CGMS-34 KMA-WP-09

Prepared by KMA
Agenda Item II/6
Discussed in WGII

Operational Cloud Amount Estimation of KMA with Geostationary Satellite Data

This paper reports on Cloud Amount Estimation, which is operated in KMA. Hemispheric Cloud Amount is calculated using geostationary satellite data. This report summarizes the algorithm and shows verification result for three months of 2005.

Operational Cloud Amount Estimation at KMA

1 Introduction

A new algorithm for the hemispheric cloud amount has been used for the real time operation. The hemispheric cloud amount, which is different from the cloud fraction derived by the nadir view, is satellite-derived ground-based cloud amount. Its main application area is the analysis of current sky condition for the newly launched Digital Weather Forecasting System of KMA. The Hemispheric cloud amount calculated by using geostationary satellite is derived by two stages processing, which starts with the cloud detection processing followed by calculation of cloud amount by applying a simple geometric relationships of the detected cloud and its location. Here, we briefly introduce the processing and its validation results.

2 Detection of cloud

To derive the necessary information for the hemispheric cloud amount, we first detect the cloud presence followed by a cloud classification process. For the cloud detection, we compare the measured radiance with the clear sky radiance. The cloud classification process categorizes the detected cloud pixel into three cloud types.

The major process for the cloud detection is to have accurate clear sky radiance. We take the minimum (maximum) composite of VIS reflectance (IR brightness temperature) during the previous several days to derive the clear sky radiance. The range of composite date depends on the climatology of the brightness temperature over Korean peninsula and adjacent sea area. During the fall season, the composite period is reduced to accommodate rapid variation of the surface temperature. On the other hand, during the rainy season when cloudy sky conditions linger over longer period, the composite period is expanded to the previous 15 days.

For the “not clear” pixel, cloud classification process is applied. For the cloud classification, we use threshold approach that compares the measured radiance values with the pre-defined threshold values. The various threshold values depend on time (daytime/nighttime/twilight) and space (land/sea). Various dual channel difference methods with the necessary threshold values are also used in this step. The result of cloud detection provides the categorization of 3-types cloud that is closely related to the height of detected cloud. These 3-types include low cloud (St, Sc; named Cld1), mid-upper cloud (including uncertain cases; named Cld2) and vertically well-developed cloud (Cu, Cb; named Cld3).

Figure 1 shows an example of the cloud detection along with the IR and VIS imageries showing relatively well-classified cloud types. For example, the low cloud over East (Japan) Sea is well detected and classified as a low cloud, similarly northwest edges of an approaching typhoon. High clouds associated with the typhoon are also well classified as the high cloud. However, there are several clear sky pixels which are classified as uncertain or mid to upper clouds. This is mainly due to the slight over detection of the cloud detection process.

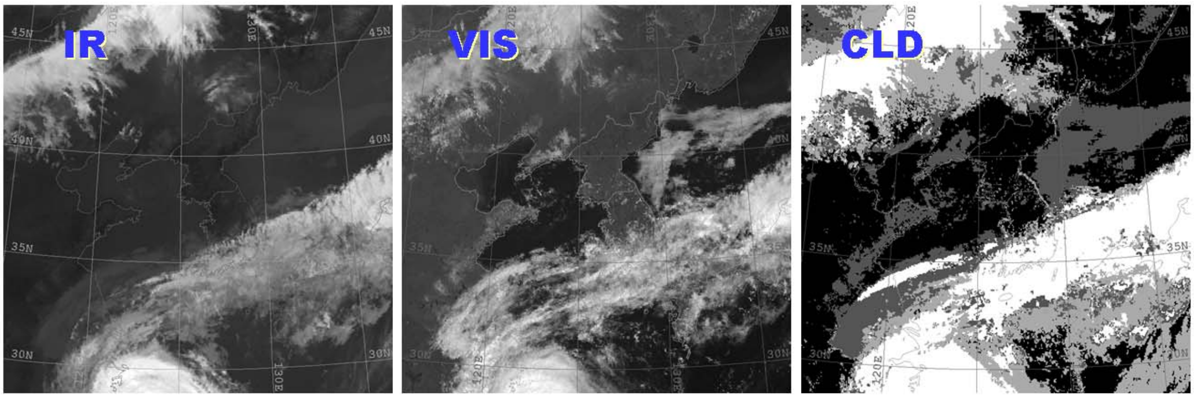

Figure 1 Infrared, visible and resulting cloud imageries on 01:33 UTC of September 11, 2005. Black area is the clear sky pixels, while white, light gray and dark gray represent vertically developed cloud, mid-upper cloud including uncertain case and lower cloud, respectively.

3 Calculation of cloud amount

Cloud amount using a conventional nadir-view perspective such as averaging cloud area within the 3x3 or 5x5 pixels looks unrealistic. Figure 2 shows two cloud amount maps derived by the nadir-view and ground-view perspectives. As expected the 5x5 pixels averaged cloud fraction show almost two categories, overcast and clear, while the new estimation show much realistic results.

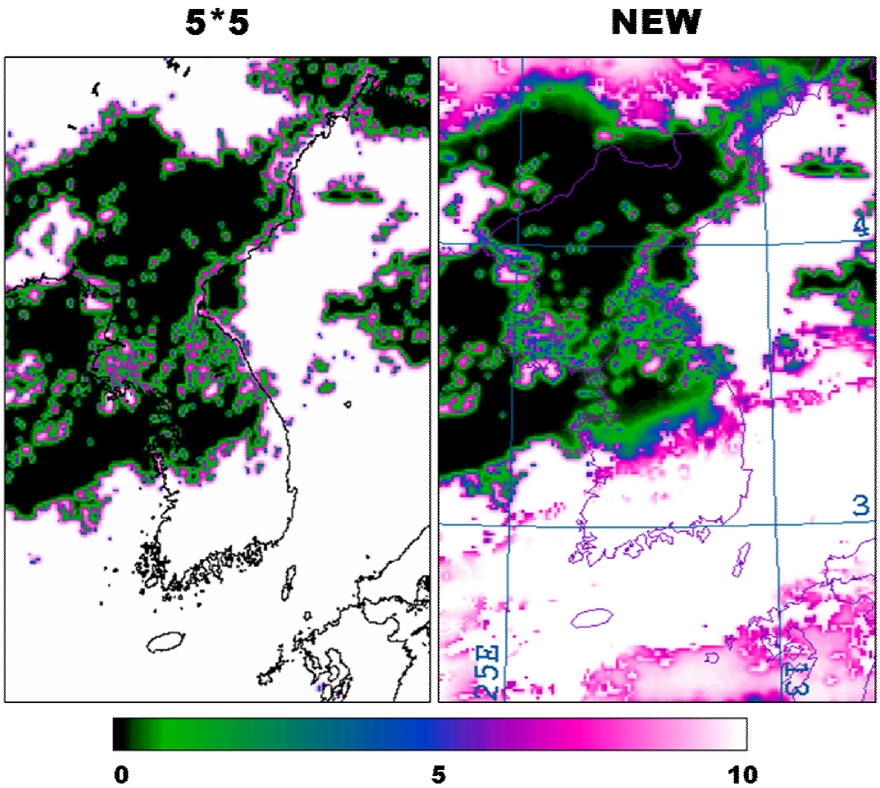

Figure 2 The comparison of cloud amount derived by nadir-view and ground-view perspectives. The used satellite imageries are the same as shown in Figure 1. The black, green-blue, pink, white represent clear, partially cloudy, cloudy, overcast, respectively.

To derive the cloud amount, we assign the three cloud types into a fixed cloud altitude for each cloud type at each pixel (5 km x 5 km). We then integrate the total cloud field of view as shown in Figure 3. The cloud field of view at each pixel is calculated by using the distance between the observation point and cloud pixel and cloud base and top altitude.

We first integrate lower clouds (the case of Cld1 or Cld3) only. If lower cloud is clear (the case of Cld2), then we integrate for mid-upper cloud (the case of Cld2 or Cld3) that could be seen through the clear pixel of lower cloud.

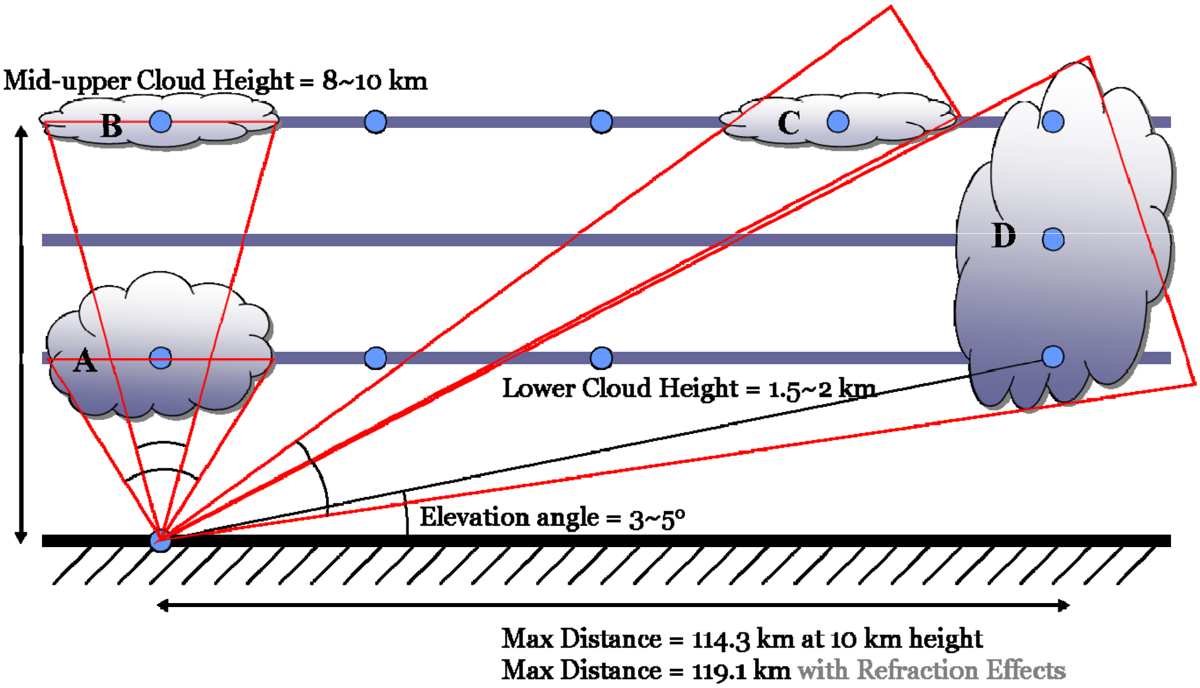

Figure 3 The integration of viewing angle method. Viewing angles from an observer vary with the cloud base height (A, B) and the distance to cloud pixel (B, C)

4 Validation

We compared the cloud amount derived by MTSAT-1R with the synoptic observation data at 14 KMA weather stations during the September 2005 to June 2006. The total number of data is 22,366. As the synoptic observation reports cloud amount at 11 steps (0 being clear sky, 10 being overcast), the satellite cloud amount is also assigned to 11 steps. The results show the bias 0.20 with rms difference of 3.05, with no significant temporal variation of the error characteristics (not shown). However, as shown in Figure 4, there are slight diurnal characteristics of error statistics with a positive bias during the daytime and a slight negative bias during the nighttime. Also, the rms difference is slightly larger in nighttime with a maximum of 3.47. Currently, it is not clear whether the larger rms difference during nighttime is due to the cloud detection process or human error.

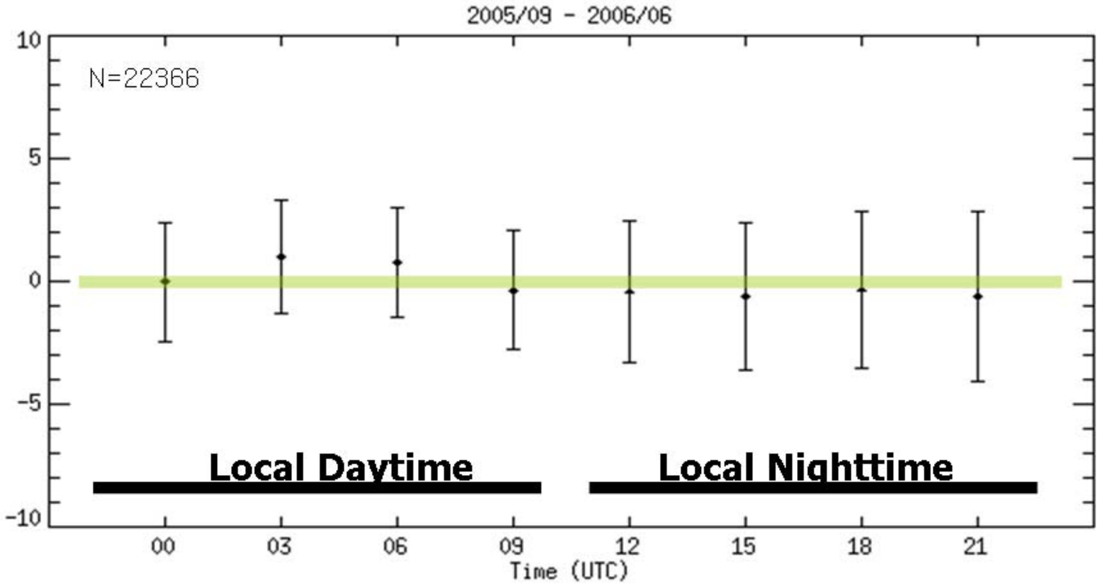

Figure 4 The verification results comparing with eyeball observation. The used data in comparison are extracted with 3-hour interval during September 2005 to June 2006 of 14 KMA's observation stations.

5 Summary

For the application of real time cloud analysis in the Digital Weather Forecasting System of KMA, a hemispheric cloud amount algorithm using a geostationary satellite has been developed. The algorithm consists of two processes, cloud detection with a simple cloud classification and integration of cloud field of view. The validation results show promising preliminary results, while there are several possible improving areas, such as improvement in the cloud detection, improvement in the cloud height assignment, and possibly improvement in the pixel based cloud size.

On the other hand, the algorithm is suitable for the real time application. It is fast, taking less than 2 minutes for 5 km x 5 km resolution over the Korean peninsula including adjacent sea area, and is accurate enough to fill the gap of current synoptic observation in terms of both time and space. Current products are fed directly into the Digital Weather Forecasting System of KMA that will be launched operationally in late 2006.