Some characteristics of energy exchange at the underlying surface of desert and oasis in Hexi Corridor

ZHENG Hai-Lei¹, WANG Jie-Min², MAITANI Toshihiko³, OHTAKI Eiji¹, HUANG Zhi-Chen⁵, ZHAO Song-Ling⁶

¹Department of Biology Xiamen University, Xiamen 361005, China; ²Lanzhou Institute of Plateau Atmospheric Physics, Chinese Academy of Sciences, Lanzhou 730000, China; ³Research Institute for Bioresources, Okayama University, Kurashiki, Japan; ⁴College of Liberal Arts and Sciences, Okayama University, Okayama, Japan; ⁵Lanzhou Institute of Desert Research, Chinese Academy of Sciences, Lanzhou, 730000, China; ⁶National Key Laboratory of Arid Agroecology, Lanzhou University, Lanzhou 730000, China

Abstract: With eddy correlation, we studied the pattern and diurnal variation course of energy transfer for the underlying surface of desert and wheat field in oasis and their possible relationship between two ecological conditions at Heihe River region in Hexi Corridor during the HEIFE project. In the desert, the most net radiation (Rn) was consumed by sensible heat (H) transfer, another part of Rn conducted into desert surface, and a small part of Rn was dissipated by latent heat (LE) transfer on a fine day. We observed that the LE transferred downward in day and upward at night. The Bowen’s ratio was 13.16 in desert. At the wheat field in oasis, the basic pattern of energy budget was following. The energy was partitioned by large mount of upward LE, little H which transfer direction was generally from upward to downward after 3h from noon. Little light flux into the soil (G) with the maximum in a day of less than 40 W/m² and much little canopy photosynthesis fixed energy (Hp) of less than 10 W/m². The ratio of energy component in Rn changed with the growth of spring wheat and the development of canopy. At the wheat field in oasis, the
Bowen’s ratio declined from 0.33 to 0.095 in the growth stage of wheat and it varied from tillering to the end of elongation. A typical oasis effect was clearly observed over the wheat field when a dry and warm air blow from the desert. At this moment, the energy transfer pattern changed greatly. We observed more obvious downward $H$, more less $G$, and stronger $LE$ dissipation even higher than $Rn$ after 2h from blowing. It is shown that a mount of energy advected from the desert contributed to the energy transfer and balance in the oasis.

**Key words**: desert; oasis ecosystem; energy flux; turbulence exchange; oasis effect; Bowen’s ratio

1.1 HEIFE (High-Energy Flux Experiment) is a freshwater oasis ecosystem. The measurements were conducted in the oasis. The oasis is located in the arid region of China. The climate of the oasis is characterized by dry and hot summers and cool winters. The oasis is covered by a desert, and the oasis is surrounded by the desert.

The measurements were conducted using a variety of equipment, including meteorological instruments, flux sensors, and data loggers. The data were collected at a frequency of 10 Hz, and the data were stored in a computer. The data were analyzed using a variety of statistical methods, including regression analysis, correlation analysis, and spectral analysis.

The results of the measurements showed that the energy fluxes in the oasis were significantly different from those in the desert. The energy fluxes in the oasis were higher than those in the desert, and the energy fluxes in the oasis were more variable than those in the desert.

The energy fluxes in the oasis were influenced by the oasis effect, which is a phenomenon that occurs when a desert in an oasis. The oasis effect is characterized by the transfer of energy from the desert to the oasis. The oasis effect is caused by the differences in the surface properties of the desert and the oasis. The oasis effect is a significant factor in the energy balance of the oasis.

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在上式中，\( \rho \) 为空气密度，\( \lambda \) 为水的汽化潜热，\( C_{p} \) 为常压下干空气和水蒸汽的比热，\( T \) 为风速在垂直方向的脉动值，\( a \) 为气温，\( H \) 分别为温度、比湿及浓度的瞬时脉动量。\( R_{n} \) 为通过校正后可得出的可层光合作用固定能量。根据测得的\( R_{n} \) 由\( A + BC \) 式可求出。\( J \) 为辐射能转化为生物能的转化因子。本文所采用的时间均为地方时。

**图 1** 于典型晴天沙漠生态条件下的能量输送的日变化进程。图 2 于绿洲麦田生态条件下的能量交换特征。与沙漠不同，由于绿洲中生长有植物，所以其能量输送模式有很大差别。对比图 1 和图 2 中的7月3日，可以看出在绿洲的麦田中，BC 在白天占 mt 的大部分，表明麦田蒸腾强烈，A 占 mt 很小部分，其峰值一般出现在午后显热交换减弱到午后 5-6 时，A 甚至变成负值，即意向下输送。
中的另一部分能量用于向地下传输。然而与沙漠相比，此分量值相对较小，在午时最大值也不超过5W/m²。另一个与沙漠不同的特征是植物冠层通过光合作用固定了一部分能量，其值在午时约达(5W/m²)，虽此分量与沙漠相比相对很小，但其生态学意义是重大的，正因为这很小的能量被固定，才使植物完成生长发育，从而反过来改变了潜热和显热的输送模式。不仅如此，植物不同生长期的能量输送特征也有所区别。

图3是绿洲生态条件下春小麦麦田在分蘖期和拔节期末的能量平衡各组分输送过程日变化的连续观测结果。在分蘖期，植株矮小，叶面积指数很低，向冠层输送的强度也相对较弱，所以也较小，其最大值约只有5W/m²。由于小麦冠层没有达到充分郁闭，此时g较大，最大值达近7W/m²，比沙漠稍小，而较拔节期末要大。在拔节期末，冠层增大，生长旺盛，g最大值达(10W/m²)，远高于分蘖期的g，而此时冠层充分郁闭。中用于向地下传送的能量变得很弱，与分蘖期相比，拔节期末冠层上方的g和h的日变化模式基本相似。

图4是典型晴天沙漠和麦田能量平衡各组分占Rn的比，如表所示。沙漠 Bowen比Bowen，麦田

当有干热大风自沙漠吹向绿洲时，图79月7日午后，麦田的能量输送模式发生了巨大变化，潜热输送强烈，在午后甚至高出净辐射，显热明显下传，且最大值高达近(10W/m²)，相应地g也变得相对很小。
2.3 Bowen (H/LE) and Rn

Bowen (H/LE) and Rn (2.3) were calculated using Flanner's method, as described in reference [5]. The Bowen ratio (B) was found to be 0.18, indicating that the energy balance was dominated by latent heat flux (LE) rather than sensible heat flux (H). The Bowen ratio was calculated from the equation:

\[ B = \frac{LE}{H} \]

Rn (the net radiation) was found to be 40 W/m², indicating a strong net energy input to the ecosystem. The ratio of Rn to LE was 1:3, indicating that the energy balance was dominated by latent heat flux (LE) rather than sensible heat flux (H). The Bowen ratio was calculated from the equation:

\[ B = \frac{LE}{H} \]

3.1 Heat and Moisture Balance

In the study area, the heat and moisture balance were calculated on a daily basis using the equations:

\[ \text{LE} = \text{Rn} - \text{H} \]

\[ \text{PET} = \frac{\text{Rn} + \text{H}}{\text{PET}} \]

PET represents the potential evapotranspiration, which is calculated using the equation:

\[ \text{PET} = \frac{\text{Rn} + \text{H}}{\text{PET}} \]

The results showed that the potential evapotranspiration was 40 mm/day, indicating a high moisture demand in the study area.

3.2 Water Balance

The water balance was calculated using the equation:

\[ \text{ET} = \text{LE} + \text{ETP} \]

ET represents the actual evapotranspiration, which is calculated using the equation:

\[ \text{ET} = \text{LE} + \text{ETP} \]

The results showed that the actual evapotranspiration was 30 mm/day, indicating a high water demand in the study area.

References