Estimation of radiation budget using geostationary satellites

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Abstract

SW radiation budget is estimated using geostationary satellites (GMS-5, GOES-8, GOES-10, METOSAT-5, METEOSAT-7). Each satellite data are calibrated, and optics properties of the cloud are retrieved. An accurate calibrated data propose the better accuracy for analysis of cloud and radiation budget. In this study, cloud and SW radiation budget analysis are done by CAPCOM algorithm and EXAM SYSTEM. On the other hand, aerosol optical thickness is retrieved by L-REAP algorithm. We discuss the possibility of aerosol-cloud-radiation interaction in north Pacific ocean and north Atlantic ocean.

Keywords **:** Radiation budget, Aerosol, Cloud, Radiation, Interaction

1. Introduction

Clouds can cool the Earth by reflecting solar radiation and also can keep the Earth warm by absorbing and emitting terrestrial radiation. They are important in the energy balance at the Earth surface and the Top of the Atmosphere (TOA) and are connected complicatedly into the Earth system as well as other climate feedback processes. Aerosols reflects solar radiation and cools the earth, and it is called a direct effect. Moreover, aerosols influences the condensation of the cloud particles by indirect effect. Thus, cloud and aerosol are one of the important element in Earth energy system, and it's important to be estimate radiation budget to better understand climate and environmental change.

Wetherald and Manabe discussed the cloud feedback process using a General Circulation Model (GCM) [Wetherald and Manabe, 1988]. Tsushima and Manabe tested the cloud feedback sensitivity to global mean surface temperature based on explicit definition of feedback processes. GCM has strong sensitivity for global mean surface temperature although analysis of sensitivity based on observations are negligible [Tsushima and Manabe, 2001]. Cloud modeling is a big uncertainty for the climate model and long term analysis for the global change would be estimated. It is important to evaluate the influence of cloud for Earth's radiation budget based on observations.

Geostationary satellite observations are useful for estimating the upward and downward radiation budget at the surface and the TOA over wide regions and at high temporal resolution. We develop a vicarious calibration technique for the global analysis. An accurate calibrated data propose the better accuracy for analysis of cloud and radiation budget. (In this study, four satellites: GMS-5, GOES-8, GOES-10, METOSAT-5, METEOSAT-7 are used for analysis). An accurate calibrated data propose the better accuracy for analysis of cloud and radiation budget. Additionally, the possibility of aerosol-cloud-radiation interaction is discussed.

2. Methods

2.1.Calibration of satellites observation data

The geostationary satellite has a big advantage for estimation of radiation budget because of highly time-resolved data. One of key factors in the estimation is a sensor calibration. It has some issues in the calibration procedures. In this study, five geostationary satellites (GMS-5, GOES-8, GOES-10, METEOSAT-5, METEOSAT-7) is used for radiation budget analysis. Each satellite were calibrated by Global Space based Inter-Calibration System (GSICS) proposed method based on three component using the radiative transfer code RSTAR6. The satellites data calibrated in high accuracy achieves a accurately radiation budget analysis.

2.2.Retrieval of cloud optical properties

We used the Comprehensive Analysis Program for Cloud Optical Measurement (CAPCOM) [Nakajima and Nakajima, 1995; Kawamoto et al., 2001]. This algorithm was also adopted as one of the standard algorithms for the Advanced Earth Observing Satellite II/Global Imager (ADEOS-II/GLI) products [Nakajima, 1999]. we applied CAPCOM to five geostationary satellites data to retrieve only the cloud optical thickness using the VIS channel

2.3.Estimation of radiation budget

We develop a high speed and accurate algorithm based on Neural Network (NN). The advantages of the NN approach are to be speed of the computations and allows to produce numerous parameters since it does not require a large data base. Figure 1 indicates a three layers network structure. Neuro-link Network solver (NN solver) is built by improved learning algorithm “Dist.-BP” that has an anti-local minimum and a survival rule of neuron depending on nerves activities [Takenaka et al., 2009; 2010]. 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 incorporate dprecisely, LUT becomes huge volume. An increase in parameter needs not only the increase of LUT volume but also complex interpolation of LUT. The NN solver traces radiative transfer code System for Transfer of Atmospheric Radiation (RSTAR) [Nakajima and Tanaka, 1986, 1998] for high speed and accurate computation. The Extreme speed and Approximation module Multiple drive System (EXAM SYSTEM) controls NN solvers by multi-threading. EXAM SYSTEM applies to MTSAT-1R, estimates the solar radiation at the TOA and the surface with semi-real time, and evaluated against in situ observations. The EXAM SYSTEM uses eight Central Processing Unit (CPU) cores, And logically sliced target area

3. Result and discussion

Radiation budget product is generated based on five geostationary satellites (Fig 2). Each satellites products are smoothly connected by accurate calibration (Fig. 3). In past report, we pointed out the possibility of aerosol-cloud-radiation interaction in north Pacific ocean [Takenaka, 2009; 2010]. It indicate aerosol and thin cloud has a same pattern. They kept by strong diffuse component in
the east Asian to North Pacific ocean region. On the other hand, those characteristics (direct and diffuse component) showed the same trend in North Atlantic Ocean in ADEOS-II/GLI result [Takenaka, 2009; 2010]. In this study, we focus the North Atlantic Ocean region using developed radiation product. Figure 4 and Figure 5 indicate the downward SW flux at the surface diffuse component and direct component (June and September, 2002). We found the strong diffuse component in north Atlantic ocean in June 2002, And direct component is blocked. Those trend are not shown in September. Figure 6 shows the influence of cloud on downward SW flux. Diffuse and direct component trend are caused by low optical thickness cloud. Moreover, aerosol optical thickness increases in north Atlantic ocean (Fig.7). These trends shows the same trend in east Asia to North Pacific ocean.

- Formation of a Virtual Laboratory for Diagnosing the Earth's Climate System -

In order to diagnose the earth's climate system under severe stress such as a global warming, the cooperative research centers (CCSR, HyARC, CAOS, and CEReS,) construct "Virtual Laboratory", and research climate and environmental studies cooperatively with properties of each center. CEReS activities are Geostationary satellites global data archives and construction of Satellite information data base. Moreover, development of atmospheric radiation budget product. We aim at the contribution to a climate model and the better understanding of the climate system.

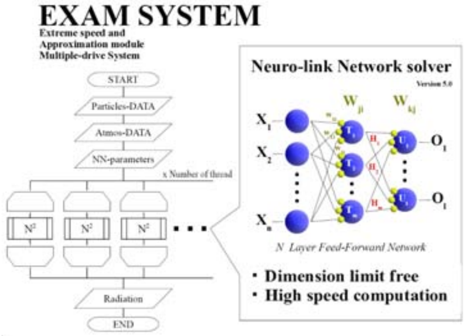

Figure 1: Schematic illustration of EXAM SYSTEM. NN solvers traces radiative transfer calculation.

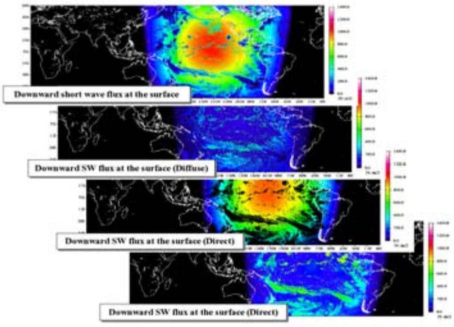

Figure 2: Test product of SW radiation budget product using five geostationary satellites. September 2-3 , 2002.

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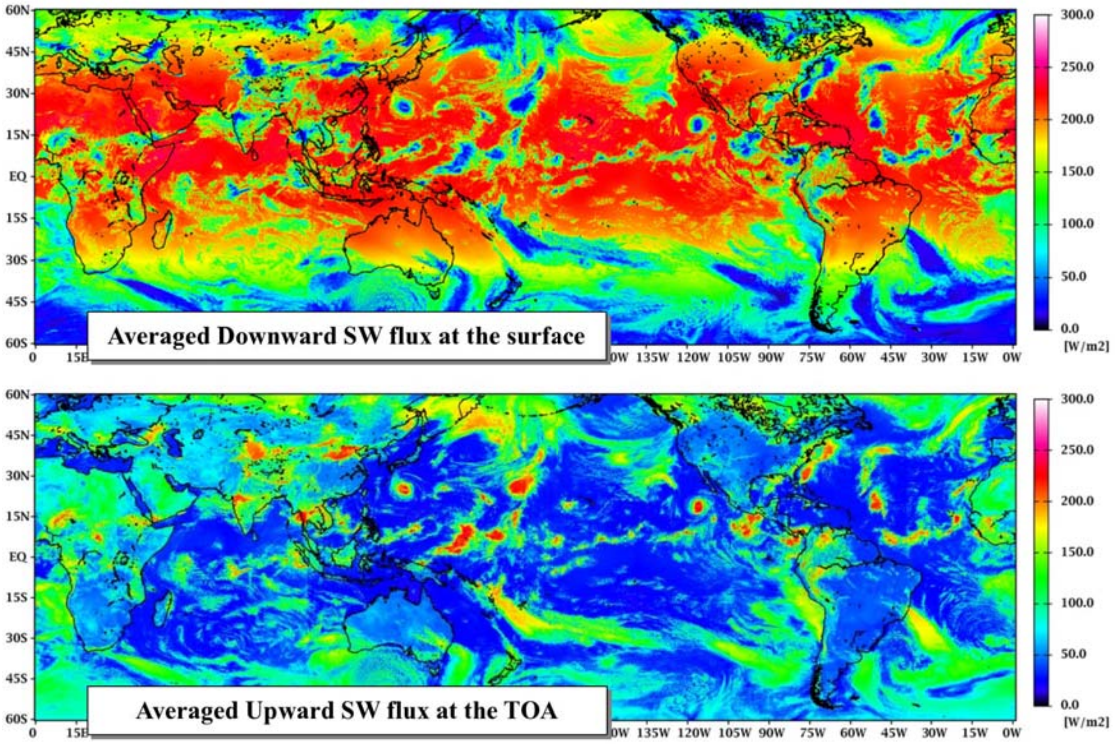

Figure 3: Averaged Downward SW flux at the surface and Upward SW flux at the TOA.

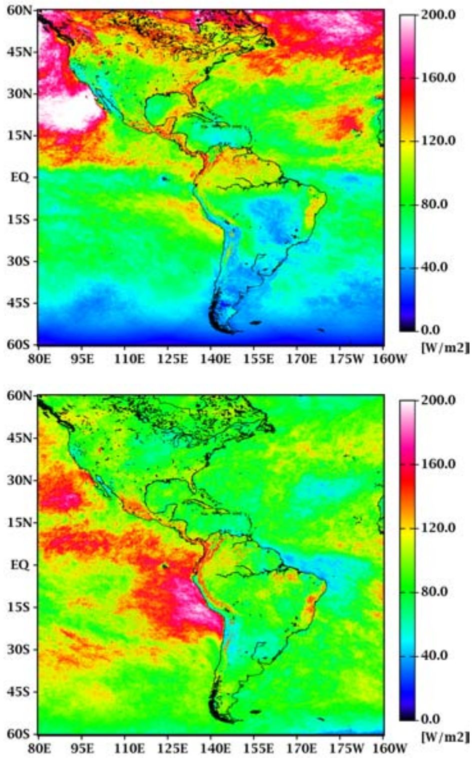

Figure 4: Downward SW flux at the surface diffuse component. Upper side: June 2002. Lower side: September 2002.

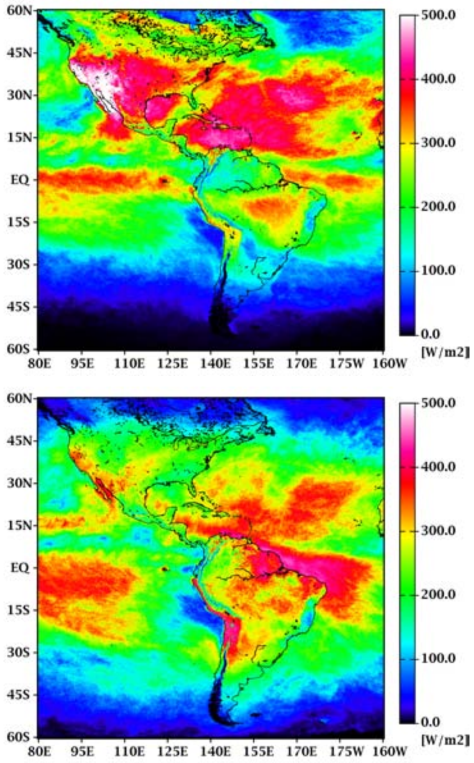

Figure 5: Downward SW flux at the surface direct component. Upper side: June 2002. Lower side: September 2002.

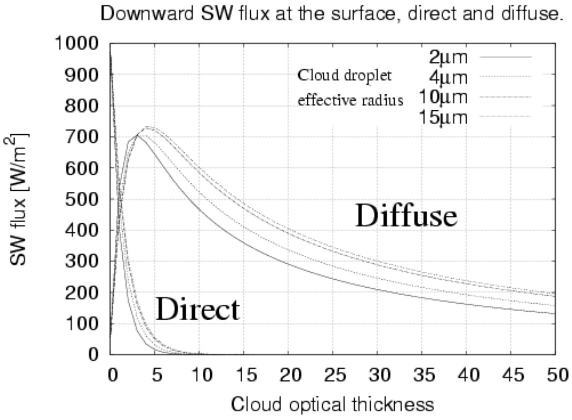

Figure 6: Influence of cloud on downward SW flux at the surface direct and diffuse component.

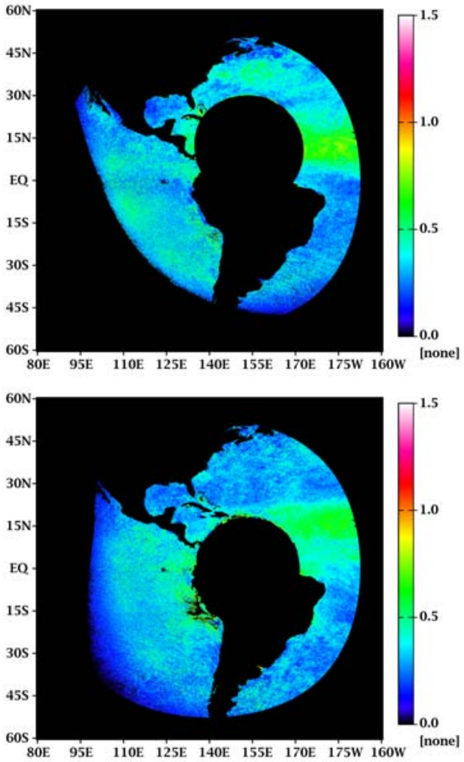

Figure 7: Aerosol optical thickness retrieved from GOES-8. Upper side: June 2002. Lower side: September 2002.