Estimation of solar irradiation in Korea peninsula by using GMS-5 data

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Abstract

Solar irradiation controls the exchange of heat energy between atmosphere and land or ocean, and becomes an important factors to the radiance flux at the surface and the biosphere. In order to estimate solar irradiance and earth albedo in Korea peninsula during 1996, GMS date and paramaterization model was combinationally used. In clear sky, the paramaterization model was used to estimate solar iradiance. Also in cloudy sky, the earth albedo was used to calculate the interceptive effect of solar irradiance. The hourly solar irradiance [the hourly earth albedo] showed generally very low values with <1.00 MJ/m^{2}hr [high values with >0.65] on the middle part (36.00-36.50°S) and the Southeastern part (near 34.50°S) in Korea peninsula, respectively. Satellite estimates (GMS data) with pyramometer measurements (in-situ data) were compared for 21 observed stations. Totally, correlation coefficient showed high values with 0.85. In the monthly variation, correlation coefficient of the spring and summer with rms=about 0.42 MJ/m^{2}hr was better than the autumn and winter with rms >0.5 MJ/m^{2}hr. Generally monthly variations of correlation coefficient between satellite estimetes and pyranometer measurements showed r=0.936 in clear sky during 1 year except only May, June, July and August.

Introduction

Solar irradiation is very important and essential factor to study agriculture, weather, climate monitoring and biosphere. Generally, it should be used to calculate the heat flux at the surface, to estimate the grouth of plants on amount of evaporation, to develop the system of application on solar energy and to monitoring the inaccessible lands as ocean, moutain and desert, etc.

The estimation of solar irradiation from meteorological satellite have recently studied and this method can overcome somewhat difficulties to the empirical methods. Satellite data offer not only regular data with a large coverage for space but also good data with a optical thickness of cloud. Usually, physical model by using visible data from meteorological satellite (Gautier *et al.*, 1980) and statical model by using the style and amount of cloud (Davies *et al.,* 1975; Atwater and Ball, 1980) had proposed to estimete solar irradiation.

The objective of this study on the accurate estimation of solar irradiation is to offer the basic data for the analysis of heat flux, quantatively to estimate the interceptive effect of solar irradiation by cloud, to applicate the development of low boundary condition in numerical model, to predict the production of agriculture and fisheries by monitoring and to develope the algorithm for the estimation of solar irradiation from GMS-5 data, respectively.

Data and Methods

In this study, our method as the combined visible data from GMS-5 and paramaterization model was used in order to estimate solar irradiance over a 50 x 50 Km^2 in the East Asia and the Korea peninsula from January through December 1996. This paramaterization model become the basis of Dedieu *et al.*'s radiative transfer model (1987). Then, we used radiative transfer model on the estimation of solar irradiation, under clear sky conditions, E is modeled as follows:

$$E = E_0 \, d^{-2} \cos(\theta_s) T(\theta_s) \frac{(1-A)}{(1-A_s)} \text{ --------------------(1)}$$

Here, E is the downward solar irradiance at the surface of the earth, E_0 is the solar constant (1367 W/m^2), d is the radius vector (the ratio of actual to mean sun-earth distance), θ_s is the solar zenith angle, and

$$T(\theta_s) = \tau_o \tau_w \tau_r \tau_g \tau_a \text{ --------------------------------(2)}$$

$T(\theta_s)$ is a clear-sky transmission factor, accounting for gaseous absorption, Rayleigh and Mie scattering. The so-called, τ_0, τ_w, τ_r, τ_g and τ_a are the ozon (Lacis and Hansen, 1974), water vapour (Yamamoto, 1962), Rayleigh (Bird and Hulstrom, 1981), gases (Bird and Hulstrom, 1981) and aerosol (Bird and Hulstrom, 1981) effects, respectively.

$$A = \alpha(\theta_s) \times \frac{L}{\cos(\theta_s)} + \beta(\theta_s) \text{ --------------------------(3)}$$

A is the earth albedo, L is the observed GMS-5 data, A_s is the surface albedo, and α and β are the coefficient used to produce solar irradiation (Masami and Tomoo, 1992).

This study was carried out in two situations. 1) In clear sky, generally the paramatizatedmodel was used to estimate solar iradiance, and 2) in cloudy sky, the earth and surface albedo were used to calculate the interceptive effect of solar irradiance, respectively. Finally, in order to know exactly the validation of two data, we calculated the correlation coefficient between GMS-5 data and in-situ data for 21 observed stations.

Results and Discussion

Composite image at 1200UT on May 1996 over the East Asia showed the distribution of clouds. The cloudy band with latitude presented strongly along the South China Sea and the middle part of Korea peninsula, respectively (Fig.1). Then, the hourly solar irradiance [the hourly earth albedo] showed generally very low values with <1.00 MJ/m^2.hr [high values with >0.65] on the middle part (36.00-36.50°S) and the Southeastern part (near 34.50°S) in Korea peninsula (Fig.2 and Fig.3), respectively. It should be explained that distribution of solar irradiation [earth albedo] by using our method has inversely (proportionally) very well relation with distribution of clouds.

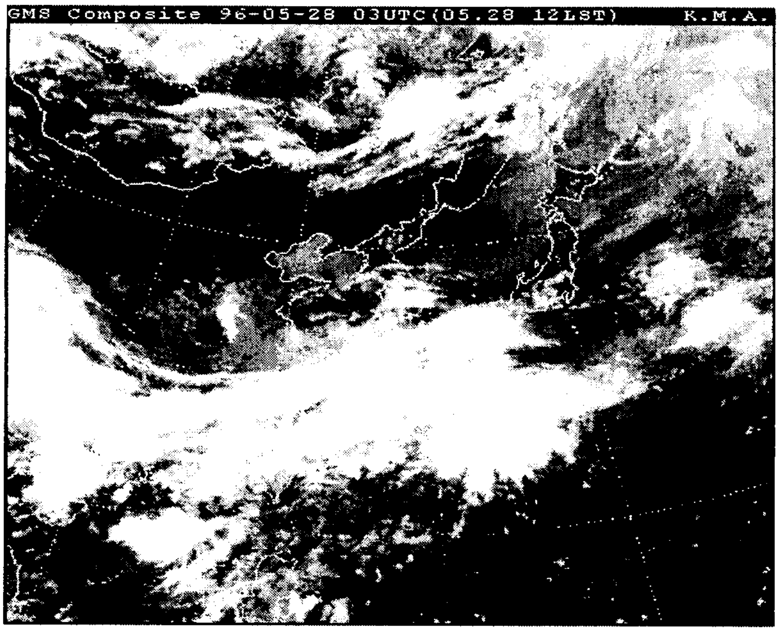

Figure 1. Composite image of GMS-5 at 1200 UTC on May 28 1996.

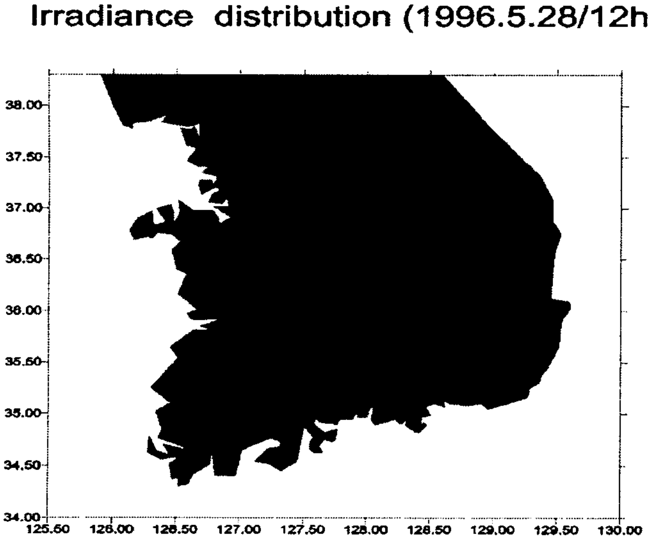

Figure 2. Map of the hourly solar irradiance at the surface as GMS-5 satellite estimates at 1200 UTC on May 28 1996 over Korea peninsula. The bar scale range from 0.00 MJ/m^{2}hr (blue color) to 2.60 MJ/m^{2}hr (red color).

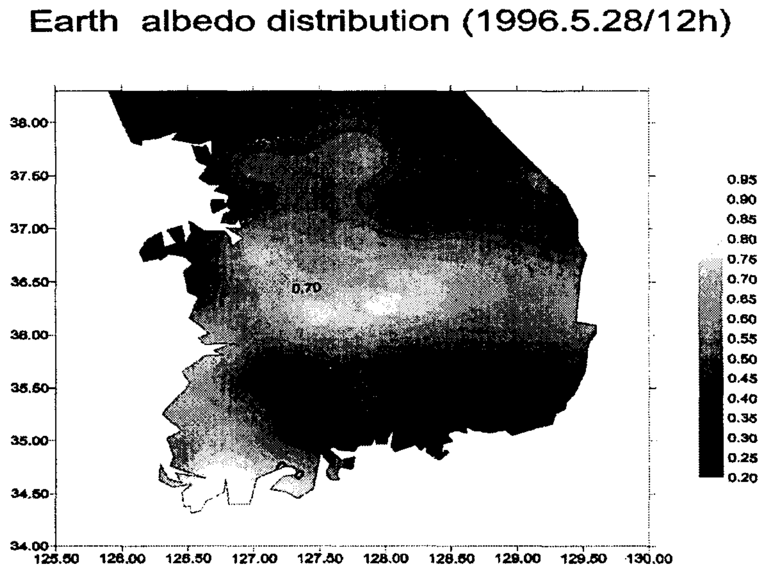

Figure 3. Map of the hourly earth albedo at the surface as GMS-5 satellite estimates at 1200 UTC on May 28 1996 over Korea peninsula. The bar scale range from 0.20 (blue color) to 0.95 (red color).

For the hourly solar irradiation, we compared satellite estimates (GMS data) with pyramometer measurements (in-situ data) for 21 observed stations. Totally, correlation coefficient showed high values with 0.85 (Fig. 4).

In the variation of monthly solar irradiation, correlation coefficient of the spring and summer with rms=about 0.42 MJ/m^2hr was better than the autumn and winter with rms >0.5 MJ/m^2hr (Fig. 5). But in the case of clear sky, generally there were great differences with correlation coefficient of 0.936 between satellite estimetes and pyranometer measurements except only May, June, July and August (Fig. 6). This result should be considered because the transmittance of paramaterization model was incompletely estimated to solar irradiance.

Finally, albedo presented usually low values in the coastal area against to the land area because albedo was averaged with the ocean pixel and the land pixel together.

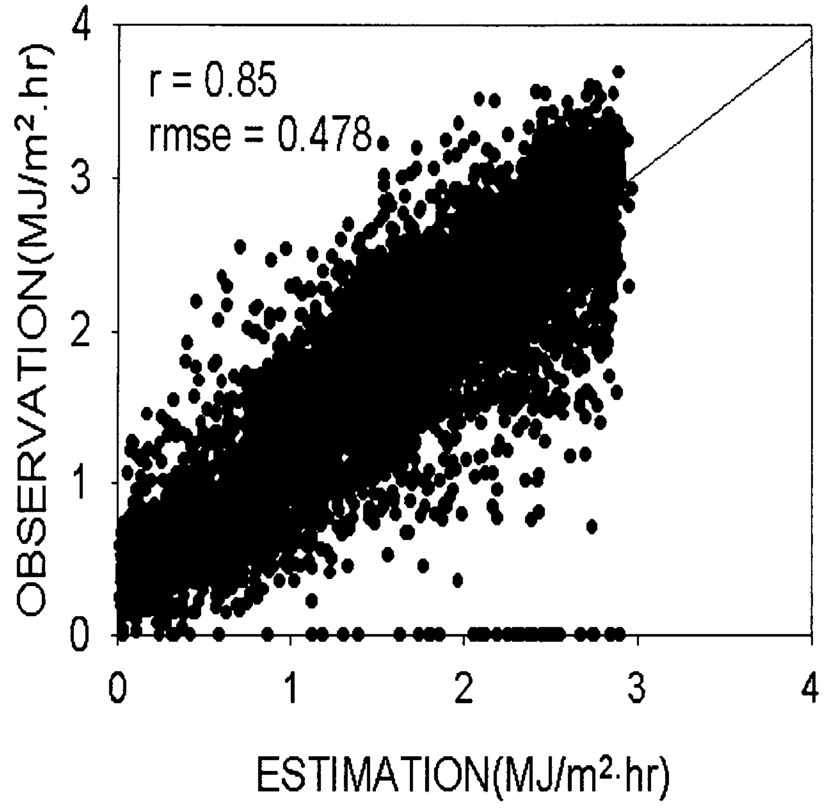

Figure 4. Hourly pyranometer measurements plotted against the hourly solar irradiance at the surface as GMS-5 satellite estimates from January through December 1996 (1052 cases, r=0.85 rms=0.478 MJ/m^2.hr).

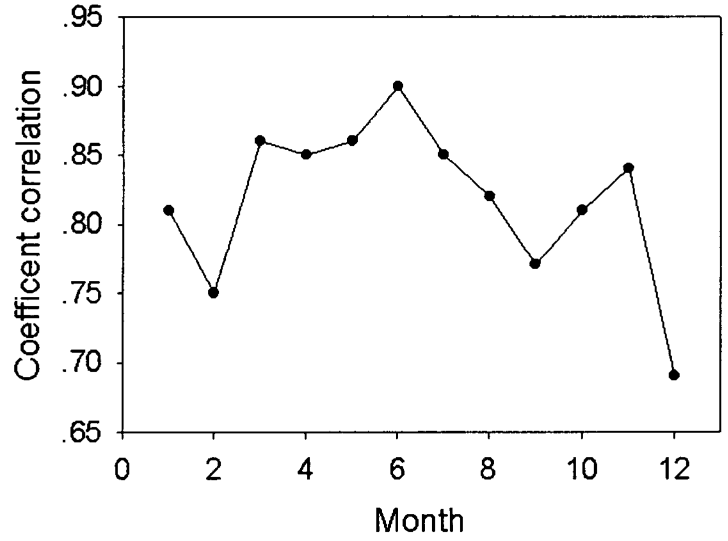

Figure 5. Variations of correlation coefficient between monthly satellite estimate and monthly pyranometer measurements.

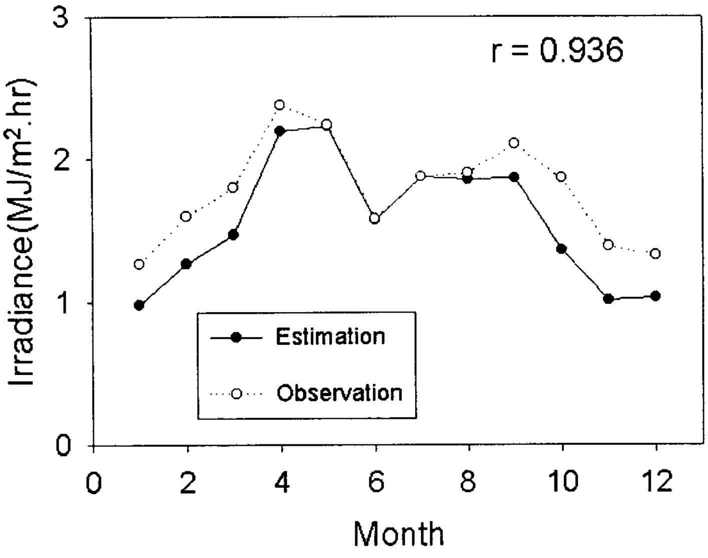

Figure 6. Comparison monthly satellite estimates and monthly pyranometer measurements.

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