A microburst in Hong Kong

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Microbursts are small-scale, radially divergent flows near the ground surface, which are typically associated with thunderstorms or other lesser forms of convective cloud systems. They arise when strong downdraughts hit the ground and spread out in all directions. They are, therefore, also referred to as downbursts. Some authors have adopted a radial velocity difference of 10 m s^{-1} (about 20 kn) over a distance of 4 km or less as the threshold to distinguish microbursts from less malign forms of downbursts (Wilson *et al.* 1984).

Microbursts have been identified as the cause of several major aircraft accidents in the USA. Most reports of microbursts so far have come from North America. There are also recent reports of downbursts from Japan (Ohno *et al.* 1994). This article reports on a microburst in Hong Kong, which is located within the tropics, in contrast with the extra-tropical location of Japan and the USA.

The event occurred on 19 February 1992 and was monitored by the low-level wind shear detection system set up in the late 1970s (Bell and Tsui 1981). It consists of an array of five anemometers located under the approach/departure flight paths and on the runway of the Hong Kong International Airport. The system has been useful in the tracking of squall lines (Chen and Lee 1978). It is shown here that, with careful analysis and with one or two additional automatic weather stations, the presence of microbursts might be inferred from anemometer observations.

The event

It was an overcast day in Hong Kong on 19 February 1992. Warm moist air from the south-west overrode a shallow layer of cool modified continental air coming in from the east (Fig. 1), giving rise to fairly continuous drizzle in the morning. The moist layer was about 3 km thick and was capped by very dry air aloft. There was also a temperature inversion between about 400 and 650 m. Patches of rain were observed on the radar along the coast of southern China, moving generally from west to east along the coast.

Shortly after 12 noon local time (0400 GMT), the sky turned very dark at the Royal Observatory (RO) headquarters. A radar echo was observed about 10 km to the north-west, which later crossed the northern part of the territory from west to east (Fig. 2, p. 100). The most intense part of the echo skirted RO to the north and was closest around 12.30 p.m. Atmospheric pressure started to rise smartly at 12.24 p.m. and it was thought that this signified

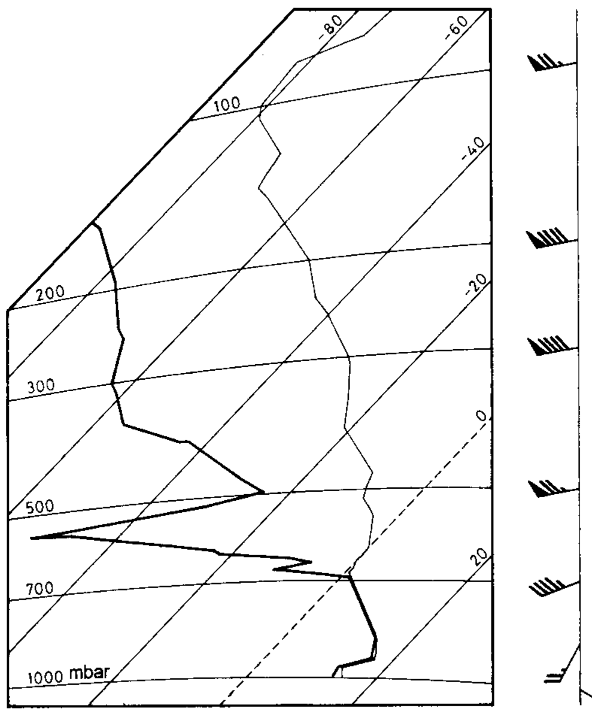

Fig. 1 Hong Kong upper-air ascent and winds at 8 a.m. local time (0000 GMT) on 19 February 1992

the arrival of a squall line. However, as wind directions changed abruptly from easterly to northerly around the same time, the wind speed also dropped for a minute or two. Although the wind speed rose again as winds backed further into north-westerlies, little more than 10 kn was observed. The sky turned brighter for a few minutes. Winds then resumed easterly, accompanied by a rapid decrease in atmospheric pressure and a much darker sky again. The time sequences of pressure, wind speed and direction recorded by an automatic weather station at RO at 1 min intervals are shown in Fig. 3. Noting that the phenomenon was most probably moving eastward similar to the radar echo, the time axis in Fig. 3 has been turned around, opposite to normal convention, so that it can also be interpreted as an east–west cross-section of the phenomenon, east being to the right. While all the changes were taking place, there was very little rain, only 0.2 mm between 12 noon and 1 p.m. There was also no report of thunder.

The short duration of the pressure bump and the rapid resumption of easterlies after a brief spell of northerlies prompted the thought that we might have witnessed a microburst passing close to RO. Wind data from the anemometers of the low-level wind shear detection system, also recorded at 1 min intervals, were examined. It was found that at both ends of the runway, which is about 4 km east-north-east of RO, the easterly flow was also interrupted for a few minutes but winds were *southerly* before easterlies resumed. It looked as if a centre of divergent flow had travelled eastward and passed to the north of RO but to the south of the runway.

To reconstruct the spatial picture of the phenomenon from observations at fixed points, we further assume that the phenomenon travelled eastward at a steady speed and that its flow pattern remained more or less unchanged over the period of interest. The 12.30 p.m. wind observations were plotted for selected stations. Observations before (after) 12.30 p.m. were then plotted to the right (left) of the respective stations and displaced by the distance which the phenomenon would have travelled in the time elapsed. The speed of travel was estimated by noting the time delay between RO and the south-east end of the runway when easterlies turned into northerlies in a similar manner. A coherent pattern of airflow emerged following these procedures and is shown in Fig. 4. Streamlines have been added to highlight the divergent flow, the centre of which was very close to RO at 12.30 p.m.

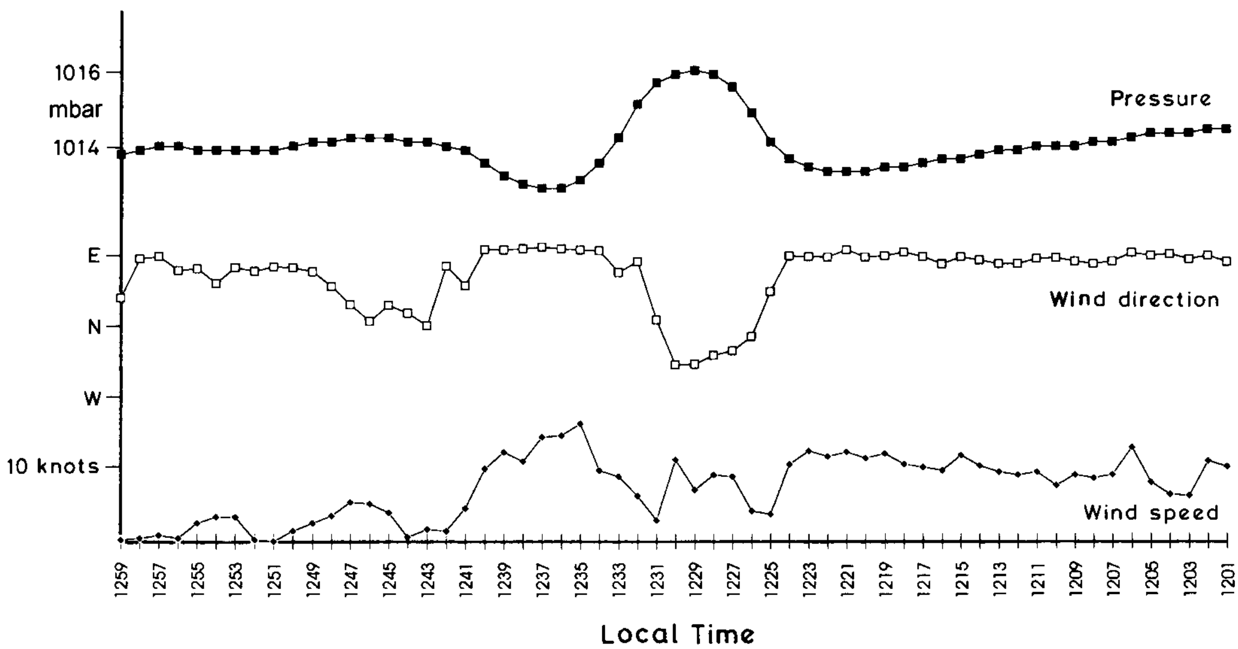

Fig. 3 Time-series of pressure, wind speed and direction at Hong Kong Royal Observatory on 19 February 1992. Note the reversal of the time axis.

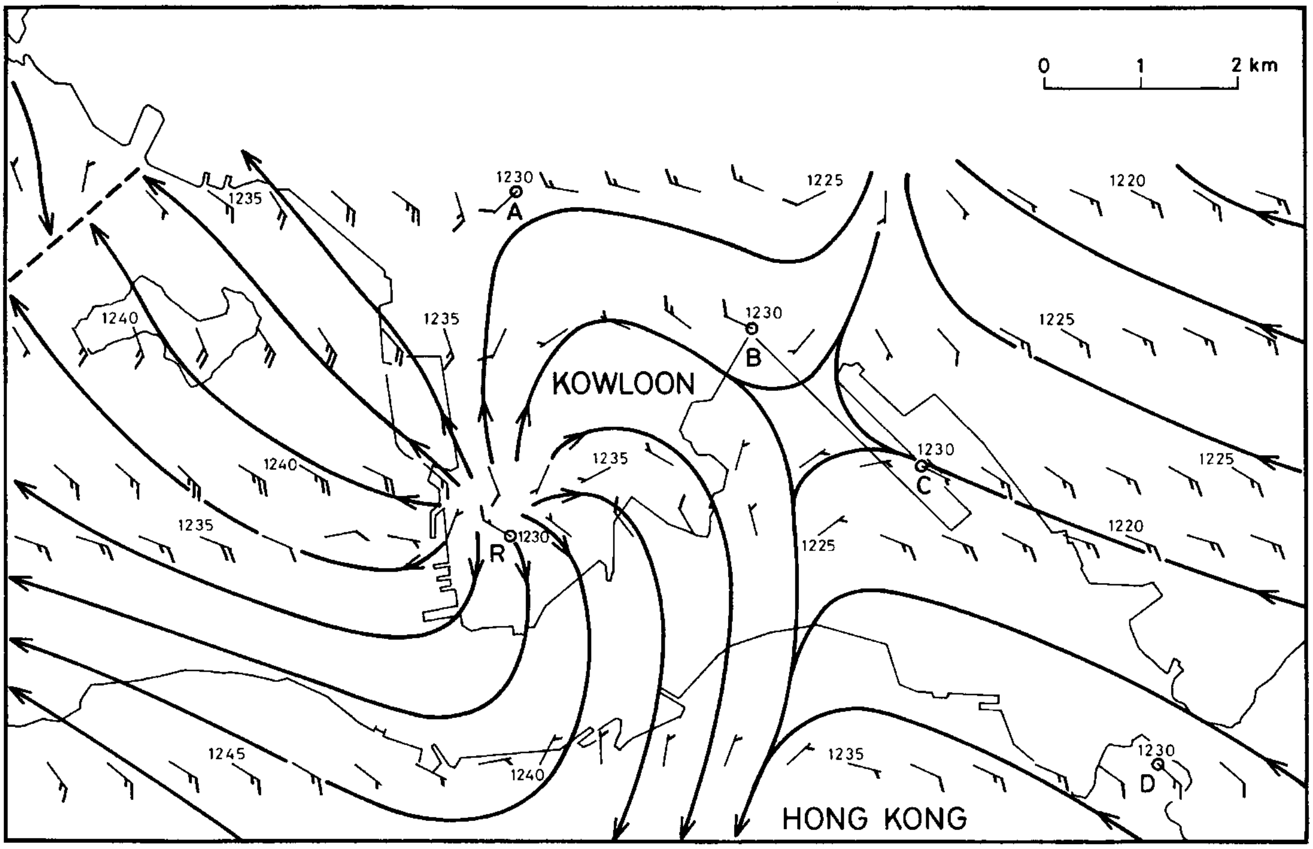

Fig. 4 Reconstructed flow pattern of the microburst at Hong Kong on 19 February 1992. A, B, C, D – anemometers constituting the low-level wind shear detection system, R – Royal Observatory.

If an aircraft had flown through the centre of the divergent flow in a south-east to north-west direction (or vice versa) it would have experienced a headwind loss of 27 kn over a distance slightly more than 1 km. The event, therefore, qualified as a microburst. This microburst, as has been observed elsewhere, was asymmetric. There was a zone of winds exceeding 20 kn in the western semicircle while winds in the eastern semicircle were generally lighter.

Discussion

This study establishes the fact that microbursts do occur in a subtropical location such as Hong Kong. It also shows that the presence of microbursts could be inferred from a network of anemometers reporting at 1 min intervals. Naturally, it will not be an easy task in an operational environment because an a priori estimation of the propagation speed of the disturbance is necessary in order to produce a picture similar to Fig. 4.

While the winds associated with the event were by themselves benign to aircraft flights, it was the loss of headwind over a short distance that would have caused concern to pilots, especially when taking off and landing, owing to the sudden loss of lift. In the case presented here, the divergent winds on the forward half of the microburst were significantly weaker than those on the rear half. This was opposite to the typical pattern associated with travelling microbursts as described by Fujita (1985). It is not clear what brought about this deviation from the norm. It was perhaps related to the low-level east-south-easterlies of about 15 kn which prevailed before the microburst descended to reach the ground.

Many practical difficulties are involved in setting up an anemometer network around an airport. An alternative approach to microburst detection is through the use of high-sensitivity Doppler radar to measure winds in the airport airspace. One such radar will be set up to monitor the airspace of the new international airport under construction in Hong Kong (Shun and Johnson 1995).

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March 1843 – a chilling month

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Most people have an interest in weather conditions, and justifiably so, since these impact greatly upon many facets of our lives. This interest often turns to fascination when the subject involves an extreme weather event. Many have heard of 'the year without a summer' which occurred in 1816 and is described in some detail in *American weather stories* (Hughes 1976), with extracts from publications in the north-eastern USA, there being few observations elsewhere at this time. However, few know of the events in late 1842 and early 1843, the 'long winter', unless they have read *Early American winters II, 1821–1870* (Ludlum 1968). As noted there, the winter began in the autumn and extended into spring, but the most phenomenal aspect appears to be the extremely cold March of 1843 that was experienced over a vast area.

As will be appreciated, temperature reports in 1843 were not numerous in the USA, and west of the 100°W longitude they were almost non-existent. Nevertheless, from around 1820, Army surgeons were required to make observations at military installations and by 1843 almost 60 stations were reporting, about 30 per cent being in New England and New York State. The Smithsonian Institution instituted a corps of observers in the 1840s but, again, for the first few years almost all were in the extreme north-east. In 1843, observations at the forts were made at sunrise, 9.00 a.m., 3.00 p.m. and 9.00 p.m., mean daily temperatures being calculated as the average of these.

Due to the problems associated with the instrument exposure and accuracy, plus the demands of the military which limited the observers' available time, it would be foolish to place too much reliance on, for example, any particular mean monthly temperature. However, when such values are seen in the context of the whole and a cohesive pattern evolves, then confidence is increased. This is what happened when studying the conditions of March 1843.

Ludlum (1968) cites Fort Snelling, Minnesota, as having a mean temperature of 25 degF (14 degC) below average in March 1843 and, upon checking conditions in the south-west, it was found that values at three forts in Louisiana and Oklahoma (Indian Territory as it was then called) were some 18 to 20 degF (10 to 11 degC) below average. This difference is extremely large, particularly for March, and focused attention on the rest of the country. Figure 1 shows the relevant data obtained for other forts across the eastern USA. The direction of the isallotherms to the west is somewhat conjectural as no data were found. The core of 25 degF deviations could be interpreted nowadays as some 750–800 heating degree days above average! It is unlikely that such a deviation over a large area has ever been recorded in the USA, and its occurrence in March is amazing. Stations reporting deviations of 20 degF (11 degC) or more are given in Table 1, together with the deviation for Fort Jesup, Louisiana, which was very large for such a southerly location.

Ludlum (1968) consulted many newspapers of the time, almost all from the north-eastern states.

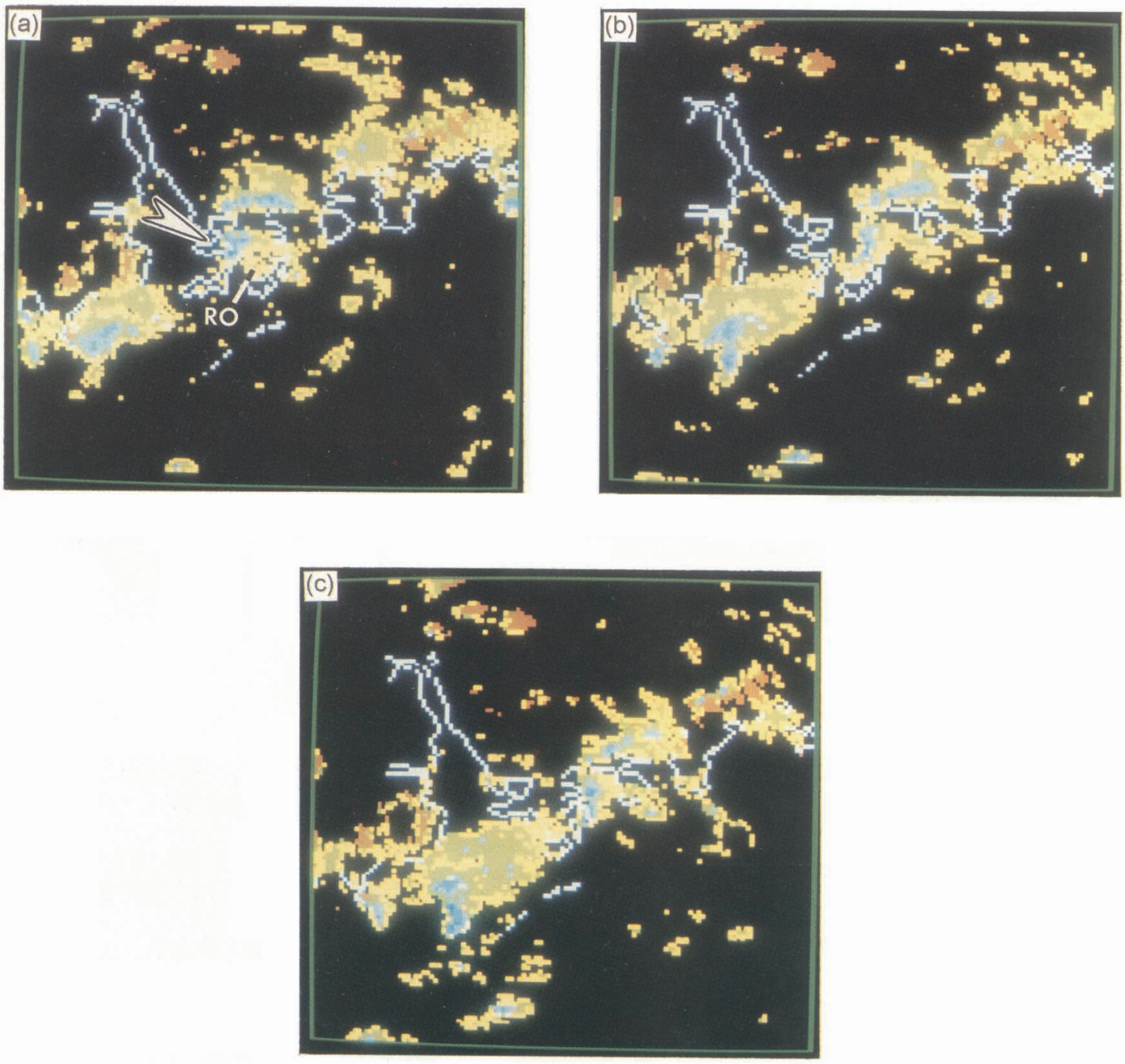

Fig. 2 *Radar pictures at 3 km altitude at (a) 12.11 p.m., (b) 12.29 p.m., and (c) 12.41 p.m. on 19 February 1992. The echo of interest is identified by an arrow in (a) The location of Hong Kong Royal Observatory (RO) is also marked.*