CAS/CAeM AVIATION RESEARCH DEMONSTRATION PROJECT (AvRDP) PROGRESS

TECO

CAeM

July 2018

AvRDP OBJECTIVES

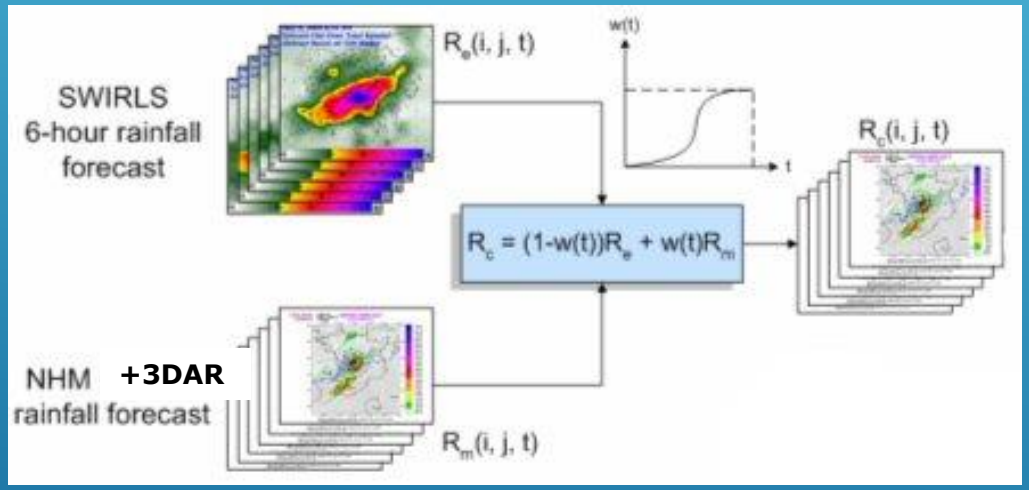
A joint effort between CAS and CAeM, in 5 years (2015-2019)

- Phase I (MET Capability enhancement) to conduct research in **nowcasting and mesoscale modelling** at a number of **international airports** located in Northern and Southern Hemisphere with a view to supporting the development of the next generation aviation initiative, the Aviation System Block Upgrade (ASBU) under the new Global Aviation Navigation Plan (GANP) of International Civil Aviation Organization (ICAO). Key concepts under ASBU are the development of seamless **Trajectory-Based-Operation (TBO**, or "gate-to-gate").
- Phase II (MET-ATM translation) to collaborate with the respective Air Traffic Management (ATM) to **translate** the Meteorological (MET) information into ATM Impact products so as to **demonstrate the benefits** of the MET information (nowcast and mesoscale modelling) in the aviation industry;
- Capacity Building to help in **capacity building** via the knowledge gained in AvRDP other WMO Members who need to enhance their aviation MET services so as to meet the ASBU initiative.

* *Not just enhancing flight efficiency but also safety and environment-friendly by optimizing trajectory and hence reducing fuel waste*

BLENDING LE WITH MESOSCALE MODEL

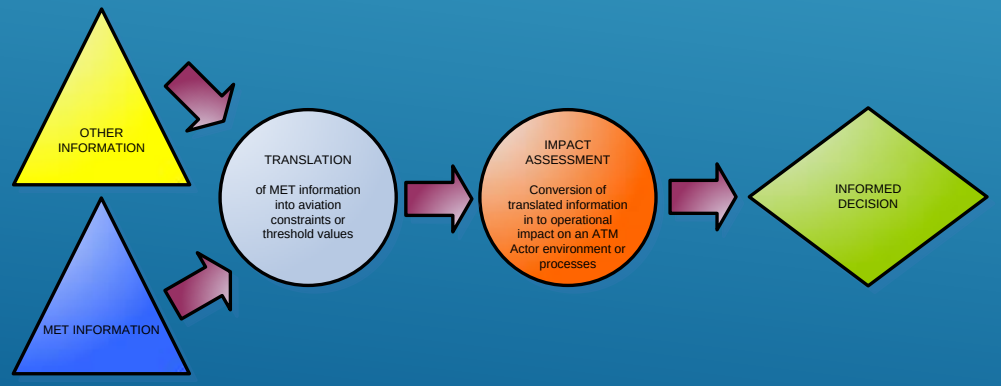
- Nowcasting component – LE
  - *0 - 6 hr QPF by extending the linear extrapolation of radar echoes*
- NWP component – Non-hydrostatic Model (NHM)
  - *0 – 6 hr QPF by 2-km non-hydrostatic numerical model*
  - *3DVAR, Doppler, dual-radar 3D wind, GPS/PWV, etc.*



- Spatial & intensity adjusted
- Dynamic-weighting

PHASE II: TRANSLATE MET INFORMATION INTO ATM IMPACT

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



TIMELINE

Nov 2014	**Endorsement of the AvRDP proposal by WWRP SSC**
Nov 2014 – Feb 2015	Formation of AvRDP SSC and identification of AvRDP Participants
24 – 26 Jun 2015	Kick-off Meeting cum Science Meeting
May 2015 – July 2017	**Phase I – MET capacity research** (AvRDP Airports or Participants who need longer preparation time may choose to enter Phase I in late 2015 or after)
May 2015 - Oct 2015	1st IOP for convective weather (over Airports in Northern Hemisphere)
Nov 2015 – Mar 2016	1st IOP for winter weather, visibility and ceiling (over Airports in Northern Hemisphere)
Dec 2015 – Mar 2016	2nd IOP for convective weather (Southern Hemisphere)
May 2016 - Jul 2016	3rd IOP for convective weather (Northern Hemisphere)
Nov 2016 – Mar 2017	2nd IOP for winter weather, visibility and ceiling (Northern Hemisphere)
May 2015 – July 2017	Nowcasting research including MT verification on convective weather
Nov 2015 – July 2017	Nowcasting research including MET verification on winter weather, visibility and ceiling
20 - 22 Jul 2016	AvRDP Training Workshop on aviation nowcasting
22 – 23 Jul 2016	2nd SSC Meeting
25 – 29 Jul 2016	Preliminary Phase I results to be presented in WWRP Symposium on Nowcasting and Very-short-range Forecast
Jul 2016 – Jun 2018+	**Phase II – MET-ATM impact translation and validation** To be expanded after the WMO Intercommission (CAS/CAeM/CBS) AeroMetSci-2017 Conference (AvRDP Airports or Participants who started the IOP in late 2015 or later may choose to enter Phase II in late 2016)
Jul 2017 – Jun 2019	Research on MET-ATM impact translation
Jul 2017 – Jun 2019	Demonstration of MET-ATM impact
Fall 2017	Participate in the AeroMetSci-2017 Conference
Jan 2018 – Jun 2019	4 more airports joining the Project
Oct 2019	2nd AvRDP Training Workshop focusing on ATM-MET integration
Jul 2019	Concluding Meeting

3RD AvRDP SSC (6-7 NOV 2017, MeteoFrance)

- The Meeting agreed on adding 4 new airports
  - LED (Russia), IGI (India), NRT (Japan), SIN (Singapore)
- Time line:
  - The meeting decided to extend Phase II of the project to summer 2019.
- Verification:
  - It was proposed that verification activities be focused on convection
  - It was agreed that a Guidance material for meteorologists on how to evaluate convection be prepared.
- Training Workshop:
  - The meeting agreed to organize a three-day training workshop in October 2018 (Venue TBD) focusing on Aviation Impact (MET-ATM translation)
- AvRDP activities to be incorporated in the WWRP Implementation Plan (2016-2023)
- Project Implementation Plan for the (CBS/CAeM/CAS) Inter-commission Aviation Research Project (2019) to be developed and presented to WMO Congress in 2019 (EC-68 supported the transition of the AvRDP to an extended aviation research project)

FOCUS ON VERIFICATION

- **Aviation weather forecast verification strategies**
- Air traffic volume and complexity is at a tipping point, need to reduce uncertainty important (large operational impacts) . Quantifying /reducing uncertainty of forecast requires understanding and supports the decision-making process.
- Verification information must (a) prioritize questions of importance in decision making) b) be meaningful to and easily understandable by operators; (c) avoid complex/ cryptic scientific measures; (d) be clearly connected to operational impacts; and (e) include information about forecast calibration (for both deterministic and probabilistic forecasts).
- Verification results should be stratified by both relevant operational considerations (e.g., traffic volume) and physical attributes (e.g., potential for convective weather, geographic attributes)
- Better understanding of achievable accuracy may inform / modify thresholds used in ATM procedures.
- Close interaction required to understand user needs for information about forecast quality and uncertainty. This exercise will be site- and decision-maker- (procedure) specific. Design of meaningful measures will require multiple interactions.

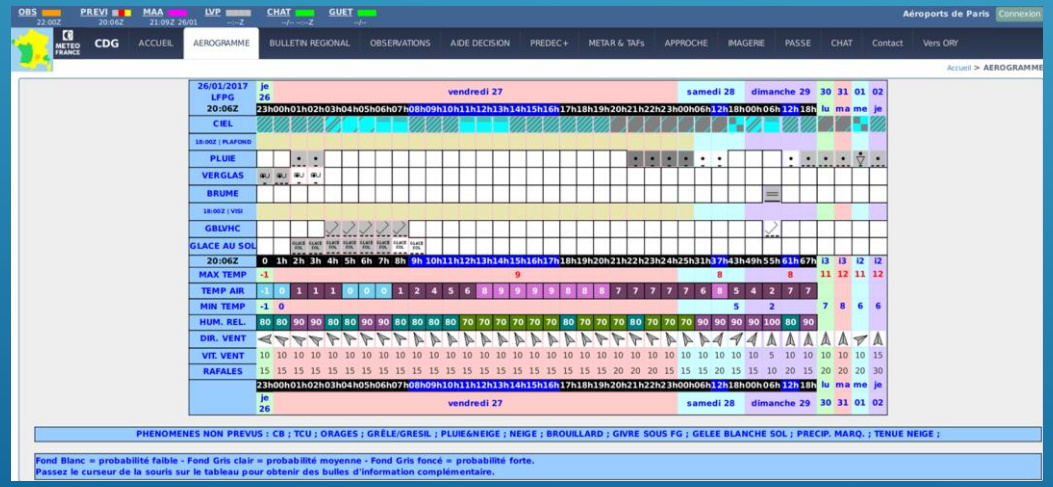
AvRDP AIRPORT STATUS

- Most participating airports have finished Phase I and moving on to Phase II
  - HKG – working on Phase II focusing on convection impact on airport capacity
  - CDG – completed Phase I and engaging with ATM to move forward to Phase II
  - SHA – jumped directly to Phase II
  - JNB – completed Phase I and engaging with ATM to move forward to Phase II
  - YYZ - completed Phase I and have difficulties to engage ATM to working on Phase II
  - YFB – working on Phase I (polar weather) but has no plan to work on Phase II
  - Paper presented during the AMET Sci-Conference 2017

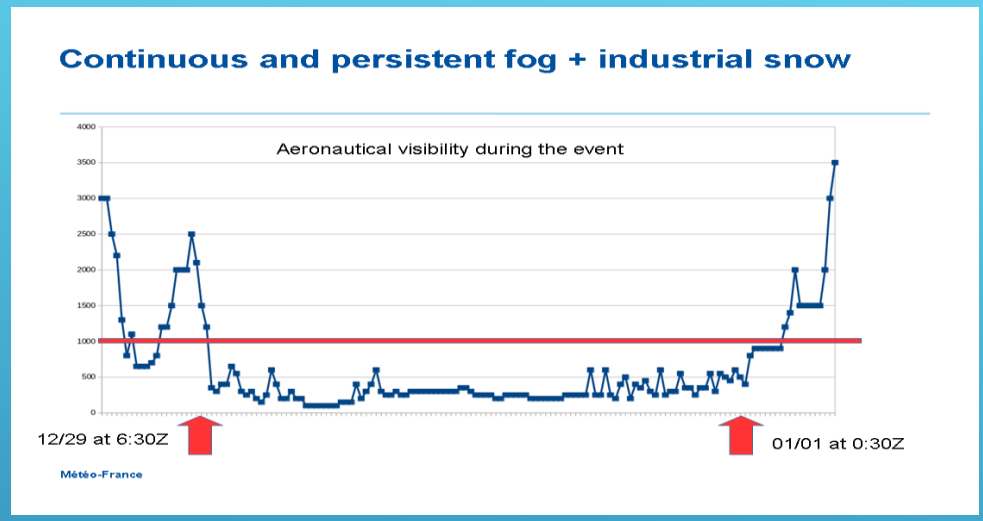
- 4 New Airports to participate
  - Russia Pulkovo Airport (LED) – focusing on low cloud and fog
  - Singapore Changi Airport (SIN) – focusing on lightning and tropical cyclone
  - Japan Narita Airport (NRT) – focusing on convection, low ceiling and winds
  - India New Delhi Airport (IGI) – focusing on convection and fog
  - Newly engaged airports will proceed to Phase II as early as possible to subsequently be timely aligned with the other airports who had joined the project earlier on.

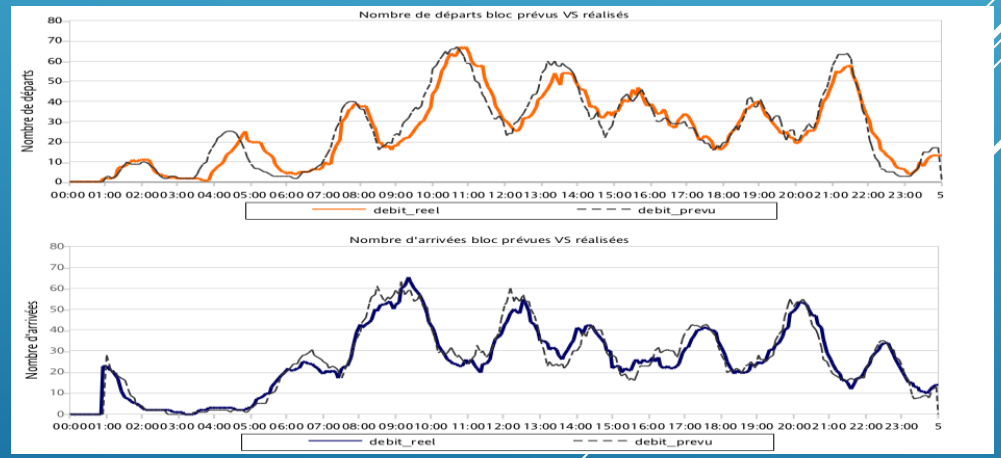
CDG - ATM IMPACT PARAMETER AIRPORT CAPACITY

- Impact of winter weather, including fog, industrial snow and freezing rain using the 1.3 km resolution, hourly updated, rapid output (15min), NWP Nowcasting system AROME-PI.
- A statistical model PEIP which determines on-ground aircraft icing probability has also been developed.
- Integrated AROME-PI forecast with ATM via the CDM@CDG tool for diagnostic and assessing the airport conditions for decision-making.



Weather predictions from CDM@CDG tool





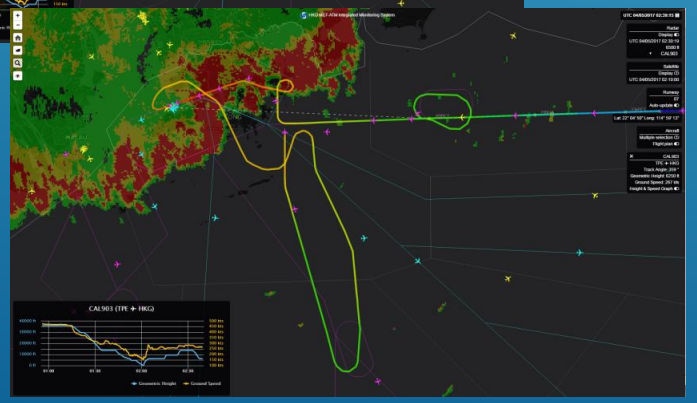
Departure and Arrival Rate well predicted

ATM Impact Parameter (1) – airspace capacity

Refining flight avoidance probability

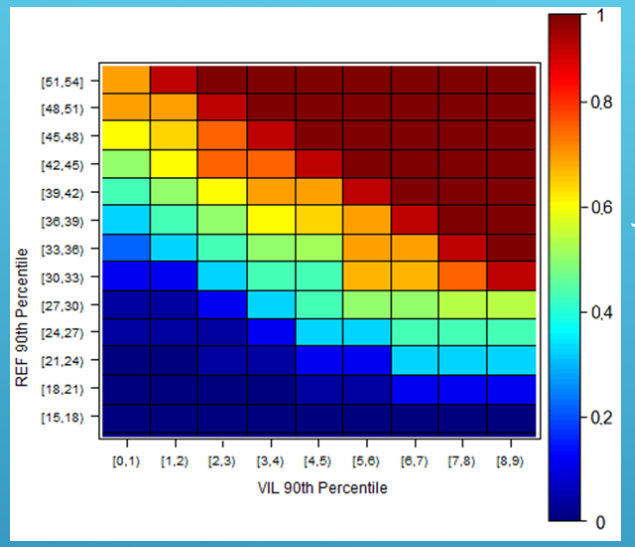
Deviation and Missed approach

Looping and missed approa ch



Looping and missed approach

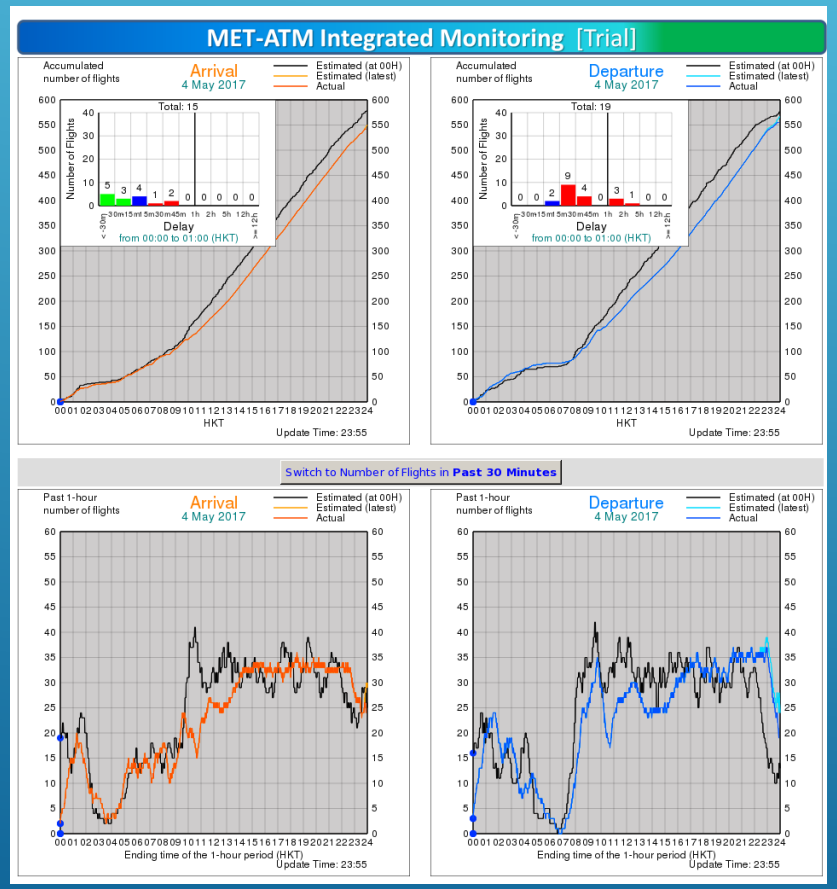
Impact thresholds



+ Trajectory Based SigConv F/C
+ Flight trajectory

Airspace capacity

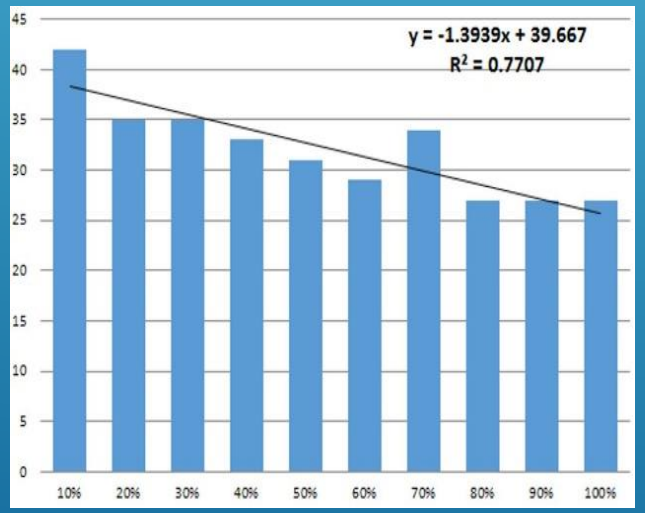
ATM IMPACT PARAMETER (2) – AIRPORT CAPACITY REDUCTION - HKG

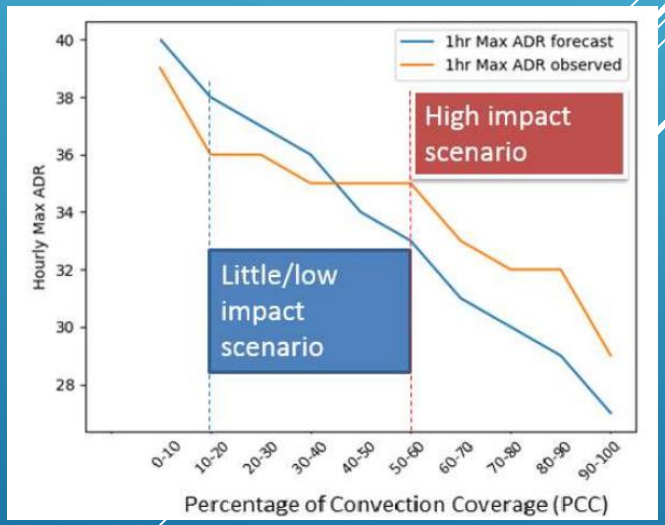


Hourly airport arrival and departure rate

Significant echo coverage percentage

evaluation





Reduction of AAR/ADR as a function of echo density within the approach/departure airspace

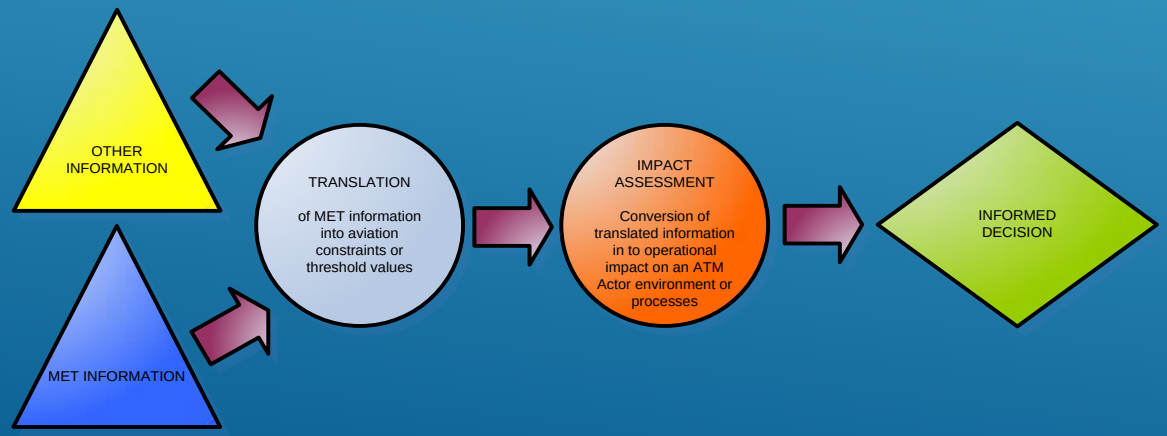
RELATIONSHIP TO WWRP PLAN

- R&D to assess current capabilities and gaps
- Impact quantification by close cooperation with end users, WRT ATM systems and procedures in use
- Develop quantified vulnerability information to known and expected scenarios as part of a (safewty and economy-oriented) risk management
- Develop (scenario-specific) uncertainty measures to improve ranking of HAZMET information in ATM decision making
- Establish a common understanding of capabilities, achievable reliability and minimum required performance of deterministic and probabilistic MET info through joint workshops
- Develop and agree verification and validation techniques with users to quantify relative weight of MET information in CDM
- Further develop, test for readiness and demonstrate advanced methods (based e.g. on ultra-high resolution of observations, NWP and nowcasting, ensemble techniques)

Q & A

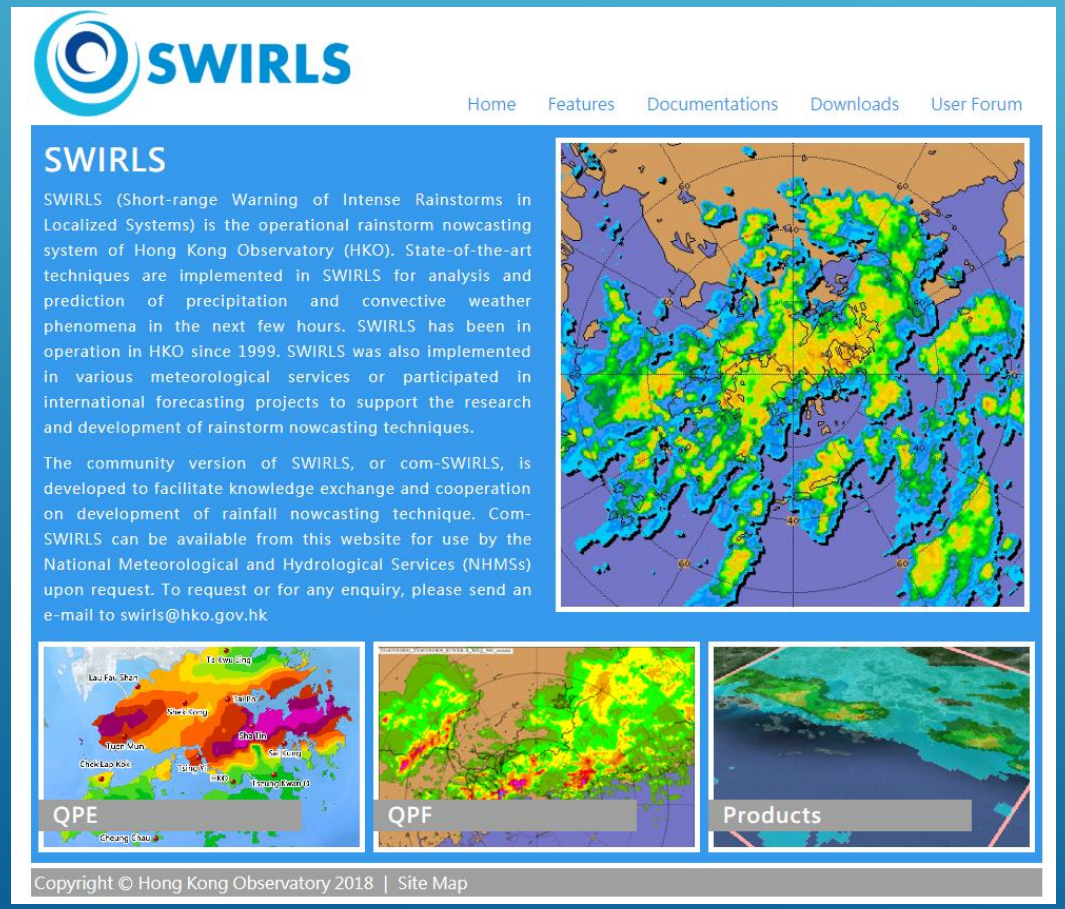
TRANSLATION MET INFORMATION INTO ATM IMPACT

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



COMMUNITY SWIRLS – STATE-OF-THE-ART RADAR-BASED NOWCASTING SYSTEM

http://swirls.hko.gov.hk/index.html



Current users (operational):
- South Africa - SAWS
- India - IMD

Implementing for operation:
- Vietnam – VMHA
- Philippines - PAGASA
- Myanmar - DMH
- China – SWPC of NMC

HKO REGIONAL METEOROLOGICAL CENTRE RSMC ON NOWCASTING UNDER WMO

http://swirls.hko.gov.hk/rsmc/aviation.html

Hong Kong Observatory
RSMC on Nowcasting

Home | Nowcasting Products | Com-SWIRLS | Research Development | Verification | Collaborations | Training

Aviation Nowcasting

- Real-time SigConv
- Real-time ICI
- ATNS
- ATLAS
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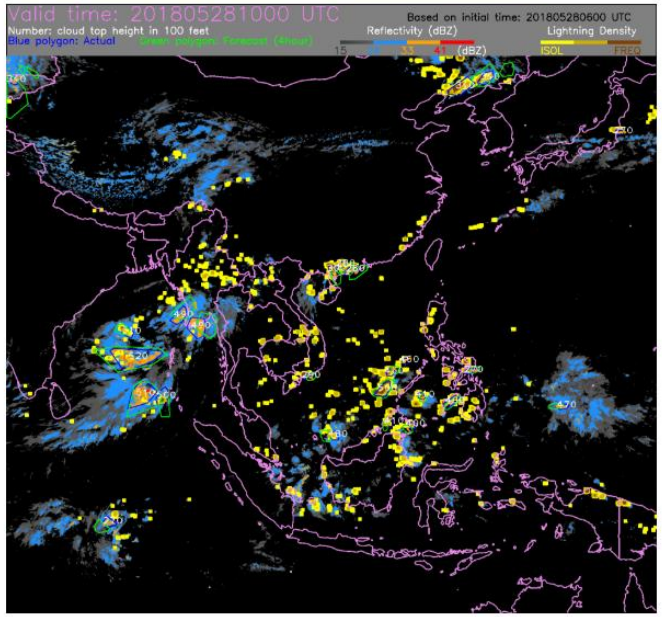
Real-time SigConv (Significant Convection)

Significant convection present imminent threats to in-flight aircraft for the associated hazards of lightning, turbulence, icing, rain and hail...etc. Limited by the range and coverage of on-board weather radar, pilots may not have a complete picture of the distribution and short-term evolution of convective systems within their intended flight path. The product shown here uses multiple channels, high resolution meteorological satellite data and real-time global lightning data to automatically identify and nowcast the hazardous areas of significant convection for aircraft's avoidance. More details of the satellite-based algorithm can be found in the paper: Development of Satellite Reflectivity Retrieval Technique for Tropical Cyclone Rainfall Nowcasting.



- Real-time SigConv
- Real-time ICI
- ATNS
- ATLAS
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Real-time ICI (Ice Crystal Icing)

At the core of deep convection, small ice crystals may be thrown upward by the strong updrafts to very high altitude. As aircraft passing through regions of dense high altitude ice crystals, which might be undetected by aircraft radar, these small ice crystals may form a thin ice layer on the engine blades and cause the engine to lose power. This phenomenon is known as ice crystal icing (ICI) or engine icing. The product shown here uses multiple channel, high resolution meteorological satellite data to automatically detect and nowcast the hazardous areas which may have high potential of ICI for aircraft's avoidance.

Please refer to HKO News Bulletin for the Aviation Community http://www.weather.gov.hk/aviat/outreach/1024index038.htm for more details.