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RA II WIGOS Project Newsletter

DEVELOPING SUPPORT FOR NATIONAL METEOROLOGICAL AND HYDROLOGICAL SERVICES IN SATELLITE DATA, PRODUCTS AND TRAINING

Contents of this issue

Himawari-8 utilization training

The Himawari-8 geostationary meteorological satellite managed by the Japan Meteorological Agency (JMA) began operation on 7 July 2015, replacing the previous MTSAT-2 operational satellite. In order to deliver Himawari-8 imagery, JMA established two new services known as HimawariCast (by which primary sets of imagery are provided via a communication satellite) and HimawariCloud (by which full sets of imagery are provided to National Meteorological and Hydrological Services (NMHSs) via an Internet cloud service). Most NMHSs in the Asia and Pacific regions currently incorporate Himawari-8 data from these services into their weather monitoring and forecasting activities.

Himawari-8's observation capability is far superior to that of the previous MTSAT-series satellites. To maximize the benefits of this capability, JMA runs the following training activities for NMHSs in the Asia and Pacific regions:

<u>Training at the 6th Asia/Oceania Meteorological Satellite Users' Conference</u>

In conjunction with the 6th Asia/Oceania Meteorological Satellite Users' Conference (AOMSUC-6) held in Tokyo in November 2015, JMA hosted training at its HQ and gave practical presentations on the utilization of Himawari-8 imagery. Over 50 trainees from more than 30 countries attended.

Training seminars for individual NMHSs

JMA dispatches experts to a number of NMHSs in the Asia and Pacific regions to conduct training seminars on Himawari-8 utilization. The trainers check on the NMHS's status of Himawari-8 imagery acquisition, provide advice if necessary, and give presentations to support the enhancement of NMHS weather monitoring and forecasting capacity based on the use of Himawari-8 imagery.

JMA believes these training activities contribute to the improvement of meteorological services and support the mitigation of natural disasters in the relevant regions. The Agency remains committed to its ongoing efforts to strengthen partnerships with Himawari-8 users.

(Yukihiro KUMAGAI, JMA)

Himawari-8 Volcanic Ash Product

Volcanic ash from eruptions falls and accumulates on the ground over wide areas, and also floats and disperses in the air for extended periods. As volcanic ash clouds can cause serious issues for aircraft, such as body damage and even engine failure, information on the distribution and altitude of such clouds is essential for aviation safety. Toward the provision of quantitative information on volcanic ash clouds from frequent multispectral observation by the Himawari-8 satellite, JMA has introduced a volcanic ash product retrieval algorithm developed by NOAA/NESDIS (Pavolonis et al. 2015). This algorithm involves the use of multispectral analysis and data from the visible, near-infrared and infrared bands of Himawari-8 to detect volcanic ash clouds. It also requires numerical weather prediction data and sea surface temperature data as ancillary input. Using a combination of radiative transfer theory, statistical modeling and image processing techniques, it allows the identification of volcanic ash clouds with a very low false alarm rate. Physical parameters such as ash cloud height and optical depth are calculated using the optimal estimation approach (Pavolonis et al. 2013). Figure 1 shows examples of Himawari-8 volcanic ash products for eruptions at Kuchinoerabujima (a volcanic island in southern Japan) and Rinjani (a volcano on the island of Lombok in Indonesia). These products are provided to the Tokyo VAAC to support prompt and accurate issuance of volcanic ash advisories to aviation-related organizations. Toward the evaluation/validation of the volcanic ash product and to improvement of both the volcanic ash cloud detection rate and the accuracy of retrieved physical parameters, JMA is currently developing a test bed system that will allow comparison of volcanic ash products using different retrieval algorithms and/or ancillary data.

(Yuta HAYASHI, JMA/MSC)

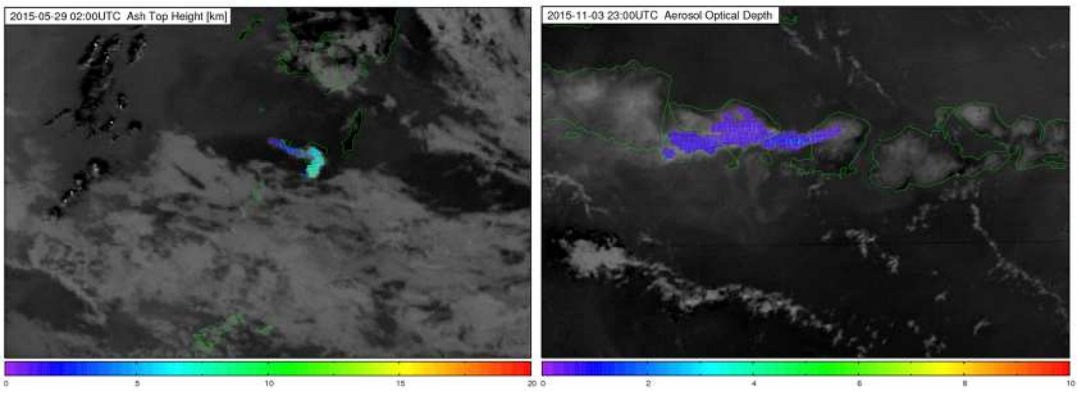


Figure 1. Examples of Himawari-8 volcanic ash products. Left: estimated height of an ash cloud from Kuchinoerabujima at 02 UTC on May 29, 2015. Right: estimated aerosol optical depth of an ash cloud from Rinjani at 23 UTC on Nov. 3, 2015. Both are laid over an image showing brightness temperature differences between the 10.4 and 12.4 μm observation bands of Himawari-8.

Quality improvement of Himawari-8 observation data

On 9 March 2016, JMA updated the Himawari-8 ground processing system to improve the quality of Himawari-8 image in Himawari Standard Data (HSD) and related products. This is a first major update in the Himawari-8 ground system since Himawari-8 has begun its operation as a new-generation geostationary meteorological satellite on 7 July 2015. This article reports the content of the updates.

Implementation of coherent noise reduction processing

The AHI imagery contains some coherent noise. This results in north-south stripes over low-radiance scenes such as cloud-free ocean in visible and near-infrared bands, deep convective cloud in infrared bands and deep space. A noise reduction process for band 7 was applied on 18 June 2015 before the start of Himawari-8 operation (02:00 UTC on 7 July 2015). The process was also applied to a number of bands in which noise is efficiently reduced (1, 2, 4, 5, 6, 10, 11, 12, 13, 14 and 15) at 05:00 UTC on 9 March 2016. The algorithm corrects periodic noise identified in deep-space observation data using a Fourier transform.

Figure 2 shows the reflectivity of band-4 observation over the ocean at 00:20 UTC on 25 November 2015. Figure 2 (A) features a nominal color palette (i.e., black and white on a color scale from 0 to 1). Figure 2 (B) is similar to Fig. 2 (A), but focuses on the low reflectivity range (i.e., the minimum and maximum reflectivities are changed from 0 and 1 to 0.005 and 0.03). Figure 2 (C) shows the image resulting from application of the noise reduction process to Fig. 2 (B). It can be seen that the significant striping observed in the latter is effectively reduced.

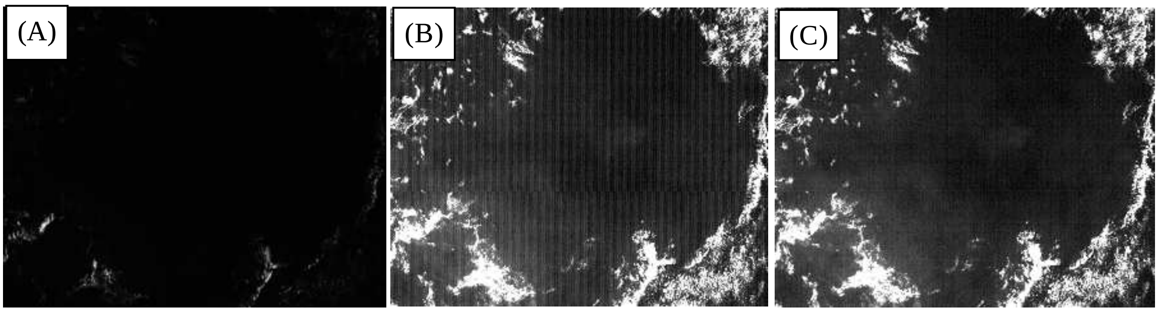


Figure 2. (A) Reflectivity of band-4 (0.86 μm) observation at 00:20 UTC on 25 November 2015 with a nominal color palette (i.e., black and white on a color scale from 0 to 1). (B) As per (A), but with the minimum and maximum reflectivities changed from 0 and 1 to 0.005 and 0.03. (C) As per (B), but with the noise reduction process applied.

Improvement of band-to-band co-registration processing for infrared bands

Band-to-band co-registration errors involve relative misalignment between sensor bands. To combat this, a new co-registration process was applied to infrared bands 7, 8, 9, 10, 11, 12 and 15 at 05:00 UTC on 9 March 2016.

Figure 3 shows the co-registration error of band 11 with respect to band 13 observation estimated using a pattern-matching approach with common features such as coastline and cloud edge observed via the two bands. Figures 3 (A) and (B) represent errors before and after the improvement of the process, respectively. In the old and new processes, the co-registration correction amount is determined using pattern matching analysis based on calculation of cross-correlation. In the new process, the correction derived in the current observation cycle is simply applied to data in the next observation cycle for each swath. In the old process for band 7, the correction amount is optimized using sensor temperature information derived from in-orbit testing. As correction for bands 8 to 16 in the

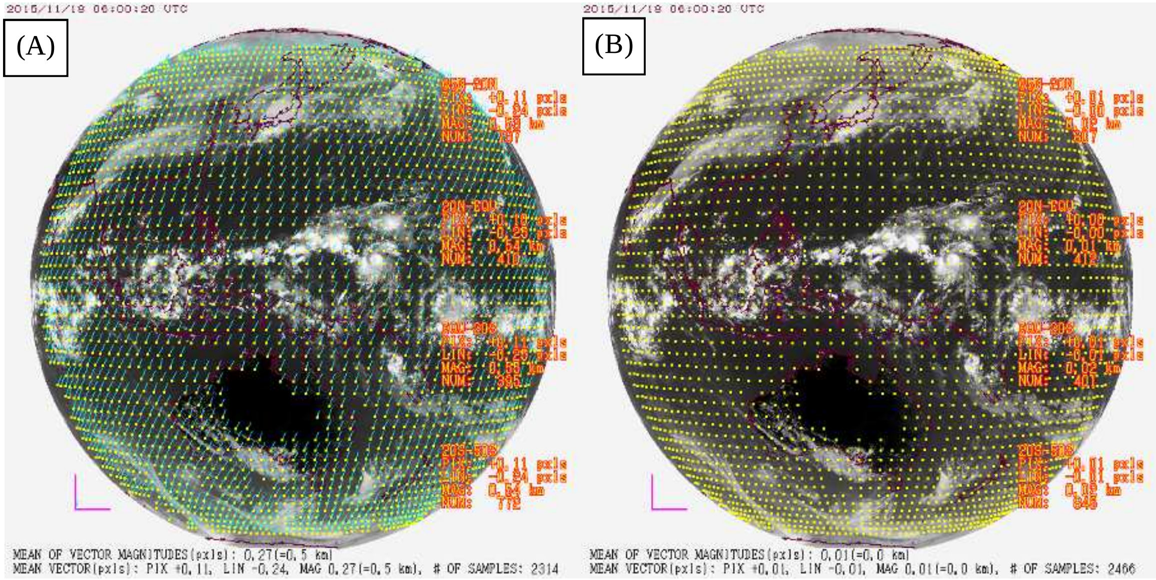


Figure 3. (A) Band-to-band co-registration errors of band 11 with respect to band-13 observation at 06:10 UTC on 18 November 2015. (B) As per (A), but with the new processing applied. Yellow dots show validation points, and light-blue segments with yellow dots represent the direction and length of the misalignment to be corrected.

old process is also based on observation data obtained during in-orbit testing, this process may not be applicable to data for all seasons. The co-registration mismatch was reduced from 0.27 pixels (approx. 540 m) to 0.01 pixels (approx. 20 m) on the HSD 2 km resolution band after application of the new process (Fig. 3). In addition, the new band-to-band co-registration process includes a parameter change and a few minor bug fixes for ground processing software. These changes also help to alleviate the co-registration mismatch. Table 1 shows band-to-band co-registration errors of all infrared bands with respect to band-13 observation validated by observation at 15:10 UTC on 17 November 2015. Most errors for infrared bands are significantly reduced by the new process, which will also be applied to bands 1, 2, 3, 4, 5, 6, 14 and 16 in the future.

Improvement of resampling processing

The resampling process was modified to address the issue of unnatural spotted pixels in band-to-band differential imagery. The modification was applied to all AHI bands at 02:00 UTC on 9 March 2016.

Figure 4 (A) shows a pre-modification color composite image. Some unnatural dark pixels appear on the edge of clouds due to both inadequate resampling and band-to-band co-registration error (the latter is described in Section 2). The post-modification image in Fig.

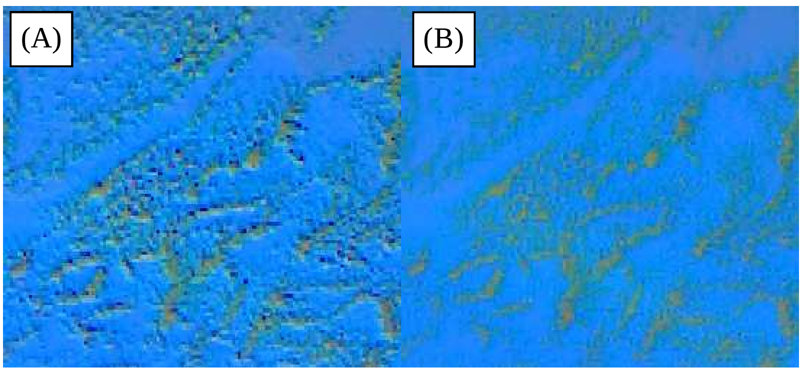


Figure 4. (A) Dust RGB color composite image taken over the Pacific Ocean at 00:10 UTC on 9 December 2015. (B) As per (A), but with the modified resampling process applied.

4 (B) shows few such pixels. The correction of band-to-band co-registration error also contributed to this improvement.

(JMA/MSC)

Introduction of GK-2A Data Processing System

Introduction

As a core part of the GK-2A ground segment, 52 kinds of meteorological products will be developed from November 2014 to May 2019. The meteorological products are composed of 23 primary products and 29 secondary products. These are developed by four domestic development teams which categorized according by characteristics of the products such as scene and surface analysis, cloud and precipitation, aerosol and radiation, and atmospheric condition and aviation as shown in Table 1. The proto-type algorithms of 23 primary products have been developed as the results of the second year's project which is finished in January 2016, and the proto-type algorithm of 29 secondary products will be developed by the end of February of 2017. More than 16 professors from 10 universities are participating in developing algorithm.

Table 1: GK-2A Meteorological Products

※ **23 Primary Products** and 29 Secondary Products

Scene & Surface Analysis (13)	Cloud & Precipitation (14)	Aerosol & Radiation (14)	Atmospheric condition & Aviation (11)
Cloud detection	**Cloud Top Temperature**	**Aerosol Detection**	**Atmospheric Motion Vector**
Snow Cover	**Cloud Top Pressure**	**Aerosol Optical Depth**	**Vertical Temperature Profile**
Sea Ice Cover	**Cloud Top Height**	**Asian Dust Detection**	**Vertical Moisture Profile**
Fog	Cloud Type	**Asian Dust Optical Depth**	**Stability Index**
Sea Surface Temperature	**Cloud Phase**	Aerosol Particle Size	Total Precipitable Water
Land Surface Temperature	Cloud Amount	**Volcanic Ash Detection and Height**	Tropopause Folding Turbulence
Surface Emissivity	Cloud Optical Depth	Visibility	**Total Ozone**
Surface Albedo	Cloud Effective Radius	**Radiances**	SO_2 Detection
Fire Detection	Cloud Liquid Water Path	Downward SW Radiation (SFC)	**Convective Initiation**
Vegetation Index	Cloud Ice Water Path	Reflected SW Radiation (TOA)	Overshooting Top Detection
Vegetation Green Fraction	Cloud Layer/Height	Absorbed SW Radiation (SFC)	Aircraft Icing
Snow Depth	**Rainfall Rate**	Upward LW Radiation (TOA)	
Ocean Current	Rainfall Potential	Downward LW Radiation (SFC)	
	Probability of Rainfall	Upward LW Radiation (SFC)	

Scene and Surface Analysis

The group of 'scene and surface analysis' is composed of six primary products and seven secondary products. The primary products are cloud detection, which is the basic product for retrieving the other products, fog, snow cover, sea ice cover, sea surface temperature and land surface temperature.

Especially, the cloud detection plays an important role as it affects the availability as well as the accuracy of the other products. The NMSC of KMA, who adopted the static threshold method, has taken leading role in developing the algorithm of cloud detection with the support by Pukyong National University who are developing the dynamic threshold by using Bidirectional Reflectance Distribution Function (BRDF) modeling method. The two methods will be merged after evaluation.

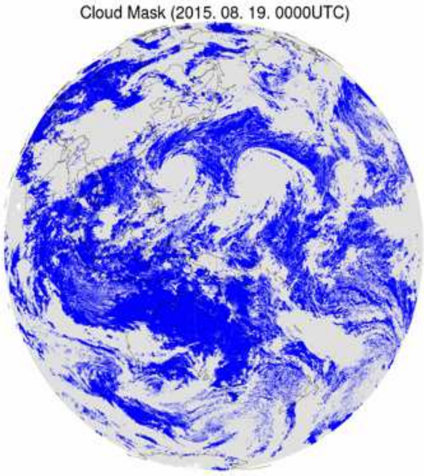
To retrieve the land surface temperature, 11.2 μm and 12.3 μm channels and ancillary data are used with the support of the pseudo match-up database that is constructed from radiative transfer model using TIGR dataset to consider the various atmospheric and land surface conditions.

The fog retrieval method uses the difference of reflectance of visible channels in daytime, while the difference of brightness temperature of two infrared channels such as 3.8 μm, and 11.2 μm in nighttime. In addition to these basic methods, the evaluating procedure for weighting and threshold values considering physical and textural characteristics of fog are added in daytime, nighttime, and dawn, respectively. To improve the underestimation over the boundary between fog and clear area, and small-scale fog over sub-pixel, the spatial continuity will be checked and high resolution GIS information will be introduced over the mountain area.

To detect the snow and sea ice, DTW (Dynamic Time Warping) technique ~~is~~ that uses the variation of reflectance pattern depending on the solar zenith angles is applied. The technique uses the spectral library of the reflectance of snow, sea ice and cloud which are prepared in advance, and then examines the similarity with the observed reflectance spectral profile to detect the snow and sea ice cover.
In general, to retrieve the sea surface temperature empirical relationship between satellite observations, such as 11.2 μm, 12.3 μm and in-situ buoy SST measurements are usually used such as Multi-Channel SST (MCSST) method. Recently, a radiative transfer model (RTM) enable near real-time simulations of clear-sky brightness temperatures (BTs) using the atmospheric variable inputs. A hybrid SST algorithm has been applied, which is based on a regression between RTM-simulated clear sky BTs and in-situ SST.

The followings are the updates compared with pre-existing algorithm

- 1.3 μm channel can improve the detection of cirrus
- 1.6 μm channel can improve to discriminate between snow and cloud
- 8.7 μm channel can improve the detection of cloud
- Increased number of visible and near IR channels makes the retrieval of vegetation index, land surface reflectance etc.
- Improve the accuracy of fog detection through the dynamic threshold and advanced auxiliary information such as land cover, emissivity and topography



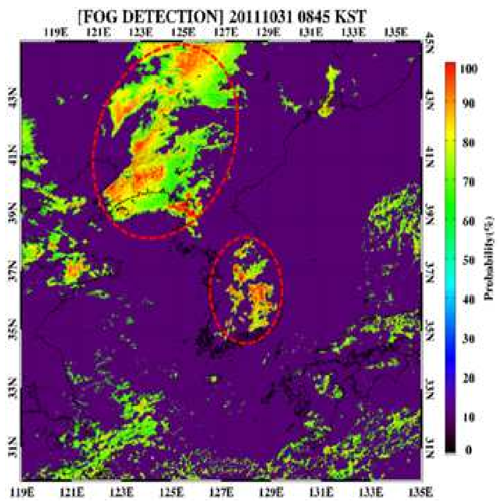


Figure 5. Cloud mask and fog detection

Cloud and Precipitation

The group of ‘cloud and precipitation information’ is composed of five primary products and nine secondary products. The primary products are cloud top temperature, cloud top pressure, cloud top height, cloud phase, and rainfall rate.
Cloud phase is the first retrieved and important product because its quality can affect the accuracy of the other products such as cloud top temperature, cloud top pressure, and cloud top height.
Cloud top temperature, cloud top pressure, and cloud top height are usually used for monitoring and analyzing rapidly developing clouds as well as assigning height of the atmospheric motion vector. To improve the accuracy, radiance fitting

and advanced radiance rationing method are adopted to consider the realistic cloud emissivity.

Rainfall rate algorithm uses the predefined database combination of infrared observation from GEO and rainfall rate from MW of LEO. The accuracy of the rainfall rate retrieval increases with increase in the number of rainfall cases when constructing the Look-Up-Table. The algorithm designs to categorize into two types of clouds: shallow cloud and not-shallow cloud. This can improve the accuracy of rainfall rate of low cloud. In addition, the algorithm divides into four latitudinal bands (80~30S, 30S~EQ, EQ~30N, 30~80N) to consider the locally characterized rainfall pattern.

The followings are the updates compared with pre-existing algorithm.

- Improve the accuracy of rainfall rate by categorizing cloud type, implementing dynamic matching method and advanced inverse transformation method
- Improve the accuracy of cloud top temperature by applying realistic cloud emissivity
- Improve the consistency between cloud optical properties and cloud type
- Develop the cloud optical information in nighttime, previously only daytime product

Aerosol and Radiation

The group of 'aerosol and radiation' is composed of six primary products and eight secondary products. The primary products are aerosol detection, aerosol optical depth, Asian dust detection, Asian dust optical depth, volcanic ash detection and height and radiances.

In day time, Aerosol and Asian dust detection use visible channels (0.4, 0.6 μm) and shortwave-IR (3.8 μm) observation data and thermal IR channels (8.6, 11, 12 μm) to improve accuracy of detection. In night time, it uses only thermal IR channels data to detect aerosol and Asian dust. To detect more accurately aerosol and Asian dust, it is removed snow and ice surface and cloudy pixels that affect aerosol detection accuracy in advance. After detecting the existence of Asian dust and aerosol in each pixel, their optical depths can be estimated through pre-defined look-up-table of reflectance considering the scattering of atmospheric trace gases and the surface reflectance which constructed by radiative transfer model. Aerosol and Asian dust products is developed land and sea algorithms separately to reflect their surface characteristics, and then they will be integrated in 2016.

Radiation is defined as a value of the average radiance (Radiance) in a certain area rather than for each pixel. In particular, the clear-sky radiation (CSR) calculates the average value in a certain area using only the clear-sky region of the pixel in the observed values for respective channels. Minimize the observation noise, and uses the average value for the constant region, in that obtained by using the clear-sky pixels surrounding the pixel value for the region corresponding to the part of the clouds.

The followings are the updates compared with pre-existing algorithm.

- Develop radiative transfer model optimized to GK-2A/AMI channels and many kind of radiation products for NWP model and climate monitoring
- Develop a discrimination method of aerosol type such as Asian dust and smoke considering surface effect and atmospheric correction
- Develop volcanic ash products such as ash detection, height and mass for volcanic eruption monitoring

Atmosphere condition and Aviation

The group of 'atmospheric condition and aviation' is composed of six primary products and five secondary products. The primary products are Total Ozone, Vertical Temperature and Moisture Profile, Stability Index (SI), Atmospheric Motion Vector (AMV), and Convective Initiation.

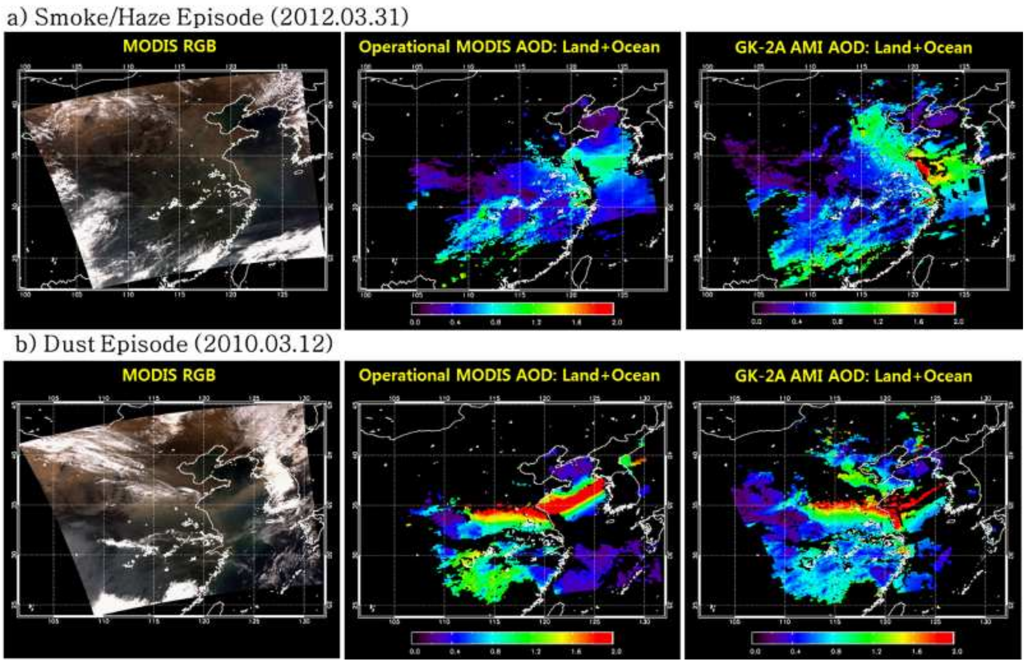


Figure 6. Aerosol Optical thickness

The AMI Atmospheric Profiles (AAP) algorithm is developed to calculate total precipitable water, total ozone and atmospheric stability index of five types using atmospheric vertical temperature and moisture profiles. The AAP algorithm is based on the statistical-physical method where prior information is combined with satellite measurements in a statistically optimal way, and a physical RTM is used to relate the atmospheric properties to the measurements. A physical retrieval method of AAP chooses a first guess temperature and moisture profiles and calculate the weighting functions, and then the radiance in each channel of the sensor is estimated using a RTM forward model.

This algorithm is processed two modes of clear sky and low cloud. It is calculated total precipitation, total ozone, stability index with atmospheric temperature and moisture profiles for the clear sky and is calculated total ozone for cloudy pixel (if consist low cloud)

The AMV is wind product is calculated from cloud and moisture motion using same spatial and temporal continuous satellite images. The process is consisted 4 steps, target selecting, tracking, height assignment and QI/QC. Specially, the height assignment, is effect on the AMV accuracy, use cloud height from GK-A and RTM for cloudy sky and vertical temperature data from RTM.

Convective Initiation use convective cloud separation, clustering, cloud top temperature change rate, multi-channel threshold test for cloud developing to distinguish convective cloud quickly developing during short time period. Multi-channel threshold test is tried a optimization trough a machine learning as well as threshold decision of interest variables by experimental method.

In the computing method to Atmospheric condition and aviation, Gk-2A algorithm will be improved comparing with COMS' algorithm using below;

- Improve of AMV calculating method introducing new cloud height assignment method and estimation bias
- Produce stability Index and total ozone through developing a calculating method of vertical temperature and moisture profile by increase AMI channel to get cloud height information.
- Produce atmospheric information(temperature and moisture profile, total precipitable water, convective initiation) of high resolution through introducing neural network and machine learning

Future Plan

Proto-type algorithm of 23 primary products for GK-2A will be modified through performance analysis process until May 2019. And 29 secondary products will be developed until 2016 and will be processed its' modification and vilification 2017 to 2018. The products' algorithm, is developed as a software by optimization and standardization, and installed on the ground segment on NMSC will be worked operational system after GK-2A launch

The schedule for GEO-KOMPSAT-2A and 2B program is shown in Figure 7.

(KMA/NMSC)

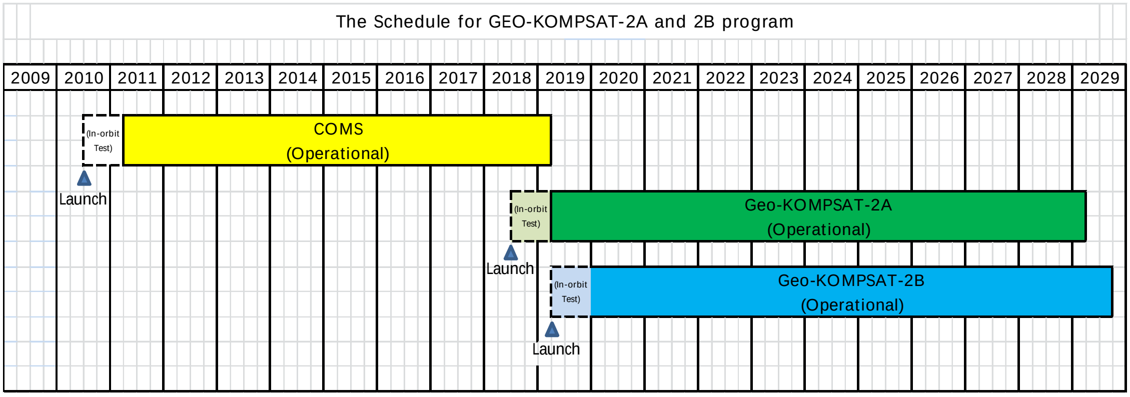


Figure 7: Schedule for the GEO-KOMPSAT-2

Members of the Coordinating Group

JAPAN (Co-coordinator)
Mr Takeshi OTOMO
Senior Coordinator for Satellite Systems
Satellite Program Division
Japan Meteorological Agency

REPUBLIC OF KOREA (Co-coordinator)
Dr Dohyeong KIM
Senior Researcher
Satellite Planning Division,
National Meteorological Satellite Center
Korea Meteorological Administration

BAHRAIN
Mr Adel Tarrar Mohammed DAHAM
Acting Director
Ministry of Transportation

CHINA
Mr Xiang FANG
Director, Remote Sensing Data Application
National Satellite Meteorological Center
China Meteorological Administration

HONG KONG, CHINA
Mr Lap-shun LEE
Senior Scientific Officer
Hong Kong Observatory

INDIA
Mr A. K. SHARMA
Deputy Director General of Meteorology
India Meteorological Department

KYRGYZSTAN
Ms Mahkbuba KASYMOVA
Head, Department of Weather Forecasting
Kyrgyzhydromet

MALDIVES
Mr Ali SHAREEF
Deputy Director General
Maldives Meteorological Service

OMAN
Mr Humaid AL-BADI
Chief, Remote Sensing and Studies Section
Oman Department of Meteorology

PAKISTAN
Mr Muhammad ASLAM
Senior Meteorologist
Allama Iqbal International Airport
Pakistan Meteorological Department

Mr Zubair Ahmad SIDDIQUI
Deputy Director/Senior Meteorologist
Institute of Meteorology & Geophysics
Pakistan Meteorological Department

RUSSIAN FEDERATION
Ms Tatiana BOURTSEVA
Chief, Information Department
ROSHYDROMET

Dr Oleg POKROVSKIY
Principal Scientist, Main Geophysical Observatory
ROSHYDROMET

UZBEKISTAN
Mr Sergey Klimov
Acting Chief, Hydrometeorological Service
UZHYDROMET

VIET NAM
Ms Thi Phuong Thao NGUYEN
Researcher, Research & Development Division
National Center for Hydrometeorological Forecasting
Ministry of Natural Resources and Environment of Viet Nam

EUMETSAT (OBSERVER)
Dr Volker GAERTNER
Head of User Services Division
EUMETSAT

Dr Kenneth HOLMLUND
Head of Remote Sensing and Products Division
EUMETSAT

From the Co-editors

The co-editors invite contributions to the newsletter. Although it is assumed that the major contributors for the time being will be satellite operators, we also welcome articles (short contributions of less than a page are fine) from all RA II Members, regardless of whether they are registered with the WMO Secretariat as members of the WIGOS Project Coordinating Group. We look forward to receiving your contributions to the newsletter.
(*Dohyeong KIM, KMA, and Takeshi OTOMO, JMA*)

RA II WIGOS Project Home Page

http://www.jma.go.jp/jma/jma-eng/satellite/ra2wigosproject/ra2wigosproject-intro_en_jma.html

Editorials and Inquiries

Takeshi OTOMO (Mr.)
Senior Coordinator for Satellite Systems
Satellite Program Division
Observation Department
Japan Meteorological Agency
1-3-4 Otemachi, Chiyoda-ku
Tokyo 100-8122, Japan

Tel: +81-3-3201-8677
Fax: +81-3-3217-1036
Email: ootomo@met.kishou.go.jp

Dohyeong KIM (Dr.)
Senior Researcher
Satellite Planning Division,
National Meteorological Satellite Center
Korea Meteorological Administration
64-18 Guam-gil, Gwanghyewon, Jincheon,
Chungbuk, 365-830, Republic of Korea

Tel: +82-70-7850-5705
Fax: +82-43-717-0210
Email: dkim@kma.go.kr

(Editor-in-chief of this issue: Takeshi Otomo)