한국농림기상학회지, 제11권 제3호(2009)
Korean Journal of Agricultural and Forest Meteorology, Vol. 11, No. 3, (2009), pp. 123~125

편집장 통신

Reply to Comment by Kang and Kim on "Estimation of Net Radiation in Three Different Plant Functional Types in Korea"

Hyojung Kwon*
Global Environment Lab., Dept. of Acmospheric Sciences, Yonsei University, Seoul 120-749, Korea
(Received September 7, 2009; Accepted September 24, 2009)

"한국의 세 개의 다른 식생기능형태에서의 순복사 추정"에 대한 의견의 답변

권 효 정*
연세대학교 대기과학과/지구환경연구소
(2009년 9월 7일 접수; 2009년 9월 24일 수락)

I thank Kang and Kim (this issue) for their interests and constructive comments on Kwon (2009) in which the objectives were to find the site-specific relationship between net radiation (R_N) and solar radiation (R_S) in major plant functional types in Korea and to examine its applicability for estimating R_N. The authors addressed six major points requesting clarification and suggesting improvement. Below, my replies are provided.

I. THE USE OF DAILY INTEGRATED DATA FOR REGRESSION

Kang and Kim is correct that only the daytime data (excluding nighttime data) should be used to derive a relationship between R_N and R_S. However, the usage of daily sums to draw R_N-R_S relationships can be found in the literature (e.g., Shaw, 1958; Kjaersgarrd *et al*., 2007). In addition, the daily sums are used to estimate daily R_N for further applications such as the estimation of daily evapotranspiration. Such applications motivate the use of radiation balance equation for R_N estimation (e.g., Allen *et al*., 1998). Despite the unaccounted influence of cloud cover and albedo on R_N, based on the error assessment, the R_N estimated from a simple linear regression produced practically useful and acceptable results. Consideration of the influence of cloud cover and albedo on R_N is an appropriate next step for further analysis and therefore Kang and Kim's efforts are appreciated.

II. THE USE OF THE MEASURED ALBEDO

I agree with Kang and Kim that, instead of using the observed albedo, other alternative values should be used. However, the influence of using alternative values of albedo on R_N was small. One of the alternatives was to use albedo values reported in the literature for deciduous forest (0.15-0.25), coniferous forest (0.1-0.15), and cropland (short green vegetation: 0.1-0.2, dry vegetation: 0.2-0.3) (Hartman, 1994). They indicate that actual values of albedo at each site were generally lower than those from the literature. Other literature, however, reported more comparable values of albedo: 0.10-0.20 for deciduous forests, 0.05-0.15 for coniferous forests, and 0.10-0. 25 for agricultural lands (e.g., Arya, 1988).

Another alternative was to use climatological values of albedo at the sites. The monthly climatological values that Kang and Kim provided were almost identical with those observed in 2008 (e.g., the values of *d* index ranging from 0.98 to 1.0 and the values of RMSE rang-

* Corresponding Author : Hyojung Kwon (hyojungkwon@yonsei.ac.kr)

ing from 0.001 to 0.02 for the three sites). The comparison between R_N calculated with the climatological values of albedo and that with the daily values of albedo in 2008 showed good agreement as well (e.g., *d* index was 1.0 and RMSE was 0.26 MJ m^{-2} d^{-1} at the Gwangneung deciduous forest site). The negligible discrepancy was due to almost no year-to-year variation in albedo. Given that (1) the observed albedos are within the general range of the reported values and (2) the inter-annual variations of albedo at each site were negligible, the use of the observed albedo (if available) is not inappropriate.

III. THE USE OF LINEAR COEFFICIENTS FOR WHOLE YEAR DATA

The purpose of Kwon (2009) was to estimate R_N using R_S over a yearly temporal scale and thus the error assessment was conducted over the entire year data but not over each season. The possible inaccuracy associated with the use of yearly data for the error assessment was clearly mentioned in Kwon (2009).

IV. METHODLOGICAL IMPROVEMENT

There may be a methodological limitation in estimating R_{LN} following Allen *et al.* (1998).

$$R_{LN} = -\sigma\left[\frac{T_{\max}^4 + T_{\min}^4}{2}\right](a - b\sqrt{e_a})\left(c\frac{R_S\downarrow}{R_{s0}} - d\right) \qquad (1)$$

where σ is the Stefan-Boltzmann constant, $T_{\max}$ and $T_{\min}$ are the maximum and minimum air temperatures (in K), e_a is actual vapor pressure (in kPa), $R_S\downarrow$ is shortwave radiation, R_{S0} is clear-sky solar radiation, and a, b, c, and d are the calibration coefficients. These coefficients are subject to local calibration. Eq. (1) is the equation used for R_{LN} calculation in conjunction with FAO-56 evapotranspiration (Allen *et al.*, 1998). And many applications use Eq. (1) without modification of the calibration coefficients (e.g., Zhang *et al.*, 2008). Kwon (2009) also used the coefficients given by Allen *et al.* (1998), which were empirically calibrated for cropland (Brunt, 1932). This was one of the reasons of an overestimation of the daily R_N especially in the winter.

The daily data for the entire year of 2008 were used to draw the calibration coefficients for each site using curve fitting function with MATLAB (Version 7.7).

Table 1. Comparison of calibration coefficients given in Allen *et al.* (1998) with the local calibration coefficients for each site. GDK, GCK, and HFK indicate Gwangneung deciduous forest, Gwangneung coniferous forest, and Haenam cropland, respectively

	Brunt (1932)	GDK	GCK	HFK
a	0.34	0.20	0.44	0.17
b	0.14	0.09	0.22	0.06
c	1.35	1.96	0.90	1.64
d	0.35	−0.20	−0.01	−0.09

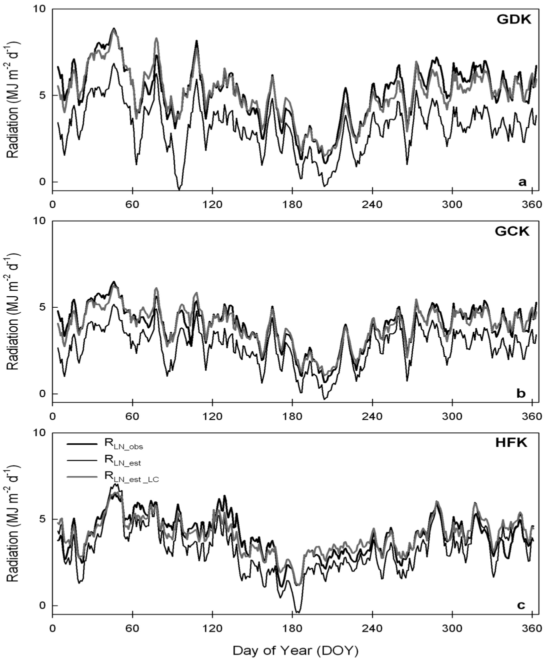

Fig. 1. Comparison of net longwave radiation. R_{LN_obs} is the observed net longwave radiation, R_{LN_est} is the estimated net longwave radiation with calibration coefficients given by Allen *et al.* (1998), and $R_{LN\_est\_LC}$ is the estimated net longwave radiation with locally calibrated coefficients for each site.

The locally calibrated empirical coefficients and the estimated R_{LN} using those values are shown in Table 1 and Fig. 1, respectively. Comparing against the observed R_{LN}, the estimated R_{LN} with the coefficients by Allen *et al.* (1998) showed much larger discrepancy than that with the local coefficients for the sites used in Kwon (2009). At the Haenam cropland site, the degree of the discrepancy between the observed R_{LN} and the estimated R_{LN} with the coefficients by Allen *et al.* (1998) was relatively smaller likely because the coeffi-

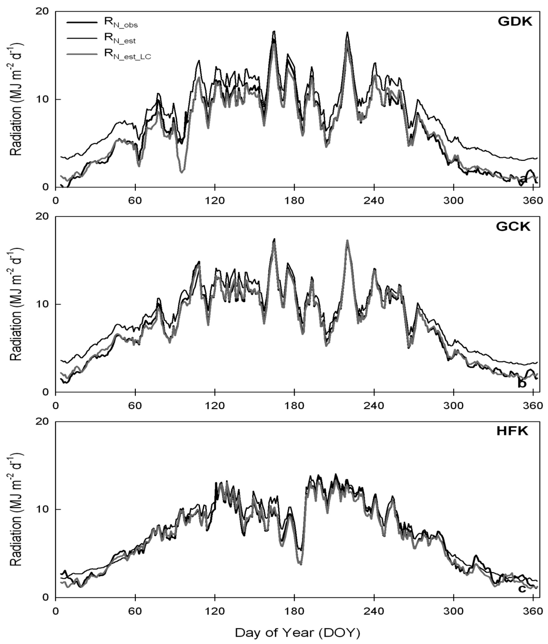

Fig. 2. Comparison of net radiation. R_{N_obs} is the observed net radiation, R_{N_est} is the estimated net radiation with calibration coefficients given by Allen *et al.* (1998), and $R_{N\_est\_LC}$ is the estimated net radiation with locally calibrated coefficients for each site.

cients by Allen *et al.* (1998) were calibrated for cropland. The improved R_{LN} estimation with the local coefficients produced a better agreement between the observed and the estimated in R_N for all three sites (Fig. 2). This confirms that 1) the coefficients given by Allen *et al.* (1998) is not proper to apply for forest sites and 2) an overestimation of R_{LN} can induce substantial errors in R_N estimation.

Finally, for the other two additional comments, (i.e., the use of sunshine duration, the error assessment), I applaud the efforts of Kang and Kim in taking advantage of the existing database of sunshine duration to approximate $R_S\downarrow$ and the validation of such an approach in the estimation of R_N.

ACKNOWLEDGMENT

The KoFlux data used in this study were produced by the support from the Long-term Ecological Study and Monitoring of Forest Ecosystem Project of Korea Forest Research Institute and the Korea Meteorological Administration. This study was supported by a grant (Code: 1-8-3) from Sustainable Water Resources Research Center of 21st Century Frontier Research Program, and the A3 Foresight Program from the Korea Science and Engineering Foundation.

REFERENCES

Allen, R. G., L. S. Pereira, D. Raes, and M. Smith, 1998: Crop Evapotranspiration: Guidelines for Computing Crop Requirements. *Irrigation and Drainage Paper,* 56 Food and Agriculture Organization of the United Nation, Rome.

Arya, S. P., 1988: Introduction to micrometeorology. Academic Press, 328 pp.

Brunt, D., 1939: Physical and Dynamical Meteorology. Cambridge University Press.

Hartman, D. L., 1994: Global Physical Climatology. Academic Press. 411pp.

Kang, M., and J. Kim, 2009: Comment on "Estimation of net radiation in three different plant functional types in Korea". *Korean Journal of Agricultural and Forest Meteorology, this issue.*

Kwon, H., 2009: Estimation of net radiation in three different plant functional types in Korea. *Korean Journal of Agricultural and Forest Meteorology,* **11**, 79-85.

Kjaersgarrd, J. H., R. H. Cuenca, F. L. Plauborg, and S. Hansen, 2007: Long-term comparisons of net radiation calculation schemes. *Boundayr-Layer Meteorology*, **123**, 417-431.

Shaw, R. H., 1956: A comparison of solar radiation and net radiation. *Bulletin of the American Meteorological Society*, **37**, 205-206.

Zhang, Y. Q., F. H. S. Chiew, L. Zhang, R. Leuning, and H. A. Cleugh, 2008: Estimating catchment vaporation and runoff using MODIS leaf area index and the Penman-Monetith equation. *Water Resources Research*, **44**, W10420, doi:10.1029/2007WR006563.