# Estimation of Insolation over the Oceans around Korean Peninsula Using Satellite Data

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**Abstract**

Surface solar radiation over the sea is estimated using Visible and Infrared Spin Scan Radiometer data onbord Geostationary Meteorological Satellite(GMS) 5 for January, 1997 to December 1997 in clear and cloudy conditions. The hourly insolation is estimated with a spatial resolution of 5× 5 km grid. The island pyranometer belonging to the Japan Meteorological Agency is used for validation of the estimated insolation. It is shown that the estimated hourly insolation has RMSE(root mean square) error of 104 W/m$^2$. The variability of the hourly solar radiation was investigated on 3 areas over seas around Korean Peninsula. The solar radiation of East Sea is similar to Yellow Sea. The maximum value of solar radiation is on June of year. The maximum value in south sea is on August because weather is poor by low pressure and front in June

## 1. Introduction

As solar radiation is the important variable in growing of animal and plant, using of solar energy etc. as well as motive power which causes movement of all geophysical fluid including the atmosphere , it is very important to acquire precise information of hourly and spatial distribution . Solar radiation incident on the upper side of the atmosphere is simply calculated by astronomical law however it is not easy to infer hourly and spatial distribution on land surface with high accuracy, because sunbeam is scattered, reflected and absorbed by aerosol and cloud in atmosphere while arrive from the upper side of the atmosphere to land surface(Kimball, 1928).

Although direct observation by observing network with high density is desirable, it is not easy for budget and management, particularly direct observation on sea is impossible. Various empirical equation which infer solar radiation on sea surface has been proposed and managed by use of other climate factor such as cloudiness which is easy to observe comparatively from for a long time. Required cloud amount data in these empirical equation is getting by ship data, but there are problems which is not equal to hourly and spatially as well as quantity and quality of data.

In addition, it's difficult to see that these empirical equation would be able to use in all round the world, because these are made by based on data of special region. Although as there was

not other ways, many meteorologist has calculated the solar distribution of ocean based on these equation(Bunker, 1976; Hsiung, 1986).

In recently, the problem which has occurred when this equation had been used is solved as study about inference of solar radiation by using data from meteorological satellite is spurred. Solar radiation arrived on land surface can infer by use of visible channel data of Geosatationary Meteorological Satellite. This method parameterize scatter and extinction of solar radiation in the atmosphere in clear sky and infer solar radiation arrived on land surface as adding reflection and extinction effect by cloud in cloud sector . It is also performing inference of daily average solar radiation by use of VISRR/ GMS.

Inference of distribution of global solar radiation also has been studied by use of global cloud distribution data by geostationary meteorological satellite and polar stationary satellite.

Studies having purpose of high accuracy as well as these has been performed. The advantage of satellite data is regularly to get data, which is in large scope.

To infer solar radiation having high accuracy from satellite data of high quality would be helpful to search the earth environment as well as the ocean science

## 2. Data and Methodology

### 2.1 Satellite data

GMS-5 satellite which is Geostationary Meteorological Satellite of Japan shot in 1995 is composed of five channel, each of which is divided into Visible(0.55-0.90), Water vapor(6.5-7.0), ir1(10.5-11.5), ir2(10.5-12.5).

Visible data which is mainly used in this study is data that observe Asia region centering Korea, having spatial resolution 0.05×0.05°, from 1st Jan ,1997 to 31st Sep ,1997.

In former study, used spatial resolution of satellite data by interpolation, but in this study, used resolution of pixel as it is for inference of more accurate value. This GMS data received from KMA. Time of data is at intervals of 3hours as 00,03,06,09,12,15,18,21 UTC. As there are some problem to get average value by data intervals of 3 hours, we got hourly solar radiation by use of 00,03,06UTC data which can get solar radiation value and verified it.

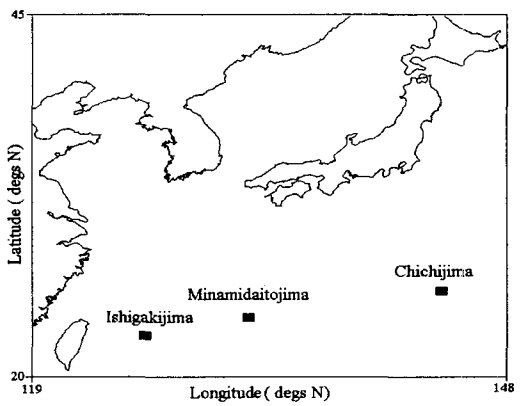



Fig 1 Positions of JMA Pyranometer around Japan Peninsular

### 2.2 Island data

It is data for validation of inferred sea surface solar radiation, and needs solar radiation value on sea surface. We used Island data which manages in Japan because it can't get regularly solar radiation value from sea around Korea yet. Each of islands that would be compared in this study locates on the south of Japan. Island has many kinds of meteorology factors, solar radiation among them has hourly, daily, monthly. In this,

we used hourly data for verifying with GMS data and set the location of each region on Fig, 1.

2.3 equation

In inference of solar radiation used climate data of satellite until now, the method to infer as regression equation based on statistical relation between reflection from visible observation and real solar radiation, and method to infer solar radiation by put satellite data into model which is made through out physical processing of radiation. In this study, inferred solar radiation through out the method by physical inference of Kawamura et al (1998).

First , divided into when there are cloud or not by use of each visible, infrared channel for the classification of cloud. Used pixel value of satellite as it is for confirmation of existence of cloud, but there are some problem to conclude existence of cloud by pixel value of the moment because the information from satellite image is too momentary. Therefore in this model, we got average by selecting of total 9 pixel value as add pixel of satellite and pixel around it, and the price is used to judge cloud. According to judged base, constructed the model by dividing into being cloud or not.

3. Results and Discussion

3.1 Verifying of validity for inferred sea surface.

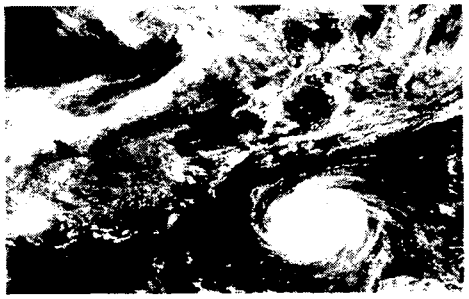
Compared sea surface solar radiation value inferred to calculation by model with JMA island data on land surface from Jan, 1997 to Sep,1997, and verified them. Fig 2. shows relation between estimated value by physical model and observed value. Used statistical method called RMSE to know relation of each region. The formula is as following:

$$RMSE = \sqrt{\frac{\sum_{i=1}^{N}(y_i - x_i)^2}{N}}$$

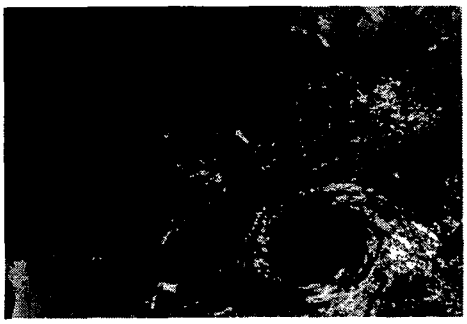
$$MBE = \frac{\sum_{i=0}^{N}(y_i - x_i)}{N}$$

In this formula, Yi represents estimated solar radiation value and Xi represents solar radiation value inferred by satellite.

From the comparison between the estimated value and real observed value, correlation coefficient is 0.91 that is comparatively good value. The estimated value was correct at low solar radiation but when the solar radiation value high, the value was underestimated.



(a)



(b)

Fig 2 Hourly field of the solar radiation around East Asia, (a) GMS satellite imagery,(b)

Calculated sea surface solar radiation from the GMS imagery at 15th August 1997.

3.2 Change of sea surface solar radiation around Korean Peninsula

Among prices got as result of model by use of satellite data, monthly change set to know change of solar radiation around Korean Peninsular. This price is 09,12,15(LST) in a day, and its monthly average value represented as time series data by diving into East sea, west sea and south sea. As we can know in results, East Sea value and west value appear similarly, but south sea has difference of 200w/㎡ in maximum than these region. Maximum of a year appears in August which are differ from the other regions. Maximum should be appeared in June having summer solstice when we saw in solar altitude, but as more cloud created by effect of low pressure, there are high possibilities that solar radiation became a little. Minimum of all three regions appears in November and December than in January

4. Conclusion

Inferred solar radiation on sea surface by use of visible channel of GMS satellite, and verified it with pyranometer observed data which is observed in study island. The method is to infer solar radiation on sea surface as putting satellite data by use of physical processing of radiation and then dividing into with and without cloud.

The correlation between solar radiation which is inferred by GMS-5 data and solar radiation of island region was 0.91 and RMSE was 104w/㎡. With inferred solar radiation value, variation of solar radiation of sea surface around Korean Peninsular is got dividing into East sea, West sea and South sea. East sea and West sea is similar , but it appeared than other region, particularly maximum variation of year appeared in August, not June. Consider needing more study about this and would be able to get better price if judgement about existence of cloud is getting better in algorithm

5. Acknowledgment

This research was performed for the National Hazards Prevention Research Project, one of the Critical Technology - 21 Programs, funded by the Ministry of Science and Technology of Korea.

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