WORLD METEOROLOGICAL ORGANIZATION

WMO Space-based Weather and Climate Extremes Monitoring

SWCEM Newsletter

Issue 7 | September 2022

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1. Outcomes of the Fourth Session of the WMO Steering Group for the SWCEM in East Asia and Western Pacific

The Fourth Session of the WMO Steering Group for the Space-based Weather and Climate Extremes Monitoring in East Asia and Western Pacific (SG-SWCEM-EAWP) was held online from 23 to 24 March 2022.

The Chair of SG-SWCEM-EAWP, Professor Yuriy Kuleshov, reminded the participants that 23rd March is the World Meteorological Day, and the theme for 2022 is Early Warning and Early Action. He highlighted that this topic fits very well with the activities that the SWCEM community carry out trying to address challenges posed by climate changes using space-based observations. He also noted the importance of collaboration with another WMO initiative – Climate Risk and Early Warning Systems (CREWS).

The key objective of the session was to review the progress of the project since the Third session of the SG-SWCEM-EAWP in October 2020. Progress reports were presented by representatives from Global Satellite-derived Product Providers (GP-SAT): JAXA and NOAA, and WMO Regional Climate Centres (RCCs): RA-II RCC Beijing/China, RA-V SEARCC-Network node/Philippines, RA-V SEARCC-Network node/Singapore, and RA-V Pacific RCC-Network node/Australia as well as the National and Meteorological Service (NMHS) in RA II: MetService of Malaysia. It was noted that the presentations from Members demonstrated very well how the scientific methodology of blending in-situ and space-based observations resulted in improving accuracy of outcome products.

The report on CREWS was presented by the Chair of SG-SWCEM-EAWP. It was noted that CREWS was established at COP-21 in 2015, recognizing the urgency of enhancing early warning systems to assist vulnerable countries with climate change adaptation.

It was highlighted that the UN Secretary-General announced on the World Meteorological Day the following target: “Within the next five years, everyone on Earth should be protect-ed by early warning systems against increasingly extreme weather and climate change”. WMO was tasked to lead the effort and present an action plan to achieve this goal at the next UN climate conference in Egypt this November 2022. It was suggested adding a recommendation resulting from the SG-SWCEM-4 meeting: SWCEM to contribute to the new UN target, which should be followed by developing a more specific action plan how SWCEM members can contribute to this initiative.

The complete report of the meeting is available from the WMO SWCEM Portal: https://community.wmo.int/meetings/4th-session-wmo-steering-group-swcem-east-asia-and-western-pacific-sg-swcem-eawp-4.

2. GLOBAL SATELLITE-DERIVED PRODUCTS PROVIDERS (GP-SAT)

2.1. JAXA/EORC

JAXA has provided the Global Satellite Mapping of Precipitation (GSMaP) product for the SWCEM East Asia and Western Pacific regional operational subproject (SWCEM-EAWP) (domain: 50E-120W; 40N-45S) via the JAXA/EORC ftp site. After registration at the JAXA site (https://sharaku.eorc.jaxa.jp/SWCEM/registration.html), SWCEM-EAWP members have access to available data derived from the GSMaP Near-real-time Gauge-adjusted Rainfall Product version 6 (GNRT6, Tashima et al. 2020) since April 2000 such as accumulated rainfall, drought index and the statistics (climatology, percentile values and percentage of rainy days in a month). These data can be viewed graphically on a homepage "JAXA Climate Rainfall Watch" (https://sharaku.eorc.jaxa.jp/GSMaP_CLM/).

In June 2022, we started to provide Gauge adjusted real time GSMaP (GNOW), in addition to the GNRT6 with 4-hour latency to the SWCEM EAWP members. The GNOW is an hourly precipitation rate with a few minutes latency with 30 minutes updates (Kubota et al. 2020). In addition, the JAXA has updated the statistics of the GNRT6 from 21 year to 22 year since June 2022.

A new version (Product version: V05, Algorithm version: v8) of the GSMaP product was released in December 2021 (Kubota et al. 2022). Table 1 summarizes recent major updates of the GSMaP products. In this article, algorithm versions are used for classification among the updates.

***Table 1:** Recent major updates of the GSMaP*

Date	Product version	Algorithm Version
Sep. 2014	V03	v6
Jan. 2017	V04	v7
Dec. 2021	V05	v8

The GSMaP algorithms consist of passive microwave (PMW) algorithms, a normalization module for PMW retrievals, a PMW-IR Combined algorithm, and a Gauge-adjustment algorithm. Features in the new version (v8) are summarized as follows. In the PMW algorithm, retrievals extended to the pole-to-pole. Databases used in the algorithm were updated. For example, heavy orographic rainfall retrievals were improved. The normalization module for PMW retrievals (Yamamoto and Kubota 2022) were newly implemented to make more homogeneous PMW retrievals, in particular, for microwave sounders. A basic idea of the PMW-IR combined algorithm is using morphing and Kalman filter. In addition, a histogram matching method by Hirose et al. (2022) was implemented in the new version to reduce the IR retrievals with reference to the PMW retrievals. In the gauge-adjustment algorithm, a precipitation estimate is adjusted using the NOAA CPC Global Unified Gauge-Based Analysis of Daily Precipitation. Artificial patterns appeared in past versions were mitigated in the new version.

Preliminary validation results using the gauge-adjustment ground radar data over the Japan land areas confirmed better results in the new version of the satellite only products (Kubota et al. 2022). Furthermore, evaluation results in the Thailand are shown here. This evaluation was conducted under the agreement between the JAXA and Hydro-Informatics Institute (HII) of the Kingdom of Thailand.

Figure 1 shows time series of the precipitation rates over the Southern area of Thailand, comparing several versions of the GSMaP_NRT with reference to the NOAA CPC rain gauges.
Data from 1st December 2016 to 31st January 2017 were analysed here. Overestimations were found in the GSMaP_NRT v6 and v7. On the other hand, the new version, v8, shows a mitigation of the overestimation.

Figure 2 shows horizontal maps of correlation coefficients with daily estimates with reference to the NOAA CPC rain gauges, comparing several versions of the GSMaP_NRT. The v7 and v8 tended to show higher correlation coefficients than the v6.

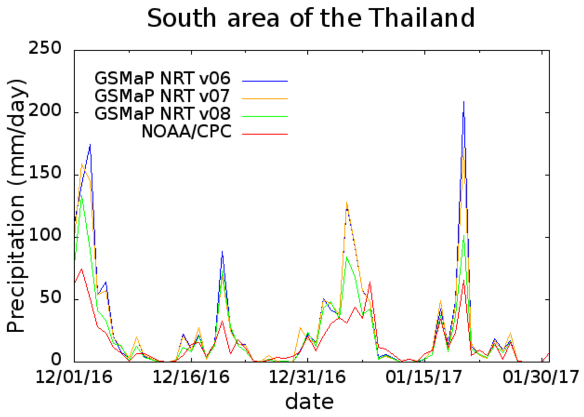


Figure 1: *Time series of the precipitation rates over the Southern area of Thailand. A blue line shows the GSMaP_NRT v06, an orange line shows the GSMaP_NRT v07, and a green line shows the GSMaP_NRT v08. A red line shows the NOAA/CPC rain gauge.*

Currently, the v8 of GSMaP during 24-yr data since 1998 is under reprocessing using JAXA supercomputer system. Note that the GNRT6 is available only after April 2000, and therefore the JAXA is planning to extend the reprocessing more with 2 years and 3 months. After the reprocessing, the JAXA will check the characteristics of the new GSMaP dataset carefully. Thus, the JAXA will change the statistics for SWCEM-EAWP from 22 year (previous version; GNRT6) to 24 year (new version; GNRT8). These efforts can lead to more reliable space-based precipitation monitoring and the JAXA will continue to contribute to implementation of the SWCEM-EAWP.

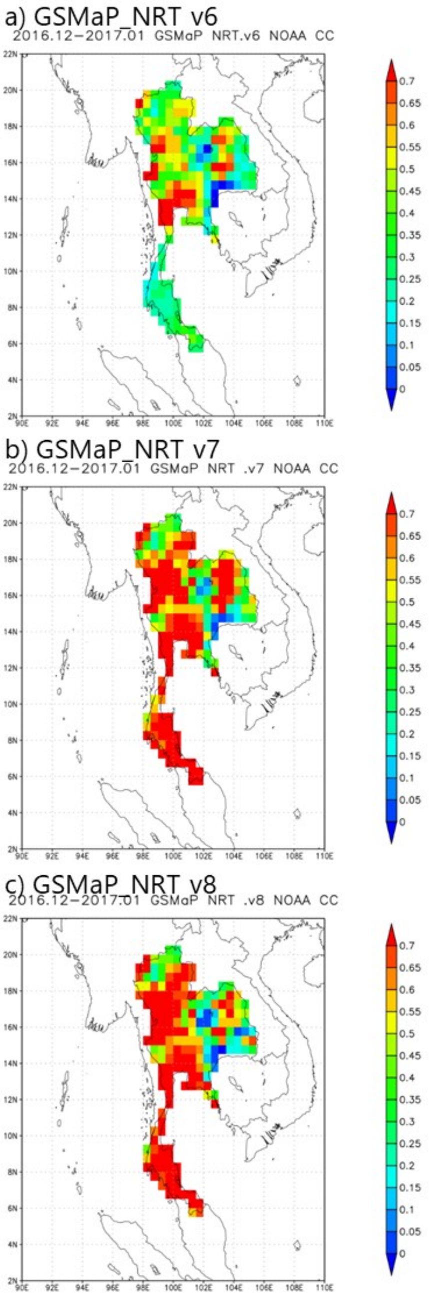


Figure. 2: *Correlation coefficients with daily estimates with reference to the NOAA CPC rain gauges for a) GSMaP_NRT v6, b) GSMaP_NRT v7, and c) GSMaP_NRT v8.*

Reference:

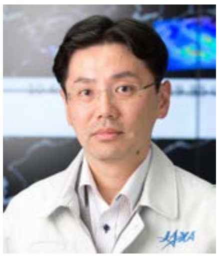
Kubota, T. et al., 2020: Global Satellite Mapping of Precipitation (GSMaP) products in the GPM era, Satellite precipitation measurement, Springer, vol. 67, pp.355-373. https://doi.org/10.1007/978-3-030-24568-9_20.

Kubota, T., et al. 2022: A new version of Global Satellite Mapping of Precipitation (GSMaP) product released in December 2021, EGU General Assembly 2022, Vienna, Austria, 23–27 May 2022, EGU22-3328, https://doi.org/10.5194/egusphere-egu22-3328.

Hirose, H., T. Kubota, T. Tashima, T. Mega, and T. Ushio, 2022: Histogram Matching to Improve Homogeneity in Satellite Merged Precipitation Products, IEEE GRSL, accepted.

Tashima, T., T. Kubota, T. Mega, and T. Ushio, and R. Oki, 2020: Precipitation extremes monitoring using the near-real-time GSMaP product, IEEE J. Sel. Topics Appl. Earth Observ. Remote Sens., https://doi.org/10.1109/JSTARS.2020.3014881.

Yamamoto, M. K., and T. Kubota, 2022: Implementation of a Rainfall Normalization Module for GSMaP Microwave Imagers and Sounders. Remote Sensing. 14(18), 4445. https://doi.org/10.3390/rs14184445



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3. WMO Regional Climate Centres (RCCs)

3.1. RA V Pacific RCC-Network node on Operational Data Services, Melbourne, BoM, Australia

The WMO RA-V Pacific Regional Climate Centre (RCC) Network is a virtual Centre of Excellence that assists National Meteorological and Hydrological Services (NMHSs) in the Pacific Islands region to deliver better climate services and products and to strengthen their capacity to meet national climate information and service delivery needs.

In WMO SWCEM Newsletter Issue 5, October 2021, activities of the WMO RA-V RCC on Evaluation of Satellite Precipitation Estimates over the South West Pacific Region were briefly describe. In this issue, Evaluation of Satellite Precipitation Estimates over Australia is presented [1].

The estimation of precipitation is of great value to society, and in the modern era, it can be conducted through a number of methods. These methods are broadly categorized into those based on satellite, model reanalyses, and rain gauges. Within these three sources, an even greater number of algorithms exist, resulting in a multitude of precipitation datasets. The accurate verification of these datasets enables users to select the dataset which is the most performant.

Traditional validation against gauges or radars is much less effective when the quality of these references (which are considered the ‘truth’) degrades, such as in areas of poor coverage. In scenarios like this where the ‘truth’ is unreliable or unknown, triple collocation analysis (TCA) facilitates a relative ranking of independent datasets based on their similarity to each other. TCA has been successfully employed for precipitation error estimation in earlier studies, but a thorough evaluation of its effectiveness over Australia has not been completed before. This study investigated the effectiveness of TCA for precipitation estimates over Australia by comparing three satellite datasets (GSMaP, CMORPH and CHIRPS).

The study area of mainland Australia and Tasmania extends from 112.125°E to 155.875°E and 9.875°S to 44.125°S. Three satellite precipitation datasets widely used in evaluation studies were selected: the Japan Aerospace Exploration Agency’s (JAXA) Global Satellite Mapping of Precipitation (GSMaP V6), the U.S. National Oceanographic and Atmospheric Administration’s (NOAA) Climate Prediction Center morphing technique (CMORPH V1), and Climate Hazards Group’s Infrared Precipitation with Stations (CHIRPS V2). GSMaP and CMORPH data were made available through the WMO’s Space-based Weather and Climate Extremes Monitoring (SWCEM) [2].

This study assesses the use of TCA for precipitation verification over Australia using satellite datasets in combination with reanalysis data (ERA5) and rain gauge data (Australian Gridded Climate Dataset, AGCD) on a monthly timescale from 2001 to 2020. Both the additive and multiplicative models for TCA were evaluated. These results were compared against the traditional verification method using gauge data and Multi-Source Weighted-Ensemble Precipitation (MSWEP) as references. AGCD (KGE = 0.861), CMORPH-BLD (0.835), CHIRPS (0.743), and GSMaP (0.708) were respectively found to have the highest KGE when compared to MSWEP.

Using MSWEP as the truth resulted in GSMaP obtaining a better KGE than CHIRPS. The ranking of the other datasets remained the same compared to the in-situ comparison, though the superiority of AGCD over CMORPH was greatly reduced. The variance ratio for GSMaP and CMORPH was greater than for the in-situ validation, while CHIRPS consistently underestimated the variance. The spatial variation of the RMSEs is visualized in Figure 1.

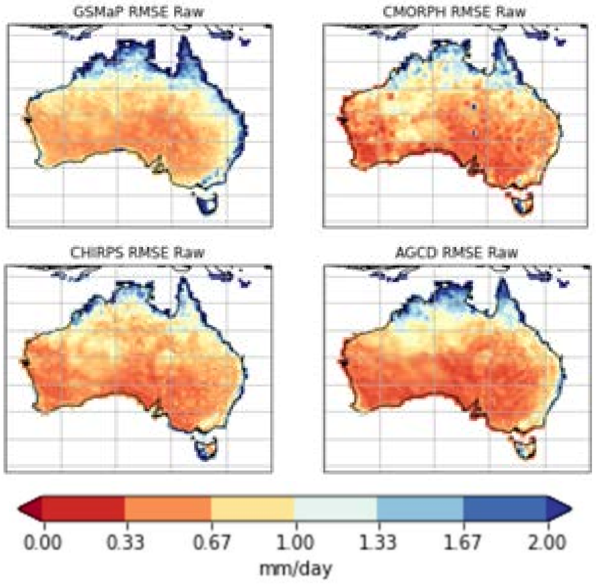

Figure 1: *RMSE errors for comparing each dataset to MSWEP across all seasons. Lower values indicate better performance.*

The RMSE for all the datasets is greatest over northern Australia, likely related to the large rainfall totals in that region over JJA. CHIRPS and GSMaP also display noticeable RMSEs over western Tasmania, while large RMSEs also exist along the eastern coast of Australia for GSMaP.

The different error models yield some differences in the ranking of the datasets. Primarily, if M CC is considered, then CMORPH is the most performant; otherwise, the other metrics suggest CHIRPS is the most performant. GSMaP is the least performant of the three. This has similarities to the traditional comparisons where GSMaP had inferior values of RMSE and Pearson correlations in both the in situ and MSWEP validations. CMORPH is the dataset with the most direct correction to gauge data, and, generally, it is the most performant dataset where gauge density is relatively high. GSMaP has a greater presence over the gauge-sparse interior, while CHIRPS seems to perform well over northern Australia, which could be related to better performance for rainfall from tropical modes or that which occurs at heavier intensities. Figure 2 shows the spatial distribution of the CC from the triple collocation.

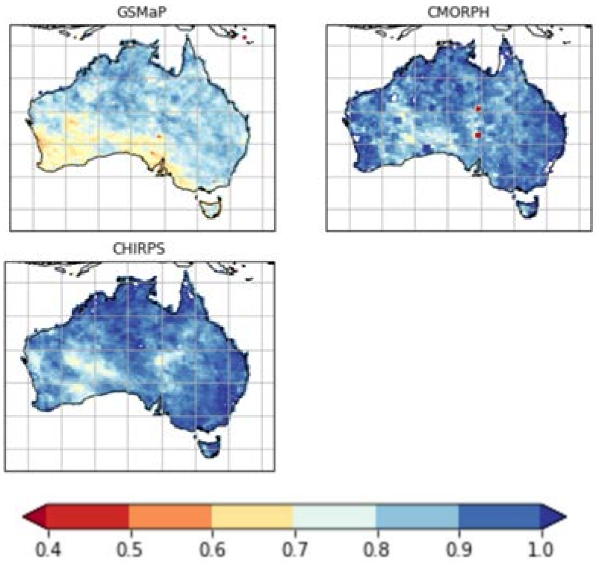

Figure 2: *CC metrics between each SPE with AGCD and ERA5. Higher values indicate better performance.*

The CCs of the satellite datasets are lowest over southwest Australia while being higher over northern and southeast Australia. There are two spots of very low CC in CMORPH over the interior of the mainland, which could be from the assimilation of poor station data.

The multiplicative TCA gave correlation rankings that matched two traditional forms of validations, whereas, in the additive version, the order of CMORPH and CHIRPS was reversed. However, the correlations of these two datasets were similar amongst all the verifications, making a reversal in the order of these two datasets a reasonable discrepancy. A greater disparity was observed in the multiplicative TCA error, where although the dataset rankings were the same as the other validations, the performance of CHIRPS appeared to be significantly overinflated while that of CMORPH was underestimated. Additionally, the additive TCA had a better match, spatially, to that of MSWEP compared to its multiplicative counterpart.

The additive TCA showed better skill scores than the multiplicative version for monthly precipitation verification over Australia. Overall, apart from the multiplicative TCA errors, the results obtained via TCA were largely consistent with those from the gridded and the in-situ comparison both in terms of ranking and relative performance. This demonstrates the value of TCA in assessing the performance of datasets, especially over data-sparse regions, though care

must be taken to ensure that the requisite assumptions are met.
Based on the results, recommendations are made for the use of Satellite Precipitation Estimates over Australia.

References:
1. Wild, A., Chua, Z-W., Kuleshov, Y., 2022: Triple Collocation Analysis of Satellite Precipitation Estimates over Australia. Remote Sensing. 2022, 14, 2724. https://doi.org/10.3390/rs14112724
2. Kuleshov, Y.; Kurino, T.; Kubota, T.; Tashima, T.; Xie, P. WMO Space-based Weather and Climate Extremes Monitoring Demonstration Project (SEMDP): First Outcomes of Regional Cooperation on Drought and Heavy Precipitation Monitoring for Australia and Southeast Asia. Rainfall—Extrem. Distrib. Prop. 2019, pp. 51–57 . http://dx.doi.org/10.5772/intechopen.85824

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4. WMO Secretariat

4.1. SWCEM Outreach

Implementing recommendations of the Fourth Session of the SG-SWCEM-EAWP, achievements of the SWCEM were presented at the 50th Annual Meeting of the Coordination Group for Meteorological Satellites (CGMS) on May 20, 2022; at the 10th Workshop of the International Precipitation Working Group (IPWG) on June 15, 2022; and at the 19th Asia-Oceania Geosciences Society (AOGS) Annual Meeting in August 2022.

4.1.1. CGMS

The Coordination Group for Meteorological Satellites (CGMS) is the group that globally coordinates meteorological satellite systems. This includes protection of in orbit assets, contingency planning, improvement of quality of data, support to users, facilitation of shared data access and development of the use of satellite products in key application areas. The coordination is pursued from an end-to-end perspective, through development of multi-lateral coordination and cooperation across all meteorological satellite operators in close coordination with the user community such as WMO, IOC-UNESCO, and other user entities. Further information about the CGMS could be found at https://cgms-info.org/.

The CGMS turns 50 years in 2022. It started with geostationary meteorological satellites, gradually expanding to include polar and highly elliptic orbit observations for weather, oceans and climate. CGMS aims to provide an end-to-end system – from providers to the global users' community. WMO SWCEM contributed a working paper CGMS-50-WMO-WP-06 to the CGMS Working Group II "Satellite Data and Products" and participated in the meeting under agenda item 4 "Working papers on climate and greenhouse gas (mitigation, adaptation, long-term monitoring)". On May 20, 2022 Professor Kuleshov delivered a presentation titled "WMO Space-based Weather and Climate Extremes Monitoring (SWCEM) in the South-East Asia and the Western Pacific Ocean Regions". Links to the working paper CGMS-50-WMO-WP-06 and to the presentation are available from the CGMS website at https://www.cgms-info.org/agendas/agendas/CGMS-50 (select "Working Group II" tab, scroll down to agenda item 4).

4.1.2. IPWG

The International Precipitation Working Group (IPWG) was initiated in 2000 after the 52nd session of the WMO Executive Council recommended involving relevant science groups in a systematic manner to improve satellite system utilization. The IPWG was then endorsed by the Coordination Group for Meteorological Satellites (CGMS). The IPWG provides a forum for operational and research users of satellite precipitation measurements to exchange information and fosters the development of better measurements and improvement of their utilization, the improvement of scientific understanding, and the development of international partnerships.

Further information about the IPWG could be found at https://www.isac.cnr.it/~ipwg/.

The IPWG invited the WMO SWCEM to participate in training and outreach activities (interaction with users) in the workshop in Fort Collins organised on June 13 – 17, 2022 (https://www.cira.colostate.edu/conferences/2022_ipwg/). A webinar titled "Training and Outreach on satellite-based products to monitor weather, climate, and extreme events" was conducted on June 15, 2022. Focus of the webinar was on how satellite-based products can help to monitor extreme events including droughts, and how this is communicated to the users. Professor Kuleshov delivered a presentation titled "Space-based Weather and Climate Extremes Monitoring (SWCEM) program: Drought Monitoring over Papua New Guinea". Link to the presentation is available at https://rammb.cira.colostate.edu/training/rmtc/video/IPWG_20220615_kuleshov/

4.1.3. AOGS

Asia Oceania Geosciences Society (AOGS) was established in 2003 to promote geosciences and its application for the benefit of humanity, specifically in Asia and Oceania and with an overarching approach to global issues. Presently, AOGS has over 15,000 members from 90 countries. Achievements of the WMO SWCEM were presented at the 18th Annual Meeting (AOGS2021) last year (see SWCEM Newsletter issue, August 2021 for details). Further information about the IPWG could be found at https://www.asiaoceania.org/society/public.asp?page=home.asp .

AOGS conducted the 19th Annual Meeting (AOGS2022) on August 1 – 5, 2022. A special session titled "Climate Change and Tropical Climatic Hazards in Asia Oceania" was organised at the AOGS2022. Six presentations which describe achievements of the WMO SWCEM and its synergies with the CREWS were delivered during this session on August 1, 2022.

#1: WMO Space-based Weather and Climate Extremes Monitoring (SWCEM) for East Asia and Western Pacific
Prof Yuriy Kuleshov (Bureau of Meteorology, Australia)

#2: New Version of the Global Satellite Mapping of Precipitation (GSMaP) Towards the Enhancement of WMO SWCEM Activities
Dr Moeka Yamaji (Japan Aerospace Exploration Agency, Japan)

#3: Using WMO SWCEM Satellite Precipitation Estimates for Creating an Improved Satellite-gauge Dataset Over Australia
Mr Zhi-Weng Chua (Bureau of Meteorology, Australia)

#4: Evaluating Satellite Soil Moisture Datasets for Drought Monitoring in Australia and the South-west Pacific
Ms Jessica Bhardwaj (Bureau of Meteorology, Australia)

#5: Climate Risk and Early Warning Systems (CREWS) International Initiative: Building Resilience of Papua New Guinea to Drought
Prof Yuriy Kuleshov (Bureau of Meteorology, Australia)

#6: Validating a Tailored Disaster Risk Assessment Methodology: Drought Risk Assessment in Local PNG Regions
Ms Isabella Aitkenhead (Bureau of Meteorology, Australia)

4.2. Early Warning System for Drought Implemented in PNG by CREWS

On the 23rd of March 2022 - World Meteorological Day - the Secretary General of the United Nations (UN), António Guterres, announced an ambitious UN goal that everyone should have access to weather and climate Early Warning Systems (EWS) within the next five years, to adapt to climate change and more extreme weather. He noted "We must boost the power of prediction for everyone and build their capacity to act. On this World Meteorological Day, let us recognize the value of early warning and early action as critical tools to reduce disaster risk and support climate adaptation."

In late September, the 2022 Asia-Pacific Ministerial Conference on Disaster Risk Reduction

(APMCDRR) was held in Brisbane, Australia highlighting the United Nations drive to implement Early Warning Systems around the globe. One such system highlighted at the conference was the achievements of the World Meteorological Organization – Climate Risk and Early Warning System (CREWS) project in Papua New Guinea (PNG), which involved Bureau of Meteorology staff working closely with the Papua New Guinea National Weather Service to build the PNG resilience to drought.

To build PNG's resilience to impact of future droughts, the PNG National Weather Service, and the Bureau of Meteorology, in partnership with the World Meteorological Organization, successfully implemented a CREWS project developing a real time drought risk assessment, and a user-centred integrated Early Warning System for drought, providing accurate and timely information about the current state of drought and its likely development. The drought risk assessment for PNG integrates drought hazard, exposure and vulnerability components, WMO Space-based Weather and Climate Extremes Monitoring (SWCEM) products and outputs from Bureau's dynamical climate model ACCESS-S2.

The WMO's SWCEM was established recognizing needs to better utilize and improve monitoring of weather and climate extremes from space to complement surface-based observations and successfully implemented in Asia and the South-West Pacific, with focus on monitoring drought and heavy precipitation. Global Satellite Data Providers for the Space-based Weather and Climate Extremes Monitoring are JAXA and NOAA. They provide satellite precipitation estimates at various timescales from hours to months, statistics and indices such as the SPI and the VHI which are valuable for drought monitoring.

Thanks to the WMO CREWS and the SWCEM, the PNG National Weather Service now issues a monthly Drought Update bulletin which is distributed to stakeholders from government, agriculture, energy, health and water sectors, as well as to the PNG Disaster Management Team and the United Nations Development Program, allowing for a proactive and targeted approach to drought in the country.

The CREWS Partner Event session and discussion at APMCDRR also noted:

- Strengthening Observing Systems is important to enhance Climate Risk Assessments and Early Warning Systems. Space-based observations are integral part of the global observing system; they provide valuable information on a global scale and complement surface-based observations. It was recommended to further expand the WMO SWCEM.

- Strengthening Predictive Systems is also important for enhancing Early Warning Systems. This could be achieved by accelerating the uptake of sub-seasonal to seasonal climate forecasts from dynamical climate models by Meteorological Services and Regional Climate Centres in Asia-Pacific.

- Enhancing the capacities of countries to communicate and disseminate early warnings and impact-based forecasts is critical.

A press release giving more details of the WMO-CREWS PNG project is available at: https://public.wmo.int/en/media/news/early-warning-system-drought-implemented-png-crews