MODIS 衛星画像を用いた乾燥灌漑地域の蒸発量の推定
Estimation of Evaporation from Arid Irrigated Area using MODIS Satellite Imagery

○薛　鋳、 赤江剛夫[1]、 守田秀則
○Xue Zhu, Akae Takeo and Morita Hidenori

1. INTRODUCTION

For sustainable development of irrigated agriculture in arid areas, improvement of water use efficiency is essentially required to maintain current production levels and meet food and fiber for population growth in future. To achieve high water use efficiency, a key consideration is to reduce unnecessary soil water loss due to evaporation. Generally, the evaporation in field scale can be quantified based on the available meteorological data. However, the meteorological data covering over large scale regions is sometimes unavailable. In this study, we selected Hetao Irrigation District (HID) as a typical arid research area with irrigation. The regional daily evaporation was determined based on a developed Maximum Surface Temperature model (MST). The model requires the data of Land Surface Temperature (LST) that can be obtained from Moderate Resolution Imaging Spectroradiometer (MODIS) satellite imagery. The regional evaporation was estimated combining the MST model and the MODIS image.

2. MATERIALS AND METHODS

2. 1 Datasets

To conduct the study, land surface temperature (LST) data is required. The 8-day LST data over the HID for the irrigation period from April to October, 2009 were available by downloading and processing MODIS (Aqua) satellite imagery from MODIS Land website. The Aqua MODIS can provide with the maximum and minimum LST at 13:30, and 01:30 in local time, respectively.

2. 2 Method

In this study, the MODIS Land Surface temperature satellite imageries were processed into corresponding regional surface temperature using ERDAS Imagine GIS software. Then, the regional daily evaporation of each cell was determined by the developed MST model, as shown in **Eq. (1)** (Xue, Z and Akae, T. 2010).

$$E_d = 7.2(\rho C_p c_h + 4\varepsilon\sigma T_{\min}^3)\Delta T_{\max} / \lambda \tag{1}$$

where E_d is daily evaporation (mm d^{-1}), ρ is air density (1.21 kg m^{-3}),C_p is specific heat of air at constant pressure (1010 J kg^{-1} K^{-1}), c_h is exchange coefficient (40 m h^{-1} in this study), ε is emissivity of soil surface (0.95), σ is Stefan-Boltzmann constant (5.67×10^{-8} W $m^{-2}K^{-4}$), $T_{\min}$ is minimum surface temperature (K), $\Delta T_{\max}$ is difference in maximum surface temperatures between dry and drying soils (K), and λ is the latent heat of vaporization (2.45 MJ kg^{-1}).

The daily evaporation in the model mainly depends on the difference in maximum surface

---

[1]岡山大学大学院環境学研究科:Graduate School of Environmental Science, Okayama University

キーワード: 蒸発，表面温度，衛星画像

temperature between dry (without evaporation) and drying soils. The surface temperature of sand dune in the district was used as that of dry soil.

3. Results and discussion

Over the irrigation period of 2009, the LST of the district could be obtained using MODIS image. Such as **Fig. 1** shows that the spatial distribution maps of maximum and minimum land surface temperatures over the HID in July, 2009. The LST over the district varied from a minimum of 12.4℃ to a maximum value of 50.4℃ in July. On the other hand, the maximum LST over the district was the range of 32.9 to 50.4 in July, 2009. The minimum land surface temperature difference between the irrigated land and sand dune was found to be small, the difference was within approximately 5℃.

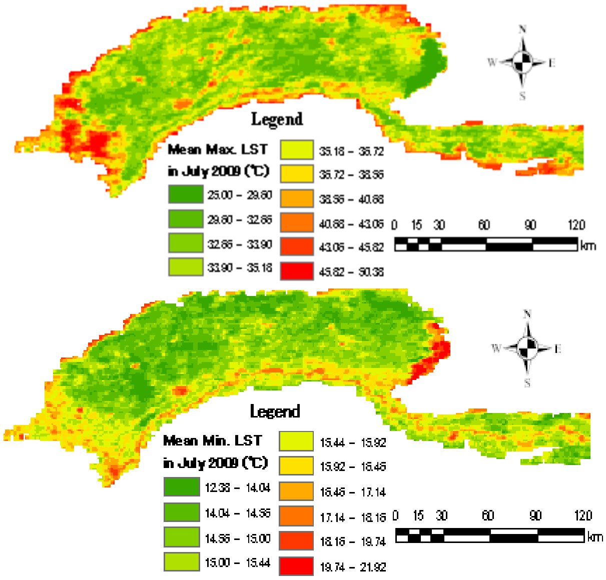

Fig.1 Spatial distribution maps of maximum (*top*) and minimum (*bottom*) land surface temperatures over the HID in July, 2009

Combining the MST model and the above LST data, the regional daily evaporation over the district was determined in July. **Fig. 2** gives the spatial distribution maps of evaporation over the district in July, 2009. The mean regional daily evaporation over the land in the whole district was 1.2~3.5 mm/d in July. The evaporation was shown relatively higher in the eastern part of the district. Throughout the cropping season, the estimated evaporation was considered reasonable from water balance of the district (**Table 1**).

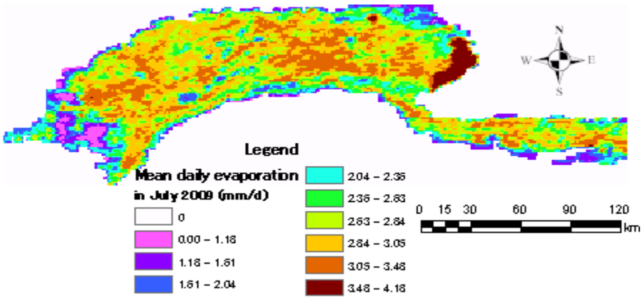

Fig.2 Spatial distribution maps of evaporation over the HID in July, 2009

Table 1 Mean daily evaporation over three parts of the HID for the irrigation period of 2009 (mm/d)

	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Mean
Western	1.51	2.19	2.41	2.79	2.34	1.44	2.32	2.14
Middle	1.91	2.24	2.26	2.88	2.53	1.48	1.69	2.14
Eastern	1.94	2.51	2.30	2.86	2.69	1.69	2.57	2.36
Whole	1.78	2.31	2.32	2.84	2.52	1.54	2.19	2.22

4. Conclusions

The results obtained from this study concluded that the LST from MODIS satellite imagery can be used for estimating regional daily evaporation. The daily evaporation distribution map can specify particular water consuming areas over the district where high daily evaporation may be occurred, it is helpful for the efficient management of water resources by reasonable allocation of irrigation water.

Reference: Xue Zhu and Akae Takeo. (2010): Estimation of Evaporation from Drying Soil Column with Different Initial Soil Water Content by Maximum Soil Surface Temperature, *Annual meeting of JSIDRE*, Kobe University.