Utilizations of GOES-9 Data in METRI/KMA: Sea Surface Temperature, Atmospheric Motion Vector

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Abstract: KMA successfully began to receive and utilize the GOES-9 GVAR data since May 22nd 2003 when GOES-9 replaced the long-lived GMS-5 for Western Pacific and East Asian region until operation of MTSAT-1R in 2004. To take advantage of improvements of the GOES-9 data over the GMS-5 data, such as the increase of the temporal and spatial resolution and addition of 3.9µm channel, we have improved several algorithms to derive the meteorological products. Here we show two examples of algorithms, sea surface temperature and atmospheric motion vector, and preliminary results of validation of the improved algorithm.

Keywords: GOES-9, SST, AMV.

1. Introduction

The geostationary meteorological satellite plays important roles in the many fields of operational meteorology, including monitoring of the tropical cyclones, fog and special events such as yellow sand outbreak, derivation of atmospheric motion vector (AMV) and sea surface temperature (SST), and so on. The long-lived GMS-5 (Geostationary Meteorological Satellite-5) of Japan had been the satellite for East Asia region and was replaced with the U.S. GOES-9 on 22nd May 2003. GOES-9, located at 155°E longitude, will be the primary geostationary meteorological satellite for this region until the launch of MTSAT-1R in 2004. With the replacement of satellite, KMA (Korea Meteorological Administration) successfully began to receive the GOES-9 GVAR data through the modified GMS-5 receiving system from May 2003.

Here, we briefly introduce the GOES-9 satellite, its advantages over previous GMS-5, followed by the meteorological parameters derived from the GOES-9 satellite data at KMA in Section 3. The paper is concluded in Section 4.

2. GOES-9 Satellite

1) Short History of GOES-9

GOES-9 was launched in May 1995 and become operational as the GOES-WEST, located at 135°W, from January 1996. Due to the problem in the scan mirror's motor of Imager, NOAA (National Oceanic and Atmospheric Administration) operated it in mitigation mode to increase the scan motor's lifetime. Instruments were turned off and the satellite was tilted away from the Sun for 6 hours every night during spring and fall season. Despite of this effort, the second momentum wheel became making a noticeable noise resulted from vibration in the bearings which provided 3-axis stabilization for the spacecraft. Consequently, NESDIS (National Environmental Satellite, Data and Information Service) shut off this wheel and controlled the attitude by using the small spare wheel and the first momentum wheel running faster. However, it also started to demand more power and became fairly warm to maintain its rotation rate, as though its bearing was threatening to fail in early July 1998. NESDIS tried to fix it, but GOES-9 was brought out of cold on-orbit storage and was only used to gather data for analysis the problem of 3-axis system. Eventually, in 17th January 2002, GOES-9 was turned off (Chesters and Jentoft-Nielsen, 2002 [1]). In the meantime, the failure of MTSAT program and postponement of the launch of MTSAT-1R brought it a new life. As an alternative solution of the absence of geostationary meteorological satellite in the East-Asian region between GMS-5 and MTSAT-1R, JMA attempted to utilize the GOES-9 as a backup of GMS-5 in cooperation with US NOAA/NESDIS.

2) Advantages and Disadvantages of GOES-9 Data

Compared to the previous GMS-5, GOES-9 has several advantages such as the additional 3.9µm channel (short wave infrared; SWIR), high spatial and temporal resolution. The SWIR data is useful for the detection of the nighttime low-level cloud and for the derivation of SST at night. GOES-9 has spatial resolution of 1km and 4km for visible and IR channels, respectively compared to the 1.25km and 5km resolution of GMS-5, while the temporal resolution is 30 minutes. Finally, digitization of GOES-9 is 10 bit instead of 8 bit and is helpful for a better radiometric resolution.

On the other hand, GOES-9 data show some defects due to the problems shown before transferring to the current position. For example, significant noise in the visible and 12µm imagery is seen which is attributable to the problem in the stabilization system. Another example is the calibration of each different detector, eight detectors in visible, two in SWIR and longwave IR, and one in water-vapor (WV) channel (channel 3). Currently, we apply the calibration coefficients provided in the website (Weinreb et al., 1997 [2]) on GOES-9 calibration for each detector.

3. Meteorological Products from GOES-9

1) Sea Surface Temperature (SST)

1. Algorithm

To retrieve SST using satellite measurement data, it is well known that two main procedures are needed. One is cloud screening and the other is correction of water vapor effect. Most extensively used water vapor correction algorithm is the statistical algorithm such as MCSST algorithm (Multi-Channel SST; McClain, 1985 [3] and many others). The overall flowchart of current GOES-9 SST retrieval processes is shown in Figure 1.

For the cloud screening we applied set of threshold and spatial uniformity tests. The single window channel, dual channel difference between 11µm and 12µm, and spatial uniformity test of 11µm are time independent, while the albedo (daytime) and difference between 3.9µm and 11µm (nighttime) tests are time dependent. Based on the visual inspection and radiative transfer calculation (Tahara, personal communication, 2003), we apply temperature dependent threshold values for dual channel difference of 11µm and 3.9µm test. This new approach is justified by the fact that 11µm is more sensitive to the water vapor loading compared to 3.9µm and the water vapor amount is usually dependent on the boundary temperature over the ocean. Thus, the threshold value increases with the increasing 11µm brightness temperature.

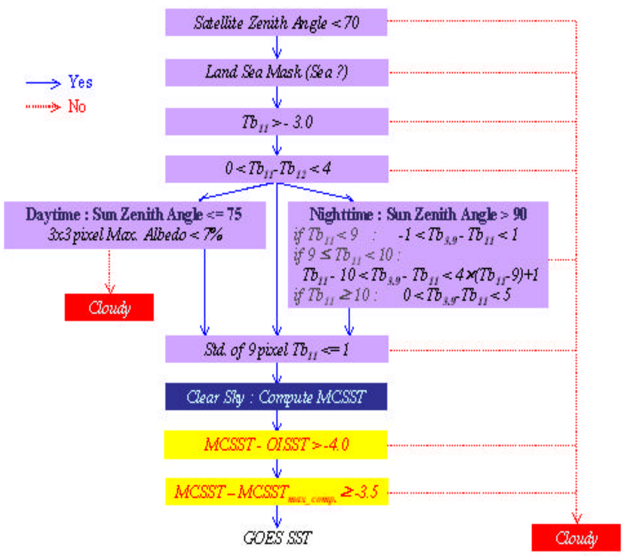


Fig. 1. Cloud screening procedure (unit of temperature is Celsius).

We apply the multi-regression equation to the clear sky pixel using following equation;

$$SST = aTb_{11} + bBTD + cBTD(\sec\theta - 1) + d. \quad (1)$$

where Tb_{11} is GOES brightness temperature of 11µm channel in Kelvin, and BTD is brightness temperature difference between split window channels, θ is the satellite zenith angle, and a, b, c, and d are the regression coefficients (Table 1). We used the regression coefficients derived as a best fit by Wick et al (2002) [4], due to the lack of collocated data during the short operation period in East-Asian region.

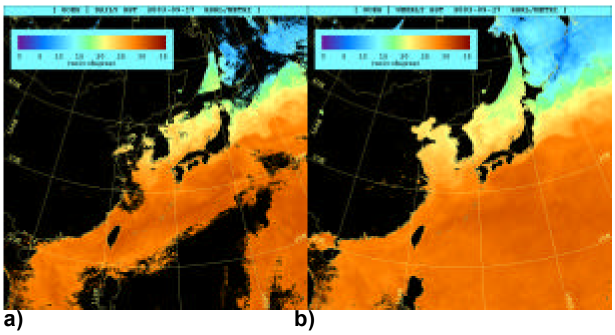
Table. 1. MCSST regression coefficients used in this paper.

a	b	c	d
1.0361	1.9132	0.8597	-10.0473

Finally, we apply an additional cloud screening test which compares the derived SST with the NCEP Reynolds weekly OI-SST and GOES-9 daily maximum composite SST value, respectively, in order.

2. Applications and Validation

With the 30 minutes temporal resolution, KMA produces an hourly SST field. Using the hourly SST field, the daily and weekly mean composite SSTs are derived with application of further screening procedure (Ahn et al., 2001 [5]). The daily and daily updated weekly GOES-SST is available at http://satweb.metri.re.kr.



a) b)

Fig. 2. Examples for SST imagery produced in METRI/KMA, a) daily and b) weekly mean composite.

Comparison between GOES-9 MCSST and SST observed from buoy are performed to evaluate this SST retrieval algorithm. Since GOES-9 have been operated in East-Asian region for short period, it is difficult to state the accuracy. However the short-term statistical validation result shows that it has about –0.5°C bias and 1.2°C rms difference (shown in figure 3), and it is similar error statistics value of SST derived from GMS-5 (Ahn et al., 2001 [5]). But it should be noted here that the collocated dataset consists mainly of relatively high SSTs because the period analyzed in this paper is short and only summer. On the other hand, the generation of SST using GOES-9 GVAR data has been very stable and looks promising so far.

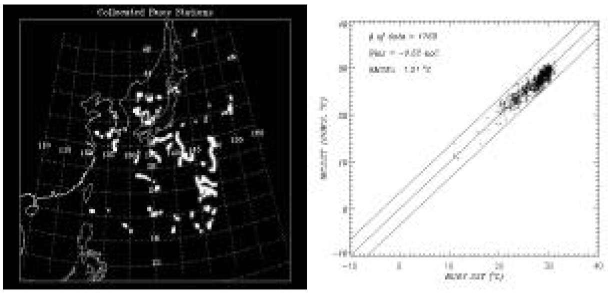


Fig. 3. The locations of buoy stations collocated with GOES-9 data (left) and scatter plot (right).

2) Atmospheric Motion Vector (AMV)

KMA began to produce the AMV data using GOES-9 images since September 2003 after several improvement of algorithm used for the GMS-5 data. The new procedure of AMV estimation is composed of four steps, target selection, height assignment, automatic target tracking and quality control. GOES-9 IR images with the interval of 30 minutes are used, with the target area is 32x32 pixels for cloud tracking. The height of AMV is determined by IR-WV method to correct the height of semi-transparent cloud, which use the calculated IR-WV method to brightness temperatures by radiation model utilizing the AVN model (aviation model) data (RH, Temperature) as input data. AMV is estimated by cross-correlation method within the search area, which is different for each target area. The search area is determined by the maximum wind speed of AVN within target area. Since AMV estimated by this approach contains considerable errors, final value is determined after application of the quality control procedures, which are the valid check, the spatial coherence check and the comparison of AMV model results. Figure 4 shows an example of the derived wind vectors form GOES-9 satellite images. For the validation, we continuously accumulate the collocated rawinsonde and satellite derived wind data.

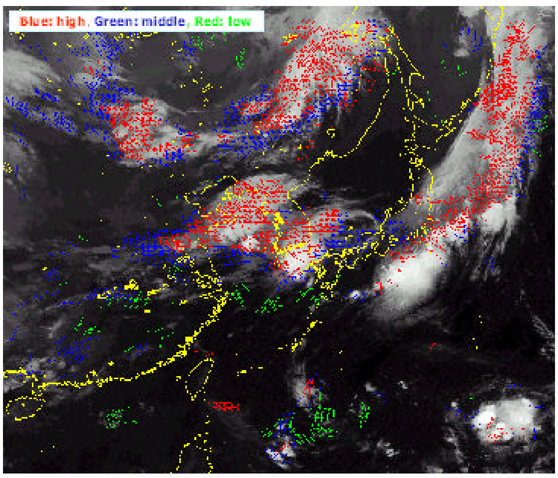


Fig. 4. An example of derived AMV using GOES-9.

4. Conclusion

With the replacement of GMS-5 with the GOES-9 based on the contingence plan, KMA started to receive and utilize GOES-9 data from May 2003. For a better application of it, we have been improving the algorithm for producing of SST and AMV. Although GOES-9 is not a best condition, there are some effective advantages of GOES-9. Especially SWIR channel, which is an additional channel against GMS-5, is very useful for detection of nighttime low-level cloud, so it proves to be helpful to eliminate the cloud contamination in retrieving SST. And GOES-9 SST derived using MCSST method is making stable and good results. Also we apply the so-called IR-WV method only to the high level cloud for producing the AMV, and it will be operated as soon as possible. The overall performance of new procedure of SST and AMV compared with observation data from conventional instrument, such as buoy and rawinsonde, is now under going.

Acknowledgement

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