POSTER 11

Estimation of Sunshine Duration in a Mountainous Watershed Using the KMA Sky-Condition Forecast Product

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I. Introduction

As elements of weather that are used to predict crop growth and climate risk, temperature and precipitation have been continuously studied in order to achieve precise forecasting of these parameters. However, there is a relative lack of research on downscaling of sunshine hours to account for terrain. Kim and Yun(2015) suggested a technique that simulated sunshine hours using ‘Sky Condition’, a regional forecast service provided by the Korea Meteorological Administration (KMA), which simulated sunshine hours at a 5-km grid resolution, assuming a horizontal plane with no shadow cast by the surrounding terrain. Kim *et al.*(2016) introduced a sunshine-topography correction coefficient, by using a shade relief map to construct a formula relating the shading effect of the surrounding mountains to the number of observed sunshine hours on sunny days. This study estimates sunshine hours in a mountainous watershed area with complex terrain, in which the reliability of the forecast using the ‘Sky Condition’ technique, based on the horizontal plane assumption, was insufficient. Here, the sunshine-topography correction coefficient suggested by Kim *et al.* (2016) was used, and the improvement in forecast was investigated.

II. Materials and Methods

Hadong-Gun Akyang-Myun, in Gyeonsangnamdo Province, is a mountainous watershed area in which the west-facing slope and east-facing slope closely face each other, and there is a flat area of cropland (Moodimideul) located inside the watershed area. A series of observation stations, comprising two points on the west-facing slope, one point on the east-facing slope and one point in the flat cropland area, were installed to monitor sunshine hours from November 2015 to July 2016. In addition, ‘Sky Condition’ data, from a short-term regional forecast provided by the KMA, were collected. ‘Sky Condition’ utilizes 5 km × 5 km grid data, with 4–6 grid cells covering Akyang-Myun. The process for estimating sunshine hours using the ‘Sky Condition’ grid data can be divided into two parts.

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First, horizontal plane sunshine hours are generated by converting ‘Sky Condition’ data to a 10-point scale (0–10) of cloud cover, and then converting this into a 5-km grid of sunshine hours using the cloud amount-sunshine rate equation (Kim and Yun, 2015). The next step in the process is to downscale the sunshine hours to reflect topographic influence, using the formula which relates brightness values (BV) of shade relief maps, generated using a digital elevation model (DEM) with 30-m grid resolution, and the sunshine hours according to the solar altitude and azimuth angle (Kim *et al.*, 2016).

$$y = 60.53 \times (1 - EXP(-0.0277 \times BV)) \qquad (1)$$

Equation 1 is a regression equation that estimates sunshine duration (y, in minutes). This is constructed by inserting the hourly average value of the shade relief map produced every 10 minutes into BV (Kim *et al.*, 2016), but in this study we used BV values based on 30 minute intervals. Sunshine hours per day calculated with Equation 1 represent cloudless conditions, and the sunshine-topography correction coefficient is then generated by dividing the daily results of Equation 1 by the possible sunshine duration on the corresponding date (Kim *et al.*, 2016).

The sunshine hours for a complex terrain are calculated by multiplying the sunshine-topography correction coefficient by the horizontal plane sunshine hours. We compared the observed and estimated sunshine hours at corresponding points, and calculated mean errors (ME) and root mean square errors (RMSE) for all dates for horizontal plane sunshine hours other than zero, in a mountainous watershed area in Akyang-Myun from November 2015 to July 2016.

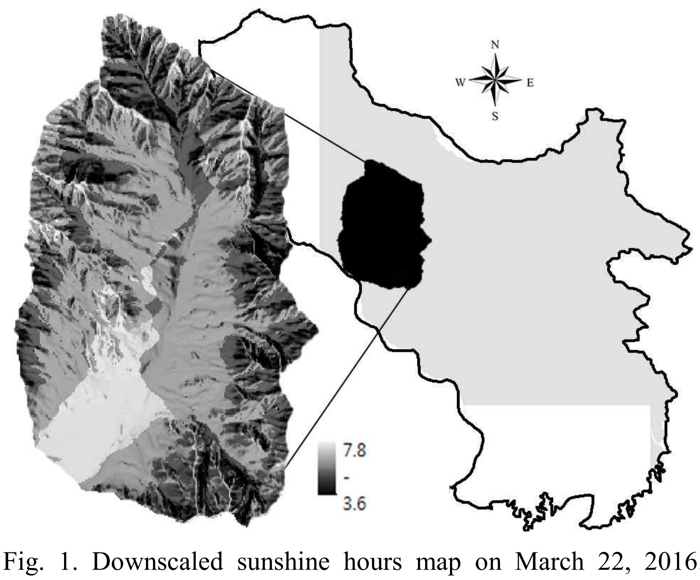

Fig. 1. Downscaled sunshine hours map on March 22, 2016.

III. Results

Fig. 1 shows the sunshine distribution at 30-m grid resolution in Akyang-Myun. It confirms that detailed topographic characteristics are reflected, since the ridges and flat areas have relatively more sunshine hours than the sloping areas.

Fig. 2(a) and 2(b) represents the comparison of estimation errors between the existing horizontal plane sunshine hours using KMA’s ‘Sky Condition’ (before) and the sunshine hours obtained by applying the sunshine-topography correction coefficient (after). The existing horizontal sunshine hours were on average considerably overestimated compared to the actual measured values. However there was a general tendency toward decreased bias due to the reduction of ME after correction for topographic influence Fig. 2(a). RMSE was decreased, compared to horizontal solar radiation, after the sunshine-topography correction coefficient was applied to all observation points Fig. 2(b). This shows that the solar radiation shading effect inside the mountainous watershed area, which is caused by the ridge of the opposite slope, was reflected in the existing sunshine hours.

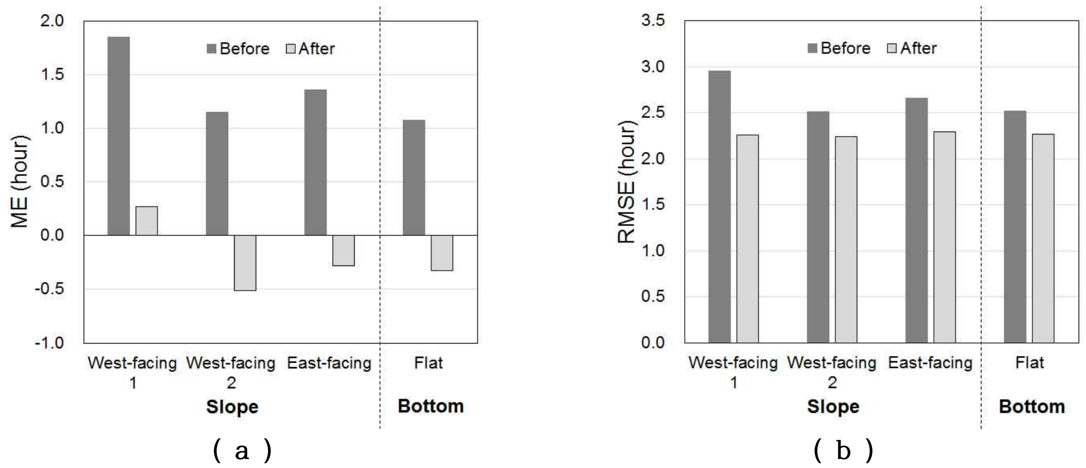

Fig. 2. Comparison of estimation errors of horizontal plane sunshine hours and topographic corrected sunshine hours at each observation point. (a) Mean Errors, (b) Root Mean Square Errors.

Fig. 3(a) and 3(b) is a one-to-one correspondence point of the estimated and observed values of sunshine hours, which reveals that horizontal plane sunshine hours generally show a tendency toward overestimation Fig. 3(a). However, a tendency toward underestimation was shown when the sunshine hours increased after the correction using the sunshine-topography correction coefficient Fig. 3(b). We used average values of 1-hour intervals (hh : 30) instead of 10-minute intervals for BV in Equation (1). Therefore, if sunrise occurred before, or sunset occurred after the half-hour mark, the sunshine duration would be incorrect by a corresponding amount, affecting the estimated value of the sunshine-topography correction coefficient and leading to underestimation.

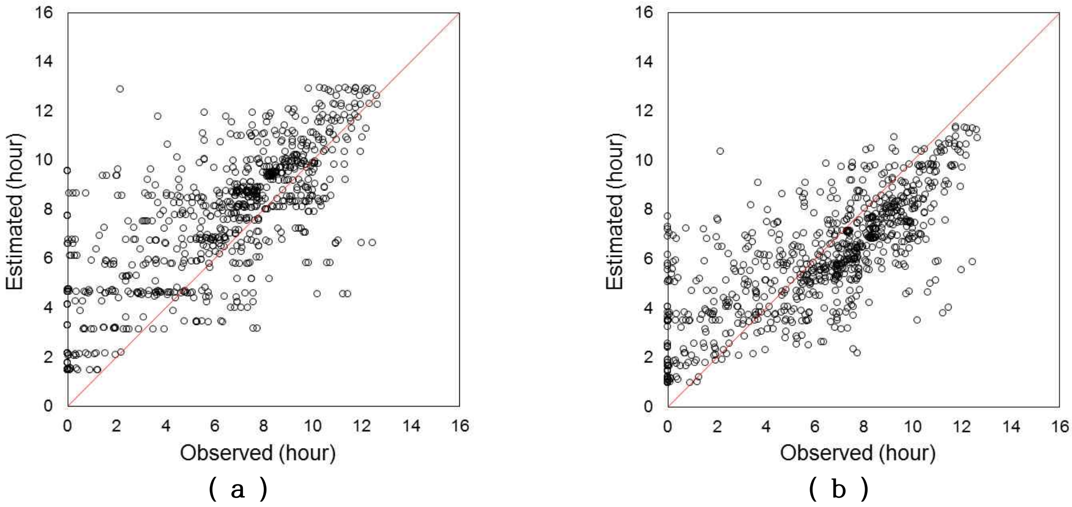

Fig. 3. Graph of one-to-one correspondence of estimated horizontal plane sunshine hours (a), estimated sunshine hours reflecting terrain effects (b), and observed values.

Acknowledgements

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References

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