AOMSUC-12 Summary Report

The 12th Asia – Oceania Meteorological Satellite Users' Conference (AOMSUC-12), hosted by the Japan Meteorological Agency (JMA), was held online from 11th to 18th November 2022 on the theme of Full Exploitation of Today's Advanced Global Meteorological Satellite Observing System, with the following schedule:

1. Satellite data and product application training
   Nov. 11th and 14th
   Attendees: 123
2. 12th Asia – Oceania Meteorological Satellite Users' Conference (AOMSUC-12)
   Nov. 15th – 17th
   Attendees: 187
   The plenary session will feature six specialized topics:
   (1) Space program and data access updates
   (2) JAXA's coordinated efforts for the earth observation for environmental monitoring
   (3) Application for numerical weather prediction
   (4) Application for weather analysis and nowcasting
   (5) Application for land surface, sea surface, and climate monitoring
   (6) Space weather
3. Joint RA II – RA V Coordination Meeting
   Nov. 18th
   Attendees: 83

- Total attendees registered for any conference: 204
- Agenda and presentation materials:
  https://www.data.jma.go.jp/mscweb/en/aomsuc12/presentations.html

The AOMSUC-12 (JMA) secretariat coordinated the agenda and schedule in collaboration with the International Conference Steering Committee (ICSC, consisting of representatives from co-hosting organizations and academic experts from each country), who set the basic policy for the conference.

In 2010 the Australian Bureau of Meteorology (AuBoM), the China Meteorological Administration (CMA), the Japan Meteorological Agency (JMA), the Korea Meteorological Administration (KMA), the World Meteorological Organisation (WMO), and the Group on Earth Observations (GEO) organized the first Asia Oceania Meteorological Satellite Users' Conference in Beijing, China. Since that first conference, conferences have been held annually in China (2010, 2014, 2021), Japan (2011, 2015), Korea (2012, 2016), Australia (2013, 2019), Russia (2017), and Indonesia (2018).

In June 2016 the Permanent Representatives of Australia, China, India, Indonesia, Japan, the Russian Federation, and the Republic of Korea, together with the Secretary-General of WMO, signed the

Memorandum on the Asia-Oceania Meteorological Satellite Users' Conference during the sixty-eighth session of the WMO Executive Council in Geneva.
The 2016 Memorandum formalises the AOMSUC as a permanent mechanism for facilitating dialogue and improved collaboration among the space agencies and user communities in the Asia-Oceania region, and for enhancing the use of satellites for weather, climate, and disaster mitigation services.
Over the past decade, the AOMSUC has become the premier annual event for the meteorological and broad earth sciences community across Asia Oceania where satellite operators, users, scientists, and students from Asia Oceania and across the globe come to share their findings and plans for the use of meteorological satellite data.

Opening Remarks

Mr. Kotaro Bessho from JMA gave opening remarks as the Chair of the Opening Ceremony, introducing three presenters from JMA, WMO, and ICSC.
He welcomed the first presenter Mr. Naoki Hasegawa, Director-General of JMA.
Mr. Hasegawa expressed his delight to welcome participants to AOMSUC-12, an event to share cutting-edge information of meteorological satellite programs and promote satellite data utilization in Asia and Oceania.
Expressing appreciation for efforts and help from all sponsors, Mr. Hasegawa emphasized the increased importance of the roles of meteorological satellites and that such satellites were indispensable for national meteorological and hydrological services, especially for disaster risk reduction. So new generations satellites are now planned in the world, especially the infrared sounders on geostationary meteorological satellites are becoming standard as already operated, prepared, and planned in China, Europe, and the US respectively.
JMA also plans to equip the next Himawari satellite with an infrared sounder, which will be started operation in 2029 under its recently established 10-year strategic plan towards 2030. The new Himawari will also have space environment monitoring sensors.
Mr. Hasegawa concluded his remarks stating the sessions would cover various topics and thanked audiences for their participation and contribution to the meeting.

Dr. Wenjian Zhang, Assistant Secretary-General of WMO first welcomed all the participants to the event and appreciated JMA for the great efforts and arrangements.
He then highlighted the importance of (1) Earth system approach and (2) Early Warning.
For the earth system approach, he mentioned the sixty years history of World Weather Watch (WWW), which was triggered by satellite observation and emphasized the collaboration of satellite operators and space agencies is essential and strengthen new collaboration with R&D satellite is also necessary.
Regarding the Early Warning, a WMO's new initiative for COP started, and collaboration among space agencies, satellite operators and users, especially small island states is needed. He emphasized this users conference is great opportunity for continued capacity development for these countries and lead to early action.

Dr. James Purdom, Chair of the International Conference Steering Committee, first thanked for the previous opening remarks and emphasized that they needed to pay particular attention to what the two presenters have said and the vision they presented.

He told that he had been involved with satellite meteorology for over fifty years, and added “We're fortunate in that we walk in the footsteps of giants. Because we are where we are today because of the vision and foresight of those that came before us, we truly owe these people our gratitude.” He added that the space system that is available to us today came about due to strong international cooperation and that cooperation, from the operational perspective, was largely fostered by the Coordination Group for Meteorological Satellites (CGMS), and the WMO and its Space Program.

He emphasized the need to work doubly hard to take advantage of what had been presented to them, with infrared geostationary sounding, lightning mappers, capabilities to measure rainfall and precipitation from low earth orbiting satellites, and so forth. He welcomed all participants as chair of the International Conference Steering Committee and on behalf of that committee.

AOMSUC-12 Training Event

The training events were conducted fully virtual on 11 and 14 November 2022. There were 123 participants (trainees and trainers) from 29 countries and regions registered on this training event.

On the first day of training events, Dr. James PURDOM, Chair of International Conference Steering Committee (ICSC) and Dr. Bernie CONNELL of WMO, Co-chair of the Virtual Laboratory for Training and Education in Satellite Meteorology (VLab) gave keynote presentations. Later the first day, training by the satellite operators including CMA, JMA and KMA, to introduce their satellite data service, products and utilizations. Mr. XIAN Di from CMA introduced FENGYUN Satellite program overview and updates, data and product services, their applications and plans. Mr. HANDA Taro, Ms. NAIKI Shiho, Mr. SAITO Kotaro and Ms. SAKURAI Mayuko from JMA introduced the tutorial of the utilization of SATAID RGB imagery of Himawari and its application in some case studies occurred in 2022. Mr. Seon-Yong LEE, Ms. Ok Hee LEE and Mr. Taekyu JANG from KMA introduced the application to typhoon, severe weather detection and data services of GK2A. The chair of the first day training was Mr. WEN Bo from CMA.

On the second day of training events, Mr. Joe COURTNEY from BoM gave a lecture on tropical cyclone analysis, Dr. William STRAKA from NOAA gave a lecture on inundation product creation, and Mr. Muhammad HANIF AFFAN YUSRON from BMKG gave a lecture on precipitation estimate. As Joint Australia-China VLab Centres of Excellence Regional Focus Group meeting, Mr. Bodo ZESCHKE from BoM and Mr. XIAN Di from CMA reviewed the satellite image viewer used by regional focus group in the past and the efforts of analysis in cooperation with relevant organizations for significant cases. The chair of second day training was Mr. YAMADA Kazutaka from JMA.

Closing remarks of the training events were given by KMA and ICSC Co-chair. Dr. Jinho SHIN from KMA thanked all participants for their contribution and announced that KMA would host the AOMSUC-13 in

November 2023. Then Dr. Allen HUANG, ICSC co-chair appreciated the 2-day training course as very constructive, very comprehensive, very successful. He congratulated JMA for making such a wonderful opportunity for all participants virtually able to attend. Then comments praising every effort of the secretariat team were given and the training events were closed.

SESSION SUMMARIES

Session 1: Space program and data access updates

Session Chairs: Mr. Kotaro Bessho (JMA), Dr. James Purdom (ICSC-chair)

The session consisted of 8 oral presentations.

Dr. Kenneth Holmlund, Head of Space Systems and Utilization talked about **Advancing the WMO WIGOS Vision for 2040.** He introduced the WMO Strategic plan, which outlines the key long-term goals of the World Meteorological Organization (WMO). In the last decades, the demand for weather, climate and water monitoring and prediction data has explosively grown to support essential services needed by all sectors of society. In such a context, the 2021 Extraordinary World Meteorological Congress (11-22 October) approved the new WMO Unified Data Policy Resolution, reaffirming the Organization's commitment to the free and unrestricted exchange of data. Dr. Holmlund also gave a brief overview of the WMO WIGOS (Integrated Global Observing System) Vision 2040 and new challenges that need to be taken into account in advancing the Vision. The WMO WIGOS Vision presents the ground and space-based observing system needed to be operated in 2040 to address the future observational needs of the WMO community.

The co-chair thanked Dr. Holmlund for his presentation on user requirements and where the system has gone. Then he also thanked all members in WMO for the excellent presentation, because WMO is made up of the members across the globe that put together the backbones of these presentations.

Ms. Agnes Lane, Program Manager, National Space Program for Earth Observation talked about **Utilisation of satellite data at the Bureau**. The Bureau of Meteorology, Australia, has substantially used Earth observations from space for several decades, and this continues to grow at a significant pace. The Bureau currently assimilates data from over 30 satellites into weather prediction and visualisation systems. This is crucial for the provision of weather forecasts and warnings across Australia and beyond, to support national commitments for safety and security. Ms. Agnes Lane gave an overview of satellite activities in the Bureau, and the Bureau's recent partnership with the Australian Space Agency on the early planning for Australian built meteorological satellites. A participant asked if the Bureau used the level two products for direct irradiance simulation for Wimsatt and AMSAT. A colleague of Ms. Lane answered that they used level two products for Wimsatt while using dry soil moisture product and surface temperature from AMSAT-2. Another participant asked if they used soil from the Canadian satellite or just Sentinel. Ms. Lane answered that they use data from the Canadian satellites only when there was some coverage gap. There was a question about how the Bureau was using TerraSAR X data for NWP models. Agnes answered that they used it for radio occultation.

Mr. XIAN Di, NSMC/CMA talked about **Status of FengYun Satellite Program and Future Development.** He presented the status of the development of FengYun meteorological satellites, which have made major strides over the past 50 years, achieving the upgrade of polar and geostationary meteorological satellite series and their continuously stable operations to persistently provide data and product services globally. By the end of 2022,

19 Chinese self-developed FengYun meteorological satellites have been launched successfully. In 2021, two satellites have been added to FengYun family, including FY-4B, the first operational new generation geostationary satellite, and FY-3E, the first early-morning orbit satellite in China's polar-orbiting meteorological satellite. FY-3E and FY-4B operational data have been released to public since June 1st, 2022. To promote global users application experience on FengYun satellite application, NSMC are developing a lightweight application called 'FengYun Earth'. This application will release an trail version at the end of 2022. Two FY-3 polar-orbiting satellites to be launched, which will be arranged by the layout of three solar synchronous polar-orbiting satellites in early-morning, mid-morning and afternoon, and one precipitation measurement satellite in inclination orbit by 2025. In addition, FY-4 GEO optical satellites and microwave satellite to be launched.
The co-chair recommended audiences to check an excellent presentation given at the training event held in the previous week, which was also from CMA, on the access to their products, data and services, adding that it was a most excellent and informative presentation.

Dr. Paolo Ruti, EUMETSAT talked about **EUMETSAT in action eyes to check the pulse of Earth**. As coordinated research and new investments in earth observation and prediction is required for increasing society's resilience to high-impact natural events and climate change, EUMETSAT (The European Organisation for the Exploitation of Meteorological Satellites), together with its international partners, provides the backbone of the global meteorological space based observing system. EUMETSAT will launch Meteosat Third Generation first satellite, at the end of 2022, and the new generation of its polar systems and several new missions of the Copernicus Programme in the next five years on behalf of the European Union. Dr. Paolo Ruti presented an overview of the main applications of those systems to key sectors, ranging from nowcasting to long term climate record and CO_2 monitoring.
A participant asked if there were plans to eventually have the geostationary satellite operating a flexible mode when it does sounding, rather than fixed patterns. Dr. Ruti said that there would be some possibilities and he certainly saw some private sector development in the telecommunication where they were trying to explore very special applications that probably could answer the participant's request in the near future.

Mr. Kotaro BESSHO, Japan Meteorological Agency talked about **Status of Himawari-8/9 and their follow-on satellite program**. The Japan Meteorological Agency (JMA) has been operating the Himawari-8 geostationary meteorological satellite and its back-up, Himawari-9. The pair of satellites will support JMA's continuous satellite observation data provision for the Asia-Oceania region until 2029. JMA is now planning the switch over from Himawari-8 to -9 on December 2022. By FY2023, Japan plans to start manufacturing the Geostationary Meteorological Satellite that will be the successor to Himawari-8 and -9 that will be put into operation in around FY2029. JMA will pursue a seamless geostationary earth orbit satellite system, including the deployment of hyperspectral infrared sounders. The infrared sounder is considered as one of potential payloads of Himawari follow-on satellite. Mr. Bessho presented the status of JMA's consideration of the specification of follow-on satellite and their sensors.
The co-chair asked about the GEO hyperspectral sounder and Mr. Bessho said that JMA was understanding

potential satellite providers of infrared sounders via request for proposal. Then a participant asked if JMA had any plan for future on Himawari-10 to change it with true green channels, moving from 0.51 microns to 0.55 and Mr. Bessho said that they were planning to the move slightly from 0.51 to 0.55.

Mr. Sung-Rae Chung, National Meteorological Satellite Center of KMA talked about **KMA's Current Activities on GK2A and Future Satellite Program**. The National Meteorological Satellite Center (NMSC) of the KMA has been operating the 2nd Korean meteorological satellite, the Geo-KOMPSAT-2A (GK2A) since July of 2019. Its various geophysical products have been utilized for short-range forecast, Numerical Weather Prediction (NWP) data assimilation and climate monitoring research. The GK2A data and images are available through various ways such as NMSC webpage, Open API, realtime FTP service and satellite broadcast. The KMA is planning with mission analysis and feasibility phase for the GK2A follow-on satellite targeted to be launched on the first quarter of 2031. It will have an upgraded imager and space weather instruments. For the future, the KMA GEO satellite program will continue based on CGMS baseline and WMO Integrated Global Observing System (WIGOS) vision 2040. Mr. Chung introduced KMA's long-term satellite development plan, the multi-GEO program i.e. the hyperspectral IR sounder onboard geostationary satellite parallel with GEO imager.
A participant asked what sort of means are available to receive GK2B data. Mr. Chung answered that GK2B was not distributed by KMA so it was needed to contact the Ministry of Environment or Ministry of Oceans and Fisheries.

Ms. Irene Parker, National Oceanic and Atmospheric Administration (NOAA), National Environmental Satellite, Data, and Information Service (NESDIS) talked about **NOAA: Current and Future Satellite Systems**. To meet challenges of high-quality, timely, and global observations from Earth observing satellites, NOAA is evolving its business model to stay current with the expanding complexity of Earth observing contributors, including its partner meteorological satellite agencies of Asia. NOAA operates 16 environmental satellites. Over the past five years, NOAA's advanced geostationary and polar-orbiting satellites, the GOES-16, GOES-17, and NOAA-20 (JPSS series) have become operational. GOES-18 will become operational in early 2023 and JPSS-2 will be launced on November 1, 2022. Furthermore, NOAA plans to launch one additional satellites between 2023 and 2031. These missions, along with other NOAA collaborations (COSMIC, JASON, DSCOVR, etc.) are key contributions to the WMO space-based portion of the Global Observing System (GOS). In addition, NOAA is evolving its approach to common ground systems, satellite architecture, data stewardship, data distribution, and user preparedness. Ms. Parker provided not only an overview of NOAA's current satellites and plans for future satellites, but also a review of our important partnerships and examples of our products and applications of potential interest to users in Asia and Oceania.

Session 2: JAXA's coordinated efforts for the earth observation for environmental monitoring
Session Chairs: Dr. Takuji Kubota (JAXA), Ms. Misako Kachi (JAXA)

This session started from a keynote speech and consisted of 7 presentations. Each presentation covers the coordinated efforts for the earth observation for environmental monitoring including collabolation between JAXA and JMA.

The keynote speaker, Dr. Riko Oki, Japan Aerospace Exploration Agency (JAXA), presented "**JAXA Earth Observation Overview**". JAXA currently operates six Earth observation missions, GOSAT, GOSAT-2, GCOM-C, GCOM-W, GPM/DPR and ALOS-2, for water cycle and climate studies, disaster mitigation, and various application studies including weather forecasts. Regarding future satellite missions, two ALOS series satellites will be launched in near future, ALOS-3 and ALOS-4. GCOM-W follow-on mission (AMSR3) with high-frequency channels will be installed on the GOSAT-GW satellite along with the GOSAT-2 follow-on mission. Japan will provide the world's first satellite-based cloud vertical motion information by the Cloud Profiling Radar (CPR) to the EarthCARE, Europe-Japan joint mission. JAXA is currently conducting R&D of the Precipitation Measuring Mission carrying the Ku-band Doppler Precipitation Radar to succeed and expand currently operating GPM/DPR. Then Dr. Oki also outlined recent topics (typhoon, eruption) and collaboration with JMA. There was a positive feedback on the presentation appreciating that JAXA covers such a broad area in Earth observations and question regatding possible future collaboration area. Dr. Oki responded that they need some validation using ground instruments such as ground radar for validating the GSMaP.

Mr. Yasuhiko Sumida, Japan Meteorological Agency, presented "**Cooperation for Use of Satellite Data Between JMA and JAXA**" outlining cooperative efforts of the Japan Meteorological Agency (JMA) and the Japan Aerospace Exploration Agency (JAXA). JMA and JAXA signed a cooperative agreement in 2003. Since then, the two agencies have promoted a wide range of cooperation, including the use and exchange of satellite data, algorithm development, and technical exchange. This cooperation has been strengthened with development of Himawari-8/9 in the following areas: 1) JMA's operational use of Himawari products using algorithms developed by JAXA, 2) publication of Himawari data using JAXA data server for researchers, 3) data assimilation of JAXA satellite data into NWP. Nowadays, it is indispensable for the work of JMA. Mr. Sumida also discussed the future collaborations between JMA and JAXA through the use of next-generation geostationary meteorological satellite "Himawari-10." A question about the usage of GPM/DPR data in data assimilation in JMA was raised in chatbox and Mr. Sumida confirmed that assimilation of DPR data in JMA already started since January 2016.

Dr. Akihiko KUZE, Japan Aerospace Exploration Agency, presented "**Greenhouse gases observation from space by GOSAT series satellites since 2009**". JAXA has been operating the GOSAT and GOSAT-2 satellites, which have been measuring carbon dioxide (CO_2) and methane (CH_4) for more than a decade. Over this period, JAXA has accumulated data on radiance spectra of reflected sunlight with two linear polarizations

and thermal emissions. Utilizing the multiplex advantages of the Fourier Transform Spectrometer (FTS), the EORC L2 algorithm retrieves the partial column densities of lower- and upper- tropospheric CO_2 and CH4, at roughly 0- 4 km and 4- 12 km, respectively. Thirteen years of total and partial columns data on 2, 2, and 11 vertical layers of CO_2, CH_4 and water vapor (H_2O), respectively, and solar-induced chlorophyll fluorescence (SIF) are available at https://www.eorc.jaxa.jp/GOSAT/GPCG/download_v2/. JAXA has examined the lower-tropospheric CO_2 products from GOSAT target observations to estimate emissions over global megacities. A participant raised a question about the possibility of performing the validation activity in Australia. Dr. Kuze answered that Australia was actually very supportive for validation, so they were collaborating with the Australian group for validating satellite data over large greenhouse gases emission sources such as coal, oil and gas mining.

Prof. Keiya Yumimoto, Kyushu University, presented "**Aerosol data assimilation with data from multiple space-borne observation platforms**". Airborne particulate matter (aerosols) has a wide range of impacts on climate change, air quality, and human health. To mitigate these aerosol impacts, numerical aerosol prediction has become an operational and critical part of society's infrastructure around the world. In recent years, data assimilation techniques have been incorporated into numerical aerosol prediction with aerosol optical thickness (AOT) observed by onboard satellite imagers. Prof. Yumimoto gave an overview of a composite aerosol assimilation forecasting system that could simultaneously assimilate observation data obtained from GCOM-C/SGLI and EarthCARE/ATLID in addition to Himawari 8/AHI and verify the impact of each data on forecast accuracy. A participant raised a question on the distribution of Himawari/AHI AOT information in the vertical direction. Prof. Yumimoto responded that AOT included only horizontal information so in that case, they fixed the vertical profile. Another participant asked about the Lidar information and Prof. Yumimoto explained the simulation using a comparison of the Lidar as an example.

Mr. Keiichi Ohara, Japan Aerospace Exploration Agency, presented "**Evaluation and Comparison of Long-term Total Precipitable Water Products by the GCOM-W/AMSR2**". Water vapor is a strong greenhouse gas with a feedback effect closely related to climate systems such as clouds and precipitation. As concluded in the Intergovernmental Panel on Climate Change (IPCC) Working Group I (WG I) Sixth Assessment Report (AR6), the combined water vapor and lapse rate feedback makes the single largest contribution to global warming. Therefore the long-term observation of water vapor is important to understanding global climate and water cycle changes. Mr. Ohara gave a presentation on the Advanced Microwave Scanning Radiometer 2 (AMSR2), a Japanese passive microwave radiometer onboard the Global Change Observation Mission—Water (GCOM-W) satellite. The GCOM-W/AMSR2 can observe more than 99% of the Earth surface and estimate amount of total precipitable water vapor (TPW) over the ocean. A participant asked if the research team planned to use the information of lower atmospheric temperature, for example, the atmospheric temperature profile, to obtain the information on the lower atmosphere. Mr. Ohara said that the JAXA TPW algorithm used temperature information at certain height in lower atmosphere but it was not enough to

represent the impact specific temperature profile such as inversion layer, suggesting more information should be used to improve the accuracy in case of inversion layer.

Dr. Takuji Kubota, Japan Aerospace Exploration Agency, presented "**Recent progresses of the Global Satellite Mapping of Precipitation (GSMaP) Products**". The Global Satellite Mapping for Precipitation (GSMaP) produces high-resolution and high frequent global precipitation map based on multi-satellite passive microwave radiometer observations with information from the Geostationary Infrared (IR) instruments. Output product of GSMaP algorithm is 0.1-degree grid for horizontal resolution and 1-hour for temporal resolution. The GSMaP near-real-time version product (GSMaP_NRT) has been in operation at JAXA since November 2007 in near-real-time basis with images and binary data being available at JAXA GSMaP web site (http://sharaku.eorc.jaxa.jp/GSMaP/). Dr. Kubota presented recent progresses of GSMaP, including a new version of the GSMaP products released in December 2021. JAXA plans to reprocess the GSMaP standard version in a period during the past 24 years since Jan. 1998. The GSMaP real-time version (GSMaP_NOW) with the new algorithm was also released in December 2021. Accuracy improvements of the GSMaP products were confirmed by validations with the gauge-adjustment ground radar data over the Japan. A participant asked what was the difference between simple GSMaP and GSMaP_NOW. Dr. Kubota explained that major difference was data latency, and GSMaP_NOW is a real-time product with zero latency.

Prof. Tomoo Ushio, Osaka University, presented "**High Resolution GSMaP with Himawari**". Global Satellite Mapping of Precipitation (GSMaP) is a system to produce global surface precipitation field with 0.1 degree and 1 hour resolution from geostationary infrared imager and microwave radiometer in low earth orbit. Recently, a new Himawari was launched into orbit and the primary instrument aboard the new Himawari, the Advanced Himawari Imager (AHI), is a 16 channel multispectral imager to capture visible light and infrared images of the Asia-Pacific region. The AHI can produce images with a resolution down to 500m so this high-resolution images. Prof. Ushio gave a presentation on the team's efforts to make a higher resolution GSMaP using the data from Himawari 8 satellite. A participant asked if the research team planned to extend the use of the Himawari data to other GEO data. Prof. Ushio said yes, adding that as soon as it would become available, he would like to use another high-resolution GEO IR data set. He also added that they need to adjust the data set in some way. Another question was regarding data gap between two different microwave sensors, the polar orbiting satellites and Himawari data, for example. Prof. Ushio said that they had installed some mitigation scheme, which reduced the gap between sensors.

Ms. Jezleer Tymico Montajes, Geomatics for Environment and Development, Manila Observatory, presented "**Extreme Weather Bulletin and Emergency Observation/Mapping Activities of the Manila Observatory**". The Manila Observatory (MO) is a non-profit research institution with a focus on atmospheric and earth science research. In response to the needs of various partner organizations, MO prepares and issues extreme weather bulletins (EWB) to consolidate forecast information on extreme weather events, particularly tropical cyclones (TC), and the associated potential risks to vulnerable areas. The EWB together with local

situation reports or news trigger the emergency observation/mapping (EO/M) activities that assess the impacts of the TC in areas of interest. Ms. Jezleer Tymico Montajes presented examples of MO's work for TC events in 2021 outlining potential enhancements of EWB to be addressed in a new project, which will explore workflows and methodologies for EO/M optimization on the Microsoft Planetary Computer. Ms Montajes also introduced how they used Sentinel Asia's OPTEMIS and IDC dashboard and future steps. A participant asked if MO corporated with other national agencies and Ms. Jezleer answered that MO was in partnership with agencies like PAGASA and Philippines Space Agency. The participant also asked if there were discrepancies between MO's projected extreme weather and those from PAGASA and Ms. Montajes responded that their data was shared with stakeholders and publicized via SNS.

Session 3: Space weather

Session Chairs: Dr. Oh Daehyeon (NMSC/KMA), Dr. Zhao Ming-Xian (NSMC/CMA)

The session consisted of 6 oral presentations.

The session opened with a keynote presentation by Dr. Mamoru Ishii, National Institute of Information and Communications Technology (NICT) titled **Update of National and International Activities for Space Weather Research and Operation**. As the importance of space weather is increasing with glowing ICT technologies, many actions for improving space weather research and operation are proceeded in national and international. Dr. Ishii introduced three topics in which NICT plays a key role in this presentation. According to a report issued in June 2022 by the Committee for the advancement of space weather forecast, a committee established in the Ministry of Internal Affairs and Communications of Japan, NICT needs to implement necessary research and take actions needed, such as operation of a new space weather alert criteria. NICT has thus started a project to develop and deploy instrument for measuring space environment for safe and stable use of satellite operation, aviation and human activities in space, with a plan to develop three kinds of sensors to measure energetic protons and electrons and charging on surface and inside spacecraft. NICT's international activity and contribution was also discussed.

The chair asked if the alert criteria discussed was for the global or state line is specialized for the middle latitude for only Japan or for the globe. Dr. Ishii answered that it was specialized for Japan.

Dr. Zhao Ming-Xian, National Satellite Meteorological Center (National Center for Space Weather), talked about **A New Index to Describe the Response of Geomagnetic Disturbance to the Energy Injection from the Solar Wind**. Dr. Ming-Xian gave an overview of a new non-dimensional global geomagnetic disturbance index that his team's has established. This index can describe the development of geomagnetic storms. The relationship of the developed index and the Dst index has been verified, which gives a correlation coefficient (CC) of about 0.72. The team used Spectral Whitening Method (SWM), which was proposed by Wang et al., Ann. Geophys, to design the station index and global index of geomagnetic disturbance. The team’s examination results illustrate that the developed index effectively depicts the evolution of storm sudden commencement and its trend is well related to the associated energy injection term Q in amplitude, which provides an alternative means of geomagnetic storm forecasting.

The chair asked, how many stations were used in the index and if using more stations improved the index or not. Dr. Ming-Xiann answered that in their work, they kind of chose eight stations, as illustrated in Figure 3, and explained from two aspects why more stations would not get better correlation coefficients with the index.

Ms. Ye Qian, National Satellite Meteorological Center, the China Meteorological Administration, talked about **The Frequency-Domain Characterization of Cosmic Ray Intensity Variations Before Forbush Decreases Associated with Geomagnetic Storms**. Non-recurrent geomagnetic storms caused by Coronal Mass Ejection (CME) can induce serious impacts on space- and ground-based equipment. However, these non-recurrent geomagnetic storms are hard to predict since CMEs are not periodic. Previous studies have shown that the

variations of Cosmic Ray Intensity (CRI) before non-recurrent storms may forebode the coming geomagnetic storm while it is still difficult to extract the variations due to the complexity. Ms. Qian gave outlined her team's efforts to forecast ICMEs(Interplanetary CME)-driven geomagnetic storms and results thereof. In order to identify the precursory signal in CRI variations triggered by CME, an ensemble self-adaptive time-frequency analysis method was proposed and applied to 65 non-recurrent geomagnetic storms (1998 to 2019), showing that the precursory signals were successfully identified in 43 of 45 storms after excluding 20 storms accompanied by ground level enhancement.
A participant asked how many false alerts were actually made, namely how many times the method indicated that there might be solar ejection but this did not occur. Ms. Qian answered that the study was just a test to attempt to forecast the geomagnetic storms and more studies would be needed to improve the method.

Dr. Oh Daehyeon, National Meteorological Satellite Center (NMSC), talked about **Energetic Electron Flux Measurements using KSEM PD on GeoKompsat-2A**. KSEM, the Korean Space Environment Monitor, consists of three main sensors. PD for energetic particle measurements, MG for magnetic field measurements, and CM for satellite charging measurements. KSEM) aboard theGEO-KOMPSAT-2A (GK-2A) has measured these in geostationary orbit at the longitude of 128.2°E, since July 2019. KSEM PD provides near-real-time energetic particle flux condition of space environment on the location where is nearly opposite side to the location of GOES-16 satellite. Dr. Daehyeon reported the recent energetic electron flux measurements of KSEM PD and the initial results of cross-comparisons with the data from MPS-Hi, a particle detector of GOES-16, and gave a brief review on electron flux responses of KSEM PD and MPS-Hi to enhanced space environment conditions.
There was a request on detailed explaination on the comparison of GK-2A and GOES, as it was difficult to compare these measurements directly due to the difference between the local time of the of GK-2A and GOES. Dr. Daehyeon answered that the difference in the rotation was the key point of calibration and they had to handle their locational difference. Another question was raised on the reason of the variation of measurements of GK-2A and GOES and Dr. Daehyeon answered that they were trying to find out what makes this different.

Ms. Lee Dong-Hee, National Meteorological Satellite Center, Korea Meteorological Administration, talked about **Radiation exposure estimation and information service using the Korean Radiation Exposure Assessment Model for aviation route dose (KREAM)**. In general, the radiation originated from galactic cosmic rays (GCR) or/and solar energetic particles (SEP) are estimated by numerical models because every commercial aircraft could not embed an instrument for measuring the radiation dose rate. Regular and systematic monitoring of radiation exposure is required to protect aircrew and passengers' health from the adverse effect of ionizing radiation. KMA estimates and services the effective radiation dose using the Korean Radiation Exposure Assessment Model for aviation route dose (KREAM). The KREAM can estimate the radiation dose considering both GCR and SEP. Ms. Dong-Hee introduced her team's efforts to estimate radiation exposure using the KREAM and information service using it. She concluded that all models examined tended to underestimate the total cumulative dose in cases with high dose rates.

There was a request for detailed information on the URL website given in the PPT because the target page was not found via the link. Ms. Don-Hee answered that they were constructing English page. Another question was raised on the main differences between the examined three modes: NAIRAS, KREAM, and CARI-7. Ms. Don-Hee briefly explained the differences.

Dr. Hou Zhenyong, Peking University, talked about **Three-dimensional Propagation of the Global Extreme-ultraviolet Wave Associated with a Solar Eruption on 2021 October 28**. Dr. Zhenyoung presented a case study for the global extreme ultraviolet (EUV) wave and its chromospheric counterpart 'Moreton-Ramsey wave' associated with the second X-class flare in Solar Cycle 25 and a halo coronal mass ejection (CME). The EUV wave was observed in the Hα and EUV passbands with different characteristic temperatures. With multi-wavelength and dual-perspective observations, the team found that the wavefront likely propagates forwardly inclined to the solar surface with a tilt angle of ~53.2º. Dr. Zhenyong concluded that their study results suggested that this EUV wave was a fast-mode magnetohydrodynamic wave or shock driven by the expansion of the associated CME, whose wavefront was likely a dome-shaped structure that could impact the upper chromosphere, transition region and corona.

Session 4: Application for atmospheric monitoring and nowcasting

Session Chairs: Dr. Moeka Yamaji (JAXA), Dr. Huang Allen (SSEC/CIMSS, UW-Madison)

The session consisted of 30 oral presentations.

The session opened with a keynote presentation by Dr. Jinho SHIN, National Meteorological Satellite Center (NMSC) / KMA, titled **Satellite analysis and nowcasting applications in KMA NMSC: present and future.** Image information obtained from geostationary meteorological satellites equipped with advanced meteorological imagers is particularly helpful for nowcasting as it can detect and warn of rapidly developing convective clouds in advance. Satellite images with high spatial and temporal resolutions are very helpful in preventing typhoon damage. The satellite products obtained by combining image information and numerical model results have recently been able to provide more useful by applying artificial intelligence technologies. In such a case, Infrared images are trained using artificial intelligence technologies to create a night-time proxy visible image to clearly and distinctly obtain information about lower clouds and fog, which were difficult to detect at night.

A participant asked how the team detected the correct CI and how they determined which cloud was correct or not. Dr. Shin answered that when KMA's satellite observed and detected CI information, the data was compared to the radar or other data to verify the detection accuracy. A follow-up question was raised on the threshold consideration of radar signal and Dr. Shin said he would email later to provide accurate answer. Another question was raised on the lead time for AI-generated satellite imagery.Dr. Shin answered it was almost real-time.

After the keynote presentation, the session was divided into two parallel sessions.

Session 4: Application for atmospheric monitoring and nowcasting (Parallel 1)
Session Chairs: Dr. Moeka Yamaji (JAXA), Dr. Huang Allen (SSEC/CIMSS, UW-Madison)

Dr. Allen Huang, SSEC/CIMSS, UW-Madison, talked about **Facilitating Exploitation of International LEO/GEO Meteorological Satellite Observing Systems Through Community Satellite Processing Package (CSPP)**. Since 2012, Space Science and Engineering Center (SSEC) and its Cooperative Institute for Meteorological Satellite Studies (CIMSS) have been continuing to facilitate the efficient use of polar orbiter satellite data. This has been conducted through the development of a Community Satellite Processing Package (CSPP) that supports the Suomi-NPP/JPSS and GOES-16 with CSPP Geosynchronous Earth Orbit (GEO) component. SSEC/CIMSS is also adding support for other international sensors onboard European Metop-A/B/C, Chinese FY-3 LEO satellites and, most recently, Advanced Himawari Imager (AHI) onboard Japanese Himawari-8 and 9 GEO satellites. In this presentation, Dr. Huang gave a brief overview of the past and then focused on recent development of and plans for Community Satellite Processing Package (CSPP), and International TOVS and ATOVS Processing Packages (IAPP) that facilitate the exploitation of global meteorological satellite observing systems. Specifically, a focus was put on the imaging and sounding products and their subsequent integrated usage on near-real-time weather nowcasting, air quality monitoring/forecasting, fire, flood, and droughts.

Dr. Xiuqing HU Hu, National Satellite Meteorological Center (NSMC), talked about **FY-3E EM satellite performance and application on orbit at first year**. After about one year on-orbit commissing, FY-3E will be transitioned to the operational mode. Three are brand-new instruments, including the wind radar (WindRAD), solar spectral irradiance monitor (SSIM), and solar X-ray and ultraviolet imagers (X-EUVI). Seven are improved instruments, including medium resolution spectral imager-low light (MERSI-LL), microwave temperature sounder-III (MWTS-III), high spectral infrared atmospheric sounder-II (HIRAS-II), GNSS radio occultation sounder-II (GNOS-II), solar irradiance monitor-II (SIM-II), space environment monitor-II (SEM-II), triple-angle ionospheric photometer (Tri-IPM). The inherited microwave humidity sounder-II (MWHS-II) also comes with better specifications. Performance of all instruments met the required specification and generate the expected retrieval products although they faced with the challenge of some new complicated straylight and thermal environment fluctuation on this special orbit. The successful launch of FY-3E enables the satellite community to meet the baseline configuration agreed by CGMS members in supporting the “WMO Vision for the GOS in 2040”.

Ms. Mayu Sumita, Meteorological Satellite Center of Japan Meteorological Agency, talked about **Pre-Operational Validation of AHI on Himawari-9, in navigation and calibration**. Japan Meteorological Agency (JMA) is planning to switch the operational geostationary meteorological satellite over from Himawari-8 to Himawari-9 on 13 December 2022. Himawari-8 data have contributed to prevention and mitigation of weather-related disasters in East Asia and Western Pacific regions since 7th July 2015, its commencement of the operation. Himawari-9, which was launched on 2nd November 2016 and has been on standby in orbit as a

backup of Himawari-8, will take over the role of Himawari-8 as an operational satellite. Himawari-9 is equipped with the Advanced Himawari Imager (AHI), which has the same specification as Himawari-8. Accurate image navigation and radiometric calibration are essential for the meteorological missions. The previous test observations have revealed that the accuracy in navigation and calibration is almost the same as Himawari-8, and it will be validated and tuning again by pre-operational observation. Ms. Sumita introduced the preliminary results from the pre-operational observation of Himawari-9.
A comment was raised by a participant introducing their team's case study comparing Himawari 8 and 9 on a website, which emphasized that particular RGB composite would have to be retuned for the new Himawari 9 to give the similar performance.

Mr. Shin Koyamatsu, Meteorological Satellite Center of Japan Meteorological Agency, talked about **Pre-Operational Validation of AHI on Himawari-9, in level 2 products**. Together with the multi-band imageries, level 2 products, such as Fundamental Cloud Product (FCP), High-resolution Cloud Analysis Information (HCAI), Atmospheric Motion Vector (AMV), and Clear Sky Radiance (CSR) are derived from Himawawari-8 observation. The previous test observations have revealed that the accuracies of Himawari-9 products were almost the same as those of Himawari-8. Mr. Koyamatsu introduced the preliminary results from the pre-operational observation of Himawari-9 for the validation of level 2 products, such as FCP, HCAI, AMV and CSR.

Mr. Shiro Omori, Japan Meteorological Agency, talked about **Introduction of JMA's satellite-based nowcasting products**. In JMA, several satellite-based nowcasting products have been generated from Himawari-8/9 imagery and have been provided for various purposes. Convective cloud information (CCI), fog detection and volcanic ash product have been provided for aviation safety and effective air control. Sunshine duration product is provided as 2-D extension of pointed ground-based observation, and aerosol product is also provided to monitor aeolian dust event. Besides that, SST product is also provided to monitor the global SST. Mr. Omori gave an overview and current status of these products.
A participant asked if their data, such as the sea surface temperature graph using the 10-minute data, was going to be made more widely available or only for Japanese. As Mr. Omori was not there already, another participant from JAXA answered, on behalf of Mr. Omori, that they provided the same algorithm to JMA and JAXA also processed the SSD from Himawari 8 and 9 in JAXA's Himawari monitor, adding that those data were available for the whole Himawari area. Then the facilitator recommended audiences to check related data on JMA and/or JAXA websites if they were interested in.

Mr. Bodo Ivar Zeschke, Australian Bureau of Meteorology Training Centre (BMTC), talked about **Satellite Meteorology Training in WMO RA V during 2021/2022: The Australian VLab Centre of Excellence experience.** Mr. Zeschke presented summarises of the satellite meteorology training conducted by the Australian VLab Centre of Excellence over the past year. A focus was put on the monthly Regional Focus Group meetings as well as collaboration with other Centres of Excellence within the context of the WMO Global

Campus. Relevant topics included dissemination of the latest developments in effectively utilising regional geostationary satellite data and polar orbiting satellite data and associated resources within WMO RA V and adjacent regions. Mr. Zeschke also reviewed the celebration of the 100th Australian VLab Centre of Excellence Regional Focus Group meeting.
A participant from BMKG, Indonesia appreciated Mr. Zeschke's presentation and thanked for supporting BMKG and for supporting his team in Indonesia. Mr. Zeschke appreciated the comment and the facilitator recommended him to share some relevant information via the chat.

Dr. Takuji Kubota, Japan Aerospace Exploration Agency (JAXA), talked about **Recent activities of the International Precipitation Working Group (IPWG)**. The International Precipitation Working Group (IPWG) was established as a permanent Working Group of the Coordination Group for Meteorological Satellites (CGMS) in 2001. The IPWG is cosponsored by CGMS and the World Meteorological Organization (WMO) and focuses the scientific community on operational and research satellite based quantitative precipitation measurement issues and challenges. It provides a forum for operational and research users of satellite precipitation measurements to exchange information on methods for measuring precipitation and the impact of space borne precipitation measurements in numerical weather and hydrometeorological prediction and climate studies. Dr. Kubota summarized highlights and actions of the 10th IPWG Workshop held in June, 2022 in Fort Collins, CO, USA, and presented future plans of the Working Group.
A participant asked when experimenting with small satellites in the microwave, how they could assure that the data was of equivalent quality across these different platforms. Mr. Kubota answered that the calibration was a big issue and it was still needed to calibrate small satellite data in a comparison to more accurate microwave radiometers such as AMSR2 or AMSR3 data, for example. He added that future technological development would solve this issue. Another participant celebrated IPWG's participation in AOUMSUC. It was also recommended to visit IPWG website.

Ms. Adinda Dara Vahada, Meteorological, Climatological and Geophysics Agency (BMKG), talked about **Detection of short-lived convective clouds using geostationary satellite images**. Remote sensing by satellite and radar plays an important role in providing nowcasting information. Weather forecasters in regions where are uncovered by radar observations, need to rely satellite product analysis to issue the nowcasting or early warning. Ms. Vehada gave an overview of her team's efforts to explore the pattern of cloud formation in initial development based on Himawari-8 images. In their study, two cases in East-Nusa Tenggara (2021) and in Bengkulu (2022) identified two short-lived convective clouds which coincided with moderate/heavy rainfall. After analyzing the real time images processed by BMKG, Enhanced Water Vapor, and Rapid Developing Cumulus Area (RDCA) product, results show that cloud-cells were detected in 10-20 minutes lifecycle, with diameter size of 3-5 km. Overall, there are certain characteristics related to short-lived convective clouds that must be considered by forecaster while producing nowcasting or early warning.
A participant asked if the team had evaluated the performance of rainfall potentials and if such performances were regional dependent or not. Ms. Vehada said that they had not evaluated such performance but they hoped

that they would finish the documentation of this evaluation task from rainfall potential products by the end of the year.

Dr. Moeka Yamaji, Earth Observation Research Center, Japan Aerospace Exploration Agency, talked about **Seasonal differences of precipitation and microphysical characteristics over the Asian monsoon region using spaceborne dual-frequency precipitation radar**.
Dr. Yamaji introduced their team's study, which aimed to reveal climatological differences in precipitaion microphsical characteristics between pre-monsoon and monsoon seasons over the Asian monsoon region. They used the Dual-frequency Precipitation Radar satellite product aboard the Global Precipitation Measurement Mission Core Observatory from 2014 to 2021, to statistically analyze the characteristics of precipitation, sucs as mass-weighted mean diameter (Dm) and frequency of heavy ice precipitation. The results showed statistically significant seasonal changes. Microphysical characteristics of large Dm and frequent occurrence of heavy ice precipitation were observed over the Indian subcontinent and Indochina Peninsula in the pre-monsoon season and over the western Himalayan region in the mature-monsoon season The relationship between precipitation rate and Dm can differ among seasons.
A participant asked if the team's study results applied to seasons other than monsoon period and Dr, Yamaji answered that this study focused on monsoon and pre-monsoon period mainly and there was another study not focusing on monsoon, adding that it seemed a very interesting field of the research topic. Another participant commented that the study area (Bangradesh) was really good case study area because it provided potentially very strong contrasts.

Dr. Hitoshi Hirose, Japan Aerospace Exploration Agency (JAXA), talked about **Introduction of confidence flags to the Himawari-8 precipitation estimation algorithm**. The Himawari-8 precipitation estimation algorithm (HPA) can estimate precipitation from IR multiband observations of geostationary meteorological satellites (GEOs) by using the Random Forest machine learning method (Hirose et al., 2019). Case studies near Japan show that the HPA has high accuracy in estimating linear precipitation zones and three water vapor bands contribute to the estimation accuracy. By limiting the learning sample to the summer area of Japan, overestimation of heavy rain area was reduced. However, in cases where optically thick upper-level clouds covered large areas, overestimation of heavy rain area was often occurred. This is because the effectiveness of the IR multiband is significantly reduced for optically thick upper clouds. Dr. Hirose gave an overview on their study, in which a confidence flag was introduced to isolate overestimation of heavy rain areas and the case analysis showed that the confidence flag was able to detect a significant portion of the heavy rain area overestimated by the HPA.
A participant asked about details of classification approach and Dr. Hirose further explained the team's approach. The participant also commented on the benefit of using combinations of multiple AI ensamble approaches.

Dr. An Hung Nguyen, Le Quy Don Technical University, talked about **Precipitation estimation using Himawari-8 in Vietnam**. Vietnam is an area of complex weather characteristics, which is clearly affected by

climate changes. The increased occurrence frequency of strong storms and heavy rains for many days in the large extent caused floods, flash floods, landslides continuously, and severe consequences of properties and people's lives. Precipitation estimation for the nationwide range in realtime has an important significance in offering rain and flood predictions in order to support economic and social developments and people's safety. Using Himawari-8 satellite data combined with ground measurement station data to build the precipitation map for the nationwide range in near real-time has become a new research direction, which helps to provide additional information for the areas of lack of rain gauge and weather radar data. Dr. Nguyen outlined their work that used Random Forest machine learning model to estimate precipitation in Vietnam with moderate temporal and spatial resolutions (about 0.04 degree and every 60 minutes), which could be extended to precipitation estimation using other geostationary satellite data such as GeoKomSat and FengYun.

Mr. Giacomo Roversi,(1) Department of Physics and Astronomy, University of Bologna, Italy, (2) Institute of Atmospheric Sciences and Climate (ISAC), National Research Council (CNR), Rome, Italy, talked about **Intercomparison of operational precipitation products in Vietnam**. The INDRA project (Research and development of INtergrateD RAinfall measurements platform for application in agriculture, hydro-meteorological hazard prevention and mitigation, and water management) is a bi-lateral scientific cooperation project between Italy and Vietnam. The Project aims to improve the quality of low-latency rainfall products firstly by measuring the uncertainties associated to the various QPEs(quantitative precipitation estimates) available over the Vietnamese area, and then building an algorithm which exploits complementary strengths of the different instruments. Quantitative reference is taken from the ground network of around 1500 rain gauges. QPEs come from the following sources: the Vietnamese ground weather radar network, the IMERG Early Run and Final Run releases, the south-Korean GEO KOMPSAT-2A and the Chinese FengYun-4A geostationary satellites, the DPR onboard the GPM Core Observatory, and the European ERA5-Land reanalysis. Results show the ground radars are unmatched by all the other sources (with CC of 0.66 and CV of 1.49). Geostationary QPEs tend to overestimate precipitation, particularly at the higher regimes, while more complex products like ERA5 and IMERG have latency drawbacks.
There was no Q&A session held because the presenter was absent from the event and did not give a presentation.

Mr. Heikki Pohjola, World Meteorological Organization (WMO), talked about **The current status and the future plans of WMO Observing System Capability Analysis and Review Tool for space-based capabilities (OSCAR/Space)**. The WMO Observing System Capability Analysis and Review tool for space-based capabilities (OSCAR/Space) is a publicly available, online resource established and maintained by the WMO in the context of the WMO Integrated Global Observing System (WIGOS). It is a key tool and information source to support the WMO Rolling Review of Requirements (RRR) process, WMO Gap Analysis and the Coordination Group of Meteorological Satellites' (CGMS) Risk Assessment, which are the key inputs to monitor the compliance of CGMS baseline and satellite programmes in the implementation of the space-based component of the Vision for WIGOS in 2040. The information content in OSCAR/Space must therefore be constantly maintained in collaboration with the space agencies. Mr. Pohjola presented the current status of and

future development plans to keep OSCAR/Space as a high-quality information source on satellite programmes, satellites and their instruments operated by CGMS members as well as by non-CGMS satellite operators and commercial satellite operators for the benefit of the Earth observation satellite community worldwide.

Mr. Bony Septian Pandjaitan, Sud division for Weather Satellite Imagery Management Indonesia Agency for Meteorology Climatology and Geophysics, talked about **Parallax correction methods and objective detection of overshooting cloud tops surrounding extreme weather events location In Indonesia**. The need for satellite-derived products to monitor convective clouds that trigger extreme weather in tropical areas such as Indonesia is very high. The presence of an overshooting top (OT) in convective clouds is often associated with the presence of extreme weather at that location. However, the presence of OT detected by satellite is still in an inappropriate location. This is a natural consequence of the parallax error generated by the Himawari 8 Satellite. Mr. Pandjaitan and his colleagues aimed to objectively detect the presence of OT in locations of extreme weather events using Himawaari-8 images. To this end, they tested 3 methods for correcting satellite parallax errors with respect to the actual OT position and evaluated these 3 methods with a case study of extreme weather in Java Island. The test result shows that the image's product with this OT feature without parallax correction is able to detect the presence of OT around extreme weather locations with a distance difference of about 13 km. All of these parallax correction methods are able to correct the OT position so that the distance between the OT location and extreme weather locations becomes only less than 3 km.

Session 4: Application for atmospheric monitoring and nowcasting (Parallel 2)
Session Chairs: Ms. Suling Ren (NSMC/CMA), Mr. Hiroshi Suzue (JMA)

Mr. Hiroshi Suzue, Japan Meteorological Agency, talked about **Introduction of the Project for Enhancing Utilization of Himawari-8/9 Data - Rapidly Developing Cumulus Area (RDCA) Determination –**. The Japan Meteorological Agency (JMA) has provided a Japan-area version of Convective Cloud Information (CCI) since 2016 and an Asia and Western Pacific version since 2018 for aviation safety and air traffic control. One element of the product - Rapidly Developing Cumulus Area (RDCA) data - is determined using logistic regression analysis for a statistical approach with only Himawari-8/9 observation data as input. This technique has been adopted in Southeast Asia via bilateral cooperation and an ESCAP/WMO Typhoon Committee project. Mr. Suzue presented an overview of RDCA determination and the transfer of related technical expertise.
A participant asked two questions: how the team obtained lightning data and how they dealt with quality control the lightning data over sea area for their product. Mr. Suzue answered that they used JMA's lightning detection system to obtain lightning data and they used the same method in the land and sea for the RDCA determination. Another participant asked Mr. Suzue's opinion on RDCA determination in tropical areas, especially in Indonesia, and Mr. Suzue answered that that should be easier to detect RDCA than in the Japan area, it was still needed to recreate the coefficients or RDCA determination though.

Ms. Ayufitriya, Indonesia Agency for Meteorology Climatology and Geophysics (BMKG), State College Of Meteorology Climatology And Geophysics (STMKG), talked about **Cumulonimbus Cloud Prediction Using Rapidly Developing Cumulus Area (RDCA) Products At Ambon Pattimura Airport**. In the last decade, air transportation has become the best solution to connect every province in Indonesia, which is an archipelagic country. The process of landing and taking off airplanes is highly dependent on weather conditions. Cumulonimbus (Cb) clouds are considered the most dangerous because they can cause extreme weather such as heavy rain, hail, lightning, and can even produce thunderstorms. The delivery of information regarding the potential growth of the Cb cloud needs to be optimized to support flight safety and minimize the impact it can cause. The use of remote sensing tools, such as weather satellites and radar, is believed to provide solutions for these problems. Though weather radar has an important role in generating early warnings to reduce disaster risk, it still has limitations, especially in the area of observation. The RDCA product from the Himawari satellite is useful for determining the location of cumulus clouds that have the potential to become Cb. Ms. Ayufitriya overviewed her team's research, which put focus on utilizing RDCA to identify Cb clouds.
The chair commented that the product of RDCA seemed to be usable in strong convection system early warning and Ms. Ayufitriya agreed with the opinion.

Mr. Shibin Balakrishnan, Scientist-C, India Meteorological Department, Ministry of Earth Sciences, talked about **Investigation of severe hailstorm over northwest India during 2020- A satellite perspective**. Hailstorms are highly destructive severe weather events and cause catastrophic destruction to livestock and property. Satellite data is beneficial to delineate the deep convective clouds over informationsparse ocean and

densely populated urban areas. This study investigates severe hailstorm events over parts of northwest India during the premonsoon period of 2020. The satellite data of research if from the imager payload of the INSAT 3D geostationary satellite. The synoptic features associated with hailstorm events are also studied. The study utilizes the visible and infrared channel data to understand convective cloud development and subsequent intensification. The hailstorm events are also explored with NWP model data to understand the synoptic signatures which led to the devastating severe weather event over north India. Mr. Balakrishnan was going to give an overview of their study, which also tried to identify the limitations of the utilized data and further scope for improvement in the future prediction of such severe weather events, but he was absent from the event.

Presenter: Mr. Rion Suaib Salman, State College Of Meteorology Climatology And Geophysics (STMKG), talked about **Convective Initiation Analysis using Day Cloud Phases Distinction RGB on Tropical Region.** Observations of the atmosphere over the eastern part of Indonesia provide useful information for a meteorological forecaster. In case extreme weather event, it is very essential to help them to make nowcasting or early warning. Japan Meteorological Agency (JMA) develops recipe of RGB product that can describes more detail about convective initiation and storm growth. This RGB takes advantage of cloud reflectance between the visible and near infrared to provide increased contrast between background surface and phases of cloud such as water and ice. Based on JMA recipe, the STMKG team uses Himawari 8 imagery with Advance Himawari Imagery (AHI) and need three composite band to produce the product: red, green, and blue colors. The team started analysis using the SATellite Animation and Interactive Diagnosis (SATAID) application, earning results that for the tropical region it performs better in describing details of the condition when bad weather occurs.
A participant commented that the work was very useful because the cloud phase was very important in extreme weather and also for weather modification. Mr. Salman appreciated the comment and said that they would work to make a verification.

Dr. Scott Shipman Lindstrom, UW-Madison Space Science and Engineering Center (SSEC), Cooperative Institute for Meteorological Satellite Studies (CIMSS), talked about ProbSevere LightningCast Probabilities over Guam using Himawari imagery. The NOAA/CIMSS ProbSevere portfolio includes the product LightningCast Probability, which uses 4 GOES-R ABI channels (0.64, 1.61, 10.3, 12.3) to diagnose the likelihood that lightning will occur in the next 60 minutes. This product has enthusiastic users in the USA National Weather Service, and its use has been demonstrated in experimental testbeds. A RealEarth instance that includes LightningCast imagery using Himawari-8 AHI data has recently been developed for the USA National Weather Service office on Guam and forecasters there are testing and documenting its used for Lightning Decision Support at airports on Guam. Dr. Lindstrom described the LightningCast, its migration to AHI data, and how the forecasters use it on Guam.
A participant asked about their efforts on the nighttime detection and Dr. Lindstorm answered that their nighttime detection was using the split window difference. Another participant asked questions on the team's calculation of the contribution for the channels in the algorithm used and the comparison of the results with the lightning imager observation. Dr. Lindstorm introduced another researcher's work. Another question was raised

on if the team distinguished different kinds of lightning in their products and Dr. Lindstorm answered they didn't.

Dr. Samaneh Sabetghadam, Institute of Geophysics, University of Tehran, Iran, talked about **Application of satellite remote sensing to assess springtime atmospheric aerosol loading over the South-West Asia**. Assessment of atmospheric aerosol properties is crucial to understand impact of aerosols on Earthatmosphere system, and satellite remote sensing is a key tool to assess the variation of aerosol properties. Aerosol optical depth, which is the vertical integral of the fraction of incident light either scattered or absorbed by aerosols, represents the amount of aerosol load in the column of the atmosphere. On the other hand, Angstrom exponent is an indicator of aerosol size distribution in the column of atmosphere. The team's study conducts a spatiotemporal analysis on the daily value of the collection 6 MODerate Resolution Imaging Spectroradiometer (MODIS) aerosol products to estimate aerosol loading and types during March to May 2019, over the south-west Asia. Different countries in this region have aerosol properties that are extensively variable due to the different sources of pollutants. Results show that the highest springtime value of aerosol load is found over the Arabian Peninsula, with the second largest aerosol concentration over Western and Southern Iraq, followed by a peak over Dashte-Kavir, Iran.

Dr. W. Paul Menzel, CIMSS/SSEC/UW, talked about **Monitoring Volcanic Emissions with a GEO-LEO Fusion Approach**. The team demonstrated the spatial-temporal fusion of CrIS and TROPOMI with VIIRS and ABI to enhance delineation of the emissions of the Cumbre Vieja volcano eruptions on La Palma in the Canary Islands for two days in October 2021. Changes in SO_2 and ash plumes are studied using the fusion approach. In sounder and imager data fusion, sounder low resolution depiction of volcanic emissions (e.g. SO_2 and ash) can be transferred to imager high resolution (through spatial fusion). When further connecting LEO products to time sequences of GEO imager radiances, a GEO-like perspective of atmospheric changes in time can be created (through temporal fusion). More generally, products from any hyperspectral sounding instrument such as AIRS, IASI and CrIS or from a trace gas detection
instrument like TROPOMI, when paired with LEO imager or GEO imager measurements, can be enhanced to reveal more spatial detail and -in the case of GEO imagers - also more temporal detail. The presenter had prepared for the presentation but was absent from the event and did not give a presentation.

Dr. Chris Lucas, Australian Bureau of Meteorology, talked about **A census of deep volcanic eruptions in the tropics as observed by Himawari-8**. Volcanic eruptions are significant aviation hazards due to the formation of airborne volcanic ash clouds. Particularly important are eruptions that reach the upper troposphere and stratosphere where ash may be spread more broadly. Climate impacts on longer time frames may appear in more intense eruptions. Satellite platforms in geostationary orbit are a key resource in the detection and monitoring of these events. Imagers onboard modern geostationary satellite platforms, such as the 16-channel Advanced Himawari Imager, particularly when combined into RGB composite imagery, provide the means to better monitor. Dr. Lucas's team examines the characteristics of multiple deep eruptions in the tropics, those that

interact with the tropical tropopause layer that begins around 14 km altitude. Approximately 20 eruptions in the Himawari-8 field of view that met the criterion were examined.
A participant asked if the same can be said for volcanoes in the middle or high latitude area and Dr. Lucas said he did not do any parallax corrections on his work and he thought that dynamics were different in those eruptions, adding that he never really considered the mid-latitude-type eruptions in any great detail.

Mr. Hancheol Lim, Satellite Planning Division, NMSC, KMA, talked about **Development of fog convergence technology and Application for road weather service based on geostationary meteorological satellites**. The fog is one of the key causes of transportation accidents by vehicle, ship, and aircraft and it is also the factor that directly impacted agriculture. Consequentially, more detailed and more accurate fog information services by a geostationary meteorological satellite are demanded from the end users in the transportation sector. It is the reason that we update the accuracy of the GK2A fog product as well as expand service to a new application field. KMA was developing the convergence technology between GK2A AMI (Advanced Meteorological Imager) data and GK2B GOCI (Geostationary Ocean Color Imager) data to support detailed fog service, and a new project for road weather service by KMA was also started in 2022. The new project plans to construct the road weather observation site on a highway test-bed to measure black ice, fog, etc.
The presenter had prepared for the presentation but was absent from the event and did not give a presentation.

Mr. Takuma Yamaguchi, Faculty of Engineering Sciences, Interdisciplinary Graduate School of Engineering Sciences, Kyushu University, talked about **Development and validation of the cirrus cloud mask method by using near infrared band observed from geostationary satellite**. Observation of cirrus clouds are important for clarifying the processes of climate system and its variability, since cirrus clouds affect not only the radiation budget but also the amount of water vapor entering the stratosphere. The 1.38 ㎛ band, which is a strong absorption band of water vapor, detects effectively the optically thinner cirrus clouds. The Moderate Resolution Imaging Spectroradiometer (MODIS) have successfully detected the presence of cirrus clouds by applying the threshold method of 1.38 ㎛ band. The optically thinner cirrus clouds have been also detected by geostationary satellites, Feng-Yun-4A (FY-4A), Geostationary Operational Environmental Satellite-16 (GOES-16), and GEO-KOMPSAT-2A (GK-2A), which are equipped with near-infrared 1.38 ㎛ band. Mr. Yamaguchi presented their efforts to develop the detecting method of cirrus clouds by using Level 1B products of the geostationary observation satellites (mainly GK-2A).
A participant gave an update of JMA's related activities: the JMA was considering the specification of our follow-on satellite, maybe named as Himawari 10, which might be launched in 2028. Another question was raised on how to determine the threshold value on slide 7 and Mr. Yamaguchi said he referred to MODIS cloud mask but he had to customize the thresholds.

Ms. Hye-In Park, Researcher, National Meteorological Satellite Center/KMA, talked about **Retrieval and Evaluation of Atmospheric Temperature and Humidity Profiles using Geostationary Hyperspectral Infrared Sounder**. The hyperspectral infrared sounder is known to play an import role in now-casting, data

assimilation on NWP, and climate change monitoring. In particular, the first hyperspectral infrared sounder in GEO, FY-4A/GIIRS launched by CMA in December 2016, would be very useful for monitoring the three-dimensional information of atmospheric temperature and humidity fields with high temporal and spatial resolution. It observes around the Chinese region including the Korean Peninsula with 16 km spatial resolution every hour with 1,650 channels. In order to improve the accuracy of satellite-based atmospheric vertical profiles and its application in now-casting, KMA has been expanded 1D-VAR based GEO-KOMPSAT-2A AMI Atmospheric Profile(AAP) algorithm for FY-4A/GIIRS. To expand the AAP algorithm to the GIIRS, channel selection and systematic bias correction of GIIRS were performed removing channels sensitive to gas absorption, considering weighting function as evenly distributed vertically for temperature and humidity. Ms. Park shared their verification results and plans.
A question was raised on what factors could decrease the lower water vapor retrieval accuracy and Ms. Park replied that she didn't know the answer to that question and would try to find out more about that.

Ms. Suling Ren, National Satellite Meteorological Center, talked about **FY-4A/GIIRS Temperature Validation in Winter and Application in Cold Wave Monitoring**. In order to improve the operational application ability of the FY-4A new sounding dataset, the team carried out the validation of the FY-4A Geosynchronous Interferometric Infrared Sounder (FY-4A /GIIRS) temperature using the balloon sounding temperature from meteorological sounding stations. More than 350,000 samples were obtained through time–space matching and the results show that the FY-4A/GIIRS temperature mean bias (MB) is 0.07℃, the mean absolute error (MAE) is 1.80℃, the root-mean-square error (RMSE) is 2.546℃, and the correlation coefficient (RR) is 0.95. The FY-4A/GIIRS temperature error is relatively larger in the upper and lower troposphere, and relatively smaller in the middle troposphere; that is, the temperature at 500 hPa is better than that at 850 hPa. Ms. Ren gave furtherdetails of their efforts on validation and data reconstruction.
A participant asked what kind of information they used and Ms. Ren replied that she used humidity product level two product adding that another person performed the retrieval work of the product.

Dr. Scott Shipman Lindstrom, UW-Madison Space Science and Engineering Center (SSEC), Cooperative Institute for Meteorological Satellite Studies (CIMSS), talked about **Creating new ways to view LEO Satellite observations of winds and waves**. There are several websites that allow users to click and view scatterometry data of winds, or altimetry data for waves (e.g., https://scatterometer.knmi.nl/tile_prod/ and https://manati.star.nesdis.noaa.gov/). However, these websites show only small sectors, and usually one time, which can be a challenge for long-term monitoring of weather. Accordingly, Dr. Lindstrom and his colleague have created websites (https://manati.star.nesdis.noaa.gov/) that scrape online data sources for imagery, and use that imagery daily to create week-long animations of scatterometry winds, altimetric waves, and AMSR-2 windspeeds from GCOM. He discussed how this had been done, and what the results looked like.
There was a question raised on if there were any SAR wind or wave data on the OSPO website. Dr. Lindstrom said yes and he would put the link in the chat later, adding that there were SAR wind data but not wave data.

Dr. Yi-Xuan SHOU, National Satellite Meteorological Center, talked about **Tropopause folds measured by Fengyun-4: Preliminary validation and their relation to hazard weather events**. Tropopause folds, an important mid-latitude atmosphere phenomenon within the upper troposphere and lower stratosphere, are intimately linked to upper level frontogenesis and jet stream dynamics. They are often considered as the key processes for the stratosphere-to-troposphere transports and some hazard weather events. Dr. Shou presented an overview of the team's study that used a statistical-physical combined method to establish a tropopause folding retrieval model based on Fengyun-4 geostationary satellite observations. By comparison with the tropopause foldings detected from GEOS-5/MERRA-2 reanalysis data using the 3-D labeling algorithm based on the 3-D distributions of PV (potential vorticity) and θ (potential temperature) in the stratosphere and troposphere, the tropopause folds identified based on Fengyun-4 observations have the HR (hitting rate) of ~0.8. Both of the two datasets show a similar seasonal cycles with the maxima frequency in winter.
A participant shared websites provided during the training session on the FengYun viewers where users can actually look at the various FengYun products. These sites provides the folding quite nicely rendering both in the Southern Hemisphere and over the Northern Hemisphere.

Mr. Ying Wa Chan, Hong Kong Observatory, talked about **Operational application of deep learning model for auto-detection of atmospheric gravity waves over the Asia-Pacific region**. The Hong Kong Observatory (HKO) applied high-pass filtering technique to 6.2μm water vapour channel of the Japan Meteorological Agency's Himawari-8 (H-8) geostationary satellite imageries for identifying atmospheric gravity waves (AGW) over the Asia-Pacific region. In 2018-2022, HKO collaborated with NVIDIA to develop a deep learning model with object detection technique using the Faster Region-based Convolutional Neural Network (FasterRCNN) for auto-detection of AGW. The network was pre-trained with the Microsoft Common Objects in Context (COCO) dataset. It was then trained using over 750 pilot reports collected in January 2018 – June 2021 which reported AGW triggered severe turbulence as depicted by human. The model achieved reasonable skill with an average precision of 0.782 for intersection-over-union (IoU) of 0.50. Mr. Wa introduced their efforts on the development and verification the model.
A participant asked if there was a possibility for false signals to the west of Sumatra to be lightning to the area. Mr. Wa replied that it was possible but it's difficult to get pilot reports to get more details about the nature of the turbulence, though turbulence reported by aeroplanes even though they are well clear of the actual thunderstorm. This provides one limitation.

Session 5: Application for land surface, sea surface, and climate monitoring
Session Chairs: Prof. Yuriy Kuleshov (BoM/RMIT), Dr. Pallavi Govekar (BoM)

The session consisted of 11 oral presentations.
The session opened with a keynote presentation by Dr. Mitchell D. Goldberg, NOAA's National Environmental Satellite, Data and Information Service (NESDIS), titled **NOAA's New Strategic and Implementation Plans in Response to the Climate Crisis**. With President's Biden executive orders on Tackling the Climate Crisis at Home and Abroad; Protecting Public Health and the Environment and Restoring Science to Tackle the Climate Crisis and Advancing Racial Equity and Support for Underserved Communities, NOAA responded with a strategic plan with three major components. First, building a Climate Ready Nation by establishing NOAA as the primary federal authoritative provider of climate information and services in the wholeof-government response to tackling the climate crisis. Second, making equity central to NOAA's mission. Third, accelerate growth in an information-based blue economy. To be more agile, NOAA created a new Climate Council to develop and evaluate strategy and a Weather, Water, Climate Board (WWCB) to implement. Since the start of the Biden administration, NOAA has been working on implementation plans which essentially allowed us to respond very quickly to new funding opportunities including Disaster Supplementals, the Bipartisan Infrastructure Law (BIL), and the Inflation Reduction Act (IRA). The presentation provided an overview of the societal challenge areas NOAA, followed by a discussion on mitigating impacts of extreme events in the era of climate change, including floods, wildfires, and drought assessments.

Prof. Jinlong Fan, National Satellite Meteorological Center, talked about **Mapping the Global Agricultural Drought with Chinese Meteorological Satellite Data**. Under the global climate change, the global agricultural drought is attracting the attentions from agricultural community in the world in order to alleviate the impact. Thanks to the global coverage and the relative long time series of the second generation FENGYUN polar orbiting satellite, the normalized difference of vegetation index NDVI and the brightness temperature BT retrieved from FY3C VIRR were used to develop the drought index. The vegetation condition index VCI model between the current value and the historical range in the past 8 years of NDVI was built while the temperature condition index TCI model between the current value and the historical range in the past 8 years of BT in 11um was also set. And then the Vegetation Health Index VHI was further computed with the VCI and TCI. The VHI was categorized into 5 classes, namely, Extreme Drought, Severe Drought, Moderate Drought, Light Drought and Normal. Professor Jinlong introduced the technology in detail and how the users may take the facilitate to obtain their own agricultural drought map routinely.

Prof. Lixin Dong, 1 Key Laboratory of Radiometric Calibration and Validation for Environmental Satellites, 2 National Satellite Meteorological Center (National Center for Space Weather), China Meteorological Administration, talked about **Evolution, validation and application of Land Surface Temperature product on FY-3 Polar orbit Meteorological Satellite**. Land surface temperature (LST) is a very important physical variables characterizing land surface change process and the driving factors of land - atmosphere energy

exchange. It is widely used in the fields of surface energy balance, climate change, resource and environment monitoring. The team has reported the development and evolution of Fengyun 3 (FY-3) LST algorithm. Some candidates split window LST algorithms are compared to evaluate their applicability for the Medium Resolution Spectral Imager (MERSI) onboard the FY-3 satellite using simulated data by the MODTRAN radiative transfer model. And then the enterprise algorithm of FY-3 LST is determined and the operational products are produced in clear sky condition. Secondly, the MERSI LST products was validated by using the in-situ data and Moderate Resolution Imaging Spectroradiometer LST product. The validation results indicate that the preferred LST algorithm meets the required accuracy (2.5 K) of the FY-3 mission. Finally, some application of LST products in the field of high-temperature process monitoring and the study of island LST change before and after volcanic eruption was introduced.

Mr. Jie Chen, National Satellite Meteorological Center, talked about **The FY-3D Global Active Fire product: Principle, Methodology and Validation**. Wildfires have a strong negative effect on environment, ecology and public health. However, the potential degradation of mainstream global fire products leads to large uncertainty on the effective monitoring of wild fires and its influence. To fill this gap, the team produced FY-3D global fire products with a similar spatial and temporal resolution, aiming to serve as the alternative and continuity for MODIS global fire products. Firstly, the sensor parameters and major algorithms for noise detection and fire identification in FY-3D products were introduced. For visual-check-based accuracy assessment, five typical regions, Africa, South America, Indochinese Peninsula, Siberia and Australia, across the globe were selected and the overall accuracy exceeded 94%. Meanwhile, the consistence between FY-3D and MODIS fire products was examined. The result suggested that the overall consistence was 84.4%, with a fluctuation across seasons, surface types and regions. They further evaluated the suitability of FY-3D fire products in China. The overall accuracy was higher than that of MODIS fire products.

Dr. Ruijing Sun, National Satellite Meteorological Center, talked about **Introduction of FY-3/MWRI soil moisture product and its applications**. Microwave Radiation Imager (MWRI) onboard the FengYun-3D (FY-3D) satellite of China Meteorological Administration was launched in November, 2017. MWRI is a highly sensitive microwave radiometer that woks at five different frequencies: 10.65, 18.7, 23.8, 36.5 and 89GHz with dual polarization. The current soil moisture production retrieval algorithm of FY-3D/MWRI uses the brightness temperature to eliminate the effects of surface roughness and vegetation simultaneously. For the bare surface soil estimation part, the algorithm is developed on a parameterized surface emission model which uses a physically based soil moisture inversion technique for application with passive microwave measurements. In the validation with ground observations in western China, the average root mean square error of the soil moisture product is about $0.06 cm^3/cm^3$ in low to moderate vegetation cover area. This accuracy can meet the needs of applications in drought, flood and agriculature monitoring. Furthermore, in order to derive higher accuracy soil moisture with higher spatial resolution, the soil moisture products of SMAP working at L-band and AMSR2 which has C-band are integrated with MWRI.

Dr. Caroline Anne Poulsen, Bureau of Meteorology, talked about **Solar Monitoring in Australia**. Solar power is a rapidly expanding industry in Australia, the solar capacity of Australia is amongst the highest in the world and solar energy now accounts for over 10% of Australia's total electrical energy production. Increased solar capacity is pushing demand for accurate high resolution surface solar irradiance (SSI) measurements. The measurements are used to aid with siting of new solar plants and monitor the output. Nowcasts are becoming essential to estimate demand and control the network. The Bureau of Meteorology (BoM) have recently implemented the surface solar irradiance Heliosat-4 algorithm for Himawari-AHI. A regional bias correction was developed using machine learning techniques. The data has been processed from the beginning of the Himawari-8 mission in 2015 to the present. The new SSI measurements provide better temporal and spatial resolution and now extend to coastal regions of Australia, so the diurnal cycle of solar insolation can be studied for sensitive marine regions such as the Great Barrier Reef. The results have been validated over land and over the ocean. The presentation outlined the applications for solar irradiance data, present some validation results and some key statistics for the Australian region.

Dr. Pallavi Govekar, Australian Bureau of Meteorology, talked about **New IMOS Himawari-8 and Multi-sensor Sea Surface Temperature products**. Sea surface temperature (SST) products within a few kilometres of coasts that can resolve fine-scale features, such as ocean upwelling, are increasingly in demand. The Australian Bureau of Meteorology (BoM) currently produces operational, real-time SST from the Himawari-8 geostationary satellite every 10 minutes at ~2 km spatial resolution. For ease of use, these native resolution SST data have been composited to hourly, 4-hourly and daily SST products and projected onto the rectangular Integrated Marine Observing System (IMOS) 2km grid. In response to user requirements for gap-free, highest spatial resolution and highest accuracy SST data, the BoM composites the geostationary Himawari-8 data with data from the Visible Infrared Imaging Radiometer Suite (VIIRS) and Advanced Very High-Resolution Radiometer (AVHRR) satellite sensors to construct new "Geo-Polar Multi-sensor L3S" products on the IMOS grid. Dr. Govekar presented validation of such products against in-situ SST data and demonstrate applications for the new products.
A participant asked if the team would use the microwave over the regional result, like SM-SAT or GPM and Dr. Govekar answered they might consider adding microwave data to their sattelite data but they were only using their multi sensor products because they wanted to ensure accuracy of the data.

Dr. Lin Tian, National Satellite Meteorological Center, China Meteorological Administration, Beijing, China, talked about **Inversion of Ocean Transparency based on FengYun meteorological Satellite**. Ocean transparency can be an important physical quantity for describing the optical properties of seawater as it directly indicates the turbidity and the inherent optical properties. The research of spatial and temporal distribution of Ocean transparency has great significance on monitoring of ocean water quality and underwater military activities. Satellite remote sensing has advantage in high sampling frequency and wide coverage observation, which is convenient to obtain Ocean water transparency data with high spatial-temporal resolution. Dr. Tian’s

research aims at the requirements of ocean transparency monitoring in marine environment assessment, navigation and underwater activities. The results show the empirical inversion algorithm has a high correlation with the in-situ measured Secchi depth. In order to improve the spatial coverage and reliability of the retrieved quantity, the team merged ocean color data from multiple satellite sensors.
A participant asked to share the whole presentation and Dr. Tian agreed to share the presentation to JMA. Another participant asked if they had any methods to deflect the rapidly drop of the sea surface temperature in gap filling. Dr. Tian answered that when combining different satellite sensors together, they consider bias and standard deviation.

Dr. Zhiwei Wang, National Satellite Meteorological Center(NSMC), China Meteorological Administration (CMA), talked about **Introduction of FY-4B instruments and Results of post-launch calibration and Testing.** FY-4B satellite was launched successfully on June 3, 2021, which was the second one of China's second-generation geostationary satellites titled FengYun-4. The primary payloads onboard FY-4B are Advanced Geostationary Radiation Imager (AGRI), Geostationary Interferometric Infrared Sounder (GIIRS), and Geosynchronous High-speed Imager (GHI). Compared with FY-4A, a new water vapor channel is added, four channels' band settings are optimized, and the resolution of the short wave and the medium wave is improved to 2km in FY-4B/AGRI. Based on post-launch Calibration and Validation, the SNR of the reflection channel and the sensitivity of the IR channel have met the specification. The radiometric calibration bias has met the specification of 0.7K in IR bands, while 5% in VIS/NIR bands. FY-4B/GIIRS is an infrared Fourier transform spectrometer based on a Michelson interferometer. It measures the hyperspectral atmospheric upwelling infrared radiance in the two spectral bands: the long-wave IR (LWIR) and the mid-wave IR (MWIR) band. FY-4B/GHI is an experimental multi-spectral flexible imaging radiometer. Dr. wang presented performance status of these sensors.
A participant asked if their calibration results were open to the public and Dr. Wang answered they had only Chinese version published and would make results open to the world.

Prof. Yuriy Kuleshov, Australian Bureau of Meteorology SPACE Research Centre, Royal Melbourne Institute of Technology (RMIT) University, talked about **WMO Space-based Weather and Climate Extremes Monitoring (SWCEM) for East Asia and Western Pacific**. Recognizing needs to better utilize and improve monitoring of weather and climate extremes from space, the World Meteorological Organization (WMO) established a flagship initiative - the Space-based Weather and Climate Extremes Monitoring (SWCEM). The team started the SWCEM with the demonstration project for Asia-Pacific (2018-2019), and were able to bring clear benefits of translating science of satellite remote sensing to operational services. Recognizing SWCEM achievements in Asia and the Pacific, the Eighteenth World Meteorological Congress (Cg-18) in 2019 adopted the SWCEM Implementation Plan and requested to consider the possibility of implementing similar projects in Africa and South America. The demonstration project was focused on monitoring drought and heavy precipitation and it was implemented in the South-East Asia region and the Western Pacific Ocean area. The Japan Aerospace Exploration Agency (JAXA) and the Climate Prediction Center, National Oceanic and

Atmospheric Administration (CPC/NOAA) provide satellite data and products for the region. SWCEM precipitation products produced by JAXA are based on the Global Satellite Mapping of Precipitation (GSMaP). Professor Kuleshov outlined their efforts on such projects.

Mr. Kadek Sumaja, Indonesian Agency for Meteorology Climatology and Geophysics, talked about **The Climate Comfort and Risk Assessment for Tourism in Bali, Indonesia**. Tourism is one of the main economic resources in Bali unfortunately mostly affected by climate conditions. However, it is still unclear how climate change may affect tourism in tropical archipelagos like Bali Island. Moreover, climate comfort is one of the most important factors that must be taken into account to increase the number of tourists visiting because it may alter the pattern of tourist visits as well as tourist preferences. Therefore, Mr. Sumaja presented his team's study that analyzes the comfort level of the tourism climate using three different methods as Holiday Climate Index (HCI), humidity index (Humidex), and correlation. Furthermore, using a GIS application, they map the climate comfort level in each observation to find the most comfortable month. While the most comfortable month for traveling in Bali is August and the least comfortable month is December and January. The number of tourist arrivals to Bali is greatly related to the number of tourist visits. The results of this study are expected to assist tourists, the tourism sector, and local governments in making pre-travel decisions based on climatic comfort information and tourism policy to enhance the Bali tourism business.

Session 6: Application for numerical weather prediction

Session Chairs: Dr. Kozo Okamoto (JMA/MRI), Prof. Fuzhong Weng (CMA)

The session consisted of 11 oral presentations.

The session opened with a keynote presentation by Dr. Fiona Isobel Smith, Bureau of Meteorology, titled **Review of satellite radiance observations in operational numerical weather prediction**. Satellite data comprise over 95% of the observations that are used in Numerical Weather Prediction (NWP) models to provide the best estimate of the atmospheric state used as the starting point to produce forecasts. A large proportion of these observations are radiance data from infrared and microwave sounder instruments. For most NWP centres, the radiance observations are also the most impactful, and forecast skill is critically dependent on them. Dr. Smith reviewed the status of satellite radiance data assimilation in NWP centres across the world.

A participant asked if we currently had some alternative information to replace, to get the equivalent information of the aging SSMIS. Dr. Smith answered that she was looking at a microwave sounding capability which is potentially launched on an Australian Earth observation satellite and had been weighing up whether a conical scanner was better. Referring to Windsat follow-on mission to be launched 2023, she hoped to see some alternatives in the future. She also mentioned that the instruments like AMSR-2 are providing useful surface sensing capability from Microwave. Another participant asked her opinion if we could take core approaches for both regional and global systems or different approaches are needed. Dr. Smith answered it was very difficult to find time to tailor assimilation system to the limited area models and what we really needed was a better method of assessing impact of satellite data in limited area models. Further question about targeting observation by GEO infrared sounder especially for regional model in the future was raised, and Dr. Smith answered that she is sure there will be benefits if we can ensure the NWP models take the data in.

Prof. Fuzhong Weng, CMA Earth System Modeling and Prediction Centre, talked about **Assimilation of FengYun Satellite Data in CMA-GFS Using Advanced Radiative Transfer Modeling System (ARMS)**. A fast and accurate radiative transfer model is required for assimilation of satellite data into numerical weather prediction model. To accelerate the uses of current and future FengYun satellite data, CMA has developed its first generation of satellite observation operator (ARMS) and continues its updating and readiness for the new missions. ARMS has the capabilities similar to RTTOV and CRTM but is designed with more flexibilities with plug and play of new radiative transfer solvers, new scattering data bases of aerosols, clouds and precipitation, and new ocean two-scale emissivity model and reflectivity model. Prof. Weng presented an overview of ARMS science capabilities and its major applications.

Dr. James Purdom raised a question: where are we on the use of satellite data versus soundings, microwave and hyperspectral over land? The presenter said they could start using lot of microwave sound data and he thought a lot of progress had been made in the area. Dr. Purdom said he was glad to hear that because 50% to 60% of the Northern Hemisphere was covered by land, so they could not use a huge amount of satellite data currently. The team's efforts should have significant impact if completed, he said.

Dr. S. Indira Rani, National Centre for Medium Range Weather Forecasting (NCMRWF), Ministry of Earth Sciences (MoES), Govt. of India, talked about **A brief review of the current status and future requirements of satellite microwave data for NWP**. Currently, the global NWP assimilation systems benefit the data from satellites in the early morning (FY-3E: 6 am ECT), mid-morning (MetOp: 9.30 am ECT), and afternoon (JPSS:1.30 pm ECT) orbits. The mid-morning and afternoon orbits cover the data in both ends of the 06/18 Z (± 3 hours) assimilation cycles leaving a gap in the middle. FY-3E and NOAA series of satellites (up to NOAA-19) provide data in the latter half of the 00/12 Z (± 3 hours) assimilation cycles. Dr. Rani outlined the current status and future requirements of satellite Microwave data for NWP.

A participant asked what kind of new satellite data would help them in India regions to improve local forecast. Dr. Rani answered that the high-resolution hyperspectral data from the geostationary orbit will definitely help them to improve mainly the extreme weather event forecast. She also said they had already started getting hyperspectral data from CMA and asked CMA colleagues to give access to the full orbital data of FY-3D and FY-3E.

Dr. Keiichi Kondo, Numerical Prediction Division / Meteorological Research Institute, Japan Meteorological Agency, talked about **Impact of microwave radiance assimilation over land using dynamic emissivity in the global NWP system of JMA**. Assimilating the microwave radiance observations is essential for numerical weather prediction systems (NWPs). For the radiance assimilation, it is important to estimate land surface emissivity and land surface temperature(LST) which spatiotemporally varies depending on surface conditions. A dynamic emissivity (DE) method can dynamically estimate emissivity and LST from satellite observations and reduces uncertainty related to the radiative transfer calculation. The Japan Meteorological Agency/Meteorological Research Institute (JMA/MRI) is working on applying the DE method to the global NWP system of JMA. The DE method was applied to surface-sensitive channels of the advanced microwave sounding unit (AMSU-A) and advanced technology microwave sounder (ATMS), and was evaluated by data assimilation experiments. As a result, the forecast skill was improved where the STDV between brightness temperatures of background and observation became smaller especially in summer.Dr. Kondo presented the most recent updates.

A participant asked How they got emissivity and LST separate and Dr. Kondo answered they used two experiments. The questioner then commented that emissivity and LST must be obtained from separate sources because these two contribute to the total radiance.

Ms. Izumi Okabe, Meteorological Research Institute of Japan Meteorological Agency, talked about **Impact of Aeolus wind data assimilation on typhoon track forecasting**. As the first satellite mission to give wind profile information on a global scale, Aeolus was launched in 2018, and its horizontal line of sight (HLOS) wind data has been available from the European Space Agency (ESA) Earth Online Portal since May 2020. The significant positive impact of this data on numerical weather prediction (NWP) has been reported in many researches. Ms. Okabe and colleagues investigated the impact using JMA's global data assimilation (DA) system and the global spectral model (GSM), finding the forecasting accuracies of analisis were significantly improved in terms of

multiple aspects. They also investigated its impact on typhoon track forecasting in detail. Assimilation experiments were conducted on 20 typhoons from August to November 2020. The result showed that the improvement ratios depended on the relative position relationship between Aeolus's coverages and typhoon centers (TCs). The detail of the results was shown in the presentation.
A participant asked how many cases they have done for showing the impact zone for typhoon. Ms. Okabe answered that 20 typhoons occurred in the experiment's period, and the experiment's period was about 100 days and four times analysis per day so they investigated 400.

Dr. Kozo Okamoto, Meteorological Research Institute of Japan Meteorological Agency, talked about **All-sky infrared radiance assimilation of Himawari-8 in the global data assimilation system at JMA**. Infrared all-sky radiance (ASR) assimilation has been developed for Himawari-8 in the global data assimilation system of JMA. Compared to clear-sky radiance (CSR) assimilation currently implemented, this development is expected to enhance the observation coverage, reduce sampling dry bias, and extract more observation information in meteorologically sensitive regions, and then improve analysis and forecasts. There are many challenges in the development of infrared ASRassimilation including poor representation in radiative transfer model (RTM) and forecast model. Data assimilation cycle experiments suggested the ASR assimilation of water vapor bands of Himawari-8 improved up to 48-h forecasts of upper- and middle tropospheric water vapor and temperature especially in tropics over CSR assimilation. Dr. Okamoto shared the results of sensitivity experiments, which demonstrated cloud-dependency predictors are important in the presence of significant O-B bias.
The chair asked what was the parameter from observation he mentioned, if it was information independent from the other channels. Dr. Okamoto answered that that did not depend on other observations and they used just the Himawari 8 observations and the forecast model parameters calculated from the background model. Another participant asked if they had found any time-dependent O-B pattern. Dr. Okamoto said no. Another question was on observational error covariance in terms of cloud types.

Mr. Naoto Kusano, Numerical Prediction Division, Japan Meteorological Agency, talked about **Impact of clear-sky radiances at CO2 band in the JMA's global data assimilation system**. Clear-sky radiance (CSR) data derived from Himawari-8, GOES-16/-17, Meteosat Second Generation (MSG)-2/-4 are currently used in the JMA's operational global data assimilation system. CSRs at water vapor (WV) bands of 6.2, 6.9 and 7.3 μm are assimilated in order to obtain information about WV amount at the mid and upper troposphere for analysis of the system. The team tried CSRs at CO2 band of 13.3 or 13.4 um assimilation to extract information about temperature at the low troposphere. The validation using GCOM-C LST product showed that accuracy of retrieved LST is higher than FG LST. The result of assimilation experiments showed that use of CO2 band CSRs with the LST retrieval successfully improved analysis accuracies and forecasts scores of not only temperature but also relative humidity and wind speed. Mr. Kusano presented details of such experiments and their efforts.
The Chair asked how they got the LST information. Dr. Okamoto answered that they retrived LST from other channels than Himawari 8, a window channel.

Prof. Ryoichi Imasu, Atmosphere and Ocean Research Institute, The University of Tokyo, talked about **Investigation of loading an infrared sounder on a geostationary satellite by the infrared sounder subcommittee of the Next Generation GEO/Mission Investigation Team (NGG/MInT).** In 2013, the Remote Sensing Subcommittee under the Task Force (TF) on the Future Space System Development was established as an organization that was supported by 23 academic societies related to earth observation in Japan. It summarizes user requirements for satellite remote sensing, and its activities such as discussions on future mission plans have started. As one of the sub-organizations, the Next Generation GEO / Mission Investigation Team (NGG/MinT) was established to discuss the future geostationary-satellite based sensor development. Meanwhile, due to the persistent requirements for greenhouse gas observations from the geostationary orbit, JAXA also studies the feasibility of imaging FTS based on the thermal infrared sounders mounted on the greenhouse gas observation satellites, GOSAT and GOSAT-2. Proffesor Imasu reported on the activities of the Infrared Sounder Subcommittee.
The Chair asked if the greenhouse gas spectral resolution was good enough to capture the most of greenhouse gas. Professor Imasu answered that though it was enough for detecting CO2 and of course, other temperature and water vapor profiles, the most serious problem was the spectral band. It is still difficult to achieve that joint requirements from both, he said. Other questions covered the profiles used for assimilation and OSSE.

Mr. Hiroyuki Shimizu, Numerical Prediction Division, Japan Meteorological Agency, talked about **Assimilation of hyperspectral infrared sounder radiances in the JMA's meso-scale NWP system**. Assimilation of hyper spectral infrared sounder (HSS) radiances observed by satellite is beneficial for improving temperature and water vapor profiles in numerical weather prediction (NWP). JMA has been assimilating HSS radiances in the global NWP system. The JMA team is now working on assimilation of HSS radiances in the meso-scale NWP system. Data assimilation experiments were conducted for summer and winter season. The results showed that tropospheric temperature and water vapor forecasts have slightly improved. Precipitation forecasts have also improved.
A participant encouraged the team to consider using all channels through principal components, which can bypass all apodization impacts that were negative for the use of data. A participant asked how many channels they employed for the assimilation and Mr. Shimizu answered that they used about 10 channels and 9 channels or so for the temperature and water vapor, respectively.

Ms. Hiromi Owada, Japan Meteorological Agency, talked about **Observation system simulation experiments for a hyperspectral infrared sounder onboard a geostationary satellite**. The Japan Meteorological Agency (JMA) has been considering the Himawari-8/9 follow-on program since JFY 2018, keeping in mind the CGMS baseline and the Vision for WIGOS in 2040. Particular focus has been placed on the deployment of hyperspectral infrared sounders (HSSs) across the full GEO ring. HSSs on board geostationary satellites (GeoHSSs) are highly regarded as potential payloads for global observation networking (as recommended by the Vision for WIGOS in 2040) and for their capacity to help improve JMA's services in relation to extreme weather monitoring,

nowcasting and numerical weather prediction (NWP). JMA has conducted Observation System Simulation Experiment (OSSE) for GeoHSS to assess related effects on NWP. Ms. Owada reported the results of OSSEs with recent cases.
The Chair asked on the spatial resolution for OSSE. Ms. Owada answered that she calculated the simulated brightness temperature from ERA5 data set, adding that the model resolution was 20 km for global and 5km for regional system. Then the questioner emphasized the importance of studying the best permutation of the spatial and temporal resolution.

Dr. Tadashi Fujita, Meteorological Research Institute, Japan Meteorological Agency, talked about **Mesoscale OSSE for the potential impact of a geostationary hyperspectral infrared sounder**.
The potential impact of a hyper spectral infrared sounder on a geostationary satellite (GeoHSS) is investigated in a regional numerical weather prediction system, assuming the Himawari follow-on satellite. A reanalysis-based observing system simulation experiment (OSSE) technique is applied to the Baiu seasons of 2018, 2017, and 2020 including heavy rainfall cases. Temperature and relative humidity pseudo-observations are generated by a 1D-Var retrieval scheme based on the spectral characteristics of the GeoHSS. Clear-sky radiances computed from the pseudo-truth atmospheric profile, ERA5, are used as observations in the 1D-Var. Statistical verifications and case studies show that the impacts on precipitation are seen especially at the longer lead times, which are often accompanied by improved small lows on the Baiu front and upper-level troughs.
A participant asked if they had done some validation of the simulated radiance when doing the simulated radiance from ERA5. A JMA colleague replied that they had not done exact validation for the radiances. Another participant praised JMA's research on this theme and encouraged them to continue to investigate the performance.

Closing Remarks

The co-chair Dr. Allen Huang from the University of Wisconsin-Madison firstly thanked all over 110 participants and praised all wonderful sessions. He also expressed his appreciation for JMA staff who made efforts in organizing AOMSUC-12 virtually, as it was not so easy to exchange ideas and renew friendships remotely.
He then summarized the five days of the conference, looking back each session briefly.
Then he invited a KMA representative, Dr. Dohyeong Kim, a host of the next conference (AOMSUC-13) in South Korea. The representative from KMA explained the plan of AOMSUC-13, which would be held from 3 to 10 November 2023 in Jeju or Busan, and expressed he looked forward to meeting all participants at AOMSUC-13.