



RA II WIGOS Project Newsletter

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

Contents of this issue

	Page
◇ The 13 th Asia-Oceania Meteorological Satellite Users' Conference (AOMSUC-13) Report issue	1
◇ The 1 st Meeting of Expert Team on Satellite Observations and Applications (ET-SOA) in RA II	5
◇ Weather Forecast Service for the Gangwon 2024 Winter Youth Olympic Games using GK2A Satellite Data	7
◇ Proxy Radar from GK2A Satellite Data using AI Technique	8
◇ Himawari-10 – a Follow-on Satellite to Himawari-9	10
◇ Validation of AHI on Himawari-9 in Level 1 Products	11
◇ The 51 st Coordination Group for Meteorological Satellites Plenary Session	14
◇ The 23 rd Session of the Global Space-based Inter-Calibration System Executive Panel	14
◇ FengYun Satellite User Conference Promotes Global Application	15
◇ China Launched Two Satellites of FY-3 Series	17
◇ FY-3G Rain Measurement Satellite	20
◇ Members of the Coordinating Group	22
◇ From the Co-editors	22

The 13th Asia-Oceania Meteorological Satellite Users' Conference (AOMSUC-13) Report

Introduction

The thirteenth Asia/Oceania Meteorological Satellite Users' Conference (AOMSUC-13) was held in Jincheon and Busan, South Korea from November 3-11. AOMSUC-13 was hosted and sponsored by

the Korea Meteorological Administration (KMA), and was co-sponsored by the China Meteorological Administration (CMA), the Japan Meteorological Agency (JMA), the Russian Federal Service for Hydrometeorology and Environmental Monitoring (ROSHYDROMET), the Agency for Meteorology, Climatological and Geophysics of the Republic of Indonesia (BMKG), the Australian Bureau of Meteorology (AuBOM), the India

meteorological Department (IMD), and the World Meteorological Organization (WMO).

AOMSUC-13 was a major step forward in the hosting of preparation and hosting of the event: after the past four years that were affected by the COVID-19 pandemic (2020 being cancelled and 2021 and 2022 being virtual) as it brought our community back together for an in-person conference: the Korea Meteorological Administration also took the hold step forward of extending the length of AOMSUC by an extra day for training event and an extra day for the in-person conference. An after-training and conference assessment by trainees and conference attendees strongly endorsed and greatly appreciated this extension of those activities.

The AOMSUC-13 began with a three-day training event in Jincheon that brought

together participants from WMO Regions II and V: this portion of the AOMSUC was both in-person and virtual. Including lectures and attendees, 37 people from 18 countries participated in the face-to-face training event and 15 people participated on-line. The next four days of AOMSUC-13 were the conference portion consisting of 19 oral and 9 poster presentations and was attended by over 170 people from 25 countries. The final day of the AOMSUC-13 was a smaller, focused meeting that was attended by 41 people from across WMO Regions II and V: “The fifth meeting of the coordination group of the WMO Regional Association (RA)-II and RA-V WIGOS project to develop support for NMHSs in satellite data, products and training.”



Figure 1. Group photo at the AOMSUC-13

Conference Summary

The Opening Session concluded with two keynote presentations. The first keynote by Dr. Wenjian Zhang of WMO addressed the

value of Earth Observing Satellites in meeting WMO’s mission. In his keynote address, Dr. Zhang emphasized the value of Earth Observing Satellites in WMO’s mission in Climate and its effect on health and well-being globally. He also stressed the role of satellite

data in Disaster Risk Reduction in many areas including floods, fires, and land changes that could lead to landslides. In summary, Dr. Zhang thanked the AOMSUC for its various activities and stressed the importance of working in cooperation with a “Global Spirit”, of working toward improvements in the WMO Global Observing System (WIGOS), and of extending activities to include new Service Areas. The second keynote was presented by Dr. William J. Blackwell, MIT Lincoln Laboratories, and addressed the capabilities that are being demonstrated by small satellites and cube satellites in low Earth orbit for specialized applications. He spoke specifically of microwave cube satellites in a prograde orbit (30-degree positive inclination) for observing atmospheric precipitation and it’s assessing the structures and changes in developing cyclones. The attendees were very appreciative of the role small satellites could play in the future space-based portion of the WIGOS.

The Conference portion of AOMSUC-13 was divided into twelve oral sessions and one poster session. The one poster session has nine very interesting posters that dealt with a variety of specialized applications and they can be viewed on line at the conference website. The twelve oral presentation sessions included 59 presentations: their abstracts and presentations are able to be accessed through the conference website. Those oral sessions covered the following topical areas:

- (a) The Space Program and Data Access Updates (Session 1-I)
- (b) Satellite Activities and data Exchange (Session 1-II)
- (c) Application for weather analysis and Nowcasting Sessions 2-I, II, III and IV)
- (d) Application for numerical weather prediction (Session 3-I and II)
- (e) AI/ML in satellite data processing (Session 4)
- (f) Application for land surface and sea surface derived from satellite

observations (Sessions 5-I and II)

(g) Space weather (Session 6)

(h) Performance and calibration of satellite instruments (Session 7)

Note that each presentation summary is provided at the last section of this report.

In those two opening sessions, 1-I and 1-II, satellite operators from KMA, KARI, CMA, JMA, JAXA, NOAA, EUMETSAT, and IMD as well as AuBOM, representing the user community perspective, presented current plans and anticipated improvements to their respective satellite systems providing meteorological and other environmental satellite data and products across the Asia/Oceania region as well as globally.

Both oral presentations and posters were of the highest quality without exception. The conference was very successful in meeting the four major conference goals as set forth by Dr. Purdom in his welcoming remarks. It was evident throughout the conference that the new generation of geostationary and polar orbiting satellites have already had a major impact across the globe – great scientific adventures await us as we move forward with science and product development and new applications with these data: the satellite operators are meeting their commitment as we inaugurate this new era in the Space Based Component of the WMO Integrated Global Observing System (WIGOS). The participants welcomed the efforts being undertaken to introduce and utilize an unprecedented stream of new data; it was agreed that this early coordination in the generation of new products and services and the preparation for their utilization by the worldwide user community must be energetically sustained. It will be a significant undertaking for the operational space agencies and the users to bring to fruition the dream of “full utilization” and these annual activities of the Asia/Oceania satellite community (AOMSUC) are an important part of that effort. At the end of AOMSUC-13, India looked forward to hosting AOMSUC-14

in the Fall of 2024 in a format like that used for AOMSUC-13. The venue and precise dates will be announced in early 2024. At the close of the conference Dr. Purdom, Chair of the AOMSUC International Conference Steering Committee thanked the AOMSUC so-sponsors and conference participants for their support to him as ICSC Chair since the inception of the conference in 2010. He then turned the Chair of the AOMSUC ICSC over to Dr. Allen Huang. Dr. Purdom will remain a member of the ICSC as Chair emeritus.

As the new chair, Dr. Huang acknowledged the participants from EUMETSAT, and NOAA, for their invaluable contribution, which has made AOMSUC continue to be successful and productive. Dr. Huang also attributed Dr. Purdom, the father of AOMSUC, for his long-lasting contributions and was joined by the attendees with a long-standing ovation with profound expressions of appreciation to Dr. Prudom.

Dr. Huang also made a comment about a significant increase in the papers reporting the use AI/ML approach. He took this closing remark occasion to caution us that powerful tool, such as AI/ML, is often associated with risks of lack of understanding and abusive use and might prevent our desire to learn from the complicated theory and take shortcuts without gaining into the insight of highly nonlinear weather forecast system that we are living in.

Dr. Huang further mentioned that IMD director general, Dr. Mrutyunjay Mohapatra in his report on the “Recent Update of the IMD Satellite Program” has officially announced to host AOMSUC-14 in India in the year 2024. In addition to IMD’s forthcoming announcements, the WMO space program website will be an ideal site to get the updated AOMSUC-14 announcement.



Figure 2. Photos from the AOMSUC-13

Training Summary

The 13th Asia Oceania Meteorological Satellite Users' Conference (AOMSUC-13) training event took place from November 3 to 5, 2023, at the National Meteorological Satellite Center in Jincheon, Chungcheongbuk-do, Republic of Korea. This training event marked the first face-to-face session since the pandemic and was attended

by 19 meteorological forecasters from 17 countries in Asia and Oceania. Additionally, 6 to 10 participants joined online as trainers or trainees.

Nineteen instructors from the U.S., China, Japan, Australia, Indonesia, and Korea led lectures on weather phenomenon analysis using geostationary and low-orbit satellites. They shared insights and practical skills related to satellite usage. Emphasizing

cooperation between instructors and trainees, daily discussions using satellite images and practical exercises on satellite image analysis using each country's analysis system were conducted. Online survey tools such as Socrative and Slido were employed to gather options.

This training event focused on sharing knowledge about satellite technology and its applications among experts from various countries, emphasizing the accuracy and efficiency in weather forecasting through practical exercises and discussions using actual satellite images. The training served as a valuable opportunity for meaningful

communication and cooperation, fostering the exchange of information on the development and utilization of future weather satellites.

Presentations and selected photos at AOMSUC-13 Conference may be downloaded via the following link:

https://nmsc.kma.go.kr/enhome/html/conference/AOMSUC_2023.do

(Written by ICSC and arranged by JaeGwan KIM, KMA)



Figure 3. Photos during training event at the NMSC of KMA

The 1st Meeting of Expert Team on Satellite Observations and Application (ET-SOA) in RA II

Introduction

The 1st meeting of the RA II Expert Team on Satellite Observations and Application (RA II ET-SOA) was held via video conference on July 6, 2023. The meeting was attended by representatives from WMO, CMA, JMA, and KMA. The meeting was opened by Dohyeong KIM, the leader of the RA II ET-SOA. He noted that this meeting is a good chance to be

familiar with each other for members of RA II ET-SOA, as well as to review the previous activities and plan future activities in RA II. He also noted that space-based observation and its application are essential for monitoring of extreme weather, climate change, and climate events. SATO Yoshiaki, chair of RA II Working Group on Infrastructure, gave a remark to the meeting. He recalled that a set of resolutions were approved by recent WMO congress to echo the advice of the Early Warning for All (EW4ALL) initiative by the United Nations.

Summary

The meeting established the critical role of space-based observations in monitoring extreme weather and supporting the UN's EW4ALL initiative. It was determined that the RA II Operating Plan needs to be updated to align with these global initiatives, specifically regarding satellite utilization for nowcasting and data provision for Numerical Weather Prediction (NWP). Furthermore, the vital role of satellites in the Global Greenhouse Gas Watch (G3W) was recognized, emphasizing the continued importance of capacity development within the region.

The meeting reviewed and coordinated various international satellite projects and upcoming events for 2023. Key focus areas included the progress of the RA II WIGOS project, the outcomes of AOMSUC-12, and the development of a Work Plan encompassing LEO satellite utilization and rapid scan cooperation between CMA, JMA, and KMA. Additionally, the progress of the GK2A Marine Weather Broadcast Service

was presented, noting its successful operation since 2020 in providing essential weather data to ships and remote areas across the RA II and RA V regions.

To improve the effectiveness of the expert team, it was decided to bridge the gap between satellite providers and the user community. It was agreed that the membership of the RA II ET-SOA should be expanded to include more user representatives, a process expected to be finalized following the RA II session in 2024. For immediate action, the meeting concurred that experts and speakers from other regions (RA I, RA III, RA IV, and RA V) would be invited to the joint coordination meeting in November to strengthen inter-regional communication and support the establishment of a global satellite operation center.

(JaeGwan KIM, KMA)

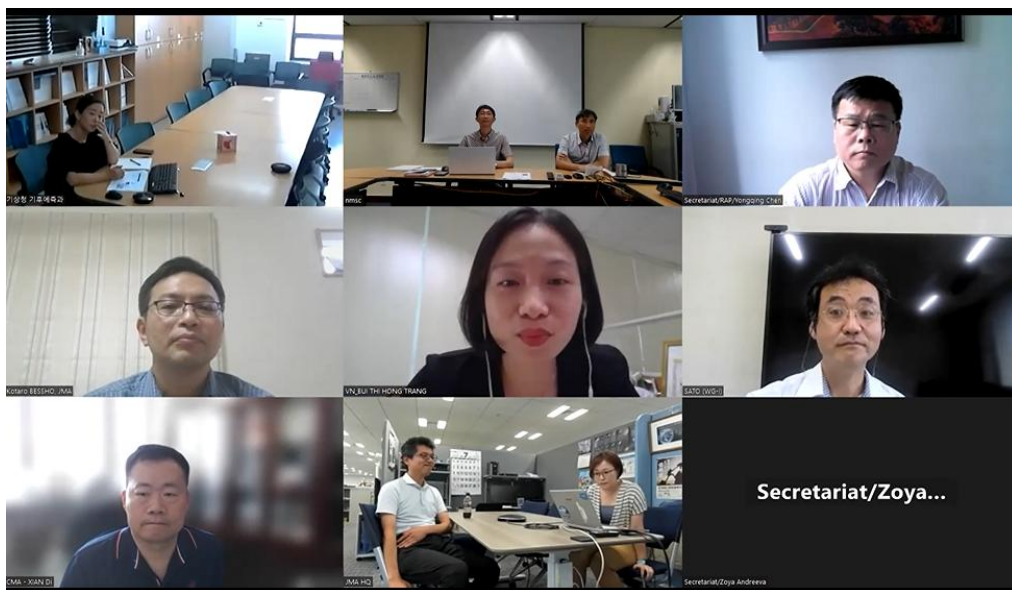


Figure 4. Screenshot of the 1st online meeting of the ET-SOA

Weather Forecast Service for the Gangwon 2024 Winter Youth Olympic Games using GK2A Satellite Data

Overview of activities of weather forecast service group

To ensure stable operation and progress of the Gangwon 2024 Winter Youth Olympic Games, the Korea Meteorological Administration has formed a weather forecast group of 26 people (1 person from the National Meteorological Satellite Center) to provide weather conditions and forecasts.

Gangwon 2024 Winter Youth Olympic Games were held in 4 cities of Gangneung, Pyeongchang, Jeongseon, and Hoengseong in Gangwon-do for 14 days from January 19 to February 1, and a total of 1,900 youth athletes from 80 countries participated in 15 ice and snow sports.

The weather forecasters of KMA provided real-time weather conditions, forecasts, and notifications for four stadiums: Gangwon Office, Pyeongchang Alpensia, Hoengseong Welli Hilli Park, and Jeongseon High1.

The weather forecasters attended athlete delegation meetings, jury meetings, main operation centre meetings, and Chefs de Mission meetings to conduct weather forecast briefings.

KMA operated weather observation vehicles and stadium weather observation networks and provided numerical weather data and prediction for each stadium.

Utilization of satellite data for weather service

During the Olympic Games, forecasters used RGB day and night composite images, fog images, and enhanced water vapor

images to analyze snow clouds. In particular, in the snow Olympic Stadium, located in a high mountainous area, it was light snow even though under very weak low-level clouds. Because snow sport games were held in high mountainous areas, falling snow flurry or strong winds can affect the progress of the Olympic Games. Real-time weather information such as satellite data and radar echo data, AWS (Automatic Weather System) observations and etc. was very useful to service the forecast.

Good evaluations from Olympic officials and media for weather service

The weather forecasters team announced at the jury meeting the day before the ski jumping competition (January 19) that a strong snowstorm was expected in the afternoon of the competition day, so the ski jumping competition schedule was advanced by one hour to ensure that the competition proceeded smoothly without any accidents due to the weather. We provided rapidly weather information through continuous advance communication about hazardous weather to the MOC (Main Operation Centre), allowing competition operation resources such as snow removal, transportation, and manpower to respond efficiently. International sports officials and media gave good evaluations to the customized point weather information for each stadium provided in real time and forecast support from KMA

NMSC/KMA: <https://nmsc.kma.go.kr>
(Ok Hee KIM, KMA)



Figure 5. Weather Forecast activities such as MOC and CdM Weather briefing

Proxy Rada from GK2A Satellite Data using AI Technique

Introduction

Weather satellites can observe clouds over large areas, while weather radars provide near-surface rainfall intensity information. For effective early response to hazardous weather conditions such as typhoons, continuous radar data production over a broad area, including beyond the Korean Peninsula, is required. However, due to the observation radius and elevation angle of radars, there are gaps in coverage and areas of relatively low accuracy, particularly over regions including the East China Sea. Additionally, receiving data from foreign radars can be unstable, highlighting the need for supplementary solutions. This research

employs the GK2A geostationary satellite and AI techniques to generate proxy radar data, overcoming these limitations.

Methodology

The AI model used in this research is Pix2PixCC, a modification of the Pix2Pix model based on conditional generative adversarial networks (cGANs) with an added investigator to consider the correlation between the target and output. The generator uses U-Net architecture to produce outputs closely resembling the target, while the discriminator employs patchGAN to distinguish between the generated outputs and the targets. The training performance improves through the competition between the generator and discriminator, guided by

loss functions including Mean Absolute Error (MAE) and Mean Squared Error (MSE) of the real and fake feature maps, as well as the correlation coefficient calculated by the inspector.

Data

Input data comprises brightness temperature values from ten infrared channels of the GK2A satellite and cloud detection data (CLD mask) with values indicating cloud, probably cloud, and clear conditions. The target data for training included reflectivity composites from the Tri-nation High-Resolution Sector (HSR) over the East China Sea. Training utilized summer observation data from June to August 2020 over the largest non-gap observation area of 576x576. A custom loss function, weighted MSE, was introduced to improve model accuracy by assigning higher weights to more significant reflectivity values.

Data Preprocessing

Quality control (QC) processes were implemented to exclude outliers and anomalies, such as those caused by solar interference, from the training dataset. A random selection of 8,000 samples was used for training to avoid data bias, and the grid spacing of the HSR composites was adjusted from 1 km to 2 km to match the GK2A data.

Results

The inclusion of CLD mask data significantly improved the detection of echoes in the proxy radar output, particularly reducing the overestimation of echo areas. The model was able to produce continuous echo outputs in regions with high observation altitudes or relatively low accuracy, aiding in the early detection and monitoring of typhoons moving through observation gap areas. Verification against HSR images over about a month

yielded a Probability of Detection (POD) and correlation coefficient above 0.55, with an RMSE of approximately 6 dBZ. The validation results were notably better over the Korean Peninsula compared to the broader East Asia region.

Case Studies

Typhoon SONGDA:

The middle figure (figure 6) represents the Radar Composited map, where the black solid lines and white areas denote radii of 240km and 480km, respectively, and the grey areas indicate observation gaps. The figure on the right shows the final proxy radar output generated by the model. During the passage of Typhoon SONDA, it moved northward from the area circled in red to the area circled in blue. Through the proxy radar imagery, it was possible to preemptively grasp the reflectivity information of the typhoon moving through the observation gap areas. Additionally, it was observed that continuous echoes were produced even in areas of high observation altitude or those circled in blue, where the accuracy is relatively lower, indicating the absence of lower-layer echoes.

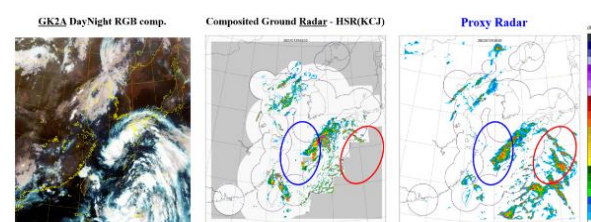


Figure 6. Proxy radar for typhoon SONGDA

Typhoon KROSA:

Figure 7 shows Typhoon KROSA. In the conventional Radar Composited map, the area circled in red persistently showed observation clutter. However, the proxy radar data based on satellite information did not simulate this clutter, confirming its effectiveness. Furthermore, in the area circled

in blue, it was observed that typhoon rainbands were continuously produced, indicating the model's capability to enhance radar data accuracy and fill in observation gaps efficiently.

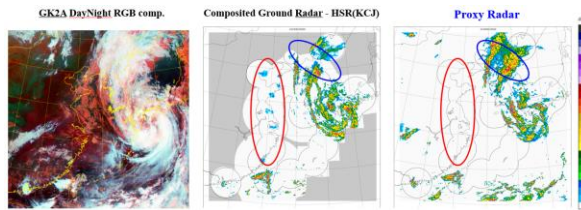


Figure 7. Proxy radar for typhoon KROSA

Conclusion

The proxy radar data, converted to rainfall intensity through the Z-R relationship, is currently provided to operational meteorology at approximately 10-minute intervals for East

Asia and the Korean Peninsula. Future plans include extending the training period to 9 months to generate winter proxy radar data and improving the model's performance by utilizing time-series data and expanding the training dataset. This research successfully demonstrates the potential of using GK2A satellite data and AI to generate proxy radar data, offering a promising solution to enhance radar coverage and accuracy. Ongoing improvements and future expansions of this work are expected to significantly contribute to the monitoring and early detection of severe weather phenomena.

(Eun Ha SOHN, KMA)

Himawari-10 – a Follow-on Satellite to Himawari-9

Introduction

The Japan Meteorological Agency (JMA) plans the seamless introduction of a new geostationary earth-orbit satellite system in consideration of the CGMS baseline and the Vision for WIGOS in 2040. In FY 2018, JMA began consideration of the Himawari-8/9 follow-on program and contracted manufacturing of Himawari-10 in March 2023, with initial operation scheduled for FY 2029 (Figure 8).

Himawari-10 will carry the visible/infrared imager (Geostationary Himawari Imager: GHMI), infrared sounder (Geostationary

Himawari Sounder: GHMS). The GHMS is intended to improve JMA's services in extreme weather monitoring, nowcasting and numerical weather prediction. JMA will also fly the space environmental suite developed by the Ministry of Internal Affairs and Communications (MIC) and the National Institute of Information and Communications Technology (NICT) on Himawari-10 as a hosted payload (Figure 9).

Ongoing evolution is planned for the Himawari satellite series to address universal concerns around climate-related issues such as heavy rain, droughts and floods across East Asia and the Western Pacific.

(SUMIDA Yasuhiko, JMA)

JFY	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
Himawari-8	Standby	Standby	Standby	Standby	Standby	Standby	Standby	Standby	Standby	Standby	Standby	Standby	Standby
Himawari-9	Operation	Operation	Operation	Operation	Operation	Operation	Operation	Operation	Standby	Standby	Standby	Standby	Standby
Himawari-10		Satellite manufacturing & in-orbit testing	Satellite manufacturing & in-orbit testing	Satellite manufacturing & in-orbit testing	Satellite manufacturing & in-orbit testing	Satellite manufacturing & in-orbit testing	Satellite manufacturing & in-orbit testing	Satellite manufacturing & in-orbit testing	Operation	Operation	Operation	Operation	Operation

Figure 8. Himawari-8/9 and Himawari10 timeline

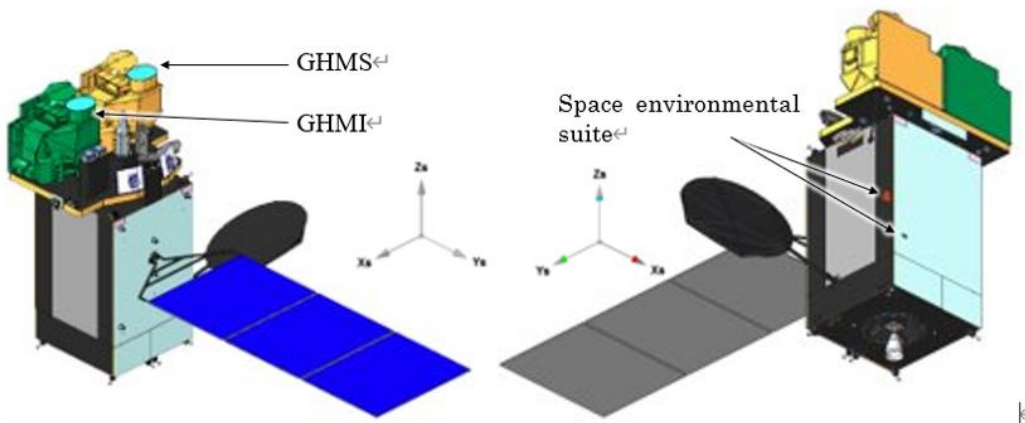


Figure 9. Himawari-10 Outline

Validation of Himawari-9 in Level 1 Products

Introduction

On 13 December 2022, JMA switched over operation from the Himawari-8 geostationary satellite to its Himawari-9 successor after a period of data quality monitoring for AHI data from the latter (starting on 27 September 2022) based on parallel observation. Himawari-9 data validation for Level 1 and Level 2 products is described in the working paper CGMS-51 Working Group [1]. This article outlines validation for Level 1 products in image navigation and radiometric calibration.

Image navigation and registration

JMA/Meteorological Satellite Center (MSC) provides the information on Himawari-9

image navigation performance at the following webpage:

Himawari Navigation Monitoring:

<https://www.data.jma.go.jp/mscweb/data/monitoring/navigation.html>

Figure 10 shows the results of landmark analysis for Himawari-8/9. Outcomes based on B13 (10.4 μm) data indicate one-month averaged landmark errors of 0.26 and 0.27 km in November 2022 for Himawari-8/9 data, respectively, demonstrating similar navigation accuracy. Inter-band co-registration performance was also evaluated with reference to B13 (10.4 μm). Although performance varies by band, verification for both satellites showed values of less than 60 m, which corresponds to 0.03 pixels for all bands at the sub-satellite point. Himawari-8/9 exhibit comparable performance.

Radiometric calibration

Himawari-9 radiometric calibration performance information is also available at :

Himawari Calibration Portal:

https://www.data.jma.go.jp/mscweb/en/oper/calibration/calibration_portal.html

Figure 11 summarizes calibration performance as evaluated using radiative transfer calculation with reference to MODIS based on direct comparison (ray matching) with observation by VIIRS for Himawari-8/9 VNIR bands in September 2022. Himawari-8/9 AHIs data are consistent with references up to around 5%, although differences from references and validation methods are seen. The sensitivity of Himawari-9 AHI VNIR bands is stable in the months after parallel

observation commencement. Monitoring will be continued.

Figure 12 shows infrared-band brightness temperature bias with hyper spectral sounders used for references. The observed brightness temperatures of Himawari-8/9 are within 0.3 K of the references, and the difference between the two satellites is also within 0.3 K.

References

[1] CGMS-51 WG-II JMA-WP-03,

<https://www.cgms-info.org/agendas/agendas/CGMS-51>

(YAMADA Kazutaka, JMA)

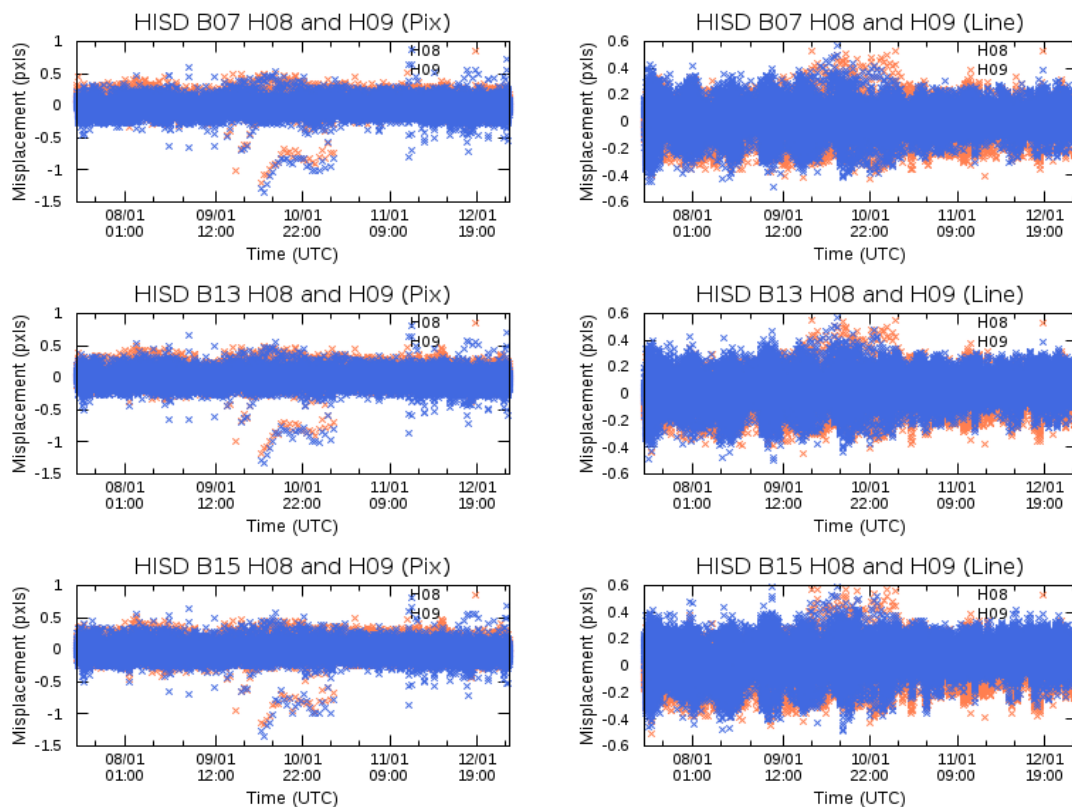


Figure 10. Navigation performance based on landmark analysis of B07 (3.9 μm), B13 (10.4 μm) and B15 (12.4 μm) of Himawari-8/9. Landmark errors from 7 July to 13 December 2022 for the Himawari-8 (orange crosses) and -9 AHIs (blue crosses) are shown. The red circles show midnight data point in the eclipse period. It is considered that relatively large deviation occurs at the time of updating for ground system orbit information.

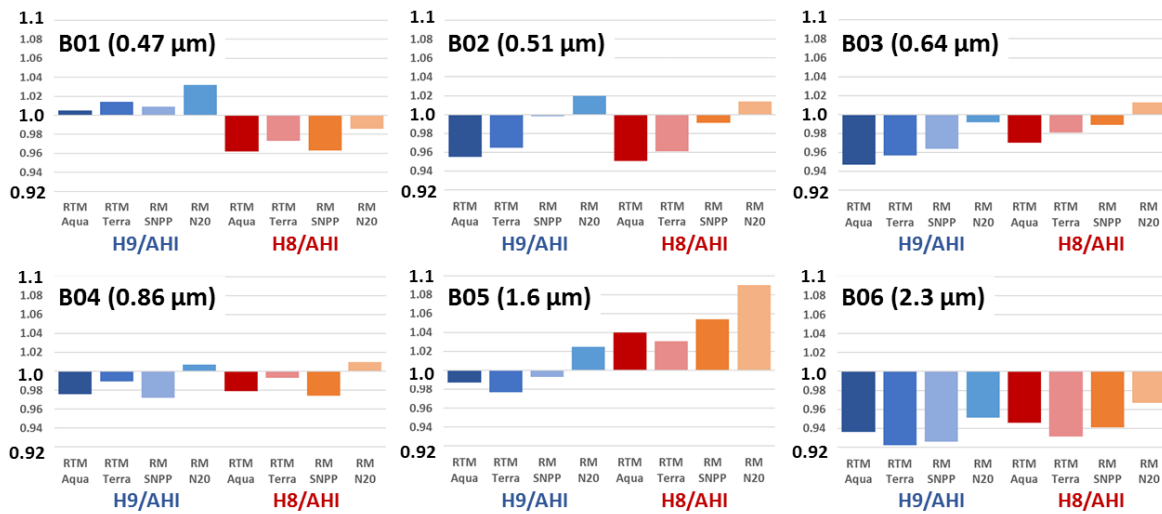


Figure 11. AHI/reference ratios based on regression of AHI observation and references. RTM represents the radiative transfer model-based approach. The data periods are from 1 to 30 September 2022 for the RTM-based approach and from 2 to 30 September 2022 for the ray-matching approach.

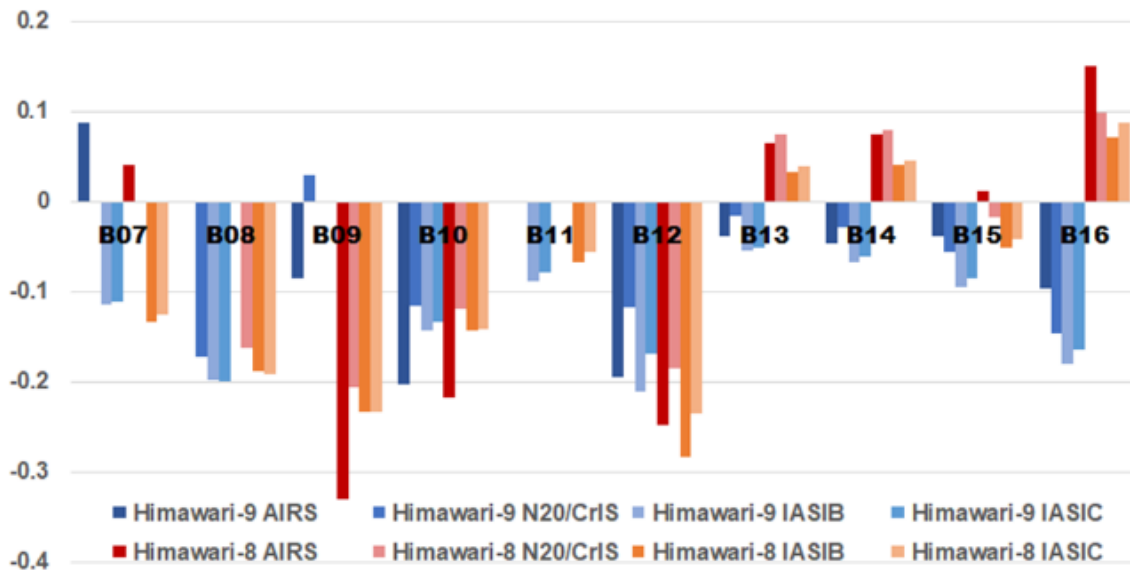


Figure 12. Brightness temperature bias of Himawari-8/9 IR bands with reference to observation from hyper-spectral sounders such as Aqua/AIRS, NOAA-20/CrIS, Metop-B/IASI and Metop-C/IASI, showing values in brightness temperature equivalent to a clear-sky sea surface. The data period is from 2 to 30 September 2022. Bias wrt. CrIS at B07, bias wrt. AIRS at B08 and bias wrt. AIRS and CrIS at B11 are omitted due to large uncertainty.

The 51st Coordination Group for Meteorological Satellites Plenary Session

Introduction

The 51st Coordination Group for Meteorological Satellites (CGMS-51) Plenary Session was held in a hybrid face-to-face and online format at JMA headquarters from 26 to 28 June 2023. The CGMS is composed of representatives from meteorological satellite operators, space agencies and international organizations such as the World Meteorological Organization (WMO). Hosting of the plenary session, held annually since 1972, rotates among the member organizations, with the duty this year falling jointly to JMA and the Japan Aerospace Exploration Agency (JAXA). The session had 131 participants (95 in person) from 22 organizations in 12 countries. Representatives from the participating organizations presented on the status of their satellite observations and future plans. Fruitful discussions were also held on coordination of observation

functions/products and collaboration among satellite operators.

JMA gave two oral presentations and announced its commencement on the production of Himawari-10 featuring infrared sounder equipment capable of 3-D atmospheric water vapor monitoring.

Programs and presentation materials can be accessed at:

<https://www.cgms-info.org/agendas/agendas/CGMS-51-Plenary>

(WATANABE Ibuki, JMA)



Figure 13. CGMS-51 Plenary Session participants

The 23rd Session of the Global Space-based Inter-Calibration System Executive Panel

Introduction

The 23rd Session of the Global Space-based Inter Calibration System (GSICS) Executive Panel (GSICS-EP-23) was held in a hybrid in-person and online format at JMA headquarters from 29 to 30 June 2023 following the CGMS-51 Plenary. GSICS is an international collaborative effort initiated in 2005 by the World Meteorological Organization (WMO) and the Coordination Group for Meteorological Satellites (CGMS). It is intended to support consistent accuracy among space-based observations worldwide for weather forecasting, climate monitoring and environmental applications. The

Executive Panel (EP), which consists of representatives from the participating agencies, sets strategic priorities and monitors/evaluates GSICS evolution and operations.

The activities of GSICS working groups were reviewed and discussed at the meeting, and reports on GSICS-related activities were given by JMA, JAXA, NICT and other participating agencies.

Main points to note from the meeting:
-Mitch Goldberg, who has led GSICS activities since its establishment, stepped down as the GSICS-EP chair, and Bojan Bojkov of EUMETSAT was appointed as the new chair.

-The Space Weather Sub-Group was endorsed and accepted as a new subgroup of the GSICS Research Working Group (GRWG) with Tsutomu Nagatsuma of NICT as subgroup chair.

-Collaboration with the International Satellite Cloud Climatology Project (ISCCP) was reported, and this activity will continue as part of GSICS user feedback.

Meeting programs, presentation materials and the final report can be accessed at: <https://community.wmo.int/en/meetings/gsics-ep-23>

(WATANABE Ibuki, JMA)

FengYun Satellite User Conference Promotes Global Application

Introduction

The 2023 FengYun Satellite User Conference was held from November 13 to 15 in Xiamen, Fujian Province. The China Meteorological Administration (CMA) and the China National Space Administration (CNSA) jointly hosted the conference. It aims to strengthen international exchanges, improve international service capabilities, and better serve FengYun satellite users in countries along the "Belt and Road." Since the first conference was held in 2019, FengYun Satellite has continued to grow in scale, scope, and influence. By the time of the meeting, FengYun Satellite had provided high-precision real-time data and analysis for 129 countries and regions, mainly for countries along the "Belt and Road." FengYun Satellite has provided more than 140 emergency disaster reduction services. This conference attracted over 270 participants from 30 countries, regions, and organizations, including 56 foreign guests (6 online participants).

The conference was divided into 10 parts: opening ceremony, press briefing, keynote, invited talk, discussion on the application requirements of FengYun satellites for the Belt and Road Initiative, FengYun satellite industrialization application roundtable forum, three special sessions, enterprise exhibition, and closing ceremony. The summary of the meeting communication and



Figure 14. GSICS-EP-23 participants

related activities is as follows:

Conference Report

In the opening ceremony, Chen Zhenlin, Administrator of CMA; Kang Tao, a member of the Fujian Provincial Government Party Group; Li Guoping, Chief Engineer of CNSA; and Abdullah Ahmed Armandus, President of the World Meteorological Organization, delivered opening remarks. A press briefing was held, which released the first set of pictures of FY-3F and data of FY-3G to be shared globally, the launch of the FengYun Satellite International Application Competition, the list of the first batch of visiting scholars of the FengYun Satellite "the Belt and Road" program, and the FengYun Earth International Edition.

The four keynotes at this conference include "The Development and Applications of China's FengYun Meteorological Satellites" by Zhang Peng, Deputy Director General of the National Satellite Meteorological Center, "The Role of Earth Observation Satellites in the Responsibilities of the World Meteorological Organization" by Natalia Donoho, Head of WMO Space Systems and Utilization Division, "The Application of China's Earth Observation System in the Meteorological Field" by Zhao Jian, Director of the Earth Observation and Data Center of CNSA, and "The Application of Wind and Cloud Satellite MERSI Sensors in the National Fire Monitoring System" by Burtsev

Mikhail, Senior Researcher at the Russian Academy of Sciences.

In addition, the conference also invited 10 representatives from EUMETSAT, ECMWF, FAO, CNSA, the National Satellite Meteorological Center, the World Meteorological Center (Beijing), and the Shanghai Academy of Spaceflight Technology to give invited talks, summarizing the main progress of relevant institutions and their prospects. They all emphasize that FengYun Satellite Constellation plays a significant role in promoting the "Belt and Road" initiative and building a community with a shared future for humanity. Dr. Niels Bormann's report provides a detailed introduction to applying FengYun satellite data in the ECMWF NWP system. He pointed out that satellite data contributes 77% to short-term forecasting, especially the operational orbit of FY-3E, which is not yet covered by satellites from the United States and Europe and plays a vital role. Compared with FY-4A, FY-4B GIIIRS observation data quality has also significantly improved. Dr. James Purdom, winner of the Chinese Government Friendship Award, summarized and proposed eight critical challenges for developing satellite meteorological science, including exploring the principal components of images, how to better utilize 1-minute interval images, stationary microwave stars, and small satellite constellations. Peter Warupi, a forecaster at the Papua New Guinea Meteorological Administration, reported on the application of FengYun satellites in the validation of numerical weather forecasting models in Papua New Guinea and proposed three requirements: 1. CMA will assist Papua New Guinea in rebuilding a new satellite system and updating it promptly, 2. Provides training on the MICAPS system, and 3. The observation range of geostationary satellites will better

cover the Papua New Guinea region in the future.

Discussion was held on the application requirements of FengYun Satellites for the Belt and Road Initiative. Six guests, including Natalia Donoho, Head of WMO Space Systems and Utilization Division, and Rion Suaib Salman, a weather forecaster from the Indonesian Meteorological Agency, participated in this roundtable forum. Among them, Natalia Donoho introduced the goals and action plan of the WMO planetary program and expressed hope that FengYun satellites can play an essential role in this program. Rion Suaib Salman stated that the Indonesian Meteorological Agency extensively uses FengYun satellite data in its services. FengYun satellite data has a high coverage rate in Indonesia and has many refined products to help them make more accurate forecasts. They hope to obtain more flexible formats, such as GIS data, to make forecasting more convenient.

In the following days, special session was organized on weather, climate, and disaster applications, ecological agriculture applications, and application and training of meteorological satellite industry. HUAYUN ShineTek and CMA Training Center covers topics such as the technology, current status, and future development of the FengYun satellite and application industries. Guests pay attention to the various problems and challenges faced by the future development of the FengYun satellite industry, explore solutions and ways to strengthen industrial applications, and seize the opportunities of various related industries in the subsequent development of FengYun satellites.

FENGYUN Satellite User Conference (FYSUC):

<https://www.nsmc.org.cn/conference/fysuc/index.html>

2023 年风云气象卫星国际用户大会 2023 FENGYUN Satellite User Conference



Figure 15. 2023 FengYun Satellite User Conference

China Launched Two Satellites of FY-3 Series

FY-3G

At 9:36 a.m. on April 16, 2023, a Long March-4B rocket blasted off from the Jiuquan Satellite Launch Center in northwest China. It soon sent the FENGYUN-3G meteorological satellite (FY-3G) into its preset orbit. It is the third precipitation measurement satellite worldwide which can realize proactive measurement. Since then, China has become the only country worldwide that operates meteorological satellites in four near-earth orbits.

Precipitation is a crucial process in the energy and water cycle of the earth and is an essential factor in weather forecasting. FY-3G, as a significant component of global precipitation detection under the framework of the World Meteorological Organization (WMO), will dramatically ramp up monitoring and forecasting of clouds and precipitation under the severe weather system and meteorological disaster prevention, reduction and relief capacities against the backdrop of global climate change.

FY-3G is equipped with four operational payloads: Ku/Ka-band dual-frequency precipitation measurement radar, microwave imager, optical imager, and near-infrared multi-

angle polarization imager. Its primary payload, precipitation measurement radar, was the first independently developed in the country. Its ground system can provide data and IT resources supporting a platform for its operational application and realize the quality surveillance of operational data throughout the procedure.

FY-3G has finished in-orbit testing, verified its indicators regarding satellite platforms, payloads, and others, and dealt with meteorological disasters like rainstorms and typhoons during the primary flood season.

FY-3F

At 11:47 a.m. on August 3, 2023, the Long March 4C carrier rocket successfully launched from the Jiuquan Satellite Launch Center, smoothly delivering the Fengyun-3F satellite (FY-3F) into its preset orbit, marking a complete success for the launch mission. The Shanghai Academy of Spaceflight Technology developed both the satellite and the rocket. This launch was the 100th launch of the Long March 4 series carrier rocket and the 481st launch of the Long March series carrier rocket.

FY-3F is the sixth satellite in China's second-generation low-orbit meteorological satellite series. The satellite is equipped with 10 powerful and advanced remote sensing instruments. FY-3F will acquire global ozone distribution and

monitor global radiation balance, snow and ice coverage, and sea surface temperature through full-spectrum and quantitative observations. It will provide remote sensing information required for short-term climate prediction and climate change estimation, significantly improving the observation accuracy of atmospheric temperature and humidity vertical profiles, atmospheric trace gases, and balloon radiation balance energy. This will further enhance China's capabilities and level in global numerical weather prediction, global climate change response, ecological environment monitoring, and comprehensive disaster prevention and reduction, as well as China's international leadership and voice in addressing climate change.

Two of the remote sensing instruments carried by the satellite, the ultraviolet hyperspectral ozone nadir sounder, and the ultraviolet hyperspectral ozone limb sounder, have been newly developed. Three instruments, including the medium-resolution spectral imager, microwave imager, and earth radiation sounder, have undergone technical improvements and performance enhancements. Based on ensuring global imaging and atmospheric vertical sounding operations in polar orbit meteorology, the satellite focuses on atmospheric quantitative sounding and climate change monitoring, with a calibration accuracy improved by approximately 100% and a comprehensive enhancement in quantitative observation capabilities. It is mainly applied to weather forecasting, ecology and agriculture, environment, disaster monitoring operations, and research. The ozone nadir sounder carried by the satellite is China's first instrument for high-spectral sounding of atmospheric trace components in the ultraviolet-visible wavelength range, with comprehensive capabilities reaching an advanced international level. The ozone limb sounder is China's first instrument for high-spectral atmospheric sounding in the ultraviolet-visible wavelength range using a limb observation mode, filling the gap in ultraviolet hyperspectral limb sounding for China's

meteorological satellites. After the satellite's launch, China's meteorological satellites will usher in a new chapter in ultraviolet hyperspectral sounding.

With a launch weight of approximately 2,700 kilograms and an operating altitude of 830 kilometers, the FY-3F satellite, as a sun-synchronous morning orbit satellite, will replace the FY-3C satellite, which has been in orbit for nearly 10 years after its on-orbit operation. The new generation of FY-3 morning orbit satellites, while ensuring the continuity of observation data for global numerical weather forecast satellites, will form the "strongest echelon" of China's four LEO meteorological satellite operational networking observations with the D (afternoon orbit), E (morning orbit), and G (precipitation satellite).

observing atmospheric parameters during the morning hours, with Earth surface imaging observations as the focus. The observation data is primarily used for weather forecasting, ecology and agriculture, environment, disaster monitoring operations, and research. The FY-3 afternoon satellite focuses on observing atmospheric parameters during the afternoon hours, with atmospheric quantitative sounding and climate change monitoring as the focus. The observation data is primarily used for weather forecasting, atmospheric chemistry, and climate change monitoring operations and research.

The FY-3 precipitation satellite focuses on observing severe weather systems with heavy precipitation, providing three-dimensional structural information on precipitation in global low and middle-latitude regions, and supporting improved accuracy in precipitation weather forecasting.

So far, China has 9 FengYun meteorological satellites in orbit, providing data products and services for 129 countries and regions worldwide. All satellite data and products are accessible through the National Satellite Meteorological Center portal website:

FengYun Satellite Data Center:

<http://satellite.nsmc.org.cn/PortalSite/Data/DataView.aspx?currentculture=en-US>



Figure 16. A Long March-4B rocket carrying FY-3G meteorological satellite blasted off from the Jiuquan Satellite Launch Center in northwest China on April 16, 2023. Source: Xinhuanet

Figure 17. Website of the FengYun Satellite Data Center

FY-3G Rain Measurement Satellite

Introduction

China's rainfall mission is part of the second generation of the polar-orbiting meteorological satellite program, the FengYun-3 (FY-3) program. FY-3G was launched on 16 April 2023 as China's first precipitation monitoring satellite and the third in the world after TRMM and GPMCO. After successfully deployed in orbit, FY-3G has been observing precipitation information to help improve the accuracy of the weather forecast and to understand the characteristics of precipitation climatology.

Precipitation Measurement Radar

The core instrument of the FY-3G satellite is the PMR. PMR is a dual-frequency radar that is composed of a Ku-band radar and a Ka-band radar, as shown in Fig. 2. Because of the tradeoff between the precipitation measuring requirements for the PMR and the constraints from the satellite, the same frequency bands as DPR are chosen. In the normal observation mode, the PMR can measure the rain echoes from the sea level to 18 km in height within the scanning angle range of $\pm 20.3^\circ$ and measure Earth surface echoes and the mirror echoes caused by multiple scattering. The PMR simultaneously transmits four pulses with a duration of $1.67\mu\text{s}$ and a frequency interval of 6 MHz per time. At least 124 independent samples can be obtained for each scanning angle using frequency agility technology and variable pulse repetition frequency technology. The peak transmission power of each band radar is about 720 and 360 W, respectively, to ensure the measurement accuracy of 1 dB when detecting the minimum detectable precipitation.

The Designed Products for Applications

The instruments on the FY-3G satellite can produce critical geophysical parameters, including clouds, precipitation, cryosphere, and atmospheric profiles, with a complete remote sensing products system.

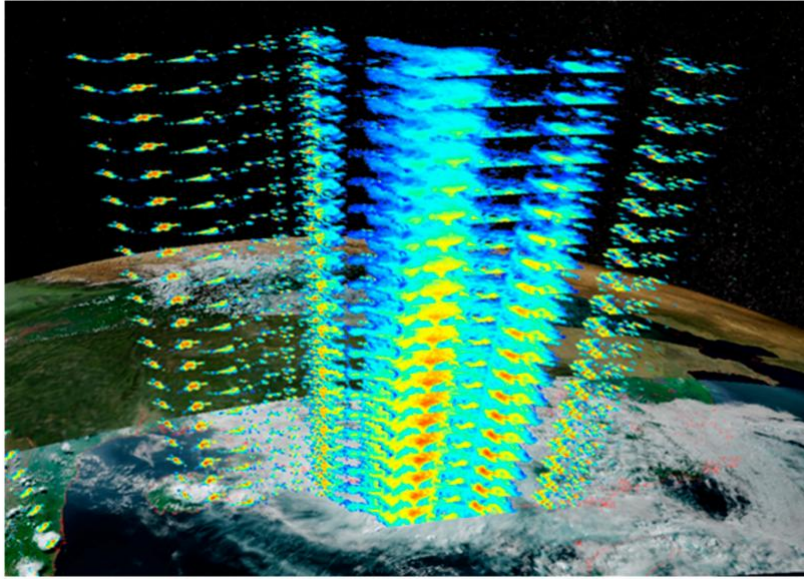
On 15 May 2023, the first set of images of FY-3G was released to the public. The observation images of 6 payloads onboard FY-3G showed the 3D structure of different precipitation layers, enabling better monitoring and forecasting of severe precipitation systems. During a severe convective weather process in South China on 7 May, FY-3G captured the 3D structure of the rain and cloud system (Figure 18). The images in A are shown with 100-m interval, revealing the 3D structure of the rain system from 3.75 to 6 km from the surface. Figure B shows a larger rain area, including rain near the surface, which is superimposed on the cloud image of the optical imager onboard FY-3G.

Summary and Future Perspective

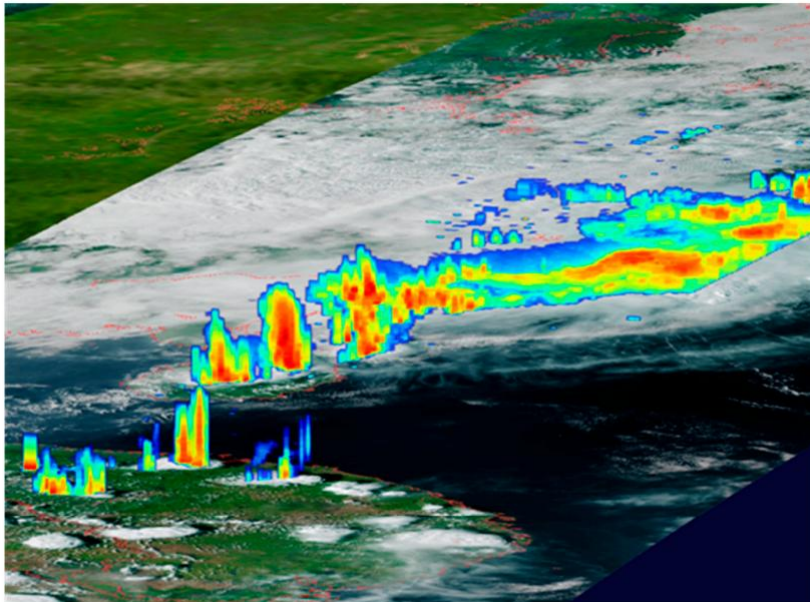
As China's first rainfall mission, FY-3G provides state-of-the-art precipitation observations worldwide. Built upon the success of the FY program and former rainfall satellites TRMM and GPM, FY-3G demonstrates a solid capability to obtain much-needed information about rainfall and snowfall in a timely and efficient manner. The commission test results improve our understanding of global precipitation, give insights into Earth's water and energy cycle, and advance the forecasting of extreme events but also lay the foundation for the next generation, FY-5.

NSMC/CMA: <http://www.nsmc.org.cn>

(FY-3G Rain Team, CMA)



A The vertical distribution of the precipitation captured by FY-3G PMR



B The spatial distribution of the precipitation captured by FY-3G PMR

Figure 18. The 3D structure of the precipitation system was captured by FY-3G PMR at 16:35 am on 7 May 2023 near Hainan and southern Guangdong province—the vertical (A) and spatial (B) distributions of the precipitation.

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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 Kenichi KATSUYAMA, JMA)

RA II WIGOS Project Home Page

<https://www.jma.go.jp/jma/jma-eng/satellite/ra2wigosproject/ra2wigosnewsletter.html>

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