POSTER 10

Relationship Between the Observed Sunshine Duration and the Grid Cell Brightness in Complex Terrain

Seung-ho Kim[1]*, Soo-ock Kim[2], and Jin I. Yun[1]

[1]*College of Life Sciences, Kyung Hee University, Yongin 17104, Korea*

[2]*National Center for Agro-Meteorology, Seoul National University, Seoul 08826, Korea*

I. Introduction

The sunshine duration, among meteorological factors, has direct effects on agriculture. Receiving sunlight is an important factor affecting crop growth. If the sunshine duration is too short, crops either experience hindered growth or wither away (Chun *et al*., 2001). In contrast, if the sunshine duration is too long, the eradication of crops may occur. As such, the sunshine duration is a basic factor observed in agricultural meteorology. However, the data on the sunshine duration provided by a synoptic weather observatory situated in open terrain can either be reduced or show daily irregularities for mountainous areas due to shading effects. Therefore, farms and orchards located in such areas can experience delayed growth or defects in crops compared to open terrains in the same region. If the regional variation of sunshine duration based on topography can be predicted, it would be useful for planning the location for farming and responding to climate change. According to WMO standards, adequate sunshine duration is achieved when the direct sunlight energy is above the standard value (120 W m^{-2}). Topography effects occur when direct sunlight dips below the standard value due to the surrounding topography or other obstructions. However, since direct sunlight is difficult to measure or estimate, finding a proxy is necessary. In this study, the use of a basic function of GIS, the ‘Hillshade,’ was introduced to quantify the topography effects that reduce the sunshine duration.

II. Materials and Methods

The ‘Hillshade’ function takes the skyline, the boundary line between the earth and sky, from a 360° view from an observatory site and expresses the inner topography of this skyline using a Digital Elevation Model (DEM). The ground surface brightness, which changes with

* Correspondence to : brown0201@naver.com

the shadow from the surrounding topography according to the position of the sun during the day, the slope of the earth surface, and the slope aspect, was calculated and expressed in values between 0–255.

The ground slope, ground slope aspect, solar zenith angle, and solar azimuth angle were each expressed by S, d, Z, and β, respectively, and the brightness value, BV, at the observation site was calculated with the following equation:

$$BV = 255 \times ((cosZ \times cosS) + (sinZ \times sinS \times cos(\beta - d)) \quad (1)$$

A BV of 0 indicates complete shade and that of 255 indicates a completely open state (Burrough, 1988).

Agyang-myeon, located in Hadong-gun, Gyeongsangnamdo, Korea province, was surveyed with a western slope (Site 1), an eastern slope (Site 2), and an open terrain (Site 3), with one daylight observatory installed at each site. The sunshine duration data at 10-minute intervals were collected from May 2015 to May 2016 for one year (Fig. 1). The weather conditions were studied using data for 'sky conditions' from a local weather forecast, and data from the 50 days with the clearest weather were selected.

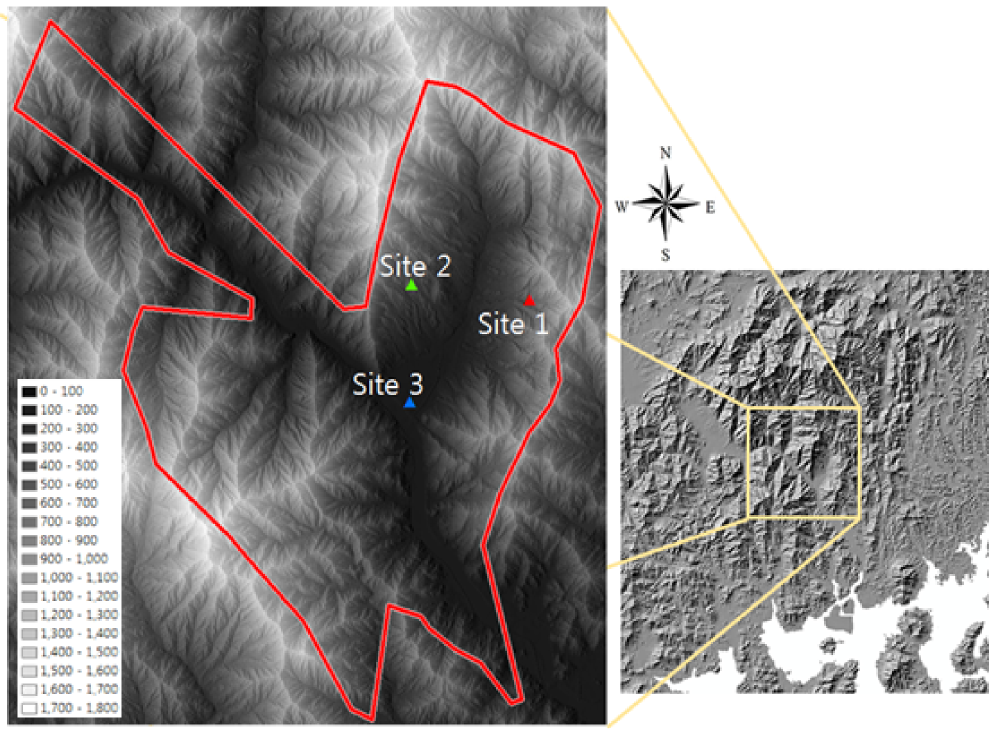

Fig. 1. Solar observation points and the skyline outline (red line).

From this, 25 days were selected randomly to calculate the altitude and the azimuth of the sun, and the *BV*s for every 10 minutes at the three sites were calculated using Equation 1. All calculations were based on the 30 m resolution DEM.

The 10-minute sunshine duration data collected from the observation sites were summed over 60 minutes and were compared to the average *BV* value of the same period.

Ⅲ. Results and Discussion

The relationship between the *BV* and sunshine duration on a clear day showed that the sunshine duration increased rapidly until the *BV* reached an average of 120. When *BV* was higher than 120, the sunshine duration reached the maximum value (60 minutes) (Fig. 2).

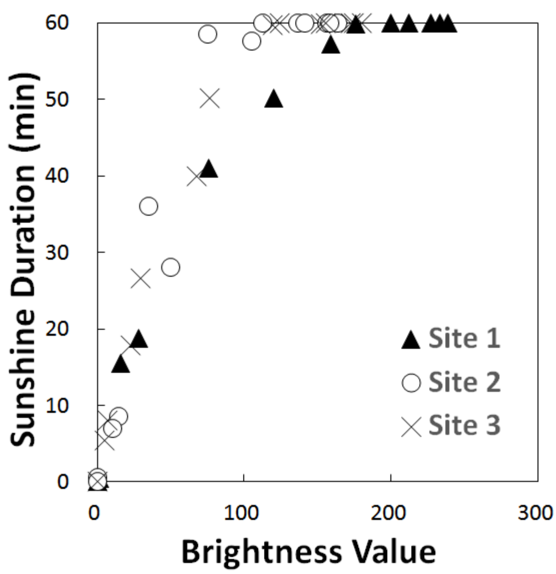

Fig. 2. *BV* versus sunshine relationship.

The *BV* and sunshine duration relationship can be expressed with an exponential saturation curve.

$$y = 60.53 \times (1.001 - EXP(-0.0277 \times x)) \qquad (2)$$

where x is the one-hour average *BV* y and is the sunshine duration accumulated for one hour (units in minutes).

Using this equation, the data from the remaining 25 days (those not used for deriving the equation) were used to estimate the sunshine duration using the hourly *BV*s from the three observation sites. When compared to the observed values, the RMSE was 0.42 for Site 1, 0.55 for Site 2, and 0.23 for Site 3, which qualify for minimum practicality in the agricultural sector (Fig. 3).

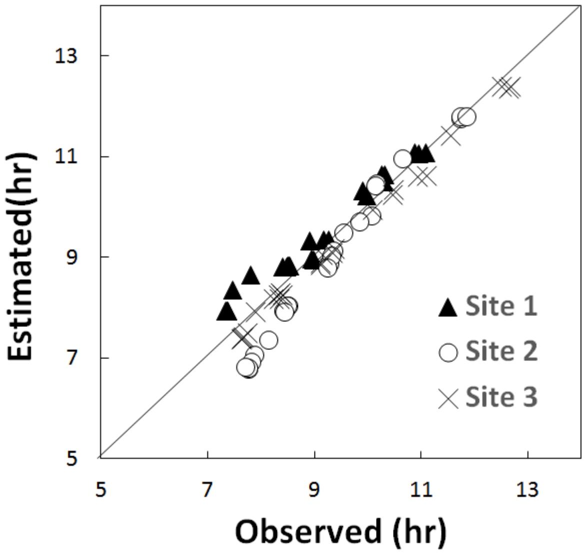

Fig. 3. Graph of estimated values of one-day accumulation of sunshine duration versus measured values.

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References

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