Explanation

Retrieval of Cloud, Water Vapor, and Aerosol Properties Using ADEOS-II/GLI Data

Makoto KUJI*[1], Nobuyuki KIKUCHI*[2] and Akihiro UCHIYAMA*[3]

Abstract

Retrieval algorithms of cloud, water vapor, and aerosol, were developed for ADEOS-II/GLI dataset. The retrieval algorithm was applied to ADEOS-II GLI data, using oxygen A-band (763 nm) for cloud geometrical properties such as cloud top and bottom heights. As a result, a global map of the heights was obtained as a preliminary one. Columnar amount of water vapor was also retrieved using near infrared bands (1150 nm) over land in particular, which is possibly complementary to the water vapor amount retrieved with microwave radiometer over ocean. Monthly global maps of columnar water vapor amount were obtained together from ADEOS-II/GLI and ADEOS-II/AMSR. Further, Columnar amount of yellow sand (Kosa aerosol), which is one of the UV-absorbing aerosols, was retrieved using near ultraviolet bands (380 nm) with 1 km spatial resolution over land. The retrieved aerosol property was compared to a ground-based lidar observation inland China and it was found that the result was consistent with each other. Although our algorithms seem to work well, these results are still preliminary, and detailed validation studies are necessary in furture.

Keywords : ADEOS-II/GLI, cloud, water vapor, UV-absorbing aerosol, oxygen A-band

1. Introduction

Surface radiation budget is still one of the most uncertain issues in terms of atmospheric radiation budget study on the earth. Although a lot of efforts were made to estimate it, there still uncertainty due to uncertainties arising from atmospheric properties such as cloud, aerosol, and water vapor over land in particular. Advanced Earth Observation Satellite-II/Global Imager (ADEOS-II/GLI) is designed for observing earth atmosphere and surface properties. GLI is a moderate resolution imager with 1 km spatial resolution mainly, which has 36 spectral channels over near ultraviolet, visible, near infrared, and thermal infrared.

One of the GLI missions for the atmospheric discipline is to investigate a radiation budget at surface. It is necessary to know properties of cloud, water vapor and aerosols for an improvement of the estimation. We developed retrieval algorithms of cloud, water vapor, and aerosol properties using GLI data. Based on the retrieval algorithms, we obtained the properties and made validation studies for the preliminary results.

Firstly, Cloud top and bottom heights are key properties to estimate radiation budget at the top and bottom of the atmosphere as well as cloud optical and microphysical properties. GLI has an oxygen A-band channel, which is useful to estimate cloud top and bottom heights. Secondly, Water vapor is one of the most important greenhouse gases as well as aerosol modulator through humidity effect. It is important to retrieve water vapor amount over land since microwave radiometry has difficulty to retrieve water vapor amount over land currently due to the variety of surface emissivity. GLI has a water vapor absorbing channels in near infrared spectral region, which is feasible to estimate water vapor amount over land under clear sky condition. Thirdly, Aerosol is a key factor for the radiation budget under clear sky condition as well as water vapor amount. GLI has near ultra violet channel (380 nm), which is capable of better estimation of UV-absorbing aerosol loading arising from biomass burning and salutation of dust particles over land in particular. In this short article, we show the retrieval outline of cloud, water vapor, and aerosol properties using GLI data.

2. Retrieval and Results

In this section, we show the retrieved results of cloud, water vapor, and aerosol properties using ADEOS-II/GLI data.

2.1 Cloud

GLI has a specific channel (Ch. 17) around 763 nm spectral

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band, which is strong oxygen-absorbing one, known as oxygen A-band (P-branch). According to signal simulations, this spectral band has a potential to estimate cloud geometrical thickness[1].

Based on the signal simulations, we developed the retrieval algorithm and made a validation study using the airborne data with Multichannel Cloud Radiometer (MCR) and Cloud Laser System (CLS) onboard Earth Resources 2 (ER-2) high altitude aircraft. The data was provided from National Aeronautics and Space Administration (NASA) in USA. As a result, we confirmed the retrieval algorithm worked well to estimate cloud top and bottom heights even though we cannot validate cloud bottom height with airborne LIDAR system for optically thick clouds in particular at that time[2].

After the launch of ADEOS-II, we applied this algorithm to GLI data and made a validation study with Frequency Modulated - Continuous Wavelength (FM-CW) radar in Asian Atmospheric Particle Environmental Change Studies (APEX) intensive field campaign. As a result of the validation study, the satellite-retrieved cloud top and bottom heights are comparable to the ground-based remote sensing measurements by about several hundred meters[3].

We also made extended simulations for the valid range of retrieved parameters. As a result, this algorithm would be applicable the following range : Optical thickness 4 to 128, effective particle radius 4 to 32 μm, top height and geometrical thickness up to 10 km[4].

And finally, we obtained the global map of cloud top and bottom heights as a preliminary result in Fig. 1. Figure 1 shows a global map of cloud top and bottom height for March 20, 2003, as well as visible (678 nm) imagery. We will continue to analyze the GLI data with the algorithm and make validation studies.

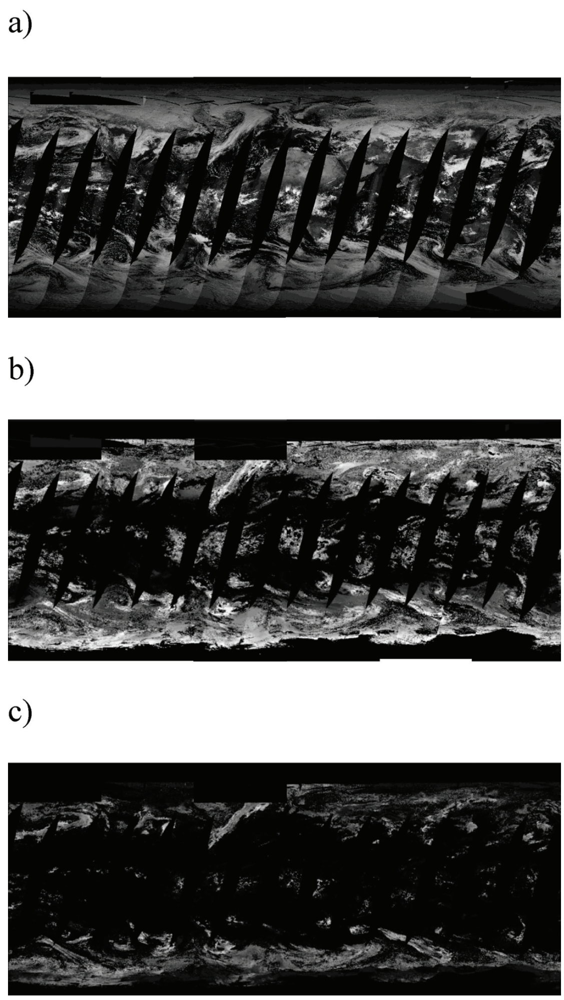

Fig. 1 A global map of cloud top and bottom heights retrieved with GLI data in March 20, 2003. a) channel 13 (visible ; 678 nm), b) cloud top heights, c) cloud bottom heights. Color scales are normalized to the maximum and minimum of each panel.

2.2 Water vapor

We developed a retrieval algorithm for water vapor amount (vertically integrated water vapor amount i.e., precipitable water) using GLI near infrared channel (1135 nm) based upon the MODIS algorithm. With a sensitivity study, this algorithm is more suitable to water vapor amount over land (higher albedo region) than over ocean (lower one)[5].

We applied the algorithm to the GLI data and made a validation using radiosonde observation. We confirmed the retrieved results are comparable to the radiosonde observation at some observation sites over a northern America continent. It is, however, necessary to make a more synchronized comparison since radiosonde observation had time lag around several hours from satellite overpasses[6].

Even though detailed validation study is ongoing, this algorithm was applied to GLI data over land on a monthly basis. Fig. 2 shows a global map of columnar water vapor amount (precipitable) water. The water vapor amount was estimated with GLI and AMSR over land and ocean. From Fig. 2, you could see a good seasonal variation of columnar water vapor amount between spring and summer over both land and ocean.

2.3 Aerosol

We developed a retrieval algorithm for aerosol using near ultraviolet channel (380 nm) of GLI based on the Total Ozone Monitoring Satellite (TOMS) sensor algorithm (so-called Direct Method)[7]. It is expected that finer spatial resolution of 1km with GLI will reveal more detailed feature of aerosol over land, compared to larger spatial resolution of several 10km with TOMS.

We applied our method to GLI data so as to retrieve columnar amount of Asian dust (Kosa) aerosol inland China. In this retrieval, we specified the aerosol altitude with in situ LIDAR measurement since the uncertainty of aerosol altitude

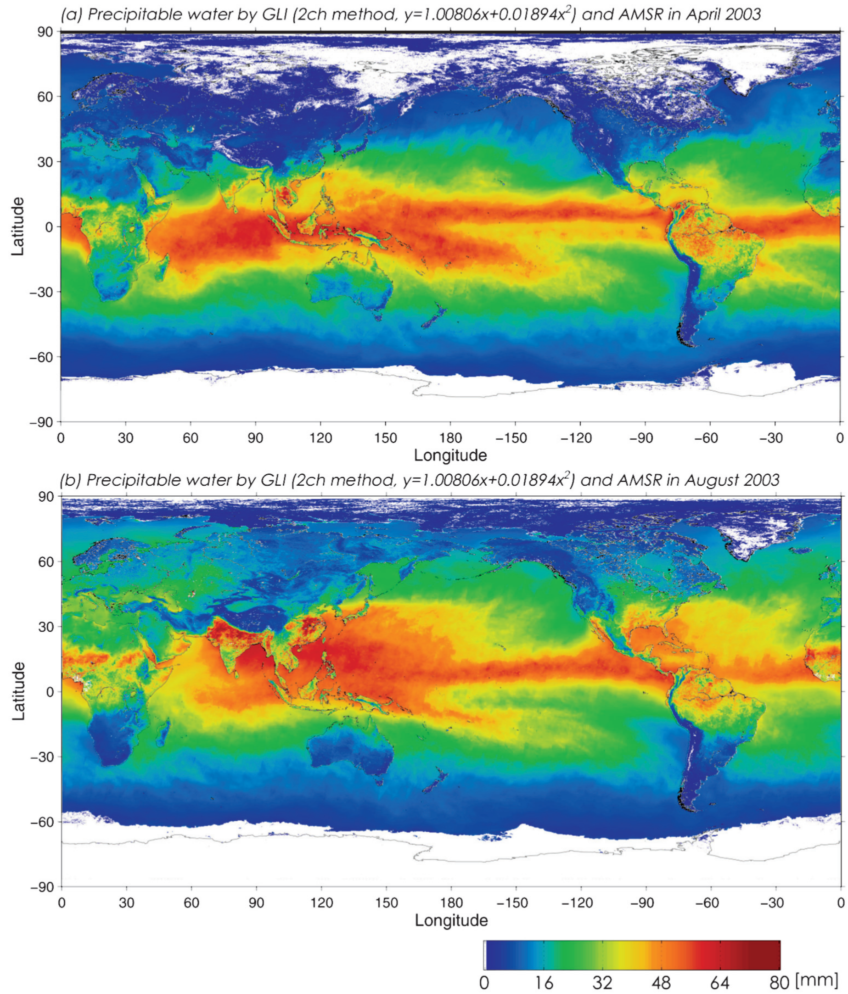

Fig. 2 A global map of monthly average columnar water vapor amount (precipitable water) retrieved with GLI and AMSR onboard ADEOS-II. Upper panel : April, lower panel : August (by courtesy of JAXA/EORC).

is one of the most influential factors in the retrieval. We confirmed the retrieved optical thickness was comparable to that from LIDAR measurement[8)].

We also applied the algorithm for a sulfuric haze event around Japan. As a result, we found that satellite retrieved spatial distribution was consistent with regional chemical transport models simulation[9)].

3. Summary

We developed retrieval algorithms to estimate cloud, water vapor, and aerosol properties using the GLI specific channels such as oxygen A-band, near infrared water vapor absorbing band, and near ultra violet spectral regions, respectively. These algorithms were applied to the ADEOS-II/GLI data and we obtained initial results. We are analyzing GLI data and validating the results. We hope our effort will contribute to better estimation of surface radiation budget studies eventually.

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