International Civil Aviation Organization

WORKING PAPER

SEVENTH MEETING OF THE ASIA/PACIFIC METEOROLOGICAL REQUIREMENTS WORKING GROUP (MET/R WG/7)

Bangkok, Thailand, 21 – 23 May 2018

Agenda Item 4: MET information required to support end-user systems

UPDATES ON ASIA/PACIFIC REGIONAL GUIDANCE FOR TAILORED METEOROLOGICAL INFORMATION AND SERVICES TO SUPPORT AIR TRAFFIC MANAGEMENT OPERATIONS

(Presented by MET/R WG Ad Hoc Group – Australia, China, Hong Kong, China, Japan (rapporteur), New Zealand, Republic of Korea, Singapore, Thailand, Vietnam and IATA)

SUMMARY

This paper presents proposed updates on Asia/Pacific Regional Guidance for Tailored Meteorological Information and Services to Support Air Traffic Management (ATM) Operations. The draft has been developed by MET/R WG ad-hoc group consisting of Australia, China, Hong Kong, China, Japan (rapporteur), New Zealand, Republic of Korea, Singapore, Thailand, Vietnam and IATA.

1. INTRODUCTION

1.1 ICAO APAC Meteorological Requirements Task Force (MET/R TF) 4th meeting, held in July 2015 in Tokyo, noted that so-called 'ATM-tailored' MET information, when provided to support international air navigation, is still required to comply with the Annex 3 'General Provisions'. However, the detailed technical specifications for the information are yet to be specified in Annex 3. The meeting also noted the specific regional guidance material is necessary to assist States in developing and implementing tailored meteorological information and services supporting effective ATM.

1.2 The meeting agreed to develop the regional guidance material, and ad-hoc group consisting of Australia, China, Hong Kong, China, Japan (rapporteur), New Zealand, Republic of Korea, Singapore, Thailand and Vietnam was tasked to develop a draft regional guidance material for tailored meteorological information to support ATM operations. At MET/R WG 6th meeting, IATA agreed to review and provide comments on the draft document and join the ad hoc group to work on future developments of the draft.

2. DISCUSSION

2.1 The regional guidance aims to foster States' implementation and enhancement of MET information and services for ATM within APAC region. The guidance captures most of the necessary processes from preparatory to operational phases. A stepwise (process-wise) structure of the guidance is expected to allow each State to refer to chapters, sections or subsections useful for the

commencement, implementation or improvement of its MET information and services to support effective ATM. Furthermore, it provides detailed operational services, with specific examples and an operational scenario as Appendices.

2.2 MET SG/21 had reviewed the draft guidance proposed at MET/R WG/6 and, although some suggestions were made for improvements, no objections were raised concerning suitability of the document for dissemination to and use by States in the Region. However, the document was not formally endorsed by MET SG/21 and therefore not presented to APANPIRG for final endorsement in the MET SG/21 Report. At APANPIRG/28 meeting, the Secretariat advised that, in accordance with the APANPIRG Procedure for the Endorsement and Application of Asia/Pacific Regional Guidance Materials in various Air Navigation Fields, and in order for the document to be made available more speedily for use by States in accordance with the Conclusion ATM/SG/5-2, it would be appropriate for the material to be circulated to States for appropriate action following consultation with the APANPIRG Chairperson and examination by ICAO Headquarters.

2.3 Although the process necessary for the circulation of the guidance has not been completed yet, the ad-hoc group continued updating the draft guidance. After MET/R WG/6 meeting, IATA proposed changes for the first version of the guidance to clarify some descriptions so that it becomes more understandable. Based on the proposal from IATA, the ad-hoc group discussed further on the revision of the guidance. The draft proposal for the update of the guidance is provided in **Attachment A** to this paper.

3. RECOMMENDATION

3.1 It is recommended that the METSG/22 adopt the following draft Conclusion:

Draft Conclusion MET/R WG/7/x – Update on Regional Guidance for Tailored Meteorological Information and Services to Support ATM Operations

a) The MET/R WG review the draft updated guidance and provide comment to the ICAO RO MET no later than 1 June 2016; and

b) The ad hoc group, consisting of Australia, China, Hong Kong, China, Japan (rapporteur), New Zealand, Republic of Korea, Singapore, Thailand, Vietnam and IATA finalise the updated guidance for approval at the MET SG in June 2018.

4. ACTION BY THE MEETING

4.1 The meeting is invited to:

a) note the information contained in this paper; and

b) adopt the Draft Conclusion in paragraph 3.1.

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INTERNATIONAL CIVIL AVIATION ORGANIZATION

ASIA/PACIFIC REGIONAL GUIDANCE FOR TAILORED METEOROLOGICAL INFORMATION AND SERVICES TO SUPPORT AIR TRAFFIC MANAGEMENT OPERATIONS

Version 0.4.0, XX 2018

Adopted by APANPIRG/xx in September 20XX

RECORD OF AMENDMENTS AND CORRIGENDA

Amendments			
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Corrigenda			
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<To be inserted later>

1. Introduction

1.1 Purpose and overview of the guidance

This guidance aims to foster States' implementation and enhancement of meteorological (MET) information and services for air traffic management (ATM)[1] within Asia/Pacific (APAC) region.

The guidance captures most of the necessary processes from preparatory to operational phases. Furthermore, it provides detailed operational services, with specific examples and an operational scenario on ATM-tailored MET information and services. Information in this guide can also be used to facilitate further improvement by the States who have already implemented ATM-tailored MET services.

A stepwise (process-wise) structure of the guidance is expected to allow each State to refer to chapters, sections or subsections useful for the commencement, implementation or improvement of its MET information and services to support effective ATM.

1.2 Development of the regional implementation guide

ICAO APAC Meteorological Requirements Task Force (MET/R TF) 4th meeting, held in July 2015 in Tokyo, noted that so-called 'ATM-tailored' MET information, when provided to support international air navigation, is still required to comply with the Annex 3 'General Provisions'. However, the detailed technical specifications for the information are yet to be specified in Annex 3. The meeting also noted the specific regional guidance material is necessary to assist States in developing and implementing tailored meteorological information and services supporting effective ATM and agreed to develop the regional guidance material.

Ad-hoc group consisting of Australia, China, Hong Kong, China, Japan (rapporteur), New Zealand, Republic of Korea, Singapore, Thailand and Vietnam was tasked to develop a DRAFT regional guidance material for tailored meteorological information to support ATM operations.

Detailed historical background of efforts for implementation and enhancement of MET information and services for ATM in APAC Region is described in 1.4.

1.3 Importance of ATM-tailored MET information and services

With unprecedented growth in air traffic movements in the Asia/Pacific Region, ATM is paramount for the continued assurance of safe, efficient and timely aircraft operations. Recognizing the importance, various States have continued to evolve their ATM systems and procedures to meet the growing demand and to maintain safety as the priority. Additionally, neighbouring States are increasingly collaborating on activities

[1] *Note. ATM is defined in PANS-ATM (Doc 4444) as follows;*
The dynamic, integrated management of air traffic and airspace including air traffic services, airspace management and air traffic flow management – safely, economically and efficiently – through the provision of facilities and seamless services in collaboration with all parties and involving airborne and ground-based functions.

such as Air Traffic Flow Management (ATFM), which are enhanced by the incorporation of dedicated support from MET services.

Information sharing and collaborative decision-making (CDM) by relevant stakeholders are indispensable for the successful provision of effective and efficient ATM. Aircraft operations are influenced by atmospheric conditions and meteorological phenomena, and so adverse conditions can have a significant impact on ATFM planning and provision.

In Asia/Pacific, we experience diverse weather features on a daily basis as the region is influenced by climates varying from tropic to sub-polar and is further complicated by geography including both broad land masses and wide oceanic areas. It is therefore critical that the region's ATM, and particularly ATFM operations are supported by tailored MET information and services to ensure safe, efficient and orderly aircraft operations.

1.4 Historical backgrounds

Since ICAO endorsed the *Global Air Traffic Management Operational Concept* (GATMOC, Doc 9854) in 1996, States have worked on the enhancement of ATM. In the Asia/Pacific Region, since the late 1990s, ATM (and ATFM) has evolved significantly in several States. Subsequently, tailored MET information and services has been recognised as critical information for the effective provision of ATM and subsequently has been incorporated as part of the strategic and tactical ATM operations of those States. For example, in Japan, the Air Traffic Meteorology Center (ATMetC) of the Japan Meteorological Agency was established in February 2006, as a specialized MET service provider for the Air Traffic Management Center (ATMC) of the Japan Civil Aviation Bureau (JCAB).

In 2001, ICAO APANPIRG Communications/Navigation/Surveillance and Meteorology Sub-Group (CNS/MET SG) formed the MET/ATM Task Force (TF) to facilitate regional implementation of meteorological services in support of ATM. The first Regional MET/ATM Seminar was held at the ICAO Regional Office in Bangkok, Thailand, in February 2006. In order to enhance regional implementation, in 2009, APANPIRG agreed to call for the 1st meeting of the MET/ATM TF to plan the 2nd Regional MET/ATM Seminar and TF Meeting in 2010 timeframe. In February 2011, the Seminar and the 2nd meeting of the TF were held in Fukuoka, Japan, where experts from MET, ATM and other international organizations in the Asia/Pacific region gathered to discuss their plans and best practices on the development and implementation of meteorological services in support of ATM. The meeting also included a technical tour to the ATMetC to provide an example of the collaborative work undertaken between MET and ATM organisations. Subsequent TF meetings, and later the MET/R Working Group, successor to the MET/ATM TF, continued the important work of developing regional guidance to assist Asia/Pacific States with implementation or improvement of MET information and services to support ATM.

2. Implementation procedures

2.1 Preparatory phase (processes toward implementation)

2.1.1 Communication channel establishment

The most important step in the implementation of ATM-tailored MET information and services is to establish a good communication channel for mutual collaboration between MET and ATM organizations. To develop and facilitate an implementation plan, it would be useful to exchange views and information and build mutual understanding of each other's services, through regular consultations and meetings with clear focus.

In addition, consultation with collaborative decision-making (CDM) stakeholders from the initial stage will be desirable for smoother and better planning. This will further assist in implementation process, given that CDM is an essential element in ATM operational concept and concerned parties including Airspace Users, such as major airlines, are supposed to participate in CDM.

2.1.2 Service Identification

2.1.2.1 Understanding of ATM and aircraft operations

ATM operations vary in each State depending on its technical capabilities and characteristics of their responsible airspace. Better understanding of the State's ATM system is necessary to determine the scope of MET information and services to support ATM. This aspect will assist in understanding the local ATM requirements and determining the most appropriate process.

Additionally, procedures for aircraft operation adopted by airlines are also important in defining ATM-tailored MET information and services. The safety and efficiency of aircraft operations are fundamentally dependent on weather conditions. For example, each aircraft has maximum crosswind threshold values for take-off and landing. Adverse weather conditions may force aircraft to fly irregular flight routes and conduct unusual operations, which could result in significant diversion from the normal and planned distribution of air traffic. In this context, understanding aircraft operation procedures will be helpful in designing more *fit-for-purpose* MET information and services.

2.1.2.2 Past Events and Case Studies

Investigation on weather-related impact on air traffic flow is essential to determine what kind of MET information and services are required to effectively support ATM. One practical approach, in cooperation with airlines, is to compare operational records (including causes of delay, if available) with past weather data.

Once ATFM is implemented, focus could be on more direct ways to use the flow management record in the ATFM process in addition to the aircraft operation record for the comparison with past weather data.

2.1.2.3 Service proposal (Proposal from MET organization)

Through the above-mentioned process, it is expected to obtain better understanding of the ATM processes based on aircraft operational procedures and possible weather impact on air traffic flow. The next step would be to develop a draft plan for MET information and services in support of ATM and propose it to the ATM organization. The proposed plan could be conceptual process with specific explanation and prototypes of MET information or services, if possible, to seek practical feedback from ATM organisation.

2.1.2.4 Service development (Requirements from ATM organization)

With the feedback from the ATM organization described in 2.1.2.3, the MET and ATM organisations could modify and make necessary changes to the proposed plan. This will ensure both parties (MET and ATM) are aware of the requirements and limitations and are able to adopt a practical plan for the region.

This would be an iterative process, until the proposed plan for MET information and services becomes matured.

2.1.2.5 Service definition

When the proposed plan becomes well matured through the processes above, the provision of MET information and services in support of ATM can be formalized. The plan should also describe how the ATM tailored MET products will be utilised in conjunction with the published MET products, are made available to the Airspace Users in a timely fashion so that all stakeholders are in possession of the same information at the same time. It may be that bespoke MET information solutions, tailored to the specific ATM service provider, are also made available to the Airspace Users as part of CDM arrangements.

2.1.3 System development

The next step is to develop a system and associated software applications necessary to provide ATM-tailored information and services defined in the process 2.1.2.5.

2.1.4 Trial run of the system and service

It is essential to conduct a trial run of the system and procedures to test secure delivery of the defined MET information and services. If any issues are identified through the trial run, these issues have to be resolved through close consultation with the stakeholders concerned (mainly the ATM organizations), before installation and commencement of services. In addition, the trial process will assist in determining the level of confidence. The outcomes of the trial should be well documented to assist with the future requirements.

2.1.5 Service provision agreement

In parallel with the system development, to ensure continuous provision of the defined information and services is maintained, it is important to formalize a written agreement (or to amend an existing agreement, if applicable) between the MET and ATM organizations. The Agreement should include the MET and ATM capabilities, and outline the operational processes, the working relationship and the communication channels. When such an agreement is later implemented with airlines or other stakeholders, existing agreements should also be amended accordingly.

2.2 Operational phase (processes for continuous improvement)

2.2.1 Operational trial

Before MET information and services are provided operationally, an operational trial should be conducted so that forecasters and ATM officers can familiarize themselves with the provision and usage of the new information and services. The trial period should be set based on agreement between the parties concerned. A post implementation of the operational trial should be conducted to ensure lessons learned from the process are documented and improvements are made prior to implementation.

2.2.2 Provision of MET information and services

MET information and services developed according to the process described in 2.1 are provided to ATM officers in accordance with the service provision agreement between the MET and ATM organizations.

2.2.3 Verification and evaluation

After the implementation of ATM-tailored MET information and services, it is required (i) to regularly verify and evaluate its quality to ensure that it practically supports ATM and (ii) to improve MET information and services.

2.2.4 Continuous improvement

Regular evaluation meetings between relevant parties such as Airspace Users, ATM and MET organizations are one of the basic approaches to continuously improve the implemented information and services. When a weather event has a significant impact on ATM, it is also recommended that stakeholders conduct a post-event analysis to identify lessons learnt and subsequent improvements.

3. MET information and services in support of ATM

In this chapter, MET information and services which are effective for supporting ATM operations are listed. As it will require cost, resources, technology, and time to introduce all of the products and services, some of which may not be defined in ICAO Annex 3, it is worthwhile to consider implementing them in a stepwise manner, depending on the situation in each State.

Examples of MET information and services for ATM in some States are described in Appendix 1. In addition, operational scenarios of MET/ATM collaboration, such as how MET information and services are provided to ATM officers, are described in Appendix 2.

3.1 Participation of MET organizations in CDM

CDM is an approach where relevant stakeholders share necessary information in order to make decision collaboratively, enabling enhanced ATM operations. MET CDM is a process involving meteorologists with an understanding of the effects of weather on ATM so as to support an accurate prediction of arrival/departure rates and en-route information. This process involves a collaboration of CDM stakeholders to generate products suitable for better pre-tactical traffic management strategies and optimised use of available capacity. The expected role of a MET organization in CDM is to provide necessary meteorological information at and around relevant aerodromes and air routes in a timely manner.

To achieve effective CDM, aeronautical meteorologists should have a basic understanding of ATM and Air Traffic Control (ATC) procedures, such as, inter alia, runway weather minima and aircraft operating criteria so that they would be able to foresee aviation impacting weather and provide appropriate briefings to ATM and ATC in a timely manner..

In a case where an event or phenomena has a significant impact on normal air traffic flows (e.g.: mass deviation of aircraft), it is vital to ensure that common situational awareness is maintained at all times among affected stakeholders. Rapid identification of the possible cause of such a situation (e.g. adverse weather condition, runway closure) allows both ATM and MET organizations to take immediate action in a collaborative manner to mitigate the impact.

3.2 Weather briefing in support of ATM

Direct weather briefings for ATM officers is an effective method to share current and expected weather assessments in and around major aerodromes and air routes, including any expected impacts on aircraft operation and air traffic flow.

Regular weather briefings in support of ATM may be provided several times per day. Depending on rostered shift arrangements in ATC centres, MET briefings may be scheduled for groups of controllers just prior to commencing their operational duty.

Where unexpected weather phenomena may affect aircraft operation and/or air traffic flow, or the actual weather deviates significantly from that forecast, a special briefing should be provided by MET forecasters. Special briefings can be either proposed by MET forecasters or requested by ATM officers.

3.3 ATM-tailored meteorological information

3.3.1 Impact-based weather information

Tailored MET information that shows possible impact on air traffic flow (e.g. when and where the weather phenomenon affects air traffic flow) can be useful to

support the management of air traffic capacity in each ATC sector and execution of air traffic flow controls.

Information that can be more specific on the impact to air traffic flow will be extremely valuable; for example, a probabilistic forecast of impact to ATFM may provide a quantitative estimate of reduction in air traffic capacity. To develop such *impact-based* information, consensus among stakeholders has to be developed regarding relationships between specific weather events and their possible impacts on air traffic flow.

3.3.2 Information for common situational awareness

It would be helpful for ATM representatives and other relevant stakeholders to understand the backgrounds of such the relevant weather phenomena (e.g. occurrence process and characteristics), as well as the associated forecast confidence, which would facilitate risk assessment and more effective and efficient ATM operations. It is desirable to provide relevant graphical information which can explain weather phenomena effectively, such as pressure distribution chart or weather radar and satellite imageries, and/or weather advisories with simple descriptions.

3.4 Information and products developed for other use

Existing meteorological information may also be useful to support ATM. Some examples are listed below.

- OPMET information
- Volcanic ash advisory (VAA) and tropical cyclone advisory (TCA)
- WAFS products (WINTEM chart, SIGWX chart and gridded global forecast of cumulonimbus clouds, icing and turbulence)
- Two-minute real-time observation data at congested aerodromes
- Weather radar imagery
- Specific phenomena based information, such as Thunderstorm and lightning information
- Satellite imagery and derived products
- Nowcasting products
- Numerical weather prediction data and derived products
- Earthquake and tsunami information

3.5 Means of provision

3.5.1 Dedicated information sharing system

To facilitate CDM, information sharing among all relevant stakeholders in MET and ATM is necessary, to enable common situational awareness is maintained. In order to support ATM operations, a system should be acquired or developed which enables ATM officers to utilize MET information at any time. Similarly, MET

forecasters need an environment through which they can look at ATM-related information to provide appropriate meteorological information. It is thus required that dedicated systems for information sharing between MET and ATM organizations be established, so that ATC officers and MET forecasters can effectively exchange necessary information at any time, and preferably from their operational positions.

3.5.2 Means of communication

Listed below are some examples of means for which ATM stakeholders to communicate and to share necessary information with each other.

- Hotline (direct phone line)
- Web-chatting system
- Telephone or video conference system
- Use of common CDM software/application
- Joint use of an operation room
- Information sharing web-portal

4. Future progress in MET/ATM services

4.1 Global Air Navigation Plan (GANP)

In 2014, the 38th Session of the ICAO Assembly amended the Global Air Navigation Plan (GANP) and formulated the Aviation Systems Block Upgrades (ASBUs), the implementation plan of the GANP, as proposed by the twelfth ICAO Air Navigation Conference (AN-Conf/12). The ICAO Meteorology Panel (METP) was established in September 2014 and is now discussing the future introduction of new standard practices of MET information and services in support of ATM for the terminal area, along with the ASBU Block 1, which is to be ready by 2019.

In the future, States in a position to do so would be required to provide ATM-tailored MET services based on globally consistent requirements. Since this global standardization is being welcomed among users such as airlines and pilots, the States in the Asia/Pacific Region may adapt their systems accordingly when such standards are available.

4.2 Future integration of MET information into ATM decision-making

The ICAO Air Traffic Management Requirements and Performance Panel (ATMRPP), in coordination with the METP and other panels concerned, has discussed future integration of MET information into ATM decision-making system, along with the Global Air Traffic Management Operational Concept (GATMOC). The “Concept for the integration of Meteorological information for ATM” has been developed by the ATMRPP and other bodies concerned. It provides guidance on methods and procedures to interpret MET information as it relates to possible constraints on air traffic flow. It supports estimation of the potential impact of the meteorological condition to ATM and

provides ATM officers with possible actions to be taken, e.g. selecting most safe and effective diversion routes.

4.3 Next generation air transportation system developments

To deal with growing air traffic congestion, some States or Regions have been planning the development of next generation air transportation systems. These include NextGen (United States), SESAR (Europe) and CARATS (Japan). It is important for MET organizations to make the best effort to improve their capability in the provision of MET information and services to meet such future requirements and facilitate the development of a new generation air transportation system.

Appendix 1 Specific Implementation Examples

Hong Kong, China

1. ATM-tailored MET information and services

Under the agreement between the Hong Kong Observatory (HKO) and Civil Aviation Department (CAD), HKO provides a suite of ATM-tailored MET information and services in support of international air navigation.

1.1 Tactical Decision Products

1.1.1 Taking the opportunity of the replacement of CAD's Air Traffic Management System (ATMS), closer integration of tailored MET information with ATMS was realized to support ATC in tactical decision making. These include a) 10 layers of Constant Altitude Plan Position Indicator (CAPPI) imageries from 1 km to 10 km with range 256 km of the two Doppler weather radars in Hong Kong; and b) 1 layer of the HKO Aviation Thunderstorm Nowcasting System (ATNS) 1hr forecast for the assessment of the significant convection over HKFIR at 3 km height.

1.1.2 On the ATC console of the new ATMS, either weather radar imagery of a specific height or an ATNS forecast can be chosen to be overlaid with the aircraft indicators (Figure 1). Further details can be found in the presentation included in Joint Session ATFM/SG/7 and MET/R WG/6.

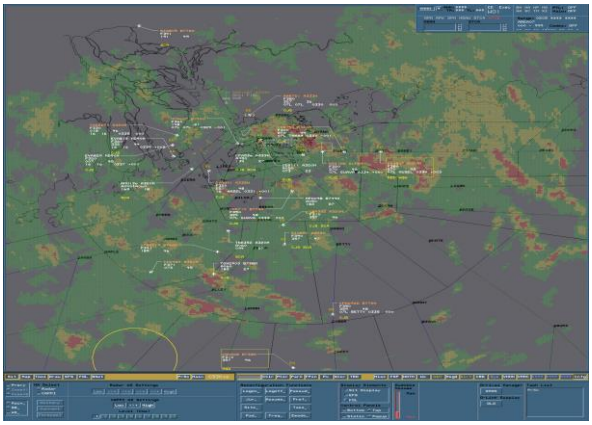

Figure 1. ATC console display showing aircraft positions overlaid on a CAPPI imagery

1.2 Meteorological Services for Terminal Area (MSTA) Products

1.2.1 The Hong Kong Air Traffic Flow Management Unit (ATFMU) of CAD regularly assesses the capacity of the Hong Kong International Airport (HKIA), which depends on both the runway and airspace capacity, in the next few hours. In collaboration with CAD, HKO has been providing tailored MSTA, grouped under the product named Significant Convection Monitoring and Forecast (Figure 2), to support ATFM operation since 2010. These are briefly summarized in the following paragraphs. Further details can be found in MET/R TF/3 WP07.

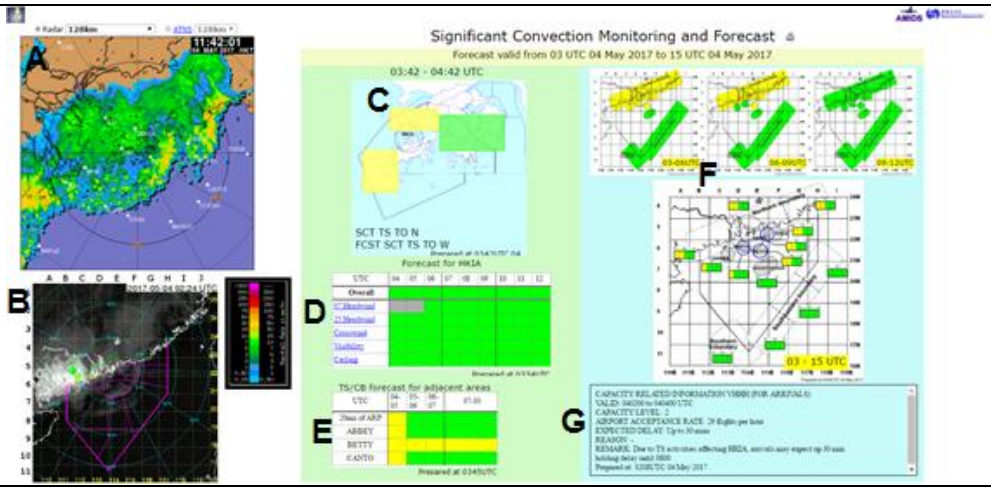

Figure 2. Integrated web display of the MSTA forecast suite including : A) Choice of Real-time radar and lightning data picture or ATNS forecast; B) Composite of latest radar and deep convection satellite image; C) 1hr convection nowcast for arrival/departure corridors; D) 9hr performance-based weather forecast for the aerodrome; E) 6hr blended convection forecast around HKIA and the major waypoints; F) 12hr significant forecast time series for key ATC areas; and G) Airport Capacity Notification issued by ATFMU/ATC of CAD to airports within the region.

1.2.2 The suite of MSTA products to support runway capacity estimation includes: a) ATNS to automatically forecast the future location of weather cells that may block the intended flight path or significant points in the airspace; b) a 1hr convection nowcast for arrival/departure corridors; c) a 6hr convection forecast for the aerodrome (20nm of airport reference point, ARP) and the major waypoints; and d) a 9hr performance-based weather forecast for the aerodrome. To support airspace capacity estimation, the HKO provides a 12hr significant convection forecast time series for key areas in the HKFIR based on blended NWP and nowcasting outputs. While the forecasts of these products are generated automatically, they could be adjusted manually by Aviation Forecasters.

1.2.3 All the above products/systems use three levels of colour code to indicate the impact to air traffic, viz GREEN for mild or no impact, AMBER for medium impact and RED for significant impact. Though the actual criteria for defining the colour codes vary across different forecast products, the simple three levels of colour code are adopted uniformly in all the forecast/nowcast products described above. The Significant Convection Monitoring and Forecast also includes the latest capacity notification issued by ATFMU/ATC after taking into account the above significant convection nowcast and forecast information as well as consultation by Aviation Forecaster via regular and ad hoc weather briefings (para.1.5 below).

1.3 Arrival Management and other Miscellaneous tailored Products

1.3.1 25 layers of gridded upper wind and temperature forecasts over southern

China and the northern part of the South China Sea at a resolution of 0.2 degrees at hourly interval for up to 24 hours are provided for trajectory prediction of individual aircraft for collision avoidance. The data is also being used by an Arrival Management application system for aircraft arrival sequencing.

1.3.2 Apart from the above products, other major tailored products include a) Weather Summary for HKIA which includes, inter alia, local winds, radar, satellite, lightning information and lightning alert for the airport, weather synopsis, aerodrome forecast with possible alternative scenario, TAFs of nearby airports, SIGMET for the HKFIR, TC track, weather analysis and forecast charts as well as the latest airport capacity notification (Figure 3); and b) HKIA Local Routine/Special Report and MET page showing the latest observation report, data from the Automatic Meteorological Observing System, windshear alerts, forecast of HKIA and neighbouring aerodrome, and a probabilistic wind forecast time series (Figure 4) at HKIA based on ensemble model outputs to facilitate uncertainty assessment during TC situation.

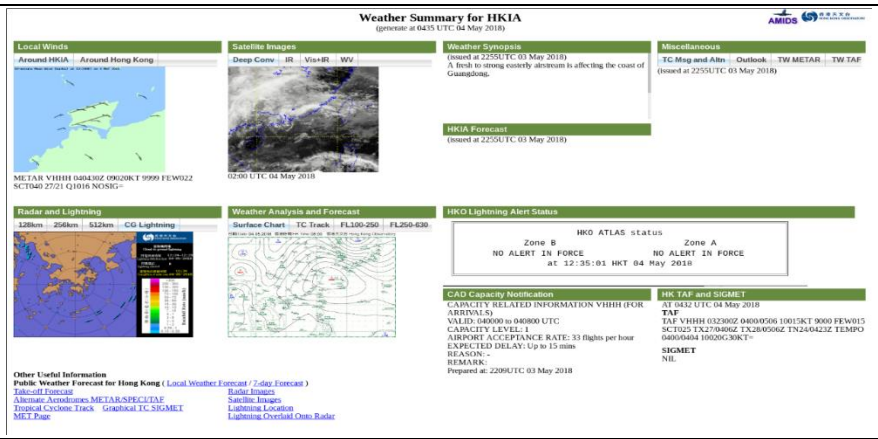

Figure 3. Weather Summary for HKIA provided by HKO

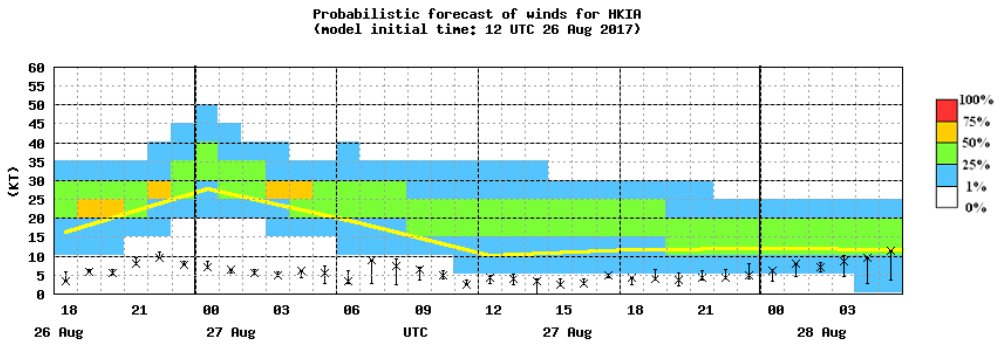

Figure 4. An example of probabilistic forecast of winds at HKIA during TC situation. The probability of wind speed with time are shown in colour. The deterministic model forecast (in yellow line) is also displayed on the time series plot for users' reference.

1.4 Lightning Nowcast Products

1.4.1 For the protection of ground personnel from being injured by lightning strikes, the HKO has developed the Airport Thunderstorm and Lightning Alerting System

(ATLAS), a nowcasting system for detecting and nowcasting lightning activities over HKIA. The system will generate RED or AMBER alerts based on either detection or forecast of cloud-to-ground lightning activities (CG). When CG is detected within 10 km or forecast to be within 5 km from the ARP, AMBER alert will be issued. When CG is detected or forecast to be within 1km boundary of the airport island, RED alert will be issued. To further enhance ground staff safety, the system will also generate a "Wireless Headset Procedure" alert to promote them to switch to use wireless headsets when CG is detected within 16 km of the airport.

1.5 Weather briefing

1.5.1 HKO provides twice daily MET weather briefings to ATFMU/ATC, once in the early morning and once in the early afternoon, through teleconference. The briefing mainly makes use of the MSTA products and the Weather Summary for HKIA discussed under 1.1 and 1.3.2 above. Timely updates are also provided through a hotline should there be any change in the weather conditions.

1.5.2 In preparation for adverse weather such as the approach of tropical cyclone (TC), additional weather briefings are conducted for the whole aviation community at HKIA to heighten common situation awareness and to support Collaborative Decision Making.

2. Means of Provision

2.1 The tactical decision products and the arrival management products discussed under para. 1.2 and 1.3.1 respectively are ingested directly into CAD's ATMS. Products under para. 1.3.2 b) are sent to CAD's ATS Data Management System (ATSDMS).

2.2 The rest of the products, including MSTA and miscellaneous tailored products are provided via the web-based Aviation Meteorological Information Dissemination System.

3. Other useful information

3.1 Regular high level meetings with CAD and the Airport Authority Hong Kong are held on an annual basis. Regular working level meetings with ATC are held generally a few times every year.

A Verification System has been set up for verification of both the ICAO Annex 3 and MSTA products.

Japan

1. ATM-tailored MET information and Services

1.1 ATMetC

The Japan Civil Aviation Bureau (JCAB) established the Air Traffic Management Center (ATMC) in Fukuoka in 2005 as a core organization for ATM in Fukuoka FIR. In line with ICAO's global concept for ATM, ATMC facilitates safe and efficient flight operation through ATM close cooperation with Airspace Management (ASM), Air Traffic Flow Management (ATFM) and oceanic ATM. At the same time as ATMC began operation, the Japan Meteorological Agency (JMA) established the Air Traffic Meteorology Center (ATMetC) to provide meteorological information and services in support of ATMC. ATMetC forecasters work in the same operation room as ATM officers to directly provide weather information and briefings tailored to ATM officers' needs. MET information and services specifically tailored for ATM requirements are as follows.

1.1.1 Air Traffic Meteorological Forecast (ATMet Category Forecast) (Figure 1)

- Target areas: major aerodromes and ATC sectors
- Contents: the potential for meteorological impact on air traffic flow with four color-coded categories (red, yellow, blue and white)
- Issuance time: every hour except from 14 to 16 UTC (midnight)
- Forecast time: up to 6 hours

1.1.2 Briefing sheet (Figure 2)

- Target: Strong wind for Tokyo (RJTT) and Heavy snow for New Chitose (RJCC)
- Contents: the probability of occurrence of impact on air traffic flow with four color-coded categories
- Issuance time: when significant weather is forecasted within 12 to 15 hours
- Forecast time: up to 16 hours

1.1.3 CDM conference

- Target areas: Fukuoka FIR and neighbor FIRs
- Providing methods: TV teleconference system
- Regular conference: 0620 and 2345 UTC
- Extra conference: As necessary (except midnight)

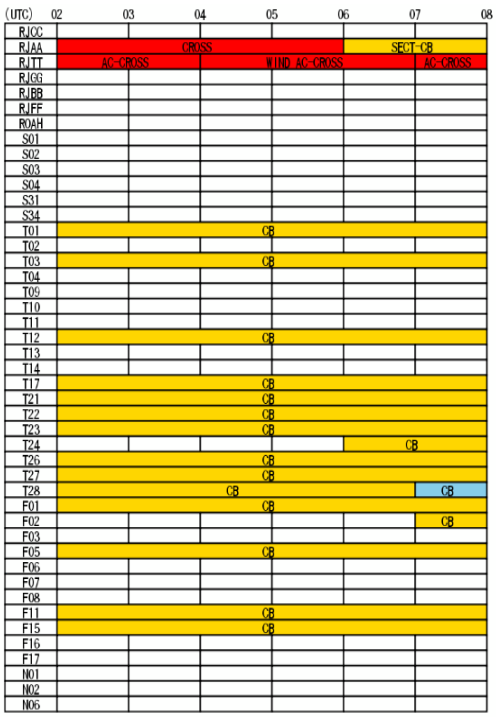

Figure 1 ATMet Category Forecast

1.1.4 Briefing (regular/extra)

- Target areas: Fukuoka FIR
- Providing methods: Face to face or information-sharing terminal at ATM officer's desk
- Regular briefings: 0130, 0445, 0550, 0915, 1200, 1945, 2000, 2220, 2315 UTC
- Extra briefings: As necessary (24 hours)

1.2 TMAT

To deal with increasing air traffic demands in Tokyo metropolitan area, JCAB organized the Traffic Management Units (TMUs) in 2011 as a branch of ATMC and they were placed at Tokyo international airport and Tokyo Area Control Center in order to conduct tactical and flexible ATFM in and around the Tokyo metropolitan area. JMA organized Tokyo Metropolitan Area Team (TMAT) at Tokyo international airport in 2014 as a branch of ATMetC to provide TMUs with meteorological information and detailed briefings focused on significant weather which affects air traffic flow in and around the Tokyo metropolitan area, including the approach control area of Tokyo / Narita international airport and its neighboring area.

1.2.1 ATM CIEL (Figure 3)

- Target areas: Tokyo/Narita international airport, Tokyo approach control area and ATC sectors around Tokyo metropolitan area
- Contents: Level of expected impact of significant weather on ATM
  - ✧ High : Need to reduce capacity value (CAPA) significantly
  - ✧ Medium : Need to reduce CAPA
  - ✧ Slight : Need to reduce CAPA slightly
  - ✧ None : Not need to reduce CAPA
- Issuance time: every hour except from 14 to 16 UTC
- Forecast time : up to 6 hours (temporal resolution: 10 minutes to 1 hour)
- Targeted weather phenomena:
  - ✧ Tokyo/Narita international airport: Thunderstorm, Visibility, Ceiling, Wind, etc.
  - ✧ In and around the Tokyo approach control area: CBs, Convective clouds and Wind

1.2.2 Wx Bulletin (Figure 4)

- Target areas: Tokyo/Narita international airport, Tokyo approach control area and ATC sectors around Tokyo metropolitan area
- Contents: Brief comments on phenomena expected to affect air traffic flow, and appropriate images to explain weather conditions and forecast
- Issuance time: 00 and 06 UTC

- Forecast time: up to 6 hours

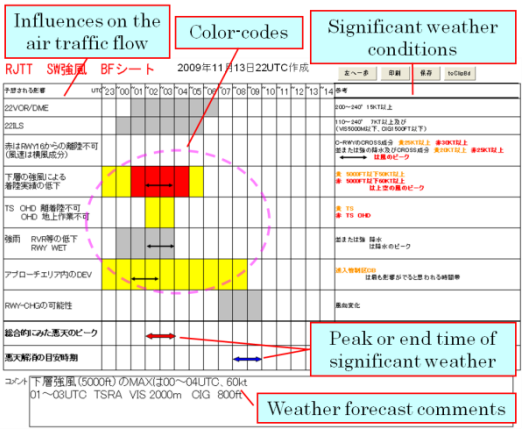

Figure 2 SIGWX Briefing sheet

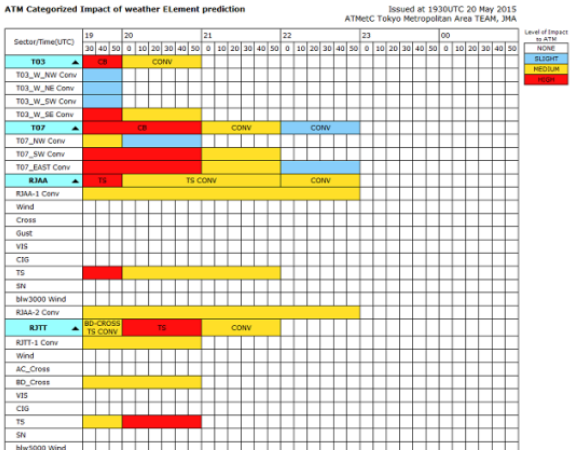

Figure 3 ATM CIEL

1.2.3 Briefing (regular/extra)

- Providing methods: Video conference, telephone and online chat
- Regular briefings: 0500, 1130, 2030 and 2250 UTC (four times/day)
- Extra briefings: As necessary (24 hours)
- Target areas: Responsibility area of Tokyo ACC and Tokyo approach control area

2. Means of Provision

2.1 ATMetS2

JMA established dedicated information distribution system, called ATMetS (“2” means second generation system). Terminals for the system are located at each ATM officer's desk.

2.2 MetAir

JMA has developed aviation weather information provision system, called MetAir. Users can obtain forecast products for airspace and aerodrome in a real time basis. Airlines can receive MET products through MetAir.

2.3 **Web chat system** (Figure 5)

As prompt decision making is required for ATM within terminal area, speedy and appropriate information sharing is necessary. Especially for weather briefing services, TMAT coordinates with TMUs whenever needed using online chat tool developed by JMA which enables quick information provision, in addition to video conference and telephone. As text information remains in the chat tool, TMU officers can reaffirm the contents of briefings at any time. Also, graphical information can be posted on the tool. This function helps TMU officers to easily understand the weather condition which is sometimes difficult to grasp only by the explanation on the telephone.

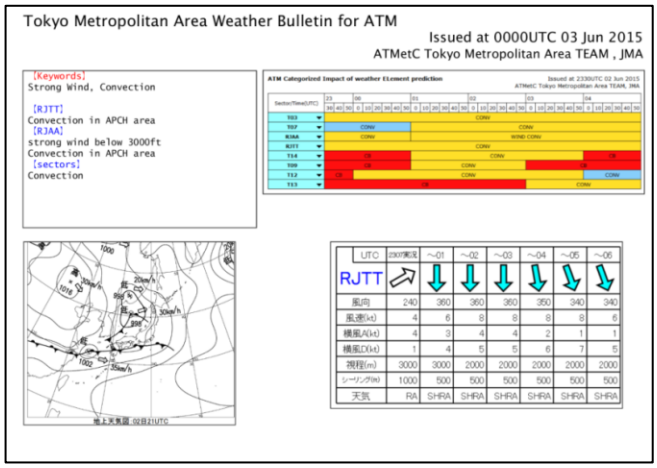

Figure 4 WX Bulletin

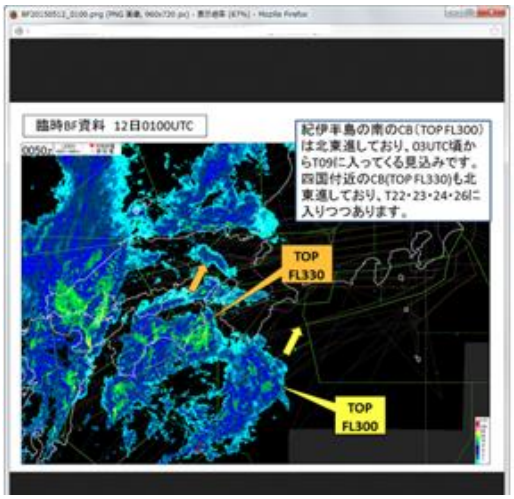

Figure 5 Graphical info on online chat

3. Other

3.1 Verification

ATMet category forecast criteria are weather conditions (or sometimes a combination thereof) defined through verification processes carried out by ATMetC in coordination with ATMC. This process involves three main steps:

a) Investigation of impacts on ATM in previous significant cases;

b) Confirmation of operational rules and conditions with reference to aircraft operation manuals and flight operations manuals; and

c) Checking of the latest requirements from ATM officers, such as high-priority airways and altitude, and important air navigation facilities (waypoints or typical holding areas).

Each criterion is verified by calculating the Weather Impact Ratio (WXIR), which is the ratio of the frequency of cases in which a weather condition has influenced air traffic flow to all cases of the weather condition concerned.

WXIR = (Number of occurrence of air traffic controls) / (Number of occurrence of WX conditions)

Meteorological services provided to support ATM need to be flexibly applicable to the various operational variables of such management, including ATC procedures, airways and aircraft types, which are also developed in parallel. It is therefore highly important to ensure close and continuous coordination with ATM officers in order to revise criteria appropriately based on the results of verification using WXIR in consideration of operational requirements. Through such continuous improvement, the gap between ATM operational requirements and MET capability can finally be closed (Figure 6).

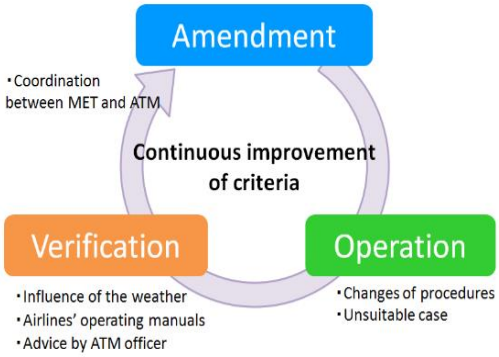

Figure 6 Continuous improvement of criteria

Singapore

1. ATM-tailored MET information and services

Meteorological and Air Traffic Management (MET/ATM) Collaboration in Singapore

The provision of air navigation services in the Singapore Flight Information Region (FIR) is undertaken by the Civil Aviation Authority of Singapore (CAAS), and Meteorological Service Singapore (MSS) is the aeronautical meteorological service provider. The following lists some examples of MET information and services implemented in Singapore, specifically tailored for ATM requirements.

1.1 Weather briefing for ATC

MSS provides daily MET weather briefings through teleconference to air traffic controllers at the start of the morning shift. Aided by visuals from a dedicated weather information portal which provides an integrated view of meteorological information in graphical and tabular formats (Figures 1), operational meteorologists will bring air traffic controllers through the weather conditions that can be expected around Singapore and the surrounding region. Timely updates are also provided by operational meteorologists through a hotline should there be any change in the weather conditions.

1.2 MET Support for Air Traffic Flow Management (ATFM)

In support of CAAS' operational trial with other air navigation service providers (ANSP), airlines and airport operators based on the multi-nodal ATFM concept for the region, MSS worked closely with CAAS to customize MET products to enable air traffic flow planning. Close weather watch is provided for key areas, such as the approach and departure paths of the airport and the holding areas that serve arrivals into the airport. To match the planning horizon for ATFM, the forecast period extends up to 6 hours ahead, in 30-minute and hourly blocks for specific periods as agreed with CAAS. The forecast is presented in color-coded, tabular format for easy interpretation and to support air traffic flow planners' decision-making.

1.3 Improvements to SIGMET Information

To augment SIGMET information for the Flight Information Region (FIR), forecast of significant weather up to 12 hours ahead is provided for the different sectors of the FIR. This serves to extend the period covered by SIGMETs. In addition, MSS is also working with MET Watch Offices (MWOs) of neighboring States in a WMO SIGMET

Pilot Project to coordinate the issuance of cross-FIR SIGMETs to airspace users, air traffic controllers and planners with significant meteorological information that is harmonized for weather phenomena straddling across two or more FIRs.

1.4 Nowcasting for convective weather

Tropical weather systems tend to be dominated by thunderstorms that are localized and short-lived but yet have great impact on air traffic operations. Given the nature of our local weather systems, there is limited predictability, and forecasts tend to be short range. This poses difficulties for ATM. To address these challenges, Singapore has a multi-year project in collaboration with UK Met Office to develop Numerical Weather Prediction (NWP)/Nowcasting capability for Singapore. The project aims to build a tropical convective-scale NWP/Nowcasting system that can to provide improved weather forecasts to support ATM decision making.

2. Means of Provision

2.1 ATC Weather Information Portal

MET information is provided via ATC weather information portal, such as radar images satellite images with graphical SIGMET, graphical forecast of take-off conditions and trial i colour-coded thunderstorms forecast for holding stacks. (Figure 1)

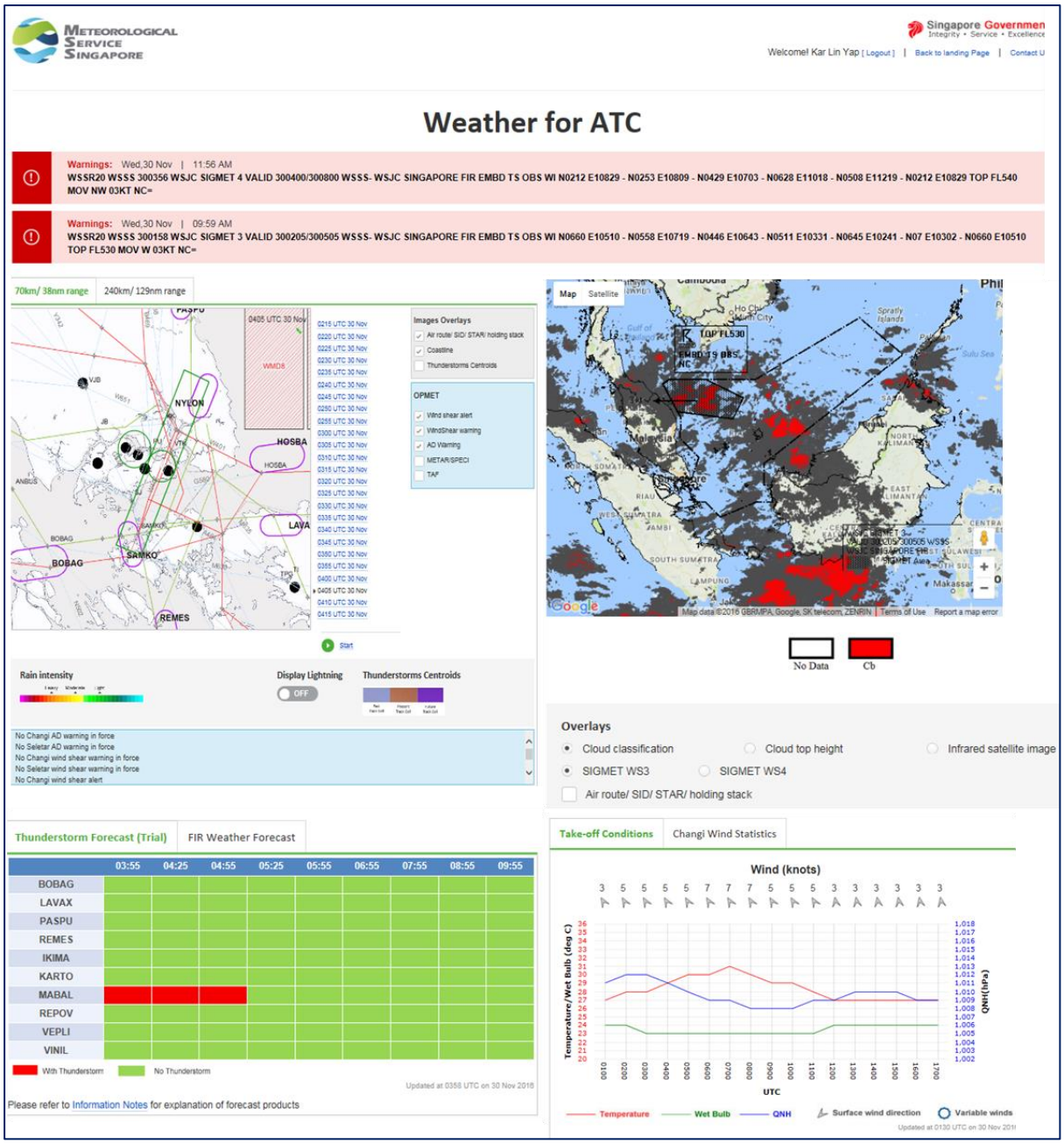

Figure 1: ATC Weather Information Portal. From top left and clockwise: i) Display of radar images & products, lightning, and OPMET information; ii) satellite images with graphical SIGMET; iii) graphical forecast of take-off conditions; iv) trial issuance of colour-coded thunderstorms forecast for holding stacks.

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Appendix 2 Operational Scenario – Case of MET/ATM Collaboration –

Scenario 1:

CBs affected air traffic flow around approach control area of Tokyo International Airport (18 August, 2015)

1. Overview

A developing squall line was moving eastward along the coast of Tokai and Kanto Region of Japan. It caused many deviations from the planned air-routes and holdings in and around the terminal area, for aircraft approaching from west to Tokyo International Airport (RJTT). The Air Traffic Management Center (ATMC) reduced air traffic capacity (CAPA) in the affected ATC sectors, such as sector T09 and T14, and executed air traffic flow controls for aircraft flying in / heading to the air space. In addition, because some westbound aircraft departed from RJTT were forced to enter into neighboring sectors, such as sector T12 and T13, to avoid developed CBs of the squall line, ATMC finally conducted capacity reduction and flow controls for those ATC sectors to prevent possible conflicts between eastbound and westbound aircraft within those sectors (See Fig. 1 and Fig. 2).

This case shows how MET forecasters and ATM officers collaboratively dealt with this adverse weather condition described above, which occurred around a congestive international airport.

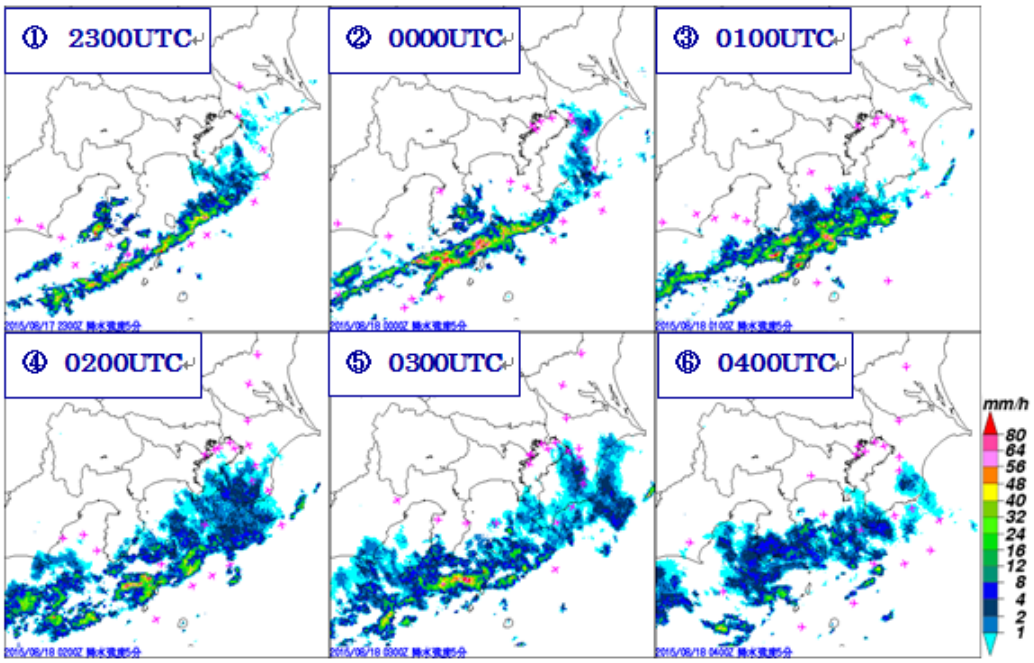

Figure 1 Radar echo intensity from 23:00 UTC 17th August to 04:00 UTC 18th August. Airplane-shaped marks indicate aircraft positions.

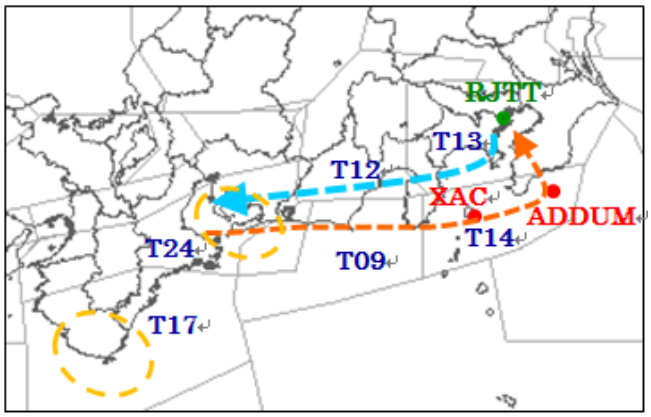

Figure 23 Name of ATC sectors (blue text) and reporting points (red text)

- Yellow circle: Holding area for aircraft flying to RJTT
- Orange arrow: Regular air-routes for aircraft approaching from western Japan to RJTT
- Light blue arrow: Regular air-routes for aircraft flying from RJTT to western Japan

2. MET/ATM collaboration

Described below is the collaborative actions taken by MET forecasters and ATM officers in this case (MET: Air Traffic Meteorology Center, Japan Meteorological Agency (ATMetC/JMA), ATM: Air Traffic Management Center, Japan Civil Aviation Bureau (ATMC/JCAB))

17th August 2015

20:00 UTC Special briefing was provided by MET

MET: "Echo top height of the CB clouds would reach more than FL460 in sector T09."

MET: "CB clouds will approach sector T14 around 21 UTC and then Tokyo Approach Control Area (ACA) around 22 UTC."

20:40 UTC Latest status of air traffic was reported by ATM

ATM: "Deviations have occurred in sector T17 and T09, because of CB clouds. We are now watching the situation of these CB clouds carefully."

21:00 UTC Special briefing was provided by MET

MET: "The CBs in sector T09 will approach XAC (reporting point) around 22 UTC and then ADDUM (reporting point) around 23 UTC.

ATM: "When will the CBs go away from Tokyo ACA?"

MET: "It will be after 00 UTC of 18th."

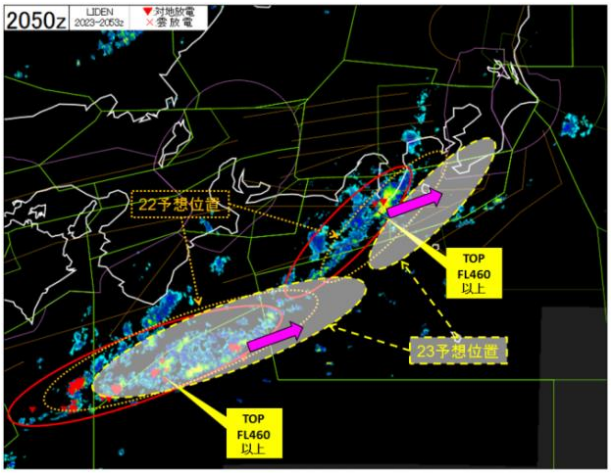

Figure 34 Material for non-regular briefing at 21:00 UTC on 17th August

21:20 UTC EDCT[1] was issued for flights heading to RJTT from west

22:00 UTC CAPA[2] was reduced to 93% in sector T09

22:10 UTC EDCT was issued for flights heading to RJTT through sector T09

23:08 UTC Special briefing was provided by MET

MET: "The CBs near XAC are now moving east and will approach ADDUM around 00 UTC."

MET: "The CBs newly developed around sector T09 will move to the eastward. Then it will be merged with CB cloud area of the east."

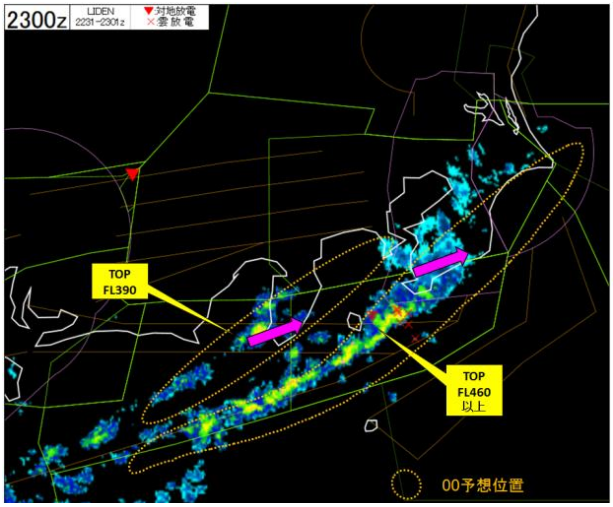

Figure 45 Material for non-regular briefing at 23:08 UTC on 17th August

23:10 UTC Entrance Interval was reduced for sector T09

23:30 UTC CAPA was reduced to 88% in sector T12, 89% in sector T13

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[1] *Expected Departure Clearance Time (EDCT)* is assigned for the flights to certain aerodrome or airspace when air traffic volume is expected to exceed the ATC capacity of the aerodrome of the airspace.

[2] *CAPA* is an acronym for the ATC capacity of an aerodrome or an ATC sector.

23:35 UTC Departure Interval was reduced for sector T12

23:40 UTC EDCT was cancelled for flights heading to RJTT through sector T09

18th August 2015

01:10 UTC Special briefing provided by MET

MET: "Developing CB area in T14 and T09 sectors will move to the northeast or the east-northeast and the peak of the development will continue until around 03 UTC."

MET: "A part of the CBs may spread to sector T12 and T13, but it would not be expected to spread largely to the north. CB clouds in T17 sector will move to the northeast or the east-northeast and spread into T09 sector around 09 UTC, but it will eventually weaken from around 06 UTC."

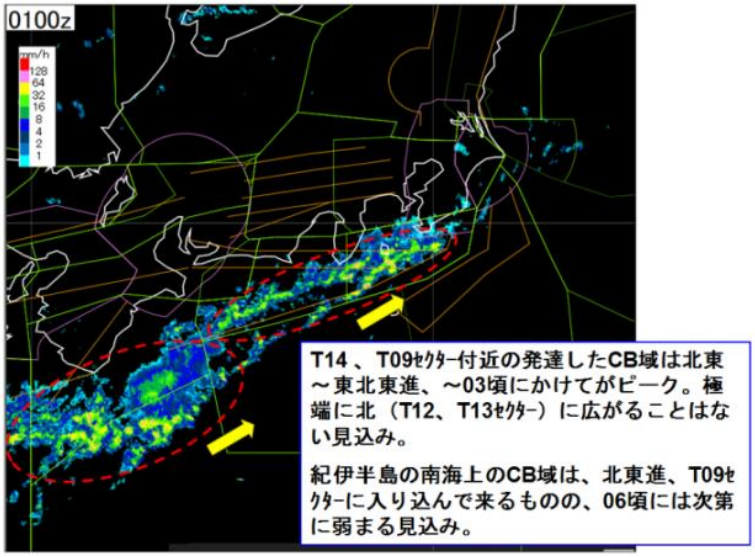

Figure 56 Material for non-regular briefing at 01:10 UTC on 18th August

02:00 UTC Entrance Interval was restored for T09 sector

06:00 UTC Departure Interval was restored for T12 sector

09:30 UTC EDCT was cancelled for flights heading to RJTT from west

3. Summary

In this case, ATM officers shared the latest situation of air traffic flow with MET forecasters and on the other hand, MET forecasters provided special briefings for ATMC with regard to prediction of CB clouds which affected ATC sectors, such as T09 and T14. Additionally, MET forecasters paid attention also to the situation of CB clouds developed in T12 sector, because a number of westbound aircraft departed from RJTT flew into T12 and T13 sectors and, as a result, significant conflicts between eastbound and westbound aircraft were anticipated in those sectors. Based on such interactions, ATMC officers

appropriately managed air traffic flow with frequent special briefings from MET forecasters.

This case shows how mutual coordination between MET forecasters and ATM officers will improve the efficiency and the safety of air traffic flow under adverse weather conditions.