{cases} \tag{5}$$

Suitable correlation to calculate φh, φw and φm depend on atmosphere stability have been clarified at sparse grassland:

$$Ri > 0.17, \quad \begin{cases} \phi h = 6.11 Ri/(1-Ri) \\ \phi w = 1.22\,\phi h \\ \phi m = \phi h \end{cases} \tag{6}$$

$$-0.35 < Ri \le 0.17, \quad \begin{cases} \phi h = EXP(1.12 Ri/(1-Ri)) \\ \phi w = 1.22\,\phi h \\ \phi m = \phi h \end{cases} \tag{7}$$

$$Ri \le -0.35, \quad \begin{cases} \phi h = EXP(0.63 Ri) \\ \phi w = 0.71 \phi h \\ \phi m = \phi h \end{cases} \tag{8}$$