AOMSUC-10 Summary Report

The tenth Asia-Oceania Meteorological Satellite Users' Conference (AOMSUC-10) was held in Melbourne, Australia from 2-7 December 2019. AOMSUC-10 was hosted and sponsored by the Australian Bureau of Meteorology (AuBOM), and was co-sponsored by the China Meteorological Administration (CMA), the Japan Meteorological Administration (JMA), the Korean Meteorological Agency (KMA), the Indonesian Agency for Meteorological, Climatological and Geophysics (BMKG), Roshydromet and Roscosmos of the Russian Federation, the India Meteorological Department (IMD), the India Space Research Organization (ISRO), the World Meteorological Organization (WMO), and the Group on Earth Observations (GEO).

Exciting times are underway with satellite meteorology, oceanography and ecology across Asia-Oceania with the new generation of international meteorological/environmental satellites. An exceptionally robust constellation of geostationary satellites provides digital data from instruments that include lighting mappers, hyperspectral atmospheric sounders and high resolution multispectral visible/infrared imagers; many of those imagers scan the full Earth disc as frequently as every 10 minutes, and for special weather events as frequently as every two minutes. A fleet of advanced international polar orbiting satellites provide high resolution digital data from multichannel visible, infrared and microwave imagers, microwave sounders and hyperspectral high-resolution infrared sounders. This robust constellation of polar orbiting and geostationary satellites are providing data for a range of environmental, meteorological, ocean and climate related applications. The satellite operators are meeting their commitment as we introduce this new era of the Space Based Component of the WMO Integrated Global Observing System (WIGOS). Participants welcomed the efforts being undertaken to introduce and utilize this unprecedented stream of new data. Numerical weather prediction accuracy out to ten days or more has especially profited from these core and new generation satellite data sets. The future for meteorological, oceanographic and environmental services using those satellite data and products are bright. New and sophisticated applications are serving a variety of users across the Asia-Oceania region. The prospects for young scientists entering the field of satellite meteorology and environmental applications is exceptionally promising, particularly when coupled with the growth in computer and communications technology. Exciting times are here, and exceptional times await humankind as we, the Asia-Oceania Meteorological Satellite Users Community move forward and exploit the potential presented to us from these new data sets.

AOMSUC-10 began with a two-day training event, that brought together participants from WMO Regions II and V. Including lecturers and attendees, 45 people from 26 countries throughout the Asia-Oceania region participated in the training event. The training event (summarized later in this document) was held the Royal Melbourne Institute of Technology (RMIT University) in Melbourne: the training area was exceptionally suited for such a training event and technical computing and network support was exceptional. The next three days of AOMSUC-10 were the Conference portion consisting of 62 oral, 20 poster presentations and a closing panel session. The Conference was attended by over 138 people from 28 countries. The final activity associated with the AOMSUC-10, held on December 7 was a smaller, focused meeting: "The 2nd Joint Meeting of the WMO RA II WIGOS Project and RA TT-SU for RA II and RA V NMHS."

The Conference portion of AOMSUC-10 took place at the Melbourne Conference and Exhibition Centre, Melbourne, Australia. The Conference was officially opened on December 4 by Dr. Nichole **Brinsmead**, Group Executive Data and Digital, Australia Bureau of Meteorology. Conference Opening Addresses were presented by:

- Australia: Dr. Nichole Brinsmead, Group Executive Data and Digital, AuBOM
- Australia: (Uncle) Perry Wandin, elder of the Wurundjeri people
- Australia: Dr. Anthony Murfett, Deputy Head Australian Space Agency
- International Conference Steering Committee: Dr. James Purdom, Chair, AOMSUC ICSC
- People's Republic of China: Dr. Xinwen Yu, Deputy Administrator of CMA
- India: Dr. Sumon Goyal, Head Satellite Applications, IMD
- Indonesia: Dr. A. Fachri Radjab, Director Public Weather Services, BMKG
- Japan: Mr. Kotaro Besso, Senior Coordinator for Satellite Systems, JMA
- Republic of Korea: Dr. Seonghoon Cheong, Director, Satellite Development Division, NMSC/KMA
- Russian Federation: Prof. Vasily Asmus, Director SRC Planeta, Roshydromet
- WMO: Dr. Werner Blalog, Space Programme, WMO

Dr. Brinsmead welcomed the participants to the AOMSUC-10 Conference, stressed the importance of satellite data to AuBOM in meeting their mission objectives and wished success for the conference. Dr. Brinsmead welcome remarks were followed by a Traditional Welcome to Country from (Uncle) Perry Wandin an elder of the Wurundjeri people who are the traditional owners of the lands on which the convention center where the AOSMUC-10 took place. In his welcome he presented the conference participants with interesting historical context with respect to the people who originally were the inhabitants of the Melbourne area.

After the opening remarks of Dr. Brinsmead and the traditional welcome, welcoming remarks were made by the Australian Space Agency, ICSC Chair, and those cosponsors that were present at AOMSUC-10. Welcoming remarks from the newly formed Australian Space Agency (ASA), Dr. Anthony Murfett, Deputy Head ASA. Dr. Murfett reported that ASA is investing half billion dollars already with a goal to create 20,000 new jobs and build to be a respected space agency and planning to invest up to 12 billion to 2030. Dr. Murfett covers four key focus of ASA on international partnership; building national capability; inspiring next generation; and conduct business and research. He concluded with a video introducing ASA for general public.

Welcome remarks from the ICSC Chair: Dr. James F.W. Purdom, Chair of the AOMSUC International Conference Steering Committee welcomed the participants and iterated the four main goals of AOMSUC: 1) promote the importance of satellite observations and promote their utility; 2) advance satellite remote sensing by fostering scientist to scientist interaction; 3) provide a means for satellite operators to interact directly with the user community; and, 4) engage young people entering the field.

Mr. Fachri **Radjab**, , Director of Center for Public Weather Services, BMKG, Dr. Nichole **Brinsmead**, Group Executive Data and Digital, Australia Bureau of Meteorology AuBOM, and Dr. **Suman Goyal,** India Meteorological Department, as representatives of users across Oceania reflected on the importance of the AOMSUC in bringing together satellite operators and the user community. They noted the positive efforts to engage the user community and to offer training with AOMSUC in order to achieve improved satellite data utilization. They thanked the satellite data providers for their good efforts in sharing data and information across the region. Dr. Goyal expressed India's desire to host a future AOMSUC.

Dr. Xinwen Yu, CMA, Dr. Kotaro Besso, JMA, and Dr. Seonghoon Cheong, NMSC/KMA, and Prof. Vasily Asmus, SRC Planeta Roshydromet, as satellite operators across Asia/Oceania all spoke of the opportunities afforded to Asia/Oceania with the greatly improved observing capabilities presented by the new generation of geostationary and polar satellites being introduced recently and over the next few years. They addressed new satellite opportunities that they had introduced since the AOMSUC-9. They recognized the importance of AOMSUCs in promoting the importance of satellite observations and improving their utility, as well as providing a means for them to interact directly with the user community. CMA, KMA and JMA all announced that they would provide special rapid scan service to users in Asia/Oceania upon request to help in their disaster reduction efforts. All expressed their strong support for AOMSUC.

In particular, Dr. Yu of CMA reported that CMA has developed a future action plan for the international application and service of Fengyun meteorological satellites. This action plan has outlined CMA's actions for a wider range of FY satellite data and products, an improved capacity of FY meteorological satellites in international services, and an enhanced capacity building of international users. He further pointed out that more FY data are open and available to international users, including those from FY-2H and FY-4, which has further increased data types and coverage of FY satellites. In particular, FY-2H globally provides more meteorological observations over the Indian Ocean. Users can make access to FY meteorological satellite data and products via several channels such as CMACast user stations, direct receiving stations, public clouds, and World Meteorological Center-Beijing. Dr. Yu concluded that in 2020, the 11th Asia-Oceania Meteorological Satellite Users' Conference will be held in China again.

Dr. Werner Balogh from the WMO Space Programme, representing all Members of WMO expressed the WMO's strong support for the AOMSUC. He extended his appreciation for all who were to present at the conference and wished for successful results. He pointed out that of the 17 United Nations Strategic Development Goals that WMO contributed to 12, and he urged Members to strive toward the effective use of satellite data and products toward meeting those goals.

The Conference portion of AOMSUC-10 was divided into six oral sessions with a seventh wrap-up (question/answer) session. Posters were conveniently set up in the coffee break area, which allowed for their viewing during break times. The six oral presentation sessions each was co-chaired by two ICSC members and an expert from ABOM, covered the following topical areas:

Session 1: Current and Future Meteorological Satellite Programs and User Activities/Plans within Asia/Oceania

Session 2: Facilitation of Data Access and Utilization, including Training Activity

Session 3: Application of satellite data to Numerical Weather Prediction and derivation of atmospheric parameters

Session 4: Application of satellite data to weather forecasting

Session 5: Application of satellite data to the derivation of surface parameters and phenomena

Session 6: Performance and calibration of satellite instruments

The AOMSUC-10 venue was exceptionally well suited for a major international gathering; audio visual support was outstanding, and staff was always on hand when needed. It was evident to all that an exceptional effort had been put forth by the staffs of the AuBOM in the planning and organizing of AOMSUC-10. Both oral and poster presentations were of the highest quality without exception. The conference was very successful in meeting the four major conference goals as set forth by Dr. Purdom in his welcoming remarks. It was evident throughout the conference that the new generation of geostationary and polar orbiting satellites have already had a major impact across Asia-Oceania – great scientific adventures await us as we move forward with science and product development and new applications with these data. The satellite operators are meeting their commitments as we inaugurate this new era in the Space Based Component of the WMO Integrated Global Observing System (WIGOS). The participants welcomed the efforts being undertaken to introduce and utilize an unprecedented stream of new data; it was agreed that this early coordination in the generation of new products and services and the preparation for their utilization by the worldwide user community must be energetically sustained. It will be a significant undertaking for the operational space agencies in the coming years foster the dream of "full utilization." These annual conferences of the Asia-Oceania satellite community are an important part of that effort. At the end of AOMSUC-10, Dr. Xiang **Fang** announced that CMA/NSMC looked forward to hosting AOMSUC-11 in the area of Beijing China during the fall of 2020 with a format similar to that of AOMSUC-10.

Session co-chairs provided summaries of their sessions, below, while Mr. Bodo **Zeschke** provided the summary of the training event, also below. The activity of the Coordination Group that met on the final day of AOMSUC-10 is an ongoing WIGOS activity, its summary may be found by going to the WMO WIGOS web site.

Abstracts and presentations at AOMSUC-10 may be downloaded from the conference website: http://www.bom.gov.au/research/aomsuc-10/index.shtml. Selected photos taken during AOMSUC-10 will also be available on the website.

AOMSUC-10 Training Event

The AOMSUC-10 Training Event was conducted on the Royal Melbourne Institute of Technology (RMIT) University Campus, Melbourne Victoria 2-3 December 2019. There were 45 attendees as well as presenters from 26 countries throughout the Asia-Oceania region and also including some attendees from the USA and Europe.2

For this AOMSUC-10 we attempted a number of ground-breaking initiatives. Firstly, the two days were divided into a predominantly interactive teaching session on the Monday utilising the Socrative cloud based learner response system. Audience interaction was further enhanced by panel and group discussions conducted during Tuesday morning's sessions. The Training Event also hosted a Regional Focus Group meeting as conducted by the Australian VLab Centre of Excellence.

The opening address was presented jointly by the AOMSUC-10 Chair Dr Jim Purdom, RMIT University representative Dr Ronald Maj, Australian Bureau of Meteorology (BOM) representative Dr John Le Marshall and Bureau of Meteorology Training Centre (BMTC) representative Mr. Bodo Zeschke.

The basics of satellite spectral bands and their uses as well as application of these bands into the generation of RGB composites was presented by Dr Purdom and Mr Zeschke respectively during the first two sessions of the training. Mr Zeschke also introduced the participants to the Socrative cloud based learner response system as the interactive tool for this Training Event.

The introduction to nowcasting using satellite data and products to Tropical Cyclones, thunderstorms and heavy precipitation was presented by Joe Courtney and Dean Narramore of BOM and Mr Andersen Panjaitan of BMKG Indonesia respectively. According to the results of a recent WMO survey of 33 countries across RAII and RAV these types of hazardous weather were found to be of greatest importance.

The afternoon sessions concluding the first day included presentations demonstrating the SATAID and SLIDER satellite image rendering tools by Mr Akihiro Shimizu of the Japan Meteorological Agency (JMA) and Dr Curtis Seaman of the Cooperative Institute for Research in the Atmosphere (CIRA). Nowcasting applications using GEO-KOMPSAT-2A data was presented by Dr Hyesook Park of the Korea Meteorological Administration (KMA).

Tuesday morning's session commenced with representatives from the China Meteorological Administration (CMA), JMA, KMA and the National Oceanic and Atmospheric Administration (NOAA) showcasing how to access their respective satellite data in a panel led discussion.
This was followed by a presentation by Dr Jim Purdom demonstrating the versatility of the SLIDER satellite data visualisation tool, reinforcing the corresponding presentation of the previous day.
Mr Toshiyuki Kurino of JMA and Professor Yuriy Kuleshov (BOM) introduced the WMO Space-Based Weather and Climate Extremes Monitoring Demonstration Project (SEMDP) showing many examples to the audience.

After morning tea the attendees divided into smaller groups and consulted with experts in consolidating the content of the previous sessions. It was gratifying to see the great engagement across these groups. After lunch Mr Zeschke hosted the 75th Regional Focus Group (RFG) meeting as conducted by the Australian VLab Centre of Excellence. This was followed by a Socrative question and answer session asking for feedback and giving participants the opportunity to recommend useful topics for future RFG meetings.

Finally, it was time for the attendees to don their Anaglyph 3D glasses as we all took a peek into what the future would hold. Mr Zeschke presented a session pertaining to the effective utilisation of satellite data from multiple satellite platforms, including useful earth limb case studies as well as three dimensional stereo satellite imagery. During the final session of the Training Event participants were asked to offer feedback on the effectiveness of the training and this was summarised by the AOMSUC-10 Chair during the concluding address. During this address Dr Purdom mentioned that this had been a very interesting two days training with good interaction. Dr Purdom observed that all attendees were engaged during the training event. He noted that clearly the attendees had come away from the training with new knowledge and understanding. Overall the Chair was happy with what had happened during the event. He reflected that there are very few training events that last for just two days. For future AOMSUC Training Events a duration of three days was recommended, with an alternative of a two day event consisting of 12 hours of training per day. In particular such a training event should be composed of "blocks" of training in which interactive lectures were followed by corresponding practical sessions that further explore the topic of the lecture. There is also the possibility to cover additional topics such as satellite derived products in greater depth.

In the summary addresses the coordinators of the Training Event Mr Jeff Wilson and Mr Bodo Zeschke thanked the organisers, presenters and participants for a very enjoyable two days of satellite meteorology. Mr Zeschke reminded the audience that the feedback provided during the summary session was indeed only "the tip of the iceberg" and that the information contained in the audience response to the Socrative questions would be forwarded to relevant parties for future follow up action.

SESSION SUMMARIES

Session 1: Current and Future Meteorological Satellite Programs and User Activities/Plans within Asia/Oceania

Session Chairs: Dr. James F.W. PURDOM (ICSC), Dr. Allen HUANG (ICSC), Ms. Agnes LANE (ICSC and AuBOM)

Dr Boris Kelly-Gerreyn, Acting General Manager, Data-Chief Data Officer of the Australian Bureau of Meteorology informed the AOMSUC about **Satellite activities at the Australian Bureau of Meteorology**, including the key areas of satellite data assimilation, development of satellite based products and services, and international cooperation. The Bureau of Meteorology receives, processes and archives over 30 satellite data streams in real time and near-real time. Satellite data many of the weather and warning services delivered to the Australian community and are assimilated into the Bureau's Numerical Weather Prediction models and are displayed in real time on the Bureau's web page. Demand for satellite data is also increasing as users discover the enhanced capabilities of the new generation of meteorological satellites, allowing them to integrate satellite observations with other data types using state of the art processing techniques. Dr. Kelly-Gerreyn discussed BOM routinely use more than 20 types of satellite data and operate 8 real-time direct broadcast facilities and that significantly improve the NWP forecast skill when using the data collected. He concluded with examples of operational research products that have been used for many disciplinary areas and stated that the accuracy of the 4-day forecast when using all available satellite data is equivalent to a 1-day forecast without using any of the satellite data – a great testimony about the value of meteorological satellite data for Australia.

Mr. FANG Xiang, from the National Satellite Meteorological Center, China Meteorological Administration, updated the conference on **The Latest Progress on Chinese FengYun Satellite and its Applications.** Compared with the first generation polar-orbiting satellite, FY-3D which was launched in November 2017 is more capable in terms of vertical temperature and humidity sounding, ozone detection, and microwave imaging. The new generation of geostationary satellites, introduced with FY-4A is in operation by providing data and products from its imagery, sounding and lightning mapping payloads. In June 2018, FY-2H was successfully launched and positioned at 79 degrees east longitude to ensure the observational coverage over the Indian Ocean. Both FY-3D and FY-2H have been providing operational services to domestic and overseas users since January 1, 2019, and CMA introduced the Emergency Support Mechanism of FengYun Satellites for extreme meteorological or environmental events. CMA will operate the FengYun satellite in a rapid scan imaging mode over the affected area and provide customized monitoring products to the requestor.

Over the past several years CMA has provided receiving equipment of FengYun satellites for 22 countries and provided services for more than 90 countries and regions. It has held international training courses attended by more than 900 international participants in the past three years.

Mr. FANG reported that 2,600 DVB-S users have been actively receiving FY series of data and products (>120) including FY4-A first GEO hyperspectral IR sounding and LMI lightening data with microwave data showing large than 5K warm core anomaly was observed for a typhoon case. He further reported that the new FY-3D will have a payload of 10 sensors including 5 continuing sensors, 2 improved and 3 new sensors. The future program will include 9 new FY satellites until 2025. High speed imager will feature resolution ranging from 250m, 500m, 1000m to 2000m, early AM orbit will continue with low-light bands and wind measuring capability. He also mentioned that the 2019 FY users meeting draw participants from 30 countries and FY NOW and FY Earth apps are available to mobile users.

Dr. Suman Goya from the India Meteorological Department, talked about **Present and future Meteorological Satellites of India.** Dating back to the APT (Automatic Picture Transmission) era IMD is one of the earliest met departments in the world to use satellite data for weather monitoring and forecasting. The first ever dedicated Indian meteorological satellite METSAT was launched in Sep 2002 (renamed as Kalpana-1 in 2003 after the Indian born American Astronaut Dr. Kalpana Chawla) with an important addition of a high level Water Vapour channel. Oceansat-2, launched on September 23, 2009, carries Ocean Colour Monitor, Ku-band Scatterometer and a Radio Occultation Sounder for Atmospheric studies. This Scatterometer data available at 1 km resolution. In 2011, an INDO-French mission known as Megha-Tropiques was launched for studying the water cycle and energy exchanges in the tropics. It is a member of the eight-satellite constellation for Global Precipitation Measurement (GPM). With its circular orbit inclined 20 deg to the equator; the Megha-Tropiques is a unique satellite for climate research that aids scientists seeking to refine prediction models.

Currently IMD has 2 dedicated meteorological geostationary satellites INSAT 3D and INSAT 3DR have 6 channel imager and 19 channel sounder capacity. The best spatial resolution is 1km for Vis, 4km for IR and 8km for WV. The combined temporal resolution is 15 minutes with INSAT 3DR having facility of rapid scanning. The imagery and products are made available on a web-GIS based Real-time Analysis and Information Dissemination (RAPID) system. The radiance data is also assimilated in the operationally run NWP models of IMD. These satellites have also carried Data Relay Transponders to facilitate reception and dissemination of meteorological data from in-situ instruments located across vast and inaccessible areas. A polar orbiting satellite ScatSat-1 was launched as a continuity mission for Oceansat-2 Scatterometer to provide wind vector data products for weather forecasting, cyclone detection and tracking services to the users for the analysis of scatterometer based winds at Sea surface.

Future satellite plans include GISAT with high resolution, hyper-spectral payload having very high spatial resolution of ~ 50m to 500m and temporal resolution of 10 minutes with multiple scan scenarios. The satellite is expected to be launched in near future. Another polar orbiting satellite Oceansat-3 dedicated for Ocean observations is under development. Near real-time access to the products is under consideration through ISRO and EUMETSAT.

Dr. A. Fachri Radjab from the Agency for Meteorology, Climatology and Geophysics of Indonesia, Jakarta, Indonesia informed AOMSUC-10 of **Satellite Data Utilization to Support Disaster Risk Reduction Plans in Indonesia**. Indonesia is vulnerable to natural hazards due to its geographical position and mountainous topography. In addition, an extensive area of peatland over Sumatera and Kalimantan aggravated forest fire spread. Every year Indonesia is suffering significant loss of life and property. From the ten most commonly reported disasters, nine are directly or indirectly related to weather or climate. BMKG has built an early warning system to support disaster risk reduction that includes automatic production and dissemination of digital format products in WMO CAP standard. One important component of the system is satellite based products which are used for convective cloud development and heavy precipitation monitoring, high temporal resolution of hotspots, haze dispersion monitoring, and volcanic ash dispersion. Other products relate to climate services including long term rainfall average, frequency of convective cloud and dry days monitoring to support drought early warning. Challenges remaining include satellite products development including early warning of local scale extreme weather, marine parameters, and validation of current products.

Mr. Radjab reported that with 17,504 islands located in two oceans with trade wind and monsoon weather 3,271 natural disasters were occurred in 2019 with 77% of it related to hydro-meteorological. Thirty-four forecast users are actively forecasting thunderstorm, forest fire, flood and land slide events and BMKG's integrated forecasting systems are routinely producing warning map to monitoring and mitigating the impacts. GeoHotSpot based on AHI; FY-2; Terra/Aqua MODIS data are developed for fire monitoring and haze dispersion, GSMaP based consecutive dry days is also issue for draught monitoring.

Mr. Kotaro BESSHO-san from the Japan Meteorological Agency, Tokyo, Japan talked about the **Status of Himawari-8/9 and their new services.** The Japan Meteorological Agency (JMA) has been operating the Himawari-8 geostationary meteorological satellite since 7 July 2015. The Agency also began the operation of Himawari-9 serving as back-up to Himawari-8 on 10 March 2017. Himawari-8 and -9 are in geostationary orbit at around 140.7°E ; switchover from Himawari- to 9 is planned for in or around 2022. They will support JMA's stable provision of continuous satellite observation data for the Asia-Oceania region until 2029, providing observation and data collection services for the East Asia and Western Pacific regions. Operational information regarding Himawari-8/9 is provided on JMA's Meteorological Satellite Center (MSC) web page at https://www.data.jma.go.jp/mscweb/en/operation8/.

In January 2018, JMA launched a new international service "HimawariRequest", in collaboration with the Australian Bureau of Meteorology. The service allows NMHS users in Himawari-8/9 coverage area to request Target Area observation covering a 1,000 km x 1,000 km area every 2.5 minutes. As of 11 October 2019, JMA had taken registrations from twenty NMHSs in RA II and RA V, and opened the service to the sixteen whose preparations for request submission were complete. There have been 15 international request observations since the commencement of the service.

JMA has started the usage and dissemination of new satellite products as below. The ASWinds sea surface wind product is currently provided to RSMC-Tokyo for typhoon analysis and in June 2019 it was released on the MSC website to support tropical cyclone monitoring for disaster risk reduction activities in the Asia-Oceania region. The new AOD retrieval algorithm developed by JAXA is currently in operational use. The resultant data product is provided every 10 minutes and used to monitor Aeolian dust events and will be assimilated into JMA's aerosol prediction model. A fog detection product has been provided online since March 2019 for Japan domestic aviation operators with a global version of the product under development.

Mr. BESSHO reported that AHI image navigation quality is now better than 0.2 pixels with stable but small degradation. When validated against with IASI it has an estimated error of 0.2K. The new product – AMV based sea-surface wind (ASWind) at 4 km resolution with 30 minutes would be very useful for typhoon intensity classification. AHI AOD is now assimilated by JAXA into NWP model at every 10 minutes interval. Convective cloud information (CCI) is available as well. Important announcement about the transition of Himawari-8 to Himawari-9 will occur at 2022. HimawariCast will be using JCSAT-2b communication satellite and LRIT will be terminated and replaced with HRIT. JDDS will be replaced by HTTPS new service.

Dr. Seonghoon Cheong, National Meteorological Satellite Center, Korea Meteorological Administration, presented information on the **Current status and future plans on KMA Satellite Programme.** The Geo-KOMPSAT-2A geostationary meteorological satellite (located in 128.2°E) began operation at 00 UTC on 25 July 2019, continuing the COMS (Communication, Ocean and Meteorological Satellite) mission of strengthening Korea's capability to monitor the atmospheric environment over Asia-Pacific region. The Geo-KOMPSAT-2A data and images are now available through NMSC webpage (http://nmsc.kma.go.kr/enhome/html/main/main.do).

From Geo-KOMPSAT-2A data KMA produces 52 geophysical products such as scene/surface, cloud/rainfall, radiation/aerosol, and atmospheric condition and aviation. KMA also utilizes the Advanced Meteorological Imager (AMI) data for nowcasting and short-range forecast application, and expects to improve the NWP performance based on the improved temporal resolution.

For meteorological observation, KMA operates the AMI at 10 minute timelines to include 3 observation areas: full disk, extended local area (ELA with 3,800 by 2,400 km^2) and local target area (LA with 1000 by 1000 km^2). KMA broadcasts all 16 channels of AMI in full resolution via GK2A named Ultra HRIT and also maintains HRIT broadcast corresponding to COMS five channels. And the landline based real-time FTP data service similar to Himawaricloud is also available.

KMA will provide rapid scan images every two minutes to the users over the Asian Pacific region (RA II and RA V) by receiving the users' official request via dedicated web tool. KMA expects that the rapid scan images could provide significant improvements in the real-time monitoring of hazardous weather such as Typhoon, thunderstorm and volcano events. KMA expects that Geo-KOMPSAT-2A will also be utilized for climate change monitoring, hydrology and environmental applications.

Dr. Cheong reported that 10 minutes AMI full disk and 2 minutes AMI are available for RA II and RA V. The rapid scan target observation will also be available with first priority for disaster events (typhoon; fire; dust and thunderstorm). Visible and infrared rapid scan AMV are produced and RDT is developed. Night time aerosol is being developed, LDUS is for UHRIT through DVB-S2; SDUS can be received by 2 axis tracking antenna on board ships for real-time applications.

Prof. Vasily Asmus, Director, SRC Planeta, Moscow, presented a **Report on the status of current and future Russian Earth observation satellite systems** based on activities at SRC Planeta, ROSCOSMOS Moscow (Dr. Khailov) and ROSHYDROMET (Dr. Tasenko). The Russian space system for hydrometeorological and environmental monitoring consist of three polar-orbiting meteorological satellites (METEOR-M series), three geostationary meteorological satellites (ELECTRO-L series to be placed at 14.5W, 76E and 166E orbital positions) and two highly elliptical orbit satellites (ARCTICA series). Currently, this orbital constellation consists of 11 Earth observation satellites: four meteorological satellites (polar-orbiting METEOR-M N1, N2 and N2-2, and geostationary ELECTRO-L N2); six natural disaster monitoring satellites of KANOPUS-V series; one environmental monitoring satellite of RESURS-P series.

METEOR-M N1 satellite has reached the end of designed lifespan (5 years), but has not been decommissioned as some instruments are still functioning. Meteor-M N2 satellite is operational, despite reaching EOL. Basic payload of Meteor-M N2 satellites consists of MSU-MR Scanning Radiometer (1 km spatial resolution, 6 channels, VIS/IR); KMSS VIS Scanning Imager (6 channels implemented by 3 cameras, 50 m and 100 m spatial resolution); Severjanin X-band Side-Looking Radar (500 m and 1000 m resolution); MTVZA-GY Imaging/Sounding Microwave Radiometer (26 channels, 10.6-183 GHz); IKFS-2 Infrared Fourier-transform Spectrometer (hyperspectral atmospheric sounder, spectral range 5-15 μm, spectral resolution ~ 0.5 cm^{-1}); data collection system (DCS). The polar-orbiting METEOR-M N2-2 was launched into an afternoon orbit on July 5th, 2019 and is currently in the commissioning phase.

The key payload of ELECTRO-L N2 (76E) consists of MSU-GS imager that provides data in three visible and seven IR channels. The spatial resolution at sub-satellite point is 1 km for visible and 4 km for IR channels. The period between scanning sessions for all channels is 30 min, and in the more frequent mode - 15 min. The launch of Electro-L N3 (165.8E) is scheduled for 2019. The payload will be similar to Electro-L N2 spacecrafts, but with improved MSU-GS instrument performance.

The work on the development of ARCTICA-M project on the "Molnya" highly elliptical orbit was started in 2011, and the first satellite is planned to be launched in 2020. It will provide the observations over the Arctic region. The payload of Arctica-M satellites will be similar to Electro-L series.

The Russian orbital constellation should comprise of eight high resolution satellites of RESURS and KANOPUS series. The next launch of RESURS-P satellites is scheduled for 2020, while two KANOPUS-V satellites are planned in 2025.

The Roshydromet ground segment consists of three SRC Planeta federal satellite centers, responsible for receiving, processing, disseminating and archiving of the satellite data: European (Moscow-Obninsk-Dolgoprudny), Siberian (Novosibirsk) and Far-Eastern (Khabarovsk). These centers together give full coverage of Russia and neighbouring territories. The ground segment also includes the network of DCP (more than 650), LRIT and HRIT stations. The segment provides reception of data from 12 Russian and 22 foreign Earth observation satellites. The system is the largest in the Russian Federation and one of the largest in the world in terms of amount of satellite data received (more than 1.4 Tb per day), the number of satellite-based products issued (more than 530 types per day), and the number of users supported (more than 560 users at federal and regional levels). The main purpose of the system is to provide data and products for use in operational meteorology, NWP, hydrology, agrometeorology, climate studies and environmental monitoring, as well as support of data collection system from Roshydromet network of ground observation sites via geostationary satellites.

Dr. Asmus has also talked about the expert use of AHI data using a special colour enhancement technique to highlight volcano without interference from other weather features. Special technique to produce cloud-free images was also demonstrated.

Dr. Mark S. Paese, M.S., Deputy Assistant Administrator, for National Oceanic and Atmospheric Administration (NOAA) provided an overview of **NOAA; geostationary; polar-orbiting; forecasting; architecture, products.** In his address he pointed out the broad remit concerning NESDIS's activities is driven by our planet's incredible complexity and constantly changing nature. Forecasting weather, understanding climate trends and changing ecosystems, and monitoring environmental hazards requires high-quality, timely, and global observations from Earth observing satellites.

To meet these challenges NOAA is evolving to stay current with the expanding complexity of Earth observing contributors including our partners among the meteorological satellite agencies of Asia.

NOAA continues to forge partnerships around the globe to share the Earth observation on a full and open basis and to ensure users have the information they need to address pressing policy concerns.

Over the past three years, NOAA's advanced geostationary and polar-orbiting satellites, the GOES-R, GOES-S, and NOAA-20 (JPSS series) have become operational. NOAA plans to launch two additional GOES series and three additional JPSS series satellites between 2022 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). NOAA is evolving its approach to common ground systems, satellite architecture, data stewardship, data distribution and user preparedness to ensure a more mission-effective, integrated, adaptable organization that anticipates and responds efficiently to changing technology (e.g. CubeSats, Cloud), emerging partnerships and evolving observation requirements. This evolution requires a new approach to our satellite observing system architecture as well as to NESDIS product development and prioritization processes.

Dr. Mitch Goldberg, NOAA/NESDIS presented on behalf of Dr Kenneth Holmlund, EUMETSAT, on **Monitoring Weather, Climate and Environment from space – An overview of EUMETSAT Satellite Programmes**. EUMETSAT (The European Organisation for the Exploitation of Meteorological Satellites) provides near-real time Earth observation data from geostationary and polar orbiting satellites. These satellites carry a wide range of instruments like sounders (infrared, microwave, UVN, GNSS receivers), imagers, spectrometers, altimeters and scatterometers. In addition to the provision of near-real time data for atmosphere, ocean and land monitoring, these data are used in support of climate monitoring.

Today the core of the meteorological observations are provided by the geostationary Meteosat Second Generation (MSG) and EUMETSAT Polar System (EPS) programmes. The continuity of the observations provided by these missions are secured through the Meteosat Third (MTG) and EPS-Second Generation (EPS-SG) programmes with first launches in the early 2020's with programme lifetimes until 2040 and beyond and which will also embark the Sentinel-4 and -5 instruments for atmospheric composition and air quality monitoring. The product services provided by EUMETSAT are generated in a distributed application ground segment, including the EUMETSAT Satellite Application Facilities, which are now in their third Continuous Development and Operations Phase.

Of specific interest for the Asia-Oceania region are the polar orbiting satellites. In addition to the EPS and in the future EPS-SG satellites, EUMETSAT provides data from the Jason surface ocean topography missions and operates the European Commission Copernicus Sentinel-3 mission. The Sentinel-3 satellites, first launched in February 2016, provide continuity to the European ERS, ENVISAT and SPOT satellites, with high-resolution and high-quality observations of sea and land-surface temperatures and ocean colour together with SAR altimetry.

Dr. Werner Balogh, WMO Space Programme, World Meteorological Organization, Geneva, Switzerland, provided **WMO Space Programme Update**. In the presentation he provided an update on recent developments in the World Meteorological Organization (WMO) related to the space-based observing system component of the WMO Integrated Global Observing System (WIGOS). The WMO Space Programme's aim is to increase the effectiveness and contributions of space based observing systems to WMO Programmes and to coordinate the related meteorological and environmental satellite matters and activities. As such, the WMO Space Programme acts as a bridge between satellite operators and users and is supported by a dedicated WMO Space Programme Office (SAT) consisting of the Space-Based Observing System Division (SBOS) and the Satellite Data Utilization Division (SDU). The Programme's objectives are achieved through strong partnership with the Coordination Group for Meteorological Satellites (CGMS) and the Committee on Earth Observation Satellites (CEOS) and their respective working groups and subsidiary bodies.

The presentation also reviews the outcome of the eighteenth World Meteorological Congress, held in June 2019, of relevance to the work of the WMO Space Programme in the Asia and the Pacific Region (Regional Associations II and V).

Dr. M. Kachi (with contributions from his JAXA colleagues; Murakami, H. ; Kubota, T.; Kuze, A.; Tadono, T.; Oki, R.; and Nakajima, T.) of Japan Aerospace Exploration Agency (JAXA), Tsukuba, Japan presented the **Current Status and Future Plan of JAXA Earth Observation Missions for Climate Studies and Operational Applications.** Japan Aerospace Exploration Agency (JAXA) currently operates six Earth observation missions for water cycle and climate studies, disaster mitigation, and various application studies including weather forecasts. The latest one is the Greenhouse-gases Observing SATellite-2 (GOSAT-2). The GOSAT series objective is to provide accurate measurement of greenhouse-gases. JAXA also launched the Global Change Observation Mission (GCOM) - Climate (GCOM-C) carrying the Second-generation Global Imager (SGLI) in December 2017 and has released SGLI products to public since December 2018. The objective of the GCOM series satellites is to contribute to climate change studies and operational applications by combined information of optical and microwave imagers. Currently, AMSR2 follow-on mission (AMSR3) is planning to share the satellite payload with GOSAT-2 follow-on mission. AMSR3 will be almost equivalent capability to AMSR2 except additional high-frequency channels (166 & 183 GHz) for snowfall retrievals and numerical weather prediction. JAXA and NASA led the Global Precipitation Measurement (GPM) mission under international partnership. JAXA provides the Dual-frequency Precipitation Radar (DPR) onboard the GPM core observatory and AMSR2 onboard the GCOM-W satellite for the GPM mission to provide high-frequent and accurate global precipitation observation. JAXA's Global Satellite Mapping of Precipitation (GSMaP) is hourly merged-satellite global precipitation products. In June 2019, we have released GSMaP realtime version (GSMaP_NOW) with 0-hour latency over global area, while near-real-time version (GSMaP_NRT) is 4-hour latency. GSMaP is especially used in areas where ground observation capability is not enough, such as isolated islands and developing countries, for heavy rainfall and tropical cyclone monitoring. JAXA also operates the Advanced Land Observing Satellite-2 (ALOS-2) carrying Synthetic Aperture Radar (SAR) for land monitoring and disaster mitigation, including flood plain detection. Two ALOS series satellites will be launched during 2020-2021, ALOS-3 carrying advanced optical imager and ALOS-4 carrying advanced SAR. Combination use of multi-satellite and numerical models is one of JAXA's targets to expand satellite data utilization in various fields. For example, JAXA produces the geophysical parameters by Himawari-8 under collaboration with Japan Meteorological Agency (JMA) to be consistent with that of SGLI. Aerosol products by Himawari-8 and SGLI will be assimilated to model for aerosol forecasts. JAXA also collaborates with the model community to utilize multi-satellite data into atmosphere, land and ocean models for better monitoring and forecasts.

Session 2: Facilitation of Data Access and Utilization, including Training Activity

Session chairs: Dr Paul MENZEL (ICSC), Prof Vasily ASMUS (ICSC), Dr Boris KELLY-GERREYN (ICSC and AuBOM)

The session consisted of fifteen (15) papers, eleven (11) of them oral presentations and the remaining four as posters. Of the fifteen presentations, the first, a keynote, covered the history of the development of remote sensing capability and the future for the use of satellite data and products. Four presentations addressed the data access, five detailed the utilization aspects, and five reported on training related issues.

The session opened with a keynote presentation by Dr. Purdom titled "Realization of a Dream: The New Generation of Meteorological Satellites." In his presentation he traced the remarkable growth in satellite capability through substantial scientific effort. The story unfolded from the origins of the meteorological satellite era with the launch of TIROS-1 in 1960 to the complex multichannel, multispectral satellite era of today. He pointed out that to get to where we are today required strong leadership, vision, research and utilization and that international cooperation played a major role in bringing to fruition the dream that has evolved over the last 55+ years. Moving forward will require similar efforts. Further, he emphasized that the space agencies have met the challenge of providing vibrant polar and geostationary satellite systems; it is our challenge to help realize the potential benefit offered by those data.

Regarding the four data access papers, one detailed the new baseline approved in 2018 by the Coordinating Group of Meteorological Satellite (CGMS) operators. The CGMS baseline enumerates the observations, measurements, and their supporting missions that provide meteorological and environmental data required to support the WMO application areas, including Space Weather. Two presentations reported on the Direct Broadcast Network (DBNet) system which is designed to provide fast acquisition, processing, and global delivery of satellite products from direct readout data, primarily for Numerical Weather Prediction (NWP) applications with stringent timeliness requirements. They provided an overview of the entire DBNet system along with a sub-set provided by the NOAA Direct Broadcast Real-Time Network. A fourth presentation provided an overview of the NESDIS satellite data, processing and distribution, with an emphasis on the various direct readout capabilities available from NOAA satellites. These capabilities serve the users of environmental satellite direct broadcast data and those operating their own satellite data receiving stations.

Utilization was the focus of the next four papers. Interactive tools are necessary to efficiently use all the different types and large volumes of satellite data and products. Various systems and software packages were introduced that enable the efficient derivation and analysis of products. One example, the SLIDER web application, can be used not only on computers, but also on mobile devices such as phones and ipads, enabling a wide outreach to the general public. The CSPP LEO and GEO processing packages on the other hand support the derivation of science data for environmental decision makers. Finally a presentation detailed the reprocessing of Suomi NPP data by NOAA/STAR with unified algorithms ensure that all JPSS satellite data, starting with SNPP from the beginning of the time series through the JPSS life cycle, will be consistent on a common reference frame with known uncertainty.

Addressing education and training requirements, two presentations and several posters covered activities by the Australian Centre of Excellence for the WMO Virtual Laboratory for the Asia-Pacific Region; the development of guides for the use of RGB products; the use of 3-D imagery by blending synchronous images from Himawari-8 and GEO-KOMPSAT-2A as well as GOES-16 & GOES-17 data; and the availability of training resources from CIMSS, covering the contiguous United States and parts of the Pacific. Another poster focused on satellite data and products used in Sri Lanka.

Session 3: Application of satellite data to Numerical Weather Prediction and derivation of atmospheric parameters

Session 3 Chairs: Dr Mitch GOLDBERG (ICSC), Mr Kotaro BESSHO (ICSC) and Dr Helen BEGGS (AuBoM).

The session consisted of eleven (11) presentations, ten (10) oral and one poster. The papers covered application areas as well as techniques for assimilation of satellite data into NWP suites.

Dr Litovchenko from ROSHYDROMET described the Russian space weather monitoring system and the recent establishment of the Russian Space Weather Centre in ROSHYDROMET to support civil aviation through data from spacecraft, data from ionospheric stations, GNSS receivers and riometers, from both Russian and foreign observational platforms. Using modern solutions for modelling of the ionosphere and using data from a large area, the Russian Space Weather Center is able to provide services to pilots in real time mode. More information is available at http://ipg.geospace.ru.

Dr Chedzey from Curtin University described a study investigating cloud microphysical parameters in defining regional precipitating clouds. The study uses parameters such as cloud top pressure, cloud effective emissivity, cloud effective radius, cloud optical thickness and cloud top temperature along with data from the Global Precipitation Climatology Project (GPCP) as a comparative precipitation source with a similar spatial and temporal relevance to the HIRS and MODIS data sets. The investigation covers 34 years of data (between 1985 and 2018) and highlights two specific Western Australian regions of differing climate - the temperate Southwest region of the state and the tropical Kimberley region in the north. It was found that extending the classification scheme to include cloud physical and microphysical properties has substantially improved the characterisation of regional precipitating clouds in the Southwest and Kimberley regions of Western Australia.

Dr Gong (CMA) described a new technique to identify deep convective clouds (DCCs) which are often used as targets for monitoring the calibration stabilities of the reflective solar bands of various imagers. The new technique combines the brightness temperature difference (BTD) between a water vapor absorption channel and a window channel, and its measurement noise ratio (BNR) is adopted and applied to DCC identification. The BNR method improves the DCC detections over the legacy method because it is less contaminated with high clouds not thick and bright enough. Because BNR affects more on the left tails (less reflective) than the modes of the histograms of reflectance, the improvement is more significant on the mean reflectance than the mode. BNR detects fewer DCCs than BT11, but with more confidence. This allows the weekly and daily time series for monitoring RSBs in higher temporal frequencies. This method can be applied to other imagers with collocated advanced infrared sounders for detecting DCCs and monitoring the calibration stabilities of RSBs. The work has been published in Gong et al. (2019) JGR Atmospheres.

Dr Ma (CMA) described a dynamic channel selection method to assimilate radiance of microwave temperature sounding channels. The selection is undertaken by analysing the sensitivity to variations in Cloud Liquid Water (CLW) profiles to radiance to a channel of a microwave temperature sounder. It is found that the higher the frequency, the less is the impact of CLW. After analysing the impact from cloud fraction and cloud top height on radiance, three look-up tables are set up which is the basis of the dynamic channel selection method. In dynamic channel selection, the unified cloud top height on MWTS-2 FOVs could be calculated by fusing the cloud top height from MERSI-2 pixels synchronously and observations from various channels could be removed or retained based on the real-time and dynamically distributed cloud top height. In this way, not only the strong precipitation areas are accurately identified and removed, but also more observations above cloud top height are introduced into the data assimilation. It was noted by Mitch Goldberg that Dr Ma's study is a very interesting use of Imagers and MW sensors to assimilate radiances of MW temperature sounding channels, but he noted that in the future we won't necessarily have imagers and MW sensors on the same platform.

Dr Menzel (SSEC/CIMSS) described a fusion process to use coarse spatial resolution infrared (IR) sounder measurements to construct radiances and derived products at imager high spatial resolution. It was demonstrated that VIIRS/CrIS fusion can create MODIS-like bands for VIIRS, and connecting LEO sounder products (from CrIS) to time sequences of GEO imager radiances (from ABI) can create a GEO sounder-like perspective of atmospheric changes in time. Dr Menzel described how sounder products (from HIRS, AIRS, IASI, CrIS) provided at imager spatial resolution, through fusion with paired imager measurements (from AVHRR, MODIS, VIIRS, ABI, AHI), are found to reveal more horizontal and vertical detail. With the fusion of data from past and present sounders and imagers, it is possible to improve continuity in cloud and moisture products over the generations of weather satellites.

Dr Takayabu (University of Tokyo) described the development of a mid-latitude version of Spectral Latent Heating (SLH) algorithm using data from the Dual-frequency Precipitation Radar on the Global Precipitation Measurement satellite. High-resolution simulations of extratropical precipitation systems with the Local Forecast Model (LFM) of the Japanese Meteorological Agency (JMA) have been utilized to develop spectral look-up tables for the mid-latitude precipitation systems. Combining the tropical module and the mid-latitude module, level 2 and level 3 data of current GPM SLH Ver.6 are produced and released in October 2018. For access see https://gportal.jaxa.jp/gpr/?lang=en. Dr Takayabu described a new nudging method with Kalman Gain for LH assimilation into a 3DVar data assimilation system. A JMA study of assimilating the GPM SLH latent heating into the JMA Local Forecast Model (LFM) showed forecast skill is improved in a very short-term (1-3h) precipitation forecast.

Dr Hordyniec (RMIT University) demonstrated self-efficacy of GPS RO retrievals in capturing atmospheric circulation features near the tropopause. The comparison with ECMWF reanalysis shows good agreement with flow patterns derived from GPS RO that allow identification of jet core positions. On average RMSE values are at the order of 4 m/s. Larger errors up to 7 m/s are observed towards subtropics due to the impact of gradient winds and generally underestimated RO geostrophic winds. The interface near Ferrel and Polar circulation cells is shown to produce a response in the tropopause parameters that can support the distribution of mid-latitude jets. He showed that the thermal definition of the tropopause inferred from RO temperature profiles can closely match the dynamical approach expressed by potential vorticity surfaces. The distribution of tropopause temperature for meridional cross sections passing through jet streams suggests strong horizontal gradients near jet latitudes which could be utilized for determining jet core positions and boundaries of circulation cells.

Dr John Le Marshall (AuBoM) described the increasing benefits to meteorological analysis using Earth Observations from Space. The improvements in NWP capability indicated by large-scale average verification statistics are also reflected in forecasting of individual extreme weather events such as tropical cyclones and very heavy rainfall. He provided examples of the improvements in moisture analysis by generating real-time GNSS Zenith Total Delay (ZTD) data over the Australia region; the generation and assimilation of near continuous error characterised, locally generated 10 min wind data (Atmospheric Motion Vectors) from Himawari-8 for operational analysis and forecasting; as well as opportunities for improving EOS capability in relation to improved radio occultation coverage and high resolution atmospheric sounding.

Dr WENG (Chinese Academy of Sciences) described how the new generation of Chinese FengYun satellites observe global earth atmosphere at spatial, spectral and/or temporal resolutions vastly exceeding those of earlier instruments. On the FY-3D satellite, there are both hyperspectral infrared sounders and advanced microwave sounding channels at 118 GHz. The hyperspectral IR sounder is also onboard FY-4A geostationary satellite platform and provides atmospheric sounding at much high temporal resolution. The Advanced Radiative Transfer Modeling System (ARMS) is a fast and accurate radiative transfer models used for NWP satellite data assimilation specifically designed for satellite instruments launched in China. ARMS has a much improved capability to simulate aerosols, clouds and precipitation through T-matrix scattering software. Surface emissivity models at microwave frequencies are updated with polarization-dependent roughness parameters. ARMS is now being integrated with the 4Dvar-global/regional assimilation and prediction system (GrAPES) to assimilate microwave and infrared sounder data. The bias correction schemes are being refined after the ARMS simulation uncertainties are fully characterized with respect to each category of instruments. The importance of addressing the ocean foam coverage and effect on emissivity, and the importance of accurate calibration of satellite sensors, was discussed.

Dr So (Hong Kong Observatory, HKO) described how the HKO use Himawari-8 geostationary images for weather monitoring, by applying high-pass filtering to the 6.2 micron water vapour channel in order to identify atmospheric gravity waves (AGWs) over the Asian region. Eddy dissipation rate information, derived from aircraft data and pilot reports, were used to validate the AGWs identified in the satellite imagery. The high-pass filtered water vapour imagery were used to train a deep learning model with object detection using the Faster Region-based Convolutional Neural Network (RCNN) for auto-detection of AGW. An independent set of Himawari-8 images were used to validate the model. Preliminary results show good model skill. The audience was impressed with the study as an important application of geostationary satellite data and a deep learning model to improve aircraft passenger safety.

Dr Tingwell's (AuBoM) poster provided an overview of the Bureau's NWP systems consisting of a global model, six city-scale models and a relocatable tropical cyclone model. By 2020, all of these will include data assimilation incorporating satellite radiance data which provide significant impact in our forecast system. The Bureau's global configuration assimilates brightness temperatures from ATOVS, IASI, ATMS, CrIS, AIRS, and from 2019 the Bureau have added SSMIS, AMSR-2 and Himawari-8. The Bureau are currently working on the addition of all-sky microwave data assimilation, in line with the Met Office scheme. The six capital-city convective-scale model configurations and the tropical cyclone model use data from ATOVS, IASI, ATMS, CrIS and AIRS, from both global and direct readout sources. In the near future the Bureau hopes to add brightness temperatures and 'GeoCloud' retrievals from Himawari to the city systems.

Session 4: Application of satellite data to weather forecasting

Session Chairs: Dr John LE MARSHALL (ICSC) & Dr Seonghoon CHEONG (ICSC) & Dr Beth EBERT (AuBOM)

In this session, JMA requested information, comments, suggestions and requests from AOMSUC-10 attendees for the consideration of Himawari follow-on satellites, especially for their data dissemination system.

The WMO Integrated Global Observing System (WIGOS) Task Team presented a survey on the Satellite Data Utilization, which was coordinated in 2018 by Korean and Japanese Meteorological Organisations along with BOM in Australia. There were 22 respondents from RA II and 11 from RA V. The most frequent use of satellite data was imagery applications, followed by nowcasting and forecast verification. Internet was the most frequent access method. Of products not yet available, the largest demand is for convective products such as atmospheric instability and lightning, also turbulence and rain profiles. New generation GEO data has made the biggest improvements in services for lightning, flash flood and tropical cyclone hazards. More training (esp. face to face), better communications and data processing tools would all be valuable. The final report will be presented at the 2nd Joint Meeting of the RA II WIGOS.

One goal of US National Weather Service Weather Ready Nation initiative is to harness cutting edge science and technology to provide the best observations, forecasts and warnings. The NOAA presentation highlighted the many contributions made by international satellites in geostationary and low earth orbits in Asia-Oceania region to improving the weather and hazard forecasting for convection, typhoons, turbulence and volcanic ash in the western and central Pacific Ocean. NOAA makes online satellite training resources available for the global community. GOES-17 imagery is being degraded (esp. WV imagery); work is currently underway to fix it.

IMD (Indian Meteorological Department) discussed the use of products from INSAT, METEOSAT, scatterometer, and microwave in monitoring and predicting severe weather such as tropical cyclones, mesoscale convective systems, thunderstorms and dust storms. Microwave imagery can greatly help in deriving the location and intensity of the cyclonic disturbances and thereby provide validation for tropical cyclone track forecasts, which were shown to have improved significantly during recent years.

Session 5: Application of satellite data to the derivation of surface parameters and phenomena

Session Chairs: Dr Werner BALOGH (WMO) & Dr Suman GOYAL (IMD) & Dr Alessandra MONERRIS (AuBOM)

Dr Weng (ICSC) gave a presentation on estimation of PM2.5 concentrations over central East China using Himawari AOD and meteorological parameters using an ensemble learning model. The estimated PM2.5 concentrations agree well with ground-based data with an overall cross-validated coefficient of determination of 0.86 and a root-mean-square error of 17.3 $\mu g\ m^{-3}$.

Dr Beggs (AuBOM) described the most widely used SST products from the Integrated Marine Observing System (IMOS), and gave examples of how they are used within the Australasian region (including Indonesia, Papua New Guinea and New Zealand) to monitor ocean phenomena, such as marine heatwaves, coastal upwelling, mesoscale eddies, shelf water fronts, cold river plumes and coral bleaching metrics.

Dr Ryu (Sejong University) reported on a soil moisture retrieval algorithm based on temperature vegetation dryness index (TVDI), a function of land surface temperature (LST), and the normalized difference vegetative index (NDVI) using the Himawari-8 data. The TVDI-based soil moisture algorithm in comparison to the GLDAS soil moisture showed good statistical results.

Dr Wang (National Satellite Meteorological Centre, Beijing) reported on the production of a 1 km spatial resolution global land cover classification map using data for 2017-2018 from the Visible and Infrared Radiometer (VIRR) on board FY-3C satellite. Comparisons of the final product with MODIS land cover maps and GlobCover map revealed general agreement, though there were some differences for some mixed classes such as crop/natural vegetation mosaic, savannah, and wetland.

Ms Park (Sejong University, Seoul) described an ABI green band generation method using a conditional generative adversarial nets (CGAN) technique with data observed in the visible range) of the GOES-16/ABI sensor. The CGAN-based model was found to effectively generate non-existent spectral bands of satellite sensors in a variety of scientific applications and studies of the Earth's atmosphere, sea, and land surfaces.

Dr Batzli (SSEC/CIMSS, University of Wisconsin-Madison described how the RealEarth data discovery and visualization platform can be used for monitoring disasters such as floods and fires. The platform provides rapid visual access to recent and near real-time data in standards-based web mapping formats, and users can upload their own data and view it almost immediately.

Dr Goldberg (NOAA/NESDIS/JPSS) described the capabilities of the new generation of operational low earth orbiting (LEO) satellites from the NOAA Joint Polar Satellite System (JPSS) and geostationary (GEO) orbiting weather satellites from NOAA GOES-R and Himawari for inundation mapping covering large geographic areas with excellent temporal coverage. Combining the LEO and GEO satellite imagery shows great advantages in flood mapping.

Mr Salman (BMKG) studied the sea-air interaction in the Maluku region. Local surface observations and remote sensing data from MTSAT-2, Himawari-8 and NOAA were used to analyse the phases of two tropical cyclones, Kirrily (2009) and Lili (2019).

Mr Panjaitan (BMKG) described satellite data usage during forest fire disaster events. He examined consecutive dry days as drought parameter related to hotspot, hotspot climate based on long term hotspot data, and RGB adjustment for thick smoke detection and its comparison to pm 2.5 data from ground measurement. He found that forest fire is highly correlated to rainfall pattern, thus consecutive dry days is an effective tool to estimate forest burning initiation.

Session 6: Performance and calibration of satellite instruments

Chairs: Dr. Fuzhong Weng (ICSC), and Dr. Toshiyuki Kurino (ICSC) and Dr. Christopher Griffin (Australian Bureau of Meteorology).

The session introduced and summarized the activities of WMO initiatives such as the SWCEM-SEMDP demonstration project for drought and heavy precipitation (presented by Dr. Yuriy Kuleshov) which is about to become operational; and the GSICS framework which is presented by Dr. Mitch Goldberg. GSICS enabled all the space agencies to share the reference data sets for cross-calibrating the instruments to the reference sensors such as infrared hyperspectral sounders such as IASI , CrIS and HIRAS. JPSS proving ground initiative is also presented by Dr. Mitch Goldberg and shows many new products and application facilities demonstrated prior to operations at NOAA and other users. The next topic is settled into an extended collection of talks related to L3Harris ABI-class imagers, with a particular focus on the performance of the recently launched AMI sensor on GK-2A and the use of the GSICS framework.

ABI-class imager presentations began with Dr. Paul Griffiths talk on the performance of the absolute AMI sensor performance, in terms of stability and trending, coverage, navigation, noise and thermal performance, demonstrating performance comparable to GEOS-16 and superior to the specification requirements over life. Dr. Minju Gu gave a presentation on the intercomparison of GK2A with LEO Hyperspectral sounders using GSICS methods, followed by Dr. Minsang Kim's presentation on the production histogram equalized radiative transfer corrected true color images from AMI showing to work around the green channel availability in AMI.

The presentation of Dr. Yeonjin Lee, compared AMI with (Himawari-8) AHI, using GSICS ideas with strict consideration to restricting comparison to the places where direct comparison should demonstrate the lowest variability. Currently, anomalies were observed and discussed. The following presentation by Dr Yang H, J. which discussed GSICS methods to compare AMI with AHI demonstrating similar performance between the two instruments. In broad terms the results presented seemed consistent. Studies identified biases when the scene temperatures are greater than 300K scene (over central Australia) and also the bias at 3.8um is found at low temperatures, which will be subject of further investigation. The session was rounded out by a presentation by Dr, Fangfang Yu on GEOS-17 performance also using GSICS methods, showing that in spite of problems with the loop heat pipe, reasonable performance has been achieved, with perhaps some work still to do on Ch16.

The entire session demonstrated very clearly the value of the GSICS framework in measuring and categorizing the in-orbit performance of operational satellites and providing a meaningful ways of comparison between platforms. The session also highlighted the success of KOMPSAT-2A (GK2A) satellite and its AMI instrument and the completion of calibration with comparable performance to AHI.

Closing Panel Discussion

The final session for AOMSUC-10 was a Q&A session chaired by Agnes Lane (local host), Jim Purdom (ICSC chair) and Allen Huang (incoming ICSC chair). Participants submitted questions during the three days of the conference, the questions were collated and answered during the session.

Following some questions about conference logistics, the first set of questions related to data access. Participants showed interest in a "one stop shop" for geostationary images and products of the Asia-Oceania region. The session chairs suggested that this could be raised at CGMS.

A NWP user of satellite data asked whether it was possible for data providers to provide consistently formatted data to improve the use of satellite data. The CGMS/GODEX-NWP members of the audience agreed to look into this.

Regarding access to real-time data from FY-3 and -4 series satellites, including lightning data, refer to the presentations from CMA.

A question relating to the rapid-scan data from JMA, KMA and CMA geostationary satellites. Participants were interested to hear whether the three agencies would implement a coordination mechanism to minimize duplication and maximize efficiency in the event of multiple requests for the same time. The operators agreed to look into this. Regarding prioritization of Himawari requests, refer to the protocol established by JMA.

A question on an addition to the conference program, to include presentations from end users such as emergency managers, aviation, defence and others, to hear about how important the satellite products are to them, including examples of impact and value to society. The panel thought this would be a valuable addition to the conference program, and will be considered by the ICSC.

A question on training, participants asked for more VLab Training to analyze Aviation Weather hazards, high impacts synoptic, and meso-scale weather systems. This will be considered by future hosts.

The Q&A session was considered a valuable addition to the conference program. It provided an opportunity for participants to submit their questions, feedback or concerns to the community, anonymously if they chose. Due to the interactive nature of the discussions it was considered an improvement to the old panel discussion format, and should be considered for future AOMSUC events.

Participants at AOMSUC-10

Title	First name	Last name	Organisation	Country
Ms	Melissa	ANDERSEN GARCIA	NOAA NESDIS	United States of America
Mr	Ryskeldi	ASANHODJAEV	Agency on hydrometeorology under MES Of the Kyrgyz Republic	Kyrgyz Republic
Dr	Vasily	ASMUS	SRC Planeta	Russian Federation
Mr	Manik	BALI	NOAA	United States of America
Dr	Werner	BALOGH	World Meteorological Organization (WMO)	Switzerland
Dr	Sue	BARRELL	Science & Technology Australia	Australia
Dr	Sam	BATZLI	CIMSS/SSEC University of Wisconsin-Madison	United States of America
Dr	Helen	BEGGS	Bureau of Meteorology	Australia
Mr	Kotaro	BESSHO	Japan Meteorological Agency	Japan
Dr	Bertukan	BIADEGLGNE	Bureau of Meteorology	Australia
Mr	Habibur Rahaman	BISWAS	India Meteorological Department	India
Ms	Nichole	BRINSMEAD	Bureau of Meteorology	Australia
Dr	Gilbert	BRUNET	Bureau of Meteorology	Australia
Dr	Helen	CHEDZEY	Curtin University	Australia

Dr	Seonghoon	CHEONG	Korea Meteorological Administration	Republic of Korea
Mr	Beomkyu	CHOI	KMA	Republic of Korea
Dr	Geoffrey	CURETON	CIMSS/SSEC University of Wisconsin-Madison	United States of America
Dr	Ren	DIANDONG	Bureau of Meteorology	Australia
Mrs	Natalia	DONOHO	NOAA/NESDIS	United States of America
Ms	Alexis	DR. RUIVIVAR	PAGASA	Philippines
Dr	Sheldon	DROBOT	L3Harris	United States of America
Dr	Beth	EBERT	Bureau of Meteorology	Australia
Mr	Viliami	Fa'anunu	Tonga Meteorological Services	Tonga
Dr	Xiang	FANG	China Meteorological Administration	People's Republic of China
Mr	Georges	FAREATA	METEO FRANCE FRENCH POLYNESIA	French Polynesia
Mr	Jeremy Garcia	FLORES		Peru
Dr	Bayasgalan	GERELCHULUUN	Information and Research Institute of Meteorology, Hydrology and Environment, National Agency for Meteorology and Environmental Monitoring	Mongolia
Dr	Jordan	GERTH	NOAA National Weather Service	United States of America

Ms	Aruna	GILLKUM	Bureau of Meteorology	Australia
Ms	Tamara	GNJIDIC VUKSA	MetService	New Zealand
Dr	Mitch	GOLDBERG	NOAA	United States of America
Dr	Xinya	GONG	China Meteorological Administration	People's Republic of China
Dr	Pallavi	GOVEKAR	Bureau of Meteorology	Australia
Dr	Suman	GOYAL	India Meteorological Department	India
Dr	Christopher	GRIFFIN	Bureau of Meteorology	Australia
Ms	Minju	GU	Korea Meteorological Administration	Republic of Korea
Mr	Liam	GUMLEY	CIMSS/SSEC University of Wisconsin-Madison	United States of America
Dr	Yang	HAN	China Meteorological Administration	People's Republic of China
Dr	Xiuzhen	HAN	China Meteorological Administration	People's Republic of China
Mr	Bryan	HODGE	Bureau of Meteorology	Australia
Dr	Sungwook	HONG	Sejong University	Republic of Korea
Dr	Pawel	HORDYNIEC	RMIT University	Australia
Mr	David	HOWARD	Bureau of Meteorology	Australia
Mr	Xiaoping	HU	China Meteorological Administration	People's Republic of China

Dr	Hao	HU	Chinese Academy of Meteorological Sciences	People's Republic of China
Dr	Yi	HUANG	The University of Melbourne	Australia
Dr	Allen	HUANG	CIMSS/SSEC University of Wisconsin-Madison	United States of America
Mr	Kiho	HYUN	Korea Meteorological Administration	Republic of Korea
Ms	Misako	KACHI	Japan Aerospace Exploration Agency	Japan
Dr	Boris	KELLY-GERREYN	Bureau of Meteorology	Australia
Ms	Norhadizah Bt. Mohd	KHALID	Malaysian Meteorological Department	Malaysia
Dr	Dohyeong	KIM	Korea Meteorological Administration	Republic of Korea
Dr	Hyun-Goo	KIM	Korea Institute of Energy Research	Republic of Korea
Mr	Minsang	KIM	Korea Meteorological Administration	Republic of Korea
Mr	Junho	KIM	Korea Meteorological Administration	Republic of Korea
Dr	Edward	KING	CSIRO	Australia
Dr	Yuriy	KULESHOV	Bureau of Meteorology	Australia
Mr	Adarsh	KUMAR	Fiji Meteorological Service	Fiji

Mr	Toshiyuki	KURINO	World Meteorological Organization (WMO)	Switzerland
Ms	Mary Ann	KUTNY	NOAA Satellite & Information Service (NESDIS)	United States of America
Ms	Agnes	LANE	Bureau of Meteorology	Australia
Mr	Eric	LAU	NOAA	United States of America
Dr	John	LE MARSHALL	Bureau of Meteorology	Australia
Dr	Jin	LEE	Bureau of Meteorology	Australia
Ms	Yeonjin	LEE	Ewha Womans University	Republic of Korea
Ms	Chunxiang	LENG	China Meteorological Administration	People's Republic of China
Dr	Lin	LIN	University of Maryland	United States of America
Dr	Scott	LINDSTROM	CIMSS/SSEC University of Wisconsin-Madison	United States of America
Dr	Konstantin	LITOVCHENKO	Roshydromet	Russian Federation
Mr	Luis Clemente	LOPEZ-BRAVO	The University of Melbourne	Australia
Dr	Chris	LUCAS	Bureau of Meteorology	Australia
Dr	Mervyn	LYNCH	Curtin University	Australia
Dr	Gang	MA	China Meteorological Administration	People's Republic of China
Mr	Maytee	Mahayosananta	Thai Meteorological Department (TMD)	Thailand

Dr	Ronald	MAJ	RMIT University	Australia
Mr	Leon	MAJEWSKI	Bureau of Meteorology	Australia
Dr	Michael	MANTON	Monash University	Australia
Mr	Limoni	MATIVA	Tuvalu Meteorological Service	Tuvalu
Dr	Peter	MAY	Bureau of Meteorology	Australia
Ms	Elizabeth	MCDONALD	Bureau of Meteorology	Australia
Miss	Rylea	MCGLUSKY	ESRI Australia	Australia
Ms	Noemi Unchupaico	MEDINA		Peru
Mr	Lazarus	MELA	Solomon Islands Met Service	Solomon Islands
Dr	Paul	MENZEL	CIMSS/SSEC University of Wisconsin-Madison	United States of America
Dr	Alessandra	MONERRIS BELDA	Bureau of Meteorology	Australia
Mr	Silipa	MULITALO	Samoa Meteorological Service	Samoa
Dr	Anthony	MURFETT	Australian Space Agency	Australia
Ms	Jiangyue	NING	China Meteorological Administration	People's Republic of China
Mr	Tae-Hyeong	OH	Korea Meteorological Administration	Republic of Korea

Mr	Kyaw Lwin	OO	Department of Meteorology and Hydrology	Myanmar
Mr	Mark	PAESE	NOAA	United States of America
Mr	Andersen	PANJAITAN	Agency for Meteorology Climatology and Geophysics	Indonesia
Dr	Ki-Hong	PARK	Korea Meteorological Administration	Republic of Korea
Mrs	Na-Yeon	PARK	Korea Meteorological Administration	Republic of Korea
Dr	Hyesook	PARK	Korea Meteorological Administration	Republic of Korea
Ms	Yonok	PARK	Korea Meteorological Administration	Republic of Korea
Miss	Jeongeun	PARK	Sejong University	Republic of Korea
Dr	Efthymia	PAVLIDOU	Meteorological Service Singapore	Singapore
Dr	Rodney	POTTS	Bureau of Meteorology	Australia
Dr	Caroline	POULSEN	Monash University	Australia
Dr	James	PURDOM	AOMSUC	United States of America
Dr	Danyu	QIN	China Meteorological Administration	People's Republic of China
Mr	Achmad Fachri	RADJAB	Agency for Meteorology Climatology and Geophysics	Indonesia

Mr	Ahmed	RASHEED	Maldives Meteorological Service	Maldives
Mr	Mikael	RATTENBORG	World Meteorological Organization (WMO)	Switzerland
Mr	Jonathon	ROSS	Geoscience Australia	Australia
Mr	Nofiano Gregorio Henrique	RUAS	National Directorate of Meteorology and Geophysics	Timor Leste
Dr	Chris	RUDIGER	Monash University	Australia
Ms	Sumin	RYU	Sejong University	Republic of Korea
Mr	Rion Suaib	SALMAN	Agency for Meteorology Climatology and Geophysics	Indonesia
Dr	Curtis	SEAMAN	CIRA/Colorado State University	United States of America
Dr	Quanxi	SHAO	CSIRO	Australia
Mr	Akihiro	SHIMIZU	Japan Meteorological Agency	Japan
Mrs	Fiona	SMITH	Bureau of Meteorology	Australia
Mr	Chi Kuen	SO	Hong Kong Observatory	Hong Kong China
Miss	Monju	SUBBA	National Center for Hydrology and Meteorology	Bhutan
Dr	Fenglin	SUN	China Meteorological Administration	People's Republic of China

Mr	Bounteum	Sysouphanthavong	Department of Meteorology and Hydrology Lao PDR	Lao
Dr	Yukari	TAKAYABU	The University of Tokyo	Japan
Dr	Chris	TINGWELL	Bureau of Meteorology	Australia
Mr	Vincent	VILLANI	Bureau of Meteorology	Australia
Dr	Jinsong	WANG	China Meteorological Administration	People's Republic of China
Dr	Yuanyuan	WANG	China Meteorological Administration	People's Republic of China
Dr	Jane	WARNE	Bureau of Meteorology	Australia
Dr	Fuzhong	WENG	Laboratory of Severe Weather, Beijing	People's Republic of China
Mr	Awalikara Galappaththige Mudit	WIMALASURIYA	Department of Meteorology	Sri Lanka
Dr	Xuebao	WU	China Meteorological Administration	People's Republic of China
Mr	Ryuji	YAMADA	WMO	Singapore
Ms	Hyeji	YANG	Korea Meteorological Administration	Republic of Korea
Dr	Xinwen	YU	China Meteorological Administration	People's Republic of China
Dr	Fangfang	YU	University of Maryland	United States of America

Mr	Bodo	ZESCHKE	Bureau of Meteorology	Australia
Miss	Shirley	ZHANG	Bureau of Meteorology	Australia
Dr	Yong	ZHANG	China Meteorological Administration	People's Republic of China
Ms	Wenhui	ZHAO	Monash University	Australia
Dr	John	ZILLMAN	Bureau of Meteorology	Australia