World Meteorological Organization

Weather • Climate • Water

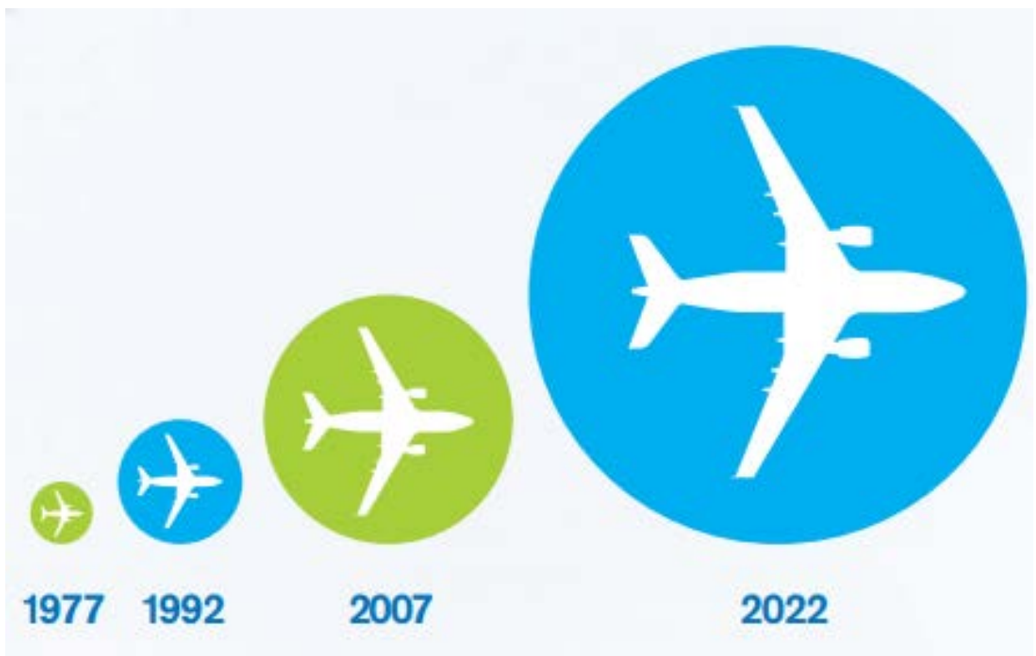
Overview of WMO Joint CAS/CAeM Aviation Research Demonstration Project (AvRDP)

Peter PW Li
Hong Kong Observatory
Chair, AvRDP Science Steering Committee

WSN16
25-29 July 2016
Hong Kong

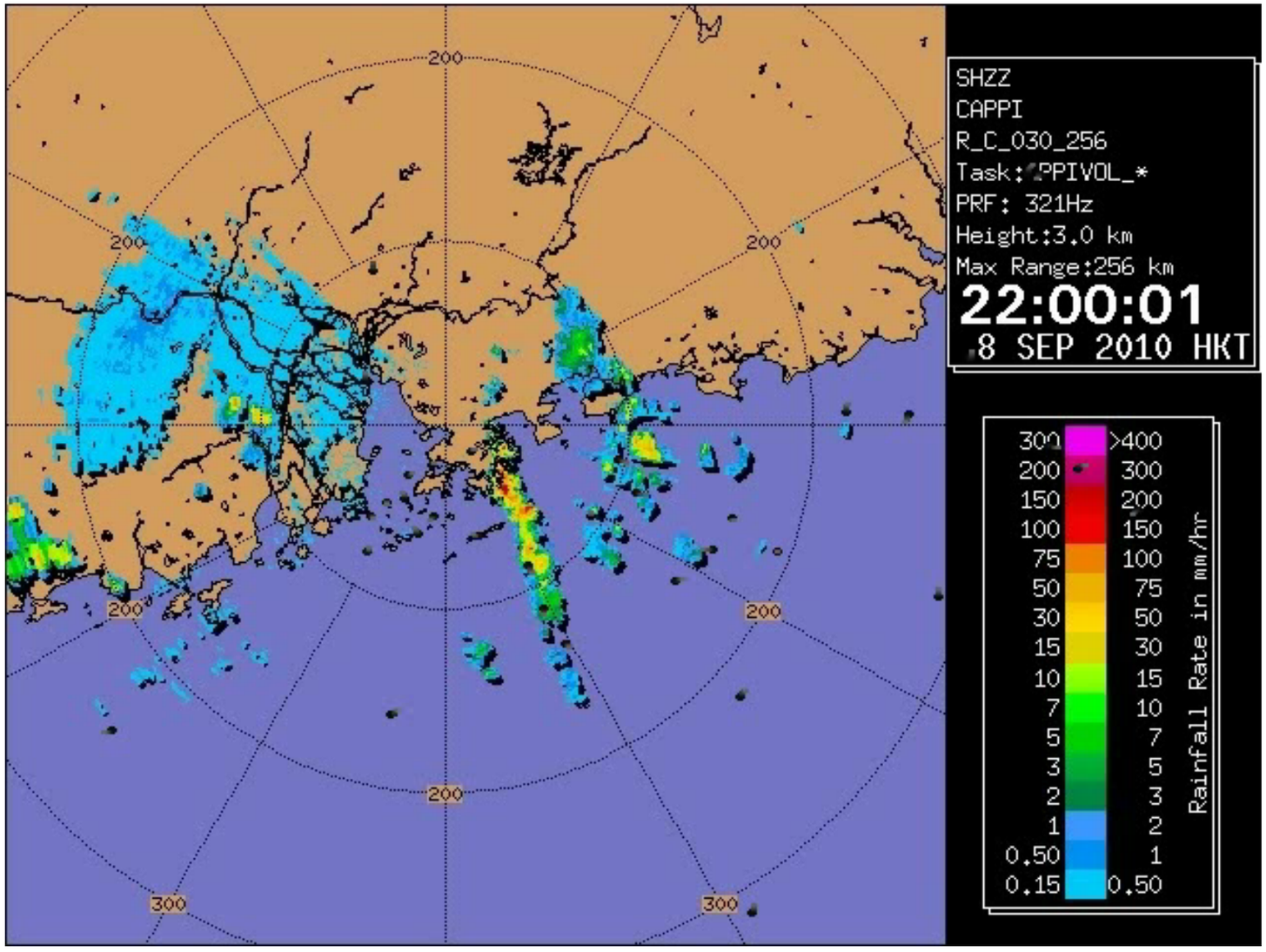
New Era of Aviation Industry

- Aeronautical meteorology is entering into an era of rapid and fundamental changes, in response to the continuous growth of aviation transport and the need of new concepts for Air Traffic Management (ATM)
- More frequent extreme weather under climate change also bring impact to aviation industry
- The ASBU methodology under the new Global Air Navigation Plan (GANP) (2013) aims at safe, sustained growth, increased efficiency and responsible environmental stewardship



Weather Impact on Air Traffic

IATA 2006 Safety Report:
43% of accidents occurred during operation in adverse weather



Pilot/Airline/ATM needs advance, detailed and flight specific weather information for strategic planning and tactical decision-making to achieve safe, efficient and environmental flight operations

AvRDP Objectives

WMO Congress XVII: Aviation meteorological services as one of the 7 priorities in 2016-2019

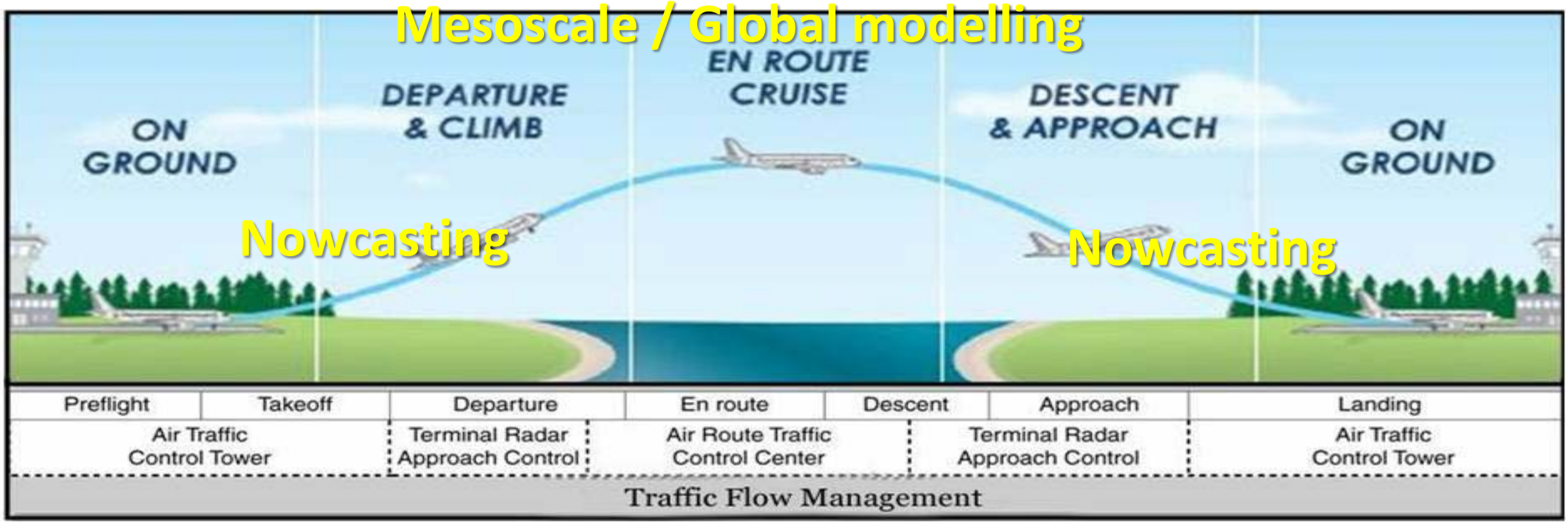
AvRDP is a joint effort between CAS/WWRP and CAeM (may involve CBS in Phase II), in the next 4 years (2015-2018):

- to conduct research and development in **nowcasting and mesoscale modelling** at several international airports located in Northern and Southern Hemisphere with a view to supporting the Trajectory-Based Operation (TBO) under the new Global Aviation Navigation Plan (GANP);
- to collaborate with the respective Air Traffic Management (ATM) to **translate** the MET information into ATM Impacts;
- to provide guideline on **verification** of aviation MET/ATM products
- to help **capacity building** other WMO Members who need to enhance their aviation MET services to meet ASBU.

** Nowcast or nowcasting hereafter refers to all techniques/systems including observation-based, expert system-based, human-machine interfaced and meso/microscale NWP or any combination thereof which can generate high resolution, rapidly updated forecasts for the next 0-6hr ahead*

Trajectory-Based Operation (TBO)

Transition from nowcasting scale -> mesoscale -> global scale -> mesoscale -> nowcasting scale

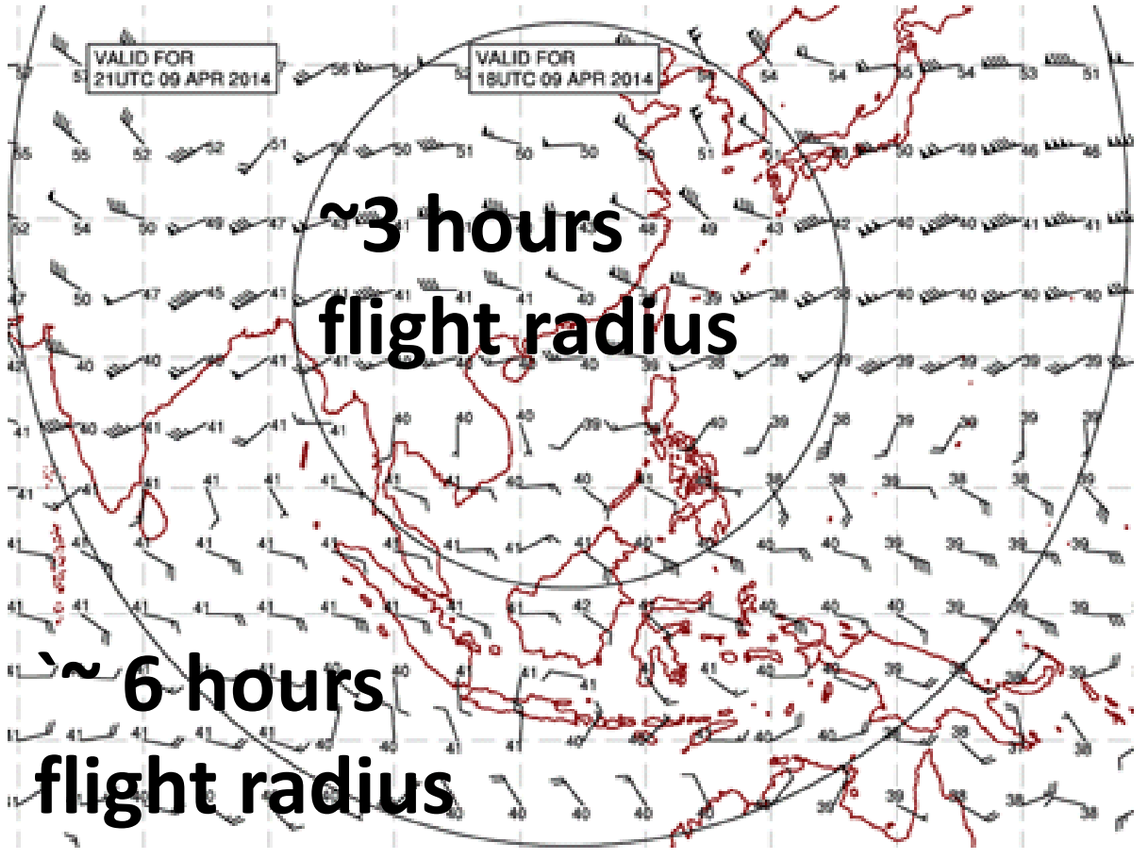


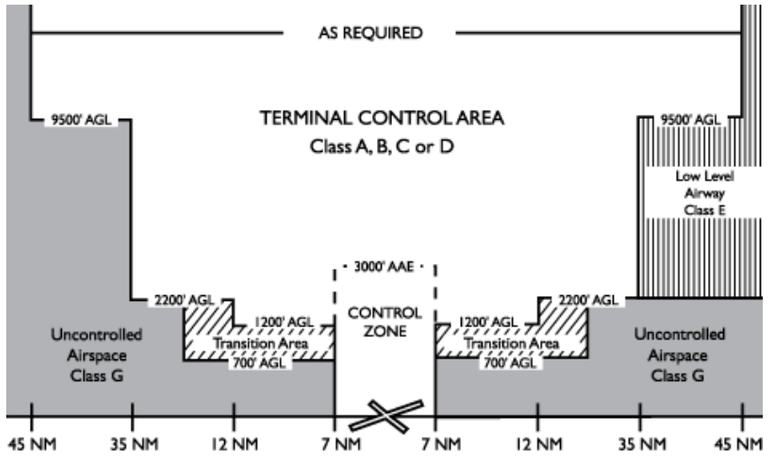
Terminal Control Area: Location specific

En Route Phase: Mainly supported by global/regional Multi-model Aviation Weather Forecast Centre (AWFC)

Terminal Control Area: Location specific

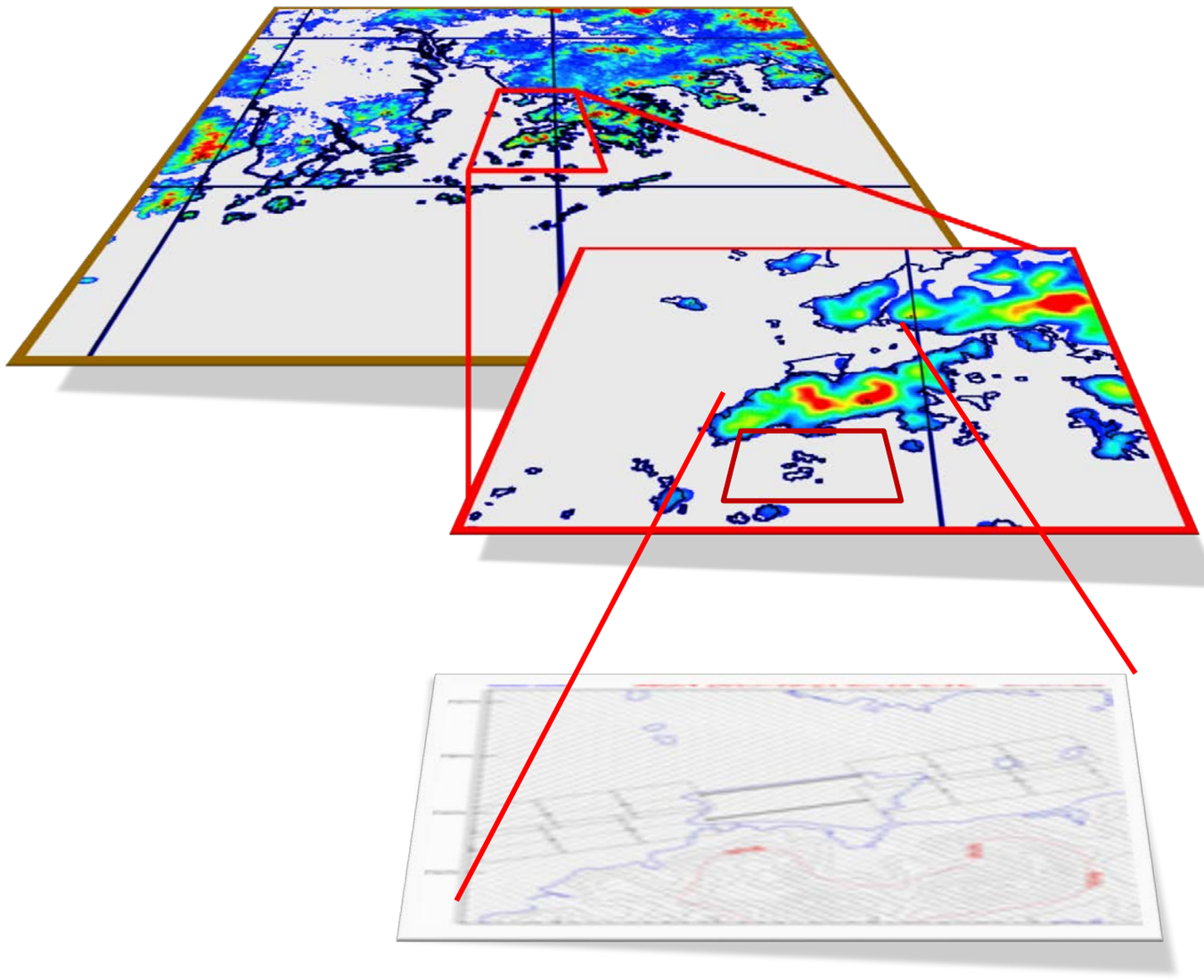
The closer to the Terminal Control Area / Aerodrome, the finer weather information required





This is the area needs 0-6 hr nowcast

Meteorological Service for the Terminal Area (MSTA)



Spatial resolution Δx from 10's km to sub-km
Temporal resolution Δt from hours to minutes
Update frequency from hours to minutes

CAeM/ICAO Conjoint Meeting
7-18 July 2014, Montreal, CA

French - Français | Spanish - Español | Russian - Русский | Arabic - العربية | Chinese - 中文

ICAO Meteorology Divisional Meeting

(in part conjointly with the Fifteenth Session of the World Meteorological Organization (WMO) Commission for Aeronautical Meteorology (CAeM) including Technical Conference)

Recommendation 2/10 —Development of meteorological service for the terminal area

That ICAO, in close coordination with WMO, be tasked to:

a) include meteorological service for the terminal area and other relevant operational requirements in Block 1 and subsequent blocks of the aviation system block upgrade methodology to highlight potential related impacts on air traffic flow in consideration of air traffic control and air traffic management (ATM);

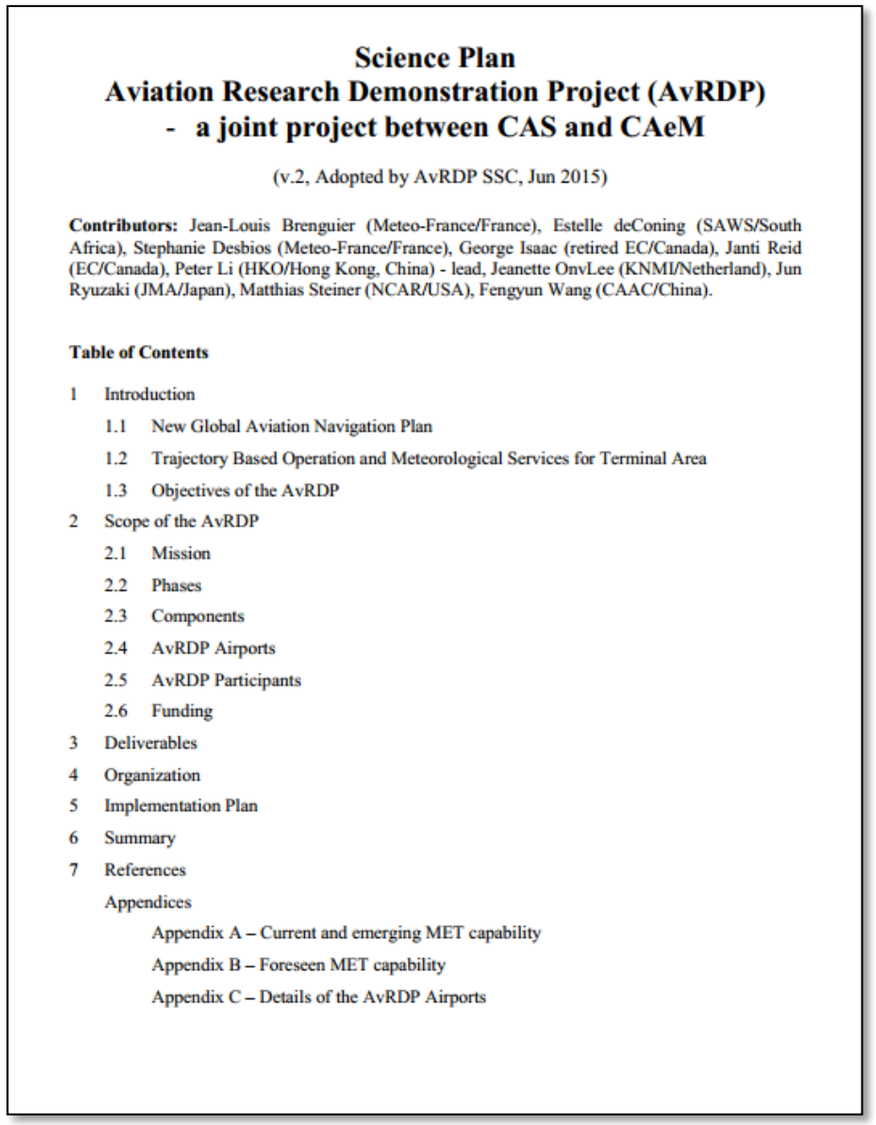
b) develop ATM-tailored meteorological service for the terminal area to meet future ATM requirements identified by the *Global Air Navigation Plan* (Doc 9750) and reflect the appropriate functional and performance requirements in the relevant provisions, noting outcomes from ICAO expert groups on meteorology, ATM and flight operations.;

c) develop guidance on verification methodology toward the continuous improvement of meteorological information to ATM; and

d) integrate the information concerning meteorological service for the terminal area into the future system-wide information management environment underpinning the future globally interoperable ATM system.

AvRDP Science Steering Committee

- Adopted Science plan including the implementation plan
  - Phase I – MET capability research focusing on MET research and development.
  - Phase II – MET-ATM impact translation and validation
    focusing on translating MET information into ATM impact and demonstrate the benefit to aviation community.



Science Plan
Aviation Research Demonstration Project (AvRDP)
- a joint project between CAS and CAeM

(v.2, Adopted by AvRDP SSC, Jun 2015)

Contributors: Jean-Louis Brenguier (Meteo-France/France), Estelle deConing (SAWS/South Africa), Stephanie Desbios (Meteo-France/France), George Isaac (retired EC/Canada), Janti Reid (EC/Canada), Peter Li (HKO/Hong Kong, China) - lead, Jeanette OnvLee (KNMI/Netherland), Jun Ryuzaki (JMA/Japan), Matthias Steiner (NCAR/USA), Fengyun Wang (CAAC/China).

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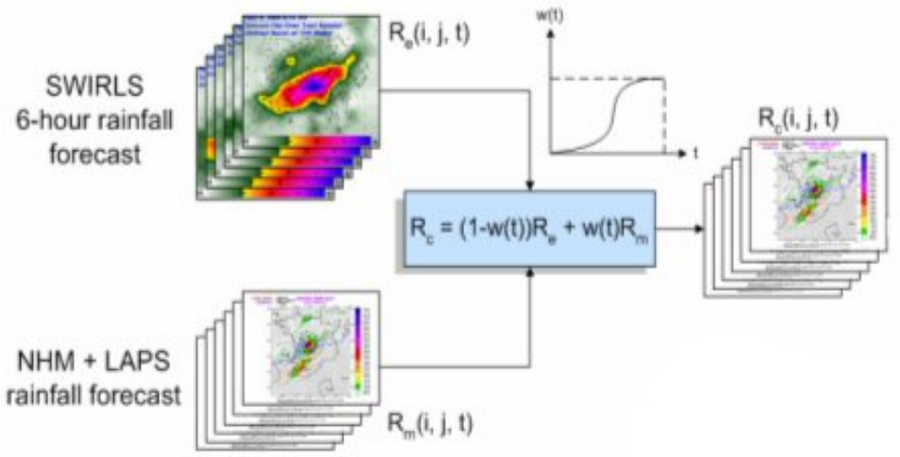
** Airports which start the Intense Observation Period (IOP) in late 2015 or later may choose to enter Phase II in late 2016*

AvRDP Components

- **Nowcasting component**
  - New Technologies
  - Radar/satellite nowcast blended with mesoscale model
  - Ensemble nowcasting product
  - Uncertainty/reliability estimation
- **Impact component**
  - Translation of MET forecast into ATM impact
- **Verification component**
  - Verification methods for deterministic and probabilistic products
- **Capacity building component**
  - Training/Workshop for WMO members



AvRDP Airports

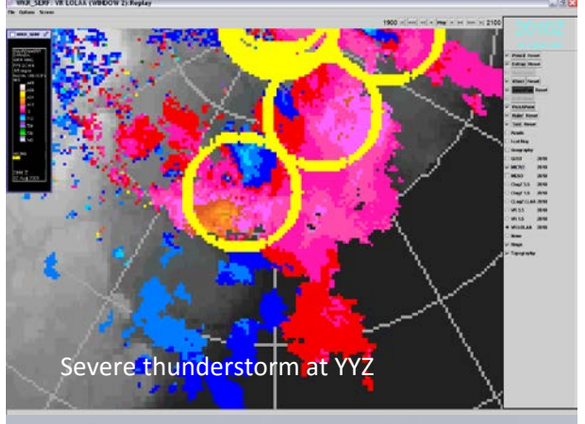
- The AvRDP would be held at different airports to study different impacting weather at different climatological locations

- An AvRDP Airport will collect meteorological observations including advanced remote sensing data, NWP data etc. and to provide them to AvRDP Participants to execute nowcasting or model simulation over the airport

- The hosting airport will conduct inter-comparison and verification in order to assess each nowcast system's performance, translate and study the ATM impact


Severe thunderstorm over HKG


Fog/visibility at HKG


Severe thunderstorm at YYZ


De-icing at YYZ

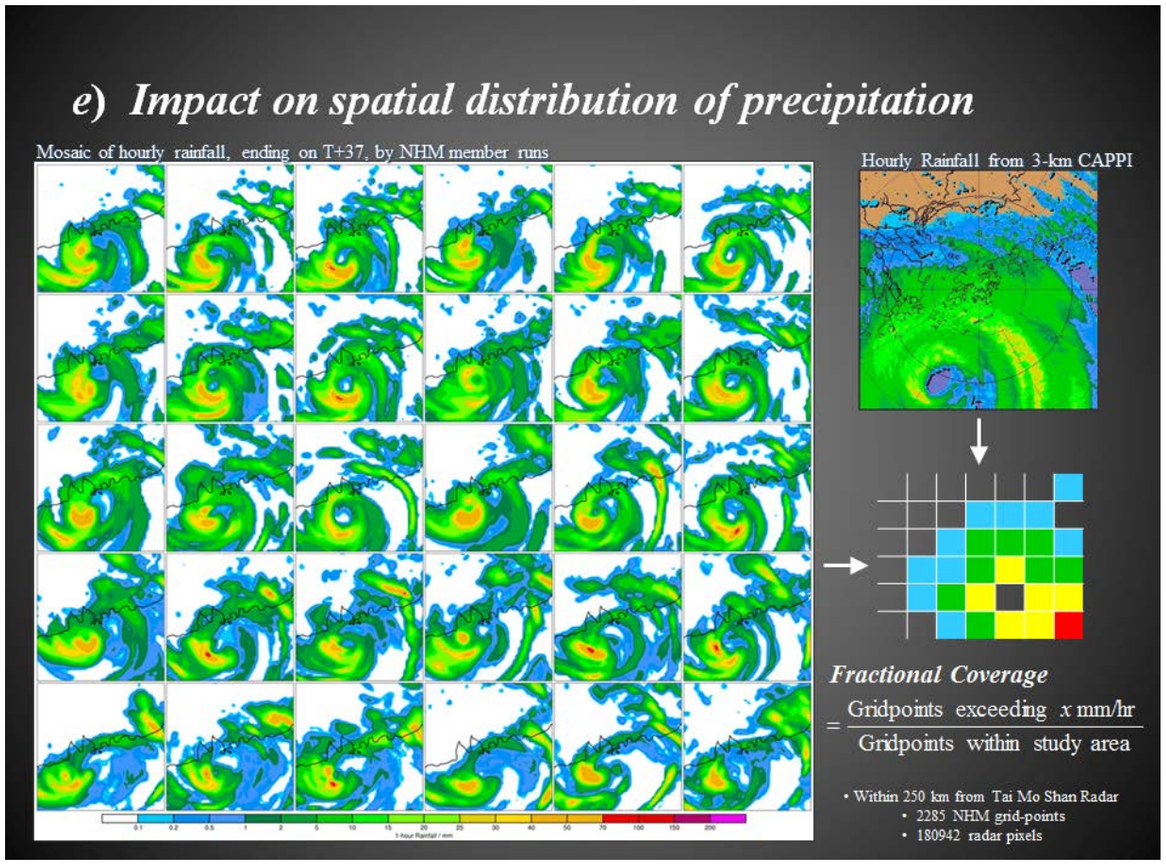
AvRDP Airports (initially)

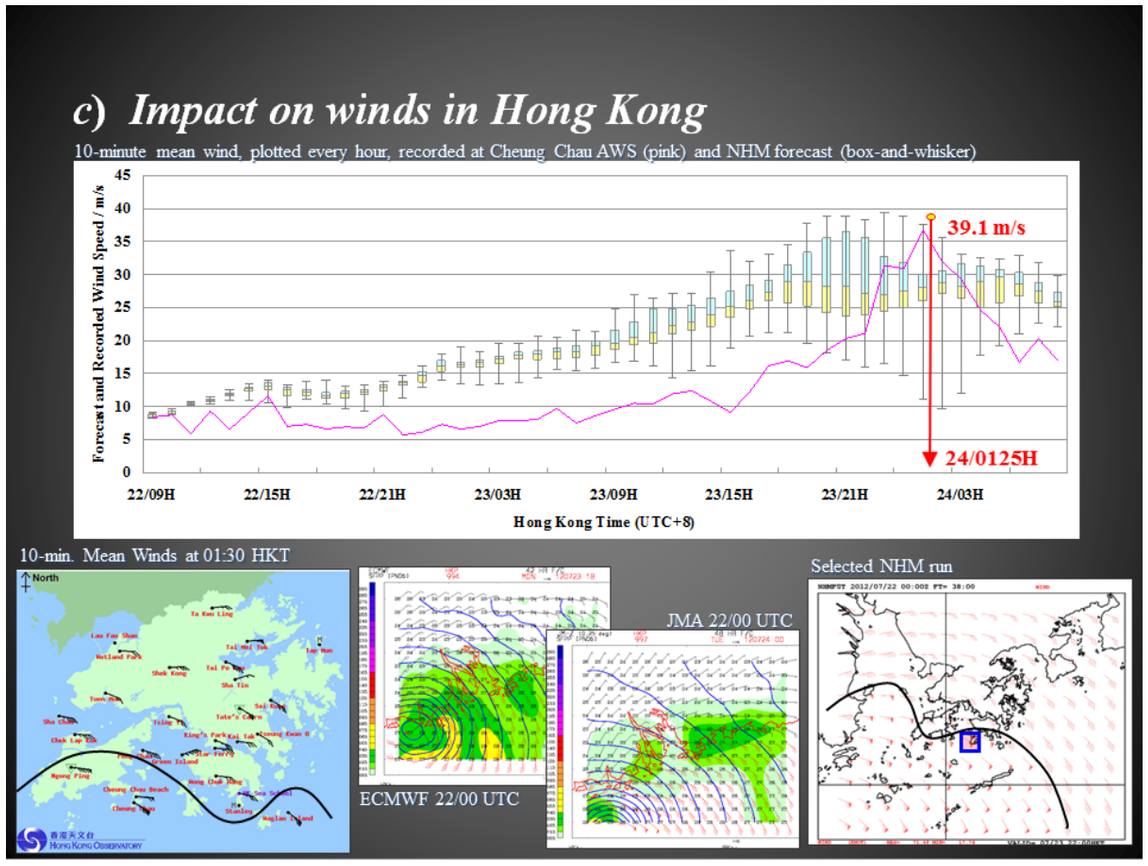
AvRDP Airport	Climatological regime	Weather elements to be studied in AvRDP
Charles de Gaulle Airport (CDG) 	Mid-latitude in Northern Hemisphere Location: Inland	Winter weather - snowfall, icing, low temperature Fog
Hong Kong International Airport (HKG) 	Subtropical in Northern Hemisphere Location: Surrounded by water Next to high mountain	Convection and Thunderstorm Low visibility and ceiling
O.R. Tambo International Airport (Johannesburg Airport) (JNB) 	Subtropical in Southern Hemisphere Location: Inland	Convection Fog
Shanghai Hongqiao Airport (SHA) 	Subtropical/mid-latitude in Northern Hemisphere Location: Inland not far away from River Estuary and East China Sea	Convective weather
Toronto Pearson International Airport (YYZ) and **Iqaluit Airport (YFB)**  	Mid-latitude in Northern Hemisphere Location: Inland but not far away from Lake High-latitude in Northern Hemisphere Location: On Frobisher Bay	Winter weather – snowfall, icing, precipitation type and amount, visibility, wind speed, direction shear, and gust, turbulence, and low ceilings Convective Weather Artic weather – Winds, blowing snow, fog, visibility, ceiling

Uncertainty (confidence) of MET information

Under ASBU, not only the meteorological information's spatial and temporal resolution and accuracy performance need to be enhanced, but also the uncertainties information would need to be provided for ATM risk assessment.

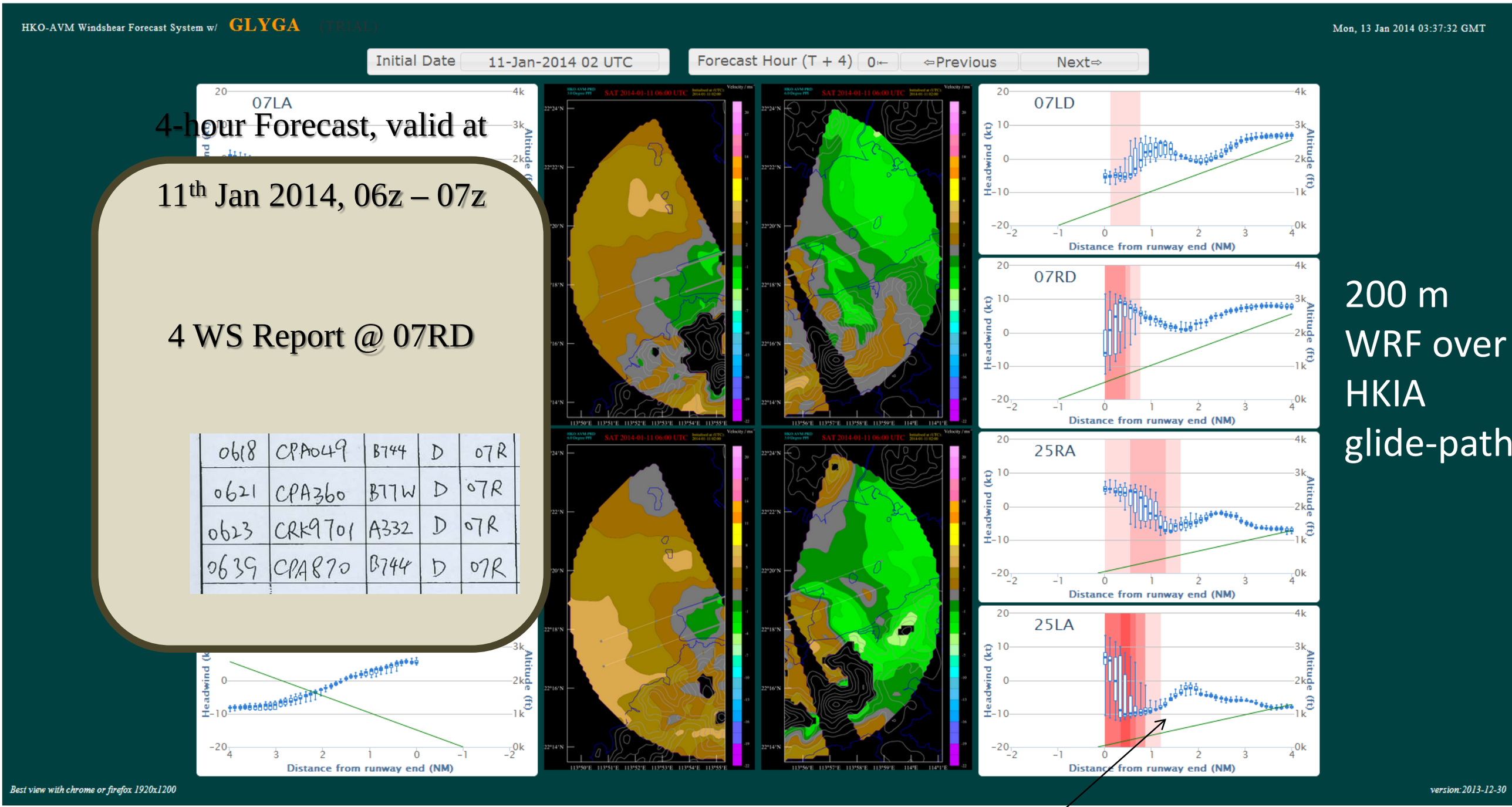
Or, Hon and Wong (2013)





Ensemble NWP and Nowcast

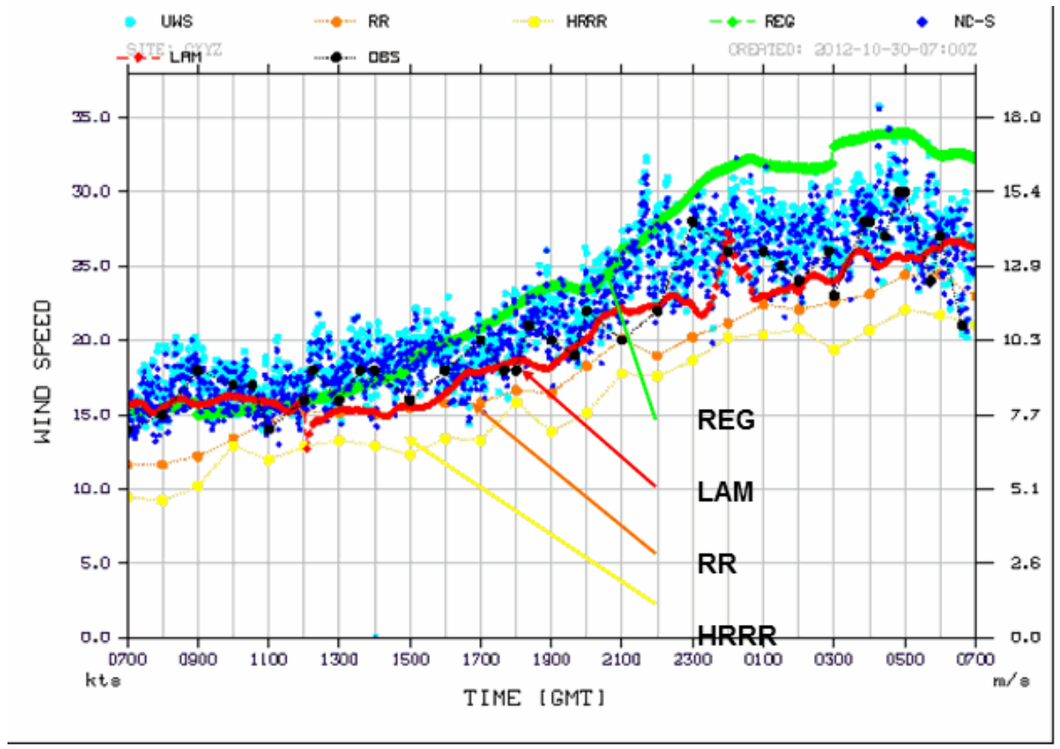
Rapid-output model wind field for windshear Guidance

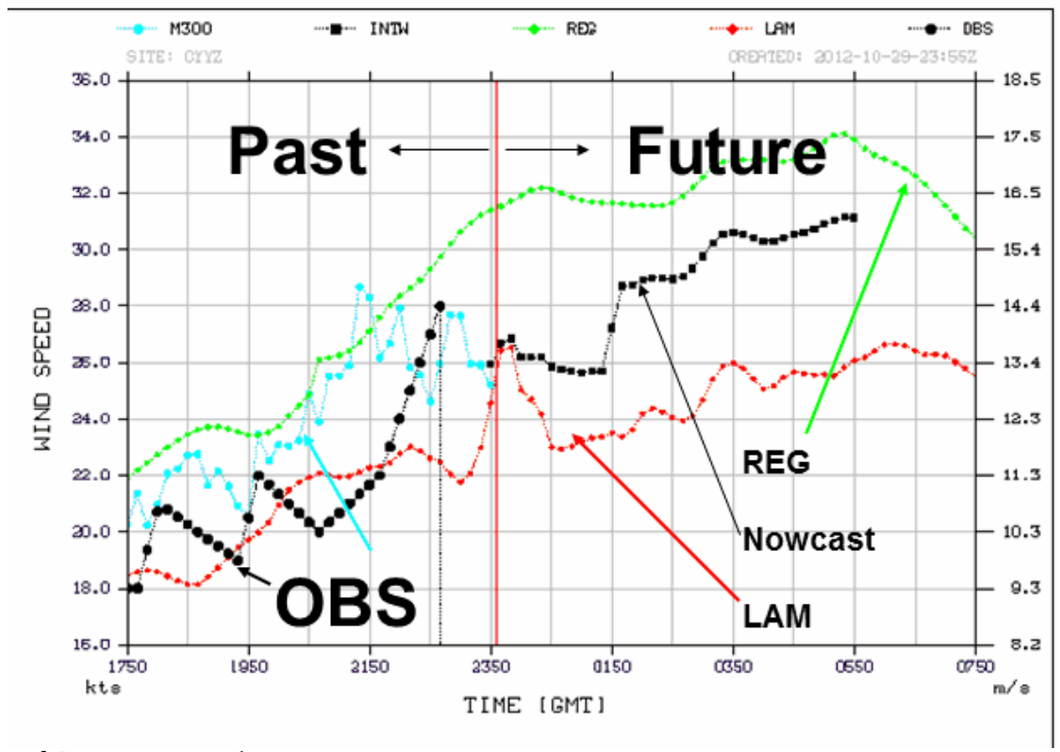


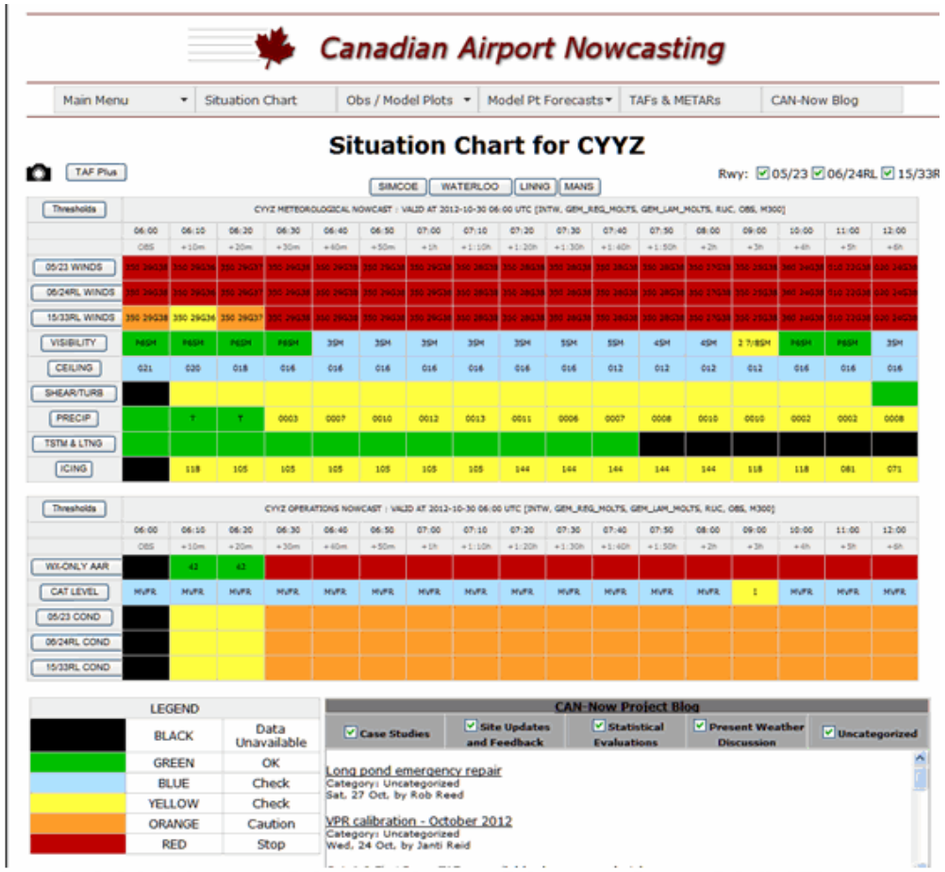
200 m WRF over HKIA glide-path

Model forecast headwind profiler by minutely output wind field

Wind, Visibility, etc nowcasts







CAN-Now Situation Chart for CYYZ During Hurricane Sandy (above)

Plot of Winds for 24 h ending 07 UTC 30 October 2012 (top left). Note plots of RR and HRRR.

Nowcast for Winds at 00Z showing INTW forecast values midway between GEM REG and LAM, which is what happened (bottom left)

Figure Courtesy of George Isaac and Laura Huang

Translate MET information into ATM Impact. What Impact?

- Airport Capacity in network operation
- Airspace Capacity
- Arrival/Departure Delay
- Fuel consumption
- Aircraft de-icing, runway clearance, engine icing in freezing fog
- Lightning strike affecting ground ops..

HKG 1st IOP for Convection in Northern Hemisphere (mid May – mid Sep 15)

- A number of significant convection cases
- A few typhoon cases
- Observational data
- Nowcasting data
- Mesoscale model data
- NWC + NWP blended data
- ATM data
  - Airport Capacity data

HKO IOP Data and Data Manual

香港天文台
HONG KONG OBSERVATORY

AvRDP HKG (May – Sep 2015)
IOP Brief and Data Manual

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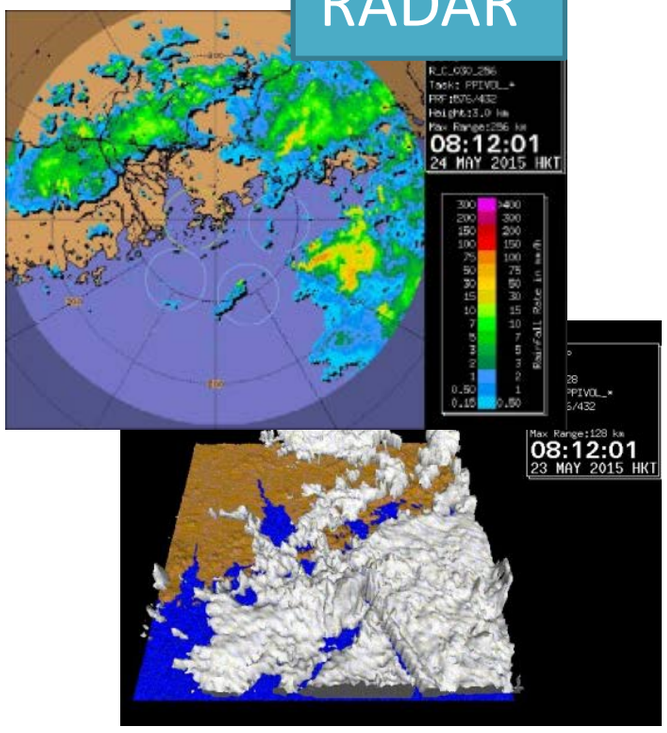
Appendices

HKO IOP Data

Airport	Observations								Nowcasting system and model			ATM data				
	Weather Radar (conventional or Doppler)	Geostationary Satellite	Wind profiler	LIDAR	Anemometer	Visibility sensor	AMDAR/ACARS data	Other observations	Nowcasting system	Micro/mesoscale NWP	Regional model	PIREP	Aircraft data	ATM capacity data	Air traffic data	ADS-B (since 2016)
HKG	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

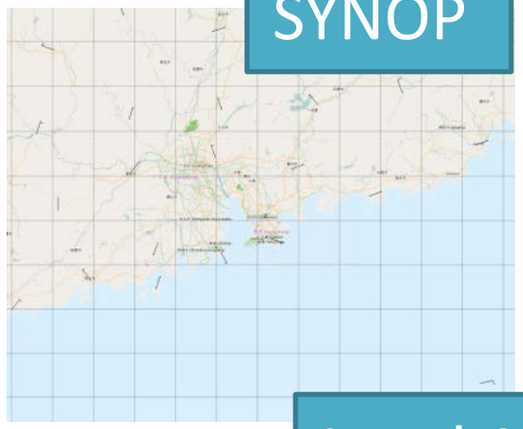
Observational Data collected

RADAR

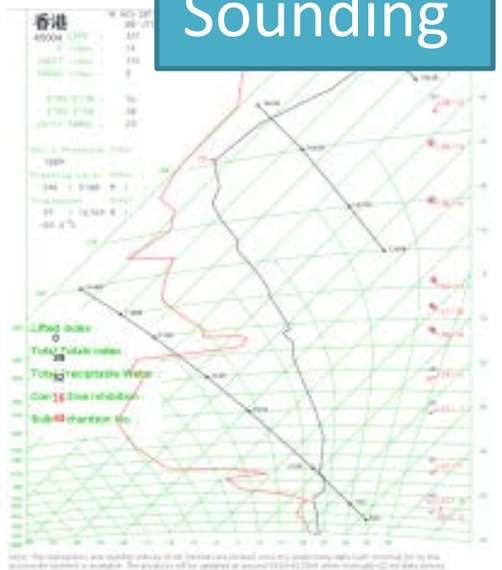


METAR

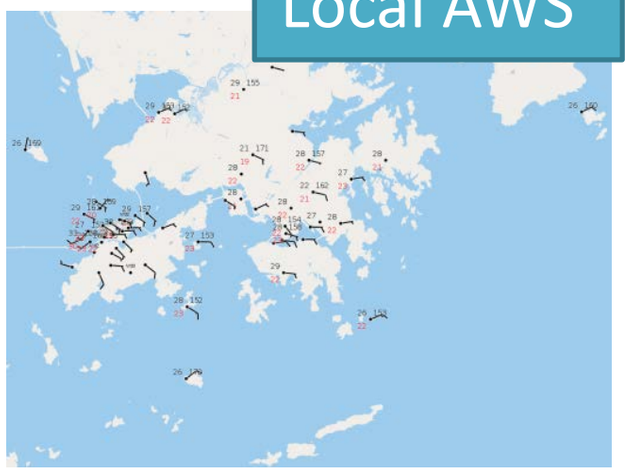
SYNOP



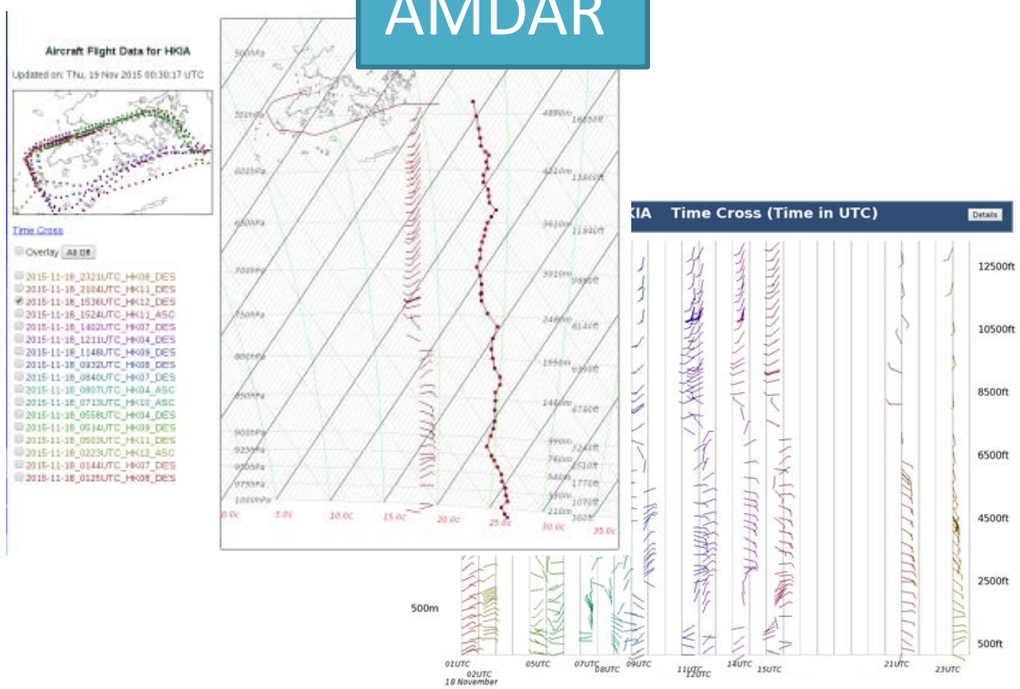
Sounding



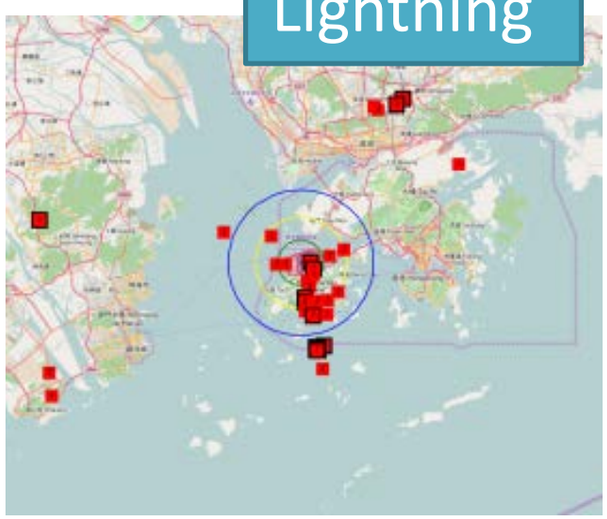
Local AWS



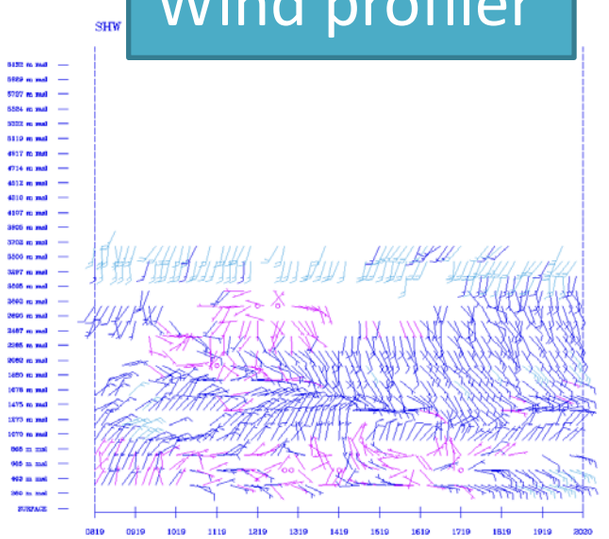
AMDAR



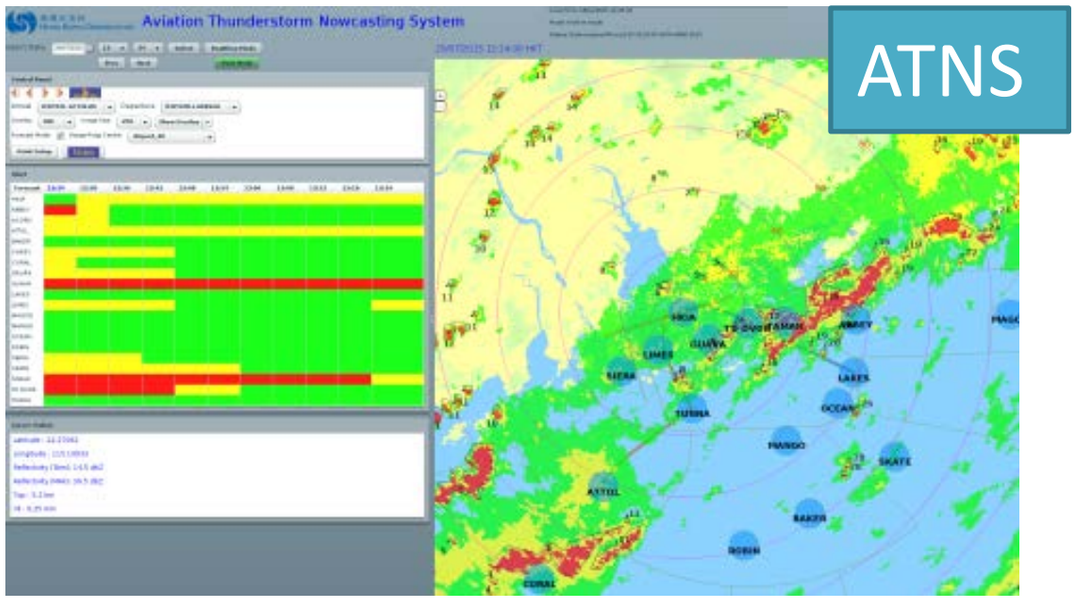
Lightning

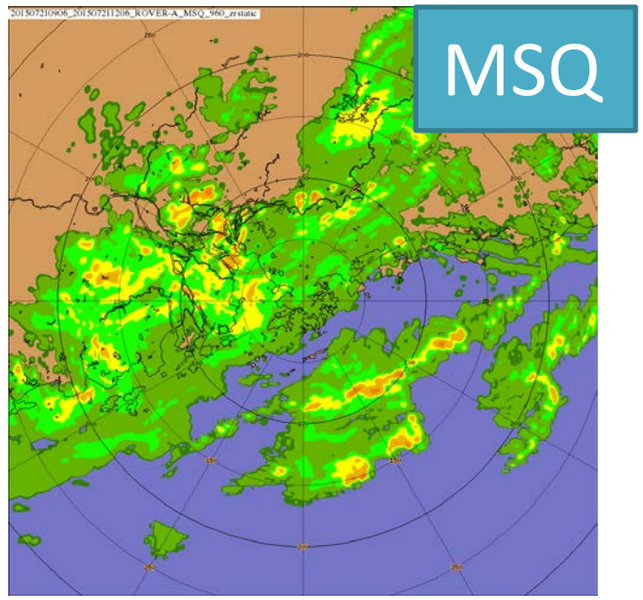


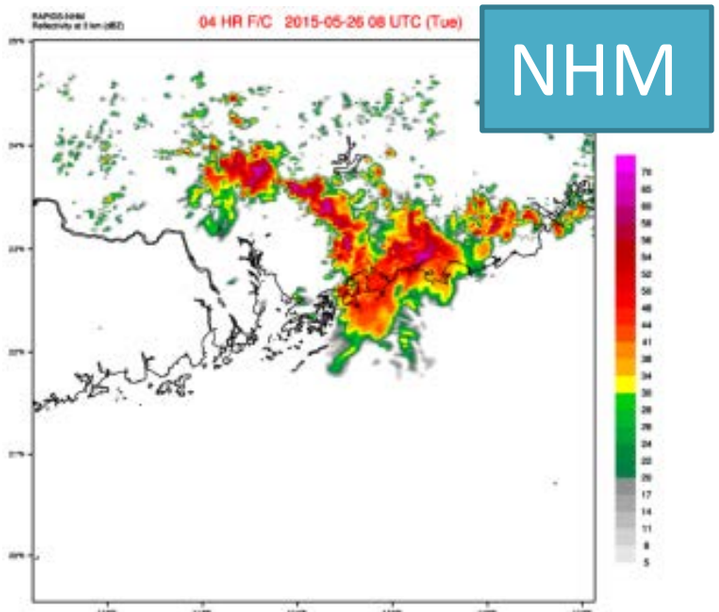
Wind profiler



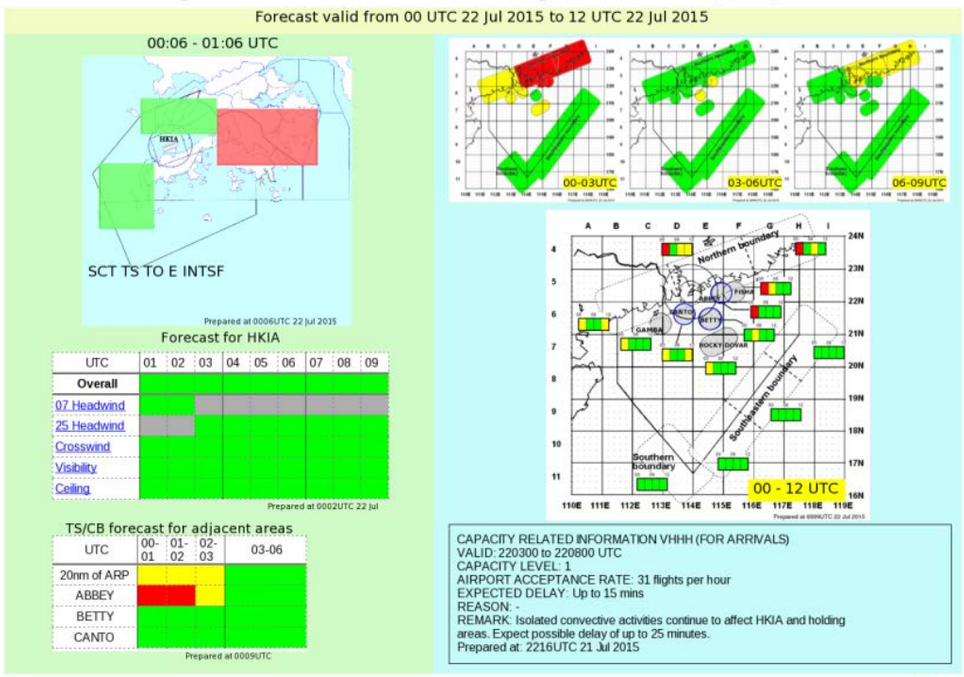
Nowcasting / Model / ATM data collected



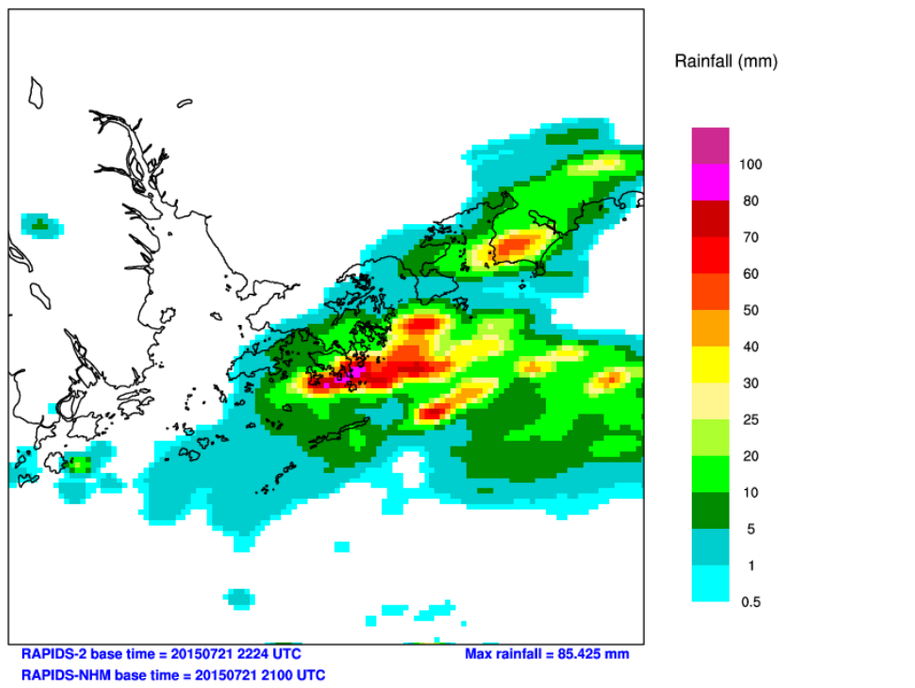




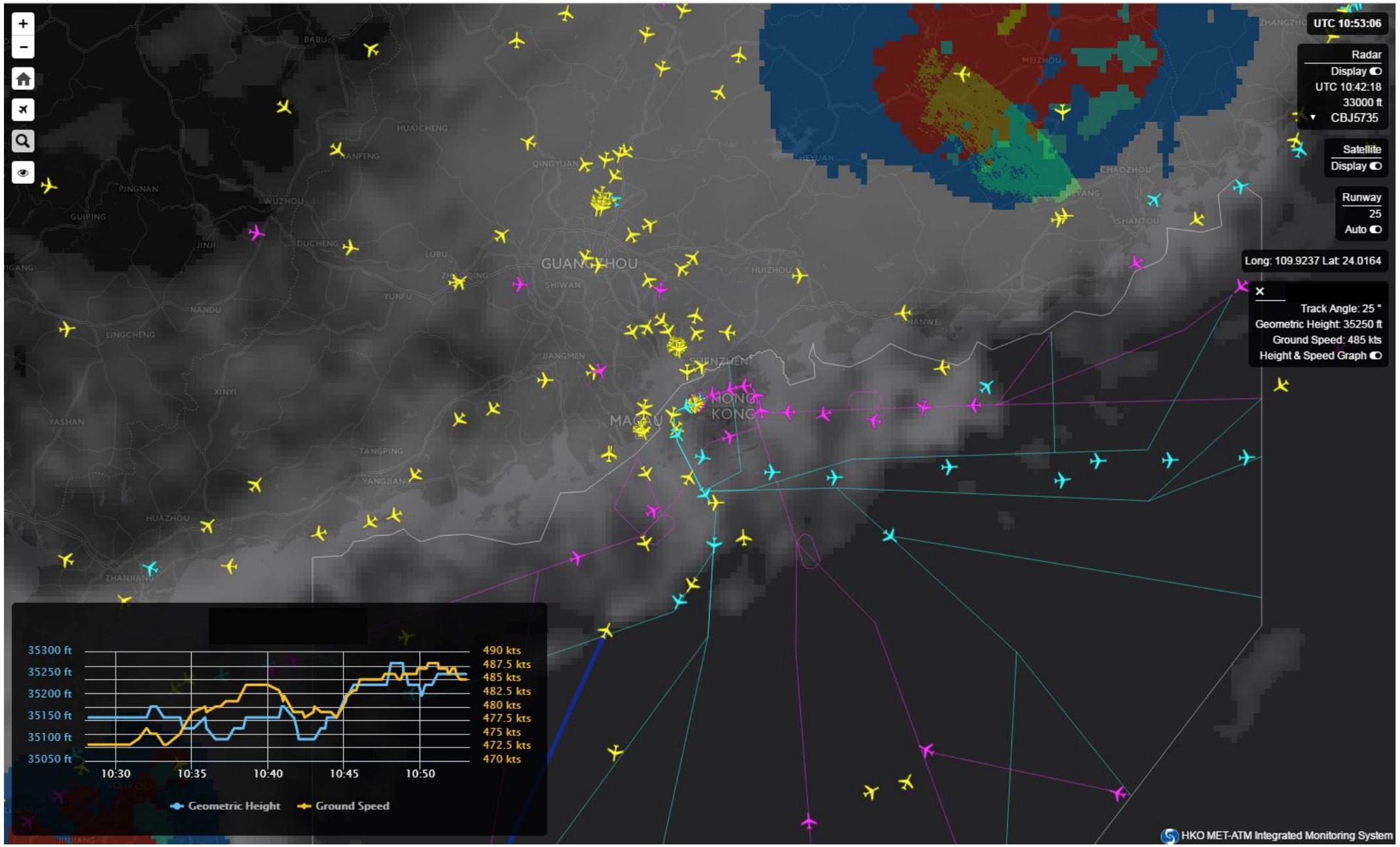
SigConv and Capacity Notification



RAPIDS



ADB-S collected (prepared for Phase II)



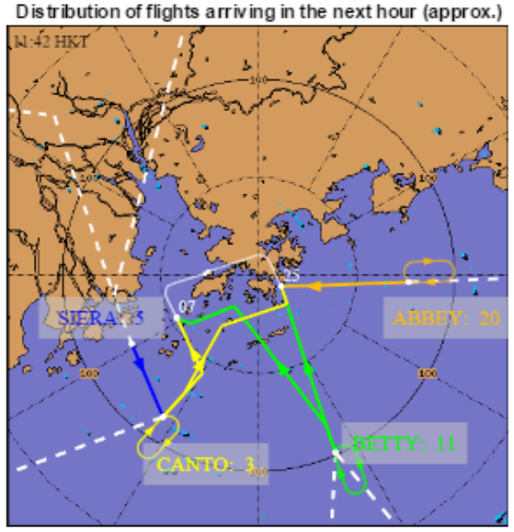
ABS-B overlaid with weather radar and satellite

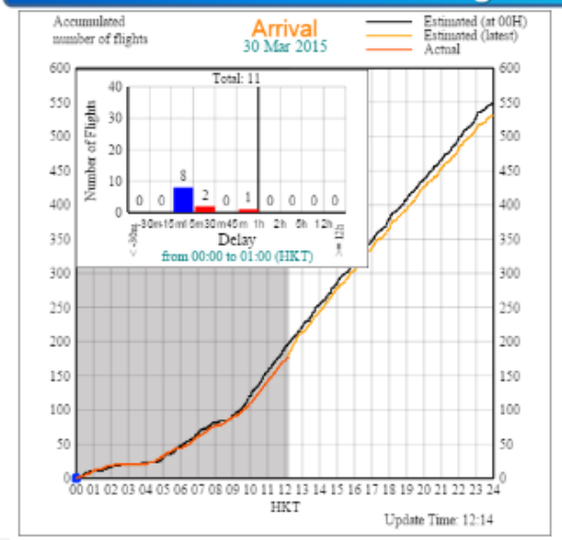
Airport Air Traffic Data

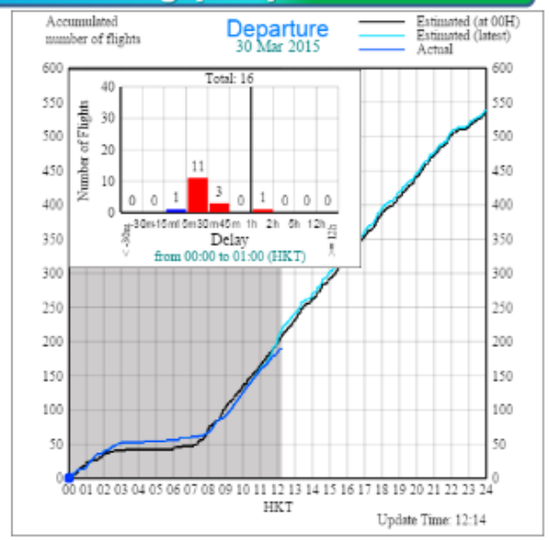
香港天文台 Hong Kong Observatory

MET-ATM Integrated Monitoring [Trial]

Distribution of flights arriving in the next hour (approx.)







Capacity Forecast (for Arrivals)

Last update:	2015-03-29 22:06
VALID:	300000 to 300800 UTC
CAPACITY LEVEL:	1
AIRPORT ACCEPTANCE RATE:	32 flights per hour
EXPECTED DELAY:	Up to 15 mins
REASON:	-
REMARK:	

Traffic Interruption Related Messages from ATIS

Last Update: 04:04 UTC

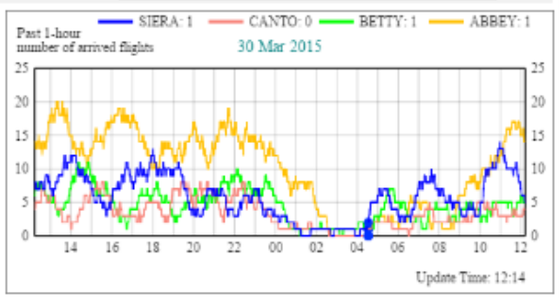
HONG KONG ARRIVAL INFORMATION

A-TIME	0404
A-RUNWAY	25R
A-INFO-D2	
A-SUPPL1	
A-SUPPL2	
D-WXCHG	

HONG KONG DEPARTURE INFORMATION

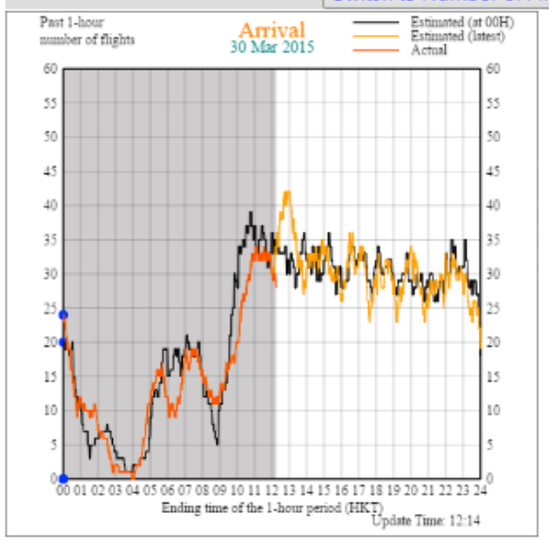
D-TIME	0404
D-RUNWAY	25L
D-SUPPL1	

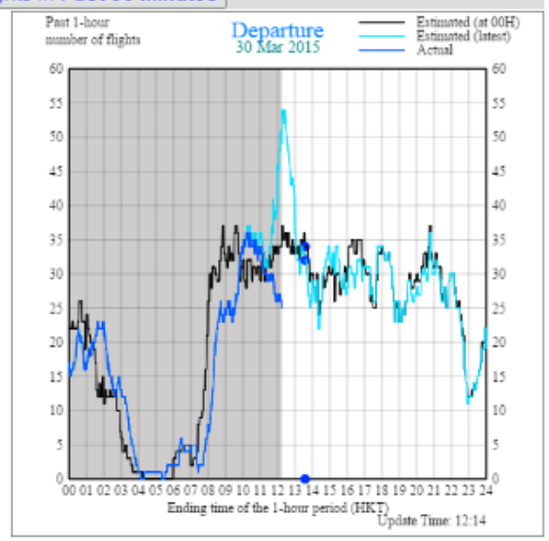
	SW Route (CANTO)			S Route (BETTY)			E Route (ABBEY)		
TAR	ELDT	RWY	STAR	ELDT	RWY	STAR	ELDT	RWY	STAR
6B	0415	25	2B	0416	25	2A	0410	25	2B
6B	0422	25	2B	0421	25	2B	0417	25	2B
6B	0432	07	3A	0426	25	2A	0413	25	2B
6B				0441		2B	0417	25	2B
6B				0441		2B	0424	25	2B
				0454		2B	0425	25	2B



One-year Statistics

Switch to Number of Flights in **Past 30 Minutes**





Traffic Interruption Related Messages from NOTAM

Last Update: 12:13 HK

VALID FROM:	2015-03-26 02:00 UTC
VALID TO:	2015-03-26 04:00 UTC
(ISSUED AT:	23 07:03 UTC)

Flow Restriction (from ATC Watch Manager)

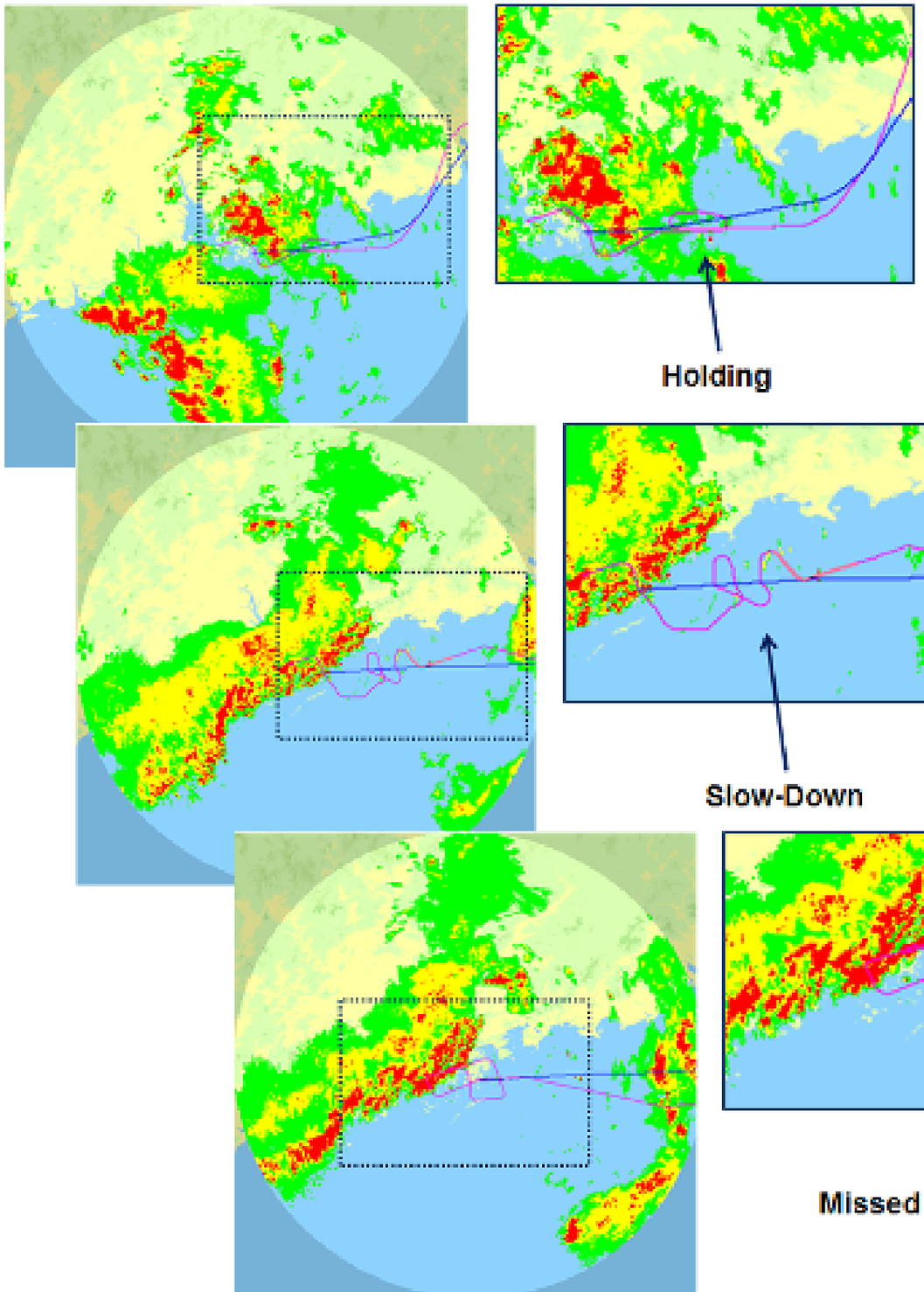
Last Update: 2015-03-29 17:33

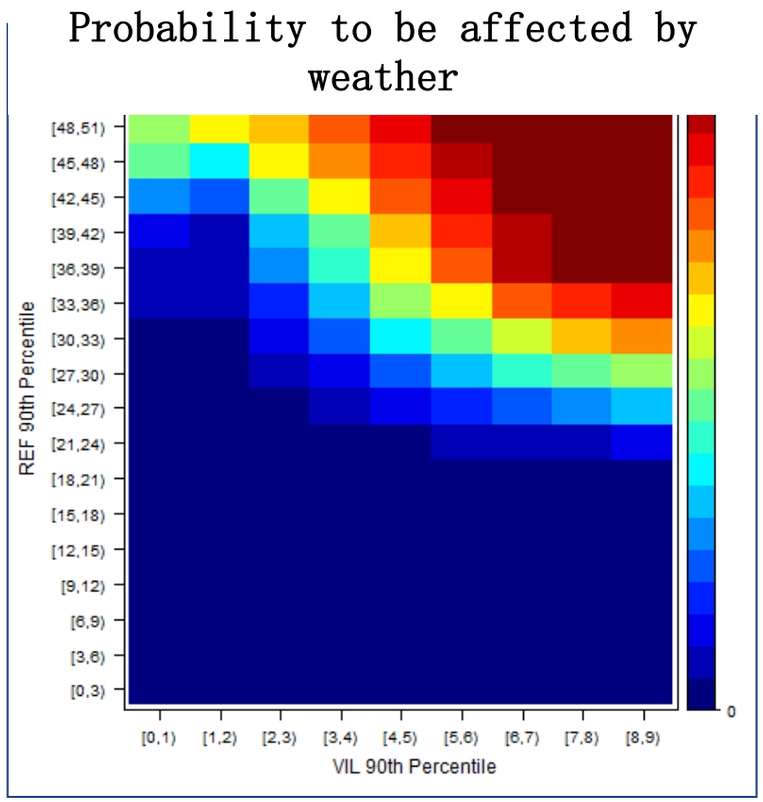
[Re: Traffic departing from Hong Kong via BEKOL destined for ZBAA expect delay]

To whom it may concern,

Effect of Significant Convection to Capacity

Types of effect of significant convection





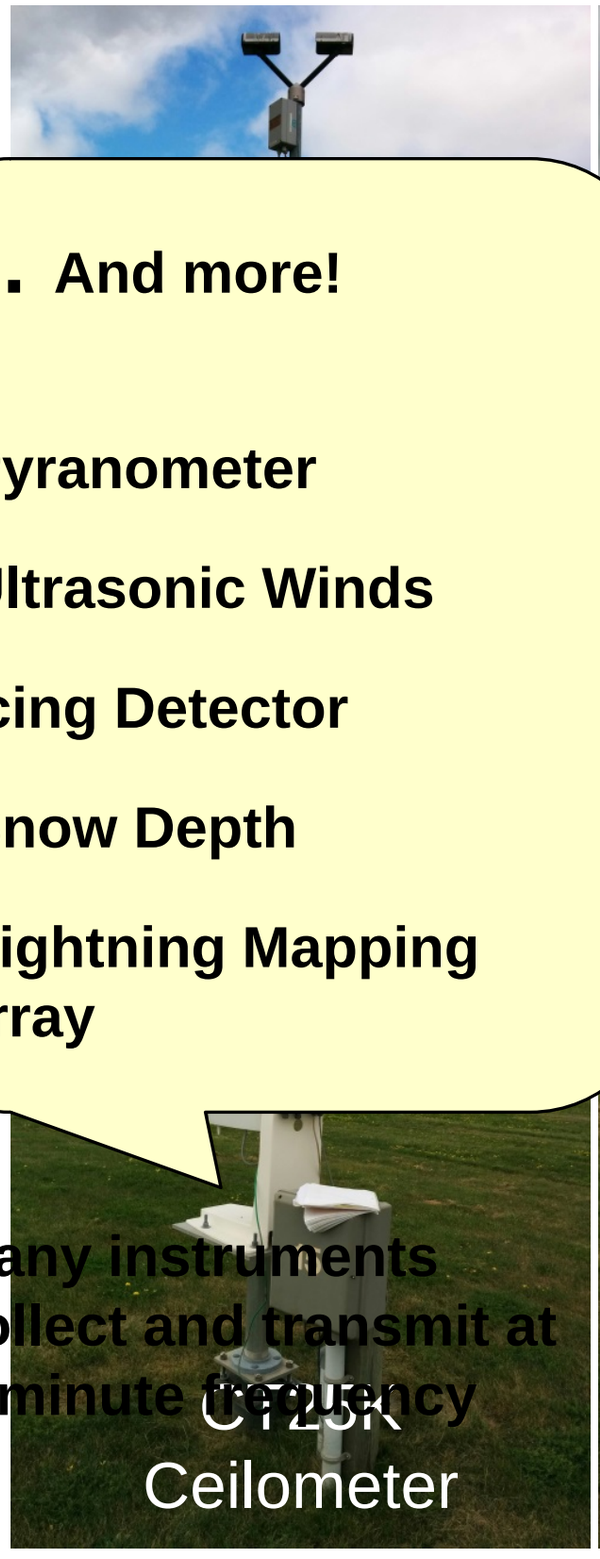
+ Trajectory Based SigConv F/C

+ ADS-B flight position

+ …

Capacity Forecast

Winter IOP-1: YYZ Observations



CT25K Ceilometer

POSS

Jenoptik Ceilometer

FD12P

WXT520

X-Band VPR

Web Cameras

… And more!

-Pyranometer

-Ultrasonic Winds

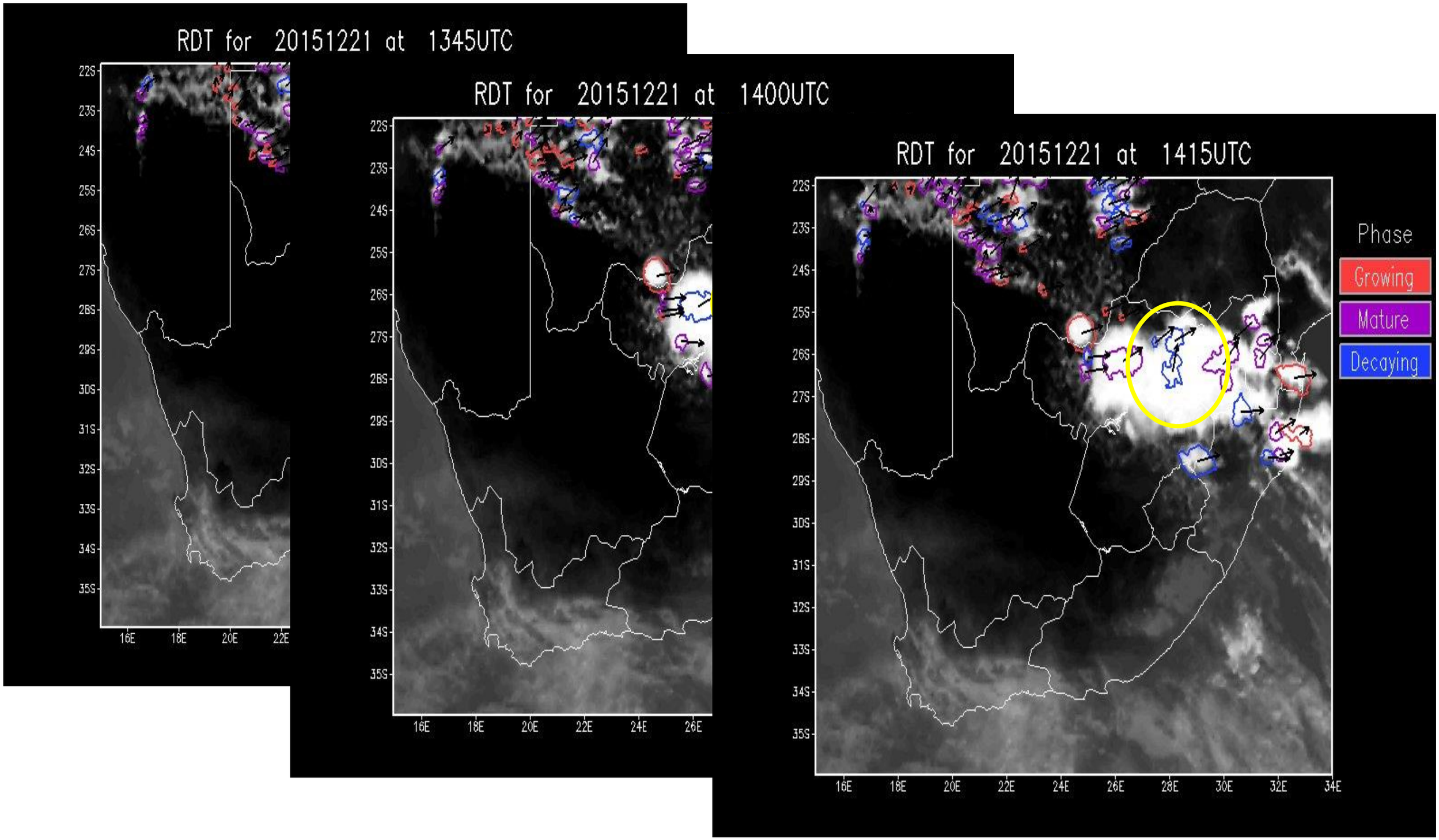
-Icing Detector

-Snow Depth

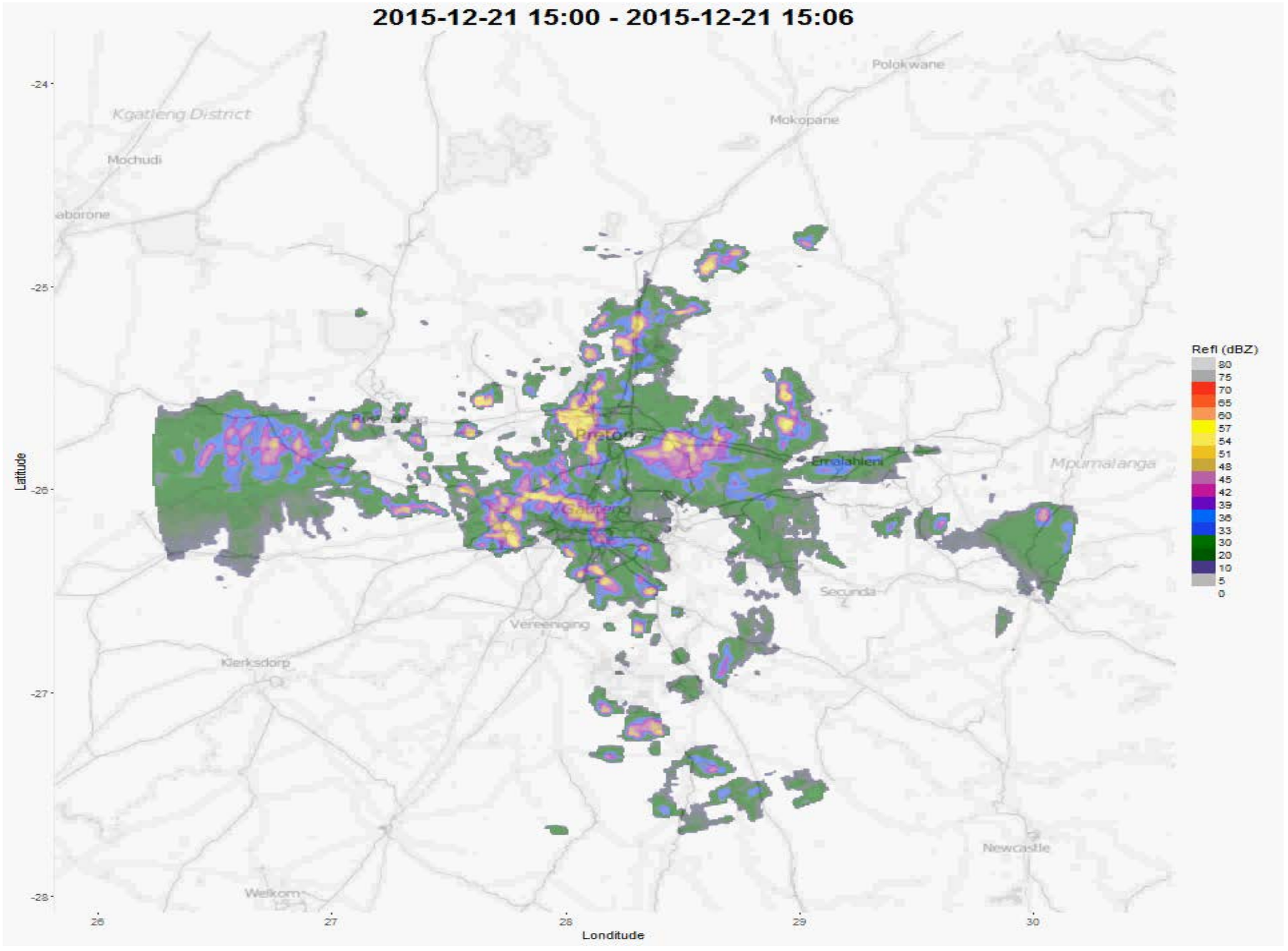
-Lightning Mapping Array

Many instruments collect and transmit at 1-minute frequency

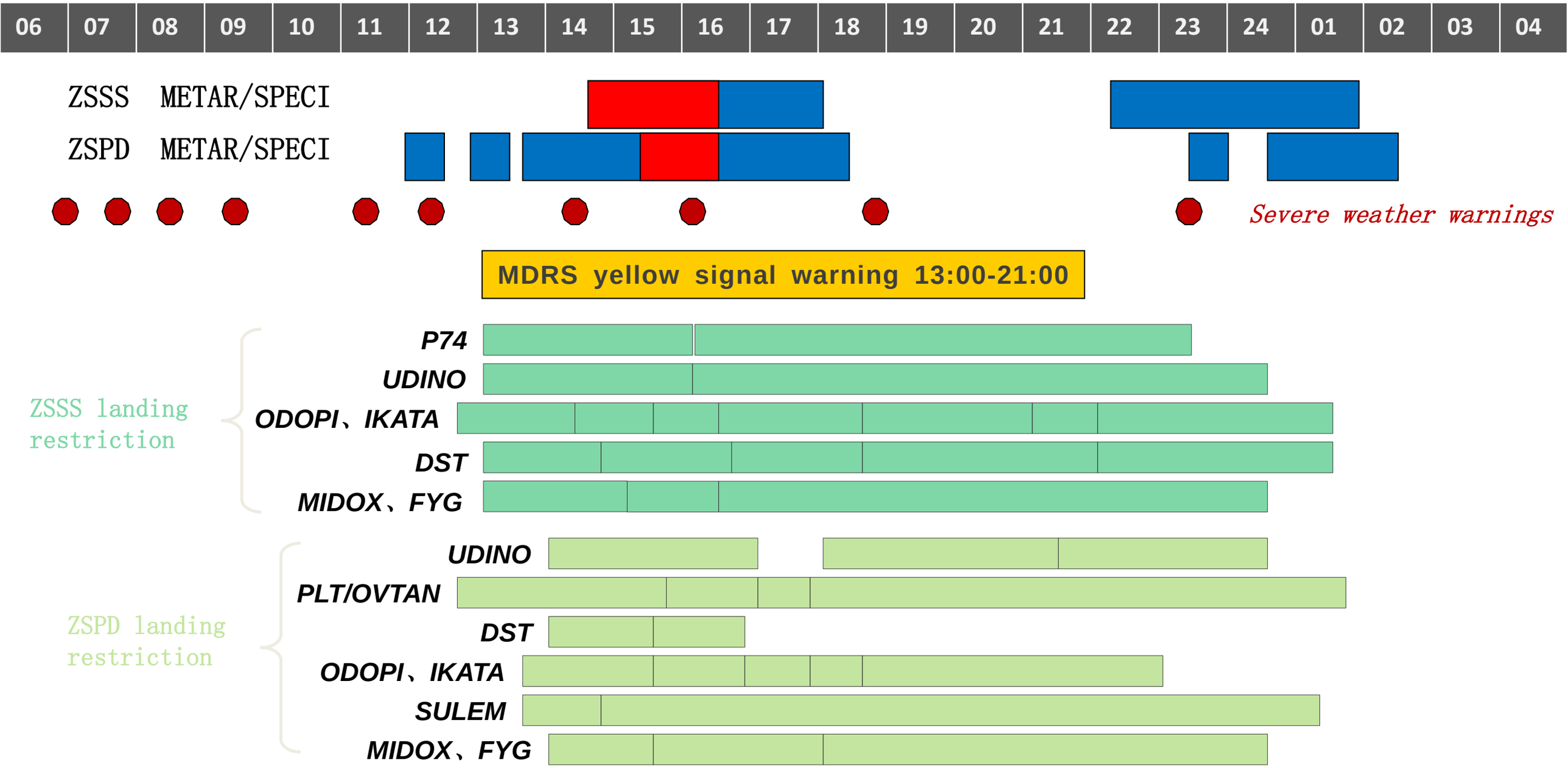
NWC SAF RDT


RDT for 20151221 at 1345UTC
RDT for 20151221 at 1400UTC
RDT for 20151221 at 1415UTC
Phase
Growing
Mature
Decaying

Com-SWIRLS


2015-12-21 15:00 - 2015-12-21 15:06
Polokwane
Kgatleng District
Mokopane
Mochudi
-24
-25
-26
-27
-28
Latitude
Refl (dBZ)
80
75
70
65
60
57
54
51
48
45
42
39
36
33
30
20
10
5
0
Mpumalanga
Secunda
Vereeniging
Klerksdorp
Newcastle
Welkom
26
27
28
29
30
Londitude

SHA MET-ATM Impact Translation – Case Study



Oberved RA CB

Oberved TSRA CB

Severe weather warnings

Shanghai terminal area yellow signal warning (MDRS)

ZSSS landing restriction

ZSPD landing restriction

March 8, 2016

Works on the way

- Preliminary research results from the Participating Airports to be presented in this Symposium (WSN16) – look for “AvRDP theme”
- (On-going) Further discussion with ATM expertise on translation MET information into ATM impact products as well as methods of validation
- (On-going) Development guidance on verification towards continuous improvement of MET products to ATM

Capacity Building Workshop

20 Jul (Wed)	21 Jul (Thu)	22 Jul (Fri)
Aviation Research Demonstration Project	Probabilistic Nowcast Meososcale modelling	Satellite-based nowcast
Radar-based nowcasting techniques	Seamless Nowcast & SESAR	Breakout discussions
Aviation Mesoscale Numerical Weather Predication	Low Visibility Nowcast	Nowcasting System: Community-SWIRLS (hands-on training)
Aviation Nowcasting System CAN-NOW	Winter Weather Nowcast	

Expansion of AvRDP into an Inter-commission Aviation Research Project (CAS/CAeM/CBS)

- To better support the integration of MET information with aviation operation, WMO Executive Committee 68 (June 2016)
  - agrees with WWRP SSC recommendation for expansion of AvRDP into an Inter-Commission (CAS/CAeM/CBS) Aviation Research Project
  - to prepare a coordinated road map for the Project in support of future operational solutions for ATM in early 2017
  - endorses the organization in 2017 a **scientific event** with the objective to identify needs and plan research activities during ASBU Block 1 & 2 (2018-2028)

Research areas to be considered

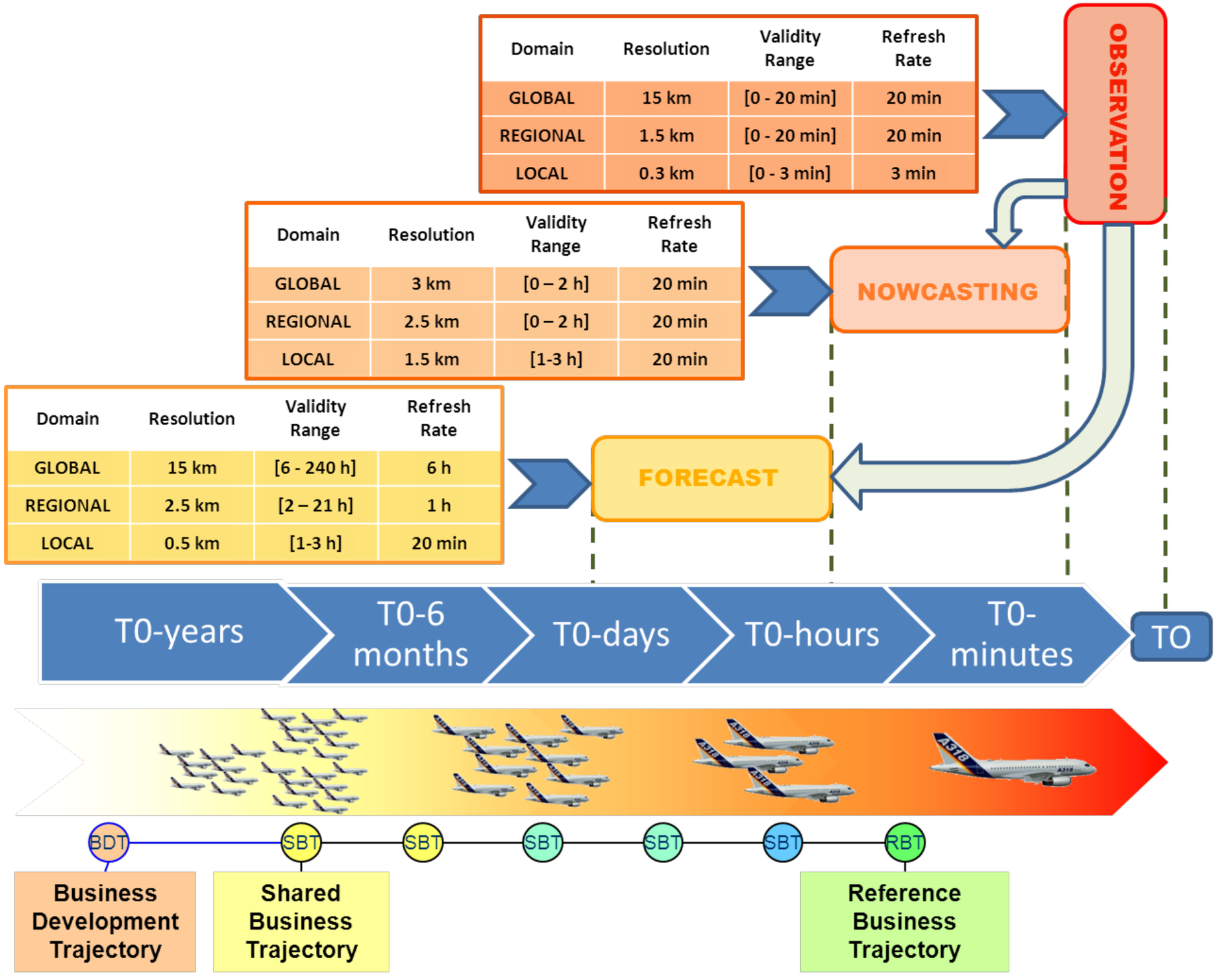
- **Improved observations, forecasting and warnin**gs
  - Enhanced 4-dimensional information for meteorological hazards, enhance global MET information, enhance high resolution MET information for airports and terminal areas
- **Integration, use cases, fitness for purpose and delivery**
  - Integrate MET information into ICAO System-Wide Information Management (SWIM), support Collaborative Decision Making (CDM), support Trajectory-Based Operations (TBO)
  - support different ATM decision horizons – from “immediate” (0-20 minutes) to several days ahead
- **Climate change impacts on aviation industry**
- R & D be of such a nature that developing countries can also benefit to enhance aviation safety in areas where highly sophisticated instruments and computer resources are not always available

Desirable MET Information

Domain	Resolution	Validity Range	Refresh Rate
GLOBAL	15 km	[0 - 20 min]	20 min
REGIONAL	1.5 km	[0 - 20 min]	20 min
LOCAL	0.3 km	[0 - 3 min]	3 min

Domain	Resolution	Validity Range	Refresh Rate
GLOBAL	3 km	[0 – 2 h]	20 min
REGIONAL	2.5 km	[0 – 2 h]	20 min
LOCAL	1.5 km	[1-3 h]	20 min

Domain	Resolution	Validity Range	Refresh Rate
GLOBAL	15 km	[6 - 240 h]	6 h
REGIONAL	2.5 km	[2 – 21 h]	1 h
LOCAL	0.5 km	[1-3 h]	20 min



Connection with other WGs, Projects

- Collaborate with JWGFVR to develop verification & validation methodologies for AvRDP;
- Collaborate with NMRWG, PDEFWG, DOAWG to explore the possibilities of developing enhanced probabilistic MSTA products under AvRDP;
- Collaborate with ATM on how to demonstrate the benefits for the aviation community
- Keep in view other on-going aviation initiatives: SESAR, NextGen, CARATS
- Collaborate with CAeM ET/ASC (Aviation Science and Climate)

Summary

- The next generation aviation brings challenges to the existing nowcast and mesoscale modelling sciences. Through improving nowcasting services, it is hope that it could reduce impacts of significant weather (e.g. convection, winter weather, etc.) on air traffic to enhance safety and improve flight efficiency.
- AvRDP is held at different airports to study different impacting weather at different climatological locations to identify the gap and advance the current nowcasting techniques in support of the development of the TBO and MSTA concepts.
- The Project is to be expanded to cover broader coverage and applications.
- AvRDP is also tasked to help WMO Members' capacity building to meet the next generation aviation needs.
- It is a good opportunity for research community to utility the high density high resolution data to improve the nowcast and modelling services.

AvRDP Website (https://avrdp.hko.gov.hk)

Contact: pwli@hko.gov.hk

Thank You