CT Algorithm Theoretical Basis Document

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Version 4	26 December 2012	-	- Unchanged about contents besides ATBD form.

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List of Acronyms

COMS	Communication, Ocean, and Meteorological Satellite
ISCCP	International Satellite Cloud Climatology Project
MODIS	Moderate Resolution Imaging Spectroradiometer
CT	Cloud Type
MSG	Meteosat Second Generation
SEVIRI	Spinning Enhanced Visible and Infrared Imager

1. Overview

Cloud Type (CT) is an essential element to be used as input data for objective mesoscale analysis models, discrimination of precipitation clouds, and radiative flux calculations of oceans and land. Since 1983, the International Satellite Cloud Climatology Project (ISCCP), has classified CT utilizing traditional CT classification techniques with information from infrared and visible channels of satellite.

Many scientists performed research for the Earth energy budget and cloud-radiation interaction, meso-large scale models, and precipitation algorithm development, using ISSCP type data. Derrien and Le Gleau (2005, IJRS) developed a CT classification technique using the European geostationary satellite sensor, Meteosat Second Generation (MSG) / Spinning Enhanced Visible and Infrared Imager (SEVIRI). This algorithm is used in European weather forecasting with basic system of space-borne instrument such as MSG satellites (Meteosat-8 and Meteosat-9) / SEVIRI sensors.

2. Background and purpose

ISCCP CT classifies a total of 9 cloud types; cirrus; cirrostratus; deep convection; altocumulus; altostratus; nimbostratus; cumulus; stratocumulus; and stratus (ISCCP website: http://isccp.giss.nasa.gov/cloudtypes.html). This CT is established through climatic comparison with optical property and traditional morphologic CT classification of clouds observed from satellites. This CT retrieval algorithm is a threshold algorithm using Cloud Top Pressure (CTP) and Cloud Optical Thickness (COT).

The ISCCP CT classification is based on approximate and climatic relationship (ISCCP website:http://isccp.giss.nasa.gov/cloudtypes.html) of optical variables and classic and morphologic CT classifications observed from satellites. It is well suited for statistical analysis, but is not applicable for special weather conditions. This classification is extensively used because it is familiar to the public (Hahn *et al.*, 2001).

SEVIRI CT is comprised of and spectrum and texture analysis of scene analysis from algorithms using threshold value. Threshold value mainly changes depending on Numerical Weather Prediction (NWP) simulation data for Sun Zenith Angle and Satellite Zenith Angle, geometric locations such as relative azimuth angle, and vertical distribution of water vapor and temperature.

The final product is divided into five types of opaque clouds; top; high; medium; low; and bottom level clouds, semi-transparent clouds; thick; normal; thin clouds above low level), and ten types of clouds in the low level.

SEVIRI CT consists of a complicated threshold tests, and the name of the final retrieved CT differs from CT of ISCCP (http://www.meteorologie.eu.org/safnwc/).

SEVIRI CT classifies high level ISCCP CT semi-transparent clouds (cirrus) in more detail in particular. Also, for retrieval, the channel is similar to meteorological COMS sensors. Nevertheless, SEVIRI CT is less familiar for most forecaster than ISCCP in traditional CT classification. This COMS CT algorithm takes these points into account, and adapted ISCCP and SEVIRI mentioned above. Therefore, each COMS CT algorithm adapted complements the other. It has the advantage of employing weather and climatic research data.

3. Algorithm

3.1 Theoretical Background and Basis

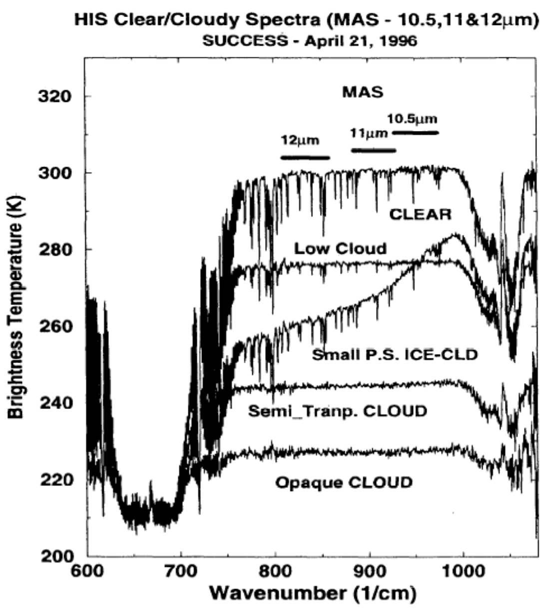
The height of a cloud and optical texture, microphysical particle properties creates the difference of radiance emitted from the cloud's surface. Fig. 1 is the infrared spectrum between 9.1㎛ and 17㎛ observed in a high-spectral resolution infrared spectrometer on ER-2 aircraft. We can identify 9.6 ㎛ (1040 cm^{-1}) of a strong ozone absorbing band and 15 ㎛ (667 cm^{-1}) of a carbon dioxide absorbing band. A window region of 10-12㎛ (1000-830 cm^{-1}) spectrum is sprinkled with an absorption line of water vapor.

Except for thin cirrus with small ice particle, low level clouds consisted of liquid water and thin clouds consisted of large ice particles do not change the spectrum in the atmospheric window region like blackbody. Opaque clouds emit a small radiance versus thin clouds. Low level clouds in the atmospheric window region have a high radiance. We can utilize radiative properties due to difference of absorbency, difference of cloud top temperature by this particle phase to classify CT. The case of initial CT classification using the spectrum properties (Inoue, 1987) has designed a so-called split window method that can directly retrieve the CT from satellite observation. This method operated in Advanced Very High Resolution Radiometer (AVHRR) classified with six CT using two split window (11,12㎛) channels.

The latest European Satellite Application (SAF) Nowcasting and Very short range forecasting

(NWC), through SEVRI channels of MSG satellite has designed an improved method of CT classification not only using infrared channels but also near-IR and visible channels (Derrien and Le Gleau, 2005). This algorithm was based on the CT algorithm developed by SAF NWC. This algorithm mainly aims to support Nowcasting application.

Fig. 1 Spectra of brightness temperature observed from a high spectral resolution infrared spectrometer from the high-flying ER-2 aircraft over a domain, 31.1°-37.4°N, 95.0°-95.3°W, on April 21, 1996, indicating wavelength-dependent window brightness temperature changes according to various cloud types. The type of cloud indicated for each spectrum is identified from the Cloud Lidar System aboard the ER-2 (taken from Smith et al. 1998).



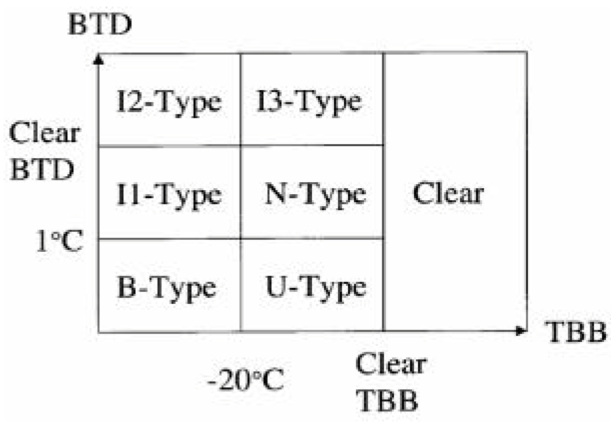


Fig. 2. Cloud type classification diagram according to the split window technique (Inoue, 1989). Six cloud types are classified using clear/cloudy and -20 ℃ channel-4 brightness temperature thresholds, along with clear and 1 ℃ brightness temperature differences.

3.2. Retrieval method

3.2.1. Look Up Table (LUT) retrieval method

We retrieve using both threshold methods of two CT classification. After opaque cloud classification, SEVIRI CT is classified with semi-transparent clouds and a rag of clouds. ISCCP CT classifies nine types using threshold value as input for cloud optical thickness and cloud top pressure.

This COMS Cloud Type module (hereafter, CT module), follows in detail the design concept of CT classification from MSG/SEVIRI by Derrien and Le Gleau (2005, IJRS), Le Gleau (2005, Software Manual), but will be adequately simplified for domestic circumstances in Korea.

ISCCP CT module in CT module follows the concept of Rossow and Schiffer (1999), so omits a discussion in this section. CT module provides the results of discriminable CT classification with the threshold test of COMS five channels.

CT type of ISCCP is retrieved using information of cloud optical thickness and cloud top height, CT of 9 types is retrieved at the same time (Rossow and Schiffer 1999). Accordingly, ISCCP CT algorithm is performed with the last step in total cloud analysis. It cannot retrieve at night because it uses cloud optical thickness. The threshold value for CT classification uses static threshold value provided in ISCCP (http://isccp.giss.nasa.gov/cloudtypes.html).

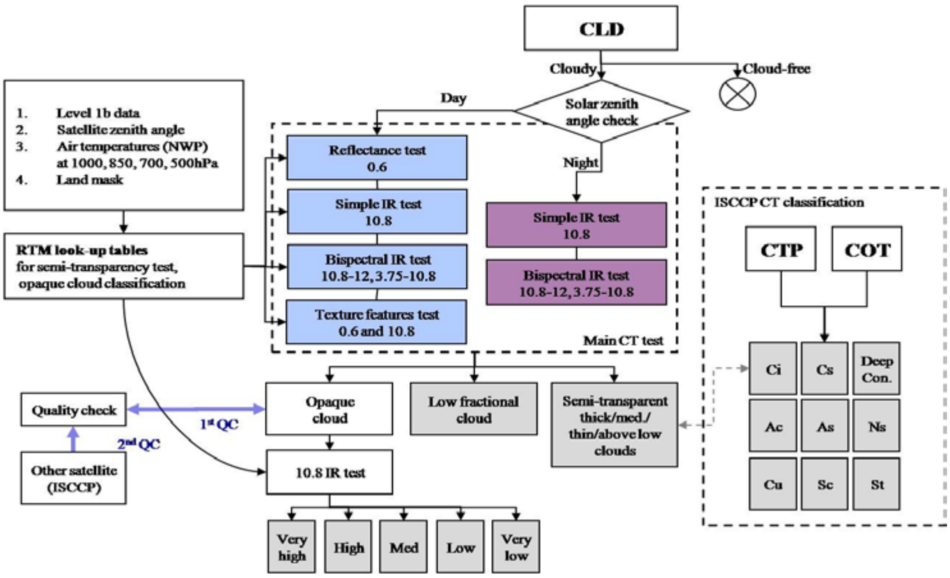
The purpose of the main CT classification in the CT retrieval algorithm for SEVIRI consists of a test of all threshold values to separate high level transparent clouds and low level fractional clouds from opaque clouds. CT classification extracts for cloud pixels identified from cloud detection. It makes the day and night decision considering the Sun Zenith Angle, and it differs in tests of threshold value.

The threshold uses the static value and the dynamic threshold value at the same time. the dynamic value changes depending on water vapor integrated for the vertical distribution of temperature of NWP, total atmosphere, or depending on observation time using climate data. The opaque clouds decided through this threshold test are classified into five types; very high; high; medium; low; very low cloud depending on its latitude for infrared window channel.

In the case of semi-transparent high level clouds, it is classified into four types of; thick; normal; thin; above low cloud depending on transmittance.

3.3. Retrieval process

Fig. 3 Flow chart of CT algorithm



The flow chart for retrieval process of this algorithm is shown in Fig. 3. The input data is divided into static data and dynamic data. The static data consists of surface information and threshold value necessary to threshold test, and climate data. The dynamic data included for each channels brightness temperature and reflectivity. Threshold value of the CT module has a different value depending on time of day. This threshold value is obtained to interpolate a look-up table (LUT) for satellite zenith angle and total water vapor. The LUT is prepared to calculate through Radiative Transfer Model (RTM) simulation. The physical meaning for using the threshold test is different depending on the time (daytime or nighttime). We separate opaque clouds and semi-transparent and fractional clouds using a decided threshold value.

A high level semi-transparent cloud can distinguish with the opaque cloud uses the properties of Tb10.8 - Tb12.0 value, Tb6.75 - Tb10.8 value or Tb3.75 - Tb10.8 value (Liou 2002, Derrien and Le Gleau 2005, Le Gleau 2005). However, for high level semi-transparent clouds, this accuracy is quite low when compared with detected images in NIR 1.38 ㎛ (Gao et al. 1993, Gao et al. 1998, Gao et al.

2002) for water vapor absorption of special developed MODIS sensor of NASA for cloud detection of this kind (Choi et al., 2005, IJRS).

Daytime is classified as CT according to the threshold value of this as the input value of Tb10.8-12.0, Tb3.7-10.8, Tb10.8, and Refl0.65. The final step is classified into very high, high, medium, low, or very low using the value of Tb10.8 for CT classified in the previous test.

3.3.1. Distinction between fractional clouds and high level semi-transparent clouds during nighttime

a. The normal $Tb_{10.8}$ - $Tb_{12.0}$ value is higher cirrus than the opaque cloud. Especially, as temperature difference between the cloud top and surface is high, this value is distinct. If a semi-transparent cloud is too thick or thin, the difference of this brightness temperature decreases.

b. $Tb_{6.75}$ – $Tb_{10.8}$ value, cirrus is higher than thick cloud. Especially, for bigger temperature differences between a cloud top and surface, this value clearly appears high.

c. $Tb_{3.75}$ - $Tb_{10.8}$ value, it is very effective in identifying semi-transparent clouds. In the case of semi-transparent clouds on the warm surface, $Tb_{3.75}$ is higher than $Tb_{3.75}$ because this is high nonlinear of transmittance of ice phase cloud and the Planck function in 3.8㎛. The properties are more effective for bigger temperature differences between a cloud top and surface. With noise problems of SWIR channels this properties may not be used in the case of very cold Tb3.8.

3.3.2. A distinction between fractional clouds and high level semi-transparent clouds during daytime

a. In the daytime can be defined dispersion of $Tb_{10.8}$ and $Refl_{0.6}$ as follows

Varilog $Tb_{10.8}$ = log (1+std($Tb_{10.8}$㎛))

Varilog Re0.675 = log (1+std(Re0.675㎛)/13.)

b. $Tb_{10.8}$ - $Tb_{12.0}$ value has a higher value for cirrus than normal opaque clouds. Especially, if the temperature difference between a cloud top and surface is big, the value appears high. If a semi-transparent cloud is too thick or thin, the difference of this brightness temperature decreases.

c. $Tb_{6.75}$ - $Tb_{10.8}$ value has a higher value for cirrus than clouds of normal thickness. Especially, in the case of large temperature difference between cloud top and surface, the value appears high.

d. Cirrus have a smaller $Refl_{0.6}$ beside opaque clouds having the same radiative temperature.

e. Cirrus are more variable spatially for temperature that reflectivity of visible channel. The SEVIRI type of output data is classified as opaque clouds, semi-transparent, low level fractional clouds. The opaque clouds are classified again on high, medium, low level clouds. High, semi-transparent clouds separate again as thick, thin, and clouds above low level. ISCCP clouds are classified into 9 types; cirrus; cirrostratus; deep convection; altocumulus; altostratus; nimbostratus; cumulus; stratocumulus; and stratus

3.3.3. QC flag

The QC flag for CT was presented in Table. 1. Quality check was performed for height of approximate clouds divided into 3 types (high, medium, low level clouds). If the height of clouds classified by SEVIRI and ISCCP belong to the same category, the flag is 128 or the flag is 64.

Table 1. QC flag for CT

CLA - CT		
bit	**Bit Interpretation**	**Field Description**
8~7 (SEVIRI-ISCCP cloud type comparison result Very low/low SEVIRI clouds correspond to low ISCCP clouds(Cu, Sc, St) Middle SEVIRI clouds correspond to middle ISCCP clouds(Ac, As, Ns) Very high/high/semitransparent SEVIRI clouds correspond to high ISCCP clouds (Ci, Cs, Deep Convection) **unavail => 0**	128 64	Consistent Inconsistent

3.4. Validation

3.4.1. Validation method

The validation of CT is executed in two methods for real-time validation of CMDPS and selfvalidatiion of developer checked accuracy of algorithm separately. CMDPS validation was validated through Proportion Correct(PC), Pierce Skill Score(PSS), Heidke Skill Score (HSS) that compared the CT classified by each SEVIRI and ISCCP with MODIS satellite data.

The self-validation of developer, the validation of this CT algorithm (SEVIRI type CT) is performed as compared with ISCCP type database converted through cloud optical thickness and cloud top height.

a. 1 step : It performs CT classification of ISCCP type from MODIS data.

b. 2 step : It compares the results retrieved by ISCCP type classification and SEVIRI algorithm. In the case of comparison, it is compared by equivalence relationship between two groups indicated in table 2.

Table 2. Equivalence between ISCCP types and CT types

ISCCP types	CT types
Cirrus	Thin/Mid/Thick semitransparent cloud
Cirrostratus	high opaque cloud
Deap convective cloud	(Very) high opaque cloud
Altocumulus	Mid opaque cloud
Altostratus	Mid opaque cloud
Nimbostratus	Mid opaque cloud
Cumulus	Low opaque cloud
Stratocumulus	Low opaque cloud
Stratus	(Very) low opaque cloud

3.4.2. Validation data

(1) CMDPS Validation

CT was verified based on MODIS satellite data. The data is divided into the data of Terra and Aqua satellite. The date used the data from November 1 to November 5.

(2) The self-validation of developer

We used MODIS cloud data (MOD06, collocation 5) to compare with the product retrieved using CT algorithm. This data includes Cloud Phase (CP), Cloud Top Height (Cloud Optical Thickness) of the nadir resolution, 5km (1km) (Platnick et al. 2003). Improved points in collection 5 data than the previous version can be found in other references (Baum et al. 2005, King et al. 2006, Yang et al. 2007). The validation the granule (5 minutes observation data) collocated in the Pacific Northwest (10°-30°N, 113°-149°E) during August 5-11, 2006

A recent MOD06 cloud phase is retrieved in two methods. it is test of Bispectral IR and Shortwave IR.

Bispectral IR test use the 8.5 ㎛ and 11 ㎛ band. This method is a simplification of test of trispectral IR using the 8.5, 11, 12 ㎛ introduced by Strabala et al. (1994) (Menzel et al. 2006)..

Shortwave IR test is the method using a mix of Visible, NIR, and IR bands. It is part of Cloud optical thickness module (King et al. 2006). This method is only available to be retrieved in daytime, but it is difficult to use the channels of MTSAT-1R, so this validation used MODIS cloud phase retrieved from the test of Bispectral IR. MODIS cloud phase is retrieved and divided into four categories; liquid; ice; mixed; and uncertain phase.

Cloud optical thickness and effective particle radius of MOD06 is a representative value for the whole of an atmospheric column decided using simultaneous visible and NIR channels(0.6, 0.8, 1.2, 2.1㎛). The initial retrieval range of MOD06 cloud optical thickness is 0.1 (Choi et al. 2005) and the maximum retrieval range is 100. In the case of the effective particle radius, the valid retrieval range is 2~30㎛ in liquid phase clouds, and 5~90㎛ in ice phase clouds.

Meanwhile, MOD06 cloud top height is retrieved by the CO_2 slicing method (also known as the radiative comparison method). The radiative comparison method uses the CO_2 absorption band between 13.2 and 14.4㎛ (Menzel et al. 1983, 2006). Cloud top height has an interval over 10hPa between 95 hPa and 1040 hPa. This is more sophisticated level than cloud top height retrieved by CMDPS. Cloud top height retrieved by CMDPS is calculated on 50 hPa between 100 hPa and 1000 hPa.

3.4.3. Temporal and spatial collocation method

(1) CMDPS validation

CT validated the results of SEVIRI and ISCCP for each Terra and Aqua satellite data. This was also validated for global region, by latitude divided into low latitude and middle latitude. Low latitude was defined as the region below 30°and middle latitude was defined the region from above 30°to below 60°. For temporal and spatial collocation, the difference parts more than 2 pixels in 5x5 pixels of MODIS to validate in case of homogeneous region are excluded.

(2) The self-validation of developer

It retrieve performing CT algorithm as a input data of MODIS radiance, performed the validation exactly to match agreement of ISCCP pixels of validation ancillary data.

3.4.4. Validation result analysis

(1) CMDPS validation

The validation results for ISCCP CT and SEVIRI CT are shown in Table 3. All accuracy of the two CT show that they are not dependant on latitude. PC presents in SEVIRI CT higher than ISCCP CP. PSS and HSS are higher than ICSCCP and SEVIRI. The accuracy for Aqua is also higher than Terra.

Table 3. Validation result of cloud type.

		Latitude	Date	PC	PSS	HSS
ISCCP	Mod06	Global	11/01~11/05	0.667	0.604	0.587
		Low		0.611	0.547	0.515
		Mid		0.765	0.676	0.662
	Myd06	Global		0.674	0.615	0.595
		Low		0.651	0.576	0.556
		Mid		0.721	0.656	0.616
SEVIRI	Mod06	Global	11/01~11/05	0.429	0.196	0.137
		Low		0.39	-0.052	-0.022
		Mid		0.495	0.311	0.267
	Myd06	Global		0.411	0.135	0.087
		Low		0.442	-0.04	-0.02
		Mid		0.341	0.202	0.141

(2) The Self-validation of developer

Table 4. Validation results from the cross-comparison between CT and ISCCP CT.

		ISCCP CT										
		No proc.	Cu	Sc	St	Ac	As	Ns	Ci	Cs	Deep conv.	Total
CT	No proc.	13.0	-	-	-	-	-	-	-	-	-	13.0
	Frac.	1.8	0.8	-	-	0.1	-	-	-	-	-	2.7
	Very low	6.9	2.4	2.2	0.2	1.1	-	-	0.1	0.1	-	13.0
	Low	6.3	1.1	1.3	0.2	2.0	-	-	0.9	0.4	-	12.2
	Medium	9.8	0.2	0.6	0.5	7.0	-	-	1.6	2.4	1.1	23.3
	High	9.0	-	-	-	6.4	-	-	0.2	3.7	1.4	20.8
	Very high	3.2	-	-	-	-	-	-	-	1.8	1.0	6.0
	Semi thick	1.7	-	-	-	-	-	-	0.8	1.1	-	3.6
	Semi med	1.9	-	-	-	0.3	-	-	2.6	-	-	4.9
	Semi thin	0.2	0.2	0.1	-	-	-	-	0.1	-	-	0.7
	Semi above	-	-	-	-	-	-	-	-	-	-	-
	Total	53.9	4.8	4.1	0.9	16.8	-	-	6.3	9.6	3.5	100

Validation results showed that the separation of high level semi-transparent clouds above low level clouds was unsatisfactory. ISCCP altocumulus and altostratus do not exist in the analysis data. We can not compared with semi-transparent mid-stratus of SEVIRI CT. Many pixels unclassified in CT classification of ISCCP is classified in SEVIRI CT classification.

If we are used calibrated radiance and brightness temperature of a hourly Full-disk provided from Japanese Advanced Meteorological Imager (JAMI) sensor on board Multi-functional Transport

Satellite(MTSAT-1R) as a input data for simulated images of COMS, the retrieval accuracy of cloud optical thickness and cloud top height are less than MODIS. The accuracy of ISCCP CT depends on the retrieval accuracy of cloud optical thickness and cloud top height. In connection with the accuracy of this product, refer to ATBD Cloud Optical Thickness (COT) and ATBD Cloud Top Temperature/Pressure(CTTP).

4. Analysis method of retrieval results

The reflectivity derived in Level 1B data has the range of 0~100%. Brightness temperature has the range of 170~350K. Prec. and Acc. of the two values are expected to have about 0.1 in total. As mentioned earlier, exact values will be decided at PSR point of time established for the specification of Meteorological images on board COMS.

Temperature and water vapor profiles by induced pressure are used in the NWP model. It also uses as input data monthly mean climate value (a minimum sea surface temperature, reflectivity of mean 0.65, mean water vapor, mean pressure in certain pressure). CT of each layer is classified into output data.

Table 5. Detailed Output data for the CT algorithm.

OUTPUT DATA								
Parameter	Mnemonic	Units	Min	Max	Prec	Acc	Res	To
SEVERI cloud types ISCCP cloud types	severi_cloud_type isccp_cloud_type	-	-	-	-	-		CT_Sev CT_Isc

Prec: Precision, Acc: Accuracy, Res: Resolution

5. COMS version and algorithm improvement after COMS satellite launch

5.1 Algorithm improvement

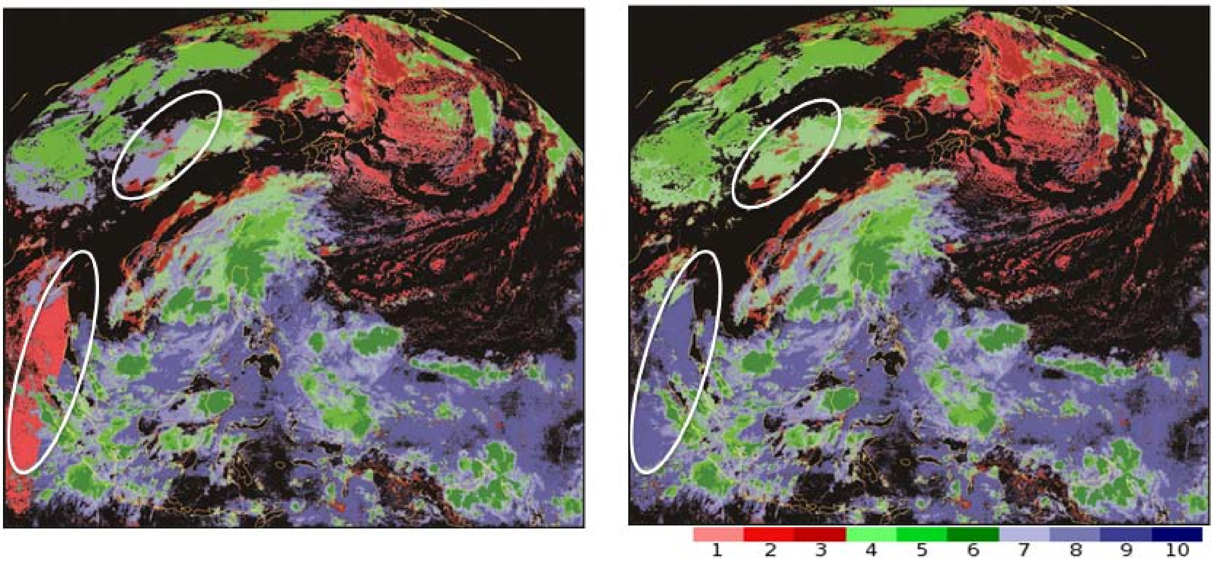
We performed the improvement to solve the discontinuity of day and night time in SEVIRI CT. The 4th and 9th CT in the white circle near the west of the Korean Peninsula in Fig. 4(a) shows the divide according to boundary of day and night. Also the 2nd and 9th CT in the west of Indonesia can observe to appear according to boundary of day and night.

In the case of discontinuity problems of 4th and 9th CT near the Korea Peninsula, we solved the problem to change that cannot use 3.7μm–11μm for the identification of nighttime semi-transparent clouds (Fig. 4(b)). Also, in order to solve the discontinuity of the tropic 2nd and 9th CT, we used the threshold test of 11μm and 11μm-12μm to delete the threshold test of 3.7μm-11μm in the 7th, 8th, 9th nighttime test.

```
! 2.3.1.4. High semitransparent and thin cloud type
!(hcho201111)     IF ((bt45(i,j)>=bt45thk .OR. bt24(i,j)>=bt24lo ) .AND. &
!(hcho201111)         bt24(i,j)>=bt24thnlo(i,j)) THEN
                  IF (bt45(i,j)>=bt45thk) THEN ! (hcho201111)
                     cloud(i,j)%type_seviri = 9 ! sem. thin (restored,hcho201109)
!                    cloud(i,j)%type_seviri = 5 ! CCY(20110412)
                  END IF

               ELSE IF (level_1b(i,j)%ir1>=bt4lo(i,j).AND.  &
                           level_1b(i,j)%ir1< bt4lo(i,j)+d) THEN

! 2.3.1.5. Semitransparent and thin cloud type
!(hcho201111)     IF ((bt45(i,j)>=bt45thk .OR. bt24(i,j)>=bt24vl ).AND.  &
!(hcho201111)         bt24(i,j)>=bt24thnlo(i,j)) THEN
                  IF (bt45(i,j)>=bt45thk) THEN ! (hcho201111)
                     cloud(i,j)%type_seviri = 9 ! sem. thin (restored,hcho201109)
!                    cloud(i,j)%type_seviri = 5 ! CCY(20110412)
                  END IF
               END IF semi0
```

In the case of the discontinuity problem of the tropic 1st and 9th CT, the value of 3.7μm-11μm have 1st CT in negative regions and 9th CT in positive regions. This cannot resolve to adjust the threshold value. In the case of nighttime can do that must abandon CT retrieval of one of 1st and 9th CT. We improved and abandoned 1th retrieval in actual algorithm. The bottom code is content applied to this.

```
! 2.3.1.6. Fractional cloud type
                 IF ((bt45(i,j)>=bt45thk .OR. bt24(i,j)>=bt24lo) .AND. &
                     bt24(i,j)< bt24thnlo(i,j)) THEN
!(hcho201111)          cloud(i,j)%type_seviri = 1 ! frac.
                 END IF

              ELSE IF (level_1b(i,j)%ir1>=bt4lo(i,j)     .AND. &
                       level_1b(i,j)%ir1< bt4lo(i,j)+d) THEN

! 2.3.1.7. Fractional cloud type
                 IF ((bt45(i,j)>=bt45thk .OR. bt24(i,j)>=bt24vl) .AND. &
                     bt24(i,j)< bt24thnlo(i,j)) THEN
!(hcho201111)          cloud(i,j)%type_seviri = 1 ! frac.
                 END IF
              END IF frac0
```



(a) (b)

Fig. 4. SEVIRI Cloud Type (a)before and (b)after removing day-night discontinuities showed in white ovals.

5.2. Validation result after COMS version

We performed validation for a month in November 2011 of improved algorithm in 5.1. The results are shown in the table below. The improvement of the algorithm has to remove the discontinuity. The statistic value of the actual validation do not show a high difference, but in the case of PC value showed slightly improved results from 0.58 to 0.60. The performed results to divide low latitude and middle latitude regions show better statistic value than previous results. It can not only remove the discontinuity, but also improve the actual validation results.

Table 6. Statistical result before algorithm modification

	20111101~20111130	Low latitude(latitude<30)	Middle latitude (30< latitude <60)
col_num	9966112	7478929	2487183
vam_num	9271106	7213819	2057287
PC	0.58	0.66	0.29
PSS	0.14	0.10	0.06
HSS	0.10	0.07	0.04

Table 7. Statistical result after algorithm modification

	20111101~20111130	Low latitude(latitude<30)	Middle latitude (30< latitude <60)
col_num	5508563	4230277	1278286
vam_num	5115048	4080881	1034167
PC	0.60	0.68	0.27
PSS	0.12	0.08	-0.01
HSS	0.08	0.06	-0.01

6. Problems and possibilities for improvement

In making the CT algorithm, the problem is greatly summarized in two steps. The first is the choice through radiative transfer simulation. The selection of threshold value is known as the properties of sensors on board COMS satellites. After the actual measurement is performed, the continuous correction in comparison with ground measurement values is necessary.

In the case of the SEVIRI CT, the daytime detects semi-transparent clouds for high level clouds such as cirrus. On the other hand, cirrus is detected too much during nighttime. This is judged to have too strict criteria for test of visible channel in daytime. We modified the algorithm to detect high clouds in the daytime, to remove the threshold value test of visible regions in the threshold value test of high semi-transparent meanly thick clouds. However, the difficulty for opaque cloud detection during nighttime still remains a problem.

Second is validation of the algorithm. The optimal method for the validation of the algorithm is a comparative analysis with ground measurement results. We are having difficulty securing the current ground measurement data. Therefore, it is difficult to complete the validation. The results of the actual validation using ground measurement data will help to improve of algorithm through the process checking bias correcting the threshold value and feedback process: the validation using ground measurement data adjusts threshold value to decrease the bias.

Aside from this, remain into the improvement task in the future for the insertion of quality test code(Table 6) for Standardization code, the insertion of Contingency plan coed etc remain the improvement task in the future. The discontinuity of day and night through COMS version and algorithm improvement is solved, but in the case of ISCCP CT, the results of 1st CT were not retrieved, so an improved method is needed.

Table 8. Data format and quality test results for the CT algorithm.

Quality flag			
Parameter	bit	Value	Meaning
Cloud type	4	0	non-processed, undefined, cloud-free
		1	fractional cloud
		2	very low cloud
		3	low cloud
		4	medium cloud
		5	high cloud
		6	very high cloud
		7	high semitransparent thick cloud
		8	high semitransparent meanly thick cloud
		9	high semitransparent thin cloud
		10	high semitransparent above low or med-level cloud
ISCCP Cloud type	4	0	Ci
		1	Cs
		2	Cb
		3	Ac
		4	As
		5	Ns
		6	Cu
		7	Sc
		8	St
COMS input data	2	0	undefined
		1	all useful COMS channel available
		2	at least one useful COMS channel available

define illumination and viewing conditions	3	0	undefined
		1	night
		2	twilight
		3	day
		4	sunglint
describe the quality of the processing itself	2	0	non processed
		1	good quality
		2	poor quality
		3	bad quality

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