LOW LAYER WIND SHEAR OVER DAKAR

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Abstract :

Low layer wind shears are dangerous for planes. Their observation and study are one of the main fields where the aeronautical community is waiting for a progress after their meeting held in Paris in 1964 where it was recommended for the first time to study this phenomenon over the world airports. Leopold Sedar Senghor Airport is situated on a peninsula where wind shears between the surface and the altitude of 110 m had been observed during a campaign in 1968/1969. Using twice-daily radiosonde data and Era-Interim reanalyses we compute the wind speed vertical gradients for all available levels between the surface and 850 hPa. It is shown that reanalyses smooth the vertical profiles and do not indicate the small scale large wind shear values displayed by radiosonde. The operational means used in aviation to fight against the wind shear effects are not successful. We end this study with the suggestion of a method of wrestling.

1- INTRODUCTION

WMO defines the wind shear as a local variation of the vector wind. We distinguish the horizontal and the vertical wind shear. It is this last type which interests us in this study.

In an atmospheric slice, we can distinguish several layers defined by a bottom and a top of pressure P_{i-1} and P_i. We define the indication I_i of this layer as:

$$I_i = \frac{\sqrt{(U_{i-1} - U_i)^2 + (V_{i-1} - V_i)^2}}{P_i - P_{i-1}}$$

where U_i and V_i indicate the zonal and meridian component of the wind at the top of the layer which average pressure is $(P_i + P_{i-1})/2$

Wind shear is one of dangerous meteorological phenomena for the aviation on which no method of efficient fight is still available. The dangerous wind shears are the ones that the plane meets between 100 and 500 m during their landing and takeoff phases.

Meteorological Offices supply data of observation and forecast from the ground at heights of more than 20 km but the meteorological information contained between the ground and the level 850hPa is not exploited in case of availability and is not communicated to the pilots

The pilots use this meteorological information to feed the embedded computer of the plane; they can be surprised by the existence of a wind of more than 40 Kt stronger than an announced wind by the Weather report

Wind shear can cause a rupture in the balance of the forces applied on the plane and may provoke an accident

The used means of observation are the soundings TEMP and PILOT at the rate of 2 and 4 networks per day in our airports. Meteorological classic radars, LIDAR, SODAR, Wind profiler radar, LLWAS which are equipments able to detect wind shear can also help.

Their use did not prevent ICAO (2005) to adopt the Aircraft Meteorological Data Relay (AMDAR) program initiated par WMO (1969, 2003) which consists of asking the pilots having met the phenomenon to broadcast the information to the other pilots exploiting this airport. This program is a recognition of the insufficiency of the used equipments and methods.

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In this work, we used radiosonde data at Dakar to show that these data contain good information about the wind shear. We showed some severe cases of wind shear accompanied with strong wind. Besides, we presented means used to detect the wind shear with their quality and their defect. We end this work with the proposal of a more effective method of detection and alert in the wind shear.

2- Data and Method

Used data are:

- Twice daily (00 and 12 UTC) wind data at Dakar radiosonde station from the ground to 850 hPa level for year 2001;
- Four times daily (00,06,12 and 18 UTC) wind Era-Interim reanalyzed data at the nearest grid-point (15°N, 17.15°W) on the ground, and on 1000, 975, 925, 900, 875 and 850 levels.

Using radiosonde data, we listed the cases wind shear accompanied with wind of speed superior to 20 m/s. The studied grid-point has eight levels of measure between the ground and 850 hPa; we calculated I_i in seven layers contained between these two levels.

3- RESULTS

The variations of the wind shear around the average are more or less important according to the seasons and as we calculate them using the radiosonde observation data Figure 1-a or using the reanalyzed data Figure 1-b.

Figure 1-a shows the series wind shear presenting fast variations all year long with strong amplitudes which alternate with average and weak amplitudes. The daily observed wind shear vary from some hundredth in more than 0.6 m/s /hPa.

The series of the daily wind shear obtained using reanalyzed data Figure 1-b present fast variations of strong amplitude during the dry season from October to May. The variations observed during summer are generally very weak except for a case observed toward the end in September.

This result is in agreement with the study carried out at Dakar airport in 1968/1969 which showed strong values of the wind shear during the dry season.

However the daily values wind shear calculated using ERA-Interim reanalyzed data are relatively weaker than those obtained using radiosonde data: they vary some hundredth of m/s / hPa in approximately 0.45 m /s / hPa. This result comes certainly from the smoothing of the model which generates the reanalyse.

These data, filtered using an order 8 Hamming filter, are shown in Figure 2. We can see the strong variations of the Figure 1.a with regard to Figure 1.b

One of the objectives of the study is to bring to light the detectability of a wind shear in a radiosonde report automatically supplied by the software associated with the system. Although presented today in this work, these situations of wind shear were not available for the services of aviation of Dakar airport at the time of the observation. So, an information so important for the security of planes, having been observed, is not put at the disposal of planes because of the organization and of the plan of load of meteorological offices.

Table 1 shows six various cases of severe wind shear observed at Dakar during year 2001. The first date concerns Table 1.a where the wind of the ground of 4 m/s is surmounted by a wind of 20.4m/s weakening until it reaches 3.6 m/s at 850 hPa level. At March 24th (Table 1.e) the ground wind of 6 m/s is surmounted by weak wind until 1000 m before the wind takes the value of 23.6 m/s at 1404 m. This second case of wind shear is less dangerous for plane. We then established the list of the means of communication, navigation and surveillance used in the Aviation to detect the wind shear.

Table 2 presents this list of means with their quality and their defect for detecting wind shear.

According to an ITU report (1997) concerning the wind profiler radar, the air traffic surveillance radars, endowed with a shone isotropic power higher than a power of the main beam of wind profiler radars, work in the same band in the neighbourhood of 1000 MHz, for several years. We observe generally a degradation of the quality of wind profiler radars which can be imputed to the broadcasts of surveillance radars.

We realize profiles of measures of meteorological elements in situ in the first 500 meters upright of the meteorological station of the airport, all 100 m for example, using the appropriate sensors of pressure, temperature, humidity and wind.

Such a sounder allows to assure the follow-up of the wind and will be capable of serving as alert in wind shear. The sensors will communicate with a computer the measurements. Responsibility being in the computer to calculate the wind shear all 10 mn for example and to emit a warning message in case of overtaking of certain threshold to be defined.When the wind shear does not answer any more the criteria, another message of the end of wind shear will be emitted.

Using captive balloon, or wind tower, we shall be able to collect Boundary Layer information and to study the unknown profiles of climatic elements over the airports: basic condition to improve our knowledge of some phenomena and the weather prediction in our region.

4- CONCLUSION

Here is near half a century when the international aeronautical community sounded the alarm to ask for the beginning of organization of the wrestling against the wind shear phenomenon. It followed itself of important efforts of technological and industrial research for the innovation of effective tools of wrestling. But these efforts must be doubled because no perfect tool was able to be used in an operational way. Because of little satisfaction which offer nowadays installed equipments on the ground, the international aeronautical community implemented an alarm system based on the report supplied by the pilots themselves.

In this work, we suggest a simple method based on the exploitation of the sounding mean and the implementation of captive balloons or wind towers. From a widened dialogue in the international meteorological community, could result the implementation of a mean of effective fight against the effects of the wind shear.

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- World Meteorological Organisation (WMO), 1969: The vertical wind shear in the low layers of the atmosphere, *WMO* Technical Note No **93**
- World Meteorological Organisation (WMO), 2003: Aircraft Meteorological Data Relay (AMDAR) Reference Manual *WMO* No **958**

FIGURE CAPTION

Figure 1: Wind shear indices. In X-coordinate, the number of the observation or reanalyse in the year and in ordinate the wind shear indices in m/s/hPa; In Fig 1.a radiosonde data of 00 and 12 UTC are used and in Fig 1.b Era-Interim reanalyses for 00 and 12 UTC are used.

Figure 2 Wind shear indices filtered using an order 8 Hamming filter. In X-coordinate, the number of the observation or reanalyse in the year and in ordinate the wind shear indices in m/s/hPa.

TABLE CAPTION

Table 1: Some various cases of severe wind shear observed at Dakar during year 2001.

Table 2: Analysis of the strength and weakness of used equipments to serve as an alert system of vertical wind shear.

* according to a ITU Report (1997)

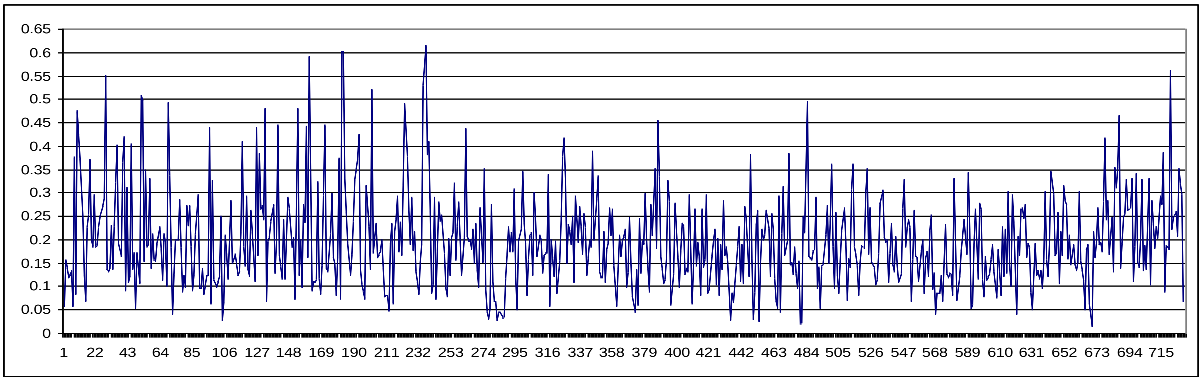

Fig 1.a

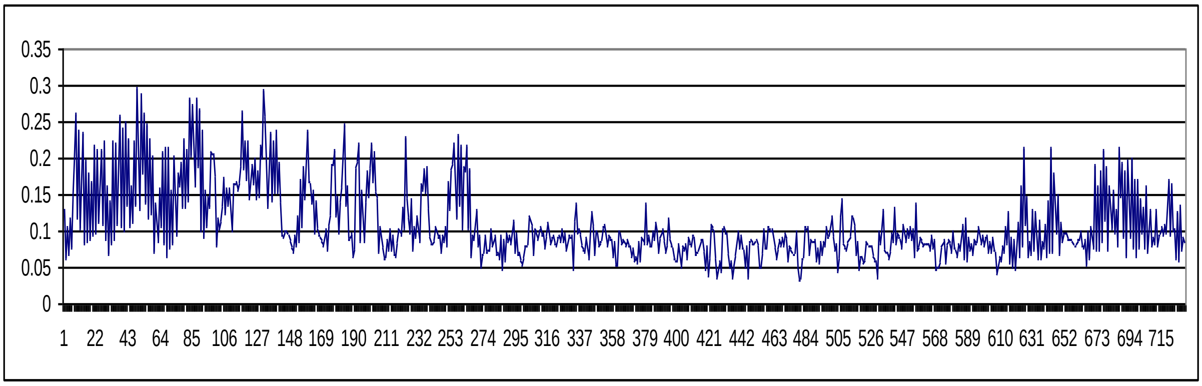

Fig 1.b

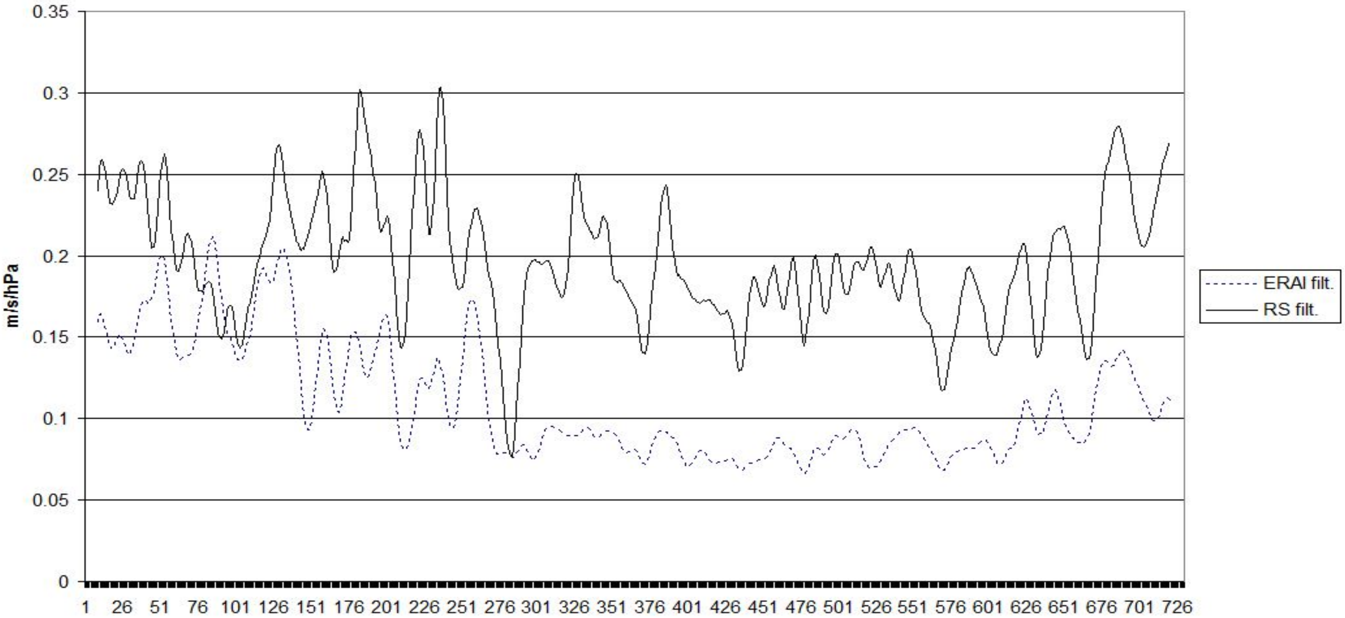

Figure 2

a- Febuary 13 2001 at 12 UTC

min	s	hPa	gpm		m/s	deg
0	0	1011.3	28	/////	4.0	90
1	20	957.0	516	/////	20.4	44
2	3	925.0	817	/////	14.2	35
2	44	896.1	1097	/////	11.0	25
3	46	850.0	1533	/////	3.6	134

b- March 6 2001 at 12 UTC

min	s	hPa	gpm		m/s	deg
0	0	1011.8	28	/////	5.5	40
1	20	955.3	524	/////	20.3	108
1	59	925.0	805	/////	15.1	112
3	18	870.1	1334	/////	5.2	124
3	50	850.0	1559	/////	9.5	58

c-March 7 2001 at 12 UTC

0	0	1011.4	28	/////	5.0	20
0	56	976.1	338	/////	21.7	37
1	48	938.7	686	/////	28.6	49
2	10	925.0	817	/////	27.5	52
2	54	895.0	1108	/////	15.8	54
3	16	880.5	1252	/////	15.1	65
4	3	850.0	1561	/////	15.1	66

d-March 11 2001 at 12 UTC

0	0	1010.1	28	/////	4.0	30
1	0	973.5	349	/////	20.2	40
2	13	925.0	801	/////	14.8	61
3	18	881.0	1229	/////	9.6	84
3	38	867.7	1361	/////	9.3	90
4	5	850.0	1541	/////	9.0	91

e-March 24 2001 at 12 UTC

0	0	1010.0	28	/////	6.0	360
1	10	968.7	386	/////	4.6	81
1	16	965.2	418	/////	4.7	88
2	12	925.0	792	/////	7.0	143
2	36	908.5	950	/////	9.4	164
3	2	890.5	1125	/////	15.0	178
3	42	862.4	1404	/////	23.6	169
4	0	850.0	1531	/////	20.0	168

f-April 28 2001 at 12 UTC

0	0	1008.8	28	/////	6.0	30
1	4	981.3	267	/////	22.9	29
1	44	964.2	421	/////	21.0	10
3	4	925.0	792	/////	15.9	34
3	48	903.6	1000	/////	14.0	43
4	26	885.5	1179	/////	7.4	21
4	56	871.8	1317	/////	6.0	54
5	37	850.0	1540	/////	6.2	61

Table 1

Equipment	Strength	Weakness
Classic meteo radar	Horizontal wind shear	Not used in aviation
SODAR	Temperature inversion upright of the place	Not used in aviation
LIDAR	Wind vertical profiling and physical properties of Aerosol	Not used in aviation
Anemometers (LLWAS)	Possible in hilly relief	Not possible in plain
Wind Profiler Radar	Possible	Difficult to be used*, in airports with ATC radar, as alert system
Sounding - By pilot balloon - By radiosonde - By captive balloon or Wind Towers	 0 to 4 times per day 0 to 4 times per day Permanently	 Not as alert system Not as alert system Usable as alert system as explained below

Table 2