Estimating Solar Radiation Using Sunshine Duration: Assessment of the Angstrom-Prescott coefficients for estimation of solar radiation in Korea

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INTRODUCTION

- Observation data of solar radiation is less available than those for other meteorological variables although solar radiation is an important input variable to agricultural models that simulate productivity of an agricultural ecosystem.
- Models to estimate solar radiation using meteorological variables have been developed using sunshine duration as an input variable.
- One of the model to estimate solar radiation is the Angstrom-Prescott model that depends on two coefficients obtained empirically at a specific site or for a climate zone.

OBJECTIVE

- The objective of this study was to examine if the Angstrom-Prescott model with a single set of empirical parameters would be useful to obtain reliable estimates of solar radiation in a region.

MATERIALS AND METHODS

- Angstrom-Prescott model

$$\frac{H}{H_0} = a + b\left(\frac{S}{S_0}\right)$$

where H : the global solar radiation
H_0 : the extraterrestrial solar radiation
S : the actual sunshine duration
S_0 : the theoretical sunshine duration
a, b : empirical coefficients

- Empirical coefficients
  - Oort et al. (2015): $0.1 \le a \le 0.4$, $0.3 \le b \le 0.7$, $0.6 \le a+b \le 0.9$
  - Frere and Popov(1979): a = 0.18; b = 0.55 for cold and temperate zones (AP_{Frere})
  - Choi et al. (2010): site specific empirical coefficient (AP_{Choi})
- Weather data
  - Daily solar radiation was estimated using sunshine duration at 20 sites in Korea for 30 years.
  - A data client for web-based weather database, was used to retrieve daily data from Korea Meteorological Administration.
- Analysis
  - Concordance correlation coefficient(CCC) was calculated between observed and estimated solar radiation.
  - Value of CCC was determined for every combination of a and b to identify a set of empirical coefficient to have maximum CCC at a given condition (AP_{Max})
- Implementation
  - Solar radiation was estimated using an R script that implements the Angstrom-Prescott model.
  - The values of CCC was also obtained using R.
  - R packages 'epiR' was included to calculate the value of CCC.

RESULTS

- During crop growing periods, the values of CCC tended to be higher than other periods except for summer monsoon periods (Fig. 1A).
- After 1990, the values of CCC were considerably higher than those for the past (Fig 1B).

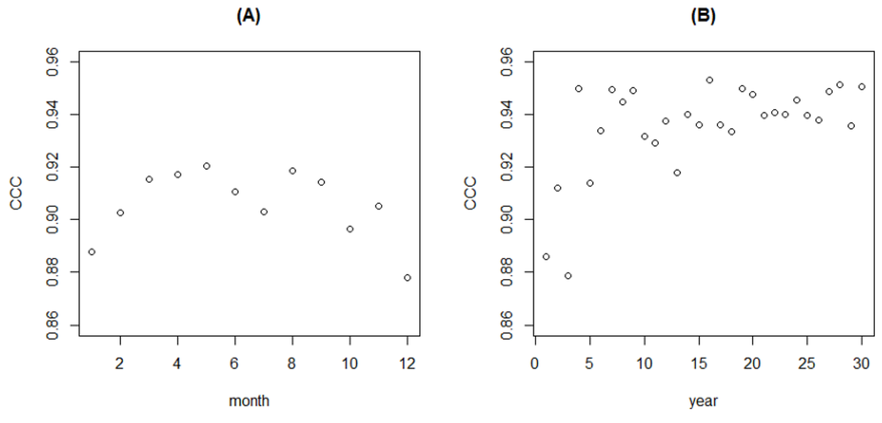

Fig. 1. Variation of CCC between estimated and observed solar radiation over months (A) and years (B)

RESULTS

- Rural areas tended to have greater values of CCC than urban areas (Fig. 2).

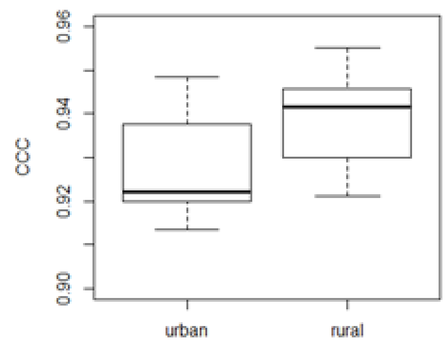

Fig. 2. Variation of CCC between observed and estimated solar radiation for urban and rural areas

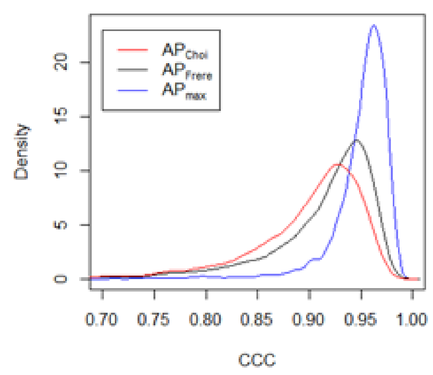

Fig. 3. Distribution of CCC between observed and estimated solar radiation using AP_{Choi}, AP_{Frere}, and AP_{max}

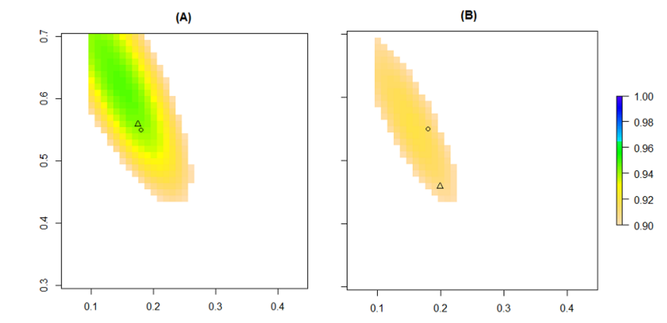

Fig. 4. CCC by AP coefficients for for Daegwallyeong (A) and Suwon (B), respectively. Circle and triangle represents AP_{Frere} and AP_{Choi}, respectively.

- Site specific coefficient such as AP_{Choi} tended to have lower CCC than AP_{Frere}. (Figs. 3-4)
- AP_{Frere} was included in each range of AP coefficients that resulted in reasonable accuracy of solar radiation estimates by site, year, and month (Fig. 5)

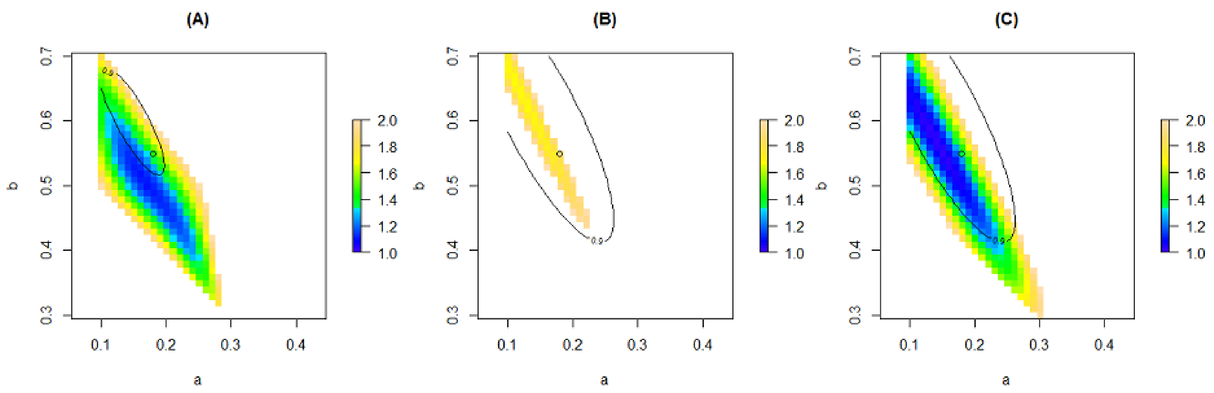

Fig. 5. CV(%) for average CCC by months (A), years (B), and sites (C). CCC value was >0.9 within the oval area for a given set of a and b

DISCUSSION

- These results suggested that AP_{Frere} would be useful to provide estimates of solar radiation as an input to crop models in Korea.
- The use of AP_{Frere} would result in reasonable estimation of solar radiation over a crop growing period at different sites, which would be useful to produce spatial estimates of solar radiation.
- Further studies would be merited to examine feasibility of using AP_{Frere} to obtain gridded estimates of solar radiation at a high spatial resolution under a complex terrain in Korea.

ACKNOWLEDGEMENT

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