Summary report on the Regional WIGOS Project

Capacity Building in Radar Techniques

Regional WIGOS Centre Tokyo

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CONTENTS

1 Project Overview 1

1.1 Background 1

1.2 Activities 1

2 Radar capabilities in the Asian region 2

2.1 Current situation in each Member 2

2.1.1 Radar observations 2

2.1.2 Use of radar data and products in forecasting operation 6

2.1.3 Provision and exchange of radar data products 8

2.1.4 Regulations and capacity building for radar operations 9

2.2 Regional situation in radar observation 10

2.2.1 Radar network still under development, observation data used qualitatively 10

2.2.2 Radar network mostly developed, data utilization still developing (ex. QPE implemented) 10

2.2.3 Radar network developed, advanced use of data implemented (ex. use for QPF, meteorological warnings, data assimilation into NWP models) 11

2.2.4 Other common situations in the region 11

2.2.5 Data exchange 12

3 Experimental Radar Data Exchange in Southeast Asia 13

3.1 Overview 13

3.2 Guidelines for the Experimental Radar Data Exchange 13

3.3 Implementation method 14

3.4 Result 15

3.4.1 Achievements 15

3.4.2 Challenges 16

4 Future Prospects 16

Appendix 1. Current status of Members' radar capabilities 18

Appendix 2. Guidelines for the Participation in Experimental Regional Radar Composite Data Exchanges in Southeast Asia 19

Appendix 3. Rules for weather radar observation in the Japan Meteorological Agency (JMA) 24

1 Project Overview

1.1 Background

Southeast Asian countries have experienced natural hazards such as heavy rain and typhoons, and the use of weather radar can be very effective in Disaster Risk Reduction (DRR) activities. In the 2000s, domestic radar networks were developed in many countries, but at that time it was difficult for many Members to operate the radars and process the data properly, and the radars were not fully utilized. In addition, as many Members in Southeast Asia border each other, it was recognized that it would be effective to exchange radar data within the region, but as there was no framework or data policy for data exchange, this had not been achieved.

In this situation, where there was an urgent need to strengthen radar capabilities and exchange radar data within the region, a radar project was launched under the Typhoon Committee's Annual Operating Plan in 2011 to realize these goals. Subsequently, the regional WMO Integrated Global Observing System (WIGOS) project in RA II and V and the ASEAN project were launched with similar objectives. Under these frameworks, technical cooperation between Japan and other Members, knowledge sharing and experimental radar data exchange have been promoted.

In recent years, radar has also been envisaged as a key element of the Regional Basic Observing Network (RBON) which WMO is promoting as an observing network to address regional challenges. Also, there is an increasing need to strengthen radar capabilities among WMO community.

1.2 Activities

Activities aimed at strengthening Member's radar capabilities and regional radar data exchange have been carried out under the radar initiative of three international frameworks of the Typhoon Committee, WMO and ASEAN. In the first half of the 2010s, technical cooperation mainly between Japan and other Members was carried out to improve radar data processing and quality control capabilities, introduce a nationwide composite process, and exchange radar data. As a result, capacity development was achieved in Thailand and Malaysia, and an experimental radar data exchange between Thailand, Malaysia, and Japan, was initiated in 2016.

Since the second half of the 2010s, international radar workshops attended by Members in Southeast Asia and others were held in Japan to share knowledge and discuss the expansion of data exchange. In the current regional WIGOS project, a series of three workshops was held from 2023 to 2025 to summarize the status of radar observations in the region and discuss data exchange.

Regarding data exchange, the Guidelines for experimental radar data exchange were developed by Japan, Malaysia, Thailand and Indonesia in 2019, on the basis of which data exchange is being expanded. (For more information, see chapter 3)

2 Radar capabilities in the Asian region

2.1 Current situation in each Member

As part of knowledge sharing and technical cooperation, one of the major activities for developing radar capabilities in Southeast Asia, among participating Members[1], the current status and challenges of radar observation are summarized as follows based on the reports in the three workshops held between 2023 and 2025[2].

2.1.1 Radar observations

2.1.1.1 Radar networks

- Wavelength, number of radars
  - In the Southeast Asian region, C-band radars are the most widely operated, but approximately half of Members operate both S-band and C-band radars.
  - Some Members such as Thailand, Viet Nam, Indonesia and UAE mainly operate C-band radars, and other Members such as India and Bangladesh mainly operate S-band radars.
  - S-band radars are operated for wider coverage, such as monitoring typhoons and tropical cyclones approaching from the sea.
  - Approximately half of Members use X-band radars in urban and mountainous areas.
  - Several Members that do not cover the entire national territory and have identified improving coverage as a challenge.
- Transmitter
  - Magnetrons are often used, but Solid-State Power Amplifiers (SSPA)[3] are also used in

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[1] Indonesia, Malaysia, the Philippines, Singapore, Thailand, Viet Nam, India, Bangladesh, Pakistan, Sri Lanka, and the United Arab Emirates

[2] The current status reported from participating Members with the workshop in 2025 is shown in Appendix 1.

[3] The advantages of SSPA include lower power consumption than magnetrons and klystrons, the low possibility of failure, the narrow bandwidth of transmitted radio waves, and the ease of maintenance.

some cases. Klystrons are used in a few cases.

- Single / dual-polarization, years of installation
  - ➢ As radars are updated, dual-polarization radars are increased, and many Members operate both single and dual-polarization radars.
  - ➢ A number of radars have been installed for more than 10 years, with the oldest being more than 20 years old.
  - ➢ Challenges such as the renewal of radars and related equipment were reported below by the Members.
    - ✧ Even though old radars after 20-25 years of operation have become out of service because of frequent malfunctions and the unavailability of spare parts, old radars cannot be updated due to budget shortfalls. (Pakistan, Bangladesh)
    - ✧ Hardware and software upgrades are difficult. (UAE)
- Scan strategy
  - ➢ All Members conduct 3D volume scanning. The frequency of scans varies from Member to Member: every 5, 10, and 15 minutes. In many Members, the bottom layer and 3D volume scans are performed at the same frequency.
  - ➢ Almost all Members observe continuously 24/7, but some have intermittent observations.

2.1.1.2 Maintenance arrangements

- Operation
  - ➢ NMHSs operate the weather radars. The number of staff involved in operations, monitoring, and maintenance varies from Member to Member, staff shortages are a challenge in some Members.
  - ➢ Many Members have staff at both the headquarters and each site.
- Scheduled maintenance
  - ➢ Regular maintenance is carried out at different frequencies in each Member, ranging from daily to annual inspections. Some Members have maintenance contracts with manufacturers.
  - ➢ Challenges such as lack of technical skills of staff, difficulties in securing technical personnel and in obtaining sufficient support from manufacturers were reported below by the Members.
    - ✧ There is a lack of training and capacity building for the radar technical issues regarding the maintenance procedures in all NMHSs. It will become more expensive

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※ Reference; Solid-state Weather Radar made in JAPAN
https://www.jma.go.jp/jma/en/Publications/japanese_weather_radar.pdf

the price of the radars themselves and the maintenance contracts, so that more capacity building of the radar personnel for the maintenance procedures is timely. (the Philippines)

- ✧ Insufficient technical level of staff. (Viet Nam, Pakistan)
- ✧ Difficulties in securing suitably qualified engineers. Training for radar operators and engineers is limited in scope. There is no institutional training for technicians; since 2016, the organization has not been able to recruit technicians and is therefore understaffed. (Bangladesh)
- ✧ No radar is currently operational, and no technology or expertise is available. (Sri Lanka)
- ✧ Remote support from the radar manufacturer is not available when the contract is overdue. Limited funding for maintenance and repairs was found in some cases, affecting data stability. (Viet Nam)

- Spare parts management
  - ➢ Many Members manage spare parts, but they cite long delivery times and the fact that some parts are not available because the radar has been installed for many years as challenges.
  - ➢ In some Members, spare parts are managed by contractors.
    - ✧ Even when spare parts are available, they take time to manufacture, and in some cases, it took more than several months to secure the product because it had to be ordered from overseas, or it took four years to restore it. (Bangladesh)
    - ✧ The necessary parts have been acquired from a radar that has stopped operating as production of spare parts has ended. (Pakistan)

2.1.1.3 Transmission and storage of observation data

- In almost all Members, observation data are transmitted immediately from the site to the center system.
- Some members share level 3 Cartesian gridded data, while others share filtered Level 2 Polar data.
- The spacing of range or azimuth in the polar coordinate format is different between Members.
- Data in several different formats is transmitted to the center system, as different manufacturers have different data formats.
- Challenges in dealing with signal processing and the products of different manufacturers were reported[4].

[4] JMA operates weather radars from three different manufacturers, but the data processing and signal processing are exactly the same, which is because JMA offers strict requirements and specifications for radar procurement.

  - The mix of radars manufactured by different manufacturers and the different methods of signal processing by different manufacturers require familiarity with signal processing. (India)
  - It is difficult to deal with different methods of signal processing and different formats of output data and products. (the Philippines)
- Most Members transmit using fiber optic or copper cables or a combination of these and mobile links, but some use mobile and satellite links.
- Challenges were reported in the instability of the communications environment, narrow bandwidth, and lack of redundancy. This prevents the transmission of raw data from the observation site to the main station center system.
  - When raw data is transmitted from radar sites, file corruption can occur due to unstable communications, resulting in erroneous data in some cases. (Indonesia)
  - Until recently, the narrow bandwidth of satellite links (512 kbps) used at one of the most remote sites meant that large amounts of data could not be sent, and only JPEG-format image files could be sent, but bandwidth has improved (15 Mbps) with the new satellite communications service. However, during bad weather conditions such as thunderstorms, there are times when communication is not sufficient, and data is sent after several minutes. (the Philippines)
  - A redundant communication network is required. (the Philippines, Indonesia, Viet Nam)
  - In some cases, when communication failures occur, it takes time for the telecom company to prepare the link and it takes weeks and sometimes months to restore it. (the Philippines)

2.1.1.4 Signal processing, quality control and data processing

- All Members implement clutter removal.
  - Challenges in lacking knowledge on the removal of non-precipitation echoes[5] were reported.
    - It is difficult to remove interference, abnormal propagation and clutter sufficiently by filtering. (interference: Indonesia, Malaysia, UAE, etc.; abnormal propagation and clutter: Viet Nam, UAE, Singapore).
- Approximately half of Members implement the Doppler velocity unfolding, and the dual pulse repetition frequency (DUAL PRF) method is used by the majority.
- Comprehensive quality control is implemented by manufacturer-developed software (J-Birds, IRIS, Rainbow) in many Members, although some Members (Indonesia = SIDARMA) implement it through self-developed software. Some implement it using Open Source Software

[5] Regarding contamination by wind farms, JMA deals with it by advanced Moving Target Indicator (MTI) based on dual-polarization radar data.

(OSS) (UAE = LROSE, developed by NCAR and CSU in the USA).

- In almost all Members, the main processing of observation data is carried out by central systems.
- CAPPI and PCAPPI are generated in half of the Members.

2.1.1.5 Technical research and development

- Some Members (Thailand, Viet Nam, UAE) have departments that develop processing and software for radar operations, as well as developments related to Quantitative Precipitation Estimation (QPE), Quantitative Precipitation Forecasting (QPF) and hydrometeor classification. Research on Hail probability forecasting has been carried out in the UAE.
- Approximately half of Members use OSS (PyArt, Wradlib, LROSE).

2.1.2 Use of radar data and products in forecasting operation

2.1.2.1 Major radar data and products used in forecasting

- Many Members use precipitation intensity and QPE in forecasting.
- Some Members also use precipitation nowcast (QPF) and lightning nowcasts, tornado and hailstorm probabilities, storm tracking, etc.

2.1.2.2 Use of radar data in precipitation monitoring, precipitation forecasting, and meteorological warnings

- Almost all Members use radar data quantitatively and use it for quantitative monitoring and forecasting of precipitation.
- All Members use radar data for meteorological warnings.

2.1.2.3 QPE

- It has been implemented in all but a few Members (Pakistan, Bangladesh and Singapore).
- In Thailand, Viet Nam and Malaysia, this is being implemented using the JMA-based methodology (calibration of QPE by rain gauge observation data) provided through Japan International Cooperation Agency (JICA).
- In the UAE, quality control is carried out by LROSE particle identification detection filtering (no quality control by rain gauge data due to a sparse rain gauge network).
- In other Members, implementation is by manufacturer-developed software.
- Challenges in improving the accuracy of QPE[6] were reported.
    - No Z-R equation set up for localized heavy rainfall, limited rain gauge network and

[6] Regarding improvement of QPE by dual-polarization data, JMA partially uses K_{DP}, for example, in heavy rainfall areas.

insufficient for calibration, use of dual-polarization data to improve future QPE but not fully utilized. Calibration of dual-polarization radar and monitoring of Z_{DR} bias are also issues. (Malaysia)

2.1.2.4 QPF

- Some Members have implemented QPF (Viet Nam, Malaysia, India, Indonesia and Pakistan).
- NWP models[7] are used in Malaysia and Indonesia, and Optical flow is used in Viet Nam.
  - RaINS (Malaysia).
  - STEPS (Indonesia)
  - Optical flow algorithm (Viet Nam)

2.1.2.5 Creation of quantitative indices for floods, landslide disasters, and inundation damage using radar data

- Almost all Members have not yet developed quantitative indices, but Thailand and Viet Nam have developed flood and other risk maps based on accumulated precipitation.
- The UAE is considering the use of radar data and other meteorological data for flash flood guidance.

2.1.2.6 Use of Doppler velocity

- About half of the Members used Doppler velocity to monitor extreme events, such as tornadoes, gusts and thunderstorms.
- Some Members assimilate Doppler velocity into NWP models (e.g., WRF) (Thailand, Viet Nam, UAE).

2.1.2.7 Use of polarization data

- It is used in some Members (Viet Nam, Malaysia, Singapore) for quality control and improved precipitation estimation and classification of severe phenomena.
- The challenge is to improve the technology for the use of dual-polarization data.

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[7] At the workshop, it was suggested that machine learning could contribute to improving the accuracy of QPF in the future. In the NWP model, convection often does not occur in the right place or at the right time. By using machine learning to learn from statistics the places where convection is most likely to occur, it may be possible to generate convection in the right place and at the right time in nowcasting.

2.1.2.8 Data assimilation into NWP models

- Assimilation of precipitation intensity, Doppler velocity, etc. to WRF and COSMO models in about half of the Members (Thailand, Viet Nam, the Philippines, Malaysia, Indonesia and UAE).

2.1.2.9 Cooperation and collaboration with the Hydrological Department

- Nearly half of the Members provide or exchange radar data to the hydrological department[8].
  - Thailand: SeAFFGS (Southeast Asian Flash Flood Guidance System).
  - Viet Nam: provision of radar data as input to flash flood, landslide and urban flood warning systems.
  - The Philippines: The Hydrometeorology Division of PAGASA, utilizes the S–Band and C–Band Radar Data together with their X-Band Radar network for Flood Forecasting, Monitoring, and Issuance.
  - Malaysia: Sharing radar data with the Department of Irrigation and Drainage (DID)
  - Indonesia, Singapore: Exchanging radar data with hydrological authorities.
  - UAE: Providing radar data, mainly reflectivity to hydrological authorities.

2.1.3 Provision and exchange of radar data products

2.1.3.1 Publication of radar products on website

- All Members have published radar data products on their website, and many Members publish national composite maps of reflectivity, precipitation intensity and QPE, as well as QPF, accumulated precipitation, risk maps and storm forecast products.

2.1.3.2 Provision of radar data

- To the relevant ministries.
  - Almost all Members provide radar data in real-time (Bangladesh provides warning messages but data). There are several data formats such as GRIB2, NetCDF, ASCII, etc., native format of manufacturer-developed software, or shared as images.
- To the private sector
  - Approximately half of the Members (Thailand, Viet Nam, the Philippines, Malaysia and the UAE) provide data.

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[8] Japan's Ministry of Land, Infrastructure, Transport and Tourism (MLIT) operates 26 C-band and 39 X-band radars nationwide, and JMA exchanges radar data with MLIT in real time. JMA uses data from the MLIT C-band radars in addition to its own radars for QPE. In this process, JMA performs quality control to the MLIT polar coordinate data and converts them to a Cartesian coordinate system.

  - The data and its format provided are different, with some Members offering historical data for a fee.
- To the Public
  - Almost all Members provide data in various formats via the website and provide non-real-time on-demand data for a fee.

2.1.3.3 Radar data exchange with other Members

- Thailand, Viet Nam, Indonesia and Singapore, which participate in the South-East Asia Radar Network, exchange national composite data on precipitation intensity (GRIB2 and HDF5).
- UAE exchanges reflectivity (NetCDF, LROSE-MDV) and raw data (RAINBOW format) in the GCC radar network.

2.1.4 Regulations and capacity building for radar operations

2.1.4.1 Radar observation regulations

- There are radar observation regulations in many Members[9].
- Many Members have manuals for operation, maintenance and troubleshooting.
- Many Members make regular reports.
- Although in some Members, the regulations do not cover the full scope and reports are not issued.

2.1.4.2 Human resource development

- Some Members have contracted manufacturers to provide on-site training, while others provide OJT and in-house training by knowledgeable personnel within the organization.
- Joint research with universities is carried out in several Members, and in some cases joint research is also carried out with neighboring NMHSs in the framework.
- Some Members participate in short-term seminars and other events invited by other Members.

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[9] JMA conducts various types of observations under the Meteorological Service Act. In the case of weather radar observations, there are regulations such as the Guide to the Weather Radar Observation that stipulate operational matters. In addition, matters related to the operation of radio stations are also governed by the Radio Act and other related laws and regulations. The radar observation operations are carried out under these rules and regulations. These regulations are very important for the stable and well-organized operation of weather radar. The outline of the law system in radar operation in JMA is shown in Appendix 3.

2.2 Regional situation in radar observation

- Based on the current status and challenges of radar observations summarized in chapter 2-1, the situation is generally categorized and described in the following three categories.
  - Radar network still under development, observation data used qualitatively
  - Radar network mostly developed, data utilization still developing (ex. QPE implemented)
  - Radar network developed, advanced use of data implemented (ex. use for QPF, meteorological warnings, and data assimilation into NWP models).
- In addition, the major situation common to each Member and the situation regarding data exchange are also described.

2.2.1 Radar network still under development, observation data used qualitatively

- In some Members, it is difficult to secure funding and they rely on grants from donors. As a result, procurement of relevant equipment and replacement of aging radars and equipment has not been possible for many years, resulting in frequent failures that cannot be restored and may result in operational outages or intermittent operations.
- Maintenance, inspections and troubleshooting are handled by staff, but there are issues such as a lack of staff skill levels and difficulties in securing appropriate technical personnel.
- In some cases, there is no stable data communication network and data in the form of latitude and longitude (Level 3 data) rather than polar coordinates (Level 2 data) are transmitted to the headquarters by satellite or mobile lines.
- The processing of observation data is carried out in the software developed by manufacturers and is limited to qualitative data use.

2.2.2 Radar network mostly developed, data utilization still developing (ex. QPE implemented)

- Many Members include large or major parts of their landmass in their radar coverage, but many also recognize improving coverage as a challenge.
- The radar is in continuous operation and carries out 3D volume scanning.
- Due to an unstable power supply, some Members have UPS and generators at sites.
- Maintenance, inspections and troubleshooting are basically handled by staff, and some Members have maintenance contracts with manufacturers.
- The lack of a technical level of staff is one of the major challenges.
- Observation data are transmitted in real-time to the center system in polar coordinate format.

It is sometimes difficult to transmit data successfully to some Members due to unstable communication lines.

- The processing and quality control of observation data is carried out using methods provided by JMA, as well as software developed by manufacturers and OSS (LROSE).
- Some Members have generated CAPPI and many others have generated PCAPPI.
- The process of creating a domestic composite has also been implemented.
- Although the update to dual-polarization radars is underway, improvements in technology related to QPE and data quality control using dual-polarization data are required.

2.2.3 Radar network developed, advanced use of data implemented (ex. use for QPF, meteorological warnings, data assimilation into NWP models).

- Some Members implement QPF.
- Some Members have developed flood and landslide risk maps using accumulated precipitation.
- Some Members make use of NWP models, and several Members assimilate Doppler velocity, dual-polarization data and other data into NWP models such as WRF and COSMO models.

2.2.4 Other common situations in the region

In addition to the above categories, other situations and challenges common to all Members include the following.

2.2.4.1 Planning and specification

- The challenge is to keep up with the latest knowledge and technology in the radar market, a situation that requires a lot of time to create and update specifications.
- The planning of radar observation networks and radar specifications needs to be drafted and determined, taking into account the characteristics of each radar frequency band, after clarifying the objectives of radar operation, such as the use of observation data for disaster management information.

2.2.4.2 Operation and maintenance

- Securing spare parts is one of the common challenges. It can take a long time to obtain them, or if the radar or other parts are old, they may no longer be manufactured.
- Beam blocking by topography and artificial structures makes it difficult to secure a radar

installation site or make it necessary to consider relocation.

- Radio frequency interference (RFI) caused by wireless LANs is another challenge for many Members. Countermeasures are taken through filtering, coordination with national radio ministries and the use of Dynamic Frequency Selection (DFS). The New Wide Band Radio LANs used in the C-Band poses more of a challenge to remove, especially when high density networks are rolled out close to a radar.

2.2.4.3 Quality control and utilization of observation data

- The mix of radars from different manufacturers and different signal processing methods is one of the challenges.
- Regarding the removal of non-precipitation echoes, the removal of interference, anomalous propagation and clutter is also a challenge. In some Members, quality control is carried out using self-developed methods, but it is also implemented using methods of JMA, software developed by manufacturers and OSS.

2.2.4.4 Capacity building

- Capacity building and training based on the situation of each Member, such as quality control and use of observation data including advanced techniques using dual-polarization data, improvement of observation systems, and practical training for maintenance procedures, are required.

2.2.5 Data exchange

- In many Members, observation data are shared and exchanged with relevant ministries, such as hydrological departments.
- The data is exchanged in a variety of formats, such as GRIB2, NetCDF, ASCII, and output formats from manufacturers' software or OSS, and is basically provided in real-time.
- International data exchange is basically a routine exchange of national composite data on precipitation intensity or reflection intensity between Members participating in the South-East Asia Radar Network and the Gulf region radar network. However, some Members do not realize exchange due to data policies, and differences in data formats are identified as a challenge.
- Issues related to Southeast Asia radar data exchange are mentioned in more detail in 3.4.2.

3 Experimental Radar Data Exchange in Southeast Asia

3.1 Overview

As described in Section 1-1, radar data exchange is one of the main activities for developing radar capabilities in Southeast Asia, and the experimental data exchange was initiated in 2016 between Thailand, Malaysia, and Japan as part of the Typhoon Committee project activities. In 2019, the Guidelines for Participation in Experimental Regional Radar Composite Data Exchange in Southeast Asia were developed by the abovementioned Members and Indonesia, within the Typhoon Committee project and the Regional WIGOS project. Since then, Members that have agreed to the Guidelines have joined the data exchange. As of February 2025, six Members exchange radar data under the Guidelines: Japan, Thailand, Malaysia, Indonesia, Viet Nam, and Singapore.

3.2 Guidelines for the Experimental Radar Data Exchange

The main contents of the Guidelines are as follows. In order to allow flexibility and make it easier for Members to participate, the Guidelines do not specify technical details, but only determine the framework for data exchange, such as guiding principles and data policies. When a new Member wishes to participate, it confirms its acceptance of the Guidelines through an exchange of letters between the coordinator (Japan) and joins the data exchange. The following is the outline of the Guidelines, and the full text is shown in Appendix 2.

- Guiding Principles:

The experimental radar data exchange shall be implemented by NMHSs who participate in either or both of the Regional WIGOS Project and/or the Typhoon Committee Project on radar capacity building and have accepted the Guidelines

The radar data exchange shall be mutually beneficial for all participating Members.

The Guidelines shall be coordinated and managed by the coordinator (Japan) and co-coordinators (Indonesia, Malaysia and Thailand).

- Radar Composite Data Exchange:

Participating Members shall exchange nationwide or sub-nationwide composite data in (near-) real-time and coordinate technical details on the data exchange with the other participating Members.

The data obtained through the data exchange and derived products from the data shall be used by participating Members only for their internal use. However, participating Members are allowed to provide a regional composite map in a graphical format to NMHSs of the Typhoon Committee and/or ASEAN for their internal use.

The data exchange is to be implemented by participating Members on a reasonable efforts basis, and participating Members shall accept no liability for any damages caused by the data exchange.

- Technical Cooperation:

Participating Members should provide other participating Members, if requested, with technical assistance in radar composite techniques, within their resources available.

3.3 Implementation method

Since the Guidelines don't set out technical details, basically, Members exchange data which they already produce. The specification of radar data exchange is decided through mutual coordination but is not strict.

<Technical matters regarding data exchange>
Element: Nationwide composite precipitation intensity (mm/h)
Spatial resolution: e.g., 0.01 degrees
Altitude represented by data: e.g., 2km
Time interval: Hourly
Timeliness (latency): Real-time exchange
Data format: e.g., GRIB2 (Japan, Thailand, Viet Nam and Singapore), HDF5 (Indonesia)
* As for Malaysia, radar composite image products on their website are tentatively used due to restrictions by their data sharing policy.
Communication method: Internet (partially GTS)

The experimental radar data exchange is carried out using the WIS server operated by GISC Tokyo. Each Member sends its national composite data to the WIS server (password-protected area) via the Internet using HTTPS. If HTTPS transmission via the Internet is difficult, Japan can receive the data via GTS line and put the data on the WIS server. Japan also creates regional composite data using nationwide composite data provided by each Member and stores it on the WIS server for use by participating Members.

Each Member can download data provided by others and the regional composite data on the WIS server as needed. Only data for the past 24 hours is stored on the server.

3.4 Result

3.4.1 Achievements

Initially, data exchange was initiated between Thailand, Malaysia and Japan in 2016, and joined by Viet Nam in 2024, and by Singapore and Indonesia in 2025. Therefore, a regional radar observation network covering a wide area of Southeast Asia has been established. The regional composite radar images are shared on the Numerical Typhoon Prediction website run by RSMC Tokyo (Typhoon Center) with Typhoon Committee Members (Figure 1).

The Experimental radar data exchange is launched as a demonstration aiming for a permanent mechanism based on the Members' needs. In order to establish a permanent radar data exchange in the future, it is necessary to discuss and confirm the purpose and decide the specifications of data exchange.

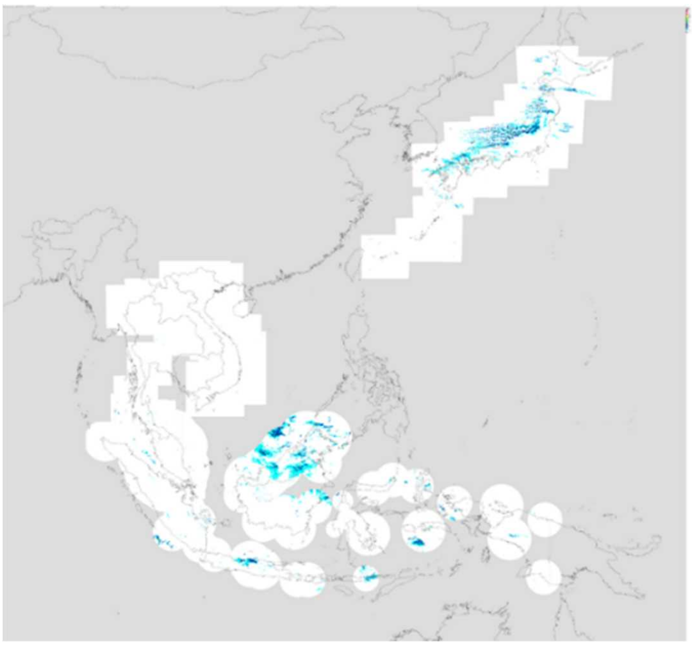

Figure 1. Regional Radar Composite Imagery (05 UTC, 6th February 2025)

3.4.2 Challenges

It was found that inconsistencies in radar observation among Members create some difficulties in conducting data exchange.

- Data specification:
  - Each Member decides their own radar observation specification (i.e., observation strategy, spatial resolution and timeliness of data distribution, etc.). The specification of data exchange needs to be coordinated as much as possible, based on the purpose of the exchange.
- Data policy:
  - Some Members strictly limit the external provision of observation data and are unable to exchange any observation data, while others are able to exchange products (Level 3/4) such as national composite data but unable to exchange Level 2 data such as volume data of each radar site.
- Data format:
  - Members use various formats depending on their radar operating system or manufacturer. It makes them difficult to use others' data. It is required to define a standard format.
- Data quality:
  - The quality of radar data differs depending on the participating Member, and many observation data appeared to have noise due to various factors.
  - If each Member can share their knowledge and improve their technical capabilities, it is expected that the uses of the exchanged data will expand and there will be mutual benefits.
- Agreement formation among participating Members:
  - When there is a new Member that wishes to participate in data exchange, Japan, as the coordinator of the Guidelines for the Experimental Radar Data Exchange, individually coordinates with the Member and exchanges letters of intent. To avoid such a significant amount of administrative work, it is desired to establish a radar data exchange mechanism under an international framework such as RBON.

4 Future Prospects

- In Southeast Asia, there is a strong desire among Members to monitor the precipitation situation in their own and surrounding areas, and efforts have been made to exchange radar data. Members in the region develop their Guidelines for experimental radar data exchange and have gradually expanded participants. Meanwhile, in recent years, WMO has been promoting the establishment of RBON, which is defined in accordance with the needs of each RA's Member. It is highly expected that the sub-regional effort should continue to expand and evolve into RBON.

- In order to incorporate radar data into RBON, the results and lessons learned through the radar network initiative in Southeast Asia need to be taken into account.
  - As data policy differs among Members, it is necessary to start with exchanging Level 3/4 data (e.g., nationwide composite data) rather than Level 2 data (volume data). Some Members are not allowed to exchange any data internationally, and others can only exchange L3/4 data, not L2 data, according to their data policy.
  - By not specifying the specification of radar data exchange, Members could easily join using the nationwide radar composite they already produce. However, differences between Members make it difficult to utilize each other's data. The data format in Cartesian coordinate needs to be standardized and the minimum and target requirements of other specifications (e.g., spatial resolution, time interval, timeliness) should be decided, depending on the purpose of the data exchange.
- In order to increase the effectiveness of regional radar networks through data exchange, it is important that each Member enhances their capability and exchanges high-quality data. Technical cooperation through international frameworks such as WMO, mutual cooperation among Members, and development assistance programs by development donors are expected to contribute to the capacity development.
- At a workshop held at JMA in February 2025, the following were agreed as examples of requirements for future data exchange.
  - Purpose: Monitoring high impact phenomena (e.g., heavy rain, tropical cyclones) by Members
  - Data exchange platform: WIS2.0
  - Data type: Nationwide composite data
  - Data format: Cartesian coordinate format (standard format should be developed)
  - Variable: Precipitation intensity (mm/h), Reflectivity (dBZ)
  - Data distribution interval: 1 hour or less
  - Timeliness: 20 minutes or less (after observation time)
  - Spatial resolution of data: 2 km or less
  - Altitude represented by data: 2 km or less

Appendix 1. Current status of Members' radar capabilities

(See the attached PDF)

Appendix 2. Guidelines for the Participation in Experimental Regional Radar Composite Data Exchanges in Southeast Asia

Guidelines for the Participation in Experimental Regional Radar Composite Data Exchanges in Southeast Asia

This document (hereinafter referred to as the "Guidelines") states the guidelines for the participation in the experimental regional radar composite data exchanges in Southeast Asia under the ESCAP WMO Typhoon Committee project, *Development of regional radar network* and the WMO Integrated Global Observing System (WIGOS) Regional Association II and V project, *Capacity Building in Radar Techniques in the Southeast Asia*.

1. Guiding Principle

The experimental radar composite data exchange shall be:

1.1 implemented by National Meteorological and Hydrological Services (NMHSs) who participate in either or both of the said projects and have accepted this Guidelines (hereinafter referred to as "participating Members").

1.2 mutually beneficial for all participating Members.

1.3 coordinated and managed by the coordinator (Japan Meteorological Agency) and the co-coordinators (Indonesian Agency for Meteorology, Climatology, and Geophysics, Malaysian Meteorological Department and Thai Meteorological Department) of the regional WIGOS project.

2. Radar Composite Data Exchanges

(Data Exchanges)

A Participating Member shall:

2.1. exchange nationwide or sub-nationwide weather radar composite data of its own in a digital format, with the other participating Members, on a (near-) real-time basis.

2.2. coordinate and agree the technical details on the radar composite data exchange, including data format, time interval, and telecommunication, as described in Annex I of this Guidelines, with the other participating Members.

2.3. provide technical information related to radar operation and data processing, as described in Annex II of this Guidelines to the other participating Members, to ensure their appropriate use of exchanged radar composite data.

(Conditions of use)

2.4. The data that participating Members obtain through the radar data composite exchange and derived products (*) from the obtained data shall be used by participating Members only for their internal use, to support their operation on a non-profit basis and shall not be provided to any third parties.

2.5. Notwithstanding the condition of the preceding item, participating Members are allowed to provide the regional composite radar map in a graphical format (e.g., jpg, jpeg, gif and png) to the NMHSs of the ESCAP/WMO Typhoon Committee and/or those of Association of Southeast Asian Nations (ASEAN) for their internal use.

2.6. The above said conditions of use shall be kept in effect for all participating Members notwithstanding the termination of their participation in the radar composite data exchanges.

(*) Derived products are defined as products whose construction would suffer significant degradation by removal of the obtained data and from which the obtained data can be retrieved easily.

(Disclaimer)

2.7. This experimental radar composite data exchanges is to be implemented by participating Members on a reasonable effort basis.

2.8. Participating Members shall accept no liability for any damages caused by the radar composite data exchanges.

3. Technical Cooperation

Participating Members should provide other participating Members, if so requested, with technical assistance in radar composite techniques, within their resources available.

4. Focal Points

Participating Members should designate and keep up to date focal points in the areas of international coordination, telecommunication and radar composite processing.

Annex I

Technical information on radar data national composite

Basic Information

- Country/Region
- NMHS name
- Website of domestic radar observation

Information on national composite data

- Number of all radars
- Number of radars used for national composite
- Representative height above sea level (km)
- Observation period (min)
- Representative time (Starting/Ending time of volumetric scan)
- Composite method (Max value adopting method/Average method/etc)
- Latitude of northern end (degree)
- Latitude of southern end (degree)
- Longitude of western end (degree)
- Longitude of eastern end (degree)
- Latitudinal grid interval (degree)
- Longitudinal grid interval (degree)
- Software to produce national composite data
- Data format of composite data (NOTE: Technical documents should be attached.)
- Comments

- Last update

Annex II

Technical information on radar operation and data processing on each radar site

General information

- WMO ID
- WIGOS Station Identifier
- Site name
- Status (Active/Inactive)
- Owner
- Latitude (degree)
- Longitude (degree)
- Ground height (m)
- Tower height (m)
- Band (X/C/S)
- Beam width (degree)
- Frequency (MHz)
- Pulse width (micro-sec)
- Minimum Pulse Repetition Frequency (Hz)
- Maximum Pulse Repetition Frequency (Hz)
- Signal processor
- TX type (Solid-state, Klystron, Magnetron)
- Power (kW)
- RX type
- Doppler function (Doppler/Non-Doppler)
- Polarization (Single/Dual)
- Manufacturer
- Lowest elevation angle used for observation (degree)
- Highest elevation angle used for observation (degree)
- Minimum task cycle time (min)
- Maximum task cycle time (min)
- Minimum Detectable Signal (dBm)
- ZR in summer
- ZR in winter
- ZR in other seasons
- Installation year

- Total number of elevation angles for volumetric scan
- Elevation angles (Observation order)
- Required time for volumetric scan (min)
- Azimuth resolution (degree)
- Range resolution (m)
- Max detection range (km)
- Data format of stored polar coordinate data
- Westward bias of polar coordinate data, including magnetic declination (degree)
- Communication type to centralized system
- Operation (Remote/On-site)
- Comments

Quality control
- Bias of reflectivity (dB)
- Minimum threshold level of received signal power (dBm)
- Minimum threshold level of reflectivity (dBZ)
- Minimum threshold level of precipitation intensity (mm/h)
- MTI filter (ON/OFF)
- Clatter map (YES/NO)
- Speckle filter for removal of isolated noise (ON/OFF)
- Real-time calibration using rain gauges (YES/NO)
- Correction for rain attenuation (YES/NO)
- Precipitation intensity estimation using dual-polarization (YES/NO)

Elevation angle composite data of each radar site
- Type of elevation angle composite (PCAPPI/CAPPI)
- Representative height above sea level (km)
- Elevation numbers used for elevation angle composite
- Effective earth radius (km)
- Smoothing for radius direction (YES/NO)
- Smoothing for azimuthal direction (YES/NO)

Maintenance
- Periodic maintenance by NMHS’s staff
- Periodic maintenance by manufacturers
- Replacement cycle of transmitter
- Last update

Appendix 3. Rules for weather radar observation in the Japan Meteorological Agency (JMA)

In Japan, the Meteorological Service Act mandates JMA to establish and maintain various observation networks. With regard to weather radar observation, JMA makes an internal rule Guide to Radar Observation to stipulate operational matters, and manuals under the guidelines (Figure 2). Matters related to the operation of radio stations are stipulated in related laws and regulations such as the Radio Act, and the responses to these Acts and Manuals are reflected in the abovementioned guidelines and manuals. These laws and internal regulations are extremely important for the stable and systematic operation of weather radar.

・Meteorological Service Act

This law comprehensively regulates meteorological services that JMA carries out as a national organization and the observation, forecasting, and information provision services including observation and forecasting services provided by organizations other than JMA.

・Rule of weather observation

This rule comprehensively regulates observation operations carried out at the headquarters and local observatories. Regarding radar observation, observation times, observation categories, administrative observatory for each observation site and so on are regulated in this rule.

・Guide to radar observation

The guide covers the equipment and instruments used for radar observations and the operations carried out at the headquarters and administrative local observatories.

Specifically about operations, this guide comprehensively covers maintenance and management (dealing with malfunctions, regular inspections, etc.), monitoring and quality control of observation data, management of observation systems, data management, analysis and research to understand changes in data characteristics for quality control and improvement of observation data, management of radio waves in accordance with the Radio Act, and storage of observation data, referring to WMO Guide to Instruments and Methods of Observation (WMO-No.8).

・Manuals

The Manuals provide specific details of the implementation for the items covered in the guide. In particular, the maintenance manual clearly shows the purpose of the inspection (Acquisition of normal observation data, conducting observations within the terms of the license based on the law, and preventing serious damage or failure of equipment), the correspondence between each inspection item and purposes, and the technical information to be inspected, and is designed to be useful for capacity development of staffs through regular inspections (Figure 3).

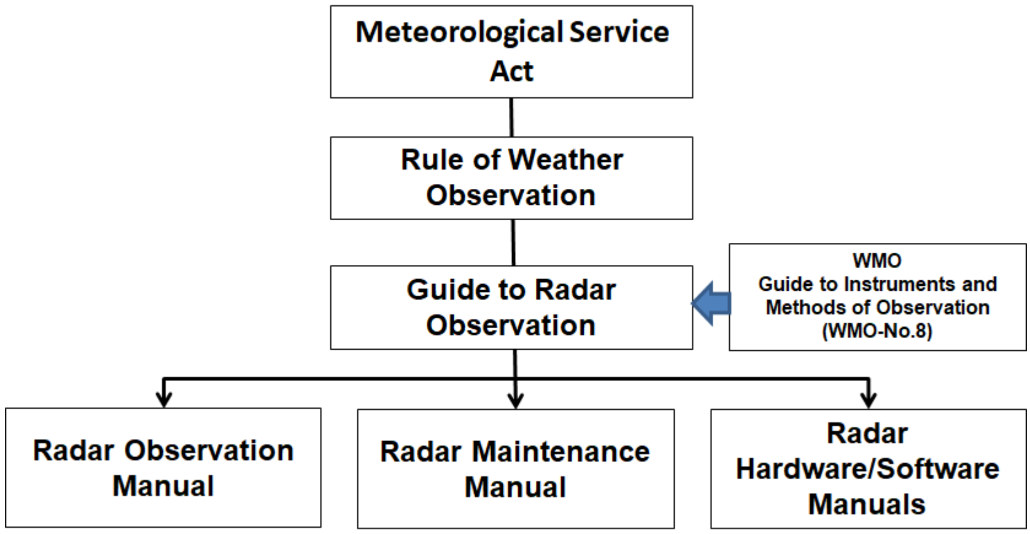

Figure 2. The Law system of weather radar operation in JMA

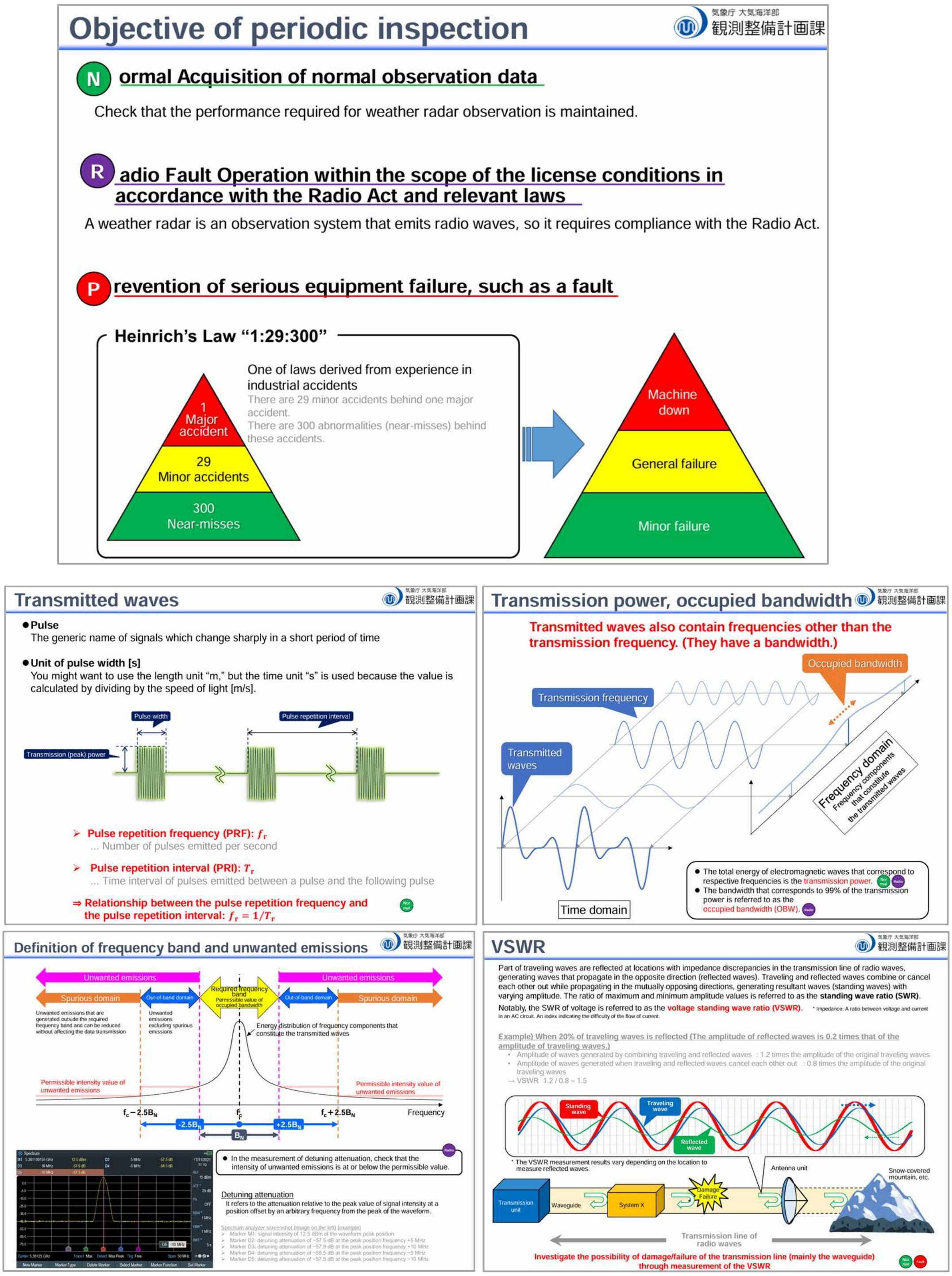

Figure 3. Sample snapshots of the maintenance manual in JMA

The maintenance manual is intended to show the correspondence between each inspection item and the purposes, as well as technical information about the inspection items.