Dual Doppler LIDAR Retrieval Of 2D Wind Field

P.W. Chan & A.M. Shao*

24th International Laser Radar Conference,
23-27 June 2008, Boulder, Colorado, USA

*College of Atmospheric Sciences, Lanzhou University
DUAL DOPPLER LIDAR RETRIEVAL OF 2D WIND FIELD
P.W. Chan¹, A.M. Shao²

¹Hong Kong Observatory, 134A Nathan Road, Kowloon, Hong Kong, China, pwchan@hko.gov.hk
²College of Atmospheric Sciences, Lanzhou University, Gansu 730000, China, sam@lzu.edu.cn

ABSTRACT
Two Doppler LIDARs are operated inside the Hong Kong International Airport (HKIA) for detecting low-level windshear. The radial velocity data measured by the two LIDARs in Plan-position Indicator (PPI) scans are used to retrieve 2D wind field in the vicinity of the airport using variational method. Though the two LIDARs are separated by a short distance of about 350 m, the wind field retrieved from the two LIDARs shows improvements over that retrieved from a single LIDAR in various weather conditions by comparison with the surface anemometer data.

1. INTRODUCTION
There are two Doppler LIDARs (locations in Figure 1) operating inside HKIA for alerting of low-level windshear. Besides scanning along the flight paths to detect windshear to be encountered by the landing/departing aircraft, they are also configured to perform PPI (i.e. azimuthal) scans to give an overview of the wind distribution in the airport area. To better visualize the wind pattern, the radial velocity data from the first LIDAR have been used to retrieve the 2D wind field using variational method [1]. With the introduction of the second LIDAR in 2006, the retrieval of the 2D wind field by combining the radial velocity data from the two LIDARs is studied in this paper. The quality of the retrieved wind field is examined by comparing with the wind field revealed by the measurements from a dense network of surface anemometers (red dots in Figure 1).

2. RETRIEVAL METHOD
The PPI scans of the lowest elevation angles are considered in this study, namely, 0-degree PPI scan of the first LIDAR and 1.4-degree PPI scan of the second LIDAR. The dual LIDAR retrieval method is similar to that employed in [2], but with the radar data replaced by the LIDAR data. In summary, it considers the minimization of the difference between the retrieved wind field and the background wind field (obtained in the first step of the retrieval method) as well as that between the retrieved and the measured radial velocity (the actual LIDAR data), the requirement of fulfilling conversation of momentum for the radial velocity component, and the smoothing of the retrieved wind field involving the divergence, vorticity and Laplacian of the field. The single LIDAR retrieval method is same as that in [1] and only the first LIDAR (Figure 1) is used.

3. EXAMPLES OF DUAL LIDAR RETRIEVAL
The first example is a sea breeze case under the prevailing easterly wind. The dual LIDAR retrieval depicts the convergence between the background easterly and the sea breeze westerly along the sea breeze front (Figure 2(a)), similar to the surface anemometer observations (Figure 2(c)). On the other hand, single LIDAR retrieval gives the convergence between southeasterly and southwesterly winds only (Figure 2(b)). The winds retrieved to the west of the airport in both cases are however biased with exaggerated southerly component. This is believed to be due to the impact of the background wind field and the relatively weak radial velocities from the LIDARs.

The second example is a gust front case associated with intense convection. The major features are the northerly winds behind the gust front and the appearance of a vortex over the airport. Though both the dual LIDAR and the single LIDAR retrievals capture the vortex well (Figure 3(a) and (b) respectively), the former better depicts the strong northerly winds behind the gust front (Figure 3(c)). The latter only gives northeasterly to east-northeasterly winds to the northeast of HKIA, which does not seem to be consistent with the surface observations.

The third example is the prevalence of terrain-disrupted easterly winds over the airport in the spring. With the constraint of radial velocity data from both LIDARs, the winds on the airfield have more easterly component, especially over the centre and the southeastern part of the airport (Figure 4(a)), which is more consistent with the surface observations (Figure 4(c)). The single LIDAR retrieval gives the prevalence of southeasterly flow over the airport only (Figure 4(b)). On the other hand, the winds retrieved over the southwestern part of the airport are still biased with exaggerated southerly component for both cases.

4. CONCLUSIONS
Though the two LIDARs of HKIA are separated by a relatively short distance of about 350 m only, the retrieval of 2D wind field is improved by considering data from both LIDARs compared to that based on a single LIDAR. The improvement in the retrieved wind
vectors is achieved as far as several kilometres away from the LIDARs, especially to the east of the airport. With the relocation of the first LIDAR to a location closer to the south runway of HKIA in early 2008, the separation of the two LIDARs will increase to about 1.8 km and the improvements gained with dual LIDAR wind retrieval are expected to cover an even larger area. Issues with the exaggerated southerlies to the west of HKIA may be improved.

REFERENCES


Figure 1 Geographical situation near HKIA and the locations of the LIDARs. Height contours: 100 m. Red dots are the locations of the surface anemometers.

Figure 2 Sea breeze case at 07:25 UTC, 27 February 2007. (a) 2D wind field retrieved from the two LIDARs overlaid on the radial velocity from the first LIDAR. (b) 2D wind field retrieved from the first LIDAR only overlaid on the radial velocity from the first LIDAR. (c) wind data (represented by green wind barbs) from the surface anemometer network in the vicinity of HKIA.
Figure 3  Gust front case at 02:05 UTC, 24 April 2007.  
(a) – (c) same as Figure 2.
Figure 4  Easterly wind case at 18:13 UTC, 13 March 2007. (a) – (c) same as Figure 2.