International Civil Aviation Organization

EIGHTH MEETING OF THE COMMUNICATIONS/NAVIGATION/SURVEILLANCE AND METEOROLOGY SUB-GROUP (CNS/MET/SG/8) OF APANPIRG

Bangkok, Thailand, 12 – 16 July 2004

Agenda Item 12: MET support for operations at aerodromes and terminal areas

LATEST DEVELOPMENT IN THE USE OF A DOPPLER LIGHT DETECTION AND RANGING (LIDAR) SYSTEM FOR WINDSHEAR AND TURBULENCE DETECTION

(Presented by Hong Kong, China)

SUMMARY

This paper presents information regarding the latest development in the use of a Doppler LIght Detection and Ranging (LIDAR) system for windshear and turbulence detection at the Hong Kong International Airport.

1. INTRODUCTION

1.1 The Hong Kong Observatory (HKO) operates a suite of weather sensors for windshear and turbulence detection at the Hong Kong International Airport (HKIA). These weather sensors include a terminal Doppler weather radar (TDWR), a network of 20+ anemometers and three wind profilers (see Figure 1 for the location of these sensors). In the past couple of years, a number of enhancements have been made. One of the enhancements relates to the anemometer-based system for windshear detection and is covered by a separate information paper for the meeting. Another enhancement is the installation of a pulsed Doppler LIDAR at HKIA for detection of windshear and turbulence detection in clear-air conditions. In this paper, the latest development in the use of the Doppler LIDAR is presented.

2. WINDSHEAR DETECTION

2.1 The pulsed Doppler LIDAR system is strategically placed on the roof-top of the air traffic control (ATC) complex between the two parallel runways (Figure 1). At this location, the LIDAR is able to scan the approach and departure corridors of both runways. Operating on a principle similar to that of Doppler weather radar, albeit at a much shorter wavelength (2 microns compared with a few centimetres for weather radar), the LIDAR is capable of detecting return signals from aerosols carried in the air. It is currently configured to perform sector scans at several different elevation angles as well as a number of vertical scans to enable the monitoring of wind conditions out to about 3 nautical miles from the respective runway thresholds. LIDAR data are collected automatically and are typically updated once every two minutes.

2.2 Since its installation, the LIDAR has captured many interesting windshear events in clear air and facilitated the monitoring of windshear by the forecasters. These include sea-breezes (Figure 2), gust front ahead of thunderstorms (Figure 3) as well as complex wind flow behind hilly terrain. Scientific studies are ongoing to identify LIDAR signatures of terrain-induced windshear in the spring season when a majority of wind shear events are reported by aircraft. Terrain-induced flow patterns like the lee wave (Figure 4), hydraulic jump (Figure 5), velocity streaks (Figure 6), shear line (Figure 7) and vortex shedding (Figure 8) have been identified. New forecasting guidelines based on wind flow patterns revealed by the LIDAR have been formulated based on these findings to help the aviation forecaster issue runway-corridor specific windshear alerts.

2.3 To summarize, the Observatory has demonstrated the capability of the LIDAR in detecting windshear in clear air when the laser beam is not attenuated or blocked by precipitation and water droplets. The LIDAR has proved useful in supplementing the TDWR in windshear detection for a much wider range of weather conditions. In 2003, with the use of the LIDAR data by the aviation forecasters, the hit rate of wind shear alerts issued by HKO reached 95%, with the false alarm rate on a continual decreasing trend. Automatic windshear alerting algorithms are being developed with the objective to integrate the LIDAR with the existing windshear warning system to further enhance the overall alerting service for the airport.

3. TURBULENCE DETECTION

3.1 LIDAR data collected in a turbulence episode during the passage of Typhoon Imbudo on 24 July 2003 suggested the possible application of LIDAR in low level turbulence detection. On that day, a total of 31 aircraft reported encountering turbulence at HKIA. Of these, 15 were moderate to severe turbulence reports. It was a single day with the largest number of severe turbulence reports since the opening of HKIA in 1998. LIDAR Doppler radial velocities and spectral widths were compared with aircraft recorded wind and accelerometer readings during the turbulence episode. The study has found that the turbulence events were terrain-induced and the LIDAR Doppler velocity display (Figure 9) revealed the presence of small-scale wind disturbances with length scale of only a few hundred metres over the approach and departure corridors. Good correlation was found between the variance of the Doppler velocity field and aircraft acceleration data. Further studies will be conducted to explore the use of the LIDAR to supplement the existing anemometer-based algorithm for turbulence detection.

4. ACTION BY THE MEETING

4.1 The meeting is invited to note the information provided in this paper.

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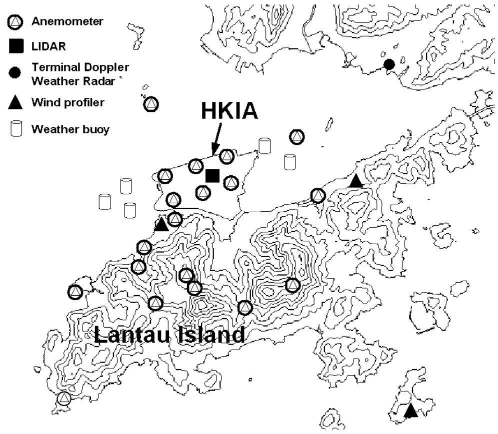

Figure 1 - Map of HKIA and the surrounding area, with 100-metre terrain contours.

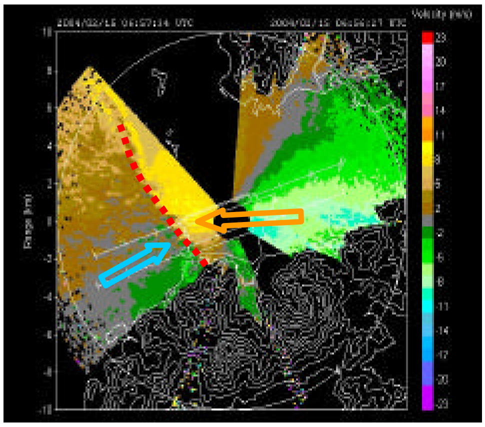

Figure 2 - LIDAR Doppler velocity display at 1.0 degree elevation, revealing a convergence line (red dotted line) with 20-25 knots wind speed gain between a westerly sea breeze (blue arrow) and background easterlies (orange arrow). Cold/warm colours indicate winds blowing towards/away from the LIDAR.

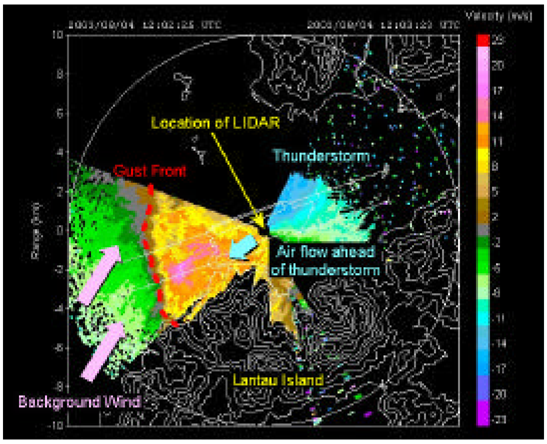

Figure 3 – LIDAR Doppler velocity display at 1.0 degree elevation, revealing a gust front (red dotted line) with about 35 knots wind speed gain across.

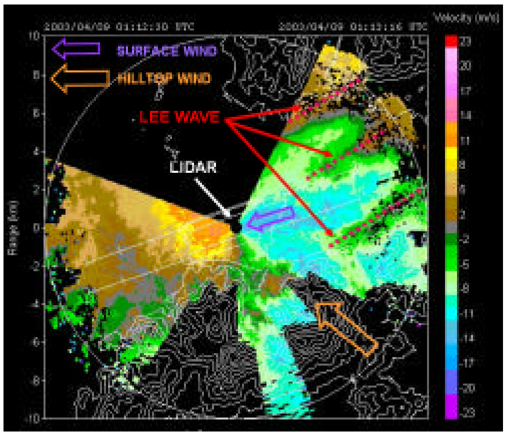

Figure 4 – LIDAR Doppler velocity display at 4.5 degree elevation, revealing lee waves to the east of the airport. An aircraft departing towards the east a few minutes later reported a loss of 15 knots at a height of about 520 m.

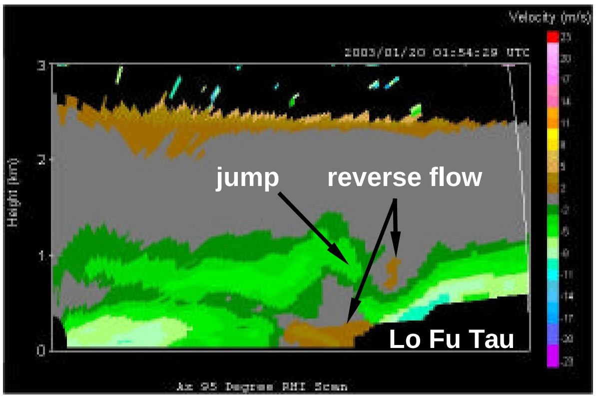

Figure 5 – LIDAR RHI Doppler velocity display at 95 degree azimuth, revealing a hydraulic jump feature downwind of a 465 m hill (Lo Fu Tau) over Lantau (the air flow was from right to left).

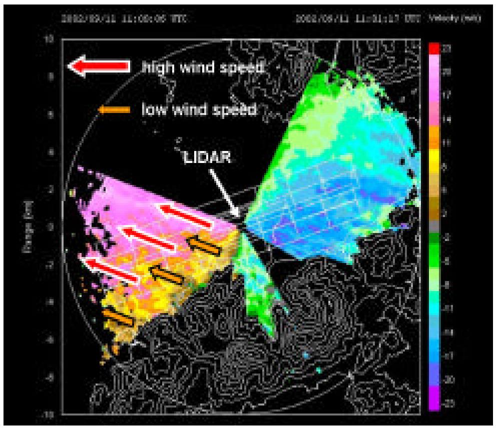

Figure 6 – LIDAR Doppler velocity display at 1.0 degree elevation, revealing high- and low-speed streaks downwind of rugged terrain in high winds associated with severe tropical storm Hagupit.

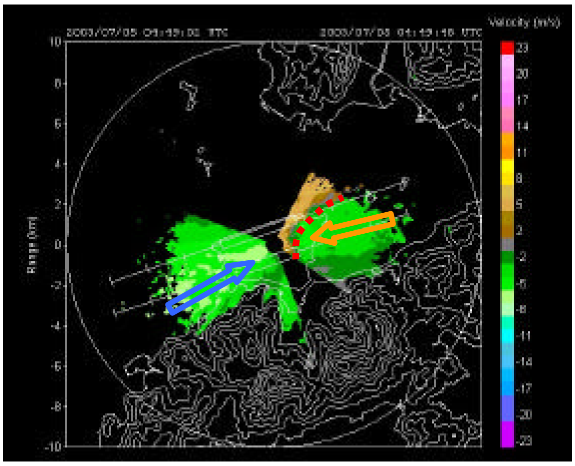

Figure 7 – LIDAR Doppler velocity display at 1.0 degree elevation, revealing a terrain-induced shear line (red dotted line) over HKIA when the terrain-induced easterlies (orange arrow) converged with the background southwesterlies (blue arrow).

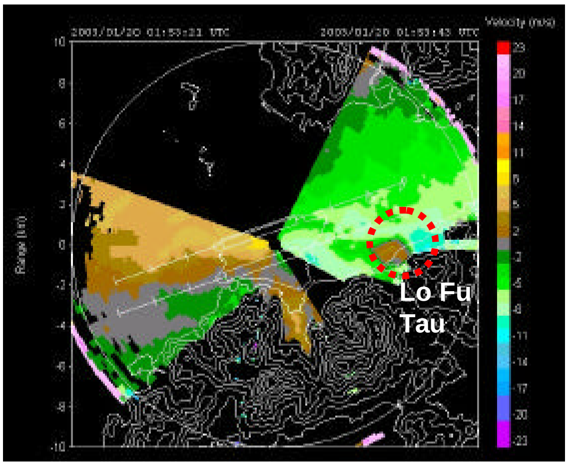

Figure 8 – LIDAR Doppler velocity display at 1.0 degree elevation, revealing a vortex (red dotted circle) downwind of Lo Fu Tau over Lantau under an easterly air flow.

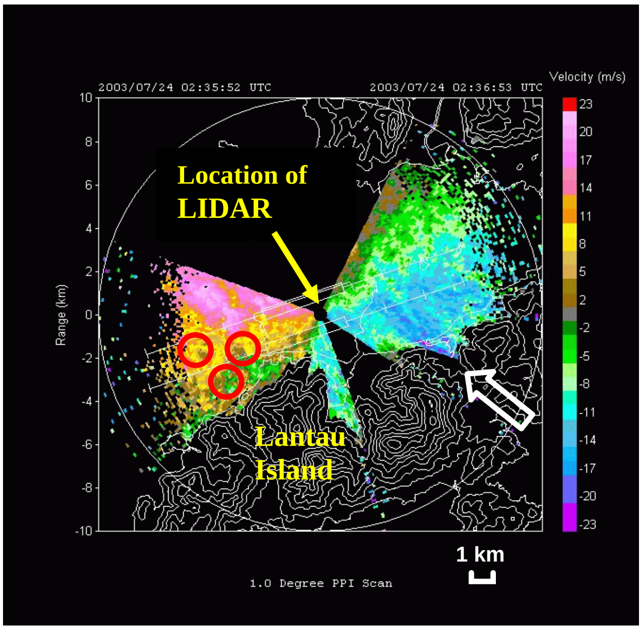

Figure 9 – LIDAR Doppler velocity display revealing small-scale wind disturbances with marked wind changes over a length scale of several hundred metres (see areas circled in red). The white arrow indicates the background wind direction.