Estimation of radiation budget using ADEOS-II/GLI

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Abstract

The Global Imager (GLI) observed data provides the particle product including detailed optical properties. This products promotes radiation budget studies for better understanding of Earth system. In this study, analysis of seven months in 2003 (April to October) was carried out. The GLI land and ocean aerosol and cloud particle products are included by Neural Network (NN) algorithm in Shortwave (SW) fluxes analysis. The downward SW fluxes at the surface is discussed for the influence of cloud with the direct and the diffuse components. On the equator, the global SW flux is weakened by a influence of clouds over the intertropical convergence zone (ITCZ). And, the diffuse component is predominant in the northern hemisphere side in April and May that is a remarkably seen in the Pacific and the Atlantic Oceans. This diffuse component trends may have a close relation between the activity of the cloud and the aerosol of the northern hemisphere. The North Pacific Ocean in middle latitude has been kept bright by scattering of clouds, and the blocking of the direct component is distinctive trend.

Keywords **:** ADEOS-II/GLI, Solar radiation, Radiation budget

1. Introduction

The Global Imager (GLI) is equipped the Advanced Earth Observation Satellite - II (ADEOS-II), it observes the land, ocean, and atmosphere with 36 channels [Nakajima, 1999][1). It retrieves detailed particle optical characteristics in the atmosphere for a better understanding of global climate and Earth system. Clouds have enormous influence in Earth's radiation budget that is closely relates to Earth's energy budget. Clouds cool Earth by reflecting solar radiation, while it keep Earth warm by absorbing the terrestrial radiation and emitting to Earth surface. Because cloud modeling is not optimized well, these effect is uncertainty in General Circulation Model (GCM) [Tsushima and Manabe, 2001]. It perturbs the long term analysis for climate change of global warming. Aerosols have the effects of reflection and absorption on the solar radiation, and relates to cloud activities. Some particles cause the complex change of nominal particle optical characteristics by internal or external mixing. Because it changes the absorbing and the scattering characteristics of atmosphere, it has influence on the atmospheric radiation. In addition, because aerosols which become cloud nucleus, also influence cloud activities. Therefore, it become the uncertainty of radiation budget in the direct and the indirect effect. It is necessary to evaluate the influence of particles for radiation budget. Thus, accurate estimation of Solar fluxes are first step of them. In this study, downward and upward SW fluxes at the surface and TOA are estimated using ADEOS-II/ GLI particles product and surface albedo product. The ADEOS-II has once a day sampling because of a polar orbit (Sun-synchronous Sub-recurrent Orbit). However, the estimation of the solar fluxes including a strict optical characteristics has an effective meaning. These products of the ADEOS-II/GLI is used to discuss the influence of detailed optical characteristics of atmospheric particles. The estimated solar fluxes of the direct and the diffuse components indicate regional characteristics.

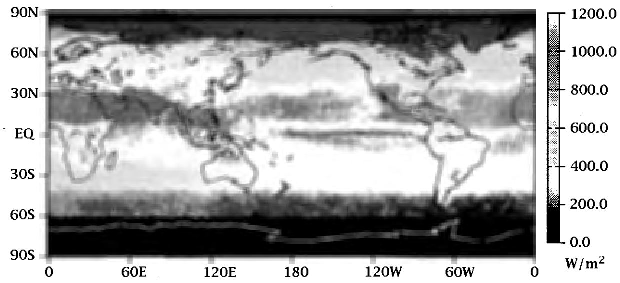
2. GLI products

The ADEOS-II/GLI standard products are used to estimate the solar fluxes in this study. Particles optical characteristics and surface albedo retrieval algorithm utilizes the ADEOS-II/GLI observation data to the maximum. The latest land and ocean aerosols, water and ice clouds, and surface albedo products are used that is a test version. Ocean surface aerosols are retrieved by Retrieval of Aerosol Optical Properties (REAP) [Higurashi and Nakajima, 2002][2]. The four-channel method for the aerosol retrieval is effective based on aerosol type classification. Water and ice clouds are analyzed by Comprehensive Analysis Program for Cloud Optical Measurement (CAPCOM) [Nakajima and Nakajima, 1997][3] based on the solar reflection method. It estimated optical properties and spatial distribution of cloud. Moreover, a land surface aerosol is added new product. New algorithm for land surface aerosols covered from dark to bright target, that proposes the desert, the forest area aerosols and other various surface aerosols [Fukuda and Nakajima, 2008][4]. In addition, land surface albedo is updated by using Bidirectional Reflectance Distribution Function (BRDF) model. Analysis of the surface albedo based on the geometrical conditions correct to the surface Bidirectional Reflectance Factor (BRF) [Yu, 2008][5]. These are included estimation of solar radiation at the surface and the TOA.

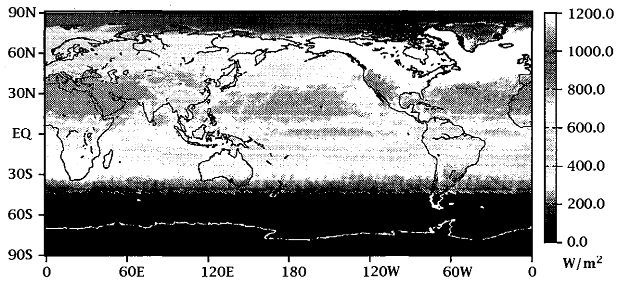
3. Algorithm

Solar fluxes at the surface and the TOA are estimated by Neural Network algorithm. We developed an algorithm based on NN and applied to ADEOS- II/GLI for estimation of radiation budget. The NN approach is one of the solution to following problems. In general, satellite based estimate methods often use a Look-up Tables (LUT). Since pre-calculated values are used, the LUT methods are effective for large amount of data processing. However, if the effects of absorbing gasses and the particle optical characteristics are

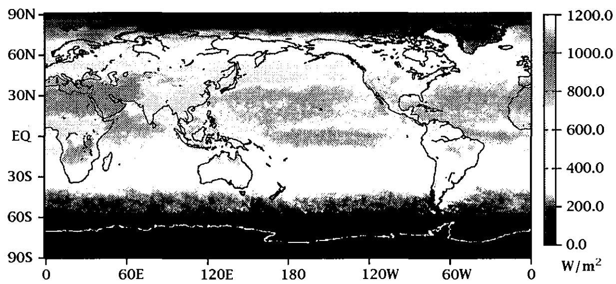
Global flux



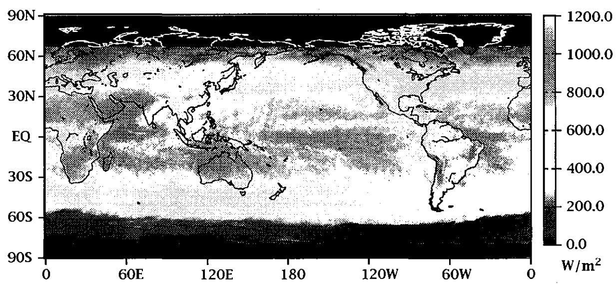
(a) April, 2003



(b) June, 2003



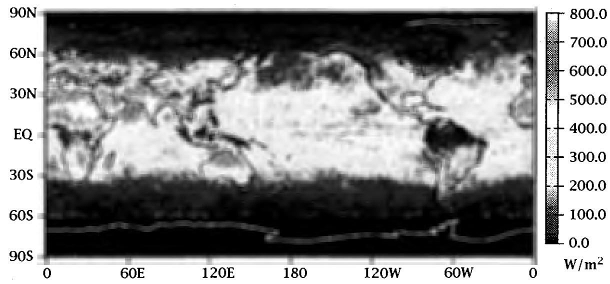
(c) August, 2003



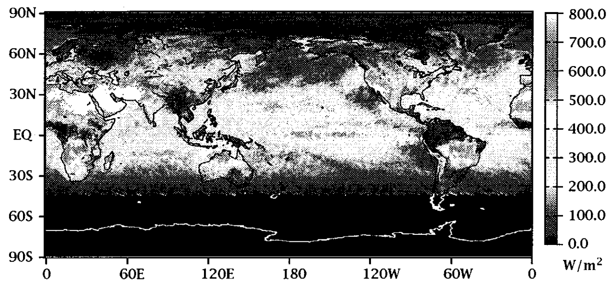
(d) October, 2003

Figure 1: Monthly averaged downward shortwave flux at the surface that include the GLI particle product (land and ocean aerosols, water and ice cloud, land surface albedo). (a) April, 2003 (b) June, 2003 (c) August, 2003 (d) October, 2003

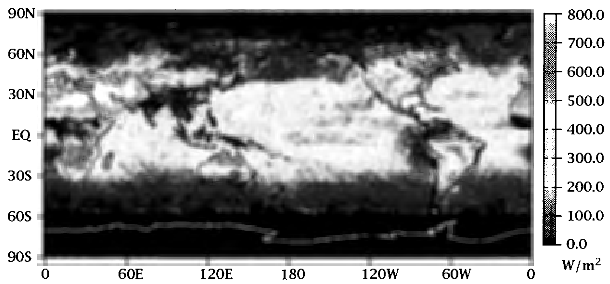
Direct component



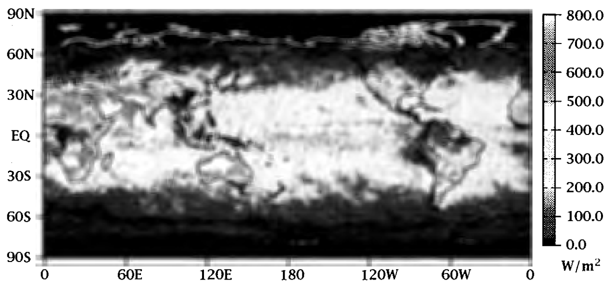
(a) April, 2003



(b) June, 2003



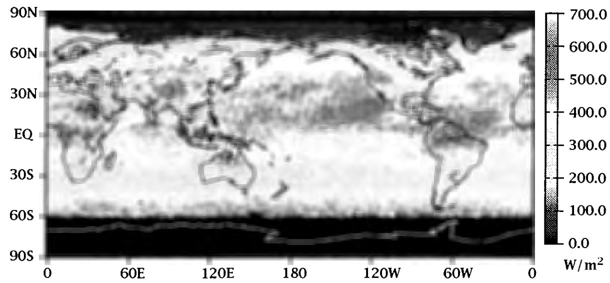
(c) August, 2003



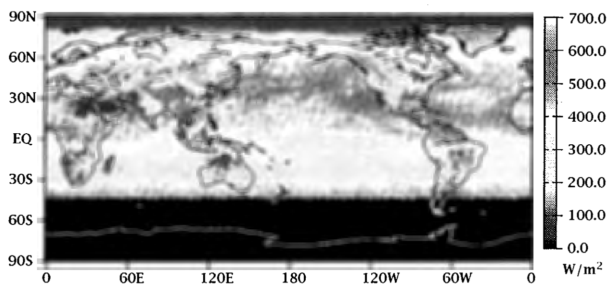
(d) October, 2003

Figure 2: Same as Figure 1, but for direct component. (Monthly averaged downward shortwave flux at the surface, direct component)

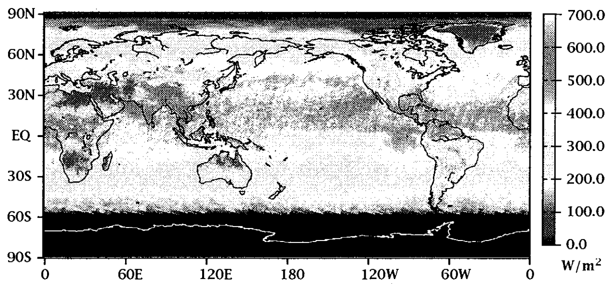
Diffuse component



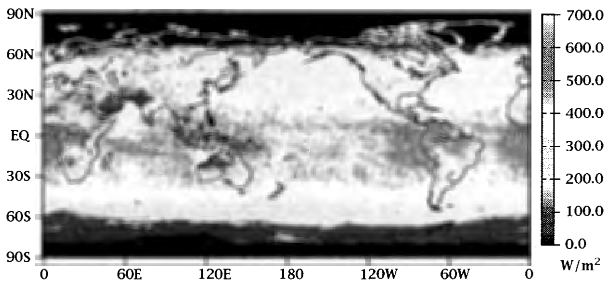
(a) April, 2003



(b) June, 2003



(c) August, 2003



(d) October, 2003

Figure 3: Same as Figure 1, but for diffuse component. (Monthly averaged downward shortwave flux at the surface, diffuse component)

incorporated precisely, LUT becomes huge volume. An increase in parameter needs not only the increase of LUT volume but also complex interpolation of LUT. We apply the Extreme speed and Approximation module Multiple drive System (EXAM SYSTEM) for estimation of solar fluxes with the GLI products. The EXAM SYSTEM integrated these parameters of atmospheric radiation into the solar fluxes. Neuro-link Network solver (NN solver) for estimation are built by improved learning algorithm "Distortion-BP" [Takenaka et al., 2008][6]. It estimated the solar fluxes at the surface and the TOA.

4. Result and discussion

Figure 1 indicates the downward SW flux at the surface. It is strongly distributed in low latitudes (around equator) through the period. Because, equator has the influence of clouds of intertropical convergence zone (ITCZ), it indicates the weakened line of the global flux. Figures 2 and 3 are direct and diffuse components of downward SW flux at the surface, respectively. Contrast of rainy and dry season are clearly in India. Direct component is predominant in April (Fig. 2a), but it has very low value in August(Fig. 2c). While the diffuse component has a reverse trend. It was brought by the cloud. This trend indicates rainy season from June to September. For the other regions, such as North Africa to Middle East has the strong global flux, very strong direct component is predominant due to few clouds. Northern Australia shows the same trend for the same reason. The most important effects of clouds are the blocking of direct component and strong diffuse component caused by thin clouds (Fig. 4). In North Pacific Ocean, a strong scattering was caused by a thin cloud. Therefore it has been kept bright by scattering, and the blocking of the direct component is distinctive trend. This trend close relation with the activity of the cloud and the aerosol of from East Asia to North Pacific Ocean. Its a trend remarkably seen in the North Pacific Ocean and the North Atlantic Ocean. And, the West coast of north side of South America has the same trend. Especially, blocking of direct component is indicated ADEOS-II/GLI observation period (April to October, 2003).

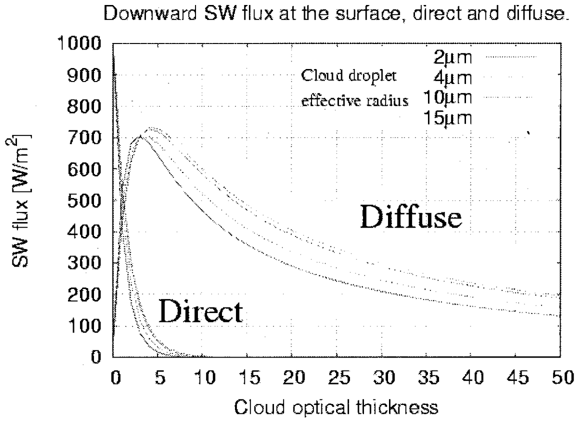


Figure 4 : Influence of cloud on downward SW flux at the surface, based on classification of cloud droplet effective radius. The kind of lines indicates the difference of a cloud droplet effective radius. (Solar zenith angle =20.0 degree. US standard atmosphere, surface albedo is 0.03.

References

1) Nakajima, T., T. Y. Nakajima, M. Nakajima, and the GLI Algorithm Integration Team (GAIT) (1999), Development of ADEOS-II/GLI operational algorithm for earth observation, SPIE, 3870, 314-322.
2) Higurashi, A., and T. Nakajima (2002), Detection of aerosol types over the East China Sea near Japan from four-channel satellite data., Geophys. Res. Lett., 29(17), 1836, doi:10.1029/2002GL015357.
3) Nakajima, T. Y., and T. Nakajima (1995), Wide-area determination of cloud microphysical properties from NOAA AVHRR measurements for FIRE and ASTEX regions, J. Atmos. Sci., 52, 4043-4059.
4) Fukuda, S., T. Nakajimal, A. Higurashi, N. Kikuchi, and T. Y. Nakajima (2008), Aerosol retrieval from GLI over land and its comparison with ground observation, CEReS symposium 2008.
5) Cui, Y., et al., (2008) An empirical anisotropy correction model for estimating land surface albedo for radiation budget studies, Remote Sensing of Environment, doi:10.1016/j.rse
6) Takenaka, H., T. Y. Nakajima, A. Higurashi, A. Higuchi, T. Takamura, R. T. Pinker, Estimation of Solar radiation by Neural Network, J. Geophys. Res. (submitted).