Cloud cover and optical thickness from GMS-5 image data

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1. Introduction

Cloud is an important component for global and local climate. Its distribution and variation express an integration of atmospheric conditions. Cloud also directly affects to local climate through radiative process. Heat budget at the surface is decided mainly by radiation budget. In daytime, shortwave radiation dominates the total radiation budget and longwave radiation decides it in nighttime. Cloud plays a role not only on shortwave radiation, but on longwave radiation through cloud cover and temperature at cloud bottom. Diurnal change of the radiative flux belongs to the diurnal changes of cloud, atmospheric and surface conditions, and it has large amplitude. The radiative flux is important element for environmental and climate models. Hence it is needed to make properties of the diurnal variation of cloud clear.

In the present study, 1 hourly cloud cover data, which is processed from GMS(Geostationary Meteorological Satellite)-5 of Japan Meteorological Agency, is introduced. As famous cloud data set, ISCCP (International Satellite Cloud Climatology Project) is distributing global 3 hourly data. However it is more valuable to produce 1 hourly data, because incoming solar radiation changes quickly.

2. Data and analysis

Cloud fraction and optical thickness are products of the present study. The geostational satellite can give hourly data for the analysis. GMS-5 locates over 140 ° E is appropriate for this purpose. This satellite has four sensors, visible, water vapor and infrared split window channels. The area for estimate covers from 60° N, 80° E to 20° S, 160° E. A unit area in the study is defined as the 0.5 degree x 0.5 degree in Lat. and Long. Original GMS-5 data is re-sampled into 0.05° x 0.05° in geographical scale at the Institute of Industrial Science, University of Tokyo. Hence there are 100 pixels in a unit area. ECMWF (European Centre for Medium-range Weather Forecasts) objective analysis data is adopted for profiles of temperature, water vapor, and atmospheric pressure.

Cloud detection algorithm is composed of three steps. At first, the reference thermal infrared brightness temperature of clear sky is decided from relative comparison of temporal-spatial variation and statistical screening of the comparison (Rossow and Garder, 1993). Then the thermal infrared brightness temperature at each pixel is compared with the reference temperature of clear sky one by one. The temperature on a pixel is distinguished as cloudy if the temperature difference is 2.5 K less than the reference temperature of clear sky. Secondly, cirrus is detected by a split window method. Difference of 11um and 12 um channel depends on the optical absorption characteristics of cirrus cloud. Inoue (1987) classifies cirrus using AVHRR data. In the present study, 1.5 K is adopted for the threshold. In the stage, cirrus was classified into the cases over 253 K and under 253 K. Optical thickness cirrus are assumed to be 2.2 and 7.4, respectively in warmer and colder case (Inoue, 1987). Thirdly, water clouds are classified into 3 layers according to ISCCP category (Rossow and Garder, 1993). The thermal infrared brightness temperature of 11um channel, which is assumed to be cloud top temperature, is used for classification.

Cloud type, convective or stratus, is also distinguished by the imhomogeneity index, which means variance of infrared thermal temperature in the unit area except the gap between cloud top and the surface. Higher index shows convective type, otherwise stratus.

To retrieve cloud optical thickness, the sun reflection method, which was described in detail in Nakajima and Nakajima (1995), was adopted. This method was developed for AVHRR data, hence it needs visible, near infrared and infrared window channels. For GMS-5, the near infrared channel is not available. Therefore information on cloud effective radius cannot be estimated. In the present study, the effective radius is assumed to be 10um.

3. Results

Fig.1 shows total cloud fraction in January and July, 1996, 1997 and 1998 from GMS-5. Fig.2 shows total cloud fraction from ISCCP C2 dataset (1984-1990). Both result show similar pattern, but Fig.1 shows less cloud near the equatorial over the Gulf of Bengal in January. Also Fig. 1 shows more cloud over the continent (western part in the map). In July, Fig.1 shows clear contrast between land and ocean over the gulf of Bengal, while Fig.2 does not show such contrast. It should be discussed that the difference comes from the interannual variation or methodology.

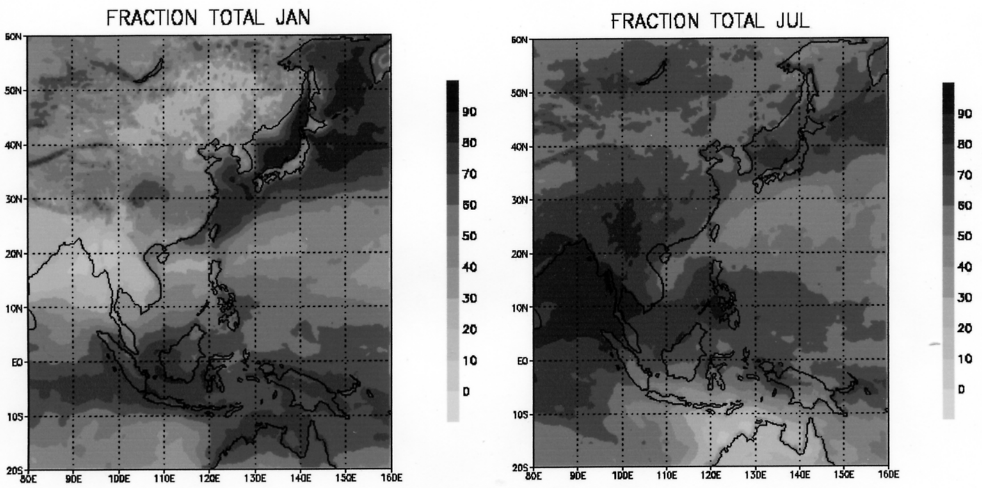

Fig.1. Monthly averaged cloud fraction from GMS-5.

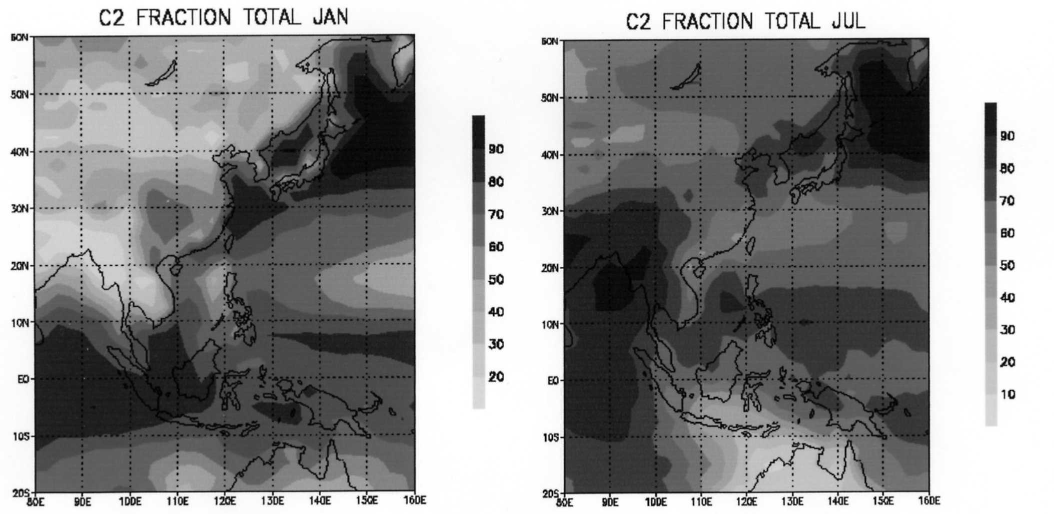

Fig.2. Monthly averaged cloud fraction from ISCCP C2 dataset.

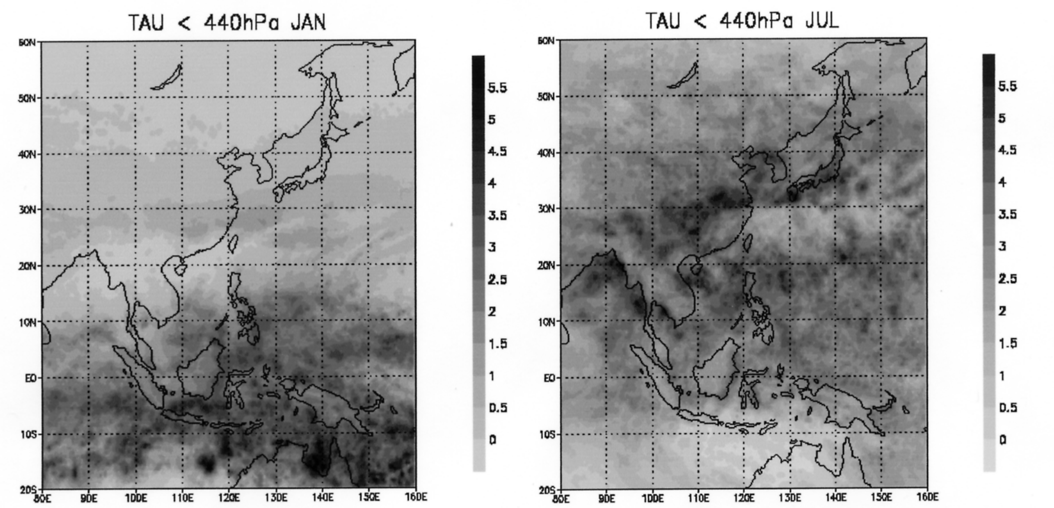

Fig.3. Cloud optical thickness for high cloud (cloud top < 440 hPa) in 1996.

Fig.3 shows the retrieved cloud optical thickness of high cloud, which is defined that the cloud top altitude is upper than 440 hPa. The July data shows also dense thickness over the gulf of Bengal, but shows thin thickness over the land near the coast.

Those data are used as input parameters to estimate downward surface solar flux in the next presentation.

References

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