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ICAO ASIA/PAC METEOROLOGY / AIR TRAFFIC MANAGEMENT (MET/ATM) SEMINAR

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Objective Quantification of Weather Impact on Aircraft Operations due to Significant Convection Using Weather Radar Parameters

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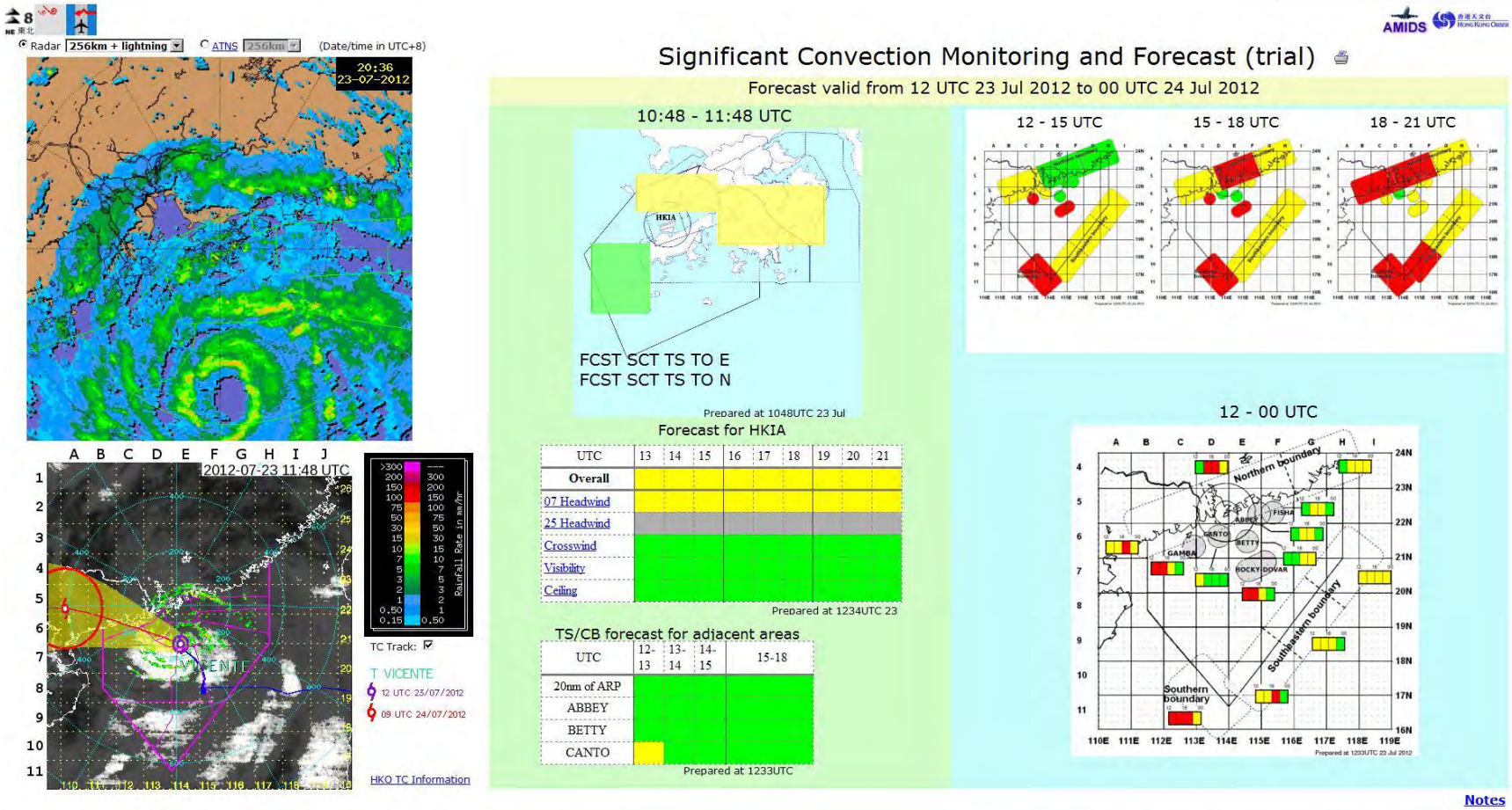


- HKO developed a series of significant convection related MSTA products (further details to be discussed in MET/R TF/3)
- Use 3 levels of colour code to indicate impact to air traffic

  GREEN - mild or no impact

  AMBER - medium impact

  RED - significant impact

Issue: Relation between convection intensity and severity of impact to aircraft was still not well understood.

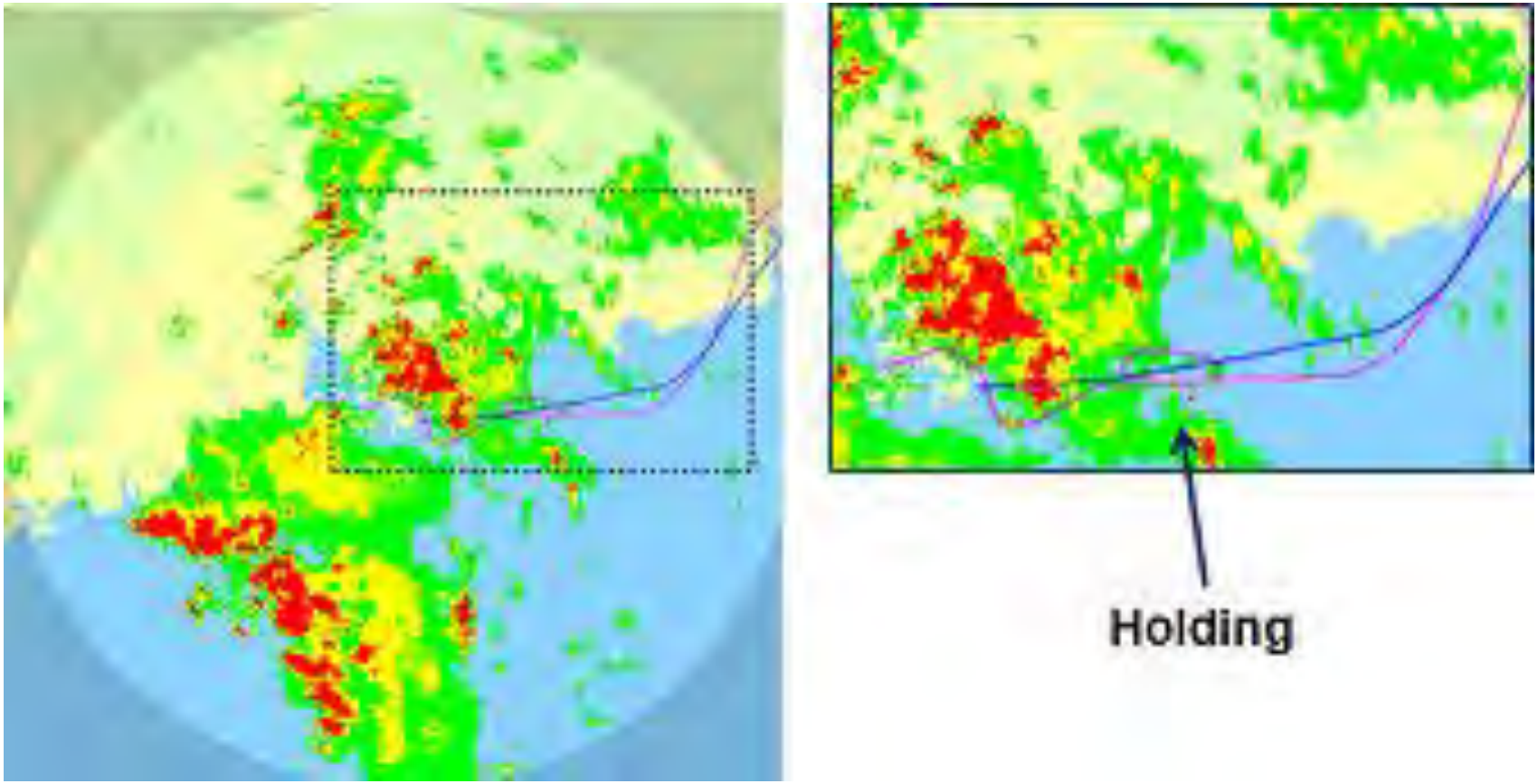
To address the issue, HKO has:

1. developed an objective methodology to identify common weather avoidance actions based on flight data.
2. analyzed the statistics of weather radar intensity, including 3km Constant Altitude Plane Position Indicator (CAPPI) reflectivity and Vertical Integrated Liquid (VIL), when avoidance actions are detected.
3. assessed the impact of significant convection to aircraft operations

   weather radar echoes ←→ weather avoidance actions

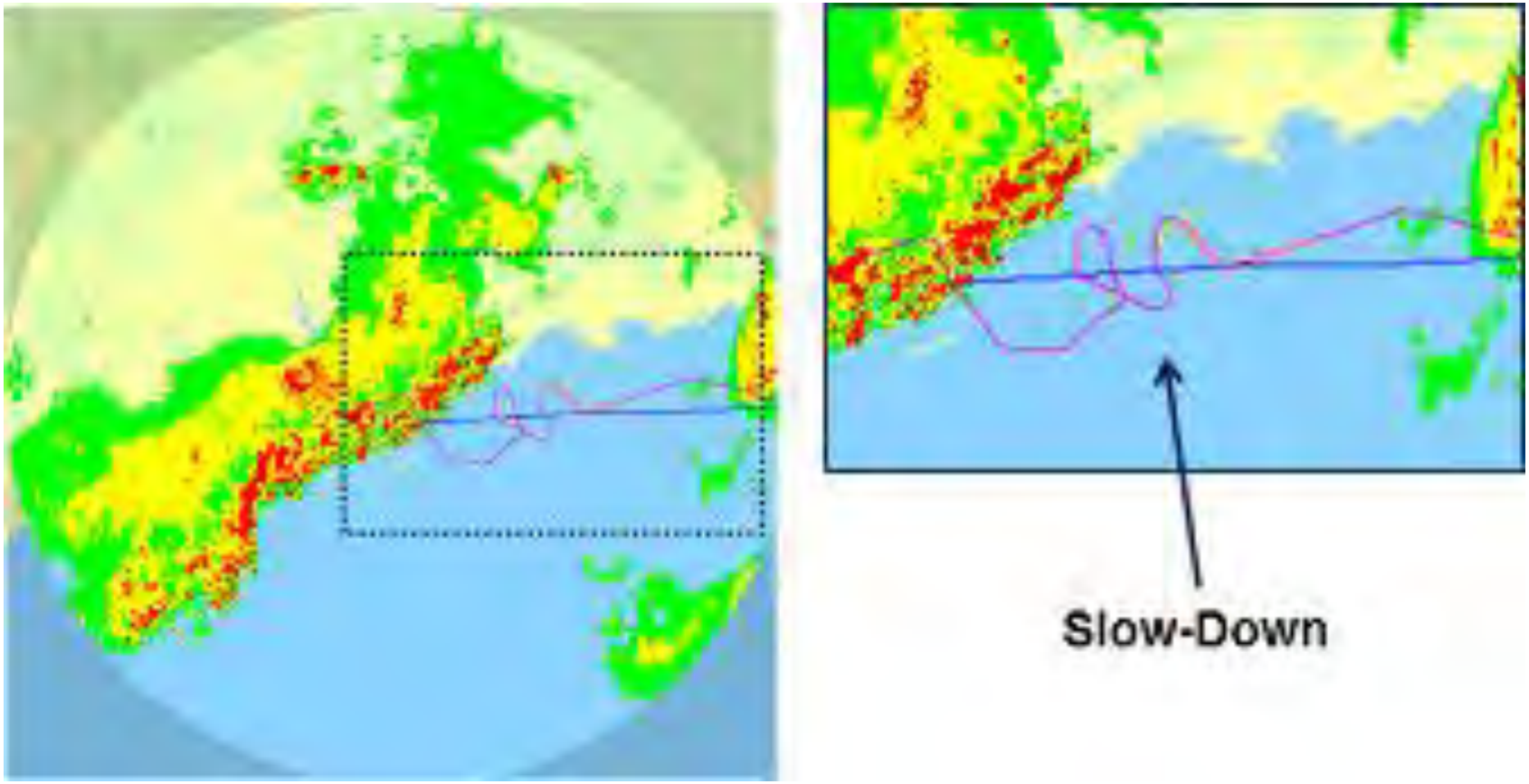
4. performed statistical analysis with a view to objectively quantifying the impact of significant convection on air traffic.

Objective Identification of Weather Avoidance Action - Holding



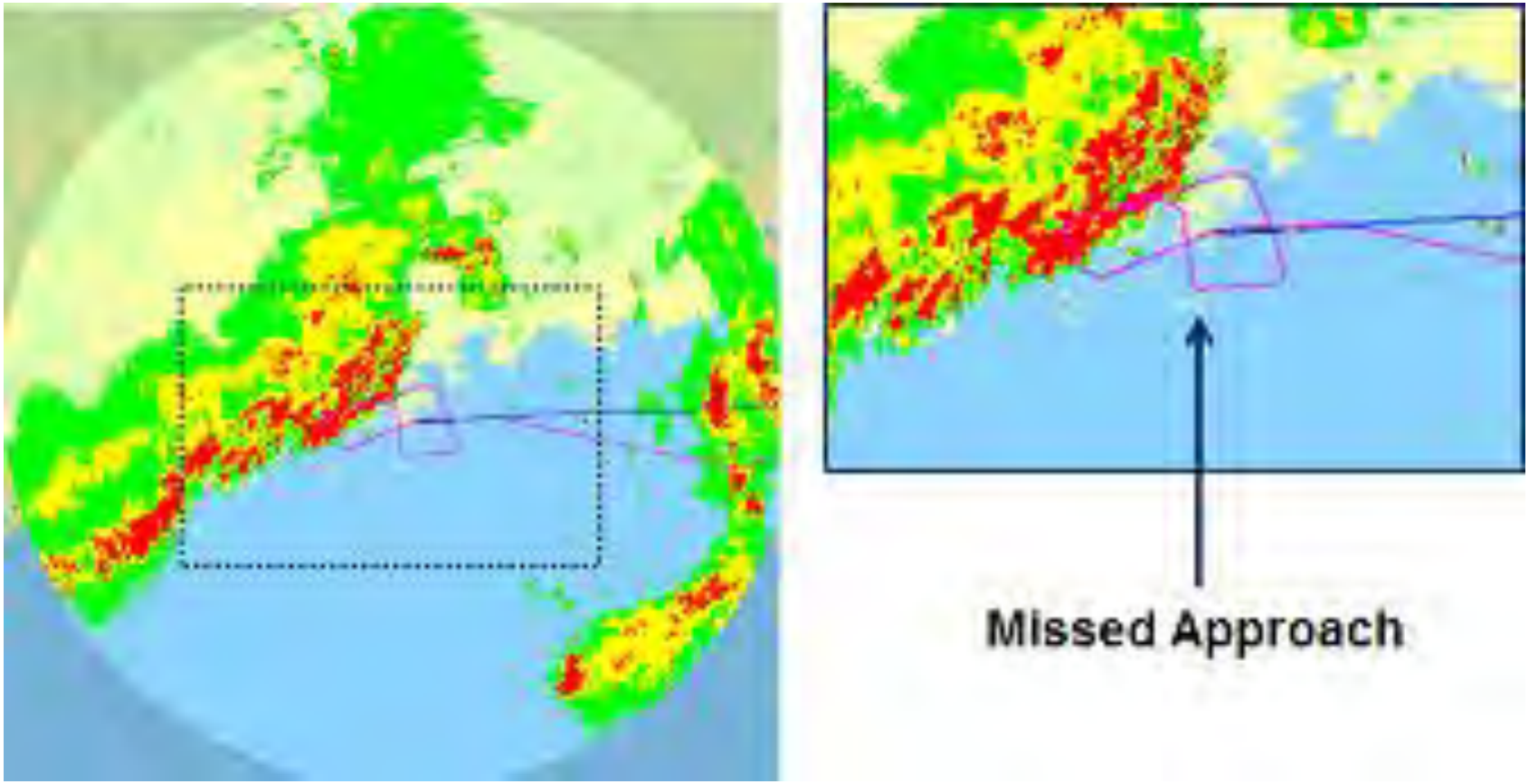
Key: to detect if there is any looping pattern.

Objective Identification of Weather Avoidance Action – Slow-Down



Key: to detect if there are any large and frequent variation in aircraft's heading.

Objective Identification of Weather Avoidance Action – Missed Approach



Key: to detect if an aircraft enters the aerodrome and then goes out.

Objective Identification of Non-Impact

Purpose: to achieve a more representative statistics, the number of flights which took no action when encountering significant convection, i.e. flying according to the planned flight route without significant deviation was also included in the statistics.

Key: to detect if largest separation between actual and planned flight position < 10km.

Objective Identification of Weather Avoidance Actions

- Holding
- Slow-down
- Missed Approach
- Non-impact

Note: more than one avoidance action in an actual flight, for example “holding” followed by “missed-approach”, may coexist for the same aircraft.

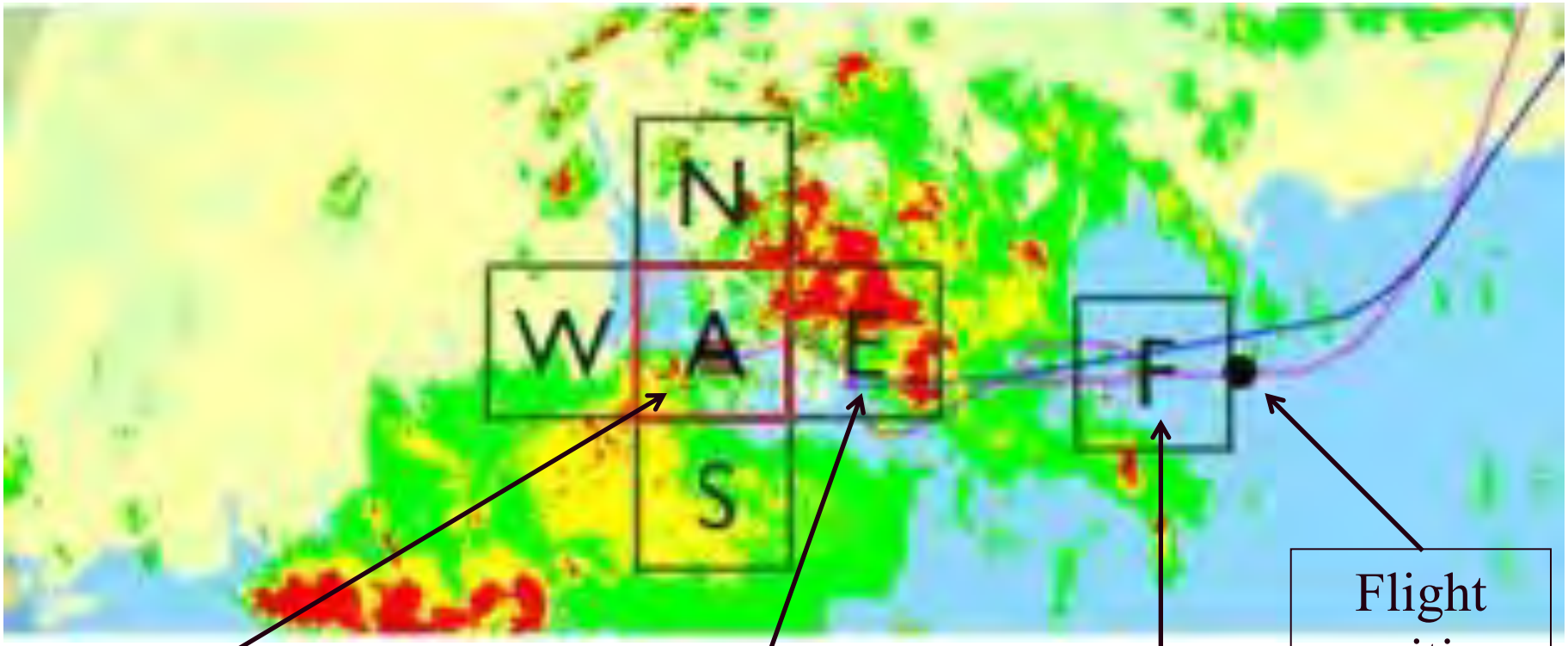
Data Analysis

- The radar 3km CAPPI reflectivity and VIL in an area of around 54km x 54km immediately ahead of the aircraft were extracted to compute the 90th percentile quantities so as to remove any noise.
- This served as the representative intensity of the convection ahead.

Data Analysis

- Besides the area ahead of the flight path, similar representative convection intensities at and near the aerodrome were also computed.
- Since avoidance action may due to significant convection over the aerodrome instead of immediately around the aircraft.

Data Analysis



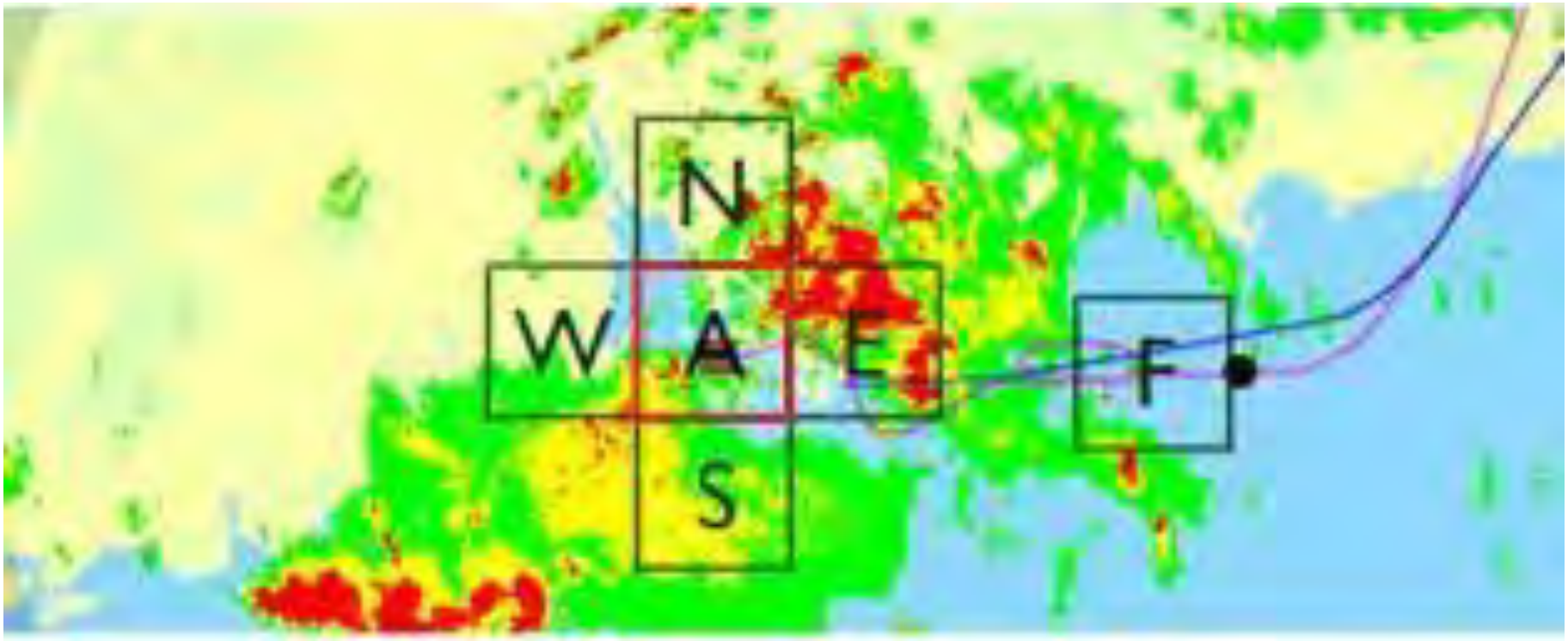
Box covering aerodrome area

Box covering east of aerodrome area

Flight position

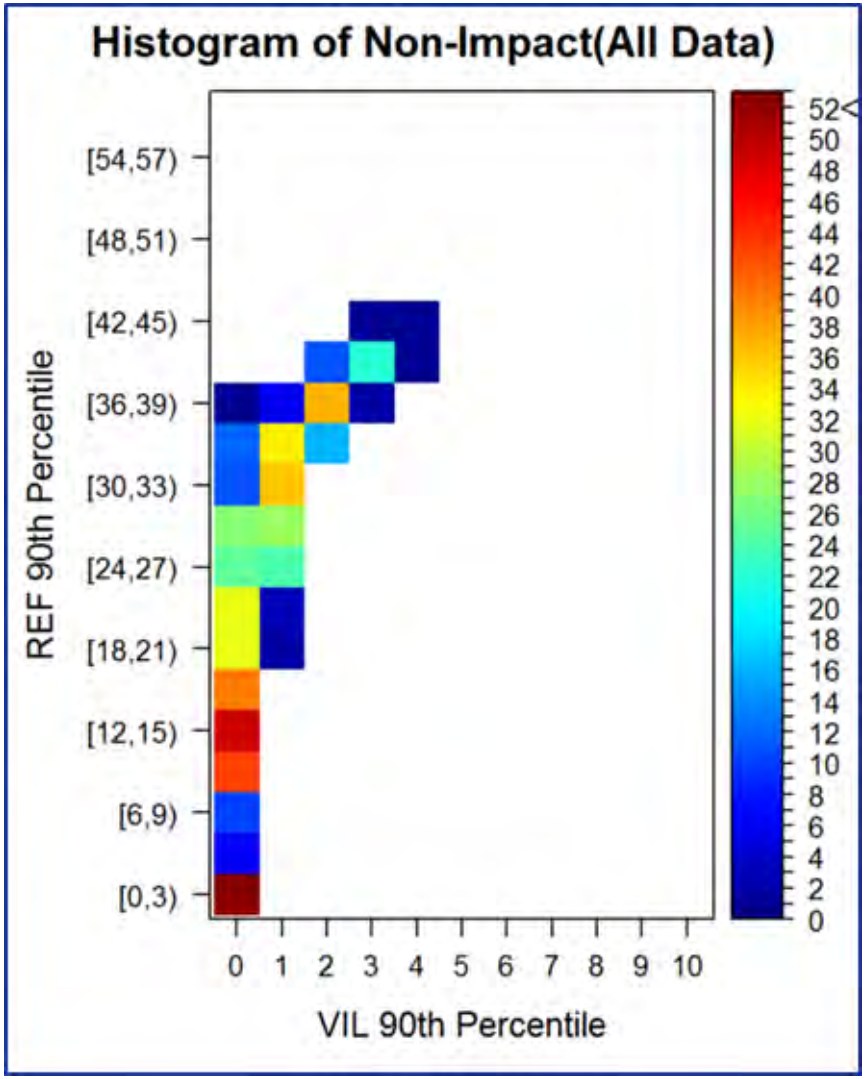
Box immediately ahead of aircraft - covering future flight path

Data Analysis



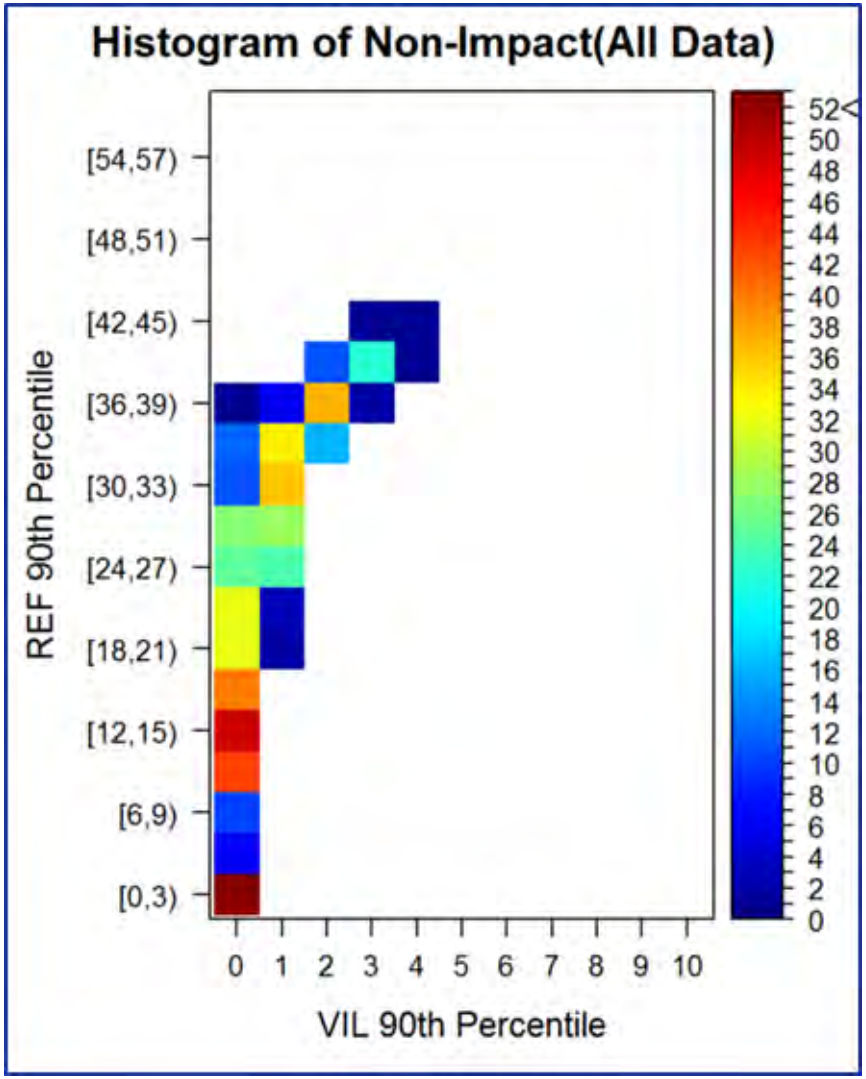
- The most intensive one of all these areas was used for compiling statistics on distribution of weather radar intensity for avoidance action taken and not taken.

Preliminary Result



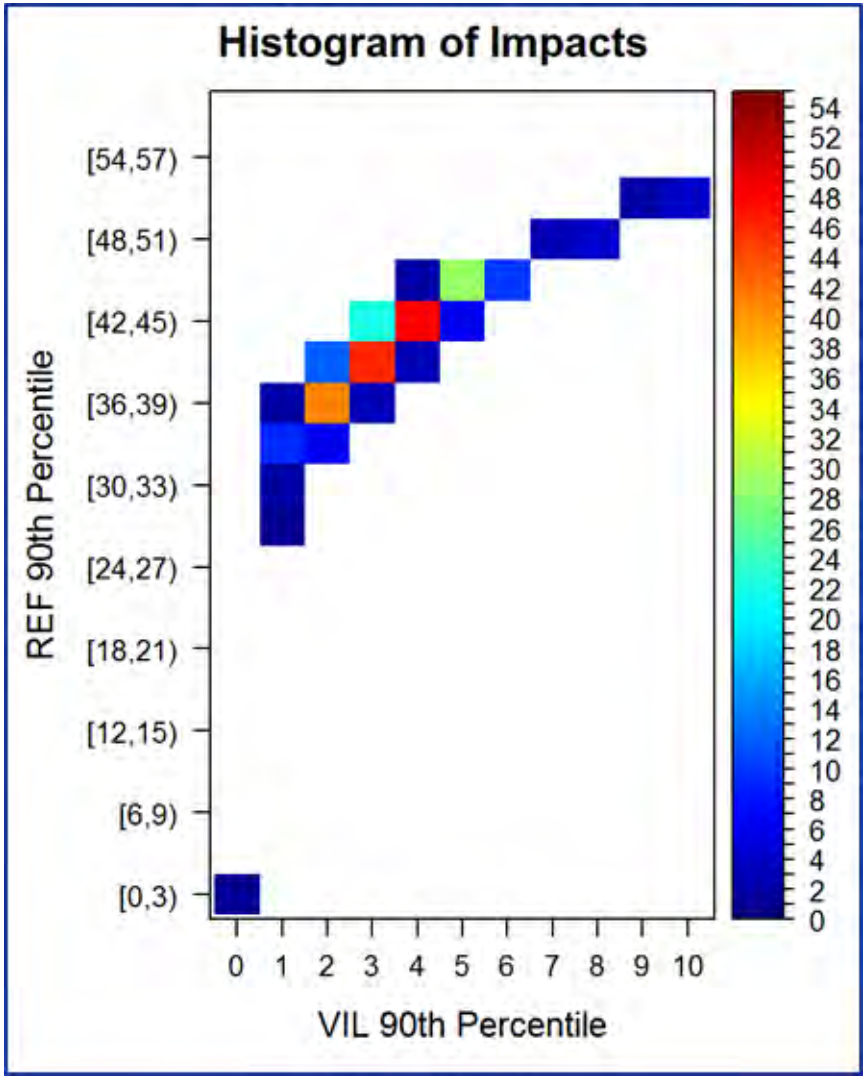
- In terms of frequent plot;
- X and Y axis are the convection intensities as represented by the 90th percentile of VIL (in mm) and the 90th percentile of 3km CAPPI reflectivity (in dBZ) respectively.

Preliminary Result – Non-Impact Flights



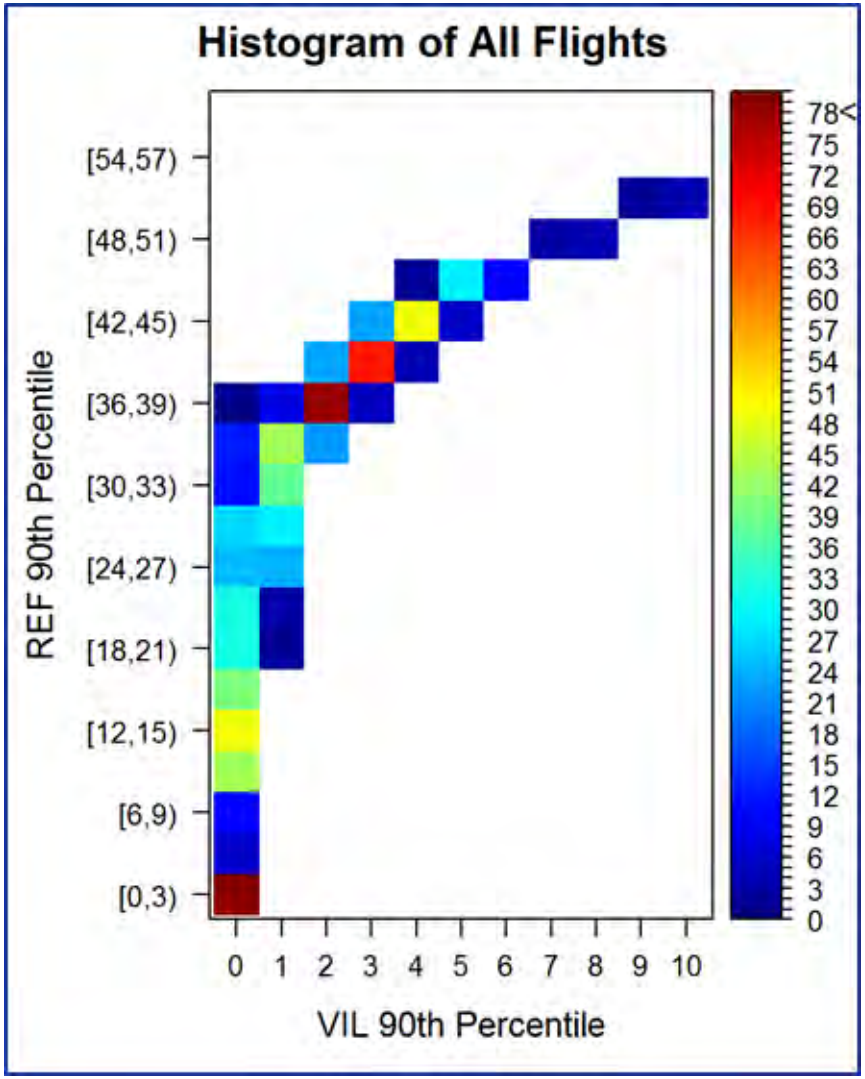
- Reflectivity values for most (orange and warmer color) non-impact flights were lower than 24dBZ, with VIL lower than 2mm.
- VIL condition for "non-impact" flights was more clear-cut as there were a very limited number of non-impact flights with VIL more than 3mm.

Preliminary Result – Impact Flights (Holding & Slow-down)

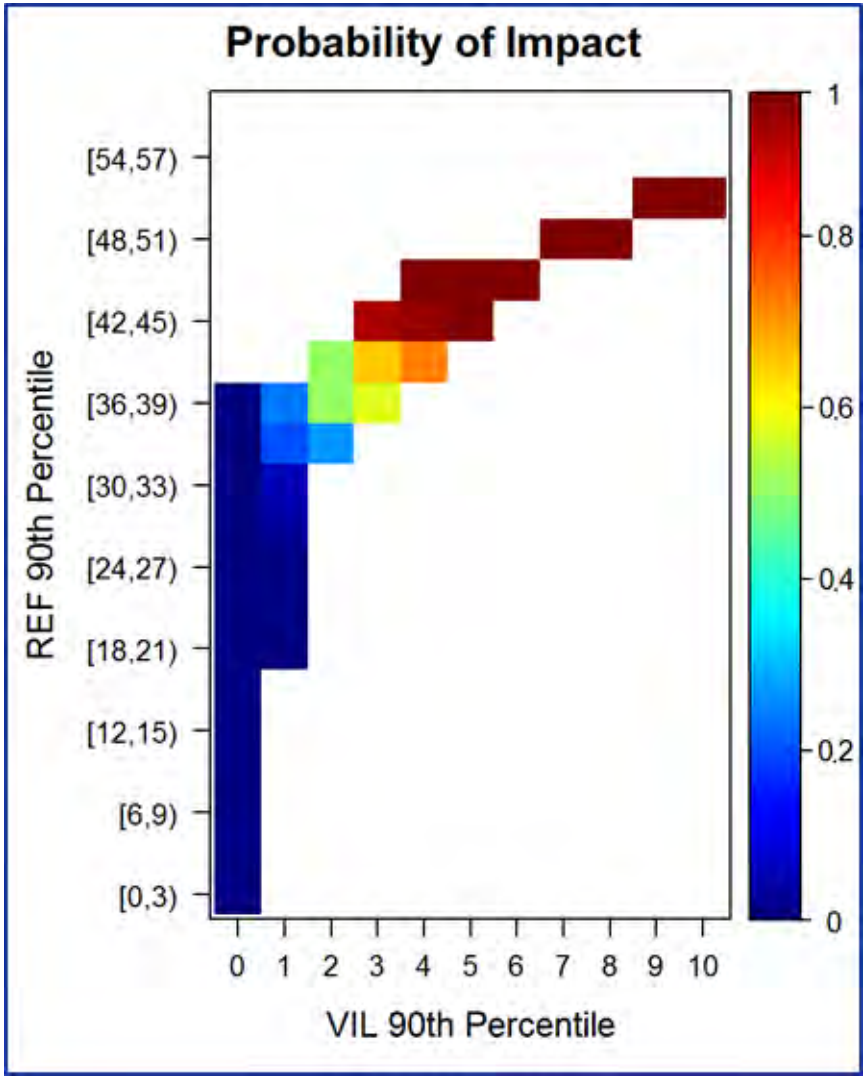


- Most of the avoidance actions were taken when reflectivity values were around 42dBZ or higher and VIL around 3-4mm or higher.
- Flights with identified "missed approach" have not been included in this study due to the small number of cases.

Preliminary Result – All Impact and Non-Impact Flights

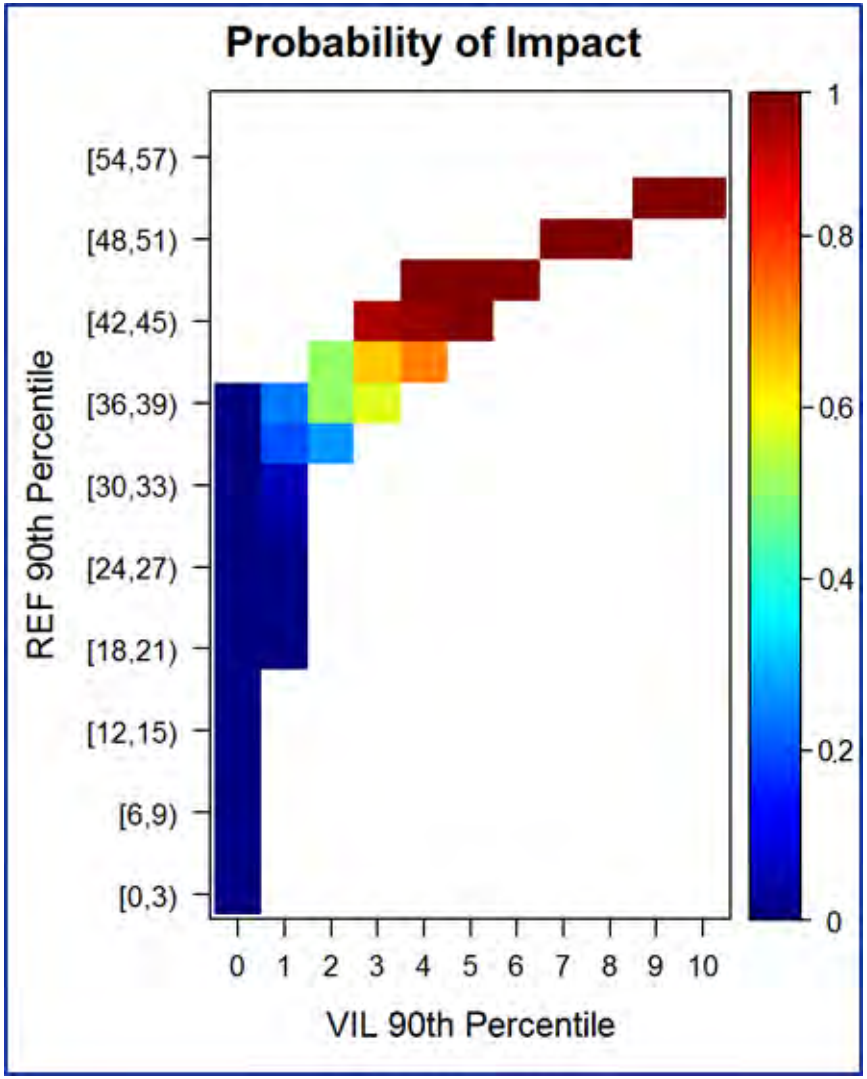


Preliminary Result – Probability of Impact



- Derived probability of avoidance, or probability of impact.
- Avoidance actions were unlikely when reflectivity and VIL was below 36dBZ and 2mm respectively.
- On the contrary, the probability of avoidance actions taken was more than 50% when reflectivity and VIL was above 39dBZ and 4mm respectively.

Preliminary Result – Probability of Impact



- Provides an objective ground to assess impact of significant convection to aircraft operations;
- Serves as a key component for the future development of probabilistic forecast of capacity of aerodrome/airspace associated with significant convection.

Further Studies

- Collect more flight position data;
- Enhance the objective algorithms to identify other avoidance actions, such as “path finding” and “deviation”;
- Derive a more robust probability of impact.

~~ Thank you ~~

Questions and Answers