Improvement of impact-based MET information in collaboration between MET and ATM

Japan Meteorological Agency (JMA)

Japan Civil Aviation Bureau (JCAB)

気象庁
Japan Meteorological Agency

国土交通省
Ministry of Land, Infrastructure, Transport and Tourism

ICAO APAC MET/ATM Seminar, 22 April 2024

Contents

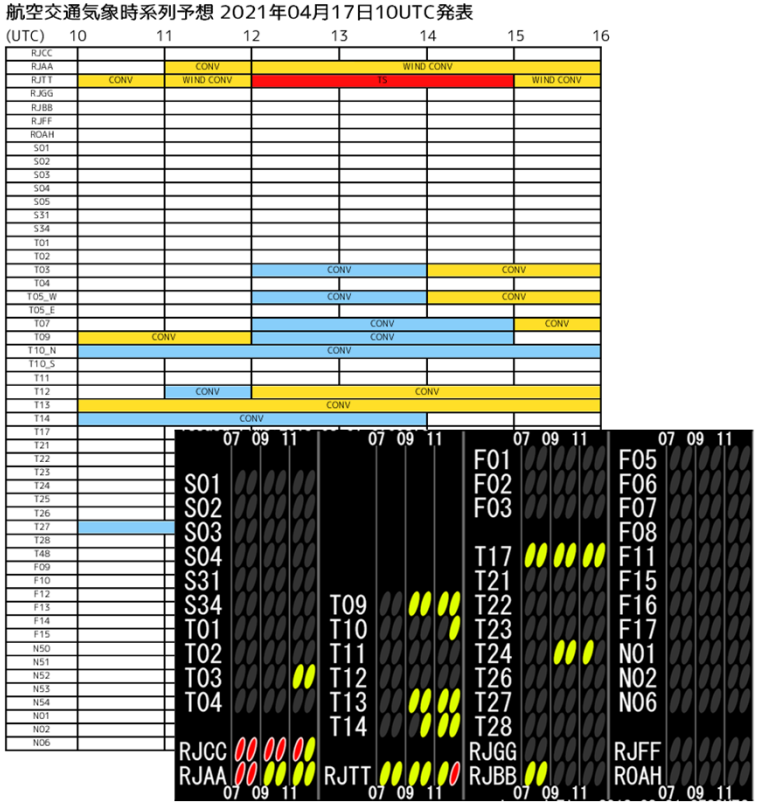
1. Introduction
   - JMA's products to support JCAB's ATM operation
   - Color-code criteria
2. Verification of impact-based ATM-tailored MET information
   - Case study
   - Statistical verification
3. Recent enhancement by MET/ATM collaboration
4. Challenges on verification of impact-based product
5. International cooperation

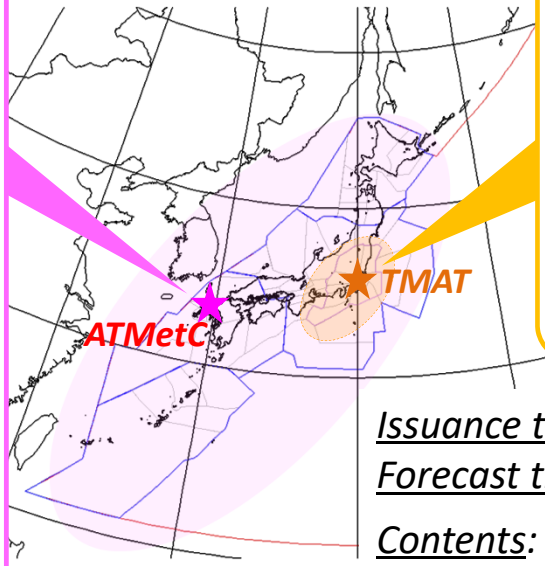
1. Introduction: JMA's products to support JCAB's ATM operation

- **Sequential category forecasts**

ATMet Category Forecast

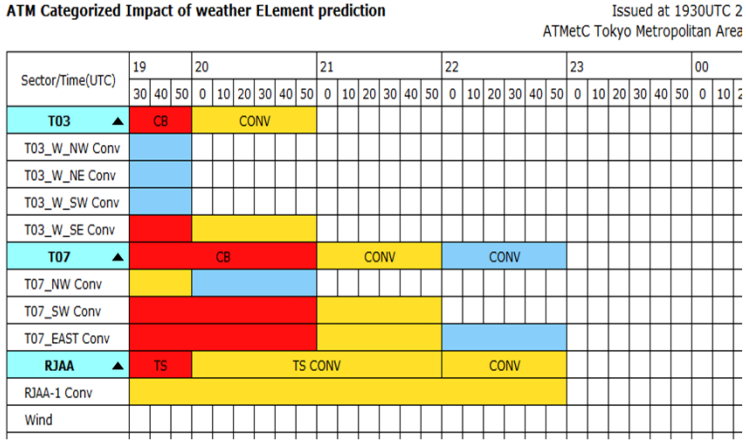
For all domestic airspace and major airports





ATM CIEL

For Tokyo Metropolitan Area air space and airports



Issuance time: hourly (except 14 – 16 UTC)
Forecast time: up to 6 hours ahead

Contents:
expected impacts of weather conditions on air traffic flow

High	Medium	Slight	None

Target phenomena:

Airports: Thunderstorm, Visibility, Ceiling, Wind, etc.
Approach control area: CBs, Convective clouds and Wind
ATC sectors: CBs and Convective clouds

気象庁 Japan Meteorological Agency

国土交通省 Ministry of Land, Infrastructure, Transport and Tourism

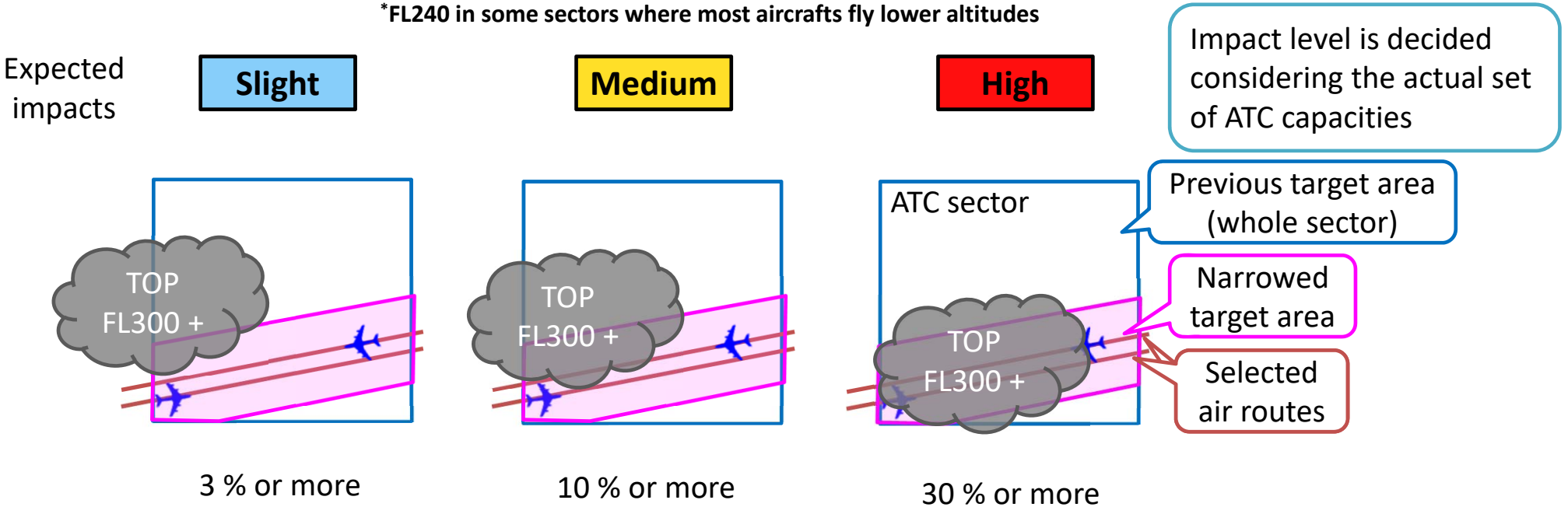
1. Introduction: color-code criteria

Thresholds for the category forecasts had been reviewed and improved.

- Improved criteria for Convective clouds in ATC sectors (2020 –)

Coverage of CBs (top ≥ FL300*) in narrowed along the congest air-route target area

*FL240 in some sectors where most aircrafts fly lower altitudes

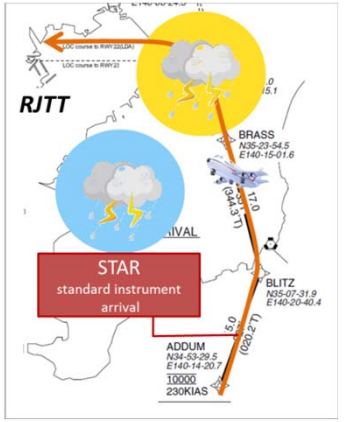


✓ Areas to calculate ATM SIGWX index (i.e., the first guess data) was also revised to be same as the narrowed along congest air-route target area

1. Introduction: color-code criteria

– Based on the situation that affect aircraft operations and actual ATC capacity

e.g. whether convective clouds on the arrival route or not, WX minimum for visibility and ceiling applied at the airport



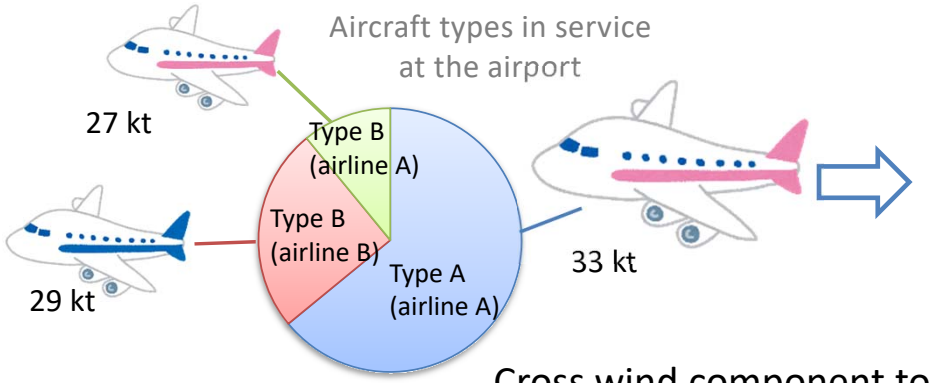
Level of impact	Existence of convective clouds in the approach control area
High	-
Medium	**Exist on the STARs***
Slight	**Exist but not on the STARs***
None	**Not exist**

Impact levels are determined with considering actual ATC capacity

***STAR: Standard Arrival Route**

1. Introduction: color-code criteria

– Based on the threshold for aircraft operations and proportion of the types of aircrafts in service at each airport
e.g. Cross wind limitation of aircraft,
WX minimum for visibility and ceiling applied at the airport



Set the criteria of cross wind speed for each impact level, based on the affected proportion of aircraft type/airlines at each exact cross wind speed. Criteria was finally set after the verification based on actual WX events.

Level of impact	Cross wind component to the RWY (for RJTT RWY 34/16)	
	Dry condition	Wet condition (moderate/heavy precipitation)
High	**Above/and 33 kt**	**Above/and 25 kt**
Medium	**Above/and 29 kt**	**-**
Slight	**-**	**-**
None	**Below 29 kt**	**Below 25 kt**

気象庁 Japan Meteorological Agency

国土交通省 Ministry of Land, Infrastructure, Transport and Tourism

2. Verification of impact-based ATM-tailored MET information

A) Case Study:

ATMetC routinely conducts case studies since its establishment to find issues and see effect of product improvements

B) Statistical verification:

objective evaluation of product performance

2. Verification of impact-based ATM-tailored MET information

Case Study: first step to understand requirements

事例調査

－ 2023年7月19日 関東北部のCBに伴うT03/T07セクターでのDEV －

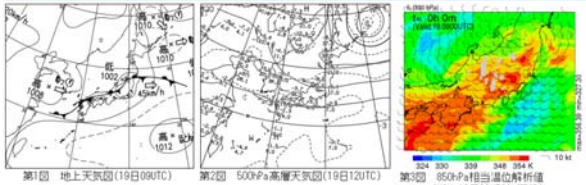
要旨

2023年7月19日夕方は、前線近傍の関東北部～東北で対流雲が発達・拡大した。そのため、T03/T07セクターでは対流雲を避けるため隣のセクターへDEVし、一時的にRJTTN到着機・出発機で対面通行状態になった。対流雲の発生は予想されていたためRJTTNではTTL SPCの調整があらかじめ実施されていたが、DEV発生に伴いT03/T07セクターでCAPA調整も実施されたが、制御は実施されなかった。
臨時BFのタイミングが遅れたため、引き継ぎ時の体制も含めて課題があると感じられた。

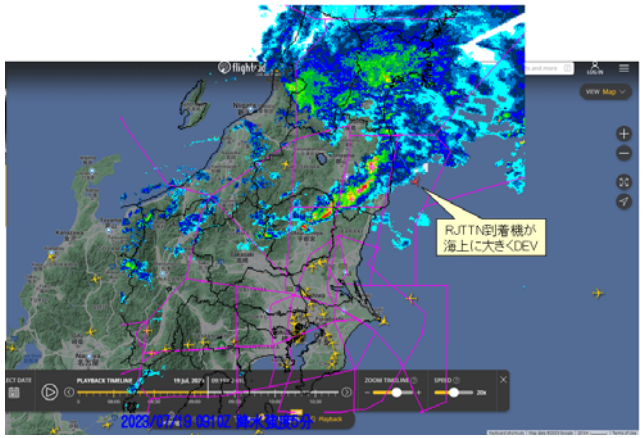
1. 運航に影響を及ぼした気象現象

(1) 総観場

19日09UTCでは東シナ海から東西日本を通って日本の東に前線がのびており、前線上の北陸には低気圧があって東進していた。500hPa高層天気図では、太平洋高気圧の張り出しの目安である5880mの等高度線が九州から伊豆諸島に見られたが、東日本は5820m高度帯の緩い谷場となっていた。また、19日09UTC初期値MSMの初期データを見ると、東日本には地上昇温の効果も含まれるが850hPaで348K以上の暖湿気が流入していたため大気の状態が不安定であった。



第1図 地上天気図(19日09UTC)　第2図 500hPa高層天気図(19日12UTC)　第3図 850hPa相当温位解析図 (MSM 19日09UTC初期値)



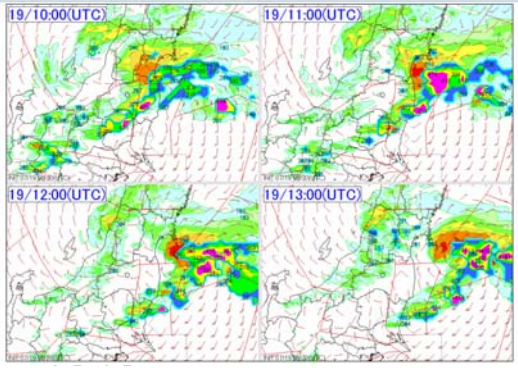
Case study is the most fundamental way to understand the mechanism of weather impacts on ATM, including identifying what weather elements and how they affect to ATM operation.

4. BF

(1) 0754UTC臨時BF

T03セクターでCBが拡大し、RJTTN出発機のT07セクターへのDEVの可能性があったため、LFM降水予想資料を印刷し、東席・北席に資料を手交しながら臨時BFを実施し、以下のことを説明した。

- T03セクターでCBが拡大しているため、RJTTN出発機がT07セクターへDEVする可能性がある
- その後T03/T07セクターがCBで塞がれた状態になる
- 11UTC頃からT03セクターでCBの隙間が出てくるため、RJTTN到着機のT03セクターDEV可能性がある
- T07セクターのCBは12UTC過ぎまで残る見込み



3. 交通流への影響

昼頃から北陸～東北南部にエコー息が掛かっていたため、04UTCからT01/T02セクターでCAPA調整が実施された。また、夕方から関東北部～東北南部でCBが発達する予想だったため、RJTTNでTTL SPCが-1分された。

夕方になりT03セクターでCBが拡大し始め、RJTTN出発機のT07セクターへのDEVが出始めた0750UTCからT03/T07セクターでもCAPA調整が実施された。

10UTC以降もT02セクターにはCBを含むエコーが広がっていたが、CAPA調整は予定通り1000UTCで終わり延長されなかった。

CAPA調整表（東北南部～関東北部を抜粋）

時刻(UTC)	03	04	05	06	07	08	09	10	11	12
RJTTN				TTL SPC 12分(-1分) (0600-1200)						
T01/T02セクター		CAPA 96% (0400-1000)								
T03/T07セクター						CAPA 90% (0750-1200)				

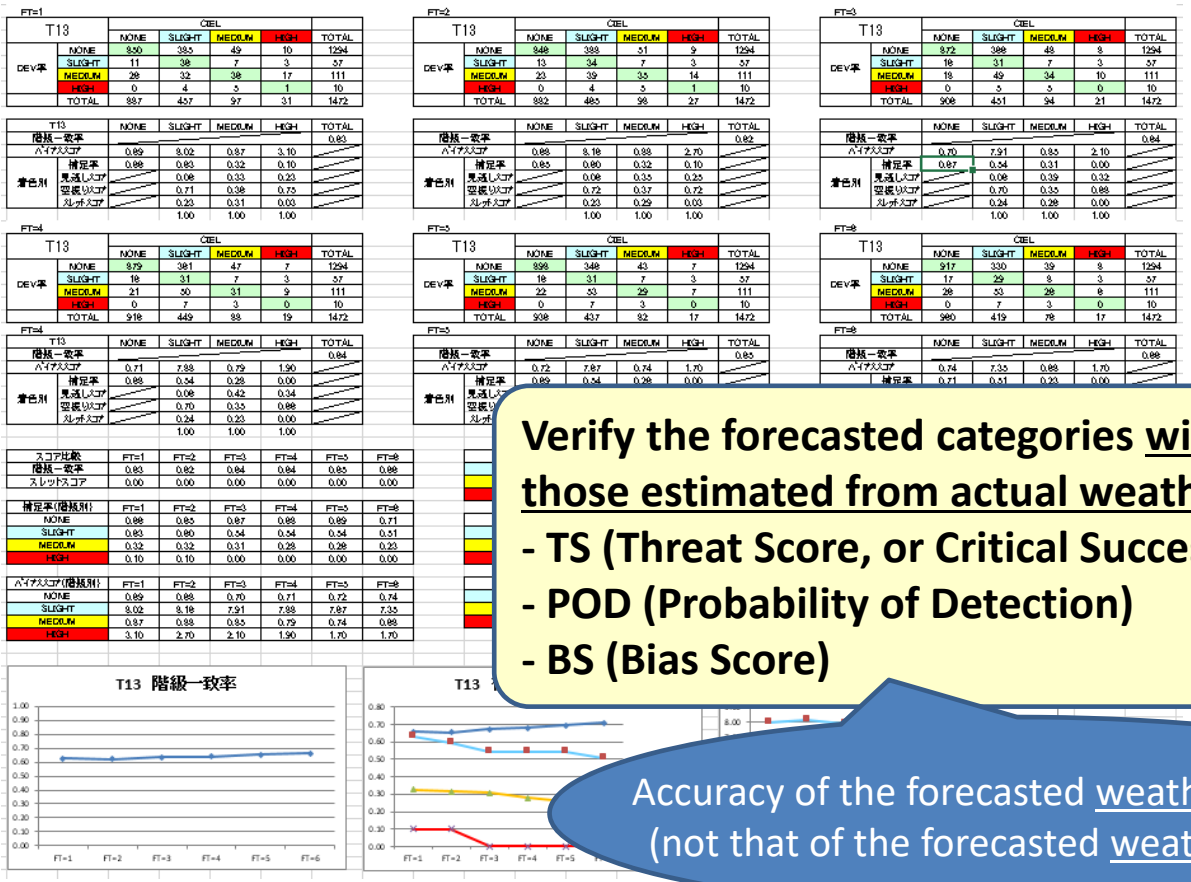
Japan Meteorological Agency

国土交通省
Ministry of Land, Infrastructure, Transport and Tourism

2. Verification of impact-based ATM-tailored MET information

Statistical method: for assessment/verification of products

Statistical method taken for quantitative and objective verification to improve products.



Verify the forecasted categories <u>with comparing those estimated from actual weather conditions</u>.
- **TS (Threat Score, or Critical Success Index)**
- **POD (Probability of Detection)**
- **BS (Bias Score)**

Accuracy of the forecasted <u>weather condition</u>
(not that of the forecasted <u>weather impact</u>)

気象庁
Japan Meteorological Agency

国土交通省
Ministry of Land, Infrastructure, Transport and Tourism

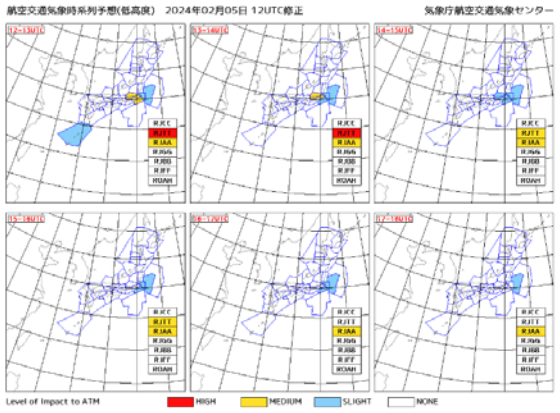
2. Verification of impact-based ATM-tailored MET information

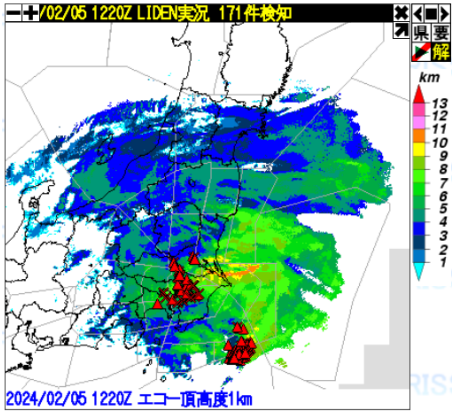
Category forecasts around airports

- As they are derived from TAF elements, categories derived from METAR elements are used to verify their accuracy.
- The forecasts need to be tuned to represent weather impact on ATM.

Category forecasts for airspaces

- Compare the categories with proportions of the area where radar echo top is same or higher than the criteria (FL300 or 240).
- Note the proportions are not something to indicate weather impact on ATM.





Where is the true value?

Exploration continues...

気象庁
Japan Meteorological Agency

国土交通省
Ministry of Land, Infrastructure, Transport and Tourism

3. Recent enhancement by MET/ATM collaboration

Issue arise

Introduce a new element **SIG CLOUD** into the category forecasts

There were cases that many deviations requested where the categories forecasted lower impact.

ATMC

「ACC requested us to reduce ATC capacity value of XX sector for flow control.
How's the current weather condition and forecast of the area?
The category forecast is white (no impact).」

ATMetC

「Middle level clouds are dominant. They seem strati form clouds rather than convective clouds though radar reflectivity is little bit higher.」

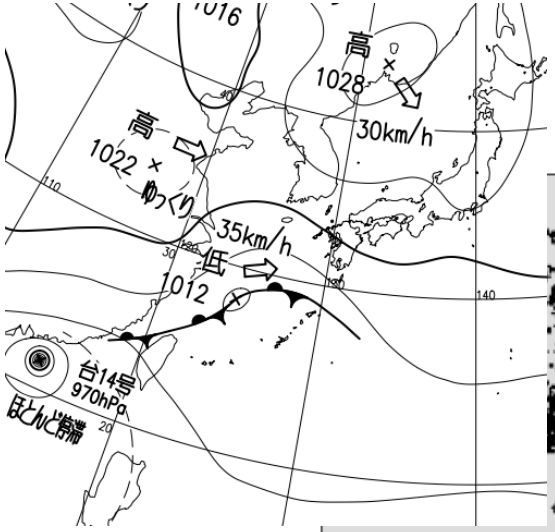
ATMetC explored additional target phenomena and criteria for the category forecasts.

Additional target phenomena **SIGNIFICANT CLOUD** introduced in July 2024
(SIG CLOUD: non-convective clouds with high radar reflectivity or anvil cloud)

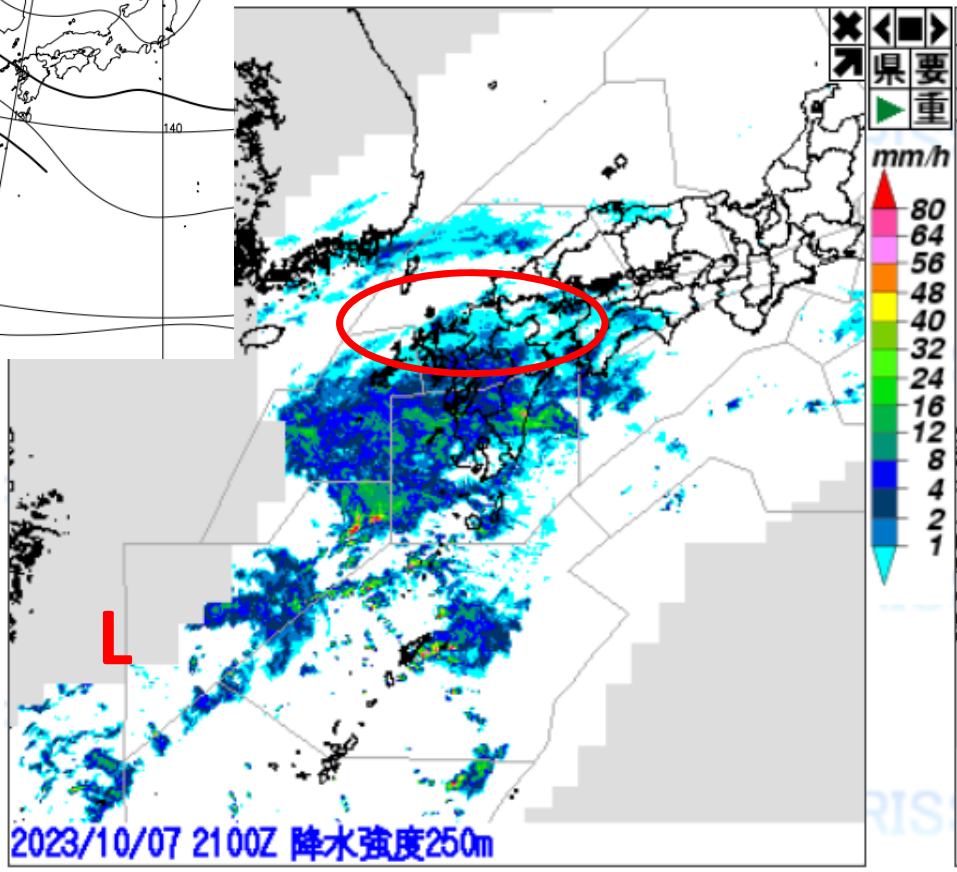
3. Recent enhancement by MET/ATM collaboration

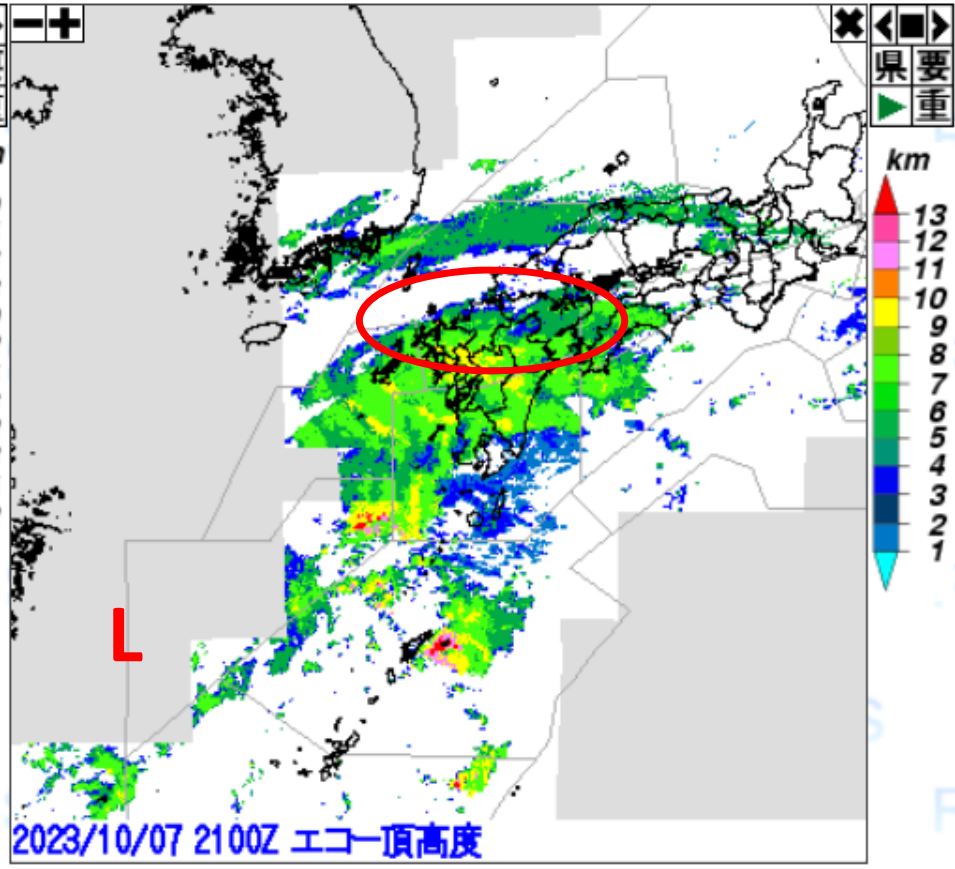
Case study

Introduce a new element **SIG CLOUD** into the category forecasts



It was a day of non-convective clouds with high radar reflectivity when the air traffic manager asked the weather condition.



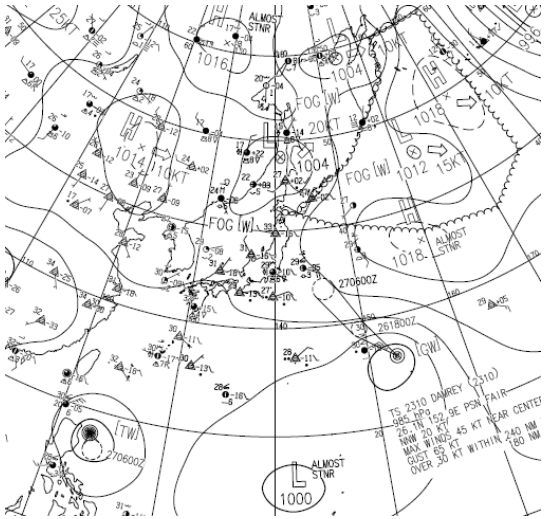


気象庁
Japan Meteorological Agency

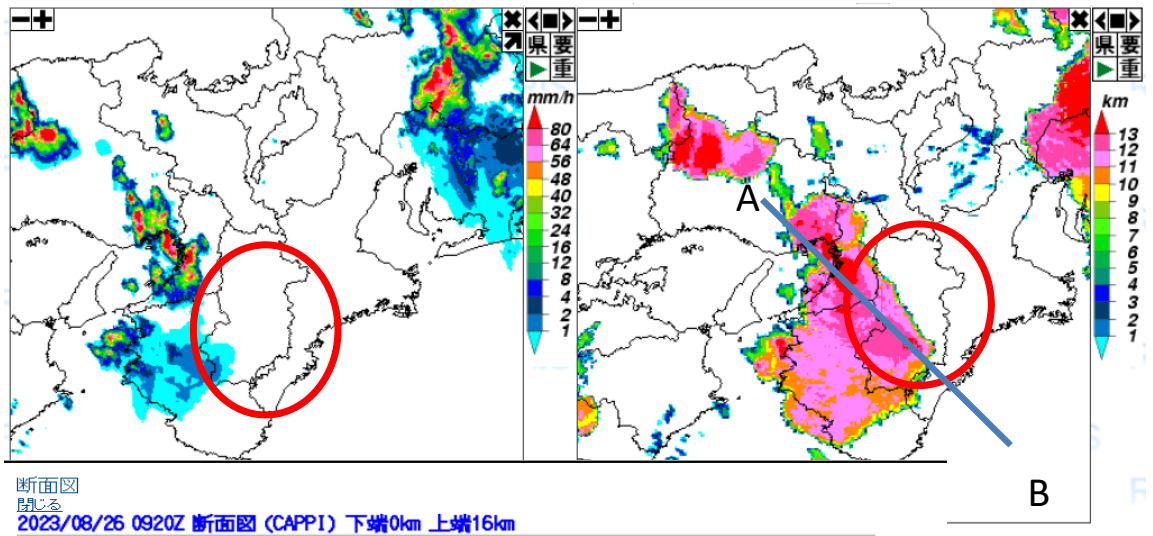
3. Recent enhancement by MET/ATM collaboration

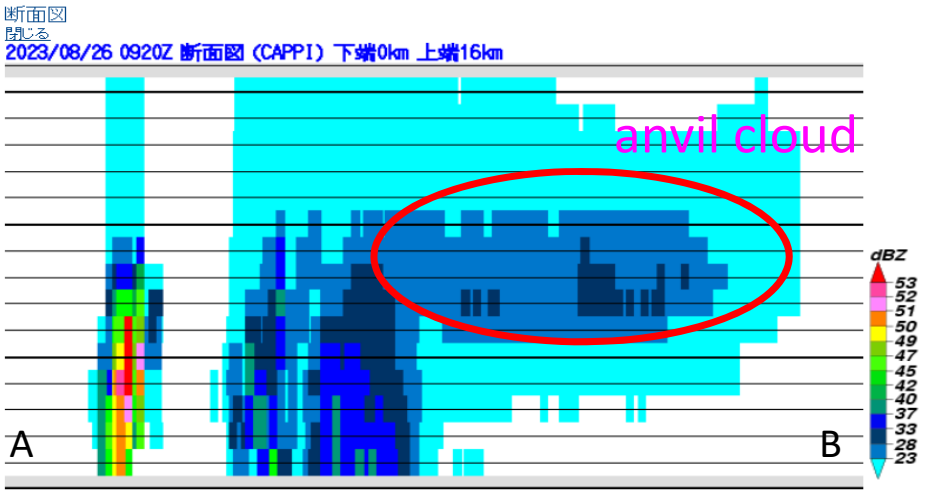
Case study

Introduce a new element **SIG CLOUD** into the category forecasts



Another case: deviation requests to avoid anvil cloud





気象庁
Japan Meteorological Agency

国土交通省
Ministry of Land, Infrastructure, Transport and Tourism

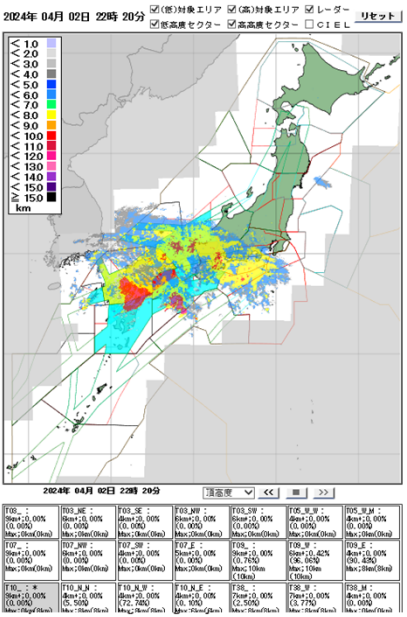
3. Recent enhancement by MET/ATM collaboration

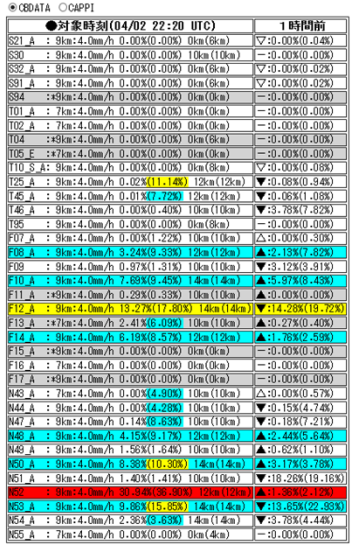
Developing techniques

Introduce a new element **SIG CLOUD** into the category forecasts

Preparation to include SIG CLOUD as a target phenomenon

- Conduct statistical validation on SIG CLOUD
- Develop SIG CLOUD monitoring tool
  ... new step for SIG CLOUD extraction introduced into the existing CB monitoring tool
- Studies for MET/ATM Operators





CB monitoring tool improvement

SIG CLOUD extraction process flows are being exanimated mainly by statistical validation.

Using radar data to detect SIG CLOUD (under investigation)
e.g.,

non-convective clouds with high radar reflectivity
- TOP over FL300 - over FL370 >= 40% AND over FL370 < 3%

anvil cloud
- TOP FL370 - 4 mm & Top 300 > 10% and 4 mm & Top 300 < 5 and TOP 300 > 30%

Verification of impact-based products

Evaluation of “impact to air traffic flow” has some complexity.

What is the cause of complexity?

- Air traffic disruption occur not only due to weather condition
  but also various elements such as air traffic volume, aircraft accident …
- There is a need to separate weather condition from other elements
  to verify weather related impact.

Issues:
Definition of the impact of adverse weather
Definition of the true value for verification

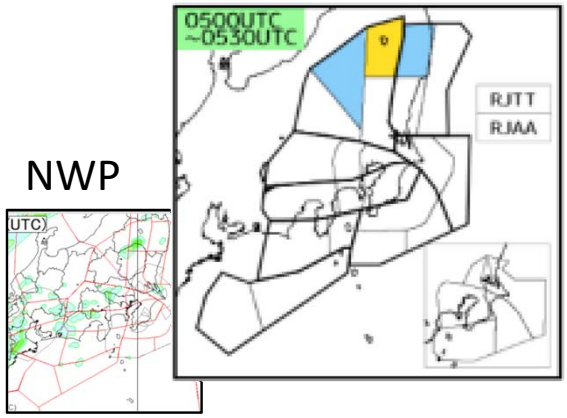
4. Challenges on verification of impact-based product

Definition of true value:

Trying to identify appropriate indicator to evaluate the impact on ATM.

Category forecast

NWP



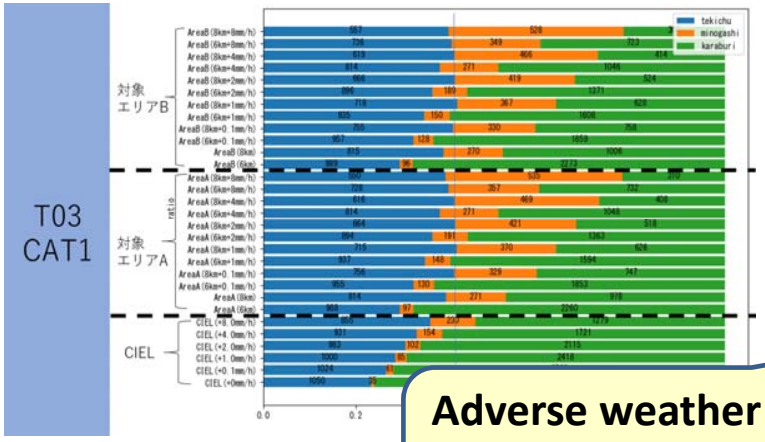
Evaluation using radar observation

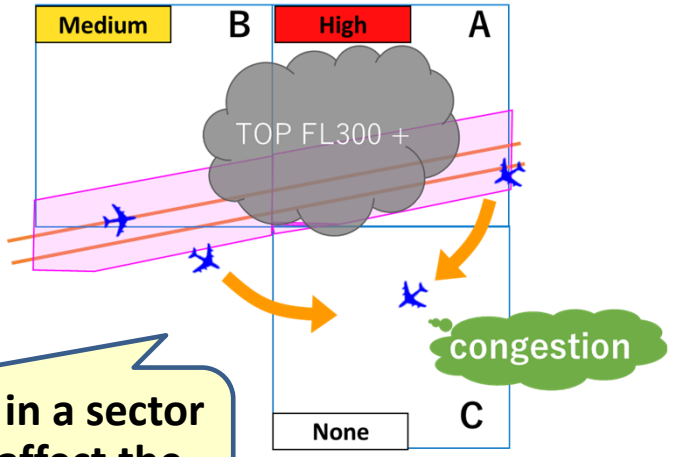
VS

ATC capacity

As of	Sector	MET factor	CB TOP FL	Time start	Time end	CAPA
0001	T07	CB	400	2320	1200	93
0001	T09	CB	400	2100	0700	90
0001	T10	CB	400	2100	0700	87
0001	T12	CB	400	2310	0220	94
0001	T13	CB	400	2310	0220	94

Each ATM officer manually decide ATC capacities with considering not only weather conditions but also other factors





Adverse weather in a sector could indirectly affect the capacity of other sectors

気象庁
Japan Meteorological Agency

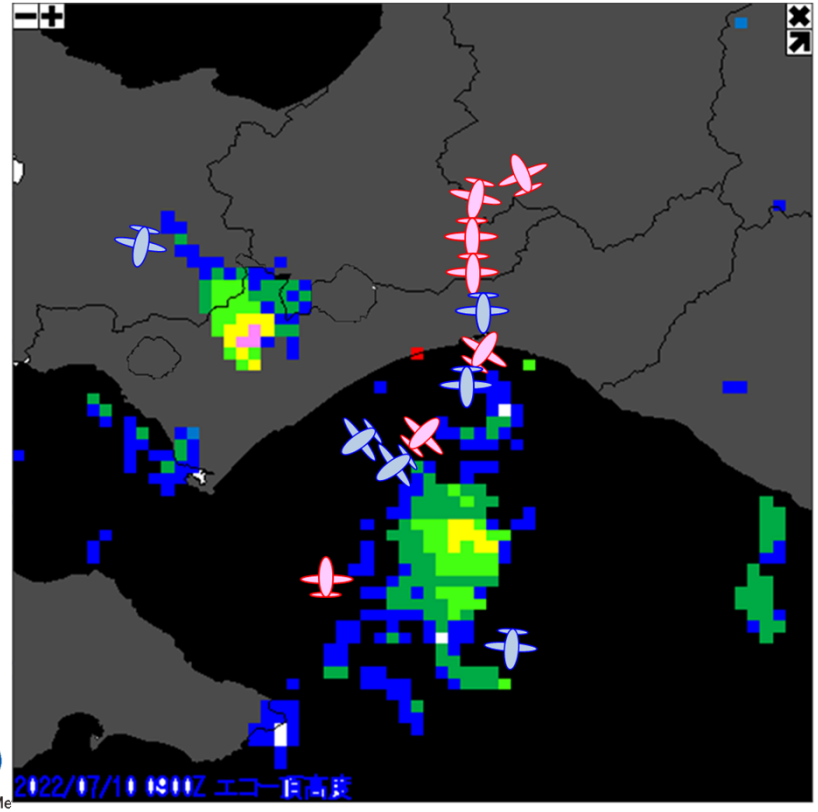
国土交通省
Ministry of Land, Infrastructure, Transport and Tourism

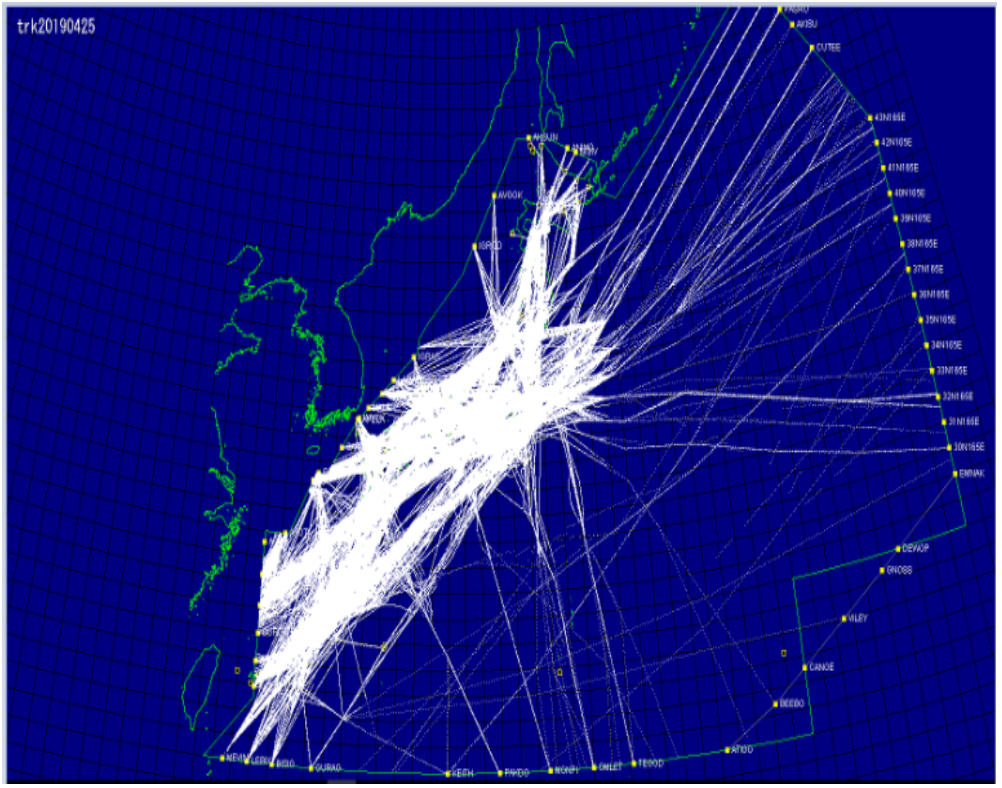
4. Challenges on verification of impact-based product

Definition of true value:

Trying to identify appropriate indicator to evaluate the impact on ATM.

E.g., Amount of deviated aircrafts – trying to obtain it from ADS-B trajectory data





Japan Me

国土交通省
Ministry of Land, Infrastructure, Transport and Tourism

4. Challenges on verification of impact-based product

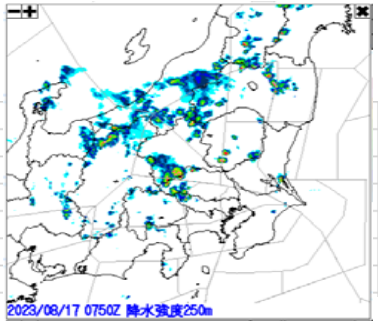
Definition of true value:

Trying to identify appropriate indicator to evaluate the impact on ATM.

Reason

ATC capacity

17	木	4	T09	N	2230	2240	2300	97		WX		90			7:30	8:00
17	木	16	T12	S	710	750	905	97	MINIT KAGNA:21NM	WX		88	EDT		16:10	18:05
17	木	17	T13	N	700	720	730	60		WX		84			16:00	16:30
17	木	10	T87	S	220	400	450	117	EDCT			91	EDT		11:20	13:50
17	木	6	T88	S	2300	40	840	124		WX		91	EDT		8:00	17:40
17	木	9	F16	S	0	200	550	101	EDCT				EDT		9:00	14:50
17	木	5	N52	N	2230	2240	2320	107		WX		91			7:30	8:20



Possible further steps: jointly develop a format to review associated data.

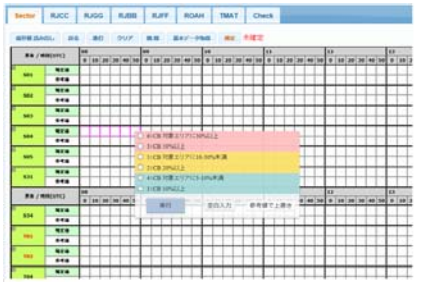
For example,

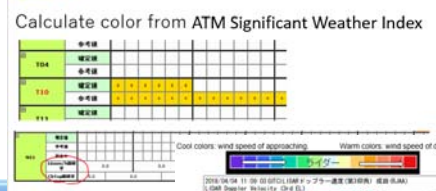
- Have a common format to log both MET and ATM operations/trials
- Record non-meteorological factor(s) considered in setting ATC capacity

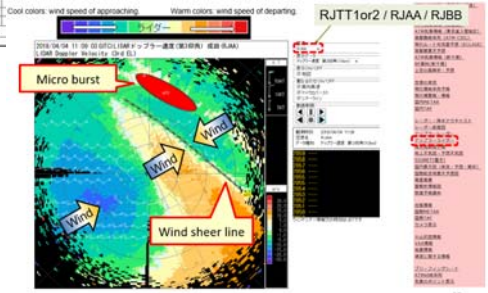
5. International cooperation

Technical exchange meeting between Singapore and Japan (Feb. 2024, Japan)

- During the meeting, Singapore contingent visited ATMC/ATMetC in Fukuoka to observe Japan's MET/ATM collaboration.
- Two States took this opportunity to learn their ATM-tailored MET services each other, and exchange views on how the services can be improved.







気象庁
Japan Meteorological Agency

国土交通省
Ministry of Land, Infrastructure, Transport and Tourism

Conclusion

- MET/ATM collaboration is essential to develop and improve impact-based MET products to effectively support ATM operations.
  - Remember there are non-meteorological factors to affect ATC capacities.
  - Such factors cannot be ignored in validation process.
- Sharing technical information including practices and plans among APAC States would help to improve MET service quality.
  - Some findings in a State may be applied to other States as well.
  - There may be differences due to the scope of ATFM (e.g., cross-border or domestic) and MET/ATM integration stage.