ASCI 517 – Advanced Meteorology

Research Topic: Microburst, Downbursts & F Factor

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For the subject at hand a brief definition of each phenomenon will be provided hereunder, so that the reader can be better familiarized with the terms which will be rendered during the course of this research.

- Downbursts: Can be defined as localized downdrafts located under thunderstorms.
- Microbursts: Can be defined as downbursts with winds extending 4 kilometers or less.
- Macrobursts: Can be defined as larger downbursts with winds extending more than 4 kilometers.

Impact of Phenomenon on Aviation

This phenomenon is of particular importance to aviation due to the inherit risks it poses on aircrafts during takeoff and landing, and the short time for pilots to react once detected. Although microbursts are also responsible for damages to objects on the ground, such as large as trees, in aviation however, as in all weather phenomenons, the consequences are undoubtedly magnified.

Due to the particular characteristics of this phenomenon, which will be discussed hereunder, it proves to be very hazardous to all aviators, hence proper training in identification and response should be of the outmost importance, since it can occur in basically all types of conditions, such as dry or humid regions, as well as in thunderstorms or even clouds that may not contain thunder and lightning.

This research will also try to demonstrate the importance this phenomenon poses to the aviation industry, as it might have a direct link to the advent of gradual atmospheric changes in coming years, such as global warming.

Therefore, an inherit necessity of furthering the research and development in this field and the use of applied state of the art equipments for aircraft.

Fundamental Characteristics

Microbursts are characterized by downburst winds of four kilometers or less. Nevertheless, despite its small size, the concentration of localized wind can reach as high as 168 miles per hour (146 knots). The leading edge of a microburst can evolve into a gust front (Ahrens, 2010).

Macrobursts in the other hand are larger downbursts that extend more than four kilometers. The rapid changes in wind speed and wind direction is commonly referred to in aviation as “windshear”, and has been a direct contributing factor of multiple airline accidents. According to the NTSB (2010), one of the atmospheric conditions capable of producing dramatic shears is the downburst from convective or cumuliform clouds.

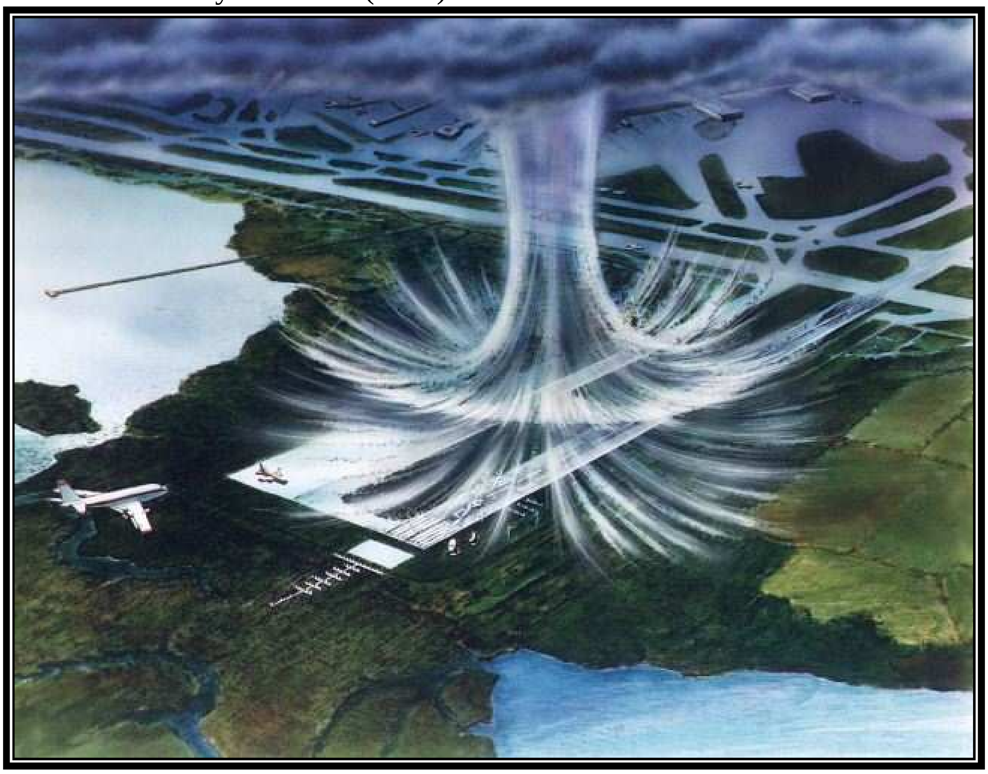
The basic characteristics of an aircraft traversing a microburst “windshear” is an initial outflow on the front side, which increases the headwind component, causing the airplane to rise and its indicated airspeed to increase. Several seconds later, the headwind component begins decreasing and the airplane traverses the central core downdraft, which can be very strong (Fujita, 1981).

Finally, the airplane encounters the back side of the microburst, and the tailwind component begins to increase, causing the airplane to sink and its indicated airspeed to decrease. According to the NTSB (2010), the time across this whole feature is anywhere from 20 to 40 seconds.

This indicates that pilots do not have a very long time to adjust, and can therefore create serious performance problems for an aircraft. If we assume the data that the microburst's horizontal outflow winds are 30 knots, then during the 20 to 40 seconds required to traverse the area, an airplane would encounter a 60-knot horizontal windshear.

For a better edification, below we can appreciate an image rendering of a microburst, courtesy of NASA (2010):

FIGURE I-I. Mircroburst Image Illustration
Source: Courtesy of NASA (2010).



For a more comprehensive research, it would also be beneficial to further divide the characteristics manifested in both dry and humid regions:

- Dry regions:

According to Ahrens (2009), in dry regions, a microburst can contain an intense horizontally rotating vortex that is often filled with dust. For instance, in eastern Colorado many microbursts originate from virga, which is basically falling rain from a cloud but evaporates before reaching the ground.

- Humid regions:

According to Ahrens (2009), in humid regions, many microbursts are accompanied by blinding rain, and are associated with severe thunderstorms. The clouds can be both, multicell or even ordinary cell thunderstorms, with clouds that produce only isolated showers. These clouds may or may not contain thunder and lightning.

As we can appreciate from the above characteristics, we can safely deduct that this phenomenon not only poses a direct hazard to the pilots navigating an aircraft, as it relates to rapid gain and subsequent loss of altitude and performance, but since the leading edge of a microburst can contain an intense horizontally rotating vortex (Ahrens, 2010), which lifts dust and heavy particles from the ground; it also poses an indirect threat to the integrity of an aircraft fuselage, as well as a threat of jet intake, which by itself can be as catastrophic scenario as any since it will cause potential damage in a crucial moment of the flight; in other words during landing or take off. A scenario like this will signify very little reaction time for the flight crew.

<u>Does it affect all types of aviation?</u>

The microbursts and downbursts phenomenon affects all types of aviation, military or commercial, and regardless of aircraft type. As previously discussed, it can occur in any region and it's not limited only to severe thunderstorms.

According to ICAO statistics, between 1970 and 1985, there were 28 aviation accidents with 700 fatalities caused by low level microbursts "windshear". As follows, qualitative support of accidents caused by this phenomenon will be put forth as direct examples of how the phenomenon affects aviation. These have been retrieved from previous findings and official accident investigation reports. These will serve the purpose of providing direct and tangible proof.

Accidents attributed to the microburst phenomenon:

a. On August 2nd, 1985; one of the most well known accidents attributed to this phenomenon, the Delta Airlines flight 191 which crashed during landing at Dallas Fort Worth, Texas.

<u>Findings' Summary:</u> The Safety Board determined that the probable causes of the accident were the flight crew's decision to initiate and continue the approach into a cumulonimbus cloud which they observed to contain visible lightning, as well as the lack of specific guidelines, procedures, and training for avoiding and escaping from low-altitude windshear; and the lack of definitive, real-time windshear hazard information. This resulted in the aircraft's encounter at low altitude with a microburst-induced, severe windshear from a rapidly developing thunderstorm located on the final approach course (NTSB/AAR-83/05, 1986).

b. On July 9th, 1982; a Pan American World Airways Boeing 727 crashed after encountering a microburst shortly after takeoff. One hundred forty five passengers and eight persons on the ground were killed in Kenner, Louisiana (NTSB, 1981).

<u>Findings' Summary:</u> The Safety Board determined that the probable cause of the accident was the airplane's encounter during the liftoff and initial climb phase of flight with a microburst induced windshear, which imposed a downdraft and decreasing headwind, the effects of which the pilot would have had difficulty recognizing and reacting to in time for the airplane's descent to be arrested before its impact with trees (NTSB, 1983).

c. On June 24th, 1975; a Boeing 727 crashed during approach to JFK International Airport. 115 passengers killed (NTSB, 1976).

d. On July 07th, 1980; a Tupolev 154B-2 crashed as it climbed from Almaty Airport at Kazakhstan. 163 passengers killed (NTSB, 1981).

<u>Findings' Summary:</u> The Safety Board determined that the probable cause of the accident was the airplane's encounter during the liftoff and initial climb phase of flight with a microburst induced windshear which imposed a downdraft and decreasing headwind.

Tools and Methods Utilized to Mitigate Adverse Effects

It wasn't after the crash of Delta Airlines flight 191 in 1986, which captured and concentrated a great deal of spotlight on this phenomenon that serious steps were made.

Once the official findings were published, which according to the NTSB's executive summary report (AAR-86/05, 1985), the accident was attributed to: "The lack of ability to detect microbursts aboard the aircraft; the radar equipment aboard aircraft at the time was unable to detect wind changes, only thunderstorms". These statements proved to be the catalyst so that a serious solution would be found.

After the formal investigation from the NTSB was concluded, NASA researchers at Langley Research Center took the initiative of modifying a Boeing 737-200 and adapting an on-board Doppler Weather Radar. This experiment resulted in the creation of the "airborne wind shear detection and alert system".

Subsequently the Federal Aviation Administration mandated that all commercial aircraft must have on board wind shear detection systems.

How successful are these mitigation techniques? Why?

On September 1, 1994, the weather radar model RDR-4B of the Allied-Signal/Bendix (presently Honeywell) became the first predictive wind-shear system to be certified for commercial airline operation. In the same year, Continental Airlines became the first commercial carrier to install an airborne predictive wind-shear detection system on its aircraft. By June 1996, Rockwell Collins and Westinghouse's Defense and Electronics Group (presently Grumman/Martin) also came up with FAA-certified predictive wind-shear detection systems.

It is safe to say that after the advent of the Windshear Detection System on commercial aircraft, the accidents attributed to this phenomenon have dropped considerably.

Is there still more to be learned? What is in store for the future?

Ongoing research is still essential for this phenomenon; in fact, the Intelligent Transportation Systems Society (IEEE) is presently conducting research for further developments of this system the above system.

Important to point out is that per mandate of the FAA the windshear detection system is only installed on engine commercial aircraft, however, turboprop commercial aircraft, such as those utilized by regional carrier are not obligated to function with it, therefore, the inherit risk is still present and modern yet affordable technology should still be sought after to enable all commercial aircraft the ability to possess some sort of microburst and windshear detection system on board.

How well can the phenomena be observed/detected? (Capabilities and limitations)

Most aviators would attest that the windshear they have encountered has mostly been with a thunderstorm in the vicinity, although, it has been clearly stated in this research that microbursts and windshear can also occur on a clear day with no storm in sight.

To visually detect a microbursts/ windshear will basically depend on the location and characteristics of the soil, since the only palpable visual evidence would be the dust picked up by the wind and acting as a visual variable. Otherwise, the phenomenon would be undetectable to the human eye, just being perceived by the physical characteristics and behavior of the aircraft traversing through it.

How well can they be predicted? (Capabilities and limitations)

With today's weather detection technology, fortunately it is a phenomenon that can be easily predicted and detected, through the use of ground and aircraft detection systems, as well as high resolution Doppler radars.

However, much attention should still be focused on all types of commercial aircrafts, not just jet engines by passing adequate laws in this manner as well as the availability of making affordable on board detection systems for even the smallest of aircraft, thus contributing to making our skies even safer.

References

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