Assessing the Impact of Convective Weather on Airport Departure Rate

Hong Kong, China

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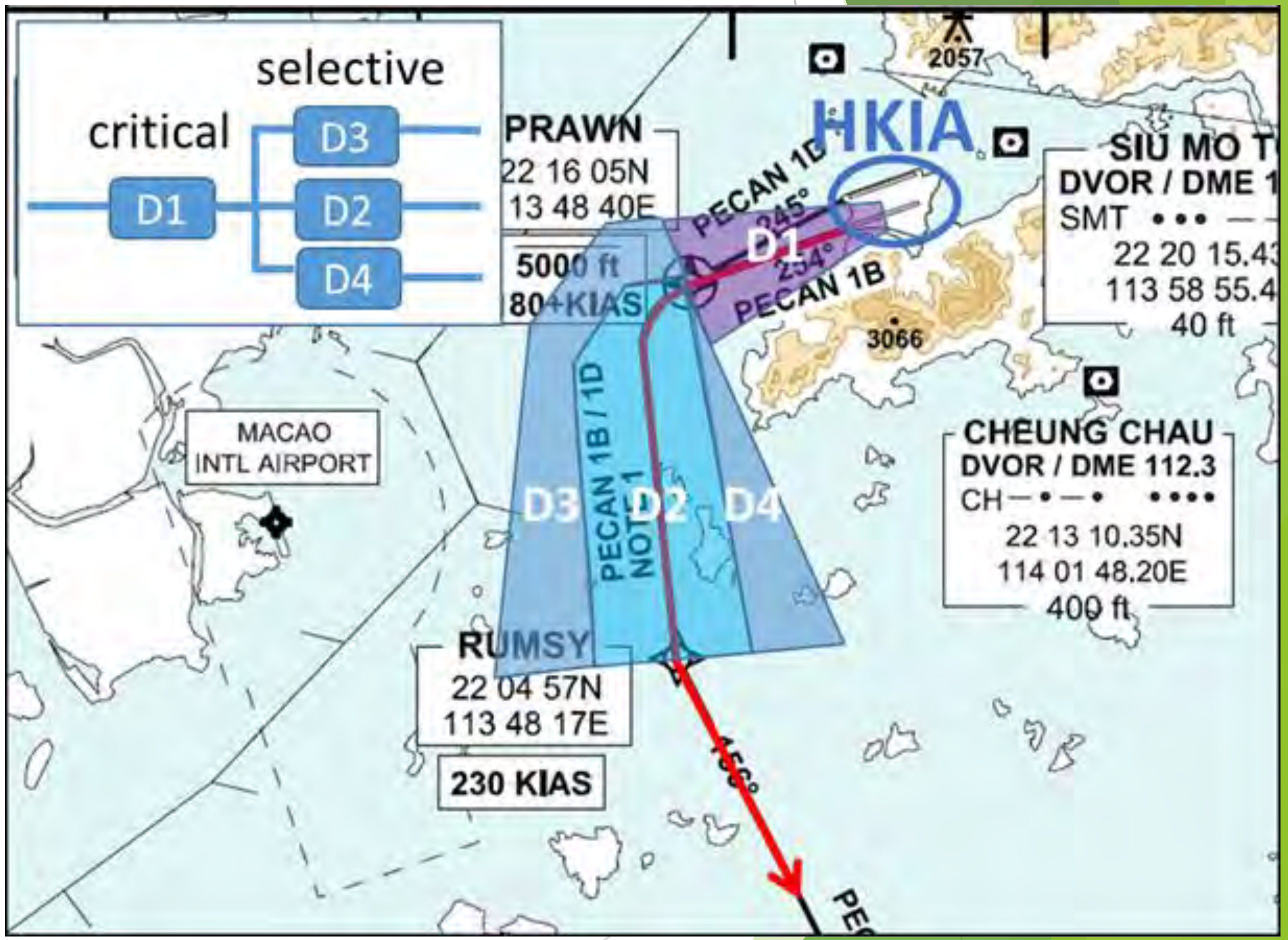
Introduction

- Significant convective weather along the departure route could have a notable impact to the Airport Departure Rate (ADR), which could in turn affect
  - the turnaround of aircraft
  - availability of parking stands and
  - arrival capacity
- If the significant convective weather persists for some time, it might even lead to apron full situation.
- an algorithm developed by Hong Kong, China to estimate the reduction in ADR arisen from significant convective weather near HKIA

ADR estimation for Runway 25 of HKIA

- Zone D1 is the foremost zone traversed by an aircraft after take-off
- After passing zone D1, the aircraft can go through either zone D2 (primary) or zone D3/D4 depending on the distribution and strengths of the convection.



Departure route of Runway 25 of HKIA and funnel-shaped departure zone

Assessment of convective weather in departure zones

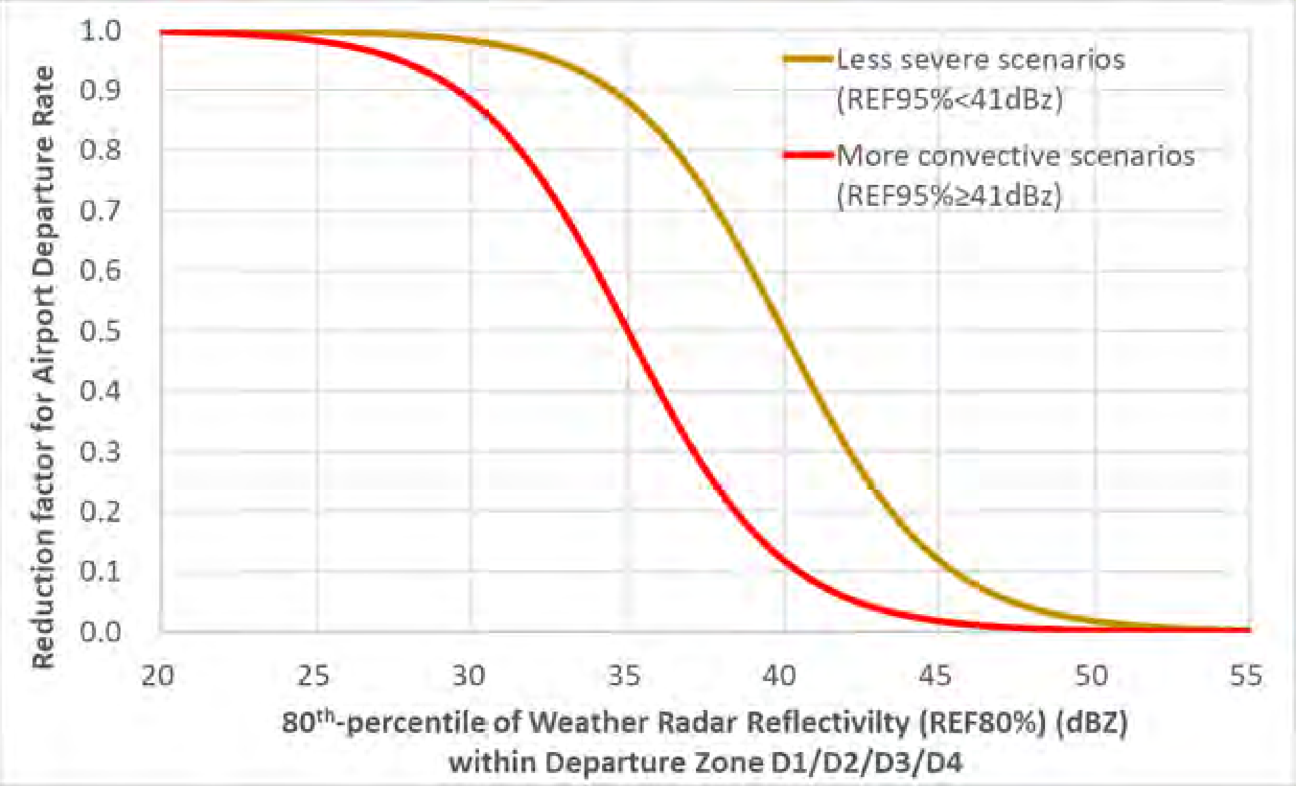
- Weather radar data every 6 minutes was used to assess the severity of convective weather in departure zones.
- The intensity of the convection is given by the reflectivity (in dBz).
- The convective activity is considered to be more severe if the intensity is higher and covers a larger area.
- In this study, 80th-percentile reflectivity (REF80%) of each of the four departure zones was calculated
  - to represent the severity of convective weather over the respective zones
  - as the basis to assess the impact in terms of the reduction of ADR

Non-linear decrease in ADR

- Nature of the departure queue is different from that for arrivals
- While hourly arrivals would depend on decisions of all pilots affected by weather in the terminal area, decision of the first pilot at the departure queue would have a determining effect to hold the movement of the queue
  - similar to the scenario of "traffic jam on a one-way track"
- A departure hold would result in a sharp decrease in ADR
  - so the ADR drops non-linearly with weather severity in the departure zones.

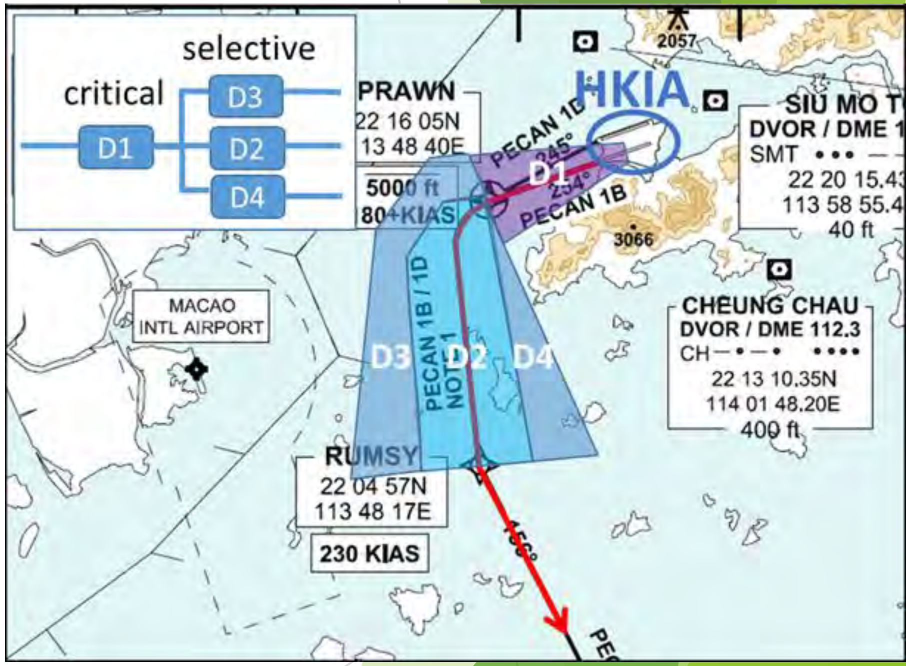
Reduction factors
- for less severe and more severe scenarios

- The non-linear ADR reduction factors used in this study against weather severity, as represented by 80th-percentile of radar reflectively within a particular zone (D1/D2/D3/D4)
- Two relationships of ADR reduction factors were constructed
  - one with more significant ADR reduction for “more severe” scenarios (red line)
    - if 95th-percentile of radar reflectively (REF95%) in the zone exceed or equal to 41dBz
  - another one with less reduction for “less severe” scenarios (brown line)



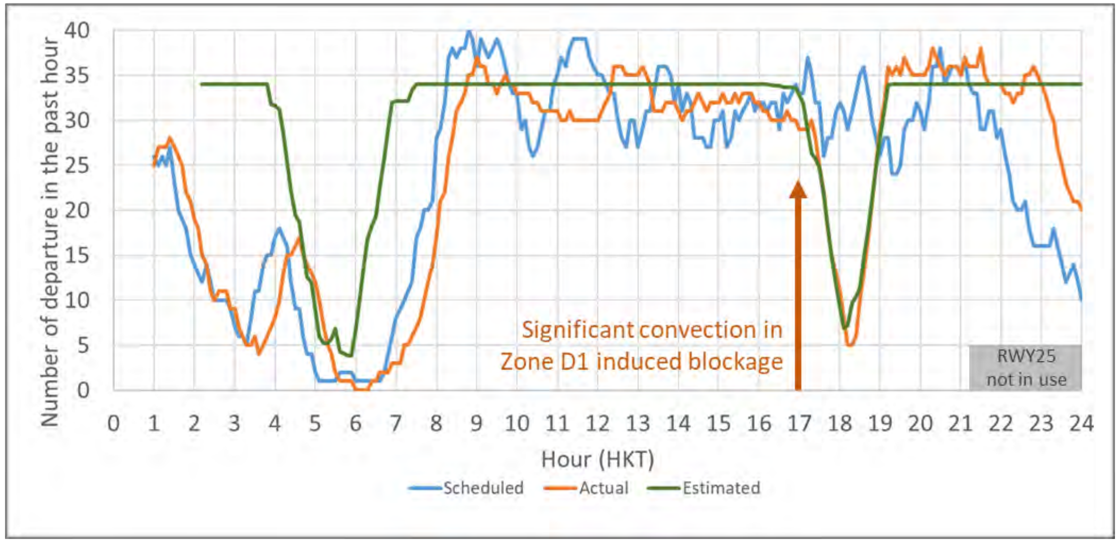
The rules and algorithms

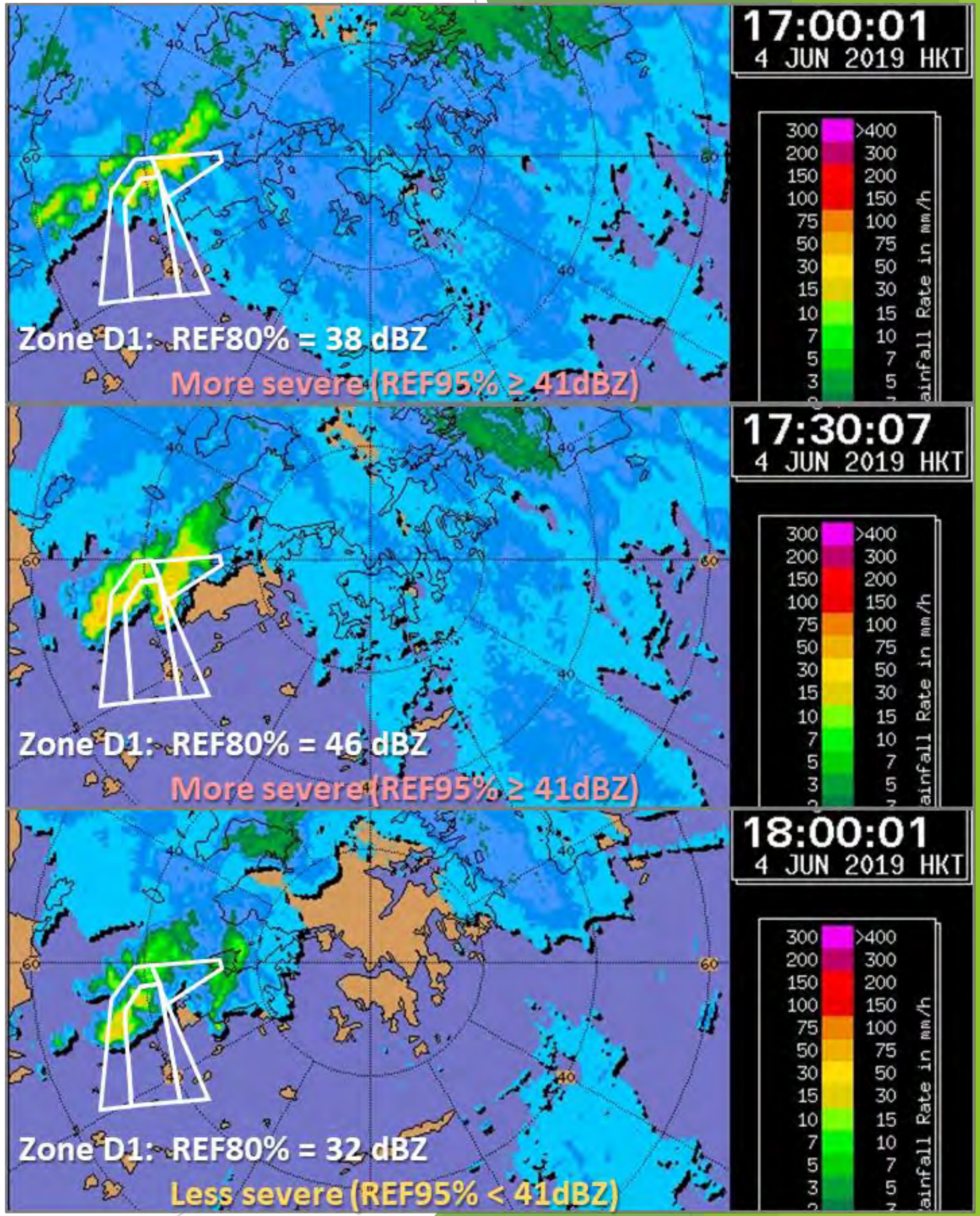
- Normal ADR of HKIA is about 34 departures per hour in daytime
- To tie in with the 6-minute update rate of weather radar data, the reference number of departures every 6 minutes is taken (which is 34/10 = 3.4)
- Estimated number of departures in a zone = (reference number of departures) x (ADR reduction factor based on REF80%)
- All flights go through zone D1 while zone D2/3/4 is selective
- Overall estimated departure number in 6 minutes is determined as the smaller number of the following to reflect the blockage due to weather in zone D2/3/4:
  - number of departures in zone D1
  - the highest number of departures in zone D2/D3/D4
- A 18-minute reaction time is added to cater for the observed delay in ADR response.



Case 1 (4 June 2019)

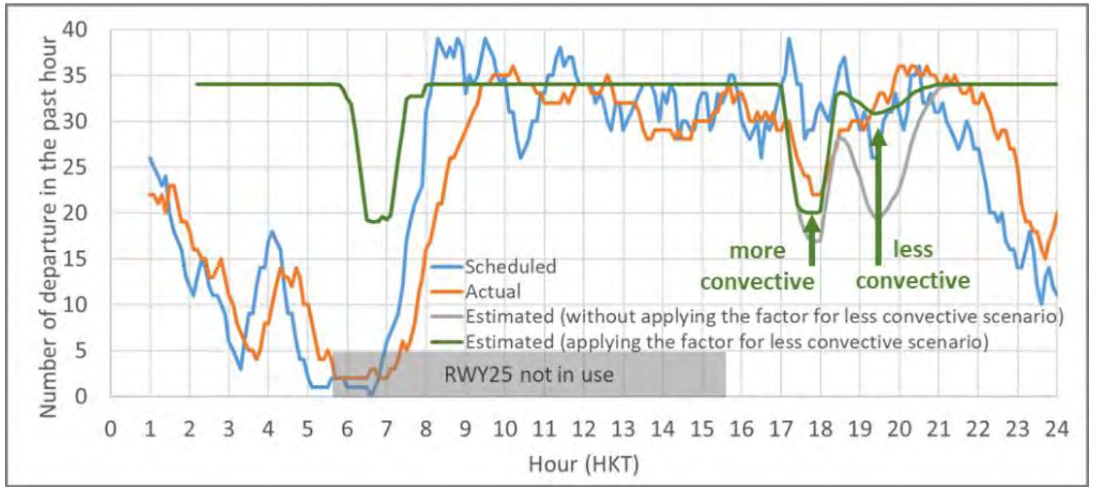
- Significant convection in zone D1 induced blockage and sharp decrease in actual ADR since 17:00 (local time)
- Actual ADR started to resume from 18:00 onwards
- The algorithm for estimating ADR could generally capture
  - the timing of the ADR change
  - the minimum ADR of around 5 departures in the episode

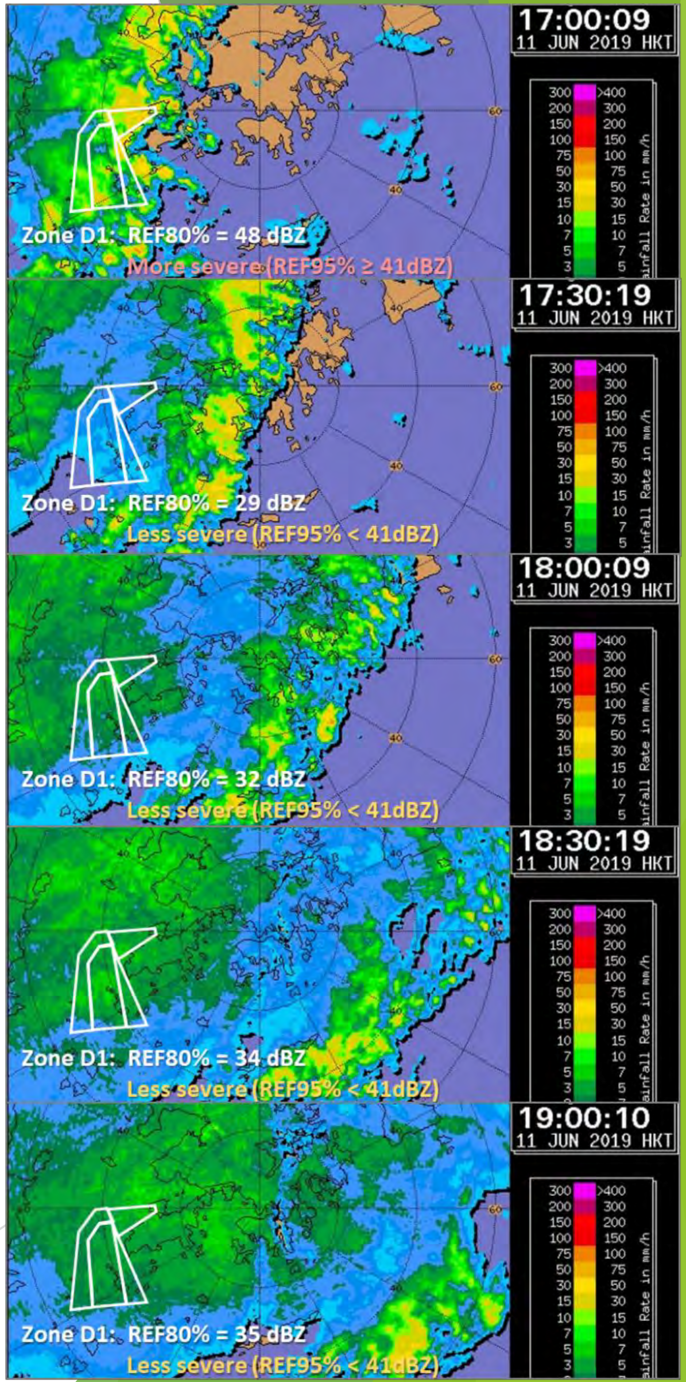




Case 2 (11 June 2019)

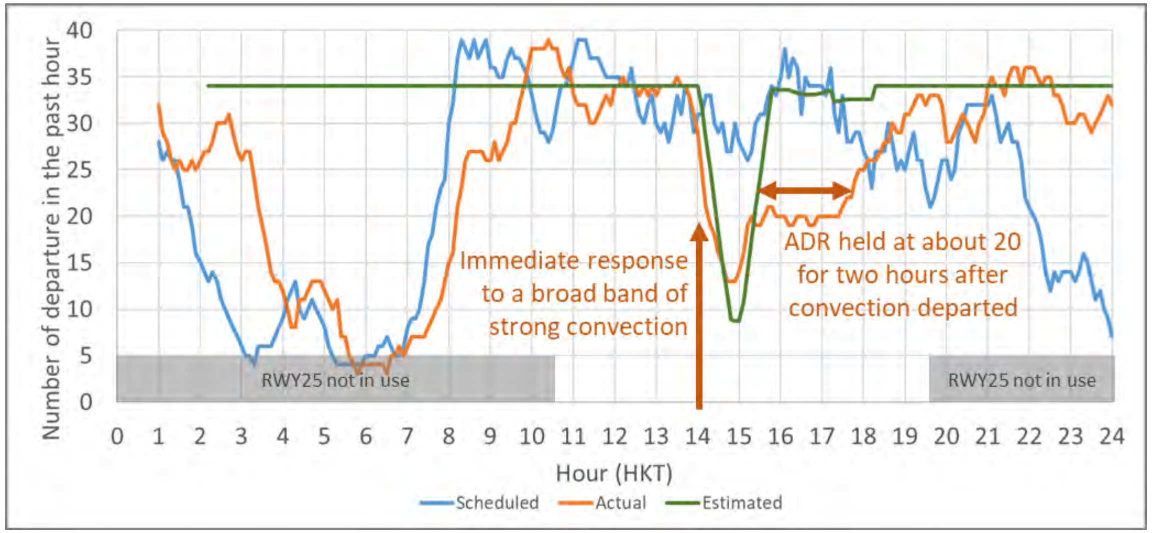
- Significant convection started to affect zone D1 around 17:00
- Intense echoes moved away from the departure zones faster than that in Case 1, resulting in a less reduction in ADR
  - which could also be captured by the algorithm
- The grey line in the ADR time series shows the ADR estimation without applying ADR reduction factor for "less severe" scenario, which deviated from the actual ADR during 18:30-20:00.
- This case shows that the broad coverage of around 35dBz had little impact on ADR.
- This was also the motivation for introducing two reduction factors in the algorithm, which could capture better the actual ADR (green line)

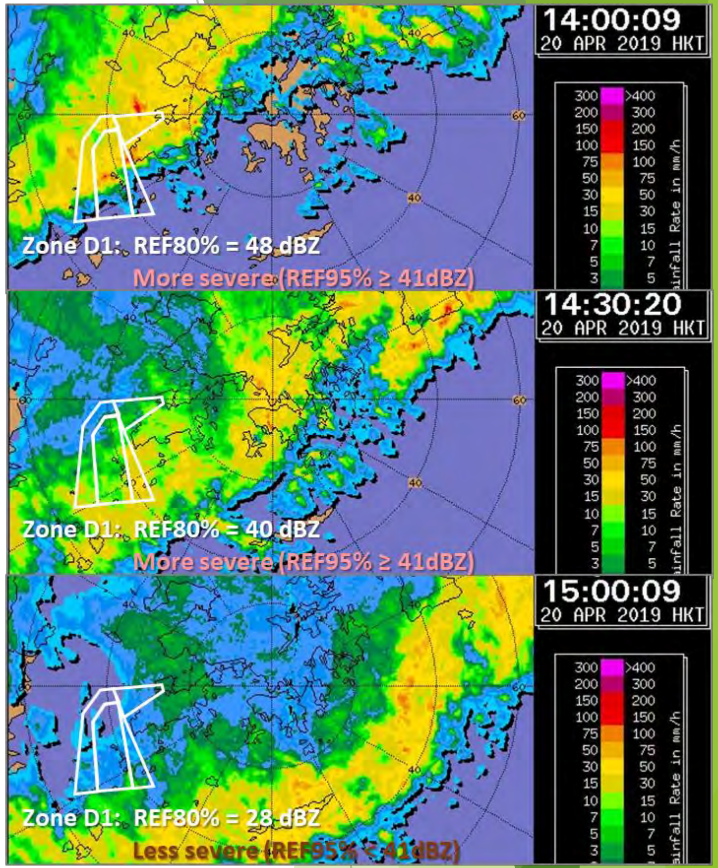


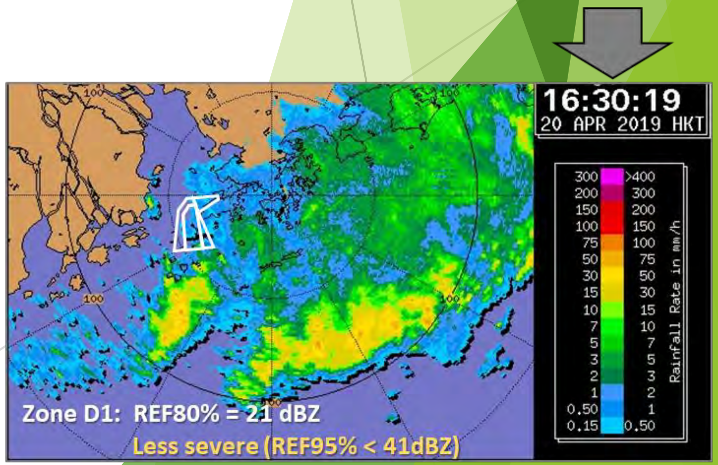


Case 3 (20 April 2019)

- The algorithm captured significant drop of actual ADR during 14:00-15:30 due to impact of the broad band of intense convection on the departure zones
- However, it was noticed that actual ADR was held at about 20 for around 2 hours even after the convection had departed
  - which might be caused by blocking effects outside the departure zone D1-D4 (such as the echo to the south) and other non-weather factors.

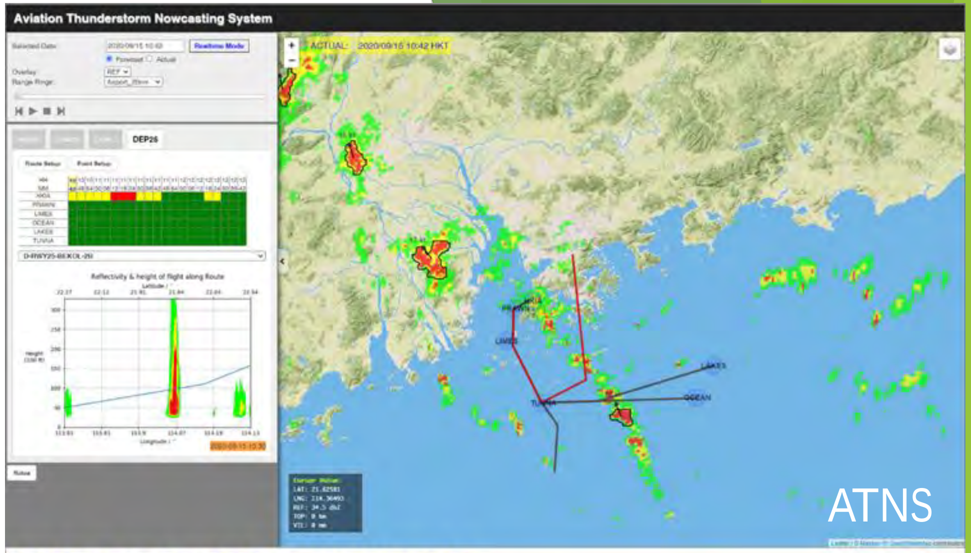






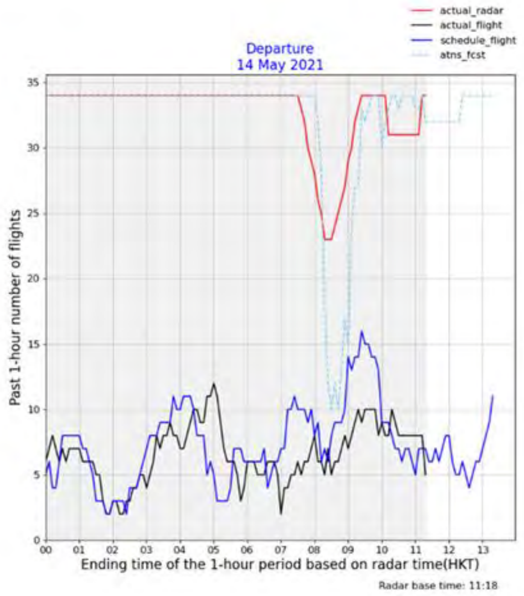
The way forward

- ADR changes could largely be explained by significant convection as expressed by the ADR reduction algorithm.
- Further study on contribution of other factors which may also affect ADR
  - distribution and structure of the convection
  - blockage outside the departure zones D1-D4
  - other non-weather factors
- Study on ADR for Runway 07 of HKIA would be conducted.
- 2-hour ADR forecast for Runway 25 of HKIA based on actual radar data and nowcasting from Aviation Thunderstorm Nowcast System (ATNS) was developed
  - put under evaluation since early 2021



ADR Forecast for Runway 25

Radar base time (yyyymmddhhmm)	ADR in first hour	ADR in second hour
202105141118	34	34



Thank you for your attention!