JP1.11 WIND SHEAR AND TURBULENCE AT THE SÃO PAULO INTERNATIONAL AIRPORT

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1. INTRODUCTION

The São Paulo International Airport (SPIA) is one of the busiest in Brazil (Fig. 1) with over 187,000 landings and take-offs and more than 13 million passengers a year (in 1999). Santos et al. (1996) used aircraft reports of wind shear and turbulence near the SPIA between 1989 and 1995 to analyzed their frequency according to the time of the day, month and season. Their results indicate that 88% of all reports were due to turbulence, more common in spring and fall. Wind shear was often related to approaching cold fronts and thunderstorms. Furthermore, the most significant events tend to occur during spring and summer between 1500 UTC and 2000 UTC. The objective of the present work is to evaluate aircraft reports of wind shear and turbulence near the SPIA against instability indexes, weather radar and satellite variables as well as surface measurements during the summers between 1994 and 1999.

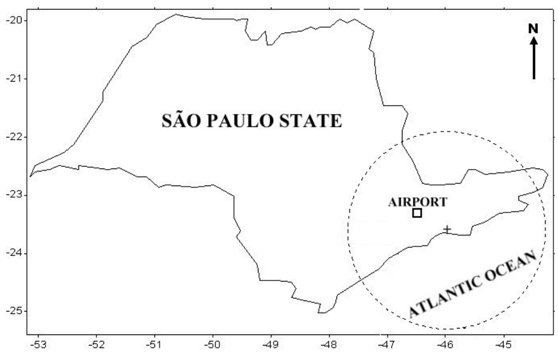

Figure 1: Map of the State of São Paulo, Brazil, with the location of the SPWR ("+") and its surveillance area (dashed circumference). The small square indicates the location of the SPIA. State boundaries and coordinates also shown.

2. METHODOLOGY

Instability indexes were estimated from 0000 UTC and 1200 UTC sounding measurements in the region. Namely, they are: K (Bluestein, 1993), SI (Showalter, 1953), Γ, Windex (MacCann, 1994), $\Delta\Theta_E$ (Atkins and Wakimoto, 1991), CAPE (Weisman and Klemp, 1982) and the bulk Richardson number - RN (Weisman and Klemp, 1986). Cloud echo tops, rainfall rates and gust wind speeds (Stewart, 1991) were obtained from reflectivity measurements with the São Paulo weather radar (SPWR). Aircraft reports of wind shear and turbulence were analyzed and identified those that caused a take-off during landing procedures. The SPIA has two runways in the direction ENE-WSE equipped with weather sensors distributed over nine sites. These data sets, numerical weather predictions and satellite data were used to diagnose case studies.

3. RESULTS

The distribution of wind shear and turbulence events by season and time of the day is shown in Fig. 2. A total of 559 cases were reported by aircrafts between 1994 and 1999. Cumulus and Cumulunimbus clouds associated with moving fronts account for 80% of the most significant events. Fog formation also affects air traffic in the winter. On average, 42% of all aborted landings during summer were caused by hazardous weather in the vicinity of the SPIA.

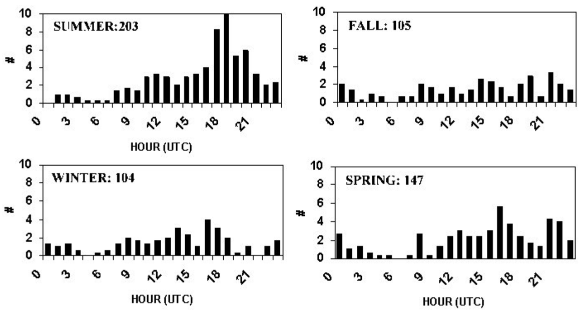

Figure 2: Total number of occurrences of wind shear and turbulence reported by aircrafts near the SPIA between 1994 and 1999, discriminated by season and hour.

Aborted landings caused by wind shear and turbulence from 1997 to 1999 were classified in two groups. One for the events associated with convective clouds in the vicinity of the SPIA and another for the events without convective clouds. Monthly averages of aborted landings caused by wind conditions with or without convective clouds are shown in Fig. 3. Events associated with convection prevail in the spring and summer, while the ones without convection in the fall and winter. Mean wind speed and direction measured at the SPIA for the above groups are shown in Fig. 4. Northerly and Northwesterly winds are stronger and dominant (46%) for cases without convection. Satellite images indicate that these events are associated with approaching cold fronts. These results agree with

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each other since winds are stronger and northwesterly ahead of the cold front. Moreover, there is short mountain range to the northwest of the SPIA, almost parallel to the runaways. During the approach of a moving cold front, it can induce strong shear and turbulence in the airport area.

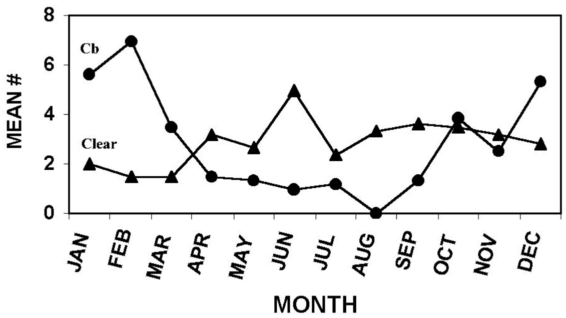

Figure 3: Monthly average of aborted landings due to wind shear and turbulence associated with convective clouds (Cb) or not (clear) in the vicinity of the SPIA from 1997 to 1999.

Convective events near the airport are associated with smaller average surface winds. Preferably, the wind direction is NE-SW due to the mountain range which is nearly parallel to the runaways. Wind effects caused by convective clouds tend to have greater impact on air traffic aloft in the proximity of the SPIA. Furthermore, ordinary convective clouds also interfere with the airport operations.

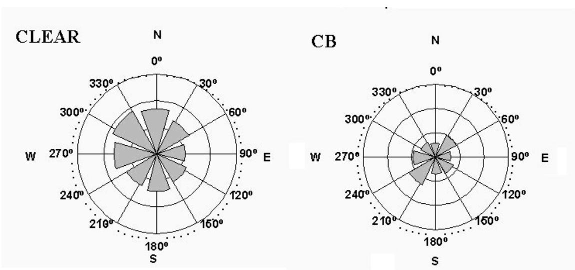

Figure 4: Average surface wind speed measured at the SPIA for landing aborts due to wind shear and turbulence with convective clouds (Cb) or without (clear) in the vicinity of the airport from 1997 to 1999. Each circle is 10 km h^{-1}.

Six convective cases were analyzed in greater detail to evaluate the skill of the instability indexes against the available data sets under extreme weather conditions. Fig. 5 shows the damage caused by one of them; air traffic was halted from 2050 UTC to 0000 UTC. Curiously, most events occurred in the summer of 1998 under an El Niño event (Pereira Filho, 1999). The indexes K, IS, CAPE were small and inconsistent with the observed thunderstorms. In most cases, $\Delta\Theta_E > 20$ K and $\Gamma > 6$ K km^{-1}. These values are associated with thunderstorms and microbursts, and strong wind gusts, respectively. The estimates of the RN were too high due to small CAPE values and low wind shear, which was estimated from model output. Radar estimates of wind gust were consistent with surface measurements at the SPIA.

Figure 5: Aerial view of the damage caused to the SPIA cargo terminal in the 2 April 1999 thunderstorm event.

4. CONCLUSION

Results suggest that events of strong downdrafts are better predicted with Windex and $\Delta\Theta_E$ indexes. They agreed well with observed areas of strong gust winds. Another sounding at 1500 UTC (not available), could give a better estimated of the CAPE. The SPWR derived variables such as gust winds, VIL and cloud echo tops were very useful in nowcasting these events. Thus, they can be used to detect and to predict turbulence and wind shear. The more frequent ordinary convective cells affect the air traffic at the SPIA. The state government is developing a new weather observing system that includes wind profilers, dual Doppler radars, mesonetworks of surface stations, a lightning detection network and others that will greatly improve the detection and prediction of hazardous weather.

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